EVALUATION OF THE SANTA ROSA AQUIFER IN GLASSCOCK COUNTY

by

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Texas Water Development Board

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INTRODUCTION

In 1985 the Texas Department of Water Resources (TDWR) was engaged in a regional investigation of the Triassic and Cretaceous deposits which underlie the Ogallala Formation on the High Plains of Texas. The investigation was prompted by the need to determine if additional usable-quality ground water exists in the area to supplement the dwindling supply currently available from the Ogallala Formation and Antlers Sand.

Several test holes were drilled as part of this investigation to supplement data provided by the few wells which penetrate the Triassic deposits. Test hole sites were carefully selected based on funds available and the likelihood of encountering usable-quality water. Originally no test holes were planned for Glasscock County because of the scarcity of funds and the likelihood of encountering poor quality water. The Glasscock County Underground Water Conservation District (GCUWCD), however, requested that the TDWR drill test holes and agreed to reimburse half of the drilling costs incurred. A contract was signed and drilling was initiated on August 22, 1985.

METHOD OF INVESTIGATION

The primary purpose of these test holes was to obtain water samples from the Santa Rosa aquifer for analysis to determine if it contained usable-quality water. Test hole sites (Figure 1) were based on the best possible location in anticipation of

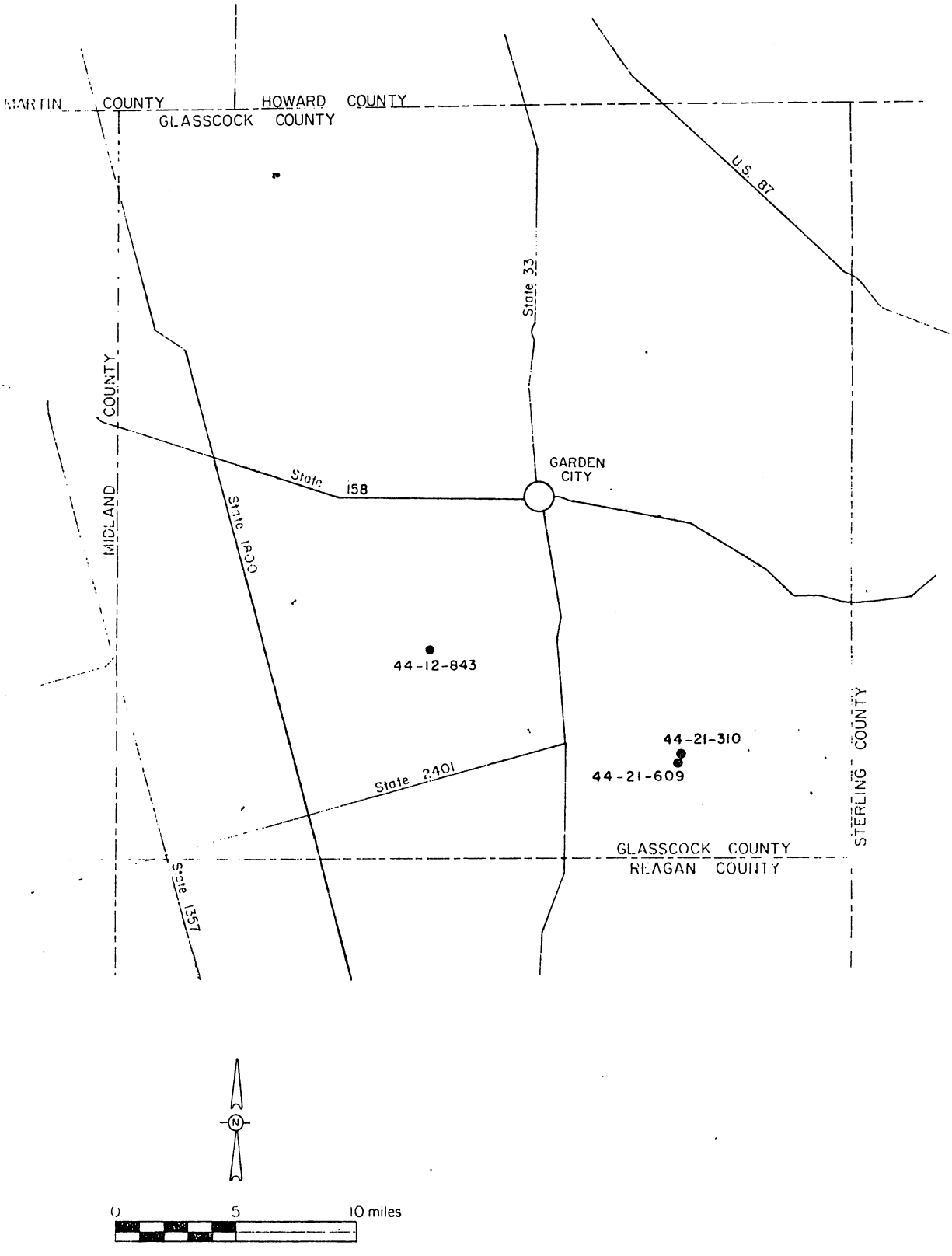


Figure 1

Location of Test Holes

encountering usable-quality water based on available information. The GCUWCD was advised from the outset that the prospect of encountering good water from the Santa Rosa in Glasscock County was very unlikely.

The first test hole, 44-12-843, was drilled to the base of the Santa Rosa and then logged with the Board's geophysical logging unit to identify the water-bearing strata present. A water sample was then collected utilizing the "El Paso Method." The method involved setting slotted pipe adjacent to the desired water-bearing zone in the Santa Rosa and then placing gravel around the pipe in the mud-filled hole to a sufficient depth to isolate it from the Antlers Sand above. The test hole was then air jetted for several hours until it was determined the water sample being collected was representative of the Santa Rosa water.

