Lambert, R.B., 2004, Hydrogeology of Webb County, Texas

INTRODUCTION

Webb County, in semiarid South Texas on the U.S.-Mexico border, is a region confronted by increasing stresses on natural resources. Laredo (fig. 1), the largest city in Webb County (population 193,000 in 2000), was one of the 10 fastest-growing metropolitan areas in the country during 1990–2000 (Perry and Mackun, 2001). Commercial and industrial activities have expanded throughout the region to support the maquiladora industry (manufacturing plants in Mexico) along the border and other growth as a result of the passage of the North American Free Trade Agreement. The Rio Grande currently (2002) is the primary source of public water supply for Laredo and other cities along the border in Webb County (fig. 1). Other cities, such as Bruni and Mirando City in the southeastern part of the county, rely on ground-water supplies to meet municipal demands. Increased water demand associated with development and population growth in the region has increased the need for the City of Laredo and Webb County to evaluate alternative water sources to meet future demand. Possible options include (1) supplementing the surface-water supply with ground water, and (2) applying artificial storage and recovery (ASR) technology to recharge local aquifers. These options raise issues regarding the hydraulic capability of the aquifers to store economically substantial quantities of water, current or potential uses of the resource, and possible effects on the quality of water resulting from mixing ground water with alternative source waters.

To address some of these issues, the U.S. Geological Survey (USGS), in cooperation with the City of Laredo, began a study in 1996 to assess the ground-water resources of Webb County. A hydrogeologic study was conducted to review and analyze available information on the hydrogeologic units (aquifers and confining units) in Webb County, to locate available wells in the region with water-level and water-quality information from the aquifers, and to analyze the hydraulic properties of the aquifers. The purpose of this report is to document the findings of the study. The information is organized by hydrogeologic unit and presented on this and six other sheets.

Previous Studies

Few studies have been devoted to characterizing the availability, yield, and quality of water from the aquifers in Webb County. Lonsdale and Day (1937) completed the first county-level reconnaissance investigation of Webb County and the major geologic units. Eargle (1968) revised the stratigraphic nomenclature of the Claiborne Group in Texas. More recently, the geology and ground-water resources of the Carrizo aquifer have been studied by the Texas Water Development Board (TWDB) and the USGS. Marquardt and Rodriguez (1977) compiled information on the locations of water and oil wells and available water-level and water-quality information from wells completed in the Carrizo aquifer in the Winter Garden area (fig. 1) of South Texas. Klemt and others (1976) used information from Marquardt and Rodriguez (1977) to develop a ground-water model for use in assessing the availability of ground water for future development. Mace and others (2000) compiled a database of hydraulic properties for wells completed in the Carrizo-Wilcox aquifer in Texas. Working with a minimal dataset in Webb County (four measurements), Mace and others (2000) estimated the average transmissivity of the Carrizo-Wilcox aquifer in Webb County to be 69 feet squared per day (ft²/d). On a more regional scale, the Texas Gulf Coast aquifer systems, including some of the aquifers in Webb County, were studied by Ryder (1987) and Ryder and Ardis (2002). Baker (1995) constructed hydrogeologic sections showing the stratigraphic framework of the Gulf Coastal Plain in Texas including one section in Webb County. The TWDB evaluated the quality of ground water in the Carrizo-Wilcox, Laredo, and Gulf Coast aquifers as part of a regional evaluation of water quality in Texas counties bordering the Rio Grande (Hopkins, 1995). The TWDB also evaluated the availability and quality of ground water in and around Bruni in response to concerns about the potential for high concentrations of arsenic and uranium in ground water resulting from commercial mine operations in the area (Adidas, 1991). CH2M Hill (1996, 1999) conducted a local geohydrologic investigation in the Laredo area to assess the feasibility of using ASR to store water in the Laredo aquifer.

Additional information on the geologic units in the subsurface of Webb County is found in numerous references relating to the oil and gas industry in South Texas. The Webb County area has oil and gas fields that produce from formations beneath the aquifers. Detailed field information including production characteristics, type geophysical logs, and location of selected oil and gas fields in Webb County is in Wolbrink (1979) and Corpus Christi Geological Society (1988). Results of other stratigraphic studies that involve the environment of deposition and reservoir morphology of the Wilcox Group and Claiborne Group in South Texas are published in Stapp and others (1986).

