Texas Water Development Board

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Evaluation of Diminished Spring Flows in the Toyah Creek Valley, Texas

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INTRODUCTION

The farming community of Balmorhea, located in the southern Toyah Basin at the foothills of the Davis Mountains (figure 1), is highly dependent on water derived from numerous springs. Major springs occurring in the Toyah Creek valley include Phantom Lake, Giffin, San Solomon, Saragosa, and East and West Sandia springs. Numerous other springs occur at higher elevations to the south and southwest. Average total flow from all of the springs in the valley is in the range of 50,000 acre-feet annually. The springs are important to the region as a source of water for irrigation and as a wetland habitat for a multitude of wildlife including the endangered Comanche Spring Pupfish. The Reeves County Water Improvement District #1 channels water from the springs through a system of canals to irrigated fields in the Balmorhea area. The purpose of this cursory study was to determine the cause of declining flow from the springs.

METHODOLOGY

In July and August of 1997, the TWDB initiated an inventory of wells and springs in the Balmorhea-Toyahvale area. A base map was constructed using GIS technology to show the orientation of springs and water wells in the region. Previous reports of hydrology and geology studies were reviewed (see list of references). Field staff visited 35 water wells, obtaining 27 depth to water measurements, and measured the flow in three prominent springs. Water levels were mapped to determine ground-water flow direction. Records of historical precipitation, spring flow, ground-water levels, and ground-water pumpage were compiled from various government agencies. Water-quality analyses from the various springs were evaluated to compare their sources of origin.

SPRINGS

In order to discern the reason for flow changes in the spring system, it is important to understand the hydrogeologic conditions under which the springs operate. Spring water originates as rainfall that percolates downward from the surface and enters the aquifer system. Underlying the gravel covered valley from Balmorhea westward to the foothills of the Davis and Apache mountains, lies a complex network of faulted formations through which groundwater traverses before it issues from the springs. Although the ground-water system throughout the valley is probably somewhat interconnected, previous studies suggest that there are separate originating sources from which the springs flow. Chemical analysis of the water from each spring helps to identify the host rock formation through which the spring water has traversed.

Phantom Lake Spring issues from a crevice in Lower Cretaceous limestone, while Giffin and San Solomon rise through gravel beds in the valley floor. All three springs are artesian in nature and are probably supplied from a large underground reservoir in the form of an extensive interconnected system of northwest-southeast oriented solution channels in the Cretaceous limestone formation. The solution channels probably extend downward into the underlying Permian formation. These Permian rock units, which are part of the Capitan Reef Limestone, are exposed at the surface in the Apache Mountains to the west.

Saragosa Springs and East and West Sandia Springs have their source in the shallow water-table aquifer that occurs in the gravel beds that cover the Toyah Creek valley. Water entering the shallow gravel aquifer originates as local rainfall, seepage from the canal system and irrigated fields, and runoff from the Davis Mountains.

Water chemistry from all of the springs shows a sodium-chloride-sulfate dominance and a similar constituent ratio pattern (figure 2) which suggests that the base flow source is a result of the mixing of waters from the Lower Cretaceous and underlying Permian (Capitan) age formations. Saragosa and East and West Sandia springs have the same constituent ratio pattern but a higher total-dissolved solids content, which indicates that dissolved constituents in the shallow gravel aquifer are concentrated as a result of evaporation. Water chemistry analyses and flow measurements from springs following significant rainfall events demonstrate that there is an immediate recharge effect; flow rates increase, water often becomes turbid, and chemical quality freshens as shown in figure 2.

The following table shows data collected by the TWDB on August 21, 1997 from Phantom Lake, Giffin, and San Solomon springs:

Spring	Flow ft°/sec	Specific Conductance µmhos/cm	Temperature °C
Phantom Lake	1.2	3490	26.4
Giffin	3.8	3330	26.6
San Solomon	31.3	3240	25.4

A comparison of USGS historical flow measurements from these three springs is illustrated in figure 3. Measurements from Phantom Lake and Giffin springs are shown from December 1989, while San Solomon Springs measurements date back only to October 1993. These measurements suggest that there have been no major recharge events to the springs since 1992.

PRECIPITATION

Historical precipitation data, obtained from the National Climatic Data Center, is shown in figure 4. The data suggests a very slight average annual increase during the past 70 year period, however, it also shows a significant below-average trend since 1992.

PUMPAGE

Although the Toyah Creek valley relies heavily on spring flow, ground water is pumped for municipal, domestic, livestock, and to an undetermined extent for irrigation use. Of particular interest is the potential for ground-water pumpage to cause a decrease in spring flow. The City of Balmorhea and Madera Valley WSC are the two primary ground-water producers in the valley (figure 6). In 1996, Balmorhea pumped approximately 198 acre-feet from one well in the Huelster well field in Jeff Davis County, while Madera Valley pumped 76 acre-feet from one well in the Huelster well field and 186 acre-feet from two wells in the McIntire well field in Reeves County. Because of the 1996 state-wide drought, pumpage by both entities that year more than doubled from previous years. Pumpage from the three wells in Jeff Davis County has resulted in a relatively local cone of depression (figure 7). Measurements from a well located near the Huelster well field show a water-level decline of approximately 10 feet over the past 20 years (figure 5). However, the affected area does not appear to be influencing the flow from the near-by Phantom Lake Spring. A cone of depression is not obvious in the area of the Reeves County wells.

