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Designation of Brackish Groundwater Zones in Duval County

Prepared for

Duval County Groundwater Conservation District

Ronald T. Green, Ph.D., P.G.
Geosciences and Engineering Division®
Southwest Research Institute
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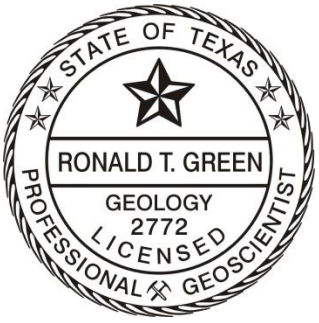

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Introduction

This report is a review of existing technical literature on the groundwater resources of Duval County, Texas and is focused to evaluate the presence, extent, and use of brackish water resources in the county. The review is motivated by Texas Legislature House Bill (HB) 30, the purpose of which is to provide meaningful incentives for the development of brackish groundwater in areas where that development would have a minimal impact on existing fresh groundwater use, while respecting private property rights in groundwater and continuing to encourage the use of brackish groundwater for purposes other than human consumption. HB 30 requires identification and designation of local or regional brackish groundwater production zones in areas of the state with moderate to high availability and potential productivity of brackish groundwater that can be used to reduce the use of fresh groundwater. These brackish production zones cannot be located in an area that is serving as a significant source of water supply for municipal, domestic, or agricultural purposes at the time of designation of the zones. This report provides guidance on the brackish groundwater resources of Duval County and whether these resources serve as a significant source of water supply for municipal, domestic, or agricultural purposes.

Evaluations of the water resources of Duval County are either more than thirty-years old (Sayre, 1937; Cromack; 1944; Austin, 1959; Mason, 1963; Baker, 1979; Shafer, 1986; Naismith Engineering Inc., 1996) or regional in extent (Chowdhury and Mace, 2007; Young et al., 2010; Scanlon et al., 2011). Early studies undertaken by the U.S. Geological Survey (Sayre, 1937; Shafer, 1986) provide the most comprehensive evaluation of the water resources in Duval County. Regional studies that support the joint planning process in Groundwater Management Area 16 (Chowdhury and Mace, 2007; Young et al., 2010; Scanlon et al., 2011) are regional in scope, do not provide detailed characterization of the local hydrogeology, and mostly rely on the earlier U.S. Geological Survey reports. The hydrogeology cited in this report is mostly taken from Shafer, which was originally published in 1974 and republished in 1986.

Geology

Duval County covers approximately 1,150,000 acres in south Texas. The stratigraphic column of the geologic formations, which crop out in Duval County, is illustrated in Figure 1 (Shafer, 1986). Significant water-bearing formations include (from deepest to most shallow) the Catahoula Tuff, Oakville Sandstone, and the Goliad Sand. As illustrated in Figure 1, the Oakville Sandstone conformably overlies the Catahoula Tuff. The Goliad Sand lies unconformably over both the Oakville Sandstone and the Catahoula Tuff and is mostly, although not always, separated by the Fleming Formation, a confining unit. The Jackson Group crops out in northwest Duval County where it is tapped by a few wells.

The Goliad Sand crops out over most of the county with the Oakville Sandstone and the Catahoula Tuff cropping out in the northwest corner of Duval County (Figure 2) where the Goliad Sand is not present.

In general, the formations in Duval County dip to the east (Figures 3 and 4) and to the south (Figure 5) toward the Gulf of Mexico. Shafer (1986) used data from existing wells to compile contour maps of the top of the Oakville Sandstone (Figure 6) and Catahoula Tuff (Figure 7) and the base of the Goliad Sand (Figure 8).

Hydrogeology

Precipitation is highly variable over time and averages approximately 24 in/yr in Duval County (Shafer, 1986). Because precipitation is highly variable, recharge also is quite variable. Recharge in Duval County has only been evaluated as part of a regional-scale investigation (Scanlon et al., 2011). Local factors, such as duration and intensity of precipitation, soil type, vegetation, and surface-runoff characteristics, that affect recharge in Duval County have not been evaluated. The approximate water elevation (feet, mean sea level) of the Catahoula Tuff and the Goliad Sand is mapped in Figure 9 (Shafer, 1986). The geologic formations that yield fresh-to-slightly saline water in Duval County include the Catahoula Tuff, Oakville Sandstone, and the Goliad Sand. Fresh-to-slightly saline water is defined here as water with Total Dissolved Solid (TDS) concentration of no greater than 3,000 parts per million (ppm). Water quality from all three formations is variable with some production of water high in dissolved solids, chloride, and hardness. These waters yield fresh-to-slightly saline water over much of the county and frequently do not meet drinking water standards in terms of TDS; however, given the limited availability of fresh groundwater in Duval County, these waters are commonly used for municipal, domestic, or agricultural purposes. All other formations either do not yield significant amounts of water or are highly saline. In general, water wells in the eastern half of Duval County pump from the Goliad Sand and wells in the western half pump from the Catahoula Tuff. Only wells sufficiently deep in the eastern half of Duval County penetrate both the Goliad Sand and the underlying Fleming Formation confining unit to extract fresh-to-slightly saline water from the Oakville Sandstone. In 1970, the Catahoula Tuff, Oakville Sandstone, and the Goliad Sand provided 0.6, 0.7, and 4.0 mgd, respectively (Shafer, 1986). Thus, the Goliad Sand is the most prominent aquifer in Duval County.

The thickness and extent of the fresh-to-slightly saline water in the Catahoula Tuff are illustrated in Figure 10 (Shafer, 1986). As illustrated, the fresh-to-slightly saline water in the Catahoula Tuff is confined to the western half of Duval County. The maximum thickness of this unit is slightly greater than 100 ft over a limited extent in the middle-west of the county, but the thickness of this unit is much less elsewhere. As illustrated by Figure 11 (Shafer, 1986), that part of the Oakville Sandstone with fresh-to-slightly saline water is confined to the eastern half of Duval County. The greatest thickness of the fresh-to-slightly saline water portion of the Oakville Sandstone is slightly more than 100 ft (Figure 11); however, the depth of this fresh-to-slightly saline water increases from west-to-east and from north-to-south (Figures 3-6). The thickness of the fresh-to-slightly saline water in the Goliad Sand is greatest in the southeast corner of the county with a thickness that exceeds 300 ft (Figure 11) (Shafer, 1986). As mentioned above, the Goliad Sand is absent in the northwest portion of the county.

A map of water well locations for Duval County has been generated using the Texas Water Development Board (TWDB) Groundwater Database. Only wells from the three aquifers (Catahoula Tuff – 175 wells, Oakville Sandstone – 39 wells, and Goliad Sand – 373 wells) are shown. Wells identified with other sources (20 wells total) are excluded from the figure. Due to their large number (91 wells), those wells identified as NA (aquifer unit not applicable) in the database are also shown. These wells are commonly previous oil/gas exploration wells that have been converted to water use (or TWDB was notified of

conversion plans). The status, depth, and aquifer supply for these wells (if ever used for water) are typically not logged by the TWDB.

Shafer (1986) presented the results of water quality sampling from wells in Duval County (Figure 16 in Shafer, 1986). The figure is not replicated here due to poor resolution. These data indicate that the TDS of samples from water wells in Duval County is frequently greater than 1,000 ppm TDS and occasionally in excess of 3,000 ppm in active water wells. Shafer (1986) used this information to identify areas where the quality of water is considered brackish, defined here as water with a TDS in excess of 3,000 ppm (Figure 13). These brackish areas are numerous and pervasive across the county. Because of the lack of adequate fresh-water resources, residents of Duval County rely on groundwater with TDS concentrations above 1,000 ppm and occasionally 3,000 ppm for municipal, domestic, or agricultural purposes.

Recent Trends in Water Resources of Duval County

The pressure surface of the Goliad Sand declined about 55 ft during 1931-1969 (Shafer, 1986). Only slight pressure declines occurred in the Catahoula Tuff and Oakville Sandstone during this same period. Limited evaluation of the water resources of Duval County has been undertaken since Shafer first published his water resource assessment in 1974. As documented in the TWDB database (http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp), there have been few water elevation measurements taken over the period since Shafer's study. Three exceptions to this generalization are Wells 8412301, 8415702, and 8445304, details of which are included in Table 1. Locations of these three wells are illustrated on a map of Duval County in Figure 15. Water elevations measured at each well are graphically presented in Figures 16-18

As illustrated in Figures 16-18, it is difficult to identify an overall trend in water elevations. First, the wells used for monitoring have not been controlled and the water elevation data have not been qualified (i.e., checked for errors in measurement, recording, etc.). Second, one well in the Catahoula Tuff and two wells in the Goliad Sand are not a sufficient number of wells to form an opinion of the general trend of changes in water level for an area as large as Duval County. Nonetheless, it could be argued that water elevations in Well 8412301 in the Catahoula Formation and Well 8445702 in the Goliad Sand exhibit slight declines over the period of measurement. Water elevations at the other Goliad Sand well, 8415304, likely reflect a change in the point of elevation reference in the late 1950s when the TWDB assumed responsibility for making depth-to-water measurements.

Similarly, there has been limited sampling and analysis of groundwater quality from aquifers in Duval County since the 1974 Duval County water-resource evaluation by Shafer (1986); thus, recent changes in groundwater quality cannot be ascertained. There is no basis to assume that water quality of the Catahoula Tuff, Oakville Sandstone, or the Goliad Sand has changed from what is indicated in Figures 9-13.

Contour maps of the thickness of fresh-to-slightly saline water in the Catahoula Tuff, Oakville Sandstone, and the Goliad Sand have been updated during this evaluation using information proved by Baker (1979) and Young et al. (2010). These revised maps are presented in Figures 19-21. As illustrated, the additional data have not substantively changed the original maps of these thicknesses prepared by Shafer (1986) (Figures 10-12).

Table 1. Duval County water wells with a history of water-elevation measurement (TWDB)

State Well Number:	8412301	8415702	8445304
Owner:	Percy Howard	San Diego Mud #1	Abraham Garcia
Water Use:	Domestic	Public Supply	Stock
Elevation (ft):	606	294	330
Well Depth (ft):	503	794	80
Water Level Observation Type:	TWDB Current Observation Well	Historical Observation Well	Historical Observation Well
Aquifer:	Catahoula Formation	Goliad Sand	Goliad Sand
Latitude:	27.859444	27.78055	27.341388
Longitude:	-98.537777	-98.241944	-98.414166
Well Type:	Withdrawal of Water	Withdrawal of Water	Withdrawal of Water

Discussion

Duval County relies on groundwater from three formations to provide for its water supply: Catahoula Tuff, Oakville Sandstone, and Goliad Sand. There is virtually no surface-water supply in the county and the groundwater resources are limited. Well capacity and pumping records for Duval County are not available. Water-quality analyses of samples taken from water wells indicate that the quality of water in these three formations is not typically classified as fresh (< 1,000 ppm TDS) and occasionally would be considered brackish (> 3,000 ppm TDS). Residents of Duval County use water of this quality for municipal, domestic, or agricultural purposes due to limited access to adequate fresh water. Based on this analysis, local or regional brackish groundwater production zones with moderate to high availability and productivity of brackish groundwater have been identified in Duval County that already serve as a significant source of water supply for municipal, domestic, or agricultural purposes. These zones include the entire Goliad Sand and Oakville Sandstone formations, which provides the preponderance of groundwater used in Duval County, and most of the Catahoula Tuff. Portions of the Catahoula Tuff found at depth and possibly the Jackson Group at even greater depths contain brackish water not currently used for municipal, domestic, or agricultural purposes. Given the depths of these potential resources and the absence of wells at these depths, insufficient information is available to fully evaluate their presence and extent.

