GAM Run 09-014
by Mr. Wade Oliver

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
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Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on September 21, 2010.
EXECUTIVE SUMMARY:

The recently modified groundwater model for the Dockum Aquifer was used to estimate future pumping under a scenario where groundwater levels declined at a rate of one foot per year in Groundwater Management Area 1 between 2010 and 2060. Pumping required to achieve this constant rate of decline over the 51 year model simulation period was estimated to increase through time from approximately 13,000 acre-feet per year to over 107,000 acre-feet per year.

For comparison, an additional run was performed with pumping set at a constant rate to achieve a 51-foot decline over the 51 year simulation period. This run differs from the above run in that the drawdown rate – 1 foot per year – is not constant. The drawdown rate changes through time but still achieves the same average drawdown over Groundwater Management Area 1 by 2060. This run required a constant pumping rate of approximately 83,000 acre-feet per year.

The annual pumping in each of the above model runs was then adjusted up and down in order to provide insight into how the drawdown results change through time under different pumping scenarios.

REQUESTOR:

Mr. Steve Walthour of North Plains Groundwater Conservation District on behalf of Groundwater Management Area 1.

DESCRIPTION OF REQUEST:

Mr. Walthour requested a groundwater availability model run that results in a 1-foot decline in the average water level of the Dockum Aquifer per year in Groundwater Management Area 1 between 2010 and 2060. The Dockum Aquifer and nearby groundwater management areas are shown in Figure 1.

METHODS:

The recently modified groundwater model of the Dockum Aquifer (Oliver and Hutchison, 2010) was used in order to estimate the pumping required to achieve the requested rate of drawdown of one-foot per year in the Dockum Aquifer. This model is a modification of the groundwater availability model documented in Ewing and others (2008) and was completed in order to more effectively simulate predictive conditions. The pumping between 2010 and 2060 was determined iteratively by adjusting pumping in Groundwater Management Area 1 each year to obtain the requested decline. For this report, this model run will be referred to as “Scenario 1.”

For comparison purposes, an additional run was performed using pumping set at a constant rate between 2010 and 2060 to achieve 51-feet of drawdown – the same overall drawdown as the above request – but without the requirement of 1-foot of drawdown per year. This run is referred to in this report as “Scenario 2.”
Once the levels of pumping that met the above two scenarios were estimated, the pumping in each scenario was systematically adjusted up and down to show how drawdown through time changes under different pumping levels. More details on pumping in the model are given in the Pumping section below.

The historical-calibration period of the model ends in 1997 while the predictive simulation documented here begins in 2010. To determine the appropriate level of pumping between 1998 and 2009, the interim period leading up to the predictive simulation, a preliminary analysis of water levels in a few selected wells in Groundwater Management Area 1 was performed. As shown in Appendix A, these hydrographs do not indicate significant trends in water levels that indicate large changes in pumping during this time period. For this reason, we considered the pumping levels and distribution for the last year of the historical-calibration portion of the model to be appropriate for the interim period. Pumping was, therefore, held constant at 1997 levels between 1998 and 2009.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the modified groundwater model for the Dockum Aquifer are described below:

- We used the modified version the groundwater model for the Dockum Aquifer described in Oliver and Hutchison (2008). This model is an update to the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008) in order to more effectively simulate predictive conditions. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- The model includes two active layers which represent the upper and lower portions of the Dockum Aquifer. Layer 2 represents the upper portion of the Dockum Aquifer. Layer 3 represents the lower portion of the Dockum Aquifer. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified model as described in Oliver and Hutchison (2010).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the lower portion of the Dockum Aquifer between 1980 and 1997 is 53 feet. This represents 2.5 percent of the hydraulic head drop across the model area.

- The MODFLOW General-Head Boundary package was used to simulate flow between the Dockum Aquifer and overlying aquifers. The water levels in the overlying aquifers were applied as described in Oliver and Hutchison (2010) using Groundwater Availability Model Run 09-001 (Smith, 2009) for the northern portion of the Ogallala Aquifer and Groundwater Availability Model Run 09-023 (Oliver, 2010a) for the southern portion of the Ogallala Aquifer.
Cells were assigned to individual counties and groundwater conservation districts as shown in the September 14, 2009 version of the model grid for the Dockum Aquifer. Because this model grid predates development of the modified model, care was taken to ensure that only those fields in the model grid that were valid for the modified model were used for analysis of results.

The recharge used for the model run represents average recharge as described in Ewing and others (2008).

Pumping used for the predictive simulations was estimated iteratively to match the requested rate of water level decline by members of Groundwater Management Area 1. Details on this pumpage are given below.

**Pumping**

The pumping for Scenario 1 (the original request) in the model was determined using an iterative process. The pumping in the model for the year 1997 (the last year of the historical-calibration portion of the model) was held constant between 1998 and 2009. Beginning in 2010, this pumping was raised over Groundwater Management Area 1 as a whole and the decline in water levels each year between 2010 and 2060 was calculated. This decline was then compared against the request (1-foot per year) and pumping was adjusted to match the request. This process was repeated until the average water level decline in Groundwater Management Area 1 each year was 1 foot. In order to elevate the pumping to the specified level, the amount of pumping above the level for 1997 was uniformly increased over all model cells that contained pumping.

With the exception of Nolan and Mitchell counties in Groundwater Management Area 7, the pumping in areas outside Groundwater Management Area 1 was held constant at 1997 levels through the predictive period. Pumping in these counties was also adjusted, at the request of Groundwater Management Area 7, to values specified for these counties. Results for these areas are presented in GAM Run 10-001 (Oliver, 2010a).

As mentioned in the Methods section above, an additional run (Scenario 2) was also performed to estimate the constant pumping rate that achieves the same average drawdown over the 51-year predictive period as the requested run above (51 feet). The pumping for this run was determined using the same process as above except that the pumping input into MODFLOW did not vary through time between 2010 and 2060. Instead, this constant pumping was adjusted to achieve an average of 51 feet of drawdown in Groundwater Management Area 1 between 2010 and 2060.