GROUND-WATER LEVELS

Hydrological studies conducted by University of Texas students reveal that water levels in wells completed in the shallow alluvial aquifer have declined since 1990 (O'Neill and others, 1995). Because Saragosa and East and West Sandia springs are gravity fed from the shallow aquifer, the lowering of the water table during this period has resulted in diminished, or the cessation of, flow from the springs. The lowering of the water table is primarily the result of below average rainfall in the valley which is the principal source of recharge to the shallow aquifer.

Water-level elevations from the 27 wells measured during the study were contoured (figure 7) to determine the direction of ground-water flow. Flow direction is indicated from southwest to northeast (figure 8), generally following the slope of the land surface. Assuming this flow direction, pumpage from the Huelster well field does not directly intercept ground water destined for Phantom Lake Spring and only indirectly for Giffin and San Solomon springs.

CONCLUSIONS

The following conclusions are based on the preceding evaluation of data and interpretation of spring and ground-water flow systems in the Toyah Creek valley.

Phantom Lake, Giffin, and San Solomon springs are fed from cavernous reservoirs developed in underlying Cretaceous and Permian limestone formations, while Saragosa and East and West Sandia springs are gravity fed from the shallow gravel aquifer.

Rainfall in the local area, which is the source of recharge to the ground-water systems that feed the springs, has been significantly below average since 1992.

The water table in the shallow aquifer that feeds Saragosa and East and West Sandia springs has declined in direct relationship with the diminished rainfall.

Although ground-water pumpage by the City of Balmorhea and the Madera Valley WSC increased during 1996 as a result of drought conditions, there is no indication that the pumpage has directly affected flow from the springs.

Therefore, recent declines in spring flow are more likely to be the result of diminished recharge due to the extended dry period rather than from ground-water pumpage. Although this cursory study does not identify ground-water pumpage as directly affecting spring flow, it is important to recognize that the improper placement of new wells could definitely have a detrimental affect on the springs. It is strongly recommended that the drilling of additional high capacity wells be preceded by an expert hydrogeologic evaluation.

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Couch, H.E., 1978, Study of the lower Cretaceous and associated aquifers in the Balmorhea District of Trans-Pecos, Texas: TWDB unpublished report, 167p.

Harden, R.W., 1972, Groundwater conditions in the vicinity of Phantom Lake, Giffin, and San Solomon Springs, Reeves and Jeff Davis Counties, Texas: Report to the Texas Water Rights Commission on behalf of Reeves County Water Improvement District #1.

La Fave, J.I., and Sharp, J.M. Jr., 1978, Origins of ground water discharging at the springs of Balmorhea: West Texas Geological Society Bulletin, v. 26, p. 5-14.

O'Neill, M., and others, 1995, Hydrologic investigation in the Toyah Basin near Balmorhea, Texas: University of Texas at Austin unpublished student paper.

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Figure 1
LOCATION OF STUDY AREA

