WATER RIGHTS AND WATER USE DATA HELP SET REGULATORY PRIORITIES IN A DEPLETING AQUIFER IN KANSAS

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ABSTRACT

The High Plains aquifer provides the sole source of water supply for most of the western third of Kansas (figure 1). This unconfined or water table aquifer includes the Ogallala formation and hydraulically connected alluvial deposits. Regional withdrawals from this aquifer exceed recharge substantially in many areas. Water level declines have decreased the saturated thickness so that well capacities are limiting in many areas. Reporting annual water use is a statutory requirement in Kansas for all beneficial uses except domestic use. Additional data available as a condition of appropriated and vested water rights are: location of diversion, place of use, maximum annual quantity, maximum rate of diversion, and type of use. More than 95% of the water use is for irrigation and the arid climate results in very small amounts of precipitation. Comparisons of the reported water used, maximum authorized quantity, consumptive use of crops, and aquifer recharge provide basic information useful in setting regulatory priorities that will protect the public interest in addressing depletion of the water supply in this area.

STATE WATER PLANNING AND MANAGEMENT

Kansas Water Office

State agencies share in the responsibility for water management and planning in Kansas. The Kansas Water Office (KWO) is the state agency that provides the water planning functions for the state of Kansas through the development and updating of the State Water

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Plan. The Kansas Water Authority is a part of the Kansas Water Office whose 13 voting members represent the various water interests in the state that advises the Governor, legislature and the Kansas Water Office on water policy issues. In addition to the members of the water authority there are 10 non voting members that represent agencies or organizations within the state that administer some aspect of water resources or other interests that rely on water resources. The Kansas Water Authority also has a basin advisory committee of local citizens for each of the 12 major river basins within the state that advises the Kansas Water Authority and the Kansas Water Office on local interests and priorities within each river basin.

The Kansas Water Office has established objectives through the year 2010 that were developed through public forums and the Kansas Water Authority. These objectives include the evaluation of the condition of the water resources of the state and to establish a plan that decreases the water level decline rates in the Ogallala formation in western Kansas.

Division of Water Resources

The Division of Water Resources (DWR), Kansas Department of Agriculture, under the direction of the Chief Engineer appropriates water according to the prior appropriation doctrine and has the authority to regulate water use to protect water supplies in Kansas. The water appropriation program within the Division of Water Resources includes a water rights section in the state office that processes new applications for permits to use water, approves changes to permits to use water, and prepares certificates for water rights that are issued by the Chief Engineer. Kansas water law requires a permit for all beneficial use except domestic use. Water rights in Kansas have terms, conditions and limitations that include a file number, priority date, location of the diversion works, annual rate, annual quantity, a place of use, and a specific type of use. There are four field offices (fig. 1) in the state that assist the public with the water appropriation process. Each field office is managed by a water commissioner who is responsible for public

assistance with the water appropriation process and has been delegated by the Chief Engineer with the authority to administer water rights according to priority in times of water shortage. Each permit to use water for beneficial use requires the user to report water use to the Division of Water Resources each year. Water use data is processed within the water rights section in the state office.

Groundwater Management Districts

There are five Groundwater Management Districts (GMD) located in the western and south central parts of Kansas (fig. 1) where ground water is the primary source of water supply. Groundwater management districts have a director and a staff that provides executive support to a board of directors elected by residents that own water rights within the district. The electorate in these districts is dominated by irrigation interests as most of the water rights are for irrigation. Membership on the board is based on a geographic distribution and by a member representing pubic water suppliers and in some districts the public at large or other specific water interests may be represented on the board. Groundwater management districts have the authority to levy a tax assessment on irrigated land and on water used. They establish water management policies and have specific delegated regulatory authority through the Chief Engineer to protect water supplies. Each groundwater management district develops a management plan and establishes regulations. The management plan must be reviewed by the Chief Engineer to ensure the plan does not conflict with state water management policies. Regulations must be reviewed and adopted by the Chief Engineer to ensure they are compatible with those of the state.

