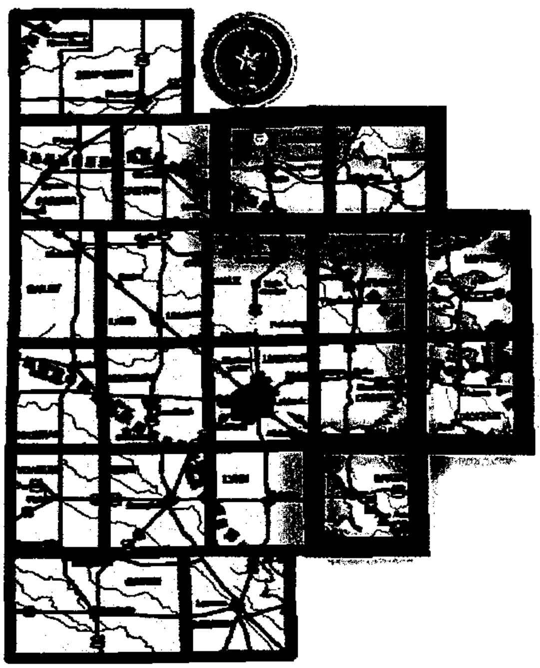
Llano Estacado Regional Water Planning Area

Ground Water Supplies in Briscoe, Dickens, Garza, Motley, and Swisher Counties



December 2001

Prepared for:

Texas Water Development Board

Prepared by:

Llano Estacado Regional Water Planning Group

With administration by:

High Plains Underground Water Conservation District No. 1

With technical assistance by:

HDR Engineering, Inc.

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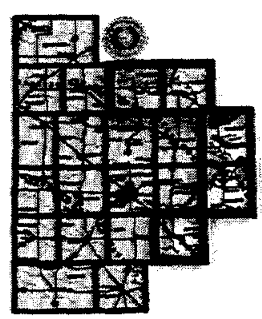

With technical assistance by:

HDR

HDR Engineering, Inc.
Austin, Texas

December 2001

HDR Engineering, Inc. Project Staff

Herbert W. Grubb, PhD,

Larry F. Land, P.E.

Grady F. Reed

Scot Laun

Kenneth L. Choffel, P.E.

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Executive Summary

During the development of the Llano Estacado Regional Water Plan adopted by the Llano Estacado Regional Water Planning Group (LERWPG) on January 3, 2001, the Planning Group encountered a serious shortage of groundwater data for Briscoe, Dickens, Garza, Motley, and Swisher Counties. Given the lack of data for these counties of the Region, the LERWPG decided to collect additional data for use in the next Regional Water Plan and for use in development of the Texas Water Development Board's (TWDB's) Southern High Plains Groundwater Availability Model (GAM). The results are summarized below.

For the Ogallala Aquifer, estimates of the quantity of groundwater in storage in 2001 in Swisher County is 4,009,000 acft, in Briscoe County is 1,613,000 acft, and in Garza County is 799,000 acft. The data for Motley and Dickens were not adequate to improve the estimates made for 1995, which were 366,000 acft and 1,169,000 acft respectively.

For the Seymour Aquifer, in Briscoe, Motley, and Dickens Counties, the data available are not adequate to allow making estimates of the quantity of groundwater in storage. However, information from monitoring wells show that at present pumping levels, there has not been a significant change in water levels. In Briscoe County, average annual pumpage from the Seymour and Alluvial Aquifers has been about 5,796 acft/yr for the 1980 to 1996 period. For this period, annual average pumpage from these aquifers in Motley County has been about 3,988 acft/yr, and in Dickens County has been about 3,540 acft/yr. It is important to note that due to the very shallow and thin nature of these aquifers, low levels of recharge and higher than normal demands during droughts can seriously interrupt the reliability of supplies. In addition, the low quality of water is a problem. Since the quality of water of the Seymour and Alluvial is highly variable and often has salinity concentrations greater than drinking water standards, extensive use of the aquifers is expected to result in reduced water quality, which will increase problems for this source of water as a long-term public and irrigation supply.

The Llano Estacado Regional Water Planning Group strongly recommends that officials of Briscoe, Dickens, Garza, Motley, and Swisher Counties make the necessary arrangements to continue the groundwater data collection begun with this study. This may require local funding, which can perhaps be matched through cooperation with the Texas Water Development Board.

Section 1
Introduction

1.0 Introduction

On January 3, 2001, the Llano Estacado Regional Water Planning Group (LERWPG) adopted a regional water plan that has wide support both within the Planning Group, and within the region. The Planning Group, however, found that there were significant concerns about the lack of groundwater data in Briscoe, Dickens, Garza, Motley, and Swisher Counties. Given the uncertainty encountered in attempts to develop water supply information for the recently completed regional plan, the LERWPG decided to collect additional data for the development of the next Llano Estacado Regional Water Plan and for the development of the Texas Water Development Board's (TWDB's) ongoing preparation of a Southern High Plains Groundwater Availability Model (GAM). In order to accomplish this task, the LERWPG contracted with HDR Engineering Inc. to conduct a special study in the five counties to fill in some of the data gaps of the TWDB Well Database (Figure 1-1).

1.1 Objectives

The objectives of this study are:

- Collect well and aquifer data in Briscoe, Dickens, Garza, Motley, and Swisher Counties and adjoining areas for the Ogallala (High Plains) Aquifer and Seymour Aquifer, including alluvial deposits in close proximity to the Seymour Aquifer;
- Prepare a database of new and existing information on the base of the Ogallala Aquifer and groundwater level measurements since 1995;
- Prepare digital maps of the Ogallala Aquifer base and water table;
- Compute a current (2001) saturated thickness map of the Ogallala Aquifer using GIS techniques;
- Calculate the volume of groundwater in storage within the Ogallala Aquifer for each of the five counties;
- Describe the current conditions of the Seymour Aquifer; and
- Estimate the groundwater supplies in the Seymour Aquifer.

In this report, estimates are presented of: (1) Current (2001) groundwater in storage in the Ogallala and Seymour Aquifers located in the five counties listed above, and (2) The current hydrologic conditions and water supplies in the Seymour Aquifer in Dickens, Garza, and Motley

Llano Estacado Water Planning Region

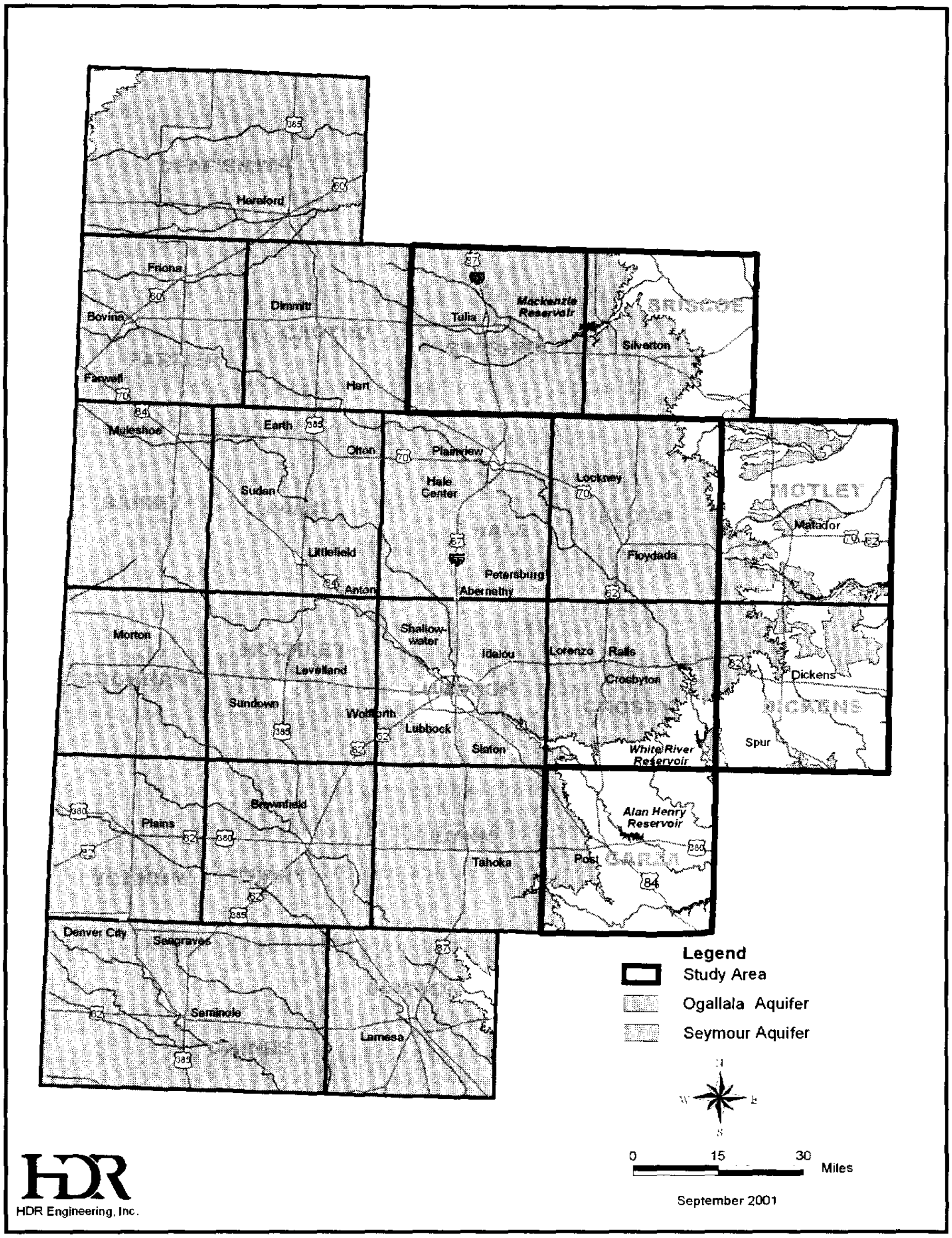

Figure 1-1. Study Area Map

Counties are described. The estimates are based upon data and information obtained from the TWDB Well Database and reports supplemented with field measurements made as a part of this study.

1.2 Acknowledgments

On behalf of the LERWPG, HDR Engineering, Inc. extends its appreciation to officials in the counties who assisted in locating wells and contacting landowners. These officials include:

Briscoe County:

Jose Mendoza – U. S. Department of Agriculture, Natural Resource Conservation Service (NRCS)

Jimmy Myers – U. S. Department of Agriculture, NRCS

Dickens County:

Toby Alver – Texas Agriculture Extension Service

Charlie Morris – U. S. Department of Agriculture, NRCS

Garza County:

Greg Jones – Texas Agriculture Extension Service

Motley County:

Lonnie D. Jenschke – Texas Agriculture Extension Service

James Gillespie – U. S. Department of Agriculture, NRCS

Swisher County:

Michael Clawson – Texas Agriculture Extension Service

Matt Kast – U. S. Department of Agriculture, NRCS

Finally, the well owners who provided permission and access to their wells were critical to the success of this field study. Their willingness and interest in the work is very much appreciated.

Section 2
Methods and Procedures

2.1 Methodology

Arc/Info, a commercial Geographic Information System (GIS), was used to plot data, create maps of surfaces, calculate thicknesses, and to calculate the volume of groundwater. Maps were developed for Swisher and for those parts of Briscoe and Garza Counties under which the Ogallala formation lies. However, due to lack of data, it was not possible to improve the accuracy of previous saturated thickness maps for Dickens or Motley Counties.

In the preparation of the digital maps for the calculations of the water table and the base of the aquifer, information from wells measured in this study, information from selected wells located near the county lines in nearby counties, and the contour patterns from a 1981 study were included to improve the interpolation of contours[1]. Grids of the digital aquifer base and 2001 water levels were created with the ARC View software. Saturated thickness maps were created by subtracting the base map from the water level map. In the case of Briscoe County, the grid size of the digital aquifer base was 1,500 × 1,500 feet. For Garza County, the grid size was 1,000 × 1,000 feet, and for Swisher County, the grid size was 1,750 × 1,750 feet. The volume of saturated thickness was calculated by summing the volume of all the grids in each county that were included in the mapped areas of the county.

2.2 Sources of Data

The sources of data and information used in the calculation of volumes of groundwater in storage in the Ogallala and Seymour Aquifers of the study area are:

- The Texas Water Development Board's (TWDB) Well Database;
- Report entitled, "Evaluating the Groundwater Resources of the Ogallala of Texas," by Knowles, Nordstrom, and Klemt, (1981)"[2];

[1] Knowles, T., Nordstrom, P., and Klemt, W. B., "Evaluating the Groundwater Resources of the Ogallala Aquifer of Texas," Texas Department of Water Resources Report LP-173, December 1982, Austin, Texas.
[2] Opcit.

- TWDB county reports[3,4,5] and a TWDB report on the rolling prairies[6] that includes the Seymour Aquifer; and
- Field data collected during the course of this study.

Information in the TWDB Well Database includes latitude, longitude, land surface elevation, well depth from ground surface, aquifer name, driller's name, well use, county of location, and for a small group of wells, depth to water level. Data documented in the report by Knowles, Nordstrom, and Klemt, (1981) included many wells that were not in the TWDB Database, including very important data on the base of the aquifer. Field data collected during this study included latitude, longitude, county, land surface elevation, aquifer name, well use, and depth to water. Where water samples could be collected, the concentration of total dissolved solids was estimated.

Information in the TWDB Well Database classifies wells in the currently defined Seymour Aquifer as completed in the Alluvium Aquifer. Parameters of major interest in this study include location, well depth, aquifer, depth to water level, and salinity of the water. Field data collected by this study included location, land surface elevation, aquifer name, well use, and depth to water. Where water samples could be collected, the concentration of total dissolved solids was estimated.

The hydrologic condition of the aquifer is described by the depth to water table and by the concentration of total dissolved solids (salinity). The supply is estimated by assessing the TWDB's recent estimates of water use and water availability and the long-term changes in the aquifer's water levels and salinity.

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[3] Popkin, B.P., "Groundwater Resources of Hall and Eastern Briscoe Counties, Texas," Texas Water Development Board Report 167, April 1973, Austin, Texas.

[4] Smith, J.T., "Groundwater Resources of Motley and Northeastern Floyd Counties, Texas," Texas Water Development Board Report 165, March 1973, Austin, Texas.

[5] Cronin, J.G., "Groundwater Resources of Dickens and Kent Counties, Texas," Texas Water Development Board Report 158, November 1972, Austin, Texas.

[6] Duffin, G.L. and Beynon, B.E., "Evaluation of Water Resources in Parts of the Rolling Prairies Region of North-Central Texas," Texas Water Development Board Report 337, March 1992, Austin, Texas.

Section 3
Calculations of Water in Storage in the Ogallala and Seymour Aquifers of the Five-County Study Area

3.1 Ogallala Aquifer

The water level data collected during this study are presented in Appendix A, Tables 1 and 2. Results of the water level measurements of Ogallala Aquifer wells that were measured in this study are shown in Appendix A, Figures A-1, A-2, A-3, A-4, and A-5 for Swisher, Briscoe, Motley, Dickens, and Garza Counties, respectively.

For each of the five counties of the study area, contour maps of the base of the Ogallala Aquifer are presented in Appendix B, Figures B-1, B-2, B-3, B-4, and B-5. These maps were prepared with data from Knowles, Nordstrom, and Klemt (1981), and extended 2-5 miles into a buffer area in adjacent counties (For list of wells in buffer areas see Appendix C). In addition, contour maps of the altitude of the water levels of the aquifer are presented for Swisher, Briscoe, and Garza Counties (Appendix B, Figures B-6, B-7, and B-8). These maps were prepared with data from this special study and the TWDB, and extended 2-5 miles into a buffer area of adjacent counties (For list of wells in buffer areas see Appendix D). In areas with sparse data, the contour pattern was adjusted to match Knowles, Nordstrom, and Klemt (1981). However, data for Dickens and Motley Counties were not adequate for the development of 2001 water level contour maps for these counties.

Saturated thickness maps were prepared for Swisher, Briscoe, and Garza Counties by subtracting the base of the aquifer from the water table (Appendix B, Tables B-9, B-10, and B-11). The volume of groundwater in storage was calculated by multiplying a specific yield coefficient of 15 percent times the saturated thickness. The specific yield coefficient of 15 percent was used as an average of the 8 to 20 percent range reported by Knowles, Nordstrom, and Klemt, (1981).

The calculated volume of water in storage in the Ogallala Aquifer in 2001 was 4,009,000 acft in Swisher County, 1,613,000 acft in Briscoe County, and 799,000 acft in Garza County (Table 3-1). However, not all of this water will be available to wells unless the wells are completed at a depth below the base of the aquifer so that as the water table declines, the water remaining in storage can drain into the wells and become available to the pumps; i.e.; a well completion technique known as "cistern wells."

Table 3-1. Estimated Volume of Water in Storage in the Ogallala Aquifer, 2001

County	Volume in Storage (acft)
Swisher	4,009,000
Motley	366,000*
Dickens	1,169,000*
Briscoe	1,613,000
Garza	799,000
Note: 1995 estimates from a previous study.	

In the area near the eastern boundary of the Ogallala Aquifer, there are two factors that affect making an accurate determination of the quantity of groundwater in storage. These two factors are: (1) Lack of information about the quantity of groundwater flowing from the Ogallala Aquifer into the underlying Dockum Aquifer before being discharged to the east and off the caprock, and (2) Small number of wells located within the area from which to obtain water level data. The problem of low numbers of measurements of water levels was overcome to some extent by this study; however, since there are so few wells in this area, additional wells need to be drilled and measured if the estimates of water availability are to be improved.

3.2 Seymour Aquifer

The Seymour Aquifer, as defined by the TWDB, consists of isolated areas of alluvium found in parts of 23 north-central and Panhandle counties, including parts of Briscoe, Motley, Dickens, and Garza Counties of the Llano Estacado Water Planning Region.[1] The Seymour Aquifer is less than 100-ft thick in most areas and supplies small quantities of water primarily for domestic, irrigation, and livestock use in these four counties. Water quality in these alluvial remnants generally ranges from fresh to slightly saline. The concentration of total dissolved solids (salinity) of most of the water exceeds public drinking water standards of 1,000 milligrams per liter (mg/L). In areas where the Ogallala or Seymour Aquifers are too thin or do not exist,

[1] Ashworth, J.B. and Hopkins, J., "Aquifers of Texas,' Texas Water Development Board Report 345, November 1995.

other geologic formations provide small to modest supplies of groundwater. These geologic formations include: Ocha Series, Dockum (Group) Aquifer, Whitehorse Group, Artesia Group, and Quartermaster Formation. Except for the Dockum Aquifer, which is classified by the TWDB as a minor aquifer, these aquifers typically produce small quantities of slightly saline-to-saline water.

The field work of this study included inventorying and measuring the depth to water in 50 Seymour and Alluvium wells. Water samples were collected from ten of the wells. These data are shown in Appendix A, Table A-2. Most of the wells that were measured were either abandoned or were being used for irrigation, and domestic and livestock supplies.[2] Results of the water level measurements are shown in Appendix A, Figures A-6, A-7, and A-8 for Motley, Dickens, and Garza Counties, respectively. Also shown is the outcrop of the Seymour Aquifer. Not shown is the Alluvium along the streams where some monitoring wells were located. In Motley County, the depth to water typically was between 50 and 95 feet in the northern part and 10 to 50 feet in the southern part. An exception is an unusually deep water level (178 feet), which is attributed to a locally high land surface elevation. In Dickens County, most of the depth to water was in the 20 to 40 foot range with the shallowest being 19 feet and the deepest being 50 feet. In Garza County, the depth to water in the alluvium ranged from 11 to 29 feet.

