GTA Aquifer Assessment 10-12 MAG

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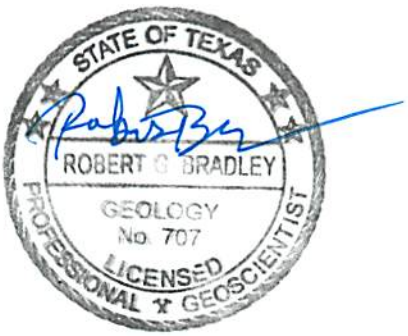

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Marble Falls Aquifer as a result of the desired future condition adopted by members of Groundwater Management Area 7 is approximately 11,063 acre-feet per year. This is divided by county, regional water planning area, and river basin in Table 3 for use in the regional water planning process The estimates were calculated based on the desired future condition stating "total net decline in water levels in San Saba County at the end of the fifty-year period shall not exceed seven (7) feet below 2010 water levels in the aquifer" and finding that "the Marble Falls aquifer is not relevant for joint planning purposes in all other areas of GMA 7."

REQUESTOR:

Mr. Allan Lange of the Lipan-Kickapoo Water Conservation District acting on behalf of the member groundwater conservation districts of Groundwater Management Area 7.

DESCRIPTION OF REQUEST:

In a letter received August 16, 2010, Mr. Allan Lange provided the Texas Water Development Board (TWDB) with the desired future condition of the Marble Falls Aquifer adopted by the members of Groundwater Management Area 7. The desired future condition for the Marble Falls Aquifer, as described in Resolution No. 07-29-10-8 and adopted July 29, 2010 by the groundwater conservation districts in Groundwater Management Area 7 is described below:

1) *total net decline in water levels in San Saba County at the end of the fifty-year period shall not exceed seven (7) feet below 2010 water levels in the aquifer;*
2) *the Marble Falls aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

In response to receiving the adopted desired future condition, TWDB has estimated the modeled available groundwater that achieves the above desired future condition for Groundwater Management Area 7.

METHODS:

A transient hydrologic budget for the saturated portion of an aquifer is described by Freeze and Cherry (1979, p.365):

$$Q(t) = R(t) - D(t) + \frac{dS}{dt}$$

where Q(t)= total rate of groundwater withdrawal
R(t)= total rate of groundwater recharge to the basin
D(t)= total rate of groundwater discharge from the basin
$\frac{dS}{dt}$ = rate of change of storage in the saturated zone of the basin

For this analysis, it is assumed that

$$R(t) = R(r) + R(e)$$

where R(r) = rejected recharge for the basin
R(e) = effective recharge

Effective recharge is the amount of water that enters an aquifer and is available for development (Muller and Price, 1979, p. 5). Rejected recharge is the amount of total (or potential) recharge that discharges from an aquifer because it is overfull and cannot accept more water (Theis, 1940, p. 1).

In addition, it is assumed that

$$R(r) \cong D(t)$$

Therefore, the total rate of groundwater withdrawal equals effective recharge plus the change in storage of the aquifer, or

$$Q(t) = R(e) + \frac{dS}{dt}$$

County and groundwater conservation district boundaries were used to split the aquifer into map areas (Figure 1). The areal extent of each aquifer map area was calculated. The Marble Falls Aquifer in San Saba County is located entirely within Regional Water Planning Area K and the Colorado River Basin. These areas are shown in Figure 2.

Annual effective recharge was calculated by multiplying the outcrop area by the average precipitation (1971-2000) and an effective recharge rate of five percent.

To calculate change in aquifer storage based on the desired future condition map areas were multiplied by the estimated aquifer specific yield and then by a uniform water level decline of 7 feet. These volumes were then divided by 50 years to obtain a yearly volume.

The calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS:

- A water-level decline of 7 feet is estimated to be uniform across the aquifer.
- The areas for each map area were calculated from the TWDB shapefile for the Marble Falls Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.3.
- Average annual precipitation was used to calculate annual effective recharge volumes.
- The average annual precipitation (1971-2000) for the aquifer map area (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Annual effective recharge is 5 percent of annual precipitation (Muller and Price, 1979, Preston and others, 1996).
- Specific yield of the aquifer is estimated to be 0.15 (Bradley, 2009; Heath, 2004; Morris and Johnson, 1967).
- Annual volumes from water level decline are calculated by dividing the total volume from water level decline by 50 years.
- Annual modeled available groundwater estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the adopted desired future condition.
- Conditions were assumed to be physically possible across the management area.

