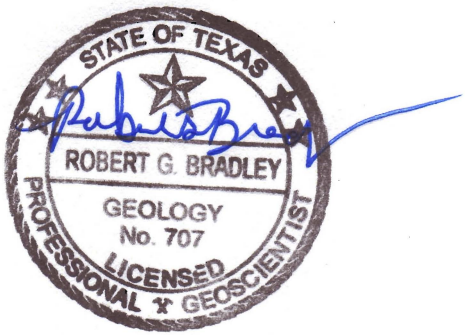
GTA Aquifer Assessment 10-02 MAG

by Robert G. Bradley, P.G.
Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-0870



Robert G. Bradley, P.G. 707, authorized the seal appearing on this document on June 22, 2011.

REQUESTOR:

Ron Fieseler, of the Blanco-Pedernales Groundwater Conservation District acting on behalf of Groundwater Management Area 9.

DESCRIPTION OF REQUEST:

In a letter dated October 22, 2008, Mr. Ron Fieseler submitted to the Texas Water Development Board (TWDB) the adopted desired future conditions (DFCs) for the Ellenburger-San Saba, Hickory, and Marble Falls aquifers in Groundwater Management Area (GMA) 9.

Petitioners appealed the reasonableness of these DFCs to the TWDB. On, November 30, 2009, representatives of the GCDs in GMA 9 met and passed a motion clarifying the area of the DFCs for the Ellenburger and the Hickory aquifers to be limited to Blanco County. Based on this action, the Petitioners withdrew their petitions relating to the DFCs for the Ellenburger and Hickory aquifers on December 14, 2009.

This report provides estimates of the managed available groundwater for the Hickory Aquifer for Blanco County. Previously these calculations were part of Aquifer Assessment 08-10mag.

DESIRED FUTURE CONDITIONS:

Hickory Aquifer – Allow for an increase in average drawdown of no more than 7 feet [through 2060].

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, 1978, p. 5). Rejected recharge is the amount of total (or potential) recharge that discharges from an aquifer because it is over-full 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, river basin, and groundwater conservation district boundaries split the aquifer into map areas (Figure 1). The areal extent of each aquifer map area was calculated. These areas were used to calculate estimated average effective recharge and pumped volumes.

These map areas were multiplied by the estimated aquifer storativity, and then by uniform water level decline of seven feet. In those cases where unconfined and confined conditions existed in the same aquifer, those were calculated separately.

Average annual pumping to achieve the desired future condition was estimated by multiplying each map area by the average precipitation (1971 to 2000) and an estimated effective recharge rate.

The final calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS:

- Water level decline of 7 feet were estimated to be uniform across the aquifer.
- The areas for each area were calculated from the Texas Water Development Board (TWDB) shapefile for the Hickory Aquifer, projected into the groundwater availably modeling (GAM) projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.2.
- Average annual precipitation was used to calculate annual effective recharge volumes.
- The average annual precipitation (1971-2000) for the aquifer outcrop map area (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Average effective recharge from precipitation is estimated to be 2.7 percent of annual precipitation (Bluntzer, 1992; Preston and others, 1996) and is only applied to outcrop areas.
- The managed available groundwater volume estimates are the sum of the annual average effective recharge amount and the volume of water depleted from the aquifer based on the desired future condition.
- Annual volumes are calculated by dividing the total volume by 50 years.
- Specific yield of the aquifer is estimated as 0.15 (LBG-Guyton Associates, 2003) and the storage coefficient is estimated as 0.0001 (TWDB, 2009; Bluntzer, 1992; LBG-Guyton Associates, 2003).
- Outcrop areas are calculated as unconfined areas of the aquifer and subcrop areas are calculated as confined areas of the aquifer.

Determining Managed Available Groundwater:

As defined in Chapter 36 of the Texas Water Code, “managed available groundwater” is the amount of water that may be permitted. The total volume from water budget calculations represents the total amount of pumping from the aquifer to achieve the desired future condition. The total pumping includes both permitted and exempt uses. Examples of exempt uses include domestic, livestock, and oil and gas exploration. Each district may also exempt additional uses as defined by its rules or enabling legislation.

Because exempt uses are not available for permitting, it is necessary to account for them when determining managed available groundwater. To do this the Texas Water Development Board developed a standardized method for estimating exempt use for domestic and livestock purposes based on projected changes in population and the ratio of domestic and livestock wells in an areas to the total number of wells.

Because other exempt uses can vary significantly from district to district and there is much higher uncertainty associated with estimating use due to oil and gas exploration, estimates of exempt pumping outside domestic and livestock uses have not been included.

If the district believes it has a more appropriate estimate of exempt pumping, they may submit it, along with a description of how it was developed, to the Texas Water Development Board for consideration. Once established, the estimates of exempt pumping are subtracted from the total pumping calculations to yield the estimated managed available groundwater for permitting purposes.