WATER USE REPORTING PROCESS

Water use report forms are sent to all of the approximately 31,000 water right holders in Kansas each January and are filled out by the water right holder and submitted to the Division of Water Resources by March 1 each year. The reports provide the annual quantity of water used, and in the case of irrigation,

the amount of land irrigated, type of crops, the number of acres, and the type of irrigation system used. Municipalities (public water supply) report monthly quantities of raw water diverted from all points of diversion, water purchased, water sold, and water delivered to users. Fines are imposed by the Division of Water Resources for late reports which has resulted in more than a 90% response rate. Flow meters are required for all municipalities and for irrigation by the groundwater management districts or the Division of Water Resources in many parts of the state. A pumping rate and the hours the diversion works have operated for the year are used to compute water use in those areas where meters are not required.

Technical assistance and quality-control follow up increase the reliability and accuracy of the water use data. The primary responsibility for quality control of the data falls with the Division of Water Resources. However, the Kansas Water Office and the groundwater management districts assist the Division in these follow up activities. Follow up activities often require telephone calls, letters or a meeting with water users to clarify some aspects of their water use report. Division of Water Resources may use regulatory means if necessary to ensure accurate reports are filed. Water use data is entered into the water rights information system at the Division of Water Resources. Data in the water rights information system is protected by controlled access but is available to anyone upon request. The water use data set is provided each year to the Kansas Water Office and the groundwater management districts to use in their planning efforts and technical assistance programs. Water use data is analyzed by the Kansas Water Office to determine typical water use amounts and to identify water users with unusual or unreasonable water use that may be targeted for possible technical assistance.

OVERVIEW OF GROUNDWATER DECLINES IN THE HIGH PLAINS AQUIFER

Water development in the Ogallala formation and hydraulically connected alluvium that make up the High Plains aquifer in western Kansas has caused declines in

water levels that exceed 100 feet since development started in the 1950s (fig. 2). Saturated thickness is less than 100 feet in much of the High Plains aquifer and exceeds 300 feet in many areas of southwestern Kansas (fig. 3).

WATER USE AND WATER RIGHT INFORMATION FOR WESTERN KANSAS GROUNDWATER MANAGEMENT DISTRICT NO. 1

Western Kansas Groundwater Management District No. 1, lies within the High Plains Aquifer, and has experienced water table declines that averaged about 35, feet ranging from less than 25 feet in some areas to more than 50 feet in most areas (fig. 4). Declines of 2 feet or less has occurred over most of Western Kansas GMD No. 1 during the 1998 irrigation season, however a decline of 4 to 6 feet has occurred in a few areas of the District during that time (fig. 5). The saturated thickness prior to development in Groundwater Management District No. 1 were between 50 and 100 feet except in southern Wallace county and central Scott County where saturated thickness exceeded 250 feet. The saturated thickness is now less than 200 feet in much of southern Wallace county and central Scott county and between 25 and 50 feet in most other areas (fig. 6). Saturated thicknesses between 25 and 50 feet are at the threshold for well yields sufficient for traditional irrigation practices and public water supplies. Continued water level declines will result in further expansion of the areas of marginal supply for irrigation and public water supply. There are wide areas that now have saturated thickness of less than 25 feet. It is anticipated that water supplies will become very limited if withdrawals continue at or near current rates.

General Depletion Rates

Groundwater supplies are being depleted as a result of long-term withdrawals that exceed recharge. The total amount of water in storage that is available for use by

normal pumping methods is between about 6 and 8 million acre feet. Annual recharge rates indicate annual recharge to be 70,000 acre feet or less. During the 6-year period 1990-1995 reported annual water use ranged from 198,000 acre feet in 1993 to 389,100 acre feet in 1990 for an average of 292,800 acre feet. Assuming a sustained average withdrawal rate equal to that reported and an annual recharge rate of 70,000 acre feet the supply would be exhausted in 25 to 35 years. It is not likely that the withdrawals would continue at rates of the recent past but it is also possible that recharge rates may be less than the estimated 70,000 acre feet. However, the thickness of the aquifer and the withdrawal rates are not equally spaced throughout the area. Water supplies in some areas would be gone in much less than 25 years.

