Revised Management Program

Southwest Kansas Groundwater Management District Number 3 (GMD3)

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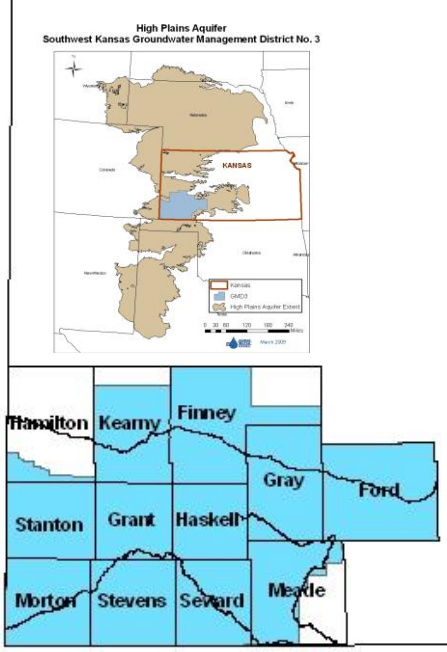
URL: HTTP://www.gmd3.org

DRAFT June 2020

All policy and methods expressed herein are proposed to be adopted for the Southwest Kansas GMD3 management program and used to advise and assist all in the management of water resources for SW Kansas. Other policy documents of GMD3 are posted on the website.



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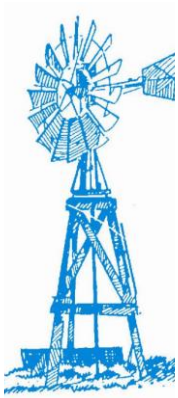

Southwest Kansas Working Water – Conserving Every Day Since 1976

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GMD3 MANAGEMENT PROGRAM EXECUTIVE SUMMARY

This document presents the nature of water supply problems in Southwest Kansas and the thinking for policy and behavior adopted to address them. Implementation of this framework will ultimately enable water users, communities, government, and others to build well-performing plans and make strategic decisions for investments that achieve the vital goal of wise water use. Eight areas of program activity are reviewed with goals to protect and enhance the instrumental and intrinsic values for a shared enjoyment of water resources. They focus on economy, water rights, conservation, river management, outreach, planning, interstate supply, models and water quality.

Cost. Water value is at a premium in southwest Kansas, the driest region in the state. Productive soils, ideal climate for large scale animal agriculture and industry has generated massive local agricultural production and water demand that allows for large investments towards ensuring a reliable water supply. Investments are also necessary to provide for water conservation. The investments come with elements of risk that require management attention. Physical supply realities, water regulation, and the reputation of how water use is viewed by others are all elements of water risk.

Wise decisions. Nearly three million acre-feet of developed annual withdrawal from abundant underground reservoir storage and a lack of sufficient water sources protected or developed to replenish it has created a depleting supply condition and a threatened water-based economy. At present, the annual deficit gap between consumption and replenishment for stable water levels is about 776,000 acre-feet. Significant opportunity exists to develop additional water conservation in our fields and in transient surface water annually leaving Kansas as river flow in amounts eight times what Kansas groundwater consumes each year. We must choose the pathways to our water supply legacy with reasoned foresight, reliable information, and responsible water governance. This can be difficult without good state government partners.

Challenges. Without expedient action, the next generation of western Kansans will not have a sufficient supply of fresh water to sustain current levels of production, economic activity, or way of life. We face a multitude of challenges, including promotion of conservation, elimination of perceived benefits from increased water use, securing an alternative water supply, and altering the administrative process to ensure that water right changes do not increase or sustain current rates of aquifer decline. Program tools include effective water planning and budgeting ahead with an eye two the next generation (25 years).

PURPOSE FOR GROUNDWATER MANAGEMENT, SUMMARY (pages 12 – 13)

GMD3 is an independent, special-purpose, local governmental unit that exists separately from other local governments such as county, municipal, township or school districts, with substantial administrative and fiscal independence to perform a set of governmental functions identified by the Kansas legislature. The legislature established policy where, in the public interest, it is necessary and advisable for groundwater management districts to form and adopt a local groundwater management program to provide the policy framework necessary to address the water supply problems throughout the district. GMD3 works with members and partners to develop and adopt the management program consistent with legislative purposes, local needs, and the public interest.

Public Interest. Under the declarations of the GMD Act (82a-1020 et seq.), the management program document and activities of the elected volunteer governing body of GMD3 (Board) are considered the local expression of public interest relative to groundwater management issues and associated endeavors. The appropriate solutions for the 12-county area of the district depend on

social, economic, hydrologic, and legal conditions. In more than 500 monthly meetings, the Board has identified water supply policy needs and deliberated on the methods appropriate to address them with the assistance of other district members, professional staff, consultants, state officials and other partners.

GMD3 MISSION, OBJECTIVES & PRINCIPLES – SUMMARY (pages 14 – 17)

MISSION: *Act on a shared commitment to conserve and develop water supply to grow the social, economic, and natural resources well-being of the district for current members and future generations in the public interest.*

GMD3 Water Vision. The best management program involves organizing water so that each member has enough and coordinating water sources, supplies and water treatment centers (and other equipment and logistics infrastructure relating to water) so that they work in the best possible way. Water use in the district occurs directly from precipitation or diverted from *waters of the state* according to water rights owned by members and established and administered under Kansas law. For established legal purposes other than produced water associated with oil and gas exploration, water use is supervised in the district under the prescribed duties and powers of the Kansas Department of Agriculture's Chief Engineer and Division of Water Resources (KDA/DWR), assisted and advised by GMD3 to implement the management program.
GMD3 Values. Members find ways to tie their work and life to the Mission and Vision for managing the vital community water resources by aligning their efforts in various ways with five core values: Individual Responsibility, Fairness, Stewardship, Community, and Water risk. Different members emphasize some values more heavily than others. The public interest in the management program recognizes that incentives for conservation and wise water use may also become cultural barriers to conservation if they are not shared or otherwise adequately addressed when implementing the management program. Enforceable policy unique to the district may be enforced by either KDA/DWR or GMD3. The GMD Act provides enumerated authority to GMD3 to advise and assist in all appropriate matters of concern to the district (K.S.A. 82a-1028(m)). GMD3 participation in review of water use proposals for state approval is "advice and assistance in the management" of groundwater in "storage" and "all other appropriate matters of concern to the district."

Economy Preservation and Development Summary (pages 36 – 39)

Water business. The business of water requires an understanding of public and private infrastructure investments and how they play a role in developing economy. We will continue work to protect river and groundwater supply for our agribusiness jobs, municipal water, and other area water benefits. The management program seeks planning for securing water supplies to meet current and future demands. We will utilize cost-effective strategies that assist members in managing water risk by reducing water demand while adding water value. Similar public resource commitments are envisioned for each strategy to accept responsibility and confront water risk by engaging people with the best information for the best course of action.
Business water risk. For business to thrive, members need predictable water risks. All private and public institutions in GMD3 face four forms of water-related risk: 1) declining water supply storage; 2) insufficient replenishment to storage; 3) regulations or lack of regulatory confidence; and 4) reputation in how their water use is viewed by the broader communities and markets. Water value at risk from those four dimensions drive development of coping strategies as land valuation declines along with declining water supply.
Water places. A thriving water-based economy must include public benefits in providing public water places that educate and elevate water awareness and water enjoyment. The management

program advises regional supply systems and institutions to add public water places for improving water awareness and capacity for wise water decisions.

Looking ahead. The federal **High Plains Study** long view to year 2020 should be revisited for new projections with federal assistance in using new data and economic realities to explore the new future of various water management strategies in the public interest of national security, energy, and water.

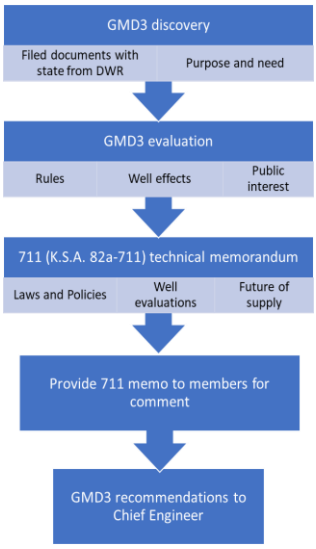
Economy Goals Summary

1. Develop evaluation projects to fulfill the Kansas Water Vision additional supply section and all phases in the *ALLOW FOR THE TRANSFER OF WATER SUPPLIES BETWEEN BASINS WHERE FEASIBLE AND COST EFFECTIVE* to lower future water risk for the district and project partners.
2. Advise and assist local economic development and develop a smart device water management app.
3. Advise and assist business interests and management partners in strategy adoption to address all four elements of water risks and wise water investment.
4. Meet a portion of the agricultural supply/demand gap and seek strategies to develop water places.
5. Seek federal assistance in forward-looking updates to the "High Plains Study" purposes in identifying opportunities to leverage existing natural and constructed infrastructure to add water and energy security and reduce water risk.
6. Investigate floodwater harvesting through a systematic study and design process to capture and convert floodwater and other surface water leaving Kansas to conserve in storage for future supply, drought resiliency, improved ecology, and economic growth.
7. Support work to provide member tools for evaluating opportunity costs and future water risk.

Water Rights Assistance Summary (pages 40 – 50)

GMD3 provides advice and assistance in fulfilling the laws, management objectives and basic use doctrines in decisions affecting member interests and the public interest. GMD3 activities that "*determine [member]destiny with respect to water use*" (K.S.A. 82a-1020) necessarily involve participation in state review for decisions affecting members. For nearly 50 years, GMD3 well evaluations considered allowable groundwater appropriation under adopted constraints of maximum allowable depletion rate under policy that has evolved with new data and model tools for the district. "[A]*ll other matters pertaining to the question*" of public interest under the KWAA (K.S.A. 82a-711(b)(5)) necessarily includes K.S.A. 82a-1020 and the GMD3 management program. GMD3 responds to KDA proposals affecting the district management program (K.S.A. 82a-1906) and approves conservation plans required by the Chief Engineer (K.S.A 82a-733). Water Conservation Areas (WCA) must also meet GMD3 rules and the management program (K.S.A. 82a-745(h).

GMD3 guidelines for evaluation of well drawdown estimates. Property right holders are entitled to seek injunctive relief from possible harm to their property rights. The process that arises when the current uses and conservation of a permanently declining water supply become injured, or supply starts to become unattainable, is addressed in these guidelines. They include a consistent, neutral procedure adopted for well drawdown estimates that provides best evidence to consider well pumping conditions found locally. These guidelines allow all members and officials to identify and consider reasonable water table lowering and critical well conditions. Evaluations for critical wells are considered 711 evaluations (K.S.A. 82a-711). The 711 evaluation is intended to advise and assist members in managing their water risk and serves to expose any objection or appeal of a proposal interposed for an improper purpose. A test period after 2017 when training was provided for DWR staff found a majority of applications met the guidelines and were recommended for approval.



Additional management considerations for advising water right decisions.

A. **Water usability depletion.** A lowering of quality, which depletes usability.

B. **Maximum allowable rate of aquifer depletion.** 40% in 25 years.
C. **Water right priority contribution**. Not claiming priority right is sharing water.
D. **Use of lesser quality water where economically and technologically feasible.**
E. **Member private property agreements in water use.** Agreements between private property right owners can be a method of resolving water supply disputes.
F. **Economy use value.** Favor use-values that grow economy and water value.
G. **Alternate supply.** Water imports or using poor quality water reclaimed to usable.
H. **Improved groundwater inventory data.** Adding data and model estimates.
I. **Flexible use of prior well allocations.** Favored for use efficiency subject to adequate evaluation to avoid adding critical well harm or water right impairment.

Water Rights Assistance Goal Summary

1. Promote free enterprise in acquiring use rights and resolving disputes over available supply.
2. Provide published guidelines for estimating well drawdown effects.
3. Achieve full consideration of the management program and board recommendations by state officials in the conduct of their duties involving the district groundwater resources.
3. Use Conserve-to-Preserve accounting implementing "due consideration" and WCA policy.
4. Further define the bottom of OHP aquifer for local source of supply management.
5. Advise and assist review of water use proposals with best evidence available to identify critical well concerns, lesser quality water options and water risk ahead one generation (25 years).
6. No penalty for member water conservation.
7. Exchange expert evaluations and information among members, partners and GMD3.
8. Seek mutual benefits and good will between members.
9. Encourage investment confidence and intervene as needed to inform and protect public interest.

Water Conservation Activities Summary (pages 51 – 66)

Wise use. Water conservation is not so much about prohibiting or defeating consumption as wise water use.

Water Conservation recognized as two types: Type (1) Use efficiency, which is the amount of valued output per unit of water diverted. And, Type (2) Maintaining aquifer storage, which involves less native storage depletion and importation of renewable water.

Unwise use and waste of water. Increase efforts to discourage unwise water use.

Conserve-to-preserve factor. Used in quantifying and reporting Type (2) water conservation, the conserve-to-preserve factor quantifies the result of an act to preserve future supply. It requires a separation of "non-use" depending on whether or not water was available to pump.

Groundwater Exploration and Protection (GE&P) Act. GMD3 will work with KDHE and other partners implementing the GE&P Act for safe lawful well drilling, data collection and water protection from contamination and wasteful water usability depletion.

Drought resiliency. The management program provides a GMD3 area Drought Resiliency Program based on the stored nature of district water supply available for drought response.

State mandated water conservation plans. Water conservation under Kansas Water Office water conservation plan guidelines focus on type (1) conservation for use efficiency defined as: "*The utilization of cost-effective water use efficiency practices to curtail the waste of water and to ensure that water use does not exceed reasonable needs.*" Many members have state-mandated conservation plans as a condition of water use where GMD3 can provide advice and assistance.

Due consideration for past management or conservation measures. The chief engineer must provide "due consideration" to implemented management and conservation measures when implementing new water right limit programs (K.S.A. 82a-744). GMD3 and the management program will advise and assist the chief engineer in accomplishing this duty.

Rivers flow to groundwater storage. GMD3 will work to protect and enhance recharge due to flood and other river flows for Type (2) water conservation.

Conservation storage in underground pore space. Waters of the state are declared a public good that is dedicated to the use of the people of the state subject to appropriation (K.S.A. 82a-702). Aquifer pore space in geological formations with either natural or artificial recharge potential is a necessary consideration under the public good of groundwater management.

Groundwater conservation preparation for water imports. Available surface water flow exceeding prior rights presents opportunity to preserve transient surface water to the benefit of Kansas. GMD3 will work to develop and organize new capture and water transportation projects utilizing available groundwater reservoir storage for more sustainable drought resiliency.

Additional wells vs. supplemental wells and "chasing water." Additional wells may be necessary to allow a partial sale and change of water right use. Additional wells preserve total pumping capacity, raising concerns for causing increasing the long-term rate of local groundwater depletion. Allowing for **"chasing water"** will eventually deplete the water supply for all. Well testing guidelines will be developed for testing wells and aquifers. A "**standby well"** is a water source security condition under the terms and limits on a lawful primary well, should catastrophic failure occur. A standby well should: 1) meet well spacing from other domestic and primary non-domestic wells; 2) be limited to 60 days of emergency pumping, and 3) be exempt from spacing to its primary well. Standby wells do not create the concern of chasing water that additional wells do.

Targeting designated Groundwater Management Areas (GMA). Management activity to accomplish special private, corporate, or governance purposes uses uniquely targeted tools.

GMD3 Upper Arkansas River IGUCA. The Upper Arkansas River IGUCA was requested by the GMD3 Board in 1984 as a GMA replacement of the requested 1977 moratorium on new appropriations. GMD3 will seek to advise and assist in each IGUCA review.

Corrective control. A corrective control is a type (2) conservation action to improve future supply.

GMD3 LEMA plans. GMD3 staff assist members and partners in developing LEMA plan proposals to be recommended to the GMD3 Board for adoption as a priority GMA with infrastructure development and corrective controls requested for acceptance by the Chief Engineer.

Adopting or changing WCA plans and agreements. GMD3 will encourage Type (2) water conservation corrective controls in a Water Conservation Area (WCA) and avoid adding impairment risk to other member wells to implement water risk mitigation strategies and protect property rights.

Multi-well use flexibility in GMD3. Multi-well use flexibility allows a "stacking" of existing allocations from other wells onto preferred source wells. This may create water risk to nearby member wells and is likely to result in a net increase in future water use. Well evaluation guidelines help to ensure that nearby wells are unlikely to be impaired by increased flexibility. Multi-well use flexibility should be limited to wells with similar production capacities to ensure that water is conserved that otherwise would have been pumped.

Water Conservation Goal Summary

1. Assist all members in evaluating and adapting their existing and proposed water use systems to meet their water supply and risk management needs with feedback on use compared to similar projects.
2. Develop new annual conserve-to-preserve calculation and recording tools with guidelines for use.
3. Advise and assist KDHE in implementing the Groundwater Exploration and Protection (GE&P) Act.
4. Support Type (1) and emphasize Type (2) water conservation.
5. Allow a conserve-to-preserve calculation to be used as an option implementing the MYFA past conservation alternate calculation and seek to update legislation to allow recent appropriations to participate.
6. Evaluate Master Water Manager pilot project to promote the EMAWC (page 53) activity and be an extension of ongoing demonstration programs in the Ogallala High Plains (OHP) Aquifer.
7. Develop policy to advise and assist "due consideration" of past conservation per K.S.A. 82a-744.
8. Protect and enhance surface water flow infrastructure to secure and enhance Type (2) conservation.
9. Maximize conservation storage of surface water and develop criteria for any necessary easements to use aquifer pore space in rock formations under private ownership.

10. Distinguish additional wells for dividing property vs. supplemental wells for more depletion rate.
11. Seek to Have standby wells: 1) meet well spacing from other domestic and primary non-domestic wells; 2) limit to 60 days of emergency pumping, and 3) be exempt from spacing from primary well.
12. Participate to advise and assist in each IGUCA review or revision.
13. Define corrective control as new type (2) water conservation that improve future groundwater supply.
14. Encourage LEMA plan proposals recommended by members that further manage supply with infrastructure development and corrective controls.
15. Emphasize the need for Type (2) water conservation corrective controls in each voluntary WCA.
16. Investigate, develop and update GMD3 water conservation plan guidelines for type (2) conservation.
17. Evaluate WCA multi-well use flexibility wells for members to determine if type (2) conservation will occur without risk of adding unmitigated critical well concerns to supply of prior rights.
18. Apply GMD3 well evaluation guidelines to: 1) manage the stacking of "paper water" from poor wells onto better wells; 2) protect past Type (2) water conservation; and 3) limit new hardship and risk.
19. Encourage policy development to allow conditional appropriation of waters otherwise lost to Kansas for conservation storage or enhanced management.
20. Seek 2016 Legislative Session HB 2059 compromise language as an addition to the KWAA.
21. Develop testing guidelines for additional wells in GMD3 declining aquifer areas.

Ark River Management Summary (pages 67 – 74)

Authority for GMD3 Arkansas (Ark) River Management activities are included in the right declared in the GMD Act and the list of district powers in K.S.A. 82a-1028 in paragraphs (g), (i), (m), (n) and (u).

GMD3 Upper Ark GMA. The portion of the basin above Garden City to the Colorado and Kansas Stateline that includes the IGUCA, ditch service areas, Hamilton County paleo river channel and tributary underflow affecting supply to GMD3 is considered the GMD3 Upper Ark Groundwater Management Area (GMA) under the management program.

GMD3 Lower Ark GMA. The Ark river reach from the Garden City river gage to the east Ford County line and adjacent areas of the IGUCA and tributary system is the GMD3 lower Ark GMA. See page 87 for a map of the Ark River IGUCA and the Upper and Lower Ark GMAs.

Resource crisis from water usability depletion. Water entering Kansas from Colorado via the Arkansas River is of poor quality reducing the value for direct use and contaminating GMD3 groundwater. Water contamination reduces its usability, reducing crop yields and creating public health and welfare concerns.

Managing for pre-compact water right supply. Existing vested rights (pre-1945) and pre-compact (pre-1949) water rights in the GMD3 lower Ark GMA below Garden City are authorized over 200 cubic feet per second (CFS) of water supply. GMD3 recommends no post-compact surface water development in the basin be considered in priority until a minimum 200 CFS at Garden City and flow at Dodge City occurs and pre-compact surface water right calls are satisfied unless an approved pre-compact offset or augmentation is approved.

River navigability for title. Title of the bed and banks of the Arkansas River up to the "normal high-water mark" was granted to Kansas from the federal government at statehood. This measure assumes no alteration by man's activity, which has occurred extensively in the basin and along the normally dry or intermittent Ark River. The normal high-water mark needs further definition for stakeholder clarity on which lands are private and which are public.

Managing GMD3 Ark River GMAs for conservation storage. Records indicate the GMD3 Ark river system can inflow to groundwater storage space about 200,000 acre-feet per month in the district. So, big opportunity exists to supply natural storage infrastructure and provide ecology restoration in the Ark River GMAs with basin imports and enhanced conjunctive surface and groundwater management.

Local leadership. The 2008 Kansas Legislature provided the Western Water Conservation Projects Fund (WWCPF), more than $9 million, to GMD3 fiduciary care to protect the purpose of public funds from legislative budget sweeps, creating an efficient tool implementing Fund purposes. GMD3 will continue the successful program in seeking funding for additional activities outside the general fund to maintain the purposes of the WWCPF and advisory committee.

Ark River Goal Summary

1. Further consider adding Hamilton County Ark River lands to the district managed area.
2. Seek federal and basin states assistance to encourage steps to augment Ark river basin supply shortages and mitigate usability depletion from contaminated river inflows.
3. Continue a 200 CFS measurement at Garden City and flow at Dodge City as the threshold practice for pre-compact rights to advise river basin operations for members in the GMD3 Upper and Lower Ark GMAs, including during wet river conditions and reservoir spills.
4. Propose river management boundaries with assistance of management program partners.
5. Develop the natural storage and ecology restoration opportunities across the Ark River GMAs.
6. Continue pursuing funding options for river projects outside the general fund to extend purposes and success of the WWCPF and advisory committee.
7. Develop water user needs of the state Ark River interstate team and compact administration.
8. Grow river management activity to enhance natural and ditch area infrastructure use and value.
9. Evaluate ongoing Colorado groundwater development and connectivity to Stateline flow.
10. Develop proof-of-concept projects to advise and assist implementing the management program.
11. Facilitate permitting for strip aggregate mining of half of the river channel within managed administrative boundaries to combat harmful river fill and flood risks.

State Water Planning Coordination Summary (pages 76 – 79)

GMD3 identifies water planning, funding needs, and program development, leveraging funds with other local, state and federal partners for coordinated advice and assistance. This includes activity in state water planning that supports both state long term goals (K.S.A. 82a-927) and goals of the management program. Members pay over three times the amount paid to run the district activity annually through various state fees into the State Water Plan Fund. Expenditures of the State Water Plan Fund should utilize performance-based budgeting to aid in implementing the management program.

State Water Planning Goal Summary

1. Seek encouragement and partnerships with the Kansas Water Office, Water Authority and their Regional Advisory Committees (RACs) to meet the needs of the management program and have it recognized in the State Water Plan.
2. Advocate to update the long-term goals and objectives of the legislature, state water plan and district management program funded by a 1/10 cent sales tax dedicated source.
3. Work with RAC members and advisors across the state to enhance understanding of any differing perspectives of common long-term water supply interests and concerns.
4. Work with legislative and other partners to enhance understanding to achieve a consistent and informed perspective on GMD Act implementation.
5. Build partnerships for statewide water transfer systems and cost/risk analysis.
6. Advocate for an interstate water management assistance fund for needed study to inform interstate partnerships to secure a long-term water supply for Kansas.
7. Provide annual state water plan fund project requests and needs to the KWO/KWA.
8. Seek planning and funding support commensurate with funds paid from the district area.
9. Advise and assist in improvements to the Water Plan Fund budgeting process that produces equitable support and encouragement to implementing the GMD3 management program.
10. Plan for use of excess reservoir storage space to meet basin needs, add conservation and increase Kansas supply yields to areas of unmet demand for water.
11. Develop SW Kansas water conservation plan guidelines and accounting tools with KWO.
12. Study improved access to floodwater for reserve storage to mitigate supply risk in the west.

Interstate Water Management Assistance Summary (pages 80 – 81)

Communicating a fact-based mutually beneficial approach will provide system improvements and good will to all basin and aquifer stakeholders and advise and assist government officials in the respective states.

Interstate Water Goal Summary

1. Advise and assist in fulfilling the 2019 legislative resolutions for improved interstate water quality.
2. Develop preferred supply protection policy and practices for the Ark River and paleo-river aquifer, Cimarron River alluvial aquifer and Ogallala/High Plains Aquifer systems.
3. Advise and assist sister state water administration directly and through members and partners.
4. Seek establishment of a Kansas interstate water management account to aid interstate management and communication of renewable supply needs.
5. Provide leadership seeking a multi-year and multi-state cooperative marketing development study.
6. Seek equitable balance in developing new interstate water management tools and agreements.
7. Advise implementation of Public Law 90-537 to include GMD3 needs as the Secretary of the Interior conducts investigations to plan for future western US water needs and reports to congress.

