BIG BEND GROUNDWATER MANAGEMENT DISTRICT NUMBER FIVE

REVISED MANAGEMENT PROGRAM

December 11, 2025

DIVISION OF WATER RESOURCES
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KANSAS DEPT OF AGRICULTURE

Approved by: ______________________________

Date: ______________________________

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INTRODUCTION

Big Bend Groundwater Management District Number Five was formed in 1976. From the date of inception, the District has actively developed management goals and established objectives to address water resource issues in the region. Progress has been made but there is more to be accomplished. With the combined efforts of the people of this District, problems can be met head on and resolved at the local level. Grassroots input and participation is critical to properly manage the local water resources.

Water resource development in Big Bend Groundwater Management District #5 (District) has greatly increased from the levels prior to 1960. Figure 1 and Figure 2 illustrate the active water rights in the District over the period of record, 1945 to 2024. The peaks in Figure 1 can be correlated to political, technological, economical and meteorological events. Meanwhile, Figure 2 shows the cumulative number of water rights and associated appropriated acre-feet within the District over time. There is an increasing demand for the use of this precious resource for a variety of needs including irrigation, municipal, industrial, and recreation. The high demand for the resource in this area has caused several areas of the District to become fully appropriated. As development expanded it became apparent that a need existed to properly manage the resource in terms of quality and quantity.

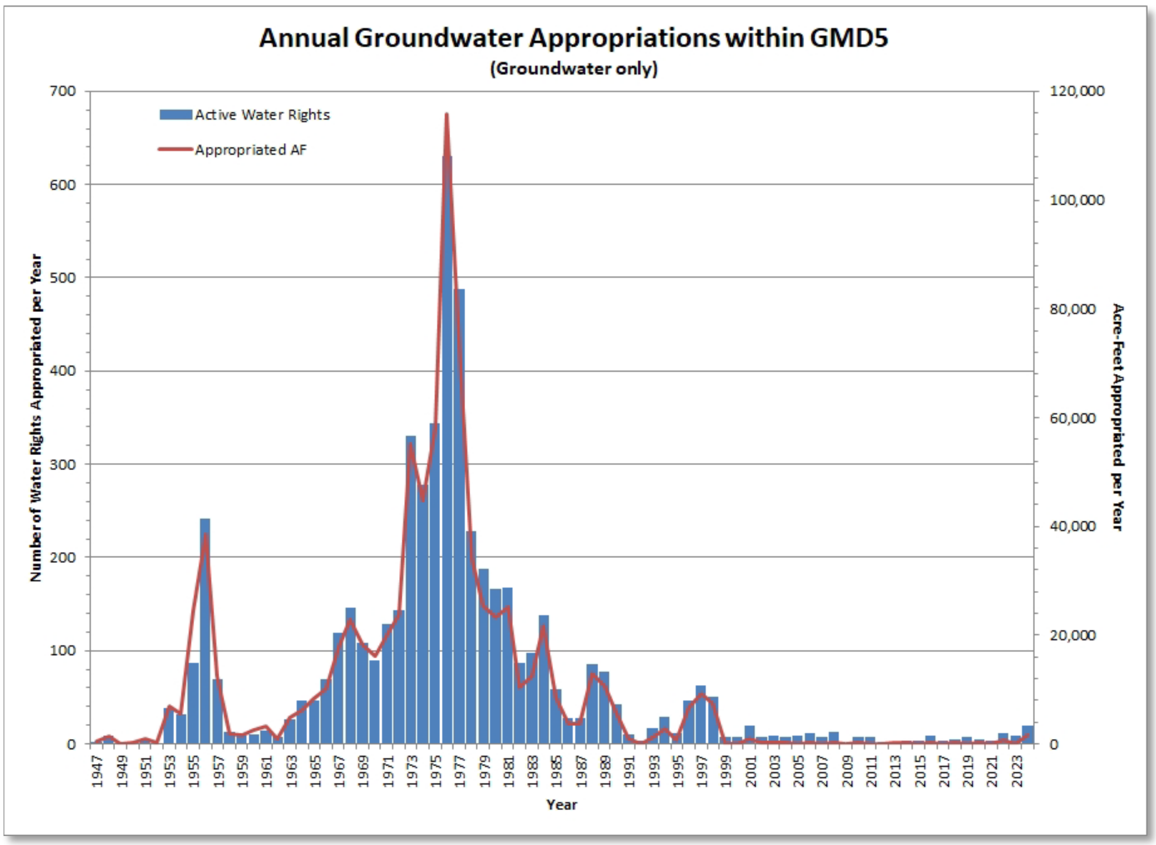

Figure 1 – Annual Groundwater Appropriations

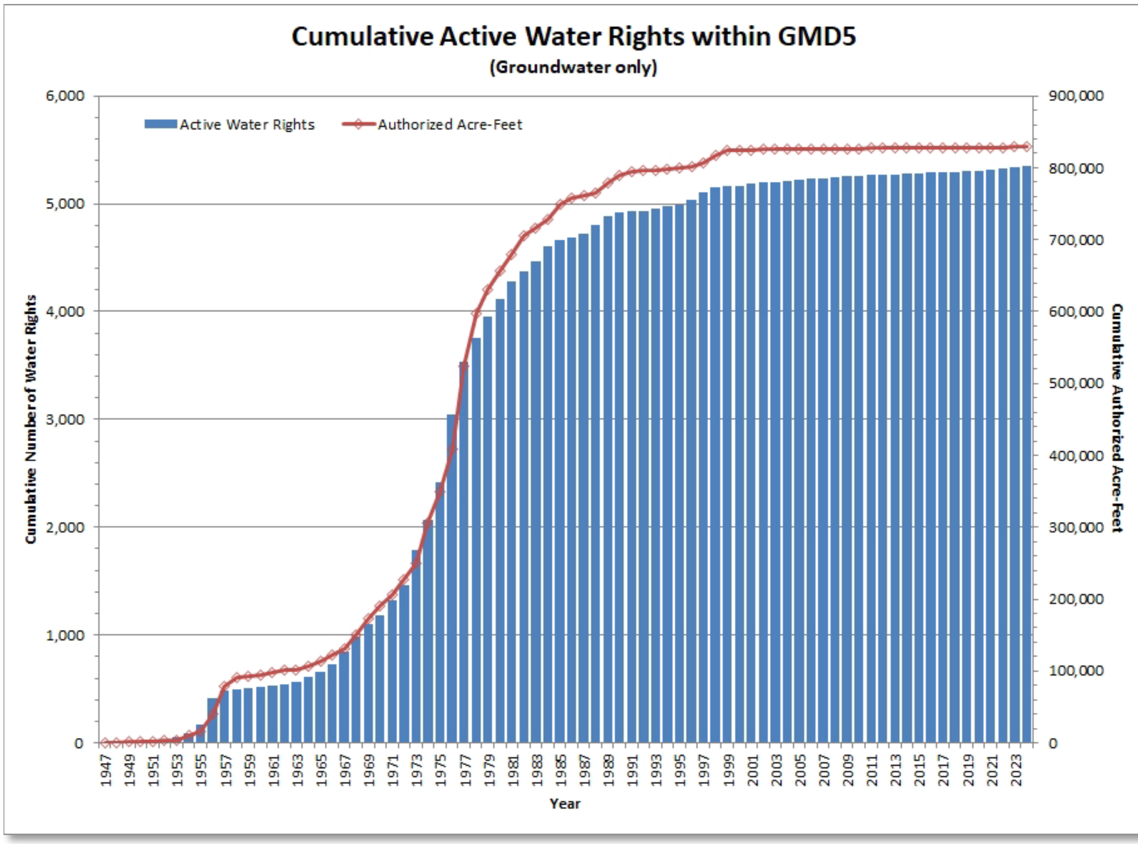

Figure 2 – Cumulative Active Water Rights

PURPOSE OF DISTRICT

The District was organized by concerned citizens to conserve, promote, and manage the groundwater resource to assure quality and quantity will be maintained for present and future needs. These citizens saw the need for the management of the groundwater resource at the local level, thus allowing local landowners and water users the opportunity to determine their own destiny with respect to the use of groundwater within the basic law of the State of Kansas.

K.S.A 82a-1020. Legislative declaration. It is hereby recognized that a need exists for the creation of special districts for the proper management of the groundwater resources of the state; for the conservation of groundwater resources; for the prevention of economic deterioration; for the associated endeavors within the state of Kansas through the stabilization of agriculture; and to secure for Kansas the benefit of its fertile soils and favorable location with respect to national markets. It is the policy of this act to preserve basic water use doctrine and establish the right of local water users to determine their destiny with respect to the use of groundwater insofar as it does not conflict with the basic laws and policies of the state of Kansas. It is, therefore, declared that in the public interest it is necessary and advisable to permit the establishment of groundwater management districts. (History: L. 1972, ch. 386, 1; July 1.)

FORMATION OF DISTRICT

Russell Herpich, irrigation engineer of Kansas State University, saw the potential of the Big Bend area for groundwater development in the 1960's and the urgent need to conserve and perpetuate this vast natural resource.

The 1972 Kansas Legislature enacted legislation enabling the formation of groundwater management districts (K.S.A. 82a-1020 et seq). The Pratt County Soil Conservation District Board of Supervisors, recognizing the benefits of such a district, called a meeting October 16, 1973, to which leaders from the area counties were invited to attend. A series of informative meetings followed, and a steering committee was formed to carry out the organization of the District according to the Kansas Groundwater Management District Act (K.S.A. 82a-1020 et seq). The following steering committee began to function April 11, 1974.

Phil Schrack, Chairman................................ Iuka, Ks
Nathan B. Hayes, Vice Chairman .... Mullinville, Ks
Boyd Mundhenke, Secretary......................... Kinsley, Ks
Larry Panning... Ellinwood, Ks
Bill Ball .... Sterling, Ks
Omar Schartz.. Larned, Ks
Bob Wendelburg .... Stafford, Ks
Don Brownlee* .... Sylvia, Ks

*Don Brownlee represented Reno County even though he could not be a legal member of the committee - 7 being the maximum number on the steering committee.

The steering committee filed a declaration of intent and a proposed map of the District with the Chief Engineer of the Division of Water Resources, Kansas State Board of Agriculture April 16, 1974.

On October 22, 1975, the description of the lands to be included in the proposed District was certified by the Chief Engineer. A petition was then circulated by the steering committee. The petition was approved December 22, 1975, and election called for March 2, 1976, to allow eligible voters of the District the opportunity to decide if the District should be organized. Results of the election were 535 votes in favor and 211 opposed, passing by a 72% majority.

The Certificate of Incorporation was issued by the Secretary of State March 9, 1976 and has been filed in the register of deeds office in each of the eight counties within the District. An organizational meeting was held March 30, 1976, at the St. John Library for the purpose of electing directors and adopting bylaws. The following list reflects the county directors since 1976.

