Report 350

Changes in Groundwater Conditions in the Edwards and Trinity Aquifers, 1987-1997, for Portions of Bastrop, Bell, Burnet, Lee, Milam, Travis, and Williamson Counties, Texas

November 1999

TEXAS WATER DEVELOPMENT BOARD

Texas Water Development Board
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Changes in Groundwater Conditions in the Edwards and Trinity Aquifers, 1987-1997, for Portions of Bastrop, Bell, Burnet, Lee, Milam, Travis, and Williamson Counties, Texas

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ABSTRACT

The purpose of this report is to update the Texas Water Development Board's (TWDB) Report 326, Evaluation of Water Resources in Bell, Burnet, Travis, Williamson and Parts of Adjacent Counties, Texas, written by Gail Duffin and Steven P. Musick in 1991. The groundwater problems identified in the initial investigation included a lack of reliable supplies for both short-term drought demand and long-term economic development (Duffin and Musick, 1991). According to TWDB Report 326, during late summer dry conditions and drought, water levels quickly drop in the Edwards aquifer due to low area-wide storage and low permeability in the Trinity Group aquifer. In the study area, utilization of both aquifers prior to 1987 exceeded the projected amount for long-term safe yield (drought reliable) supply. According to TWDB Report 326, an underground water conservation district was not recommended as an appropriate management approach due to the varied interests in the area, which precluded the consolidation of political support needed to recommend formation of an underground water conservation district. The previous report recommended a continuation of existing efforts and additional voluntary efforts to restrict further groundwater development and limit groundwater pumpage where surface supplies have been developed or will become available. Continued conversion to surface water was strongly encouraged, as well as development of long-term conservation and contingency planning for drought and other emergencies.

After review of the original study, the area was not designated as a critical area. Nonetheless, the TWDB and the Texas Water Commission (now the Texas Natural Resources Conservation Commission - TNRCC) continued to monitor groundwater levels over the ensuing five years to determine whether groundwater problems were being mitigated (TNRCC, 1997).

The findings of this report support the previous conclusions stated in TWDB Report 326. If the rate of conversion to surface water is maintained and expanded, as suggested in the 1997 State Water Plan, adequate water supplies should exist to meet the current and projected needs in the study area through the year 2030. A lack of reliable groundwater supplies for both short-term drought demand and long-term economic development is still a concern, especially in Williamson County. Careful management of the groundwater resources together with increased conversion to surface water supplies will be necessary to ensure adequate availability of water to this area through 2030.

INTRODUCTION

Purpose

The purpose of this report is to update the Texas Water Development Board's (TWDB) Report 326, Evaluation of Water Resources in Bell, Burnet, Travis, Williamson and Parts of Adjacent Counties, Texas, written by Gail Duffin and Steven P. Musick in 1991. Report 326 was prepared in response to the 1985 passage of House Bill 2 by the 69th Texas Legislature. This Act called for the identification and study of areas that were experiencing or are anticipated to experience critical groundwater problems within the next 20 years.

The present study is in response to Senate Bill 1, passed in 1997 by the 75th Texas Legislature. This Act requires the identification of those areas of the State that are experiencing or are expected to experience critical water problems within the next 25 years, including shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies.

Report 326 addressed groundwater problems in the study area related to unreliable supplies during short-term drought demands and long-term economic development. In addition, water quality in both of the major aquifers in the study area (the Trinity Group and Edwards aquifers) did not meet all of the Texas Department of Health standards for public water supply systems, particularly in the deeper down-dip portions of both aquifers.

Location

The study area, covering approximately 2,710 square miles, consists of portions of seven counties: Bastrop, Bell, Burnet, Lee, Milam, Travis, and Williamson (Figure 1). The study area includes portions of both the Trinity Group and the Edwards aquifers and is delineated by the following boundaries:

- North - Lampasas and Little Rivers;
- South - Colorado River;
- East - the downdip limit of fresh to slightly saline water (1,000 milligrams per liter of total dissolved solids) in the lower member of the Trinity Group aquifer; and,
- West - the updip limit of the Travis Peak Formation (lower Trinity Group) outcrop (Duffin and Musick, 1991).

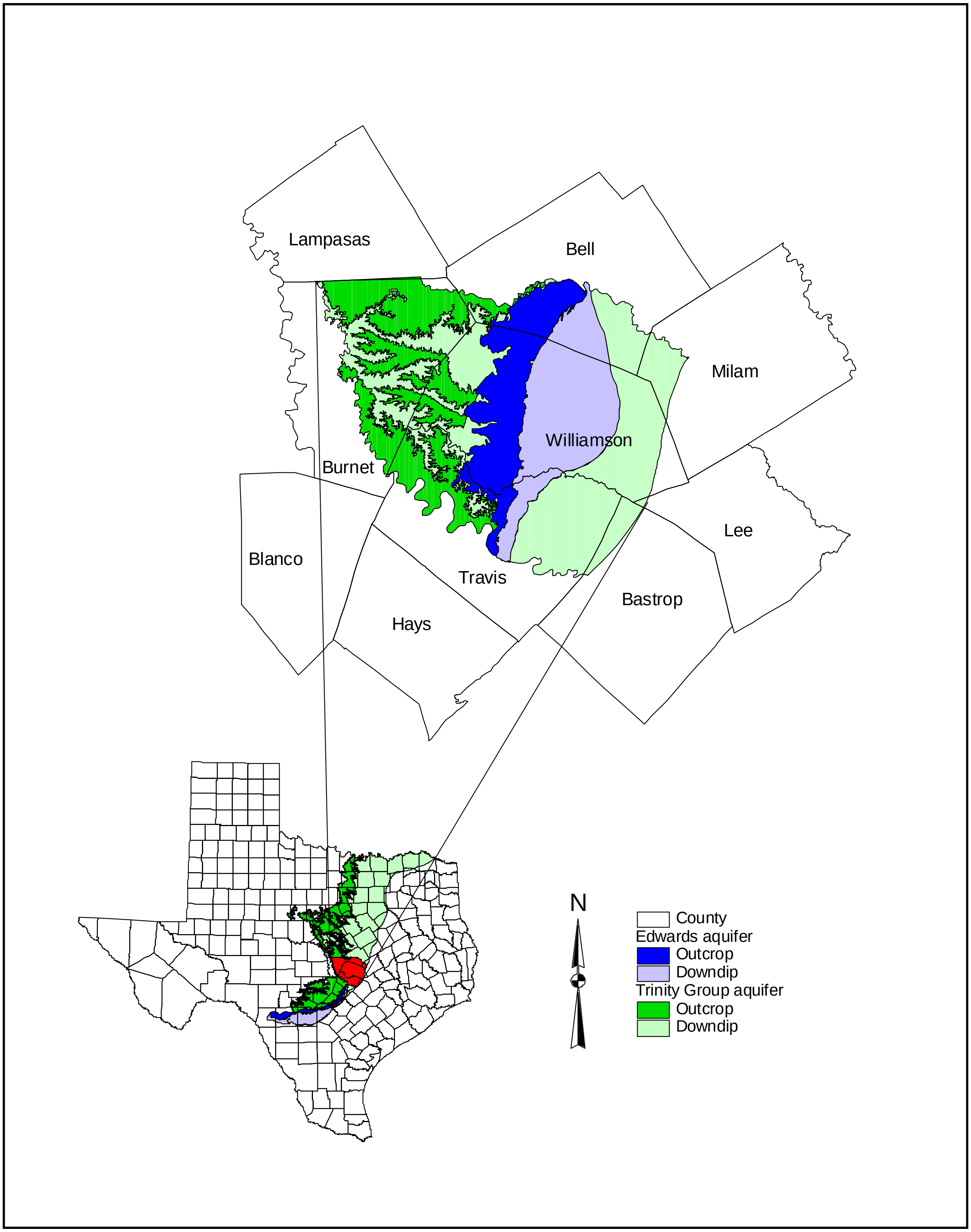

Figure 1. Location of study area (depicted in red on the State map), surrounding counties, and spatial extent of the Edwards and Trinity Group aquifers.
NOTE: The Trinity Group aquifer underlies the Edwards aquifer.

The region has moderately high relief with small limestone-capped mesas, steeply angled valleys, and dendritic drainage patterns. The soils are typically dark, gravelly, shallow to deep calcareous clays in the uplands, and reddish-brown to dark gray clay loams and clays in the bottomlands. Hot summers and mild winters characterize the climate (Werchan and Coker, 1983). Cyclic droughts occur in the region, most recently in 1996 and 1998.

HYDROGEOLOGY

Geology

The stratigraphic units in the study area containing groundwater range in age from the Ordovician Ellenburger Group to Holocene alluvium. The most important water-bearing formations, the Cretaceous Edwards and Trinity Group, are predominately limestones. The Balcones Fault Zone, with displacements of up to 400 feet, parallels the eastern boundary of the study area (Senger and others, 1990). The displacements generally restrict groundwater movement in a downdip direction and are thought to allow water of poor quality to flow into the aquifers along fault planes (Duffin and Musick, 1991). A "bad water" zone exists along the fault boundary (Senger and others, 1990).

The Edwards aquifer consists of the following:

- Georgetown Formation,
- Edwards Group, and
- Comanche Peak Formation.

The Edwards Group, composed of massive- to thin-bedded limestones and dolostones, contains most of the aquifer. Honeycomb textures, caverns, and voids in collapse breccias account for most of the significant aquifer porosity. The formation thins from about 300 feet in the Austin area to 100 feet in southern Bell County (Senger and others, 1990). Water-table conditions exist in the outcrop area and artesian conditions predominate under the confining Del Rio Clay. TWDB Reports 326 (Duffin and Musick, 1991) and 293 (Baker and others, 1986), and Senger and others (1990) provide additional details.

The Trinity Group aquifer consists of the following:

- lower Trinity hydrologic unit, containing the Hosston and Sligo members of the Travis Peak Formation,
- middle Trinity hydrologic unit, containing the Cow Creek limestone and Hensell sand members of the Travis Peak Formation, and the lower member of the Glen Rose Formation, and
- upper Trinity hydrologic unit, containing the upper member of the Glen Rose Formation and the Paluxy Formation (Duffin and Musick, 1991).

The lower Trinity hydrologic unit consists of a lower calcareous conglomeritic section, a middle calcareous section, and an upper calcareous clastic section. Regionally, the lower unit of the Trinity Group aquifer dips east to southeast. It ranges in thickness from 100 feet in the west to around 900 feet downdip in Milam County. Between the lower Trinity hydrologic unit and the middle Trinity hydrologic unit, the Hammett shale member of the Travis Peak Formation acts as a confining bed. The Hammett shale is a fossiliferous, calcareous, and dolomitic shale interbedded with thin limestone and sand layers (Duffin and Musick, 1991).

The middle Trinity hydrologic unit consists of a lower calcareous section with intermittent gypsum or anhydrite beds, a middle calcareous conglomerate section, and an upper calcareous section (Duffin and Musick, 1991).

