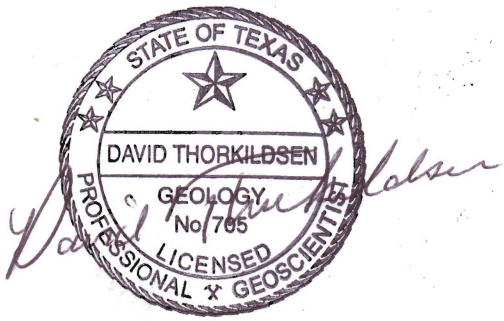
GTA Aquifer Assessment 10-34 MAG

by David Thorkildsen, P.G. and Sarah Backhouse
Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-0871



David Thorkildsen, P.G. 705, authorized the seal appearing on this document on June 22, 2011.

EXECUTIVE SUMMARY:

The estimated total pumping from the Trinity River Alluvium Aquifer that achieves the desired future condition adopted by members of Groundwater Management Area 14 is approximately 3,913 acre-feet per year and is summarized by county, regional water planning area, and river basin as shown in Table 3. The estimated managed available groundwater for Bluebonnet Groundwater Conservation District in Groundwater Management Area 14 for the aquifer is approximately 3,913 acre-feet per year between 2010 and 2060 and is shown in Table 6. Estimated total pumping was calculated based on the desired future condition stating *"from estimated 2010 conditions, the saturated thickness of the Trinity River Alluvium should be maintained at 90 percent".*

REQUESTOR:

Mr. Lloyd Behm, of the Bluebonnet Groundwater Conservation (GCD) acting on behalf of the member groundwater conservation districts of Groundwater Management Area 14.

DESCRIPTION OF REQUEST:

In a letter received August 30, 2010, Mr. Behm provided the Texas Water Development Board (TWDB) with the desired future condition of the Trinity River Alluvium Aquifer adopted by the members of Groundwater Management Area 14. The desired future condition for the Trinity River Alluvium Aquifer, as described in Resolution No. 2010-01 and adopted August 25, 2010 by the groundwater conservation districts in Groundwater Management Area 14 is described below:

- *In Walker County: From estimated 2010 conditions, the saturated thickness of the Trinity River Alluvium should be maintained at 90 percent*

In response to receiving the adopted desired future condition, TWDB has estimated the managed available groundwater that achieves the above desired future condition for Groundwater Management Area 14.

METHODS:

Groundwater Management Area 14, located in southeast Texas, includes part of the Trinity River Alluvium Aquifer. This is neither a major nor a minor aquifer, but has been determined to be relevant in Walker County for joint planning purposes.

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

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

The boundary and areal extent of the Trinity River Alluvium Aquifer was determined using the Digital Geologic Atlas of Texas (USGS and TWDB, 2006) as well as the Walker County boundary (Figure 1).

Annual effective recharge was calculated by multiplying each outcrop area by the average precipitation (1971-2000) and an effective recharge rate of 5 percent.

Water well and water-level data from the TWDB groundwater database was used to calculate saturated thickness for the Trinity River Alluvium within the Bluebonnet GCD and surrounding areas. Average aquifer saturated thickness was determined by averaging all saturated thickness estimates at individual well locations within and surrounding the aquifer map area.

To calculate change in aquifer storage based on the desired future condition the areas were multiplied by the estimated aquifer specific yield and then by the drained saturated thickness. These volumes were then divided by 50 years to obtain a yearly volume.

The calculations were completed in a Microsoft Excel worksheet.

The Trinity River Alluvium Aquifer within Walker County is located entirely within the Regional Water Planning Area H, the Trinity River Basin, and the Bluebonnet Groundwater Conservation District. A regional map of the area is shown in Figure 2.

PARAMETERS AND ASSUMPTIONS:

- Areas in acres for the aquifer were calculated in ArcGIS 9.3 using the 1:250,000 Digital Geological Atlas of Texas (USGS and TWDB, 2006).
- A 10 percent decline of saturated thickness is assumed to be uniform across the aquifer.
- Average annual precipitation was used to calculate annual effective recharge volumes.
- The average annual precipitation for the aquifer (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008) which is the average for the years 1971 to 2000.
- Annual effective recharge is 5 percent of annual precipitation (Williams, 2010; Bradley, in preparation)
- Specific yield of the aquifer is estimated to be 0.15 (Cronin and Wilson, 1967; Johnson,1967)
- Annual volumes are calculated by dividing the total volume from water level decline by 50 years.
- Annual total pumping estimates are the sum of the annual effective recharge and the annual volume of water depleted from the aquifer based on the adopted desired future condition.
- There is sufficient saturated thickness to achieve the desired future condition based on available data (TWDB, 2011).