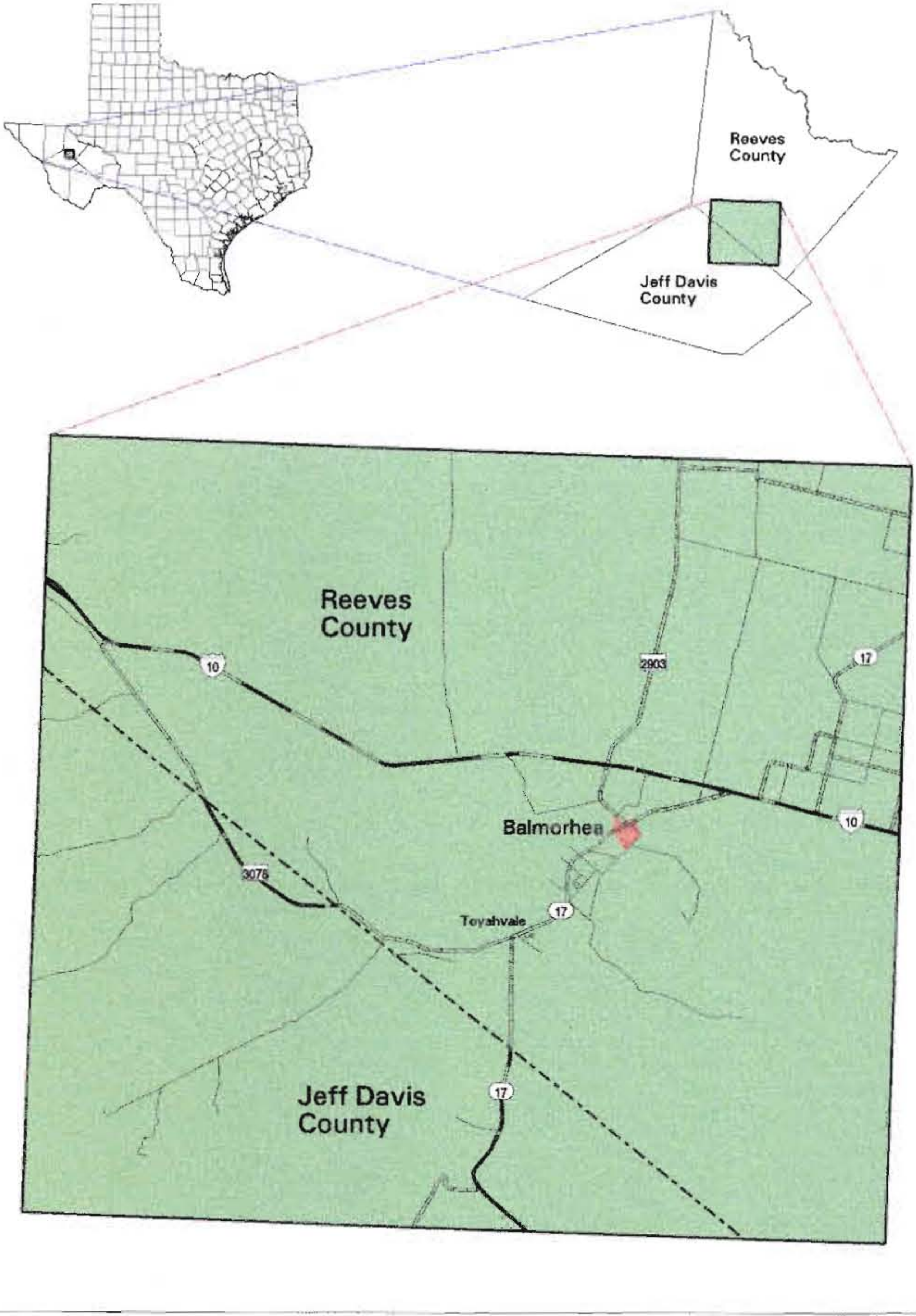

Illustration by Mark E. Hayes

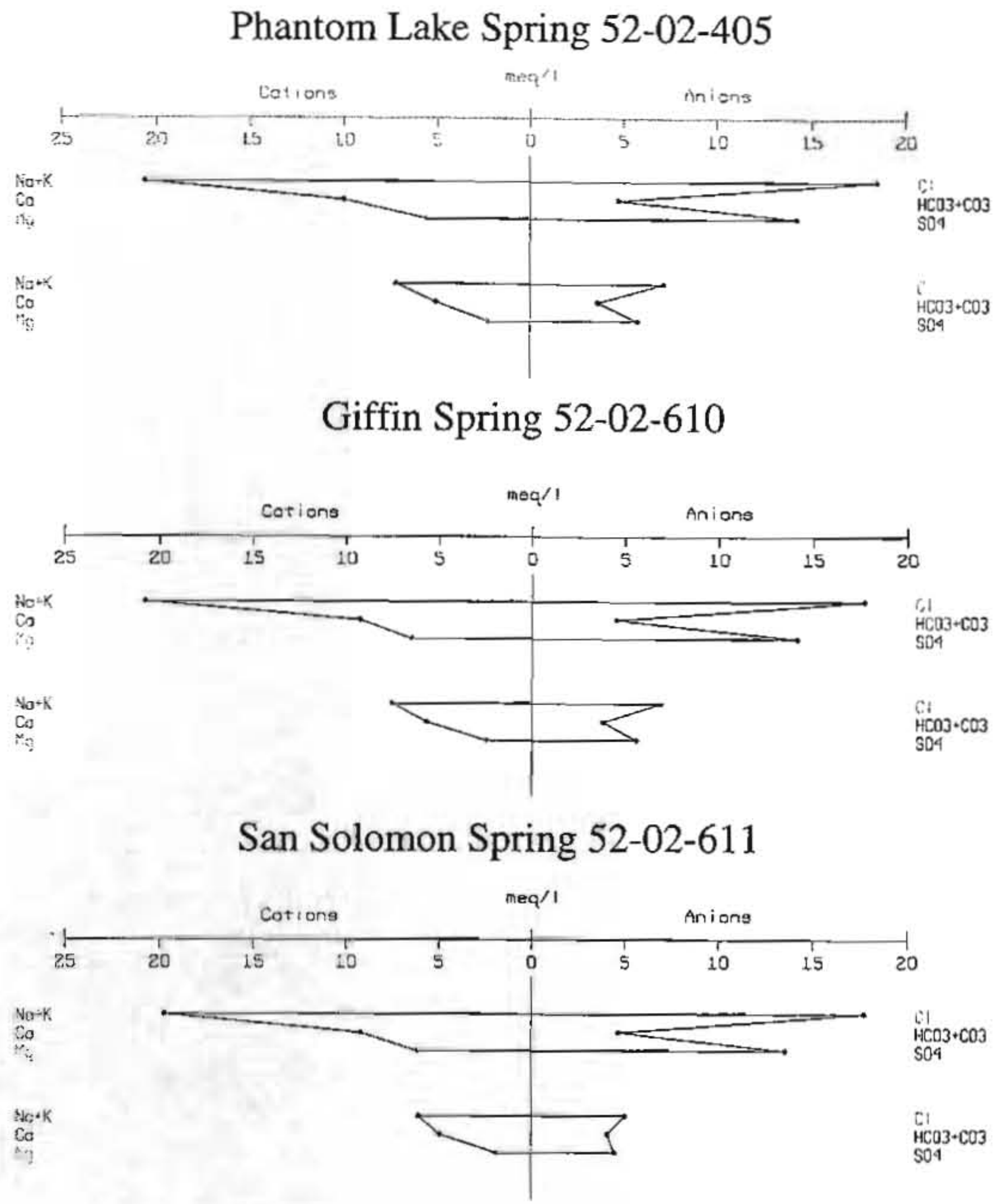

Figure 2: Stiff diagrams showing constituent concentrations of spring waters. Upper diagram shows quality during average conditions. Lower diagram