Conclusions

A preliminary evaluation of the water resources was undertaken to allow an assessment as to whether there are brackish water resources in Duval County not currently used for municipal, domestic, or agricultural purposes. In general, groundwater resources in Duval County have marginal quality in terms of TDS. In fact, groundwater with TDS greater than 1,000 TDS is commonly used for municipal, domestic, or agricultural purposes in Duval County due to the sparsity of low TDS water. Thus, brackish water resources in the Goliad Sand, Oakville Sandstone, and shallow portions of the Catahoula Tuff and Jackson Group are currently used for municipal, domestic, or agricultural purposes. Portions of the Catahoula Tuff in eastern Duval County and the Jackson Group, both of which are found at depths in excess of several thousand feet, may contain brackish water not currently used for municipal, domestic, or agricultural purposes; however, insufficient information is available to fully evaluate their presence and extent.

Comprehensive assessment of the groundwater resources of Duval County is hampered by the absence of recent technical studies of the water resources. The water-resources evaluation conducted by Shafer in 1974 and republished in 1986 still provides the most comprehensive assessment of the groundwater resources of the county. Compilation of an inventory of water wells, assessment of current usage, analysis of water quality, and refinement of the hydrogeological conceptualization of Duval County would facilitate a more thorough assessment of the current state of water resources in the county and allow for defensible evaluation of potential threats to these resources as a result of drought, pumping, and possible water-quality degradation due to oil/gas activity or other possible threats. Included in this additional undertaking would be development of refined maps that better reflect the water quality, depth, and extent of the Goliad Sand, Oakville Sandstone, and Catahoula Tuff water-bearing formations given the amount of data currently available that was not available in the 1970s. Characterization of the deeper Catahoula Tuff and Jackson Group would likely rely on oil well information given that no water wells penetrate to this depth at this time.

Figure 1. Geologic units in Duval County and their water-bearing properties (taken from Shafer, 1974)

System	Series	Geologic Formation	Approximate Thickness (ft)	Lithology	Water-Bearing Properties
Quaternary	Holocene	Alluvium	?	Very fine to fine sand, silt, and calcareous clay	Not known to yield water to wells in the county
	Holocene and Pleistocene (?)	South Texas eolian plain deposits	0-10	Fine to very fine, tan to white sand	Not known to yield water to wells in the county
	Pleistocene	Lisse Formation	0-100	Variegated red to brown calcareous clayey sand, some gravel near base	Not known to yield water to wells in the county
Tertiary	Pliocene	Goliad Sand	0-600	Fine to coarse, mostly gray calcareous sand interbedded with sandstone, gravel, and varicolored calcareous clay. An abundance of caliche over most of the outcrop	Principal aquifer in the county. Yields small to large quantities of fresh to slightly saline water to public-supply, industrial, irrigation, rural-domestic, and stock wells
	Miocene	Fleming Formation	0-1,000	Yellow to green calcareous or marly clay and some local seams of silty sand and lentils of course sand and gravel	Not known to yield water to wells in the county
		Oakville Sandstone	0-600	Medium to fine sand, sandstone, silt, bentonitic clay, and small amount of ash	Yields small to moderate quantities of fresh to slightly saline water to industrial, rural-domestic, and stock wells.
		Catahoula Tuff	0-1,400	Pink tuffaceous clay and tuff. Local lenses of sandy clay and thin to thick beds of sand and conglomerate	Yields small to moderate quantities of fresh to slightly saline water to industrial, rural-domestic, and stock wells.
	Oligocene	Frio Clay	400-600	Gypsiferious clay and thin beds of sand and silt.	Not known to yield water to wells in the county
	Eocene	Jackson Group	1,000-1,500	Brown to buff, sandy shale, fossiliferous sandstone, and beds of volcanic ash. Does not crop out in the county.	Reported to yield small quantities of moderately saline water to a few wells in the northwest part of the county.

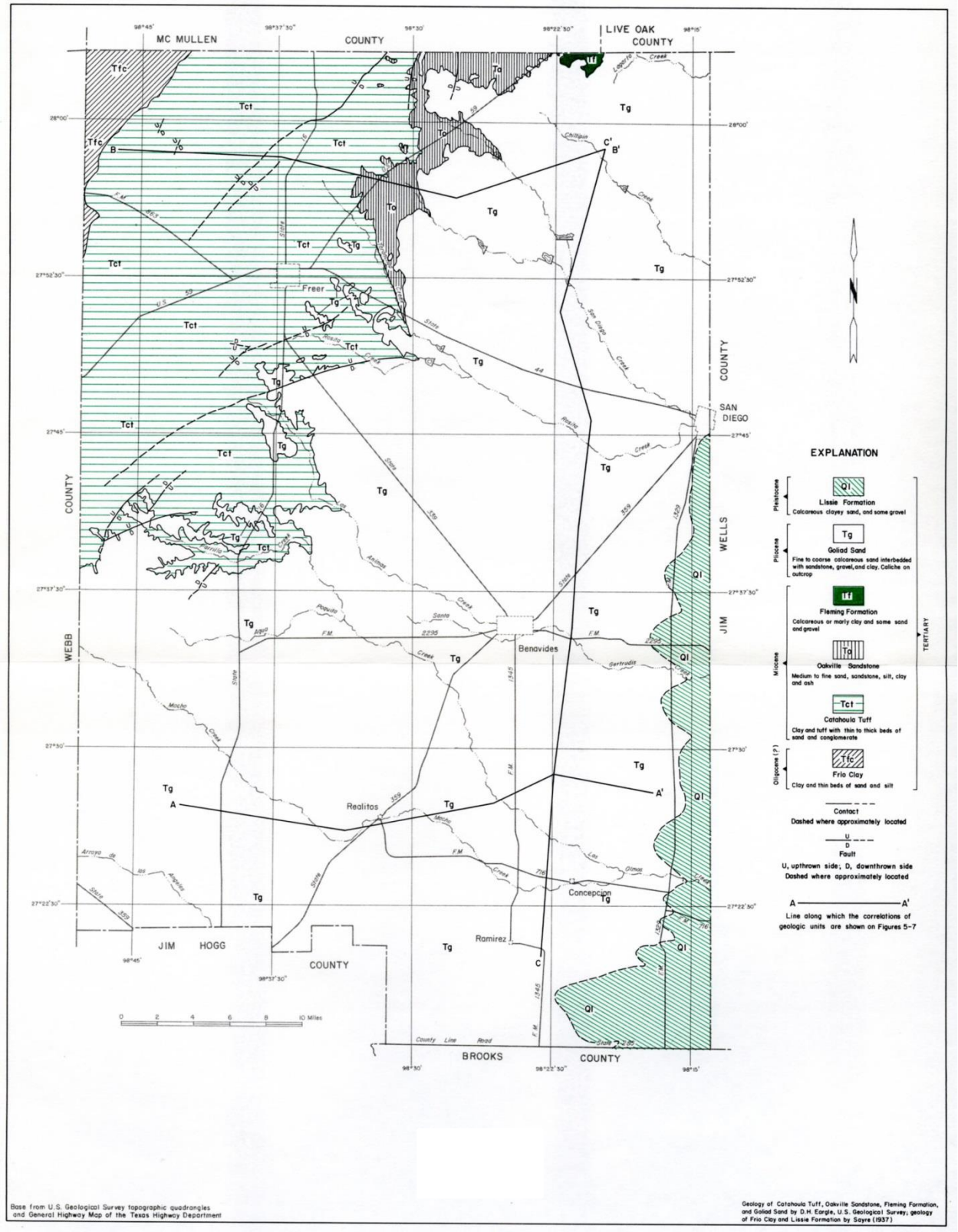

Figure 2. Surficial geology in Duval County (Shafer, 1986)

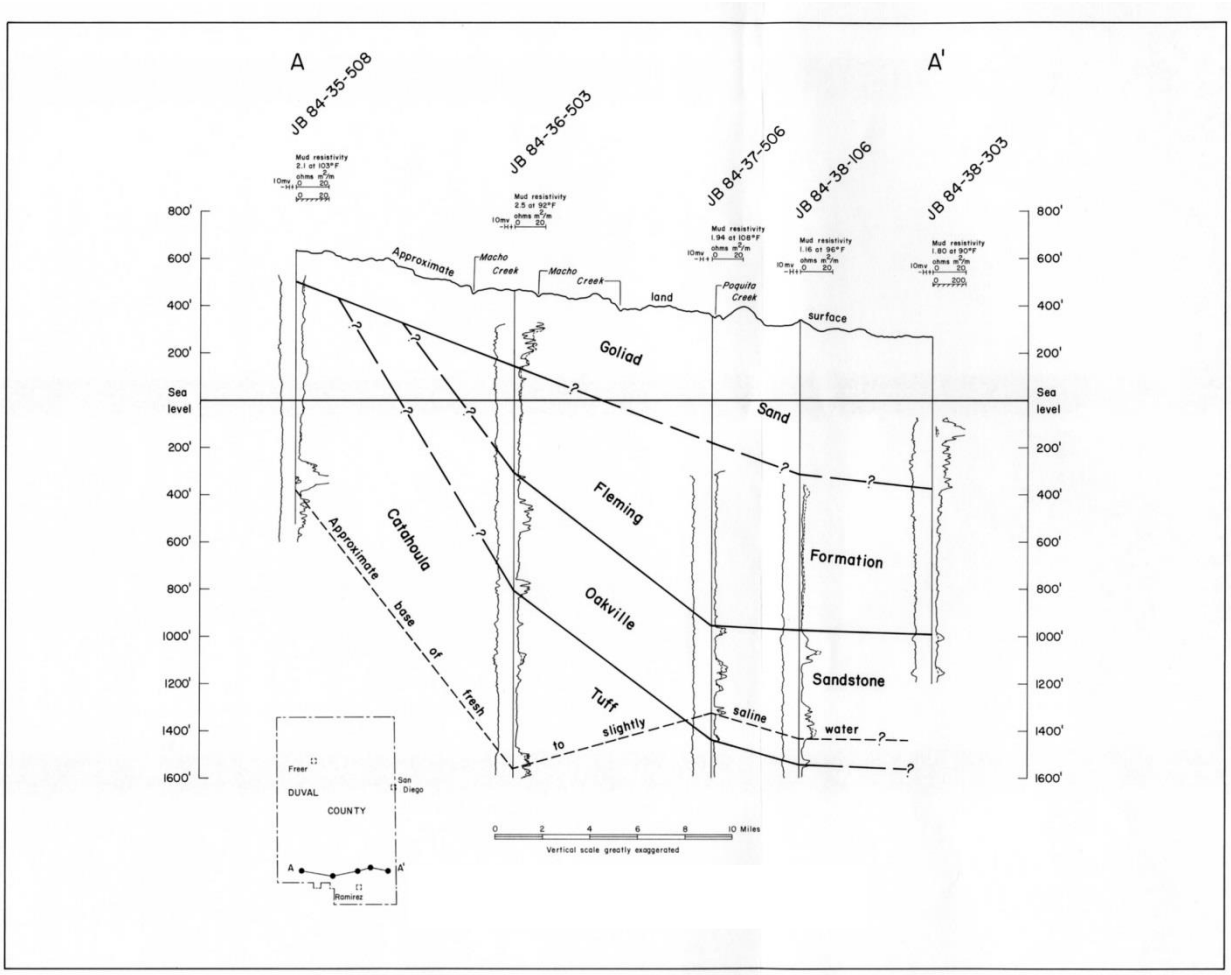

Figure 3. Correlation of geologic units along transect A-A' (Shafer, 1986)