Climatic conditions during the period of most reliable water use data collection

Water use for irrigation is assumed to vary with the climatic conditions during the irrigation season. Soil moisture and precipitation during the growing season could affect the number of applications of irrigation water and the amount of municipal use. Water use information collected by the Division of Water Resources and maintained in the current data base began in 1988. However the reliability of the data was greatly improved after 1992 because of increased quality control on reporting and increased metering requirements. A comparison of the seasonal precipitation data for the years 1989 through 1997 was used to determine the year or years that would represent a typical climatic conditions and a typical water use year, a wetter than normal year and a drier than normal year. Data in table 1 shows 1993 was the year exceeding normal by the largest amount in Western Kansas Groundwater Management District No. 1 but this was not the case for most of western Kansas. However, 1996 exceeded the normal precipitation by the largest amount in most of western Kansas so was selected as representing a wet year. There were no representative dry years in the period 1989 to 1997. The 1994 year was selected as a typical year as it was the most representative of normal precipitation for the years after 1992 .

Table 1

Comparison of average annual and seasonal precipitation with normal precipitation by year in Western Kansas Groundwater Management District No. 1

Year	Annual Precipitation Average	Normal	Pct.Diff.	Seasonal Precipitation Average	Normal	Pct.Diff.
1989	19.46	19.19	1.4	18.5	16.88	9.6
1990	20.85	19.19	8.7	16.82	16.88	-0.4
1991	19.93	19.19	3.9	16.84	16.88	-0.2
1992	23.1	19.19	20.4	18.12	16.88	7.3
1993	27.57	19.19	43.7	21.67	16.88	28.4
1994	19.37	19.19	0.9	16.06	16.88	-4.9
1995	20.09	19.19	4.7	19.19	16.88	13.7
1996	23.98	19.19	25	22.43	16.88	32.9
1997	23.81	19.19	24.1	20.67	16.88	22.5

1/ Average values from four long-term precipitation stations within Western Kansas Groundwater Management District No. 1
2/ Seasonal precipitation is for March - October.

Annual evapotranspiration for corn is estimated to be 28-30 inches in 1994

Annual evapotranspiration for corn is estimated to be 24-25 inches in 1996

Crop moisture demands represented by computed evapotranspiration of corn for climatic conditions during 1994 and 1996 are 28-30 inches and 24-25 inches respectively according to Kansas State University Extension Service information. The range in values is due to the different short season and long season varieties grown in the area. Comparing the seasonal precipitation with the computed evaoptransiration of corn shows that in the typical year 1994 that overall precipitation was within 9-14 inches of meeting crop demands, not considering the timing of needed moisture during the season. In a wet year represented by 1996, the precipitation was within 3-8 inches of meeting crop demands, not considering the timing of needed moisture during the season.

Decreasing pumping rates

Declining water tables and the accompanying decrease in saturated thickness have limited the pumping capacity of many wells. Pumping rates have decreased to the point that irrigation water use originally intended to sustain crops for optimum yields on original acreages are now controlled by pumping capacity of the wells in some areas. Pumping capacity tests, recorded in the Division of Water Resources data base, were conducted near the beginning of pumping when the water rights were developed, additional pump capacity tests have been conducted between 1990 and 1996 at many of these wells where meters were not required as part of a program to improve the accuracy of the water use reports. There were 320 wells that had pump capacity tests in the 1990's that also had a pump capacity test more than 10 years in the past. Most of the wells had tests between 10 and 20 years apart with some as long as 30 years. The pump capacity tests averaged 46% less over the 10-30 years ranging from 0 % to 94% less. It is apparent from a comparison of these pump capacity tests conducted more than a decade after the first test that well capacity is limiting water use. It is not known from this brief analysis how much of the decrease is attributed to well and pump deterioration and how much is attributed to decrease in aquifer yield or increased water use efficiency. However, it is reasonable to assume many owners would have repaired wells that had significant decreased pumping capacity if the aquifer was producing.

Water use characteristics

Compilations from the Division of Water Resources' water rights information system provides opportunities for comparisons that assist in water regulatory and water management decisions. Water appropriations processes are underway each day so the information in the water rights information system is continually changing. Therefore care must be taken in comparing compilations made at different times.