shows dilution with fresher water following rainfall recharge events.

Figure 3: Springflow Measurements of Springs near Balmorhea, Texas (1990-1997)

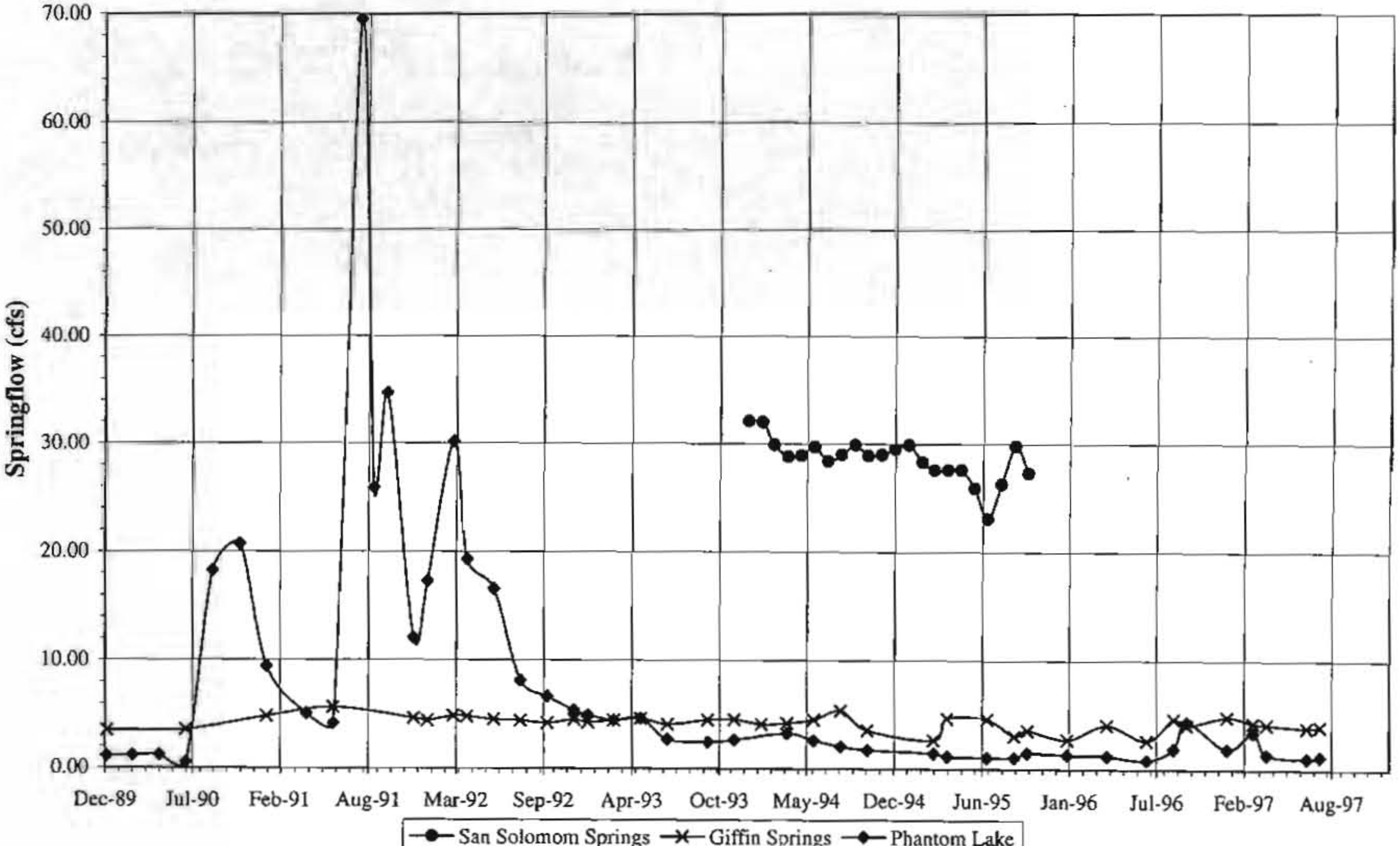

Figure 4: Annual Precipitation Totals for Balmorhea, Texas (1923-1996)