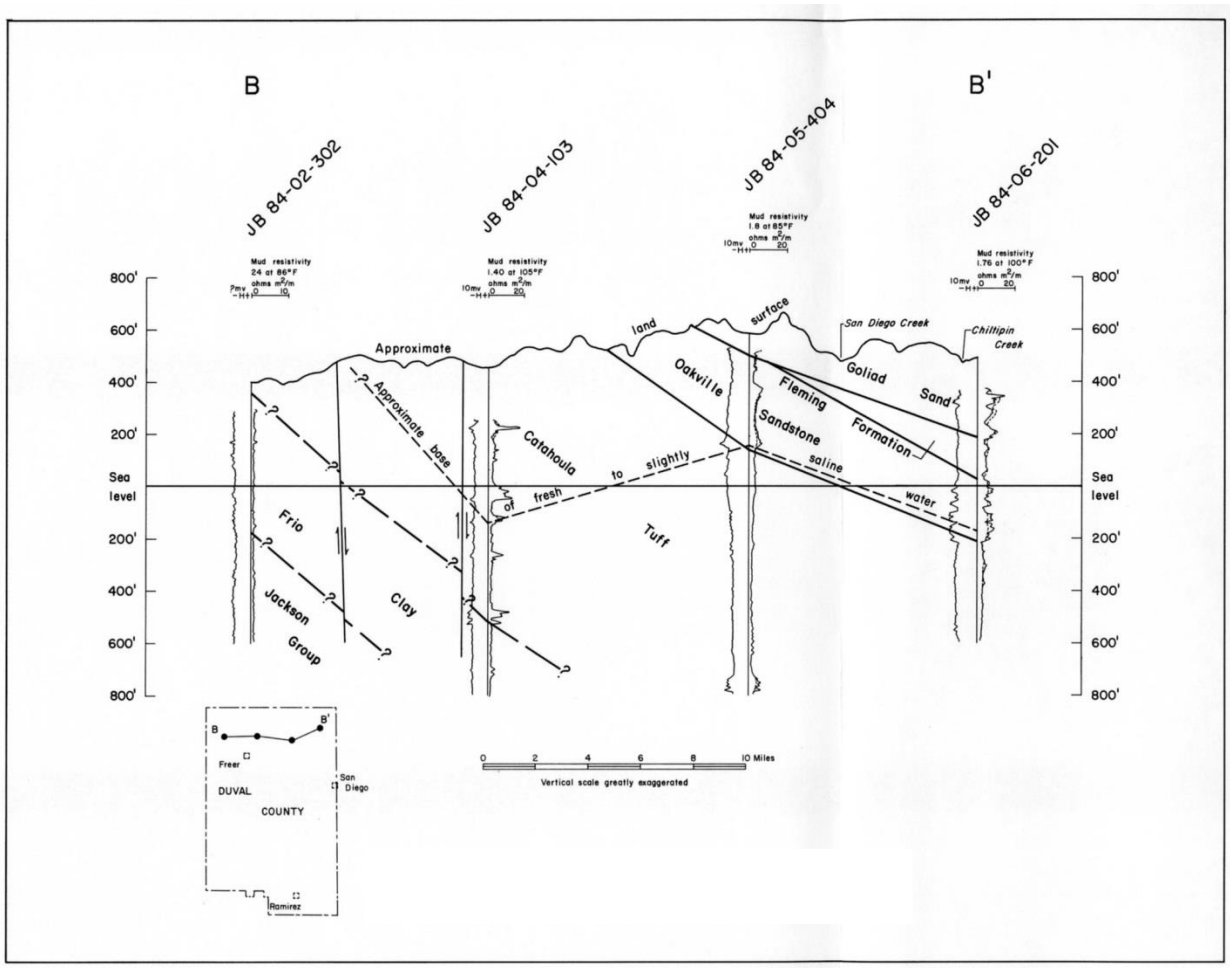

Figure 4. Correlation of geologic units along transect B-B' (Shafer, 1986)

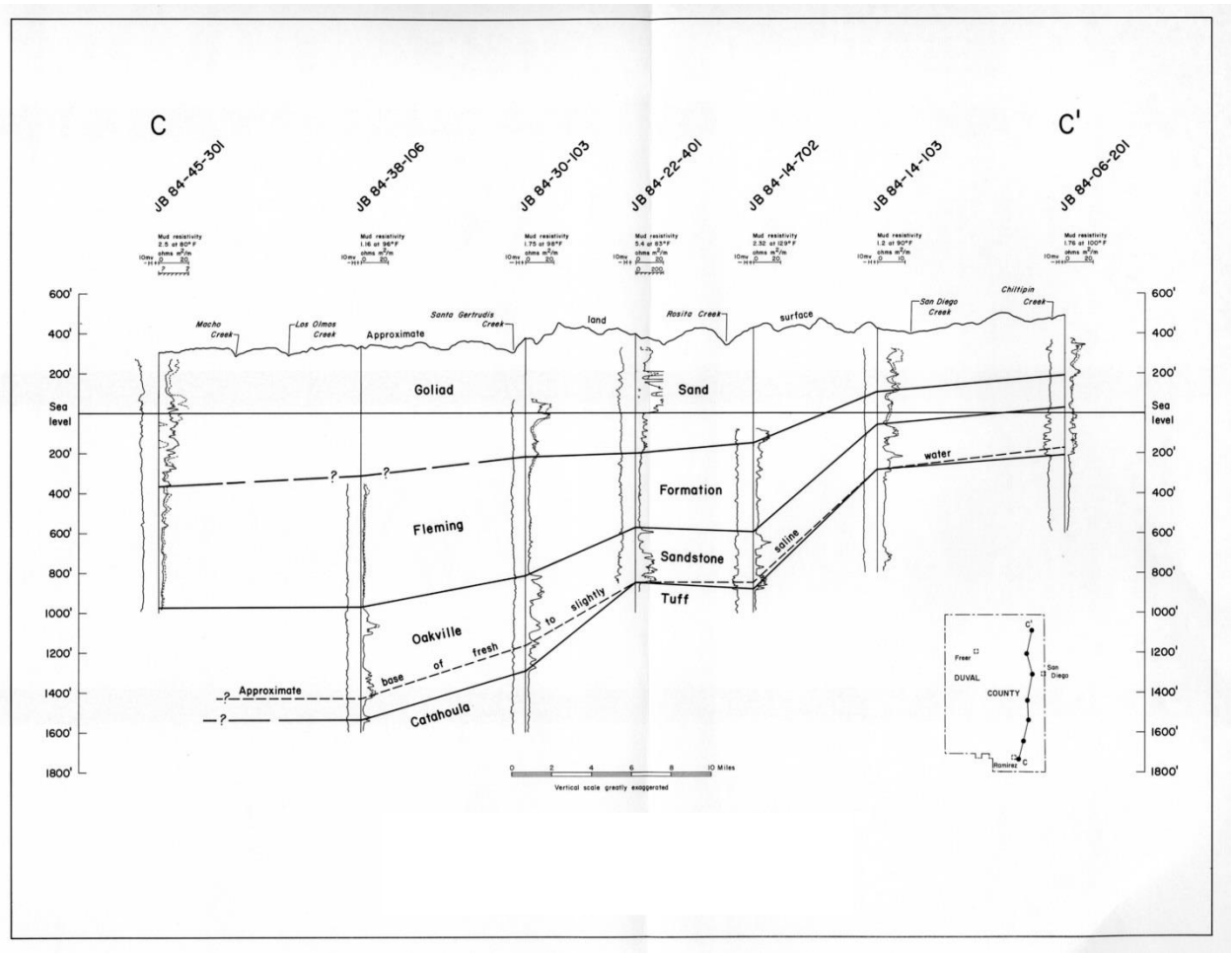

Figure 5. Correlation of geologic units along transect C-C' (Shafer, 1986)

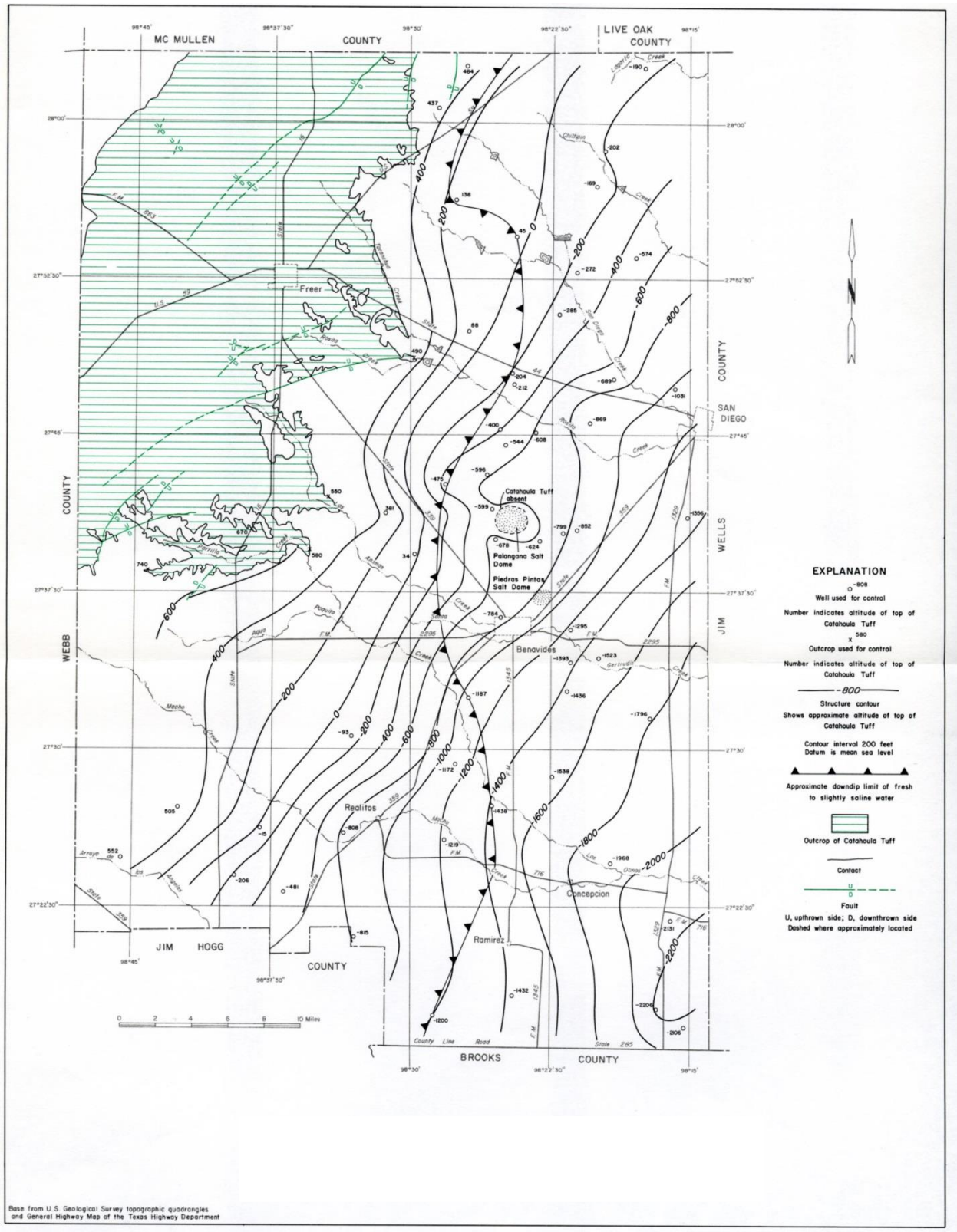

Figure 6. Approximate contour elevation of the top of the Catahoula Tuff (Shafer, 1986)