The two pumping scenarios above were also adjusted up and down in order to provide insight into the relationship between pumping and drawdown in the Dockum Aquifer in Groundwater Management Area 1. The pumping input to the model was multiplied by factors to increase (factors of 1.3, 1.6 and 1.9) or decrease (factors of 0.8, 0.6, and 0.4) the pumping over the model as a whole. These values were chosen to provide a range of
pumping values between roughly half and twice the “base” scenarios above. The relationships generated are presented in the Results section below.

RESULTS:

As described above, the pumping distribution for the last year of the historical-calibration portion of the model was held constant between 1998 and 2009 and then set to levels to meet the requirements of scenarios 1 and 2 between 2010 and 2060. The average drawdown for each decade for Scenario 1 is shown in tables 1 and 2 for each county, groundwater conservation district, and groundwater management for the upper and lower portions of the Dockum Aquifer, respectively. Table 2 also includes pumping output from the model which accounts for pumping lost due to cells going inactive. A model cell goes inactive when the water level in a cell drops below the bottom of the aquifer. In this situation, pumping can no longer occur. Table 1 does not include pumping because no pumping occurs in the upper portion of the Dockum Aquifer in the model. This same information for Scenario 2 is shown in tables 3 and 4.

As shown in Figure 1, the upper portion of the Dockum Aquifer within Groundwater Management Area 1 is limited to a small area in the southwest corner of Randall County. Drawdowns over the 51-year predictive period for this area are 19 and 20 feet for Scenarios 1 and 2, respectively (Tables 1 and 3). In Scenario 1, drawdown increases relatively steadily through the period. In Scenario 2, drawdown increases rapidly and then levels off.

Tables 2 and 4 present pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenarios 1 and 2, respectively. For Scenario 1, drawdown in Groundwater Management Area 1 averages one foot per year. This rate is variable by county, however. For example, drawdown in Oldham County is only 4 feet after the 51-year period while drawdown is 111 feet in Sherman County by 2060. The primary reason for this difference is that the Dockum Aquifer outcrops over a large area of Oldham County while it does not in Sherman County. Where the aquifer outcrops, a decline in the water level requires that the aquifer actually be dewatered. This is in contrast to the subcrop, where a decline in water level is more easily achieved by reducing the confining pressure.

For Scenario 2, drawdown in Groundwater Management Area 1 increases rapidly and then begins to level off through the 51-year predictive period, achieving an average of 51 feet of drawdown by the end of 2060. As for Scenario 1 above, the rate of drawdown varies by county.

As described in the Pumping section above, the base pumping distribution for each of the above scenarios was adjusted up and down to provide insight into how the model responds under different levels of pumping. Tables similar to Tables 1 through 4, but showing pumping and drawdown results based on these pumping adjustments are shown in Appendix B. In addition, Figure 2 shows the drawdown in the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time for pumping Scenario 1. Runs with pumping equivalent to 40 percent of Scenario 1 (a decrease) and 190 percent of Scenario 1 (an increase) are also shown. Pumping for Scenario 1 must increase from about 13,400 acre-feet per year in 2010 to over 107,000 acre-feet per year in 2060 to achieve the requested 1 foot of
drawdown per year for the “base” Scenario 1. For the model run with 40 percent of Scenario 1 pumping, pumping still increases through time, but from approximately 5,000 acre-feet per year to almost 43,000 acre-feet per year. For the model run with 190 percent of Scenario 1 pumping, pumping increases from 25,000 acre-feet per year to over 200,000 acre-feet per year. These runs result in drawdowns of 37 and 60 feet for the 40 percent and 190 percent runs, respectively.

Figure 3 shows the drawdown in Groundwater Management Area 1 through time for pumping Scenario 2. As for Figure 2 above, Figure 3 also contains the results of decreases and increases of the base pumping for Scenario 2. The shapes of the runs presented in Figure 3 are very different than Figure 2 because pumping is set at a constant rate through the predictive period in Scenario 2. At the low end, a constant pumping rate of 33,000 acre-feet per year (the 40 percent run) results in a drawdown of 36 feet after 51 years. At the high end, a constant pumping rate of 154,000 acre-feet per year (the 190 percent run) results in a drawdown of 62 feet after 51 years.

To better illustrate how the model responds through time during the “base” runs, Appendix C contains charts for each of the major water budget terms for each year of the predictive model runs for scenarios 1 and 2. Note that these charts only reflect the lower portion of the Dockum Aquifer within Groundwater Management Area 1. Appendix D contains water budget tables for each county, groundwater conservation district, and groundwater management area for the last stress period of the model run. The components of the water budget are described below:

- **Recharge**—areally distributed recharge due to precipitation falling on the outcrop areas of the aquifer. Recharge is always shown as “Inflow” into the water budget. Recharge is modeled using the MODFLOW Recharge package.

- **Pumping**—water produced from wells in the aquifer. This component is always shown as “Outflow” from the water budget. Pumping is modeled using the MODFLOW Well package.

- **Change in Storage**—changes in the water stored in the aquifer. This component of the budget is often seen as water both going into and out of the aquifer because water levels may decline in some areas (water is being removed from storage) and rise in others (water is being added to storage).

- **Overlying Aquifers**—water that flows into (or out of) the aquifer due to interaction with overlying units, primarily the Ogallala Aquifer. Interaction with overlying aquifers is modeled using the MODFLOW General-Head Boundary package. For areas overlain by the Ogallala Aquifer, the water level input to the general-head boundary package comes from predictive GAM runs 09-001 and 09-023 using the models for the northern and southern portions of the Ogallala Aquifer, respectively (Smith, 2009; Oliver, 2010a).
Springs and Evapotranspiration—water that naturally discharges from the aquifer when water levels rise above the elevation of the spring or seep or when it is close enough to the surface to evaporate or be taken up by plants. This component is always shown as “Outflow,” or discharge, in the water budget. Spring and evapotranspiration outflows are simulated collectively in the model using the MODFLOW Drain package.