Selected information was compiled for Western Kansas Groundwater Management District No. 1 as shown in table 2. Water used for irrigation and some municipal purposes may vary from year to year with variations in climatic conditions. Therefore water appropriations provide a maximum authorized annual quantity on the water right that is considered reasonable to cover a dry year. It is assumed that reported water use will be less than this quantity most years. In an extremely dry year or a series of dry years during a drought, water use may approach the maximum amount authorized. Water use must remain equal to or less than the maximum quantity authorized to remain in compliance with the Kansas water appropriations act and not be subject to enforcement action by the Division of Water Resources. The maximum authorized quantity increased about 260 acre feet between 1994 and 1996 (from 753,730 acre feet to 753,988 acre feet) due to changes in water rights during this 2 year period.

More than 95% of the reported water use for both 1994 and 1996 was for irrigation. Reported water use varies from year to year in response to climatic and crop producer's management decisions. Reported water use for 1996, that represents a wet year, was less than 1994, even though the reported acreage was more. The irrigation water used per acre as reported in 1994 and 1996 was 1.2 and 1.0 acre-ft/acre respectively. Corn is the preferred irrigated crop in western Kansas. Therefore water use is commonly compared to the water demands of corn. In 1994 and 1996 the largest amount of water required by corn in addition to the seasonal precipitation was about 14 inches which is near the

Table 2

Water use summary for Western Kansas Groundwater Management District No. 2

	1994	1996
Net authorized quantity	753,730	753,988
Reported irrigation water use	281,921	252,931
Reported acres irrigated	237,532	245,309
Net authorized quantity for those not reporting or reporting no irrigation use	113,166	97,655
Reported non irrigation water use	7,101	6,649
Estimated domestic water use	488	484
Population	2,646	2,627

amount of 12-14 inches (1.0-1.2 acre-ft/ac) reported. This does not account for the timing of precipitation which may require more irrigation to cover short term dry spells within one season.

Climatic conditions during the years when reliable water use data are available were not representative of a dry year. Well capacity in many instances has decreased the ability to produce fully irrigated corn so more drought tolerant crops such as wheat and sorghum have replaced corn in many areas. During dry climatic conditions the reported water use would be expected to be greater but would probably not be close to the maximum authorized quantity in most cases. However those water rights for which no water use was reported may begin pumping and increase water use, realizing that many of these may be abandoned or not used even during a drought. If the authorized quantity for those water rights that had no reported water use were subtracted from the authorized quantity for all water rights the remaining potential use would be more than twice the reported amounts for 1994 and 1996. Water was sometimes appropriated for more than 2 acre-ft/acre but after 1978 it was appropriated reasonably consistently at 2 acre-ft/acre which is also nearly twice the rate of 1.0-1.2 reported in 1994 and 1996. The effect of the limitations on well capacity compared to management decisions to produce less water-demanding crops will not be possible until reliable water use data is obtained under dry climatic conditions.

Reported non irrigation use, which is primarily industrial and public supply, of about 7,100 acre-ft and estimated domestic water use of about 480 acre-ft is less than 3% of the reported water use. This is only about 7% of the authorized quantity for those water rights that did not report water use in 1994. However, sufficient well capacity may limit water supplies even for these uses in some areas.

CONCLUSIONS

Water rights and water use data are collected and maintained in the Division of Water Resources water rights information system. The Kansas Water Office,

Division of Water Resources, and Groundwater Management Districts work together to support the planning, water management and regulatory functions in Kansas. Residents and irrigated agriculture in Western Kansas Groundwater Management District No. 1 rely on the High Plains aquifer for their sole water supply. Aquifer development since 1950 is depleting the aquifer. Water table declines are typically more than 50 feet. Saturated thicknesses are now between 25-50 feet in many areas. Saturated thicknesses of 25-50 feet or less are at the threshold of traditional irrigation practices.

The two years 1994 and 1996 represent a typical year and a wet year respectively– there were no dry years since 1992 when reliable data have been collected. More than 95% of the water used is for irrigation. In 1994 and 1996 the largest amount of water required by corn in addition to the seasonal precipitation was about 14 inches (1.2 acre-ft/acre) . This required amount is within the range reported of 1.0 to 1.2 acre-ft/acre. Well capacities in the past 10-20 years have decreased by more than 45% and this decrease is now limiting water use. Continued withdrawals at current rates would deplete the aquifer in 25-35 years.