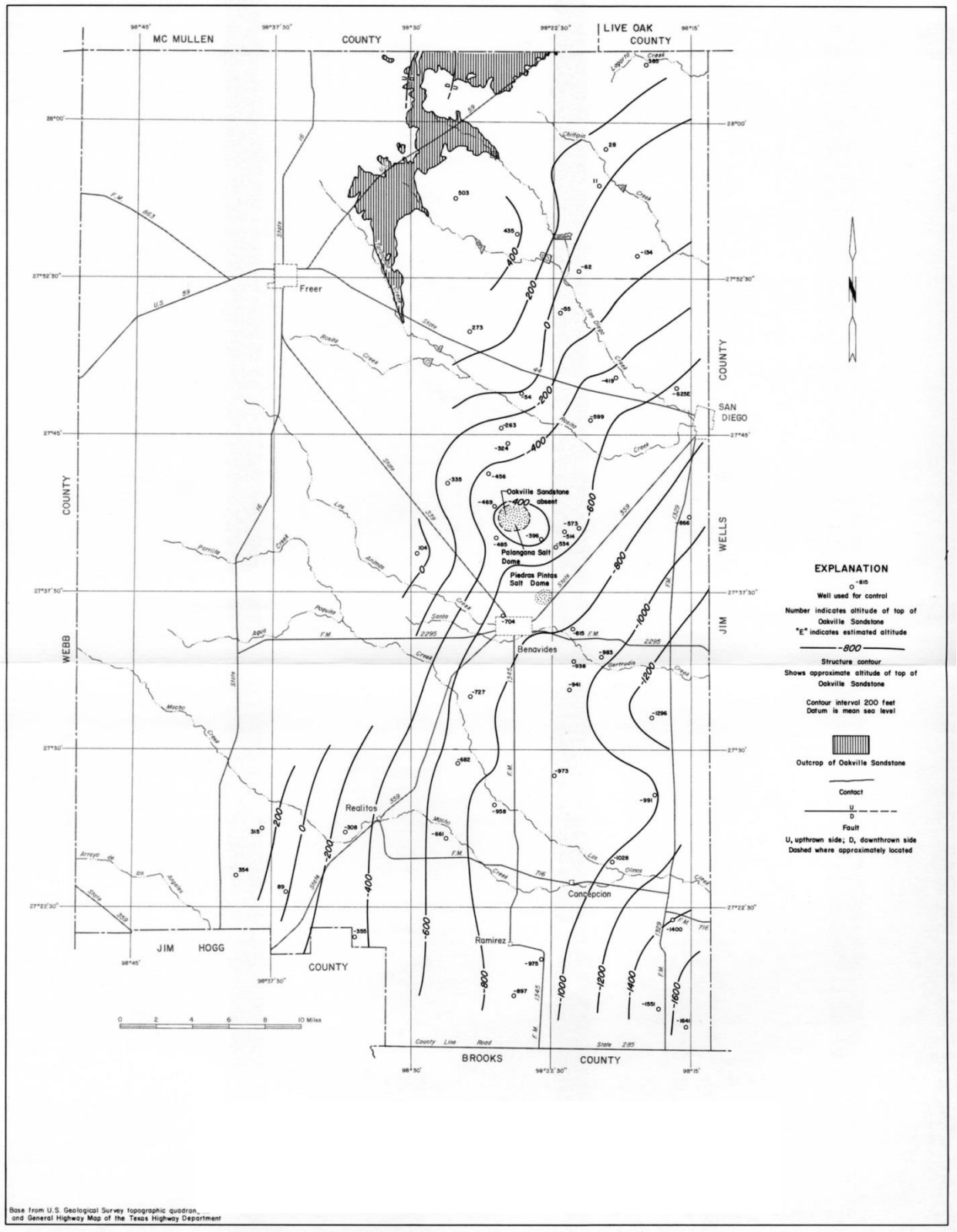

Figure 7. Approximate contour elevation of the top of the Oakville Sandstone (Shafer, 1986)

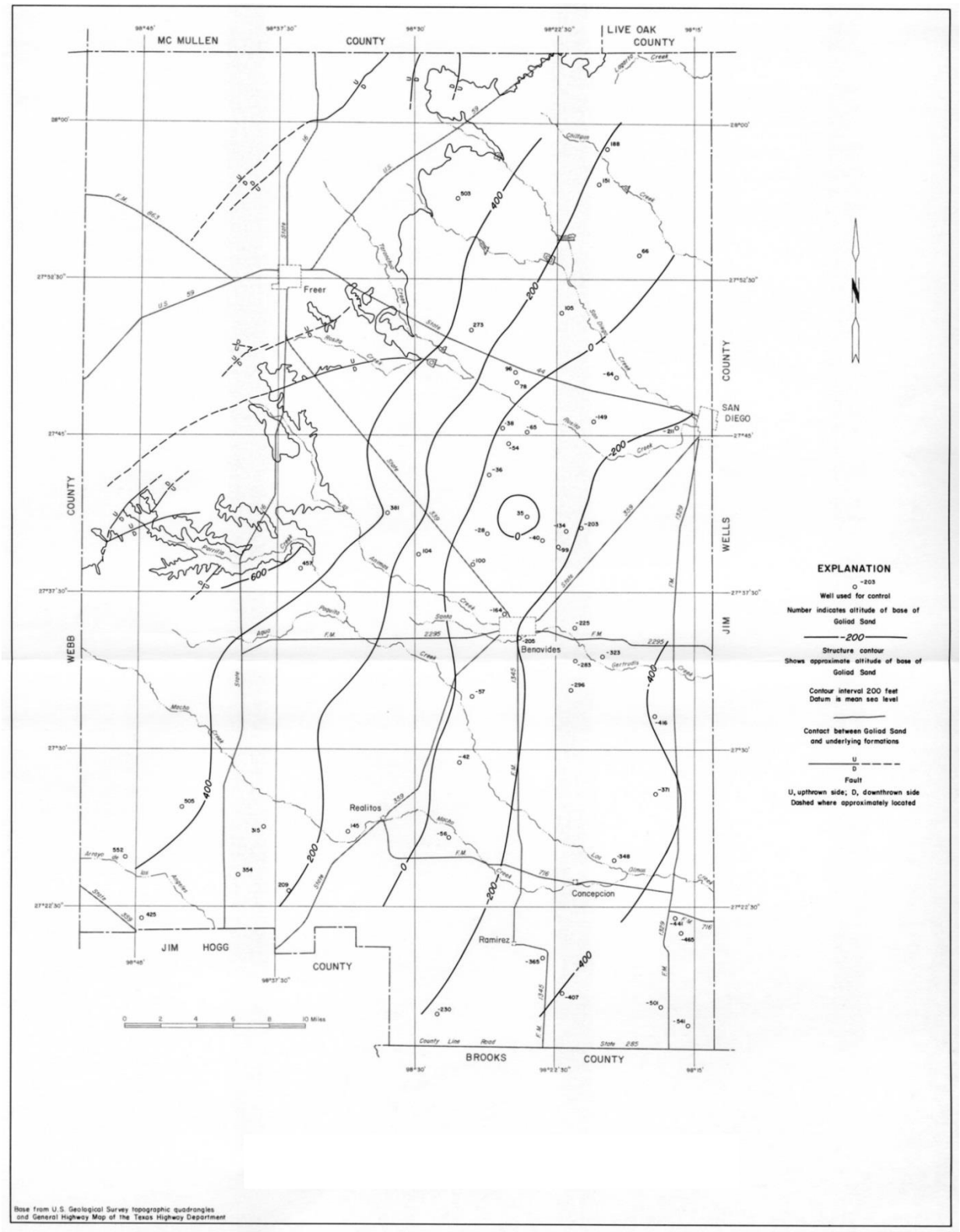

Figure 8. Approximate contour elevation of the base of the Goliad Sand (Shafer, 1986)

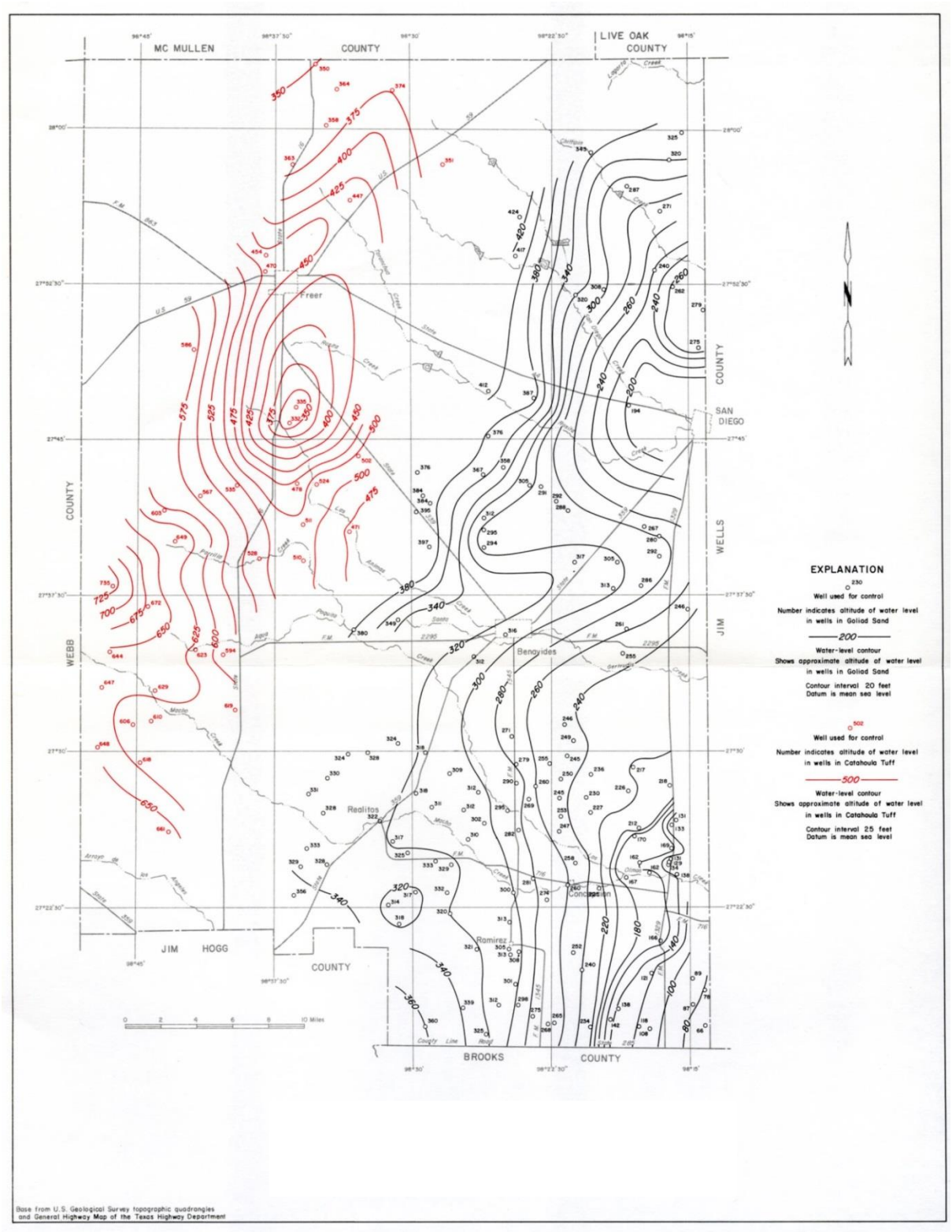

Figure 9. Approximate contour elevation of the groundwater elevations of the Catahoula Tuff (red) and Goliad Sand (black) (Shafer, 1986)

