GTA Aquifer Assessment 09-07

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The seal appearing on this document was authorized by Robert G. Bradley, P.G. 707 on November 22, 2010

REQUESTOR:

The original request was submitted by Cheryl Maxwell, of the Clearwater Underground Water Conservation District, acting on behalf of Groundwater Management Area 8. This revaluation was requested by Joe Cooper of the Middle Trinity Groundwater Conservation District.

DESCRIPTION OF REQUEST:

In a letter dated October 6, 2008, Ms. Cheryl Maxwell provided the Texas Water Development Board (TWDB) with the desired future conditions (DFCs) for the Trinity Aquifer in Groundwater Management Area (GMA) 8 and requested that TWDB estimate managed available groundwater values. The Managed Available Groundwater (MAG) values were distributed to GMA 8 in a letter dated March 31, 2009.

On June 12, 2009, the general manager and consultant for the Middle Trinity Groundwater Conservation District met with TWDB staff to discuss issues they had with the model runs done by TWDB for GMA 8 to calculate the managed available groundwater. After this discussion, staff decided to re-calculate the total pumping estimates using a water-budget approach based on the DFCs for Comanche and Erath counties.

This aquifer analysis presents revised total pumping estimates for the Trinity Aquifer in Comanche and Erath counties, within Groundwater Management Area 8.

DESIRED FUTURE CONDITIONS:

The Trinity Aquifer desired future conditions for this area are:

Comanche County

- From estimated year 2000 conditions, the average drawdown of the Paluxy Aquifer should not exceed approximately 0 feet after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Glen Rose Aquifer should not exceed approximately 0 feet after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Hensell Aquifer should not exceed approximately 2 feet after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Hosston Aquifer should not exceed approximately 11 feet after 50 years.

Erath County

- From estimated year 2000 conditions, the average drawdown of the Paluxy Aquifer should not exceed approximately 1 foot after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Glen Rose Aquifer should not exceed approximately 1 foot after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Hensell Aquifer should not exceed approximately 11 feet after 50 years.
- From estimated year 2000 conditions, the average drawdown of the Hosston Aquifer should not exceed approximately 27 feet after 50 years.

METHODS:

The DFCs for the Trinity Aquifer in GMA 8 were based on average water level changes, by county and model layers, that were provided in GAM Run 08-06 (Donnelly, 2008, p.6; Wade, 2009).

For Comanche and Erath counties, the adopted DFCs were for the model layers that represent the Paluxy Formation (layer 3), Glen Rose Formation (layer 4), and the Hensell (layer 5) and Hosston (layer 6) members of the Twin Mountains Formation.

In these counties, the stratigraphy in the outcrop and the hydrostratigraphy represented in the model are slightly different. The Hosston and Hensell members are undifferentiated in the outcrop areas. In addition, the Glen Rose Formation pinches out toward the west where the Twin Mountains and Paluxy formations combine to become the Antlers Formation (Figure 1; Fisher and Rodda, 1966).

This approach attempted to honor the adopted DFCs while using better site-specific information. However, the Twin Mountains Formation is not differentiated into members for the calculations. Therefore, the Hensell and Hosston members were aggregated in the water budget calculations.

To complete the water budget calculations, it was necessary to create shapefiles from the 1:250,000 Geologic Atlas of Texas (USGS and TWDB, 2006) in order to calculate outcrop and subcrop areas for the Twin Mountains, Glen Rose, and Paluxy formations.

The typical water budget used for total pumping calculations is the transient hydrologic budget for the saturated portion of an aquifer as described by Freeze and Cherry (1979, p. 365):