The upper Trinity hydrologic unit consists of the upper Glen Rose Formation, containing alternating marl and limestone beds. Stair-step topography typifies the upper Glen Rose Formation in outcrop due to erosional characteristics of the lithology. Gypsum and anhydrite beds, which are present in some areas, have often been dissolved leaving solution channels (Duffin and Musick, 1991). TWDB Reports 339 (Bluntzer, 1992), 326 (Duffin and Musick, 1991), 273 (Ashworth, 1983), and 195 (Klempt and others, 1975), provide additional details.

Water-level Fluctuations

Hydrographs derived from wells in the Trinity Group and Edwards aquifers were compiled from thirty years of data and evaluated for water-level fluctuations and potential long-term water-level trends. Hydrographs that were included in TWDB Report 326 were used only when additional measurements had been collected since the initial investigation. Water-level measurements discussed in this report extend through January 1998. Additional wells were selected and included in this report to obtain a spatially representative array of regional trends (TWDB, 1998). The hydrographs generally reflect changes in water levels associated with changes in annual rainfall and public supply pumpage.

In addition, potentiometric surface maps for each aquifer in the study area were constructed to analyze current regional flow patterns. The groundwater flow direction in the study area is generally to the east-southeast with anomalies occurring in areas of public supply pumpage and where faults influence flow patterns. To establish changes in water levels in the past decade, the 1997 to 1998 data were compared to measurements collected in 1987 through 1988 from the same set of wells (TWDB, 1998). The results were graphically plotted and contoured.

Rainfall records were reviewed to establish trends and to determine if a correlation exists between recharge from precipitation on the outcrops to rising and falling water levels in the wells (National Climatic Data Center, 1998). Typically, unconfined portions of aquifers have rapid responses to precipitation while confined portions may experience a delayed response that could be on the order of months to years. The criteria for rain gage selection was based on proximity to the recharge zone and the completeness of historical rainfall records. A total of four rain gage stations were selected to show rainfall variation across the study area from the early to mid-1960s to mid-1997 (Figure 2). In addition to total monthly rainfall values, the average rainfall received at each station and a three-year moving average was calculated and plotted. Based on these values, an average of 31.87 inches of precipitation per year fell on the area since the 1960s. The moving average indicates that the study area received below average precipitation for the last 3 to 4 years (1993-1997).

Edwards aquifer

Water-level data available for the Edwards aquifer indicates significant fluctuations in water levels have occurred over time (Figure 3). A noticeable decrease in water levels was observed during the severe droughts of 1983 to 1984 and 1996. Measurements included and discussed in this report extend through January 1998; therefore, the effects associated with the summer drought of 1998 are not reflected.

Wells 58-35-204 and 58-27-902 experienced the most significant water level declines (up to 120 feet of drawdown) during the 1983-1984 drought. Wells 58-19-303, 58-27-902, 58-12-405, and 58-36-402 reflect drawdown of up to 130 feet during the period of time culminating with the 1996 drought. The wells that were measured since 1996 exhibited a rise in water levels through 1997, indicating a relatively rapid rebound from drought conditions. Overall, the wells found near the recharge zone of the Edwards aquifer (wells 58-04-801, 58-12-405, 58-19-303, and 58-35-204) have current water levels equal to or slightly below water levels measured in the 1960s. The wells located downdip, near the Williamson-Travis county line, mostly in the artesian portion of the aquifer, show a decrease in water levels over time and are more affected by pumpage from nearby towns and cities (wells 58-20-102, 58-28-601, 58-36-402, and 58-27-902). The two wells depicted with the most erratic historical water levels are wells 58-36-402 and 58-28-601. Well 58-36-402 is located in Travis County near the center of pumpage for the city of Pflugerville and is not located near any major Edwards aquifer spring. Because it is located in the confined portion of the aquifer and away from the natural recharge zone, its water levels are subject to wide fluctuations as a result of pressure changes created by nearby pumpage. Well 58-28-601, located in Williamson County to the northeast of well 58-36-402, shows a similar trend. It is one of three public supply wells for the town of Hutto and is also influenced by nearby pumpage.

Water-level data from the winter of 1997 indicate groundwater flow patterns have not changed significantly in the study area portion of the Edwards aquifer since the initial study (Duffin and Musick, 1991). The predominant direction of the hydraulic gradient is to the east, as

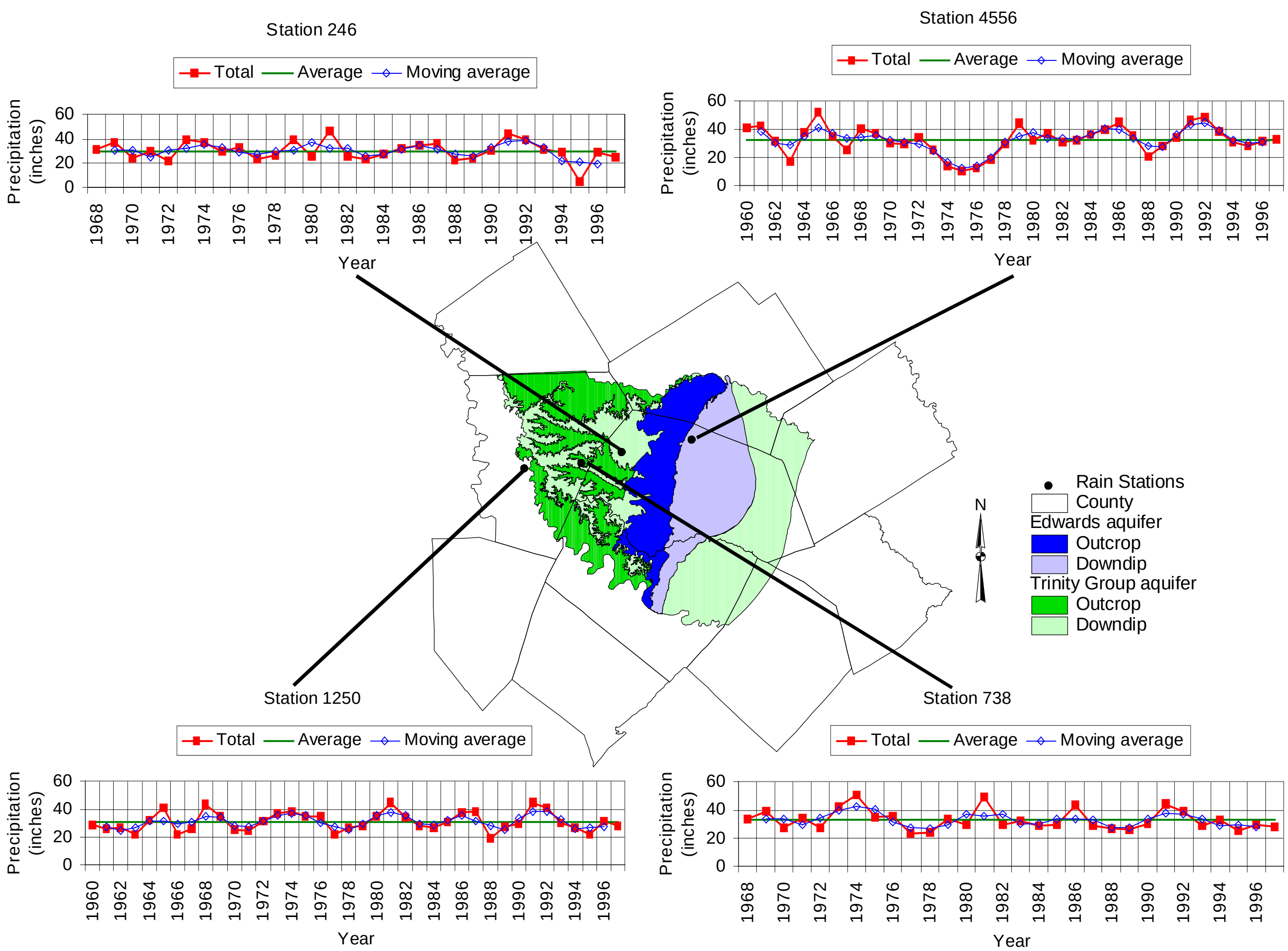

Figure 2. Graphs of total monthly precipitation values and the respective rain gage locations in the study area.

NOTE: Average rainfall received at each station is also plotted along with the three-year moving average.

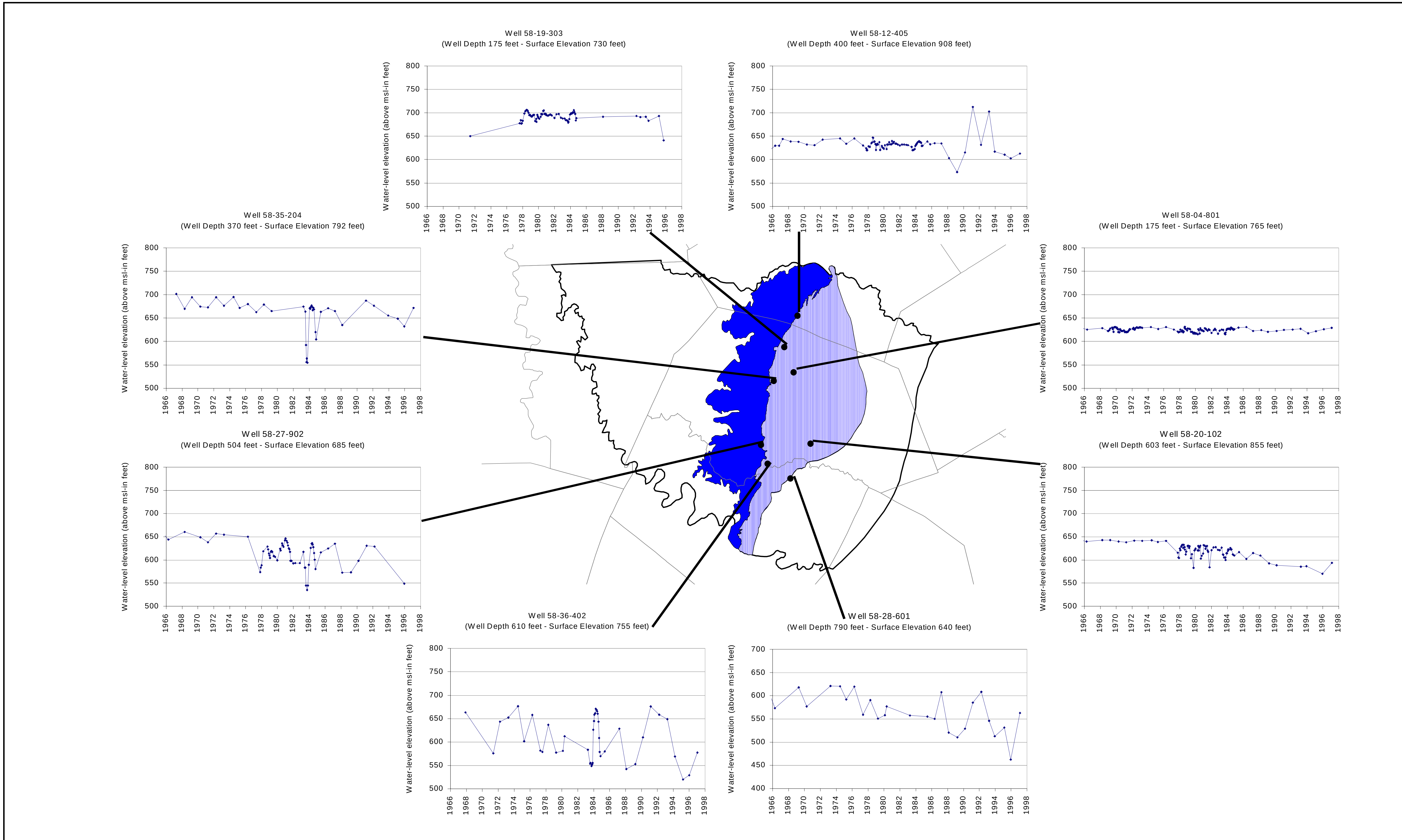

Figure 3. Water-level hydrographs for selected wells completed in the Edwards aquifer.