RESULTS:

The annual effective recharge estimate for the Hickory Aquifer in Groundwater Management Area 9 is 899 acre-feet per year.

The results (Tables 2 and 3) show 1,163 acre-feet per year of managed available groundwater for the Hickory Aquifer in Groundwater Management Area 9. The Blanco-Pedernales Groundwater Conservation District in Blanco County has 1,163 acre-feet per year of managed available groundwater in the Hickory Aquifer.

Table 1. Estimated total annual effective recharge volume for the Hickory Aquifer by map areas (See Figure 1).

GMA	Aquifer	County	GCD	Map area	Areal extent (acres)	Average annual precipitation (inches)	Average annual precipitation (feet)	Effective recharge rate (percent)	Estimated annual effective recharge (ac-ft/yr)
9	Hickory	Blanco	Blanco-Pedernales GCD	1	12,337	32	2.7	2.7	899
								Total	899

GMA = groundwater management area GCD= groundwater 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).

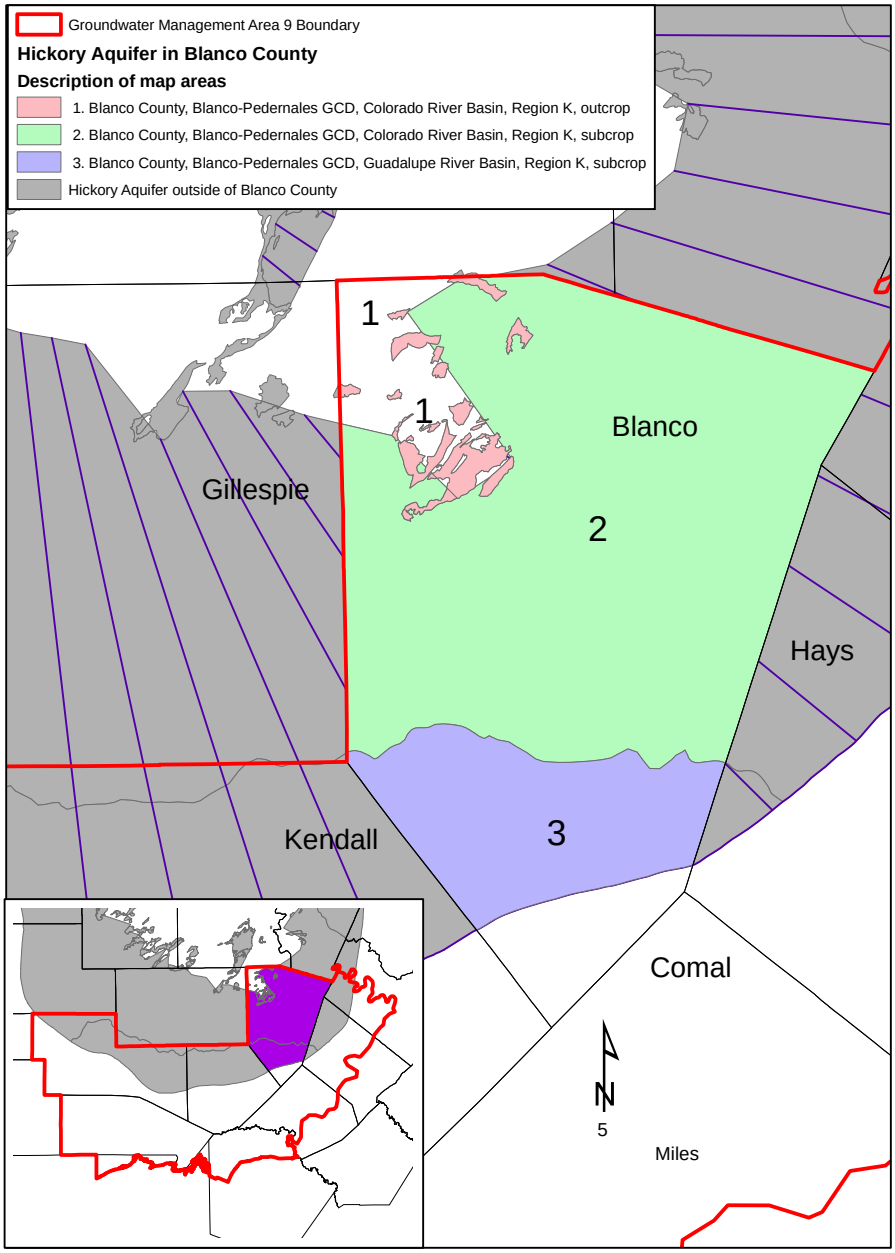


Figure 1. Map areas for calculating total pumping for the Hickory Aquifer in Blanco County. GMA = groundwater management area, GCD = groundwater conservation district.