Stream Interaction—water that flows between streams and the aquifer. The direction and amount of flow depends on the relationship between the water levels in the stream and the aquifer. Where the water level in the stream is higher than the water level in the aquifer, water flows into the aquifer and is shown as “Inflow” in the budget. Where the water level in the stream is lower than the water level in the aquifer, water flows out of the aquifer and is shown as “Outflow” in the budget. Streams are modeled using the MODFLOW Stream package.

Lateral flow—describes lateral flow within the aquifer between one area and an adjacent area (for example, lateral flow into and out of a groundwater management area).

Vertical flow or leakage (upper or lower)—describes the vertical flow, or leakage, between two aquifers, or, in the case of this model, between the upper and lower portions of the Dockum Aquifer. This flow is controlled by the water levels in each unit and aquifer properties that define the amount of leakage that can occur. “Upper” refers to interaction between an aquifer and the aquifer overlying it. “Lower” refers to interaction between an aquifer and the aquifer below it. For this model, vertical flow between the upper and lower portions of the Dockum Aquifer is reported separately from interaction of the Dockum Aquifer with the overlying aquifers described above (which is, strictly speaking, also vertical flow).

Figure C-1 in Appendix C shows the recharge through time for scenarios 1 and 2. Recharge is constant through time for both the historical period of the model to which it was calibrated (not shown) and the predictive period. Recharge to the Dockum Aquifer in Groundwater Management Area 1 is approximately 8,800 acre-feet per year.

Figure C-2 shows pumping through time for scenarios 1 and 2. This figure most clearly shows the differences in the way the two scenarios were set up. In Scenario 1, pumping gradually increases through time from approximately 13,400 acre-feet per year to over 107,000 acre-feet per year. In Scenario 2, pumping is set to a constant rate of approximately 83,000 acre-feet per year. While both scenarios achieve an average of 51-feet of drawdown over the 51-year period, the rate of pumping through time during the period is very different.

Figure C-3 shows the Net Change in Storage in the model. Note that in Scenario 2 the amount of water removed from storage increases dramatically in 2010 due to the abrupt increase in pumping shown in Figure C-2. While the increase in the rate of water removed from storage is smoother for Scenario 1, the rate at which water is removed from storage in 2060 is higher for Scenario 1 than at any point during the model run of Scenario 2.
Figure C-4 shows the net inflow from overlying aquifers (primarily the Ogallala Aquifer). This figure is similar in shape to Figure C-3 because the rapid decline in water levels in Scenario 2 induces an increase in the amount of water flowing into the Dockum Aquifer from the overlying Ogallala Aquifer. Note that the rate of inflow from overlying aquifers declines through time after approximately 2015 in Scenario 2. This is due to declining water levels in the overlying Ogallala Aquifer. As the water levels in the Ogallala decline, the gradient between the water level in the Dockum Aquifer and the water level in the Ogallala Aquifer is reduced. The amount of flow, therefore, is also reduced. In Scenario 1, however, the volume of flow from the Ogallala Aquifer increases, albeit slowly, through time. This is because the rate of drawdown in the Dockum Aquifer in this scenario is higher than the rate of drawdown in the overlying Ogallala Aquifer (in the areas where it overlies the Dockum Aquifer). This results in an increasing gradient between the two aquifers yielding an increase in the net inflow from the overlying aquifers.

Figure C-5 shows the outflow to springs and by evapotranspiration for scenarios 1 and 2. In both scenarios, outflows decline through time due to declining water levels in the Dockum Aquifer. Figure C-6, showing net outflow to streams, exhibits a very similar response as the springs and evapotranspiration shown in Figure C-5 for the same reason.

Figure C-7 shows the net lateral flow between Groundwater Management Area 1 and adjacent areas. Notice that throughout the predictive period flow is consistently toward Groundwater Management Area 1 and increases through time due to declining water levels.

Figure C-8 shows the magnitude and direction of vertical flow between the upper and lower portions of the Dockum Aquifer. Through the predictive period there is a net downward flow from the upper portion of the Dockum Aquifer to the lower portion. While the rate of this flow increases through time due to declining water levels, the magnitude is minor (less than 700 acre-feet per year) relative to the other water budget terms.

It is important to acknowledge the limitations of the precision of the sub-regional water budgets that is associated with the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary (for example, a county) is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.
REFERENCES AND ASSOCIATED MODEL RUNS:


Oliver, W., 2010a, GAM Run 09-023: Texas Water Development Board, GAM Run 09-023 Draft Report, 30 p.


Table 1. Average drawdown for the upper portion of the Dockum Aquifer for Scenario 1 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
<thead>
<tr>
<th>Scenario 1: Base</th>
<th>Base Drawdown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Dockum</strong></td>
<td>2010 2020 2030 2040 2050 2060</td>
</tr>
<tr>
<td><strong>County</strong></td>
<td></td>
</tr>
<tr>
<td>Randall</td>
<td>0 3 7 12 16 19</td>
</tr>
<tr>
<td>GCD</td>
<td>2 17 30 39 42 43</td>
</tr>
<tr>
<td>High Plains UWCD No. 1</td>
<td>0 0 1 1 1 1</td>
</tr>
<tr>
<td>GMA</td>
<td>0 3 7 12 16 19</td>
</tr>
<tr>
<td>Out-of-State</td>
<td>0 0 1 1 1 1</td>
</tr>
<tr>
<td>GMA 1</td>
<td>1 15 27 35 40 42</td>
</tr>
<tr>
<td>GMA 2</td>
<td>0 0 0 0 1 1</td>
</tr>
<tr>
<td>GMA 3</td>
<td>0 0 0 0 1 1</td>
</tr>
<tr>
<td>GMA 7</td>
<td>0 5 9 13 15 16</td>
</tr>
</tbody>
</table>