Methods

A field inventory was conducted during 1996–98 to identify municipal, irrigation, domestic, and stock wells in Webb County. Where possible, a water-level measurement was made at the time of inventory. Information from the well inventory and drillers' logs was used to identify the aquifer each well was open to or completed in and to select wells for water-quality sampling. Wells open to more than one aquifer were not used for water-level measurement or water-quality sampling. The locations of inventoried and sampled wells used in the study are shown in figure 2, and a summary of the lithologic and hydrologic properties of the hydrogeologic units are shown in table 1.

Geologic sections were constructed using geologic maps, 30-meter digital elevation model (DEM) data, wells with geophysical logs (fig. 3) and drillers' logs. The geologic sections were constructed to show the distribution and change in thickness and altitude of geologic units in Webb County. Two approximate dip sections (*A–A'* and *B–B'*; figs. 6–7) and three strike sections (*C–C'*, *D–D'*, and *E–E'*; figs. 8–10) were constructed. Probable sand and shale units and aquifer units were correlated between wells with geophysical logs using the spontaneous potential (SP) and resistivity curves.

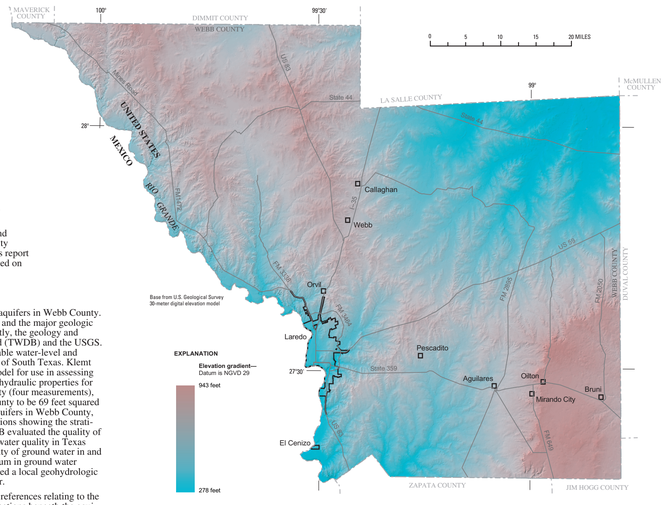

Figure 1. Location of the city of Laredo and smaller cities in Webb County.

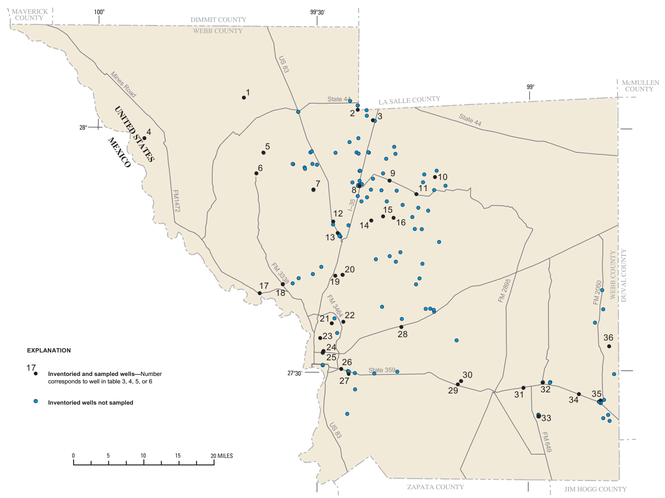

Figure 2. Location of inventoried and sampled wells.

LOCATION MAP

Using available geologic maps, drillers' logs, geophysical logs, and DEM data, contour maps were prepared showing the extent of the aquifers at land surface and in the subsurface. Subsurface stratigraphic horizons were identified using type logs from Wolbrink (1979) and the Corpus Christi Geological Society (1988) and using information provided by geologists who have worked in the area (Alvin L. Schultz, independent consultant, oral commun., 1998–2000; Richard N. Hargis, independent consultant, oral commun., 1999; and Amy Vanderhill, Pogo Producing Co., oral commun., 2000). The geologic information from the DEM data and the geophysical logs were entered into a series of geographical information system (GIS) feature datasets. The DEM data and geophysical log data were merged to create top-of-aquifer and thickness-of-aquifer maps using a software gridding program. The program interpolated altitudes of the uppermost stratigraphic unit of each aquifer to create top-of-aquifer maps and subtracted interpolated altitudes of the bottom of the lowermost stratigraphic unit of each aquifer to create thickness-of-aquifer maps. Net sand thickness maps were created by estimating the net sand thickness within an aquifer using the SP and resistivity curves on geophysical logs. Locations of geophysical log control points used to construct the maps are shown in figure 3. The average dip of the aquifers was computed using the average dip of three to four transects across GIS feature datasets from the northwestern to the southeastern part of the county for each aquifer. Because of the regional scale of the contour maps and the limitations of the computer gridding software in displaying complex subsurface structure, only regional fault zones and surficial faults (University of Texas, Bureau of Economic Geology, 1976a, b) have been included on the maps. The maps are intended to be used as a general guideline in determining the top and thickness of an aquifer.