The quality of the water in the Seymour Aquifer is a major limitation on its use. The TWDB database on concentration of total dissolved solids shows that in Motley County, 75 percent of the Seymour Aquifer wells produce water with concentrations less than 1,000 mg/L of total dissolved solids and about 10 percent of the wells produce water with concentrations greater than 2,000 mg/L of total dissolved solids. About 30 percent of the Seymour Aquifer wells in Dickens County produce water that meets the drinking water standards of 1,000 milligrams per liter (mg/L) or less of total dissolved solids, with about 40 percent of the Dickens County wells producing water that is greater than 2,000 mg/L (Appendix B, Figures B-12, B-13, and B-24).

Although, the field survey of this study increased the number of observations of water levels in the Seymour and Alluvium Aquifers in the study area counties, data are not adequate to

[2] Because the field study was conducted during the irrigation season, a relatively large number of wells of the area were pumping and therefore were not suitable for measuring the static water level. Also, wells in some of the target areas could not be measured because landowners could not be reached in order to obtain permission for access.

calculate saturation thickness maps for these aquifers. Therefore, previous estimates of water availability are presented below for information purposes.

In previous studies, the TWDB estimated the annual quantity of groundwater available from the Seymour Aquifer as the sum of estimated average annual effective recharge and estimated average annual storage depletion.[3] The average annual effective recharge rate was estimated to be 5 percent of mean annual rainfall. For purposes of computing an annual quantity from storage, it was assumed that recoverable water in storage would be depleted in 56 years. Thus, for this calculation, the estimated total volume of groundwater in storage was divided by 56 years to obtain an estimate of annual storage depletion. The estimates of quantities of water available from the Seymour Aquifer in Briscoe County are 4,063 acft/yr (Table 3-2). The estimated quantity available in Motley County in 2000 was 18,817 acft/yr, and in 2050 was 13,507 acft/yr (Table 3-2), and in Dickens County was 7,937 acft/yr in 2000, and 5,217 acft/yr in 2050 (Table 3-2). The TWDB does show the Seymour Aquifer in Garza County.

Table 3-2. Estimated Quantity of Groundwater Available Annually From the Seymour Aquifer by TWDB (acft/yr)

County	Year	
	2000	2050
Briscoe	4,063	4,063
Motley	18,817	13,507
Dickens	7,937	5,217
Garza		

[3] Muller, D.A. and Price, R.D., "Groundwater Availability in Texas," Texas Department of Water Resources Report 238, September 1979.

TWDB estimates of annual groundwater use for the period 1980–1996 for Briscoe, Motley, and Dickens Counties are shown in Table 3-3. A comparison of estimated quantities available and average withdrawals indicates that the Seymour Aquifer is being somewhat over utilized in Briscoe County, with additional capacity remaining in Motley and Dickens Counties.

Table 3-3. Estimated Average Annual Groundwater Use 1980–1996 by TWDB

County	*Seymour (Includes Alluvium)*
Briscoe	5,796
Motley	3,988
Dickens	3,540

A study of the trend in water levels in Dickens, Garza, and Motley Counties was conducted by preparing a hydrograph of water levels with measurements made by the TWDB in their monitoring well network. This network included nine wells in Dickens County, no wells in Garza County and nine wells in Motley County. Generally, the measurements were begun in the late 1950's and have been continued to the present. The measurements were made during the winter months. The results are summarized in Table 3-4.

Table 3-4. Summary of Water Level Trends in TWDB Network of Monitoring Wells (Note: Values are the Number of Wells)

	County		
Trend	*Dickens*	*Garza*	*Motley*
Significant, long-term Rise in Water Levels (more than 5 feet)	3	None	3
No Significant Change in Water Levels (no more than 5 feet)	6	None	4
Significant, long-term Decline in Water Levels (more than 5 feet)	0	None	2

As shown in Table 3-4, most of the wells showed no significant, long-term change in water level. For the wells having a significant change, six wells had significant rises in comparison to two wells with significant declines. Because the aquifer is so shallow, seemingly minor declines in water levels can greatly affect well yields and groundwater availability.

Finally, the availability of water supplies for regional water planning purposes is determined by the quality of water. Groundwater quality in the Seymour Aquifer is highly variable and often has salinity greater than drinking water standards. Extensive use of the Seymour Aquifer is expected to cause water quality to further decline, and become even poorer and problematic for use as public and irrigation supply.

3.3 Farmers' Experiences

In order to gain a better understanding of the groundwater supplies from the Seymour Aquifer in Dickens, Garza, and Motley Counties, the field staff of this study discussed water well conditions with several farmers and ranchers of these counties. Some of the comments of the farmers and ranchers are presented below.

Dickens County

- A farmer near Dickens commented that he has to run wells on a cycle of 24 hours on and 12 hours off due to low water levels. This is the first time in 50 years that his irrigation wells have pumped air, even running continually during the irrigation season.
- A farmer near Dickens reported that the salt concentration in his well has been slowly rising over the past 8 years. He attributed the cause to the drought. He is taking measures to minimize the impact by irrigating more to wash the salt through the root zone.
- A farmer a few miles south of Dickens said pumping rates for his irrigation wells have dropped about 10 percent and the salinity has increased. Also, Duck Creek has been dry for longer than he has remembered and the Dickens Springs have run dry for the first time in his memory.

Motley County

- A farmer in the western part of Motley County reported that wells go dry when the irrigators in Floyd County pump hard. He stated that wells in the northwest part of the county have gone dry.
- In general, the farmers reported that they do not pump their wells hard. In the northern part of the county, some irrigators experienced a few problems with availability; however, most are considering going into ranching because the cost of power to run their wells has become too expensive.

Garza County

- In general, the farmers and ranchers in Garza County reported that the water levels in most of their wells have been declining for some time, with some farmers reported drops in excess of 10 ft. in wells. For most in the county, this summer were some of the worst conditions many of them can remember. Some farmers in the area had converted to dryland farming due to a lack of a reliable water source from their wells. In addition, many of the wells owners stated that they did not use their wells for domestic purposes because of the salt content of the water. At least two farmers stated that in their opinion, the salt concentration has been increasing over time.

Based on long-term trends in water levels, the estimates of groundwater supplies (availability) by the TWDB and the LERWPG appear that at least the current level of pumpage is a reasonable level of development in Dickens and Motley Counties. However, the shallow nature of the aquifer where insignificant recharge and higher demands during droughts can seriously interrupt the reliability of supplies, the availability estimates at the current pumping rates during a drought of record are likely to be too high. Another factor in availability is the distribution of high capacity wells. For several reasons, the full potential of the Seymour Aquifer is not utilized because very few wells are located in some areas and many wells are located in others.

Appendix A
Water Level Data

Appendix A--Table 1
List of Wells Measured and Water Level Measurements--Ogallala Aquifer

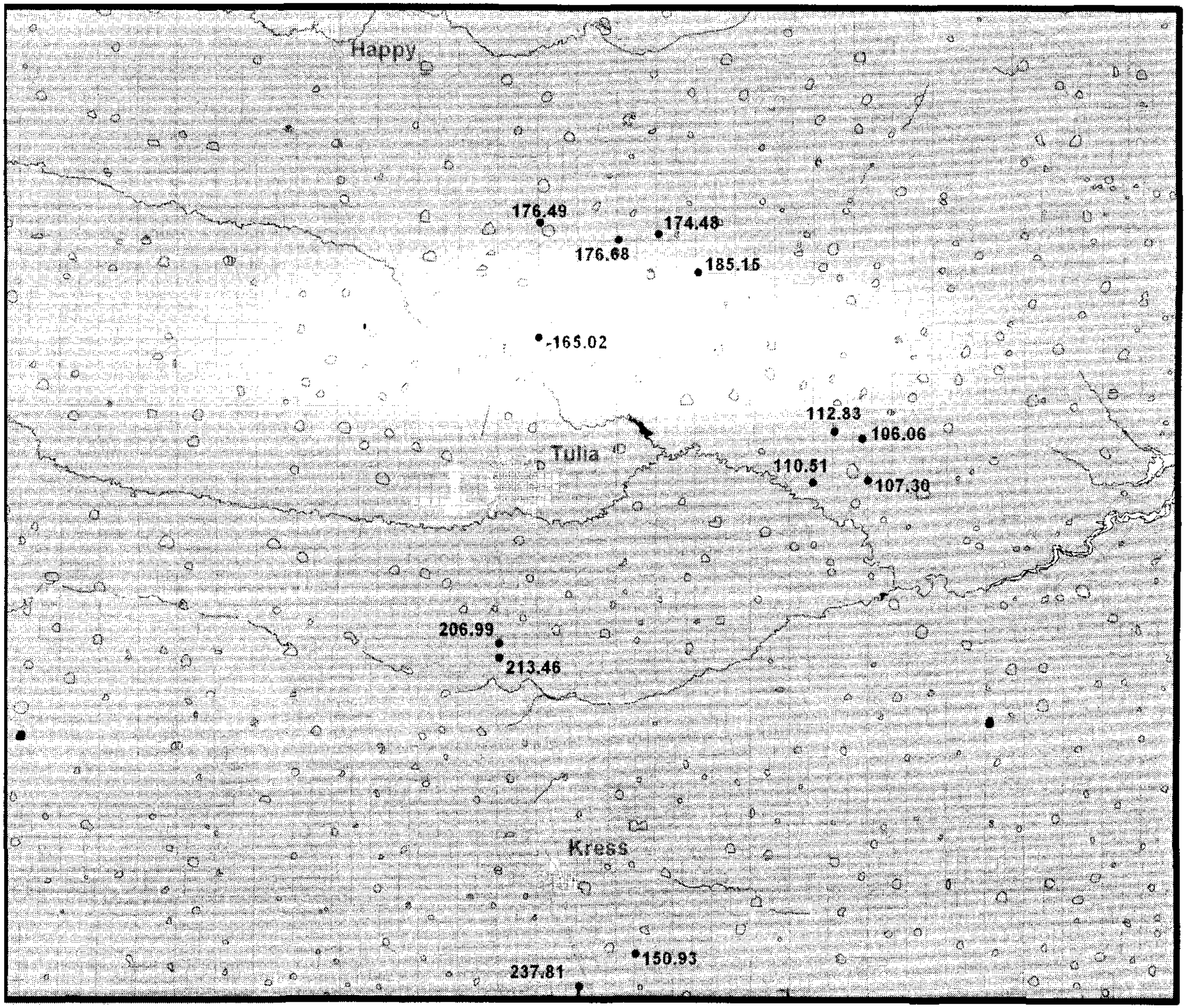
HDR Well #[1]	State Well #[2]	County	Lat	Long	Altitude (ft.)[3]	Source of Alt. Data[4]	Aquifer	Well Type[5]	Type of Lift[6]	Primary Water Use[7]	Date	Meas. (ft.)[8]	M.P.(+/-)	Recent Pumpage	Nearby Pumpage	Description of M.P.	Well Operational	Water Sample Collected
B-1	1121806	Briscoe	343845	1012522	3,327	Quad Map	Ogallala	IRR (abandoned)		IRR	7/13/2001	108.52	0"	No	No	Lip of well casing	No	No
B-2	11218B2	Briscoe	343814	1012522	3,323	Quad Map	Ogallala	LIV		LIV	7/13/2001	104.98	(-)1"	Yes	No	Top of opening in well plate	Yes	No
B-3	11299B3	Briscoe	343139	1012235	3,331	Quad Map	Ogallala	DOM	Sub	DOM	7/13/2001	131.54	(-)4"	No	No	Top of well casing	Yes	No
B-4	11474B4	Briscoe	341843	1011450	3,190	Quad Map	Ogallala	IRR (abandoned)		IRR	7/13/2001	252.62	(-)12"	No	No	Lip of hole in plate covering well shaft	No	No
D-30	22099D30	Dickens	334434	1005942	2,986	Quad Map	Ogallala	IRR	Sub	IRR	7/14/2001	247.88	(-)6"	No	No	Opening in base plate of well	Yes	No
D-31	22171D31	Dickens	334402	1005939	2,987	Quad Map	Ogallala	DOM	Sub	DOM	7/14/2001	249.63	0"	Yes	No	Electrical opening in base plate	Yes	No
G-1	23611G1	Garza	330714	1012622	2,867	Quad Map	Ogallala	DOM (abandoned)	Sub	DOM	7/15/2001	59.52	(-)4"	No	No	Opening for electrical conduit	No	No
G-2	23611G2	Garza	330704	1012808	2,867	Quad Map	Ogallala	DOM (abandoned)		DOM	7/15/2001	45.24	(-)4"	No	No	Electrical opening in base plate	No	No
G-3	23537G3	Garza	330801	1012910	2,880	Quad Map	Ogallala	IRR	Sub	IRR	7/15/2001	45.79	(-)2"	Yes (8 hrs previous)	Yes	Electrical opening in base plate	Yes	No
G-4	23537G4	Garza	330849	1012754	2,896	Quad Map	Ogallala	IRR (abandoned)		IRR	7/16/2001	70.64	(-)2"	No	No	Lip of well casing (open hole)	No	No
G-5	23526G5	Garza	331110	1013101	2,914	Quad Map	Ogallala	IRR	Sub	IRR	7/16/2001	27.68	(-)8"	Yes	No	Top of electrical opening in base plate	Yes	No
G-6	23446G6	Garza	331857	1013216	2,993	Quad Map	Ogallala	IRR (abandoned)		IRR	7/16/2001	64.37	0"	No	No	Lip of open hole in cover plate	No	No
G-7	23446G7	Garza	331857	1013207	2,992	Quad Map	Ogallala	IRR (abandoned)		IRR	7/16/2001	68.26	(-)6"	No	No	Electrical opening in base plate	No	No
G-8	23449G8	Garza	331615	1013223	2,975	Quad Map	Ogallala	IRR (abandoned)	Windmill	IRR	7/16/2001	51.21	(-)4"	No	Yes (within 30-40 yards - small well)	Lip of open well case	No	No
G-9	23449G9	Garza	331712	1013222	2,973	Quad Map	Ogallala	IRR (abandoned)	Sub	IRR	7/16/2001	54.67	(-)4"	No	Yes (within 1/4 mile)	Electrical opening in base plate	No	No
M-4	22019M4	Motley	345330	1005505	2,760	Quad Map	Ogallala				7/16/2001	134						
M-10	22018M10	Motley	345459	1005449	2,765	Quad Map	Ogallala				7/17/2001	48.3						
M-11	22018M11	Motley	345455	1005456	2,768	Quad Map	Ogallala				7/17/2001	118.5						
M-17	23089M17	Motley	335404	1010214	3,049	Quad Map	Ogallala	LIV (abandoned)	Windmill	LIV	7/18/2001	259.95	(-)12"	No	No	Lip of well casing	No	No
S-1	1119809	Swisher	343855	1014217	3,483	Quad Map	Ogallala	IRR	Sub	IRR	7/11/2001	174.85	(-)4.5"	No	Yes (1/4 mile -small well)	Well-head plate	No	No
S-2	1119717	Swisher	343846	1014321	3,493	Quad Map	Ogallala	IRR	Sub	IRR	7/11/2001	176.68	0"	No	No	Well head plate at ground level	Yes	No
S-3	1119840	Swisher	343753	1014113	3,457	Quad Map	Ogallala	IRR	Sub	IRR	7/11/2001	185.15	0"	No	No	Well head plate at ground level	Yes	No
S-4	11263S4	Swisher	343611	1014529	3,492	Quad Map	Ogallala	IRR	Turbine	IRR	7/11/2001	166.02	(-)12"	No	No	Bottom of opening in pump base (south side)	Yes	No
S-5	1118924	Swisher	343914	1014528	3,510	Quad Map	Ogallala	LIV/IRR	Sub	LIV	7/11/2001	179.49	(-)36"	No	No	Top of well casing	Yes	No
S-6	11343S6	Swisher	342745	1014633	3,498	Quad Map	Ogallala	IRR	Sub	IRR	7/12/2001	214.13	(-)8"	No	No	Top of concrete structure supporting well casing	Yes	No
S-7	11343S7	Swisher	342807	1014633	3,499	Quad Map	Ogallala	IRR		IRR	7/12/2001	207.66	(-)8"	No	No	Top of concrete pad for future well	No	No
S-8	11434S8	Swisher	341907	1014423	3,456	Quad Map	Ogallala	IRR	Turbine	IRR	7/12/2001	238.31	(-)6"	No	Yes	Side opening in well casing	Yes	No
S-9	11429S9	Swisher	341807	1014435	3,442	Quad Map	Ogallala	IRR		IRR	7/12/2001	239.4	0"	No	No	Lip of open casing	No	No
S-10	11431S10	Swisher	341958	1014252	3,450	Quad Map	Ogallala	IRR	Sub	IRR	7/12/2001	151.1	(-)2"	No	No	Top of small pipe protruding from well plate	Yes	No
S-11	11284S11	Swisher	343225	1013638	3,366	Quad Map	Ogallala	DOM		DOM	7/12/2001	107.3	0"	No	No	Lip of well casing	No	No
S-12	11284S12	Swisher	343343	1013732	3,395	Quad Map	Ogallala				7/12/2001	112.83	0"	No	No	Lip of well casing	No	No
S-13	11279S13	Swisher	343222	1013807	3,371	Quad Map	Ogallala	LIV		LIV	7/12/2001	110.51	0"	No	No	Electrical wire opening in base plate	Yes	No
S-14	11284S14	Swisher	343331	1013647	3,386	Quad Map	Ogallala				7/12/2001	106.39	(-)4"	No	No	Lip of well casing	No	No

1 Number assigned by HDR field personnel to aid in tracking sampled wells. Letter is first letter of county name followed by sequential number of well sampled.
2 This column represents the State of Texas Well # (assigned by the TWDB) if the well is a part of the State well monitoring program. If the well is not in the State database, a well number which represents the first two levels of grid assignments followed by the HDR Well #.
3 Altitude from Mean Sea Level
4 USGS 1:24,000 topographic maps
5 IRR - Irrigation, LIV - Livestock, DOM - Domestic
6 Sub - Submersible pump, Turbine - Top mounted turbine pump
7 IRR - Irrigation, LIV - Livestock, DOM - Domestic
8 Depth to water (Not adjusted for Measuring Point)

Appendix A--Table 2
List of Wells Measured and Water Level Measurements--Seymour and Alluvium Aquifers