Note: *The eastern boundary of the Edwards aquifer is portrayed using TDS levels >3,000 mg/l.*

shown by the potentiometric surface in Figure 4. From the north-central part of the City of Austin, a moderate southerly component dominates as groundwater generally flows toward the Colorado River.

A comparison of water-level elevations from the winter of 1987 to the winter of 1997 indicates an overall decrease in water levels in the middle to eastern portion of the aquifer (Figure 5). In the late 1980s, water levels in wells located in the eastern section were between 665 to 437 feet above mean sea level (msl). The average water elevation was 625 feet above msl. The same twenty-two wells were re-measured in 1997 to 1998 and found to have an average water-level elevation of 595 feet above msl (an average decrease of 30 feet), with water levels ranging from 671 to 437 feet above msl. Limited well control of the two data sets restricted a full interpretation of drawdown along the far eastern and western fringe of the study area. Of the wells investigated since the initial study was conducted, eleven wells displayed a decrease in water levels between zero and 50 feet, one well had a water-level decrease measuring between 50 and 100 feet, and water levels in another well fell 113 feet in the past decade (Well 58-20-901).

Trinity Group aquifer

Abrupt changes in water-level elevations were not generally observed in the Trinity Group aquifer (Figure 6). The two main reasons for significant drawdown are normally associated with changes in annual rainfall and industrial or public-supply production (Duffin and Musick, 1991). In the unconfined recharge zone (shown in Figure 6 as the darkly shaded area), water levels are primarily influenced by precipitation and to a lesser degree by public-supply production. In the confined portions of the aquifer however, (shown in Figure 6 as the lightly shaded area), drawdown is generally influenced more by public-supply production than by precipitation.

Grouping the wells from Figure 6 by county, the following observations can be made:

Burnet County

57-15-702 (located near the City of Burnet): Water levels remained relatively steady throughout the study period. The water level fluctuated no more than 37 feet between 1966 and 1986, and rose approximately 14 feet between 1987 and 1997.

Travis County

57-40-304 (located in western Travis County): The water level was relatively stable between 1966 and 1986, less than 26 feet of water level fluctuations were observed. The water level dropped 50 feet between 1992 and 1994 and

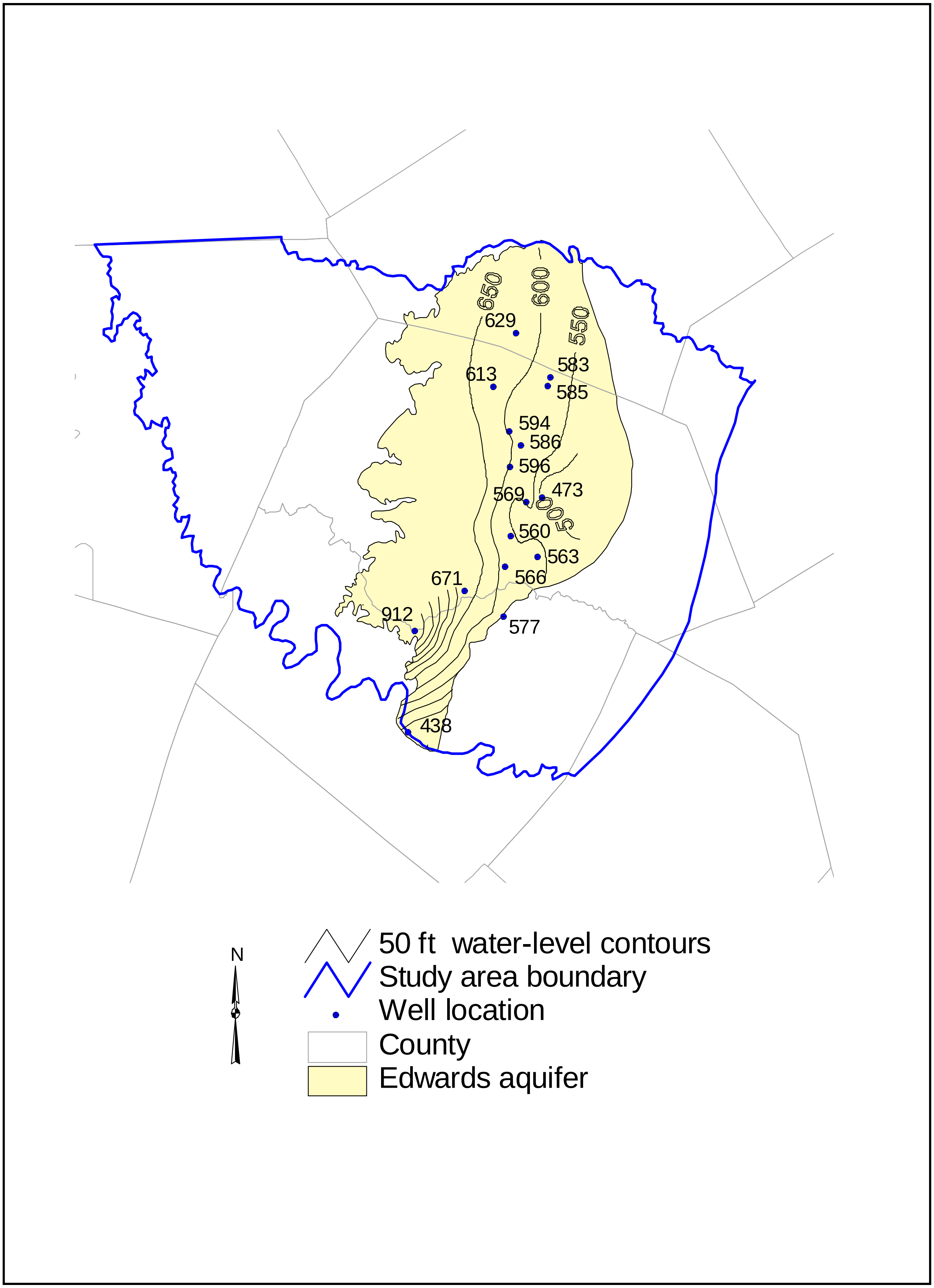

Figure 4. Potentiometric surface map for the Edwards aquifer from data collected 1997-1998.
***NOTE:** The eastern boundary of the Edwards aquifer is approximate and is portrayed using TDS levels > 3,000 mg/l.*

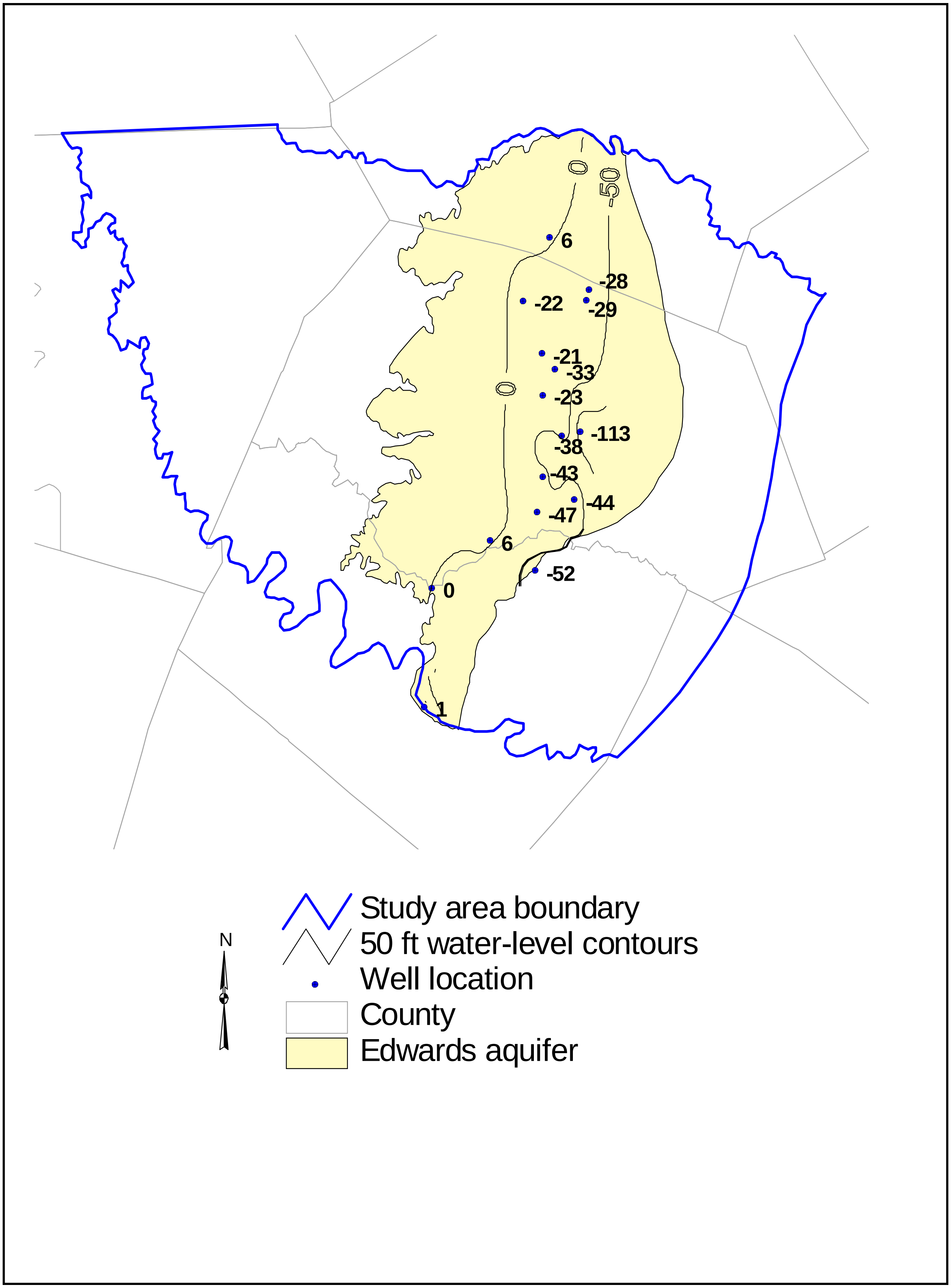

Figure 5. Water-level changes in the Edwards aquifer based on data collected 1987-1988 and data collected 1997-1998.
NOTE: The eastern boundary of the Edwards aquifer is approximate and is protrayed using TDS levels >3,000 mg/l.