Models, Research and Development Summary (pages 82 - 86)

New effort is required to update analytical and numeric models for use in informative common-sense application of statute and enforceable policy in GMD3.

Models, R & D Goals Summary

1. Update GMD3 area Ogallala/High Plains Aquifer model with a graphical user interface tool.
2. Support partner R&D for tools to help members evaluate opportunities in local renewable-energy to power flexibly scheduled water treatment and ammonia fertilizer production.
3. Work with partners to provide water use feedback and conservation reporting.
4. Collect additional data on hydrology, member test holes, index wells and water conservation.
5. Develop and update economic models and other water value economic tools.
6. Research Water marketing and transfer projects for conservation and importation of supply.
7. Develop practical programs that advise and assist members to optimize their wise water use.
8. Develop GMD3 RCPP participation for enhanced irrigation water management.

Water Quality Protection Assistance Summary (pages 87 – 88)

Water quality is both a water usability interest and a public health, safety, and welfare concern for members. GMD3 will work to efficiently advise and assist other local, state, and federal partners to meet the policy, data, and water usability protection and remediation needs of southwest Kansas. Surface land interests and the activities of the management program seek to protect district water quality while minimizing interference in the infrastructure construction and land use involving water resources, drainage, mining, river system and flood plain management.

Water Quality Goal Summary

1. Evaluate Permian saltwater data and update enforceable rule policy as needed in the GMD3 chloride management area.
2. Assist and advise KDHE bureau of water partners in governance of injection & water wells, public water supplies, permitting & compliance input, and watershed management benefits consistent with the management program.
3. Evaluate water treatment technologies for reuse of low-quality water sources for potential agriculture supply and other value benefits, working with Reclamation and other partners.

4. Evaluate the extent of old well drainage down gravel pack from upper fresh aquifers into deep brackish formations, working with KCC, KGS and other partners.
5. Support efforts of county sanitarians to protect drinking water supply sources.
6. Identify appropriate sanctions for unlicensed and unlawful well construction and use.
7. Evaluate the needs of district members to access a water quality sampling and evaluation network of drinking water wells.
8. Reduce and mitigate district aquifer contamination from tons of uranium and other minerals delivered by Ark River flows from Colorado into aquifers in GMD3.

SOUTHWEST KANSAS MANAGEMENT PROGRAM

I. PURPOSE FOR LOCAL GROUNDWATER MANAGEMENT

Southwest Kansas runs on water. Water has always been the key resource for the prosperity of all. There are other resources which may mean the difference between wealth and poverty, but none is like water as a fundamental necessity for our existence and way of life. Groundwater is the principal reserve of fresh water in Kansas. Abundant groundwater in southwest Kansas historically provided opportunity for extensive development through private investment in infrastructure. Business demand for water flourished. Groundwater levels declined in response, and local wisdom for use and management of groundwater soon became state policy, allowing the will of local servant leadership to address water supply concerns with cooperation and assistance from many partners. Ultimately, all water supply depends on precipitation, storage, and transport to valued beneficial uses. The regional economy has become threatened by use far exceeding recharge, with no plan yet in place to import water to meet demand. Similar challenges associated with water risk have pushed stakeholders and policymakers to further integrate groundwater and surface water strategies in supply projects across Kansas. Examples include Kansas River Aquifer modeling, Wichita Aquifer Storage & Recovery activities, Rattlesnake Creek augmentation for Quivira National Wildlife Refuge, and the Cities of Hays and Russell groundwater transfer project. There is opportunity to preserve the significant remaining storage using importable additional supply with water management and marketing strategies. The future economy of Kansas depends on the planning and brave actions from servant leadership at all levels, including the Board of GMD3 to update and implement a revised district management program.

Formal local advice and assistance. The need for local groundwater management activity to work with state water administration has been formally recognized since 1958 (Cimarron Basin Study). Formal local groundwater policy development and review today occurs through GMD3 to provide consideration of local methods to address water problems. State administration of water in Kansas is mainly divided among four state agencies: Division of Water Resources of the Kansas Department of Agriculture (DWR) with responsibilities for water appropriation, water rights and structures; Bureau of Water of the Kansas Department of Health and Environment (KDHE) with responsibilities for protecting Kansas's land, water, and air from pollution; the Kansas Corporation Commission with responsibilities for oil and gas activity and Wholesale water supply; and the Kansas Water Office and Water Authority (KWO/KWA) with duties of water planning, State Water Plan Storage and Water Assurance from federal reservoirs. Regional Advisory Committees (RACs) have been formed by practice of the KWO/KWA for their purposes. Other state agencies with some role in state water administration include: the Kansas Biological Survey (KBS); the Kansas Department of Wildlife,

Parks and Tourism; the Kansas Geological Survey; Kansas State University Research and Extension; the KDA Division of Conservation; the Secretary of State, the Attorney General's Office and the Kansas Department of Commerce.

Necessity of local groundwater government. The state legislature identified several purposes for groundwater management districts that include public decisions affecting economy and management that considers the conservation of groundwater resources, the prevention of economic deterioration, stabilization of agriculture, and security of fertile soils and favorable location with respect to national and world markets. The legislature provided authority to GMDs to adopt and enforce local groundwater policy. However, this local control right was modified by the legislature in 1999 to favor coordinated and transparent rulemaking by the chief engineer and by GMDs using the duties and powers granted to each water related state official.

Groundwater governance can be difficult for many reasons that include:

1. Groundwater is a shared resource.
2. Groundwater inflows and outflows are difficult to observe and cannot be measured directly.
3. Surface water and groundwater are interconnected.
4. Groundwater reservoir boundaries and characteristics may be locally unknown or poorly defined.
5. Groundwater management requires specialized model tools.
6. Groundwater conditions can vary on multiple time scales.
7. Groundwater use can pit present needs against future needs, especially in declining groundwater reservoir supply.
8. Diverse local, state, and federal interests, institutions and authorities require significant coordination activity for productive partnerships.

II. GMD3 MISSION, OBJECTIVES & PRINCIPLES

MISSION: Act on a shared commitment to conserve and develop water supply to grow the social, economic, and natural resources well-being of current members and future generations in the public interest.

GMD3 Water Vision. Good water management for Kansas ensures that each present and future member has ample supply through coordination of available water supplies, water treatment centers (and other equipment and logistics infrastructure relating to water) and funding to so that they work together in the best way. As a general principle, sentiment to discourage unwise water use increases as supplies dwindle and management information becomes more readily available. Innovation and technology are delivering help in meaningful ways. In western states like Kansas, water scarcity and the negative impact of reduced use on the economy will heighten the importance of waste reduction over time. It is important to accompany reduction in waste with reduction in use because inefficient use returns more water to the aquifer than efficient use. Under the doctrine of beneficial use, all water use must be for a beneficial purpose and tied to a reasonable need without waste. *Waters of the state* are dedicated for beneficial use by the people of Kansas for the highest public benefit and maximum economic development.

The GMD Act and "the right" to manage groundwater use. In that statute, the legislature set two elements of policy in law for groundwater management: *"…to preserve basic water use doctrine and to establish the right of local water users to determine their destiny with respect to*

the use of the groundwater insofar as it does not conflict with the basic laws and policies of the state of Kansas." In practice, to adopt and enforce policy independent of state officials, this right has had legal effect confined to what unelected state agency officials may allow under discretionary powers.

Members. A GMD3 member is an eligible voter described in K.S.A. 82a-1021(a)(5). most domestic well users in the district annually use at least one acre-foot (325,851 gallons) of groundwater and are therefore considered eligible voters of the district. A person must be a member of the District to be eligible to serve on the governing body of the District.

Local Groundwater Government. The GMD3 management program identifies problems creating water risk and sets goals and methods to address them through local policy and tools. This program is not intended to interfere with the lawful exercise of water rights. Instead, this program provides a means to advise and assist members and water officials in creating and regulating water laws and policies that best meet the local interests. The governing body (Board) of GMD3 works to build upon more than 45 years of formal local action and practices to maximize the benefits of the remaining water supply. Accordingly, this document serves as a written report of the characteristics of the district and the methods for dealing with groundwater supply problems in southwest Kansas. It describes the district area, goals, and current practices and strategies to manage groundwater use in the district. Moreover, this guidance document is not intended and should not be interpreted to limit any actions undertaken by GMD3 or options that may be considered or adopted by the governing body in future proceedings. This document will be modified by the board over time as warranted. Additional documentation of program tools, planning coordination, program guidelines, strategic agreements and partner grant assistance will also be publicly considered. GMD3 will recommend district rule reform to the Chief Engineer under the Kansas Water Appropriation Act (KWAA) , or to other state officials as needed to meet the goals that address problems identified herein described.

GMD3 Powers. To accomplish this purpose, GMD3 is granted an enumerated set of powers to carry out its purposes in K.S.A. 82a-1028. Among them include (with letter corresponding to their place on the list): (d) employ legal and technical services as needed; (e) purchase and hold land and water rights; (g) construct, operate and maintain works related to transporting, storage, and drainage of water; (h) levy water user charges and land assessments; issue bonds; (i) contract with persons firms, other government agencies; (k) construct and establish research and demonstration projects and share research data and information; (l) install and require meters; (m) provide advice and assistance in the management of drainage problems, storage, groundwater recharge, surface water management, and all other appropriate matters of concern to the district(emphasis added); (o & p) recommend to state officials rules and regulations to be adopted for the district; (q) assist in the enforcement of regulations; and (t) seek and accept grants. In addition, other powers include without limit: initiate IGUCA and LEMA proceedings and approve state required water conservation plans.

Core Values that guide the management program. Members of GMD3 find ways to tie their work and life to a worthy mission and vision in alignment with core values. GMD3 core values are exhibited in the members' approach to wise water use and incentives for groundwater conservation by balancing between five competing water values in no particular order (adapted from S Lauer, Social Aspects of Groundwater Conservation, 2020):

- Water risk – Members recognize water risk is a basic part of their property, their estates, their homes, family farms, and water dependent projects.

- Individual Responsibility - Members desire the ability to make their own water project decisions based on what they believe is best for their operations and families.
- Fairness - Members desire that the benefits and sacrifices involved in water management are equitably distributed.
- Stewardship - Members desire to preserve the benefits of groundwater for future generations.
- Community - Members desire to have good relationships with their neighbors and to have functioning towns with schools, hospitals, churches, and businesses.

Individual members emphasize some values more heavily than others. Incentives for water conservation may also become cultural barriers to water conservation if value incentives are not shared or sufficiently valued in the public interest of the implementation of the adopted management program. For example, individual responsibility may be weighed more significant than stewardship or community if it appears the dominant cultural value is individual responsibility and there is an absence of other values in public discourse or in administrative reviews for decision. *Water risk* is a value concern addressed further in the Economic Preservation and Development Activities section of this document.

Objectives of the legislature for GMDs (GMD Act):

1. Proper management of the groundwater resources of the state.
2. Conservation of groundwater resources.
3. Prevention of economic deterioration.
4. Associated endeavors within the state of Kansas through the stabilization of agriculture.
5. To secure for Kansas the benefit of its fertile soils and favorable location with respect to national and world markets.

Purposes for which GMD3 was organized in 1976:

1. Organize and develop the efforts of the entire Groundwater Management District for the proper management and conservation of its groundwater resources.
2. Provide local input into the use and management of groundwater.
3. Provide for the greatest total social and economic benefits from the development, use, and management of groundwater.
4. Support research and education concerning proper water management.
5. Work cooperatively with all federal, state, and local units of government to accomplish the objectives of the district and the GMD Act and amendments thereto.

GMD3 Management Program Guiding Principles:

1. Represent member interests (eligible voters) for water management purposes.
2. Use best data and information properly applied to manage water risk.
3. Protect each member's ability to make independent decisions about managing their project water supply.
4. Protect neighbors from infringement of their water rights.

5. Manage conflict to avoid litigation where possible.
6. Encourage higher value water uses (Type 1 conservation).
7. Slow and replace groundwater depletion (Type 2 conservation).
8. Give preference to voluntary conservation actions over local regulations and local regulations over state or federal regulations.
9. Advocate for free market mechanisms when addressing water supply needs.
10. Intervene as needed to steer the course for implementing the management program.

III. ORGANIZATIONAL HISTORY OF THE DISTRICT

Lead from local need. In the 1960s, good, creative, local problem-solving folks saw that unregulated groundwater use was hastening the decline of local water supplies. Mandatory permitting for all non-domestic uses was not provisioned in Kansas law until 1978. These local leaders insisted on the adoption of mandatory standards, registration of groundwater water rights, available supply and use limits, minimum well spacing, and special management area authority to protect local interests through managed groundwater depletion. Good state and local action followed.

Steering committee. Through local advocacy and the passage of the GMD Act, a series of informational meetings were sponsored by the Southwest Kansas Irrigation Association in the fall of 1973 to determine the will of the people relative to the formation of a local groundwater management district, also commonly referred to as a GMD. A steering committee was formed to carry out the organization of the GMD according to procedures provided in the GMD Act. On December 4, 1974, the steering committee filed a declaration of intent, along with a map of the proposed district to the secretary of state, who accepted it and passed it to the Chief Engineer for technical determinations. On August 25, 1975, the Chief Engineer issued a report that certified the description of the lands proposed to be included in the third such special district of the State with the official name *Southwest Kansas Groundwater Management District Number Three* and found that the public interest would be served by the creation of the proposed district.

Public Process. A public vote to form the district was held on February 24, 1976, following approval of the petition and the issuance of a report by the Chief Engineer. The vote resulted in 1,155 voters in favor and 230 opposed. The Secretary of State was compelled by the results to issue a Certificate of Incorporation on March 23, 1976. The Certificate of Incorporation has been filed at each county's Register of Deeds Office that is located within the district. An organizational meeting to elect the initial Board of Directors was held in Garden City, Kansas on April 6, 1976. The second Annual Meeting was held March 23, 1977 and now all annual meetings are held on the second Wednesday of March unless appropriately changed with notice.

Governing body. GMD3 is governed by a 15-member volunteer Board of Directors that is elected by a general constituency of qualified voters. Each county is represented on the Board by one director residing in that county. Any type of "water user", as defined in K.S.A. 82a-1021(k), may be elected to serve as one of the 12 county positions. There are also 3 "at-large" Board positions that are designated to represent that single type of water usage. These "at-large" water use types include Municipal, Surface water, and Industrial use. All qualified voters of the GMD present at an annual meeting may vote on each position up for election.

District financing. GMD3 activity is financed by an annual land assessment and groundwater user fee that is levied against the landowners and water users in the district. This is accomplished through an annual budgeting process that includes a review of the GMD3 financial status, management program, and draft budget for the ensuing year at the annual meeting. A public hearing of the proposed budget and level of assessments to finance the budget is also conducted annually with notice (usually in July). For 2017 through 2020, the land assessment has been $0.05 per acre and the water withdrawal or "user" fee has been $0.14 per acre-foot. Assessments are subject to change without updates to this management program document. If needed, debt funding through use of bonds is also authorized for infrastructure improvements. Groundwater User fees are generally certified to the tract of land containing the well. A verified claim of less water use may be filed annually by April 1st to alter the quantity used to calculate a parcel water user fee later that year (K.S.A. 82a-1030). Contact the GMD3 office for any questions on district exemptions and assessments.

County	Total Assessable Acres	Assessed Acres	Excluded Acres	Wells	Authorized Acre Feet
Finney	625,637.27	624,438.81	1,198.46	1,085	581,233.00
Ford	662,719.10	662,006.70	712.40	660	200,531.00
Grant	357,715.95	357,570.35	145.60	642	328,266.00
Gray	536,554.15	536,063.78	490.37	1,303	420,880.00
Hamilton	71,209.95	71,209.95	0.00	73	40,871.00
Haskell	359,790.37	359,696.36	94.01	907	461,581.00
Kearny	449,230.77	448,767.60	463.17	494	233,298.00
Meade	399,646.59	399,449.21	197.38	553	278,636.00
Morton	481,659.65	481,414.11	245.54	307	129,058.00
Seward	381,891.63	381,566.10	325.53	501	281,904.00
Stanton	439,975.96	439,848.76	127.20	625	333,354.00
Stevens	467,219.07	467,018.89	200.18	705	383,949.00
GMD3 totals	**5,233,250.46**	**5,229,050.62**	**4,199.84**	**7,855**	**3,673,561.00**

Table 1 - Eligible land for assessment and appropriations for a water user fee

All information is from GMD3 2018 assessments. Wells are those with permanent non-domestic water rights. Other uses occur from temporary wells or those used for domestic purposes that can be assessed subject to board resolution. Numbers are subject to change. Completed 9-4-2018.

Gifting to the southwest Kansas water community. Charitable contributions supporting the public water conservation work of GMD3 are tax-deductible under section 170(c)(1) of the federal Internal Revenue Code if made for a public purpose. This includes uncompensated private expenses incurred by elected board members in the conduct of their official duties. Partnerships with persons, foundations and other non-government organizations are welcomed and considered by the Board of GMD3.

Home office. The GMD3 office is in Garden City, Kansas. The Board conducts regular monthly business meetings. An annual meeting of the membership and partners is held for the election of Board members on the same day as the regular March Board meeting. Public hearings are regularly conducted by the Board or conducted by others on district matters where GMD3 is a participant, to allow input on the budget, management program activities, and other pertinent public interest activities for the district. A set of bylaws has been adopted that are revised at

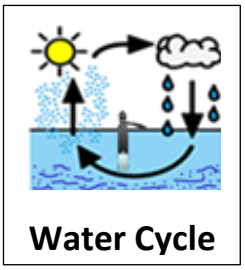
annual meetings when necessary. All Board of Directors meetings and any portion thereof are open to the public, except for executive session meetings, as prescribed by K.S.A. 75-4319. Committee meetings are generally of four or fewer board members and are also public meetings. Please complete a meeting notice form if you wish to be notified of Board of Directors meetings, hearings, work sessions or other open board business meetings. Notice forms may be obtained by contacting GMD3.

GMD3 working committees and advisory groups. GMD3 Board members are annually appointed by the Board president to serve on at least one sub-committee of the governing body. Each Board committee addresses issues on an as-needed basis. The Board committees include:

Executive
Policy and Legal
Finance
Research and Development
Renewable Supplies; and
Annual Meeting/Nominations.

In addition to formal Board committees, there are special project committees appointed or required by partner contract or other management activity. For example, the Western Water Conservation Projects Fund Advisory Committee. See: http://www.gmd3.org/about/special-meetings-and-committees/

III. CHARACTERISTICS OF THE DISTRICT



General Area Characteristics. The district area is approximately 5,338,334 acres, or approximately 8,341 square miles of land. This includes all of Morton, Stevens, Seward, Stanton, Grant, Haskell, Gray, and Ford Counties as well as parts of Meade, Finney, Kearny, and Hamilton Counties in the southwest part of Kansas and the west central part of the Great Plains region of the United States. The district is closed to most new appropriations from the Ogallala/High Plains (OHP) Aquifer. Projects must change existing rights to meet new use needs.

Number of counties served by GMD3	12
Number of non-domestic water rights	12,500
Authorized annual use	3.6 million acre-feet
Average annual use	1.8 million acre-feet
Average annual recharge from precipitation	210,000 acre-feet
Average net annual lateral groundwater reservoir inflow/outflow balance	+6,000 acre-feet gain
Average annual return flow recharge (13%)	234,000 acre-feet returned
Irrigation-enhanced precipitation recharge, inflows from Dakota, streamflow capture.	622,000 acre-feet gained or returned
Average annual net reduction in storage	**776,000 acre-feet**
Estimated max. allowed annual use to avoid 40% depletion in 25 Years (40/25 rule)	1,732,832 acre-feet

Table 2 - General water budget for GMD3.

See *KGS Water Level Change image* and *Isolating High Plains Aquifer Change* in Appendix.

Values are GMD3 gross estimates from KGS models. Model updates will improve estimates and will be referenced as they become available. Local data will vary significantly from averages.

Physiographic Region. The district portion of the US Southern High Plains is flat to rolling cropland with only a few streams; it is the driest region of Kansas. The natural vegetation includes shortgrass prairie: blue grama, buffalograss, and scattered, isolated sites with alkali sacaton, western wheatgrass, and inland saltgrass. Wildlife includes: pronghorn antelope, mule and whitetail deer, lesser prairie chicken, prairie rattlesnakes, plains leopard frogs, ornate box turtle, spadefoot toads, and Woodhouse's toads, with significant populations of coyote, fox, cottontail rabbit, black-tailed jackrabbit hare, pheasant, blue quail and bobwhite quail. Forbs also occur such as: three-foot-tall sand sagebrush, scarlet gaura, field goosefeet, scarlet globemallow, & wild begonia. Forbs such as asterand and field crops are the main food source for deer and pronghorn antelope. Sandsage prairie is a smaller area of rolling sand plains laying mainly south along the Arkansas River. It has been predominantly developed into pivot irrigation fields and rangeland, but the historic vegetation is sand sagebrush, sand bluestem, prairie sandreed, and little bluestem.

Source Water. Precipitation is generally the lowest in the state with average annual measurements of 15 to 18 inches and as little as 4 inches (2011 Morton County). There is only one surface water reservoir in the district not sustained from groundwater pumping, which is the privately owned Lake McKinney on the Great Eastern Ditch Irrigation System. Groundwater is the primary source of water supply. The most common local source of fresh water for thousands of district wells is the Ogallala/ High Plains (OHP) Aquifer. The water comes from drainage of pores in the rock and sediments at or below the water table. The OHP Aquifer sedimentary rocks include saturated stream-deposited alluvial sands and gravel sitting atop the unconsolidated, unconfined Ogallala Formation. Older, less permeable, finer grained Oligocene deposits and an unconfined hydraulically connected sub-cropping Dakota Aquifer System of Dakota sandstone, Kiowa shale and Cheyanne sandstone formations, which is commonly referred together as the Dakota Aquifer System or "Dakota Aquifer," rests below the Ogallala Formation. A key marker bed adopted for the GMD3 management program is the Cretaceous age black marine shale bed known as the Graneros shale. It is about 20 feet thick or less and readily identifiable in drillers' logs where it exists stratigraphically atop the Dakota Aquifer system except where it sub-crops along a meandering line roughly east-west across the district and generally below the Arkansas River where the Dakota Aquifer system sub-crops directly into, and is considered part of, the OHP Aquifer locally. North of the sub-crop line, the Dakota Aquifer is considered under confined aquifer conditions and therefore a separate groundwater reservoir source from the OHP aquifer system. In comparison to the thousands of wells completed in the OHP Aquifer system, less than 100 non-domestic wells are authorized to tap into the confined Dakota Aquifer groundwater reservoir capped by the black Graneros shall formation. The characteristics of these groundwater reservoirs can vary dramatically at points throughout the district and recharge areas that extend west of the district at higher elevations in southeast Colorado. Additional development in these areas of Colorado are likely reducing Dakota Groundwater reservoir supply to GMD3 over time.

Water quality. The quality (or usability) of the groundwater in the OHP and Dakota Aquifer groundwater reservoirs is generally fresh. Some areas are experiencing deteriorated water quality such as high concentrations of chloride and sulfate salts that could result in lowered crop productivity, lowered crop yield, and degraded topsoil. Electrical conductivity (EC) is used as a general measure of the chemical quality of irrigation water (see below for brief definition). Low

EC measurement is generally desirable for agricultural irrigation use because it indicates a low salt content of the water. In some locations, mineralization, including radionuclide levels, exceed recommended limits or maximum contaminant levels (MCLs) for drinking water established by the US Environmental Protection Agency (EPA). Poor quality sources can contaminate and deplete usability of existing stored fresh water supplies. River flows are declining in both quality and quantity, and poor-quality water moving into declining fresh groundwater reservoirs further reduce water usability as a supply depletion factor.

Groundwater reservoir thickness. The remaining saturated thickness of the principle OHP groundwater reservoir system ranges from 20 feet to 600 feet within the district, with significant variability in the productive portions. Thus, well capacities range from a few gallons per minute (gpm) to 3,000 gpm. Historic depletion of saturated thickness locally also varies spatially across the district as documented in the Kansas Geological Survey (KGS) High Plains Aquifer Atlas. A 2010 computer model of the GMD3 area indicates that groundwater pumping caused a nearly 30% decrease in groundwater reservoir storage from pre-development to 2007, for an average water level decline of roughly 70 feet, which equates to roughly 10 feet of actual water removed from the pore spaces of the productive portions of the area groundwater reservoir. The resulting groundwater level declines have ended the groundwater storage discharging to most streams, resulting in low to no stream flows (2014 draft Kansas Water Plan) and conservation of remaining groundwater reservoir storage and streamflow sources of supply. The dewatered groundwater reservoir space provides available storage capacity for about 63 million acre-feet (KGS model for GMD3). Due to large portions of an aquifer formation having low to no practical yield to a constructed well, saturated thickness data may not provide a good indication of practical water supply. Examples exist in the district where a well located within a half mile from a productive irrigation well may struggle to provide sufficient water for domestic use. The present GMD3 groundwater model has been found to overestimate practical supply in storage for the district. An update project is planned for 2021.