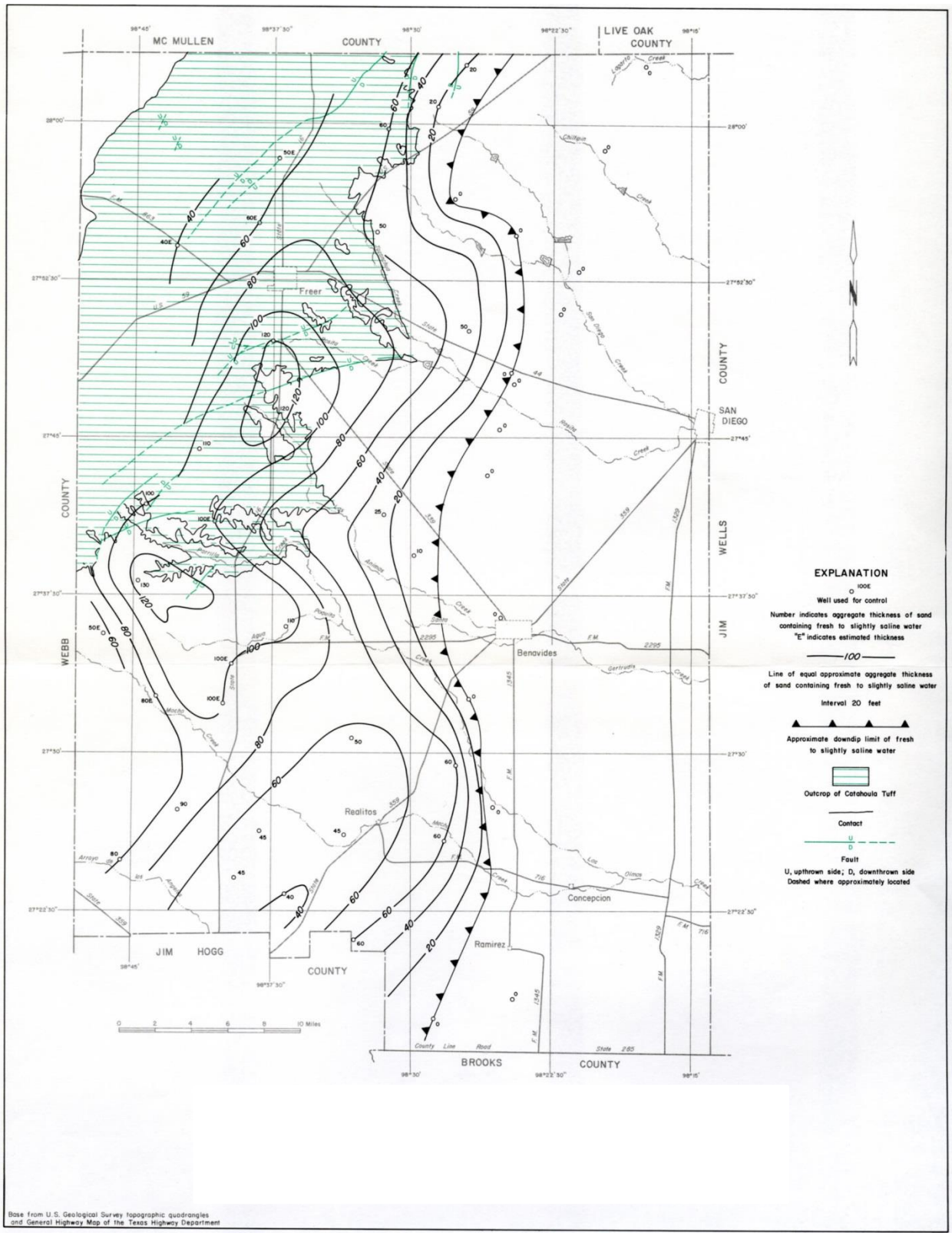

Figure 10. Thickness of the Catahoula Tuff containing fresh-to-slightly saline water (Shafer, 1986)

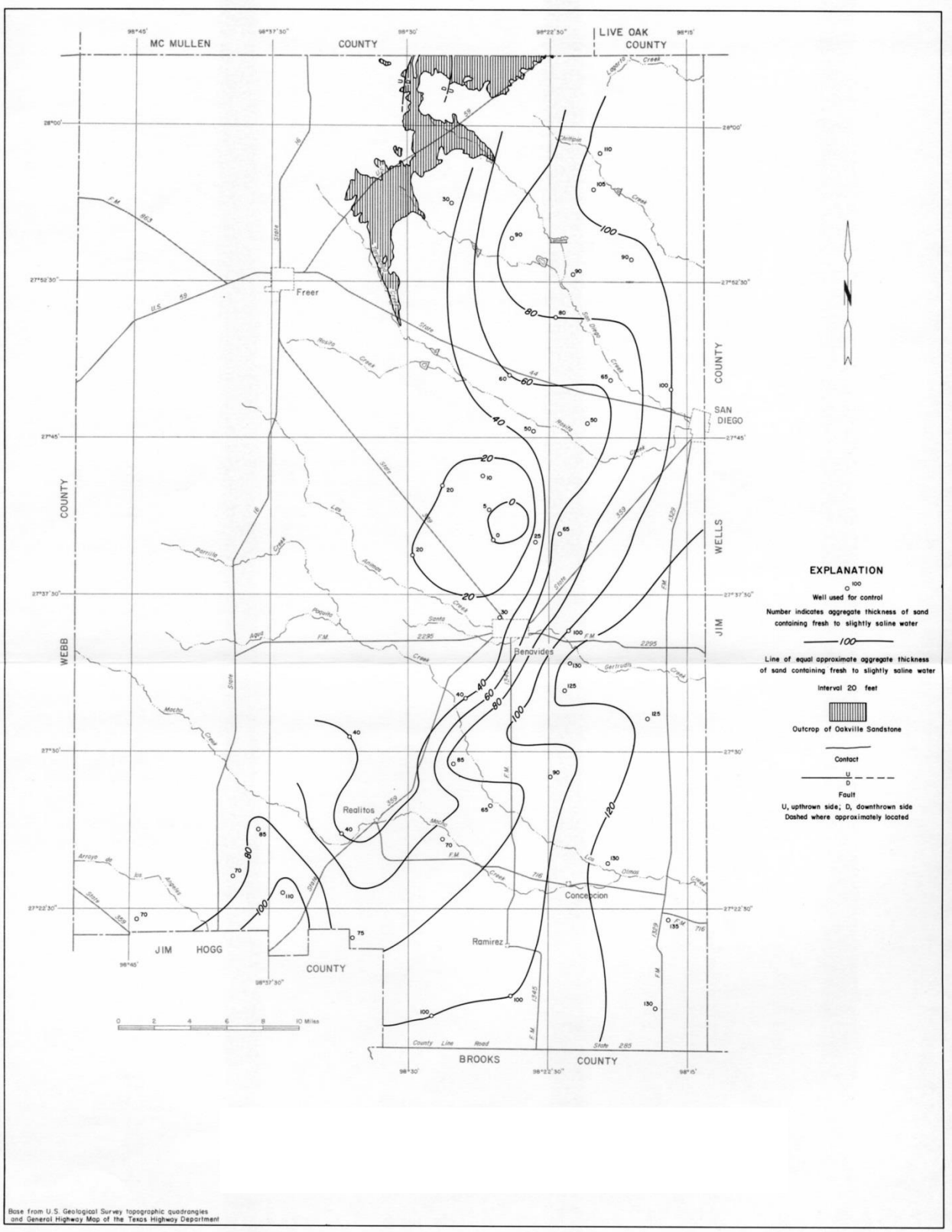

Figure 11. Thickness of the Oakville Sandstone containing fresh-to-slightly saline water (Shafer, 1986)

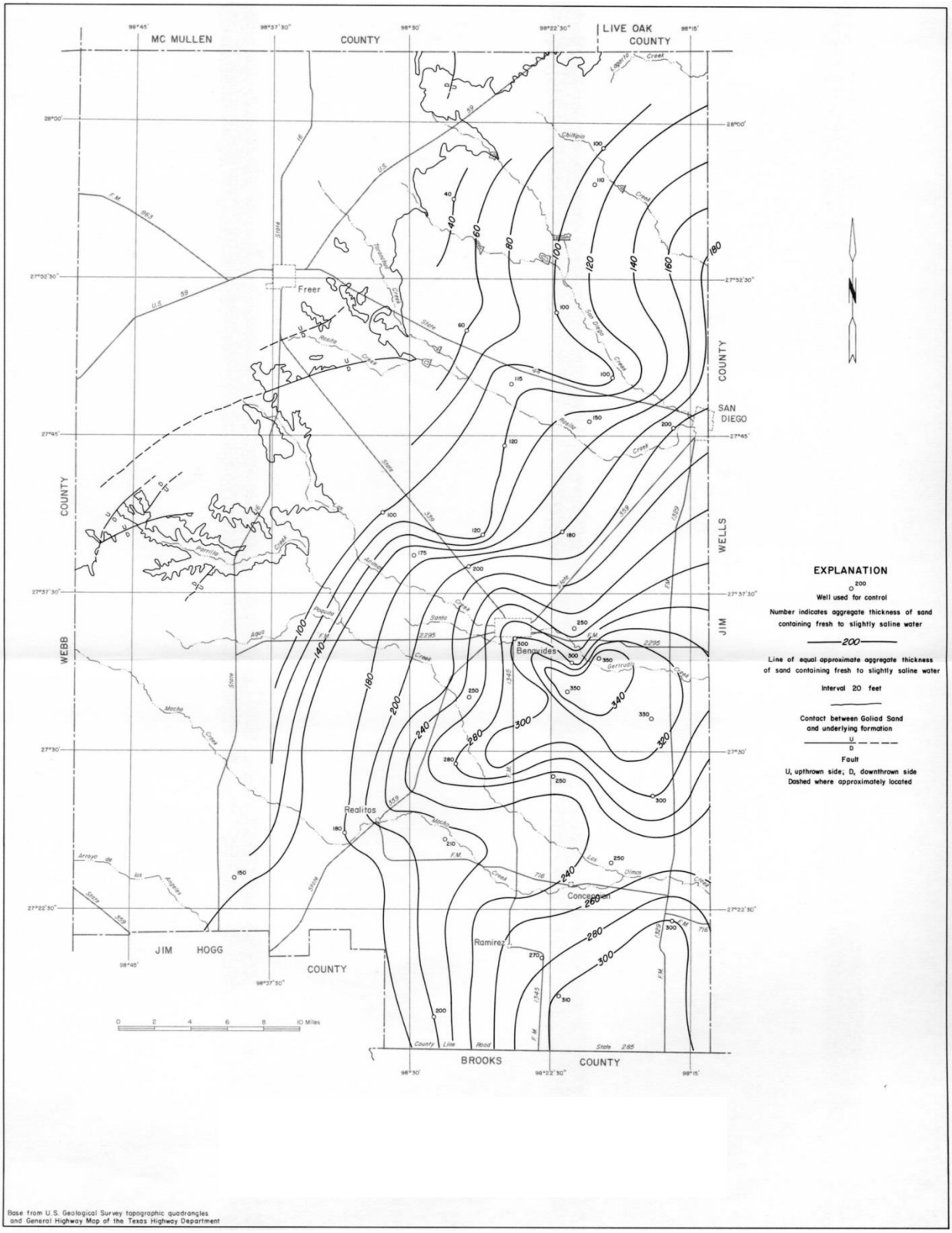

Figure 12. Thickness of the Goliad Sand containing fresh-to-slightly saline water (Shafer, 1986)