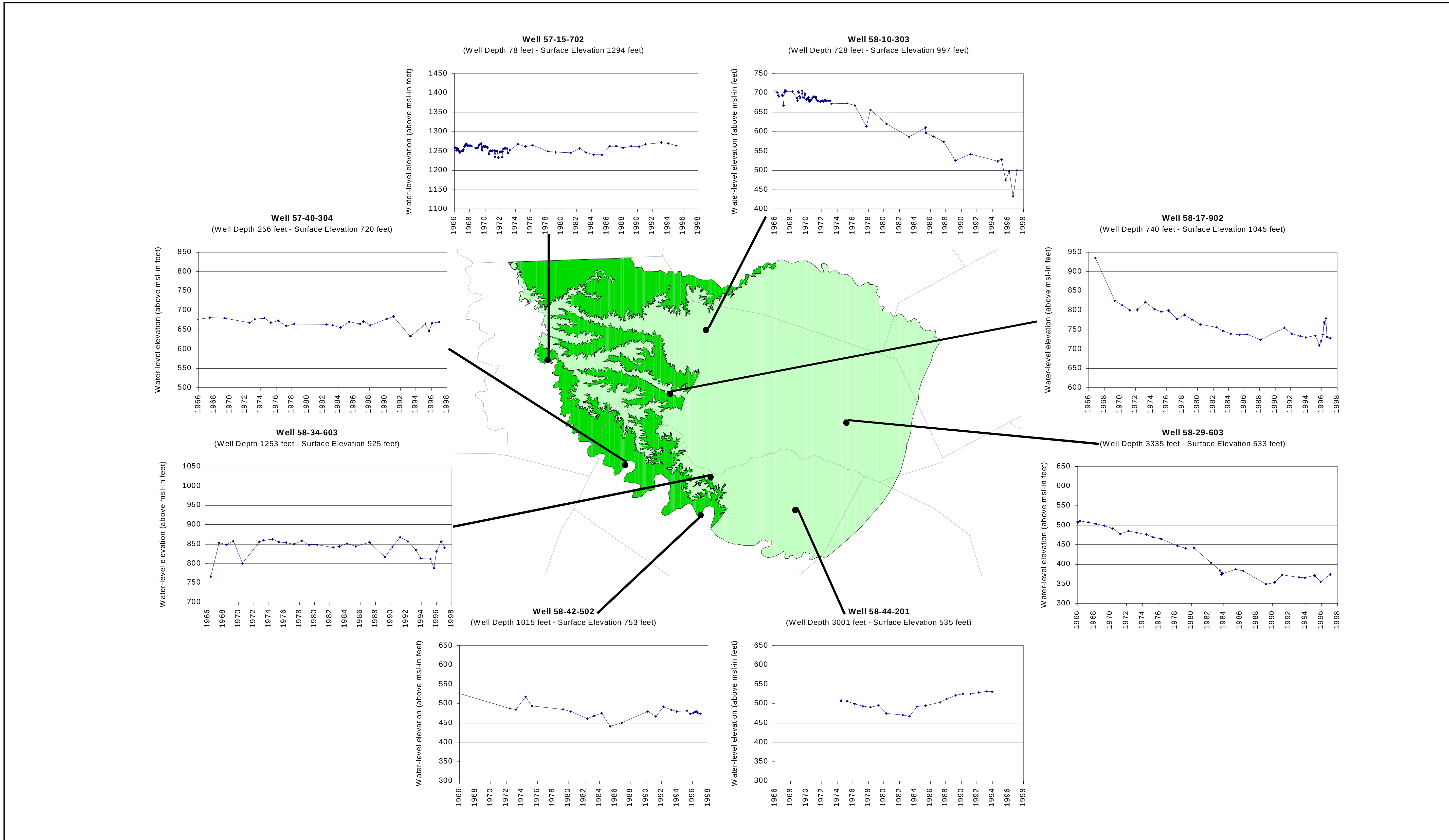

Figure 6. Water-level hydrographs for selected wells completed in the Trinity Group aquifer.

approximately 20 feet during the 1996 drought. The last measurement taken (December 1997), indicated the water level was within 2 feet of measurements taken in 1966.

58-42-502 (located 5 miles west-northwest of Austin): The water level showed significant drawdown between 1966 and 1986, dropping approximately 90 feet. Since 1986 the water level has risen as much as 30 feet.

58-34-603 (located in northwest Travis County along the Williamson County line): The water level was rather stable between 1973 and 1982. The most significant drop in water elevation occurred between 1992 and 1996 when the level dropped over 80 feet. The last measurement taken (December 1997), revealed the water level had increased by 50 feet since the 1996 drought.

58-44-201 (located near the City of Manor): A steady decrease in water levels was observed, approximately 40 feet of drawdown occurred between 1966 and 1984. Since 1984 the water elevation has increased by almost 65 feet.

Williamson County

58-29-603 (located near the City of Taylor): A steady decline in water level is apparent with approximately 160 feet of drawdown occurring between 1966 and 1990. Since 1990, water levels have fluctuated by no more than 26 feet. The last water-level measurement (January 1998) indicated the water level was still 137 feet less than the measurement taken in 1966.

58-10-303 (located near the City of Florence): A steady decline in water levels is evident with approximately 286 feet of drawdown occurring between 1966 and 1997. The last water-level measurement (January 1998) showed an increase of 67 feet occurred in one year (since 1997). Even with this increase, the water level is still 219 feet lower than the measurement taken in 1966.

58-17-902 (located near Liberty Hills, Texas): A steady decline in water levels is evident with approximately 226 feet of drawdown occurring between 1966 and 1996. Since1996, water levels have increased by no more than 70 feet. The last water-level measurement (January 1998) indicated that the water level was still 207 feet lower than measurements taken in 1966.

Flow patterns in the Trinity aquifer have historically exhibited dominant flow to the east and southeast, in a down-gradient direction. Current flow, utilizing measurements collected in the winter of 1997 to 1998, is depicted on Figure 7. Overall, groundwater still exhibits an east to southeasterly flow. While topography was not referenced when the potentiometric surface was originally constructed, it appears to have a direct correlation to the mound of water depicted in Figure 7 at the Williamson-Travis county line. When comparing the land elevations of the wells in this vicinity, the well with a water-level elevation of 857 feet above msl was found to have a surface elevation that was approximately 200 feet higher than the surrounding wells.

TWDB Report 326 noted that water-level declines had occurred within the Trinity Group aquifer from 1975 to 1986. A comparison of measurements taken in 1987 to 1997 indicates water levels have generally stabilized in 68 percent of the wells investigated (Figure 8). Six wells showed water level declines since the late 1980s (wells 58-41-101, 58-29-603, 58-18-906, 58-17-601, 58-17-401, and 58-10-303). Of these six wells, three showed declines of less than twelve feet, and the remaining three fell 32 feet (well 58-17-601: Liberty Hill, Texas), 33 feet (well 58-41-101: Bee Cave, Texas), and 74 feet (well 58-10-303: Florence, Texas). According to the previous investigation, the declining water levels are due to the low permeability of the water-producing sands and groundwater withdrawal by industrial and public supply users (Duffin and Musick, 1991).

Water Quality

Water quality varies throughout the study area. Low permeability, restricted water circulation, longer groundwater residence time, and temperature increases cause the groundwater to become more highly mineralized in the downdip portion of the aquifers. Most of the dissolved constituents in the groundwater are from the dissolution of minerals in the rocks that compose the aquifers (Duffin and Musick, 1991). Water quality samples collected in 1997 were evaluated to produce an updated understanding of water quality in both the Edwards and Trinity Group aquifers (TWDB, 1998). Changes in water chemistry across the respective aquifers are graphically depicted by means of Stiff diagrams in Figures 9 and 10. Stiff diagrams represent the concentration of major ions, and provide an indication of TDS concentration in a particular water sample.

Groundwater in the Edwards aquifer is a calcium-carbonate type water, becoming a sodium-sulfate type water downdip (Senger and Kreitler, 1984). Along the eastern extent of the aquifer, the water becomes more sodium and chloride enriched (Figure 9). The official eastern boundary of the Edwards aquifer is marked by the downdip limit of fresh to slightly saline water (> 1,000 mg/l TDS). For this report, the eastern

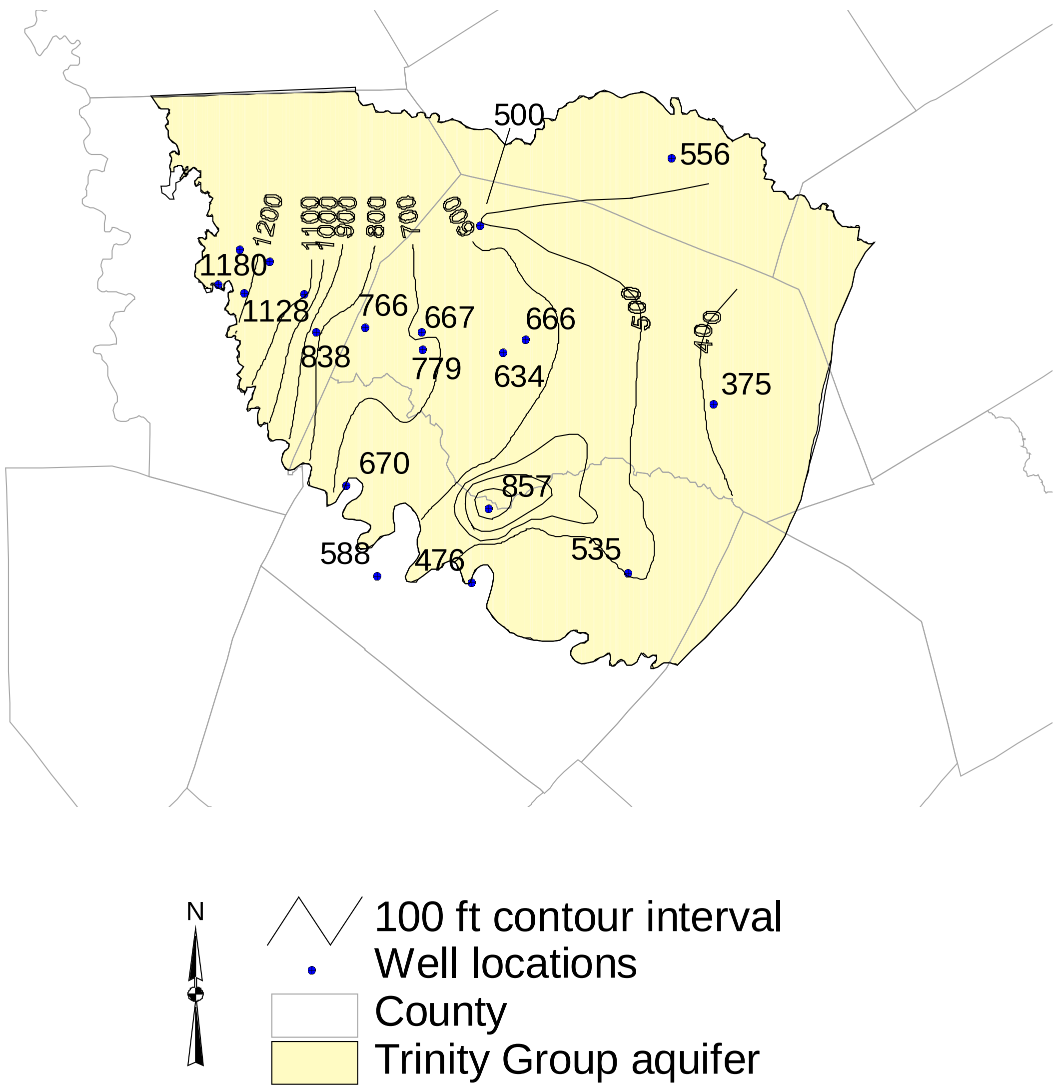

Figure 7. Potentiometric surface map for the Trinity Group aquifer from data collected 1997-1998.