Hydraulic properties of an aquifer include transmissivity, which characterizes an aquifer's ability to transmit water. Hydraulic information from drillers' reports, including discharge and drawdown, was used to obtain specific capacity, which in turn was used to compute transmissivity. The specific capacity of a well is a measure of the productivity of a well and is computed by dividing the discharge by the drawdown. Aquifer-test and specific-capacity data for Webb County from which to obtain transmissivity are scarce. Many of the wells that were inventoried had little or no useful information with regard to hydraulic properties, and access to existing wells to conduct aquifer tests was limited. Using specific capacities from available data, transmissivities were computed for the Gulf Coast, Jackson, Laredo, and Carrizo aquifers using an empirical method for interbedded sand and shale alluvial aquifers developed by Razack and Huntley (1991). These estimated transmissivities are shown for each aquifer in table 2.

Table 1. Summary of the lithologic and hydrologic properties of the hydrogeologic units in Webb County, Texas

[Lithologic and hydrologic properties modified from Lonsdale and Day, 1937; Winslow and Kister, 1956; Klemt and others, 1976; University of Texas, Bureau of Economic Geology, 1976a,b. Color shading to show aquifer. ft, feet; AQ, aquifer; <, less than; gal/min, gallons per minute; CU, confining unit; >, greater than]

Epoch	Period	Hydrogeologic unit	Group, formation, or member		Hydrologic function	Maximum thickness (ft)	Lithology	Water quality and well yields
Recent (Holocene)	Quaternary	River alluvium	Alluvial deposits		AQ where saturated	50	Stream-deposited sand, gravel, and silt	Yields variable amounts of water along streams; some suitable for domestic use
		None	Windblown sand sheet deposits		Not saturated	Unknown	Sand	Not known to yield water; low to moderate water-holding capacity
Pleistocene			Fluviatile terrace deposits		Not saturated	Unknown	Gravel, sand, silt, and clay	Not known to yield water
Pleistocene or Pliocene	Quaternary or Tertiary		Uvalde Gravel		Not saturated	25	Gravel, conglomerate, sand, and caliche	Not known to yield water
Pliocene	Tertiary	Gulf Coast aquifer	Goliad Sand		AQ	100	Reddish sand, caliche, and conglomerate, with some clay	Yields variable amounts of water at shallow depths in southeastern Webb County; quality variable, usually suitable for domestic use
Miocene			Catahoula Tuff	Fant member	AQ	1,200	Pyroclastic rocks; shaley and tuffaceous sandstone; bentonitic clay; sandstone beds as much as 20 ft in thickness	Outcrop area yields small amounts of highly mineralized water (<15 gal/min); in southeastern Webb County, wells 150–400 ft deep yield considerable amounts of water (30–150 gal/min); fresh to slightly saline water suitable for multiple uses
Oligocene		Frio confining unit	Frio Clay		CU	>230	Clay and sandy clay	Not known to yield water
Eocene		Jackson aquifer	Jackson Group		AQ	2,220	Clay, shale, sandy clay, sandstone, ashy sandstone, and volcanic ash; ashy beds contain plant fossils	Minor aquifer; yields variable amounts of slightly to highly saline water used mainly for stock
		Yegua aquifer	Claiborne Group	Yegua Formation	AQ	1,480	Clay, sandy clay, thin beds of sandstone; secondary gypsum and some limestone concretions	Minor aquifer; yields small amounts (<15 gal/min) of slightly to moderately saline water suitable for stock
		Laredo aquifer		Laredo Formation	AQ	1,510	Sandstone, glauconitic sandstone, glauconitic marl, and clay. Some limestone; fossiliferous	Major aquifer; sandstone of lower part constitutes important part of aquifer, yielding small to large amounts (5–170 gal/min) of fresh to moderately saline water. Flowing wells obtained in low areas of northeastern Webb County; suitable for many uses; might be affected by growth faults in eastern Webb County
		El Pico confining unit		El Pico Clay	CU	1,710	Clay, with interbedded sandstone; claystone and lignite coal lenses common	Yields small amounts of highly mineralized water in the outcrop area
		Queen City-Bigford aquifer		Queen City Sand Bigford Formation	AQ	2,170	Lower part of El Pico Clay includes Queen City Sand, a massive, interbedded clayey sandstone overlying the Bigford Formation. Bigford Formation is a gypsiferous clay with thin-bedded to massive, clayey sandstone, lignite, and coal	The Queen City-Bigford aquifer is a minor aquifer; the sandstone supplies small to moderate amounts of fresh to very saline water generally used only for stock; might be affected by growth faults in eastern Webb County
		Reklaw confining unit		Reklaw Formation	CU	1,050	Downdip, the Reklaw Formation is a marine shale at base of Bigford Formation that functions as a confining unit	Not known to yield water
		Carrizo aquifer		Carrizo Sand	AQ	1,250	Massive, crossbedded sandstone with small amounts of clay or shale	Major aquifer; most prolific source of fresh ground water in Webb County; generally yields moderate to large amounts (>150 gal/min) of fresh to slightly saline water suitable for all uses; might be affected by growth faults in eastern Webb County
		Upper Wilcox confining unit	Wilcox Group	Indio Formation	CU	850	Thin sandstone interbedded with carbonaceous clay, shale, and lignite	Yields small amounts of highly mineralized water suitable for stock; might be affected by growth faults in eastern Webb County. Might be hydrologically connected to Carrizo aquifer in some areas