The second test hole, 44-21-310, was drilled to near the base of the Santa Rosa and logged but, due to lost circulation and caving problems, a water sample from the Santa Rosa aquifer could not be obtained. In order to fulfill the terms of the contract, a third test hole, 44-21-609, was drilled in the same area. The hole was cased to the top of the Santa Rosa to prevent a reoccurrence of the lost circulation and caving problems. Drilling was then continued into the Santa Rosa and upon completion a water sample was collected utilizing air jetting.

Upon completion of the water sampling process, each test hole was plugged with cement to prevent contamination of the Antlers Sand water with undesirable water from the Santa Rosa aquifer. Water samples collected were transported to the Texas Department of Health Laboratories in Austin for analyses.

GEOHYDROLOGY OF THE SANTA ROSA SANDSTONE

Triassic rocks, as they occur in the subsurface in Glasscock County, are represented by the Dockum Group (Table 1) which has been described by numerous investigators as consisting of fine- to coarse-grained clastic sediments deposited by streams and rivers into a large, closed, lake environment known as the Midland Basin. Dockum sediments grade from thick sandstone sections in the lower portion to siltstone and mudstone in the upper.

The name "Santa Rosa" was given to a lower Dockum sandstone formation that crops out in northeastern New Mexico and can only very generally be traced eastward into the subsurface. In Texas, the sequence of sandstone units in the lower Dockum is collectively classified as the Santa Rosa aquifer and is not intended as stratigraphic nomenclature.

The lower Dockum sandstone in Glasscock County consists of reddish-brown, gray, and tan, fine- to coarse-grained, moderately indurated sand and silt which averages 200 feet in thickness. The strata generally dips northwestward toward the center of the depositional basin as shown on the structure maps (Figures 2 and 3) and geologic cross sections (Figures 4 and 5) which were constructed based on correlations made from geophysical logs run on two of the test holes and those of 58 oil tests (Appendix A) previously drilled in Glasscock and surrounding counties. A north to south subsurface ridge can also be identified from the figures.

Table 1. -- Stratigraphic Units and Their Water-Bearing Properties

System	Series or Group	Stratigraphic Unit	Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithologic Character	Water-Bearing Characteristics
Quaternary	Pleistocene			15	Windblown cover sand.	May yield small supplies to shallow wells.
Cretaceous	Fredericksburg	Segovia	Edwards and Associated Limestones	300	Cherty limestone and dolomite.	May contain small amounts of water in perched
		Fort Terrett			layer.	
	Trinity	Antlers Sand	Antlers Sand	100	Sand, sandstone, conglomerate, and siltstone.	Yields small to moderate supplies. Primary source of ground water in the county.
Triassic	Dockum	Upper Dockum	Chinle	660	Siltstone and clay; reddish brown.	Yields very small amounts of saline water from sand lenses.
		Lower Dockum	Santa Rosa	320	Sandstone and siltstone; reddish brown, gray, and tan; fine- to coarse-grained.	Yields small to moderate amounts of saline water.
			Tecovas	—	Clay; red to reddish brown.	Not known to yield water to wells.