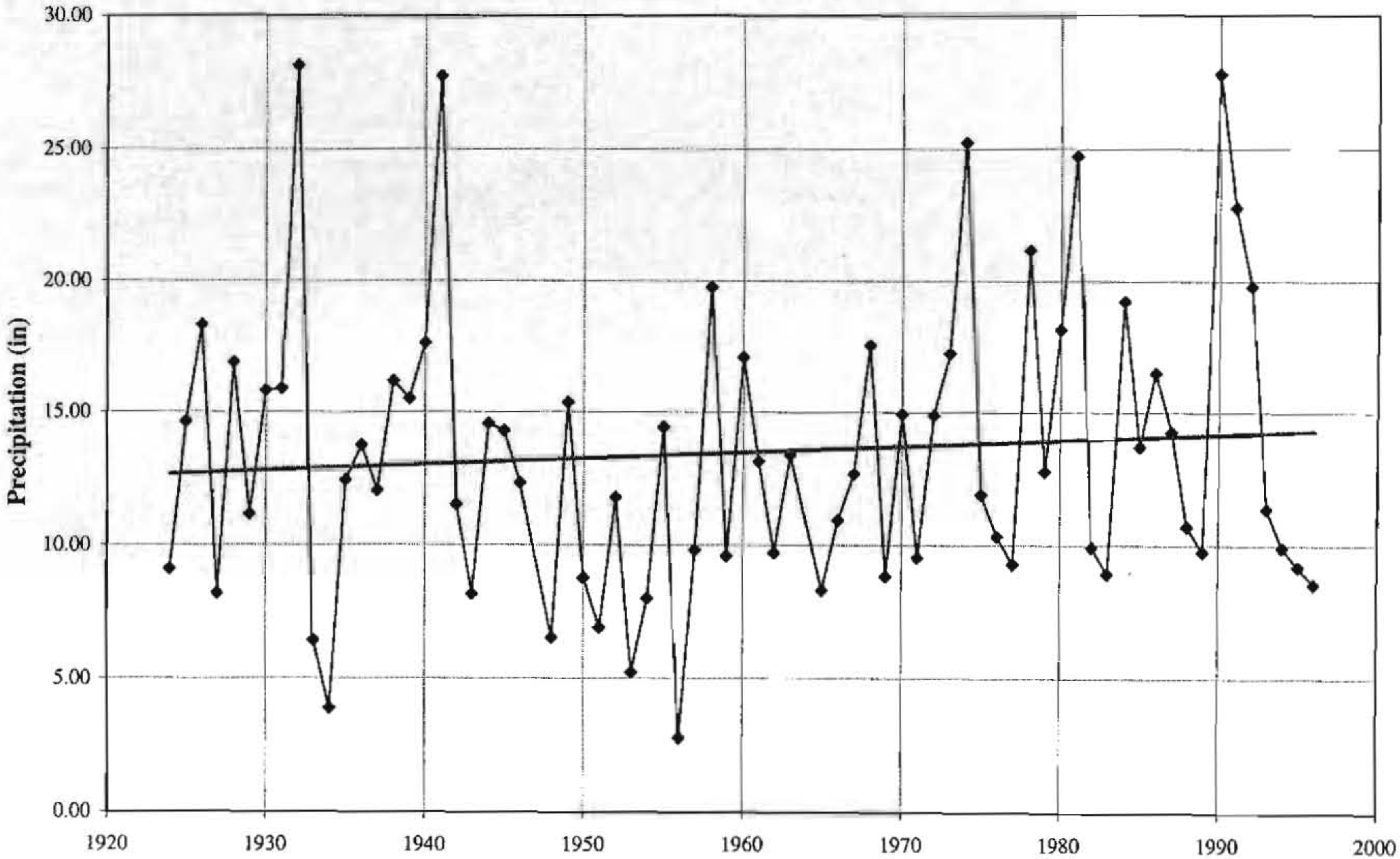

Figure 5: Depth to Water in Well 52-02-403

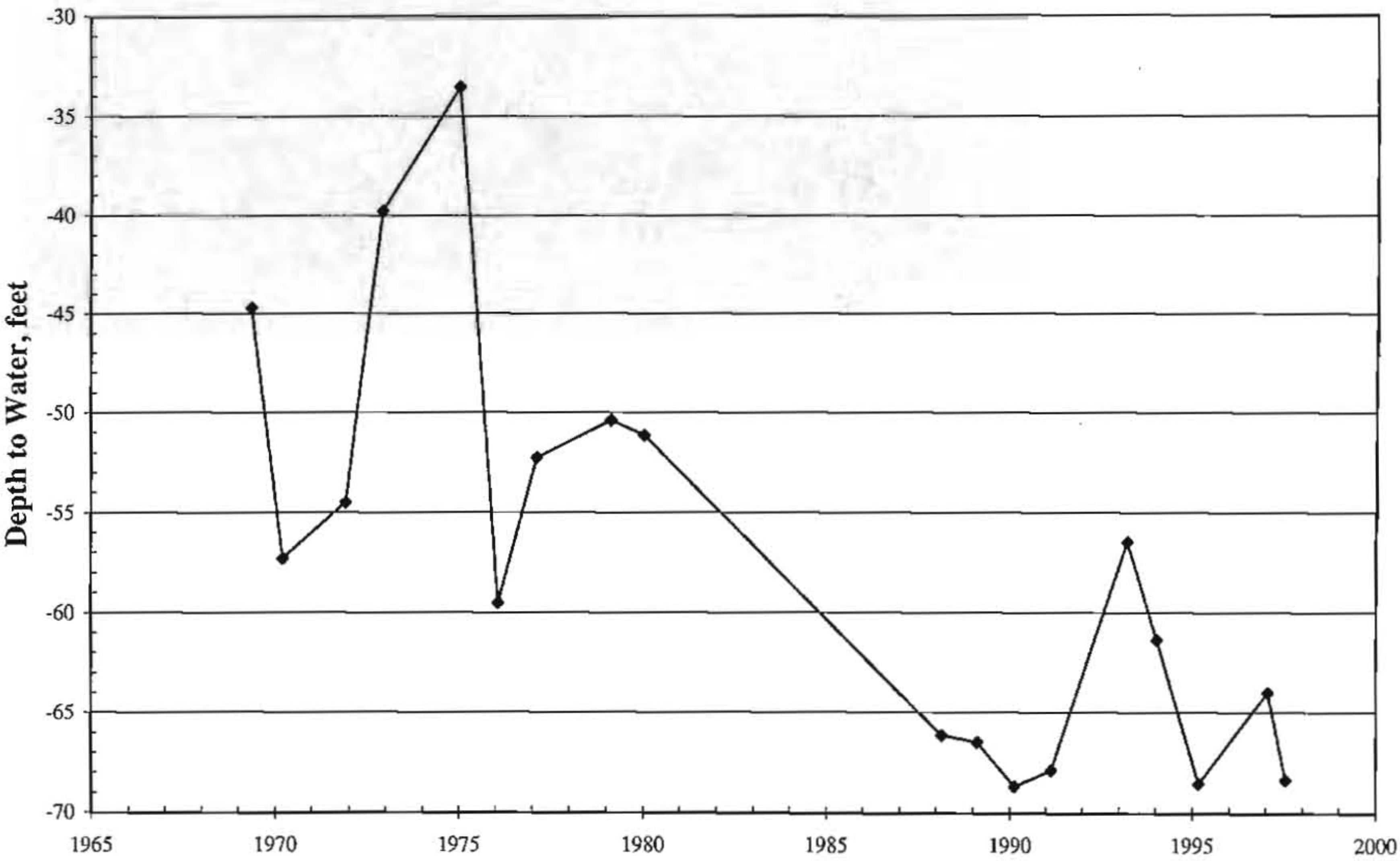