HDR Well #[1]	State Well #[2]	County	Lat	Long	Altitude (ft.)[3]	Source of Alt. Data[4]	Aquifer	Well Type[5]	Type of Lift[6]	Primary Water Use[7]	Date	Meas. (ft.)[8]	M.P.(+/-)	Recent Pumpage	Nearby Pumpage	Description of M.P.	Well Operational	Water Sample Collected	TDS (mg/L)	Comments
D-1	22345D1	Dickens	332628	1004801	2,201	Quad Map	Seymour	IRR		IRR	7/12/2001	25.5		Yes	Yes		Yes			Well had been pumping for 5 minutes prior to measurement
D-2	22345D2	Dickens	332625	1004801	2,200	Quad Map	Seymour			IRR	7/12/2001	27.4		Yes	Yes		Yes			Well had been pumped for 10 minutes prior to measurement
D-3	2234509	Dickens	332633	1004754	2,201	Quad Map	Seymour			IRR	7/12/2001	13.8		No	Yes		No	No		
D-4	2234508	Dickens	332632	1004759	2,202	Quad Map	Seymour			IRR	7/12/2001	14.1		No	Yes		No			Abandoned irrigation well, no pump in hole
D-5	22346D5	Dickens	332540	1004553	2,197	Quad Map	Seymour				7/12/2001	23.8			No		Yes	Yes	2200	Well had been pumped 24 hr. prior to measurement.
D-6	22265D6	Dickens	333455	1005002	2,414	Quad Map	Alluvium			IRR	7/12/2001	33.15		No						
D-7	2226501	Dickens	333445	1004956	2,401	Quad Map	Alluvium			IRR	7/12/2001	38.7		Yes						Well had been pumped 5 hrs. prior to measurement.
D-8	22564D8	Dickens	333356	1005032	2,377	Quad Map	Alluvium				7/12/2001	29.3		No	No		Yes			Wells have to be operated 24hr on - 12hr off to avoid pumping air. First time in fifty years this has happened.
D-9	22564D9	Dickens	333350	1005032	2,375	Quad Map	Alluvium			IRR	7/12/2001	26		No	No		Yes	No		
D-10	22333D10	Dickens	333002	1005325	2,307	Quad Map	Alluvium			DOM	7/12/2001	19		No	No		No	No		
D-11	22333D11	Dickens	333002	1005322	2,307	Quad Map	Alluvium				7/12/2001	18		No	No		Yes	No		
D-12	2234118	Dickens	332943	1005105	2,263	Quad Map	Alluvium				7/12/2001	21.3		No	No		No	No		Pump out of hole for repairs
D-13	2225815	Dickens	333123	1005542	2,349	Quad Map	Alluvium			IRR	7/12/2001	13.9		No	No		No	No		Ground fallow
D-14	2225816	Dickens	333123	1005548	2,349	Quad Map	Alluvium			IRR	7/12/2001	15.55		No	No		No	No		Ground fallow
D-15	22256D15	Dickens	333334	1005358	2,390	Quad Map	Alluvium			LIV	7/12/2001	34.9		Yes	No		Yes	Yes	971	Well had been pumped previous day.
D-16	22564D16	Dickens	333426	1005032	2,400	Quad Map	Alluvium			IRR	7/12/2001	26.8		No	No		No	No		
D-17	2225330	Dickens	333549	1005350	2,438	Quad Map	Alluvium			IRR	7/13/2001	42.75		No	No		Yes	Yes	506	
D-18	2225332	Dickens	333542	1005350	2,438	Quad Map	Alluvium				7/13/2001	38		No	No		Yes	No		
D-19	2225333	Dickens	333534	1005350	2,432	Quad Map	Alluvium			IRR	7/13/2001	39		No	No		Yes	No		
D-20	2225331	Dickens	333550	1005327	2,430	Quad Map	Alluvium				7/13/2001			Yes	Yes		Yes	Yes	509	
D-21	22256D21	Dickens	333422	1005314	2,391	Quad Map	Alluvium			IRR	7/13/2001	29		No	No		Yes	Yes	890	
D-22	22256D22	Dickens	333405	1005315	2,391	Quad Map	Alluvium			IRR	7/13/2001	22		No	No		Yes	No		
D-23	22109D23	Dickens	334533	1004501	2,425	Quad Map	Alluvium				7/13/2001	25.75								
D-24	22109D24	Dickens	334456	1004533	2,425	Quad Map	Alluvium			IRR	7/13/2001	29.35								
D-25	22117D25	Dickens	334435	1004539	2,415	Quad Map	Alluvium			IRR	7/13/2001	23.45								
D-26	22199D26	Dickens	333920	1003810	2,180	Quad Map	Alluvium			IRR	7/14/2001	37.6		No	No		Yes	No		
D-27	22199D27	Dickens	333910	1003804	2,175	Quad Map	Alluvium			IRR	7/14/2001	31		No	No		Yes	No		
D-28	22107D28	Dickens	334551	1005049	2,615	Quad Map	Alluvium			IRR	7/14/2001	50		No	No		Yes	No		
D-29	22109D29	Dickens	334446	1004512	2,427	Quad Map	Alluvium			DOM	7/15/2001	38		Yes	Yes		Yes	No		
G-10	23541G10	Garza	331453	1012031	2,445	Quad Map	Alluvium	LIV	Sub	LIV	7/17/2001	11.35	(-)2"	No	No	Electrical opening in base plate	Yes	Yes	1695	
G-11	23467G11	Garza	331618	1012033	2,550	Quad Map	Alluvium	LIV	Windmill	LIV	7/17/2001	30.58	(-)16"	Yes	No	Opening in top of well casing protruding from ground	Yes	Yes	418	
G-12	23547G12	Garza	331549	1012040	2,545	Quad Map	Alluvium	DOM (abandoned)		DOM	7/17/2001	13.98	(-)14"	No	No	Lip of well casing	No	No		
G-13	23467G13	Garza	331643	1012102	2,574	Quad Map	Alluvium	IRR	Sub	IRR	7/16/2001	28.95	(-)2"	No	No	Electrical opening in base plate	Yes	No		
G-14	23467G14	Garza	331629	1012105	2,547	Quad Map	Alluvium	DOM	Sub	DOM	7/17/2001			Yes	Yes		Yes	Yes	516	
G-15	23472G15	Garza	332002	1011149	2,319	Quad Map	Alluvium	IRR		IRR	7/17/2001	23.9	(-)8"	No	No	Lip of well casing	No	Yes	728	
G-16	23463G16	Garza	332053	1011717	2,448	Quad Map	Alluvium	IRR	Sub	IRR	7/17/2001	11.27	0"	No	No	Lip of well casing	No	No		
G-17	23479G17	Garza	331719	1010943	2,330	Quad Map	Alluvium	LIV (abandoned)	Windmill	LIV	7/17/2001			No	No		No	Yes	2690	
M-1	22027M1	Motley	345240	1005240	2,598	Quad Map	Seymour				7/18/2001	88.5								
M-2		Motley	345240	1005247	2,600	Quad Map	Seymour				7/18/2001									Ran both probes as deep as possible (110 ft). Both hit obstruction at about 45 feet, so unable to collect depth to water.
M-3	22027M3	Motley	335311	1005151	2,555	Quad Map	Alluvium				7/16/2001	31								
M-5	12589M5	Motley	340221	1004549	2,248	Quad Map	Seymour				7/17/2001	20.9		No	No		No	No		
M-6	12588M6	Motley	340131	1004802	2,342	Quad Map	Alluvium				7/17/2001	48.5		No	No		No	No		
M-7	22038M7	Motley	335328	1004013	2,208	Quad Map	Seymour			DOM	7/17/2001	18.75		Yes	No		Yes	No		
M-8	22038M8	Motley	335317	1003956	2,195	Quad Map	Seymour				7/17/2001	10.3								
M-9	22112M9	Motley	335232	1004002	2,320	Quad Map	Seymour				7/17/2001	178								
M-12	12417M12	Motley	341508	1005916	2,454	Quad Map	Seymour				7/18/2001	51.2		No	No		No	No		
M-13	12415M13	Motley	341823	1005535	2,358	Quad Map	Seymour			IRR	7/18/2001	75								
M-14	12415M14	Motley	341829	1005549	2,365	Quad Map	Seymour			IRR	7/18/2001	95								
M-15	12415M15	Motley	341841	1005543	2,361	Quad Map	Seymour				7/18/2001	83.2								
M-16	12426M16	Motley	341720	1005000	2,270	Quad Map	Seymour				7/18/2001	107.5		No	No		No	No		

See footnotes of Appendix A, Table 1.



Llano Estacado Water Planning Region

Swisher County

Depth to Water in Wells within the Ogallala Aquifer

Legend

- 27.01 Sampled Wells (Depth to Water)
- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams

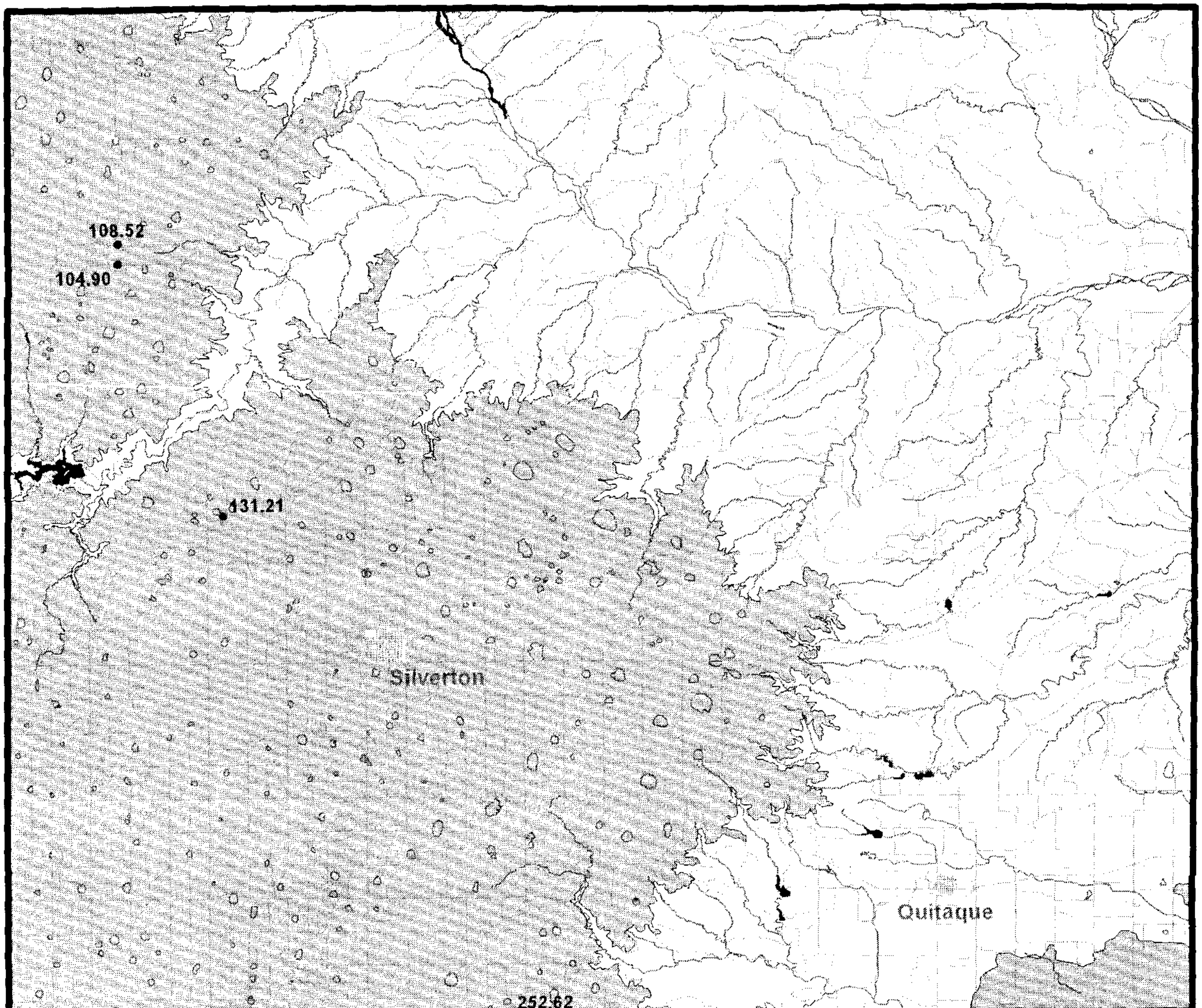
N
W E
S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix A Figure A-1



Llano Estacado Water Planning Region

Briscoe County

Depth to Water in Wells within the Ogallala Aquifer

Legend

27.01 Sampled Wells (Depth to Water)

Ogallala Aquifer

Seymour Aquifer

Cities

Lakes

Roads

Streams

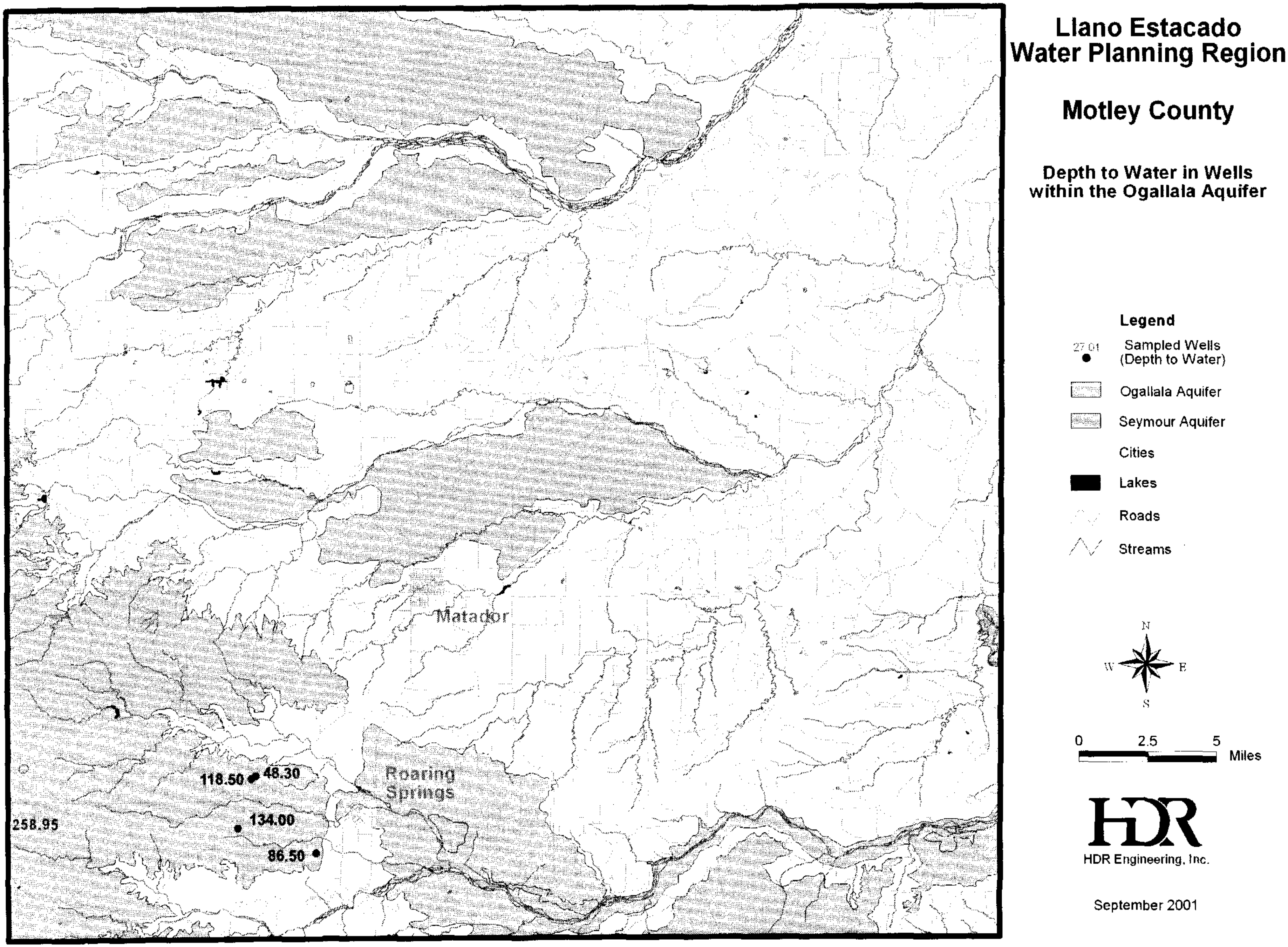
N W E S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix A Figure A-2

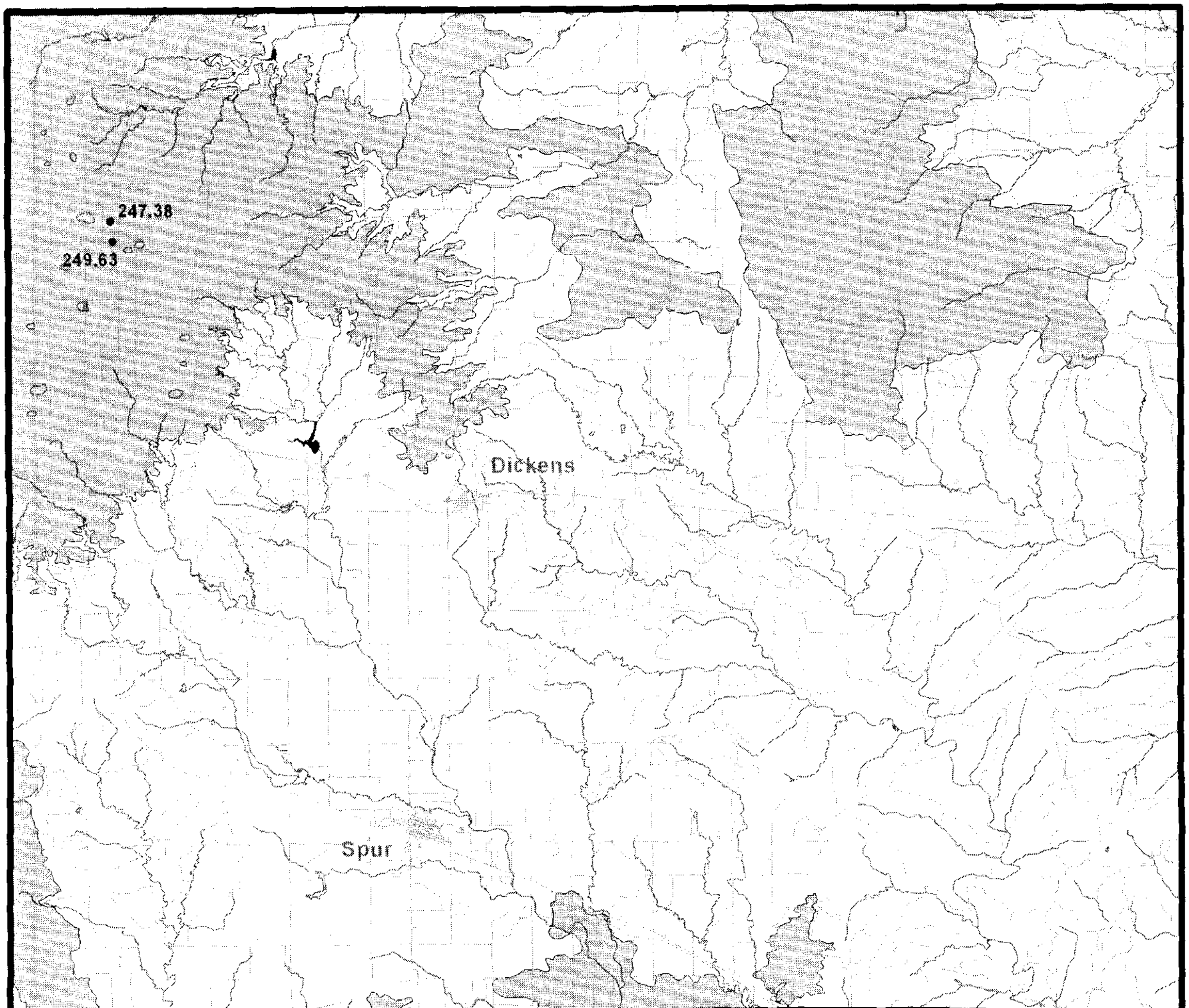


Appendix A Figure A- 3

Llano Estacado Water Planning Region

Dickens County

Depth to Water in Wells within the Ogallala Aquifer



Legend

27.01 Sampled Wells (Depth to Water)

Ogallala Aquifer

Seymour Aquifer

Cities

Lakes

Roads

Streams

N
W
E
S

0 2.5 5 Miles

HDR Engineering, Inc.