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

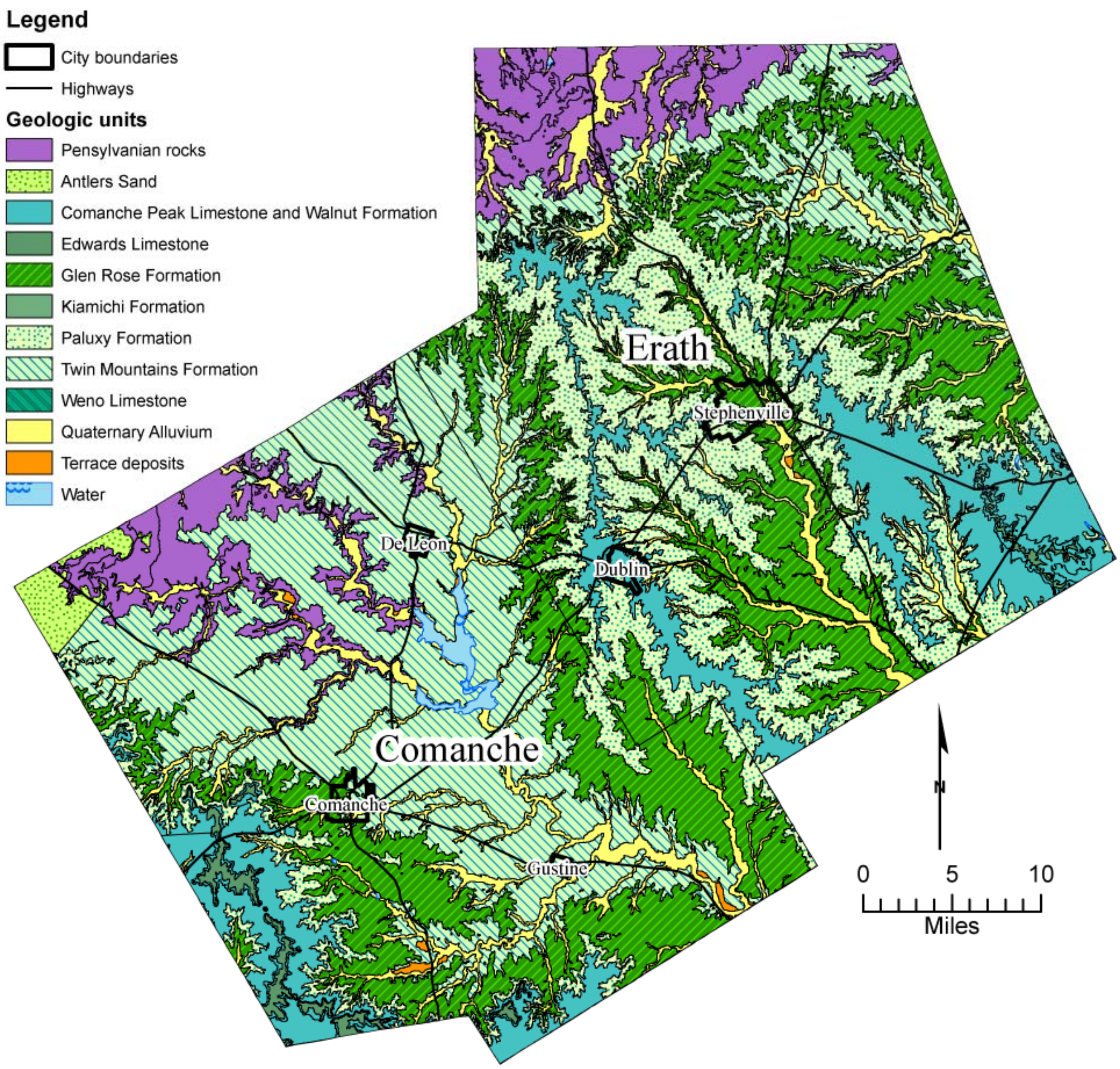

Figure 1. Geologic map of Comanche and Erath counties (modified from USGS and TWDB, 2006).

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 recharge rate that was used for the calculation is the estimated effective recharge rate and not the total recharge rate as used in a groundwater model. The assumption that rejected recharge is equal to aquifer discharge is simple, but adequate, for regional water budgets such as this. Annual effective recharge to the aquifer was calculated by multiplying each outcrop area by the average precipitation (1971 to 2000) and an estimated effective recharge rate.

Initially, the water-budget approach included data from the northern Trinity Aquifer groundwater availability model (GAM), to refine the assumptions used in the calculations.

Analyzing existing GAM run water budgets (Wade, 2009; Oliver, 2008) and looking at previous estimates (Muller and Price, 1979; Klemt and others, 1975), an initial effective recharge of 1.5 percent of annual precipitation was used in preliminary calculations.

When this was included, this resulted in similar numbers to the existing GAM run. The estimated total pumpage using this recharge rate were similar to the GAM numbers.

In addition, to account for lateral flows, the average lateral flows from GAM Run 08-84mag (Wade, 2009) were evaluated to see if they could improve the water-budget estimates. The average lateral flows were averaged from lateral flow volumes from model years 1, 5, 10, 15, and 20 from the referenced run. This showed a net outflow of 4,636 acre-feet per year from Comanche and Erath County. Based on other available data from the area, the lateral flow and the model recharge data were not used in this evaluation.

DFCs were adopted for the Glen Rose Formation and total pumping estimates were provided to GMA 8. However, within this area the Glen Rose is mostly limestone that yields only small amounts of water, with some bad quality water (Nordstrom, 1987). It is not a significant source of groundwater within Comanche and Erath Counties; therefore, in the water budget calculations no recharge was assigned.

The geologic units were subdivided by county, regional water planning area, river basin, subcrop/outcrop, and groundwater conservation district boundaries (Figures 2–4). The areal extent of each aquifer map area was calculated. The outcrop areas were used to calculate estimated annual effective recharge as described above. The total pumping is reported by county-basin splits.

Historical water use data and water-level measurements were used to estimate an effective recharge rate for the Twin Mountains and Paluxy formations. The historical pumpage from the study area is shown in Figure 5.

Analysis of water-level trends during the record of historical use data (1984-2003) (Figure 5) determined that no significant declines in water levels have occurred overall (Figures 6–9). In Comanche County, the variation of water levels between 1985 and 2003 ranges from 7.34 to 27.46 feet (Figures 6 and 7). In Erath County the total variation ranges from 5.79 to 20.53 feet (Figures 8 and 9).Two wells in the confined portions of the aquifer do show a downward trend over time (well 41-14-102, Figure 7; well 32-49-501, Figure 9).

The water-level changes for 1985 show the least change during the historic use data period (1984–2003). For early 1985, 11 out of the 19 wells used for this assessment showed less than 1-foot variation from previous measurements. In addition, the 1984 water use of 15,622 acre-feet represents the median pumpage for Erath County. The 1984 pumpage for Comanche County is 23,884 acre-feet, which is near to the median value of 23,072 acre-feet of pumpage.

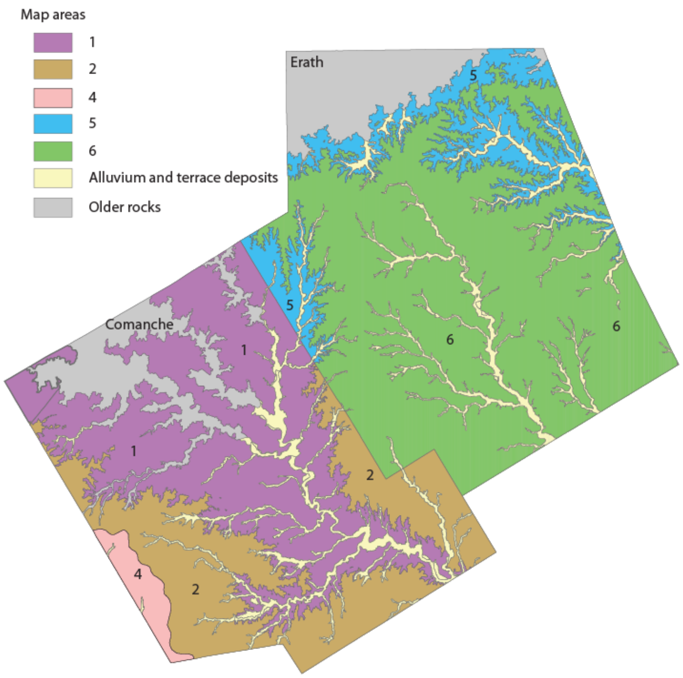

Figure 2. Index map of map areas for the Twin Mountains Formation.

