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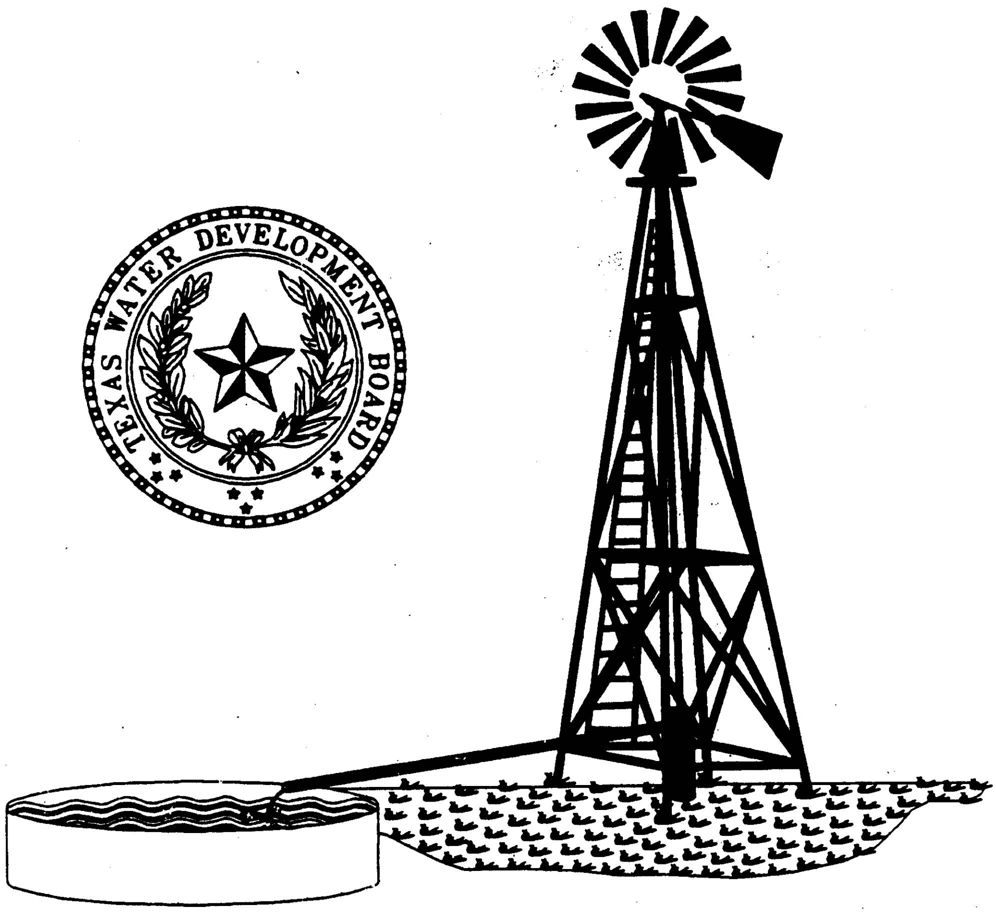
EXPLANATION OF THE TEXAS WATER DEVELOPMENT BOARD GROUND-WATER LEVEL MONITORING PROGRAM AND WATER-LEVEL MEASURING MANUAL

Janie Hopkins, Geologist



August 1994

ABSTRACT

This manual describes the Texas Water Development Board's water-level observation network and the reasoning used to determine the number and location of wells in the network A certain amount of the information covered in the ***Ground- Water Data System Data Dictionary*** (Nordstrom and Quincy, 1993) was also included in this publication to discuss entry of pertinent water-level data in and retrieval from the Hydrologic Monitoring's ground-water database. Illustrations of different water-level measuring methods and devices accompany brief explanations of how and where to measure water levels with steel tape, air lines, electric sounders, pressure gages, and automatic water-level recorders. Several types of maps and graphs provide illustrations of appropriate ways in which water-level data may be presented.

Although the TWDB is non-regulatory, the underlying purpose of this publication is to encourage consistent water-level measuring practices among all of the ***cooperators*** who provide the agency with more than half of the water levels entered in the database annually. A second intent is to share the TWDB's philosophy with any interested groups or agencies in other states who arc charged with similar water-planning activities, as well as to invite their comments concerning the program. Please feel free to contact Janic Hopkins or Phil Nordstrom at 512/463-7847, or to write us in care of:

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INTRODUCTION

Purpose

The purpose of this manual is to provide 1) a description and explanation of the water-level observation well program maintained by the Texas Water Development Board (TWDB) and other interested water districts and governmental entities, 2) a description of water-level and related well schedule data entry in the TWDB ground-water database, and 3) information about and suggestions for measuring ground-water levels, thereby encouraging consistency in data collection. Although the TWDB is responsible for selecting, establishing, and maintaining a network of water-level observation wells across the state, many underground water districts are taking over water-level measurement responsibilities from the TWDB. In 1975, two districts in the High Plains measured 993 observation wells in 17 counties; in 1994, 19 cooperators throughout the state measured almost 4,000 observation wells in 58 counties. A secondary purpose of this manual is to acknowledge and encourage the continued participation of cooperators in the TWDB water-level program.

This manual includes maps indicating the extent of data collected by the TWDB and cooperators, location of automatic recorders, amount of ground-water pumpage by county, a sample well schedule sheet, sketches depicting water-level measurement equipment, examples of information available from the TWDB ground-water database, and examples of maps made from water-level data. This manual is intended to provide only an overview of the TWDB water-level measuring program, for as Frank A. Rayner, former manager of the High Plains Underground Water Conservation District No. 1 said, “The art of measuring water levels in wells, either automatically and particularly by hand, is a talent that comes almost entirely from experience.”

Acknowledgments

The credit for the conception of this manual, as well as the TWDB’s data-system dictionary and well-sampling manual, goes completely to TWDB geologist Phil Nordstrom. Thanks to Phil for his contagious enthusiasm, his editing, and his creativity in the seemingly dry subject of data collection. With a more generous budget (not a given in any state governmental agency), more of his ideas could come to fruition.

Much of the material and all of the figures in the “Methods” section were adapted from a 1988 Idaho District U.S. Geological Survey administrative report compiled by Michael Jones. Appreciation is also extended to several U.S. Geological Survey staff in different states who discussed their states' programs: Roy Cruz in New Mexico, Gail Keetcr in California, Dave Lystrom in Colorado, and Rich Hawkinson and Susan Gandara in Texas. TWDB environmental quality specialists Lcnnie Winkclman and Robbie Ozment edited the manual, and interactive graphics technician Steve Gifford created (and adapted) graphics.

GROUND-WATER LEVEL MONITORING NETWORK

Extent of Ground-water Level Data in Texas

As of January 1, 1994, water-level measurements for slightly more than 7,500 current observation wells are in the TWDB ground-water database. Water-level data on slightly more than 8,000 historical wells (wells from which data were collected annually in the past but have since been dropped from the program) and on some 55,000 miscellaneous wells are also on record. Water levels in the vast majority of wells are measured annually during the winter season when water levels should be least influenced by pumping and, therefore, most indicative of the static water level. In addition, special projects have involved a small percentage of wells in which multiple daily measurement records are kept; these wells are equipped with automatic water-level recorders.

Of the 7,500 current water-level observation wells, approximately 3,550 were visited and most were measured by the TWDB staff in 1993. The majority of the remaining wells were measured by underground water conservation districts, the United States Geological Survey (USGS), and other cooperators as illustrated in Figure 1. Cooperators measure observation wells within their areas, which may include counties or parts of counties within their jurisdiction, while the TWDB measures the remaining observation wells. On complc-tion, all measurements are entered into the TWDB's ground-water database to enable rapid retrieval for use by staff, cooperators, other governmental entities, and the public.

Continuous water-level recorders are operated in representative wells in areas where uninterrupted records of water-level changes are needed. During 1993, the TWDB maintained 41 automatic water-level recorders in 38 counties. Figure 2 illustrates the location of all recorders operated by the TWDB and cooperators as well as hydrographs from selected recorders. Hydrographs indicate that, for the most part, long-term water-level declines are occurring in many of the major aquifers in the state. Other recorders maintained by the USGS and certain underground water conservation districts provide the TWDB with additional data (Fig. 2).

In 1992, dataloggers were installed in 36 recorders to reduce the costs of collecting data and time required to transfer information into the computer database. Several water districts have agreed to "service" the recorders

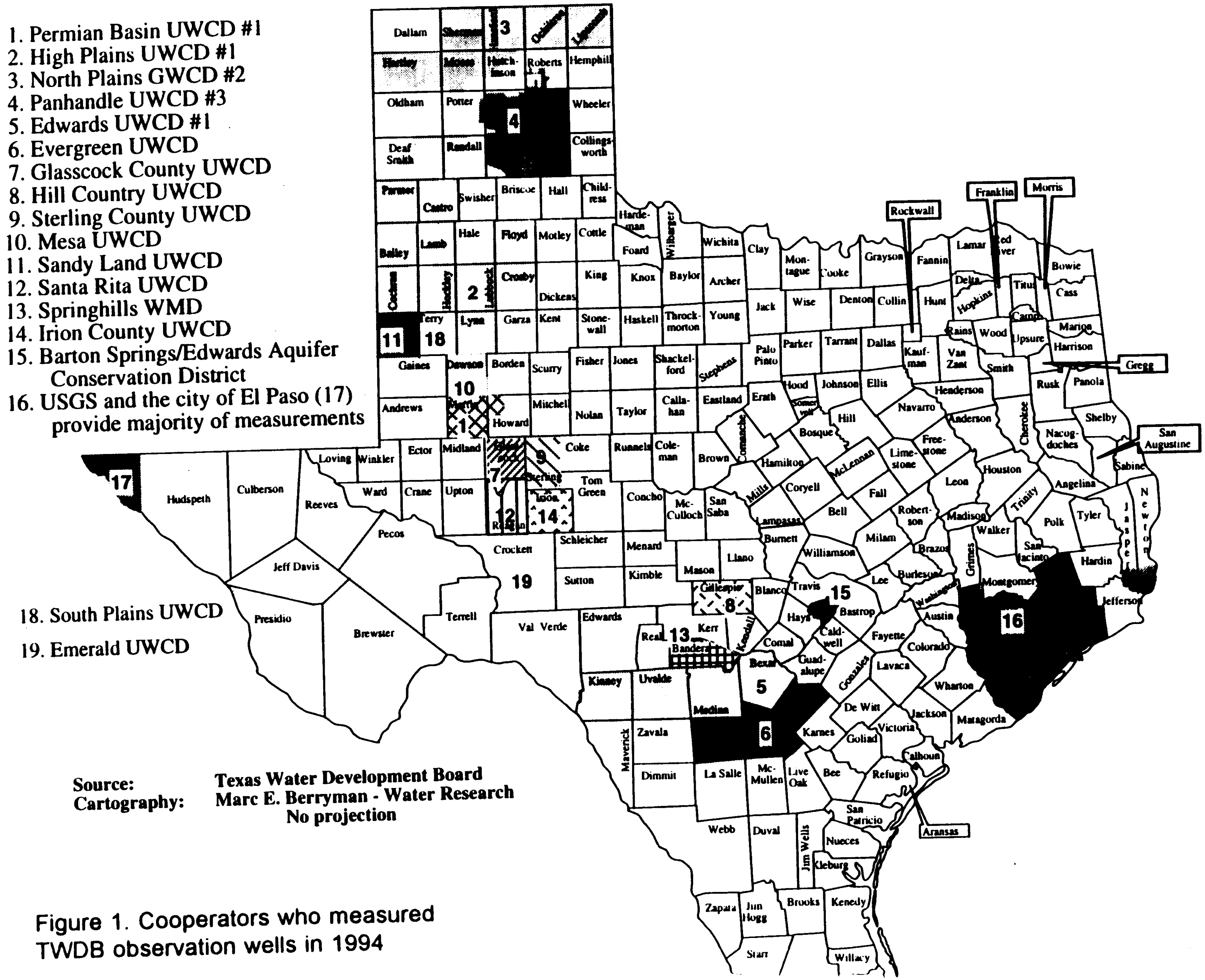


Figure 1. Cooperators who measured TWDB observation wells in 1994

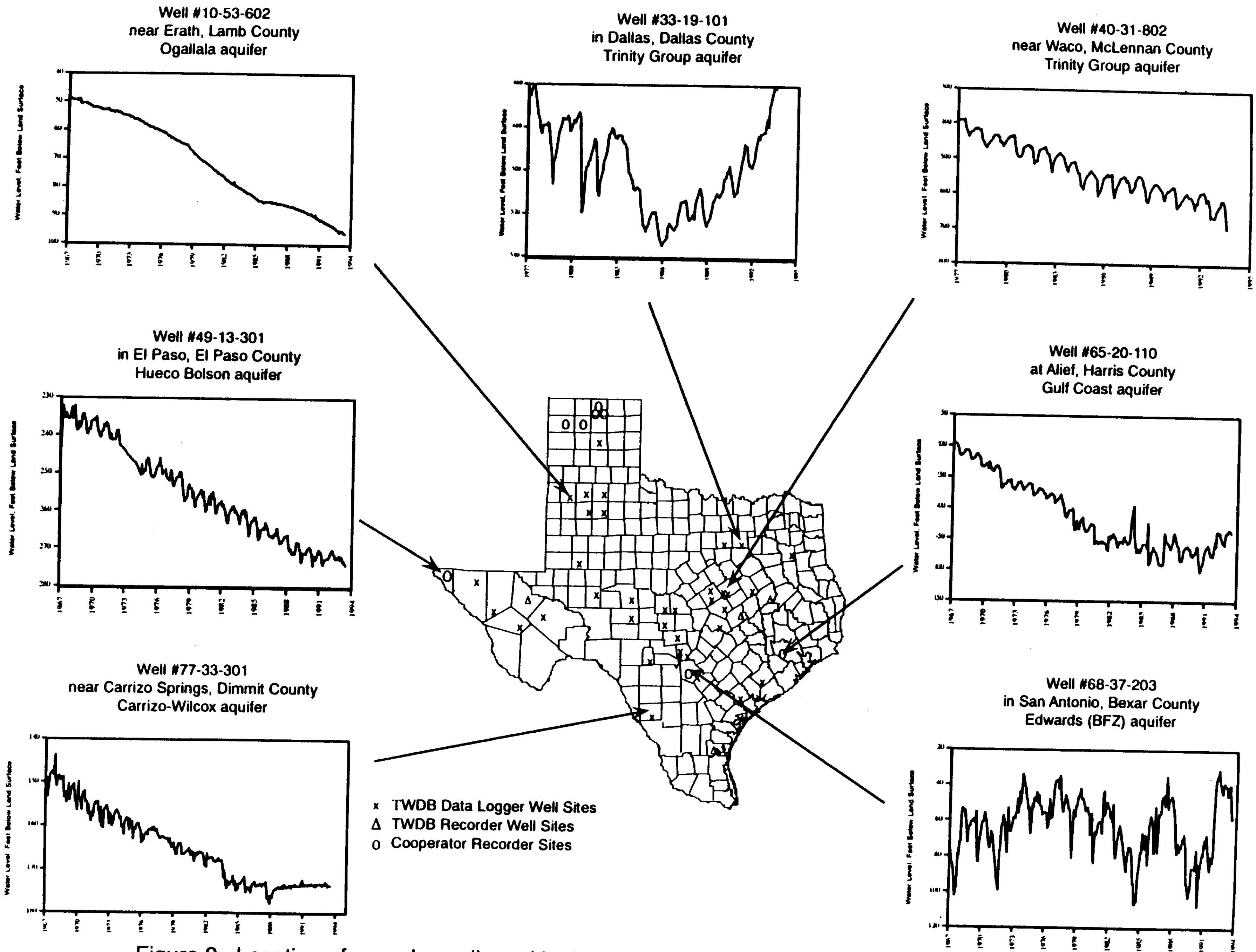


Figure 2. Location of recorder wells and hydrographs from selected wells completed in major aquifers.

(load empty datacards, test batteries, check fuses, check operations, and mail datacards to the TWDB), which should result in further reductions in travel costs incurred by the agency. The districts that service recorders are:

Glasscock County UWCD

Hickory UWCD #1 (3 recorders)

High Plains UWCD #1 (5 recorders)

Hill Country UWCD

Lipan-Kickapoo WCD

North Plains GWCD #2 (3 recorders)

Panhandle UWCD #3

Permian Basin UWCD #1

Plateau UWCSD

Determination of Adequate Water-level Observation Network

In 1992, the Ground Water Monitoring Unit of the TWDB evaluated the current observation network to determine if an adequate number of wells were monitored in each aquifer in each county. To maintain an "ideal" network, the number of water-level network wells would constantly change in response to the specific needs of different projects. For example, construction of a water-level model covering several counties requires a different amount of water-level measurements than does the construction of a one-county-wide water-level map. Although such limitations must be considered when prescribing the number and location of wells in an ideal water-level network, a minimum number of wells can be considered adequate in order to determine basic trends. That number of wells which is considered an adequate amount in each county, determined for each major and minor aquifer, is based upon the criteria listed below:

1. In counties where more than 100,000 acre-feet of ground water is pumped annually (for irrigation, municipal, and/or industrial purposes), an adequate network coverage is one monitored well per 25 square miles.