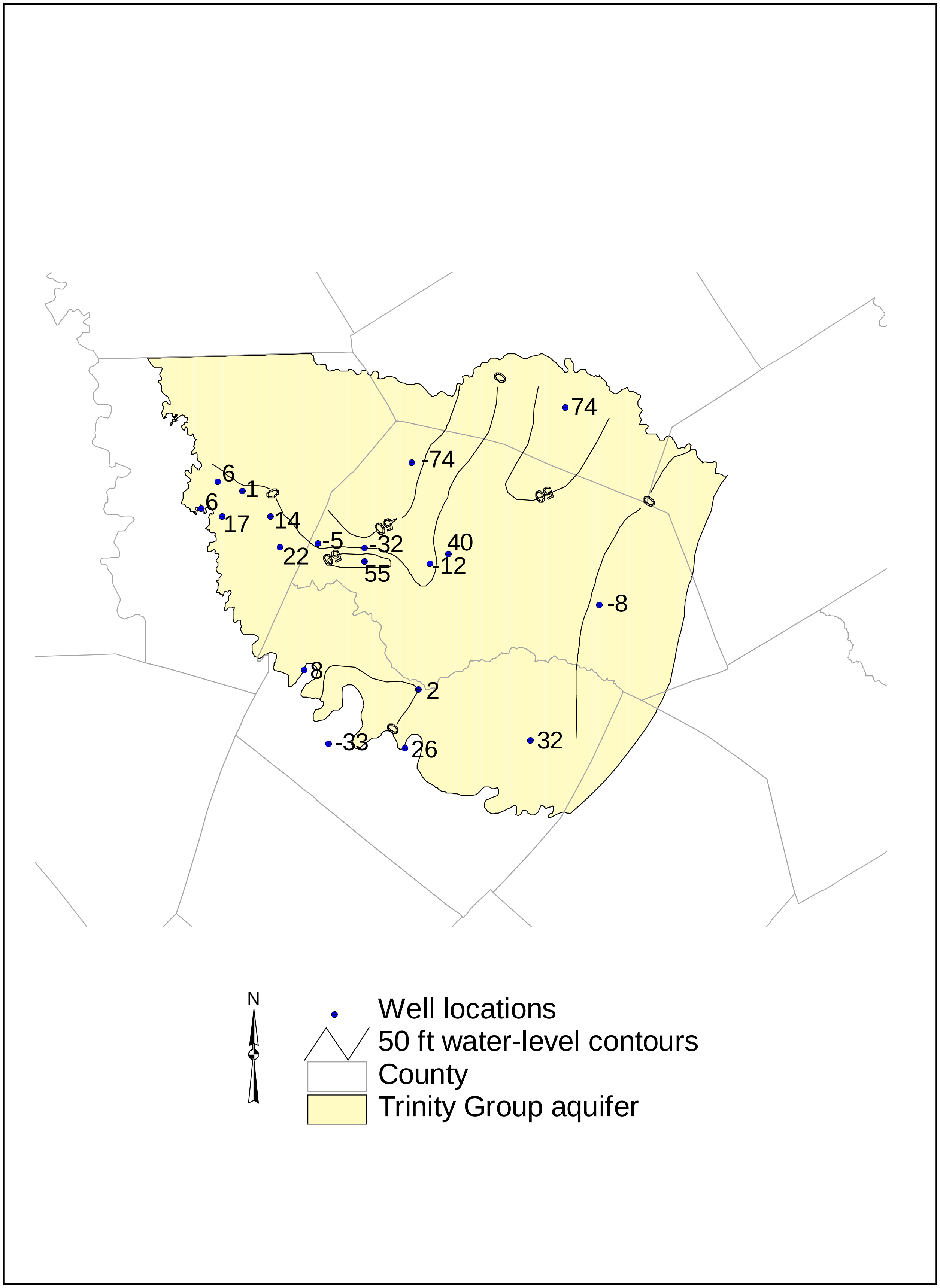

Figure 8. Water-level changes in the Trinity Group aquifer based on data collected 1987-1988 and data collected 1997-1998.

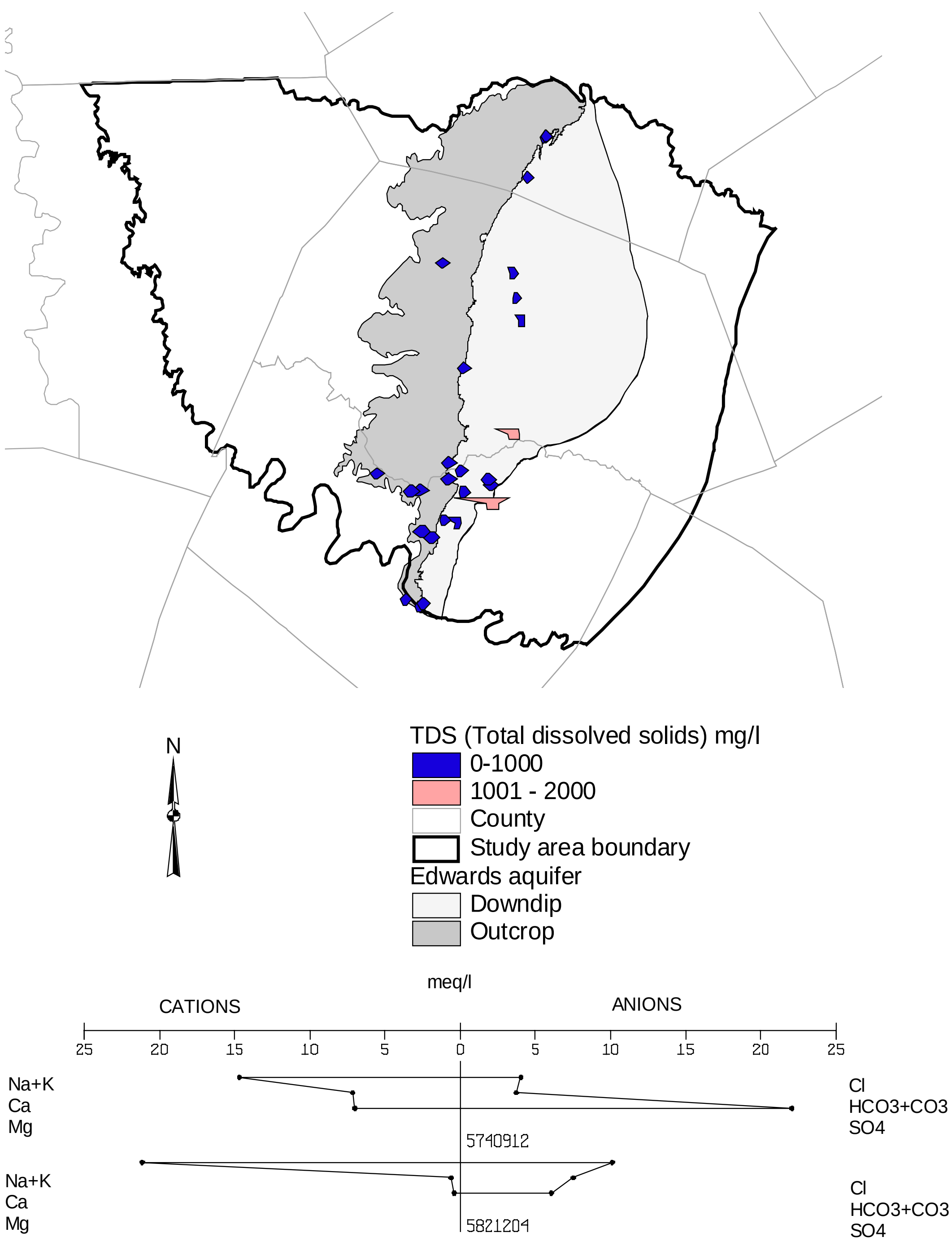

Figure 9. Water quality from samples collected in 1997 from the Edwards aquifer.

Note: *The Stiff diagrams usually show the change in water chemistry across the aquifer. Increases in TDS are shown as a color change (red indicates TDS levels > 1,000 mg/l) and supports the general delineation of the "bad-water" line marking the official eastern boundary (not shown).*