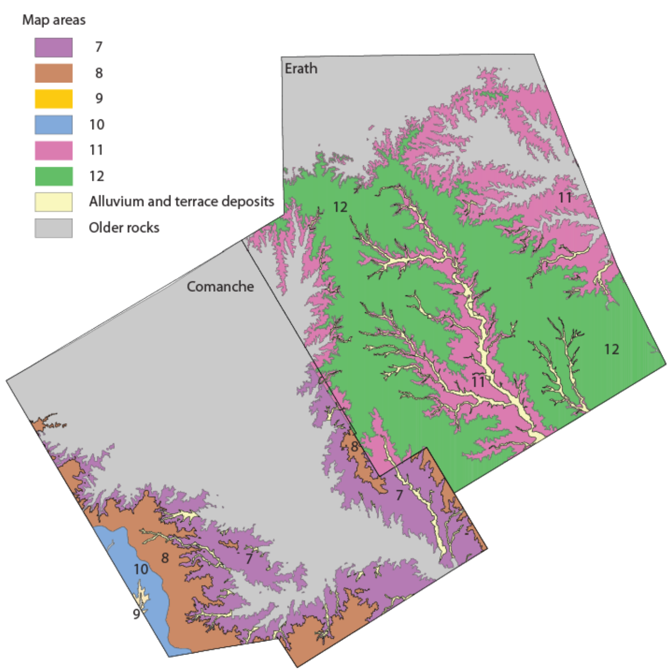

Figure 3. Index map of map areas for the Glen Rose Formation.

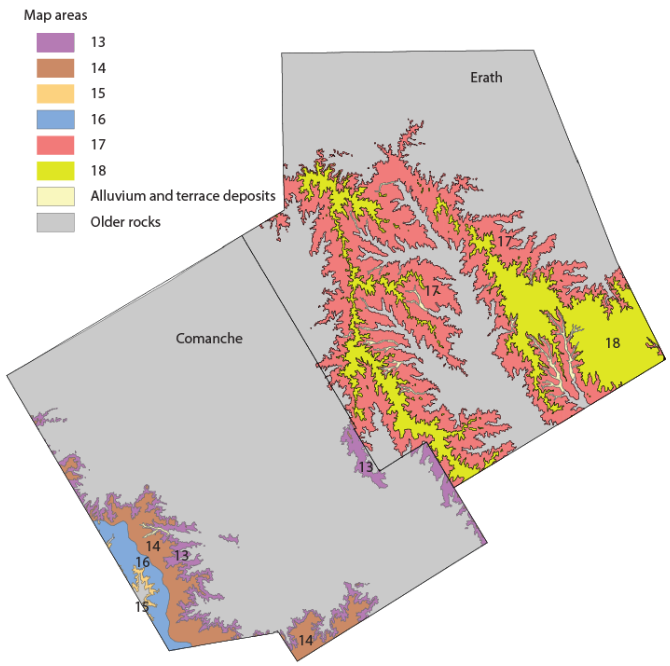

Figure 4. Index map of map areas for the Paluxy Formation.

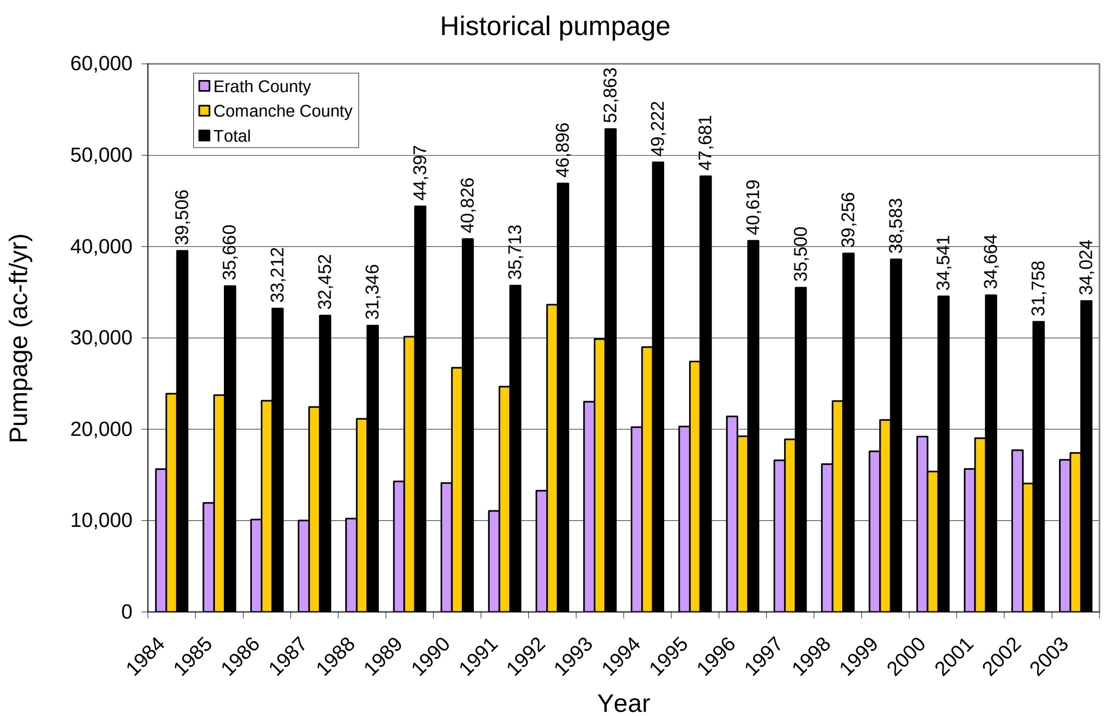

Figure 5. Historical pumpage estimates for Comanche and Erath counties (TWDB 2010a).