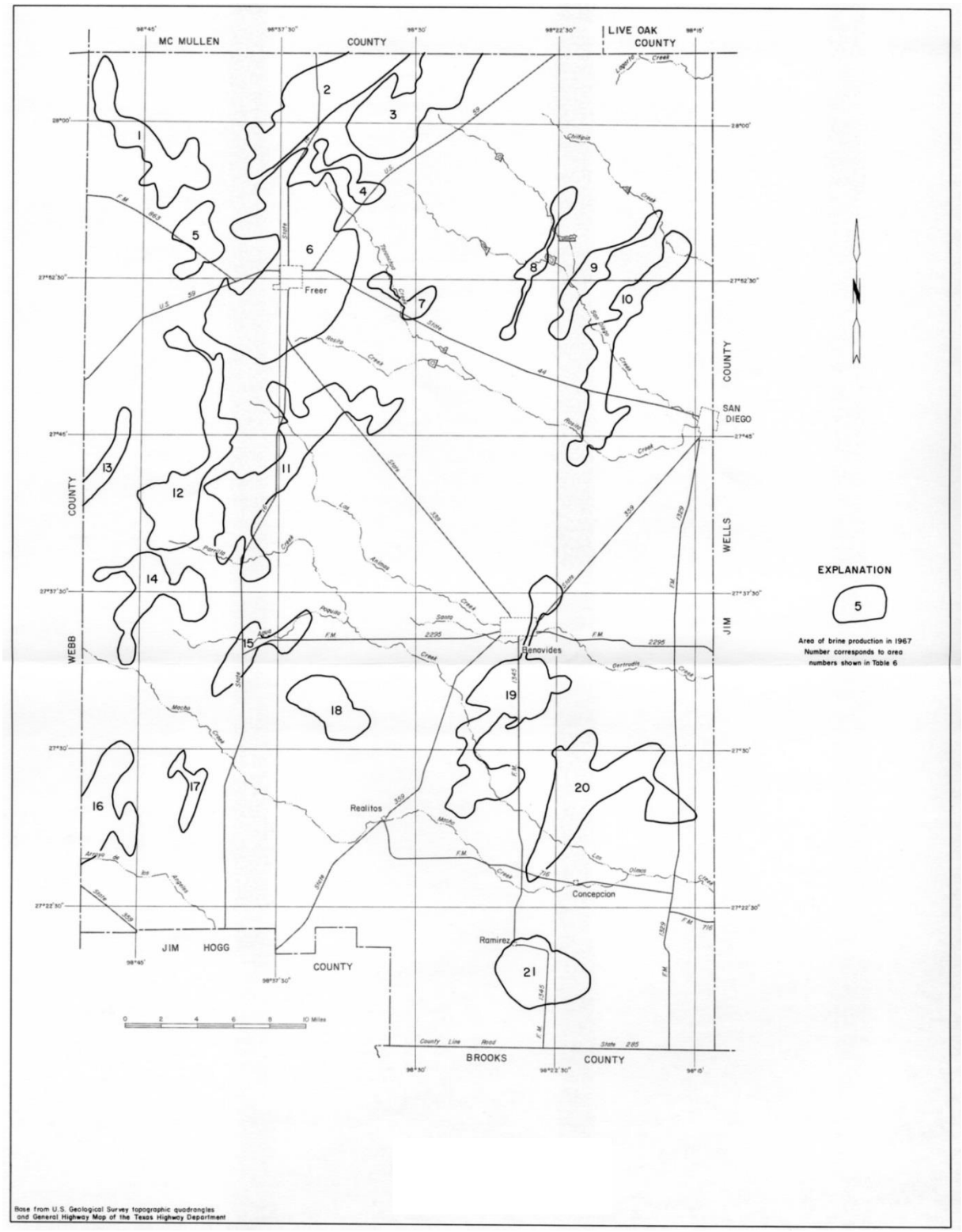

Figure 13. Areas identified with brackish water prior to 1974 (Shafer, 1986)

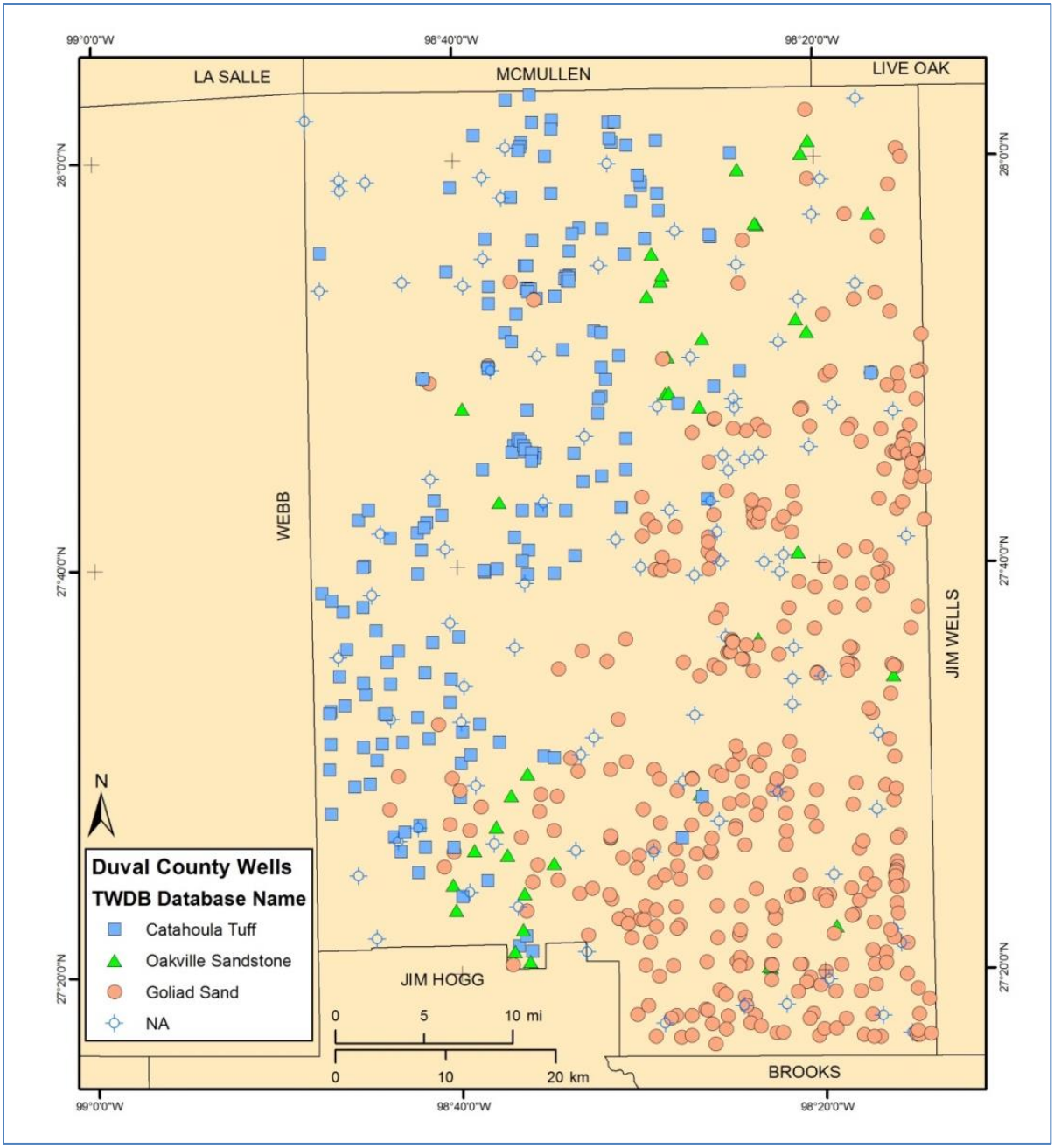

Figure 14. Map of water well locations from the Texas Water Development Board (TWDB) Groundwater Database. Only wells from the three aquifers (Catahoula Tuff – 175 wells, Oakville Sandstone – 39 wells, and Goliad Sand – 373 wells) are shown. Wells identified with other sources (20 wells total) are excluded from the figure. Due to their large number (91 wells) for Duval County, also shown are wells identified as NA (aquifer unit not applicable) in the database. These wells are commonly previous oil/gas exploration wells that have been converted to water use (or TWDB was notified of conversion plans). The status, depth, and aquifer supply for these wells (if ever used for water) are typically not logged by the TWDB.

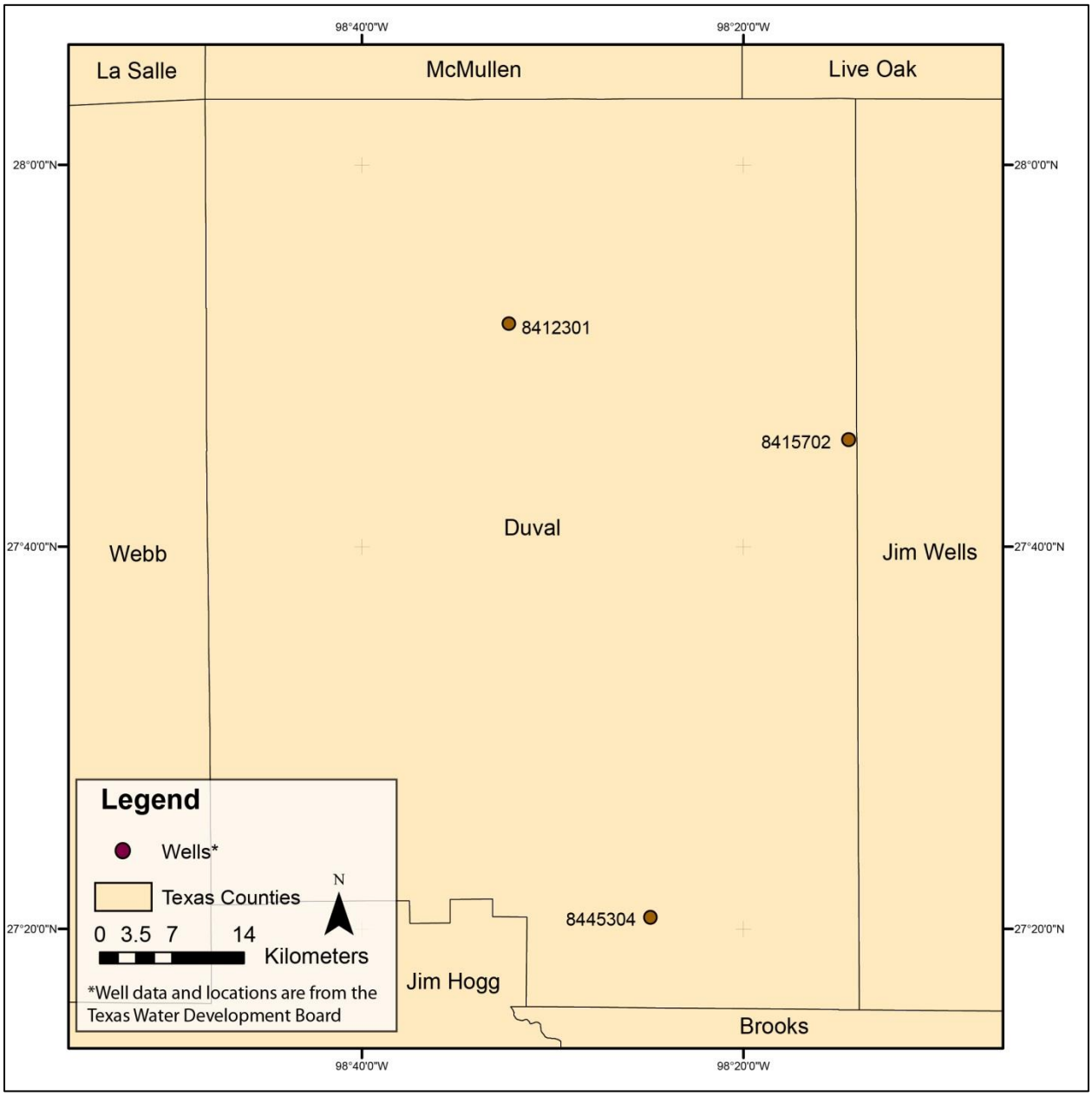

Figure 15. Locations of three wells in Duval County with a relatively long history of water-elevation measurement