River and stream groundwater resources. The Arkansas (Ark) River flows from Colorado, into Kansas and the district. It is the only water course with constant inflow into southwest Kansas. The Ark River is highly regulated upstream of the district and all flows are consumed either as deliveries to fields under surface water irrigation water rights or as inflows to declining underground reservoirs in the district. Flow across the lower portion of the Ark river basin in GMD3 (also known as the GMD3 lower Ark GMA) has become a rare event as development of basin water resources in both states occurred over time. For the intermittent river and stream segments in the district, flows occur as pulse flow from precipitation runoff events that service alluvial aquifers and the Ogallala/High Plains groundwater reservoir as conservation storage. Pulse flows are an important and declining historical source of water supply to member water rights in the district.

The Ark River Basin. Headwaters of the Ark River are in the Rocky Mountains above Leadville, Colorado. Fed by mountain tributaries on both the east and west slopes, the River supports reservoir storage, front range municipal demands and agriculture in Eastern Colorado before flowing into Kansas and the GMD3 area. Significant changes in the basin water resource system upstream have created mounting management and supply concerns all along the basin that include very low-quality river water deep percolating into the subsurface, replenishing and contaminating the groundwater. The increasingly contaminated nature of the water delivered to Kansas has reduced its usability over time, reducing crop yields and creating a drinking water crisis of public health and safety.

Ark River interstate litigation history. Kansas has contended that agricultural development demands for irrigation and other use development upstream in Eastern Colorado have depleted water coming into Kansas to the extent that irreparable injury has been done, particularly to the agricultural interests in the western part of the state. The State of Kansas and Kansas ditch companies (holders of senior surface water rights) above Garden City sued the State of Colorado and ended up before the United States Supreme Court several times. In the first half of the last century, two actions brought before the United States Supreme Court were resolved in Colorado's favor. The two states formed the Arkansas River Compact in 1948 to resolve ongoing disputes over water, particularly after the federal construction of the John Martin Reservoir in Colorado in 1946. A key purpose of the Arkansas River Compact was to resolve water disputes between Kansas and Colorado and divide the waters of the Arkansas River basin. The minimum standard concept of agreement is to preserve status quo delivery to Kansas in "usable Stateline flows" as of 1948. Pueblo and Trinidad Reservoirs were built after the compact agreement. As a result of a 1985 Kansas complaint accepted by the Supreme Court and two decades of litigation, Colorado was found to have violated the compact by unlawfully withholding over 400,000 acre-feet of water due to well development and unreplaced pumping in the basin after 1948. Settlement and damage awards of over $34 million occurred in 2006. Nothing concerning the administration of the compact or settlement agreements have addressed water quality to date. Colorado contends the compact is a water quantity agreement only. Local Kansans disagree.

GMD3 Ark River. There are six surface water irrigation ditch systems today that have historically diverted water from the Arkansas River between the Colorado-Kansas Stateline and Garden City. Collectively, these irrigation ditch companies owned by farmer-shareholders control approximately 140,000 acre-feet of senior surface water rights from available Arkansas River flows governed by a federal court decree, vested rights, and an interstate river basin compact. Surface water rights historically developed below Garden City have lost historical supply flows and now rarely receive any river flow for use. Lands below Garden City historically irrigated from surface water now rely on groundwater sources. The GMD3 management program has adopted historical practices for management of flows at the Garden City river gage and management program activities for both above and below the gage as the GMD3 Upper and Lower Ark GMA's respectively. Additional geohydrology information can be found at: http://www.kgs.ku.edu/Hydro/UARC/index.html

Interstate compacts. Both the Arkansas River and the Cimarron River sub-basin water systems (including Crooked Creek) are associated with interstate compact agreements that are both state and federal law. Each establishes an interstate administrative body with water management purposes consistent with the authorities established by each compact agreement. See compacts map in Appendix.

Colorado and Kansas Arkansas River Compact. The 1948 Colorado and Kansas Arkansas River Compact relates to the waters of the Arkansas River drainage basin primarily above Dodge City to apportion the benefits of John Martin Reservoir and to protect the usability of the basin Stateline flows available at the time of the compact. The compact is administered by an interstate administrative agency called the Colorado-Kansas Arkansas River Compact Administration (ARCA). More information is available at: https://www.co-ks-arkansasrivercompactadmin.org/

Kansas and Oklahoma Arkansas River Compact. The 1966 Kansas and Oklahoma Arkansas River Compact limits new conservation storage capacity or water transfer amounts for each state in six major topographic sub-basins tributary to the Arkansas River basin from Wichita, Kansas to

the confluence with the Arkansas River Mainstem in Oklahoma that together span the entire southern border of Kansas. The Cimarron River sub-basin, that includes Crooked Creek drainage, directly relates to the district as an upstream area. The compact also pledges cooperation between the states in man-made pollution abatements. The Kansas – Oklahoma Arkansas River Commission is the interstate administrative agency that operates this compact, and more information can be found online at: https://agriculture.ks.gov/divisions-programs/dwr/interstate-rivers-and-compacts/kansas-oklahoma-arkansas-river-compact.

Cimarron River Basin. Natural pulse flows from precipitation runoff events are identified historically in the hydrologic record and literature. These pulse flows should be protected and managed under the management program to assure continued groundwater recharge as an important renewable supply to GMD3 member water rights. The exception is an approximately 20-mile reach of the Cimarron River below Highway 54 east of Liberal, Kansas, where the river normally has base flow from upper Permian natural salt springs as flow leaves the district and the state after crossing southeast Seward and Meade counties. Cimarron River flows entering Kansas in Morton County and exiting Kansas from Meade County have decreased in quantity and quality over time. Cimarron River water entering Kansas has high sulfate concentration, whereas Cimarron River flow in southern Meade County has high chloride concentration. River salinity in Morton County has increased and in Meade County has increased substantially over time. Decreased flow of the river entering Morton County is mainly due to irrigation use in Colorado, Oklahoma, and New Mexico, although phreatophyte water consumption also contributes. Decreased flow and increased salinity of the river in Meade County is mainly from decline of fresh ground water from the High Plains groundwater reservoir that dilutes discharge of natural saline water from Permian bedrock, with some impact from phreatophyte water consumption. More geohydrology information on the Cimarron basin can be found at:
http://www.kgs.ku.edu/Hydro/Publications/2005/OFR05_26/OFR2005_26.pdf
And http://www.kgs.ku.edu/Hydro/Publications/2005/OFR05_27/index.html

Pawnee River Basin. Portions of the headwaters of tributaries to the Pawnee River system are in eastern Finney, northeastern Gray, and northern Ford Counties of GMD3. Some spring discharge from the base of thin Ogallala deposits and precipitation runoff events provide public recreation and other services at Horse Thief Reservoir on Buckner Creek in Hodgeman County and other surface structures in the basin. A portion of Hodgeman County was originally included in the district. Controversy over water flowmeters mandated by the governing body of GMD3 drove an organized objection and request in that area to leave the district. The GMD3 Board agreed to an exclusion petition that resulted in the loss of district services in Hodgeman County. The alluvial groundwater reservoirs of these headwaters contain some local water supply. However, projected yields are too small to be a significant water source to meet district demands for water.

Water supply decline. For the district OHP groundwater reservoir, the maximum allowable rate of depletion adopted for the district has been a maximum allowable 40% in 25 years. Figures from the 2008 GMD3 groundwater model indicate an overall decline in supply exceeding 30% since pre-development (50 years) conditions. However, that estimate is considered short of actual depletion based on observed well yield declines and discrepancies in the projected estimates to be improved under model updates scheduled for 2021. The district area is generally blessed with available high-quality groundwater and has some of the highest-intensity groundwater use areas in the country. Total annual use in GMD3 nears half of all groundwater use in Kansas. When combined with low groundwater recharge from rainfall and inflow from outside the district, The gap between consumption demand and replenishment supply has created a deficit of about

776,000 acre feet and large declines in water storage that will not recover nor sustain present use levels without new sources of water. Though declining, the OHP groundwater reservoir provides for the most productive agriculture region for Kansas. Technology improvements adopted for use efficiency add value to the supply and maintain the economy as supply declines reduce water availability.

Domestic water supply. Domestic water supply is a management concern in GMD3 as most domestic uses are not quantified or reported in the district and care is needed in review of other use proposals to consider domestic appropriation rights. Domestic use amounts factored into models are estimated as an averaged 15 acre-feet annually per square mile but can vary locally.

Public water supply. In Kansas, a public water supply system is defined in law by K.S.A. 65-162a and by regulation in K.A.R. 28-15a-2 as a "*system for delivery to the public of piped water for human consumption that has at least 10 service connections or regularly serves at least 25 individuals daily at least 60 days out of the year*." These systems are regulated by the state to assure the citizenry safe and pathogen-free drinking water and are comprised of water intakes, wells, and water treatment facilities. Groundwater sources supply all drinking water in southwest Kansas. The Kansas Department of Health and Environment (KDHE) oversees 68 public water supply systems in GMD3 that include municipalities, rural water districts, and privately-owned public water supply systems. If drinking water is supplied by a private water company, the Kansas Corporation Commission supervises the rates charged. There are 242 active and emergency public supply wells within the boundaries of GMD3. These wells serve anywhere from a small community of 10 or more homes to the largest cities of Garden City, Dodge City and Liberal.

Ogallala/High Plains Aquifer Characteristics.

Some hydrological question persists as to where the bottom of the Ogallala/High Plains (OHP) Aquifer exists under the adopted administrative definition that includes all formations in hydrological contact with the Ogallala Aquifer. Generally, the OHP Aquifer is a series of groundwater reservoirs consisting mainly of a widely varying assortment of sand, gravel, silt, and clay of Tertiary and Quaternary age eroded off the Rocky Mountains that were deposited by sluggish streams that flowed eastward across what became the High Plains region of the central US. Unlike the illustration of the unsaturated and saturated zones below, the groundwater reservoir sediments can differ in particle size and hydrological qualities vertically and laterally over very short distances. These rock units overlie an eroded bedrock surface of Permian and Cretaceous age. The Tertiary Ogallala Formation makes up the main part of the OHP groundwater reservoir. The Ogallala Formation is a coarse-grained unit that is highly productive from certain water-saturated intervals. The oldest part of the

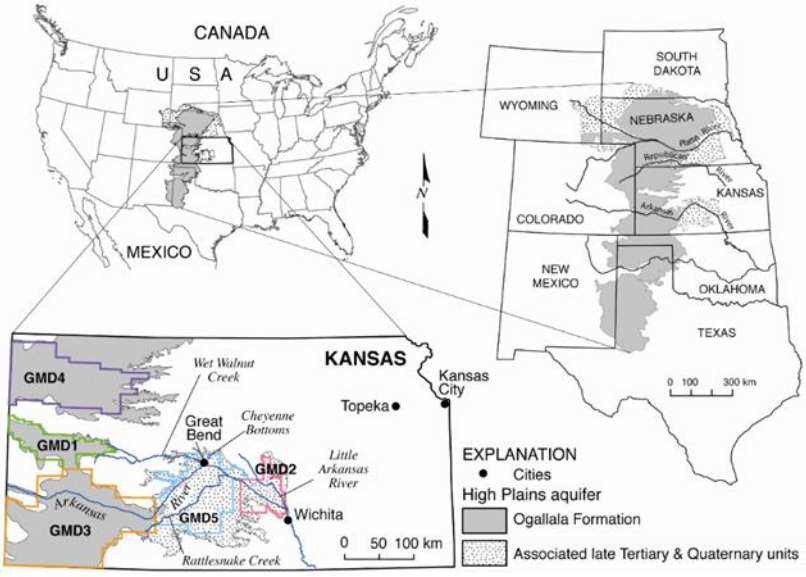


Figure 1. Extent of the High Plains Aquifer, KGS.

Miocene Ogallala Formation in Kansas is ~ 12 million years old. The older Oligocene deposits (a.k.a. White River Group/High Plains Aquifer, 26 million years or older) are finer grained than the Ogallala, not nearly as productive for water and roughly coincide with the area of the thickest Tertiary deposits in SW Kansas. They also coincide with the area of the greatest water-level declines (from KGS). Because of the similarity in composition, the older Tertiary sediments are difficult to distinguish from the younger Quaternary sediments. Many recent maps can be found in the Kansas Geological Survey High Plains Aquifer Atlas, at: http://www.kgs.ku.edu/HighPlains/HPA_Atlas/

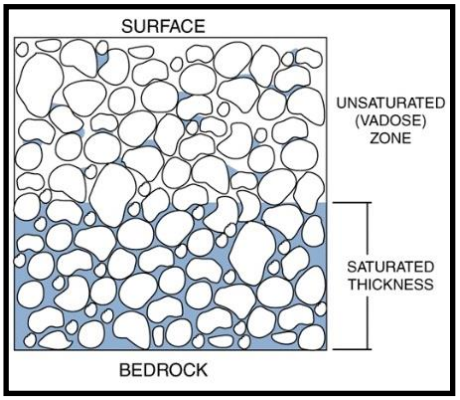


Figure 2. Formation saturated thickness

Groundwater reservoir variability. The OHP groundwater reservoir in the district varies widely in type of material, thickness, and layer continuity. Even beneath a single section of land, well yields can range from tens of gallons per minute to thousands of gallons per minute. Individual rock beds generally are not continuous and within short distances may grade laterally or vertically into material of different composition and yield to a well. Hydraulic conductivity and specific yield depend on sediment types and therefore also vary widely both vertically and laterally that create hydrologic boundary effects when wells are pumped. Some layers are cemented and are referred to as mortar beds (looks like cement) and caliche (white chalky rock). Although the groundwater reservoir is generally unconfined, confined and semi-confined conditions may occur locally. Thick shale layers are present in areas of the OHP groundwater reservoir where significant saturated formation thickness may only provide small amounts of water to wells and the density of established wells is very low.

Groundwater reservoir thickness. The thickness of the unconsolidated sediments of the OHP groundwater reservoir system varies greatly due mostly to the uneven bottom of the set of formations considered hydrologically connected. An estimated 63 million acre-feet of groundwater reservoir storage has been mined or drained of water since pre-development. Remaining saturated thickness ranges from zero to more than 500 feet as illustrated in the Kansas High Plains Aquifer Atlas (Kansas Geological Survey 2016). The areas of greatest thickness are found in the southern portions of Stevens, Seward, and Meade Counties. From the adopted definition of the OHP Aquifer, any hydrologically connected bedrock formations are considered part of the OHP reservoir, so more index well study can help answer where the bottom of the OHP Aquifer system is and how deep members should be allowed to go in relocating wells.

Groundwater flow. Regional lateral flow of groundwater is generally from west to east-southeast across the district at an average rate of about 1 foot per day or less under the normal regional tilt in the static water table. Early recharge rate studies found a similar vertical rate of descent to the water table. Locally, a higher rate of groundwater flow can be estimated where there is a greater slope in the water table, especially during local well pumping drawdown effects. Groundwater travel rates can be significantly affected where water level gradient is increased near a pumping well and flow can exceed 300 feet per day (KGS) where sufficient conditions allow. Reduction of aquifer saturated thickness over time reduces pumping capacity as saturated thickness is reduced by groundwater reservoir depletion. Depth to static water elevation from the land surface is highly variable and may exceed 400 feet.

Rivers flow to groundwater storage. All surface water flowing into or across the district is targeted and destined to become one of three uses: direct beneficial use; evaporative loss; or groundwater reservoir storage. All surface waters in GMD3 are hydraulically connected to the OHP Aquifer. Groundwater pumping has lowered static water levels throughout the district so that the water table is below the surface or bed of most river channels, causing a downward gravity flow from surface water to groundwater. For water quality purposes, Kansas Administrative Regulations (K.A.R.) broadly define groundwater as "water located under the surface of the land that is or can be the source of supply for wells, springs, or seeps, or that is held in groundwater reservoirs or the soil profile" (K.A.R. 28-16-28b(dd)). For water quantity purposes, Kansas regulations simply say "groundwater" means "water below the surface of the earth" (K.A.R. 5-1-1(ii)). Given that no water is truly static and can move both directions above and below the surface of the earth, it is useful in water rights administration to consider residency time as a measure of what may be considered a groundwater vs. surface water source of supply and whether that residency is managed or induced by mechanical means and other management activities to augment groundwater depletion.

Bedrock Aquifer Characteristics

Bedrock aquifer formations are part of the OHP Aquifer where hydraulically connected to younger formations. This creates an administrative challenge to know where the bottom of the OHP underground reservoir may be to determine actual supply and local pumping effects.

Dakota. The Dakota Aquifer system is comprised of sandstones and shale that typically yield much smaller amounts than the yield of wells in the Ogallala Aquifer. The Dakota Aquifer underlies and is in hydraulic connection with the OHP groundwater reservoir in much of the southern part of GMD3. In western Stanton, western Morton, and southern Hamilton counties, the OHP Aquifer is absent or is very thinly saturated and the Dakota Aquifer (with some Morrison-Dockum strata contributing in Stanton and Morton counties) is the primary shallow aquifer. See Dakota Aquifer information at: http://www.kgs.ku.edu/Dakota/vol3/ofr961a/man02.htm.

Confined Aquifer area. In the northern part of the district, low permeability shale and chalk overlie and hydraulically isolate the Dakota groundwater reservoir from the overlying OHP groundwater reservoir. Some wells in northern Finney County may be completed in geologic voids in the Niobrara Chalk formation and are referred to as crack wells that typically produce a high volume of water until the crack or void is dewatered. For more geologic information on groundwater above the Dakota, see: http://www.kgs.ku.edu/Dakota/vol3/ofr961a/man03.htm . In the southernmost part of the district, Cretaceous Age formations may be absent where Permian bedrock formations directly underlie the Ogallala and associated formations. For groundwater management purposes, OHP Aquifer formations include all hydrologically connected formations where hydrostatic pressures are similar and demonstrate connectivity. For more information and additional study needs, see: http://www.kgs.ku.edu/Publications/Bulletins/IRR8/05_deve.html

Morrison-Dockum. The Morrison-Dockum Formations are a distinctive sequence of Upper Jurassic Morrison and Late Triassic Dockum sedimentary formations that provide some water supply in the district that may be included as part of the OHP groundwater reservoir system where hydrostatically connected in the subsurface. They are generally composed of mudstone, sandstone, siltstone, and limestone. The lower sandstones of the Morrison are relics of the rivers and floodplains of the Jurassic period.

Permian. The Upper Permian age red beds may contain sandstones with some usable groundwater locally and may also have water quality concerns that require careful water sample evaluation, monitoring and supervision to prevent water usability depletion of fresher groundwater supplies. Further investigation of potential uses of Permian age groundwater reservoir water for irrigation can be expensive, and some geological testing and completion of deep wells for irrigation have occurred as shallower sources become depleted and oil and gas production tests indicate some limited deeper water sources are available. Efforts to evaluate the usability, reliability, and feasibility of these potential sources together with newer technologies to treat poor quality water from marginal sources to usable standards are necessary as part of the district development and management of additional supply.

Deep brackish bedrock groundwater reservoirs. KWAA requires poor quality appropriation first, where feasible. Kansas regulations require the petroleum industry to protect fresh and usable groundwater reservoirs from contamination by confirming minimum depths for surface casing in a petroleum exploration borehole. Some wells established early when surface casing depths were short or not fully cemented from top to bottom may allow usable fresh water from an upper formation to flow uncontrolled to a deeper formation or vice versa and are cause for concern. Partnerships with Kansas Corporation Commission and the petroleum industry may help protect groundwater reservoirs that will become usable groundwater sources through advancements in technology for water treatment. Kansas law requires the state to put a priority on use of poor-quality water where feasible ahead of authorizing fresh water sources. The successful implementation of this policy may require adoption of criteria under the management program.

Precipitation recharge. The climate of southwestern Kansas is semiarid, characterized by moderate precipitation, low humidity, and high evaporation. Annual precipitation increases to the east across the district and typically ranges from 16 to 24 inches annual average. Most of the precipitation falls generally during the growing season, April through September annual pan evaporation rates are about 68 inches. Drought conditions can yield as little as 4 inches of annual rainfall in the southwest corner (2012). Potential sources of natural groundwater reservoir recharge include precipitation, inflows of surface water percolating into storage, return flow from irrigation use, lateral groundwater flow, and flow from adjacent aquifers of varying quality. The most effective recharge from rain occurs on clean residue-covered soils where ET, runoff and direct evaporation are minimized.

Managed recharge. Early experiments near Lakin, Kansas and elsewhere occurred in the decade of the ‘70s in response to interest at the time to develop feasible methods of artificially recharging area groundwater reservoirs (Bulletin 20, Ks. Water Resources Board, 1977). Those studies concluded that utilization of surface runoff or imported water to recharge by water-spreading techniques would be feasible if water were made available. Managed natural and engineered techniques to enhance the recharge process hold promise for improving water supply for the district. Local natural recharge rates are affected by evaporation, soil properties, land cover, land use and proximity to sources of recharge water. Natural replenishment estimates are low, typically less than one inch of water annually. Generally, one inch of water fills about 6 to 8 inches or more of groundwater reservoir formation to saturation, depending on the size and connectivity of sediment pore spaces. Recharge rates may be higher locally, such as beneath river and ditch flows, fully irrigated land and through sandy soils. The overall imbalance between water use and recharge rates absent alternate imported supply is projected to cause billions of dollars in future

lost economy. Recent estimates from the Kansas Geological Survey indicate about 776,000 acre-feet net groundwater storage loss occurs annually on average. Managed aquifer recharge can occur through protecting and enhancing natural surface water infiltration processes that refill pore spaces. Existing historical sources that recharge aquifer supply must be protected and managed collaboratively as critical infrastructure. Managed recharge can be enhanced with artificially constructed infrastructure projects that may include infiltration basins, infiltration galleries, vadose zone infiltration wells or aquifer injection wells. Decline in surface water inflows to the district and lack of additional sources of local surface water greatly limits this activity in solving the district water supply gap. GMD3 will target key recharge water sources and inflow areas for protecting and enhancing groundwater reservoir inflows.

Weather modification. The GMD3 management program has historically provided support for a Western Kansas Weather Modification Program (originally "**Muddy Roads**" project) to increase precipitation and reduce damaging hail loss of irrigated crops and other property that reduces value from water use. Though discontinued in Kansas and GMD3, several other regions around the country and globally operate weather modification programs that add new studies indicating program benefits. China has a Sky River program using many different weather modification techniques. GMD3 will monitor programs for consideration in a future management program.

Economy

Economic engine. To grow the Kansas economy, the agriculture industry must grow and the District area that includes the golden triangle region of Garden City, Dodge City and Liberal play a big role in this activity. Significant communication and coordination occur on wise policies to support this goal. See the state strategy at: https://agriculture.ks.gov/AgGrowthStrategy/growth-strategy. In an area of the country where there is little surface water and high evaporation rate, groundwater management is an activity that preserves water supply and assures a strong economy. From the Kansas Department of Agriculture (KDA) 2016 annual report, agriculture is the largest industry, employer and economic driver in Kansas, accounting for nearly 43 percent of the state's economy and valued at more than $64 billion annually. In 2018, over $3.8 billion of Kansas' agricultural goods were shipped around the globe to 74 different countries. More than 229,000 Kansans, or 12 percent of the state's workforce, are employed in agriculture. GMD3 member farmers and ranchers not only manage the soils for sustainable production, but they also work to economically improve management and conservation of district water resources.

The corn standard. Corn is the most popular irrigated crop in the district according to annual water use reports collected by the Kansas Department of Agriculture. The value of irrigated corn produced in southwest Kansas was $582.77 million in 2013 and the total economic income generated by that corn was $842 million. The Net Irrigation Requirement (NIR) for corn ranges from 13.7" in Ford County to 15.4" in Morton County;

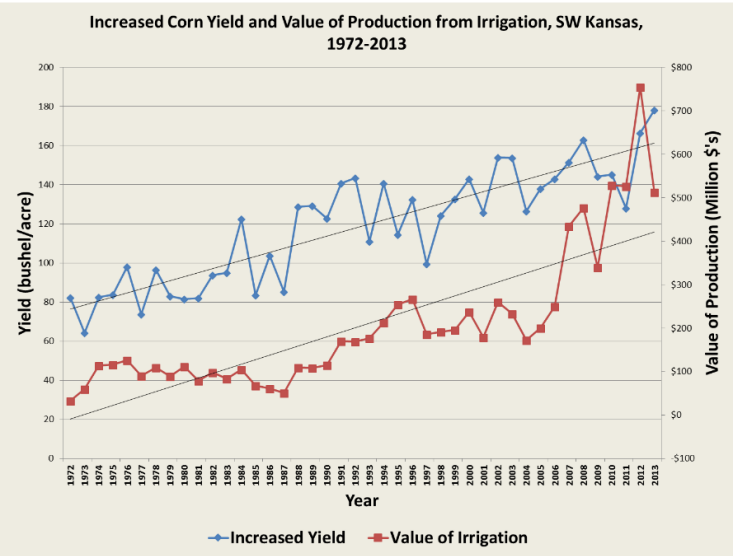


Figure 3. Corn yield and value of irrigation.

this is in addition to the average precipitation of 19 inches (K.A.R. 5-5-12, NIR at 50% chance of rainfall; K.A.R. 5-6-12, Average annual precipitation). USDA irrigated corn yield average in Kansas 1972-2016 was 165 bushels per acre (average 32 million acres harvested) and non-irrigated average 1972-2016 was 46 bushels per acre (average 557 million acres harvested). If corn acres were all dryland the economic impact from reduced value and surety would be significant. Dryland crops are often lost entirely in drought without irrigation.