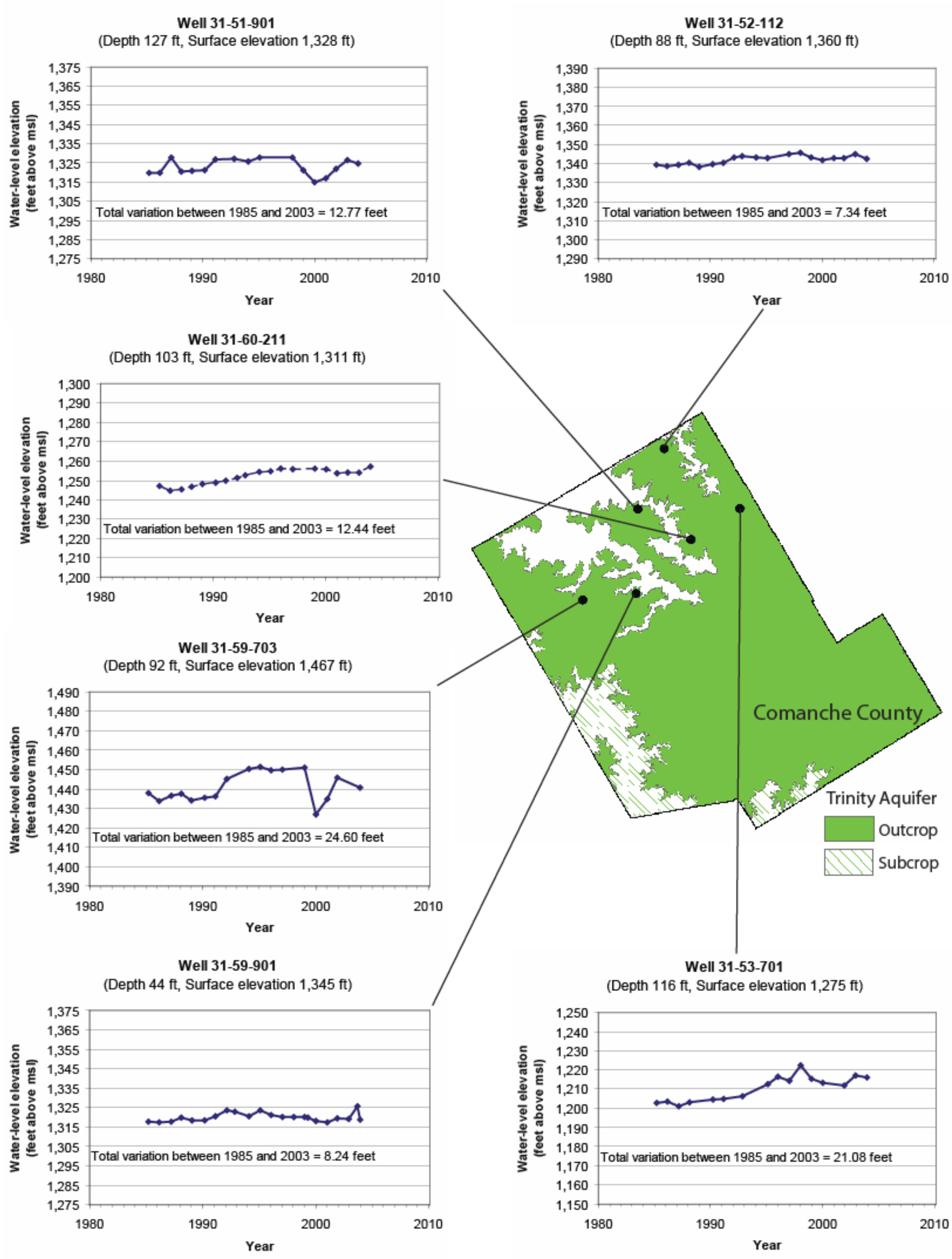

Figure 6. Water-level measurements for selected wells in northern Comanche County, Texas (TWDB 2010b).

