

# Water-Level Changes in the High Plains Aquifer, 1980 to 1994



U.S. Department of the Interior—U.S. Geological Survey

The High Plains aquifer underlies one of the major agricultural areas in the world in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. Nearly 30 percent of the ground water used for irrigation in the United States is pumped from the High Plains aquifer (Weeks and others, 1988). In 1990, 15.6 million acre-feet of water was withdrawn from the aquifer to irrigate approximately 14 million acres (Carr and others, 1990).

Water-level declines appeared in the High Plains aquifer soon after extensive ground-water irrigation development first began in about 1940. By 1980, water levels in parts of the Texas High Plains, Oklahoma Panhandle, and southwestern Kansas declined more than 100 feet. In response to these declines, the U.S. Geological Survey (USGS) began an ongoing ground-water monitoring program in 1988 to annually assess water-level change in the aquifer. Numerous Federal, State, and local water-resource agencies, in cooperation with the USGS, currently measure water levels in more than 8,000 wells annually in the High Plains.

## WATER-LEVEL CHANGE, 1980 TO 1994

The geographic patterns of water-level change in the High Plains from 1980 to 1994 largely replicate the patterns of change from predevelopment to 1980. Large water-level declines have continued in parts of the Texas High Plains, Oklahoma Panhandle, and southwestern Kansas (fig. 1). Some areas of substantial decline prior to 1980 in the

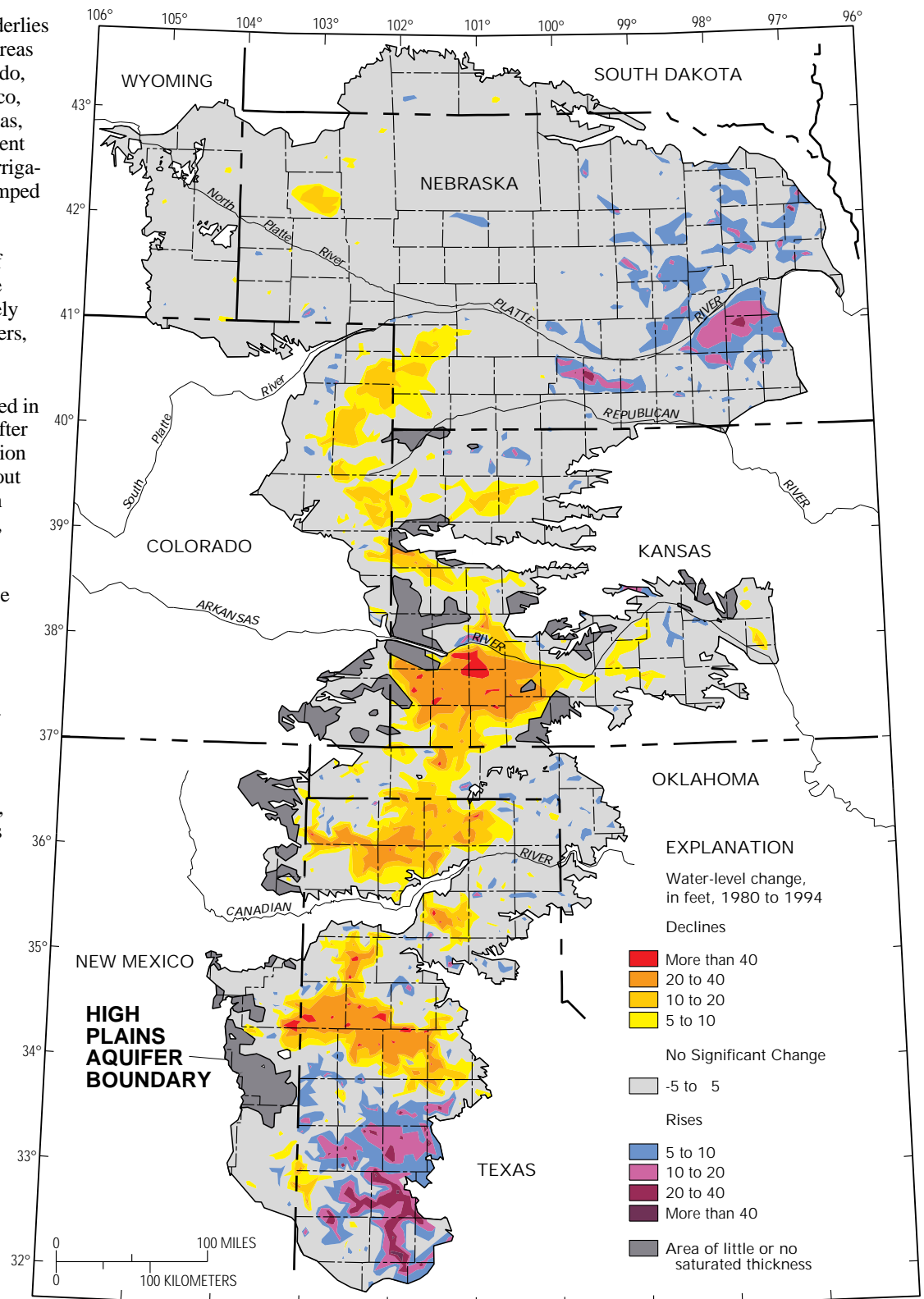


Figure 1. Water-level change in the High Plains aquifer, 1980 to 1994.