Table 2. Specific capacity and estimated transmissivity of the Gulf Coast, Jackson, Laredo, and Carrizo aquifers

[ft, feet; ft³/d, cubic feet per day; ft²/d, feet squared per day; --, not available]

State well number	USGS station number	Aquifer	Well depth (ft)	Pumping rate (Q) (ft³/d)	Drawdown (ft)	Specific capacity (ft²/d)	Transmissivity (ft²/d)
YZ–84–33–102	272 8040 98582002	Gulf Coast	300	1,040	--	--	--
YZ–84–33–705	272 3560 98584701	Gulf Coast	235	1,348	30	45	430
YZ–84–33–706	272 4010 98585101	Gulf Coast	198	1,540	90	17	225
YZ–84–33–707	272 3520 98585101	Gulf Coast	198	1,925	40	48	450
YZ–84–34–201	272 9050 98482201	Gulf Coast	225	433	36	12	180
YZ–84–34–414	272 5290 98501601	Gulf Coast	265	2,888	220	13	190
YZ–84–34–405	272 5400 98501301	Gulf Coast	345	14, 245	79	180	1,090
YZ–84–33–101	272 8040 98582 001	Jackson	340	1,213	70	17	225
YZ–77–61–903	280 1490 99225501	Laredo	380	5, 775	120	48	450
YZ–77–61–902	280 1520 99240 901	Laredo	520	13, 475	180	75	605
YZ–77–62–710	280 0340 99220101	Laredo	600	46, 200	65	711	2,735
YZ–85–04–503	275 5050 99331001	Laredo [1]	980	1, 348	340	4.0	85
YZ–85–06–701	275 3590 99203501	Laredo	170	5, 775	20	289	1,495
YZ–85–13–501	274 7590 99273 201	Laredo	520	5, 775	20	289	1,495
YZ–85–13–801	274 6330 99265 401	Laredo	550	5, 775	350	16	220
YZ–85–14–302	275 1250 99155 601	Laredo	1, 200	11, 550	80	144	940
YZ–85–14–501	274 8280 99190 601	Laredo	500	2, 888	--	--	--
YZ–85–20–502	274 0120 99343 101	Laredo	240	1, 155	220	5.0	100
YZ–85–29–102	273 5210 99274 101	Laredo	800	53, 900	100	539	2,275
YZ–85–29–204	273 5330 99260 401	Laredo	710	9,625	50	192	1,140
YZ–85–29–401	273 3310 99291 701	Laredo	300	5, 775	140	41	405
YZ–85–29–704	273 1450 99285 402	Laredo	400	46, 200	160	289	1,495
YZ–85–29–705	273 1410 99285 501	Laredo	400	46, 200	120	385	1,815
YZ–85–29–706	273 1450 99285 401	Laredo	236	4,813	140	34	360
YZ–85–29–709	273 1540 99284 801	Laredo	440	32, 148	225	143	935
YZ–85–29–709	273 1540 99284 801	Laredo	440	31, 378	154	204	1,185
YZ–85–37–205	272 9020 99251 601	Laredo	290	1, 540	180	9.0	140
YZ–85–37–206	272 9420 99262 001	Laredo	370	4,620	212	22	265
YZ–85–39–301	272 8130 99093 901	Laredo	1, 230	7, 700	185	42	410
YZ–77–49–501	281 1470995 53201	Carrizo [2]	850	1, 925	299	6.0	115
YZ–85–04–402	275 5080 99364 801	Carrizo [2]	1, 945	7, 315	260	28	315
YZ–85–19–902	273 9140 99375 601	Carrizo [2]	2, 220	5, 775	380	15	210
YZ–85–19–903	273 9030 99374 501	Carrizo	1, 918	20, 213	618	33	350