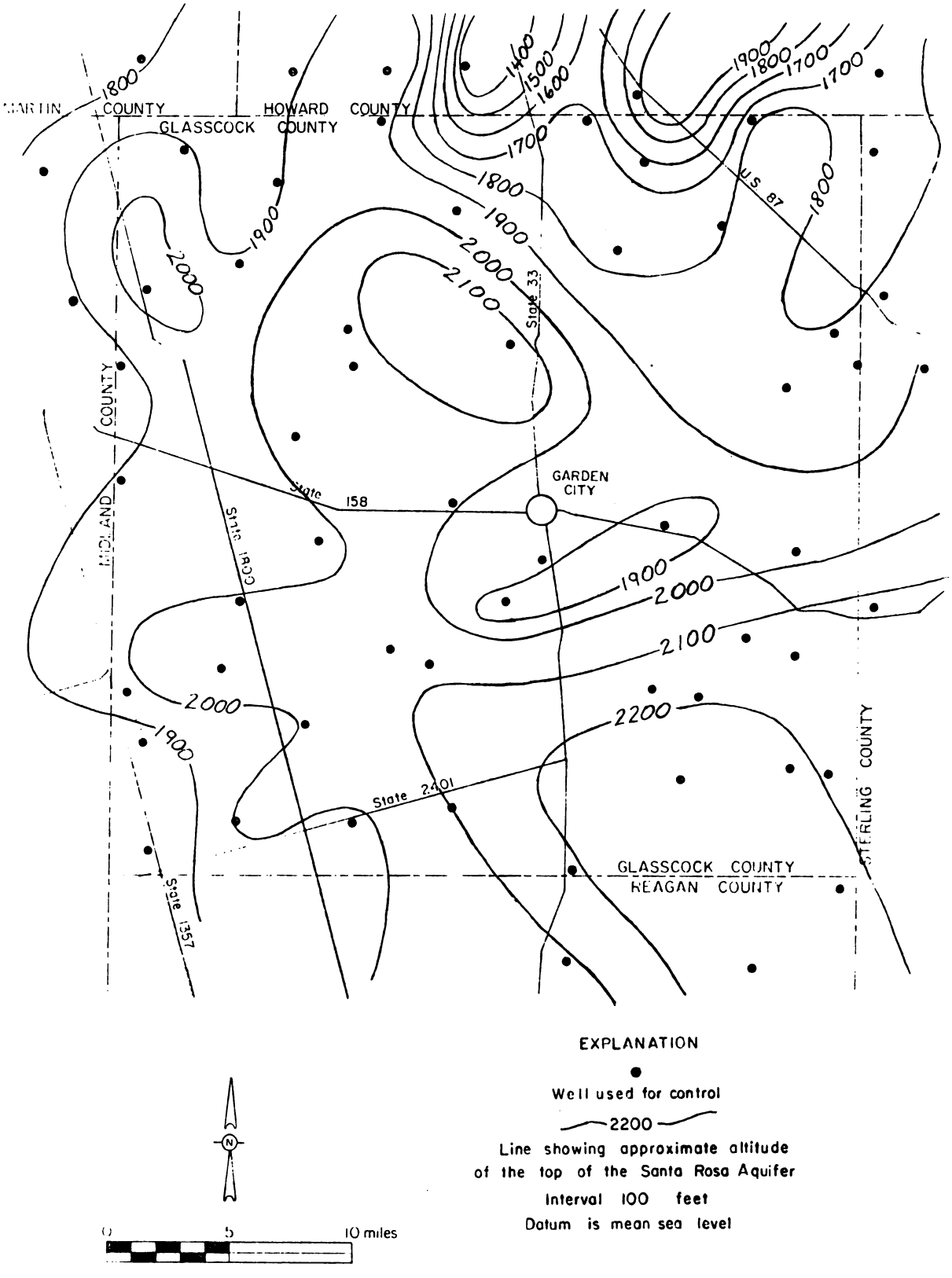


Figure 2

Approximate Altitude of the Top of the Santa Rosa Aquifer

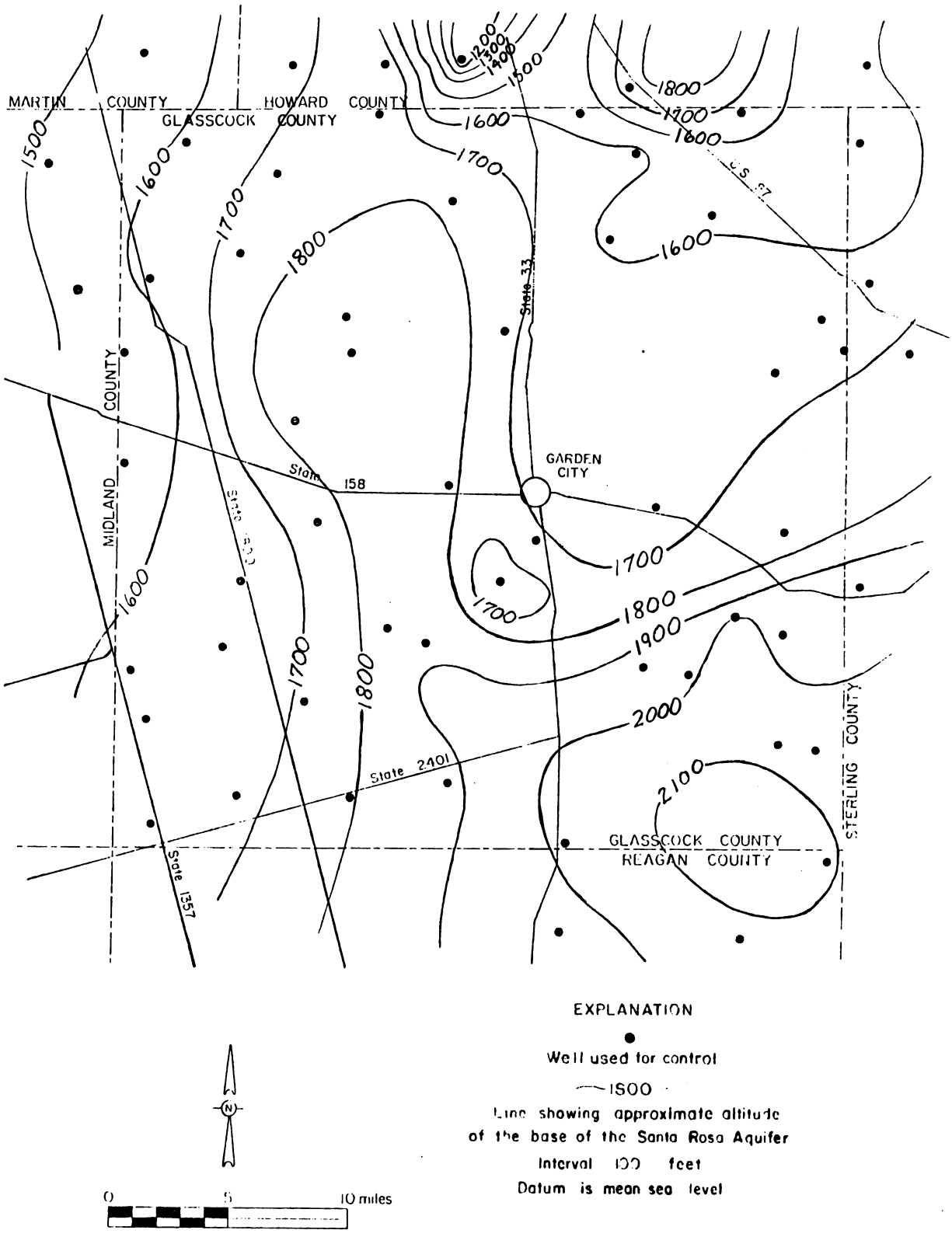


Figure 3