Table 2. Pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenario 1 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
<thead>
<tr>
<th>Scenario 1: Base</th>
<th>Pumping Average Drawdown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower Dockum</strong></td>
<td>2010 2020 2030 2040 2050 2060</td>
</tr>
<tr>
<td><strong>County</strong></td>
<td></td>
</tr>
<tr>
<td>Armstrong</td>
<td>107 457 929 1,730 3,218 5,810</td>
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<tr>
<td>Carson</td>
<td>130 243 395 653 1,133 1,968</td>
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<tr>
<td>Dallam</td>
<td>2,826 3,717 4,918 6,954 10,739 17,331</td>
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<tr>
<td>Hartley</td>
<td>1,807 3,105 4,856 7,825 13,344 22,955</td>
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<tr>
<td>Moore</td>
<td>5,053 5,305 5,646 6,223 7,296 9,164</td>
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<tr>
<td>Oldham</td>
<td>1,169 2,500 4,294 7,336 12,991 22,839</td>
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<td>Potter</td>
<td>819 1,455 2,312 3,764 6,465 11,169</td>
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<td>1,018 1,830 2,926 4,783 8,235 14,248</td>
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<td>Sherman</td>
<td>491 565 664 833 1,147 1,693</td>
</tr>
<tr>
<td>GCD</td>
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</tr>
<tr>
<td>High Plains UWCD No. 1</td>
<td>7,967 8,441 9,079 10,162 12,176 15,682</td>
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<td>North Plains GCD</td>
<td>9,326 11,386 14,163 18,870 27,623 42,865</td>
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<td>GMA 2</td>
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<td>GMA 3</td>
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<td>GMA 6</td>
<td>69 69 69 69 69 69</td>
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<tr>
<td>GMA 7</td>
<td>23,802 23,802 23,802 23,802 23,802 23,802</td>
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Table 3. Average drawdown for the upper portion of the Dockum Aquifer for Scenario 2 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
<thead>
<tr>
<th>Scenario 2: Upper Dockum</th>
<th>Spread_Base</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
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<td>GMA</td>
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<td>GMA 1</td>
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<td>15</td>
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<td>5</td>
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Table 4. Pumping and average drawdown for the lower portion of the Dockum Aquifer for Scenario 2 by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
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<th>Scenario 2: Base Lower Dockum</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
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<tr>
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<td>1,494</td>
<td>1,494</td>
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<td>13,586</td>
<td>13,586</td>
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<td>66</td>
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<td>74</td>
<td>77</td>
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<td>17,495</td>
<td>17,495</td>
<td>17,495</td>
<td>17,495</td>
<td>17,495</td>
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<td>50</td>
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<td>85</td>
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<td>8,103</td>
<td>8,103</td>
<td>8,103</td>
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<td>34</td>
<td>39</td>
<td>43</td>
<td>47</td>
<td>51</td>
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<tr>
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Figure 1. Location map showing model grid cells representing the Dockum Aquifer, groundwater management areas, the official Dockum Aquifer boundary, and the boundary of the upper portion of the Dockum Aquifer.
Figure 2. Average drawdown for the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time. Pumping was increased to 190 percent and decreased to 40 percent of the base pumping for Scenario 1.
Figure 3. Average drawdown for the lower portion of the Dockum Aquifer in Groundwater Management Area 1 through time. Pumping was increased to 190 percent and decreased to 40 percent of the base pumping for Scenario 2.
Appendix A

Selected hydrographs between 1980 and 2009 for the Dockum Aquifer in Groundwater Management Area 1
Figure A-1. Hydrograph of state well 641613 located in the outcrop portion of the Dockum Aquifer in Potter County.

Figure A-2. Hydrograph of state well 642903 located in the subcrop portion of the Dockum Aquifer in Potter County.
Figure A-3. Hydrograph of state well 659901 located in the subcrop portion of the Dockum Aquifer in Randall County.
Appendix B

Pumping and drawdown for each pumping scenario by decade
Table B-1. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 40 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

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<th>Hartley</th>
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<th>Oldham</th>
<th>Potter</th>
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Table B-2. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 60 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

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Table B-3. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 80 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

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Table B-4. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 130 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

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<th>2050</th>
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<th>2030</th>
<th>2040</th>
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Table B-5. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 160 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

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Table B-6. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 190 percent of the base of Scenario 1 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

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Table B-7. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 40 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

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<td>1,692</td>
<td>1,692</td>
<td>1,692</td>
<td>1</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>GMA 6</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>GMA 7</td>
<td>9,521</td>
<td>9,521</td>
<td>9,521</td>
<td>9,521</td>
<td>9,521</td>
<td>9,521</td>
<td>0</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>
Table B-8. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 60 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

<table>
<thead>
<tr>
<th>Scenario 2: 60 Percent of Base</th>
<th>Pumping</th>
<th>Average Drawdown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>2020</td>
</tr>
<tr>
<td>County</td>
<td></td>
<td>Acre-ft</td>
</tr>
<tr>
<td>Armstrong</td>
<td>2,319</td>
<td>2,319</td>
</tr>
<tr>
<td>Carson</td>
<td>843</td>
<td>843</td>
</tr>
<tr>
<td>Dallam</td>
<td>8,453</td>
<td>8,453</td>
</tr>
<tr>
<td>Hartley</td>
<td>10,010</td>
<td>10,010</td>
</tr>
<tr>
<td>Moore</td>
<td>6,648</td>
<td>6,648</td>
</tr>
<tr>
<td>Oldham</td>
<td>9,575</td>
<td>9,575</td>
</tr>
<tr>
<td>Potter</td>
<td>4,834</td>
<td>4,834</td>
</tr>
<tr>
<td>Randall</td>
<td>6,150</td>
<td>6,150</td>
</tr>
<tr>
<td>Sherman</td>
<td>957</td>
<td>957</td>
</tr>
</tbody>
</table>

| GCD                            |         | Acre-ft |       |       |       |       |      |       |       |       |       |       |
| High Plains UWCD No. 1         | 8,035   | 8,035  | 8,035 | 8,035 | 8,035 | 8,035 | 1    | 14    | 27    | 38    | 45    | 47    |
| North Plains GCD               | 22,336  | 22,336 | 22,336| 22,336| 22,336| 22,336| 19   | 43    | 52    | 59    | 65    | 70    |
| Panhandle GCD                  | 7,172   | 7,172  | 7,172 | 7,172 | 7,172 | 7,172 | 17   | 22    | 24    | 26    | 27    | 28    |

