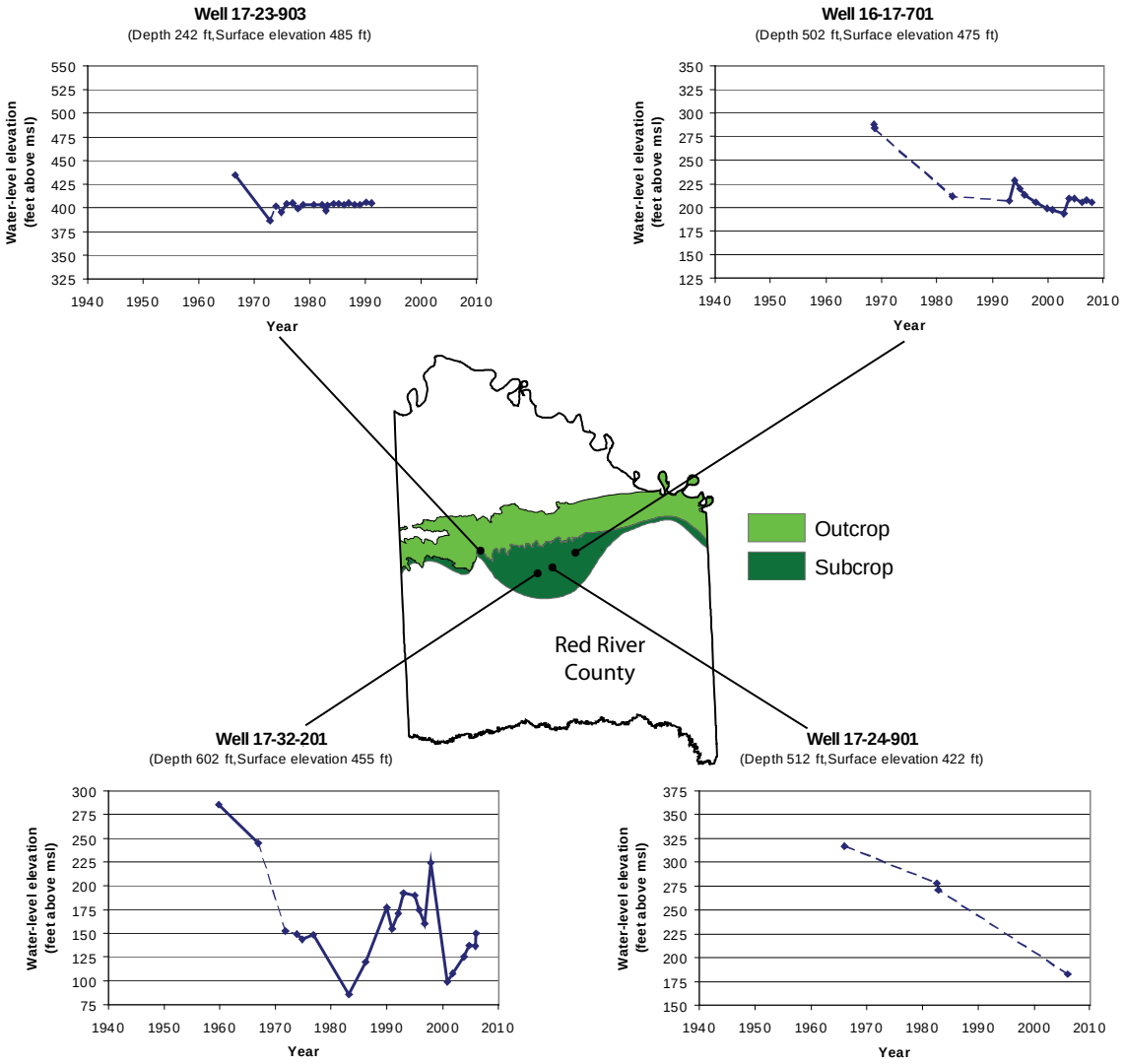

Figure 3. Hydrographs for Blossom Aquifer wells in Red River County, Texas (TWDB, 2008a).