Approximate Altitude of the Base of the Santa Rosa Aquifer

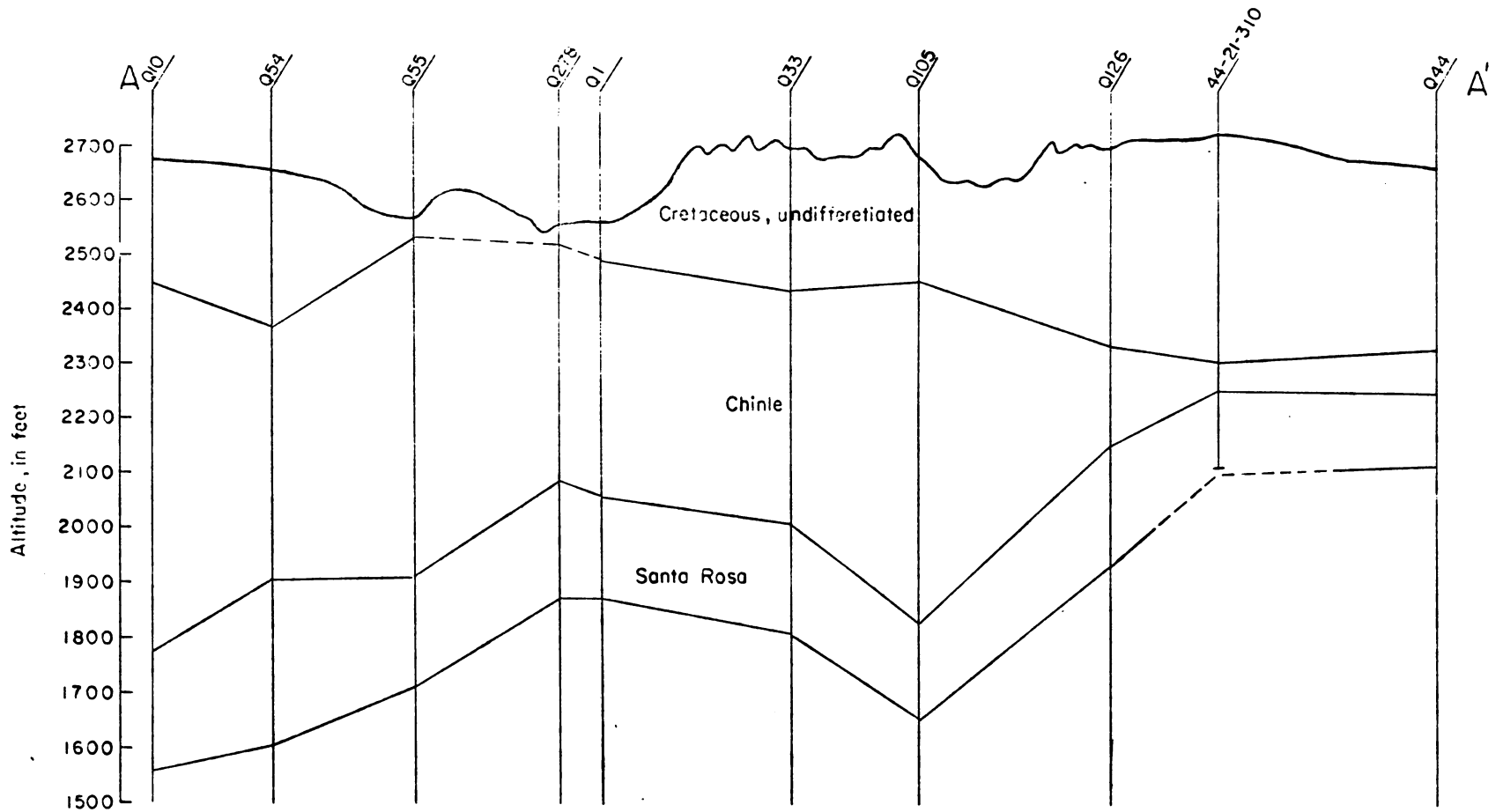


Figure 4

Geologic Cross Section A–A'

Location of cross section shown in Appendix A.