| GMA                            |         | Acre-ft |       |       |       |       |      |       |       |       |       |       |
| Out-of-State                   | 4,676   | 4,676  | 4,676 | 4,676 | 4,676 | 4,676 | 0    | 0     | 0     | 0     | 0     | 0     |
| GMA 1                          | 49,789  | 49,789 | 49,789| 49,789| 49,789| 49,789| 13   | 27    | 32    | 36    | 39    | 42    |
| GMA 2                          | 5,759   | 5,759  | 5,759 | 5,759 | 5,759 | 5,759 | 1    | 10    | 19    | 28    | 33    | 36    |
| GMA 3                          | 2,538   | 2,538  | 2,538 | 2,538 | 2,538 | 2,538 | 0    | -1    | -1    | -1    | -1    | -1    |
| GMA 6                          | 41      | 41     | 41    | 41    | 41    | 41    | 0    | 0     | 1     | 2     | 2     | 3     |
| GMA 7                          | 14,281  | 14,281 | 14,281| 14,281| 14,281| 14,281| 0    | -1    | -1    | -1    | 0     | 0     |
Table B-9. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 80 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

<table>
<thead>
<tr>
<th>County</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
<th>Average Drawdown</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County</td>
<td>2010</td>
<td>2020</td>
<td>2030</td>
<td>2040</td>
<td>2050</td>
<td>2060</td>
<td>2010</td>
</tr>
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<td>1,168</td>
<td>1,168</td>
<td>1,168</td>
<td>1,168</td>
<td>1,168</td>
<td>48</td>
</tr>
<tr>
<td>Dallam</td>
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<td>11,020</td>
<td>11,020</td>
<td>11,020</td>
<td>11,020</td>
<td>11,020</td>
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</tr>
<tr>
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<td>13,753</td>
<td>13,753</td>
<td>13,753</td>
<td>13,753</td>
<td>13,753</td>
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</tr>
<tr>
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<td>7,375</td>
<td>7,375</td>
<td>7,375</td>
<td>7,375</td>
<td>7,375</td>
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</tr>
<tr>
<td>Oldham</td>
<td>13,410</td>
<td>13,410</td>
<td>13,410</td>
<td>13,410</td>
<td>13,410</td>
<td>13,410</td>
<td>1</td>
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<tr>
<td>Potter</td>
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<td>6,657</td>
<td>6,657</td>
<td>6,657</td>
<td>6,657</td>
<td>6,657</td>
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</tr>
<tr>
<td>Randall</td>
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<td>8,491</td>
<td>8,491</td>
<td>8,491</td>
<td>8,491</td>
<td>8,491</td>
<td>10</td>
</tr>
<tr>
<td>Sherman</td>
<td>1,170</td>
<td>1,170</td>
<td>1,170</td>
<td>1,170</td>
<td>1,170</td>
<td>1,170</td>
<td>63</td>
</tr>
<tr>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>10,862</td>
<td>10,862</td>
<td>10,862</td>
<td>10,862</td>
<td>10,862</td>
<td>1</td>
</tr>
<tr>
<td>North Plains GCD</td>
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<td>28,272</td>
<td>28,272</td>
<td>28,272</td>
<td>28,272</td>
<td>26</td>
</tr>
<tr>
<td>Panhandle GCD</td>
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<td>10,030</td>
<td>10,030</td>
<td>10,030</td>
<td>10,030</td>
<td>10,030</td>
<td>21</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-State</td>
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<td>6,234</td>
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<td>6,234</td>
<td>6,234</td>
<td>0</td>
</tr>
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<td>7,678</td>
<td>7,678</td>
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<td>3,385</td>
<td>3,385</td>
<td>3,385</td>
<td>3,385</td>
<td>0</td>
</tr>
<tr>
<td>GMA 6</td>
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<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
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<td>19,042</td>
<td>19,042</td>
<td>0</td>
</tr>
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</table>
Table B-10. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 130 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
<thead>
<tr>
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<th><strong>Pumping</strong></th>
<th><strong>Average Drawdown</strong></th>
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<tbody>
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<td>2020</td>
</tr>
<tr>
<td><strong>County</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armstrong</td>
<td>5,852</td>
<td>5,852</td>
</tr>
<tr>
<td>Carson</td>
<td>1,982</td>
<td>1,982</td>
</tr>
<tr>
<td>Dallam</td>
<td>17,436</td>
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</tr>
<tr>
<td>Moore</td>
<td>9,194</td>
<td>9,194</td>
</tr>
<tr>
<td>Oldham</td>
<td>22,997</td>
<td>22,997</td>
</tr>
<tr>
<td>Randall</td>
<td>14,344</td>
<td>14,344</td>
</tr>
<tr>
<td>Sherman</td>
<td>1,456</td>
<td>1,456</td>
</tr>
<tr>
<td>GCD</td>
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<td></td>
</tr>
<tr>
<td>High Plains UWCD No. 1</td>
<td>17,663</td>
<td>17,663</td>
</tr>
<tr>
<td>North Plains GCD</td>
<td>42,865</td>
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<tr>
<td>Panhandle GCD</td>
<td>17,175</td>
<td>17,175</td>
</tr>
<tr>
<td>GMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-State</td>
<td>10,131</td>
<td>10,131</td>
</tr>
<tr>
<td>GMA 1</td>
<td>107,584</td>
<td>107,584</td>
</tr>
<tr>
<td>GMA 2</td>
<td>12,478</td>
<td>12,478</td>
</tr>
<tr>
<td>GMA 3</td>
<td>5,492</td>
<td>5,492</td>
</tr>
<tr>
<td>GMA 6</td>
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<td>90</td>
</tr>
<tr>
<td>GMA 7</td>
<td>30,950</td>
<td>30,950</td>
</tr>
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</table>
Table B-11. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 160 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
<thead>
<tr>
<th>Scenario 2: 160 Percent of Base</th>
<th>Pumping</th>
<th>Average Drawdown</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>2010</td>
<td>2020</td>
</tr>
<tr>
<td><strong>County</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armstrong</td>
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<td>7,366</td>
</tr>
<tr>
<td>Carson</td>
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<td>2,332</td>
</tr>
<tr>
<td>Dallam</td>
<td>21,287</td>
<td>21,287</td>
</tr>
<tr>
<td>Oldham</td>
<td>28,749</td>
<td>28,749</td>
</tr>
<tr>
<td>Randall</td>
<td>17,856</td>
<td>17,856</td>
</tr>
<tr>
<td>Sherman</td>
<td>1,301</td>
<td>1,301</td>
</tr>
<tr>
<td><strong>GCD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Plains UWCD No. 1</td>
<td>21,636</td>
<td>21,636</td>
</tr>
<tr>
<td>North Plains GCD</td>
<td>51,294</td>
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<tr>
<td>Panhandle GCD</td>
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<td>21,255</td>
</tr>
<tr>
<td><strong>GMA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-State</td>
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<td>12,468</td>
</tr>
<tr>
<td>GMA 1</td>
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<td>131,778</td>
</tr>
<tr>
<td>GMA 2</td>
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<td>15,358</td>
</tr>
<tr>
<td>GMA 3</td>
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<td>6,754</td>
</tr>
<tr>
<td>GMA 6</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>GMA 7</td>
<td>38,097</td>
<td>38,097</td>
</tr>
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</table>
Table B-12. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 190 percent of the base of Scenario 2 by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District.