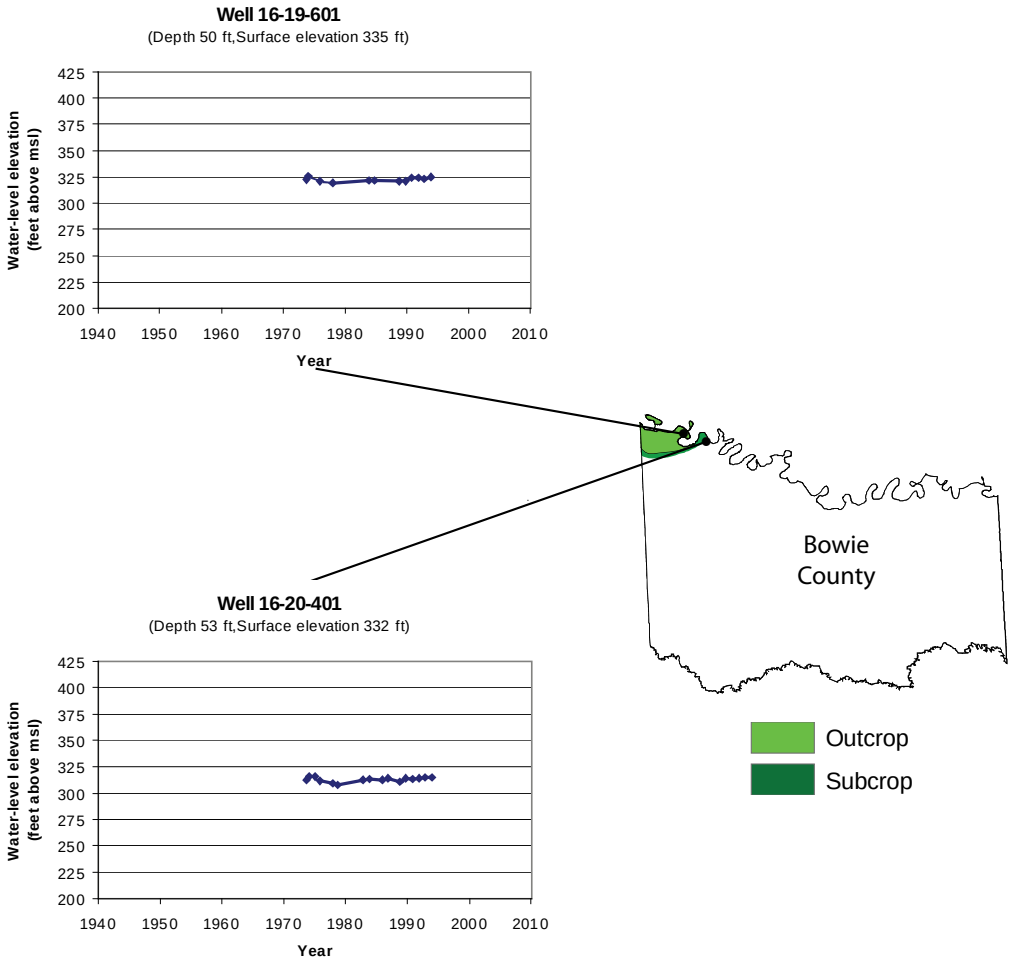

Figure 4. Hydrographs for Blossom Aquifer wells in Bowie County, Texas (TWDB, 2008a).