Table 1. Estimated total annual effective recharge volume for the Trinity River Alluvium Aquifer in Groundwater Management Area 14 (see Figure 1).

GMA	Aquifer	County	Groundwater Conservation District	Areal extent (acres)	Estimated average annual precipitation (inches)	Estimated average annual precipitation (feet)	Effective recharge rate (percent)	Estimated annual effective recharge (ac-ft/yr)
14	Trinity River Alluvium	Walker	Bluebonnet Groundwater Conservation District	19,873	46	3.8	5	3,776

GMA = groundwater management area

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

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 by a groundwater conservation district. The estimated total annual volume of groundwater calculated, however, represents the total amount of pumping from the aquifer. The total pumping includes uses of water both subject to permitting and exempt from permitting. 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.

Since 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 area 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 a 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 calculation to yield the estimated managed available groundwater for permitting purposes.

RESULTS:

The annual effective recharge estimate for the Trinity River Alluvium Aquifer is 3,776 acre-feet per year (Table 1).

The estimated total pumping from the Trinity River Alluvium Aquifer in Groundwater Management Area 14 that achieves the adopted desired future

condition is approximately 3,913 acre-feet per year. The volumetric calculations to determine total pumping are shown in Table 2.

Total pumping estimates are also summarized by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 3). The total pumping estimate is also summarized by groundwater conservation district and is shown in Table 4.

Table 5 contains the estimates of exempt pumping in the Bluebonnet Groundwater Conservation District for domestic and livestock uses. The managed available groundwater for the groundwater conservation district is the difference between the total pumping (Table 4) and the estimated exempt use (Table 5) and is shown in Table 6.

Table 2. Volumetric calculations estimating the annual total pumping for the Trinity River Alluvium Aquifer in Groundwater Management Area 14.

GMA	Aquifer	County	Groundwater Conservation District	Estimated specific yield	Areal extent (acres)	Estimated average saturated thickness (feet)	Desired percentage of saturated thickness	Desired drained thickness (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume (acre-feet)	Estimated annual effective recharge[1] (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
14	Trinity River Alluvium	Walker	Bluebonnet Groundwater Conservation District	0.15	19,873	23	90%	2.3	6,856	137	3,776	3,913

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

1 - This is the estimated total annual effective recharge volume for the Trinity River Alluvium Aquifer as shown in Table 1.

The formulas for this table are: specific yield * areal extent * desired drained thickness (based on desired saturated thickness) = 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. Estimated total pumping by decade for the Trinity River Alluvium Aquifer Groundwater Management Area 14. 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
Walker	H	Trinity	3,913	3,913	3,913	3,913	3,913	3,913

Table 4. Estimated total pumping for the Trinity River Alluvium Aquifer in the Bluebonnet 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
Bluebonnet Groundwater Conservation District	3,913	3,913	3,913	3,913	3,913	3,913

Table 5. Estimates of exempt use for the Trinity River Alluvium Aquifer in the Bluebonnet Groundwater Conservation District for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Source	Year					
		2010	2020	2030	2040	2050	2060
Bluebonnet Groundwater Conservation District	TA	0	0	0	0	0	0

TA = Estimated exempt use calculated by TWDB and accepted by the district

Table 6. Estimates of managed available groundwater for the Trinity River Alluvium Aquifer in the Bluebonnet 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
Bluebonnet Groundwater Conservation District	3,913	3,913	3,913	3,913	3,913	3,913

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.