The District extends its sincere gratitude to the individuals who have generously volunteered their time to help make it a truly effective organization.

DIRECTORS BY COUNTY

BARTON COUNTY

Larry Panning	1974-1993
Milton Meyer	1993-1999
Philip Martin	1999-2002
David Essmiller	2002-2009
Philip Martin	2009-2023
Joe Schlessiger	2023-

EDWARDS COUNTY

Ray Cudney	1976-1984
Kenneth Keen	1984-1987
Tom Stejskal	1987-1990
Kevin Schultz	1990-2002
Mica Schnoebelen	2002-2005
Darrell Wood	2005-

RENO COUNTY

Bart Zongker	1976-1980
Eugene Horton	1980-1984
Ed Shultz	1984-2013
Justin Gatz	2013-2022
Gary Hornbaker	2022-

PAWNEE COUNTY

Omar Schartz	1976-1979
Howard Zook	1979-1986
E. Lee Musil	1986-1991
Robert Lewis	1991-2005
Ron Ashworth	2005-2006
Kraig Froetschner	2006-2011
Robert Standish	2011-2018
Kerry Froetschner	2018-

STAFFORD COUNTY

Robert Wendelburg	1974-1989
Sam Crissman	1989-2001
Larry Chadd	2001-2007
Kent Lamb	2007-2019
Marlyn Spare	2019-

PRATT COUNTY

Don Fincham	1976-1977
Jerry Mott	1977-1989
Ron Schwerdtfeger	1989-1992
Eugene Stotts	1992-1998
Vernon Hirt	1998-2010
Fred Grunder	2010-

RICE COUNTY

Bill Ball	1976-1984
Greg Wellman	1984-1992
Curtis Tobias	1992-2017
Jerry Cullop	2017-2020
Craig Zwick	2020-

DIRECTOR AT LARGE

Willard McClure	1976-1979
Allen Klein	1979-1985
Kenneth Fenwick	1985-1988
Ron Arnold	1988-1994
Alan Crane	1994-2006
Kevin Schultz	2006-2011
Tom Taylor	2011-

KIOWA COUNTY

Cecil Vieux	1976-1977
John Rosenberger	1977-1982
Kenneth Rice	1982-1988
Russell Fralick	1988-1994
John Janssen	1994-2025
Kent Moore	2025-

DISTRICT OPERATION

The District office is located at 125 South Main, Stafford, Kansas. It is operated by the board of directors who are responsible for setting policy and objectives for the District. The District employs staff as necessary to carry out the programs of the District.

The board of director's focus is on best management practices to maintain quality and quantity of the local water resource. Local input is directed at new and improved methods of managing the water supply. The District supports research, education, demonstration projects and management guidelines.

The board of directors meet on the second Thursday each month to review activities of the District and develop programs. An annual meeting for all eligible voters is held early each year to provide information about the District's progress and allow additional input from the membership. Throughout the remainder of the calendar year, the District staff work closely with water users to address resource concerns and encourage proper stewardship of the regional aquifer.

DISTRICT DESCRIPTION

A. Location and Area

Big Bend Groundwater Management District #5 was named because of the proximity to the large bend of the Arkansas River in South Central Kansas. Portions of the District are located in both the High Plains section of the Great Plains physiographic province and the Arkansas River Lowland section of the Central Lowlands Province. The District encompasses approximately 2.5 million acres of land in portions of eight counties: Barton, Edwards, Kiowa, Pawnee, Pratt, Reno, Rice and Stafford (Figure 3). Table 1lists the total acreage for each county and the number of acres that have been removed from District assessment.

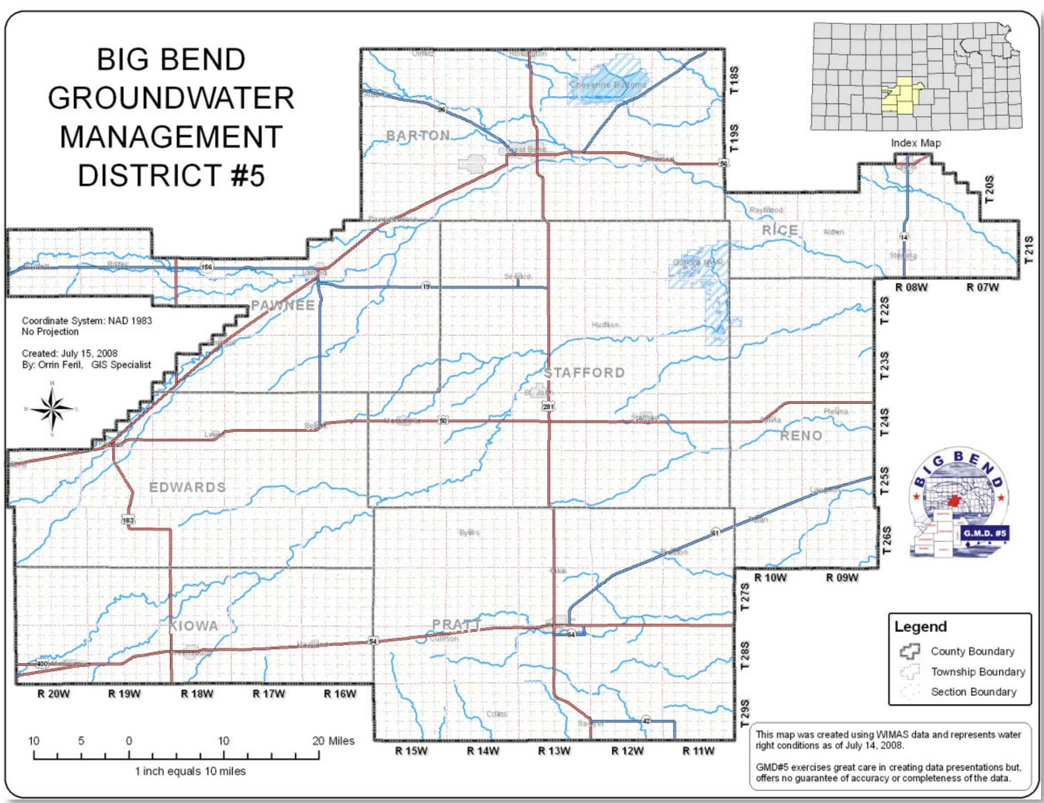

Figure 3 – District Boundaries

County	Total Acres *	Acres Assessed **	Acres Petitioned Out	Irrigated Acres ***	Number of Wells ***	Acre-Feet Assessed
Barton	295,917	295,624	19,334	93,700	708	66,622
Edwards	297,341	297,177	5,549	156,429	1,185	147,283
Kiowa	220,052	219,969	2,313	68,707	536	77,961
Pawnee	248,660	248,397	4,184	130,652	998	113,474
Pratt	430,178	429,596	17,691	129,075	1,024	136,849
Reno	216,586	216,528	4,302	28,332	226	20,366
Rice	133,117	132,762	3,136	58,742	451	42,438
Stafford	433,146	432,628	34,108	136,803	1,000	128,235
Grand Total:	**2,274,997**	**2,272,681**	**90,617**	**802,440**	**6,128**	**733,228**

Acreage And Authorized Water Use Data
10/01/2025

* Total acres calculated using updated GIS Data from Kansas Geological Survey
** Acres assessed plus acres excluded does not equal total acres due to lands exempt such as Federal land, municipalities, and tracts less than 40 acres.
*** Irrigated Acres and Number of Wells are calculated using WIMAS data from Kansas Department of Agriculture - Division of Water Resources

Table 1 – Acres & Acre-Feet Authorized by County

B. Climate

The District is characterized by a continental-type climate. This type of climate has large diurnal and annual variations in temperature. The western half of the area has been classified by Thornthwaite as "dry subhumid" while the easternmost area of the District is classified as "subhumid" (Thornthwaite, 1948).

Precipitation varies considerably from the western edge to the eastern edge, with 20 inches of average annual precipitation in the west to 27 inches in the east. The average for the District is approximately 24 inches per year. The precipitation occurs in the form of rain, sleet, snow, freezing rain, and hail. About 75 percent of this occurs in the period from April to September associated with cyclonic and convective thunderstorm activity.

Temperature fluctuations are large in a continental type climate. Annual variations range from about -10 degrees Fahrenheit to about 105 degrees Fahrenheit. The growing season is sufficiently long so that frost is generally not a problem for most crops grown in the District.

C. Soils

The District has a variety of topographic regions ranging from the broad flat loess mantled Pawnee Valley to the active sand dunes in Edwards and Kiowa Counties. The majority of the District is characterized by low undulating dune topography on which the major drainage patterns have been superimposed. The major soils found in the District are described below and are depicted on Figure 4.