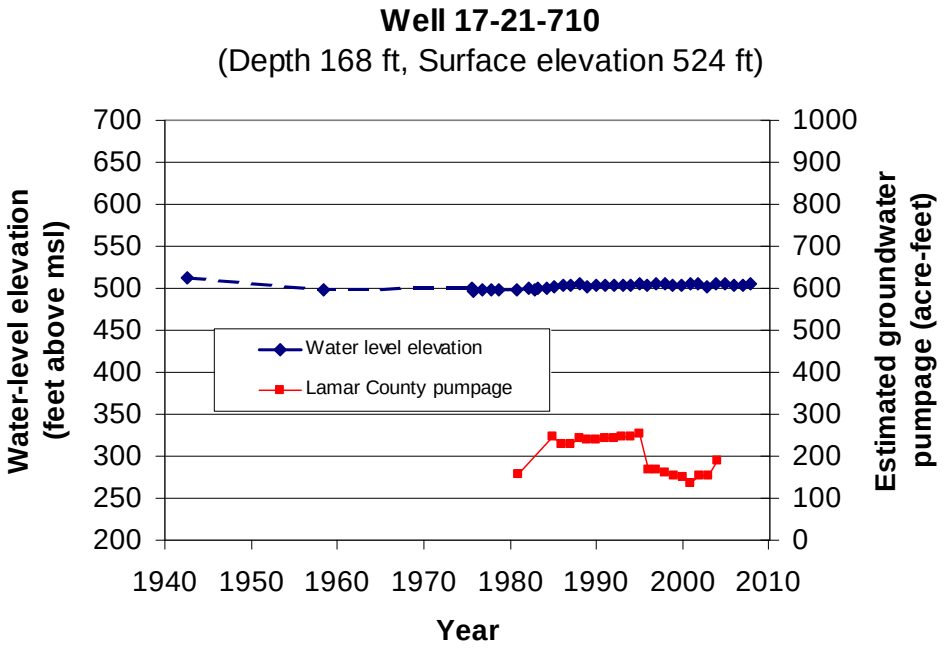

Figure 5. Water-level measurements for well 17-21-710 and the estimated groundwater pumpage for Lamar County in acre-feet.

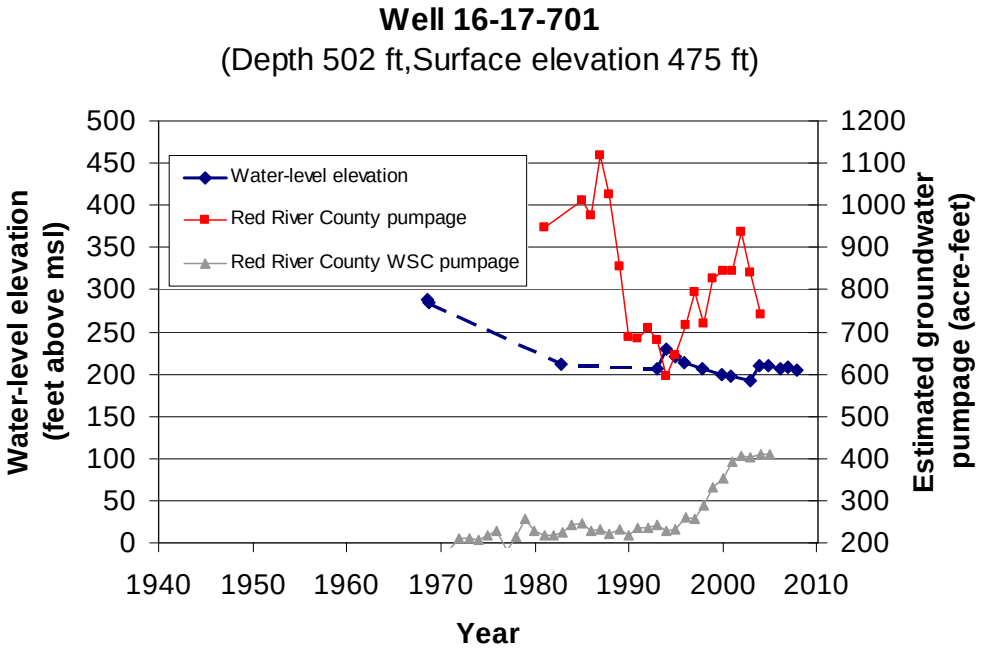

Figure 6. Water-level measurements for well 16-17-701 and the estimated groundwater pumpage for Red River County and Red River County WSC in acre-feet.

Table 1. Details of water-level data used to determine steady state periods (TWDB, 2008a).