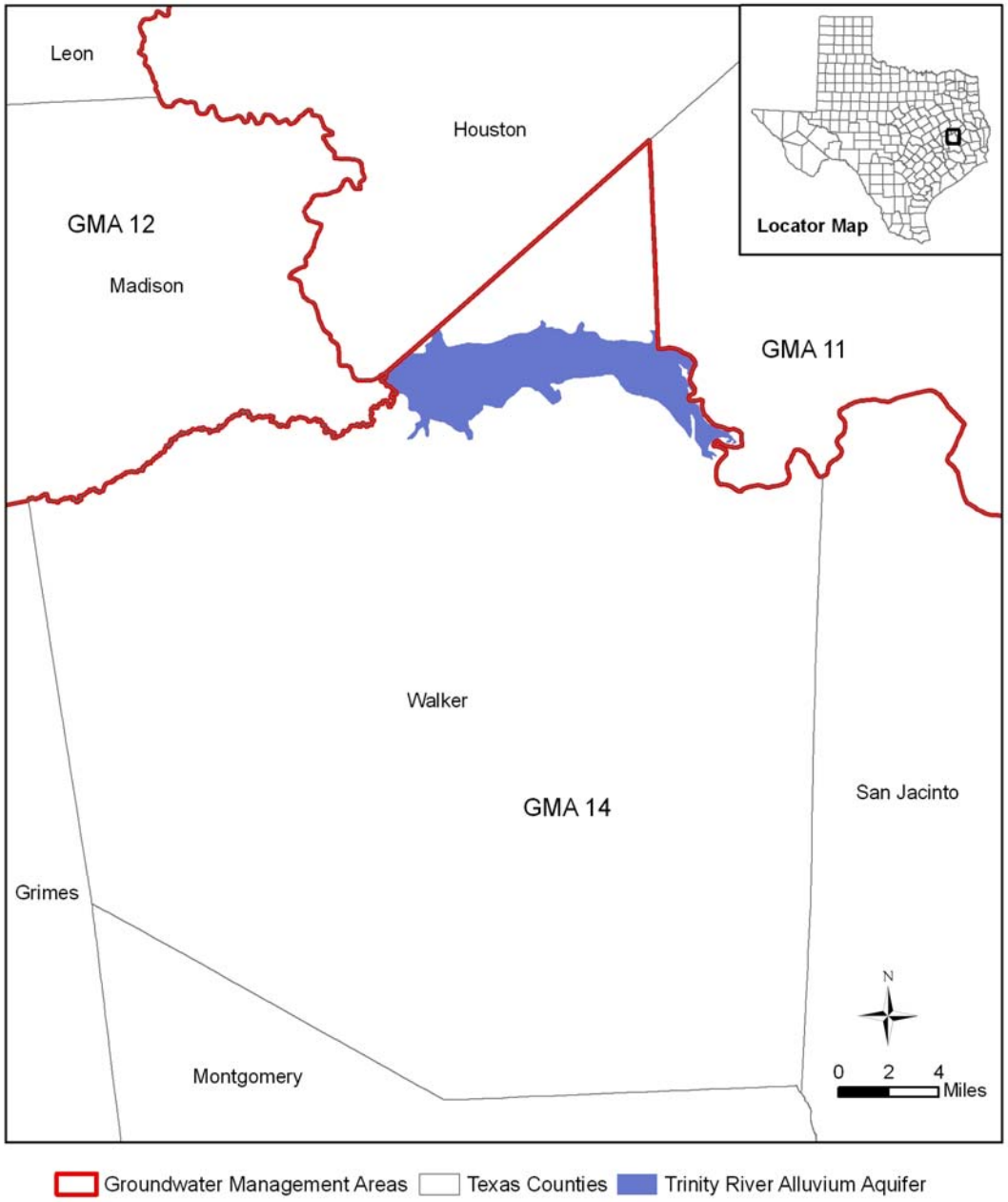


Figure 1. Map showing the area used for estimating total pumping in the Trinity River Alluvium Aquifer in Groundwater Management Area 14. GMA = Groundwater Management Area