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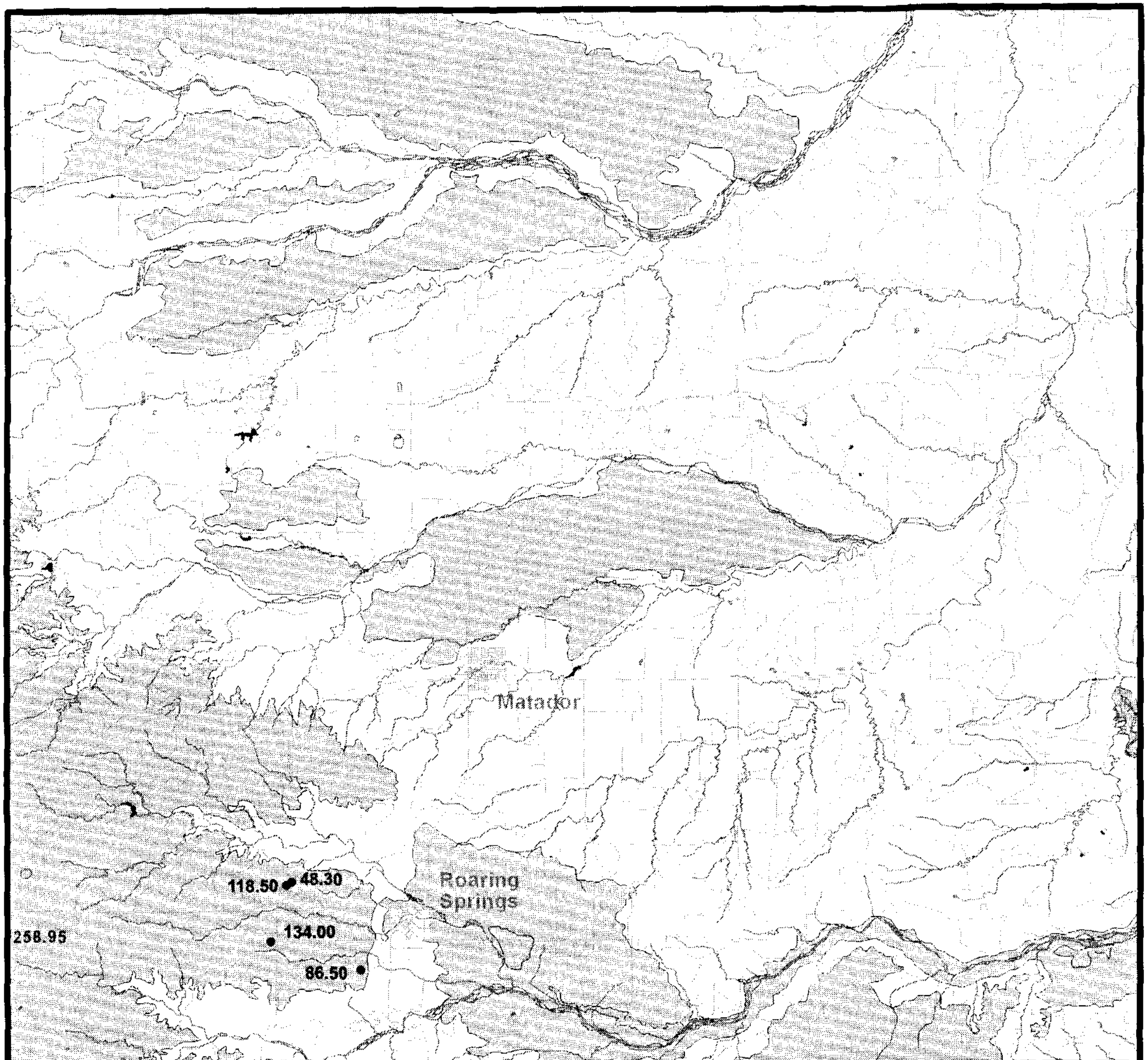
Appendix A Figure A-4



Llano Estacado Water Planning Region

Motley County

Depth to Water in Wells within the Ogallala Aquifer

Legend

27.01 Sampled Wells (Depth to Water)

Ogallala Aquifer

Seymour Aquifer

Cities

Lakes

Roads

Streams

N W E S

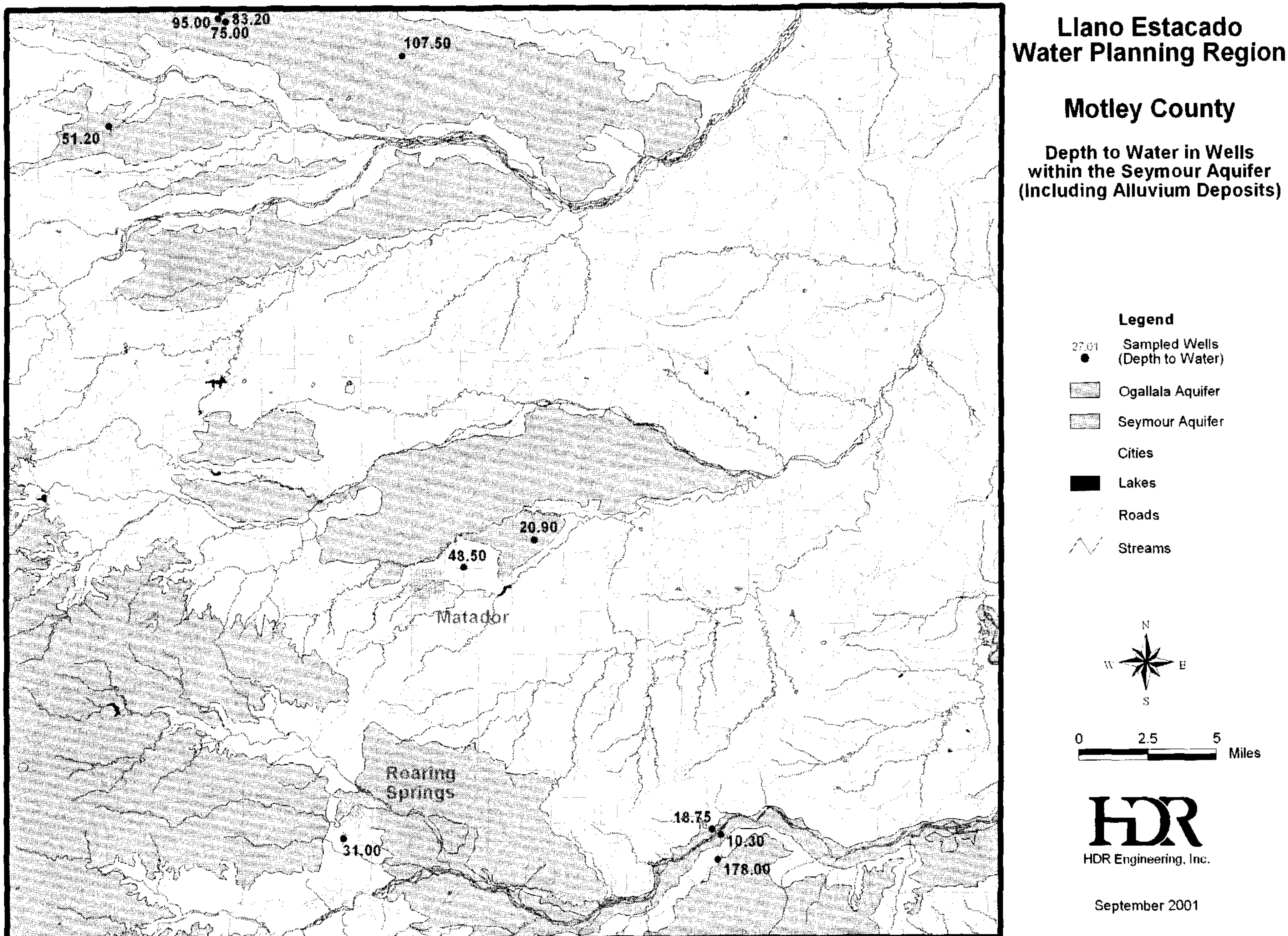
0 2.5 5 Miles

HDR

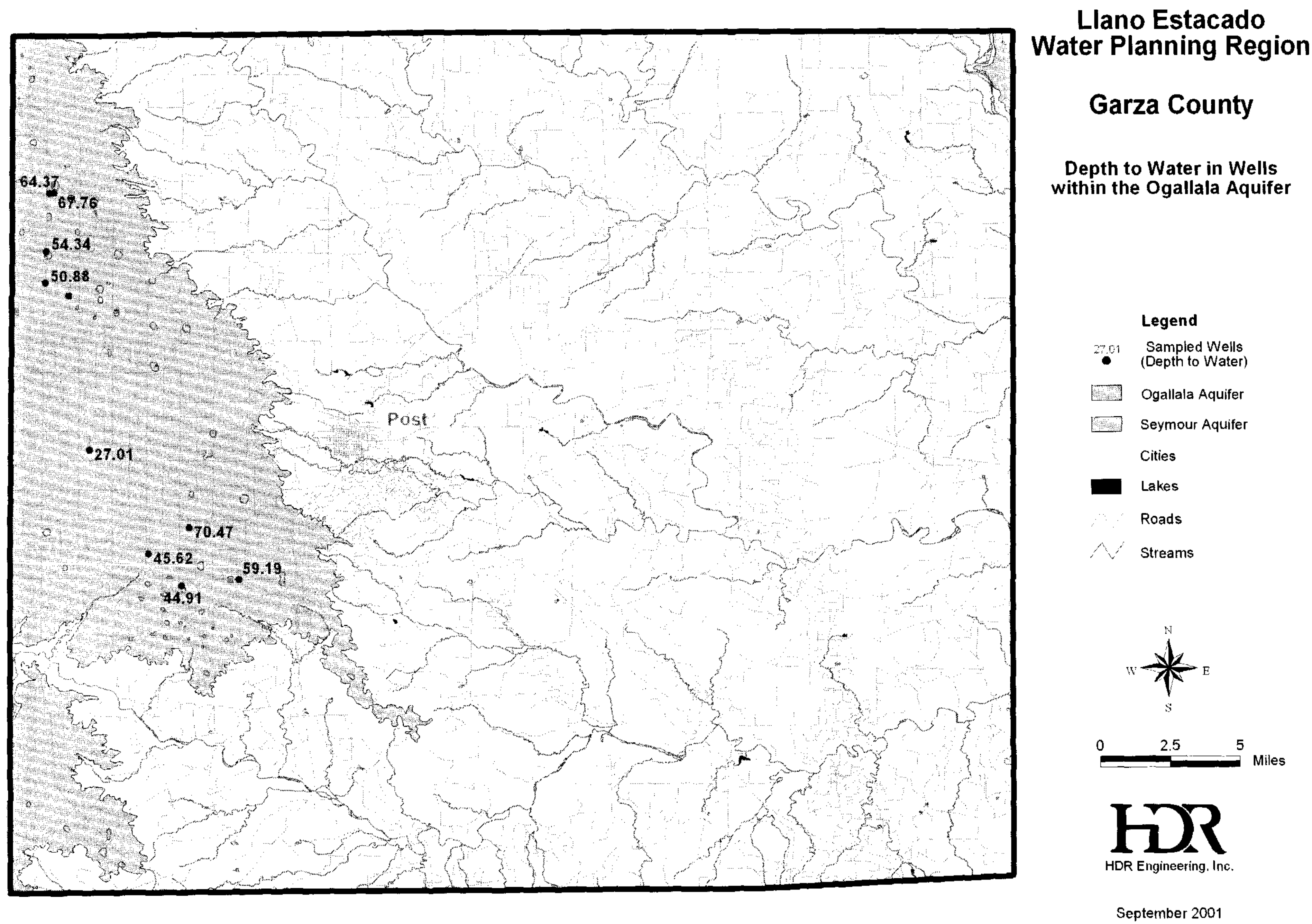
HDR Engineering, Inc.

September 2001

Appendix A Figure A- 3



Appendix A Figure A-6

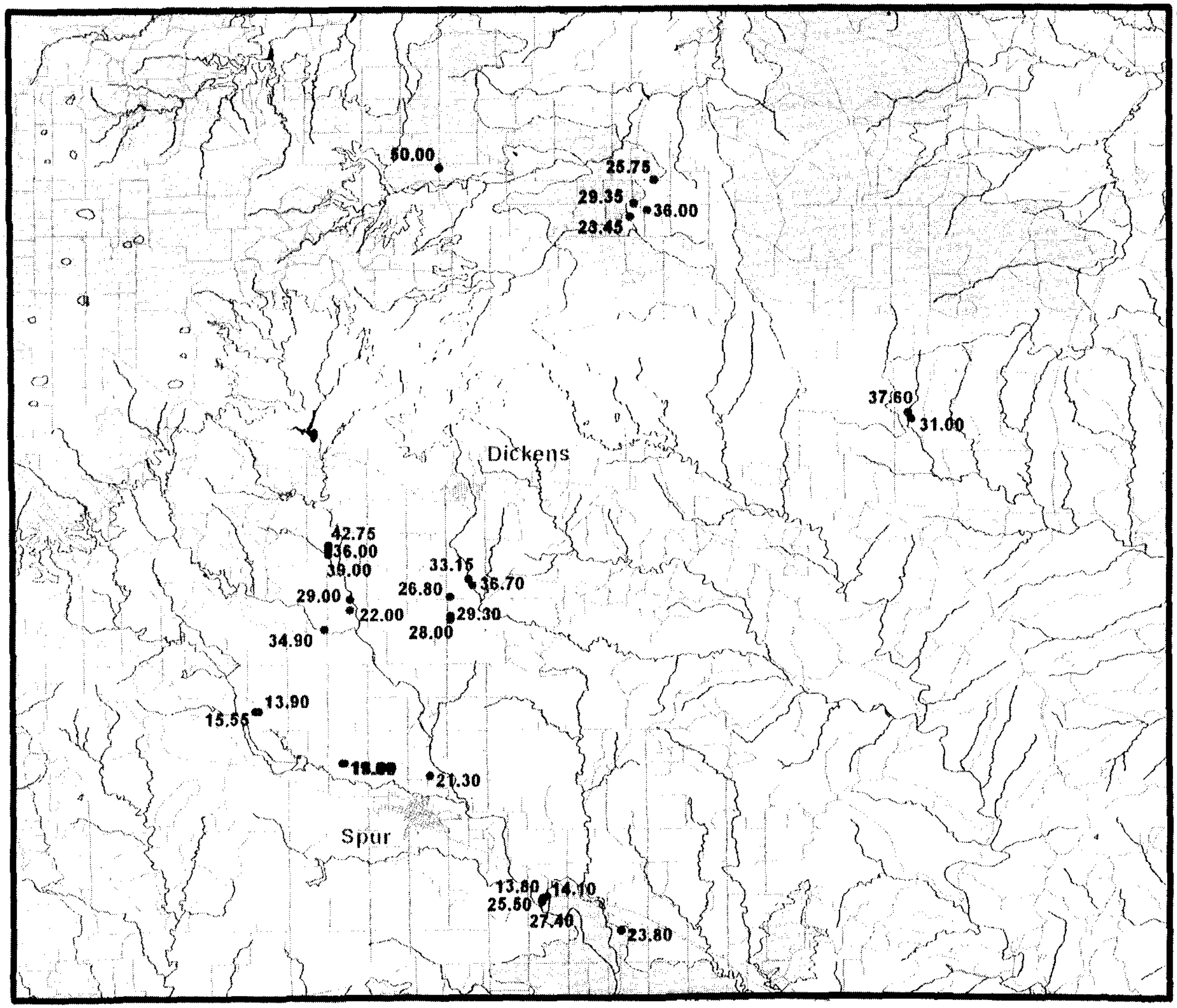


Appendix A Figure A-5

Llano Estacado Water Planning Region

Dickens County

Depth to Water in Wells within the Seymour Aquifer (Including Alluvium Deposits)



Legend

- 27.01 Sampled Wells (Depth to Water)
- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams

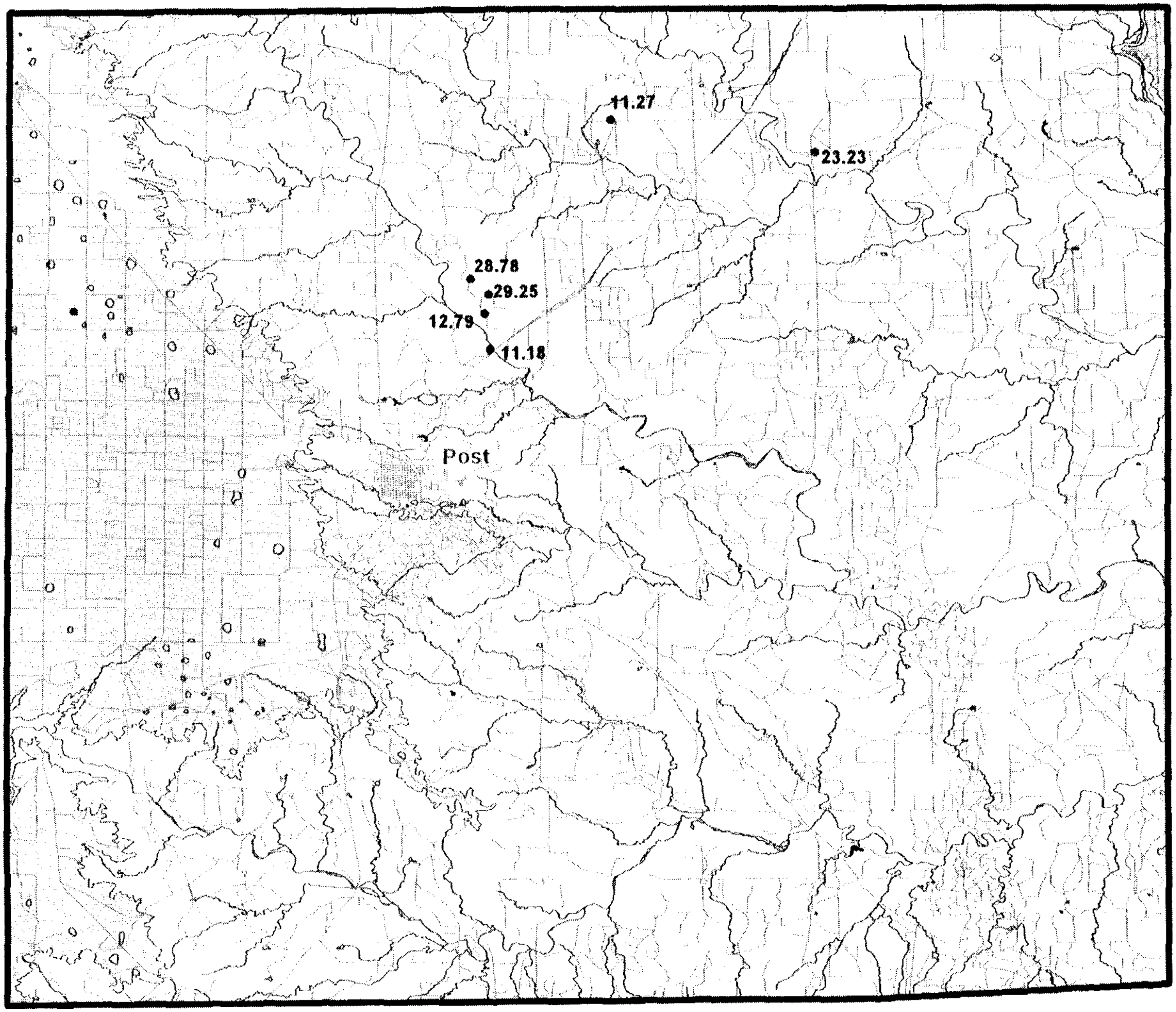
N W E S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix A Figure A-7



Llano Estacado Water Planning Region

Garza County

Depth to Water in Wells within the Seymour Aquifer (Including Alluvium Deposits)