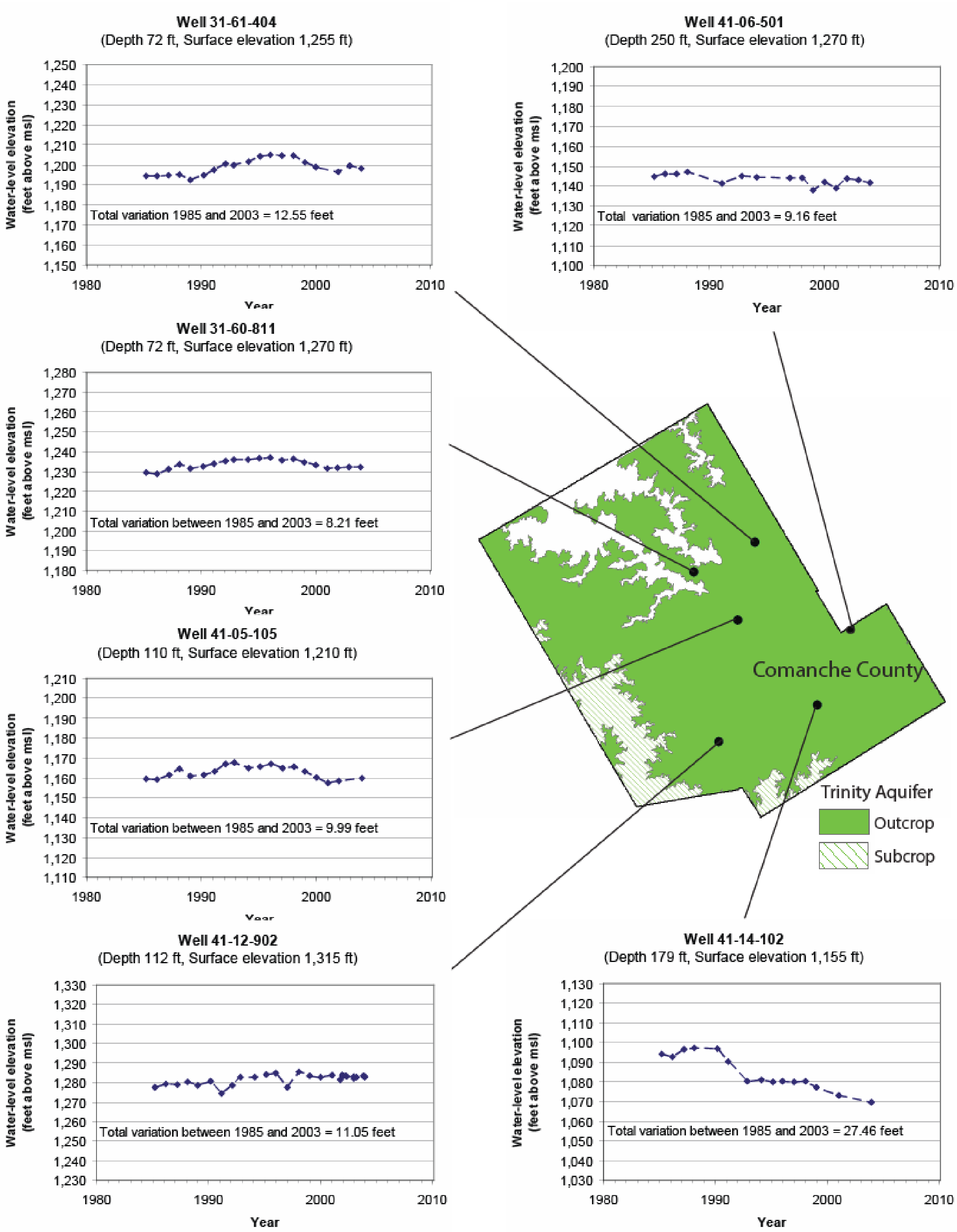

Figure 7. Water-level measurements for selected wells in central and southern Comanche County, Texas (TWDB 2010b).