County	No. of Farms	Farm Acres	Crop Acres	Irrigated Acres	Crop Mkt Value ($1000)	LVSTK Value ($1000)
Finney	450	790,500	679,472	186,357	181,137	641,954
Ford	505	669,832	529,171	67,068	108,771	406,481
Grant	315	358,649	304,628	82,239	80,280	733,861
Gray	422	556,070	439,359	116,874	119,343	871,310
Hamilton	353	544,086	435,412	20,481	41,273	294,387
Haskell	207	363,751	320,883	116,962	106,168	1,052,929
Kearny	299	516,230	415,995	53,209	76,465	204,513
Meade	407	587,924	331,600	93,775	90,381	143,004
Morton	323	401,305	330,988	31,969	40,054	94,760
Seward	282	360,711	263,690	95,497	80,237	344,461
Stanton	220	435,254	396,108	54,305	72,702	60,791
Stevens	377	455,494	369,963	138,437	109,942	230,624
Total	4,160	6,039,806	4,817,269	1,057,173	1,106,753	5,079,075

Table 4. District USDA 2017 Farm Facts
https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Kansas/st20_2_0001_0001.pdf

Economy decline from irrigation decline. When commodity prices are strong, one lost irrigated acre in Southwest Kansas can lead to an estimated loss to Kansas of $2,200 land resale value and 122.5 bu of corn at $6.78 = $831 and 2 cattle on feed, approximately equal to 1,060 usable pounds of meat or a 2012 wholesale value of $3,080 (assumes an average price of $2.90/lb. of beef). (KDA presentation to the Governors economic advisory council, 2013) This is an annual loss of $3,911 per irrigated acre transitioned completely to dryland. There are about 1,500,000 acres authorized for irrigation in GMD3. Additional production generates income from agricultural producers and input suppliers, and this income circulates through local and state economies as a multiplier of monetized water use.

Market adjustments. In 2016 the return associated with irrigation (value of production) for corn in southwest Kansas was $226,638,720, while the return to irrigation for wheat was $17,227,200. (KDA) Combined, the increased return to irrigation from corn and wheat in southwest Kansas in 2016 was nearly $243.9 million. Considering generally accepted economic multipliers, the economic impact of this increased production was valued at almost $582.2 million. It is important to note that the value of irrigation is directly impacted by commodity crop prices and dryland yields.

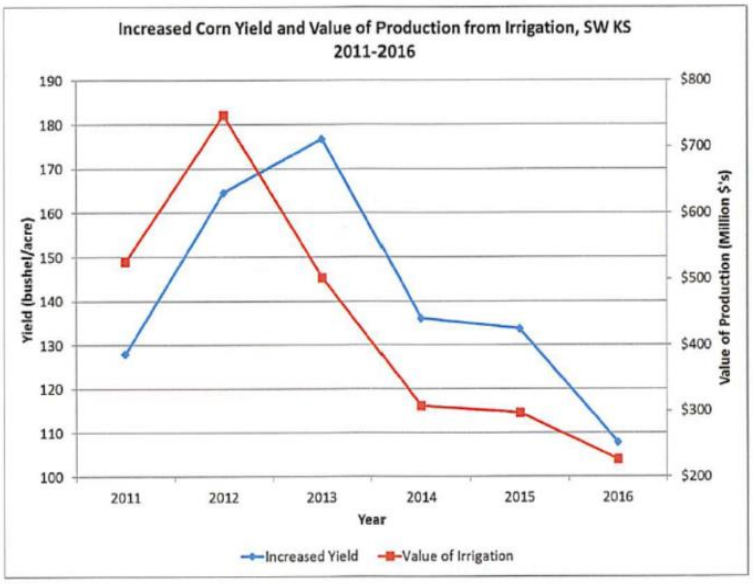


Figure 5. Market adjustment, corn yield and value, KDA.

In years with more rainfall, dryland yields are generally better, lowering the value of irrigation for that year.

Beef, Dairy and Animal Agriculture. Kansas ranked third nationally in numbers of cattle and calves on ranches and in feed yards in 2015 with 6 million head and second in the fed cattle market in 2014 (USDA, 2016). Revenue from cattle production grew more than 36% from 2010 to 2014, with cattle providing $7.75 billion in cash receipts in 2013 (KLA, 2016) and these numbers are growing. Nearly half of the state's agricultural cash receipts in 2013 came from the sale of cattle and calves. Kansas ranked 16th nationally in milk production in 2015 when milk production was valued at $746 million (USDA, 2016). Animal agriculture in the district provides a significant portion of these state numbers, due to reliability of irrigated grains and forage. The district is one of the fastest growing regions for dairy production in the United States with the advantages of open spaces, favorable climate, irrigation for consistent high-quality forage, and abundant groundwater at a safe depth that separates nutrient management activity from water stocks. GMD3 is home to the largest milk drying plant in North America, located in Garden City. Other significant animal production sectors in the district include pigs, sheep, and goats.

Economic analysis. Economics drive water use, water reclamation and water conservation development projects. Cost/benefit analysis not only evaluates the economic justification of plans, but it can assist in plan formulation and choice of alternatives. Although economic analysis is traditionally performed by economists, the implications of the economic analysis (which often can dictate whether a project is implemented) make it imperative that the concepts, methods, and tools used in the economic analysis be understandable to others, including: (a) the other specialists involved in the feasibility studies, (b) management personnel in sponsoring organizations who must make a decision concerning the proposed project, and (c) the various stakeholders who are involved in the planning process and who will ultimately be affected by the project or be asked to fund it in whole or in part. For example, in Kansas water policy, a cost/benefit analysis is required in law authorizing water conservation plan guidelines developed by the Kansas Water Office.

Opportunity cost of water. Opportunity cost is a key concept in economics expressing "the basic relationship between scarcity and choice". The notion of opportunity cost plays a crucial part in attempts to ensure that scarce water resources of Kansas are used and conserved efficiently. Opportunity costs are not restricted to monetary or financial costs, and the real cost of output forgone, lost time, pleasure, water quality or any other benefit that provides water utility should also be considered an opportunity cost. The opportunity cost of water dependent products or services includes the revenue or economy that could be earned by its alternative use. In other words, opportunity cost is the value not contributed from projects not undertaken.

Value of water in GMD3. Value drives management. Water is widely considered to be undervalued. All values and costs should be considered when valuing water because there are values and costs in every water transaction seeking to use or to refrain from using water. There are several factors that influence the value of GMD3 groundwater. A 1999 Senate Bill 287 adopted a large set of water measures that included Kansas Water Office recommendations to address depletion of water supply in the Ogallala Aquifer region, including GMD3, for the next 20 years. See http://www.kgs.ku.edu/General/Personnel/tw/abs/HB287_executive_summary.pdf . GMD3 acted to advise SB 287 work and commissioned an economic study by the Docking Institute of Public Affairs in 2000 to examine through 2020 "*The economic impact of an acre-foot of water on the economy of Southwest Kansas* (2001)." See http://www.gmd3.org/pdf/ogal1.pdf This information will likely be included in an update of the 2000 value of water study planned for

2021. Third parties may suffer indirect but significant economic impacts as water supplies decline. As the farming economy declines, so will the businesses that depend on the forage and commodity production and the banks that lend money. All the businesses that depend on a vibrant local agricultural economy are, in turn, affected. With less business activity, local governments will collect less tax revenue, causing a decline in the ability of local governments and school districts to provide services to citizens. As community life declines the area will becomes less attractive to new businesses resulting in a downward spiral of economic effects.

Damage claim. Of the many studies of the economic value of district groundwater supply, the most comparable to the Docking study example is the "Kansas' Expert Reports in Support of its Claim for Money Damages for Colorado's Violations of the Arkansas River Compact 1950-94" (1998). Using only classic cost-benefit analysis, the experts found that the value of Arkansas River water in 1998 dollars was an average $514 per acre foot for all uses (irrigation agriculture, industrial, and municipal). However, a notable deficiency of the cost-benefit analysis for groundwater occurred when experts were unable to identify present value lost for the over 400,000 acre-feet of stored groundwater found absent permanently from district groundwater storage: used to replace supply shortages of Arkansas River basin water from the Colorado portion of the basin. The missing groundwater itself was considered to have no present value as a lost future supply when projected market use values (in 50 years) were discounted back to present value. The resulting present value estimate of the missing storage was determined near zero.

The "no present value" error. An extreme supply shortage in the future should find the instrumental value of preserved water storage significantly elevated. A "no present value" view of water in the groundwater reservoir as a stored future supply is highly counterintuitive and inconsistent with the management program. It strikes at the very heart of present conservation expenditures and efforts to leave water in storage to meet higher future value demand. It implies significant waste of public investments for conservation. The recognition of this error also suggests vigilance is needed to protect against value judgements that may prejudicially and unreasonably affect the public interest. Groundwater valuation should adequately consider that storage and use have elements of both market and non-market services and product over time. Monetizing and quantifying services of groundwater and the future surface water that recharges groundwater should consider the broader natural and intrinsic values and not erroneously consider water a free good. If groundwater value is only measured by its production cost to meet near-term needs, the value will always appear cheap until the supply is nearly gone.

Water conservation cost. Both private and public water conservation activities have a cost that is in addition to what can be monetized in future use value. There is opportunity cost in lost benefits when choosing a less profitable activity over another more profitable alternative. There is public cost in lower land valuation from lower profit opportunity. Cost can occur directly as public financial support and as incentives paid for water conservation practices. Dividing the amount of water conserved in program participation into actual costs can provide a value of an acre foot of water left in storage for valued future use.

Usability factor in valuing water. A water supply must remain usable to preserve value. Models used for estimating water supply and economic value rarely apply adequate assumptions to address any water quality decline over time; what is referred to here as "**water usability depletion**." Water usability depletion is when value of use for historical supply is lessened or impaired by a decline in the water quality, causing a material depletion in the utility of the water.

This depletion makes it necessary to increase the amount of water and incur higher costs to achieve similar value services. For example, membrane filtration water treatment necessary to remove radionuclide contaminants requires additional energy expense and eliminates about 15% of the water as waste permeate disposed of through injection into deep geological formations. **A water usability factor should be employed in each water project or compact risk evaluation where water quality may affect district supply.**

Energy costs in valuing water. One cost of water includes the cost of energy to divert and transport water from storage to beneficial use. Groundwater pumping in the district uses a great deal of energy. Well depths average about 300 feet of lift. Of the 12,826 authorized non-domestic wells in the district, about 8,480 are pumped annually for irrigation. The total energy required annually in the district for irrigation is approximately 1679.04 gigawatt hours to move 2,000,000 acre-feet (Pioneer Electric Coop and state well data).

Water infrastructure as an economic force multiplier. All water supply and use depend on both natural and constructed infrastructure. Natural water infrastructure includes precipitation, natural rivers and streams, lakes, wetlands, soils, and aquifers. Constructed water infrastructure includes dams, control structures, constructed infiltration areas, wells, pumps, pipeline systems, and the energy systems to move and manage water. US Reclamation estimates that for every $1 spent in Reclamation infrastructure programs, $20 of direct economic benefit and about $40 of secondary benefits occur. When a project's benefits are estimated in terms of the growth of the national economy, rather than "cost benefit" fiscal return, the true value of a project can be measured (EIR report, Pick-Sloan: The Missouri River Development Project, 2011).

Federal cost depletion allowance. Taxpayers who extract groundwater for irrigation purposes from the Ogallala Formation are allowed a federal tax deduction for depletion. This is allowed under Revised Rulings 82-214 and 65-296 under Section 611 of the Internal Revenue Code. Section 611 grants depletion allowances for natural deposits and timber which are nonreplaceable. Revised Ruling 65-296 allows a groundwater cost depletion to taxpayers who extract groundwater from the Ogallala Formation in the Southern High Plains, whereas, Revised Ruling 82-214 amplifies the previous ruling to include taxpayers who extract groundwater from areas of the Ogallala Formation other than the Southern High Plains. In computing a cost depletion, the taxpayer must be able to show the following: 1). An economic interest in certain lands overlying the Ogallala Formation from which groundwater is being extracted for irrigation of crops. 2). An appropriation permit has been issued by the State of Kansas, which grants exclusive rights to the use of the groundwater for irrigation. 3). The amount of water under said lands that was established at the time of acquisition, the cost basis of water, the amount of exhaustion (water-level decline) for each of the taxable years involved, and the amount of cost depletion deduction.

IV. GMD3 PROGRAM ACTIVITIES - NATURE AND METHODS

GMD3 conducts groundwater use and supply evaluation, waste of water, water planning, policy development, advises and assists state water administration, collects data, assists in economic development and represents district water users and landowners in matters concerning groundwater management. The Board of Directors prepares and adopts the Management Program that contains the orderliness of thought, behavior and policy locally adopted to address the

groundwater related resource and economy concerns to advise and assist people, state and federal officials, the Governor, the Legislature, and Congress.

Kansas water law. It is important to know a little about Kansas water law that set the framework for enforceable policy that affects your decisions in managing water risk. The core of Kansas water law for groundwater is comprised of several Acts or bodies of law that include the Kansas Water Appropriation Act (KWAA) body of water use law, the GMD Act body of groundwater management law, and the Water Exploration and Protection (WEP) Act body of well construction and groundwater protection law. These Acts and amendments, and implementing rules, are intertwined in the history of the development of the state and the western US. To gain perspective of how to proceed with managing water use going forward, it is a good idea to learn some history and basics of Kansas water law. **See: Water Primer, Part 5: Water Law, KSU, January 2013. https://www.bookstore.ksre.ksu.edu/pubs/mf3024.pdf ; and Water Law Basics. https://agriculture.ks.gov/divisions-programs/dwr/water-appropriation/water-law-basics**

Groundwater Policy. Kansas groundwater policy provides for a locally prudent form of practices, procedures and orderliness of thought and behavior adopted in a management program and implemented collaboratively through a formal elected governing body that serves an ancillary role in Kansas water administration. In more than 500 monthly meetings, the 15-member elected volunteer Board of Directors of GMD3 has identified district water use and supply problems and considered the nature and orderliness of thought and behavior needed to address them, assisted by professional staff, consultants, state officials and other important partners in water use and management concerns. Even with the significant progress achieved, individual well yields and the number of irrigated fields have declined dramatically in many areas. Reduced pumping rates and unproductive wells are real and current events in an ever increasing area that indiscriminately and adversely impact drinking water wells, livestock feeding operations, dairies, ethanol plants, irrigation, municipal and industrial users, making it ever more difficult for them to meet demands for water. There are areas that offer hope for stable water supply and economic growth through a balanced approach to conserve native supply and develop additional sources of Kansas water.

GMD3 policy. The governing body of GMD3 adopts administrative standards and policies relating to the management of the district. (K.S.A. 82a-1029(n)) GMD3 Policy in this management program document and in Board resolutions are posted on the GMD3 website. For enforceable policies, GMD3 seeks rules and regulations or regulation reform adopted by the appropriate state official or agency as necessary to further implement the management program. (K.S.A. 82a-1029(o) & (p)) Proposed rules and regulations recommended to the official, department, commission or other agency shall be of no force and effect unless and until adopted by the state official, department, commission or other such agency.

GMD3 Economic Preservation and Development Activities

Water-based economy. Although water seems always present and is for the most part taken for granted where it is abundant, it is not an absolute certainty that where settlement occurs, water will follow. This fact has not escaped water experts and decision-makers, who realize the many competing needs for a precious resource that has no substitute. The business of water is not one of physical shortage but, rather, one of matching market demand with supply, ensuring that there is

water at the right location and the right time of year, at a cost that people will be able to afford and will be willing to pay for. The economy of southwest Kansas will be grown by agricultural markets and the interaction between rapid technology adoption, informed water use, and wise infrastructure investments that sustain member productivity from water managed wisely and – as appropriate -- made accessible for public use to help generate revenues, enhance state and national security, create jobs, and grow the economy. Public policy in the KWAA has guided state water allocation for 75 years *"…to conform to the public interest to the end that the highest public benefit and maximum economical development may result from the use of such water."* (K.S.A. 82a-711) The GMD3 area is the most developed region of Kansas for agribusiness. http://www.kgs.ku.edu/HighPlains/HPA_Atlas/Land%20Cover%20and%20Irrigation/index.html#Water_Rights-Percent_of_Irrigated_Acres.jpg . In response to over-appropriation and groundwater depletion, the policy of the GMD Act was added to allow local management of rights, duties and public interest to lead from local need.

Authority. GMD3 authority for Economic Preservation & Development Activities include without limit:

- K.S.A. 82a-1020 declaring the economic preservation purposes of the GMD Act and the right of water users to determine their destiny regarding water use;
- K.S.A. 82a-1028 a local body politic and corporate with certain powers;
- K.S.A. 82a-1029 to adopt the groundwater management program for the area;
- K.S.A. 82a-1041 to recommend Local Enhanced Management Areas;
- K.S.A.82a-733(g) to approve certain state required water conservation plans;
- K.S.A.82a-745 to advise on acceptable management plans for Water Conservation Areas;

Local action. Significant value has been realized in decoupling economy from local rainfall and climate variability through the development of the OHP Aquifer, providing significant gains in personal, community and national gross product. Organized local action and funding in 1976 ended unregulated development to allow local stakeholders to secure the benefit of their natural resources and favorable location to national and world markets, while avoiding the "boom and bust" economic conditions that often occur in other mining operations. The GMD Act guides the economic preservation and development activities of GMD3. Water risk is reduced through assistance and advise to government, members, partners, and private industry, allowing development of future business and economy. This improves water reliability, regulatory confidence and builds a positive reputation in wise water use.

Business water risk. Private and public institutions in GMD3 face four different types of water-related risk. First, there are the physical risk factors of available usable water; the risk that a region may lack **sufficient storage** or that the local water supply might be of poor or unstable quality. Second, is there **sufficient recharge** to replace what is consumed, degraded, or exported. Third**, local water regulations**; regulatory change or lack of regulatory surety might challenge

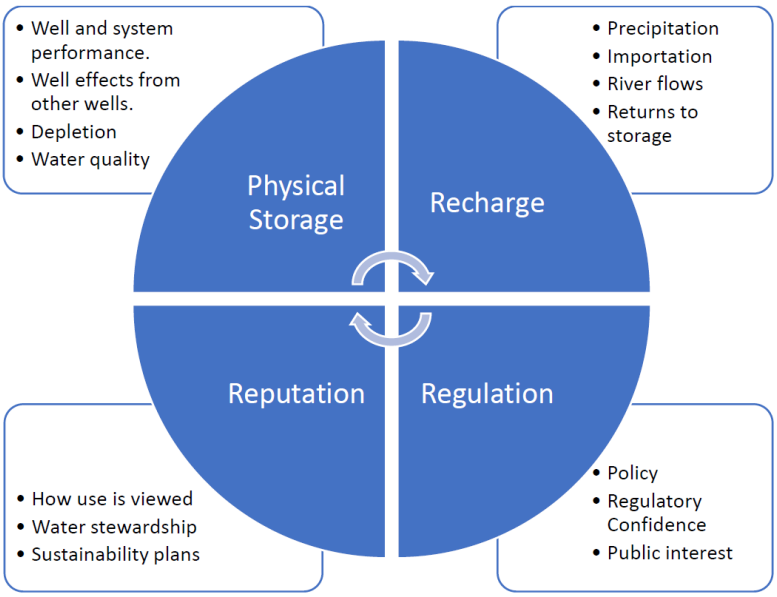


Figure 6. Business Water Risk

members' ability to do business. Finally, members face risks to their **reputation**; consideration of how use of water will be viewed by others and the broader market communities is important. The instrumental and intrinsic values at risk from those four dimensions can be quantified to drive member companies to develop water stewardship strategies and make investments to manage that risk. GMD3 will work to assist district families, farms, businesses, and communities in managing and mitigating their water risk to enhance confidence in their groundwater supply under the management program.

Supply & Demand management. For planning purposes, demand should be viewed as actual use and unmet demand. Unmet demand is evident in the district members perfected annual use authority totaling 3.6 million acre-feet, but with recent average annual reported use of 1.8 million acre-feet. Investments in less water intensive production methods and optimized water risk management have led to a more sustainable water-based economy.

Economic growth. Water conservation that (1) adds use value to the water used and (2) improves future supply of groundwater reservoir storage are the important activities to reduce risk and allow for economic growth. Advances in technology and genetics have allowed some producers to profitably shift to less water intense crops and value-added agriculture. This holds significant promise absent any new water imports. The management program activities are intended to meet the long-term agricultural water supply and demand gap and incorporate strategies to address environmental and recreational needs for water places.

Water Infrastructure Investment. Investments in private water infrastructure are decisions that provide private and public benefits through population gain, improved property valuation, and capacity to respond to water risk. In a similar way, public resources supporting major water infrastructure will create a powerful economic driver with significant return on investment for both public and private interests. Economic studies indicate water infrastructure projects are a force multiplier. An investment in sustainable water and wastewater infrastructure has a six-fold return (5 U.S. Chamber of Commerce, Why Water Infrastructure Investment Would Make A Big Splash) – proving that investment in water infrastructure is sound fiscal policy. US Reclamation estimates that for every dollar spent in a reclamation program, $20 of direct benefit is realized. Secondary benefits may be as high as $40.

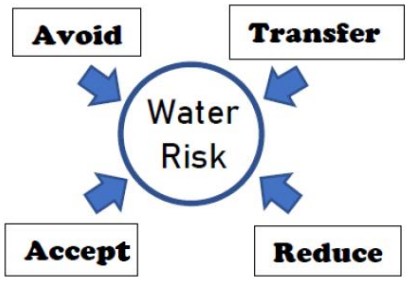


Figure 7. Water Risk Response

Alternate source water. Water projects require preliminary steps, planning, management, and control to deliver the desired outcome. Large-scale agribusiness interests in western Kansas, most prominently Southwest Kansas Groundwater Management District No. 3 ("GMD3"), revived the idea of a large-scale transfer of Missouri River waters to west-central Kansas in 2013 through several presentations to legislative committees. During the 2015-16 legislative session, GMD3 advocated for Sub. for H.B. 2059, which, among other things, would have made it easier for an applicant for water rights related to such a transfer to obtain approval. A study team for the Water Office recommended developing the bill concepts to include a detailed analysis of the bill in its final 2016 form and a summary and analysis of the larger legal, administrative, and regulatory issues raised by the bill, at both the state and federal law levels. GMD3 seeks partners in support of further of the Kansas legislature on this and other key water policy development. GMD3 will engage with the various stakeholders across Kansas and into other states, so that success can be defined to meet stakeholders' expectations and their perceptions of value.

Inhabited source water. Abundant high flow river waters that jeopardize farms and Kansas property and flowing away from Kansas hold significant source water development opportunity to close the state gap between demand and developed supply. Such transferred river water may be inhabited with aquatic nuisance species (ANS) that do not occur along the transfer paths or locally in the District. ANS concerns require management program attention assisted by KDWP&T (K.A.R. 115-18-10). In addition, inhabited source water diversions may require safeguards to protect species that are considered threatened or endangered under the Kansas Nongame and Endangered Species Act (K.S.A.32-957). Significant coordinating with Kansas partners will occur to develop appropriate safeguards to protect and enhance Kansas natural resource values and water enjoyment that is consistent with the management program.

Water west. The future of district investment-based economy is directly tied to the extent that efficient management of natural and engineered water infrastructure can be better realized. A gathering of Kansas stakeholder project partners with knowledge and interests in sustainable water and power will occur for the purposes of adapting Kansas policy, planning, and infrastructure development to phase in major water transportation system development. In 2015, a report with funding from the US Army Corps of Engineers (USACE), Kansas Water Office, and GMD3 that updated the Kansas water transfer element of a 1982 USACE High Plains Study assisted consideration of transporting Missouri river excess flows. The next steps for this activity include a development phase with further exploration, proof-of-concept (POC), demonstration project studies, and a gathering of in-state partners and interstate supporters to advise and assist the Secretary of Interior in completing a phased plan authorized in PL90-537 favorable to the interests of GMD3 and Kansas. Prior work of GMD3 has found interest is shared with sister western regions and communities, including the Arkansas River basin of southwest Kansas and southeastern Colorado. The management program commits the district to forward-looking evaluations of natural and public water infrastructure and water marketing options that reduce water risk and reduce energy cost to move excess high flow water supply west with evaluations of how to fund management decisions, including a decision to do nothing. Without a cooperative vision and strategy among local, state, interstate, and federal partner investors to address long-term water supply shortages, GMD3 consultants estimate annual future economic loss in gross state product of approximately $18 million annually, with a $10 million portion of that annual amount lost in GMD3, based on current trends.