Legend

27.01 Sampled Wells (Depth to Water)

Ogallala Aquifer

Seymour Aquifer

Cities

Lakes

Roads

Streams

N W E S

0 2.5 5 Miles

HDR

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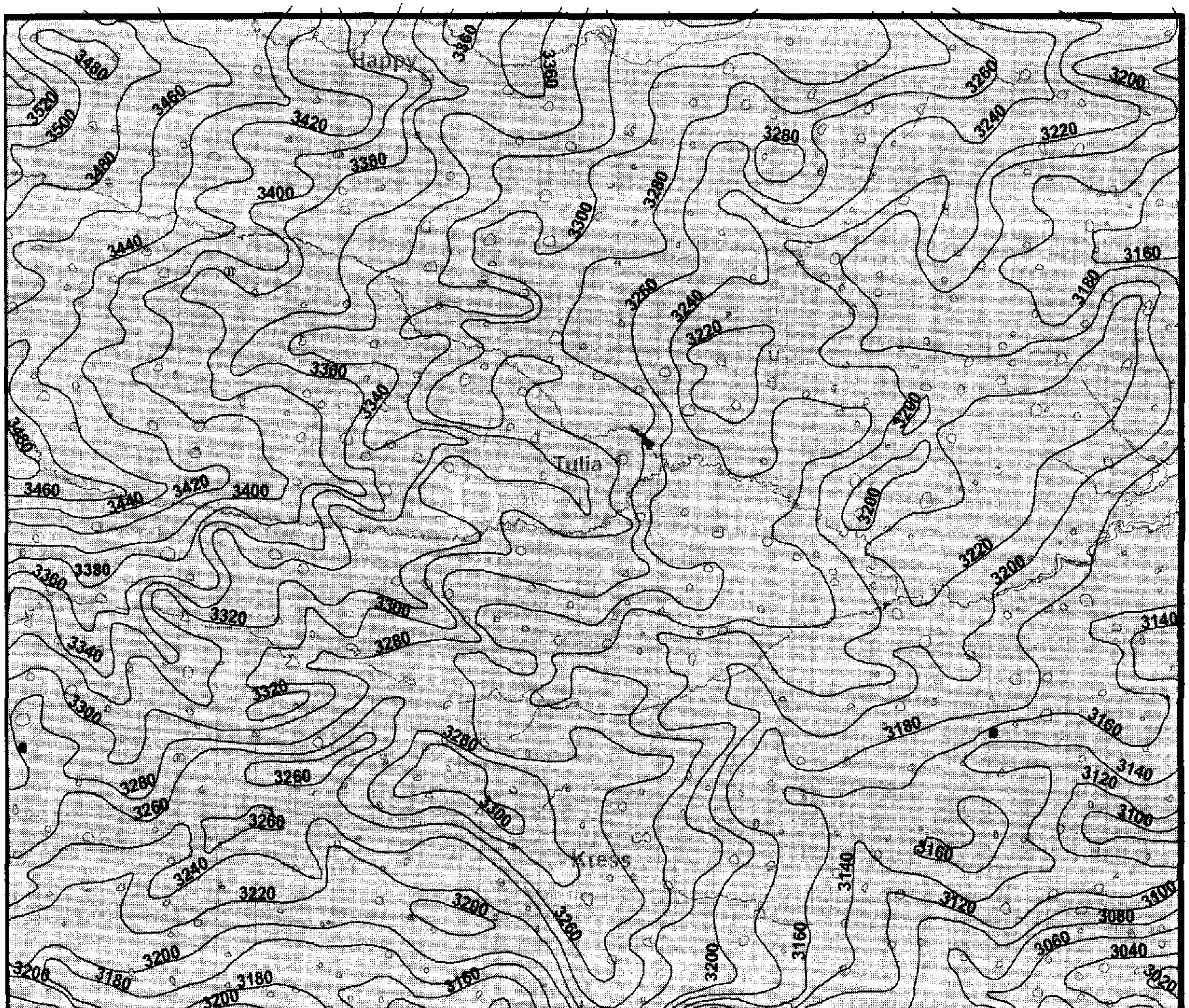
September 2001

Appendix A Figure A-8

Appendix B
Contour Maps



Llano Estacado Water Planning Region

Swisher County

Approximate Altitude of the Base of the Ogallala Aquifer

Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

Source: Texas Department of Water Resources

N W E S

0 2.5 5 Miles

HDR Engineering, Inc.

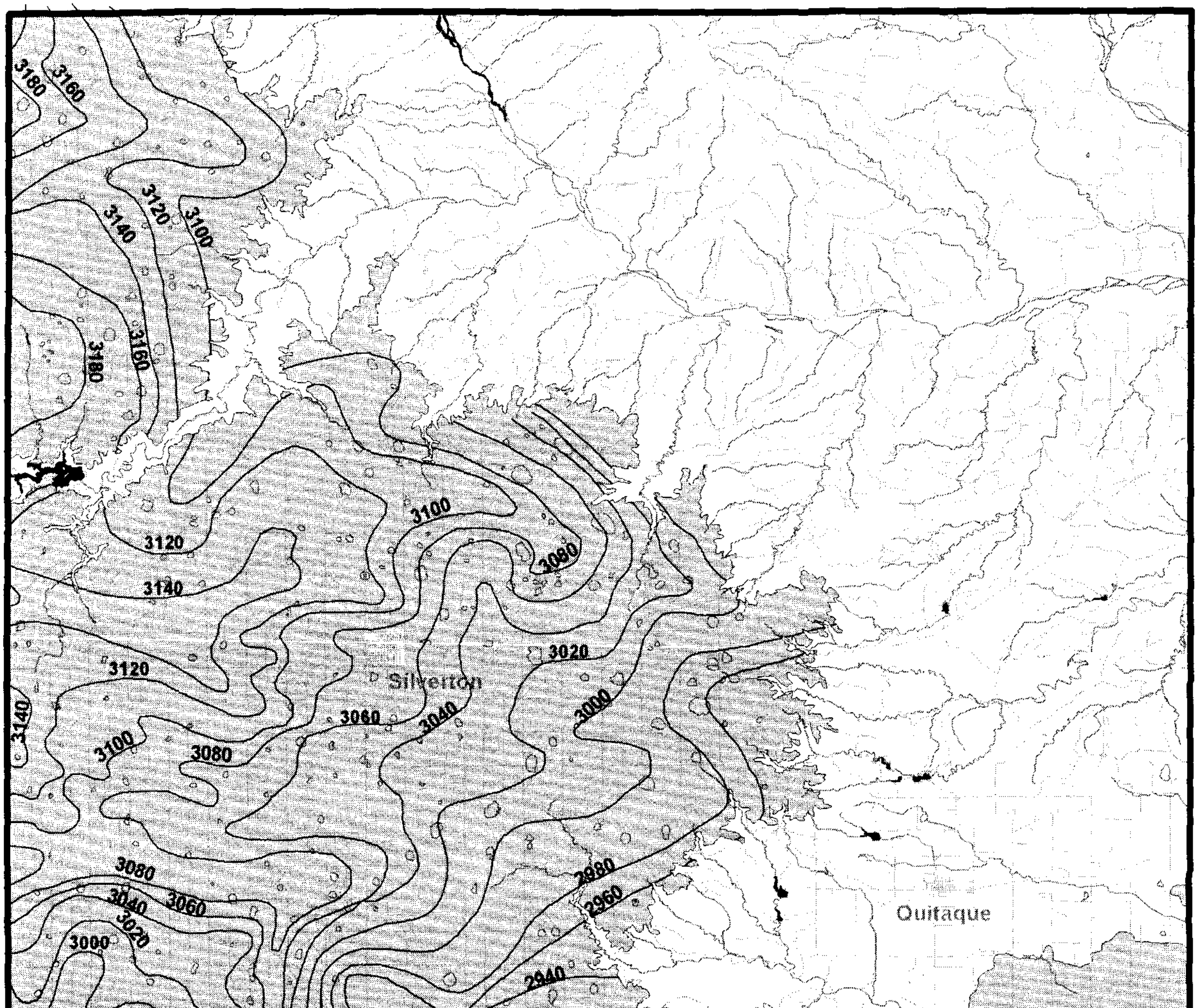
September 2001

Appendix B Figure B-1

Llano Estacado Water Planning Region

Briscoe County

Approximate Altitude of the Base of the Ogallala Aquifer



Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

Source: Texas Department of Water Resources

N W E S

0 2.5 5 Miles

HDR Engineering, Inc.

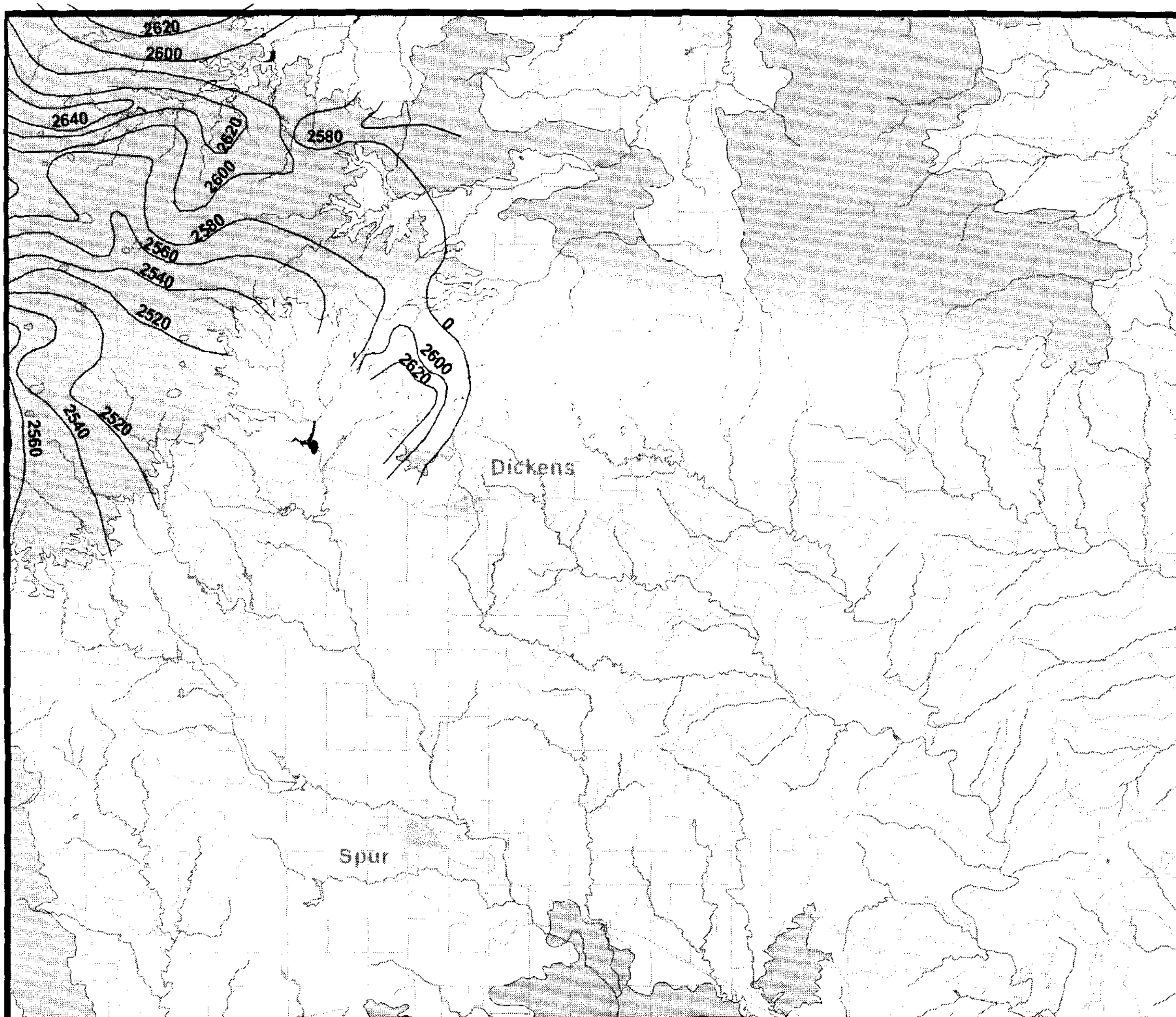
September 2001

Appendix B Figure B-2

Llano Estacado Water Planning Region

Dickens County

Approximate Altitude of the Base of the Ogallala Aquifer



Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

Source: Texas Department of Water Resources

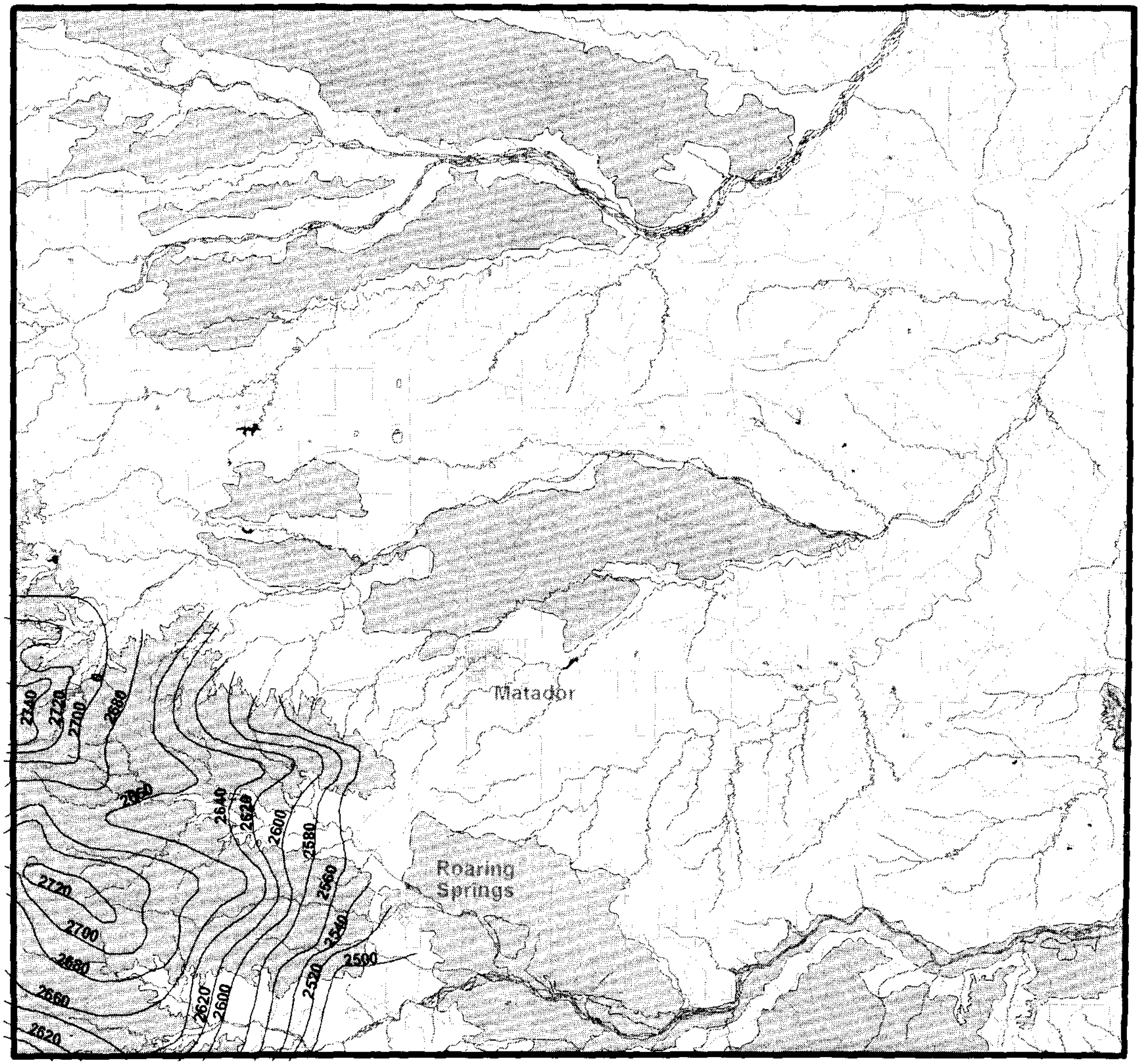
N
W E
S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix B Figure B-3



Llano Estacado Water Planning Region

Motley County

Approximate Altitude of the Base of the Ogallala Aquifer

Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

Source: Texas Department of Water Resources

N
W E
S

0 2.5 5 Miles

HDR
HDR Engineering, Inc.

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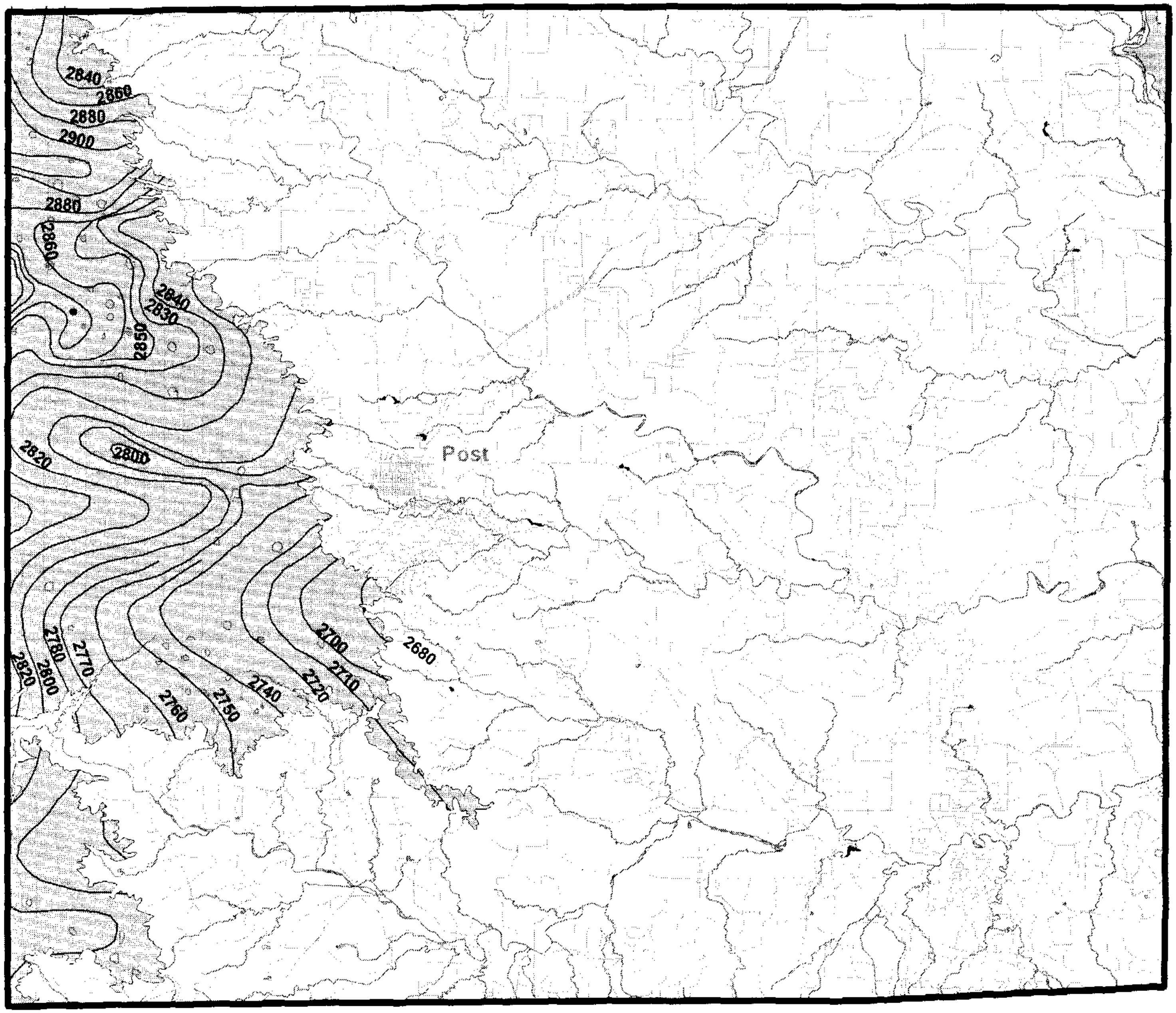
Appendix B Figure B-4