<table>
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<th>Scenario 2: 190 Percent of Base</th>
<th>Pumping</th>
<th>Average Drawdown</th>
</tr>
</thead>
<tbody>
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<td>2010</td>
<td>2020</td>
</tr>
<tr>
<td><strong>County</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armstrong</td>
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<td>8,857</td>
</tr>
<tr>
<td>Carson</td>
<td>817</td>
<td>817</td>
</tr>
<tr>
<td>Dallam</td>
<td>25,113</td>
<td>25,113</td>
</tr>
<tr>
<td>Hartley</td>
<td>34,337</td>
<td>34,337</td>
</tr>
<tr>
<td>Moore</td>
<td>11,376</td>
<td>11,376</td>
</tr>
<tr>
<td>Oldham</td>
<td>34,502</td>
<td>34,502</td>
</tr>
<tr>
<td>Potter</td>
<td>16,421</td>
<td>16,421</td>
</tr>
<tr>
<td>Randall</td>
<td>21,368</td>
<td>21,368</td>
</tr>
<tr>
<td>Sherman</td>
<td>1,333</td>
<td>1,333</td>
</tr>
<tr>
<td><strong>GCD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>25,609</td>
<td>25,609</td>
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<td>59,886</td>
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<tr>
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<td>14,806</td>
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<tr>
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<td>18,239</td>
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<tr>
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<td>8,016</td>
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<td>GMA 6</td>
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<td>131</td>
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<tr>
<td>GMA 7</td>
<td>45,244</td>
<td>45,244</td>
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</table>
Table B-13. Average drawdown in the upper portion of the Dockum Aquifer resulting from changes to the base pumping of Scenario 1. Results are shown by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Note that pumping is not shown because all pumping occurs in the lower portion of the Dockum Aquifer in the model. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

### Scenario 1: Upper Dockum

#### 40 Percent of Base Pumping

<table>
<thead>
<tr>
<th>County</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
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<th>2050</th>
<th>2060</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
<th>2060</th>
</tr>
</thead>
<tbody>
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<td>2</td>
<td>4</td>
<td>7</td>
<td>10</td>
<td>13</td>
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<td>5</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
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<td></td>
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<tr>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>4</td>
<td>7</td>
<td>10</td>
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<td>16</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
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<td>26</td>
<td>34</td>
<td>39</td>
<td>40</td>
<td>1</td>
<td>15</td>
<td>27</td>
<td>35</td>
<td>39</td>
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<td>39</td>
<td>41</td>
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Table B-13. Continued.
Table B-14. Average drawdown in the upper portion of the Dockum Aquifer resulting from changes to the base pumping of Scenario 2. Results are shown by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Note that pumping is not shown because all pumping occurs in the lower portion of the Dockum Aquifer in the model. Drawdown is in feet. UWCD is the abbreviation for Underground Water Conservation District. Negative values for average drawdown indicate an average rise in water levels.

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Table B-14. Continued.

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Appendix C

Water budgets for each stress period of the predictive model run
Figure C-1. Net recharge to the Dockum Aquifer by year in the groundwater model for Groundwater Management Area 1. AF/yr is acre-feet per year.

Figure C-2. Pumping output from the Dockum Aquifer by year in the groundwater model for Groundwater Management Area 1. AF/yr is acre-feet per year.
Figure C-3. Net change in storage (the volume of water stored in the aquifer) by year in the lower portion of the Dockum Aquifer for Groundwater Management Area 1. Negative values for the net change in storage indicate water level declines. AF/yr is acre-feet per year.

Figure C-4. Net inflow from overlying aquifers to the lower portion of the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.
Figure C-5. Outflow from the Dockum Aquifer in Groundwater Management Area 1 to springs and by evapotranspiration. AF/yr is acre-feet per year.

Figure C-6. Net outflow to streams from the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.
Figure C-7. Net lateral inflow to the Dockum Aquifer in Groundwater Management Area 1 from adjacent areas. AF/yr is acre-feet per year.

Figure C-8. Net vertical flow from the upper portion of the Dockum Aquifer to the lower portion of the Dockum Aquifer in Groundwater Management Area 1. AF/yr is acre-feet per year.
Appendix D

Water budget tables by county, groundwater conservation district, and groundwater management area for 2060 in the predictive model run
Table D-1. Water budgets by county in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year.