Table 1. Estimated total annual effective recharge volume for the Marble Falls Aquifer in San Saba County (see Figure 1).

GMA	Aquifer	County	Groundwater Conservation District	Map Area	Areal extent (acres)	Estimated average annual precipitation (inches)	Estimated average annual precipitation (feet)	Effective recharge rate (percent)	Estimated annual effective recharge (ac-ft/yr)
7	Marble Falls	San Saba	Hickory UWCD No. 1	1	50,552	28	2.3	5	5,813
7	Marble Falls	San Saba	none	2	29,698	29	2.4	5	3,564
								Total	**9,377**

GMA = groundwater management area UWCD = underground water conservation district ac-ft/yr = acre-feet per year

The formula for this table is: areal extent (acres) * estimated average annual precipitation (feet) * effective recharge rate = estimated annual effective recharge (ac-ft/yr).

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. This is distinct from “managed

available groundwater," shown in the draft version of this report dated November 22, 2010, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

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. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The estimated modeled available groundwater for the Marble Falls Aquifer in Groundwater Management Area 7 consistent with the adopted desired future condition is approximately 11,063 acre-feet per year. The volumetric calculations to determine modeled available groundwater estimates are shown in Table 2. Table 3 shows the modeled available groundwater by decade divided by county, regional water planning area, and river basin for use in the regional water planning process. Table 4 shows modeled available groundwater by groundwater conservation district.

Table 2. Volumetric calculations estimating the modeled available groundwater for the Marble Falls Aquifer in San Saba County summarized by map areas (see Figure 1).

GMA	Aquifer	County	Groundwater Conservation District	Map Areas	Estimated specific yield	Areal extent (acres)	Desired total aquifer water level decline (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume from water level decline (acre-feet)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
7	Marble Falls	San Saba	Hickory UWCD No. 1	1	0.15	50,552	7	53,080	1,062	5,813	6,875
			None	2	0.15	29,698	7	31,183	624	3,564	4,188
									Total	**9,377**	**11,063**

GMA = groundwater management area UWCD = underground water conservation district ac-ft/yr = acre-feet per year

1 - This is the estimated total annual effective recharge volume for the Marble Falls Aquifer as shown in Table 1.

The formulas for this table are: specific yield * areal extent * desired total aquifer water level decline = estimated total volume from water level decline/50 = estimated annual volume from water level decline. Estimated annual volume from water level decline + estimated annual effective recharge = estimated annual total volume.

Table 3. Modeled available groundwater available groundwater by decade for the Marble Falls Aquifer in Groundwater Management Area 7. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Regional Water Planning Area	River Basin	Year					
			2010	2020	2030	2040	2050	2060
San Saba	K	Colorado	11,063	11,063	11,063	11,063	11,063	11,063

Table 4. Modeled available groundwater available groundwater for the Marble Falls Aquifer in San Saba County by groundwater conservation district for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Hickory Underground Water Conservation District No.1	6,875	6,875	6,875	6,875	6,875	6,875
Total (excluding non-district areas)	**6,875**	**6,875**	**6,875**	**6,875**	**6,875**	**6,875**
No District	4,188	4,188	4,188	4,188	4,188	4,188
Total (including non-district areas)	**11,063**	**11,063**	**11,063**	**11,063**	**11,063**	**11,063**

LIMITATIONS:

The water budget in this analysis was determined to be the best method to calculate estimates of modeled available groundwater, however this method has limitations and should be replaced with better tools, including groundwater models and additional data that are not currently available, whenever possible.

This analysis assumes homogeneous and isotropic aquifers; however, aquifer conditions may not be uniform. The analysis further assumes that precipitation is the only source of aquifer recharge, that lateral inflow to the aquifer is equal to lateral outflow from the aquifer, and that future pumping will not alter this balance. In addition, certain assumptions have been made regarding future precipitation, recharge, and streamflow in developing modeled available groundwater estimates. These assumptions need to be considered and compared to actual future data when evaluating achievement of the desired future condition.