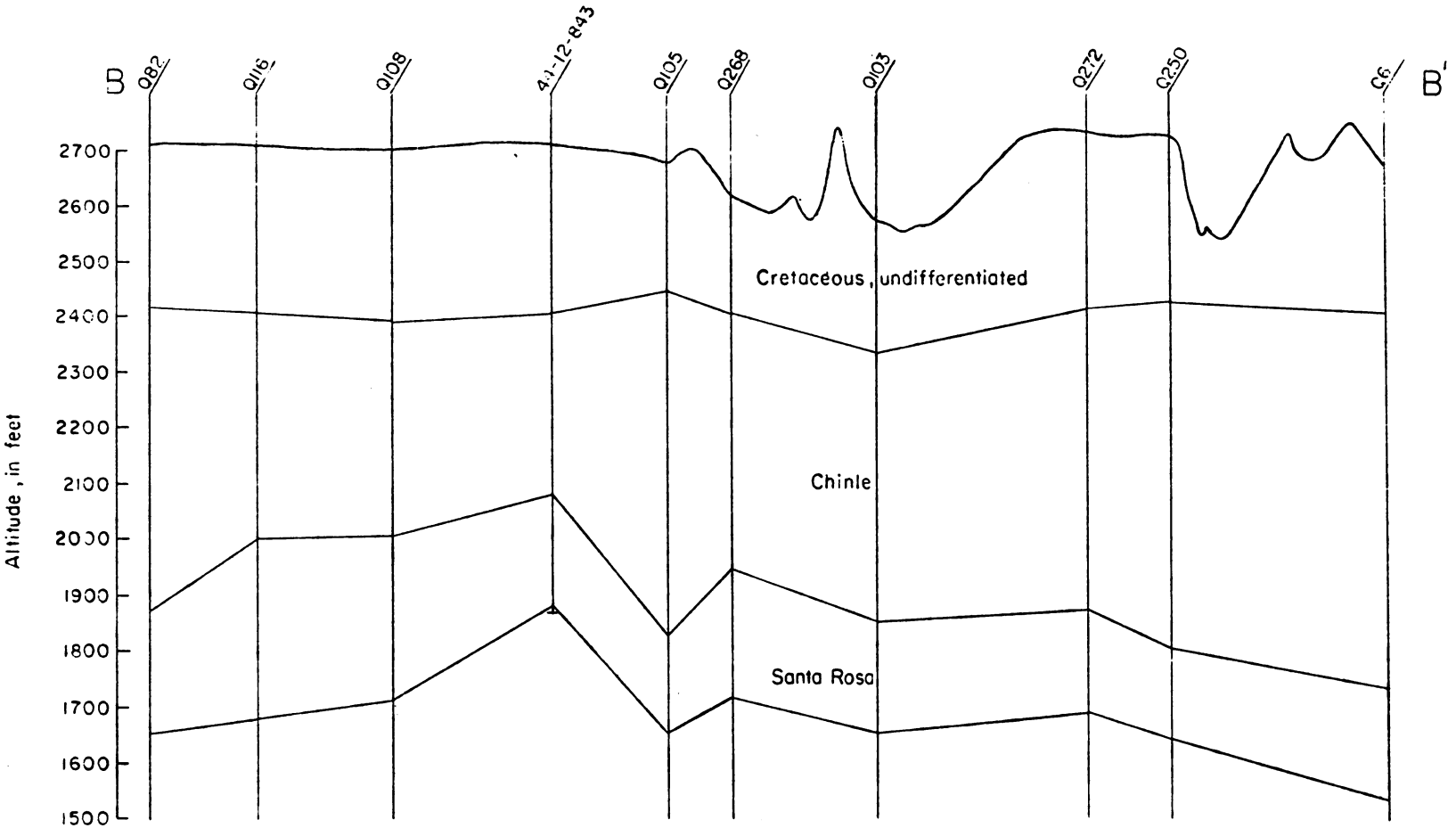


Figure 5

Geologic Cross Section B–B'

Location of cross section shown in Appendix A.

The remaining portion of the Dockum above the lower sandstone units is generally equivalent to the Chinle Formation and is referred to as the "red bed" on drillers' logs. This section consists of reddish-brown silt, clay, and mudstone with occasional lenses of fine-grained sandstone that may contain a very limited amount of usually poor quality water. Thickness of this unit in Glasscock County ranges from over 600 feet to less than 100 feet in the southeast part of the county (Figure 4).

Very little recharge occurs to the Santa Rosa aquifer in Glasscock County. The amount of water entering the Santa Rosa aquifer from above is negligible since downward movement of water from the Antlers Sand must travel through the poorly permeable Chinle Formation. Fresher water occurs in the lower Dockum northeast of Glasscock County in Howard, Mitchell, and Sterling Counties where the sandstone units are exposed at the surface and are recharged directly by precipitation. This fresh water does not migrate toward Glasscock County because the altitudes of the water levels in the aquifer are higher in Glasscock County than in the oucrop; thus creating a hydraulic gradient which causes ground-water movement toward the outcrop in Howard, Mitchell and Sterling Counties.

The Santa Rosa aquifer is artesian, which means that the water occurs under hydrostatic pressure which causes it to rise above the top of the formation. In test hole 44-12-843 the top of the formation is 628 feet below the surface. Water from the formation rose in the hole to a level of 281 feet below the surface or 347 feet above the top of the formation. It should be noted that contamination of the Antlers Sand aquifer could result if wells penetrating the Santa Rosa aquifer are not properly cased.

An analysis of cores collected from test hole 44-21-310 (Appendix C) indicates that the lower Dockum sandstones have a low permeability. The porosity of 16 cores taken between depths of 560 and 619 feet ranged from 8.0 to 27.5 percent and averaged 20 percent. A good water producing sand will generally have a porosity in excess of 30 percent. A grain size analysis conducted on three cores resulted in an average median grain diameter (D50) of 0.2 millimeters and sorting coefficient (So) of 1.3. This analysis indicates that, although the formation sands are well sorted or generally of equal size, the grain size is very small which reduces permeability. Wells completed in the Santa Rosa aquifer generally have yields which range from 10 to 30 gallons per minute.

CHEMICAL QUALITY OF THE SANTA ROSA AQUIFER

Chemical analyses of ground water collected from two of the test holes indicate that the Santa Rosa aquifer water contains a high level of dissolved minerals which limits its use for most purposes. The total dissolved solids (tds) content of the water from the two test holes were 9,854 and 8,812 milligrams per liter (mg/l), respectively (Table 2). The high concentration of dissolved minerals in the water is probably a result of the formation's low permeability which restricts the water's circulation and retards the flushing action of fresher water moving through the aquifer.