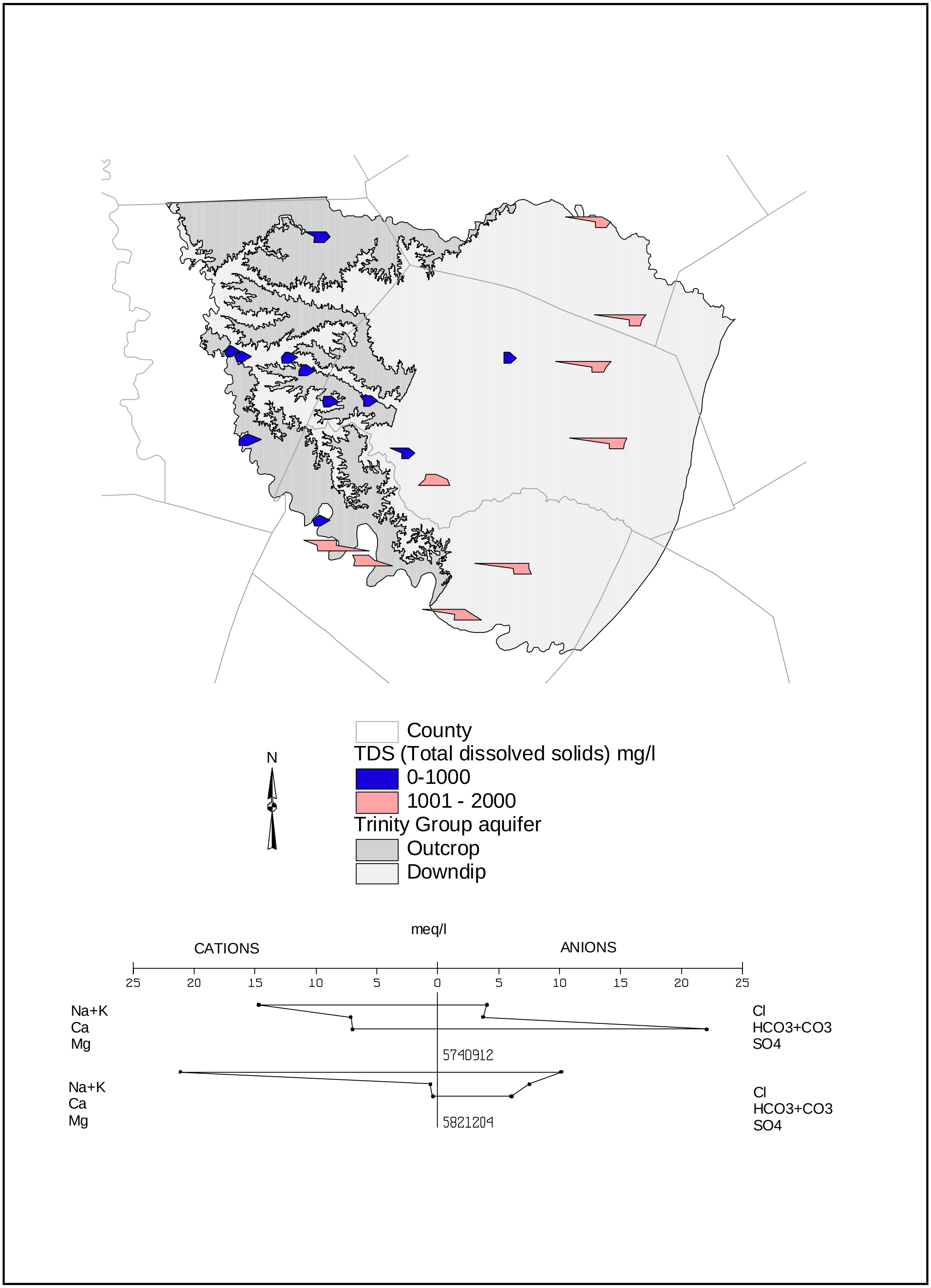

Figure 10. Water quality from samples collected in 1997 from the Trinity Group aquifer.
Note: *The Stiff diagrams show the change in water chemistry across the aquifer. Increases in TDS are shown as a color change and generally increase downdip in an easterly to southeasterly direction.*

boundary of the Edwards aquifer was extended to where TDS levels were greater than 3,000 mg/l, as discussed in TWDB Report 325 (Flores, 1990). The red Stiff Diagrams in Figure 9 mark the eastern boundary of the Edwards aquifer.

Groundwater in the western portion of the study area, within the Trinity Group aquifer, is a calcium-magnesium-carbonate type water (Figure 10). The water becomes a sodium-sulfate or sodium-chloride type water downdip. The quality of water degenerates downdip, to the south and southeast, as indicated by the increased levels of TDS (Figure 10).

Additional data and interpretation of the chemical quality of water in the study area can be found in TWDB Reports 195 (Klempt and others, 1975), 293 (Baker and others, 1986), and 276 (Brune and Duffin, 1983).

POPULATION AND WATER DEMANDS

Population

The procedure for calculating population within the study area was updated using ARCINFO©, a Geographic Information System (GIS) software program (Environmental Systems Research Institute, 1998). In the original report (Duffin and Musick, 1991), census blocks were laid over maps delineating the study area boundaries and the area and percentage of population within partial census blocks were hand-calculated. For this report, the 1990 census-block data was downloaded into ARCINFO© and the program internally calculated area and population percentages for partial census blocks (TWDB, 1998b).

The study area population has increased since the initial study was conducted in the 1980s (Duffin and Musick, 1991). Table 1 contains population figures and projections for the study area from 1985 to the year 2030. Total population within the study area increased by 151,687 residents, or 33 percent, from 1985 to 1995. From 1995 to the year 2030, a total estimated population increase of approximately 808,976 people, or 133 percent, is projected. Most of the increase is projected to occur within Williamson County and the northern portion of Travis County. Between 1995 and 2030, the population in Williamson County is expected to increase by 419,267 people, or 252 percent. The area projected to have the second largest growth, northern Travis County, is estimated to increase from a population of 416,723 in 1995 to a population of 791,306 in 2030. This is approximately a 90 percent increase. The areas projected to have a smaller population increase include Milam, Lee, and southern Bell counties. Between 1995 and 2030, the population in these more rural-type settings is estimated to increase 14 to 39 percent.

Historical Water Uses

Table 2 shows the historical water use for the partial counties in the study area (TWDB, 1998b). In 1995, approximately 130,815 acre-feet of water was used to meet the water demands for the people residing within the study area. Of this amount, approximately 83 percent was derived from surface water (109,179 acre-feet), and the remaining 17 percent (21,636 acre-feet) came from various groundwater sources. In 1995, the only partial county that used more groundwater than surface water was Bastrop County, with groundwater supplying 96 percent of its water demand. The next major consumer of groundwater in the study area was Williamson County; in 1995 groundwater supplied 42 percent of its water demand. As was noted in TWDB Report 326, Williamson County is slowly converting to surface water to meet its growing water demands. In 1985, groundwater supplied 66 percent

	1985	1990	1995	2000	2010	2020	2030
Bastrop County							
Elgin	5,418	4,846	5,415	5,553	6,499	7,612	8,734
County Other	1,557	1,931	2,214	2,491	3,152	3,825	4,481
Total Population	**6,975**	**6,777**	**7,629**	**8,044**	**9,651**	**11,437**	**13,215**
Bell County							
*Bartlett (P)	684	621	689	757	831	911	970
Holland	982	1,118	1,295	1,476	1,678	1,891	2,055
Salado	992	1,216	1,339	1,326	1,386	1,514	1,643
County Other	6,310	5,084	5,734	6,172	6,775	7,429	7,910
Total Population	**8,968**	**8,039**	**9,057**	**9,731**	**10,670**	**11,745**	**12,578**
Burnet County							
Burnet	2,363	2,075	2,358	2,400	3,034	3,494	3,891
County Other	6,642	4,759	5,574	6,055	7,216	8,722	9,953
Total Population	**9,005**	**6,834**	**7,932**	**8,455**	**10,250**	**12,216**	**13,844**
Lee County							
County Other	30	29	31	32	35	38	41
Total Population	**30**	**29**	**31**	**32**	**35**	**38**	**41**
Milam County							
County Other	899	669	687	701	730	756	784
Total Population	**899**	**669**	**687**	**701**	**730**	**756**	**784**
Travis County							
Austin (P)[1]	267,552	289,069	339,560	384,744	463,731	572,259	674,627
Jonestown	1,114	1,250	1,366	1,853	2,396	3,108	3,800
Lago Vista	1,378	2,199	2,390	3,680	4,569	5,764	6,907
Manor	1,317	1,041	1,166	1,424	1,862	2,208	2,523
Pflugerville	3,056	4,444	7,837	6,452	8,244	10,611	12,900
Round Rock (P)[1]	20	40	62	102	154	221	286
County Other	51,219	55,636	64,342	58,952	67,113	79,261	90,263
Total Population	**325,656**	**353,679**	**416,723**	**457,207**	**548,069**	**673,432**	**791,306**
Williamson County							
Austin (P)[1]	2,433	2,444	2,875	7,458	13,292	21,555	28,036
Bartlett (P)[1]	937	818	911	840	873	947	973
Cedar Park	5,895	5,833	9,762	6,752	7,267	7,972	8,935
Georgetown	13,755	14,842	19,706	24,584	37,970	57,148	67,262
Granger	1,192	1,190	1,339	1,574	2,021	2,548	3,091
Leander	3,502	3,398	5,187	5,279	8,231	12,809	15,076
Round Rock (P)*	19,874	30,923	45,747	53,402	84,027	127,823	150,443
Taylor	11,381	11,472	13,053	16,025	22,028	30,886	35,597
County Other	46,561	51,992	68,111	87,215	141,787	219,204	276,545
Total Population	**105,530**	**122,912**	**166,691**	**203,129**	**317,496**	**480,892**	**585,958**
Total of Area 1:	**457,063**	**498,939**	**608,750**	**687,299**	**896,901**	**1,190,516**	**1,417,726**

[1](P) Partial population figures are given for Austin, Bartlett, and Round Rock because their city limits transcend county boundaries and/or study area boundaries.

Table 1. Historical and projected population figures for the study area, based on 1990 census data (TWDB, 1998b).

	1985 Total	1985 Ground-water	1985 Surface water	1990 Total	1990 Ground-water	1990 Surface water	1995 Total	1995 Ground-water	1995 Surface water
BASTROP COUNTY									
Municipal Water Use									
Elgin	1,009	1,009	0	701	701	0	828	828	0
County Other	213	213	0	307	307	0	332	332	0
Total Municipal	**1,222**	**1,222**	**0**	**1,008**	**1,008**	**0**	**1,160**	**1,160**	**0**
Other Water Use									
Manufacturing	30	9	21	26	25	1	73	73	0
Irrigation	22	6	16	0	0	0	0	0	0
Steam-Electric	0	0	0	0	0	0	0	0	0
Mining	1	1	0	1	1	0	2	2	0
Livestock	81	32	49	83	33	50	86	34	52
Total County	**1,356**	**1,271**	**85**	**1,118**	**1,067**	**51**	**1,321**	**1,269**	**52**
BELL COUNTY									
Municipal Water Use									
Bartlett (P)[1]	151	151	0	128	128	0	117	117	0
Holland	101	0	101	115	0	115	112	24	88
Salado	247	247	0	452	452	0	522	522	0
County Other	1,682	69	1,613	980	37	943	1,054	50	1,004
Total Municipal	2,181	467	1,714	1,675	617	1,058	1,805	712	1,093
Other Water Use									
Manufacturing	0	0	0	0	0	0	0	0	0
Irrigation	140	8	132	90	25	65	90	30	60
Steam-Electric	0	0	0	0	0	0	0	0	0
Mining	36	36	0	0	0	0	44	44	0
Livestock	302	30	272	301	30	271	312	31	281
Total County	**2,659**	**541**	**2,118**	**2,066**	**672**	**1,394**	**2,251**	**817**	**1,434**
BURNET COUNTY									
Municipal Water Use									
Burnet	479	479	0	370	64	306	470	52	418
County Other	878	445	433	651	229	422	893	313	580
Total Municipal	1,357	924	433	1,021	293	728	1,363	364	999
Other Water Use									
Manufacturing	0	0	0	1,091	8	1,083	568	4	564
Irrigation	0	0	0	0	0	0	0	0	0
Steam-Electric	0	0	0	0	0	0	0	0	0
Mining	367	10	357	537	100	437	658	190	468
Livestock	518	207	311	472	236	236	493	247	247
Total County	**2,242**	**1,141**	**1,101**	**3,121**	**637**	**2,484**	**3,082**	**804**	**2,278**

Table 2. Historical water uses for the study area (TWDB, 1998b).
NOTE: Values reported in acre-feet per year.

