GAM Run 16-031 MAG: Modeled Available Groundwater for the Seymour, Blaine, Ogallala, and Dockum aquifers in Groundwater Management Area 6

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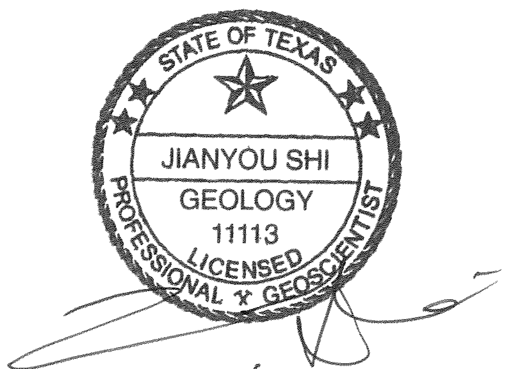
(512) 463-5076
June 30, 2017



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EXECUTIVE SUMMARY:

The Texas Water Development Board (TWDB) estimated the modeled available groundwater values for the following relevant aquifers in Groundwater Management Area 6:

- Seymour Aquifer – The modeled available groundwater ranges from 181,589 acre-feet per year in 2020 to 173,102 acre-feet per year in 2070, and is summarized by groundwater conservation districts and counties in Table 1, and by river basins, regional planning areas, and counties in Table 5.
- Blaine Aquifer – The modeled available groundwater ranges from 74,182 acre-feet per year in 2020 to 70,874 acre-feet per year in 2070, and is summarized by groundwater conservation districts and counties in Table 2, and by river basins, regional planning areas, and counties in Table 6.
- Ogallala Aquifer – The modeled available groundwater remains at 409 acre-feet per year between 2020 and 2070, and is summarized by groundwater conservation districts and counties in Table 3, and by river basins, regional planning areas, and counties in Table 7.
- Dockum Aquifer – The modeled available groundwater ranges from 172 acre-feet per year in 2020 to 171 acre-feet per year in 2070, and is summarized by groundwater conservation districts and counties in Table 4, and by river basins, regional planning areas, and counties in Table 8.

The modeled available groundwater values for Groundwater Management Area 6 estimated for counties is slightly different from that estimated for groundwater conservation districts because of the process for rounding the values.

The modeled available groundwater estimates are based on the desired future conditions for the Seymour, Blaine, Ogallala, and Dockum aquifers adopted by groundwater conservation district representatives in Groundwater Management Area 6 on November 17, 2016. The district representatives declared the following aquifers to be non-relevant for purposes of joint planning: the Trinity Aquifer; the Ogallala Aquifer in Collingsworth and Dickens counties; the Blaine Aquifer in King and Stonewall counties; the Dockum Aquifer in Dickens and Kent counties; and the Seymour Aquifer in Wichita, Wilbarger, Archer, Clay, Stonewall, Throckmorton, Young, Kent, and Jones counties. The TWDB determined that the explanatory report and other materials submitted by the district representatives were administratively complete on May 5, 2017.

REQUESTOR:

Mr. Mike McGuire, General Manager of Rolling Plains Groundwater Conservation District and Groundwater Management Area 6 Coordinator.

DESCRIPTION OF REQUEST:

In a letter dated January 17, 2017, Mr. Mike McGuire provided the TWDB with the desired future conditions of the Seymour, Blaine, Ogallala, and Dockum aquifers. The desired future conditions were adopted on November 17, 2016 by the groundwater conservation district representatives in Groundwater Management Area 6. The desired future conditions are:

Dockum Aquifer (Resolution No. 2016-001)

"a. The Desired Future Condition for Fisher County, located in the Clear Fork Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 27 feet during the period from 2020 - 2070

b. The Desired Future Condition for Motley County, located in the Gateway Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 27 feet during the period from 2020 - 2070

c. The Dockum Aquifer in Dickens & Kent Counties, not located within a Groundwater Conservation District, has been determined to be non-relevant for joint planning purposes."

Trinity Aquifer (Resolution No. 2016-002)

"The Trinity Group Aquifers within Groundwater Management Area 6 have been determined to be non-relevant for joint planning purposes."

Ogallala Aquifer (Resolution No. 2016-003)

"a. The Desired Future Condition for Motley County, located in the Gateway Groundwater Conservation District, is that condition with average drawdown of between 23 and 27 feet, calculated from the end of 2012 conditions to the year 2070 as documented in GMA 2 Technical Memorandum 16-01.

b. The Ogallala Aquifer in Collingsworth County, located in the Mesquite Groundwater Conservation District, is insignificant or nonexistent, and is determined to be non-relevant for joint planning purposes

c. The Ogallala Aquifer in Dickens County, not located within a Groundwater Conservation District, is determined to be non-relevant for joint planning purposes."

Blaine Aquifer (Resolution No. 2016-004)

"a. The Desired Future Condition for that part of Childress County North of the Red River, located in the Mesquite Groundwater Conservation District, all of Collingsworth and Hall Counties, also located within the Mesquite Groundwater Conservation District; and that part of Childress County North of the Red River located in the Gateway Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 9 feet during the period from 2020 - 2070

b. The Desired Future Condition for that part of Childress County south of the Red River located in the Mesquite & Gateway Groundwater Conservation Districts; and all of Cottle, Foard, and Hardeman Counties, also located within the Gateway Groundwater Conservation District, is that condition whereby the total decline in water levels will be no more than 2 feet during the period from 2020 - 2070

c. The Desired Future Condition for Fisher County, located within the Clear Fork Groundwater Conservation District, is that condition whereby the total decline in water levels will be no more than 4 feet during the period from 2020 - 2070 *d. The Blaine Aquifer in Motley County, located within the Gateway Groundwater Conservation District, and in Knox County, located within the Rolling Plains Groundwater Conservation District, has been determined to be non-relevant for joint planning purposes.*

e. The Blaine Aquifer in Dickens, Kent, King, Jones, and Stonewall Counties, not located within a Groundwater Conservation District, has been determined to be non-relevant for joint planning purposes."

Seymour Aquifer (Resolution No. 2016-005)

"a. The Desired Future Condition for Pod 1 in Childress [and] Collingsworth Counties, located in the Mesquite and Gateway Groundwater Conservation Districts, is that condition whereby the total decline in water levels will be no more than 33 feet during the period from 2020 - 2070

b. The Desired Future Condition for Pod 2 in Hall County, located in Mesquite Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 15 feet during the period from 2020 - 2070

c. The Desired Future Condition for Pod 3 in Briscoe, Hall [and] Motley Counties, located in the Mesquite and Gateway Groundwater Conservation Districts, is that condition whereby the total decline in water levels will be no more than 15 feet during the period from 2020 - 2070

d. The Desired Future Condition for Pod 4 in Childress, Foard, and Hardeman counties, located in Gateway Groundwater Conservation District, is that condition whereby the total decline in water levels will be no more than 1 foot during the period from 2020 – 2070

e. The Desired Future Condition for Pod 6 in Knox County, located in Rolling Plains Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 18 feet during the period from 2020 –2070

f. The Desired Future Condition for that part of Pod 7 Baylor, Haskell, and Knox Counties, located in Rolling Plains Groundwater Conservation District is that condition whereby the total decline in water levels will be no more than 18 feet during the period from 2020 - 2070 *g. The Desired Future Condition for that part of Pod 8 in Baylor County, located in Rolling Plains Groundwater Conservation District is that condition whereby the total water level decline will be no more than 18 feet during the period from 2020 – 2070*

h. The Desired Future Condition for that part of Pod 11 in Fisher County, located in Clear Fork Groundwater Conservation District is that condition whereby the total water level decline will be no more than 1 foot during the period from 2020 - 2070

i. The Seymour Aquifer Pods 5, 9, 10, 12, 13, 14, 15, that part of 4 in Wichita and Wilbarger counties, that part of 7 in Stonewall County, that part of 8 in Throckmorton and Young counties, and that part of 11 in Jones and Stonewall counties have been determined to be non-relevant for joint planning purposes."