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. 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 future groundwater pumping and water levels to know if they are achieving their desired future conditions. Because of the limitations and assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

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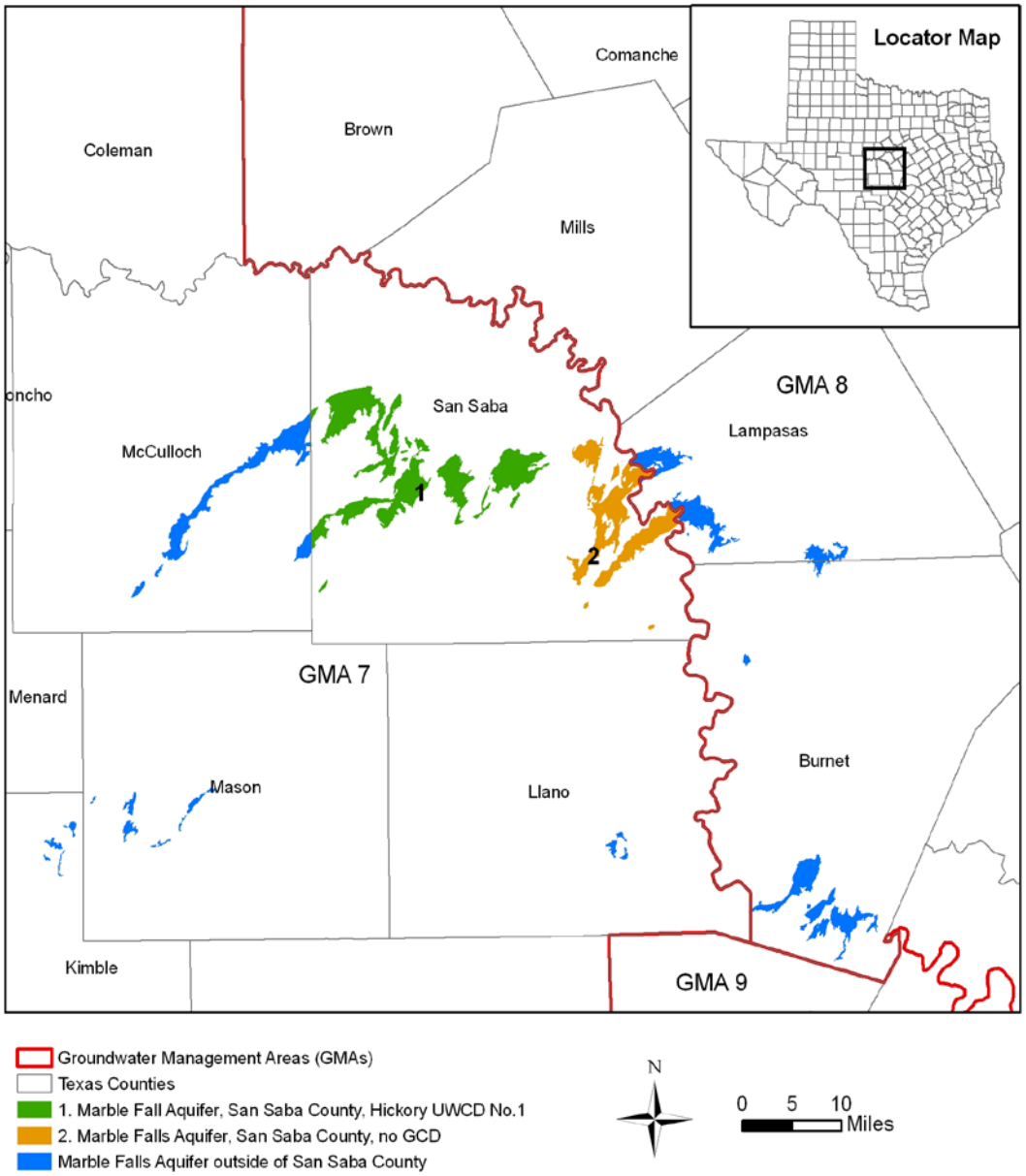

Figure 1. Map showing the areas used for estimating modeled available groundwater in the Marble Falls Aquifer within Groundwater Management Area 7.