Northern High Plains, however, have generally had either water-level rises or considerably slower rates of decline since 1980. The water-level rises in parts of the eastern High Plains of Nebraska and the extreme southern High Plains of Texas are closely associated with well above normal precipitation in these areas since 1980.

The area-weighted average water level in the High Plains (table 1) declined 1.54 feet from 1980 to 1994—about 0.11 foot annually. This compares to 9.90 feet from predevelopment (1940) to 1980—about 0.25 foot annually. The slower rate of decline since 1980 can be largely attributed to the average water-level rise of 1.88 feet (0.13 foot annually) in Nebraska. The average annual rate of decline in Texas decreased from 0.84 foot, from predevelopment to 1980, to 0.22 foot, from 1980 to 1994. Only in Kansas has the average annual rate of decline been more rapid since 1980—0.33 foot prior to 1980 and 0.44 foot since 1980. The slower rate of decline after 1980 occurred even though the 1980-to-1994 average annual irrigated acreage was more than double (14 million acres) the predevelopment-to-1980 average annual irrigated acreage (6 million acres). The following factors appear to have contributed to the much slower rate of water-level decline in the High Plains after 1980:

- Precipitation from 1980 to 1994 was generally well above normal throughout the High Plains. Average annual precipitation during 1981–93 was 21.18 inches or 1.40 inches above normal.
- Later phases of irrigation development in the High Plains shifted geographically from areas of more rapid potential rates of aquifer depletion (Central and Southern High Plains) to areas of slower potential rates of depletion (Northern High Plains).
- Significant advances in irrigation technology, such as center-pivot irrigation and gated pipe, have substantially reduced the ground-water pumpage needed to meet consumptive irrigation requirements.
- Irrigation management practices, including irrigation scheduling and the conversion to crops or varieties with smaller consumptive irrigation requirements, have further reduced ground-water pumpage.
- Water-level declines in some areas prior to 1980 prompted local regulation of

ground-water withdrawals for irrigation and development of irrigated land.

- Economic considerations, including lower crop prices and higher production costs (such as rising energy prices), have forced marginal land out of irrigated production.

**Table 1.** Average area-weighted water-level change in the High Plains aquifer, 1980 to 1994

State	Area-weighted water-level change (feet)	
	Predevelopment to 1980	1980 to 1994
Colorado	-4.20	-3.39
Kansas	-9.90	-6.12
Nebraska	0	+1.88
New Mexico	-9.80	-2.31
Oklahoma	-11.30	-1.81
South Dakota	0	+1.47
Texas	-33.7	-3.02
Wyoming	0	-2.52
<b>High Plains</b>	<b>-9.90</b>	<b>-1.54</b>

## WATER-LEVEL CHANGE, 1993 TO 1994

The area-weighted average water level from 1993 to 1994 rose in the High Plains for a second consecutive year. The 0.56-foot rise from 1993 to 1994 (table 2) was considerably larger than the average rise of 0.21 foot from 1992 to 1993 (Dugan and Cox, 1994). The larger rise may be attributed to precipitation in the High Plains that averaged 4.24 inches above normal in 1993, as compared to 2.03 inches above normal in 1992. The larger rise from 1993 to 1994 also may be associated with the accumulative effect of 3 consecutive years of above-normal precipitation in the High Plains. The area-weighted average precipitation in the High Plains during 1990–93 was 2.49 inches above normal.

Although the area-weighted average water level rose in the High Plains from 1993 to 1994 and the area-weighted average precipitation was well above normal in 1993, these conditions were not uniform across the High Plains (tables 2 and 3). Both water-level change and precipitation presented strongly contrasting regional patterns within