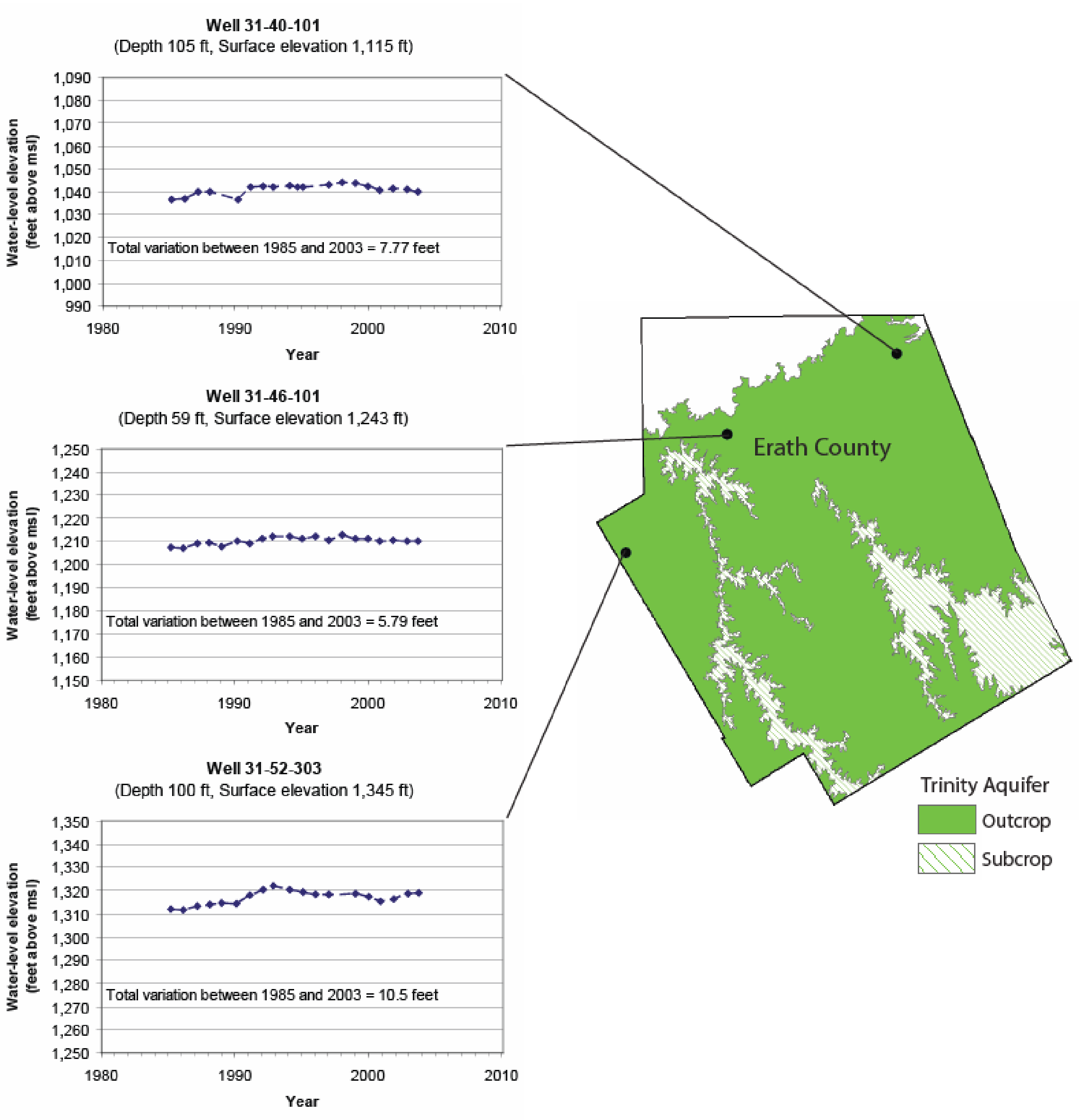

Figure 8. Water-level measurements for selected wells in northern Erath County, Texas (TWDB 2010b).

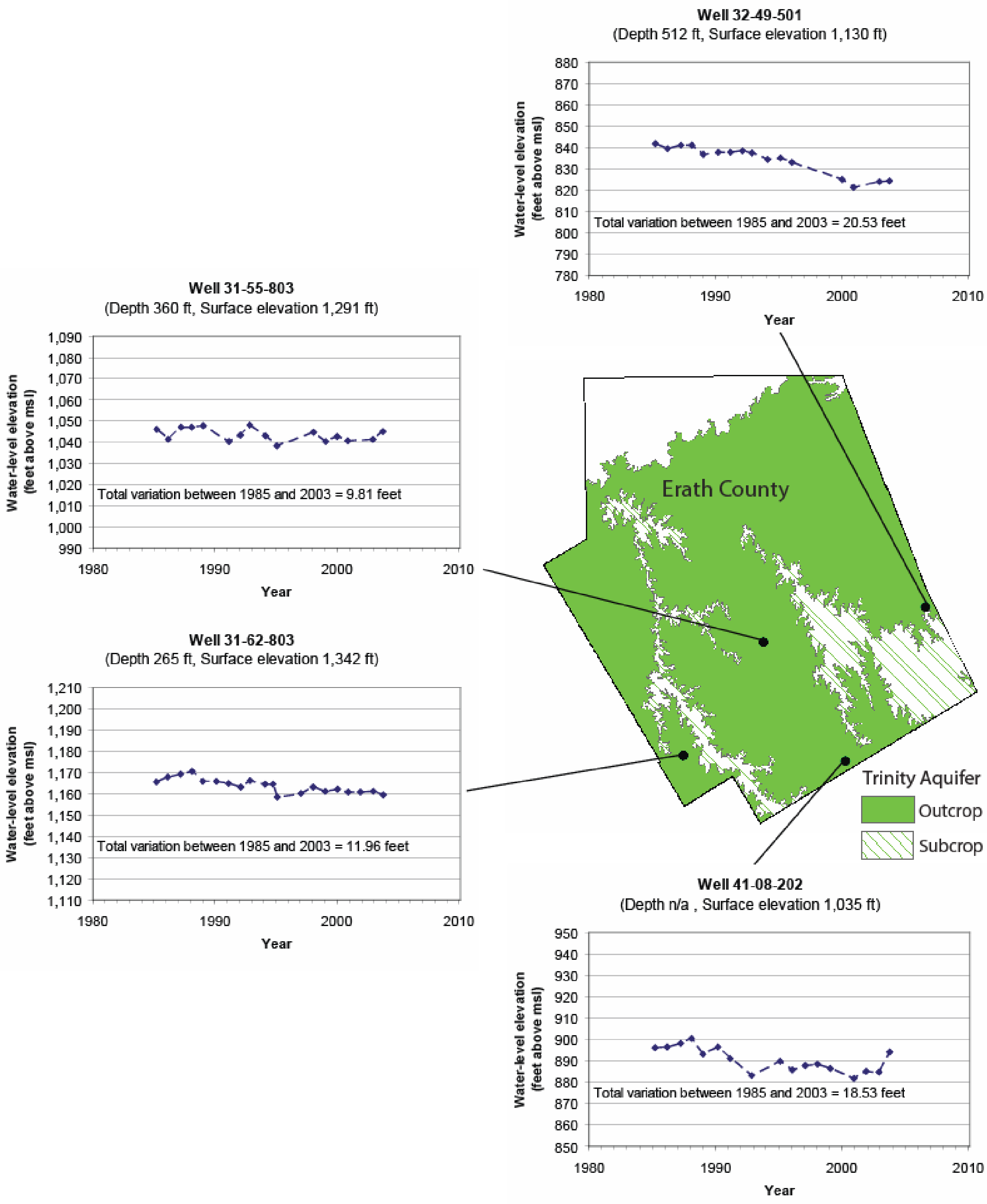

Figure 9. Water-level measurements for selected wells in central and southern Erath County, Texas (TWDB 2010b).

The total pumpage estimate for 1984 is 39,506 acre-feet per year and this is assumed to represent the total effective recharge during near steady-state conditions. This is approximately 2.5 percent of average annual precipitation.

Table 1. Estimated total annual effective recharge volume for the Trinity Aquifer by geologic strata and map areas (See Figures 1 and 2).