Figure 6

LOCATION OF WELLS AND SPRINGS

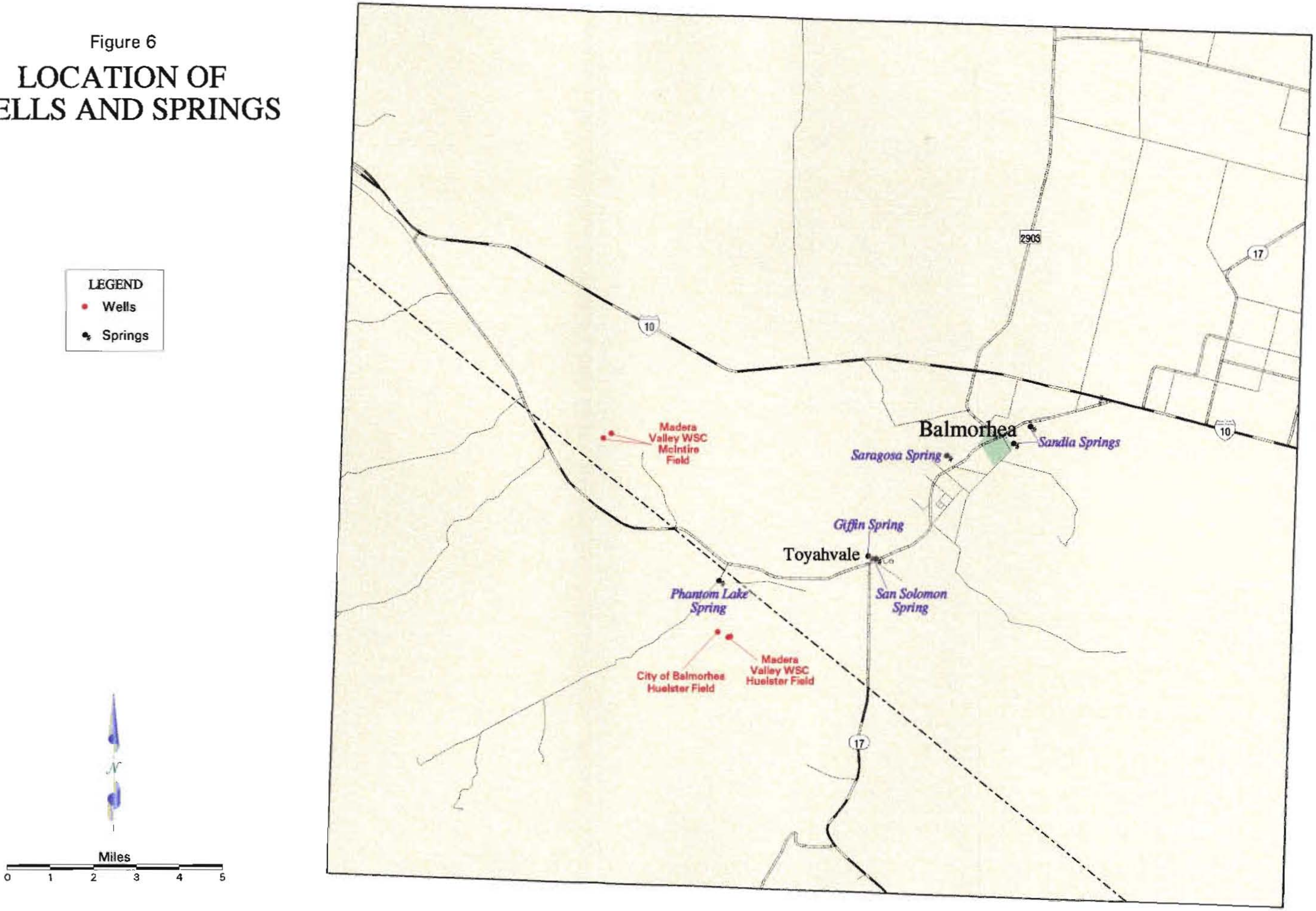

Illustration by Mark E. Hayes