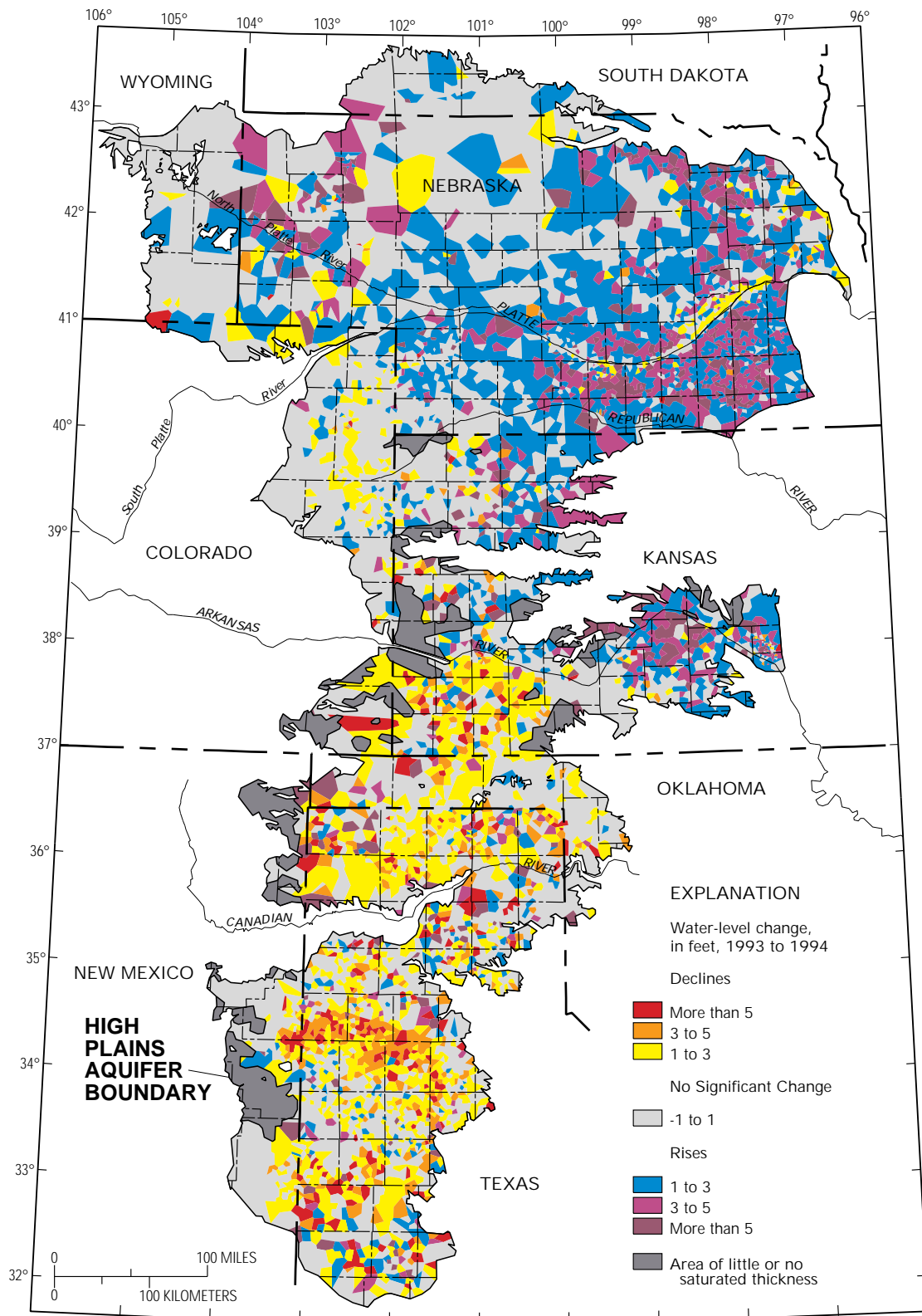
**Table 2.** Average area-weighted water-level change from 1993 to 1994

State	Area-weighted water-level change (feet)
Colorado	-0.13
Kansas	+0.55
Nebraska	+1.81
New Mexico	-0.27
Oklahoma	+0.10
South Dakota	+0.38
Texas	-0.99
Wyoming	+0.13
<b>High Plains</b>	<b>+0.56</b>

the High Plains (fig. 2). Declines exceeding 3 feet extended in a nearly continuous 100-mile arc from eastern New Mexico across the northern part of the Southern High Plains of Texas. The area-weighted average water-level decline was nearly 1 foot in the High Plains of Texas and 0.27 foot in New Mexico (table 2). Precipitation was generally below normal in 1993 in those parts of the Southern and Central High Plains with widespread water-level declines from 1993 to 1994 (table 3).

**Table 3.** Average area-weighted precipitation in the High Plains in 1993, departure from 30-year normal (1961–90), and percentage of normal

State	Average area-weighted precipitation (inches)	Average area-weighted departure from 30-year normal (inches)	Percentage of normal
Colorado	17.42	+1.14	107
Kansas	28.75	+7.26	134
Nebraska	29.38	+7.87	137
New Mexico	15.10	-1.28	92
Oklahoma	19.44	-0.25	99
South Dakota	25.69	+6.98	137
Texas	17.56	-1.37	93
Wyoming	18.01	+3.67	126
<b>High Plains</b>	<b>24.02</b>	<b>+4.24</b>	<b>121</b>



**Figure 2.** Water-level change in the High Plains aquifer, 1993 to 1994.

In contrast, water-level rises of at least 1 to 3 feet were widespread throughout much of the Northern High Plains and northeastern half of the Central High Plains from 1993 to

1994. The average area-weighted water level rose 1.81 feet in the Nebraska High Plains and 0.55 foot in the Kansas High Plains (table 2). The widespread water-level rises

throughout the Northern High Plains and parts of the Central High Plains from 1993 to 1994 were associated with one of the wettest years on record in those areas. The area-

weighted average precipitation in the High Plains of Kansas, Nebraska, and South Dakota was about 7 inches or more above normal in 1993 (table 3). Normal precipitation was exceeded by 10 inches or more over large parts of eastern and south-central Nebraska where water-level rises exceeding 5 feet were widespread.

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