After review of the submittal, the TWDB sent a request for clarification email to Mr. Mike McGuire on February 28, 2017. On March 20, 2017, Mr. McGuire responded with additional information and clarifications as noted below.

a. Predictive model format - The six predictive model runs submitted for the Seymour and Blaine aquifers were in a format that the TWDB could not open. The TWDB asked for standard MODFLOW-2000 input and output files. Mr. McGuire sent the standard MODFLOW-2000 input packages to the TWDB on a flash drive.

b. Unclear baseline condition years and baseline water level conditions for the Blaine and Seymour aquifers – The explanatory report showed a baseline year of 2020, while the modeling technical report indicated 2010. Mr. McGuire confirmed in his response that the baseline year for calculating drawdown for these two aquifers was 2010. Because this baseline year is after the end of the calibration period for both groundwater availability models (Jigmond and others, 2014; Ewing and others, 2004), available water-level data between the end of the calibration period and the baseline year were evaluated. The result of the evaluation is included in Appendix A.

c. No pumping in the Blaine Aquifer in Fisher County - The groundwater availability model for the Seymour and Blaine aquifers (Ewing and others, 2004) does not contain pumping in the Blaine Aquifer in Fisher County between 1995 and 1999. This would not only result in a zero modeled available groundwater, but would also make it impossible to match the desired future condition for the Blaine Aquifer in Fisher County. Mr. McGuire then requested the TWDB to use an even pumping distribution within the Blaine Aquifer that meets the desired future condition in the county.

d. Desired future condition of the Blaine Aquifer in Foard County - A preliminary model run indicated that even the absence of pumping would cause a drawdown larger than the desired future condition (2 feet). Mr. McGuire clarified that a ten-foot drawdown for the Blaine Aquifer in Foard County is the desired future condition.

e. Unclear baseline condition years for the Dockum and Ogallala aquifers - The desired future conditions specify a timeline from 2020 to 2070. Mr. McGuire informed TWDB to use the year 2012 as Groundwater Management Area 2 did.

f. Desired future conditions of the Dockum and Ogallala aquifer in Fisher and Motley counties – Groundwater Management Area 6 intended to use the desired future conditions from Groundwater Management Area 2 for these two aquifers in Fisher and Motley counties. In his response, Mr. McGuire stated that Groundwater Management Area 6 intended to establish the desired future conditions for the Ogallala and Dockum aquifers in Fisher and Motley counties that reflected the pumping assumptions in those counties to achieve the average drawdown of 27 feet in Groundwater Management Area 2.

g. Aquifer boundaries – Mr. McGuire informed the TWDB that all desired future conditions and associated modeled available groundwater are based on model extent boundaries.

h. Unclear averaging method for recharge (Seymour Aquifer in Haskell, Knox, and Baylor counties) – Mr. McGuire confirmed with the TWDB that the recharge is the arithmetic mean from 2001 to 2005.

i. DFC statements of “no more than” – Mr. McGuire stated that the desired future conditions are based on the average decline within the individual geographical areas described in the Desired Future Conditions Table in Section 1 of the Explanatory Report. Decline is the difference between the baseline year and 2070.

METHODS:

The desired future conditions for Groundwater Management Area 6 are based on water-level declines or drawdowns defined as the difference in well water levels between a baseline year and 2070. Depending on the aquifer, one of three groundwater availability models were used to construct predictive simulations to estimate drawdowns over the same time interval and to calculate modeled available groundwater. The aquifers and corresponding groundwater availability models were:

- Seymour Aquifer of Pod 7 in Baylor, Haskell, and Knox counties – “refined” groundwater availability model for the Seymour Aquifer (Jigmond and others, 2014)

- Seymour Aquifer (except Pod 7) and Blaine Aquifer – groundwater availability model for the Seymour and Blaine aquifers (Ewing and others, 2004)
- Ogallala and Dockum aquifers – groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015)

Some of the predictive simulations employed for the modeled available groundwater calculations were part of the Groundwater Management Area 6 submittal (Nelson, 2017), while the others were developed by the TWDB (Appendix B).

One of the first steps for a predictive simulation is to verify if the model reflects real-world conditions for the selected baseline year. If the baseline year for a desired future condition falls within the model calibration period, the water levels and/or fluxes for the baseline year have been calibrated to observed data. If the baseline year is after the end of the calibration period, water levels and/or fluxes must be evaluated between the end of the calibration period and the baseline year to confirm if the model reflects real-world conditions. If water levels and/or fluxes have remained steady during this interim period, the end of the calibration period can be used for the baseline year. However, if water levels and/or fluxes have not remained steady, pumping (and sometimes recharge) is typically adjusted until water levels and/or fluxes reflect real-world conditions.

The simulated drawdown for an area (such as a county) is the average of simulated drawdowns in active model cells with centroids located within each designated area. For the Seymour, Ogallala, and Dockum aquifers, the active model cells or modeled extents are the same as, or similar to, the official aquifer boundaries. However, the modeled extent for the Blaine Aquifer is significantly larger than the official aquifer footprint in some counties, such as in Hall and Foard counties. Therefore, in Hall and Foard counties, the drawdown for the desired future condition contains the Blaine Aquifer and equivalent geologic units in the subcrop.

Another factor that affects the drawdown calculation is related to dry model cells. For this study, a model cell is considered dry when its water level falls below a cell bottom at the baseline year. A dry cell is excluded from the average drawdown calculation. This analysis is presented in Appendix C.

The following sections summarize the predictive simulations submitted by Groundwater Management Area 6 and the predictive simulations by the TWDB. The water level drawdowns calculated by these predictive model runs are presented in Appendix B, which can be compared with the desired future conditions.

Seymour Aquifer of Pod 7 in Baylor, Haskell, and Knox Counties

Three predictive simulations submitted by Nelson (2017) were developed from runs using the refined groundwater availability model for the Seymour Aquifer in Baylor, Haskell, and Knox counties (Jigmond and others, 2014). This refined groundwater availability model only covers Pod 7 of the Seymour Aquifer (Figure 1). The predictive simulations included the calibrated period (1949 through 2005) and a predictive period (2006 through 2070). The predictive period used annual time intervals with three different pumping scenarios: 100, 80, or 75 percent of the average pumping of the last five years (2001-2005) of the calibration period (Jigmond and others, 2014).

Because the baseline year for the desired future condition (2010) is after the end of the calibration period, the TWDB evaluated the water-level data at selected wells from winter months between 2005 and 2010. Figure A1 (in Appendix A) shows the average water-level change from 2005 to 2010 in the Seymour Aquifer in Baylor, Haskell, and Knox counties. The average water levels have been stable over the selected time interval. As a result, the TWDB determined that further refinement of pumping was not necessary for the period between 2005 and 2010, and determined that conditions at the end of the calibration period can be used as conditions for the baseline year.

Next, the TWDB checked the MODFLOW-2000 well packages for the predictive simulations and found no problem with the pumping scenario that used 100 percent of the average pumping of the last five years of the groundwater availability model (2001 through 2005). As a result, the TWDB ran this scenario to obtain the MODFLOW-2000 output files. The head output file was used to calculate the drawdowns between 2010 and 2070. The TWDB then compared the drawdowns with the desired future conditions for the Seymour Aquifer in Pod 7 in these three counties. The comparison indicates that the drawdowns do not exceed the desired future conditions (Table B1 in Appendix B).

Seymour and Blaine Aquifers (excluding Pod 7 of Seymour)

The other three predictive simulations by Nelson (2017) were based on the groundwater availability model for the Seymour and Blaine aquifers (Figure 2; Ewing and others, 2004). The predictive simulations were used to determine the desired future conditions for the Blaine Aquifer and all the Seymour Aquifer except Pod 7, which was covered by the refined model described earlier. The predictive simulations included the calibrated period (1975 through 1999) and a predictive period (2000 through 2070). The predictive period used annual time interval with three different pumping scenarios: 100, 75, or 50 percent of the average pumping of the last five years of the calibrated model, 1995 through 1999 (Ewing and others, 2004).

Because the baseline year (2010) is after the end of the calibration period (1999), TWDB evaluated the water-level data at selected wells from winter months between 1999 and 2010. Figure A2 (in Appendix A) illustrates the average water-level change from 1999 to 2010 in the Seymour Aquifer within Groundwater Management Area 6. For the Blaine Aquifer, only one well from Childress County (State Well Number 1231804) meets the selection criterion and its hydrograph is presented in Figure A3. Nevertheless, Figures A2 and A3 indicate that the water level has not significantly changed over the selected time interval. As a result, the TWDB determined that further model refinement of pumping was not necessary for the period between 1999 and 2010, and determined that conditions at the end of the calibration period can be used as conditions for the baseline year.

The TWDB also checked the MODFLOW-2000 well packages for the predictive simulations from Nelson (2017) and discovered a significant inconsistency between the well package from the submittal and that from the TWDB's calculation for the 100-percent pumping scenario based on the last five years of the calibrated groundwater availability model for the Seymour and Blaine aquifers. As a result, the TWDB developed a new predictive simulation for the Seymour and Blaine aquifers using the groundwater availability model by Ewing and others (2004). Because, as discussed above, the water levels did not change much from 1999 to 2010, this predictive simulation uses the water levels of the last stress period (1999) of the groundwater availability model as the initial head for the baseline year (2010). This new predictive simulation runs from 2011 through 2070 with an annual interval and the average recharge of 1995 through 1999 of the calibrated groundwater availability model as stated in the explanatory report and Mr. McGuire's response. The initial pumping is based on the average of the last five years of the calibrated model but was adjusted during the model run to meet the desired future conditions for the Seymour Aquifer (excluding Pod 7) (Table B1 in Appendix B) and Blaine Aquifer (Table B2 in Appendix B).