Llano Estacado Water Planning Region

Garza County

Approximate Altitude of the Base of the Ogallala Aquifer



Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

Source: Texas Department of Water Resources

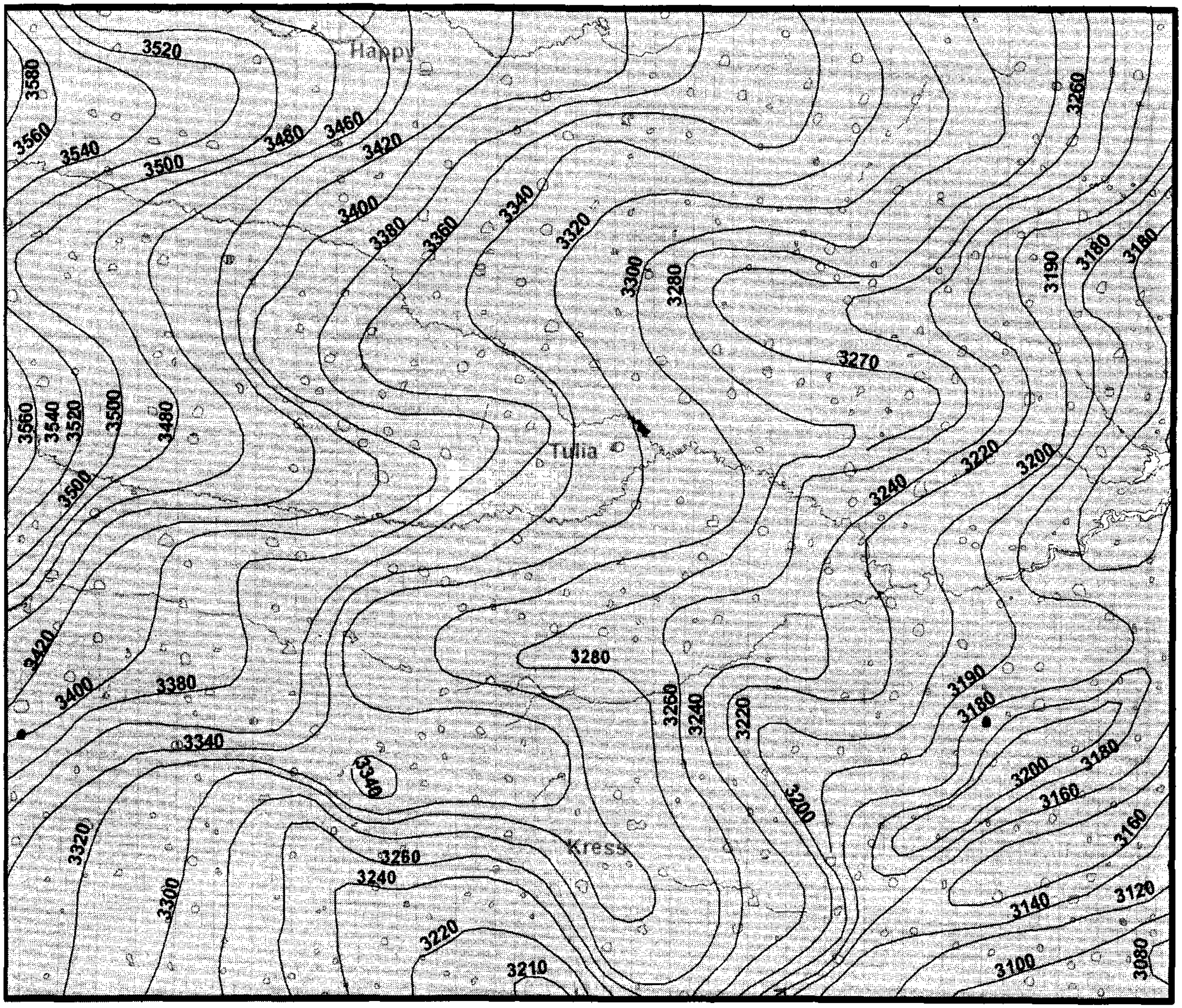
N
W E
S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix B Figure B-5



Llano Estacado Water Planning Region

Swisher County

Approximate Altitude of Water Levels in the Ogallala Aquifer, 2001

Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

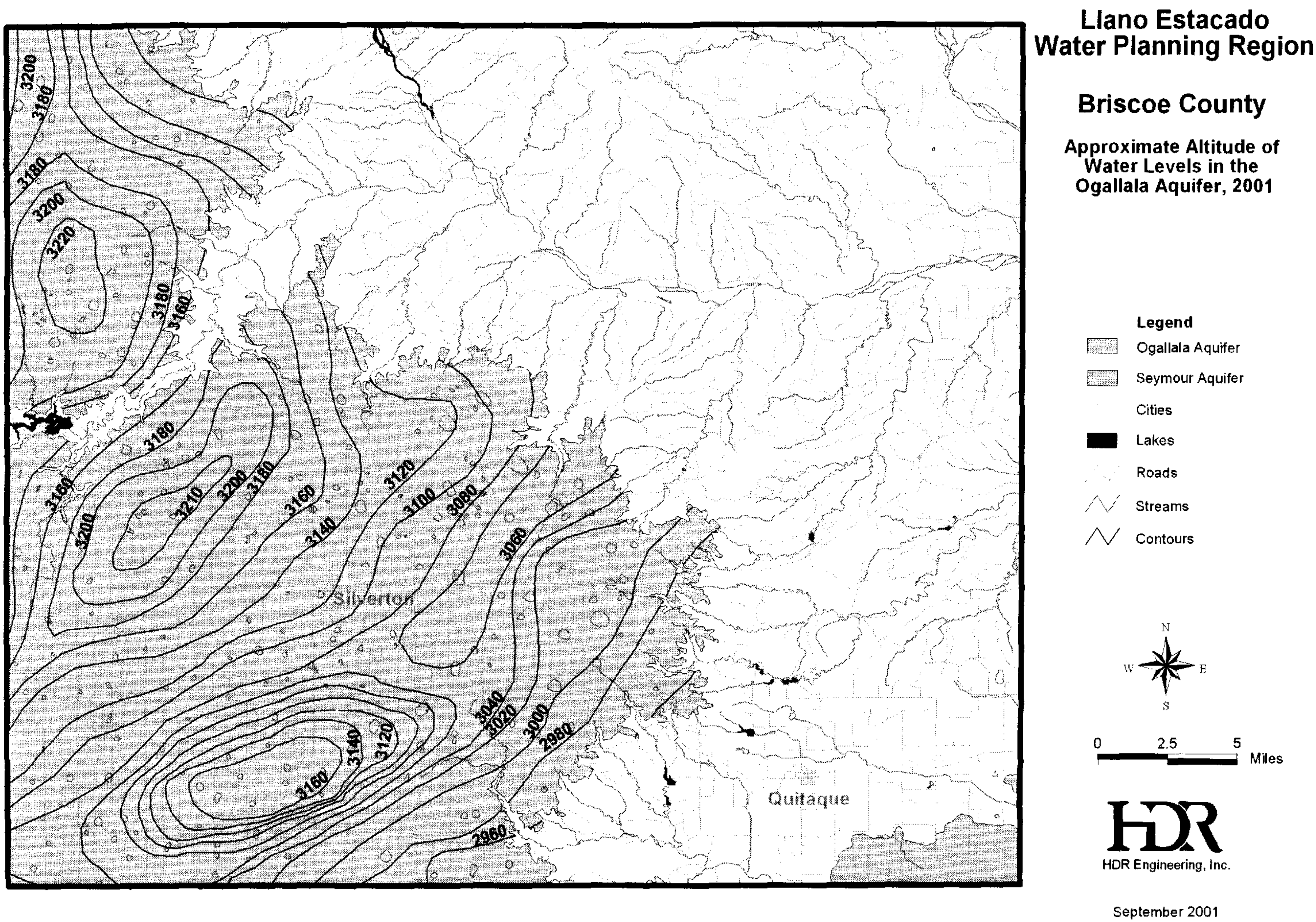
N
W E
S

0 2.5 5 Miles

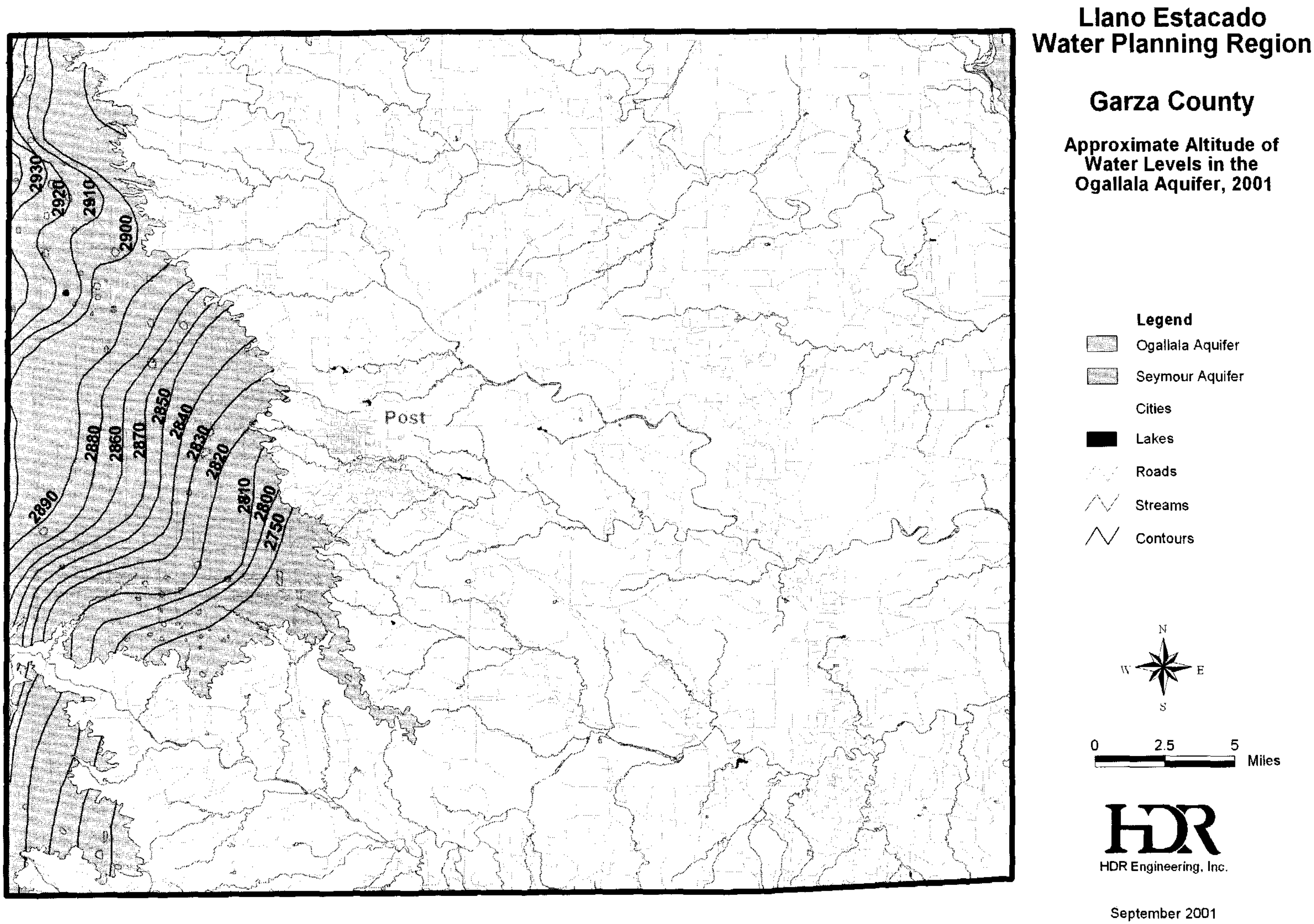
HDR Engineering, Inc.

September 2001

Appendix B Figure B-6



Appendix B Figure B-7

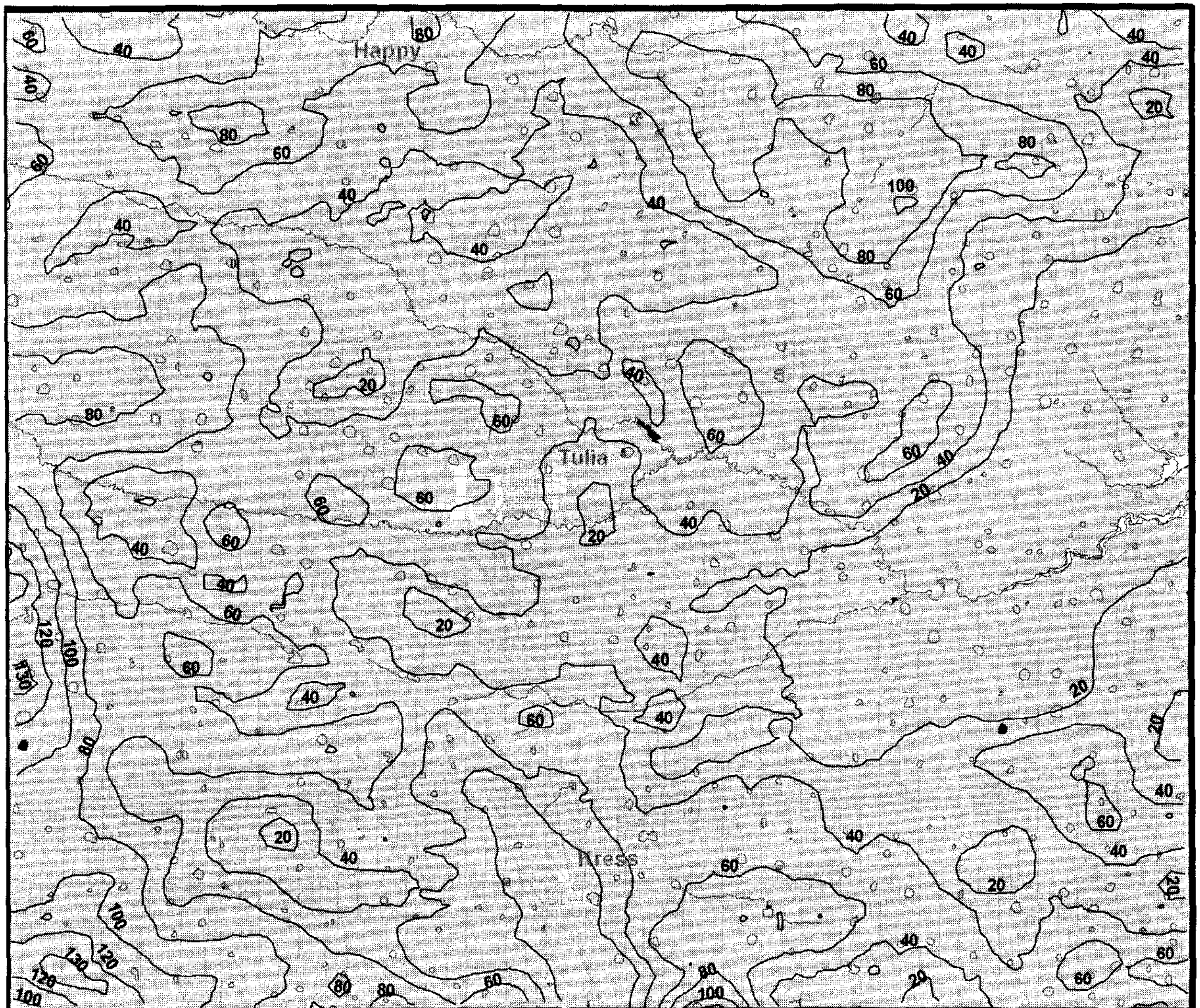


Appendix B Figure B-8

Llano Estacado Water Planning Region

Swisher County

Approximate Saturated Thickness of the Ogallala Aquifer, 2001



Legend

- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

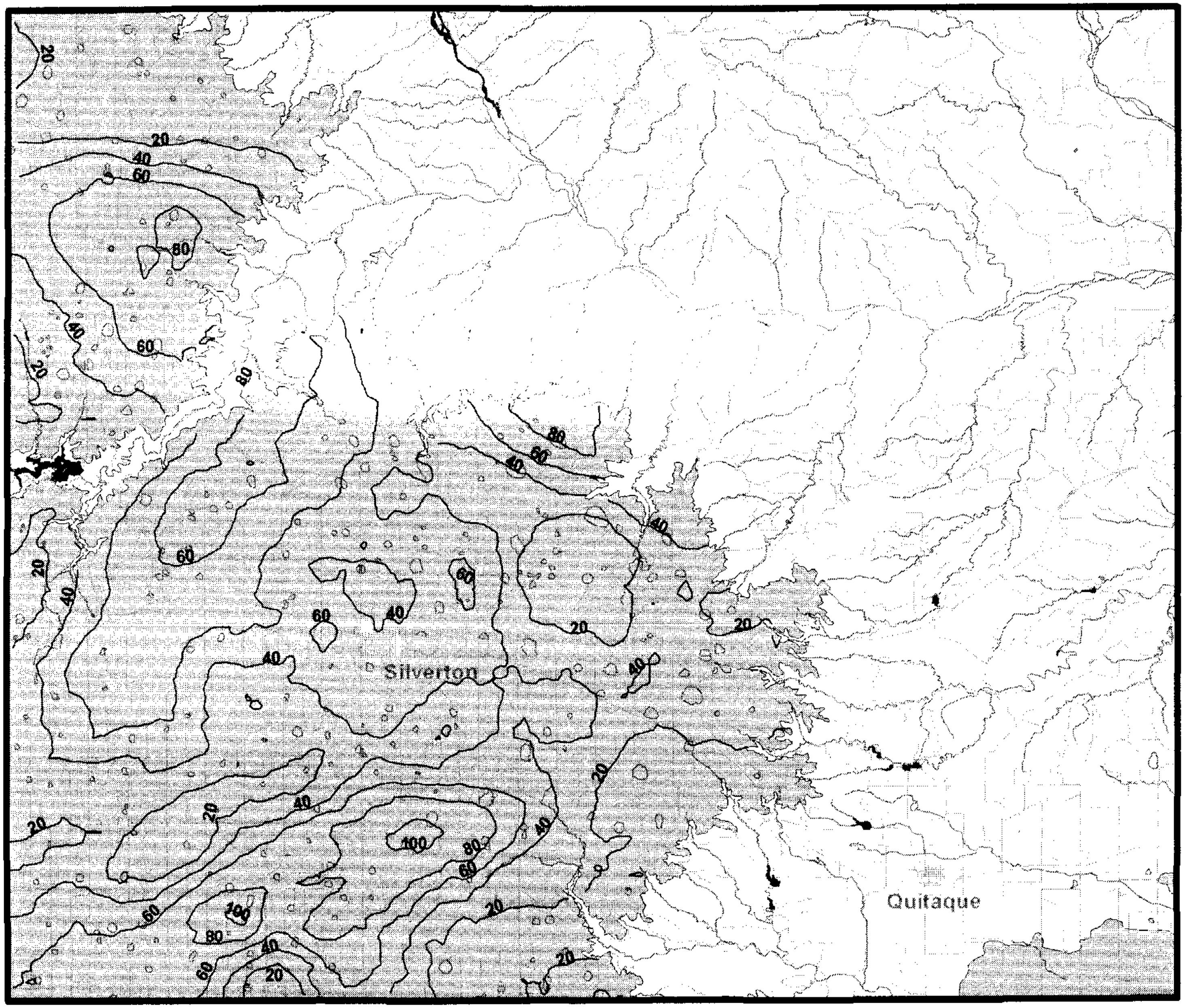
N
W
E
S

0 2.5 5 Miles

HDR Engineering, Inc.