	1985 Total	1985 Ground-water	1985 Surface water	1990 Total	1990 Ground-water	1990 Surface water	1995 Total	1995 Ground-water	1995 Surface water
LEE COUNTY									
Municipal Water Use									
County Other	6	0	6	6	0	6	7	0	7
Total Municipal	6	0	6	6	0	6	7	0	7
Other Water Use									
Manufacturing	0	0	0	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0	0	0	0
Steam-Electric	0	0	0	0	0	0	0	0	0
Mining	0	0	0	0	0	0	0	0	0
Livestock	6	6	0	6	6	0	9	9	0
Total County	**12**	**6**	**6**	**12**	**6**	**6**	**16**	**9**	**7**
MILAM COUNTY									
Municipal Water Use									
County Other	121	72	49	83	54	29	83	51	32
Total Municipal	121	72	49	83	54	29	83	51	32
Other Water Use									
Manufacturing	0	0	0	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0	0	0	0
Steam-Electric	6,760	0	6,760	2,716	0	2,716	2,677	0	2,677
Mining	1	1	0	1	1	0	1	1	0
Livestock	159	64	95	144	58	86	148	59	89
Total County	**7,041**	**136**	**6,905**	**2,944**	**113**	**2,831**	**2,909**	**111**	**2,798**
NORTHERN TRAVIS COUNTY									
Municipal Water Use									
Austin (P)[1]	60,539	587	59,952	58,284	408	57,876	59,716	299	59,417
Jonestown	159	0	159	179	0	179	170	0	170
Lago Vista	410	0	410	654	0	654	723	0	723
Manor	178	178	0	180	180	0	215	215	0
Pflugerville	551	551	0	776	776	0	1,581	1,581	0
Round Rock (P)[1]	9	5	4	8	4	4	14	6	8
County Other	8,319	599	7,720	10,290	741	9,549	10,739	848	9,891
Total Municipal	70,165	1,920	68,245	70,371	2,109	68,262	73,158	2,949	70,209
Other Water Use									
Manufacturing	2,940	85	2,855	3,110	205	2,905	4,999	250	4,749
Irrigation	273	57	216	664	372	292	895	600	295
Steam-Electric	5,178	0	5,178	4,150	21	4,129	5,517	0	5,517
Mining	1,515	0	1,515	1,283	0	1,283	1,857	0	1,857
Livestock	502	251	251	530	265	265	481	241	241
Total County	**80,573**	**2,314**	**78,259**	**80,108**	**2,972**	**77,136**	**86,907**	**4,039**	**82,868**

Table 2. Historical water uses for the study area. *(continued)*
NOTE: Values reported in acre-feet per year.

	1985 Total	1985 Ground-water	1985 Surface water	1990 Total	1990 Ground-water	1990 Surface water	1995 Total	1995 Ground-water	1995 Surface water
WILLIAMSON COUNTY									
Municipal Water Use									
Austin (P)[1]	551	5	546	494	3	491	505	3	502
Bartlett (P)[1]	206	206	0	169	169	0	154	154	0
Cedar Park	1,127	0	1,127	566	0	566	2,368	0	2,368
Georgetown	3,227	3,227	0	3,369	1,759	1,610	3,540	2,131	1,409
Granger	140	140	0	168	168	0	212	212	0
Leander	452	452	0	574	574	0	799	780	19
Round Rock (P)[1]	8,388	4,781	3,607	6,055	3,221	2,834	10,402	4,400	6,002
Taylor	2,029	2,029	0	2,038	2,038	0	1,838	0	1,838
County Other	8,191	5,603	2,588	8,329	5,031	3,298	10,147	4,617	5,530
Total Municipal	24,311	16,443	7,868	21,762	12,963	8,799	29,965	12,296	17,669
Other Water Use									
Manufacturing	247	212	35	326	233	93	1,270	528	742
Irrigation	136	1	135	148	17	131	160	18	142
Steam-Electric	0	0	0	0	0	0	0	0	0
Mining	1,661	1,600	61	1,657	1,601	56	1,660	1,617	43
Livestock	1,605	159	1,446	1,450	144	1,306	1,274	127	1,147
Total County	**27,960**	**18,415**	**9,545**	**25,343**	**14,957**	**10,386**	**34,329**	**14,587**	**19,742**
Total Municipal	**99,363**	**21,048**	**78,315**	**95,926**	**17,045**	**78,881**	**107,541**	**17,532**	**90,009**
Other Water Use									
Manufacturing	3,217	306	2,911	4,553	471	4,082	6,910	855	6,055
Irrigation	571	73	498	902	414	488	1,145	647	498
Steam-Electric	11,938	0	11,938	6,866	21	6,845	8,194	0	8,194
Mining	3,581	1,647	1,934	3,479	1,702	1,777	4,222	1,853	2,369
Livestock	3,173	749	2,424	2,986	771	2,215	2,803	748	2,055
Total Water Use	**121,843**	**23,824**	**98,019**	**114,712**	**20,424**	**94,288**	**130,815**	**21,636**	**109,179**

[1] (P) Indicates partial quanitites are listed since these cities cross county lines and/or study area boundaries.

Table 2. Historical water uses for the study area. *(continued)*
NOTE: Values reported in acre-feet per year.

of Williamson County's water demand, compared to 59 percent in 1990 and 42 percent in 1995 (see Table 2 for details).

For comparison, Table 3 shows the total amount of groundwater pumped in Williamson County. More importantly, this table includes groundwater pumped in Williamson County and used both in Williamson County and elsewhere. In 1985, Williamson County pumped a total of 18,182 acre-feet of groundwater. Six years later (a relatively "wet" year), Williamson County pumped 15,883 acre-feet of groundwater. However, in 1996 (during a relatively "dry" year), a total of 19,226 acre-feet of groundwater was pumped. Basically, population in the study area shows a steady increase, while per capita groundwater usage appears to be declining. However, historical trends suggest that during periods of drought, dependency upon groundwater increases.

Projected Water Demands

Table 4 shows the projected water demands and groundwater supply sources by "major city" and "county other" for municipal use, and other uses, which includes manufacturing, steam-electric generation, mining, irrigation, and livestock. The numbers provided were based on estimates developed by the TWDB and include information that was used to develop the 1997 State Water Plan (TWDB, 1997).

Allocation of available or new water supplies for future water use was determined by analysis of data provided by TWDB's water supply allocation model MADNESS (TWDB, 1998c). The allocation model first uses measures that are cost effective and have limited impact on the environment. If for any reason this approach cannot be used, water use and supply management measures that are more costly, controversial, or environmentally sensitive are considered. By incorporating water conservation procedures and savings, efficient use of all existing water resources is first explored before pursuing new water supply sources. Alternative water supply measures include but are not limited to: inter-basin transfers, new reservoir development or expansion of existing reservoirs, importing water from nearby under-utilized reservoirs or aquifers, reuse of water for non-municipal demands, and aquifer storage and recovery (TWDB,1998c).

Under projected conditions, the total annual water requirement for the study area is expected to increase 76 percent from the year 2000 to the year 2030. In 2030, the projected water demand is estimated to be 292,415 acre-feet per year. Total groundwater use is projected to increase by 14 percent from the year 2000 to the year 2030. By comparison, water supplied from surface water sources is projected to increase by 83 percent for the same time period. By the year 2030, it is projected that 94 percent of the total demand will be furnished by surface water.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Groundwater													
Edwards	14,006	14,857	15,108	12,447	12,660	11,748	10,422	12,414	11,926	13,258	14,047	15,433	17,239
Trinity Group	4,069	3,836	3,787	3,818	4,230	5,094	5,292	5,395	5,086	5,288	3,493	3,631	3,370
Other	107	84	120	106	115	187	169	160	202	219	206	162	158
Total Pumped	**18,182**	**18,777**	**19,015**	**16,371**	**17,005**	**17,029**	**15,883**	**17,969**	**17,214**	**18,765**	**17,746**	**19,226**	**20,767**
Estimated supply[1]	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**	**6,341**
Amount over estimated supply	**11,841**	**12,436**	**12,674**	**10,030**	**10,664**	**10,688**	**9,542**	**11,628**	**10,873**	**12,424**	**11,405**	**12,885**	**14,426**

[1] Estimated available supply per the ***1997 State Water Plan***
(Edwards aquifer - 3,685 acre-feet/year and Trinity Group aquifer - 2,656 acre-feet/year).

Table 3. Historical groundwater pumpage in Williamson County (TWDB, 1998b).

				Acre-feet per year			
				2000	2010	2020	2030
Municipal Use:							
	Major Cities						
		Ground					
			Edwards	2,883	3,052	3,438	3,720
			Trinity	619	674	743	818
			Other	1,188	1,405	1,582	1,800
		Surface		117,573	143,728	180,973	211,001
			Subtotal	122,263	148,859	186,736	217,339
	County Other						
		Ground					
			Edwards	1,084	1,201	1,260	1,277
			Trinity	2,398	2,597	2,724	2,210
			Other	2,744	3,019	3,192	3,327
		Surface		10,160	16,848	25,831	33,724
			Subtotal	16,386	23,665	33,007	40,538
			Total	**138,649**	**172,524**	**219,743**	**257,877**
Other Uses:							
		Ground					
			Edwards	936	928	943	951
			Trinity	269	267	267	225
			Other	4,371	4,356	4,386	4,422
		Surface		22,073	27,100	28,001	28,940
			Subtotal	27,649	32,651	33,597	34,538
Subtotal Study Area:							
		Ground					
			Edwards	4,903	5,181	5,641	5,948
			Trinity	3,286	3,538	3,734	3,253
			Other	8,303	8,780	9,160	9,549
		Surface		149,806	187,676	234,805	273,665
			Total	**166,298**	**205,175**	**253,340**	**292,415**

Table 4. Projected water demands by source type for study area.

Table 5 shows the projected water demands and groundwater supply sources for Williamson County (TWDB, 1997). Due to estimated limitations on the local groundwater supply sources, projected use from both the Edwards and Trinity Group aquifers is expected to decrease by 6 percent between 2000 and 2030. Meanwhile, projected demands being met by surface water are expected to increase by 156 percent. Overall, the projected annual water requirement for Williamson County is expected to increase 124 percent from the year 2000 to the year 2030.