Ogallala and Dockum Aquifers

Per Mr. McGuire's request, the TWDB used the predictive simulation for the desired future conditions adopted by Groundwater Management Area 2 to reproduce the desired future conditions and to calculate the modeled available groundwater for Groundwater Management Area 6. This predictive simulation ran from 2013 through 2017, with a baseline year of 2012, the same year as the last stress period of the calibrated groundwater availability model by Deeds and Jigmond (2015). The predictive simulation used all boundary conditions from the last stress period of the groundwater availability model except the pumping package, which was modified and adjusted during the model run to meet the desired future conditions of Groundwater Management Area 2 (see GAM Run 16-

028 for details). The simulated drawdown or desired future conditions are presented in Tables B3 and B4 of Appendix B.

Modeled Available Groundwater

Once the predictive simulations met the desired future conditions, the modeled available groundwater values were extracted from the MODFLOW cell-by-cell budget files. Annual pumping rates were then divided by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 6 (Figures 1 through 6 and Tables 1 through 6).

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the groundwater availability simulations are described below:

Seymour Aquifer of Pod 7 in Baylor, Haskell, and Knox Counties

- The groundwater availability model for the Seymour Aquifer of Pod 7 by Jigmond and others (2014) was extended to include the predictive model simulation for this analysis (Nelson, 2017).
- The model has one layer, which represents the Seymour Aquifer.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).
- During the predictive model run, some model cells went dry (Table C1 of Appendix C).

- Estimates of modeled drawdown and available groundwater from the model simulation were rounded to whole numbers.

Seymour and Blaine Aquifers

- Version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers (Ewing and others, 2004) was updated to include the predictive model simulation for this analysis.

- The model has two layers that represent the Seymour Aquifer (Layer 1) and the Blaine Aquifer as well as other geologic units that underlie the Seymour Aquifer (Layer 2).

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

- During the predictive model run, some model cells went dry (Table C2 of Appendix C).

- Estimates of modeled drawdown and available groundwater from the model simulation were rounded to whole numbers.

Ogallala and Dockum Aquifers

- Version 1.01 of the groundwater availability model for the High Plains Aquifer System by Deeds and Jigmond (2015) was used to develop the predictive model simulation used for this analysis (Hutchison, 2016d).

- The model has four layers which represent the Ogallala and Pecos Valley Alluvium aquifers (Layer 1); the Edwards-Trinity (High Plains), Rita Blanca, and Edwards-Trinity (Plateau) aquifers (Layer 2); the Upper Dockum Aquifer (Layer 3); and the Lower Dockum Aquifer (Layer 4). Pass-through cells exist in layers 2 and 3 where the Upper Dockum Aquifer was absent but the cells provided a pathway for flow between the Lower Dockum and the Ogallala or Edwards-Trinity (High Plains) aquifers vertically. These pass-through cells were excluded from the modeled available groundwater calculation.

- The model was run with MODFLOW-NWT (Niswonger and others, 2011). The model uses the Newton-Raphson formulation and the upstream weighting package, which automatically reduces pumping as heads drop in a particular cell as defined by the user. This feature may simulate the declining production of a well as saturated thickness decreases. Deeds and Jigmond (2015) modified the MODFLOW-NWT code to use a saturated thickness of 30 feet as the threshold (instead of percent of the saturated thickness) when pumping reductions occur during a simulation.

- During the predictive model run, no model cells within Groundwater Management Area 6 went dry.
- Estimates of modeled drawdown and available groundwater from the model simulation were rounded to whole numbers.

RESULTS:

The modeled available groundwater for the Seymour Aquifer that achieves the desired future condition adopted by Groundwater Management Area 6 slightly decreases from 181,589 to 173,102 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 1. Table 5 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

The modeled available groundwater for the Blaine Aquifer that achieves the desired future condition adopted by Groundwater Management Area 6 decreases slightly from 74,182 to 70,874 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 2. Table 6 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

The modeled available groundwater for the Ogallala Aquifer that achieves the desired future condition adopted by Groundwater Management Area 6 remains at 409 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 3. Table 7 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

The modeled available groundwater for the Dockum Aquifer that achieves the desired future condition adopted by Groundwater Management Area 6 remains at about 172 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 4. Table 8 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

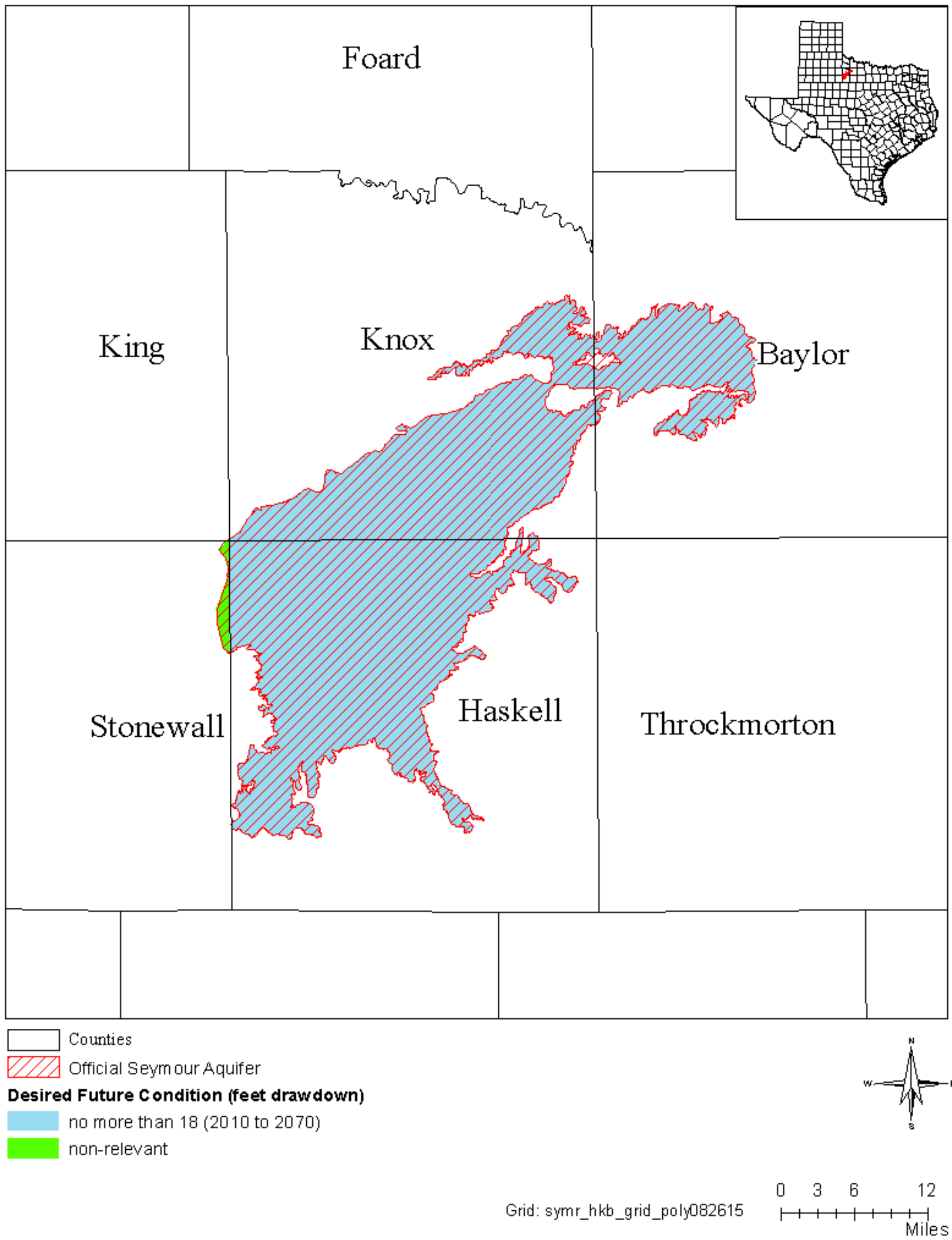

FIGURE 1. MAP SHOWING THE AREA COVERED BY THE REFINED GROUNDWATER AVAILABILITY MODEL FOR THE SEYMOUR AQUIFER POD 7, WHICH INCLUDES BAYLOR, HASKELL, AND KNOX COUNTIES WITHIN GROUNDWATER MANAGEMENT AREA 6.