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<td>-5,568</td>
<td>0</td>
<td>-1,762</td>
<td>0</td>
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<td><strong>Storage Change</strong></td>
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<td>-1,761</td>
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<td>-13,903</td>
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<td>0</td>
<td>-19,753</td>
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<td>-9,487</td>
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<tr>
<td><strong>Model Error</strong></td>
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<td>0</td>
<td>-1</td>
<td>0</td>
<td>-6</td>
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<td>-6</td>
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<tr>
<td><strong>Model Error (percent)</strong></td>
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<td>0.03</td>
<td>0.00</td>
<td>0.05</td>
<td>0.00</td>
<td>0.03</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
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</table>

D-2
Table D-2. Water budgets by groundwater conservation district (GCD) in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year. UWCD is Underground Water Conservation District.

<table>
<thead>
<tr>
<th></th>
<th>High Plains</th>
<th>UWCD No. 1</th>
<th>North Plains GCD</th>
<th>Panhandle GCD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Inflow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overlying Aquifers</td>
<td>9,096</td>
<td>4,013</td>
<td>0</td>
<td>9,952</td>
</tr>
<tr>
<td>Recharge</td>
<td>1</td>
<td>423</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Stream Interaction</td>
<td>0</td>
<td>459</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
<td>-</td>
<td>10,395</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>4,199</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Lateral Flow</td>
<td>2,872</td>
<td>9,249</td>
<td>0</td>
<td>18,106</td>
</tr>
<tr>
<td>Total Inflow</td>
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<td>0</td>
<td>28,117</td>
</tr>
<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Wells</td>
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<td>0</td>
<td>42,865</td>
</tr>
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<td>1,171</td>
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</tr>
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</tr>
<tr>
<td>Vertical Leakage Upper</td>
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<td>Vertical Leakage Lower</td>
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<td>3,180</td>
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<td>-21,234</td>
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<td>-6</td>
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Table D-3. Water budgets by groundwater management area (GMA) for the last stress period of the groundwater model run (2060) for Scenario 1. All values are reported in acre-feet per year.

<table>
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<th>GMA 2</th>
<th>GMA 3</th>
<th>GMA 6</th>
<th>GMA 7</th>
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<tbody>
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<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td><strong>Inflow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overlying Aquifers</td>
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<td>25,803</td>
<td>15,885</td>
<td>3,505</td>
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<td>26</td>
<td>21,783</td>
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<td>535</td>
<td>20,406</td>
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<td>-</td>
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<td>-</td>
<td>662</td>
<td>-</td>
<td>20,597</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
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<td>-</td>
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<td>-</td>
<td>8,187</td>
<td>-</td>
</tr>
<tr>
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<td>45</td>
<td>18,898</td>
<td>2,329</td>
<td>13,025</td>
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<td>555</td>
<td>58,476</td>
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<td>79,316</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>107,175</td>
<td>0</td>
<td>9,598</td>
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<td>6,491</td>
<td>0</td>
<td>26,596</td>
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<td>40,262</td>
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<tr>
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<td>4,434</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8,187</td>
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<tr>
<td>Vertical Leakage Lower</td>
<td>14,768</td>
<td>-</td>
<td>662</td>
<td>-</td>
<td>20,597</td>
<td>-</td>
</tr>
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<td>19</td>
<td>1,464</td>
<td>251</td>
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<td>42,006</td>
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<td>-10</td>
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<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
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Table D-4. Water budgets by county in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year.

<table>
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<th>Inflow</th>
<th>Armstrong</th>
<th>Carson</th>
<th>Dallam</th>
<th>Hartley</th>
<th>Moore</th>
<th>Oldham</th>
<th>Potter</th>
<th>Randall</th>
<th>Sherman</th>
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</thead>
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<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
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<td>0</td>
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</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>237</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
<td>-</td>
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<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>0</td>
<td>3,872</td>
<td>0</td>
<td>14,061</td>
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<td>6,005</td>
<td>0</td>
<td>20,798</td>
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<table>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Wells</td>
<td>0</td>
<td>4,338</td>
<td>0</td>
<td>1,494</td>
<td>0</td>
<td>13,586</td>
<td>0</td>
<td>17,495</td>
<td>0</td>
</tr>
<tr>
<td>Springs and Evapotranspiration</td>
<td>0</td>
<td>511</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>963</td>
<td>0</td>
</tr>
<tr>
<td>Overlying Aquifers</td>
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<td>101</td>
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<td>0</td>
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<td>0</td>
<td>905</td>
<td>0</td>
</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>43</td>
<td>0</td>
<td>2,393</td>
<td>0</td>
<td>6,077</td>
<td>0</td>
</tr>
<tr>
<td>Total Outflow</td>
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<td>1,537</td>
<td>0</td>
<td>16,080</td>
<td>0</td>
<td>29,218</td>
<td>0</td>
</tr>
</tbody>
</table>

| Inflow - Outflow                |          |        |        |        |       |        |        |         |         |
|                                 | Upper    | Lower  | Upper  | Lower  | Upper | Lower  | Upper  | Lower   | Upper   | Lower   | Lower   | Lower |
|                                 | -3,986   | -1,263 | -10,075| -8,420 | -4,676| -13,326| -5,071 | -106    | -6,177  | -395    |

| Storage Change                  |          |        |        |        |       |        |        |         |         |
|                                 | Upper    | Lower  | Upper  | Lower  | Upper | Lower  | Upper  | Lower   | Upper   | Lower   | Lower   | Lower |
|                                 | -3,985   | -1,262 | -10,069| -8,418 | -4,676| -13,319| -5,071 | -107    | -6,175  | -395    |

| Model Error                     |          |        |        |        |       |        |        |         |         |
|                                 | Upper    | Lower  | Upper  | Lower  | Upper | Lower  | Upper  | Lower   | Upper   | Lower   | Lower   | Lower |
|                                 | -1       | -1     | -6     | -2     | 0     | 0      | 0      | -7      | 0       | 1       | 2       | 0      |

Model Error (percent)            | 0.00     | 0.02   | 0.00   | 0.07   | 0.00  | 0.04   | 0.00   | 0.01    | 0.00    | 0.02    | 0.00    | 0.15   |

D-5
Table D-5. Water budgets by groundwater conservation district (GCD) in Groundwater Management Area 1 for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year. UWCD is Underground Water Conservation District.