September 2001

Appendix B Figure B-9



Llano Estacado Water Planning Region

Briscoe County

Approximate Saturated Thickness of the Ogallala Aquifer, 2001

Legend
- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams
- Contours

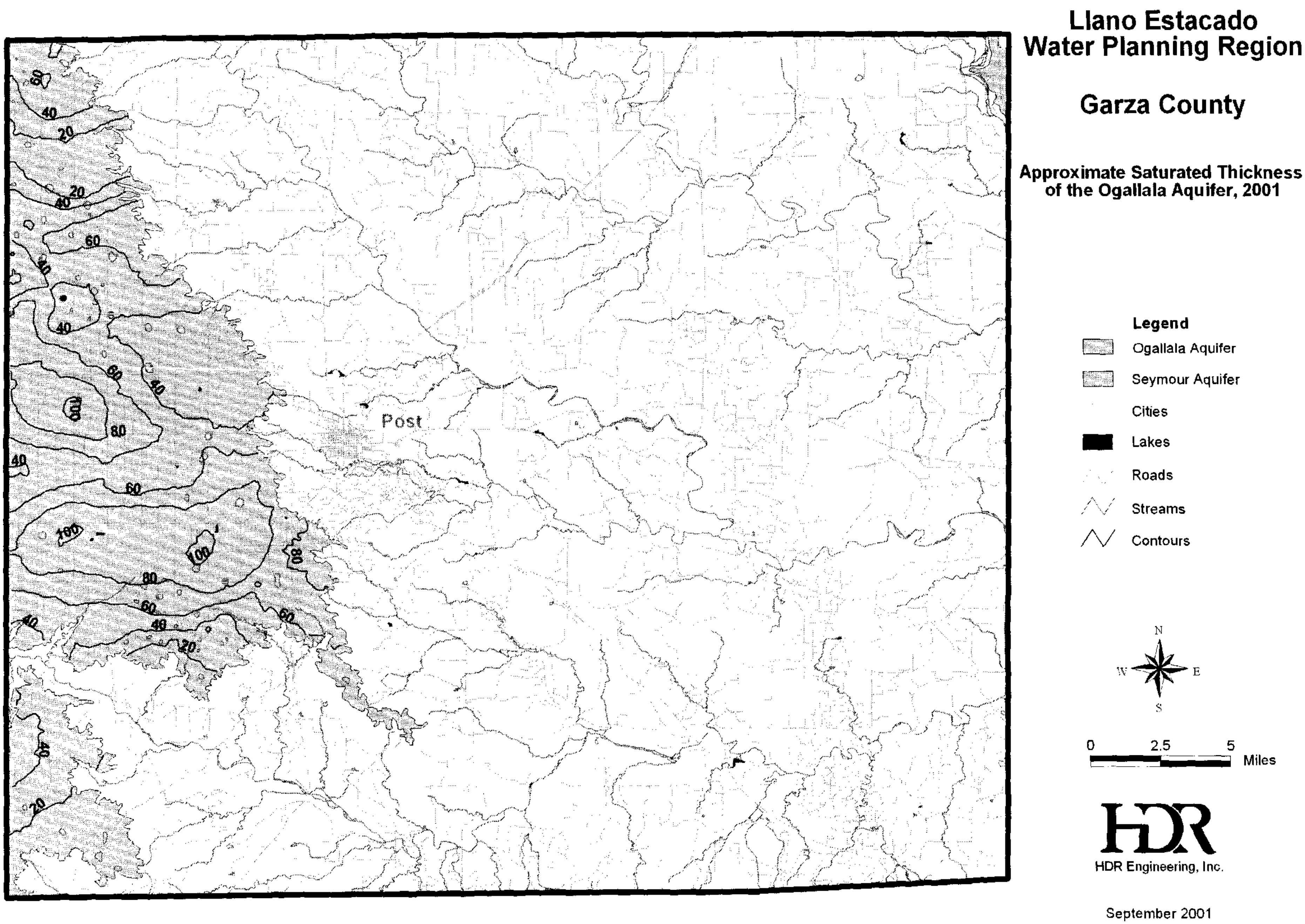
N
W E
S

0 2.5 5 Miles

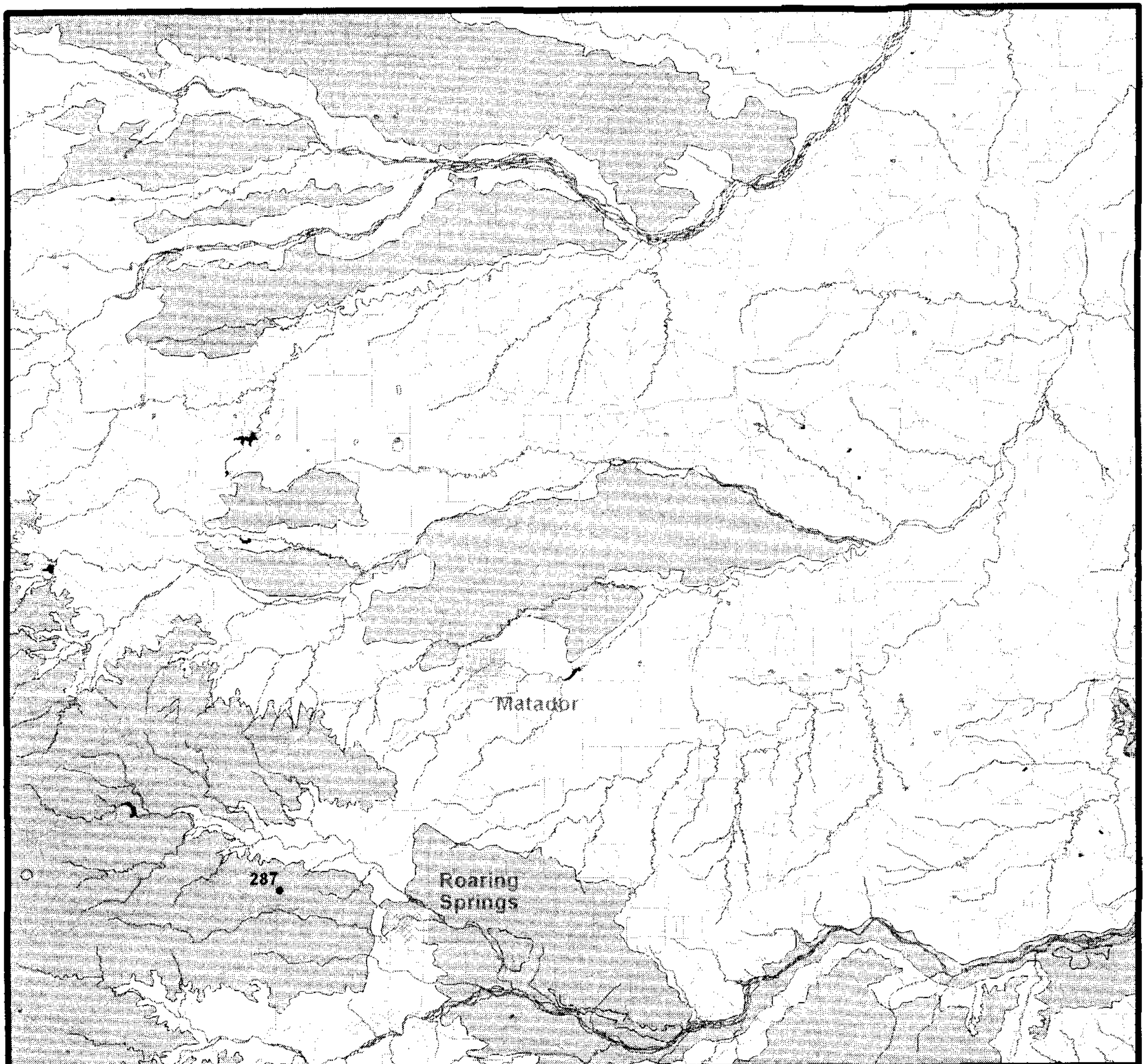
HDR
HDR Engineering, Inc.

September 2001

Appendix B Figure B-10



Appendix B Figure B-11



Llano Estacado Water Planning Region

Motley County

Total Dissolved Solids in Wells within the Seymour Aquifer, 2001

Legend

500 Sampled Wells (Dissolved Solids mg/L)
Ogallala Aquifer
Seymour Aquifer
Cities
Lakes
Roads
Streams

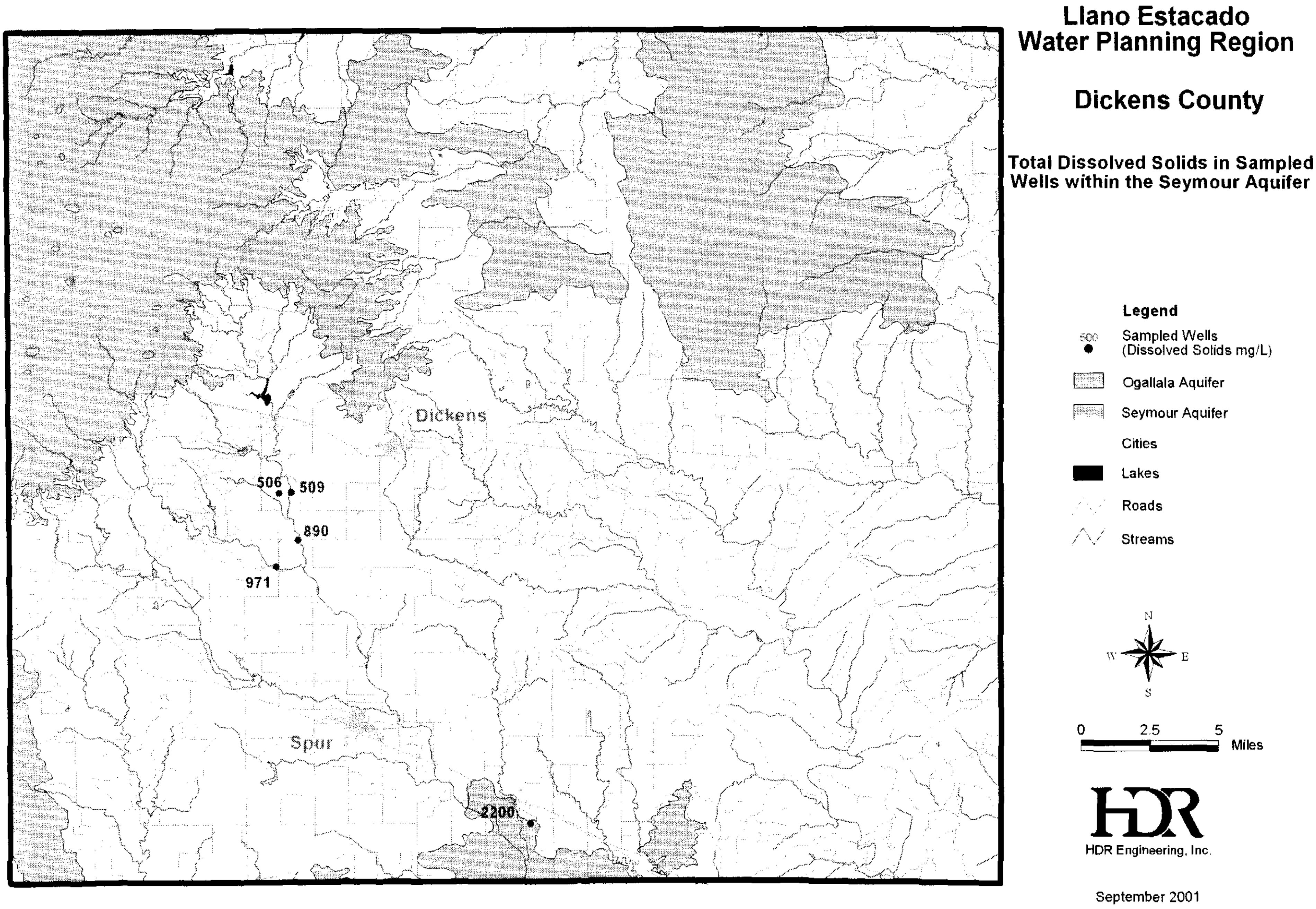
N
W E
S

0 2.5 5 Miles

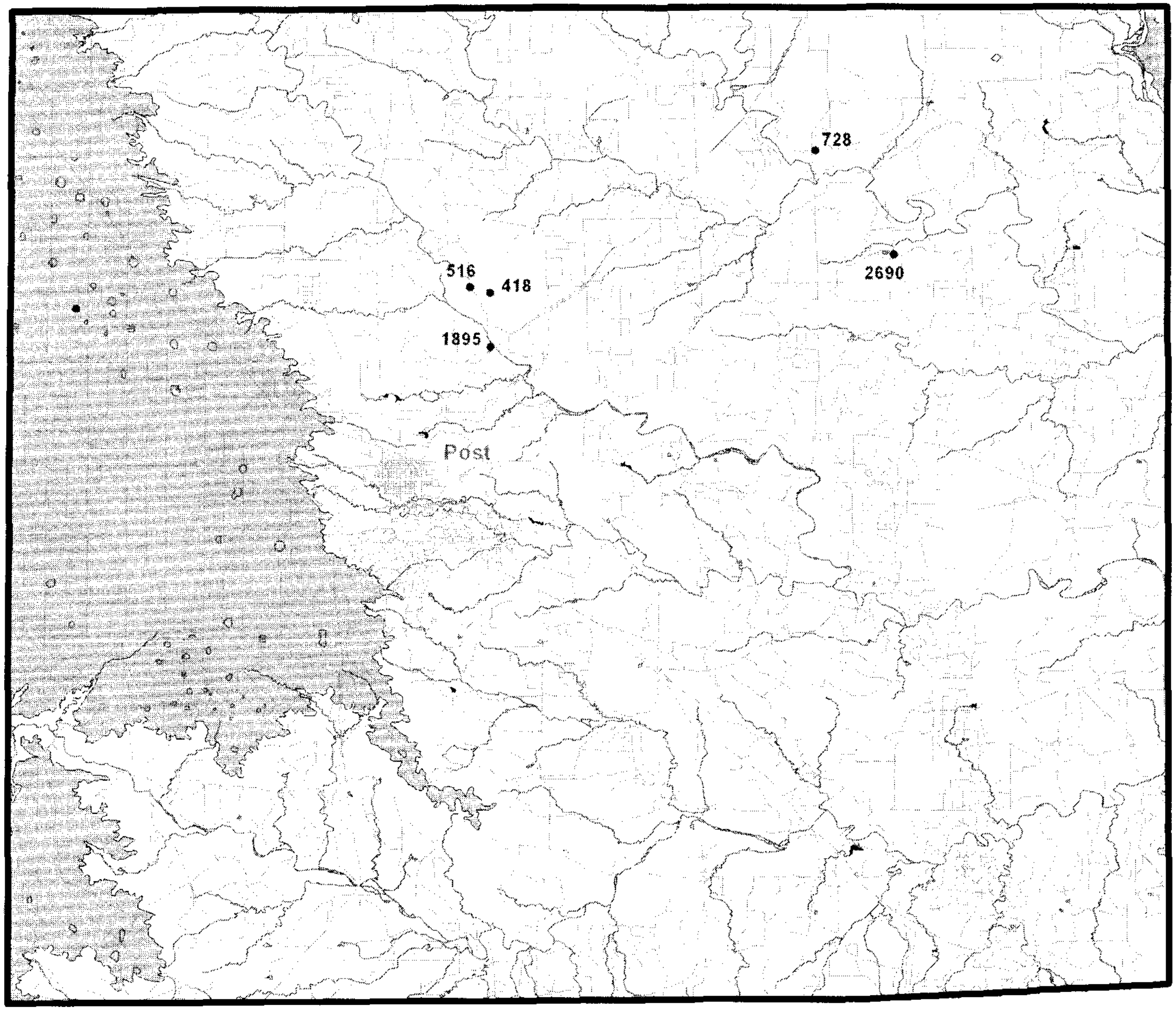
HDR
HDR Engineering, Inc.

September 2001

Appendix B Figure B-12



Appendix B Figure B-13



Llano Estacado Water Planning Region

Garza County

Total Dissolved Solids in Wells within the Seymour Aquifer, 2001

Legend

- 500 Sampled Wells (Dissolved Solids mg/L)
- Ogallala Aquifer
- Seymour Aquifer
- Cities
- Lakes
- Roads
- Streams

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HDR Engineering, Inc.

September 2001

Appendix B Figure B-14

Appendix C
Buffer Area Wells

Elevation of Base Of Aquifer

Appendix C--Table 1: Crosby County
List of Wells in 2-5 Mile Buffer Area to Dickens County
Elevation of Base of Ogallala Aquifer

State Well No.	Latitude	Longtitude	Elevation of land surface (ft)	Elevation of base of Ogallala (ft)
23-16-4A	23-48-58	101-07-23	3,051	2,689
23-16-4B	23-49-22	101-07-25	3,043	2,678
23-16-4D	23-49-55	101-06-25	3,047	2,660
23-16-5A	23-49-50	101-04-59	3,045	2,675
23-16-5B	23-48-43	101-04-04	3,037	2,694
23-16-7A	33-47-26	101-05-11	3,018	2,678
23-16-7B	33-46-05	101-06-10	3,014	2,620
23-16-7C	33-46-23	101-05-05	3,018	2,624
23-16-8A	33-47-18	101-03-03	3,023	2,628
23-16-8B	33-46-36	101-03-50	3,018	2,636
23-24-202	33-44-35	101-03-21	3,002	2,642
23-24-2A	33-44-00	101-02-37	3,002	2,557
23-24-2B	33-43-00	101-03-43	3,003	2,559
23-24-401	33-41-50	101-05-52	3,003	2,688
23-24-4A	33-40-27	101-06-00	2,982	2,556
23-24-4B	33-42-04	101-06-53	3,014	2,645
23-24-4C	33-42-10	101-05-49	3,014	2,668
23-24-5A	33-42-15	101-04-41	3,009	2,665
23-24-5B	33-42-18	101-03-43	3,002	2,657
23-24-5C	33-42-15	101-02-35	2,987	2,544
23-24-5D	33-42-25	101-03-03	2,993	2,531
23-24-5E	33-40-59	101-04-15	2,978	2,552

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Appendix C--Table 2: Floyd County
List of Wells in 2-5 Mile Buffer Area to Briscoe and Motley Counties
Elevation of Base of Ogallala Aquifer

State Well No.	Latitude	Longtitude	Elevation of land surface (ft)	Elevation of base of Ogallala (ft)
11-44-5A	34-17-58	101-32-53	3,338	3,086
11-44-6A	34-18-14	101-31-56	3,322	3,087
11-44-6B	34-17-57	101-30-48	3,305	3,065
11-44-8A	34-16-47	101-33-09	3,328	3,066
11-44-8B	34-15-39	101-33-08	3,321	3,060
11-44-8C	34-15-05	101-33-18	3,325	3,057
11-44-4A	34-18-14	101-28-48	3,310	3,038
11-44-4B	34-17-32	101-27-39	3,297	3,036
11-44-5A	34-18-21	101-27-17	3,305	3,004
11-44-5B	34-17-55	101-26-45	3,292	3,020
11-44-5C	34-18-04	101-25-06	3,284	2,987
11-44-6A	34-18-23	101-23-11	3,281	3,028
11-44-6B	34-17-57	101-23-45	3,271	2,984
11-44-6C	34-17-31	101-24-21	3,282	3,026
11-46-4A	34-18-22	101-21-48	3,274	3,021
11-46-4B	34-17-56	101-22-09	3,277	2,984
11-46-4C	34-17-50	101-21-17	3,265	3,005
11-46-4D	34-18-06	101-20-42	3,253	3,063
11-45-4E	34-17-37	101-20-26	3,250	3,044
11-46-5A	34-17-38	101-19-41	3,238	3,058
11-46-5B	34-17-31	101-18-42	3,245	2,960
11-46-6A	34-18-04	101-17-09	3,211	2,930
11-46-6B	34-18-13	101-15-50	3,207	2,910
11-47-403	34-18-37	101-13-26	3,188	2,908
11-47-4A	34-17-55	101-14-41	3,198	2,893
11-47-7A	34-17-17	101-13-22	3,190	2,883
11-47-7B	34-16-50	101-14-13	3,194	2,886
11-47-7C	34-16-49	101-13-39	3,189	2,860
11-47-7D	34-15-32	101-12-35	3,186	2,891
11-47-8A	34-16-21	101-12-03	3,182	2,886
11-47-8B	34-15-35	101-12-06	3,182	2,872
11-47-8C	34-15-36	101-11-07	3,176	2,911
23-08-1A	33-59-16	101-06-18	3,101	2,791
23-08-1B	33-58-42	101-05-45	3,094	2,789
23-08-1C	33-58-27	101-05-30	3,094	2,779
23-08-1D	33-58-22	101-06-37	3,098	2,753
23-08-1E	33-58-07	101-06-52	3,096	2,736
23-08-1F	33-57-31	101-07-00	3,093	2,744
23-08-2A	33-57-57	101-04-37	3,086	2,744
23-08-2B	33-58-02	101-03-34	3,081	2,726
23-08-2C	33-58-28	101-03-16	3,087	2,729
23-08-2D	33-58-31	101-02-31	3,083	2,723
23-08-401	33-57-00	101-06-38	3,088	2,723
23-08-4A	33-56-39	101-06-24	3,081	2,718
23-08-4B	33-56-08	101-05-01	3,076	2,721
23-08-4C	33-55-01	101-07-06	3,076	2,676
23-08-5A	33-55-58	101-03-43	3,073	2,690
23-08-5B	33-55-01	101-02-31	3,057	2,697