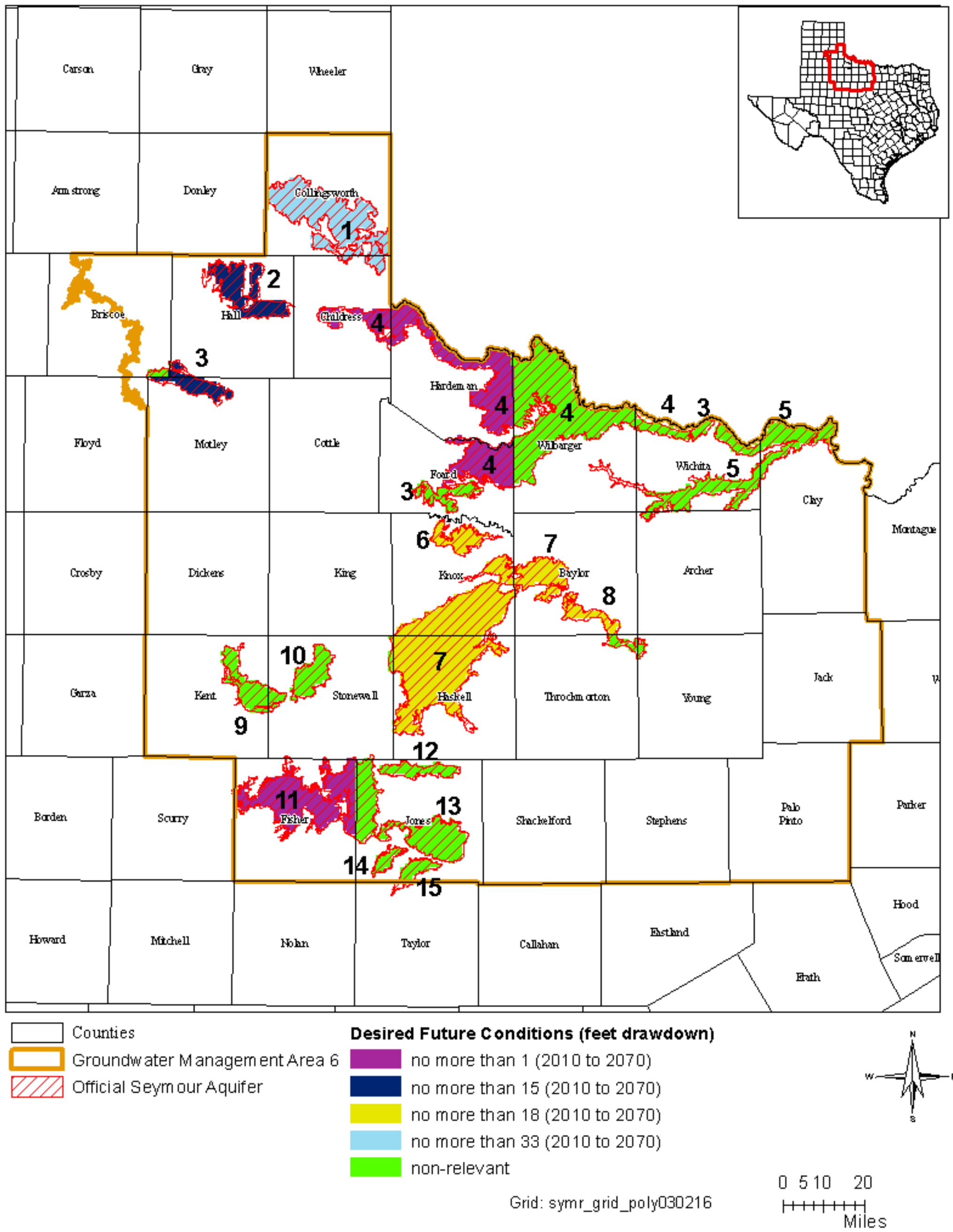

FIGURE 2. **MAP SHOWING THE AREA COVERED BY THE SEYMOUR AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE SEYMOUR AND BLAINE AQUIFERS WITHIN GROUNDWATER MANAGEMENT AREA 6. THE INTEGERS IN THE FIGURE ARE SEYMOUR AQUIFER POD NUMBERS.**

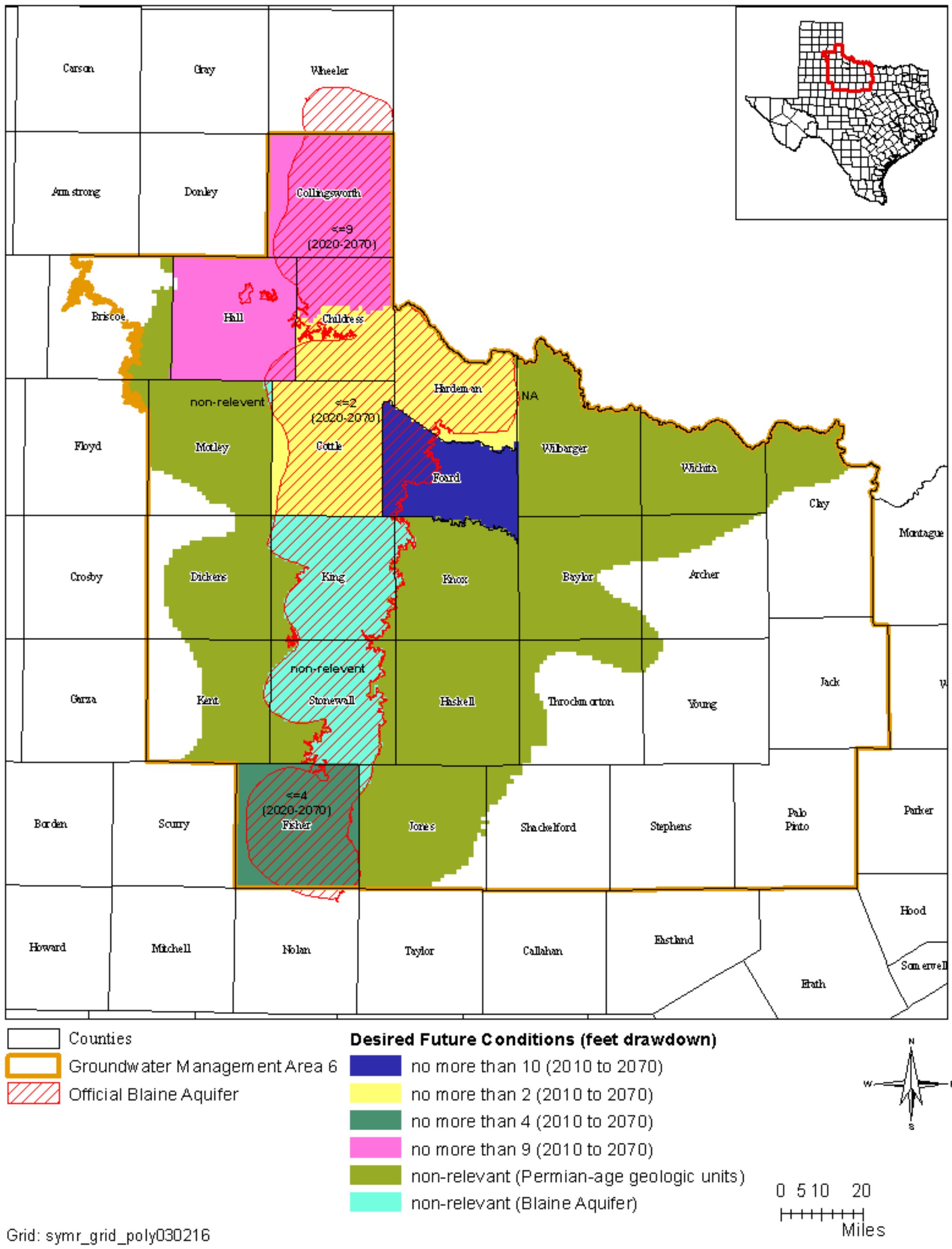

FIGURE 3. MAP SHOWING THE AREA COVERED BY THE BLAINE AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE SEYMOUR AND BLAINE AQUIFERS WITHIN GROUNDWATER MANAGEMENT AREA 6.