County	Well number	Water level data		
		Date of measurement	Elevation (feet above msl)	Difference from previous measurement (feet)
Lamar	17-21-710	1/28/1991	503.40	-0.55
		1/8/1992	503.60	0.20
		1/12/1993	503.60	0.00
		1/11/1994	503.38	-0.22
Red River	16-17-701	1/11/1994	229.00	22.00
		1/10/1995	220.00	-9.00
		11/7/1995	213.50	-6.50
		11/20/1997	205.55	-7.95
		11/2/1999	199.12	-6.43
		11/15/2000	197.00	-2.12
		11/10/2002	193.00	-4.00
	17-32-201	1/9/1990	177.00	57.00
		1/8/1991	154.52	-22.48
		1/21/1992	171.00	16.48
		1/13/1993	192.00	21.00
		1/12/1995	190.00	-2.00
		11/8/1995	175.00	-15.00
		11/9/1996	160.00	-15.00

Table 2. Groundwater pumpage estimates for the steady-state periods selected for assessment (TWDB, 2008b).

County	Groundwater pumpage estimates		
	Year	Amount (acre-feet)	Average (acre-feet)
Bowie	1989	689	95
	1990	685	
	1991	709	
	1992	681	
	1993	595	
	1994	645	
	1995	717	
	1996	794	
Lamar	1990	243	245
	1991	244	
	1992	246	
	1993	246	
Red River	1989	689	689
	1990	685	
	1991	709	
	1992	681	
	1993	595	
	1994	645	
	1995	717	
	1996	794	

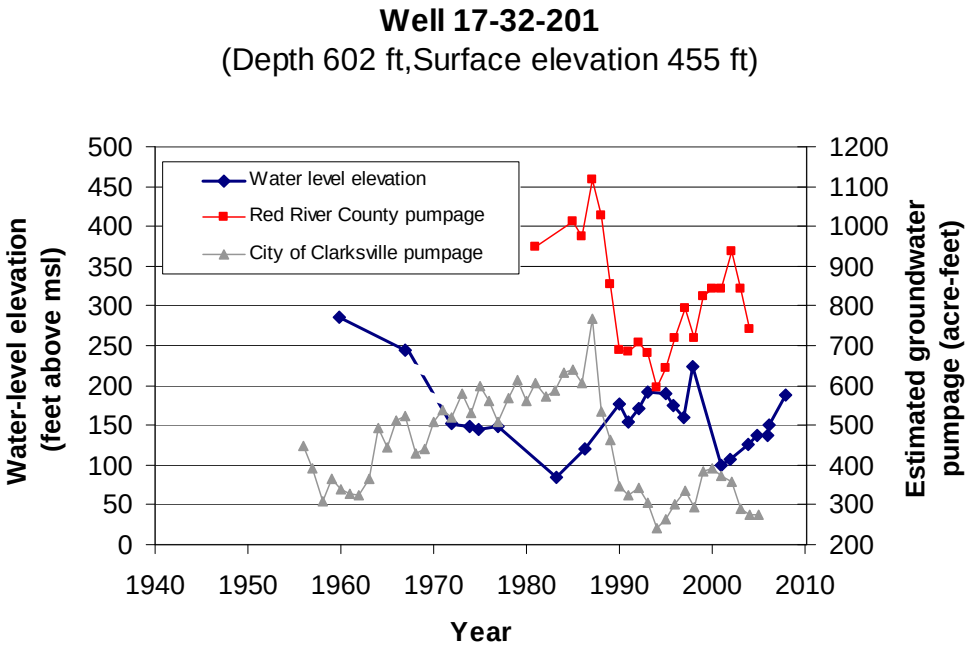

Figure 7. Water-level measurements for well 17-32-201 and the estimated Blossom Aquifer groundwater pumpage for the City of Clarksville and Red River County.