Table 2. Estimates of total pumping for the for the Hickory Aquifer by map areas (see Figure 1).

GMA	Aquifer	County	GCD	Map area	Storage coefficient	Areal extent (acres)	Desired total aquifer drawdown (feet)	Estimated volume (acre-feet)	Estimated annual volume (ac-ft/yr)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total pumping (ac-ft/yr)
9	Hickory	Blanco	Blanco-Pedernales GCD	1	0.15	12,337	7	12,954	259	899	1,158
				2	0.0001	312,552	7	219	4	0	4
				3	0.0001	78,067	7	55	1	0	1
		Total				402,956		13,228	264	899	1,163

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

1 - This is the estimated total annual effective recharge volume for the Ellenburger-San Saba Aquifer by map areas as shown in Table 1.

The formulas for this table are: storage coefficient * areal extent * desired total aquifer drawdown = estimated volume. Estimated volume /50 = estimated annual volume. Then estimated annual volume + estimated annual effective recharge = estimated annual total pumping

Table 3. Estimates of total pumping for the Hickory Aquifer in Blanco County. Results are in acre-feet per year and are divided by regional water planning area (RWPA) and river basin.

County	RWPA	Basin	Year					
			2010	2020	2030	2040	2050	2060
Blanco	K	Colorado	1,162	1,162	1,162	1,162	1,162	1,162
		Guadalupe	1	1	1	1	1	1
		Total	1,163	1,163	1,163	1,163	1,163	1,163

Table 4. Estimates of total pumping (acre-feet per year) for the Hickory Aquifer in Blanco County. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Blanco	1,163	1,163	1,163	1,163	1,163	1,163

Table 5. Estimates of exempt use for the Hickory Aquifer within the Blanco-Pedernales GCD for each decade between 2010 and 2060. Results are in acre-feet per year.

District	Source	Year					
		2010	2020	2030	2040	2050	2060
Blanco-Pedernales GCD	TA	80	93	105	116	128	141

GCD = Groundwater Conservation District Source: TA = Estimated exempt use calculated by TWDB and accepted by the district

Table 6. Estimates of managed available groundwater for Hickory Aquifer within the Blanco-Pedernales GCD for each decade between 2010 and 2060. Results are in acre-feet per year.

District	Year					
	2010	2020	2030	2040	2050	2060
Blanco-Pedernales GCD	1,083	1,070	1,058	1,047	1,035	1,022

GCD = Groundwater Conservation District

LIMITATIONS:

Managed available groundwater numbers included in this report are the result of subtracting the estimated future exempt use from the estimated total pumping that would achieve the desired future condition adopted by the groundwater conservation districts in the groundwater management area. These numbers, therefore, are the result of (1) using a simplified water budget to estimate the total pumping which achieves the desired future condition and (2) estimating the future exempt use in the area.

The water budget in this analysis was determined to be the best method to calculate a total pumping estimate, 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 these total pumping estimates. Those assumptions also need to be considered and compared to actual future data when evaluating achievement of the desired future condition.

In the case of TWDB's estimates of future exempt use, key assumptions were made as to the pattern of population growth relative to the need for domestic wells or supplied water, per capita use from domestic wells, and livestock use of water. In the case of district estimates of future exempt use, including exempt use associated with the exploration of oil and gas, the assumptions are specific to that district. In any case, these assumptions will need to be considered when reviewing future data related to exempt use.

Given these limitations, users of this information are cautioned that the total pumping 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 of using a water budget and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these managed 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:

Anaya, R., 2001, GAM technical memo 01-01(rev a): Texas Water Development Board technical memorandum, 2p.

Bluntzer, R. L., 1992, Evaluation of ground-water resources of the Paleozoic and Cretaceous aquifers in the Hill Country of Central Texas: Texas Water Development Board Report 339, 130 p.

Freeze, R. A., and Cherry, J. A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice Hall, Inc., 604.

LBG-Guyton Associates, 2003, Brackish Groundwater Manual for Texas Regional Water Planning Groups: Texas Water Development Board contract report. 188p.

Muller, D. A. and Price, R. D., 1979, Ground-water availability in Texas, estimates and projections through 2030: Texas Department of Water Resources Report 238, 77 p.

Narasimhan, B., Srinivasan, R., Quiring, S., and Nielsen-Gammon, J.W., 2008, Digital Climatic Atlas of Texas: Texas A&M University, Texas Water Development Board Contract, Report 2005-483-5591, 108p.

Preston, R. D., Pavlicek, D. J., Bluntzer, R. L., Derton, J., 1996, The Paleozoic and related aquifers of Central Texas: Texas Water Development Board, Report 346, 85p.

Theis, C.V., 1940, The source of water derived from wells: Essential factors controlling the response of an aquifer to development: Civil Engineering 10, pp.277-280.