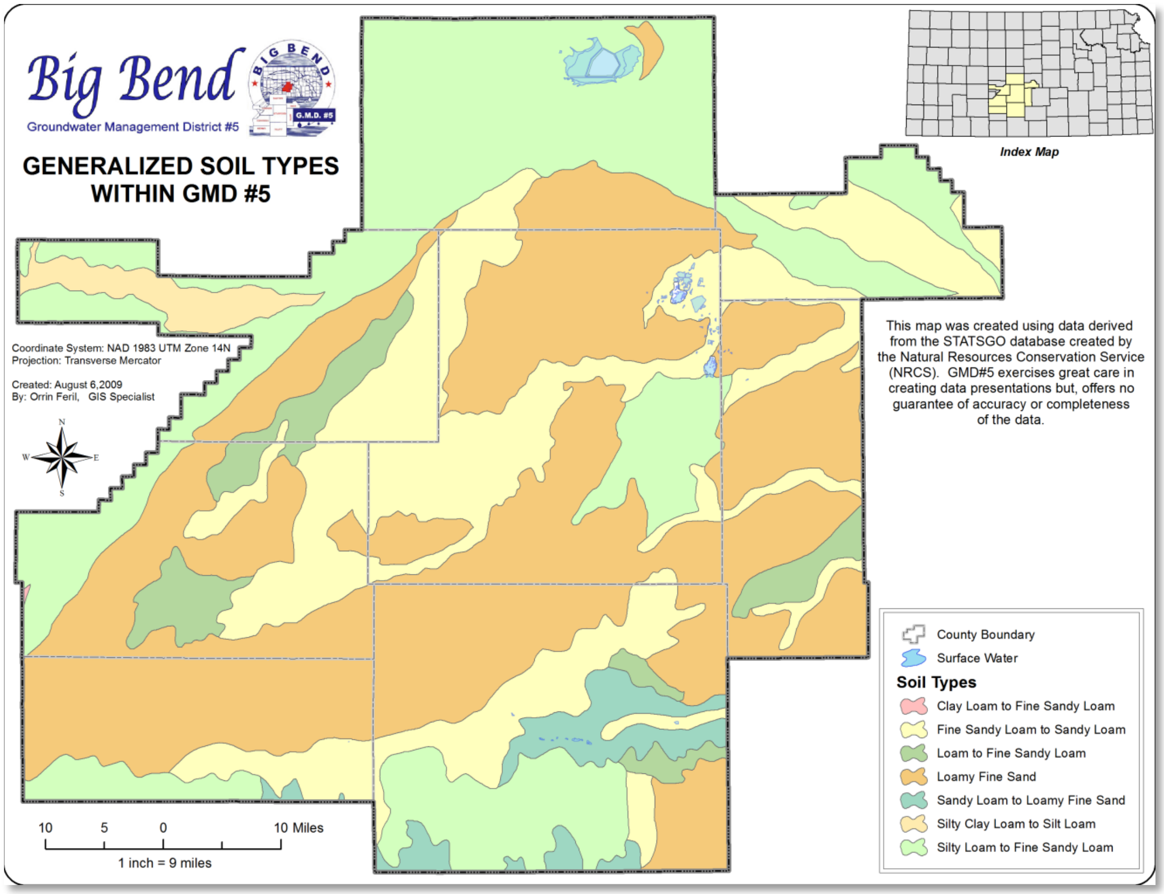

Figure 4 – Generalized Soil Types

1. The upland, hardland areas of Barton, Pawnee, Pratt, Edwards, Rice, and Kiowa Counties consist of well-developed silty and clayey soils. They are dominantly well drained, deep, fertile soils. Some small places of rock and shale occur on slopes. Water erosion and soil blowing are the major concerns of soil management.

2. The flood plain areas of the major rivers such as the Arkansas River, Rattlesnake Creek, South Fork Ninnescah River, and North Fork Ninnescah River consist of poorly drained and somewhat poorly drained sandy and loamy flooded soils. They are deep to shallow over sandy strata with a fluctuating water table. They are slightly to moderately saline. Most are frequently flooded, and some small areas have salt affected spots. The main concerns of soil management are flooding and soil blowing.

3. The flood plain areas of the Pawnee River, Walnut Creek, Blood Creek, Deception Creek, Cow Creek and Little Arkansas River consist of deep, silty and loamy soils and some smaller areas of clayey soils. These are mainly well drained but are flooded and generally have water tables at depths greater than 6 feet. The main concerns of soil management are flooding and soil blowing.

4. The uplands areas of Barton, Pawnee, Edwards, Kiowa, Stafford, Reno, Pratt, and Rice Counties are consisted of moderately sandy and clayey areas. It is the largest area of the District. It is formed in old alluvium that has been reworked upon the surface by the wind. Soils are deep and range from clay to sand. They are dominantly moderately sandy. They are fertile and well drained except small areas are low, wet, and poorly drained and formed in clayey alluvium or sandy or loamy materials underlain by clay. Other small high areas are sand hills. The main concerns of soil management are

soil blowing and soil drainage of low areas. The slope gradient of this entire area is low or very low and suitable outlets for excess water are difficult to establish.

5. The terrace and uplands consisting of silty to clayey soil areas mainly in Barton, Rice and Reno Counties along the Arkansas River and Peace Creek are deep and slowly permeable to very slowly permeable and have varying degrees of salt accumulation layers. Saline and alkali spots are common. The main concerns of soil management are soil blowing and maintaining tilth and fertility.

D. Drainage Basins

Seven major drainage basins are defined within the boundaries of the District (Figure 5). The drainage basins are the Arkansas River, Pawnee River, Wet Walnut Creek, Rattlesnake Creek, North Fork Ninnescah River, South Fork Ninnescah River and Cow Creek. The Chikaskia and Medicine Lodge Rivers headwaters also originate in the southern part of the District. In addition to these areas, there are a large number of undrained areas associated with the sand dune regions in the District.

The Arkansas River enters the District south of Kinsley near the Edwards-Kiowa County line. The river makes a large bend to the northeast passing through Larned and Great Bend. From Great Bend it makes a smooth curve to the southeast passing through Ellinwood, Raymond and Sterling. Three major tributaries, the Pawnee River, Wet Walnut Creek, and Rattlesnake Creek, enter the Arkansas River as it transverses the District.

The Pawnee River enters the District west of Burdett and travels about thirty miles to its junction with the Arkansas River near Larned.

Wet Walnut Creek enters the District west of Albert and travels about 25 miles to its junction with the Arkansas River east of Great Bend.

The Rattlesnake Creek drainage basin originates in Ford and Clark Counties. The creek enters the District west of Mullinville, crosses Kiowa, Edwards, Stafford, and Rice Counties and joins the Arkansas River near Raymond in Rice County.

Both the North Fork Ninnescah River and the South Fork Ninnescah River have their headwaters located within the District. The North Fork originates in southern Stafford County and travels northeast toward Plevna where it exits the District. The South Fork originates near Cullison, travels east through Pratt and exits the District on the Pratt-Kingman County line near Cunningham.

Cow Creek enters the District in northeast Barton County and travels approximately 10 miles before exiting the District boundary on the east side of Barton County. Cow Creek traverses approximately 15 miles of Rice County that is not included within the District boundaries before reentering the District near Lyons exiting the District on the Rice-Reno County line east of Sterling.

While Kansas regulations separate the area into these distinct surface drainage basins per K.A.R. 5-6-15, the groundwater divides, for many of the basins, are much more difficult to determine due to the aquifer characteristics. In some cases, the groundwater flow may not coincide with the drainage basin boundary. This underscores the importance of utilizing hydrologic models for management decisions.

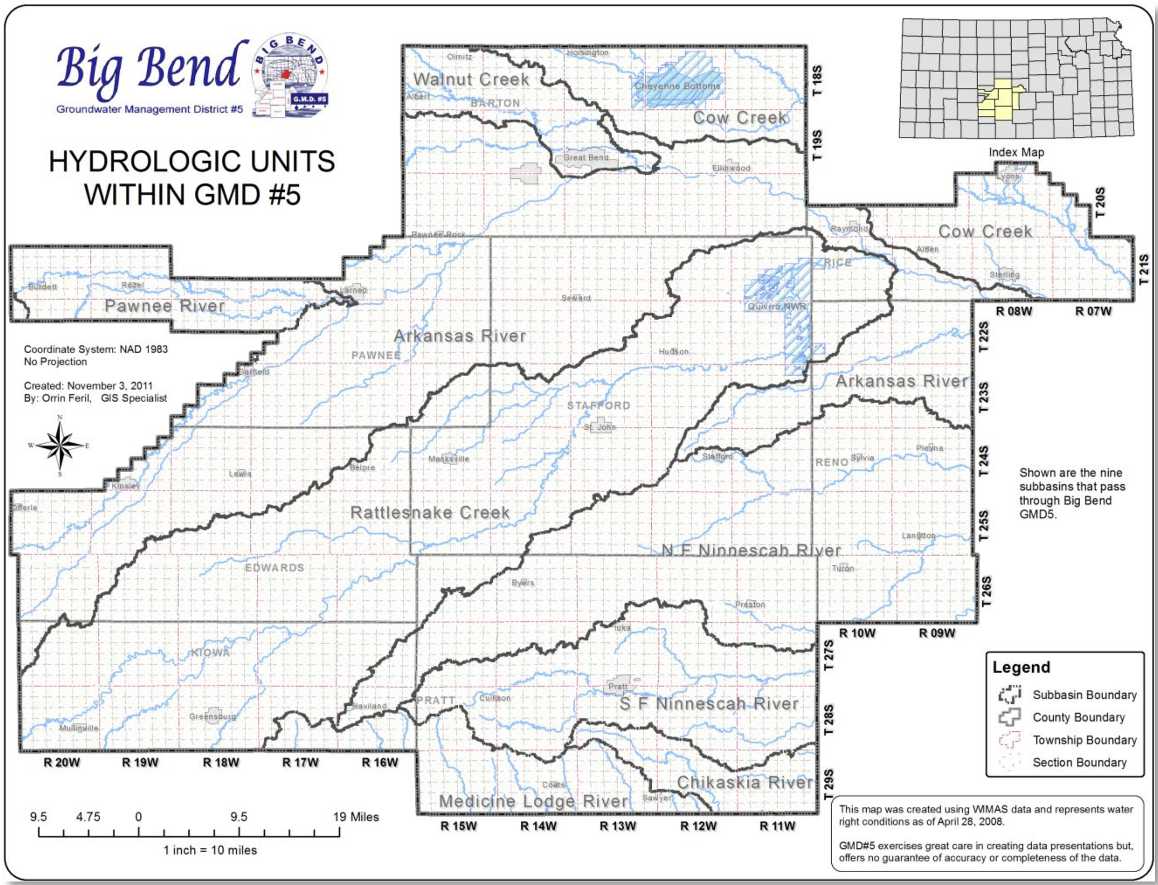

Figure 5 – Hydrologic Units

E. Wetlands

The Quivira National Wildlife Refuge, located in northeastern Stafford County, encompasses approximately 33 square miles. The naturally occurring salt marsh has been modified by man, particularly by the construction of canals and related diversion structures. The marsh and its canal system are fed by surface water from Rattlesnake Creek, local runoff, and artesian flow. The Refuge is owned by the U.S. Fish and Wildlife Service which holds a surface water right to divert water from the Rattlesnake Creek for recreational benefit.

Cheyenne Bottoms, located northeast of Great Bend in Barton County, is naturally fed by Blood and Deception Creeks and is drained by Little Cheyenne Creek. Cheyenne Bottoms encompasses approximately 31 square miles. The Kansas Department of Wildlife, Parks and Tourism also has a water right, which permits diversion of water from the Wet Walnut Creek and Arkansas River.

F. Geohydrology

The geologic units pertinent to the hydrogeology of the District vary in age from lower Permian to Holocene. The older formations of the lower Permian and lower Cretaceous form the bedrock surface in this region and are considered to be the base of the Great Bend Prairie aquifer and associated river alluvial aquifers.

Redbeds of Permian age underlie the eastern half of the District (Figure 6). The units included are the Harper Sandstone, Salt Plain Formation, Cedar Hills Sandstone, and undifferentiated lower and upper Permian rocks of the Nippewalla Group and the Whitehorse formation. These units consist of reddish-brown sandstone, siltstone, shale, salt, gypsum, anhydrite, and limestone. There are very few wells withdrawing water from these formations at the present time. This is mainly due to the highly mineralized water that occurs in these formations. The potential exists for limited development of Permian sources for such uses as secondary oil recovery and salt solution mining.