2. In counties where more than 10,000 (and less than 100,000) acre-feet of ground water is pumped annually (for irrigation, municipal, and/or industrial purposes), an adequate network coverage is one monitored well per 50 square miles.

3. Where conditions exist as described above, but also where little change in water levels has occurred (less than 50 feet of decrease per decade in artesian aquifers or less than 20 feet per decade in water-table aquifers as determined from the latest water-level change map from 1980 to 1990); or where few wells are available (as in extreme downdip limits of aquifers), adequate coverage is one well per 75 square miles.

4. In counties where there is more than 2,500 but less than 10,000 acre-feet of annual ground-water pumpage, adequate coverage is one well per 100 square miles.

5. Where conditions exist as described in #4, but also where little change in water levels has occurred or where few wells are available, adequate coverage is one well per 125 square miles.

6. In areas of where annual pumpage is less than 2,500, but greater than 1,000 acre-feet, adequate coverage is one well per 150 square miles.

7. In counties where there is an extremely small amount of annual ground-water pumpage (less than 1,000 acre-feet), one well is necessary.

These criteria apply to all counties and to that percentage of each county containing an aquifer. Quite a few counties are only partly covered by a major or minor aquifer or are not covered at all. They are not hard and fast rules, as abandoned wells are often capped or wells do not even exist in certain areas of the state, and an adequate number of wells cannot be located. They were used, however, to determine the adequate number of wells by aquifer by county. The averages of all aquifer adequacies for each county are illustrated in the map in Figure 3. Major and minor aquifer coverages are illustrated in Figures 4 and 5, respectively. In general,

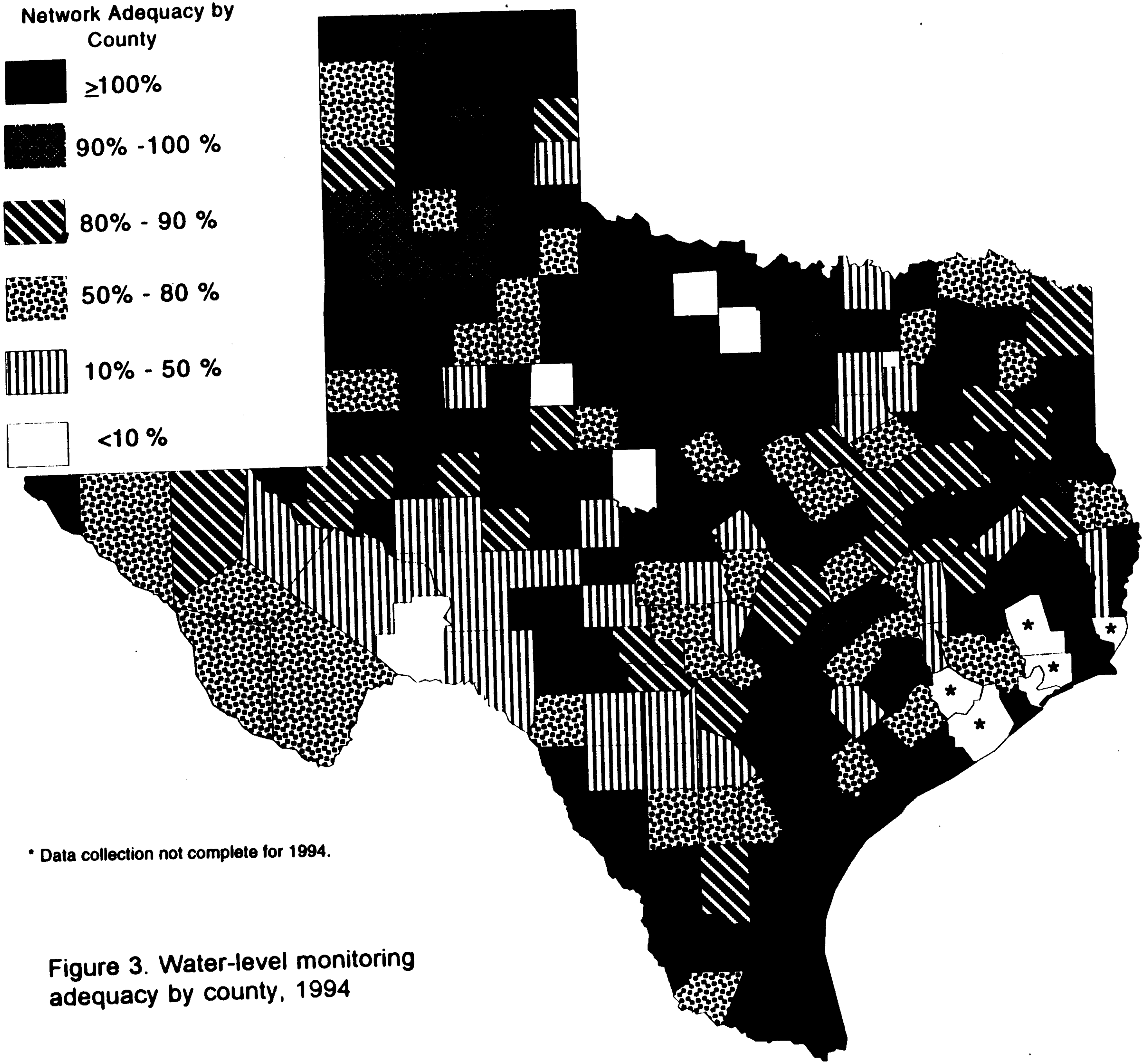


Figure 3. Water-level monitoring adequacy by county, 1994

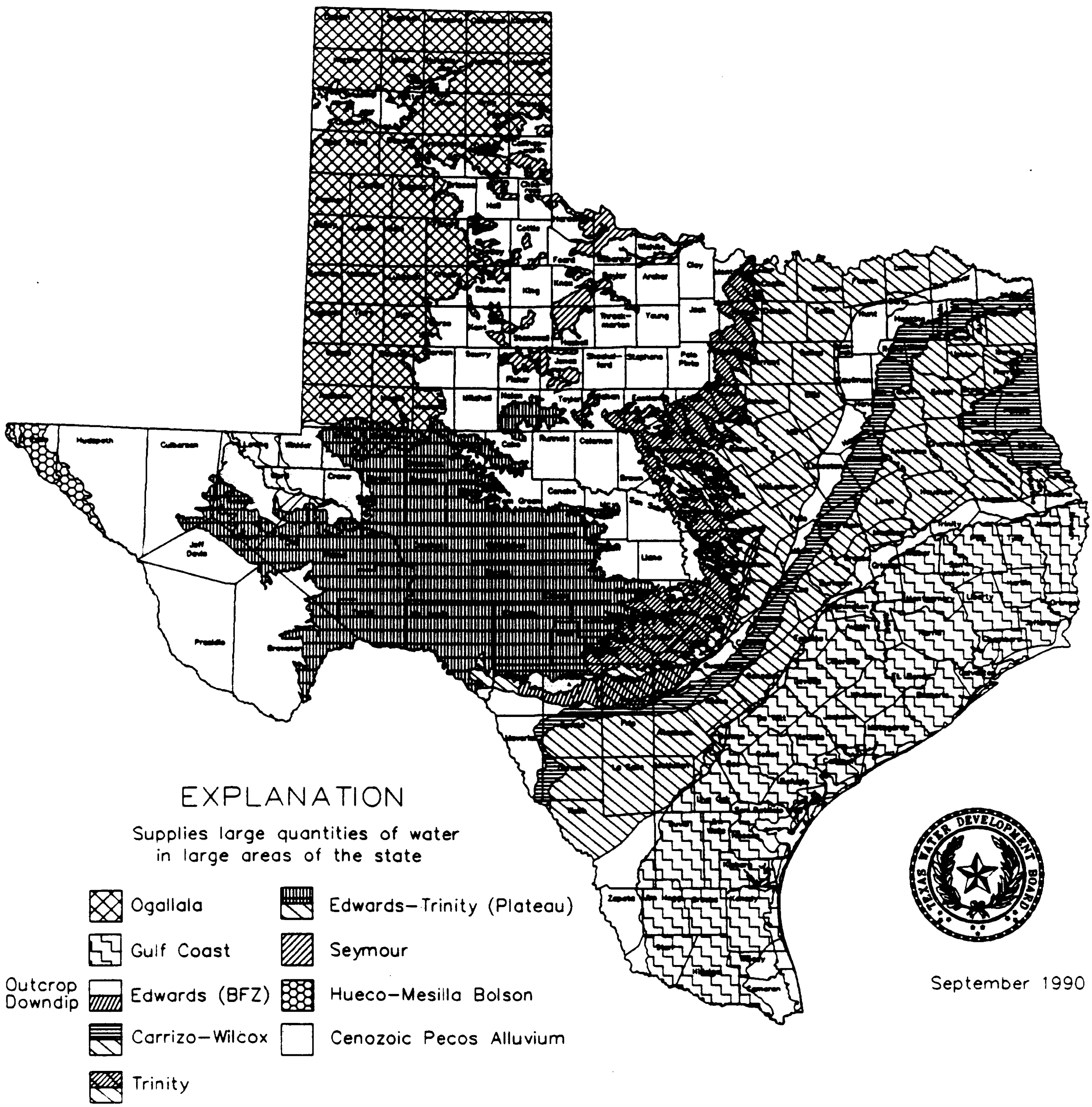


Figure 4. Major aquifers in Texas

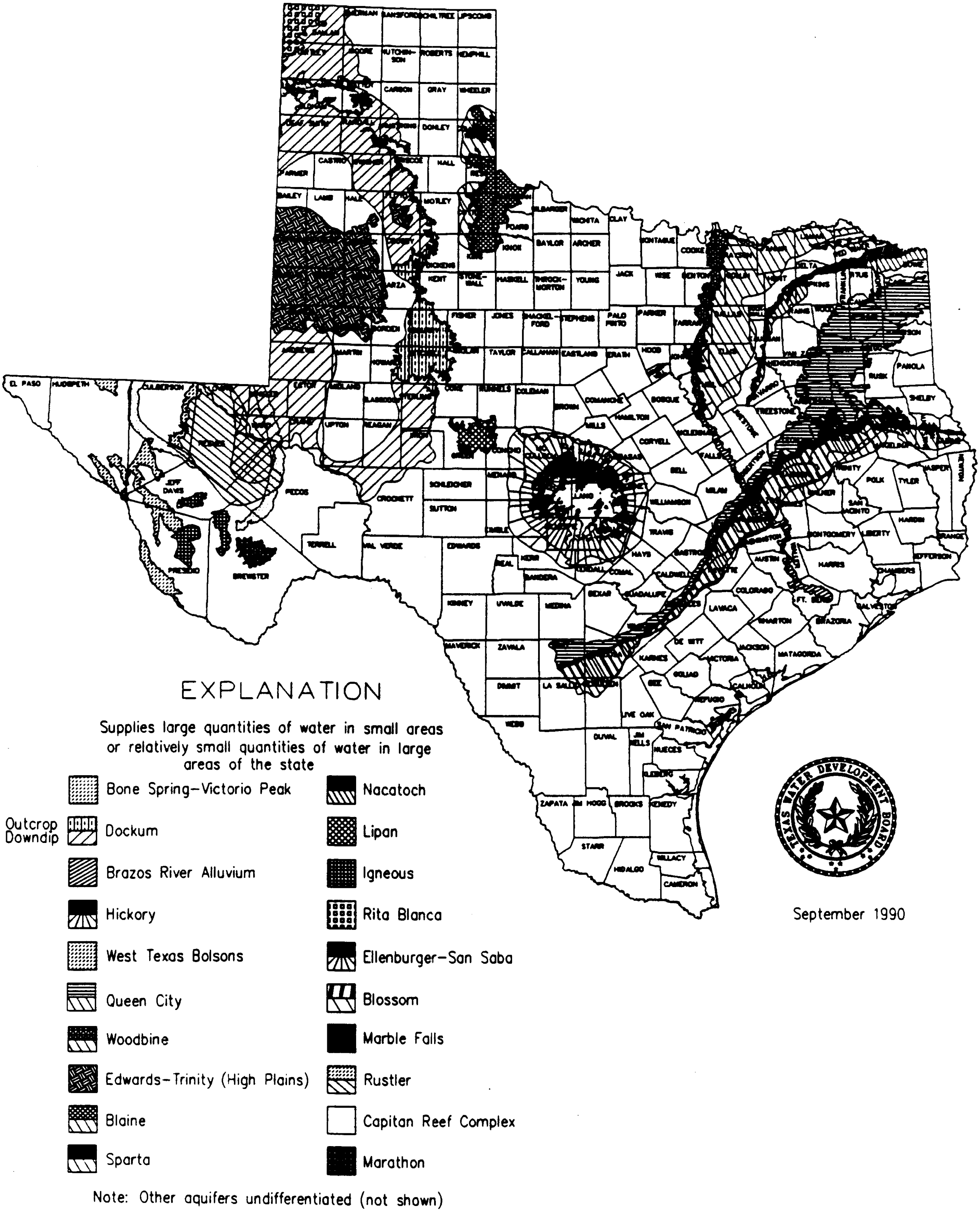


Figure 5. Minor aquifers in Texas

counties with large amounts of pumpagc (Fig. 6) did not have an adequate number of wells measured in 1994, although many counties were inadequate because historically too few wells in minor aquifers were measured.

The guidelines for determining adequacy also apply to that percentage of aquifer coverage in each county. Quite a few counties are only partly covered by a major or minor aquifer or are not covered at all. According to the definition of adequacy of the water-level network using the above criteria, the number of wells measured historically in many counties is much larger than adequate, whereas the number of historically measured wells in several counties is smaller. Thus the total 7,500 wells currently listed as observation wells is a greater number than the "adequate" network of 4,018 wells.

Typically, underground water districts and the USGS measure a larger number of wells than deemed adequate, but these are in areas such as the High Plains, Harris County, and El Paso where declining water levels are of concern. Presently, cooperators in 58 counties monitor all or the majority of wells in the water-level network and more besides. The TWDB encourages other districts to take over water-level monitoring programs in their areas and provides training and all available data. TWDB staff will aIso continue to monitor a large percentage of wells that have been measured in counties where the number of historically monitored wells is more than adequate; however,, when these wells are lost, they will not be replaced.

In counties where the number of wells has been determined to be smaller than adequate, the staff is attempting to increase adequacy through inventory of new wells. Unfortunately, wells are not available precisely where more monitoring is needed (e.g. in areas of greatest water-level decline as depicted in Fig. 7). In central Texas for example, many unused wells that would have made excellent monitoring wells have been capped as municipalities have switched to surface water.