A high concentration of soluble salts in irrigation water may cause a buildup of salts in the soil. Saline soils decrease the ability of plants to take up moisture and nutrients from the soil resulting in decreased yields. This salinity hazard is expressed in terms of specific conductance, measured in micromhos at 25 C. In general, water having a conductance above 750 micromhos at 25 C is

Table 2. -- Chemical Analyses of Water From Test Holes

STATE WELL NUMBER	44-12-843	44-21-609
DATE OF COLLECTION	09/28/85	11/20/85
AQUIFER CODE	TRDSR	TRDSR
WELL DEPTH	840	570
SAMPLE DEPTH		
WELL USE	2	2
TEMPERATURE-F		
TEMPERATURE-C		
SILICA (MG/L)	10.0	8.0
CALCIUM (MG/L)	302.0	396.0
MAGNESIUM (MG/L)	144.0	245.0
SODIUM (MG/L)	3073.0	2453.0
POTASSIUM (MG/L)	41.0	38.0
MANGANESE (MG/L)		
BORON (MG/L)		
CARBONATE (MG/L)	.0	.0
BICARBONATE (MG/L)	299.0	228.0
SULFATE (MG/L)	2120.0	1995.0
CHLORIDE (MG/L)	4015.0	3564.0
FLUORIDE (MG/L)	.9	1.7
NITRATE (MG/L)	.8	.0
IRON (MG/L)	0.19	
PH	8.0	8.2
* DISSOLVED SOLIDS (MG/L)	9853.7	8812.8
PHENOL. ALK. CACO3	.0	.0
TOTAL ALK. CACO3	245.0	187.0
TOTAL HARD CACO3	1349.0	1998.0
% SODIUM	82.70	72.30
SAR	36.4	23.9
RSC	0	0
SPECIFIC CONDUCTANCE	20160	17920

* THE BICARBONATE REPORTED IN THIS ANALYSIS IS CONVERTED BY COMPUTATION (MULTIPLYING BY 0.4917) TO AN EQUIVALENT AMOUNT OF CARBONATE, AND THE CARBONATE FIGURE IS USED IN THE COMPUTATION OF THIS SUM

unsatisfactory for irrigation. Specific conductances of the two water samples collected were 20,160 and 17,920, which is well above the safe limit.

The physical condition of soil can be adversely affected by a high concentration of sodium relative to the concentration of calcium and magnesium in irrigation water. The sodium hazard is expressed as the sodium-adsorption ratio (SAR) which is the measurement of the relative activity of sodium ions in exchange reactions with soil. A high SAR in irrigation water, as is the case with Santa Rosa aquifer water obtained from the two test holes, affects the soil by forming a hard impermeable crust that results in cultivation and drainage problems. The SAR of the two samples were 36.4 and 23.9.

Only three chemical analyses of water from wells completed in the Santa Rosa aquifer in Glasscock County are presently available. This limits our ability to predict the water quality throughout the county. Since the formation is known to have similar lithologic characteristics throughout the county, it is likely that its water may be of similar quality to that shown in the three analyses. Since the water has a tds content of approximately 9,000 mg/l, which renders it unusable for municipal, irrigation, and most industrial purposes, consideration might be given to its blending with the fresher Antlers Sand aquifer water, so the final dissolved solids content is improved sufficiently to permit its use for livestock purposes. Pumpage of Santa Rosa ground water in Glasscock County, however, should be preceded by consideration for the adverse effect it may have to the surface soils and the possible contamination to the Antlers Sand aquifer.

SUMMARY

Test holes were drilled utilizing agency staff and equipment under a cooperative contractual agreement with the Glasscock County Underground Water Conservation District. The primary purpose of the test holes was to determine if usable-quality ground water could be obtained from the Santa Rosa aquifer. Chemical analyses of water samples collected from the test holes contained a tds content of 9,854 and 8,812 mg/l, respectively. The high concentration of dissolved minerals limits its use for most purposes, especially irrigation, because of the adverse effect to the soils.

APPENDIX A

OIL AND GAS WELLS USED FOR SUBSURFACE CONTROL

Appendix A--Oil and Gas Wells Used for Subsurface Control

GLASSCOCK COUNTY

Well Q No.	Operator	Lease and Well
1	The Texas Co.	G. R. Hillger Est. No. A-1
14	Continental Oil Co.	L. S. McDowell No. 1
22	Shell Oil Co.	Currie No. 1
25	Placid Oil Co.	Sanders No. 1
33	TXL Oil Corp.	J. B. Calverley No. 1
34	Sun Oil Co.	Grady Cross No. 1
42	Atlantic Refining Co.	Driver No. 2-36
44	Atlantic Refining Co.	Schrock No. 24-2
48	Lion Oil Co.	Coffee No. 5-C
49	Jake L. Hamon	Brunson No. 1
50	Magnolia Pet. Co.	Bryans No. 1-26
54	Texas National Pet. Co.	Edmond Tom No. 1
55	A. K. Guthrie	Spruce No. 1
60	Shell Oil Co.	D. Roberts, A and B Lease A-4
61	H.M.H. Operators	Overton No. 2
68	Amerada Pet. Corp.	Bertie Boone No. 1
69	Amerada Pet. Corp.	Boone No. 1
82	Amerada Pet. Corp	TXL I No. 2
90	American Republic Corp.	Buckner Orphan's Home No. 1-17
93	Phillips Pet. Co.	McDow No. 2
95	Standard Oil Co. of Texas	W. B. Currie No. 1
99	A. K. Guthrie	Reynolds No. 1
103	Sinclair Oil and Gas Co.	Henrietta Long No. 1
105	Texaco, Inc.	Currie No. 1
108	Hanley Co.	L. C. Clark No. 1
116	Sinclair Oil and Gas Co.	Fannie Boyd No. 3
126	Texaco, Inc.	Glasscock E Fee No. 1
138	Cosden Pet. Corp.	Rape A No. 1
146	Shell Oil Co.	McDaniel No. 1
166	Seaboard Oil Co.	S. J. Bishop No. 1
173	Fred Turner, Jr.	S. C. Currie No. 1
188	Phillips Pet. Co.	Woolsey No. 1
194	Plymouth Oil Co.	Currie No. 4
195	DeKalk Agri. Assoc., Inc.	TXL I No. 1
231	Humble Oil and Ref. Co.	Alvy Crouch No. 1
250	Jack Fisher	George O'Barr No. 1
258	Roden Oil Co.	Reed I-4
259	Belco Pet. Corp.	Edwards No. 1
261	Mallard Exploration, Inc.	Cox No. 1
268	Joy Pet. Corp.	Books No. 1
272	Texaco, Inc.	G. W. Jalonick III No. 1
278	W. W. Oatman Co.	Schwartz No. 1
293	Union Texas	Glass No. 1

Appendix A--Oil and Gas Wells Used for Subsurface Control - continued.