Water management and regulatory strategies must address the short time frames of exhausting this sole source. Irrigation is the primary withdrawal from the aquifer and the remaining saturated thickness that would sustain traditional irrigation practices is in one or two locations of small areal extent. Water supplies for public supply and domestic uses, even though comparatively small, must be protected even when irrigation is no longer practical. Water use and water rights data collected and maintained by the Division of Water Resources provides essential information to monitor and manage this declining but essential resource. Comparisons of water use information and the characteristics of the aquifer provide insight into water management and regulatory priorities for the High Plains aquifer.

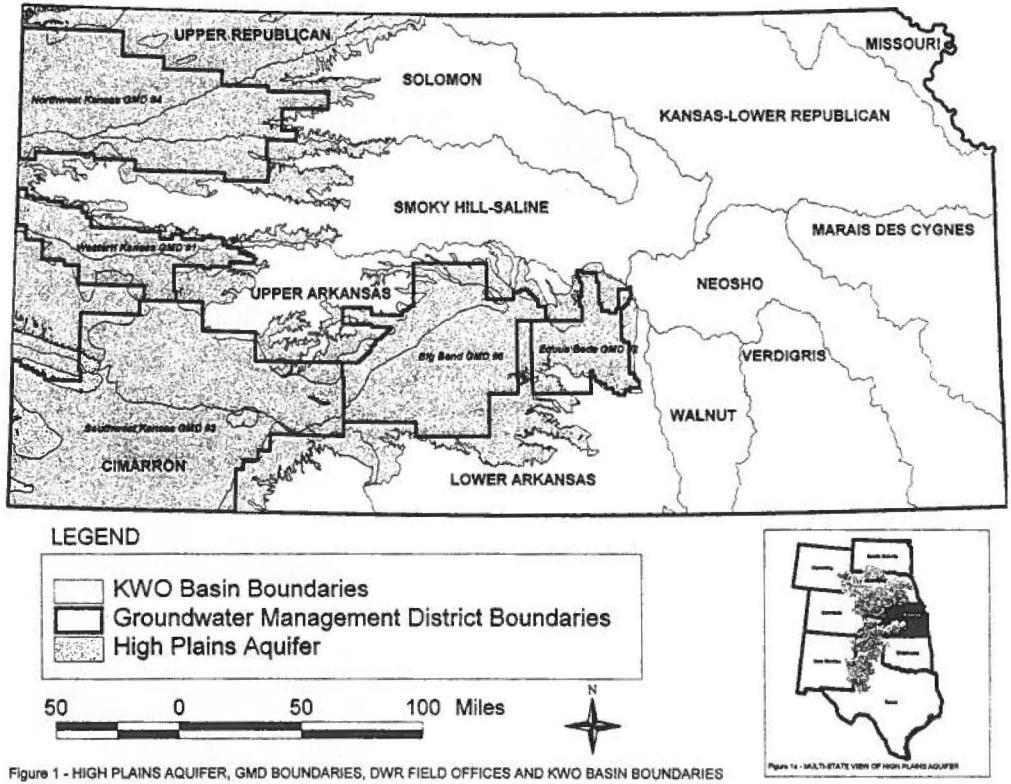

Figure 1 - HIGH PLAINS AQUIFER, GMD BOUNDARIES, DWR FIELD OFFICES AND KWO BASIN BOUNDARIES

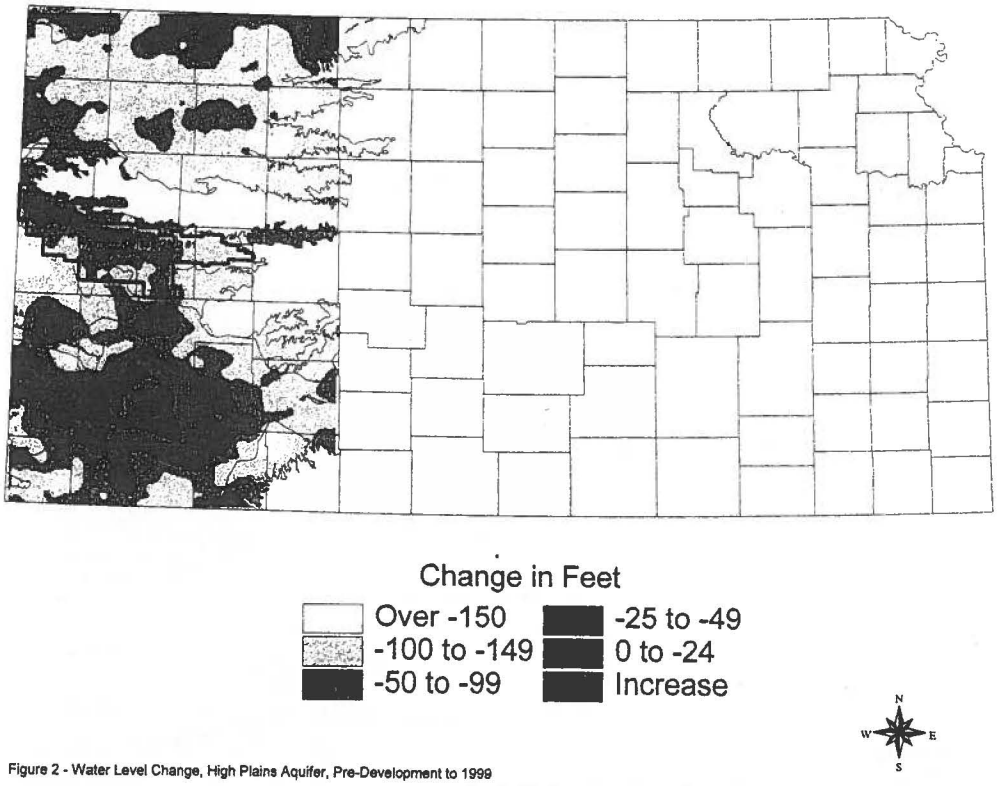

Figure 2 - Water Level Change, High Plains Aquifer, Pre-Development to 1999

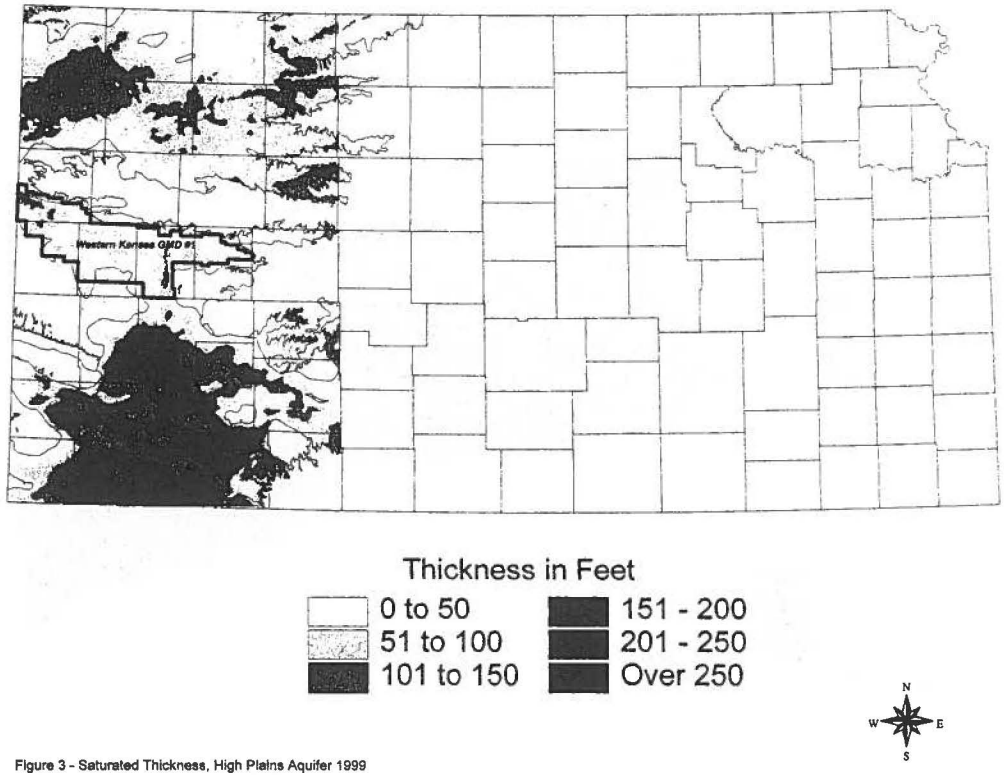