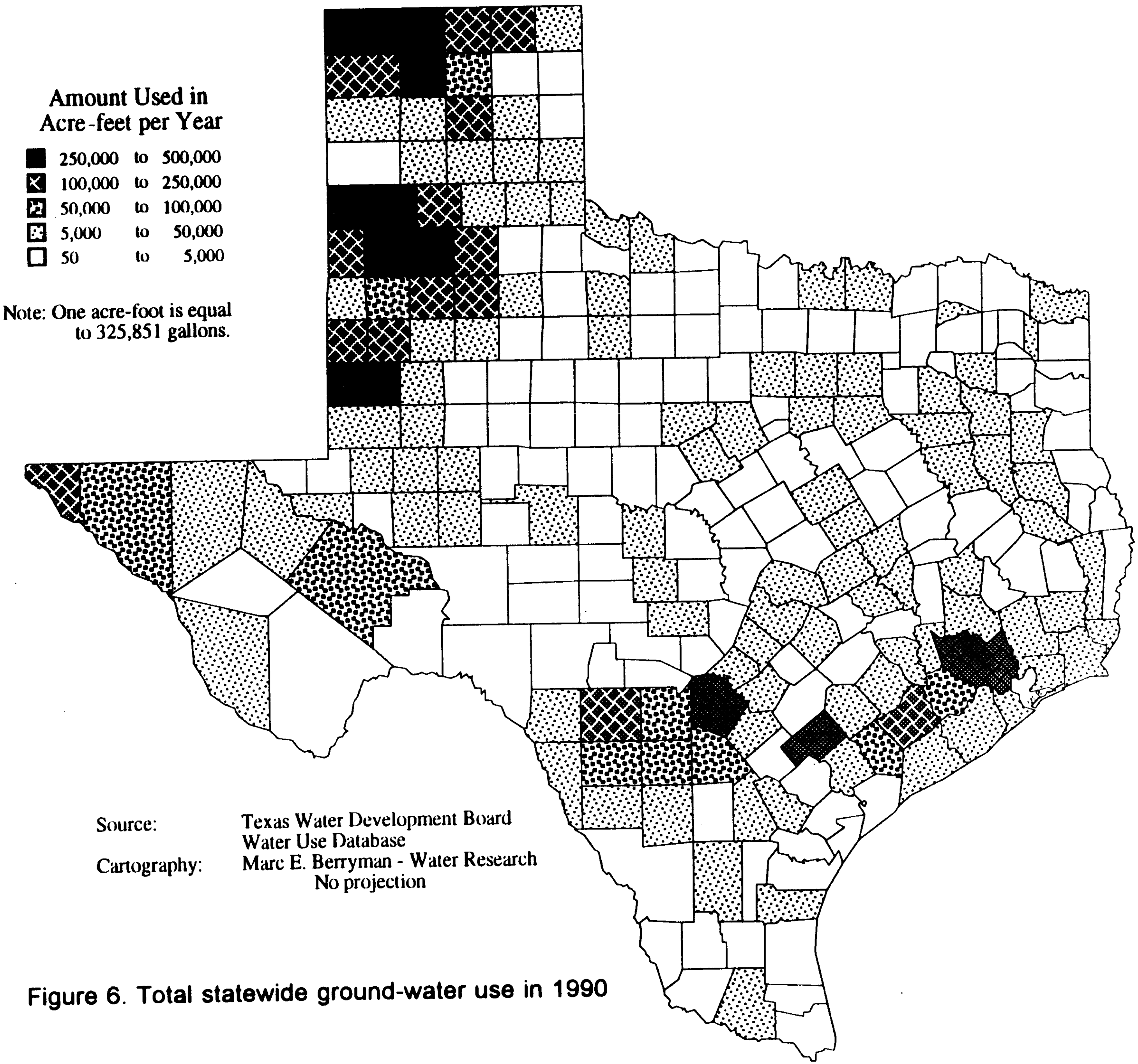


Figure 6. Total statewide ground-water use in 1990

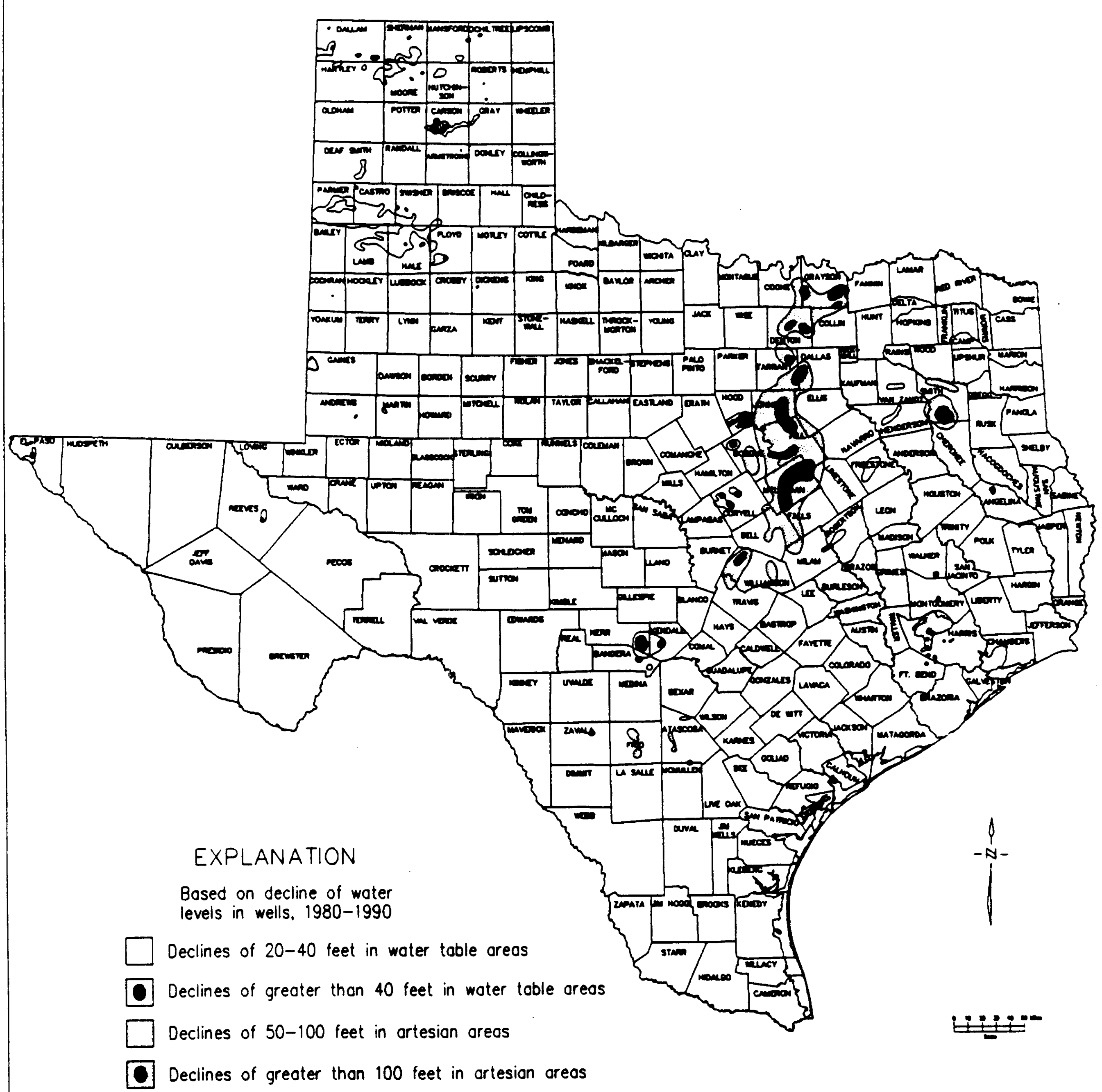


Figure 7. Areas experiencing significant ground-water level decline, 1980-1990

GROUND-WATER LEVEL DATA ENTRY

Well Record Data from Well Schedules

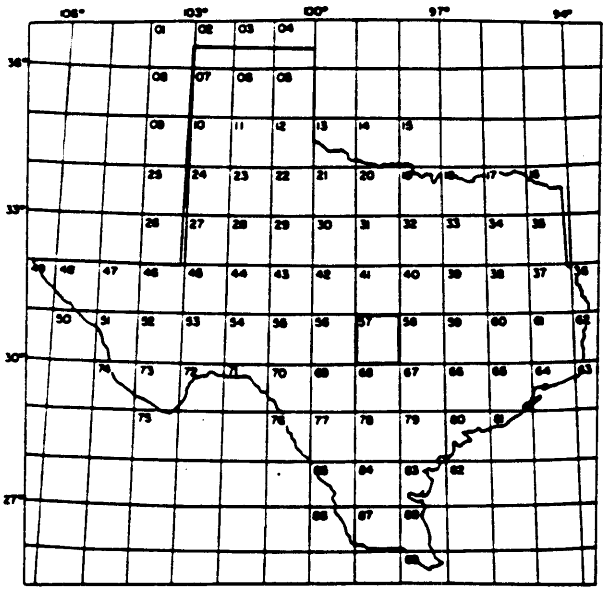
The TWDB ground-water database is contained in a UNIX-based Informix database management system software program operated on a Motorola mini-computer. The sofrware is used extensively to enter well, water-level, and water-quality data and to produce data reports. The main menu offers entry into four main screen categories: data entry forms, screen report forms, printed reports, and utility forms for database administration. The entry of well schedule data into the database is the cornerstone of the system. Without correct information about location and aquifer in which the well is completed, for example, the value of other water-level and water-quality data is questionable. It is not within the scope of this manual to describe the step-by-step data entry procedure, but a detailed explanation can be found in the TWDB ***Ground-Water Data System Data Dictionary*** (Nordstrom and Quincy, 1993).

As the use of Geographic Information Systems (GIS) increases within this agency and outside of the TWDB, accurate location information is essential. Only after an accurate location has been determined and a unique state well number has been assigned to the well (see Figure 8 for explanation of state well-numbering) may other information be entered into the database. Obtaining such information has been made easier with the help of Geographic Positioning System (GPS) receivers. Using a single receiver at a site can provide an accurate, two-dimensional location to within 300 feet; using a second receiver at a known USGS benchmark can provide accurate altitude as well. No one, whether using the best available topographic map or a GPS receiver, can locate the well better than the person at the site. Ordinarily, the well is located during initial inventory, but TWDB staff are encouraged to check locations with GPS receivers and to check any other data on the well schedules during subsequent visits to the sites.

In the TWDB ground-water database, ten different data entry forms are available (Fig. 9), beginning with the well schedule (Fig. 10) and including water-level forms for all wells in the observation network or any miscellaneous wells and recorders with five-day measurements; water-quality and infrequent constituent information; casing, well data remarks (e.g., pump test information), and lithologic data; and well data from the USGS Houston district office and the Texas Natural Resource Conservation Commission

LOCATION OF WELL 57-15-701

57 1-degree quadrangle
15 7½-minute quadrangle
7 2½-minute quadrangle
01 Well number within 2½-minute quadrangle

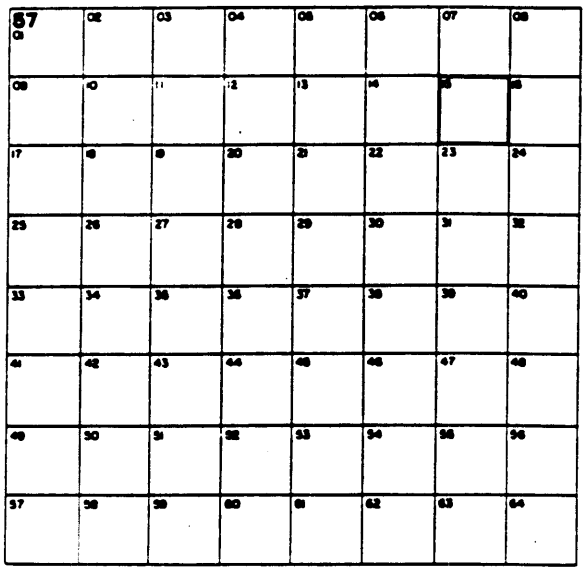


1 - degree Quadrangles

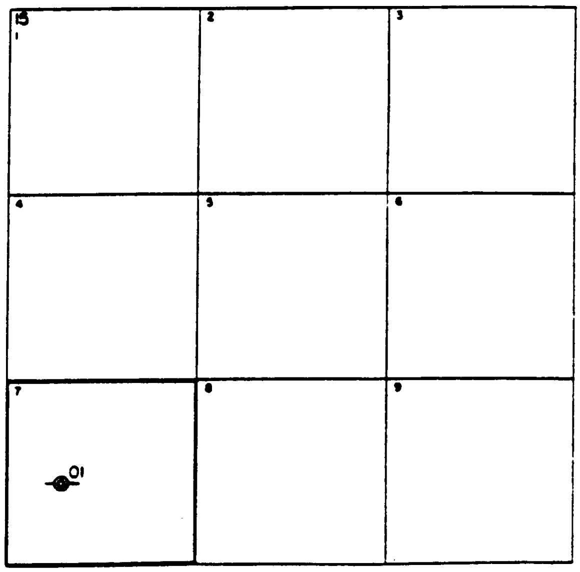
WELL-NUMBERING SYSTEM

To facilitate the location of wells and avoid duplication of well numbers, the Texas Department of Water Resources has adopted a statewide well-numbering system. It is based on division of the State into a grid of 1-degree quadrangles formed by degrees of latitude and longitude and the repeated division of these quadrangles into smaller ones as shown on the following diagram.

Each 1-degree quadrangle is divided into sixty-four 7½-minute quadrangles, each of which is further divided into nine 2½-minute quadrangles. Each 1-degree quadrangle in the State has been assigned an identification number. The 7½-minute quadrangles are numbered consecutively from left to right, beginning in the upper left-hand corner of the 1-degree quadrangle, and the 2½-minute quadrangles within each 7½-minute quadrangle are similarly numbered. The first 2 digits of a well number identify the 1-degree quadrangle; the third and fourth digits, the 7½-minute quadrangle; the fifth digit identifies the 2½-minute quandrangle; and the last 2 digits identify the well within the 2½-minute quadrangle.



7 1/2 - minute Quadrangles



2 1/2 minute Quadrangles

Figure 8. State well-numbering system

1. Well data information update screen form (well schedule)
2. Water-level update screen form
3. Water-quality update screen form
4. Infrequent constituent update screen form
5. Casing information update screen form
6. Well-data remarks update screen form
7. Lithological data entry screen form
8. Five-day water-level measurement entry form
9. Well data form for the USGS Houston District counties
10. Well data form for the TNRCC public supply well database

Figure 9. Screen data entry forms available from the TWDB ground-water database

TEXAS WATER DEVELOPMENT BOARD
WELL SCHEDULE

State Well Number - 68 15 101   Previous Well Number -   County - Comal 091
River Basin - Guadalupe River - 18   Zone - 1   Latitude - 29 51 58   Longitude - 98 14 41   Source of Coords - 2

Owners Well No. ________ Location ______ 1/4, ______ 1/4, Section ______, Block ________, Survey ________

Owner - U.S.Army Corp of Engs.   Driller - Ward and Ward Drlg.
Comal Park, well 1

Address ________________ Tenant/Oper. ________________
Date Drilled - / /1965   Depth - 390 ft.   Source of Depth -   Altitude - 990 ft.   Source of Alt. - M
Aquifer - 218GRHC GLEN ROSE LS. AND HENSELL SH AND COW CREEK LS MEMBERS OF PEARSALL FM   Well Type - W   User - 889470

WELL CONSTRUCTION   Const. Method - ________   Casing Material - ________
Screen
Completion - ________   Material - ________

LIFT DATA - Pump Mfr. ________   Type - SUBMERSIBLE PUMP   No. Stages ____

Bowls Diam. - ______ in.   Setting - ______ ft.   Column Diam. - ______ in.

Motor Mfr. - ________   Fuel or Power - ELECTRIC MOTOR   Horsepower - 2

YIELD Flow- ______ GPM   Pump- ______ GPM   Meas.,Rept.,Est- ______   Date- ______

PERFORMANCE TEST Date- ______   Length of Test- ______   Production- ______GPM

Static Level- ______ft.   Pumping Level- ______ft.   Drawdown- ______ft.   Sp.Cap.- ______GPM/ft

QUALITY (Remarks- ________________

WATER USE Primary- PUBLIC SUPPLY   Secondary- ________   Tertiary- ________

OTHER DATA AVAILAIBLE   Water Levels- M   Quality- Y   Logs-   Other Data-

WATER LEVELS   Date- 11/04/1965   Measurement- -134.00
Date- / /   Measurement-

Recorded By ________________   Date Record Collected or Updated- 08/01/1990

Casing or Blank Pipe (C)
Well Screen or Slotted Zone (
Open Hole (O)
Cemented from______to______

	Diam. (in.)	Setting(feet) From	To
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			

Reporting Agency - TEXAS WATER DEVELOPMENT BOARD
REMARKS -
Screened from 377 to 387 ft.
Cemented from 377 ft to surface.
Pump set at 273 ft. Reported yield
12 gpm with 96 ft drawdown.

Figure 10. Well schedule

Aquifer - 218GRHC
Well No. - 68 15 101

public-supply well database. Screen reports appear only on the computer's monitor, but are also available in hard copy. These reports fall into three categories and may be tailored by the selection of specific criteria (Fig. 11). An example of a record of wells is shown in Figure 12 and a water-level report in Figure 13. Such reports as these are requested daily by consultants, water-well drillers needing pertinent information prior to drilling, municipalities needing additional water due to increased population growth, and private individuals seeking to obtain domestic water supplies.

Data Reception from Cooperators

Whereas the TWDB operates one type of database management system for all ground-water data, it accepts data from cooperators in any format. Cooperators, operating different database systems, send information in a variety of forms from hard copy to computer disks. For example, an engineering group within the agency measures some 600 wells annually for the Hydrologic Monitoring Section. These data, stored in Paradox, are easily imported into the ground-water database in ASCII format. Cooperators who measure few wells arc welcome and encouraged to use the TWDB "Well Visits and Water-Level Measurements" form (Fig. 14) if they send hard copies.