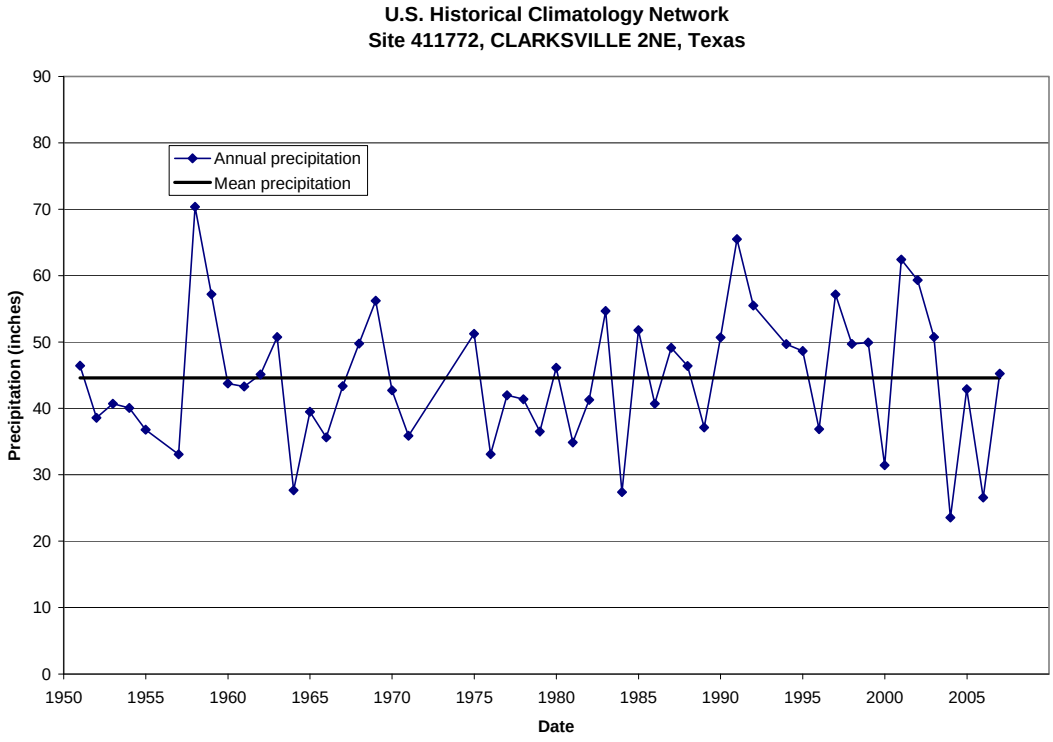

Figure 8. U.S. Historical Climatology Network precipitation for the Clarksville 2NE weather station (Williams and others, 2007).

Table 3. Assigned volume for the Blossom Aquifer by geographic subdivisions (See Figure 1).

Aquifer	Map key	County	Map key area (acres)	Total aquifer acres in county (acres)	Percent of area	Total county pumpage (acre-feet)	Assigned volume (acre-feet)
Blossom	1	Lamar	2,864	43,732	7	245	17
Blossom	2	Lamar	28,028	43,732	65	245	157
Blossom	3	Red River	23,629	121,043	20	689	138
Blossom	4	Red River	52,392	121,043	43	689	296
Blossom	5	Bowie	9,832	12,663	78	95	74
Blossom	6	Lamar	12,839	43,732	29	245	71
Blossom	7	Red River	31,477	121,043	26	689	179
Blossom	8	Red River	13,546	121,043	11	689	76
Blossom	9	Bowie	2,831	12,663	22	95	21
Total							1029

Groundwater pumpage estimates by county are multiplied by the percent of area to obtain the assigned volume for each

Table 4. Estimates of managed available groundwater for the Blossom Aquifer by geographic subdivisions (see Figure 1).

Aquifer	Map Key	County	RWPA	River Basin	GCD	GMA	GeoArea	Year	MAG (acre-feet per year)
Blossom	1	Lamar	D	Red	None	8	n/a	n/a	17
Blossom	2	Lamar	D	Red	None	8	n/a	n/a	157
Blossom	3	Red River	D	Sulphur	None	8	n/a	n/a	138
Blossom	4	Red River	D	Red	None	8	n/a	n/a	296
Blossom	5	Bowie	D	Sulphur	None	8	n/a	n/a	74
Blossom	6	Lamar	D	Sulphur	None	8	n/a	n/a	71
Blossom	7	Red River	D	Sulphur	None	8	n/a	n/a	179
Blossom	8	Red River	D	Red	None	8	n/a	n/a	76
Blossom	9	Bowie	D	Red	None	8	n/a	n/a	21

RWPG = 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.