Appendix C--Table 2: Floyd County
List of Wells in 2-5 Mile Buffer Area to Briscoe and Motley Counties
Elevation of Base of Ogallala Aquifer

State Well No.	Latitude	Longtitude	Elevation of land surface (ft)	Elevation of base of Ogallala (ft)
23-08-7A	33-54-47	101-06-24	3,073	2,695
23-08-7B	33-53-11	101-05-13	3,060	2,665
23-08-7C	33-52-51	101-06-05	3,066	2,641
23-08-7D	33-52-47	101-05-24	3,062	2,632
23-08-7E	33-52-30	101-05-01	3,058	2,649
23-08-8A	33-54-49	101-04-15	3,072	2,682
23-08-8B	33-54-19	101-04-11	3,068	2,701
23-08-8C	33-53-50	101-04-11	3,068	2,678
23-08-8D	33-52-40	101-03-36	3,052	2,662
23-16-1A	33-51-56	101-07-00	3,063	2,644
23-16-1B	33-51-51	101-05-06	3,053	2,641
23-16-1C	33-50-50	101-06-04	3,057	2,639
23-16-201	33-52-09	101-03-52	3,050	2,598
23-16-2A	33-51-17	101-02-42	3,043	2,633
23-16-2B	33-50-06	101-04-29	3,048	2,628

Appendix C--Table 3: Hale County
List of Wells in 2-5 Mile Buffer Area to Swisher County
Elevation of Base of Ogallala Aquifer

State Well No.	Latitude	Longtitude	Elevation of land surface (ft)	Elevation of base of Ogallala (ft)
10-48-4A	34-17-56	102-05-04	3,611	3,279
10-48-5A	34-18-34	102-02-37	3,586	3,213
10-48-5B	34-17-32	102-03-23	3,584	3,274
10-48-6A	34-18-18	102-01-33	3,577	3,202
10-48-8A	34-15-27	102-03-26	3,592	3,262
10-48-8B	34-16-11	102-04-31	3,606	3,271
10-48-9A	34-16-22	102-01-22	3,558	3,251
10-48-9B	34-17-00	102-01-29	3,565	3,225
10-48-9C	34-17-04	102-00-21	3,555	3,278
11-41-4A	34-18-25	101-57-56	3,547	3,246
11-41-4B	34-18-31	101-57-30	3,540	3,233
11-41-4C	34-17-37	101-59-31	3,552	3,259
11-41-5A	34-17-31	101-57-10	3,534	3,247
11-41-5B	34-18-28	101-55-52	3,534	3,164
11-41-6A	34-18-24	101-54-09	3,513	3,209
11-41-6B	34-17-55	101-52-31	3,501	3,209
11-41-6C	34-18-20	101-54-46	3,485	3,212
11-41-6D	34-17-50	101-53-57	3,500	3,210
11-42-4A	34-17-49	101-50-52	3,480	3,202
11-42-5A	34-17-51	101-48-02	3,465	3,145
11-42-5B	34-18-20	101-48-20	3,472	3,124
11-42-5C	34-17-47	101-48-53	3,472	3,139
11-42-6A	34-18-12	101-46-00	3,458	3,146
11-42-6B	34-17-53	101-47-15	3,461	3,126
11-42-802	34-15-16	101-48-26	3,445	3,107
11-43-4A	34-17-42	101-44-39	3,436	3,149
11-43-5A	34-18-08	101-41-32	3,405	3,120
11-43-5B	34-18-35	101-41-35	3,412	3,122
11-43-5C	34-17-56	101-40-47	3,392	3,089
11-43-5D	34-17-43	101-40-25	3,387	3,117
11-43-6A	34-18-35	101-38-41	3,383	3,118
11-43-6B	34-18-19	101-38-09	3,378	3,098
11-43-6C	34-17-32	101-38-42	3,376	3,088
11-44-4A	34-18-28	101-36-34	3,368	3,105
11-44-4B	34-17-31	101-35-26	3,359	3,063
11-44-4C	34-17-31	101-36-36	3,368	3,065
11-44-704	34-16-36	101-36-12	3,350	3,050
11-44-7A	34-15-52	101-35-17	3,341	3,041
11-44-807	34-15-12	101-34-56	3,332	3,027

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Appendix C--Table 4: Lynn County
List of Wells in 2-5 Mile Buffer Area to Garza County
Elevation of Base of Ogallala Aquifer

State Well No.	Latitude	Longtitude	Elevation of land surface (ft)	Elevation of base of Ogallala (ft)
23-36-7B	33-22-39	101-35-59	3,047	2,950
23-36-8A	33-23-23	101-34-54	3,047	2,914
23-36-8B	33-22-39	101-33-57	3,031	2,902
23-44-1A	33-22-19	101-37-17	3,044	2,979
23-44-1B	33-22-26	101-36-33	3,047	2,959
23-44-1C	33-22-17	101-35-52	3,044	2,952
23-44-1D	33-21-35	101-36-45	3,047	2,957
23-44-1E	33-21-27	101-35-59	3,050	2,950
23-44-1F	33-20-17	101-37-20	3,050	2,988
23-44-1G	33-20-17	101-37-01	3,050	2,981
23-44-1H	33-20-27	101-35-42	3,037	2,951
23-44-2A	33-22-16	101-34-54	3,042	2,932
23-44-2B	33-22-16	101-33-47	3,027	2,902
23-44-2C	33-21-41	101-34-51	3,037	2,950
23-44-2D	33-21-34	101-33-48	3,027	2,931
23-44-2E	33-20-34	101-34-26	3,023	2,928
23-44-2F	33-20-25	101-33-36	3,015	2,915
23-44-4A	33-19-21	101-37-15	3,033	2,971
23-44-4B	33-19-04	101-36-22	3,023	2,956
23-44-4C	33-19-29	101-35-30	3,011	2,951
23-44-4D	33-18-50	101-36-20	3,023	2,953
23-44-4E	33-18-11	101-35-45	3,006	2,948
23-44-4F	33-17-41	101-37-17	3,015	2,965
23-44-4G	33-17-36	101-36-28	3,018	2,950
23-44-4H	33-17-53	101-35-34	3,002	2,951
23-44-4I	33-17-33	101-35-14	2,998	2,946
23-44-5A	33-19-14	101-34-37	3,005	2,886
23-44-5B	33-18-29	101-34-19	3,002	2,871
23-44-5C	33-17-35	101-33-48	2,992	2,918
23-44-7A	33-17-18	101-37-02	3,018	2,969
23-52-1A	33-12-47	101-35-34	2,967	2,915
23-52-2A	33-14-19	101-34-46	2,963	2,888
23-52-7A	33-09-46	101-36-44	2,957	2,912
23-52-7B	33-09-57	101-35-15	2,949	2,886
23-52-7C	33-08-47	101-37-13	2,959	2,875
23-52-801	33-07-55	101-34-20	2,935	2,847
23-60-701	33-02-11	101-35-16	2,884	2,819
23-60-7A	33-00-38	101-36-27	2,907	2,880
28-04-1A	32-58-19	101-36-03	2,892	2,815

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Appendix D
Buffer Area Wells

Water Table Elevation Of Aquifer

Appendix D--Table 1: Armstrong County
List of Wells in 2-5 Mile Buffer Area to Briscoe and Swisher Counties
Water Table elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
1112701	344642	1013659	3,454	-152.77	2	12	2001	3,301.23
1112702	344547	1013547	3,449	-158.28	2	12	2001	3,290.72
1112801	344642	1013244	3,411	-148.34	1	31	2001	3,262.66
1112802	344640	1013437	3,436	-158.90	2	12	2001	3,277.10
1112803	344728	1013415	3,422	-144.65	1	13	2001	3,277.35
1112901	344547	1013141	3,394	-135.54	1	31	2001	3,258.46
1113702	344548	1012949	3,354	-119.14	1	31	2001	3,234.86

Appendix D--Table 2: Castro County
List of Wells in 2-5 Mile Buffer Area to Swisher County
Water Table Elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
1024305	344404	1020030	3,720	-157.22	2	12	2001	3,562.78
1024602	344110	1020229	3,729	-163.11	2	1	2001	3,565.89
1024901	343845	1020027	3,707	-185.70	2	12	2001	3,521.30
1032301	343641	1020113	3,703	-180.02	2	14	2001	3,522.98
1032601	343332	1020018	3,673	-139.82	2	14	2001	3,533.18
1040301	342910	1020021	3,642	-189.68	2	8	2001	3,452.32
1048302	342110	1020215	3,601	-242.38	2	8	2001	3,358.62
1048603	341944	1020029	3,578	-244.53	1	31	2001	3,333.47

Appendix D--Table 3: Crosby County
List of Wells in 2-5 Mile Buffer Area to Dickens County
Water Table Elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
2316501	334858	1010357	3,040	-302.41	2	11	2000	2,737.59
2324203	334422	1010236	3,000	-261.59	2	11	2000	2,738.41
2324404	334213	1010641	3,017	-293.00	1	27	1999	2,724.00
2324505	334211	1010331	2,998	-297.38	2	11	2000	2,700.62
2332701	333123	1010648	2,415	-21.40	7	18	2000	2,393.60

Appendix D--Table 4: Lynn County
List of Wells in 2-5 Mile Buffer Area to Garza County
Water Table Elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
2344101	332141	1013612	3,048	-56.19	2	22	2000	2,991.81
2344401	331926	1013517	3,010	-31.92	2	23	2000	2,978.08
2344702	331707	1013534	2,995	-24.58	1	21	1999	2,970.42
2352101	331346	1013544	2,968	-27.32	2	23	2000	2,940.68
2352701	330958	1013655	2,959	-22.06	2	23	2000	2,936.94
2352803	330905	1013335	2,927	-21.83	2	23	2000	2,905.17
2360101	330717	1013710	2,953	-17.46	2	23	2000	2,935.54
2360702	330017	1013716	2,912	-20.69	2	23	2000	2,891.31

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Appendix D--Table 5: Floyd County
List of Wells in 2-5 Mile Buffer Area to Swisher County
Water Table Elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
1144904	341646	1013218	3,322	-206.18	2	17	2000	3,115.82
1145408	341813	1012801	3,308	-223.28	2	17	2000	3,084.72
1145802	341704	1012554	3,277	-203.26	2	14	2000	3,073.74
1145806	341504	1012701	3,279	-180.37	2	17	2000	3,098.63
1145905	341533	1012444	3,262	-189.74	2	14	2000	3,072.26
1146701	341709	1012151	3,265	-228.36	2	14	2000	3,036.64
1146802	341725	1011736	3,235	-266.60	3	17	2000	2,968.40
1147404	341760	1011459	3,198	-238.58	2	10	2000	2,959.42
1147703	341601	1011302	3,183	-244.00	2	10	2000	2,939.00
2308201	335825	1010331	3,086	-281.35	2	18	2000	2,804.65
2308401	335702	1010654	3,088	-297.44	2	18	2000	2,790.56
2308503	335604	1010349	3,072	-294.05	2	18	2000	2,777.95
2308701	335422	1010649	3,075	-301.80	3	17	2000	2,773.20
2316101	335140	1010658	3,064	-343.92	2	18	2000	2,720.08
2316204	335059	1010312	3,041	-320.40	2	18	2000	2,720.60

Appendix D--Table 6: Hale County
List of Wells in 2-5 Mile Buffer Area to Briscoe County
Water Table Elevation of Ogallala Aquifer

Well ID	Lat	Long	Land Surface Elevation	Depth blw LS	Month	Day	Year	Water Table Elevation
1048605	341826	1020123	3,577	-223.65	2	10	2000	3,353.35
1141506	341823	1015545	3,532	-234.22	2	1	2000	3,297.78
1141602	341748	1015257	3,499	-222.54	2	1	2000	3,276.46
1141807	341532	1015505	3,503	-219.84	2	3	2000	3,283.16
1141808	341550	1015505	3,495	-211.84	2	1	2000	3,283.16
1141902	341603	1015327	3,499	-230.88	2	1	2000	3,268.12
1141906	341538	1015442	3,499	-214.85	2	3	2000	3,284.15
1141908	341623	1015439	3,501	-217.58	2	1	2000	3,283.42
1141909	341617	1015417	3,506	-229.83	2	1	2000	3,276.17
1141910	341632	1015400	3,505	-232.60	2	1	2000	3,272.40
1141911	341625	1015403	3,504	-233.66	2	1	2000	3,270.34
1141912	341551	1015348	3,501	-229.90	2	3	2000	3,271.10
1141913	341546	1015326	3,495	-226.76	2	3	2000	3,268.24
1141914	341604	1015258	3,488	-217.70	2	3	2000	3,270.30
1141915	341630	1015334	3,497	-226.25	2	1	2000	3,270.75
1141916	341513	1015259	3,488	-223.97	2	3	2000	3,264.03
1142609	341820	1014605	3,462	-252.35	1	31	2000	3,209.65
1142704	341602	1015156	3,481	-219.50	2	1	2000	3,261.50
1142706	341539	1015209	3,479	-219.83	2	3	2000	3,259.17
1142707	341538	1015226	3,481	-218.21	2	3	2000	3,262.79
1142901	341707	1014642	3,449	-245.00	2	5	1999	3,204.00
1143607	341808	1013829	3,378	-234.62	1	31	2000	3,143.38
1144714	341519	1013629	3,347	-214.37	1	31	2000	3,132.63
1144811	341714	1013415	3,341	-233.00	2	8	1999	3,108.00

Appendix E

Texas Water Development Board Review Comments

and

Llano Estacado Responses

S. Schuster__________
P. Thomas__________
T. Knowles_________

December 31, 2001

Mr. Jim Conkwright
High Plains Underground Water Conservation District No. 1
2930 Avenue Q
Lubbock, Texas 79405

Re: Regional Water Planning Grant Contract Between the High Plains Underground Water Conservation District No. 1 (HPUWCD) and the Texas Water Development Board (Board), TWDB Contract No. 2001-483-391, Draft Report

Dear Mr. Conkwright:

Staff members of the Texas Water Development Board have completed a review of the draft final report under TWDB Contract No. 2001-483-391. Comments are offered in Attachment 1. As stated in the above referenced contract, HPUWCD will consider incorporating comments from the EXECUTIVE ADMINISTRATOR and other commentors on the draft final report into a final report. BRA must include a copy of the EXECUTIVE ADMINISTRATOR's comments in the final report.

The Board looks forward to receiving one (1) unbound camera-ready original, nine (9) bound double-sided copies, and one (1) electronic copy of the Final Report, as well as the transfer of all data generated by the planning activities.

Please contact Mr. Stefan Schuster, the Board's designated Contract Manager, at (512) 936-2344 if you have any questions regarding this matter.

Sincerely,

(Original signed by)

Tommy Knowles, Ph.D., P.E.
Deputy Executive Administrator
Office of Planning

cc: Stefan Schuster, TWDB

Attachment 1
Review Comments On
"Ground Water Supplies in Briscoe,
Dickens, Garza, Motley, and Swisher Counties"
TWDB Contract No. 2001-483-391

Texas Water Development Board Comment:

1. Task 1, Data Collection and Compilation, has eight components. The report indicates each of the first five elements were completed. This entailed compilation and evaluation of data collected by the TWDB in times past; field studies to fill in gaps; and finally, water well inventories. Three of the five elements could not be located in the report. Those elements are:
   - GPS land surface elevations
   - Measurements of selected sample of land surface elevations of the base of the aquifer along the escarpment with GPS instruction
   - Update and complete compilation of TWDB well data files for the 2-5 mile buffer area inside adjacent counties.

   If this information is available, it should be included in the final report. If these elements were not performed, the cost of these elements will not be reimbursed as part of Task 1.

   Response: Item 1, Bullet 1: When preparing the Scope of Work, the plan was to rent a hand-held GPS unit that would provide readouts on latitude-longitude-elevation. During preparation for the fieldwork, it was determined that an elevation read-out required much more elaborate instrumentation, including a setup of three or more positioning stations, and a nearby benchmark of known elevation. Given these requirements, the GPS could not be included because the effort and expenses were much greater than the budgeted amount. An alternative procedure using elevations estimated from USGS 7.5 minute maps was used, since such elevations from the USGS maps would be consistent with other well elevations in the data base, and little or no improvement in the volume calculations would result because all the other data points for the base of the aquifer and water levels were being based on USGS maps. Funds that would have been used to rent hand-held GPS units were used instead to increase the number of wells measured, and thereby contributed to increasing the overall coverage of water level measurements in areas where data gaps exist.

   Response: Item 1, Bullet 2: Without the GPS units, the elevations of the base of the aquifer along the escarpment could not be determined. The field work that would have been done to locate elevations of the base of the aquifer was used to increase the number of wells measured, and thereby contributed to increasing the overall coverage of water level measurements in areas where data gaps exist.

   Response: Item 1, Bullet : In Section 3 of the text of the report, the process of compilation and use of data from wells in the 2-5 mile buffer area of adjacent counties was explained. The base of the aquifer and water level data from wells of the buffer area were added in Appendices C and D.

Texas Water Development Board Comment:

2. Task 2, contains three components. These were using GIS procedures to map the base of the aquifer and the water table, calculating the volume through map overlays and calculating the ground water reserves using a previously developed coefficient of specific yield. These were all conducted according to the proposed work outline.

   Response: Comment is noted.

Texas Water Development Board Comment:

3. This critique would not be complete without some statement as to the usefulness of the new data and the maps created from it. Previous investigations conducted all water level measurement exercises during the winter months when pumping from the aquifers was essentially nil. Unfortunately, this latest effort conducted water level measurements in July, when pumping is at the peak. This calls into question the validity of the information and certainly whether or not it is representative of the area.

   Response: The purpose of the data collection work was to fill in data gaps for areas where water level data had not been collected in the past. With the TWDB water level measuring program in these counties focused on monitoring wells in heavily irrigated areas, the areas with sparse monitoring well coverage was in areas where pumpage has been low. In order to avoid the effects of recent pumping, the fieldwork plan required that a well selected for measurement not have been operated for several hours before the time of the measurement. Thus, considering these factors and the natural variability of water levels, these data can be processed along with the winter measurements without any special considerations or adjustments. It is also important to note that this data collection was in response to questions raised by local area officials about the lack of data for their respective areas, and was done according to the schedule of the application for funding by the TWDB.

Texas Water Development Board Comment:

4. There is a lack of new data in the evaluations. The limited new water level data collected is not useful for the comparisons and calculations, which the authors used it for.

   Response: The overall purpose of the project was to improve the estimates of groundwater volumes in storage. The approach was (1) to fully utilize existing base of the aquifer and water level data, and (2) to improve the coverage of the water level data by adding wells and measurements in areas where density of well measurements in the past have been sparse. In the areas near the escarpment, very few wells have been drilled and, of course, even fewer have been included in well measuring programs, thus, there are very few observations in the water level database. As a result, adding even a few wells in critical areas substantially improved the ability to draw water level contours and to make volume calculations in these areas.

Texas Water Development Board Comment:

5. TWDB and USGS water level data has historically been collected in the winter months when levels should be relatively static. The authors collected their data in July, probably right in the middle or at the end of the irrigation season and these water levels should be greatly effected by the heavy pumpage. This would skew any volumetric calculations in both aquifers, but especially in the Seymour aquifer.

   Response: See the discussion in item 3. Also; volume calculations were not made for the Seymour Aquifer. In fact, all the Seymour Aquifer work was in addition to the scope of the contract.