Notebook Computers

Until recently, well schedules were completed in the field on paper, and the information was entered later in an office computer. Now TWDB personnel frequently enter this information, as well as any water levels and field measurements taken during sampling, directly into notebook computers while in the field. The data are then transferred into the ground-water database in the office. Field books containing well schedules and detailed sketch maps (Fig. 15) of the site are still taken out in the field, and water levels are entered in the fieald books by hand as back up in hard copy format. Using GIS, the TWDB has the capability to produce maps at any scale with any point- or location-specific data such as water levels, but this practice has not yet become commonplace. Well schedules are now accessible on the notebook computer screens, and thcoretically, GIS will also some day allow detailed sketches of the well site to be viewed on screen.

Texas Water Development Board
Ground–Water Data Request Form

Name ____________________ Date ______________________ Phone ____________________

Dept/Agency or Company ____

I. Record of Wells Reports

☐ Format 1 (Long) ☐ Format 2 (Short)
☐ Format 3 (Long w/Lat & Lon) ☐ Format 4 (Specify User Code)

II. Water Level Reports

Water Level Publications Report: ☐ Current obs. wells ☐ Current & Historical ☐ Current, Historical & Misc.
Water Level Recorder Report: ☐ 5 day measurements ☐ 15 day measurements
Water Level Observation Report: ☐ Current obs. wells ☐ Historical
Water Level Data Index Report: ☐ Current obs. wells ☐ Historical

☐ Well Visits and Water Level Measurements Report

III. Water Quality Reports

☐ Water Quality Publication Report ☐ Include Strontium
☐ Analysis Availability Report

Infrequent Constituent Report (grouped by Well no.):
☐ All ☐ Radioactivity only ☐ Minor Inorganic Element only ☐ Nutrient only

Infrequent Constituent Report (grouped by Constituent):
☐ All ☐ Radioactivity only ☐ Minor Inorganic Element only ☐ Nutrient only

Selection Criteria

1. FIPS County Code(s): ________ ________ ________ ________ ________ ________
2. Dates:
   ☐ Period of record or Beginning date __________ Ending date __________
3. User Codes: ________ ________ ________ ________ ________ ________
4. Aquifer Codes: ________ ________ ________ ________ ________
5. Range of State Well Numbers: ______________ to ______________

Special Selection Criteria or Instructions:

____

____

____

____

____

Figure 11. Report choices

Mar 14, 1994

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Comal

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT.)	CASING AND SCREEN DATA: CASING OR SCREEN	DIAMETER (IN.)	TOP DEPTH (FT.)	BOT DEPTH (FT.)	WATER BEARING UNIT	ALTITUDE OF LAND SURFACE (FT.)	WATER LEVEL: MEASUREMENT FROM LSD (FT.)	DATE	METHOD OF LIFT AND POWER	USE OF WATER	REMARKS
68-15-101	U.S.Army Corp of Engs. Comal Park, well 1	Ward and Ward Drlg.	1965	390					218GRHC	990	-134.00	11-04-1965 - -	S E 2	P	Screened from 377 to 387 ft. Cemented from 377 ft to surface. Pump set at 273 ft. Reported yield 12 gpm with 96 ft drawdown.
68-15-104	Canyon Enterprises The Oaks well 4	Kutscher Drlg	1965	470					218GLRSL	960	-180.00	10-07-1964 - -	S E	P	Open hole from 240 to 470 ft. Cemented from 240 ft to surface. Reported yield 50 gpm with 200 ft drawdown.
68-15-105	Canyon Enterprises The Oaks well 6	Kutscher Drlg	1964	510					218GLRSL	980	-200.00	12-01-1964 - -		P	Open hole from 255 to 510 ft. Cemented from 255 ft to surface.
68-15-107	Canyon Enterprises The Oaks well 8	Kutscher Drlg	1965	263					218GLRSU	1080	-150.00	03-18-1965 - -	N	U	Open hole from 81 to 263 ft. Cemented from 81 ft to surface. Reported yield 40 gpm with 0 ft drawdown. Unused public supply well.
68-15-108	Canyon Enterprises The Oaks well 9	Kutscher Drlg	1967	225					218GLRSU	1025	-115.00	01-00-1967 - -	S E 7.50	P	Open hole from 48 to 225 ft. Cemented from 48 ft to surface. Reported yield 35 gpm with 8 ft drawdown.
68-15-109	Canyon Enterprises The Oaks well 10								UNKNOWN	1020		- - - -	S E	P	
68-15-110	Tom Sheridan Propertys Canyon Lake Vil.,w#11	E.R. Owen Water WEll Contractor							UNKNOWN			- - - -	S E 7.50	P	Open hole from 441 to 460 ft.
68-15-115	HIGHLAND TERRACE SUBDV RTS BOX 800	CHARLIE KUHN PO BOX21	1983	700	C O	7 0	0 124	124 700	218GLRSU	1271		- - - -		U	WELL CAVED AT 442 FT
68-15-201	Tom Sheridan Propert. Canyon Lake Village	Kutscher Drlg.	1965	530					218GLRSU	1120	-350.00	08-13-1965 - -	S E 15	P	Open hole from 40 to 530 ft. Cemented from 40 ft to surface. Reported yield 20 gpm with 0 ft drawdown.

Figure 12. Record of wells for southeast Comal County

RECORDS OF WELLS, SPRINGS, AND TEST HOLES

COUNTY - Comal

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT.)	CASING AND SCREEN DATA: CASING OR SCREEN	DIAMETER (IN.)	TOP DEPTH (FT.)	BOT DEPTH (FT.)	WATER BEARING UNIT	ALTITUDE OF LAND SURFACE (FT.)	WATER LEVEL: MEASUREMENT FROM LSD (FT.)	DATE	METHOD OF LIFT AND POWER	USE OF WATER	REMARKS
68-15-202	U.S.Army Corp of Engs. North Park	Ward and Ward Drlg	1965	519					218GRHC	995	-127.00	11-04-1965 - -	S E	P	Screened from 539 to 549 ft. Cemented from 539 ft to surface. Reported yield 12 gpm with 129 ft drawdown.
68-15-203	Tom Sheridan Prop.,Inc Canyon Lake Vil.,pool	Hill Country Water, Inc	1974	660					218GRHC	1080	-395.00	07-09-1974 - -	S E 10	P	Open hole from 54 to 660 ft. Cemented from 54 ft to surface. Reported yield 18 gpm.
68-15-204	S.D. David, Jr	E.R. Owen Water Well Contractor	1962	502					218GLRSU	830		- - - -	S E 10	P	Open hole from 80 to 502 ft. Cemented from 80 ft to surface.
68-15-205	S.D. David, Jr	Hill Country Water Inc	1975	460					218GLRSU	830	-55.00	05-27-1975 - -	S E 7.50	P	Open hole from 180 to 460 ft. Cemented from 180 ft to surface. Reported yield 60 gpm.
68-15-401	Emma Reiber			212					218GLRS	1023	-109.38 0.00	09-18-1956 12-13-1960	P E	H	
68-15-501	Tom Sheridan Prop.,Inc Ponderosa Unit 2	Hill country Water, Inc	1974	460					218GLRSU	760	-350.00	07-12-1974 - -	S E 3	P	Open hole from 40 to 460 ft. Cemented from 40 ft to surface. Reported yield 10 gpm.
68-15-701	Dr. Harold Fisher			300					218GLRS	945	-254.61 0.00	12-13-1956 05-10-1960	P W	H S	
68-15-801	Jerome Schumann	Alex Fabian	1915	365					218EBFZA	970	-295.42 0.00	12-13-1956 01-15-1958	P W	H S	
68-15-802				375					218EBFZA	955	-260.22	06-07-1955 - -	P W	U	
68-15-803	Leonard Hitsfelder			372					218EBFZA	958	-227.37	06-07-1957 - -	S E	U	
68-15-901	Hueco Springs								218EBFZA			- - - -			
68-15-902	R. Pfeuffer	E.B. Kutscher	1965	38					218EBFZA	659	-19.80 -8.77	09-30-1971 06-26-1984	N	U	

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

WATER LEVEL PUBLICATION REPORT
COUNTY - Comal

WATER LEVEL MEASUREMENTS IN FEET ABOVE OR BELOW (-) LAND SURFACE

STATE WELL NUMBER	AQUIFER CODE	WELL DEPTH	ELEVATION OF LAND SURFACE	DATE OF VISIT OR MEASUREMENT	DEPTH TO WATER FROM LAND SURFACE	CHANGE IN LEVEL SINCE LAST STATIC MEASUREMENT	ELEVATION OF WATER LEVEL
68 05 605	218CCRK	187	1135	02/11/1991	-143.40		992
				04/15/1992	-127.50	15.90	1008
				02/18/1993	-133.83	-6.33	1001
				03/23/1994	-135.33	-1.50	1000
68 05 606	217SLGO	300	1225	04/15/1992	-151.40		1074
68 05 607	217SLGO	300	1165	04/15/1992	-149.90		1015
68 05 611	218TRNT	400	1290	04/28/1992	-234.22		1056
68 05 612	218GLRSL	345	1305	04/28/1992	-250.60		1054
				05/07/1992	-256.00	-5.40	1049
68 05 616	218GLRS	391	1215	04/28/1992	-195.24		1020
68 05 619	218GLRSL	238	1235	04/29/1992	-151.80		1083
68 05 621	218TRNT	300	1280	04/29/1992	-214.87		1065
68 06 405	218CCRK	47	1060	04/15/1992	-37.65		1022
68 06 406	218CCRK	28	1005	04/15/1992	-19.60		985
68 06 701	217SLGO	211	1085	02/11/1991	-193.29Q		892
				02/18/1992	-191.17Q	2.12	894
				04/16/1992	-156.90	34.27	928
				02/18/1993	-173.80	-16.90	911
				03/23/1994	-174.72	-0.92	910
68 06 702	218GLRSL	120	965	04/17/1992	-39.54		925
68 06 704	218CCRK	120	980	04/15/1992	-13.60		966
68 06 705	218GLRSL	48	966	04/17/1992	-39.17		927
68 06 707	217SLGO	250	1095	04/16/1992	-146.00		949
68 06 708	217SLGO	260	1105	04/17/1992	-156.89		948

P WATER LEVEL AFFECTED BY PUMPAGE OR RECHARGE AT THIS OR NEARBY WELL(S)
Q ACCURACY OF MEASUREMENT IS QUESTIONABLE

Figure 13. Water-level report for water levels measured after 1990, Comal County

WATER LEVEL PUBLICATION REPORT
COUNTY - Comal

WATER LEVEL MEASUREMENTS IN FEET ABOVE OR BELOW (-) LAND SURFACE

STATE WELL NUMBER	AQUIFER CODE	WELL DEPTH	ELEVATION OF LAND SURFACE	DATE OF VISIT OR MEASUREMENT	DEPTH TO WATER FROM LAND SURFACE	CHANGE IN LEVEL SINCE LAST STATIC MEASUREMENT	ELEVATION OF WATER LEVEL
68 06 709	218GRHC	135	955	04/17/1992	-17.76		937

TOTAL WELLS: 17

P WATER LEVEL AFFECTED BY PUMPAGE OR RECHARGE AT THIS OR NEARBY WELL(S)
Q ACCURACY OF MEASUREMENT IS QUESTIONABLE

TEXAS WATER DEVELOPMENT BOARD
WELL VISITS AND WATER-LEVEL MEASUREMENTS

COUNTY - Comal

WELL NUMBER	MEASUREMENT FROM LSD	DATE OF VISIT	MEAS. NO.	MEAS. AGENCY	METH. OF MEAS.	REMARK	VISIT MARK
68 05 605							
68 06 701							
68 15 903							
68 16 602							
68 16 801							
68 22 508							
68 23 206							
68 23 701							
68 23 807							
68 24 105							
68 30 312							

TOTAL CURRENT OBSERVATION WELLS: 11

Figure 14. Well visits and water-level measurements for observation wells in Comal County

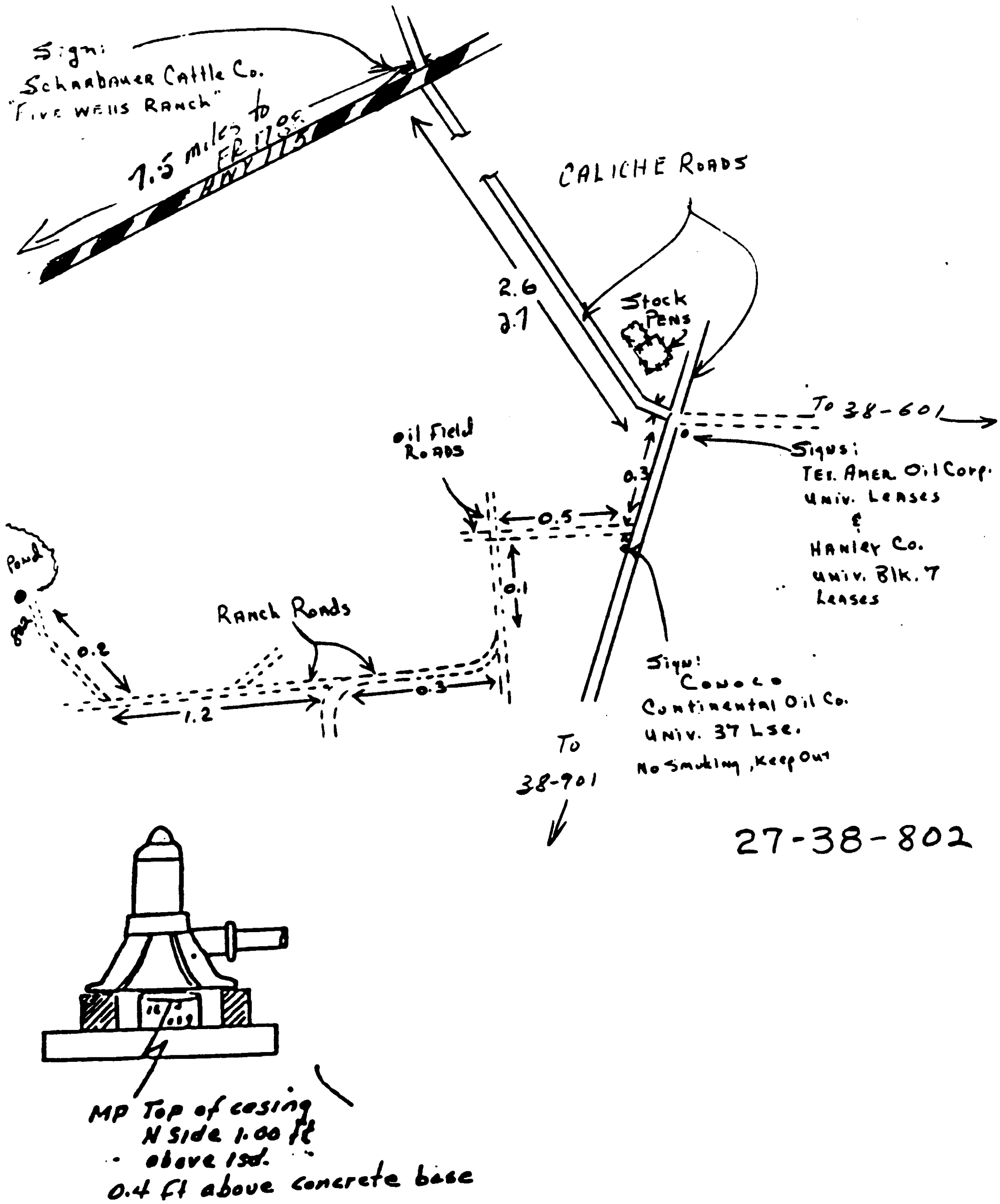


Figure 15. Well location and measuring point (MP) sketches

METHODS OF WATER-LEVEL MEASUREMENT/DEVICES

TWDB technicians most commonly use graduated steel tape (or wetted tape) to measure water levels as this is the most accurate and reliable method of measuring wells in Texas. The calibrated electric sounder, sub-merged air line, pressure gage, and float are other measuring devices used in wells where use of steel tape is not feasible or where the mcasurcmcnt taken would be unreliable, such as in a well with cascading water. The tape and electric sounder are used primarily to measure depth to water in a well on a periodic basis, i.e., monthly, bimonthly, semiannually, or annually. Water-level recorders using floats or transducers arc better suited for measuring water-level fluctuations resulting from barometric prcssurc changes, seasonal changes in recharge rates, and the effect of pumping wells. The sections that follow assume that the reader is familiar with the types of equipment being discussed; if not, lengthier discussion of measuring devices can be found in TWRI, Book 8, Chapter Al, "Methods of Measuring Water Levels in Deep Wells," and the National Handbook of Recommended Methods for Water Data Acquisition, Chapter 2.