Figure 7

ELEVATION OF 1997 WATER LEVELS

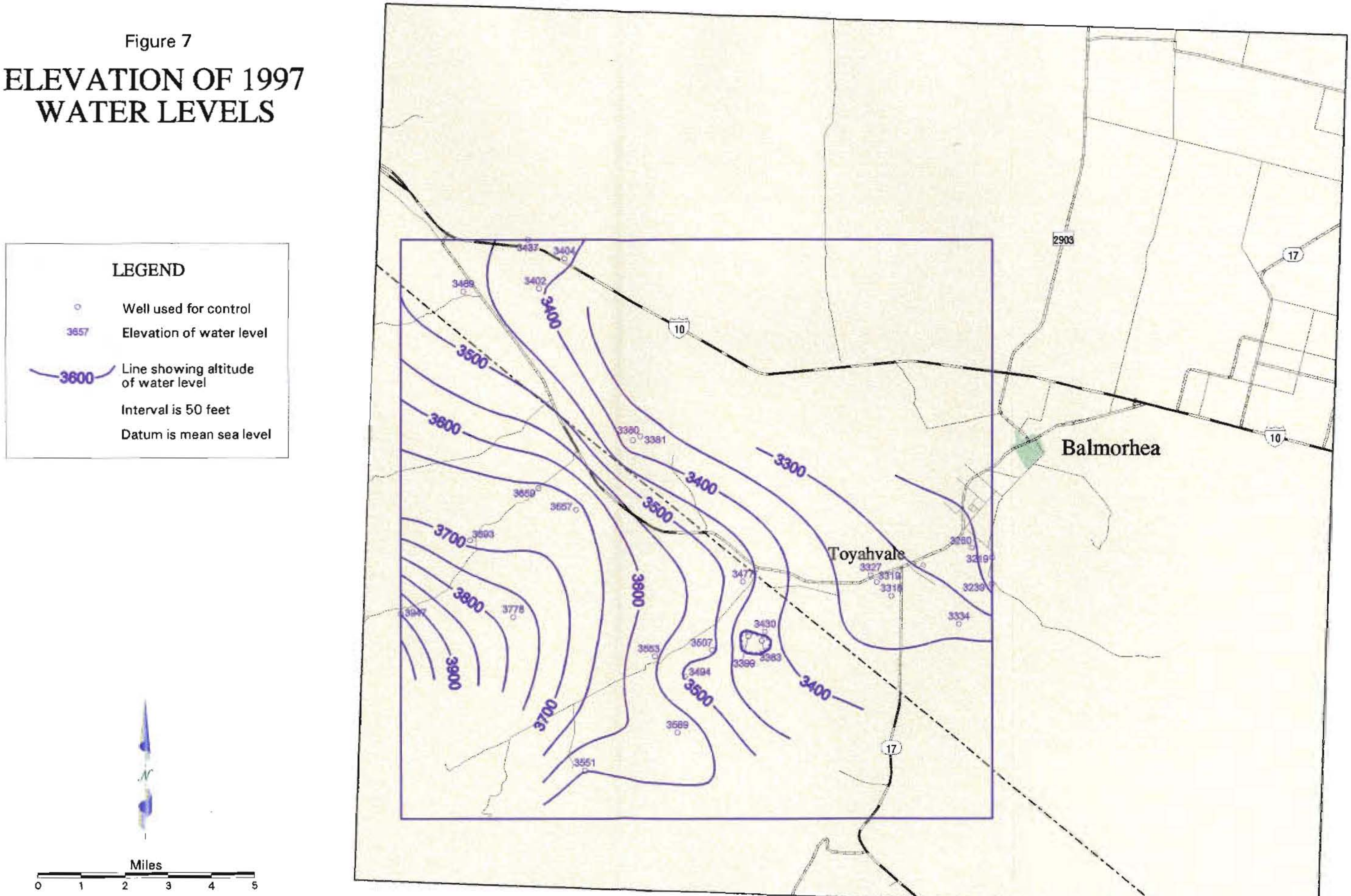

Illustration by Mark E. Hayes