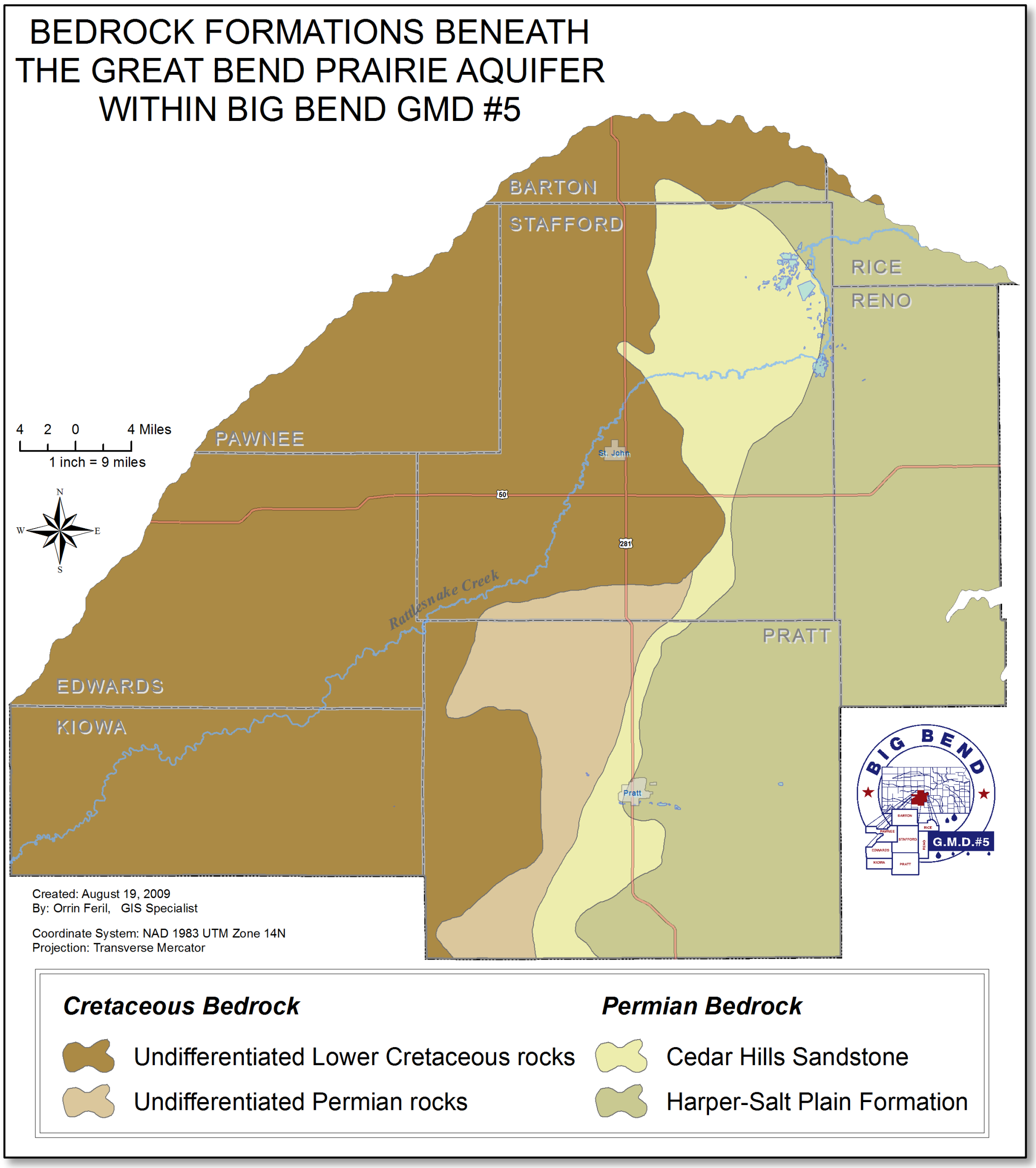

Figure 6 – Bedrock Formations of the Great Bend Prairie aquifer

The western half of the District is underlain by rocks of the lower Cretaceous age which lie unconformably on the Permian units. Included are the Cheyenne Sandstone, Kiowa Formation and Dakota Formation. These consist of sandstone, siltstone, shale, and some limestone.

The chemical quality of water from the Cheyenne Sandstone and the Kiowa Formation is very poor and renders these unfit as a source of water in the District. Some excellent quality water is obtained from Cretaceous Dakota Sandstone. However, the extent of this unit is limited in the District. The Dakota formation is used as a source of supply in Barton, Pawnee, Rice, and Edwards counties. It is mainly used for domestic and stockwatering, however, there are some areas where it is used for irrigation and municipal purposes.

Quaternary age deposits form the major aquifers in the District. These are composed of unconsolidated silt, sand, gravel, and clay which unconformably overlie the Cretaceous and Permian bedrock formations. The deposits range in age from Pleistocene to Holocene. The Pleistocene sediments were deposited by lateral shifting of streams during four glacial stages (Nebraska, Kansas, Illinois, Wisconsin) and four interglacial stages (Aftonian, Yarmouthian, Sangamonian, Holocene). They were deposited on an erosional surface of Cretaceous and Permian bedrock which must have looked similar to the Smoky Hill River area in Ellsworth County and the exposed Permian bedrock area of Barber County. The deposit thickness ranges from 0 to 300+ feet and average around 120 feet. Capped by eolian deposits of the Pleistocene and Holocene age, some of the fluvial deposits have been reworked by recent stream activity to form river alluvium. It is, however, difficult to distinguish the more recent alluvial sediments from the original Pleistocene deposits.

The Quaternary deposits are an excellent source of good quality water across most of the area. Some quality problems relating to mineral intrusion from the underling Permian bedrock units render certain areas unusable. Wells obtaining water from the Pleistocene deposits will yield from a few hundred gallons per minute to over 2000 gallons per minute, thus making these units desirable for development for all water uses.

Recharge rates in the District are estimated to be between zero and seven inches, with an overall average of 2¼ inches per year. Recharge is dependent on total annual precipitation, surface soils, depth to water, and characteristics of the strata between the land surface and water table. Most important is the timing and amount of precipitation. There have been several recharge studies conducted in the District to estimate the recharge (Sophocleous, 2004). Because of the variability in precipitation, as little 14" during drought periods to nearly 40" during wet periods, recharge should be considered as a percentage of precipitation rather than an average figure.

G. Economy

The availability of plentiful and renewable supplies of good quality water has helped to make an irrigated agricultural economy a reality in the District. The spin-off from this has bolstered the well drilling industry, irrigation service groups, and irrigation equipment dealers, thus establishing off-farm jobs that help establish a healthy economic base supporting the local communities within the area.

Other industries support the economy in the District, such as the oil and gas industry, and many small industries in and around the cities and towns in the District. The District is a prime area for the location of ethanol production due to the availability of irrigated corn production and other crops.

The stabilization of agriculture and the prevention of economic deterioration are major goals outlined in the Groundwater Management District Act and are extremely important to the District. To accomplish these goals, adequate levels of good quality water must be sustained through the administration of a strong management program, which includes education, conservation, and the implementation of policies that will promote the wise use of the resource.

Sustainable water supplies are needed for all uses including domestic**,** municipal, industrial, recreational, and agricultural. Sustainable yield is defined in the District's rules and regulations "means the long-term yield of the source of supply, including hydraulically connected surface water or groundwater, allowing for the reasonable raising and lowering of the water table".

Figure 2 illustrates the rate of development over the past seventy years. There are currently about 827,000 acre-feet of water appropriated for beneficial use within the District. This water is being withdrawn from the groundwater system by approximately 5,300 large capacity wells and is used to irrigate about 450,000 acres of land as well as supply industrial, municipal and recreational needs in the District. Figure 7 displays the difference in the amount of water appropriated within the District vs the amount of water used annually for the past 20 years.

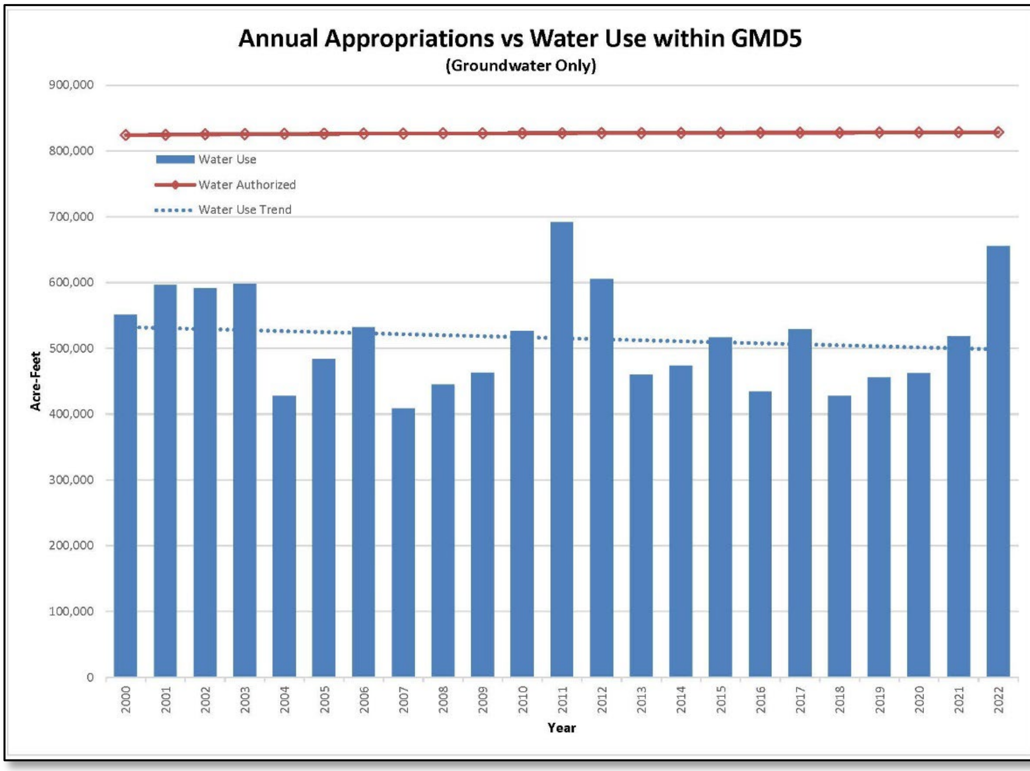

Figure 7 – Annual Water Use vs Appropriations

As Figure 8 shows, the use of water for irrigation purposes is by far the largest with roughly 90 % of all water withdrawn applied to irrigated crops. Indeed, the greatest increase in development has been for irrigated agriculture. This increased development has helped to support the economy of the region, but this economy can only be maintained if the water resource is sustained.