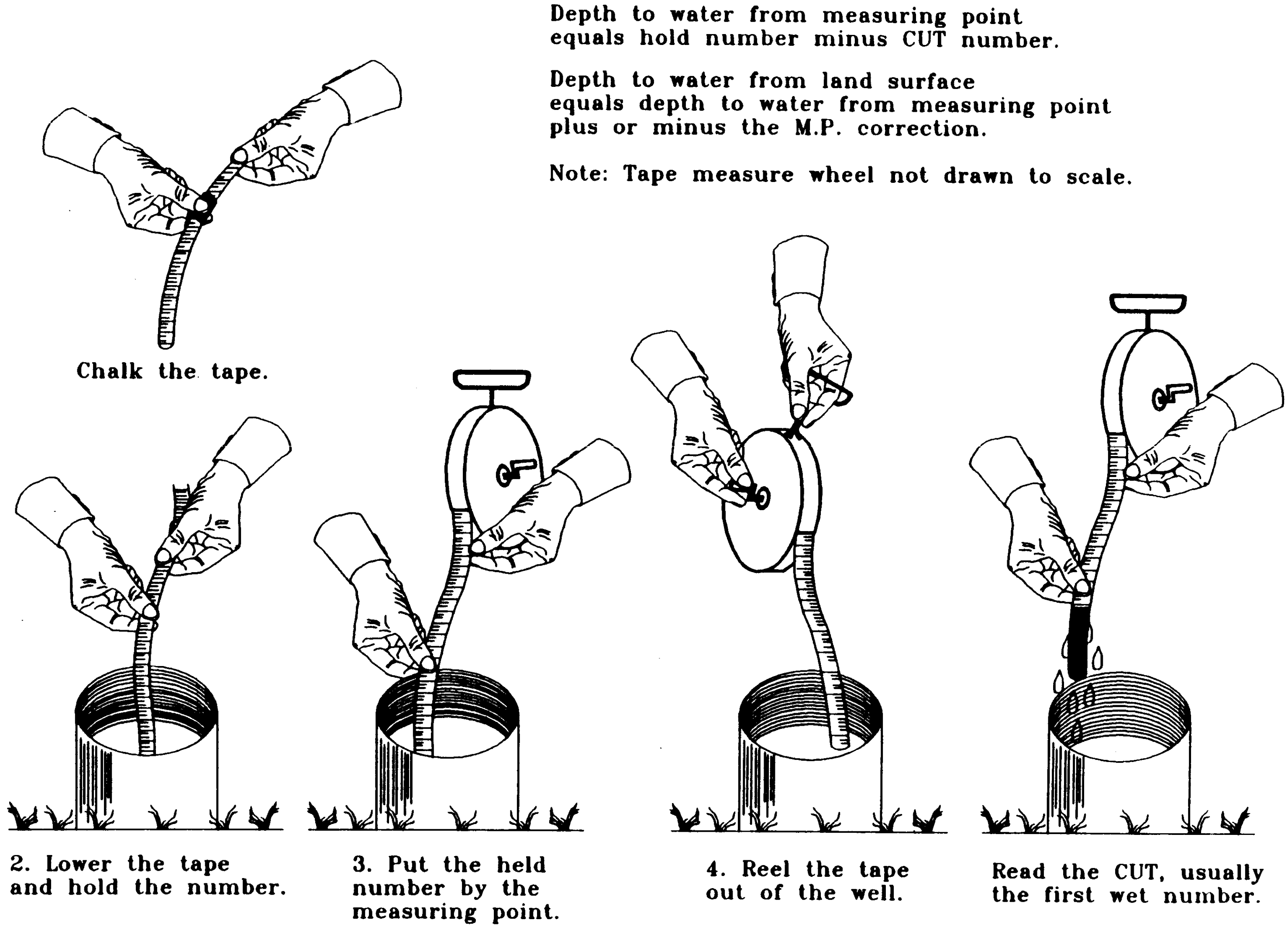
Graduated Steel Tape

The graduated steel survcyor's tapc has long been used to measure the depth to water in wells. Typically, steel tapes arc available in lengths of 100, 200, 300, and 500 feet, although some as much as 2,000 feet long have been specially made; the tapes are usually 1/4 or 3/8 inch wide; a few arc 1/2 inch wide. The shortest tape that is required to measure a water level is preferable; in addition, smaller tapes arc easier to carry and safer to use. To measure depth to water in a well, the tape is inserted in an opening in the top of the casing, base of the turbine pump, or a plate covering the casing that gives direct access to the inside of the casing. The lower 20 to 50 feet of tape is usually coated with a substance which will exhibit a marked change when wet, such as blue carpcnter's chalk or water-sensing paste; some technicians swear that a well-rusted tape doesn't even require chalking. Tapes arc generally graduated in hundredths of a foot for the first 10 to 30 feet and for 10 feet at each hundred.

The chalked end of thc tape is lowered slowly into the well to keep the tape from getting caught. As a rule, a tape that goes in correctly can be removed easily. Assuming the well is measured periodically and that depth of the water level is known from the last measurement, the tape is submerged below that level for a able distance (depending on the water-level variability in that aquifer) to make a mark on the chalk. The depth the tape is put into the well is noted at the measuring point (MP) at the top of the well. The MP should always be described, referenced to land-surface datum (LSD), and recorded so that future water levels in the well may be measured from the same point and referred to the same datum. When the tape is rc-moved, it is read at the top of the wetted part and the reading is tabulated on the data sheet along with the reading on the tape at the fixed MP. The depth to water is then calculated by subtracting the length of wetted tape from the reading held opposite the MP, and the MP amount is subtracted from the water level to calculate LSD. "Helpful hints" are illustrated in Figure 16; access to wells with turbine, jet pump, and submersible installations are illustrated in Figures 17 and 18.

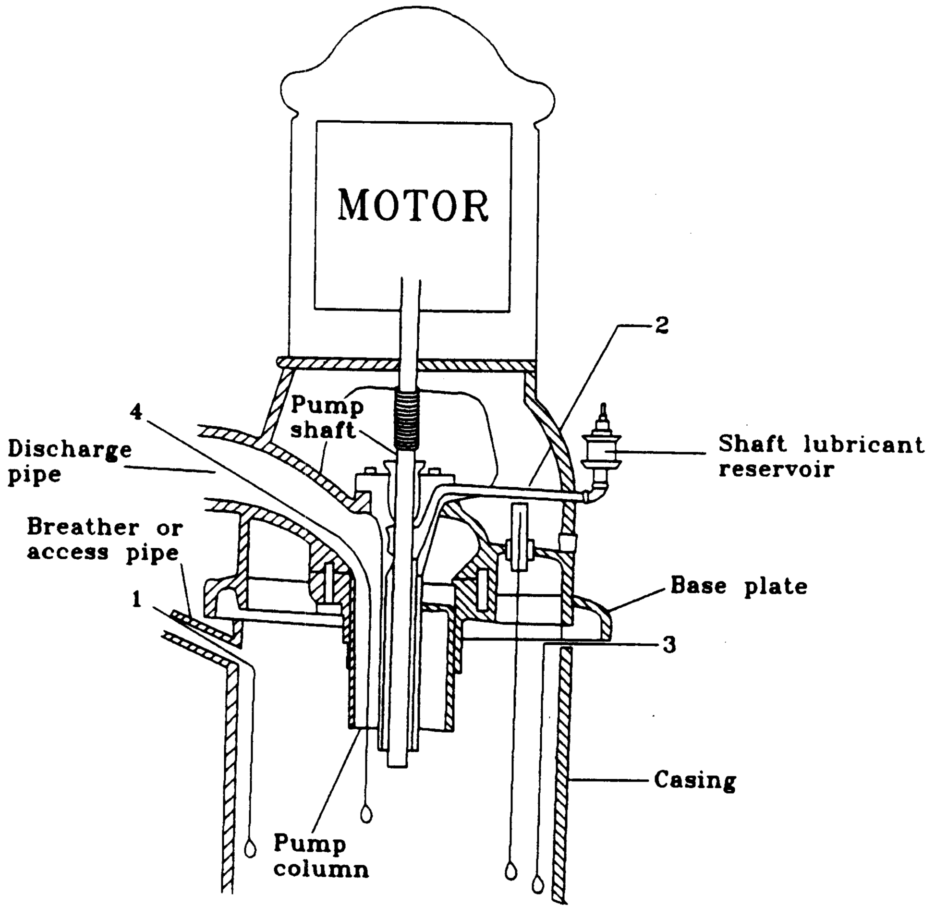
It can be argued that removing the tape by hand rather than reeling the tape in allows a more positive "feel" for possible obstructions in the well, thereby avoiding getting the tape jammed or wedged in small clcaranccs. Wtth experience, however, obstructions can be detected even when reeling the tape back onto the spool directly. For safety reasons, gloves should be worn, and care must be taken in order not to break the tape by removing it too quickly. The tape should not be allowed to accumulate on the ground to minimize the possibility of kinking the tape and to eliminate hazards such as contacting an electrical circuit, interfering with operation of equipment at the well site, or tripping the technician. While the tape should not be removed too quickly, in more arid regions of the state a rapid reading before the wetted part dries out is essential. The wetted part of the tape should be dry before it is reeled up. Measurements should always be checked against a second or third measurement. Maximum acceptable differences for check measurements generally are within 0.02 of a foot, but vary somewhat with depth to water for a non-pumping well using the wetted-tape method.

Although TWDB technicians do not usually attach weights to their tapes, two- to four-ounce weights can help make the tape hang straight; penetrate any debris such as oil, sludge or fine trash; and aid the measurer in "feeling" the way down the well. If a weight is used, it is best to attach it in such a manner that the weight will easily break free if bound up by an obstruction. Metal clips can be used to attach weights of different amounts to suit special circumstances.



Helpful hints:
1) Estimate depth to water and determine previous method of measurement from listing in field book or based on previous experience in area.
2) Feed tape down well. Do not let it fall free.

Figure 16. Helpful hints for measuring water levels with steel tapes



Some wells have a breather pipe, or other access pipe, in the side of the casing.

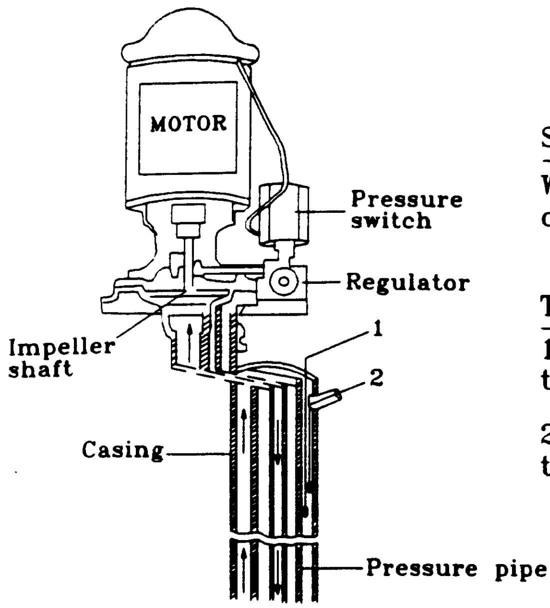
2. This is a common access opening. The water level is measured between the pump column and the casing. Sometimes the space between the casing and the pump column is very small and an unweighted tape is used. The opening may be covered with dirt, oil, etc. and will be difficult to find.

3. There may be an opening between the base plate and the casing. The tape will have to be sharply bent and fed cautiously into the well. Space available is usually very small, and considerable manipulation is needed to get the tape started down the well.

4. This method should not be used except as a last resort and only if a measurement of the well is imperative. Extreme care should be used not to drop anything down this opening, because it will fall to the pump impellers.

Exercise caution and judgement.

Figure 17. Access to well with turbine pump installation



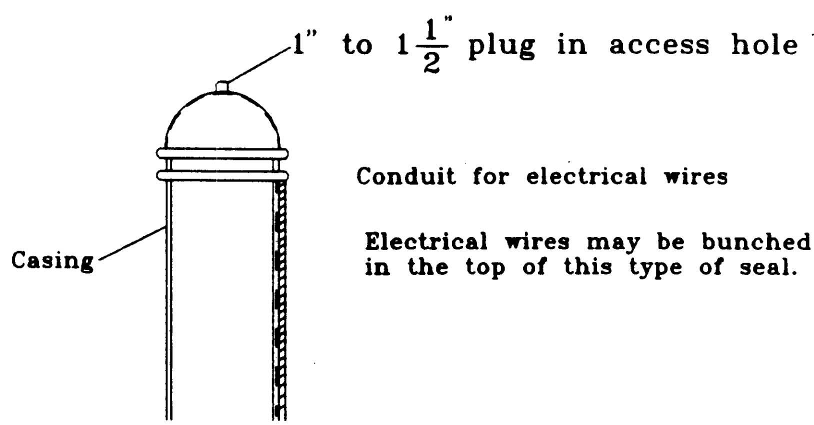
Single-pipe jet

Water level cannot be measured without complete removal of pipe works.

Two-pipe jet

1. Pump may be lifted up and access gained through the opening at the top of casing.

2. There may be an access hole or plug in the side of the casing.



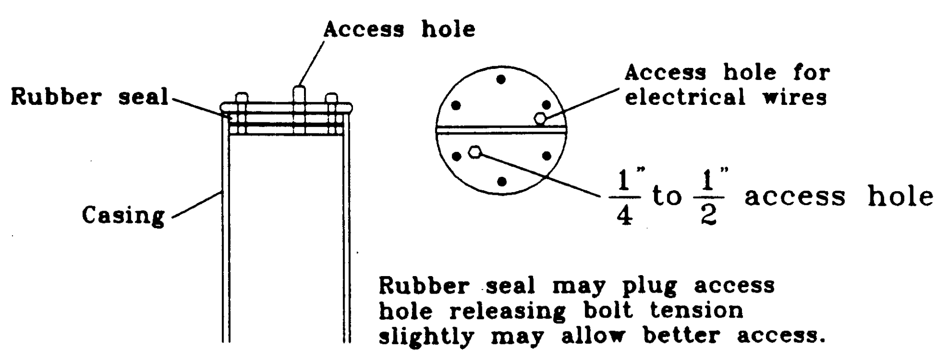


Figure 18. Access to wells with jet (top view) and submersible pumps

To determine depth-to-water measurements in wells that have not been measured previously, the tape can be inserted a few feet at a time to regular intervals, such as 25 to 50 feet, to check if water is encountered. On a second trial, the technician can lower the tape an additional 25 to 50 feet and remove it again, repeating the process until water is detected. This practice will minimize the possibility of getting the tape "balled" or "hung up" in the well. Once the depth to water is measured, a second measurement should be made to corroborate the reading.

Calibrated Electric Sounders

Calibrated electric sounders with shielded probes are used to measure depth to water under certain conditions, such as in wells in which water splashes from a pump pipe or from the wall of the well. In most models, a 9-volt battery-powered conductor operates the sounder, and both wires combined through the length of the sounding line ground the system. When the probe enters the water, an electrical circuit is completed. Contact with the water surface is indicated by a sharp needle deflection on the meter and an audio alert.

Cable is available in lengths of 100,200,300,400, and 500 feet and is mounted on a small handheld spool and stand. It consists of two steel- and copper-stranded wires covered with a tough plastic insulating jacket. Depth indication may be provided by numbered metal tags securely crimped to the cable at intervals of five feet. When the water level is between two marks, a pocket tape is used to measure from the nearest point of the line to the point that was measured. Using a two-conductor cable makes an outside ground connection unnecessary, and the instrument can function equally well in uncased test holes or in uncased wells in rock. These electric lines arc easily rcpaircd in the field; probes should be spliced at the end of the line where they will quickly break off if they become hung up.

The line should be checked for stretching and replaced as necessary. If not, mcasuremcnts will be incorrect, and a stretched line may be weakened and subject to brcaking. Ideally, the sounding line should be calibrated by first measuring the depth to water in a well with no cascading water and then verifying the measurement with a steel tape. If the sounding line is properly calibrated, the difference between the two mcasuremcnts should be less than 0.1 foot per 100 feet of depth to water. Such calibrations should be noted in the cquipment book. To minimize hazards, the sounding line should be reeled into and out of the well and not be allowed to accumulate on the ground or freewheeled down the hole.