GMA	Aquifer	Geologic strata outcrop	County	River basin	Map Area	Areal extent (acres)	Percent of total recharge area	Total effective recharge (ac-ft/yr)	Estimated annual effective recharge (ac-ft/yr)
8	Trinity	Twin Mountains	Comanche	Brazos	1	277,439	45.5	39,506	17,975
		Twin Mountains	Erath	Brazos	5	96,236	15.8	39,506	6,242
		Paluxy	Comanche	Brazos	13	33,593	5.5	39,506	2,173
		Paluxy	Comanche	Colorado	15	1,974	0.3	39,506	119
		Paluxy	Erath	Brazos	17	200,338	32.9	39,506	12,997
					Total	609,580			39,506

GMA = groundwater management area ac-ft/yr = acre-feet per year
The percent of total recharge area is the map area areal extent divided by the total areal extent of 609,580 acres of outcrop area.
The formula for this table is: percent of recharge area * total effective recharge rate = estimated annual effective recharge (ac-ft/yr).

To determine the volume from storage used, the areas were multiplied by the estimated aquifer specific yield (outcrop) or storage coefficient (subcrop), and then by the desired water-level decline necessary to maintain the desired future condition. This volume was then divided by 50 years to obtain a yearly volume. The calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS

- The areas for each area were calculated from shapefiles created from the Geologic Atlas of Texas (USGS and TWDB, 2006) for the Twin Mountains, Glen Rose, and Paluxy formations, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001).
- Areas, in acres, were calculated within ArcGIS 9.2.
- The average annual precipitation (1971–2000) for the aquifer map area (Tables 1 and 2) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Total annual effective recharge is estimated to be 39,506 acre-feet per year, which represents approximately 2.5 percent of average annual precipitation.
- Annual volumes of water taken from storage are calculated by dividing the total volume of depletion, based on the draft desired future condition, by 50 years.
- The total pumping volume estimates are the sum of the annual effective recharge amount, annual volume of water depleted from the aquifer based on the desired future condition.

- Specific yield is estimated as 0.15 for the Twin Mountains and Paluxy formations based on aquifer tests (Klemt and others, 1975; Nordstrom, 1987) and 0.01 for the Glen Rose Formation.
- Storage coefficient is estimated as 0.0001 for the Paluxy and Twin Mountains formations and 0.00001 for the Glen Rose Formation (Bené and others, 2004).
- Outcrop areas are calculated as unconfined areas of the aquifer and subcrop areas are calculated as confined areas of the aquifer.

RESULTS

The annual effective recharge estimate for the Trinity Aquifer in Groundwater Management Area 8 for Comanche and Erath counties is 39,506 acre-feet per year (Table 1). The total pumping is 32,235 acre-feet per year for Comanche County and 32,926 acre-feet per year in Erath County. The total pumping is 65,161 acre-feet per year (Table 3, Figure 7).

Limitations

Additional data are needed to create improved estimates; these estimates are a fundamental interpretation of the requested conditions. This analysis assumes homogeneous and isotropic aquifers; however, conditions for the Trinity Aquifer may not behave in a uniform manner. The analysis further assumes that lateral inflow to the aquifer is equal to lateral outflow from the aquifer and that future pumping will not alter this balance.

Note that estimates of total pumping are based on the best available scientific tools that can be used to develop total pumping and that these estimates can be a function of assumptions made on the magnitude and distribution of pumping in the aquifer. Therefore, it is important for groundwater conservation districts to monitor whether or not they are achieving their desired future conditions and to work with the TWDB to refine total pumping given the reality of how the aquifer responds to the actual magnitude and distribution of pumping now and in the future.