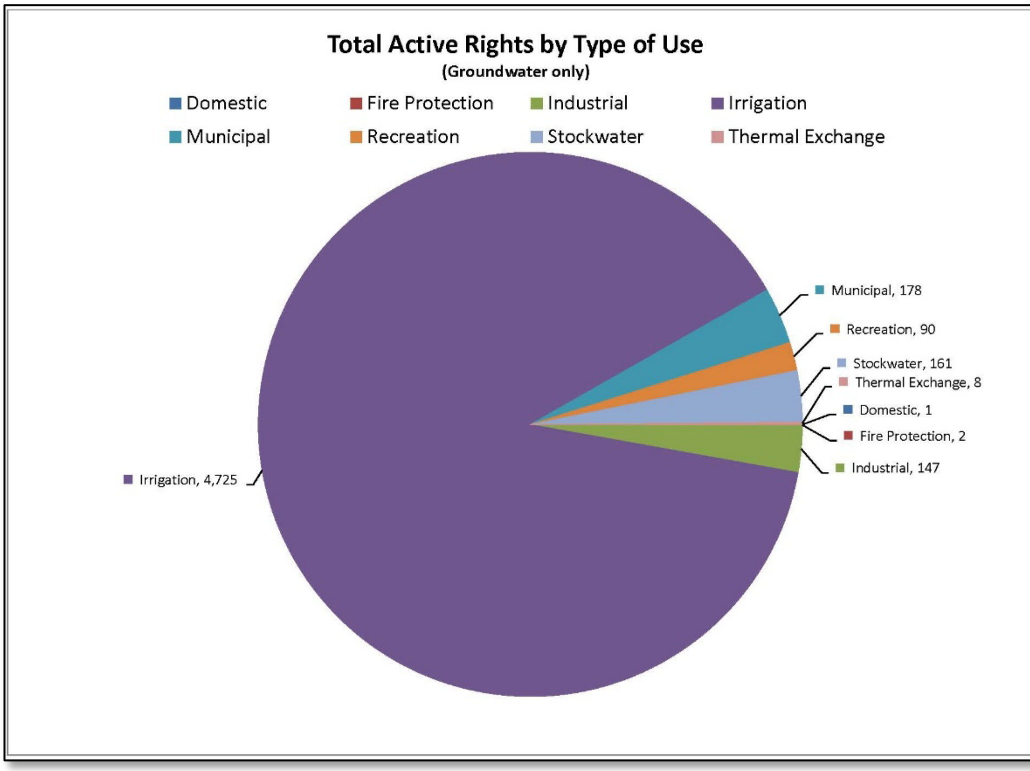

Figure 8 – Active Water Rights by Use

HYDROLOGIC MODELING

A. Background

In 2007, the District board decided it was time to have a comprehensive hydrologic model developed that encompassed the entire District area including the upland watershed areas of the Arkansas River, Pawnee River and Walnut Creek (Figure 9). The model work began in late 2008 and throughout the following year, the technical review committee provided meaningful refinements to the model. The model development was led by Balleau Groundwater, Inc. ("BGW") with technical contributions and review by Kansas Department of Agriculture–Division of Water Resources (KDA–DWR) staff and consultant S.S. Papadopulos and Associates, Inc., alongside feedback from KDA–DWR, Big Bend GMD No. 5, Water Protection Association of Central Kansas (WaterPACK) and the U.S. Fish and Wildlife Service (USFWS). The model ("BBGMDMOD") and accompanying report were completed in 2010 (Balleau Groundwater, Inc., 2010).

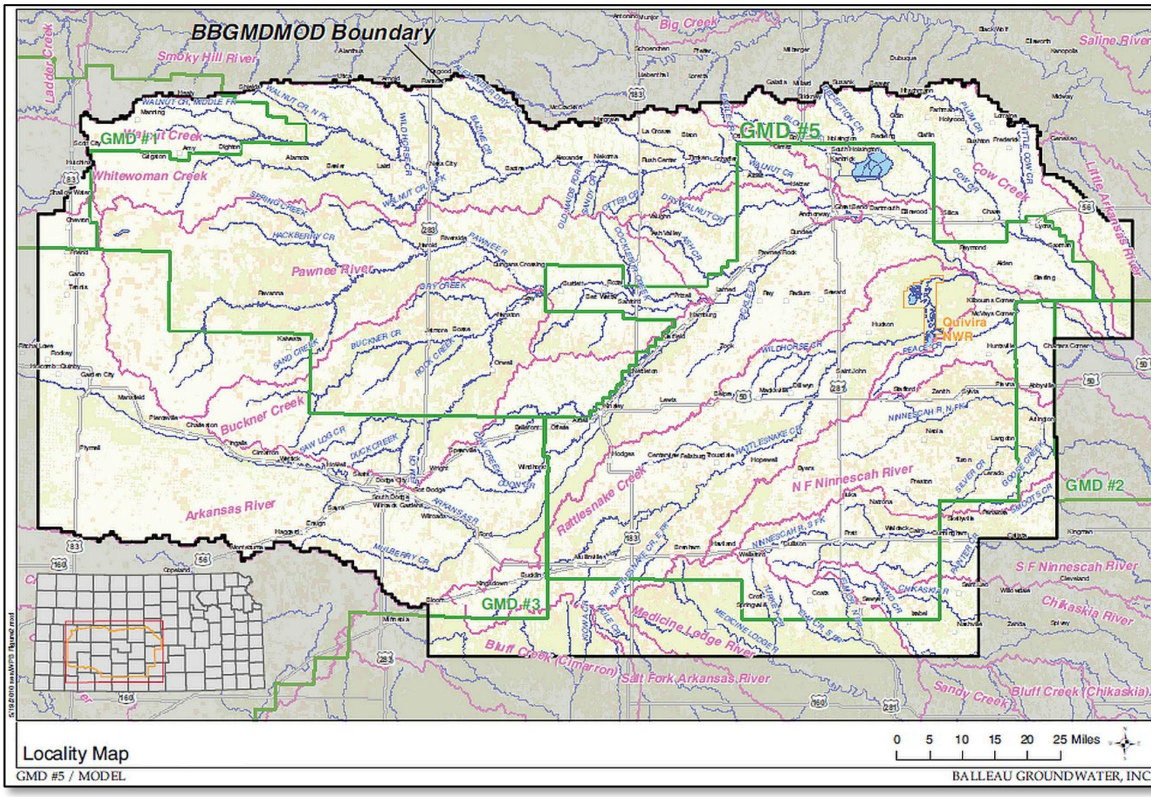

Figure 9 – District Model Boundary

B. Purpose

The purpose of developing the BBGMDMOD is to clarify the relationships between historical groundwater management activities and the associated hydrologic responses of the aquifer. With better understanding of the relationship between these actions and the aquifer responses, then management strategies can be developed that are tailor-fit to address hydrologic concerns in the future. The intent is to better predict the potential hydrologic and economic impact of management strategies. When considering management changes, the BBGMDMOD is best suited to fully analyze the impact of those changes. BBGMDMOD is currently under revision and update by BGW and is anticipated to be completed and available for use in the first quarter of 2026. The District will make routine efforts to ensure the model is maintained and updated to provide a quality tool to evaluate future management actions.

MANAGEMENT ISSUES

A. Water Quantity

Beginning in 1979, the board was aggressive in the adoption of programs restricting the amount of development. Proposed appropriations were evaluated and recommended for approval based on recharge data. The allowable amount was updated as new information became available. Many areas of the District were considered fully appropriated and closed to any further development in 1990. The remaining basins were closed in 1998. Those areas where development was allowed between 1990 and 1998 had additional restrictions put into place that would protect base flow to streams, in addition to a reduction in the sustainable yield criteria. These restrictions limited development near the streams and the number of withdrawals for a given area. Streamflow nodes were established every quarter mile on all the major streams and tributaries in the basins that had remained open for development until 1998. Allocations assigned to each streamflow node were used in the sustainable yield calculation to determine if additional development would be possible. The reduction in the allowable appropriation and the subsequent closure of the District has helped reach the goals set forth in this management program and the Groundwater Management District Act.

During the 1990's it also became apparent that management of the groundwater resource in the District had evolved into a more detailed process. It was determined that in order to manage the groundwater resource effectively, everything in a particular watershed should be evaluated. When using the watershed approach, both water quality and quantity issues become much more relevant to each other. This watershed approach is the underlying principle behind the current rules and regulations governing the District. However, it should be noted that in many cases groundwater moves from one basin to another.

Water transfers that could potentially export water out of the District should be addressed as they arise. The Kansas Water Transfer Act was developed to address such issues while allowing for District input. The District should assess the local economic impact when reviewing water transfers. Transfers of water from within the District may become more common in the future. Whenever possible, the most current version of the BBGMDMOD should be used to evaluate potential changes and impacts to regional aquifer and stream systems.

An additional strain on the delicate balance of the local aquifers is the invasive phreatophytes in the area. Several basins in the District have seen an increased presence of invasive phreatophytic trees specifically salt cedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia* L.). Overall, these phreatophytes may decrease baseflows in streams due to high rates of evapotranspiration from the alluvial zone (Shafroth, et al., 2005) and decrease biodiversity (Zhang, Yin, & Pan, 2002). Historically, it was estimated that the clearing of these trees from stream channels may result in up to 6-9 feet/year of recovered streamflow. However, in field studies the evapotranspiration by salt cedar in these areas is approximately 2.5-4 feet/year (Dahm, et al., 2002).These studies were conducted in the Pecos and Gila Rivers of New Mexico. Due to the pervasiveness of these invasive species and the potential water savings to the stream channels, it is appropriate to pursue the removal of these trees in an efficient manner.

An additional pressure on the local aquifer system is the proliferation of invasive emergent wetland vegetation, particularly Phragmites (*Phragmites australis*). District staff have noted a rapid expansion of dense Phragmites stands within riparian corridors, wetlands and shallow alluvial zones. Similar to other invasive hydrophytic species, Phragmites can reduce water availability through high evapotranspiration rates, competitive displacement of native hydrophytes and alteration of sediment and nutrient dynamics. Studies have shown that monotypic stands of Phragmites can transpire substantially more water than adjacent native vegetation, with estimated evapotranspiration ranging from 3-6 feet/year depending on stand density and climatic conditions (Lenters, et al., 2011) (Mykleby, et al., 2016). Additionally, the species forms thick rhizome mats and tall, dense canopies that suppress native biodiversity and reduce habitat quality for wildlife (Chambers, Meyerson, & Saltonstall, 1999). Given the widespread nature of Phragmites infestations and potential water savings and ecological benefits associated with reducing stand density, targeted management and removal efforts are warranted to restore more natural hydrologic and ecological function in affected basins.

Objectives outlined to reach goals of various basin programs.

1. Support the KDA–DOC Water Transition Assistance Program (WTAP). Identify and prioritize the program within all basins where water use reductions are necessary.
2. Utilize District funds in the purchase of water rights in priority areas. Whenever possible, match District funds with state and federal funding sources.