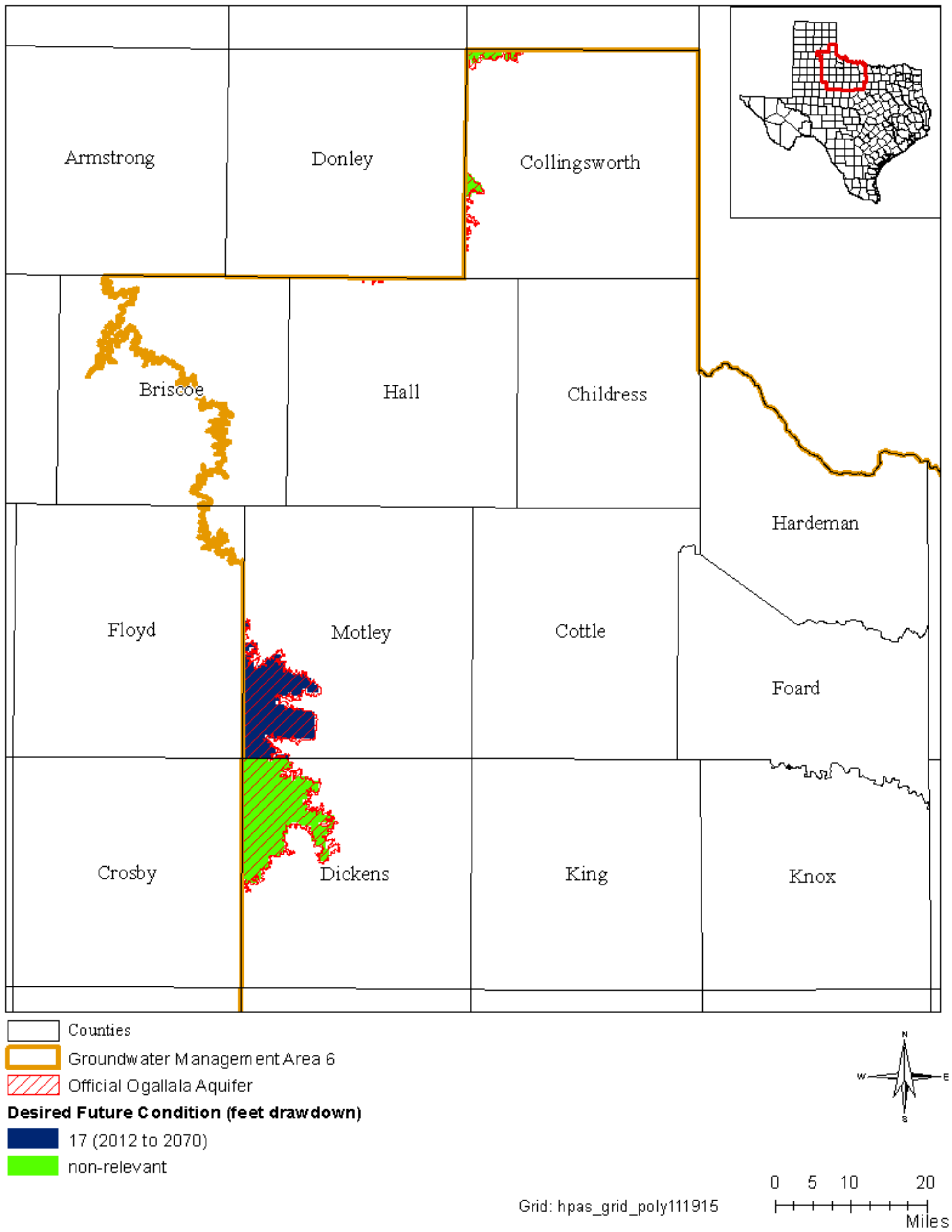

FIGURE 4. **MAP SHOWING THE AREA COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM WITHIN GROUNDWATER MANAGEMENT AREA 6.**

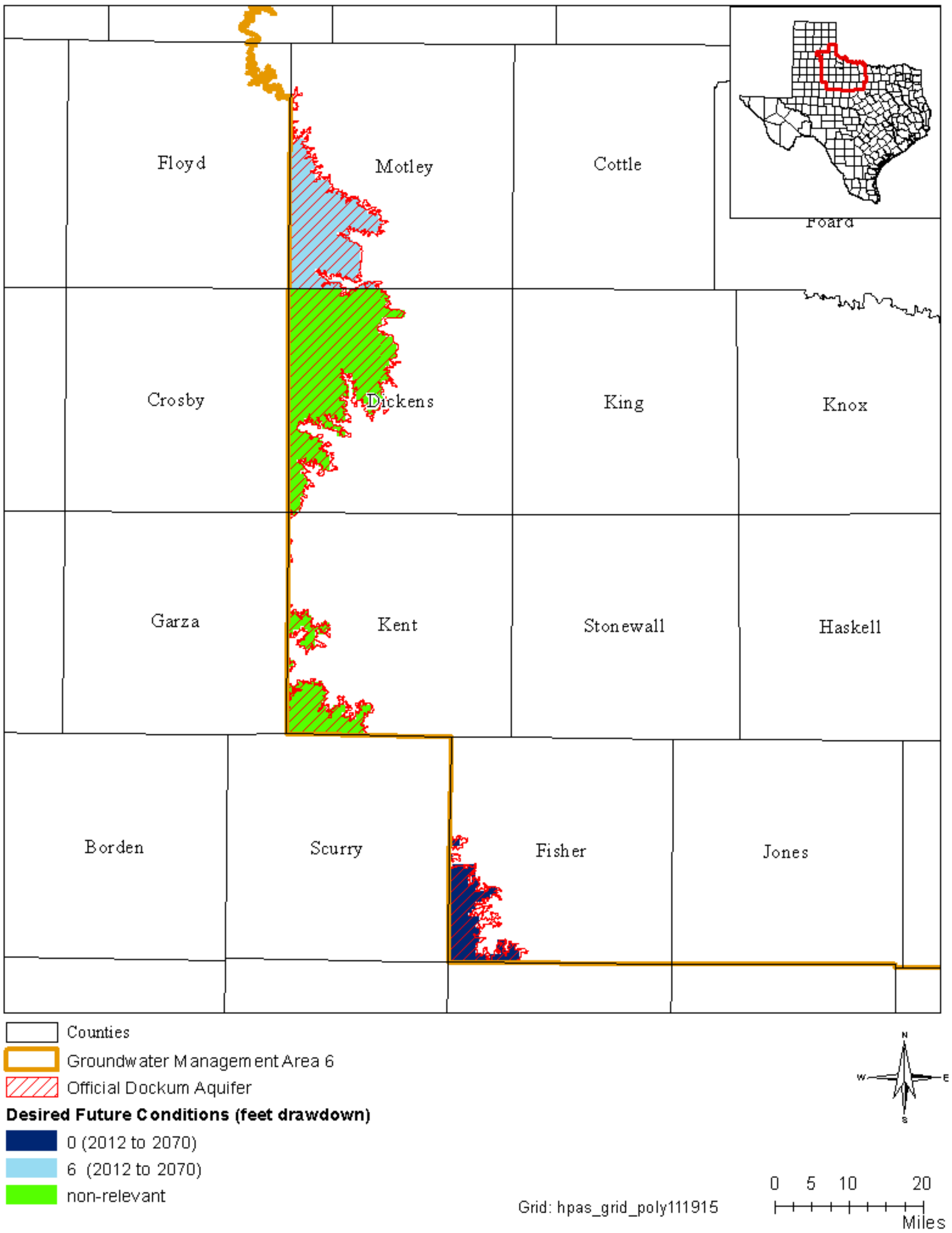

FIGURE 5. MAP SHOWING THE AREA COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM WITHIN GROUNDWATER MANAGEMENT AREA 6.