Public water places. Wise water use includes encouraging a respect and understanding of the emotional and aesthetic power of water that comes from places of water enjoyment and education. Water places are needed in conjunction with direct uses, green fields and local products for healthy communities and water services. Water places such as water bodies, water displays, playa lake education sites, water walks, recreational areas, and multi-purpose sites along natural or constructed water features enhance water value awareness, encourage responsible personal and community water stewardship, and improve local quality of life.

The High Plains Study example. Congress passed the first Water Resources Development Act (WRDA) bill in 1976 in part to address the problem of depleting Ogallala Aquifer water supplies to support 15 million acres of irrigation crop farming in the High Plains region of the United States (Water Resources Development Act) Section 193, Public Law 94-587). The Intent was clear and concise in directing the Secretary of Commerce ". . . to examine the feasibility of various alternatives to provide adequate water supplies" for the High Plains Region, and ". . . to assure the continued economic growth and vitality of the region." To carry out the Congressional

directives concerning the Ogallala/High Plains region and to fulfill a High Plains Study Council objective, two incremental management strategies to reduce water demands in the Region and three strategies to increase regional or sub-regional water supplies were formulated. The Framework for High Plains Study Management Policy Impact Assessment were to establish a **"Baseline"** trend projection of currently available water conservation and use technology and practices already in use, with no new purposeful public policy to intervene with action programs for altering the course of irrigation water consumption (the baseline). Baseline conditions were used to evaluate five strategies as follows:

1) A strategy which would **stimulate voluntary action** to reduce water demands through research, education, demonstration programs and incentives, using technology and practices either not considered Baseline practices or rates of implementation purposefully accelerated. (Management Strategy One)
2) A strategy which assumes Strategy One policies and programs and adds further water demand reduction by **mandatory programs** of a regulatory nature to control water use. (Management Strategy Two)
3) A strategy to add **local water supply augmentation** to demand reduction efforts. These actions included local practices such as cloud seeding, local storage, ground water recharge, desalination, and snowpack and vegetation management. (Management Strategy Three)
4) A strategy of **intra-state surface water inter-basin transfers**, importing water into the High Plains Region in accordance with State Water Plans. (Management Strategy Four)
5) A strategy of **interstate surface water transfers,** importing water from sources in areas adjacent to the Ogallala/High Plains Region by means of large-scale federal/state or federal projects to restore and maintain irrigation of the acreage that would have reverted to dryland farming by 2020 under Strategy One or Two. (Management Strategy Five)

Results of the Department of Commerce High Plains Study released in 1982 with a 40 page Executive Summary provides several analyses synthesized and available at: https://scholar.law.colorado.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1007&context=new-sources-of-water-for-energy-development-and-growth-interbasin-transfers Many western states have recognized that major water transfers are considerations for their states future. New prospective High Plains study and planning will provide new cost and benefit projections that will further aid in making project, policy and program choices. GMD3 participated in a 2015 update of the 1982 High Plains Study Route B Water Transfer Element not to promote the old project, but to move stakeholders and partners in the direction of future transfer projects to meet future water needs. See: http://www.gmd3.org/2019/09/27/updated-1982-high-plains-study-on-water-transfer-element/
A coalition of stakeholders was formed to support the work of developing water transfer alternatives for Kansa rural communities.

GMD3 Water Rights Administration Assistance

Regulation. Management policy tools have been adopted locally and implemented collaboratively since the beginning of GMD3 in 1976. The first district method for evaluating local groundwater depletion was adopted by GMD3 on July 12, 1978 immediately after the Kansas legislature made applications to appropriate water mandatory. This regulation tool

involved calculating the potential depletion rate due to new appropriation of groundwater rights in the section of the proposed well and the eight adjacent sections commonly described as within a 9-square-mile area. This method was later changed to a two-mile radius circle around the well of new use and was relied on in conducting state duties to move resource development from unmanaged to managed development.

Now that the district OHP aquifer is considered closed to most new appropriation, the desired culture of conservation requires a more balanced and informative application review of proposals under the KWA Act and GMD Act. Improved management tools, data, and information are available to identify critical well conditions that advise members and state duties of any potential impairment concerns for water risk management. GMD3 provides evaluation based upon the best data readily available to conduct a transparent and informative application review process so that members have the information they need to manage their water risk and make the best decisions they can for their business and livelihoods according to basic water use doctrines.

GMD3 authority. Authority for Water Rights Administration Assistance include without limit:

- K.S.A. 82a-1020 declaring the purposes of the GMD Act and establishing the right of water users to determine their destiny regarding water use as a public interest.
- K.S.A. 82a-1028(g) & (i) to construct, operate and maintain works & to contract with persons…, and enter into cooperative agreements.
- K.S.A. 82a-1028 (m) "provide advice and assistance in the management…" [of groundwater in] "storage… and all other appropriate matters of concern to the district."
- K.S.A. 82a-1028 (n) adopt administrative standards and policies relating to the management of the district which are not inconsistent with the provisions of the GMD or the KWA Acts.
- K.S.A. 82a-1028(o), (p) & (q) to recommend rules & enforce them by suitable action.
- K.S.A. 82a-1028(r) to enter upon private property within the district for inspection purposes.
- K.S.A. 82a-1028(u) to recommend … an intensive groundwater use control area.
- K.S.A. 82a-1029 adopt the official management program for the district.
- K.S.A. 82a-1041 to recommend adopted LEMA plans for implementation.
- K.S.A.82a-1042 provide formal response to any rules or GMD management program changes proposed from the Sec. of Agriculture or Chief Engineer that may alter an adopted local groundwater management program or impact water use in the district.
- K.S.A.82a-733(g) approve state required conservation plans.
- K.S.A.82a-745(d),(h) & (m) to advise in acceptable management plans for WCA's; and
- K.S.A.82a-1906(b) notification to water users of certain applications under review by DWR.

Kansas water rights. A *water right* under Kansas water law refers to the right of a person to take water under control from a water source in Kansas for beneficial use, such as from a groundwater source of supply, and to have that right continue unimpaired into the future subject to senior or prior water right demands. The western US water law doctrine of "prior appropriation" (or "first in time is first in right") has been a part of basic water policy in Kansas since the mid 1800's (See Appendix for *Kansas Water Law and History Notes*). Uniform prior appropriation policy was not fully adopted for all usable water sources until the KWA Act of 1945, whereby ownership of the water is dedicated to the use of the people of Kansas as a public good, but the right to use the public water is a private right created through an application and subsequent state grant under its police powers as a US water resources trustee. The KWA Act is administered by the Kansas Department of Agriculture's Division of Water Resources (DWR), which issues state permits to appropriate water, decisions on changing water use terms, regulate usage by responding to complaints, and keep records of all water rights. Short term and temporary permits are also issued

by DWR. The grant for lawful water use includes water user action and investment to apply the water to authorized beneficial uses and supply records that lead to receiving a vested determination (pre-1945 use) or a certified real property right. Water rights are usually documented as part of a traditional "bundle of legal rights" transferred with land from seller to buyer as an appurtenance to the land. A water right can be separated from the land and conveyed by evidence of a separate deed or lease document. Domestic rights are not required to be recorded with the state but have a water appropriation right by law for domestic use to the extent of actual use, and with all the protections of right under the KWA Act and management participation under the GMD Act. The maintenance of records by DWR allows Kansas water to be apportioned legally and managed fairly. Non-domestic water cannot be appropriated, or even threatened to be appropriated, without first making application, participating in a process of project review and receiving approval from DWR. Those who have senior water rights may be entitled to meet their needs before those who have junior rights. GMD3 works to address member information needs to advise and assist in a balance of rights, help members make requests with other water members, and to help with the management of actual water supply conditions.

Waste of water. A goal of the management program is to reduce water loss due to flood or runoff, minimize evaporation loss due to inefficiencies, and other water waste. Activity that may unreasonably and materially diminish valued water benefits through contamination, water loss and injurious activity is discouraged as being inconsistent with the public interest.

Impaired water right. All pumping wells reduce the capacity of other wells to withdraw water from the same aquifer. This effect is exacerbated in a declining aquifer where wells eventually will lose the ability to meet authorized and investment-backed demand. A system of concepts and customary practice has been adopted by GMD3 to assist and advise members and partners in implementing the KWA Act and GMD Act in southwest Kansas. This includes adoption and use of maximum allowable depletion rate and well-to-well interaction on other wells with prior use rights and to assist in resolving complaints regarding supply. Appropriate steps of discovery and evaluation provide vital information that inform market participants, clarify impacts and injury, quantify mitigation, and reduce transaction costs associated with the exercise of water rights. These district policies advise and assist the state in their duties to supervise water use by providing information that helps determine the public interest.

State and local government judgement. State officials like the Chief Engineer and agency staff of the Kansas Department of Agriculture are key partners in the implementation of the GMD3 management program for southwest Kansas. The Chief Engineer cannot grant an application to appropriate groundwater if the resulting activity will impair existing water rights. (K.S.A.82a-711 & 82a-711a) Likewise, the Chief Engineer is required to decide whether a proposed action will cause impairment of prior rights for the following activities:

- **changing location** of well pumping (K.S.A.82a-708b, 82a-711 and 82a-711a).
- **injunctions** - potential or existing impairment of prior rights (K.S.A.82a-717a).
- **limited transfer permits** (K.S.A. 82a-743).
- **WCA** (water conservation area) adding pumping location flexibility (K.S.A.82a-745).
- **rule waivers** (K.S.A. 82a-1904); and
- **management program** is compatible with basic laws and policies (K.S.A.82a-1029).

Members use waters of the state according to their water rights. A water right is not a guarantee of a water supply in turn as it is subject to the availability of water not needed to satisfy demands by owners of prior water rights. The success of water conservation activities of the management program will depend on consistency in approach toward making decisions that avoid extending or increasing local depletion rates or eliminating benefits of prior conservation. The questions of hardship or injury to the water supply of others may result from use or proposed use change has been a GMD3 concern needing advice and guidance for KWA Act decision since 1976.

Kansas law provides *"It shall be unlawful for any person to prevent, by diversion or otherwise, any waters of this state from moving to a person having a prior right to use the same."* (K.S.A.82a-706b(a)) This raises a question under the GMD3 policy of aquifer depletion whether this unlawful condition occurs prior to when a well with a prior right goes dry. Impairment may occur before a condition of complete loss of supply and GMD3 uses well drawdown constraints to identify where pumping effects may be unreasonable or even unlawful. Kansas law also provides "*with regard to whether a proposed use will impair a use under an existing water right, impairment shall include the unreasonable raising or lowering of the static water level or the unreasonable increase or decrease of the streamflow or the unreasonable deterioration of the water quality at the water user's point of diversion beyond a reasonable economic limit."* (K.S.A. 82a-711) This statute involves a prospective "will impair" question to be evaluated with some physical constraint over a reasonable future period and applying some reasonable economic constraint that considers water cost, value and risk.

The courts. The courts in the district have acted to define when impairment occurs from a standard law definition of "impair" to mean when that diversion diminishes, weakens, or injures the diversions of water under a prior right (Garetson Bros. v. Am. Warrior, Inc., 51 Kan. App. 2d 370, 389, 347 P.3d 687 (2014), review denied (Jan. 25, 2016)). This case definition of impairment was used by the chief engineer on other wells not enjoined in the case even though the adopted well spacing rules were met. The general GMD3 spacing rule is uninformative to questions of water risk and the court definition is too harsh for regular application in the economic interests of members and public interest of the GMD3 management program. GMD3 evaluations help members consider whether their concerns are prudent. Given that "impair" is not defined in statute or rule, and strictly defined in area caselaw and actively referenced in state letters advising members how to act should it occur, a reasonable even-handed method of evaluating critical well conditions is provided to nearby water users for every application to add or relocate water use that GMD3 processes. When followed, these provide a solid basis and best evidence in evaluating impairment.

GMD3 Water Rights Administration Assistance Guiding Principles:

A. **Preserve basic water use doctrine.**
B. **Maintain a public record for good decisions.**
C. **Conserve to preserve supply.** Engage members to grow present and future benefits from preserved or replenished supply. Limit "paper water" on poor wells (incapable of providing the water) from moving to good wells (a concept termed "chasing water").
D. **Dedicate native supply to existing usufruct rights.**
E. **Ensure safe drinking water.**
F. **Recognize past conservation.**
G. **Seek mutual benefits and good will.**

H. **Encourage careful risk evaluation.**
I. **Promote free enterprise.**
J. **Encourage use of water right limits over reduction as reasonable and preferred.**

Chief engineer consideration of public interest. K.S.A.82a-711(b) states as follows: *"(b) In ascertaining whether a proposed use will prejudicially and unreasonably affect the public interest, the chief engineer shall take into consideration:*

(1) Established minimum desirable streamflow requirements.
(2) the area, safe yield and recharge rate of the appropriate water supply.
(3) the priority of existing claims of all persons to use the water of the water supply.
(4) the amount of each claim to use water from the appropriate water supply; and
(5) all other matters pertaining to such question." (Emphasis added)

For "*a proposed use"* or proposed change in use, requirement (5) above necessarily includes the public interest declared in K.S.A. 82a-1020 et. seq. and maters of public interest declared by the chief engineer, including per K.S.A. 82a-1024.

Additional policy in law regarding GMDs include that the KWAA duties and responsibilities of the chief engineer are preserved by the GMD Act where nothing therein shall be construed as limiting or affecting any duty (emphasis added) or power of the chief engineer (K.S.A.82a-1039). Notwithstanding K.S.A. 82a-1039, any participating water right in a temporary program like WCA remain subject to all rules and regulations and management program of the GMD in which the water right is situated (K.S.A. 82a-745). Conservation plans and practices that are required by the chief engineer as a condition of a groundwater right in a GMD shall be subject to approval by both the chief engineer and the board of directors of the GMD unless such plans and practices are incorporated in the GMD's management program (K.S.A. 82a-733). Notification to member water users of certain applications under review by DWR is a requirement of DWR in consultation with the GMD (K.S.A.82a-1906(b)). These and other provisions of law lend credence to the necessary and advisable inclusion of GMD3 and the management program in the conduct and agency practices implementing the duties of the Chief Engineer.

Water rights administration. Adoption and enforcement of groundwater use policy appropriate for the unique practices and aquifer conditions of southwest Kansas has always been a key goal in the formation and funding of GMD3 by the water users and landowners. The GMD3 management program advises use of an analytical, transparent, and site-specific method of applying basic water use doctrine in southwest Kansas to meet member needs for managing water risk to their water rights and capital investments.

Well-to-well interaction. Proposals for new or added pumping in a local source of supply propose new well effects that may not be adequately addressed by general well spacing rules. GMD3 area rules provide minimum well spacing and move limits to implement statutory policy absent better demonstration or investigation results. As the aquifer depletes, a better evaluation process to consider well effects is needed. Significant additional data and information are now available to provide better information to today's water use proposals that should not be ignored or prohibited from the record. GMD3 guidelines for well drawdown estimates provide a fair, consistent format and methodology to evaluate project proposals on a case-by-case basis that includes the unique characteristics of each application and groundwater setting. Disputed conclusions for the aquifer numbers used should be reviewed on the record of a hearing.

GMD3 water right review assistance process. As local groundwater levels decline, the value of usable water increases. The Stages of Aquifer Depletion concepts shown in figure 7 are further complicated by local vertical and lateral formation variability in capacity to provide water to a well. Many district wells are already in the yellow stage of aquifer depletion. In well fields that span areas of green to red stage conditions, a zero-sum net effect standard for multi-well use flexibility can accelerate depletion rates as demands and "paper water' move to remaining preferred pumping wells. K.S.A. 82a-1028(m) authorizes GMD3 to "provide advice and assistance in the management of drainage problems, storage, groundwater recharge, surface water management, and all other appropriate matters of concern to the district." The question of whether a proposed use or water right change will impair existing water rights is "advice and assistance in the management" of groundwater in "storage" and "all other appropriate matters of concern to the district." The GMD3 Board seeks clear accountability to align incentives, manage risk, and communicate science based standards in their advice implementing the public interest of the management program that include the following:

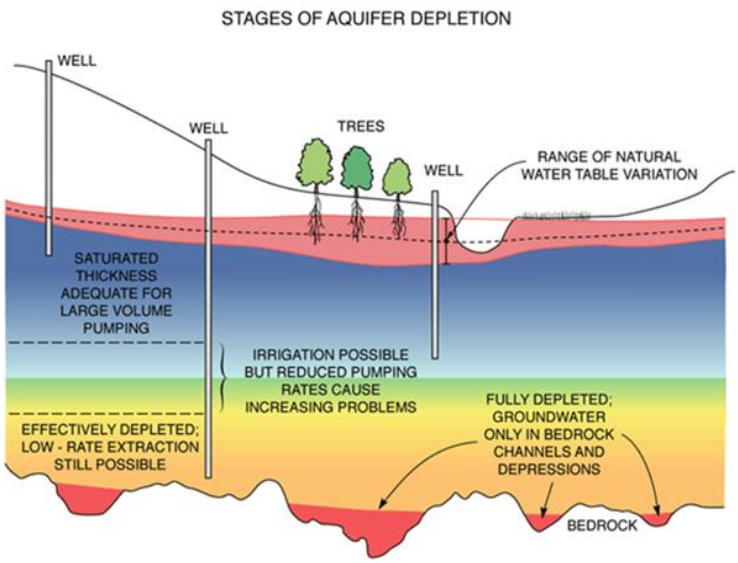


Figure 8. Stages of Aquifer Depletion, KGS

A. **Public and domestic drinking water supplies.** Steps to ensure quality drinking water for people and animals are a necessary element of the groundwater management program. No modification to historic terms of groundwater use should contribute to unreasonable or unsafe drinking water supply conditions, including deteriorating drinking water quality (Water Usability Depletion).

B. **Water usability depletion.** Water usability depletion is when the value of use of water supply is lessened or impaired by a decline in water quality, causing a material depletion in the utility of the water. The degradation of quality can either restrict or eliminate the beneficial use or reuse of water or require additional "fresh" water use to dilute or replace the degraded water.

C. **Maximum allowable rate of aquifer depletion.** The OHP aquifer is subject to a maximum allowable rate of depletion of 40% in 25 years; a limit adopted by GMD3 on July 12, 1978 and enforceable by state rule. The depletion rate cap is used as an economic constraint, given that the entire district is now considered closed to most new appropriations unless offset by unused prior use rights.

D. **Well drawdown estimates.** Well evaluations to identify critical wells (wells likely to be impaired) will be applied in a proposal review process with a framework where analytical tools such as a Theis Calculation and numerical tools such as the GMD3 Groundwater Model can be applied and considered to inform water decisions.

E. **Local source of supply.** Administrative practice and hydrological constraints such as rate of lateral movement suggest a local source of supply for a K.S.A.82a-708b(a)(3) demonstration should not allow a move beyond a 2-mile radius circle. Management program policy and guidelines may further constrain changes or change-like proposals.

F. **Private agreements between members.** GMD3 will recognize private water right administration agreements and make recommendations based on those agreements.

G. **Use of lesser quality water.** Under state law (K.S.A.82a-711), Water with a lower usability factor must be considered where technology and economics will allow it.

H. **Economic use value.** Plans or proposals that increase water use value while decreasing supply decline contribute to the public interest.

I. **Alternate supply development.** Proposals to conserve OHP aquifer water by seeking an economically and technologically feasible lesser quality alternative source should be recognized as contributing to the public interest.

J. **New flexible use among wells and their prior allocations.** New use flexibility between wells presents a new benefit and a significant risk of additional pumping effect on nearby wells. With improvements to type (1) water conservation (efficiencies), there is risk that no real type (2) water conservation (groundwater reservoir maintenance) is achieved to mitigate new use effects on the neighbor. Local hydrologic community evaluation for critical well conditions is needed to avoid impairment of nearby wells, especially where "paper water" may be re-allotted to remaining productive wells.

Preparation of applications. GMD3 staff may assist in completing an application for a state permit or for other such water-rights related member project planning and paperwork, but it shall be the responsibility of the applicant to review all such information and to submit it to the Chief Engineer as required by law and as advised by their own independent legal counsel and/or technical expert.

A**dditional wells and standby wells.** Additional wells may be necessary to allow a partial sale and change of water right use from irrigation to a higher value beneficial use. This additional well activity is distinguishable in the management program from efforts to add one or more wells to supplement or restore aquifer extraction rate capacity to replace lost capacity due to general water level decline. That statewide additional well rule may not work by itself to protect prior rights in a limited and declining supply based on experience. This raises concerns for changing purpose and conservation strategy of the management program, causing a disproportionate local rate of aquifer depletion and a "chasing water" concern that shortens the time to eventual complete depletion of supply to all. A **standby well** is different as it may only lawfully be operated should catastrophic failure of the primary well occur. A standby well meets standard spacing from other water rights. A primary well is not required to meet well spacing from its standby well and emergency operation is for 60 days.

MOU conditional change application services. Compliance monitoring assistance will be provided to implement a Memorandum Of Understanding (MOU) with the Chief Engineer for change applications under member contract agreements with GMD3 implementing the provisions of K.A.R. 5-5-9(a)(2), K.A.R. 5-5-11(b)(2) or K.A.R. 5-5-11(b)(3) and the management program and policies of the district.

Multi-well use flexibility (MUF) activity. Careful evaluation of critical well concerns and any voluntary corrective controls is needed to assure that any change in pumping allotments is consistent with provisions of law and the management program. For example, the WCA law in K.S.A.82a-745(e)(2) may allow aggregate use flexibility between participating wells as long as impairment of non-participating rights does not occur. This optional provision is likely to threaten nearby wells if those wells are identified as critical. GMD3 provides proposal review and well drawdown estimate services to applicants so that members have the information they need to make the best decision they can for their business and livelihoods looking ahead for at least one generation. Legislative tools for water management that may cause impairment locally may not be allowed. An example of this in the upper part of the Arkansas River IGUCA is where MYFA's are not allowed by the Chief Engineer because of drying seasonal surface water delivery concerns. Drying aquifer conditions present similar concerns.

Water use proposal review. Analytical and numerical tools and results will be reviewed when considering effects of use proposals or plans. The estimated effect on supply to member prior rights will follow good science for consistency with basic water use doctrine and the management program. Where good local aquifer information is not available, a pumping test of unconfined sand and/or gravel aquifer wells can improve confidence in a proposal review for decision. Elements to consider for a test include: Time of year, test pumping rate, length of test, pre-test conditions, measuring schedule, observation wells, multi-pumping wells, recovery period, and correct analysis method for the local aquifer conditions.

Application review and well drawdown estimate service. Groundwater pumping imposes stresses on natural groundwater systems and lowers the natural groundwater pressure at the location of the pump. This pulls groundwater out of storage and toward the pumping well, changing the natural groundwater pressures in an area resembling an inverted cone called a "cone of depression." Multiple wells can have additive effects. GMD3 employs guidelines for consideration of physical conditions that include the following:

- drawdown and/or stream depletion due to a proposed well pumping.
- drawdown from use under existing water rights.
- impact of drawdown on existing well completions.
- potential to obtain the rate and/or quantity of water sought.
- water availability.
- water quality.
- other information needed to support decision making.

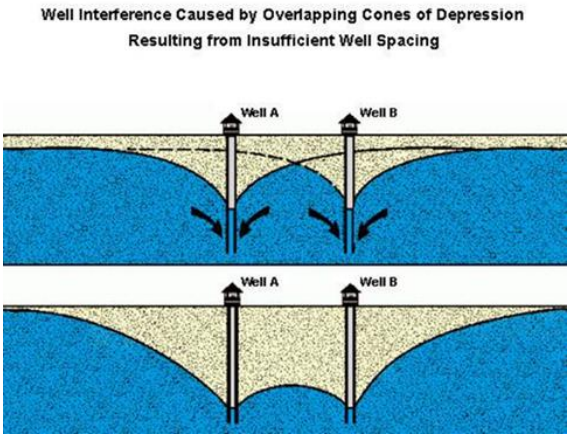


Figure 9 77 Well Drawdown Interference

The well drawdown evaluation guidelines. Well drawdown evaluation guideline will be used to inform questions of water risk and water right impairment. They may be updated and posted on the GMD3 website as needed. Guidelines have a settling effect on the general controversies of impairment of prior groundwater rights and serve as a framework for judgments on whether to investigate or to require more demonstration of local hydrology and well effects. When noticeable effects are likely to occur on critical wells, GMD3 usually recommends the applicant accept a limitation on rate and/or quantity to mitigate those concerns. A test period for the guidelines since

2017 found a majority of the applications have met the GMD3 guidelines and were recommended for approval. Guidelines address the following:

- Member water rights are real property rights that can be impaired.
- Groundwater depletion is provisioned in law and practice for the district.
- Hydrogeology is sufficiently understood.
- Mutual well interference is prevalent.
- A regional groundwater flow model (and any revisions) has been employed.
- Application and proposal reviews occur regularly.
- Minimum well spacing rules are not adequate to protect rights in many cases.
- Water right holders are entitled to seek injunctive relief/protection from property harm.