[1] Well completed in both Laredo and Queen City-Bigford aquifers; principal aquifer assumed to be Laredo aquifer.
[2] Source of data is the Texas Water Development Board ground-water database.

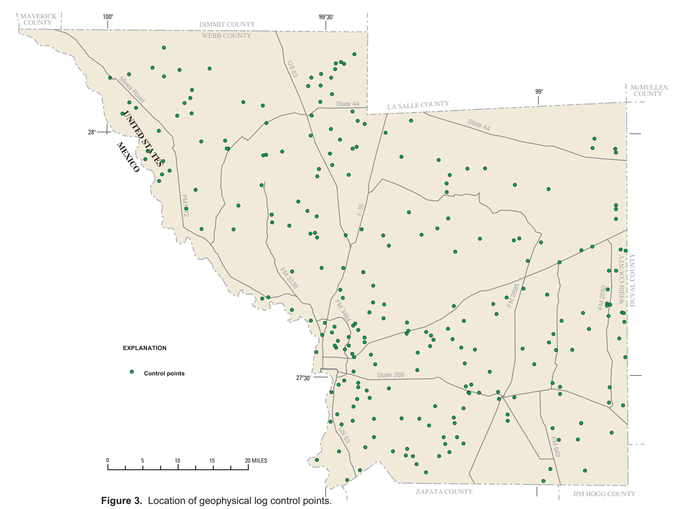

Figure 3. Location of geophysical log control points.

The quality of water from aquifers in Webb County was characterized by sampling 36 domestic, irrigation, and municipal wells (fig. 2). Although attempts were made to sample all aquifers in the county, two aquifers (river alluvium and Queen City-Bigford [table 1]) were not sampled because suitable wells could not be located. All samples were collected by the USGS and analyzed by the USGS National Water Quality Laboratory in Denver, Colo. Water samples were analyzed for major inorganic ions and trace elements using the analytical methods documented in Wershaw and others (1987), Fishman and Friedman (1989), Faires (1993), Fishman (1993), McLain (1993), American Public Health Association (1998), and Gabarino (1999). Water samples also were analyzed for nutrients using methods described in Patton and Truitt (1992) and Fishman (1993). Organic compounds, including selected volatile organic compounds, semivolatile organic compounds, base-neutral acid extracts, and pesticides were analyzed using methods documented in Zaugg and others (1995), Lindley and others (1996), and Connor and others (1998). Few organic compounds were detected, and all concentrations were low. Results are discussed in Lambert and Hartmann (1999).

Quality control samples including inorganic blanks, organic blanks, and replicates were collected to ensure the quality, precision, accuracy, and completeness of the water-quality data. Results from the inorganic blanks and the organic blanks indicated that there were some detectable concentrations of aluminum, boron, and zinc, but that the concentrations were less than the background concentrations in the environmental samples. All other analyzed constituents were not detected. These results indicate that there was no outside contamination of the samples resulting from the sampling equipment or the method used to collect the sample. The replicate samples also showed that the sampling method provided consistent constituent results between the samples. Selected analytical results from the 36 wells are presented in this report in tables 3–6 on sheets 3, 4, 5, and 7.

Acknowledgments

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