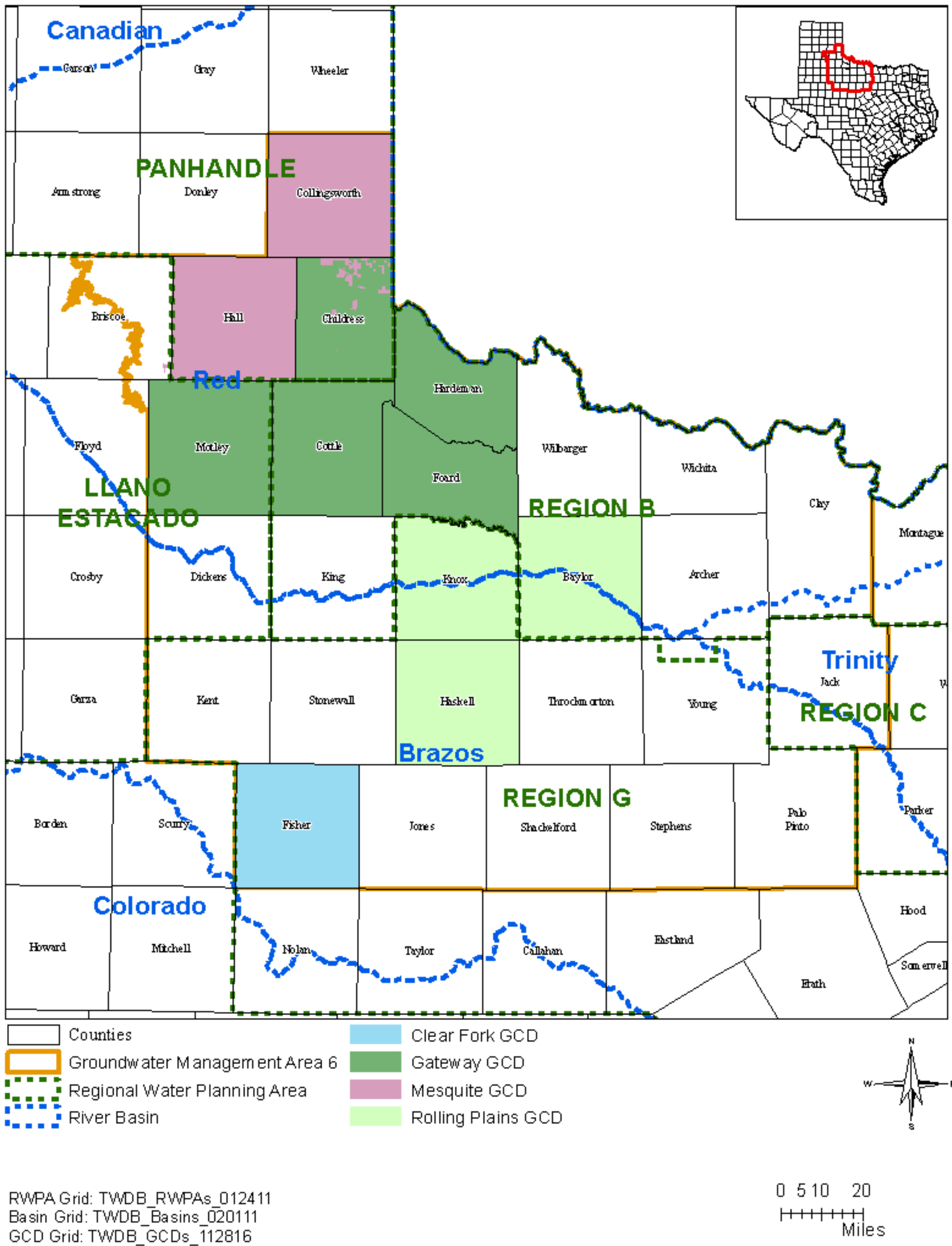

FIGURE 6. **MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (GCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 6.**

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE SEYMOUR AQUIFER IN GROUNDWATER MANAGEMENT AREA 6 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Seymour Aquifer Pod	2010	2020	2030	2040	2050	2060	2070
Clear Fork GCD	**Fisher**	**11**	**2,325**	**6,718**	**6,132**	**6,149**	**6,472**	**6,490**	**6,131**
Gateway GCD	Childress	4	40	2,875	3,230	3,301	3,292	3,301	3,282
Gateway GCD	Foard	4	4,278	11,897	4,945	5,389	8,066	7,815	3,943
Gateway GCD	Hardeman	4	531	20,378	13,040	18,885	17,520	20,002	32,868
Gateway GCD	Motley	3	2,098	4,843	6,679	4,843	4,830	3,972	3,961
Gateway GCD Total			**6,947**	**39,993**	**27,894**	**32,418**	**33,708**	**35,090**	**44,054**
Mesquite GCD	Childress	1	15	86	16	16	16	16	16
Mesquite GCD	Collingsworth	1	17,628	41,345	31,492	28,657	27,165	22,395	22,769
Mesquite GCD	Hall	2	6,837	15,446	16,751	19,666	22,861	25,861	24,595
Mesquite GCD Total			**24,480**	**56,877**	**48,259**	**48,339**	**50,042**	**48,272**	**47,380**
Rolling Plains GCD	Baylor	7	1,426	1,430	1,426	1,430	1,426	1,430	1,426
Rolling Plains GCD	Baylor	8	14	5,785	5,903	5,547	5,304	5,177	5,503
Rolling Plains GCD	Haskell	7	41,636	41,750	41,636	41,750	41,636	41,750	41,636
Rolling Plains GCD	Knox	7	25,641	25,712	25,641	25,712	25,641	25,712	25,641
Rolling Plains GCD	Knox	6	12	3,324	998	512	888	3,454	1,331
Rolling Plains GCD Total			**68,729**	**78,001**	**75,604**	**74,951**	**74,895**	**77,523**	**75,537**
Groundwater Management Area 6			**102,481**	**181,589**	**157,889**	**161,857**	**165,117**	**167,375**	**173,102**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE BLAINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 6 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2010	2020	2030	2040	2050	2060	2070
ClearFork GCD	**Fisher**	**0**	**12,855**	**12,820**	**12,855**	**12,820**	**12,855**	**12,820**
Gateway GCD	Childress	3,577	17,618	17,570	17,618	17,570	17,618	17,570
Gateway GCD	Cottle	2,688	14,766	11,621	11,653	11,621	11,653	11,621
Gateway GCD	Foard	26	6,582	6,564	6,582	6,564	6,582	6,564
Gateway GCD	Hardeman	4,233	8,488	8,465	8,488	8,465	8,488	8,465
Gateway GCD Total		**10,524**	**47,454**	**44,220**	**44,341**	**44,220**	**44,341**	**44,220**
Mesquite GCD	Childress	1,034	5,957	5,940	5,957	5,940	5,957	5,940
Mesquite GCD	Collingsworth	6,851	2,060	2,054	2,060	2,054	2,060	2,054
Mesquite GCD	Hall	10	5,856	5,840	5,856	5,840	5,856	5,840
Mesquite GCD Total		**7,895**	**13,873**	**13,834**	**13,873**	**13,834**	**13,873**	**13,834**
Groundwater Management Area 6		**18,419**	**74,182**	**70,874**	**71,069**	**70,874**	**71,069**	**70,874**

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 6 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2012 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

GCD	County	2012	2020	2030	2040	2050	2060	2070
Gateway GCD	Motley	409	409	409	409	409	409	409
Groundwater Management Area 6		**409**	**409**	**409**	**409**	**409**	**409**	**409**

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 6 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2012 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

GCD	County	2012	2020	2030	2040	2050	2060	2070
Gateway GCD	Motley	93	93	93	93	92	92	92
Clear Fork GCD	Fisher	79	79	79	79	79	79	79
Groundwater Management Area 6		**172**	**172**	**172**	**172**	**171**	**171**	**171**

TABLE 5. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE SEYMOUR AQUIFER IN GROUNDWATER MANAGEMENT AREA 6. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.

County	RWPA	River Basin	Seymour Pod Number	2020	2030	2040	2050	2060	2070
Baylor	Region B	Brazos	7	1,136	1,133	1,136	1,133	1,136	1,133
Baylor	Region B	Red	7	294	294	294	294	294	294
Baylor	Region B	Brazos	8	5,785	5,903	5,547	5,304	5,177	5,503
Childress	Panhandle	Red	1 and 4	2,961	3,246	3,317	3,308	3,317	3,297
Collingsworth	Panhandle	Red	1	41,345	31,492	28,657	27,165	22,395	22,769
Fisher	Region G	Brazos	11	6,718	6,132	6,149	6,472	6,490	6,131
Foard	Region B	Red	4	11,897	4,945	5,389	8,066	7,815	3,943
Hall	Panhandle	Red	2 and 3	15,446	16,751	19,666	22,861	25,861	24,595
Hardeman	Region B	Red	4	20,378	13,040	18,885	17,520	20,002	32,868
Haskell	Region G	Brazos	7	41,750	41,636	41,750	41,636	41,750	41,636
Knox	Region G	Brazos	7	25,699	25,629	25,699	25,629	25,699	25,629
Knox	Region G	Red	7	13	13	13	13	13	13
Knox	Region G	Red	6	3,324	998	512	888	3,454	1,331
Motley	Llano Estacado	Red	3	4,843	6,679	4,843	4,830	3,972	3,961
Groundwater Management Area 6				**181,589**	**157,891**	**161,857**	**165,119**	**167,375**	**173,103**

TABLE 6. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE BLAINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 6. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Childress	Panhandle	Red	23,575	23,510	23,575	23,510	23,575	23,510
Collingsworth	Panhandle	Red	2,060	2,054	2,060	2,054	2,060	2,054
Cottle	Region B	Red	14,766	11,621	11,653	11,621	11,653	11,621
Fisher	Region G	Brazos	12,855	12,820	12,855	12,820	12,855	12,820
Foard	Region B	Red	6,582	6,564	6,582	6,564	6,582	6,564
Hall	Panhandle	Red	5,856	5,840	5,856	5,840	5,856	5,840
Hardeman	Region B	Red	8,488	8,465	8,488	8,465	8,488	8,465
Groundwater Management Area 6			**74,182**	**70,874**	**71,069**	**70,874**	**71,069**	**70,874**

TABLE 7. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 6. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Motley	Llano Estacado	Red	409	409	409	409	409	409
Groundwater Management Area 6			**409**	**409**	**409**	**409**	**409**	**409**

TABLE 8. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 6. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Fisher	Region G	Brazos	79	79	79	79	79	79
Motley	Llano Estacado	Red	93	93	93	92	92	92
Groundwater Management Area 6			**172**	**172**	**172**	**171**	**171**	**171**