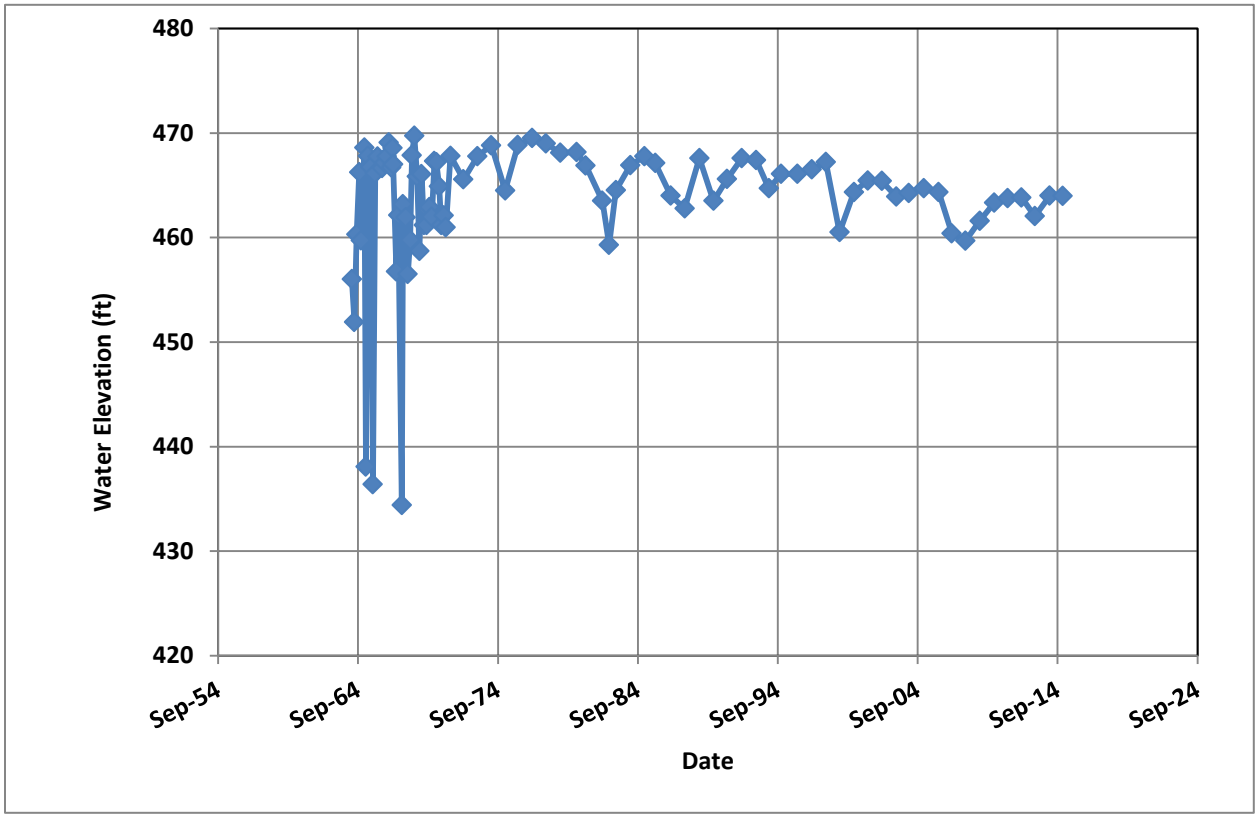

Figure 16. Groundwater elevation at Well 8412301 (TWDB database)

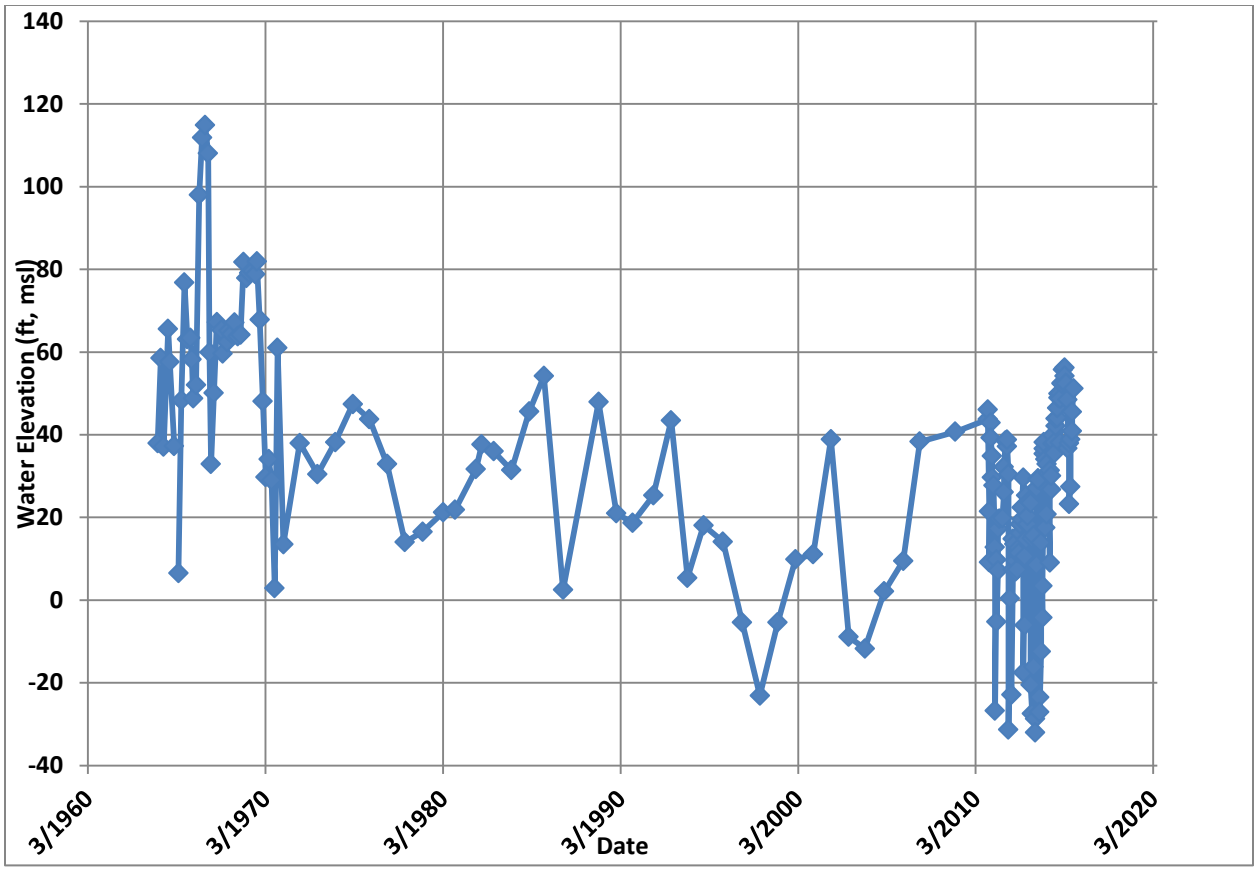

Figure 17. Groundwater elevation at Well 8415702 (TWDB database)

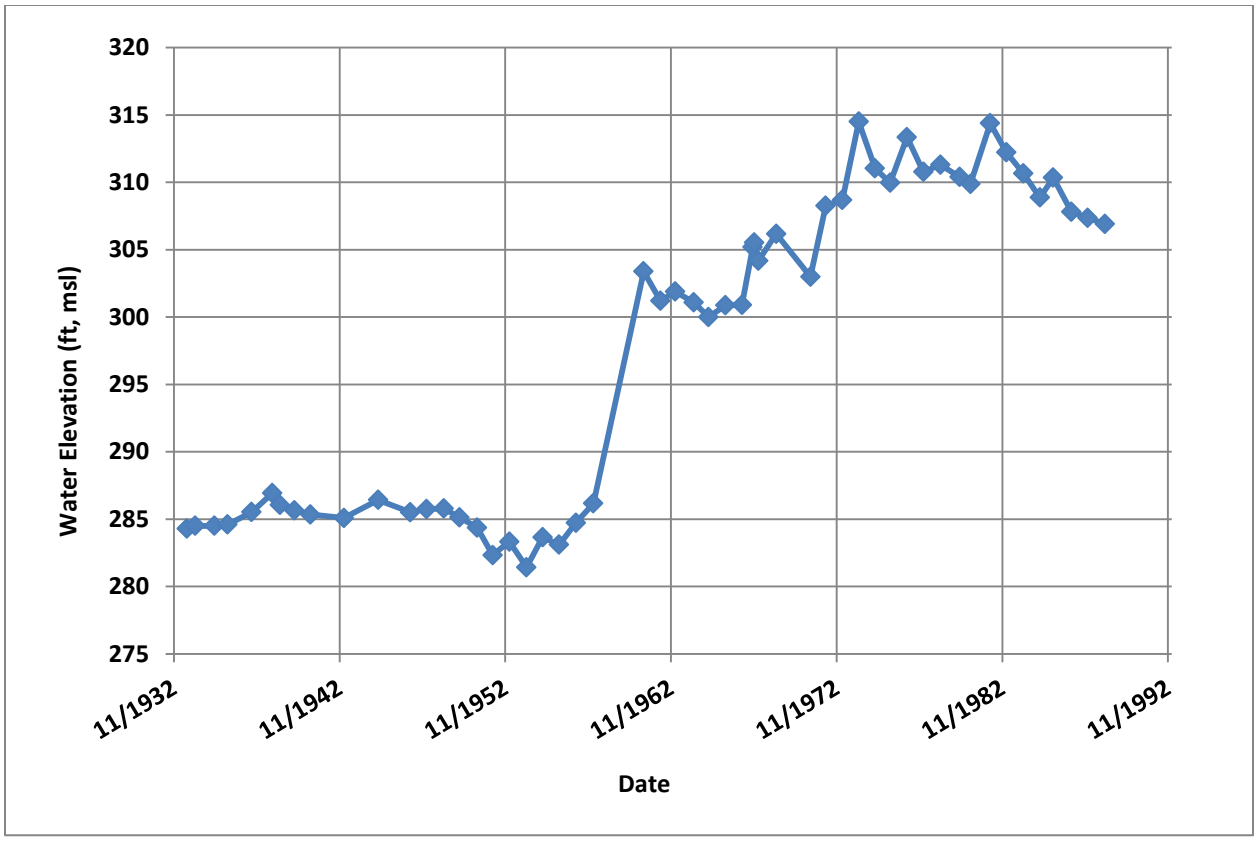

Figure 18. Groundwater elevation at Well 8445304 (TWDB database)