3. Support and cooperate with state and federal agencies to provide incentives for water use reductions and promote the use of such programs.
4. Seek to eliminate over-pumping of authorized quantities. Utilize field inspections and education outreach to promote proper stewardship of the water resources of the region.
5. Continue to support conservation programs such as irrigation scheduling, soil moisture monitoring, lower water intensive crops, strip till and other conservation tillage efforts.
6. Continue the required flow meter program for maintenance and accurate water use. A portion of the flow meter program is the utilization of the District's ultrasonic flow meter to conduct comparison testing throughout the District.
7. Continue to increase awareness of water quality concerns in the region through outreach and public education. Implement water quality testing for private, domestic wells in addition to production wells to gain a better understanding of the changing water quality of the aquifer.
8. Continue to investigate methods of artificial recharge in priority areas.
9. Investigate and develop programs to increase water use efficiency.
10. Continue to work toward long-term sustainability of the local aquifer system by working with local stakeholders and federal and state agencies to develop a holistic approach utilizing the various tools available which include but not limited to:
    a. USDA-NRCS – (CREP, CSP, EQIP, RCPP, Watershed Plan)
    b. KDA–DWR – (IGUCA, WCA, MYFA, Streamflow Augmentation)
    c. KDA-DOC – (CREP, WTAP, RCPP, ITI)
    d. District – (LEMA, Water Right Purchase, RCPP, Watershed Plan)
    e. Central Kansas Water Bank Association – (Deposit / Lease, Savings Account, CAMP)
    f. KCC – (Cathodic Protection Boreholes)
    g. KGS – (AWQUA)
11. Update, maintain and utilize BBGMDMOD to evaluate management changes over time.

The water table in the Great Bend Prairie aquifer fluctuates quite significantly depending on the timescale chosen. Due to the relatively thin saturated thickness of portions of the aquifer, water table changes depicted in feet potentially misrepresents the water availability in some of these regions. Figure 10 and Figure 11 depict the change in aquifer thickness by percent change to account for this variability across two different time scales. Figure 10 shows the percent change in aquifer thickness over the past 80 years. Figure 11 however illustrates the percent change happening in the most recent 20-year time period. An inference from these two figures is that the majority of the total depletion of the aquifer happened over 20 years ago. Meanwhile, portions of the aquifer have also seen positive trends in recent years.

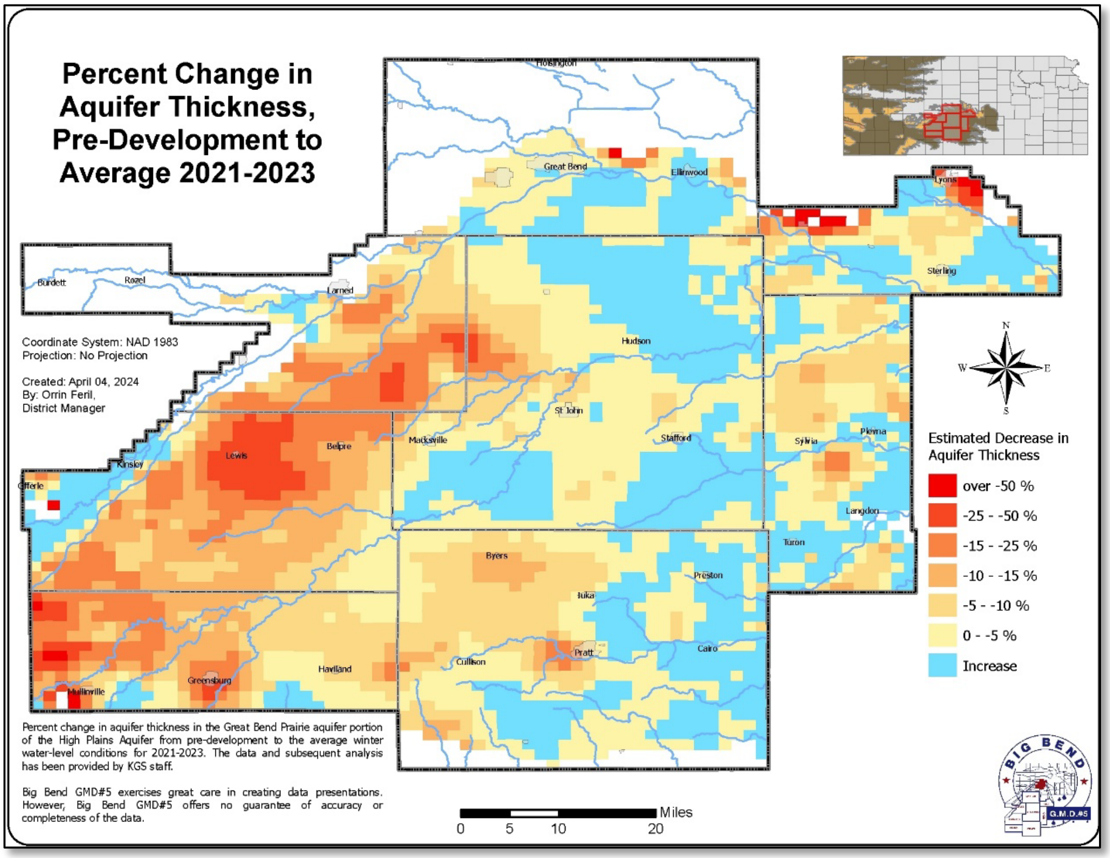

Figure 10 – Percent Change in Aquifer Thickness (Predevelopment – 2022)

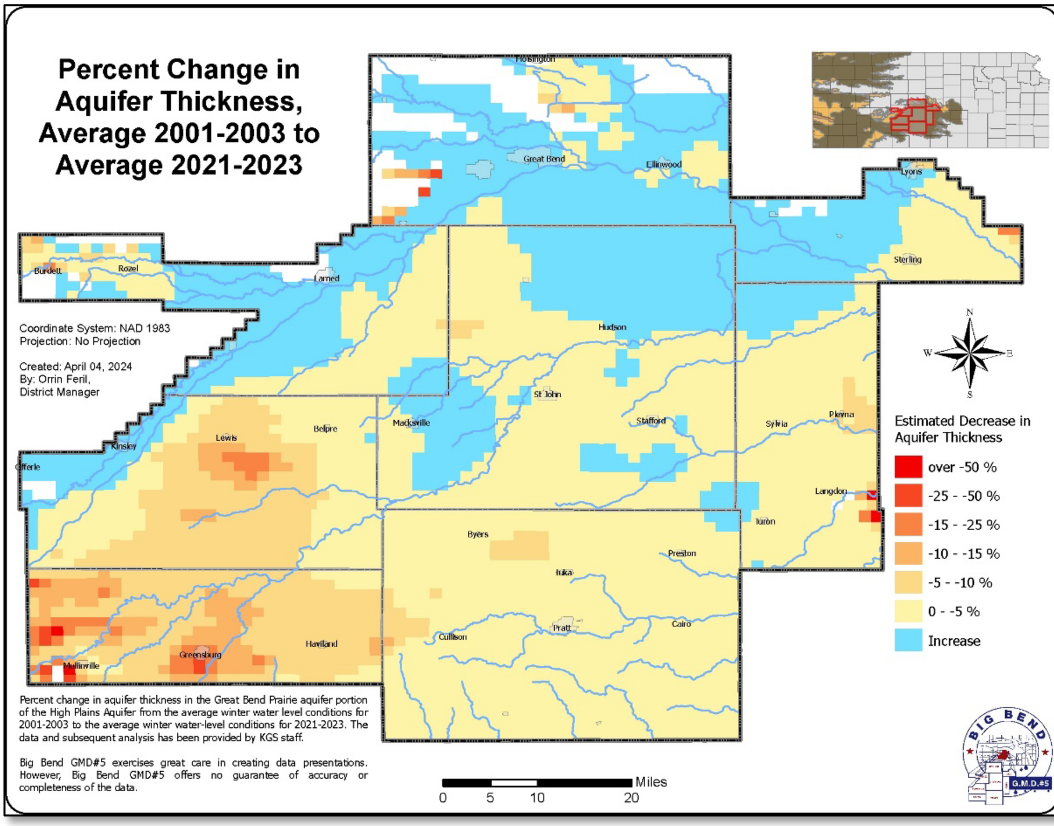

Figure 11 – Percent Change in Aquifer Thickness (2002 – 2022)

The Kansas Geological Survey (KGS) has developed a method to project historic water-level trends into the future and estimate how long the aquifer can continue supplying reliable well yields. By combining the current saturated thickness with the previous ten years of measured water level change, KGS calculates an "Estimated Useable Lifetime" for the aquifer.

This process identifies the minimum aquifer saturated thickness needed to consistently produce 200 gallons per minute from a well. Although, KGS notes that the method is most accurate for the Ogallala portion of the High Plains Aquifer located farther west of the District, it still provides valuable insight into areas that may face reduced well yields over time.

Figure 12 is the Estimated Usable Lifetime map as of 2023. Quarter sections shaded brown have already reached the minimum threshold, which in this region typically occurs along aquifer edges or over higher bedrock elevations.