Figure 3 - Saturated Thickness, High Plains Aquifer 1999

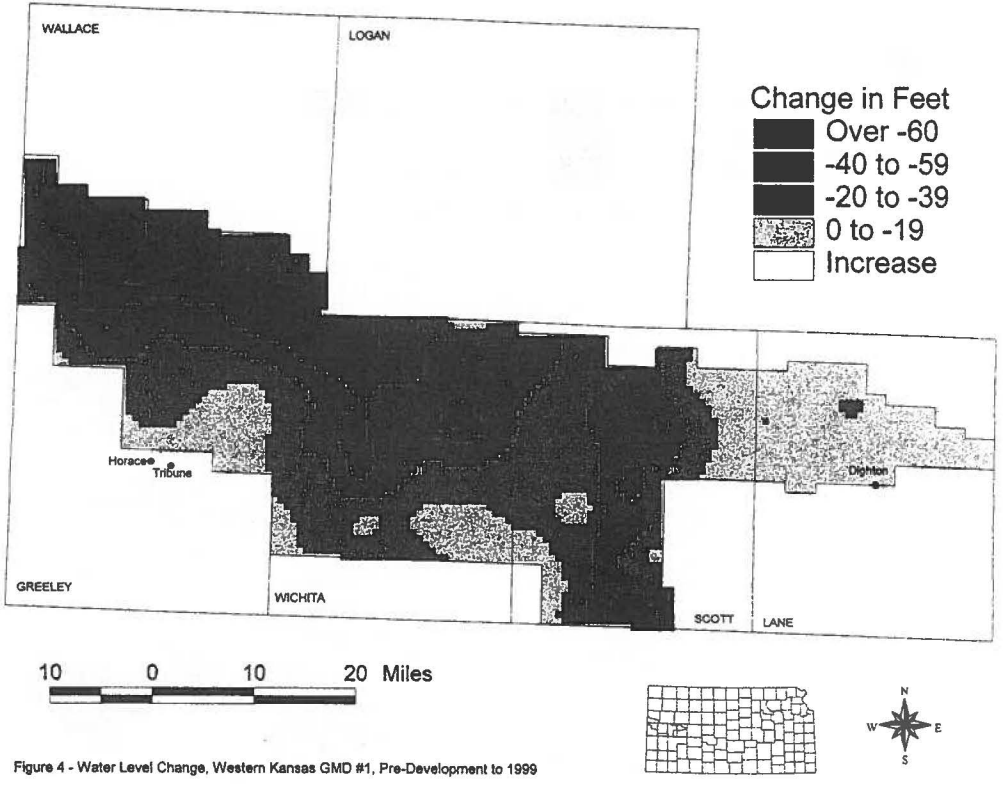

Figure 4 - Water Level Change, Western Kansas GMD #1, Pre-Development to 1999

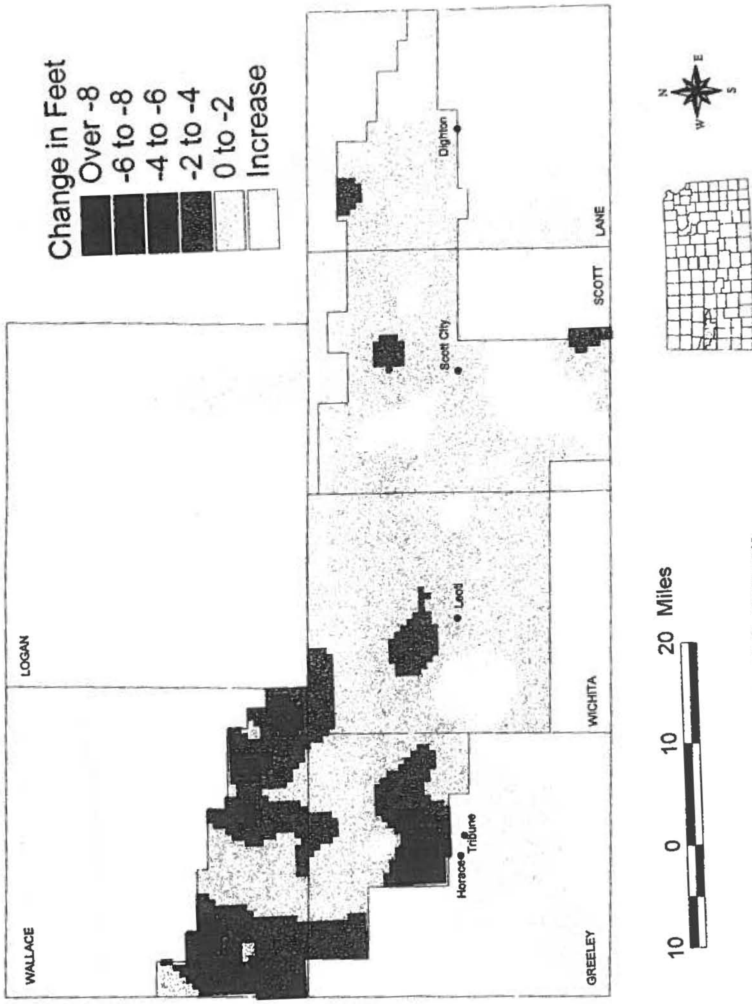

Figure 5 - Water Level Change, Western Kansas GMD #1, 1998 to 1999

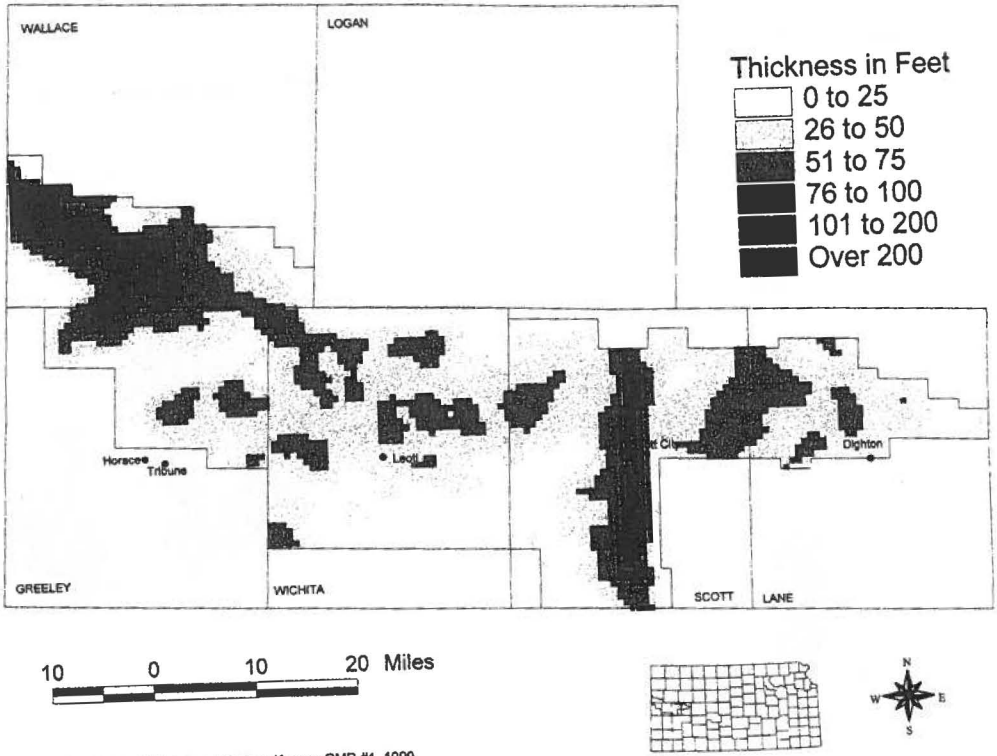

Figure 6 - Saturated Thickness, Western Kansas GMD #1, 1999