Well drawdown estimates - key guideline components.

A. **Drawdown Allowance.** Preventing any level of new impact on a well is impractical, as this would result in the denial of all applications including those causing small or de minimis impacts. A drawdown allowance is used as **a maximum reasonable lowering of a critical well's water table** to define a relatively small impact due to a proposed diversion that may be allowed to occur on wells in which economical and/or physical constraints are exceeded. A drawdown allowance can also be used as an application screening tool to determine if additional evaluation is warranted.

AVERAGE AQUIFER THICKNESS IN THE VICINITY OF A PROPOSED WELL (ft)	TOTAL DRAWDOWN ALLOWANCE OVER 50 YRS (ft)
0 - 50	1.0
>50 - 75	1.5
>75 – 100	2.0
>100 – 125	2.5
>125 – 150	3.0
>150 – 200	3.5
>200	4.0

Table 4 - RECOMMENDED ADDED DRAWDOWN ALLOWANCE

For up-to-date allowances, see GMD3 posted guidelines at GMD3.org, now at: http://www.gmd3.org/wp-content/uploads/2019/04/DRAWDOWN-ASSESSMENT-GUIDELINES-for-GMD3-2019.docx

B. **Critical wells.** Critical wells have high risk of suffering excessive supply decline and water right impairment. Wells in which economic and/or physical or other constraints are exceeded under adopted criteria are referred to as "critical wells." Adopted criteria are used unless better site-specific information is available. Wells may become critical due to the use of existing water rights in a declining supply alone or the combined effects of dynamic drawdown, existing uses, and proposed uses if one or more of the drawdown constraints are exceeded. For critical well determination, the net projected drawdown affect due to the proposal is added to the dynamic drawdown effect the neighboring well has on itself during operation and the projected water table decline 25 years into the future, either from the GMD3 model or a numerical model using better, more recent information.

C. **Economical Drawdown Constraint.** The economical drawdown constraint is calculated based upon a maximum allowable rate of depletion of 40% in 25 years. This has been a standard of constraint under the management program for over 40 years.

D. **Physical Drawdown Constraint.** Physical hardship is the loss of sufficient well yield due to excessive usable water level decline. The physical drawdown constraint is the difference between the depth to the current static water level (or depth to the potentiometric surface) and depth to the **Lowest Practical Pumping Level** (LPPL). The LPPL is determined based upon on the availability of well completion information such as the depth and thickness of the water bearing zone or confining unit, pump setting, and screen setting. For non-domestic wells in an unconfined groundwater reservoir, the LPPL may be assumed to be 60 feet above the base of the water column. If the screen interval and/or pump setting is unknown, a different LPPL may be determined to address reasonable concerns such as cascading water or other physical well concerns. The LPPL for non-domestic wells in a confined bedrock aquifer may be assumed at the base of the upper confining unit unless this assumption is unreasonable (Sterrett, 2007). If the total drawdown extends below the LPPL that well becomes a critical well.

E. **Domestic wells.** The LPPL is typically assumed to be 20 feet above the base of the water column for domestic wells unless a different value is supported. At least 20 feet may be necessary to maintain submerged conditions, avoid sediment problems, and allow for dynamic drawdown, etc. (length of pump and net positive suction head).

F. **Water usability constraint.** Usable water column for well evaluations can be significantly reduced by unusable water quality, or water usability depletion of supply. Usability constraints will be addressed as available information dictates. Water rights that authorize use in depleting areas may be held to existing use terms in response to critical well or drought-like warning conditions.

On-site diversion and flowmeter inspection services. Water flowmeters and other devices have been required by the governing body of GMD3 on all non-domestic wells for 30 years. On-site services assure good water measurement assistance and ensures groundwater programs are based on good use, aquifer and well condition data.

Timely GMD3 review process. A GMD3 application review process will be conducted with efficient use of time to respect the needs of all members and add value and confidence in the evaluations of groundwater project investments, local groundwater supply conditions, well operating needs and private property rights to use available groundwater storage for a reasonable period of time. Accordingly, review time to a recommendation may range from **less than 15 days to significantly more time** depending on a number of factors that may include: legal setting; physical setting; insufficient information provided; request for rule waiver; extent of available data; number of calculations to complete; communication time; concerns from other members; proposal revisions; GMD3 committee and board review; aquifer testing: mitigation of impairment concerns; and any hearing requested and allowed by DWR. The complete GMD3 Guidelines For The Assessment of Well

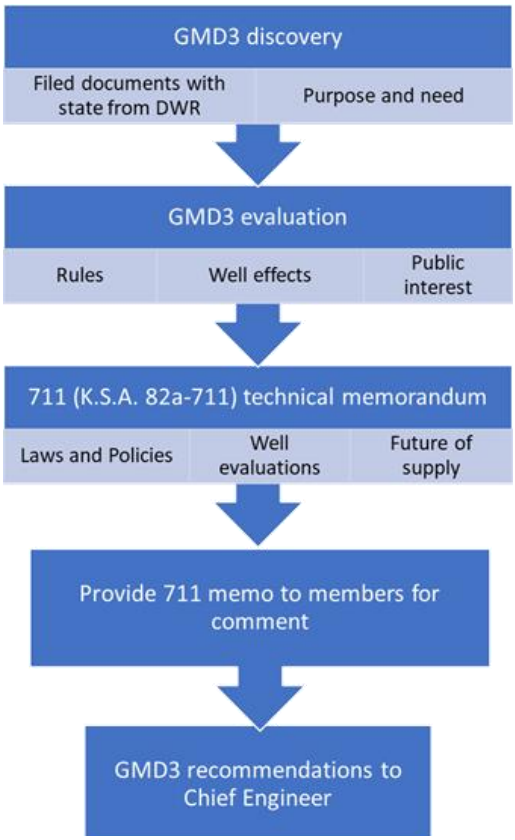


Figure 10. GMD3 Water right review assistance process.

Drawdown Estimate Guidlines can be found at: http://www.gmd3.org/wp-content/uploads/2019/04/DRAWDOWN-ASSESSMENT-GUIDELINES-for-GMD3-2019.docx

Contact GMD3 or your private consulting specialists for assistance in estimating well effects.

GMD3 Water Conservation Activities

Wise use. Water conservation demands wise use of water, even during extreme flood and drought conditions. It provides results in increased productivity, reduced aquifer decline, and moves society toward sustainability. It is essential if future generations are to have the means to live productively within the region and as a state. Wise use of water requires an understanding of the four elements of water risk (storage, replenishment, regulation, and reputation). GMD3 water conservation activities will encourage members to be wise in use and to conserve and extend supply sources while also developing alternative supply sources to replace or replenish district groundwater reservoir inventory.

- **Water Conservation -** has two types of activity under the GMD3 management program:

  (1.) **Use efficiency**
  - the amount of valued output per unit of water consumed.

  (2.) **Maintaining aquifer storage**
  - preserves and/or replenishes future useable storage.

Figure 11. The Two Types of Water Conservation

Type (1) Water Conservation: Use Efficiency. Use efficiency is the amount of valued output per unit of consumed water. This type of activity adds present economic value and benefits to each unit of water diverted from storage. It also adds risk in greater capacity to consume every drop available from declining aquifer supply. Efficient water use technologies, products and services are an effective means of economic growth and improving the bottom line of a project. As the cost of water increases, the business incentives and benefits associated with efficient use increase. Improved efficiency reduces the amount of water that returns to the aquifer. Therefore, type (1) conservation only saves water when it is accompanied by a reduction in use. When type (1) conservation is utilized as a reaction to declining well yield, it may increase groundwater consumption.

Type (2) Water Conservation: Maintaining Aquifer Storage. Maintaining aquifer or groundwater reservoir storage requires conserve-to-preserve activities. Type (2) conservation includes protecting renewable recharge sources, adopting projects with lower water use demands, reducing use through corrective controls, and administering the exercise of water rights based on long term solutions that include water importation. All are effective means of Type (2) water conservation. Aquifer maintenance activity may be coupled with type (1) use efficiency activity. A conserve-to-preserve factor evaluation tool will be developed by GMD3 to determine the

quantities of useable water in storage vs. unusable or unavailable paper water for proper water conservation accounting. Both forms of conservation are necessary elements of the management program to move the wellbeing of Kansas and District communities forward. Strengthening links between natural infrastructure (rivers, streams, playa lakes and groundwater reservoirs) with private and public constructed infrastructure (wells, tanks, pipelines, canals, pits, lakes, and surface reservoirs) will help create economic, climate and drought resiliency across the district.

Meet needs and preserve storage. GMD3 members know the difficulties of maintaining vital well operations in the face of water level decline. Because well yields drop with the water table. Type (1) water conservation has become necessary for many members to continue productive activity with reduced well yields. Type (2) water conservation can have positive effects to reduce local decline rates. The water conservation activities of GMD3 seek to have members use what they need under modern efficiencies and leave or replace in storage what they can to improve future water supply. A proper water valuing tool will inform decisions and markets about allocating water across multiple uses and services to maximize future district well-being. Properly assessing the value of water will make the cost of usability depletion and water waste apparent and will promote conserve-to-preserve practices.

Conserve-to-preserve factor. The quantity of "wet water" preserved or replenished within a local aquifer supply may be considered the water conservation (conserve-to-preserve) factor of a plan or program, expressed in acre-feet. This factor is a calculation that separates the inevitable non-use of a water right (inaccessible or depleted supply) from aquifer maintenance actions (reduced water demand or groundwater recharge) that make more water available in the future. About 44% of the 3.6 million acre-feet of perfected annual authorized groundwater within GMD3 is not used for various reasons, including voluntary groundwater conservation or diminished well yields from depleted aquifer conditions. Well yield is the rate at which a well can reliably produce water under normal operating conditions. The water that the well provides may differ from the authorized maximum allowable conditions of a water right. For diminished well yields, there is a significant amount of "paper water" (water rights on paper only, due to diminished well yield). Therefore, the conserve-to-preserve factor is a necessary element of the management program.

Reporting conserve-to-preserve amounts. Water management based on use requires water use reporting. Water management based on conservation requires water conservation reporting. Water management actions that conserve-to-preserve supply will be routinely documented for member benefits; benefits realized either in extended supply, monetary incentives or in matters of water right administration.

No conserve-to-preserve penalty. Any policy that equates lack of demand to lack of right or resource concern is not a proper basis for water management accounting. A declining groundwater supply is a resource concern that requires sustained conservation incentive and reward commensurate with the value of the resource conserved. Water planning documents tend to describe water demand in terms of water use and fail to account for the accessible supply of water being insufficient to meet demand. There is little standardized data available to quantify the extent of water conservation occurring in the district. GMD3 will help members with water conservation activities and voluntarily submit annual water conservation reports for their water right record and work to ensure that no future rules or programs penalize conservation.

Every Manager A Water Conserver (EMAWC) initiative. Each family and corporate water manager must act in their own way to manage climate variability and project water risk with wise use that improves their bottom line. Members will be encouraged to provide personal leadership in groundwater conservation to determine the destiny of their water use and the future of their water-dependent enterprise. GMD3 will provide support consistent with the management program to facilitate wise decisions and knowledge uptake. The actions of Every Manager A Water Conserver (EMAWC) activity may ultimately determine the future available groundwater supply for the farms and industry of the GMD3 area. Regular investment to maximize water system efficiency is highly encouraged Type (1) water conservation and critical in developing home-grown water management strategies.

Home-grown management plans. Climate resiliency involves incorporating water risk into plans that anticipate and respond to hazardous events related to drought or flooding. Local groundwater storage is generally slow in lateral flow, so members can expect benefits of their managed conserve-to-preserve activities to generally remain local. Groundwater management requires each project manager to conserve-to-preserve supply where possible and to develop a water budget strategy that incorporates minimum use need and long-term conservation opportunities. GMD3 will implement an EMAWC activity to incorporate actual well conditions, supply management, recharge, and alternate sources into a bottom-line water strategy for each manager. An EMAWC project level activity uses measured farm data, water rights analysis, and expert assistance to yield benefits and provide baseline awareness of changes by other local water users. Each member is responsible for the protection of their local ag industry and communities with wise water management, such as maximizing rain benefits and minimizing evaporation loss through the use of irrigation scheduling and sensor technologies.

Master Water Manager. The Master Water Manager pilot project will promote the EMAWC activity and be an extension of ongoing demonstration programs. Master Water Manager will be designed to facilitate the adoption of proven best management practices by significantly reducing the learning curve for water managers and promote adoption of Type (1) conservation. Master Water Manager participants will learn how to manage water use using conservation practices with practical, accessible tools and strategies. Lectures, problem solving, and hands-on applications will be used during teaching. The length of the program will give participants time to reflect on what they learn and build a network of water managers to rely on when implementing best practices in operations. This may be patterned from the North Texas Master Irrigator program spoken about at the Ogallala Water Summit that took place April 2018 in Garden City.

Groundwater Exploration and Protection (GE&P) Act. The GE&P Act is a body of Kansas law to provide for the exploration and protection of groundwater through the licensing and regulation of water well contractors in Kansas to protect the health and general welfare of the citizens of the state. The Act protects groundwater resources from waste and contamination by requiring proper description of the location, drilling and well construction, and proper plugging of abandoned water wells and test holes. The Act provides critical data on water supplies through well logs, well pumping tests and water quality tests which will permit the economic and efficient utilization and management of the water resources of this state. The Kansas Department of Health and Environment (KDHE) Bureau of Water handles licensing of water well contractors; provides for enforceable standards for well construction, reconstruction, treatment and plugging; requires each licensed water well contractor to keep and transmit to the state, upon request, a copy of the

log of the well, pump test data if available, and water quality samples, and maintains within the Kansas Geological Survey (KGS) a record system of well logs and water quality data available to the public. GMD3 will utilize the information made available under the GE&P Act and work with KDHE staff and other partners in its implementation in harmony with the management program.

GMD3 Drought Resiliency Program

Drought. Drought affects southwest Kansas frequently with a subtle onset that develops significant impacts over time. Long-term historical climate variability estimates over the last 1000 years produced by Layzell and others at the KGS indicate significant historical climate variability beyond modern experience and data. Vast development of local groundwater reservoir storage pumped to replace rain deficiencies has provided great drought resiliency and agribusiness advantage for the region. Significant value has been realized by decoupling economy from local rainfall and climate variability through the development and use of stored groundwater for irrigation. This has led to aquifer depletion, causing a re-aridification of irrigated farms consistent with the subtle onset of drought as reserves are diminished. The response to severity of drought relates both directly to the three drought stages of Watch, Warning and Emergency described in Tables 2 and 3 of the Kansas Drought Operations Plan, and also to the extent local aquifer inventory and infrastructure has preserved the capacity to mitigate local water shortage conditions. The Kansas Drought Operations Plan can be accessed at: https://kwo.ks.gov/reports2/climate-and-drought-monitoring-response. The Kansas 2007 Municipal Water Conservation Plan Guidelines reflect the drought response stages in the Kansas Drought Operation Plan. Programs will be implemented to inform members in their use and available supply conditions with interactive water management and technology tools. GMD3 will encourage and support regular review and updating of water conservation plans.

U.S. Drought Monitor – The U.S. Drought Monitor is produced weekly through a joint effort of the U.S. Department of Agriculture, The U.S. Department of Commerce – National Oceanic and Atmospheric Administration and the National Drought Mitigation Center. Advice from local experts throughout the nation, including the Kansas State Climatologist, is used in producing the Monitor. This composite drought map incorporates information and products from hundreds of experts representing many entities and levels of government in an effort to represent the extent, magnitude, impacts, and probability of drought occurrence. Short term management program drought response tools like Multi-Year Flex Accounts and long-term strategies for type 2 groundwater reservoir maintenance will be employed to help determine the destiny of water use in the district. GMD3 will develop water use, climate, and conservation feedback to members utilizing annual water use report, site visits and other data to inform and assist members in their decisions affecting their drought resiliency.

State mandated water conservation plans approved by GMD3. Water conservation plans mandated by the Chief Engineer as a condition of water use have been tied to many water rights in the district. They are intended to provide information and encourage Type (1) water conservation originating from a joint state and district initiative, with legislation passed the 1991 legislative session. Under that law (K.S.A. 82a-733), the Chief Engineer may require applicants for permits to appropriate water, water users with relatively high use, and water users applying for any state administered grant, loan or cost-share moneys for water-related projects to develop water conservation plans. GMD3 has historically advised and assisted the state and members with plan approval and completion of conservation plan requirements aided by State Water Plan

funding from the Kansas Water Office. The KWO develops and maintains guidelines for water conservation plans (K.S.A.74-2608). Current state guidelines for irrigation conservation plans are available at: https://kwo.ks.gov/docs/default-source/reports-page/water-conservation-reports/2006-kansas-irrigation-wcp-guidelines-jan2006.pdf?sfvrsn=6
Municipal (public water supply) guidelines are available at:https://kwo.ks.gov/docs/default-source/reports-page/water-conservation-reports/2007-municipal-wcp-guidelines-aug2007.pdf?sfvrsn=4

Water conservation under state guidelines. Under statewide Kansas Water Office guidelines, water conservation is defined as:

> "*The utilization of cost-effective water use efficiency practices to curtail the waste of water and to ensure that water use does not exceed reasonable needs.*"

This general definition implementing K.S.A. 82a-733 of the KWAA and other water use considerations focuses on use efficiency, which is Type (1) water conservation activity under the GMD3 management program. Type (2) water conservation that is emphasized in our management program needs other guidelines. GMD3 will seek to develop district guidance to assist members and others in developing an understanding of the terms and conditions of their water rights, water use agreements, and conservation activities consistent with the management program. Per Subsection (g) and (h) of K.S.A 82a-733, GMD3 will review and consider approval of conservation plans and practices and retain this authority for any proposal to set plans aside or to provide due consideration thereof in the conservation activities of IGUCAs, LEMAs, and WCAs.

GMD3 water conservation plan guidelines. GMD3 will investigate, develop and update water conservation plan guidelines for Type (2) conservation under separate guidance documentation to achieve the following:

1. Provide a plan template that can be used to develop water conservation plans to meet the requirements of the GMD3 management program, the state, federal interests, and other partners.
2. Provide considerable flexibility to develop and monitor water conservation plans consistent with the management program.
3. Provide an online source for Guidelines and Plan templates, so that members, consultants, and other management partners can easily download a template or develop a Plan.
4. Include a subsection on source conditions and management goals.
5. Make plans useful to member water managers, so that the majority of GMD3 water users can be directly involved in the management of their local water sources and use destiny.
6. Curtail waste of water using readily available best practices that ensure water use does not exceed reasonable needs.

Benefit-to-cost ratio effect of conservation plans. K.S.A 82a-733 requires the Kansas Water Office to conduct benefit-to-costs review for conservation plan guidelines. Benefits and costs should be estimated over the projected life of the water conservation plan and discounted to present day value equivalents for determination of whether benefits exceed costs under classic economic theory. A common way to compare the benefits and costs of a conservation plan is to divide total benefits by total costs. The result is called the benefit-to-cost ratio, or B/C ratio. A B/C ratio greater than one indicates that benefits are greater than costs while a B/C ratio less than one indicates that costs are greater than benefits. A B/C ratio exactly equal to one indicates that costs are expected to exactly balance benefits of the water conservation plan. Alternative

conservation projects can be ranked by their net benefits or B/C ratios to identify which projects are expected to provide the greatest amount of benefit to members and the district. GMD3 will develop more information on B/C ratio calculations for the district in a separate implementation document to advise and assist the Kansas Water Office in implementing this state law.

Water flowmeters. The GMD Act under K.S.A. 82a-1028(l) provides that GMD3 has the authority to "*install or require the installation of meters, gauges, or other measuring devices and read or require water users to read and report those readings as may be necessary to determine the quantity of water withdrawn.*" GMD3 works with members and partners to provide expert assistance in flow measurement and practical program administration. The GMD3 board was an early leader in advocating for and requiring water flowmeters and measurement reporting on all non-domestic water uses in 1991. Thousands of flowmeter inspections are conducted by GMD3 each year and feedback are provided as member service.
See inspection video at: https://www.youtube.com/watch?v=exmaiZAEMnE&t=1s.
Measurements identify opportunities for water project improvement, showcase examples of efficient use, tie use to water level response, and create other valued data uses. Use measurement empowers and demonstrates water stewardship. Hefty GMD3 seals are installed as a member service to ensure the flowmeter has remained sealed in the event the lightweight manufacturer's seal falls off.

Capping new appropriations to conserve and extend groundwater supply. GMD3 has adopted administrative conservation measures, conducted maximum allowable depletion rate water availability calculations, and made recommendations to the Chief Engineer for each new water appropriation application since water rights have been made mandatory in Kansas. This conservation partnership includes recent GMD3 action to adopt a closed aquifer policy and request that the Chief Engineer close the OHP Aquifer to new water rights with some small use exceptions. Those small use exceptions have subsequently been reviewed by GMD3 and Board resolution 2018-5 was passed to require offsets from existing rights for any new non-domestic water right to help avoid nullifying member local source conservation efforts and not inflate appropriation totals. GMD3 will have existing area water use potential identified to implement Board Resolution 2018-5. GMD3 will work with well owners in a review process to evaluate current well and groundwater reservoir conditions with each administrative request to the state. The fundamental conservation policy of GMD3 in such cases is that there is no additional water available from the source beyond what is needed to satisfy existing water rights.

GMD3 member water conservation stewardship. Members often implement undocumented groundwater conservation activities as a matter of good stewardship. A full review of the many water conservation activities is too lengthy to list here and may be enumerated in separate GMD3 implementation documents. Voluntary water conservation efforts in the district include:

- No-till farming methods which improve soil moisture retention.
- Crop selection and field rotations that require less water than historically needed.
- Improved irrigation system efficiency technology.
- Enrollment in sponsored programs of GMD3, state and federal partners.
- Local conjunctive management practices of surface water and groundwater where possible.
- Non-use of viable wells.
- Reuse of wastewater and effluent from primary beneficial uses.
- Use of lesser quality water where economically and technologically feasible.

GMD3 water conservation leadership. Public policy accelerates the adoption of conservation products and services through incentives such as cost sharing, regulatory relief, tax credits, rebates, and technical assistance. GMD3 will continue to provide leadership and support activities for water conservation as defined in this management program in coordination with other local, state, and federal partners to conserve, extend, and replenish the groundwater inventory of the district. Recent examples include:

- **Flowmeter technical assistance (FTA)** in over 2,500 annual project diversion site visits by GMD3, including flowmeter sight visits, management plan audits, and flowmeter verifications.
- **Ark River Conservation study (ARC)** conducted in 2005 to investigate water management and conservation needs and alternatives in the upper Arkansas river basin of southwest Kansas.
- **Western Water Conservation Projects Fund (WWCP Fund)** working through a nearly $10 million grant (2008) from the Kansas legislature to relocate interstate water damage award funds from SGF through a legislative budget proviso and grant agreement with the Kansas Water Office.
- **Conservation Reserve Enhancement Program** (**CREP**) working with the state and federal Farm Service Agency and other partners to retire water rights and transition irrigated agriculture to native grassland within the Ark River basin where GMD3 provides cash and in-kind services such as conducting supply verification tests for member applicants and NRCS program partner needs.
- **Water Transition Assistance Program (WaterTAP)** was promoted by GMD3, Kansas Water Congress, and partners authorized under K.S.A. 2-1930 for state conservation incentives to be administered by the State Conservation Commission. Limited state funding has been available.
- **Agricultural Water Enhancement Program** (**AWEP**) agreement with USDA/NRCS to transition irrigated acres to dryland agriculture (completed) with ongoing use of Environmental Quality Incentives Program (**EQIP**) conservation tools and opportunities.
- **Regional Conservation Partnership Program** (**RCPP**) agreement with USDA. In 2015, GMD3 was awarded a $2.4 million-dollar grant from the NRCS to help incentivize Advanced Irrigation Water Management across the region through telemetry technology, remote soil moisture, and flowmeter monitoring as added conservation activities.
- **Conservation Innovation Grant** (**CIG**) agreement (2016 - 19) with NRCS that evaluated mobile drip irrigation and other application innovations with the goal of federal implemented assistance for uptake of mobile drip water conservation technology**.**
- **System Optimization Review** (**SOR**) with the US Department of Interior, Bureau of Reclamation (Reclamation), which evaluated the irrigation ditch delivery systems along the Arkansas River corridor for targeted efficiency improvement projects.
- **Local Enhanced Management Area** (**LEMA**) discussion and facilitation concepts and surveys with members to consider local mandatory and voluntary groundwater conservation strategies with corrective controls in priority areas of the district.
- **Water Conservation Area** (**WCA**) review and policy development to assist members and the state in developing voluntary water conservation plans for meaningful corrective controls and appropriate project plans consistent with state law and the district management program.
- **Planning Assistance to States** (**PAS**) partnering with the Kansas Water Office and the US Army Corps of Engineers in 2015 to update a 1982 High Plains Study Water Transfer Element for conserving waters of the state normally lost annually from use in Kansas.
- **Public Water Supply (PWS)** 2014 GMD3 WaterSMART study grant working with Reclamation and Kansas Water Office to examine public water supply options for systems to maintain safe drinking water in the depleting usability of the GMD3 Upper Ark basin groundwater supply that includes the IGUCA above Garden City.