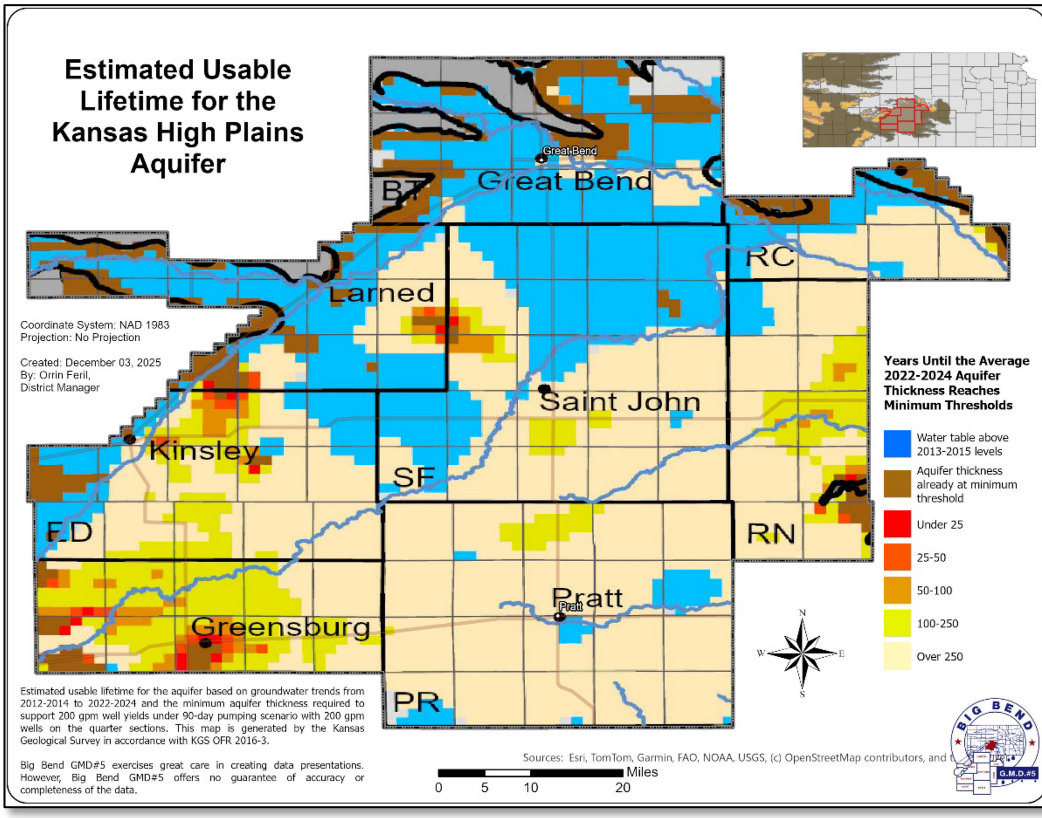

Figure 12 – 2023 Estimated Usable Lifetime

B. Water Quality

The quality of the groundwater resource is certainly as important if not more important than the quantity issue. If the quality of the resource is allowed to deteriorate, then there is no reason for restricting development from a quantity standpoint because the water will be of little value once polluted. It is extremely difficult and costly to reverse pollution once it has occurred thus the basic objective of the District is to take a preventive posture. The problems that already exist and those that will slip through the prevention program must be remedied in an orderly manner. This can best be accomplished at the local level of government, with the support of various state, federal and other local governments. Several quality issues must be dealt with by the District if we are to maintain the good quality water that we presently enjoy.

1. Natural mineral intrusion: Natural degradation of the Pleistocene sand and gravel aquifer occurs in the eastern half of the District due to dissolution of salt from underlying Permian Bedrock units. This natural intrusion has rendered the lower portion of the aquifer unfit due to the high content of sodium chloride. The dividing line between areas of no mineral intrusion and excessive mineral intrusion is approximately parallel with U.S. Highway 281. West of this divide, the Permian units are overlain by shales of Cretaceous age that form a cap that does not allow the saltwater to migrate into the Pleistocene aquifer (Figure 6). Rules and regulations have been developed that address upward movement of the chlorides into the freshwater aquifers.

2. Pollution resulting from oil and gas production: Groundwater pollution from the past and present activities of the oil and gas industry is a major problem in the District in several areas. Disposing of oil field brines in unlined pits is no longer practiced but has created many areas where the groundwater resource is no longer usable. While the District recognizes the tremendous economic benefit gained from this industry, degradation of the groundwater resource cannot be accepted. The District continually works with

landowners and the Kansas Corporation Commission (KCC) to prevent and resolve oil field related problems. This work extends into the enforcement of regulations relating to the installation of boreholes to protect against pipeline corrosion.

3. Pollution resulting from other industrial wastes: There has been extensive pollution created by the salt mining industry in Rice County. The District is currently working with the parties involved and the appropriate agencies to remediate the situation that exists southeast of the City of Lyons. This problem is a prime example of what can happen if problems are allowed to continue unattended. The cleanup cost has been staggering and could have been avoided if proper inspection and maintenance had taken place. The District continues to monitor the pollution situation in Rice County and will assist individual landowners and other entities in the mitigation of industrial wastes.

4. Agrichemical pollution: Farming has evolved over the last several decades to a highly sophisticated industry. This industry uses a wide variety of chemicals in order to maximize crop yield from the available land area. The use of these chemicals presents a potential pollution source and should be evaluated to determine the effects on the groundwater system. In recent years, the District has been monitoring increased nitrate concentrations in the aquifer. Recent studies indicate correlation with fertilizer application rates as being a source for this rise in concentrations (Lane, et al., 2020).

5. Unplugged and improperly constructed water wells: Abandoned water wells that are not properly plugged and improperly constructed water wells represent a possible source of pollution. These create an avenue for a host of contaminants to enter the aquifer. District assistance is available to landowners and other individuals who want information on plugging water wells.

6. Municipal waste lagoons, animal feedlots, and landfills: These sources of potential pollution fall into similar categories. They are currently regulated by the Kansas Department of Health and Environment (KDHE). But the question has arisen as to whether or not the levels of monitoring, inspection, and enforcement by KDHE are adequate to prevent extensive groundwater pollution. Focus efforts by the District to conduct water quality monitoring in areas around public water supplies to assist KDHE in identification of the source for water quality issues.

DISTRICT PROGRAMS

A. Conservation and Efficient application of Water Use

Irrigation scheduling and water conservation programs are actively promoted as a means to reduce consumptive use in the District while minimizing impact on the local economy. With this in mind, the District has established a network of weather stations throughout the area to allow real-time access via the phone or internet to obtain accurate and timely weather data as well as evapotranspiration (ET) or crop water use values on a daily basis (Figure 13). The information from the weather stations is utilized in irrigation scheduling programs. With the installation of the weather station network, the District focuses educational outreach designed for agricultural producers. Other programs are designed to educate District water users in reducing runoff and the reuse of tailwater, water lost to evaporation and deep percolation. The District also promotes new technologies in tillage practices, soil moisture monitoring, less water intensive crops and chemical treatments. Research on the efficient and economical use of water should be encouraged whenever possible. The District works with the appropriate entities on the management of surface water drainage problems. The objective of the District is to reduce long term water use through these programs. A strong educational program must be developed in order to expand the conservation programs and accomplish the objectives outlined.

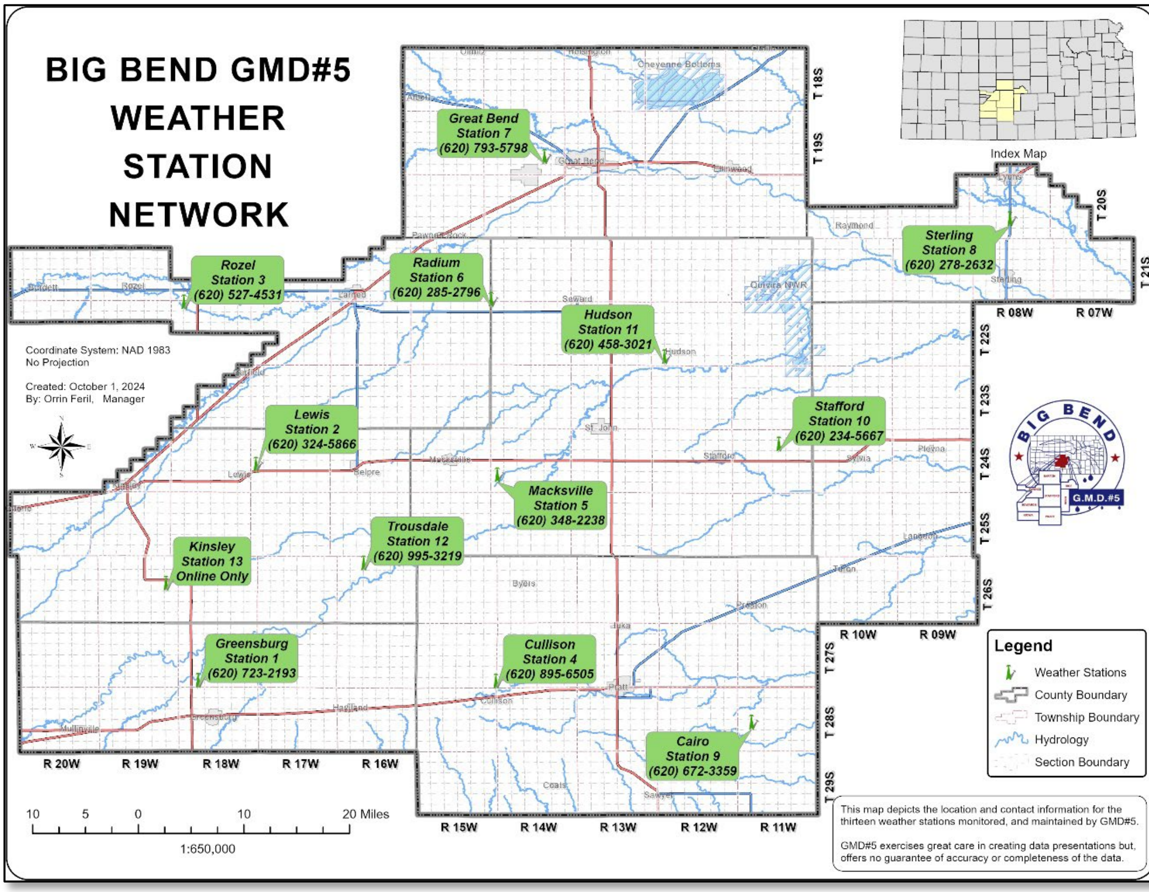

Figure 13 – Weather Station Network

B. Public Education

The District continues to be a source of information for District members in the areas of geology, water rights, water quality, and other water-related issues. The District updates members of yearly activities at the annual meeting as well as through District newsletters, educational seminars, news releases, and social media. Members are encouraged to attend the regular monthly board meetings to voice their concerns. District educational programs should also focus on the area youth to emphasize the importance in the preservation and protection of the resource. Educational programs have been developed and are presented regularly in the area school systems, local civic groups, and agricultural groups. The District actively coordinates with the Great Bend Prairie Regional Advisory Committee (RAC) to address issues throughout the region. The RAC serves an advisory role to the Kansas Water Authority for statewide water policy. Through this coordination with the RAC, the District proactively aids in developing sound water policy.

C. Accurate Data Base/GIS Data Management

The District will continue to maintain a database to include the most accurate information regarding water rights, land ownership, water levels, groundwater withdrawals, water quality, hydrogeologic characteristics, and other pertinent information available. District data collection efforts are enhanced by the various research projects and current programs ongoing in the District, and in return will be utilized in the development of future programs. Documenting reductions in consumptive use through increased irrigation efficiency programs will be necessary to determine water use savings. The District should encourage cooperation and the exchange of data between various federal, state and other local agencies in order to benefit from all available information. An example of an irrigation efficiency program the District has promoted is the Conservation Innovation Grant (CIG) project in coordination with The Nature Conservancy, Kansas State University Research and Extension, WaterPACK and Lee Wheeler Engineering. In this project, participants demonstrated through the proper implementation of technology that water savings of 10 percent or more can be achieved while maintaining crop yield outputs. The lessons learned with the success of the CIG project are helping guide the District and other regions of the state in developing larger projects for conserving water.

D. Continued Research

The District continues to conduct necessary research for a better understanding of the groundwater system of the region. This will enable the formulation of more specific programs to deal with water appropriation and water quality problems.