<table>
<thead>
<tr>
<th>Inflow</th>
<th>High Plains</th>
<th>UWCD No. 1</th>
<th>North Plains GCD</th>
<th>Panhandle GCD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Overlying Aquifers</td>
<td>9,108</td>
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<td>0</td>
<td>9,266</td>
</tr>
<tr>
<td>Recharge</td>
<td>1</td>
<td>423</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Stream Interaction</td>
<td>0</td>
<td>459</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
<td>-</td>
<td>10,413</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>4,189</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Lateral Flow</td>
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<td>17,404</td>
</tr>
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<td></td>
<td></td>
</tr>
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<tr>
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<td></td>
<td></td>
</tr>
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<td>3,964</td>
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<tr>
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<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
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<td>0</td>
<td>-</td>
</tr>
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<td>-14,663</td>
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<td>-14,658</td>
</tr>
<tr>
<td>Model Error</td>
<td>-2</td>
<td>-3</td>
<td>0</td>
<td>-5</td>
</tr>
<tr>
<td>Model Error (percent)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Table D-6. Water budgets by groundwater management area (GMA) for the last stress period of the groundwater model run (2060) for Scenario 2. All values are reported in acre-feet per year.

<table>
<thead>
<tr>
<th>Inflow</th>
<th>Out-of-State</th>
<th>GMA 1 Upper</th>
<th>Lower</th>
<th>GMA 2 Upper</th>
<th>Lower</th>
<th>GMA 3 Upper</th>
<th>Lower</th>
<th>GMA 6 Upper</th>
<th>Lower</th>
<th>GMA 7 Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlying Aquifers</td>
<td>34,181</td>
<td>19,809</td>
<td>516</td>
<td>25,339</td>
<td>15,900</td>
<td>3,513</td>
<td>1,064</td>
<td>9,499</td>
<td>0</td>
<td>341</td>
<td>5,977</td>
</tr>
<tr>
<td>Recharge</td>
<td>44</td>
<td>1,142</td>
<td>0</td>
<td>8,830</td>
<td>26</td>
<td>21,783</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7,974</td>
<td>0</td>
</tr>
<tr>
<td>Stream Interaction</td>
<td>0</td>
<td>78</td>
<td>0</td>
<td>4,297</td>
<td>535</td>
<td>20,408</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,022</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
<td>-</td>
<td>14,768</td>
<td>-</td>
<td>642</td>
<td>-</td>
<td>20,614</td>
<td>-</td>
<td>1,267</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>4,434</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>8,171</td>
<td>-</td>
<td>280</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>908</td>
</tr>
<tr>
<td>Lateral Flow</td>
<td>23</td>
<td>1,021</td>
<td>43</td>
<td>18,322</td>
<td>2,328</td>
<td>12,917</td>
<td>153</td>
<td>7,900</td>
<td>0</td>
<td>2,983</td>
<td>106</td>
</tr>
<tr>
<td>Total Inflow</td>
<td>38,682</td>
<td>36,818</td>
<td>559</td>
<td>57,430</td>
<td>26,960</td>
<td>70,235</td>
<td>1,497</td>
<td>18,666</td>
<td>0</td>
<td>12,320</td>
<td>6,991</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outflow</th>
<th>GMA 1 Upper</th>
<th>Lower</th>
<th>GMA 2 Upper</th>
<th>Lower</th>
<th>GMA 3 Upper</th>
<th>Lower</th>
<th>GMA 6 Upper</th>
<th>Lower</th>
<th>GMA 7 Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells</td>
<td>0</td>
<td>7,793</td>
<td>0</td>
<td>82,961</td>
<td>0</td>
<td>9,598</td>
<td>0</td>
<td>4,231</td>
<td>0</td>
<td>69</td>
</tr>
<tr>
<td>Springs and Evapotranspiration</td>
<td>0</td>
<td>2,107</td>
<td>0</td>
<td>6,313</td>
<td>0</td>
<td>26,506</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,541</td>
</tr>
<tr>
<td>Overlying Aquifers</td>
<td>21,994</td>
<td>5,473</td>
<td>6</td>
<td>4,235</td>
<td>17,487</td>
<td>1,269</td>
<td>324</td>
<td>12,883</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Stream Interaction</td>
<td>0</td>
<td>1,931</td>
<td>0</td>
<td>15,962</td>
<td>0</td>
<td>40,257</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7,248</td>
</tr>
<tr>
<td>Vertical Leakage Upper</td>
<td>0</td>
<td>4,434</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8,171</td>
<td>0</td>
<td>280</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Leakage Lower</td>
<td>14,768</td>
<td>-</td>
<td>642</td>
<td>-</td>
<td>20,614</td>
<td>1,267</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>5,965</td>
</tr>
<tr>
<td>Lateral Flow</td>
<td>2,292</td>
<td>19,699</td>
<td>17</td>
<td>1,346</td>
<td>250</td>
<td>16,986</td>
<td>0</td>
<td>1,505</td>
<td>0</td>
<td>1,925</td>
</tr>
<tr>
<td>Total Outflow</td>
<td>39,054</td>
<td>41,437</td>
<td>665</td>
<td>110,817</td>
<td>38,351</td>
<td>102,787</td>
<td>1,591</td>
<td>18,899</td>
<td>0</td>
<td>12,810</td>
</tr>
</tbody>
</table>

| Model Error      | -9         | -5     | 1          | -21    | -5          | -10    | 1           | -2    | 0           | 1     |
| Model Error (percent) | 0.02 | 0.01 | 0.15 | 0.02 | 0.01 | 0.06 | 0.01 | 0.00 | 0.01 | 0.00 |