If measuring depth to water in wells with an oil film or column on top of the water, as in wells with oil-lubricated turbine pumps, the height of the oil column must be determined. For example, assuming there is a 10-foot oil column, the surface of oil will be within 1.4 feet of the true water level; the oil-water contact, on the other hand, will be 8.6 feet deeper than the true water level. To adjust the depth-to-water measurement for the effect of the oil column, the top of the column can usually be measured with a steel tape and the oil-water contact with an electric sounder or with a steel tape coated with a water-sensing paste that undergoes a permanent color change when wetted. The height of the oil column is multiplied by 0.86 to obtain the height of the water column of equivalent height. Although the coefficient ranges from 0.85 to 0.88 depending on the type of oil, 0.86 represents an average value for oils typically used to lubricate turbine pumps. The height of the water column is then subtracted from the depth to the oil-water contact. For example:

Depth to oil-water contact	147.3 ft
Depth to top of oil	132.6 ft
Height of oil column	14.7 ft
Height of oil column x 0.86 =	12.6 ft
Depth to water, adjusted for effect of the oil column =	134.7 ft

Air Lines

TWBD field personnel use air lines to measure depth to water in wells in which water depths are greater than 500 feet. Air lines are commonly installed in wells equipped with large power pumps to determine the drawdown during pumping as well as fluctuations in the static water level. Generally, the well is sealed so tightly that a tape cannot be lowered into it. In the submerged air-line method, flexible plastic tubing of small diameter is installed in a well, extending from the surface to a known depth below water level (or the lowest level anticipated during a pump test). The tubing is fastened in a fixed position to a substantial support, such as the base of the pump, and its upper end is fitted with a valve and suitable connections so that a pump and pressure gage can be attached. The gage is calibrated to indicate air pressure in pounds per square inch (psi), or, more conveniently, in feet of water, using the conversion factor of 2.31 psi per foot of water.

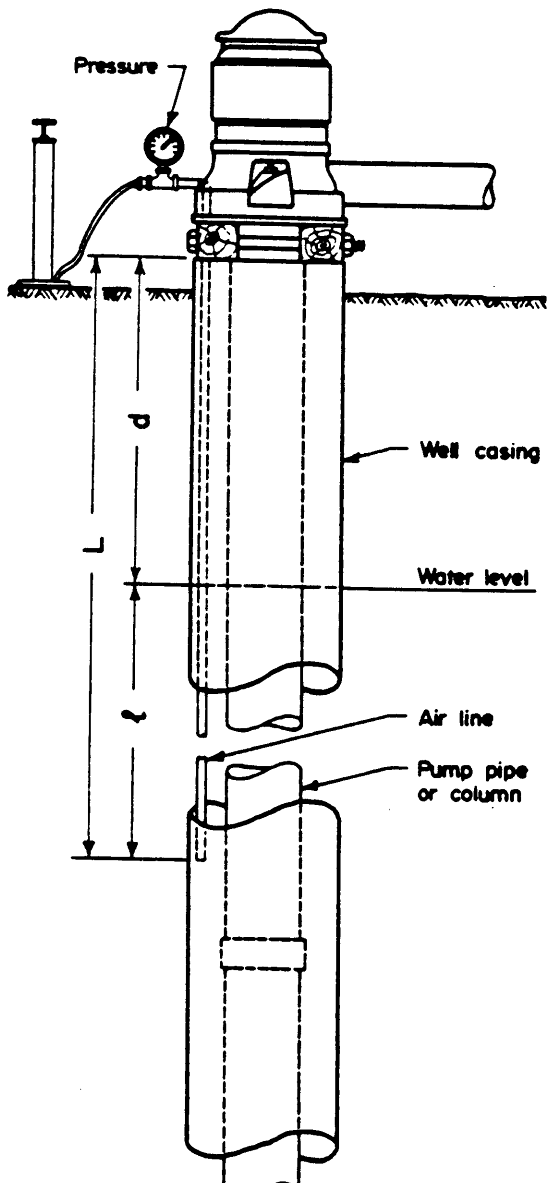
TWDB technicians use compressed nitrogen to pump air into the tubing until all the water is displaced; the gage then indicates the amount of air pressure as air escapes into the well. The pressure is gradually built up until the air begins to escape; thereafter, the pressure remains approximately constant, even though the pumping is continued. The maximum pressure that can be obtained is therefore a measure of the length of submerged air line, or depth to the lower opening in the air line (which might not be hanging exactly vertically). The difference between the depth to the opening in the air line (shown as L in the schematic in Figure 19) and the pressure head represented by the height of the column of water equal to the submerged length of air line (shown as l), is the depth to water in the well (d). Depth to water can be determined usually within 0.2 ft. of the exact value.

Measurements by the air-line method are only approximately accurate; any error in the length of the line or any holes developed by corrosion below the water level will cause even greater measurement errors. Ideally, air lines should be large enough to admit a tape for measuring to check the results of the air-pressure readings. Particularly in wells with splashing water, a tape measurement in the air line will give more accurate and reliable results than will the air-line method. Because of the great depths to water in wells typically measured with air lines by the TWDB, however, this check is rarely performed.

Pressure Gages

For measuring the water level in flowing wells--that is, wells with static water levels above the ground surface--it is necessary to use a pressure gage. In wells with low pressure, it is often convenient to measure the head directly. A short length of transparent tubing is connected tightly to the well, and the free end of the hose is raised until the flow just stops. The water level is then observed against a measuring rod to the nearest 0.01 foot. In wells where static water levels are more than a few feet above ground, a pressure gage is used to measure the head. The gage should be selected so that the anticipated water pressure falls within the middle third of the range so as not to ruin the instrument should well pressure exceed gage limits. When in doubt, a gage with a wide range should be used to make an initial estimate of the pressure, followed by use of a gage with the proper range for a more accurate measurement.

No matter what device is used to measure flowing wells, the flow of water must first be cut off so that the shut-in pressure can be observed. Some wells may be fitted with gate valves and hose bibs or similar devices, whereas other wells may be open at the top and overflow freely. These can be shut in by using a soil test plug; a rubber plug that can be expanded after insertion into the discharge pipe to stop the flow of water. A pressure gage can be connected directly to an outlet pipe in the soil plug or to some sort of flexible line such as a garden hose. The gage is attached to one of the two “open” valve positions on the line, and air is slowly



$$d = L - l$$

where

- d is depth to water, in ft
- L is depth to bottom of air line, in ft
- l is pressure head, in ft, represented by a column of water of height equal to the submerged length of the air line.

Figure 19. Typical installation for measuring water levels by air-line method

bled **from the hose** using the other "open" position. The water level is then determined by **multiplying the** pressure, in pounds per **square inch, by** 2.31 and correcting for height above or below MP.

A flowing well may be permanently damaged by cave-in of the water-bearing material at the **bottom of the** well if the increase or release of pressure when closing or opening a valve or a soil plug is too abrupt. Further-**more, a pressure** gage should not be connected to a well that has a booster pump in the system in case the pump starts and the pressure surge ruins the gage. The locations of any check valves should also be carefully noted as attaching the gage to the wrong side of the check valve may give the reading only for the pressure in the distribution line or in a storage tank Figure 20 illustrates different locations for access ports and pressure gages.

In some wells the static pressure appears to be reached almost immediately after the well is closed, but in others this may take days or longer. However, TWDB field personnel routinely wait for ten minutes for all flowing wells after shut-in before determining the water level. Water-level changes arc still readily apparent even though these measurements may not represent actual water-surface elevations. Depth-to-water mcasurc-mcnts in flowing wells arc considerably less accurate than those in nonflowing wells. Many gages cannot be read accurately to less than 0.5 foot, and few within 0.1 foot. Unless the well is permanently shut in, there is always some possibility of error as true static pressure may not be reached. Pressure-gage readings will also be erroneous in flowing wells with Ieaky casings.

Automatic Water-level Recorders

All of the recorders operated by the TWDB (Fig. 2) record fluctuations in water level where the static level is below the top of the well. Two devices used in recording wells arc the transducer and the float and pulley; only a brief description of the float and pulley will be given here as TWDB recorders arc not equipped with transducers. A somewhat more detailed explanation is given in a forthcoming TWDB report entitled, ***Manual for Servicing Automatic Water-level Recorders Equipped with Dataloggers*** (Winkclman and Mohr, in press).

The type of recorder most commonly used on nonflowing wells consists of a float that rises and falls with the surface of the water, a device for transferring the motion of the float to a recording device, and a time-driving

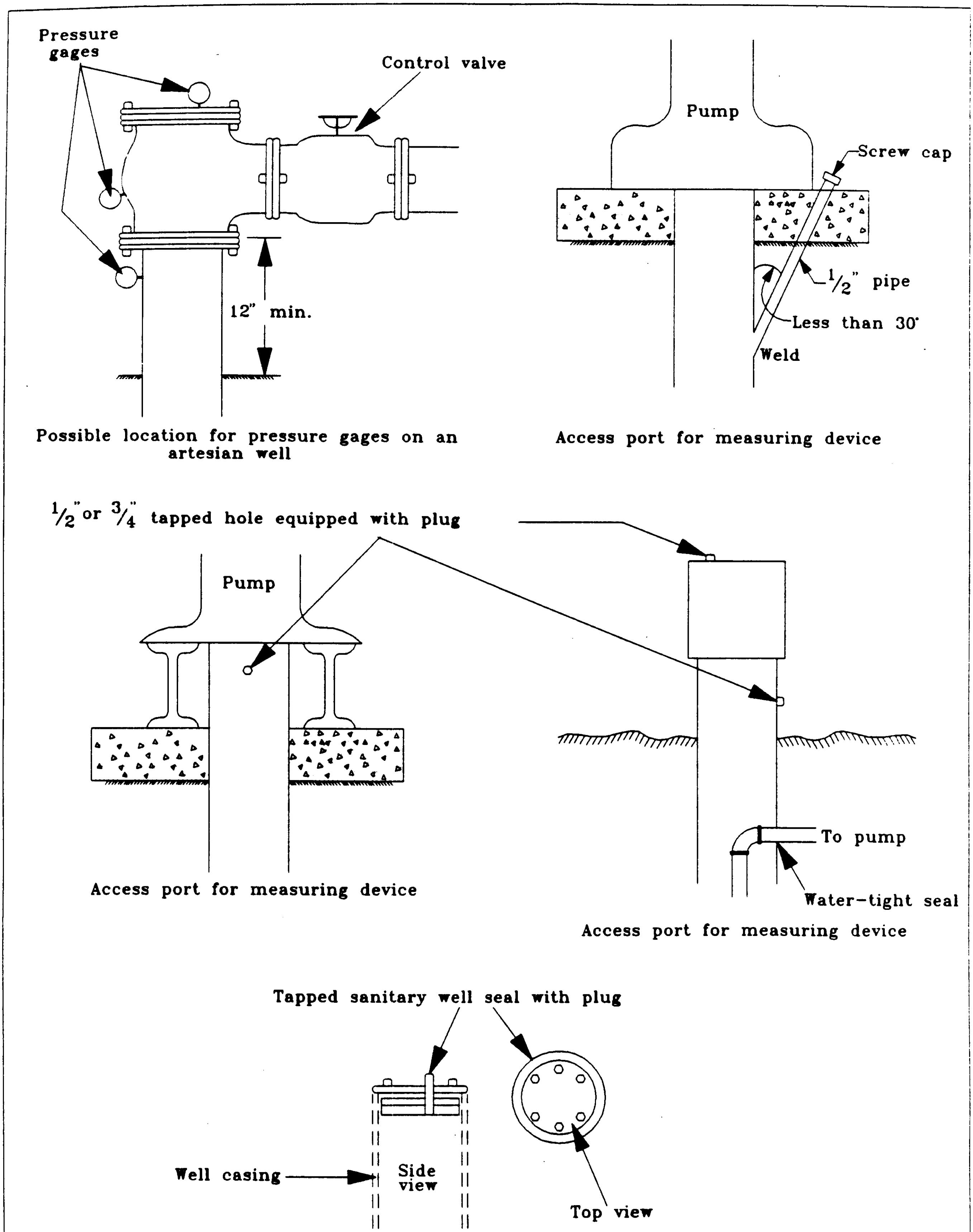


Figure 20. Methods of installing access ports and pressure gages

mechanism. A graduated cape or beaded cable, with a counterweight on one end and a float on the other, is hung over a pulley; the float moves the tape or cable up or down as the water level fluctuates, thus rotating the pulley. The float-operated pulley is connected to a chart drum with a pen to provide a graphic record. A power source, such as a spring, clock, or small motor, gives a constant indication of elapsed time by slowly moving the pen at a 90 degree angle to the chart drum movement, thus providing a constant analog record of changing levels during a specific period of time. In some instruments, the float operates the pen movement and the time mechanism moves the chart drum; in others, the float movement produces movement of the chart drum and the time mechanism activates the pen. Both methods produce a convenient graphic record. Different gage and time scales determine the length of time the chart will last--from several days to several months, allowing for unattended operation in remote areas where it may not be practical to visit the recording station except at infrequent intervals.

A well in which a recorder is to be installed should have casing that is as straight and smooth as possible to ensure free movement of the float up and down the well. Generally, a well of large diameter is more desirable than a well of small diameter, as a larger float is more sensitive to water-level fluctuations. Recorders should also be protected from the weather and from theft or vandalism. The TWDB has constructed and installed neatly painted metal shelters labeled with TWDB logos on all of its recorder wells; there are also several types of suitable shelters available commercially. Each shelter is placed in a position that allows the float and counterweight cable or tape to hang freely in the well, and each is ventilated above and below the instrument shelf to shield the recorder and attachments from moisture that may rise from the well.

As mentioned above, 36 of the 41 TWDB recording wells equipped with float and pulley recorders have been connected to dataloggers. Drum charts and pens have been eliminated, and cables have been connected to encoding devices that translate the analog movements of the cable into digital signals for storage in the dataloggers. The time necessary to transfer the recorder data into the ground-water database has been drastically reduced because charts no longer have to be "worked" by hand; the digital data are downloaded directly into the database. The data are stored on battery-operated datacards that are serviced approximately every four months by water conservation districts and TWDB personnel. In the future, the TWDB may be able to retrieve recorder data telemetrically. First, dataloggers will have to be equipped with modems for remote transfer via radio or telephone, the more likely possibility of the two. Second and most importantly, however, datacards that do not rely on batteries must be developed. Now the four- to six-month life of the battery requires that the loggers be serviced at these intervals, whereas if the data were transferred telemetrically, servicing would be performed only on an as-needed basis.

USES OF GROUND-WATER LEVEL DATA

The TWDB is committed to releasing all water-related data to the public in a variety of forms. As stated previously, choices can be made for tabulated raw water lcvcls (Fig. 13) and record-of-well information (Fig. 12) in response to specific inquiries from the public. The database is queried by staff for approximately 1,000 of these reports annually. Although water-level and/or water-quality data could be tabulated annually and simply listed by county with locations shown on an accompanying map as is practiced by the USGS, the TWDB believes it offers a much more valuable and efficient service to the public by allowing exact areas, years, aquifers, and well types to be specified in the reports produced on demand. An additional 4,000 requests arc made annually for viewing the hard copies of other well-data information housed in the file room of the Hydrologic Monitoring Section.