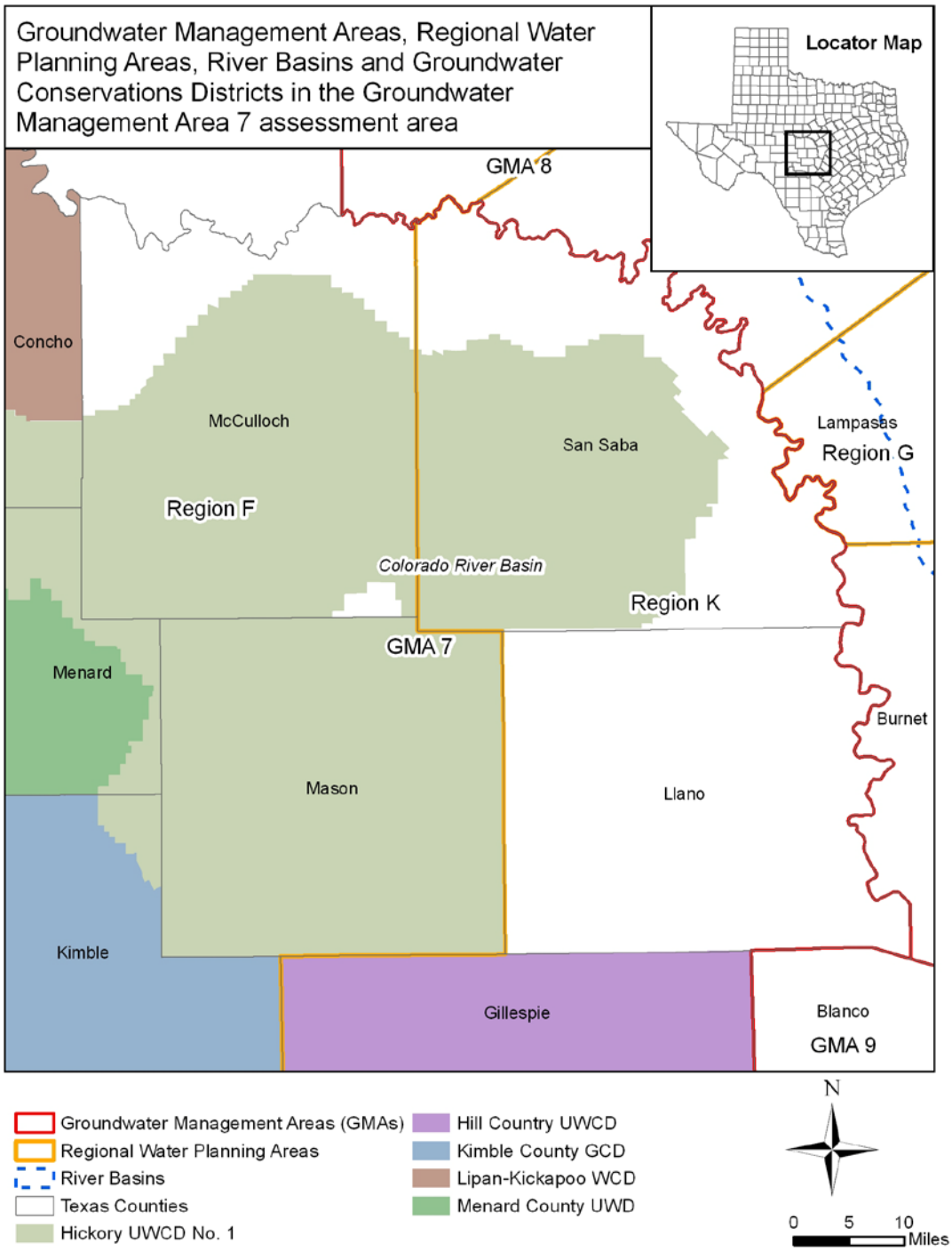

Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts and counties in Groundwater Management Area 7. GCD = Groundwater Conservation District, UWCD=Underground Water Conservation District, UWD=Underground Water District, WCD=Water Conservation District.