HOWARD COUNTY

Well Q No.	Operator	Lease and Well
59	D. O. Huddleston	McDowell No. 1
79	Continental Oil Co.	W. K. Settles No. 25-133
108	Drilling and Exploration Co.	E. W. Douthitt No. 1-2
474	Cosden Pet. Corp.	McDowell No. 1
478	Cosden Pet. Corp.	Phillips No. 1

MARTIN COUNTY

Well Q No.	Operator	Lease and Well
10	Texas National Pet. Co.	Jim Tom No. 1

MIDLAND COUNTY

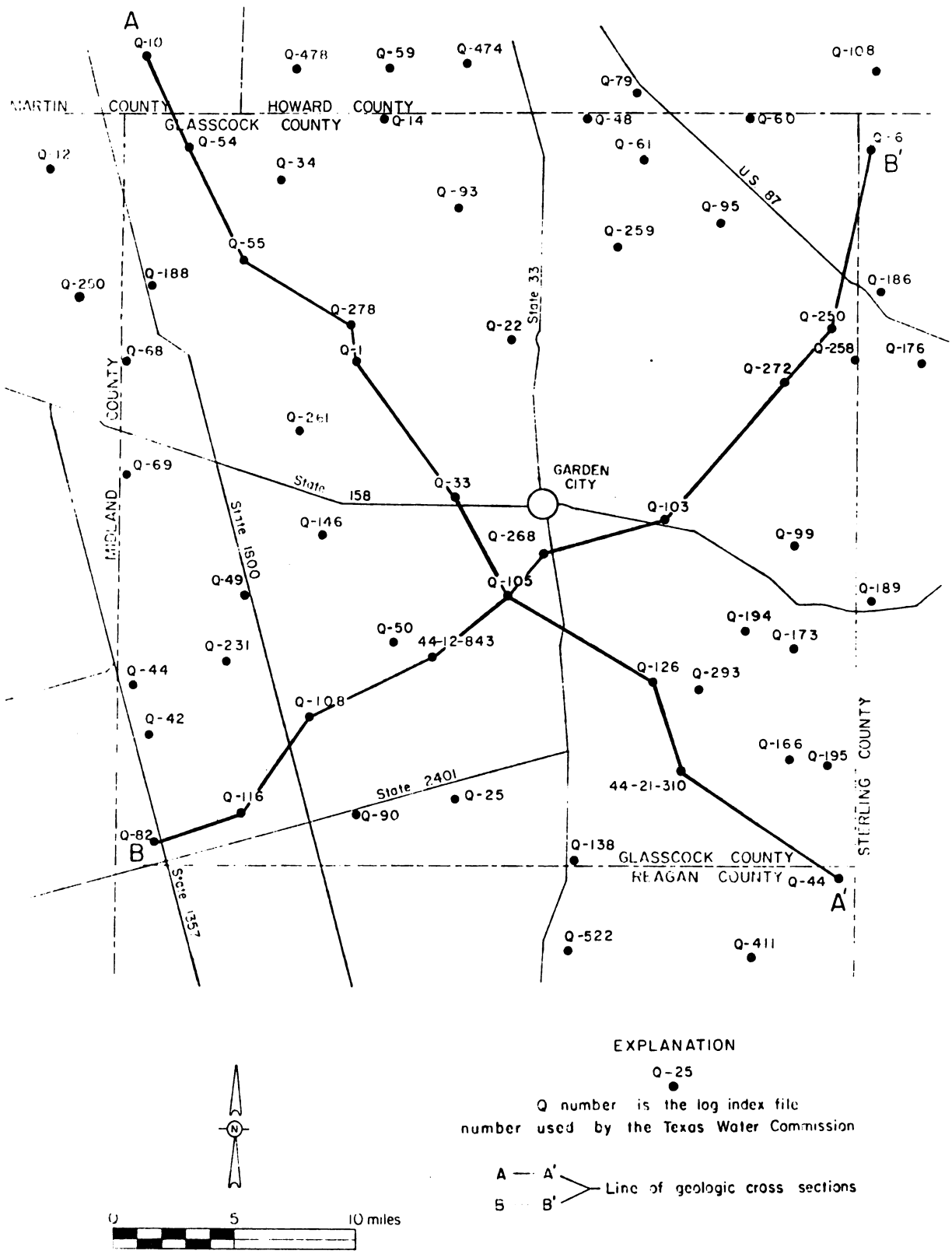
Well Q No.	Operator	Lease and Well
12	Magnolia Pet. Co.	Earl Powel No. 1
250	Sinclair Oil and Gas Co.	George Reiss No. 3

REAGAN COUNTY

Well Q No.	Operator	Lease and Well
44	British-American Oil Co.	Sarah Hull No. 1
411	Texaco, Inc.	C. H. Sugg No. 2
522	Jake L. Hamon	Suggs No. 6

STERLING COUNTY

Well Q No.	Operator	Lease and Well
6	Humble Oil and Ref. Co.	Humble W. N. Reed B No. 1
176	Roden Oil Co.	Reed K No. 1
186	Shaheen and Sons and Crown Central Pet. Corp.	Reed 16 No. 1
189	C. H. Sherrod	Reynolds A No. I-X