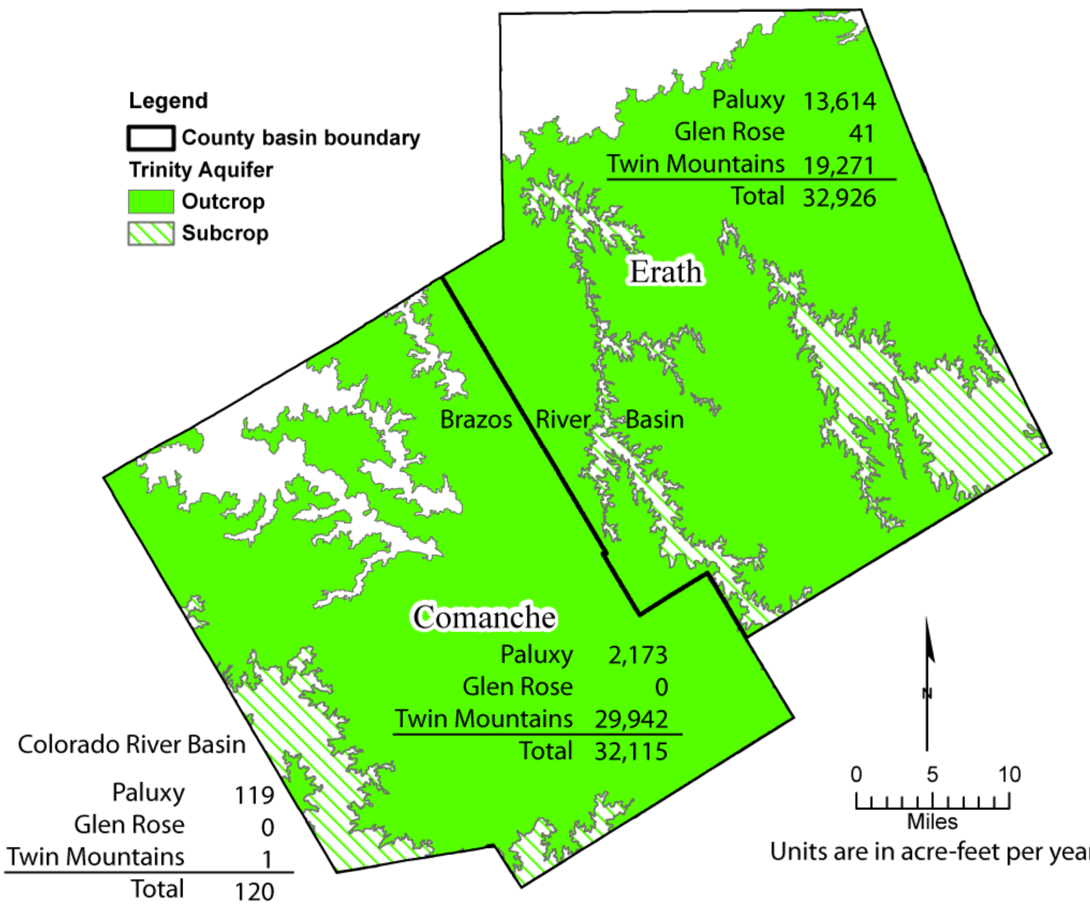

Figure 10. Total pumping estimates by county and river basin areas for the Trinity Aquifer in Comanche and Erath counties within Groundwater Management Area 8. See Table 3 for a description of MAG areas based on county, regional water planning area, river basin, groundwater conservation district, and subcrop/outcrop boundaries.

Table 2. Estimates of annual total volumes for the Trinity Aquifer, summarized by map areas.

GMA	Aquifer	Geologic strata	County	River basin	Map area	Storage coefficient	Areal extent (acres)[1]	Desired total aquifer drawdown (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume from storage (ac-ft/yr)	Estimated annual effective recharge (ac-ft/yr)	Estimated annual volume (ac-ft/yr)
8	Trinity	Twin Mountains	Comanche	Brazos	1	0.15	306,716	13	598,096.2	11,962	17,975	29,937
		Twin Mountains	Comanche	Brazos	2	0.0001	193,355	13	251.4	5	0	5
		Twin Mountains	Comanche	Colorado	3	0.0001	0	13	0.0	0	0	0
		Twin Mountains	Comanche	Colorado	4	0.0001	19,220	13	25.0	1	0	1
		Twin Mountains	Erath	Brazos	5	0.15	113,962	38	649,583.4	12,992	6,242	19,234
		Twin Mountains	Erath	Brazos	6	0.0001	487,128	38	1,851.1	37	0	37
		Glen Rose	Comanche	Brazos	7	0.01	131,615	0	0.0	0	0	0
		Glen Rose	Comanche	Brazos	8	0.00001	70,801	0	0.0	0	0	0
		Glen Rose	Comanche	Colorado	9	0.01	1,044	0	0.0	0	0	0
		Glen Rose	Comanche	Colorado	10	0.00001	17,912	0	0.0	0	0	0
		Glen Rose	Erath	Brazos	11	0.01	205,015	1	2,050.2	41	0	41
		Glen Rose	Erath	Brazos	12	0.00001	303,903	1	3.0	0	0	0
		Paluxy	Comanche	Brazos	13	0.15	34,051	0	0.0	0	2,173	2,173
		Paluxy	Comanche	Brazos	14	0.0001	37,208	0	0.0	0	0	0
		Paluxy	Comanche	Colorado	15	0.15	1,974	0	0.0	0	119	119
		Paluxy	Comanche	Colorado	16	0.0001	15,938	0	0.0	0	0	0
		Paluxy	Erath	Brazos	17	0.15	205,519	1	30,827.9	617	12,997	13,614
		Paluxy	Erath	Brazos	18	0.0001	103,565	1	10.4	0	0	0
						Total	2,248,926		1,282,698.0	25654	39,506	65,161

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

1 - The areas include the portions covered by other younger units such as alluvium or terrace deposits, therefore these values are greater than those found in Table 1 because these areas are added to include the amount of storage under these surfcial units.

The formulas for this table are: storage coefficient * areal extent * desired total aquifer drawdown = estimated total volume from water level decline.

Estimated total volume from water level decline/50 = estimated annual volume from water level decline.

Table 3. Estimates of total annual pumping based on adopted desired future conditions for the Trinity Aquifer in Comanche and Erath counties.

Map area	Aquifer	County	RWPA	River Basin	GCD	GMA	GeoArea	Year	Outcrop/ subcrop	Total annual pumping (acre-feet per year)
1	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Twin Mountains	n/a	outcrop	29,937
2	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Twin Mountains	n/a	subcrop	5
3	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Twin Mountains	n/a	outcrop	0
4	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Twin Mountains	n/a	subcrop	1
5	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Twin Mountains	n/a	outcrop	19,234
6	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Twin Mountains	n/a	subcrop	37
7	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Glen Rose	n/a	outcrop	0
8	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Glen Rose	n/a	subcrop	0
9	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Glen Rose	n/a	outcrop	0
10	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Glen Rose	n/a	subcrop	0
11	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Glen Rose	n/a	outcrop	41
12	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Glen Rose	n/a	subcrop	0
13	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Paluxy	n/a	outcrop	2,173
14	Trinity	Comanche	G	Brazos	Middle Trinity GCD	8	Paluxy	n/a	subcrop	0
15	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Paluxy	n/a	outcrop	119
16	Trinity	Comanche	G	Colorado	Middle Trinity GCD	8	Paluxy	n/a	subcrop	0
17	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Paluxy	n/a	outcrop	13,614
18	Trinity	Erath	G	Brazos	Middle Trinity GCD	8	Paluxy	n/a	subcrop	0

RWPA = regional water planning area
GCD = groundwater conservation district
GMA = groundwater management area
GeoArea = Geographic areas defined by unique desired future conditions as specified by a groundwater management area.

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