- **Basin Plan of Study (POS)** GMD3 effort in 2015 with Reclamation seeking Ark River basin planning partners in the Arkansas River basin spanning the Stateline with Colorado and includes the Hamilton County river corridor outside the district for collaborative efforts addressing contaminated water and other water concerns in the shared resource that set the stage for 2019 legislative resolutions requesting partnerships and other state and federal cooperative action.
- **Value of Water (VOW)** evaluations with the Docking Institute for Public Policy (2000) and the Kansas Aqueduct Coalition and Apparet Analytics, LLC (2015) on the value of water to Kansas and the GMD3 area.
- **Proof-of-Concept (POC)** project in 2020 demonstrating the transfer of high flow Missouri River water to GMD3 conservation storage with the aim of verifying that source import water can occur and have elements of practical potential to manage Ogallala supply decline.

Rain capture and water re-use. One way of expanding the usable supply of water is using harvested, recycled, and/or reclaimed water for irrigation and other purposes. In some cases, potable water has been the only water resource available for irrigation, either because of infrastructure, use right constraints or regulation. Under suitable conditions, irrigating crops, landscapes, and recreational areas with harvested, recycled and/or reclaimed water will increase the water available for health and human safety and provide economic, social and environmental benefits. Declining water quality will necessitate treatment to gain appropriate purity levels for use, so effects on local supply should be adequately evaluated. Any usable water is a vital and limited resource that requires management to avoid waste of valuable water resources. GMD3 will evaluate water sources and identify potential uses of lower quality water where they exist.

MYFA conservation. The MYFA law provides for flexible groundwater use from a single well over five years (**K.S.A. 82a-736).** The updated law contains two provisions for consideration of past implemented water management and conservation. GMD3 will propose local MYFA rules so that conserve-to-preserve calculations will be considered for implementation of MYFA prior conservation calculation provision and so that evaluation criteria will be adopted to evaluate the long-term effects on any source of supply.

Due consideration for past conservation measures. In 2015, the Kansas legislature added policy to the Water Appropriation Act requiring the chief engineer to give due consideration to water management or conservation measures previously implemented by a water right holder when implementing further limitations on a water right and to take into account reductions in water use, changes in water management practices, and other measures undertaken by such water right holder. The Chief Engineer should consider the GMD3 management program when implementing and approving new projects, plans and programs within the GMD3 area because the management program is adopted from his legal review and public hearing process.

Surface water storage in underground reservoirs. Water supply in river basins of the southwestern US struggle with insufficient water quality, quantity and drought. Significant water shortages in the Upper Arkansas River basin in Kansas and Colorado and adjacent river basins west, together with significant and reoccurring floods in areas east adjacent to the High Plains may get worse under projected future climate shifts to a drier southwest and wetter Missouri and Mississippi river systems. Declining water quality and quantity in the High Plains region of the basin occur as upper basin water is transferred to meet high value Colorado Front Range demands while basin supply east of Pueblo struggles with poor water quality from intense irrigation re-use and system evapotranspiration processes that concentrate mineralized water moving down basin. This transient water contaminates the heavily used and declining Ogallala/High Plains Aquifer in

a GMD3 area where 1.6 Million AF/yr of unmet demand puts added risk and pressure on management programs and water stocks. Significant growth in wind and solar energy on the High Plains and opportunity in stable capital costs suggest federal assistance may help to identify a large-scale long-term water west project across the Arkansas River basin to augment western water needs. Timing may be appropriate while significant Missouri Basin flood protection improvements are being evaluated by the U.S. Army Corps of Engineers (Corps) and an unprecedented multi-state Drought Contingency Plan is marshaled collaboratively by the U.S. Bureau of Reclamation (Reclamation) and western states to assure continued water safety, future economic growth and other water resource services vital to western water and national security. Reclamation has an established interest in aiding development of alternative fresh water sources and other assistance that include the Colorado River Basin Plan, the Fryingpan-Arkansas Project for water diversion, storage and delivery authorized in 1966 by Public Law 87-590, A 2015 Arkansas Basin Plan of Study from John Martin Reservoir in Colorado to Garden City Kansas pursuant to the authority and mandates of the Secure Water Act (SWA), Subtitle F (P.L. 111-11), and the Flood Control Act of 1944 (Pick-Sloan Act) for the Missouri River Basin. Recent reoccurring Missouri Basin flooding sparked Kansas interest to work with the Corps under a Federal Planning Assistance to States (PAS) Agreement updating the Route B Water Transfer Element of the 1982 Six State High Plains Aquifer Study (High Plains Study). Completed in 2015, the update found half again more water available for transfer then originally estimated. The original High Plains Study was authorized by the first Water Resources Development Act (WRDA) of 1976 directing the Secretary of Commerce ". . . to examine the feasibility of various alternatives to provide adequate water supplies" for the High Plains Region, and ". . . to assure the continued economic growth and vitality of the region." Working from the public laws referenced above and multiple concerns of western water management, a new look at water west for long term basin augmentation is needed.

Aquifer pore space in GMD3. The issues surrounding geological formation pore space and rock structure ownership have been raised in discussions generally connected to oil and gas operations for carbon capture sequestration into subsurface geologic formations and for ownership and management rights in topics of water rights administration, federal reserved water rights, deep formation disposal projects, and in artificial storage and recovery of water. With water being an exception in Kansas, generally ownership of the surface of the land includes ownership of all that lies beneath the surface boundaries, to include mineral, rock structures and voids (David Pierce, Washburn Law School, legislative briefing, 2011).

Estate ownership and water. Ownership of the surface estate of land can be separated from one or more mineral estates below the surface of the earth, such as groundwater. The owner of the surface estate generally retains ownership of minerals not expressly encompassed by the conveyed mineral estate. Owners of minerals (oil and gas) also have the right to access the rock structure where the oil and gas are found so they can be developed, even though the mineral owner may not “own” the minerals comprising the rock structure. Similarly, a water right to use groundwater may be a right to access the water in the poor space even though the user may not own either the surface or the mineral estate. A water right is a usufruct right to use public water where ownership is not conveyed in the corpus of the water or the channel of the stream or the rock formation. Pore space is connected with little ability to control flow regardless of ownership. Naturally stored, usable water within aquifer pore space is a part of the “waters of the state” governed under the provisions of the KWAA and the GMD Act. The GMD Act in K.S.A.82a-1021(a)(7) defines a “land owner” and includes the following: *“Owners of oil leases, gas leases, mineral rights, easements, or mortgages shall not be considered landowners by reason of such ownership.”* A natural aquifer may contain a native body of public water that is subject to

appropriation for beneficial use, but artificial recharge and conservation storage in geological formation pore space owned by another may be something different. For example, ownership of a surface reservoir storage space comes from acquiring the use of the surface estate and construction of the storage space. Use of a natural water course is provided in Kansas policy for private conveyance of water (K.S.A. 42-303) but a constructed surface reservoir on a surface water course for possessing water requires easement or ownership of the surface estate. Groundwater reservoir pore space may be used for artificial recharge or filled with non-native water under a managed plan where there is reasonable provision to satisfy prior groundwater rights to native supply. GMD3 will recognize ownership and potential use of natural and artificial water storage mechanisms and any retained ownership of artificially stored water in rock formation pore space owned by another as key factors in the question of whether any pore space use easement may be necessary.

Conservation in preparing for water importation. Multiple water sources must be managed with type (2) conservation to deliver sufficient fresh water to meet the needs of southwest Kansas. The Kansas Water Transfer Act states that no water transfer shall be approved unless a number of provisions for water conservation have occurred and have been previously implemented and that the benefits to the state outweigh the benefits for denying such transfer of water (K.S.A. 82a-1502(b) and (c)). Based on the above, GMD3 will document the conserve-to-preserve activity in the district to fulfill the purposes of the Water Transfer Act requirements and exceed statewide conservation plan guidelines by emphasizing Type (2) water conservation. This will aid the efforts to deliver additional inflows into the more than 60 million acre-feet of available underground storage space in GMD3.

Culture of conservation. Growing the demand for water conservation in a culture of market-driven uses involves a strategy of reaching out to specific industry groups and areas which have comparatively low rates of participation and engagement around water conservation and efficiency. Increased participation allows vendors to develop economies of scale and more cost-effective programs. “Growing the culture” naturally occurs as participation rates increase across the district. While programs might lose their potential for scale as more members participate, the proportion of the population engaged increases and values for water conservation are elevated. As discussed earlier, incentives for water conservation may also become cultural barriers to water conservation if value incentives are not shared or sufficiently valued in the public interest of Board recommendations and state decisions consistent with the management program.

Targeting designated Groundwater Management Areas (GMA).
A GMA is any targeted area in the district designated for unique specified groundwater management program activity. GMD3 conservation and/or management activity may exist to accomplish special private, corporate or governance purposes and use one or more institutional tools uniquely applied through the district management program in each GMA.

Conservation barriers. GMD3 and other Kansas GMDs pursued forming special GMAs for corrective controls in 1977 but found the lack of local and state authority to be a barrier in attempting to manage groundwater supply and use. Local or state permitting of all non-domestic water use was not required in Kansas at the time and the extent of water use was not known. The GMD3 Board immediately requested an official moratorium on granting new water rights by the Chief Engineer for an area in the Arkansas River basin above Garden City to allow work for data

and policy development on over-allocated areas. Water conservation barriers can be institutional as well as cultural, technological, and legal in nature. See Core Values on page 13.

Mandated water permitting and IGUCAs. Legislation was successful in 1978 to add state policy in the KWAA requiring permitting of all water rights to define water use across the state and to add policy in the GMD Act providing authority for a GMD or a group of GMD members to initiate special GMA corrective control action within their GMD. That GMA tool was called an Intensive Groundwater Use Control Area, or "IGUCA." It was designed as a request made to the Chief Engineer, who would then conduct a process to consider the need for formation of the IGUCA. The IGUCA tool, once requested by a GMD, involves a prescribed review and fact-finding process where the Chief Engineer conducts one or more public hearings and can result in an order of the Chief Engineer imposing corrective controls on water use. For areas outside of GMDs, the legislature extended the IGUCA tool for the Chief Engineer to initiate proceedings on his own initiative. A few IGUCA management orders have been developed and issued to implement mandatory corrective controls onto groundwater rights in GMA's across the state.

GMD3 Upper Arkansas River IGUCA. The Upper Arkansas River IGUCA was requested by GMD3 in 1984 as a GMA to replace the GMD3 requested 1977 moratorium on new appropriations in certain counties with high vested right (pre-1945) amounts. The request was to extend corrective controls from the Colorado and Kansas Stateline in a corridor along the river across GMD3. This IGUCA was ordered by the chief engineer after significant public process, testimony and recommendations of the Board and district members. See map of the IGUCA area in the Appendix. Any revision action should include GMD3 review and recommendations implementing the management program. Additional state information on the Upper Arkansas River IGUCA is available at: http://agriculture.ks.gov/divisions-programs/dwr/managing-kansas-water-resources/intensive-groundwater-use-control-areas/arkansas-iguca

Corrective controls. Water right administration under the prior appropriations doctrine is the most direct form of corrective control provided by the Kansas legislature for water-short supply conditions. This generally involves a complaint, opposition to an administrative action or a request to secure a water entitlement. Beyond water right administration, corrective controls are considered new program actions to secure corrections to water supply decline problems. Corrective controls are intended to benefit future supply in addition to present use constraints. It is well established that the supply problem conditions set forth in K.S.A.82a-1038 of the GMD Act exist across the entire GMD3 area for the OHP Aquifer. These conditions have been perpetuated in the customary approval decision processes of the Chief Engineer. Corrective controls in the declining OHP Aquifer must add new controls as Type (2) water conservation to maintain aquifer storage and improve future supply under the management program. GMD3 will assure new corrective control benefits fall to all members, and that members may not benefit from higher groundwater use than their peers in obtaining additional use benefits or impose new critical well risks from voluntary corrective control plans. GMD3 feedback to members on their reported water use and aquifer condition may advise and assist in evaluating the merits of voluntary corrective controls.

Special rule conservation areas. Special rule conservation areas with controls requested and established as enforceable policy or state rule corrective controls address concerns such as quantity, usability, or use practice that require administrative standards to manage or encourage efficient groundwater use while protecting useable supply. K.A.R. 5-23-4(c) is a special rule for a

water quality control area in parts of Seward and Meade Counties. Naturally occurring saltwater upwelling from Upper Permian Age formations moves into the overlying connected Ogallala groundwater reservoir formation, threatening water usability depletion in the Ogallala supply of the area.

Targeted water rights buy-back. State buy-back of water rights can occur, if funded, through the administrative activities of the KDA Division of Conservation (K.S.A. 2-1915). The Division of Conservation shall make water right transition grants available only in areas that have been designated as target or high priority areas by a GMD and the chief engineer or priority areas outside of any GMD as designated by the chief engineer.

LEMA. The Legislature added a new GMA tool in 2012 for GMDs after more than a decade of development work by Northwest Kansas GMD4 and partners. The Local Enhanced Management Area (LEMA) statute (K.S.A. 82a-1041) provides a procedural structure for the development of LEMA management plans to be adopted by a GMD and recommended to the chief engineer.

LEMA plans. A LEMA plan is a tool of local leaders and the GMD3 governing body to address local groundwater concerns. When members of GMD3 come together to seek ways to extend supply and reduce the rate of groundwater decline, the GMD3 Board has the authority to adopt a LEMA plan and seek acceptance by the Chief Engineer, who must consider only the requested plan for implementation. GMD3 has adopted LEMA plan policy that a proposal can be recommended to the GMD3 Board by members as a priority GMA to be further managed with infrastructure development and/or corrective controls in the public interest. Basic steps for establishing a GMD3 LEMA involve formulation of a plan generally accepted by area members, presentation of the plan to the Board, Board adoption of the proposed plan, Board request for a LEMA to the Chief Engineer based on the plan, two prescribed public hearings considering the proposed plan, and a decision order of the Chief Engineer approving, returning, or rejecting the LEMA. Any LEMA plan proposed to the Board for adoption shall include: 1) A clear groundwater management goal; 2) A basis for the proposed boundaries; 3) Evidence in the record of plan development that multiple alternatives were formulated for setting corrective controls on member water rights, including use of the principle of prior appropriation; 4) Reasoning for the use or rejection of each alternative; and, 5) The recommended strategy for determining the will of the eligible voters of the district having property rights within the proposed LEMA area. GMD3 will support LEMA development with facilitation resources and evaluate goals for corrective controls, including impacts to property valuation and economy.

Voluntary consent agreements. Voluntary agreements are highly effective in obtaining regulatory, conservation, or other water management needed outcomes. A federal court consent decree of 1910 uses a voluntary agreement to establish the Associated Ditches of Kansas along the Upper Arkansas River GMD3 encourages the use of consent agreements that are in harmony with the management program. Well-to-well impairment may also be resolved using contracts that respect property rights and are subject to duties of state water officials.

"Water Conservation Area (WCA)." In 2015, the Legislature provided an additional GMA tool referred to as a WCA. A WCA is a Water Appropriation tool where any water right owner, or group of owners can develop a water conservation plan for consideration and agreement of the Chief Engineer to commit water rights to conservation through voluntary corrective controls consistent with other laws and the public interest. Public interest includes the GMD Act and

GMD3 management program and recommendations of the governing body. By order of the Chief Engineer, a WCA plan consent agreement can allow new reallocated use authority that temporarily moves base water right allotments under a very junior priority of right in relation to other prior rights. WCAs encourage conservation that is properly quantified through voluntary corrective controls and may be used as an agreement tool to document voluntary water conservation. Any proposed additional pumping authority made available for a well should be carefully evaluated to avoid negating prior conserve-to-preserve local conservation efforts and adding risk of critical well conditions to nearby non-participating well owners.

Changing WCA plans and agreements. With the consent of all participating water right owners in a WCA, the Chief Engineer may amend the agreement and order to modify corrective controls or boundaries, add or remove water rights, terminate the WCA, or make other changes requested by the water right owner(s). Under the management program, GMD3 will review each WCA proposal, change, or extension and provide recommendations to the Chief Engineer that implement the management program. GMD3 supports and encourages the voluntary corrective controls in WCA consent agreements that are consistent with board policies and management program. GMD3 will adopt and enforce policy needed to implement WCAs in harmony with other concerns of the management program. For more state information on the WCA tool, see: http://agriculture.ks.gov/divisions-programs/dwr/managing-kansas-water-resources/wca.

Paper water. Members depend on the normal protections of rules adopted for the district and the judgement of the local Board of directors concerning the public interest of the management program. Local management strategies cannot succeed as designed if rules are waived unless careful evaluation of the effects on the management program occurs and is made available to support wise decisions. **"Paper water"** is considered a legitimate water right on paper but lacking divertible supply from the source as authorized. "Paper water" on wells in a depleted local source of supply must remain unused in the absence of adequate demonstration that no impairment will occur. Moving "paper water" to better yielding well locations will deny supply longevity to other member wells with prior rights to a depleting supply. It is important to review hydrological community conditions and evaluate them under the GMD3 well drawdown guidelines.

Water bank conservation review. Water banking policy has different application in declining vs. non-declining groundwater reservoir areas. The Central Kansas Water Bank is the only chartered water bank in Kansas operated in close coordination with GMD5, officed in Stafford, Kansas. Banked credits, including aquifer maintenance crediting, water savings accounting, and safety deposit box accounting, can have both good and bad implications on the management of a declining water supply. Statewide statutory provision for bank-like tools under "Flex Accounts," LEMAs, and WCAs with "carryover" use credit provisions affect aquifer management. Banking of "credits" beyond perfected water right constraints from an aquifer raises conservation use and possession questions in the predicable future times of shortage. Questions occur whether lawful possession of stored water may happen, and whether any pore space use easement for possession of water storage needs to be lawfully obtained. GMD3 will review each water bank or bank-like proposal to evaluate effects for consistency with the management program public interest.

Managing water use by the drop. Member management of water use by the drop maximizes water value and is achieved through the adoption of field-scale drip irrigation technology for agriculture and municipal applications in southwest Kansas. This technology minimizes the water thief of direct evaporation during field irrigation. Drip or other precision water application

technology requires management investments that improves water value. For example, one 15 gpm leak or preventable evaporation loss during field irrigation equates to: 1 hour = 900 gallons, 1 day = 21,000 gallons, 1 month = 648,000 gallons and 4 months = 2,592,000 gallons. In perspective, that equates to 7.95 acre-foot or 95.5 acre-inches of water.

Figure 12. Mobile Drip Irrigation. *See video: https://www.youtube.com/watch?v=3yT9yiyjB-4*

GMD3 Ark River Management Activities

The Arkansas (Ark) River flows from upstream snow melt, runoff events, aquifer discharge and reservoir storage release. The Ark River is a historically significant source of renewable water supply for southwest Kansas and is a major source of recharge to the GMD3 area. Since the 1970s, mining of groundwater near the Ark River has lowered the water table, creating a losing stream over the OHP Aquifer. All river flows are either consumed for irrigation or stored into the river alluvial aquifer, effectively operating as a terminal reservoir at the end of the basin. This water supply is affected by the Kansas and Colorado interstate compact and requires careful management program attention by GMD3 and partners.

Authority. Authority for the GMD3 Ark River Management (ARM) activities are in statutes that include without limit:

- K.S.A. 82a-1020 declaring the purposes of the GMD Act and establishing the right of water users to determine their destiny regarding water use;
- K.S.A. 82a-1028(g) to construct, operate and maintain such works as may be determined necessary for drainage, recharge, storage, distribution or importation of water, and all other appropriate facilities of concern to the district;
- K.S.A. 82a-1028(i) to contract with persons, firms, associations, partnerships, corporations or agencies of the federal government, and enter into cooperative agreements with any of them;

- K.S.A. 82a-1028 (m) provide advice and assistance in the management of drainage problems, storage, groundwater recharge, surface water management, and all matters of district concern;
- K.S.A. 82a-1028 (n) adopt administrative standards and policies relating to the management of the district which are not inconsistent with the provisions of the GMD or the KWAA;
- K.S.A. 82a-1028(o) and (p) to recommend rules and regulations;
- K.S.A. 82a-1028(q) to enforce by suitable action, administrative or otherwise, rules and regulations adopted as provided by subsection (o) or (p);
- K.S.A. 82a-1028(r) to enter upon private property within the district for inspection purposes, to determine conformance of the use of water with established rules and regulations, including measurements of flow, depth of water, water wastage and for such other purposes as are necessary and not inconsistent with the purposes of the GMD Act;
- K.S.A. 82a-1028(u) to recommend to the chief engineer the initiation of IGUCA proceedings.
- K.S.A. 82a-1029 adopt the official management program for the district; and
- K.S.A. 82a-1041 to recommend Local Enhanced Management Areas;

Basin water resources change. Hydrological change has occurred in the basin from a variety of activities, including development of reservoir storage, exchanges, transfers, re-regulation of river flows, direct diversion development, groundwater well pumping development, land use changes and water use efficiency improvements. These changes have reduced rain runoff flows, narrowed the river channel, diminished beneficial system flushing, diminished recharge to adjacent groundwater reservoirs, filled floodways with sediment and diminished water quality and usability.

Figure 13, Ark River problem bank breach

An Ark River breach is located in the reach between Garden City and Holcomb, Kansas. Pulse river flows must fill surface space and exceed underground reservoir inflow rates before river flow and aquifer recharge benefits can distribute east across the District.

Water development. Water management concerns that influenced the two states of Colorado and Kansas to enter into an Arkansas River basin compact agreement also influenced the adoption of the GMD Act in Kansas in 1972 and formation of GMD3 in 1976. Immediate action was taken by GMD3 to establish a moratorium on new appropriations in 1977 and request an IGUCA in 1984, as discussed earlier in the GMD3 Water Conservation Program section. Significant additional need and opportunity continues and necessitate collaborative work with other local, state and

federal interests, institutions and authorities to address the unique water resource needs of the Arkansas River basin affecting water supply and water usability under the management program.

GMD3 Upper Ark GMA. The portion of the basin above Garden City to the Colorado and Kansas Stateline that include the IGUCA, ditch service areas and tributary underflow affecting supply within a 25-year prospective evaluation period is considered the GMD3 Upper Ark GMA for the purposes of the management program. For this area, native river flow, runoff events, reservoir deliveries, reservoir spill supply, tributary aquifer management, irrigation return flow management and other activities upstream generally maintain river flow year-round to a point near the Kearny–Finney County line above Garden City. The problems of dwindling supply, river sediment accumulation and water usability depletion due to poor river water quality are significant growing concerns in the GMD3 Upper Ark river reach.

Compact. The Kansas-Colorado Arkansas River Compact (Compact) was negotiated in 1948 between the States of Kansas and Colorado. Article I of the Compact provides its purpose:

- *Settle existing disputes and remove causes of future controversy between the states of Colorado and Kansas, and between citizens of one and citizens of the other state, concerning the waters of the Arkansas River and their control, conservation and utilization for irrigation and other beneficial purposes.*

- *Equitably divide and apportion between the states of Colorado and Kansas the waters of the Arkansas River and their utilization as well as the benefits arising from the construction, operation and maintenance by the United States of John Martin Reservoir Project for water conservation purposes.*

The Compact does not allocate specific quantities of water to each state, but rather provides for maximum release rates for each State from the conservation pool. A provision of the Compact requires releases from John Martin Reservoir (JMR) storage be applied directly to beneficial use, without storage after release. The reservoir is located approximately 60 miles west of the Stateline and has an available capacity for irrigation water supply of approximately 338,000 ac-ft. JMR has an effective priority date in Colorado of 1948, though the Compact operations are not subject to Colorado Water Court Decree and are state law in each state and also federal law.

Additionally, the Arkansas River Compact Administration (ARCA) operates the Compact, investigates concerns and develops interstate agreements as resolutions. Resolutions include those concerning an operating plan for John Martin Reservoir (1980 Operating Plan) as amended which establishes separate accounts in JMR for users in Colorado and for Kansas along with related operating provisions affecting basin water use. ARCA adopted a resolution concerning an offset account in John Martin Reservoir for Colorado post compact groundwater pumping as Amended March 30, 1998 (Offset Account). The Offset Account is regularly reviewed to allow Colorado replacements to stream flow depletions caused by post-compact well pumping. As such, the Offset Account is not an additional water supply, but water that Kansas should have received if not for the junior Colorado groundwater pumping. Additional operating accounts are regularly requested by the state of Colorado for system efficiency improvements that require careful study to ensure no loss of usable water to Kansas and GMD3. GMD3 advocates for an interstate water management support account to support state staff efforts to inform interstate management work.