Figure 8

DIRECTION OF GROUND-WATER MOVEMENT

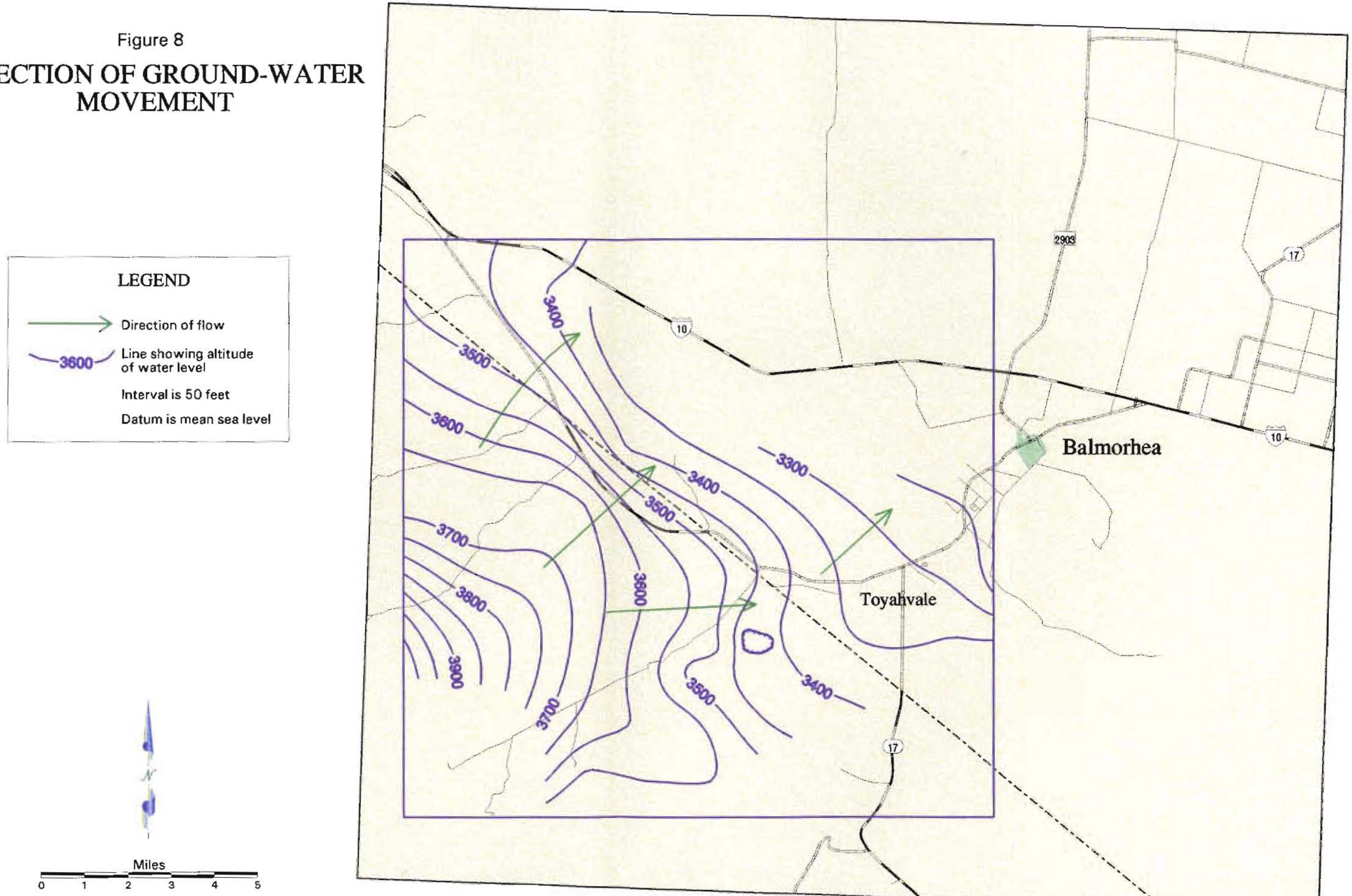

Illustration by Mark E. Hayes