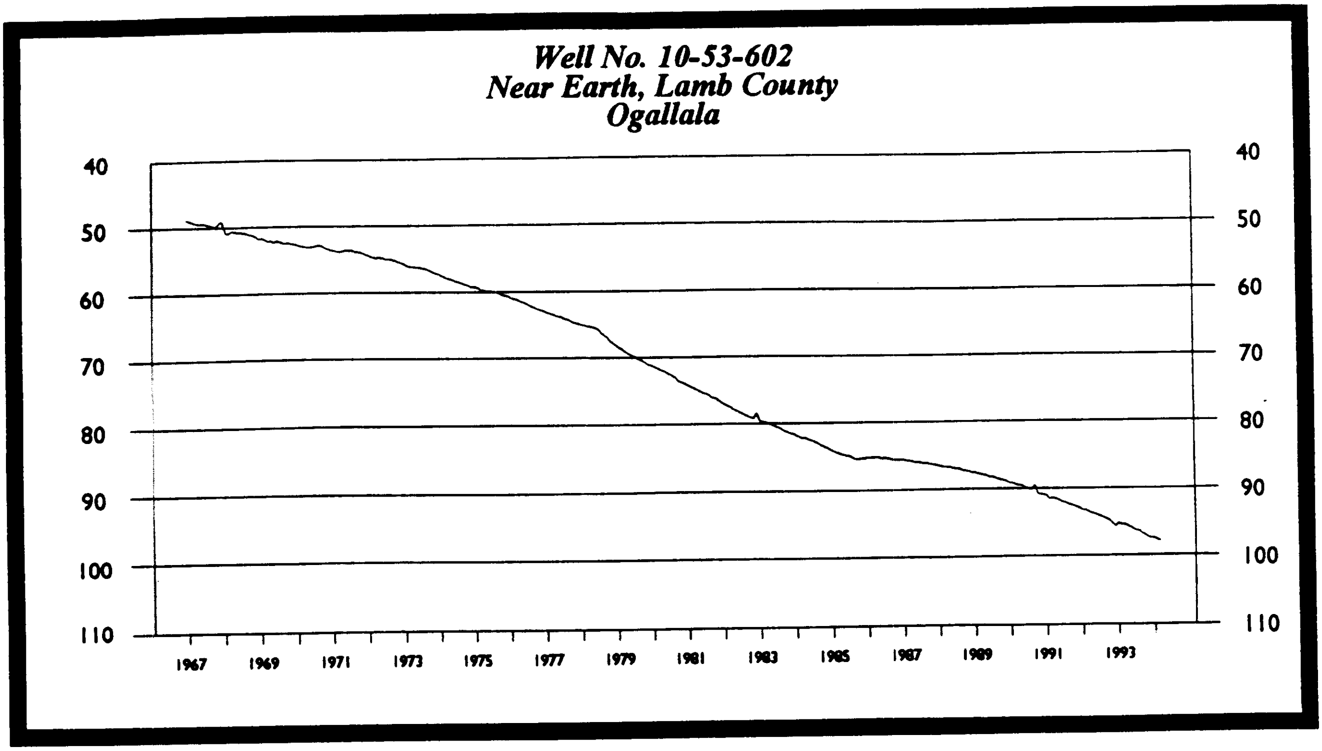
Raw water-level data arc used by TWDB personnel in the Hydrologic Monitoring, Water Supplies, and Water Research and Policy Sections; by other local, state, and federal agencies; and by private companies and individuals. This information is commonly illustrated and/or discussed in the following forms:

Hydrographs

The hydrographs in Figure 21 were created with spreadsheet software (Quattro Pro) after importing watcr-level data collected from recorder wells for the period of record. The top hydrograph illustrates the steady decline in water levels in an Ogallala aquifer well in Lamb County since 1967. The decline of approximately 20 feet per 10 years in this water-table aquifer in the High Plains is as significant as declines of 50 feet per 9.6 years in artesian aquifers. The bottom hydrograph, of a well near Waco in McClcnnan County, illustrates such a decline in the Hosston (Trinity) aquifer of nearly 150 feet per 10 years. Seasonal pumping is more apparent in hydrographs from wells completed in artesian aquifers.

Water-level Maps

The most recent water-level data can be supplied in hard copy or on computer disk and then plotted using GIS or other software. After mapping by hand or with contouring software (such as Surfer), water-level



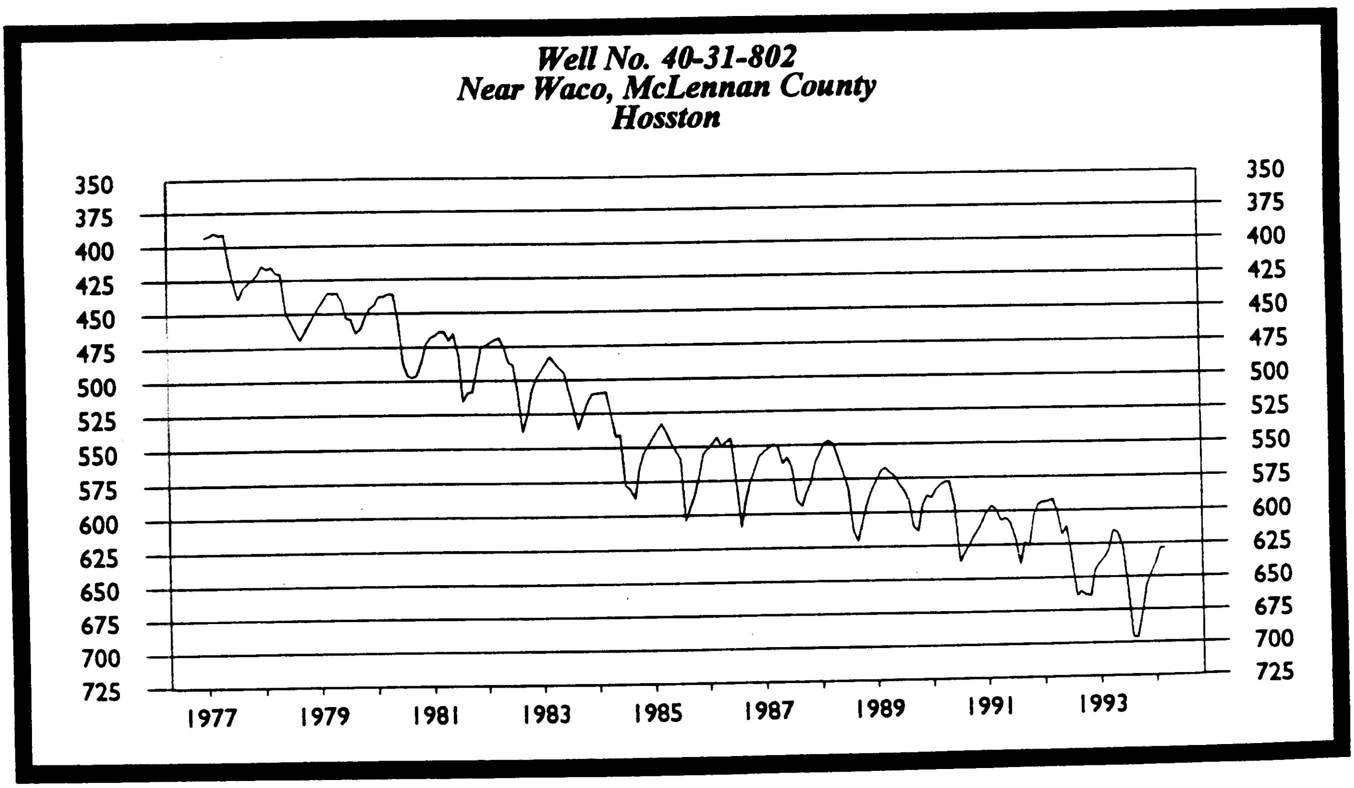


Figure 21. Hydrographs of wells completed in the Ogallala and Hosston (Trinity) aquifers

maps covering any part of one county to dozens of counties may be produced, such as the one showing the approximate altitude of water levels in the High Plains (Ogallala) aquifer, 1990, in Figure 22. When cross-contoured with an aquifer isopach map, a saturated thickness map (Fig. 23) may be generated and used along with area and specific yield to determine total volume of water in storage.

Water-level Change Maps

Water-level maps representing two different times may be cross-contoured by hand or with the help of special contouring software to produce a water-level change map for the period in between, showing both net rise and net decrease in water levels on the same map or separately as in Figures 24 and **25.** If well control is dense enough, actual differences between water levels measured at two different times in the same wells may be calculated originally in order to contour a change map.

Models

A model's cell grid must be laid over a saturated thickness map to specify appropriate parameters assigned to each cell during initial model construction. A water-level map is also used during model calibration, as in Figure **26,** to compare predicted (simulated) values with observed values. Simulated values may be displayed graphically and compared to the hydrograph at a specific site, as shown by the index well for the Edwards aquifer at Comal Springs in Figure 27 displayed beside the simulated hydrograph.

News Releases, Hydrologic Atlases, and Reports

The TWDB may announce upcoming water-level observation trips or summarize general water-level trends after yearly visits in particular counties in news releases. Water conservation districts do likewise in monthly and quarterly newsletters. The TWDB, several High Plains districts, and the USGS publish hydrologic atlases. These mainly consist of water-level or water-level change maps over part of the state accompanied by brief explanations. Reports written by TWDB personnel generally contain much more detailed information about occurrence, quality, and availability of ground water; water-level and water-quality trends over time; or discussions of modeling techniques.

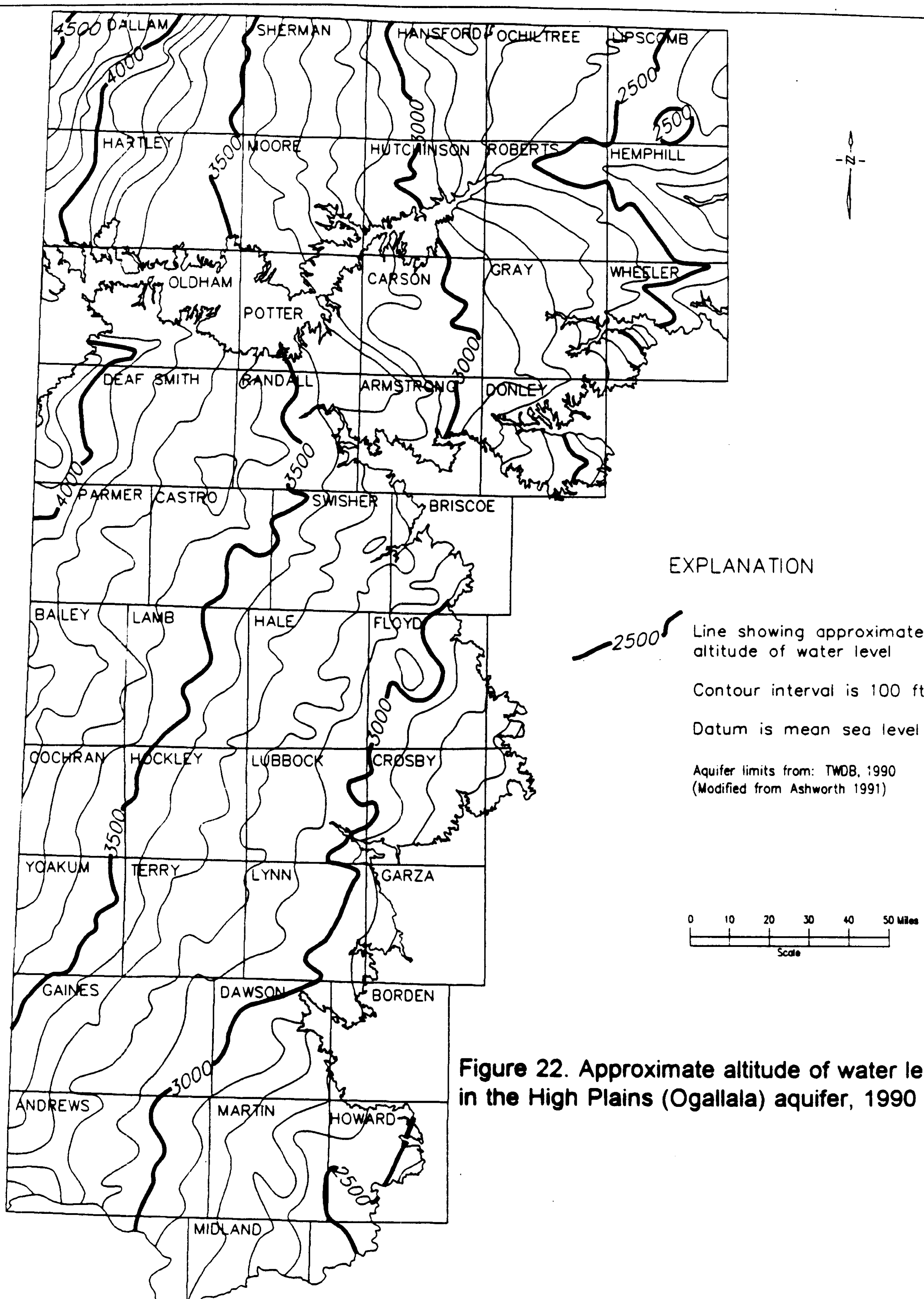


Figure 22. Approximate altitude of water levels in the High Plains (Ogallala) aquifer, 1990