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and groundwater levels in the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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Appendix A

Water Level Hydrograph

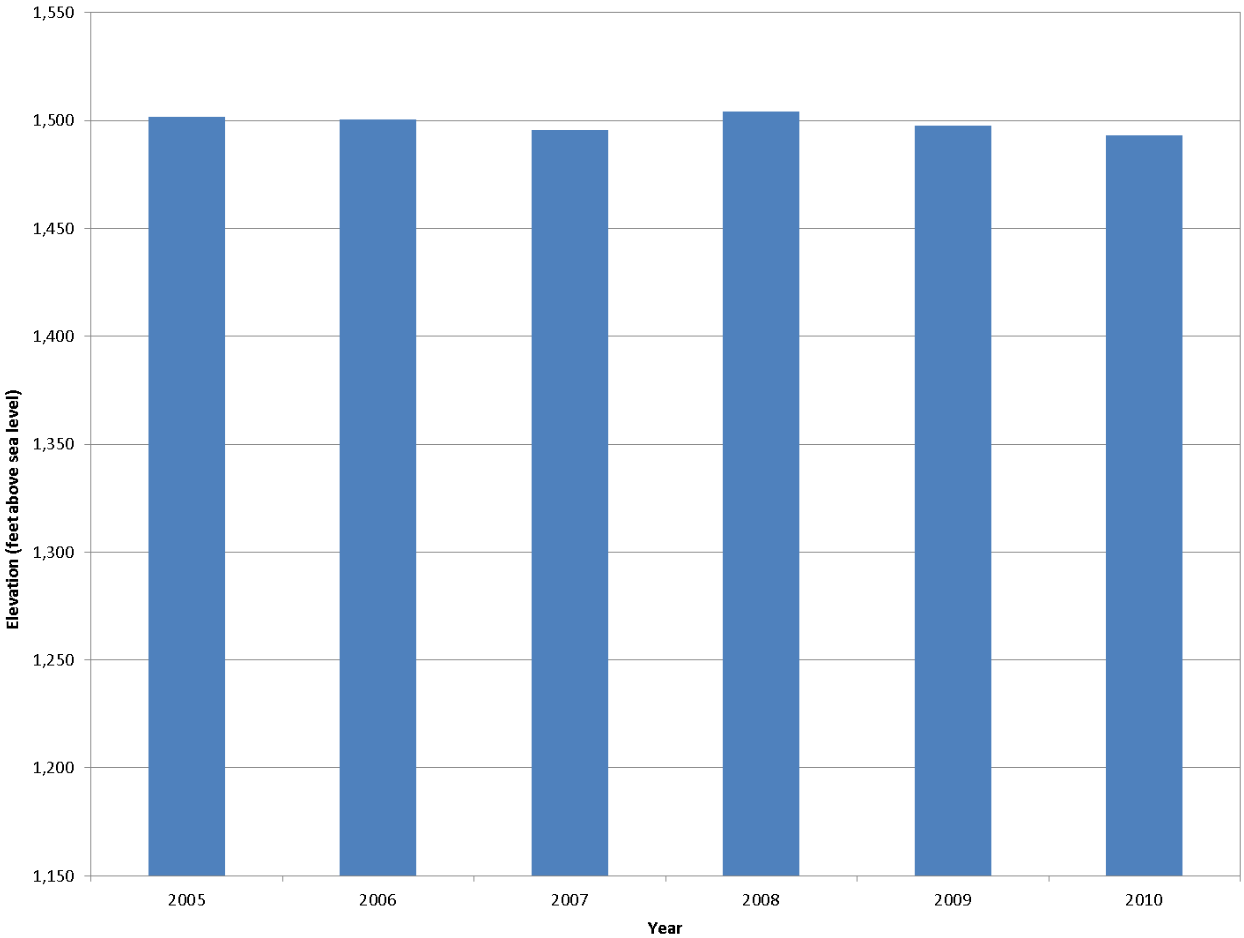

FIGURE A1. AVERAGE WATER-LEVEL HYDROGRAPH OF SEYMOUR AQUIFER IN BAYLOR, HASKELL, AND KNOX COUNTIES BETWEEN 2005 AND 2010.

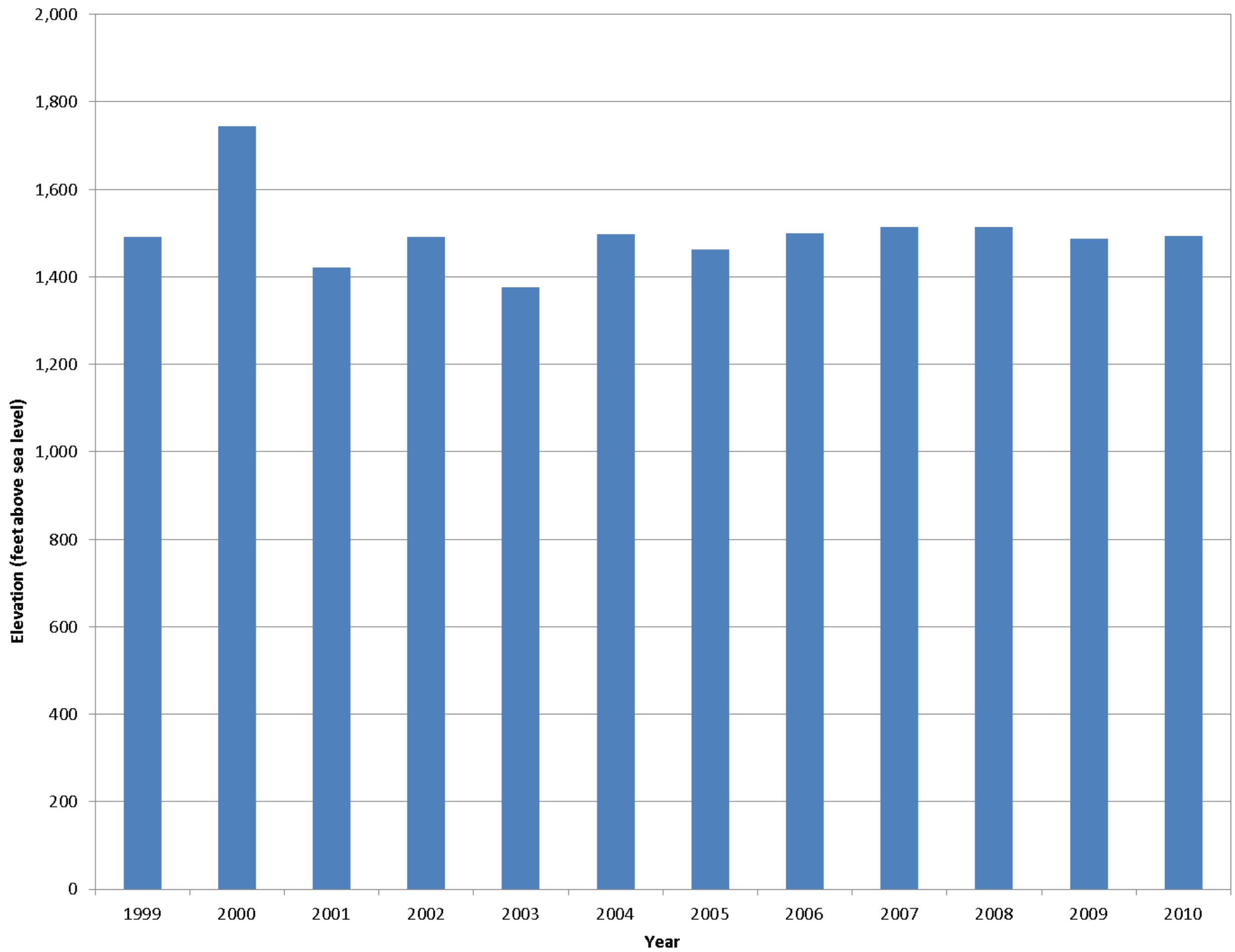

FIGURE A2. AVERAGE WATER-LEVEL HYDROGRAPH OF SEYMOUR AQUIFER IN BAYLOR, HASKELL, AND KNOX COUNTIES BETWEEN 1999 AND 2010.