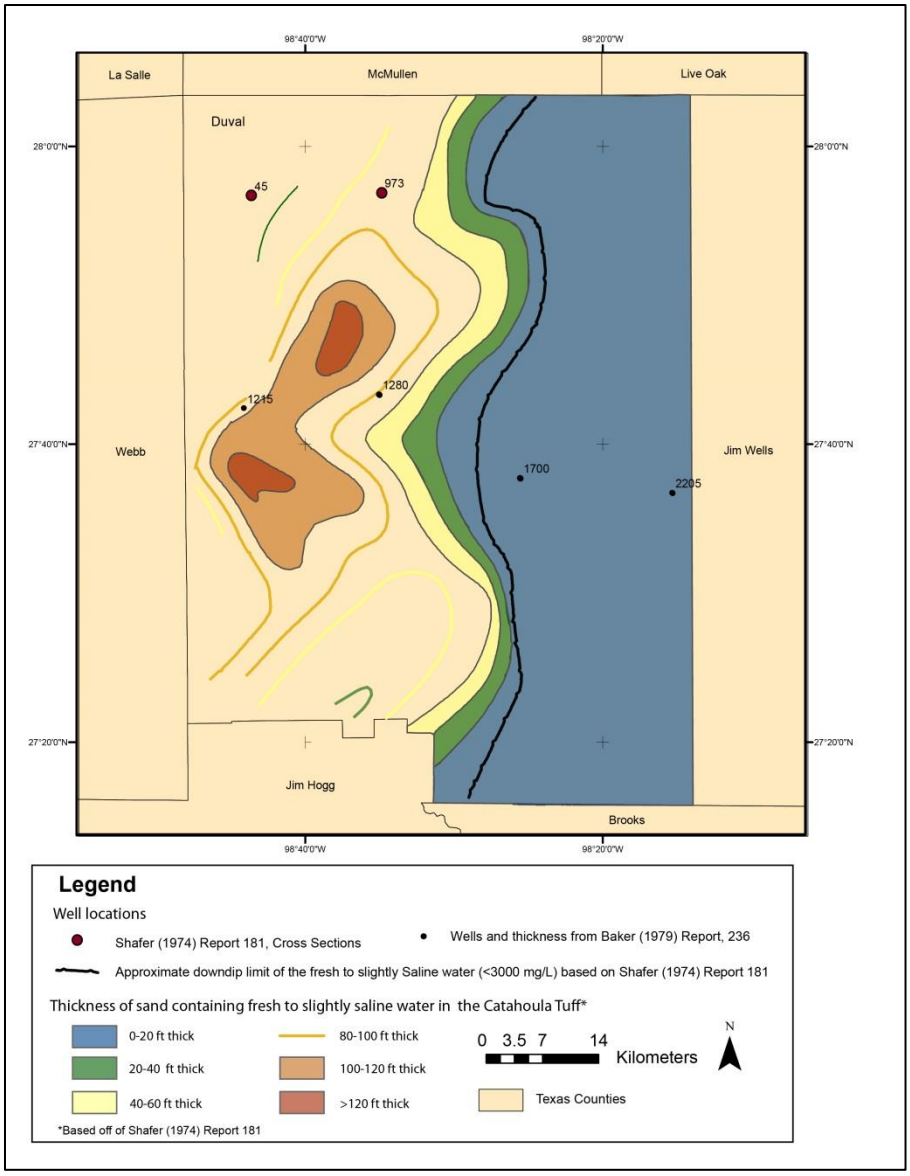

Figure 19. Updated contour map of the thickness of fresh to slightly saline water in the Catahoula Tuff (ft)

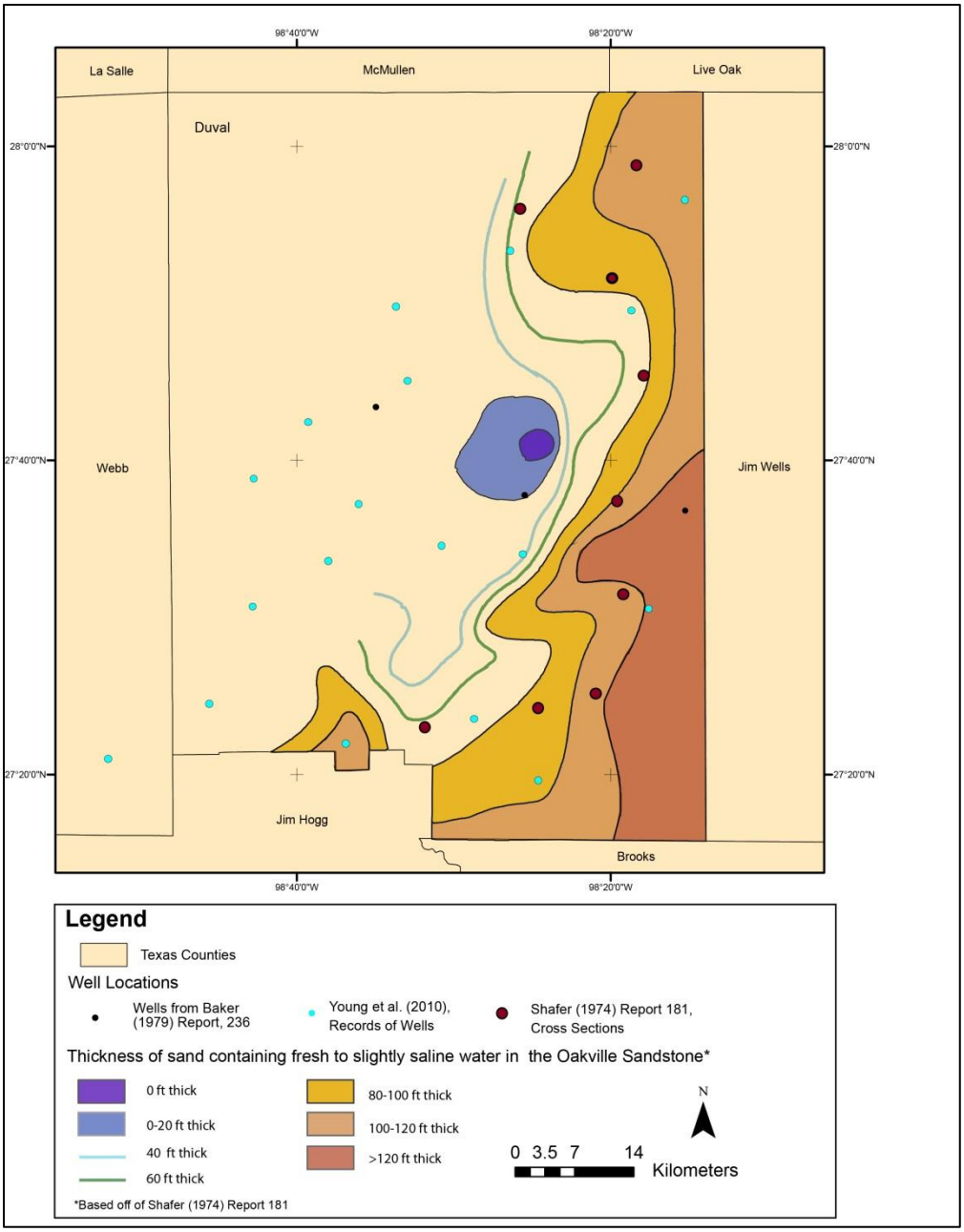

Figure 20. Updated contour map of the thickness of fresh to slightly saline water in the Oakville Sandstone (ft)

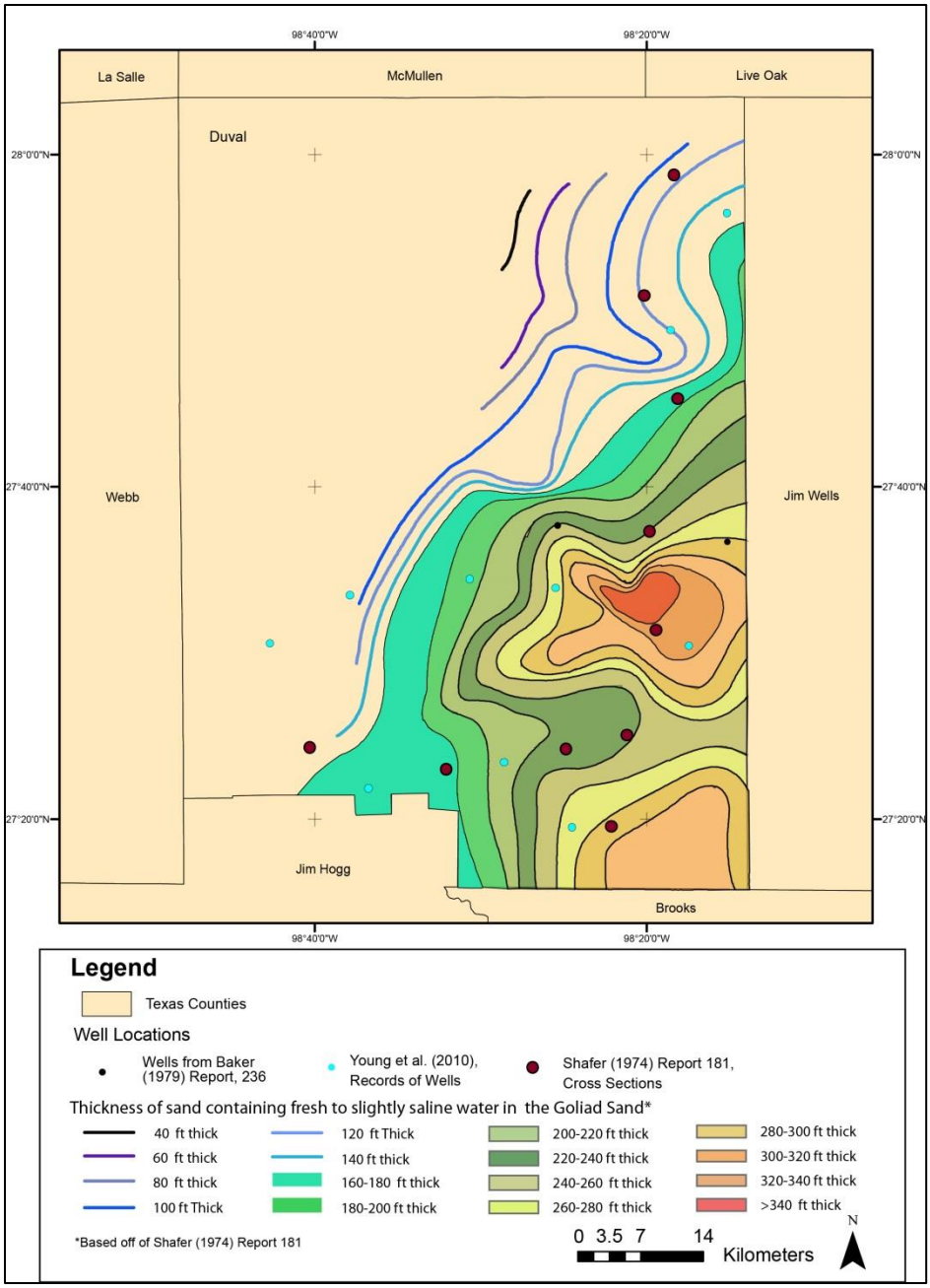

Figure 21. Updated contour map of the thickness of fresh to slightly saline water in the Goliad Sand (ft)

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