The District should also undertake evaluation and development of methods to increase groundwater recharge. Groundwater recharge projects may be instrumental in maintaining sustainable yields in the District. The District should conduct research on the interrelationship between surface and groundwater and encourage the study of such relationships by the appropriate state and federal agencies in conjunction with the District. Administrative programs such as water banking, water right purchases, water transfers and multi-year water right programs should continue to be investigated to determine their effectiveness in a management program. Continued evaluation of more efficient irrigation system equipment and technologies is also needed.

In the 1980s KGS and the District partnered to evaluate the chloride concentrations in the portions of the aquifer that experience the natural mineral intrusion from underlying Permian bedrock units. In this project, several well clusters were installed near the township corners of the Eastern half of the District. These well clusters include a deep bedrock well, shallow well, and intermediate wells depending on site-specific lithology. The deep bedrock well was logged using the District's gamma induction probe to identify the interface zone between the fresher upper zone and the brackish regions below.

Building on this foundation, the District should expand the network of township cluster wells throughout the remainder of the District. This expansion would provide better understanding of not only the water quality of the aquifer at various levels below ground but also allow for higher resolution of water quantity monitoring throughout the District.

E. Water Quality

1. Extensive research has been conducted on the natural mineral intrusion areas of the District. The purchase of an electromagnetic induction logging tool to determine the extent of the natural saltwater has greatly enhanced the District’s efforts. The District promulgated regulations requiring observation wells near all new large capacity wells to monitor and prevent the poor-quality water at the base of the aquifer from migrating upward and degrading the freshwater zone in the upper portion of the aquifer. The extensive monitoring well network established by the District and the KGS should continue to be monitored. Continued monitoring will be necessary to determine the movement of the saltwater and effects from groundwater withdrawals.

2. Present oil and gas activities that need to be addressed include routine inspection of brine and crude oil holding facilities to assure proper handling and disposal of waste products; the lining of drilling pits due to sensitive groundwater areas, and the contamination which has already occurred from not using lined or portable pits; the assurance that wells are properly plugged upon abandonment; and the elimination of brine

used in road construction activities. The District is working and will continue to work very aggressively with the KDHE and the KCC to prevent these sources of pollution from becoming major problems.

Research has been conducted to evaluate the impact of injecting oil field brine into the Cedar Hills Formation in relation to the natural mineral intrusion in the eastern half of the District. These injection wells are now being phased out as they become abandoned. The District should continue monitoring of this project because of the hydrologic connection between the Cedar Hills Formation and the freshwater aquifer in the District.

3. Continued monitoring of industrial pollution cases such as the American Salt Plume should take place. Underground storage tanks and other industrial spills are addressed by the KDHE, with most contamination being addressed as each site is discovered. However, steps need to be taken when reviewing proposed permits or potential industrial sites to educate the people about the vulnerability of natural resources. The District's participation in the water quality area will greatly help to resolve problems in the preventive mode before they become major catastrophes.

4. Three major areas concerning agricultural pollution need to be addressed. The first is the proper handling, storage, and disposal of chemicals. The practice of dumping excess chemicals and washing down trucks at the bulk storage facilities located in the District creates very real potential for long term pollution problems. The application of chemicals through the irrigation system is another potential source of pollution. This is being addressed by the chemigation safety law which mandates equipment and procedures to be followed when chemigation is practiced. The third area of concern is what happens to the chemicals after application. This has not been fully dealt with and needs to be evaluated in greater detail. There is currently research being conducted by the state and federal government to try and resolve the many unanswered questions related to the long term application of agrichemicals. The District has cooperated in conducting research into the transport and effect of these chemicals and should continue such research efforts.

5. The District will continue inspections and follow-up of abandoned wells to ensure that they are properly constructed and abandoned to help prevent possible contamination. There should be continued cooperation and support from KDHE to resolve this possible pollution threat.

6. Possible sources of pollution such as landfills, municipal waste lagoons, and animal feedlots should be recognized by the District. The District should continue to offer assistance to these water users in the design and placement of lagoons, landfills and other facilities of this nature.

7. Cathodic protection boreholes have been addressed by the District. Special cathodic protection rules and regulations have been developed and adopted by the KCC for the District that will protect the freshwater resource from the materials used in those drilling activities. Continued coordination with KCC to ensure that the well drillers and industry professionals adhere to the applicable regulatory requirements to protect the sensitive groundwater of the region.

There are many sources of pollution that should be evaluated for potential impacts to the resource. The key is prevention rather than reacting to crisis and attempting remediation because the later process is far too expensive, time consuming, and uncertain. The District should continue to take an aggressive approach to prevent pollution of the groundwater resource from any source.

F. Flow Meter Program:

The District has required the installation of in-line flow meters on all permitted wells in the District and continues to monitor the use of the flow meters to ensure compliance. The District also offers a testing service to check the accuracy of the flow meters. Staff is certified through the KDA–DWR to test the accuracy of the flow meters. The District should continue to work closely with the water users in the District to ensure that the most accurate water use data is being reported. The District will continue to work with KDA–DWR to assist in the completion of accurate water use reports and the development of educational programs to help District water users understand the importance of reporting accurate water use with inline flow meters.

G. Water Rights Administration:

The District, through cooperative efforts with KDA–DWR, shall review all applications to appropriate groundwater for beneficial use, and all changes filed from within the District to ensure compliance with District rules and regulations. The District shall recommend to the chief engineer any actions or additional requirements deemed necessary. The District shall assist water users in water right related issues when requested. The District may develop other criteria that are pertinent to the administration of water rights which do not conflict with the basic laws of the State of Kansas.

Annual Reporting

A. Kansas Legislature:

As enacted in the 2023 legislative session, K.S.A. 82a-1043 requires each Groundwater Management District to prepare and submit an annual report to the Kansas Legislature by January 25 each year. The statute goes on to require the annual reports to be published online following approval by the respective District boards of directors. The District has enacted procedures for compiling this report annually for the Kansas Legislature's review.

B. Kansas Department of Agriculture:

In addition to the reporting requirements to the Kansas Legislature, per K.S.A. 82a-1044, each Groundwater Management District is charged with identifying and setting reasonable boundaries for areas of concern within their respective boundaries. Furthermore, once identified the statute requires the development of an action plan to address these concerns in a reasonable time frame and submit this information to the Chief Engineer of KDA–DWR.

Recently, the Kansas Geological Survey published a technical publication which indicated the District is within 1.6% of sustainable water level fluctuations (Whittemore, Butler, Jr., & Wilson, 2023). This study looks at the average annual water level fluctuations in comparison to the annual withdrawals from the aquifer through well diversions. This does not, however, indicate that there are no issues still to address within the region but rather the goal of long-term sustainability is within reach for the region. In future updates to the District's management program, these areas of concern and associated action plans will be incorporated in the following section.

Areas of Concern and Action Plans

This section of the District's management program is reserved for the areas of concern and associated action plans that are currently being developed by the District board and staff based on input from water right owners in the area.

Bibliography

Balleau Groundwater, Inc. (2010). *Hydrologic Model of Big Bend Groundwater Management District No. 5.* consultant report prepared for Big Bend GMD #5.

Chambers, R. M., Meyerson, L. A., & Saltonstall, K. (1999). Expansion of Phragmites australis into tidal wetlands of North America. *Aquatic Botany*, 261-273.

Dahm, C. N., Cleverly, J. R., Coonrod, J. E., Thibault, J. R., McDonnell, D. E., & Gilroy, D. J. (2002). Evapotranspiration at the land/water interface in a semi-arid drainage basin. *Freshwater Biology 47*, 831-843.

Department of Agriculture. (2007). *Pawnee Valley IGUCA*. Retrieved from Kansas Department of Agriculture - Division of Water Resources: https://www.agriculture.ks.gov/divisions-programs/dwr/managing-kansas-water-resources/intensive-groundwater-use-control-areas/pawnee-valley-iguca

Department of Agriculture. (2021). *Walnut Creek IGUCA*. Retrieved from Kansas Department of Agriculture - Division of Water Resources: https://agriculture.ks.gov/divisions-programs/dwr/managing-kansas-water-resources/intensive-groundwater-use-control-areas/walnut-creek-iguca

Lane, A. D., Kirk, M. F., Whittemore, D. O., Stotler, R., Hildebrand, J., & Feril, O. (2020). Long-term (1970s–2016) changes in groundwater geochemistry in the High Plains aquifer in south-central Kansas, USA. *Hydrogeology Journal*, 491-501.

Lenters, J. D., Cutrell, G. J., Istanbulluoglu, E., Scott, D. T., Herrman, K. S., Irmak, A., & Eisenhauer, D. E. (2011). Seasonal energy and water balance of a Phragmites australis-dominated wetland in the Republican River basin of south-central Nebraska (USA). *Journal of Hydrology*, 19-34.

Mykleby, P. M., Lenters, J. D., Cutrell, G. J., Herrman, K. S., Istanbulluoglu, E., Scott, D. T., . . . Dong, B. (2016). Energy and water balance response of a vegetated wetland to herbicide treatment of invasive Phragmites australis. *Journal of Hydrology*, 290-303.

Shafroth, P. B., Cleverly, J. R., Dudley, T. L., Stuart, J. N., Taylor, J. P., van Riper III, C., & Weeks, E. P. (2005). Control of Tamarix in the western United States: implications for water salvage, wildlife use, and riparian restoration. *Environmental Management 35*, 231-246.

Sophocleous, M. (2004). *Ground-water Recharge and Water Budgets of the Kansas High Plains and Related Aquifers.* Lawrence: Kansas Geological Survey Bulletin 249.

Thornthwaite, C. (1948). An approach toward a rational classification of climate. *Geographical Review, Vol. 38, No. 1*, 55–94.

Townsend, M. A., & Young, D. P. (1995). Factors Affecting Nitrate Concentrations in Ground Water in Stafford County, Kansas. *Current Research in Earth Sciences, no. 238 (January)*, 1-9.

Whittemore, D. O. (1993). *Ground-water Geochemistry in the Mineral Intrusion area of Groundwater Management District No. 5, South-central Kansas.* Lawrence: Kansas Geological Survey.

Whittemore, D. O., Butler, Jr., J. J., & Wilson, B. B. (2023). *2023 Status of the High Plains Aquifer in Kansas.* Lawrence: Kansas Geological Survey.

Zhang, D., Yin, L., & Pan, B. (2002). Biological and ecological characteristics of Tamarix L. and its effect on the ecological environment. *Science in China Series D: Earth Sciences 45*, 18-22.

Revision History

- June 18, 1976 – Initial Management Program Approved
- January 5, 1979 – Revised Management Program Approved
- June 20, 1988 - Revised Management Program Approved
- January 2, 2019 - Revised Management Program Approved