MAG = Managed available groundwater in units of acre-feet per year.

REFERENCES:

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

McLauren, C., 1988, Occurrence, availability, and chemical quality of the ground water in the Blossom sand aquifer: Texas Water Development Report no. 307, 32p.

Texas Water Development Board, 2008a, Groundwater database: Texas Water Development Board, Water Science and Conservation Division.

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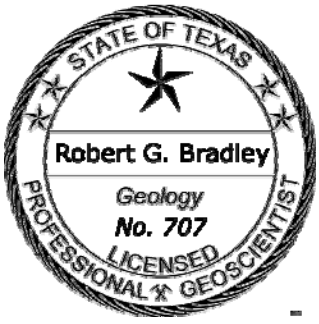
Williams, C.R, 2007, Adopted desired future conditions of minor aquifers: memorandum to Cheryl Maxwell, Groundwater Management Area 8, 19p.

Williams, C.N., Jr., M.J. Menne, R.S. Vose, and D.R. Easterling. 2008. United States Historical Climatology Network Monthly Temperature and Precipitation Data. ORNL/CDIAC-118, NDP-019. Available on-line http://cdiac.ornl.gov/epubs/ndp/ushcn/usa_monthly.html] from the Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.



The seal appearing on this document was authorized by Robert G. Bradley, P.G., on October 27, 2008.

APPENDIX 1

Williams (2007) used a two-dimensional spreadsheet model to predict pumping effects on the Blossom Aquifer. It assumes that the Blossom Aquifer is entirely unconfined. Estimates of the recharge area (outcrop), annual precipitation, recharge rate, saturated thickness, and specific yield were used to predict the saturated thickness after a specific period. Aquifer parameters used in the memorandum are from McLauren (1988). Additionally, precipitation data were from the National Oceanic and Atmospheric Administration. The outcrop area was determined from TWDB geographic information systems data.

Further, Williams (2008) split The Blossom Aquifer into two areas based on average saturated thickness; therefore, the desired future condition was split into the same areas. Lamar and Red River counties were lumped together. Bowie County was separated based on a larger estimated average saturated thickness of 65 feet.

Volumes from estimated reductions in saturated thickness and recharge volumes were calculated. Ultimately, based on this analysis, the desired future conditions were set at maintaining 100 percent of saturated thickness in the aquifer. No specific benchmark period or year was designated in the desired future condition statement or in the supporting memorandum.

In the memorandum to Groundwater Management Area 8, Williams (2007) estimated that the entire Blossom Aquifer outcrop is rechargeable material. The outcrop areal extent used for the calculations was 182 square miles. This was calculated from TWDB geographic information system (GIS) files. In TWDB report 307 (McLauren, 1988) estimated that than less than 32 percent of the outcrop defined in the report is rechargeable material (McLauren, 1988, p.4-5).

The total recharge calculated by Williams (2008) was 2,340-acre feet. In TWDB Report 307 (McLauren, 1988), the estimated total recharge to the Blossom Aquifer is 811 acre-feet per year. In comparison, the total availability for the Blossom Aquifer by North East Texas Regional Water Planning Group 2006 regional water plan is 2,270 for years 2010 through 2050, and 591 in 2060 (p.3-12)

The use of a recharge rate over the entire outcrop area may result in the overestimation of the actual recharge. This may lead to the contravention of the desired future condition, because estimated recharge exceeds the actual recharge. In addition, it is assumed that recharge by necessity needs to be greater than pumpage to maintain steady state conditions that would preserve all of the saturated thickness through the period. To add to this limitation is that the City of Paris covers a majority of the outcrop within Lamar County, which may have an effect on recharge from precipitation.