Appendix A

Location of Wells Used for Subsurface Control and Geologic Cross Sections

APPENDIX B

LITHOLOGIC DESCRIPTIONS OF TEST HOLES

Glasscock County Test Hole No. 1
44-12-843

Depth (Feet)	
0- 2	Top soil
2- 15	Caliche, white, pink, yellowish brown, soft
15- 52	Limestone, tan, yellow, light red, hard, fossiliferous, with thin, clear, crysalline layers
52-122	Limestone, maroon, gray, yellow, hard
122-126	Sand, maroon, well rounded quartz grains
126-135	Limestone, yellow, tan, and gray
135	Top Antlers Sand (Cretaceous)
135-145	Sand, clear to multicolored, fine to coarse grained, subangular to subrounded
145-158	Sand, multicolored, fine to very fine grained
158-178	Sand, multicolored, fine to coarse grained
178-198	Sand, fine grained and clay, red
198-270	Sand, multicolored, very fine to coarse grained, with occasional thin clay layers
270-300	Sand, brown, very fine grained with 10% coarse grains
300	Top Chinle (Triassic)
300-330	Silt, red, limy matrix
330-412	Silt and clay, dark reddish brown to red, with occasional hard, white to yellow limestone streaks
412-420	Shale, dark reddish brown
420-478	Silt and clay, dark reddish brown with bluish gray streaks
478-488	Sand, reddish brown, fine to very fine grained
488-547	Alternating layers of silt, clay, and shale

547-558	Sandstone, white, fine to very fine grained, well cemented
558-565	Silt, dark reddish brown, with bluish gray silty clay layers and occasional white sandstone layers
565-628	Alternating layers of reddish brown silt and clay with occasional hard white streaks
628	Top Santa Rosa Sand (Triassic)
628-638	Silt, reddish brown and very fine grained sand
638-653	Sand, fine to very fine grained, with occasional hard streaks
653-665	Silt, dark reddish brown
665-706	Sand, fine to very fine grained
706-714	Shale, bluish green to red
714-718	Sand, very fine grained
718-728	Siltstone, dark brown, hard, and tan very fine grained sand
728-740	Silt and very fine grained sand
740-745	Sand, tan, very fine grained
745-748	Sandstone, very fine grained, very hard
748-765	Sand, tan, very fine grained
765-779	Silt, dark reddish brown and shale, bluish green to red
779-815	Sand, tan, very fine grained
815-824	Sandstone, dark brown with some red and yellow, silty matrix
824	Top Tecovas (Triassic)
824-832	Silt and sand, reddish brown and white
832-840	Silt, red

Glasscock County Test Hole No. 2
44-21-310

Depth (Feet)	
0-2	Top soil
2-4	Caliche, grayish red, nodular; and fine- to medium-grained sand
4-16	Limestone, light gray, massive to thin bedded, layers of marl, occasionally cherty
16-91	Limestone, white, yellow, and tan, hard
91-98	Sand, very fine-grained
98-160	Limestone, gray to yellow, hard; and layers of fine- to coarse-grained, gray, yellow, and maroon sand
160-178	Limestone, gray and tan
178-400	(Lost circulation-no cuttings retrieved) Geophysical logs indicate base of Cretaceous Antlers Sand and top of Triassic occurs at 408 feet
408-462	Sand, very fine-grained; silt; clay, greenish blue to reddish brown (poor cutting return)
462	Top Santa Rosa
462-560	Sandstone and siltstone, dark reddish brown; bluish green shale layers, and occasional hard white streaks (poor cutting return)
560-570	Sandstone, grayish green to reddish brown, fine- to coarse-grained, thin bedded with some cross bedding, thin bluish green to yellow shale layer at base

Depth (Feet)	
570-583	Sandstone, grayish green to reddish brown, medium- to coarse-grained, shaley section at 580
583-585	Sandstone, reddish brown, fine- to medium-grained
585-587	Conglomerate, various colored chert pebbles in a sand and shale matrix, cross bedded
587-590	Sandstone, grayish green, fine- to coarse-grained, grayish green calcareous shale layer at base
590-591	Sandstone, reworked bedding
591-597	Sandstone, grayish green to reddish brown, thin bedded with cross bedding near base, clay layer at base
597-602	Sand, grayish green, medium-to coarse-grained, unconsolidated, clayey matrix
602-606	Sandstone, reddish brown to grayish green with abundant pink quartz grains, fine-to medium-grained, cross bedded, well cemented
606-612	Sandstone, grayish green with occasional reddish brown streaks, fine-grained, chert pebbles at 610, fine bedded to cross bedded
612-613	Clay, reddish brown, and shale, bluish green
613-620	Sandstone, grayish green, fine-to coarse-grained, cross bedded, shale and clay stringers

APPENDIX C

LABORATORY CORE ANALYSIS RESULTS
FOR TEST HOLE 44-21-310

APPENDIX C
Laboratory Core Analysis Results for Test Hole 44-21-310

Depth (feet)	Bulk Specific Gravity	Permeability Constant Head gpd/ft	Percent Porosity
560	2.25	.211	14.2
568	2.27	.002	16.1
572	2.19	.813	21.2
575	2.47	.0169	12.9
579	2.11	11.65	25.7
581	2.11	6.67	26.5
585	2.32	.0019	16.3
588	2.18	7.56	20.6
593	2.12	4.03	24.5
595	Grain Size Only		
602	2.21	5.49	23.4
603	2.39	.25	15.0
605	2.15	.36	22.4
607	2.57	.004	8.0
608	2.10	.42	22.3
611	2.16	.71	27.5
612	Grain Size Only		
616	Grain Size Only		
619	2.08	3.74	23.1