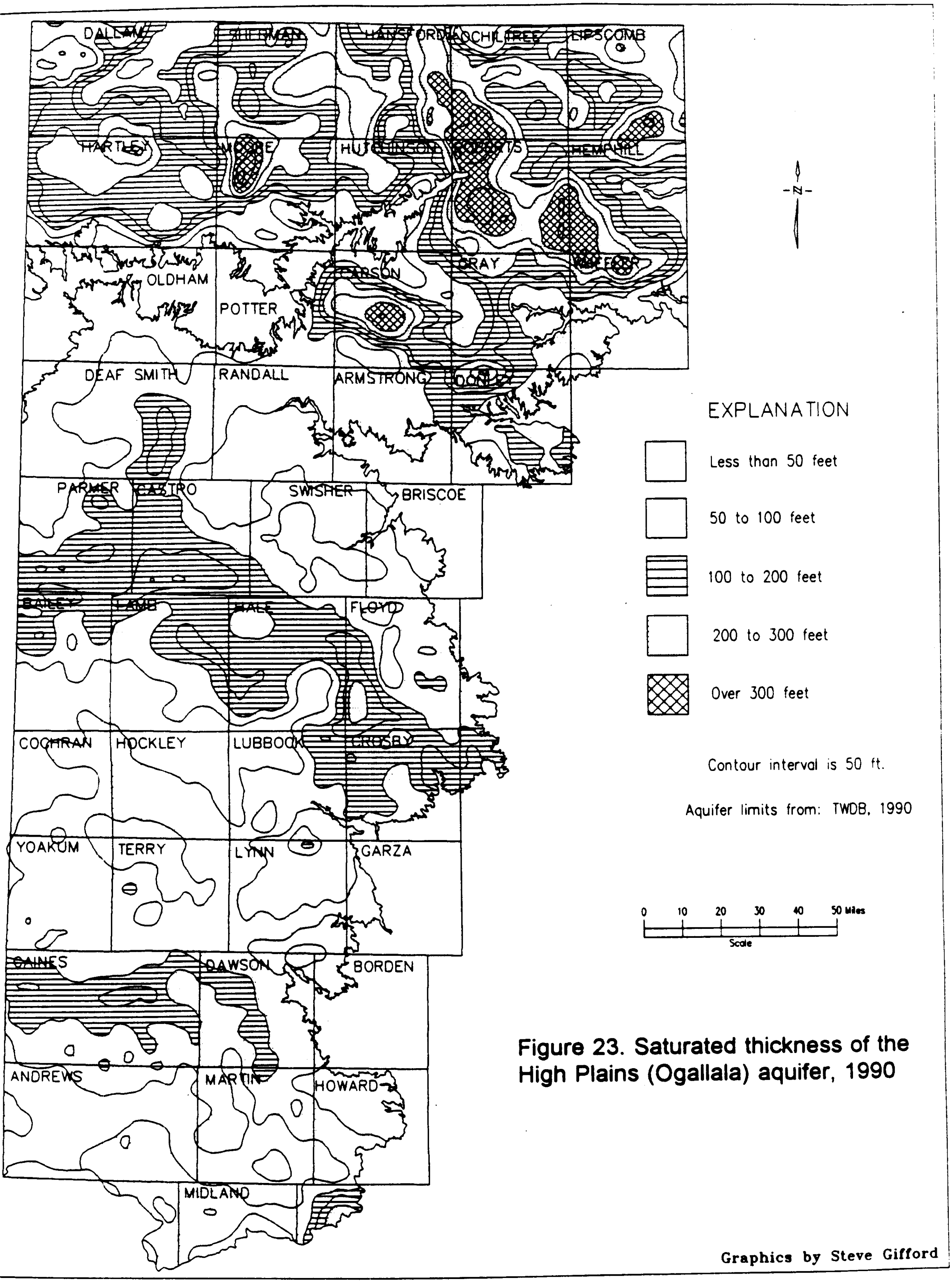


Figure 23. Saturated thickness of the High Plains (Ogallala) aquifer, 1990

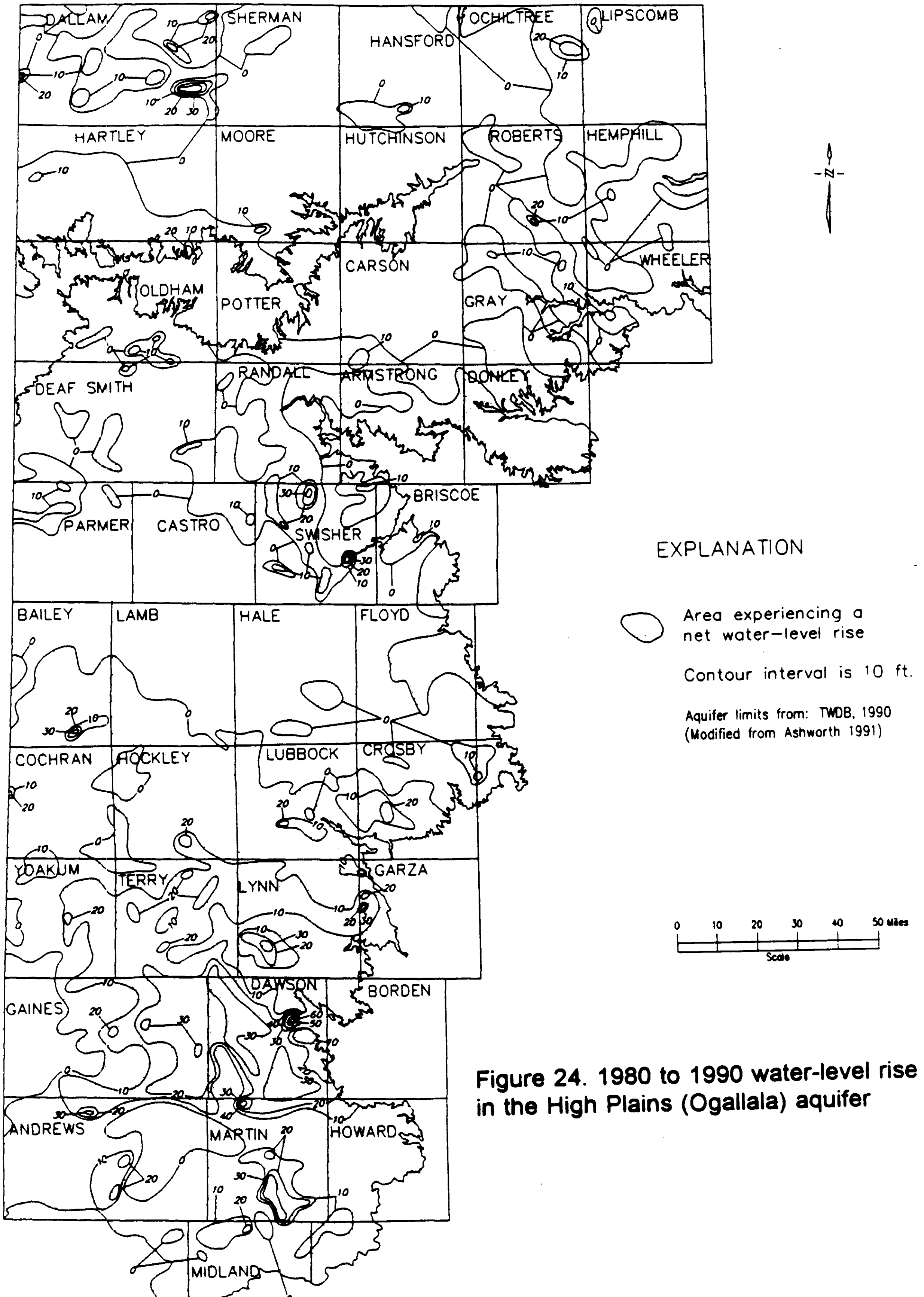


Figure 24. 1980 to 1990 water-level rise in the High Plains (Ogallala) aquifer

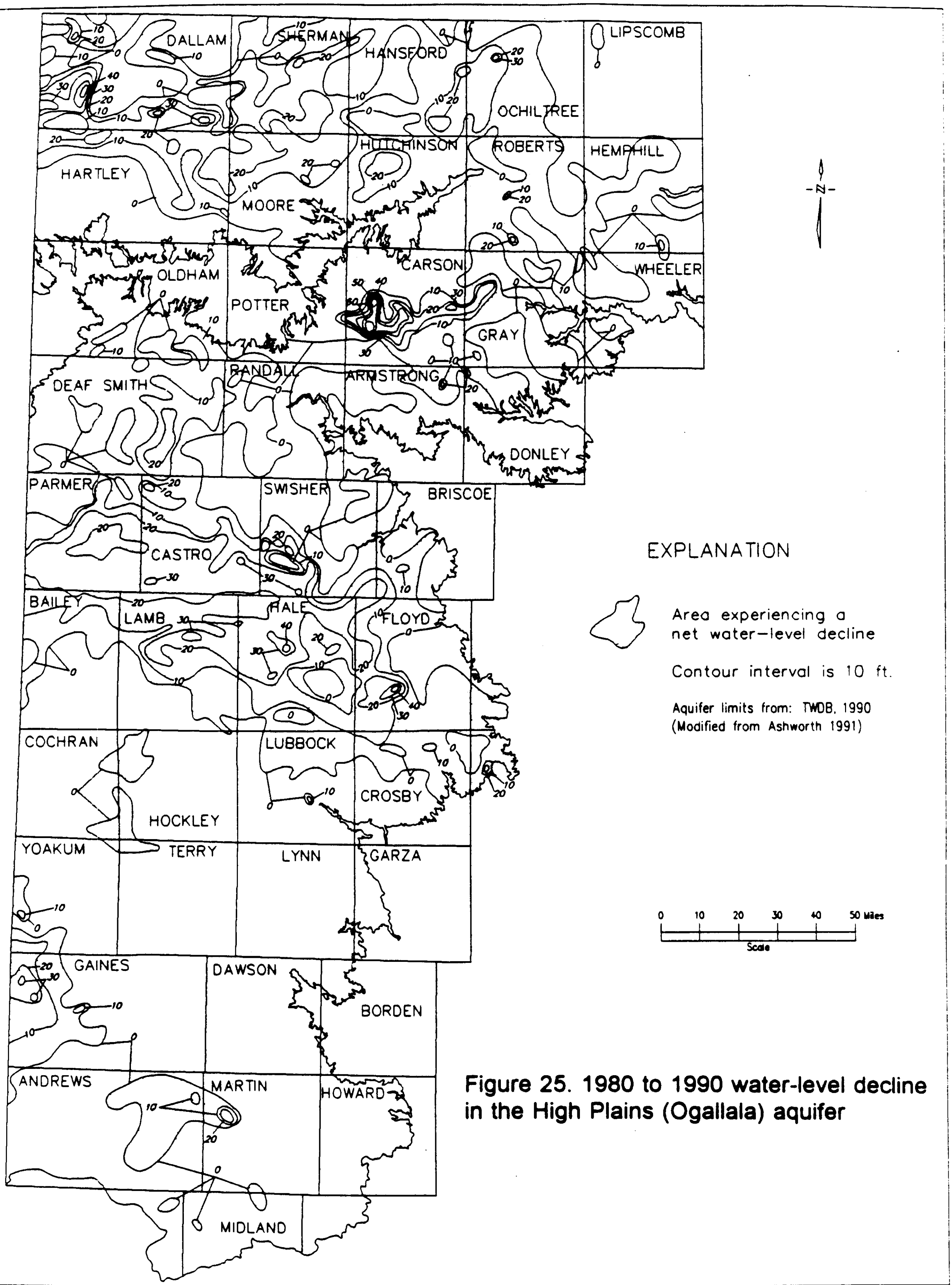


Figure 25. 1980 to 1990 water-level decline in the High Plains (Ogallala) aquifer

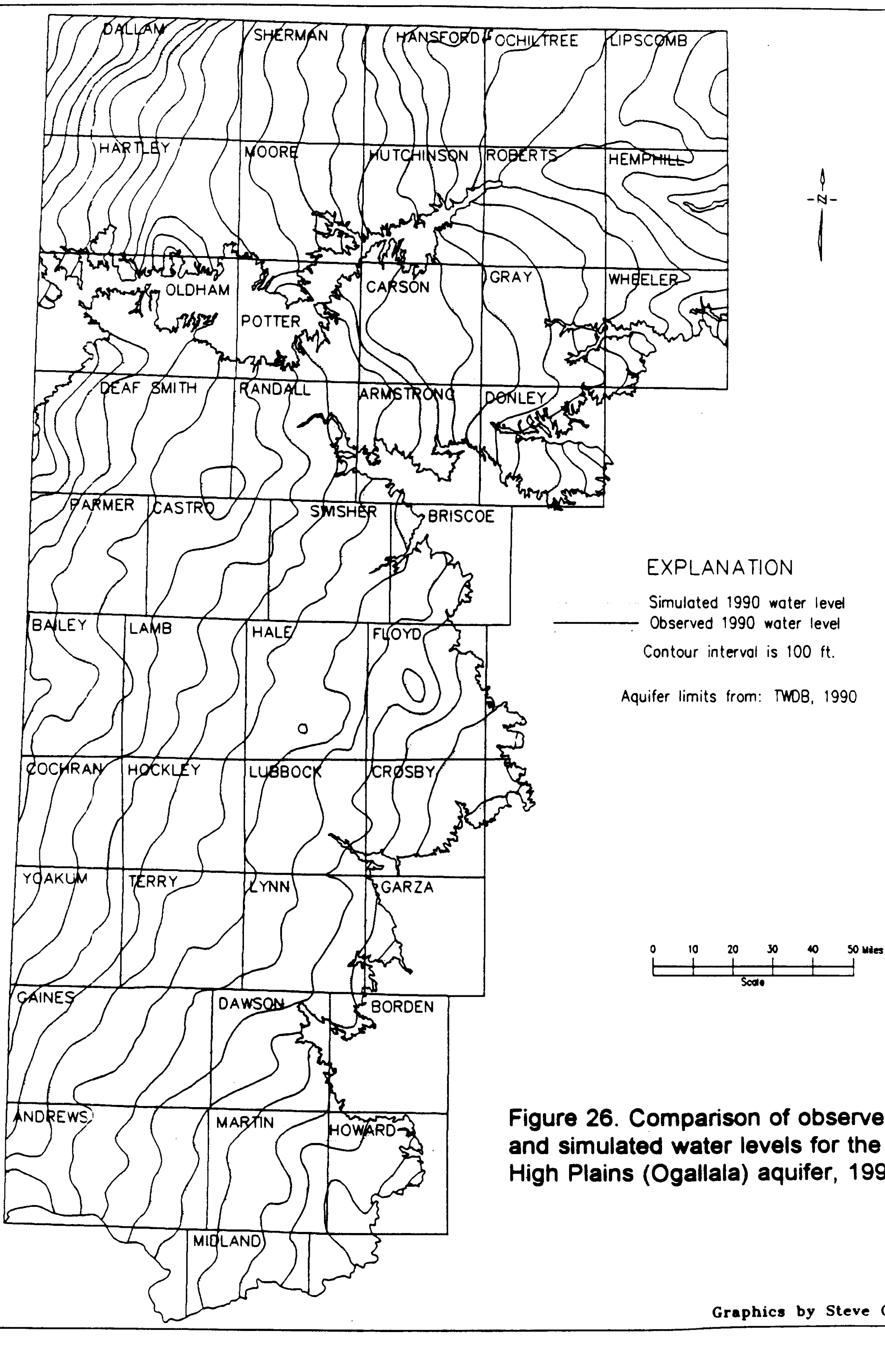


Figure 26. Comparison of observed and simulated water levels for the High Plains (Ogallala) aquifer, 1990

Graphics by Steve Gifford

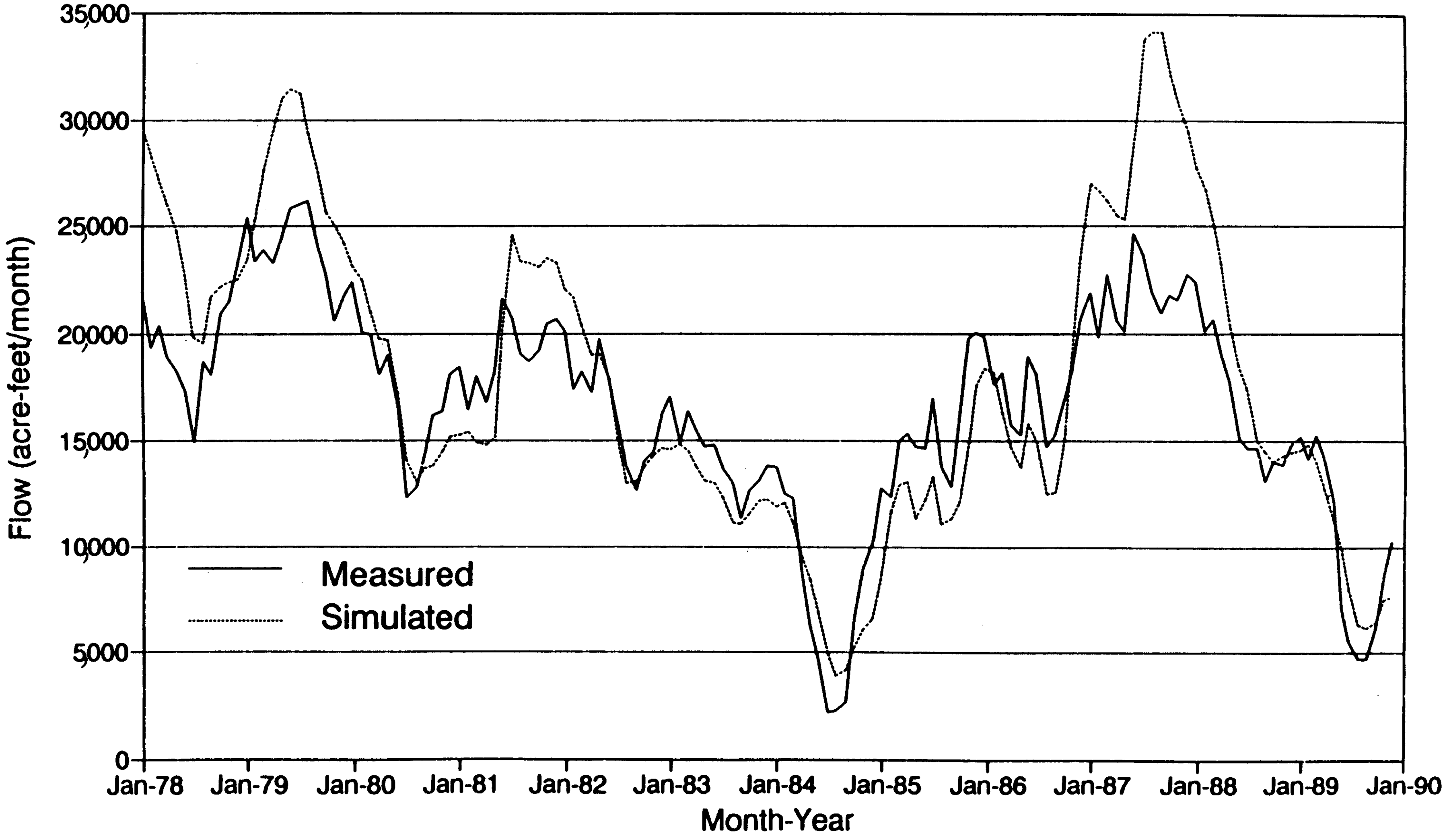


Figure 27. Measured vs. simulated water levels in the Edwards (BFZ) aquifer at Comal Springs

THE BIG PICTURE

Texas is one of the few states in the U.S. that maintains such comprehensive water-level observation and ambient water-quality sampling programs. The TWDB may be the only agency in any state to have attempted to define adequate water-level observation and ambient water-quality sampling programs. Although the USGS has collected and compiled ground-water data historically throughout Texas (and all other states), only certain areas are monitored, typically where collective agreements with other local agencies arc in effect. From this author's incomplete and informal poll, a few states such as New Mexico, Illinois, Utah, and Nebraska have fairly well-established water-level programs that provide enough data to determine long- and short-term water-level changes in their state's major aquifers. However, in certain water-poor states such as Arizona and California, less cooperation appears to exist between the USGS and state agencies, resulting in less comprehensive programs and databases; in addition, not all of the California aquifers have been completely identified because of the extremely complex geology.

Obviously the simpler geology and shallow aquifers in Texas have facilitated the collection of accurate ground-water data, but beyond this serendipitous situation, progressive policies on the part of the state Legislature have further facilitated the maintenance of comprehensive water-level and water-quality programs. Because the TNRCC is charged with regulation typically involving ground-water assessment in quite localized and shallow areas, and also in areas specifically suspected of ground-water contamination only, the TWDB is free to consider the larger water picture involving the examination and determination of how much and how good the ground water in Texas is naturally. The luxury this agency has enjoyed can be defined as a necessity if one is to use these data to plan for the future The mission statement of the TWDB underscores its commitment to "the conservation and responsible development of water resources for the benefit of the citizens, economy, and environment of Texas"; data collection of ground- and surface-water information is an integral part of maintaining a comprehensive statewide water plan to ensure such sible development of water resources.

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