	Acre-feet per year			
	2000	**2010**	**2020**	**2030**
Edwards aquifer				**aquifer**
Major Cities				
Georgetown	921	921	921	921
Round Rock	921	921	921	921
County-Other	1,307	1,307	1,307	1,307
Manufacturing	81	81	81	81
Mining	437	437	437	435
Livestock	1	1	1	1
Total Demand	**3,668**	**3,668**	**3,668**	**3,666**
Effective Recharge	3,685	3,685	3,685	3,685
Shortage/Surplus	+17	+17	+17	+19
Trinity Group aquifer				
Major Cities				
Granger	245	292	311	374
County-Other	2,411	2,364	2,345	1,760
Total Demand	**2,656**	**2,656**	**2,656**	**2,134**
Effective Recharge	2,134	2,134	2,134	2,134
Shortage/Surplus	-522	-522	-522	0
Other aquifers				
County-Other	2,500	2,500	2,500	2,500
Manufacturing	200	200	200	200
Mining	150	150	150	150
Livestock	20	16	2	0
Total Demand	**2,870**	**2,866**	**2,862**	**2,860**
Total Groundwater	**9,194**	**9,190**	**9,186**	**8,660**
Total Surface Water	**37,024**	**55,629**	**77,895**	**94,827**
Total Demands	**46,218**	**64,819**	**87,081**	**103,487**

Table 5. Projected water demands by source type for Williamson County. *(Other aquifers refer to wells for which the producing zone has not been definitively established. Effective recharge estimates are from the Texas Department of Water Resources (1990) database containing county-wide recharge estimates for individual aquifers.)*

WATER AVAILABILITY

Groundwater Availability

Approximately 147,839 acre-feet per year of groundwater is estimated to be available for the counties included in the study area in the year 2000 per the 1997 State Water Plan allocation files (TWDB, 1997). Estimated totals in the year 2000 for available groundwater for all the counties included in the study area per aquifer include:

Carrizo-Wilcox aquifer	104,615 acre-feet
Edwards aquifer	13,000 acre-feet
Ellenburger-San Saba aquifer	3,148 acre-feet
Hickory aquifer	5,411 acre-feet
Marble Falls aquifer	5,625 acre-feet
Queen City aquifer	3,996 acre-feet
Sparta aquifer	3,900 acre-feet
Trinity Group aquifer	8,144 acre-feet

Due to their location, spatial extent, and usage by major population centers in the study area, the Edwards and Trinity Group aquifers are the most affected by pumpage and therefore warrant further discussion. To determine groundwater availability, an understanding of effective recharge and recoverable storage is essential. There are several methods commonly used to approximate effective recharge and recoverable storage for an aquifer: comparison of base-flow and spring-flow measurements, percentage of precipitation upon the outcrop, comparison of pumpage data and water-level trends, the trough method, and computer models, to name a few. These methods are described in more detail in TWDB Report 238 (Muller and Price, 1979).

Edwards aquifer

Current and projected groundwater use from the Edwards aquifer is based on utilizing effective recharge only, with little or no mining of recoverable storage. According to the TWDB's 1997 State Water Plan allocation files and using full county projections, the average annual effective recharge for the Edwards aquifer for the seven counties in the study area is approximately 13,000 acre-feet per year.

For the study area, TWDB estimates effective recharge for the Edwards aquifer equal to 10,074 acre-feet per year. For this report, two methods were utilized to estimate an effective recharge rate in the study area.

One method involved calculating the ratio of outcrop area in the study area to the total outcrop area, for each county, then multiplying the ratio by the effective recharge estimate for that county, as reported in the TWDB database which contains county-wide recharge estimates for specific aquifers. The second approach was based on the "percentage of precipitation upon the outcrop" method. Using the average annual precipitation from the four rain gage stations discussed previously in this report (31.87 inches/year) and assuming 1.5 percent of the average annual precipitation falling on the outcrop can be transmitted through the aquifer (effective recharge), the following equation was developed (Muller and Price, 1979):

$$31.87 \, {}^{in}\!/_{yr} \; x \; {}^{1ft}\!/_{12in} \; x \; 0.015 \; x \; 252{,}636 \;\; acres \; (outcrop) \approx 10{,}064 \, {}^{acre-\,feet}\!/_{yr}$$

By comparison, TWDB Report 326 (Duffin and Musick, 1991) used 7,400 acre-feet per year for an annual effective recharge for the Edwards aquifer within the study area. This amount was based on minimum flow measurements taken in 1956 by Muller and Price (1979) and represents flow during drought conditions. The projected water demands for the study area indicate groundwater supplied by the Edwards aquifer from the year 2000 to the year 2030 should fall below the conservative effective recharge value reported in TWDB Report 326, as long as water supplies are allocated as summarized in Table 4. The projections suggest approximately 5,948 acre-feet per year, or 80 percent of the conservative effective annual recharge (7,400 acre-feet per year), will be required to meet the growing water demands in the year 2030 (Table 4). In comparison with the total projected demands for the study area, the amount of water that can be supplied from the Edwards aquifer in the year 2030 is only a small fraction of the total demand (an estimated 2 percent). However, this allocation assumption is based on the area's continued transition to surface water for its main water supply source, which is expected to increase from 149,806 acre-feet per year in 2000 to 273,665 acre-feet per year in 2030 (Table 4).

On a local scale, Williamson County has experienced the most significant water declines since the late 1980s (see Figure 5). The annual effective recharge for the Edwards aquifer in Williamson County is 3,685 acre-feet per year (Table 5). The total projected demand from this source averages 3,668 acre-feet per year and per the 1997 State Water Plan is limited to withdrawals equal to or below the estimated effective recharge (TWDB, 1997). Due to this limitation, projected water demands for the growing population in Williamson County is expected to be met via various surface supply sources. Historically, withdrawal from the Edwards aquifer in Williamson County has consistently exceeded the ***State Water Plan's*** estimated available supply amount. Between 1985 and 1997 groundwater production from the Edwards aquifer ranged between 10,422 to 17,239 acre-feet per year

(Table 3). This equates to 2.8 to 4.7 times the estimated available supply of 3,685 acre-feet per year. It is also noted that during periods of drought, the effects of reduced recharge will accelerate current trends of declining water levels, as illustrated in figure 3.

Trinity Group aquifer

The 1997 State Water Plan assumed the available groundwater from the Trinity Group aquifer would consist of the annual effective recharge of 5,500 acre-feet per year and mining an additional 2 percent (1,200 acre-feet per year) of the total recoverable storage (59,838 acre-feet) until the year 2030 (Muller and Price, 1979). After 2030, supply from the aquifer would be based on the estimated effective recharge of 5,500 acre-feet per year. The projected water demands and allocations for the study area indicate groundwater supplied by the Trinity Group aquifer from the year 2000 to the year 2030 should fall below the average annual recharge amount of 5,500 acre-feet per year, as estimated in TWDB Report 326 (Duffin and Musick, 1991). The projections suggest approximately 3,253 acre-feet per year, or 59 percent of the effective annual recharge, will be required to meet the growing water demands in the year 2030 (TWDB, 1998c). This allocation assumes that the substantial increase in total water demands in the study area will be met primarily via surface water supplies (Table 4). By the year 2030 only 1 percent of the total demands are expected to be met via pumpage from the Trinity Group aquifer

The evaluation of water-level changes since the 1960s indicated the most consistent water-level declines have been measured in Williamson County (see hydrographs in Figure 6). The annual effective recharge for the Trinity Group aquifer in Williamson County is an estimated 2,134 acre-feet per year (TWDB, 1998c). Table 5 shows the projected demand from the Trinity Group aquifer in Williamson County is expected to exceed the effective recharge amount up until the year 2030 by 522 acre-feet per year. The additional groundwater is being supplied by the “recoverable storage” as described in TWDB Report 238 (Muller and Price, 1979). Furthermore, Table 5 shows total future demands far exceed the amounts that can be provided by the Trinity Group aquifer and are expected to be met via surface water supplies. Historically, withdrawal from the Trinity Group aquifer in Williamson County has consistently exceeded the State Water Plan’s estimated available supply amount. Between 1985 and 1997, pumpage from the Trinity Group aquifer ranged between 3,370 to 5,395 acre-feet per year (Table 3). This equates to 1.3 to 2.0 times the estimated available supply of 2,656 acre-feet per year.

Surface Water Availability

There are currently five major reservoirs in the Brazos River basin and eight major reservoirs in the Colorado River basin that lie near or within the study area (Duffin and Musick, 1991). Of the five reservoirs located in the Brazos River basin, three are located within the study area: Lake Georgetown, Granger Lake, and Stillhouse Hollow Lake. Of the other two reservoirs, located outside the study area in the Brazos River basin (Belton Lake and Alcoa Lake), only Belton Lake supplies users within the study area. The Alcoa Corporation uses Alcoa Lake as an industrial water supply source. The total firm yield from the Brazos River basin reservoirs is 218,855 acre-feet per year (TWDB, 1998). A pipeline is currently under construction to transport surface water from Stillhouse Hollow to Round Rock and Georgetown and is tentatively scheduled to begin operation by the year 2000.

The majority of the reservoirs located within the Colorado River basin in the vicinity of the study area are part of the LCRA's Highland Lakes system: Lake Buchanan, Inks Lake, Lake LBJ, Lake Marble Falls, Lake Travis, and Lake Austin. Most of these lakes are "pass through" lakes and/or hydroelectric power generation lakes. The system's firm yield, 445,266 acre-feet per year, is stored in Lake Travis and Lake Buchanan (TWDB, 1998). The other two reservoirs in the Colorado River basin (Walter E. Long and Lake Bastrop), currently do not supply water to users in the study area. Of the eight reservoirs located within the Colorado River basin, only three are located within or on the study area boundaries: Lake Travis, Lake Austin, and Decker Lake. Sufficient surface water supplies exist from either the City of Austin or the LCRA for the northern portion of Travis County and parts of Burnet County that lie within the study area for the 25-year planning period discussed in this report (TWDB, 1997).

Additionally, several smaller ponds and reservoirs with capacities less than 5,000 acre-feet exist in the study area and supply local needs. With the installation of a pipeline from Stillhouse Hollow to Williamson County, surface water supplies are adequate to meet current and projected needs through 2030.

DISCUSSION AND CONCLUSIONS

Groundwater issues may present a problem in the study area. Rain gage data suggest the area has received below average rainfall for the past several years (Figure 2). With less recharge entering the aquifers, combined with increases in population and water demands, water levels have not recovered to pre-drought and pre-development levels.

The Edwards aquifer, which typically has rapid responses to precipitation and pumping, had not fully recovered from the 1996 drought when this report was prepared, as seen in the hydrographs depicted in Figure 3. Water levels have declined in the eastern portion of the Edwards aquifer in Williamson County in the past decade (Figure 5). This can partially be attributed to the observation period ending during a period of low precipitation and recharge. However, pumpage from the Edwards aquifer has consistently exceeded the estimated available supply between 1985 and 1997 in Williamson County (Table 5).

Water-level declines in the Trinity Group aquifer appear to have decreased in intensity in the past decade and have generally leveled out (Figures 6 and 8). However, areas that continue to meet demands through groundwater pumpage show overall declines since the 1960s, with the most significant water-level declines occurring in Williamson County. Areas that have converted to surface water (Travis County) or areas located in the recharge zone (Burnet County) show relatively stable water-level trends.

If the rate of conversion to surface water is maintained and expanded, as suggested in the 1997 State Water Plan, adequate water supplies should exist to meet the current and projected needs in the study area through the year 2030. However, from a more local perspective, it appears production of groundwater since the 1960s has had the most significant impact in Williamson County. As previously stated in TWDB Report 326, a lack of reliable groundwater supplies for both short-term drought demand and long-term economic development is still a concern. Careful management of the groundwater resources together with increased conversion to surface water supplies will be necessary to ensure adequate availability of water to this area through 2030.

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