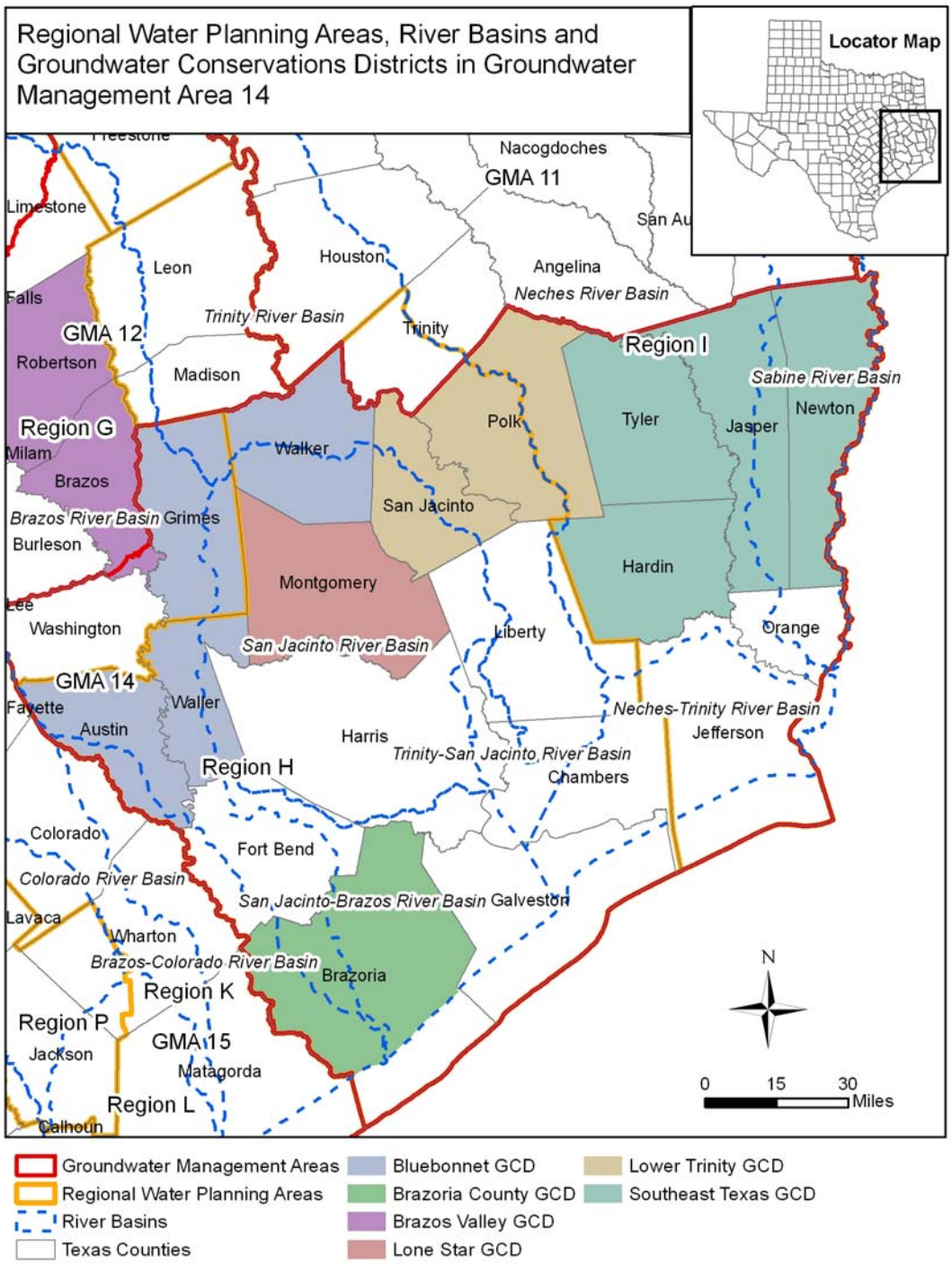


Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts and counties in Groundwater Management Area 14. GMA = Groundwater Management Area, GCD = Groundwater Conservation District

REFERENCES:

Bradley, R.G., in preparation, GTA Aquifer Assessment 10-30 MAG: Texas Water Development Board, GTA Aquifer Assessment 10-30 MAG Report, 11 p.

Cronin, J., and Wilson, C., 1967, Ground water in the flood plain alluvium of the Brazos River, Whitney Dam to the vicinity of Richmond, Texas: Texas Water Development Board Report 41, 80p.

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

Johnson, A.I. 1967. Specific yield — compilation of specific yields for various materials. U.S. Geological Survey Water Supply Paper 1662-D. 74 p.

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., Srinvasan, 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, 108 p.

Texas Water Development Board, 2011, Groundwater database: Texas Water Development Board, Water Science and Conservation Division.

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.

USGS and TWDB, 2006, Digital Geologic Atlas of Texas: U.S. Geological Survey and Texas Water Development Board, available through the Texas Natural Resources Information System.

Williams, C.R, 2010, Groundwater Management Plan of The Bluebonnet Groundwater Conservation District, Appendix G Details on the Development of the Estimates of Annual Recharge: Bar-W Groundwater Exploration, pp.G-1–G-4.