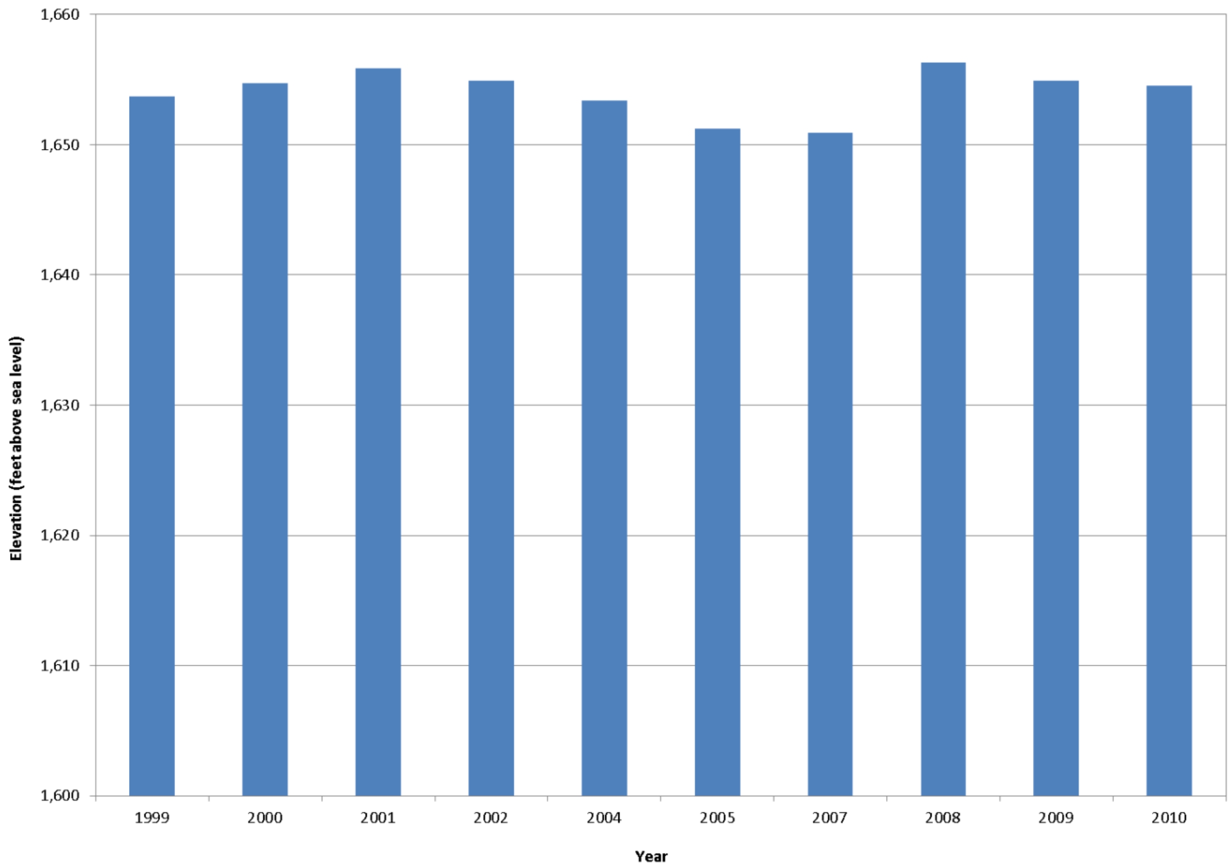

FIGURE A3. WATER-LEVEL HYDROGRAPH OF BLAINE AQUIFER IN CHILDRESS COUNTY (STATE WELL NUMBER 1231804) BETWEEN 1999 AND 2010.

Appendix B

Desired Future Conditions and Simulated Drawdowns

TABLE B1. MODELED DRAWDOWN IN SEYMOUR AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 6. MODELED DRAWDOWN WAS CALCULATED BY TWDB BASED ON MODFLOW HEAD FILE FROM GMA 6 SUBMITTAL, WHICH USED AVERAGE PUMPING OF LAST FIVE YEARS OF THE CALIBRATED MODEL. PUMPING WAS SLIGHTLY MODIFIED, AS NEEDED.

Seymour Aquifer Pod	County	Groundwater Conservation District	Modeled Drawdown (feet 2010 to 2070)	Desired Future Condition (feet drawdown)	Groundwater Availability Model
1	Childress, Collingsworth	Mesquite, Gateway	22.41	no more than 33	Ewing and others (2004)
2	Hall	Mesquite	9.91	no more than 15	Ewing and others (2004)
3	Briscoe, Hall, and Motley	Mesquite, Gateway	13.23	no more than 15	Ewing and others (2004)
4	Childress, Foard, and Hardeman	Gateway	0.97	no more than 1.0	Ewing and others (2004)
6	Knox	Rolling Plains	12.46	no more than 18	Ewing and others (2004)
7	Baylor, Haskell, and Knox	Rolling Plains	7.30	no more than 18	Jigmond and others (2014)
8	Baylor	Rolling Plains	14.80	no more than 18	Ewing and others (2004)
11	Fisher	Clear Fork	0.86	no more than 1.0	Ewing and others (2004)

TABLE B2. MODELED DRAWDOWN IN BLAINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 6. MODELED DRAWDOWN WAS CALCULATED BASED ON A PREDICTIVE SIMULATION BY TWDB.

County	Groundwater Conservation District	Modeled Drawdown (feet 2010 to 2070)	Desired Future Condition (feet drawdown)	Groundwater Availability Model
Childress North of Red River	Mesquite, Gateway	5.94	no more than 9	Ewing and others (2004)
Childress South of Red River	Gateway	1.93	no more than 2	Ewing and others (2004)
Collingsworth	Mesquite	8.43	no more than 9	Ewing and others (2004)
Cottle	Gateway	1.68	no more than 2	Ewing and others (2004)
Fisher	Clear Fork	2.41	no more than 4	Ewing and others (2004)
Foard	Gateway	6.48	no more than 10	Ewing and others (2004)
Hall	Mesquite	4.79	no more than 9	Ewing and others (2004)
Hardeman	Gateway	1.15	no more than 2	Ewing and others (2004)

TABLE B3. MODELED DRAWDOWN IN OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 6. MODELED DRAWDOWN WAS BASED ON GMA 2 DESIRED FUTURE CONDITIONS GROUNDWATER PREDICTIVE MODEL.

County	Groundwater Conservation District	Modeled Drawdown (feet 2010 to 2070)	Desired Future Condition (feet drawdown)	Groundwater Availability Model
Motley	Gateway	17	17	Deeds and Jigmond (2015)

TABLE B4. MODELED DRAWDOWN IN DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 6. MODELED DRAWDOWN WAS BASED ON GMA 2 DESIRED FUTURE CONDITIONS GROUNDWATER PREDICTIVE MODEL.

County	Groundwater Conservation District	Modeled Drawdown (feet 2010 to 2070)	Desired Future Condition (feet drawdown)	Groundwater Availability Model
Fisher	Clear Fork	0	0	Deeds and Jigmond (2015)
Motley	Gateway	6	6	Deeds and Jigmond (2015)

Appendix C

Summary of Model Dry Cells

TABLE C1. MODEL DRY CELLS FROM PREDICTIVE SIMULATION OF SEYMOUR AQUIFER OF POD 7 IN BAYLOR, HASKELL, AND KNOX COUNTIES.

County	Stress Periods	Active Cells	Dry Cells	Wet Cells	Percent of Dry Cells
Baylor	1 to 408 (1980 to 2070)	5,753	401	5,352	7
Haskell	1 to 408 (1980 to 2070)	23,697	596	23,101	3
Knox	1 to 408 (1980 to 2070)	15,927	3,117	12,810	20

TABLE C2. MODEL DRY CELLS FROM PREDICTIVE SIMULATION OF SEYMOUR AND BLAINE AQUIFERS.

Desired Future Condition Zone	Stress Period	Active Cells	Dry Cells	Wet Cells	Percent of Dry Cells
Seymour (Pod 1)	1 to 60 (2011 to 2070)	296	109	187	37
Seymour (Pod 2)	1 to 60 (2011 to 2070)	133	48	85	36
Seymour (Pod 3)	1 to 60 (2011 to 2070)	66	30	36	45
Seymour (Pod 4)	1 to 60 (2011 to 2070)	453	85	368	19
Seymour (Pod 6)	1 to 60 (2011 to 2070)	58	33	25	57
Seymour (Pod 8)	1 to 60 (2011 to 2070)	45	11	34	24
Seymour (Pod 11)	1 to 60 (2011 to 2070)	280	94	186	34
Blaine (North of Red River of Childress)	1 to 60 (2011 to 2070)	309	0	309	0
Blaine (South of Red River of Childress)	1 to 60 (2011 to 2070)	408	0	408	0
Blaine (Collingsworth)	1 to 60 (2011 to 2070)	930	0	930	0
Blaine (Cottle)	1 to 60 (2011 to 2070)	907	0	907	0
Blaine (Fisher)	1 to 60 (2011 to 2070)	900	0	900	0
Blaine (Foard)	1 to 60 (2011 to 2070)	706	0	706	0
Blaine (Hall)	1 to 60 (2011 to 2070)	900	0	900	0
Blaine (Hardeman)	1 to 60 (2011 to 2070)	708	0	708	0