Upstream reservoir development. Capture of large spring snowmelt runoff and base flows out of Colorado that historically flushed the braided river system across GMD3 has now left few options for affordable local solutions to river basin problems. Sediment load transported to points of water delivery and diversion accumulates, filling the floodway, increases flood risk and restricting surface water diversion and operating capacity of distribution systems. The river's poor and declining water quality also creates water usability depletion of the water resources of GMD3, affecting the fertility of soils receiving irrigation water within delivery areas and in adjacent groundwater use areas. Under such conditions, land valuation is diminished, and public health and the health of the local economy are threatened.

Lake McKinney. Lake McKinney is a private irrigation water storage lake owned by the Garden City Company. From study conducted by Lee Rolfs during the KS v. CO Original Action #105 case, Lake McKinney originally cost $350,000 in 1906 and was the largest manmade lake in Kansas at the time. It was called Reservoir No. 5 at first but was renamed after J.R. McKinney, the sugar beet pioneer. In 1909, capacity increased to 31,063 acre-feet at a gage height of 3,030 feet above mean sea level, a maximum depth of 30 feet and surface area of 3,200 acres. At the time of vested right determination for the associated Great Eastern ditch system, transit loss needs associated with Lake McKinney operations factored into the determination of the vested right. The capacity of Lake McKinney has since been significantly reduced due in large part to declining available river flows in the basin in the 1970s. Lake McKinney remains an important local groundwater management feature of a ditch system that provides deep percolation losses that replenish area groundwater supplies.

Water quality. Arkansas River basin lateral flow into the state and district area as OHP aquifer underflow is generally of good quality. However, water entering the state as Arkansas River flow is has seen high levels of contamination from a number of elements that include sulfate salinity and uranium. In addition to concerns of other contaminants, high radio nuclei levels have a significant effect on water treatment costs to restore water usability for public water supply and other systems. Estimates from the Kansas Geological Survey of the weight of uranium coming into Kansas annually from Colorado via the Arkansas River are concerning, indicating 10 tons delivered to Kansas each of 2017 and 2018.

Year	Average annual Sp.C., µS/cm	Average annual uranium concentration, µg/L	Average annual flow, ft^3/sec	Average daily uranium load, kg/day	Annual uranium load, metric ton/yr	Annual uranium load, ton/yr	Annual uranium load, lbs/yr
2012	4,271	73.0	28.7	5.13	1.88	2.07	4,140
2013	4,395	75.9	26.9	5.00	1.82	2.01	4,020
2014	3,813	62.7	92.1	14.1	5.14	5.68	11,400
2015	3,230	50.1	196.1	24.1	8.78	9.68	19,400
2016	3,285	51.3	201.5	25.3	9.25	10.20	20,400
2017	3,324	52.1	234.6	29.9	10.92	12.03	24,100
2018	3,409	53.9	206.6	27.2	9.95	10.96	21,900
2019	3,401	53.7	186.2	24.5	8.93	9.85	19,700

Table 5 - Colorado annual uranium delivery estimates.

Data and estimates for approach A, based on average annual flow, average annual specific conductance, and estimated average annual uranium concentration for each year (from D.

Whittemore, KGS Open-File Report 2017-2, updated January 2019 and February 2020). See: http://www.kgs.ku.edu/Hydro/Publications/2017/OFR17_2/index.html

Water contamination depletes usability. The contaminants in the Arkansas River basin water coming into the district is diminishes the utility of the water and creates a water usability depletion problem that must be addressed at significant cost to local water users. Local irrigators who rely on surface water from river flows must run water through plastic pipes beneath their pivot systems because the saline river water is highly corrosive and will collapse a galvanized steel pipe within a single growing season. Higher volumes of river water must be used for irrigation than would be the case if the water were less saline, and producers must either blend or run groundwater onto their fields after applying the river water to mitigate the effects. In turn, higher volumes of groundwater contaminated from the river water are needed to mitigate the usability depletion of the OHP Aquifer.

Water usability depletion. As reviewed in the 2015 federal Reclamation Basin Plan of Study, the contaminated river water from Colorado percolates deep into the subsurface and replenishes and contaminates the groundwater under the riverbed and ditch service areas of the basin. The saline nature of the water reduces its usefulness and reduces crop yields. As this recharge to the local aquifer continues, quality will deteriorate over time and producers will lose the ability to effectively mix groundwater with surface water to mitigate mineralization issues.

Public drinking water supplies. Within GMD3, the cities of Lakin, Deerfield, Holcomb and Garden City have experienced a decline in water quality due to infiltration of river water near their city well fields. The City of Lakin is a district member that recently had to construct a nanofiltration water treatment facility at great local expense to get their drinking water within the Environmental Protection Agency's (EPA) maximum contaminant level (MCL) for uranium. The community must now bear an ongoing water usability depletion cost of millions of dollars and 15% loss of supply necessary for waste disposal. The water extracted from the Deerfield and Holcomb wellfields has been within safe drinking water standards, but quality has been deteriorating. Those cities must develop additional freshwater sources and treatment solutions, including potential reuse. GMD3 will support efforts to provide clean drinking water and mitigate water usability depletion while avoiding compact deficiencies and mitigating public health and welfare concerns of interstate river flow.

Federal partners. GMD3 worked with the US Department of Interior, Bureau of Reclamation (Reclamation) and Kansas Water Office to evaluate public water source options in the river basin above Garden City to help identify options to mitigate deteriorating water quality and declining aquifer levels and to preserve safe drinking water. The 2014 study included the cities of Coolidge, Syracuse, Kendall, Lakin, Deerfield, and Holcomb to identify possible solutions, including construction of new facilities, infrastructure, and collaboration efforts. The 2014 study identified local potential options for future public drinking water supply and need for added study.

Federal boundaries. Federal agencies have regional administrative area boundaries that may unintentionally function as institutional barriers limiting communications and collaboration within the proposed study area by potential partners and stakeholders. Each area office has developed its own set of stakeholder partners that are not normally involved in concerns or response projects outside of the agency office administrative area. Viable solutions to address the water quality problems across the Kansas-Colorado Stateline may depend significantly on overcoming

operational boundaries of federal agencies and other potential study partners. Federal agencies with operation office boundaries that end at the Colorado-Kansas Stateline include: Reclamation, US Army Corps of Engineers, EPA, US Geological Survey, and US Fish and Wildlife Service.

2019 Kansas Legislative Resolutions. SR1729 and HR6018 were identical in message as passed by the respective houses of the Kansas legislature in the 2019 session. They requested the federal government aid in addressing water quality issues in the Arkansas River Basin in Southeast Colorado and Southwest Kansas and for state and local partners in both states, including GMD3, to cooperate in addressing the prevalence of radionuclides in the waters of the Arkansas River Basin. In response, the KWO, KDHE and KDA worked with the KGS and GMD3 in a two-year Mineralization Study, with free drinking water testing provided to participating well owners. GMD3 will participate in interstate basin water usability improvement efforts with federal and interstate partners.

Western Water Conservation Projects Fund. The KS v. CO original action no. 105 cash damage award to Kansas, after reimbursing the state for cost to litigate, was split 1/3 to the State Water Plan Fund (SWPF) and 2/3 to the Water Conservation Projects Fund (WCPF) for use in the area affected by the compact violations. The statewide Water Plan portion was used primarily as state cash cost share funding to create the Kansas Conservation Reserve Enhancement Program (CREP) under contract with USDA. However, several state legislative budget cycles resulted in removal of most of those damage funds from the Kansas CREP.

Local leadership. The 2008 Kansas Legislature provided for GMD3 to administer WCPF to assure those public funds would be preserved from legislative budget sweeps for the intended purposes and created an efficient way to accomplish the purposes of the WCPF. This also allowed the investment interest on the principle fund to accrue to those purposes under the fiduciary care of GMD3 and to leverage the fund with other grant opportunities. The WCPF became the Western Water Conservation Projects Fund (WWCPF) with project goals that have been **adopted as goals of the management program** to do the following:

1. *Maximize general public good (public interest).*
2. *Maximize efficiency of call water for ditch irrigation (low transit losses).*
3. *Maximize benefits of high river flows to improve recharge.*
4. *Mitigate water quality problems in surface and groundwater.*
5. *Reduce consumptive use of water to help stabilize the system.*
6. *Improve the stability of the hydrologic system for irrigators.*
7. *Address compact compliance.*

Projects funded in whole or in part by the WWCPF must be located in the area impacted by the Arkansas River Compact and meet eligibility requirements and goals in K.S.A. 821-1803 and Senate Bill 534. Under a state legislative budget proviso in SB 534 and KWO Grant Agreement, the Arkansas River Litigation Fund Committee established in 2005 became the advisory committee to the GMD3 board, who in turn manages the funds, approves projects and expenditures, and makes requests to the KWO Director for approval as consistent with grant purposes, in consultation with the Chief Engineer, KDA/DWR. An annual audit and activities report to the legislature is provided by GMD3. The 2019 GMD3 Legislative Report may be found at: http://www.gmd3.org/about/special-meetings-and-committees/

Ark River Watershed Group. GMD3 will continue to provide leadership in considering development of an Ark River Watershed group. All stakeholders share concerns regarding declining surface and groundwater quality, insufficient water supply, occasional flood flows, state and private land management, natural resources management, and intermittent and interruptible streamflow. Water quality within the upper portion of the Arkansas River in Kansas is very poor due largely to diminished stream flows, underlying geology of irrigated fields upstream of Kansas, and other uses. KDHE has identified this stretch of the river as impaired waters due to gross alpha (bundled with uranium), fluoride, total suspended solids, boron, selenium, and sulfate.

GMD3 Lower Ark GMA. The river reach below Garden City and adjacent areas of the IGUCA and tributary flows is considered the GMD3 lower Ark GMA. Flow recorded at the Garden City USGS river gage is now a rare occurrence beyond municipal stormwater discharge. The river reach below Garden City is essentially a closed basin where all flows that enter the area become conservation storage in the OHP Aquifer. Little or no discharge occurs downstream out of the district below Dodge City. Groundwater development and loss of surface inflows to the GMD3 Lower Ark GMA made it necessary to apply groundwater management activities immediately upon the formation of GMD3 to mitigate supply problems, limit additional appropriations and address issues associated with the relocating of wells closer to the river channel. GMD3 recognizes the importance of identifying rivers and aquifers as natural Kansas water infrastructure and works to utilize natural water infrastructure to manage river inflows to groundwater storage to improve storage and water management efficiency.

Declining interstate supply. Pulse flows are flows from runoff events that temporarily create or increase a stream's flow. Over time, the GMD3 Lower Ark GMA river reach has lost the seasonal flushing flows from upstream spring snow melt and runoff events. Declining pulse flows diminish supply to GMD3 member water rights. Groundwater mining has nearly eliminated aquifer discharge losses except for a reach of perched alluvial water table in the vicinity of the town of Cimarron following surface water diversions by ditch rights when pulse flow supply becomes available. The rare pulse flow that now occurs in the GMD3 Lower Ark GMA percolates deep into the OHP Aquifer. The lack of regular river flow also creates similar land management and flood control problems as occur in the GMD3 Upper Ark GMA. See page 86 in appendix. GMD3 will protect and enhance management of flood and pulse flow events to replenish underground reservoir storage and examine other water sources to add ecological benefits and district storage inflows while limiting or reducing flood risks.

Pre-compact water rights. There are vested rights (pre-1945) and pre-compact (1949) water rights in the portion of the Arkansas River IGUCA between Garden City and Dodge City that have a right to a cumulative rate of diversion of more than 200 cubic feet per second (CFS). Since the time of district formation and upstream reservoir construction, large extended river flow events have been rare in the reach of the GMD3 Lower Ark River GMA. In actions intended to meet pre-compact water supply use and reasonable needs during wet river conditions below the Garden City gage, state permits have historically authorized up to an additional acre foot per acre for existing surface water ditch company acreage in the GMD3 Upper Ark GMA without exceeding the total authorized amount of all vested water rights of said irrigation ditch companies**,** but only when 200 CFS average daily flow is measured at Garden City with continuous river flow measured to the Dodge City river gage. Existing vested rights and pre-compact water rights in the GMD3 lower Ark GMA are authorized over 200 cubic feet per second (CFS) of water supply.

GMD3 recommends continuing the practice of no post-compact surface water development in the basin being considered in priority until a minimum 200 CFS at Garden City and flow at Dodge City occurring without an approved pre-compact water right offset.

Ark River IGUCA review or revision. The Arkansas River IGUCA order within GMD3 currently applies little corrective control remains not already superseded by administrative rules or practices. The remaining unique limitation in place under the IGUCA Order is that OHP aquifer wells are restricted from relocating closer to the river channel than 10% of their current distance. This limitation has recently been waived in WCA cases and may need to be re-evaluated. Several modifications to the first IGUCA order from the GMD3 request and hearing process have occurred without the benefit of public process or GMD3 management program recommendations. Under statewide rules adopted by the Chief Engineer, the Arkansas River IGUCA is required to have periodic formal review now more than three years past the 7-year state deadline. GMD3 will advise and assist in any review or update of the Ark River IGUCA consistent with the management program. GMD3 will assist each proceeding or review to consider changes to the Upper Ark River IGUCA corrective controls established more than 32 years ago and provide recommendations of the governing body.

River navigability for title and management program activity. The natural infrastructure of the Ark River across the GMD3 area should be fully utilized for aquifer recharge purposes and other natural and managed resources benefits. The state may own the bed and banks up to the normal high-water line. This is the line that can be seen where high water has left debris, sand and gravel during its ordinary annual cycle. But the Ark River through the district does not have an ordinary annual cycle based on a high degree of basin resource development. Effects of water use development in the basin on what may be considered “normal high-water mark” create the need to define state property boundaries along the river corridor. Management challenges today include the lack of delegation by the Kansas legislature to any person or agency to manage the state-owned land in title as a navigable stream defined and conveyed to the state by the federal government at the time of statehood; a federal doctrine called “navigability for title.” For GMD3, this ownership and boundaries issue starts with the 1874 survey conducted shortly after the January 1861 time of statehood. Terminology on land deeds may include the phrase “plus or minus accretions” which can be confusing in a diminished river flow regime.

Ark River public land boundaries raise a set of property and easement questions that are intertwined together with the history of river flow changes under the activities of man and navigable stream law for the basin across GMD3. GMD3 Ark River interests include the management of the renewable river water supply and natural infrastructure for water supply distribution, conjunctive use with groundwater, aquifer inflow and the associated supply value concerns of water usability depletion from the poor-quality surface water. To manage this, practical state property boundary lines along the Arkansas River in GMD3 have been used as necessary. In western states and southwest Kansas, depleted groundwater reservoirs are used to substitute surface water use for groundwater pumpage (conjunctive use) or store surface water (managed groundwater reservoir inflow). Investigations, proof-of-concepts, and demonstration projects will be conducted to further develop management strategies for the Ark River natural resources across southwest Kansas.

GMD3 Outreach, Advocacy and Public Education Activities

The high value of water in Kansas is widely recognized by all entities that use and manage it. Action at the local, state, and federal level is necessary to ensure future generations of Kansans have a safe, reliable source of water to grow the economy. Programs, newsletters, presentations, websites, documentary specials, public meetings, school courses, testimony and other educational efforts are all part of the GMD3 outreach program. GMD3, under K.S.A. 82a-1020, promotes the management, conservation and use of the district groundwater resources for the stabilization and improvement of agribusiness benefits relative to national and world markets. GMD3 has a goal to assist and advise the soft infrastructure of information systems that represent and inform members and partners on local, state, and national issues that affect the district.

1. GMD3 will seek to inform, shape, and influence public policy and legislation affecting local groundwater management, district member interests, and the operations and funding of the district management program.

2. GMD3 will enhance and expand partnerships and working relationships with key officials to advance Southwest Kansas perspectives on proposed legislation and regulations at the state, interstate and federal levels that may affect water resource interests.

3. Support of membership will be required to achieve the various activities and methods of the management program. GMD3 will expand its efforts to actively engage members through original initiatives and cooperative activities for:
   a. Promotion of program activities and access to program implementation documents, website postings and other social media, with a purpose of reaching and engaging all generations of water users, young professionals, and potential partners.
   b. On-site project signage, resource education stations, community public water awareness features, and water and agriculture benefit promotions.
   c. Conduct education activities to push water saving measures and practices and maintain the economic benefits of water use, such as alternate crops, use of technology, and irrigation scheduling to reduce waste.
   d. Support research on water conservation methods.
   e. Provide a platform for those who are using less water than their peers to share their methods.
   f. Use proof-of-concept and demonstration projects to help producers to economically reduce net water supply loss.

GMD3 State Water Planning Coordination Activities

GMD3 advises and assists state matters affecting groundwater supply and economy and represents members in matters concerning groundwater management. GMD3 relies on collaborative assistance to adopt and implement the management program and makes recommendations to members, state and federal officials, the Governor, Kansas Legislature and to Congress. This requires identification of water planning needs to be communicated to the Kansas

Water Office and Kansas Water Authority for inclusion into their comprehensive water planning, water plan fund budgeting, state water agency support, and policy recommendations.

GMD3 authority. Authority for GMD3 State Water planning coordination activities include:

- K.S.A. 82a-1020 declaring the purposes of the GMD Act and the established right of water users to determine their destiny regarding water use;
- K.S.A. 82a-1029 adopt the official groundwater management program for the district area;
- K.S.A. 82a-1028(g) to construct, operate and maintain such works as may be determined necessary for drainage, recharge, storage, distribution or importation of water, and all other appropriate facilities of concern to the district;
- K.S.A. 82a-1028(i) to contract with persons, firms, associations, partnerships, corporations or agencies of the federal government, and enter into cooperative agreements with any of them;
- K.S.A. 82a-1028 (m) provide advice and assistance in the management of drainage problems, storage, groundwater recharge, surface water management, and all other appropriate matters of concern to the district.

Kansas Water Office, Water Authority, and State Water Plan. The 1981 Legislature created the Kansas Water Office and Kansas Water Authority (KWO/KWA) per the state Water Resources Planning Act (K.S.A. 82a-901 to 82a-945) to further its goal of having sound management of the atmospheric, surface, and groundwater supplies for the state (K.S.A. 82a-927). This took place under the declaration: *"the people of the state can best achieve the proper utilization and control of the water resources of the state through comprehensive planning which coordinates and provides guidance for the management, conservation and development of the state's water resources."*

KWO/KWA function: The primary statutory function of the KWO is the development and coordinated implementation of the State Water Plan. State policy is to formulate the State Water Plan on a continuing basis for the management, conservation and development of the water resources of the State (K.S.A. 82a-903). In formulating the State Water Plan, KWO considers provisions in K.S.A. 82a-907 that directly relate to the projects and recommendations of GMD3.

Kansas Water Authority. The Kansas Water Authority was established in 1981 within and as part of the Kansas Water Office. The KWA provides the leadership to ensure that their advice to the Governor and Legislature for water policies and programs address the needs of all Kansans. The Water Authority is responsible for approving water storage sales, the State Water Plan, federal contracts related to water, and regulations and legislation proposed by the Kansas Water Office. The Authority meets quarterly and consists of 13 private citizens and 11 ex officio state water agency advisors. See https://kwo.ks.gov/about-the-kwo/kansas-water-authority

FY2019 Est. Water Plan Fund revenue from statewide water user fees				GMD3 area est.
Municipal Water Fees	3 cents/1,000 gallons	$3,200,000	25.6%	$ 415,406
Clean Drinking Water Fees	3 cents/1,000 gallons	$2,800,000	22.4%	$ 192,287
Industrial Water Fees	3 cents/1,000 gallons	$1,100,000	8.8%	$ 278,800
Stockwater Use	3 cents/1,000 gallons	$450,000	3.6%	$ 114,054
Pesticide Fees	$100/Registration	$1,300,000	10.4%	$ 127,310
Fertilizer Fees	$1.40/ton	$3,500,000	28.0%	$ 342,757
Pollution Fines/Penalties	Est. $150,000	$150,000	1.2%	$ 0
Sand Royalties	$0.15/ton	$16,000	0.1%	$ 0
Total		$12,516,000		$ 1,470,614

Table 6 - Kansas Water Plan Fund Annual Sources. Estimates are from KWO

The State Water Plan Fund was created in 1989 (K.S.A. 82a-951). Funding includes revenues from statewide fees and SGF/EDIF demand transfers.

Kansas Water Plan Fund Budgeting Process. The budgeting process for use of Water Plan funds is long and deliberate. A proposed budget for the following state fiscal year is annually presented to the full Kansas Water Authority in August. The Authority-approved budget is then used by state agencies in their budget efforts with the legislature. The Governor's budget includes recommended expenditures for the State Water Plan Fund when it is presented to the Legislature each January. The Legislature makes appropriations from the State Water Plan Fund. GMD3 provides advice and assistance to the Legislature as a proponent of the State Water Plan and Fund use. GMD3 encourages comprehensive budgeting and planning that looks ahead one generation of 25 years and incorporates fair funding that includes the purposes, needs, and activities of the GMD3 management program. GMD3 contains half of the historically perfected annual demand of 3.6 million acre-feet for water withdrawals from Kansas underground reservoir storage. Only half of that demand is met annually. Demonstrated unmet demand in the district provides a basis and justification for attention to additional planning resources and state water planning. State Water Plan documents historically review demand from groundwater sources in terms of recent use and have not included consideration to supply unmet demands. Large capital improvement projects identified in the Kansas Water Vision and this management program seek to improve water supply and management across the state to meet present and future demands.

GMD3 initiatives encouraged. To achieve long-range goals, Kansas law provides "*the encouragement of local initiative in the planning, implementation, funding and operation of local water programs to the extent that the same are supportive of state water programs"* K.S.A. 82a-928(p). The state is responsible to protect, conserve, and control all waters affecting the people of the state (K.S.A. 82a-929). GMD3 understands this includes interstate aquifer lateral flow and all interstate streamflow into the district as part of historical renewable supply not covered by any compact or interstate agreement. State planning will coordinate with local and national planning to undertake the resolution of any conflicts that may arise between the water policies, plans, and projects of the federal government and the water policies, plans, and projects of the state and its people (K.S.A. 82a-931). Good planning is vital in implementing the management program.

G**oals** for water planning coordination advice and assistance activities include:

1. Seek to coordinate with partners to further implement the long-term goals and objectives of the legislature consistent with the management program for southwest Kansas.
2. Work to improve and sustain effective Water Plan budgeting process for recommendations to the Governor and Legislature that are coordinated with local planning in support of the management program covering 25 years projected costs and revenues.
3. Seek encouragement and support for local initiative and water programs and work with the Kansas Water Authority and Regional Advisory Committees (RACs) for understanding and support for the management program, per K.S.A. 82a-928(p).
4. Provide annual project funding requests and recommendations to KWO/KWA.
5. Work with RAC members and advisors across the state to enhance understanding of any differing perspectives of common long-term water supply interests and concerns.
6. Work with legislative partners to achieve a consistent and informed perspective on GMD Act implementation, needed water planning, cost and risk evaluations, and funding.

7. Work to restore dedicated state funding for timely interstate water management support studies and evaluations and assure the compact administration.
8. Support comprehensive future natural and constructed infrastructure planning for a minimum of 25 years to include groundwater transportation and storage. (e.g. January 22, 2018 letter from GMD3 to KWO/KWA seeking action on 23 Water Vision activities).
9. Seek state water planning and funding support for proposals and program assistance each year at a level commensurate with what is paid into the Water Plan Fund from the GMD3 area in support of legislative purposes. (e.g. July 22, 2019 letter and spreadsheet at: http://gmd3.org/pdf/State_Water_Plan_FY2021_Budget.pdf)

GMD3 Interstate Water Management Assistance

The GMD3 Board renewable supplies committee works to consider and recommend action for opportunities and concerns regarding hydrology. GMD3 historically receives replenishing flows from the Arkansas River and intermittent streams that include Bear Creek, Sand Arroyo Creek, and the Cimarron River, as well as the lateral flow of interstate groundwater aquifers. These replenishing flows have declined significantly over time. Local water sources are generally closed to new appropriation in GMD3, but not in neighboring states, causing loss of renewable interstate supply as those areas further develop and deplete. The Kansas Water Vision goal to *IMPROVE INTERSTATE COOPERATION SO THAT KANSANS' WATER NEEDS ARE MET AND PROTECTED* is a focus of this activity area. The **sources of usable interstate supply loss** Venn Diagram at right illustrates activities that reduce usable water supply if not adequately managed. GMD3 seeks to advise and assist state and interstate collaborations and studies to improve the equitable sharing of interstate supply and reduce district water risk.

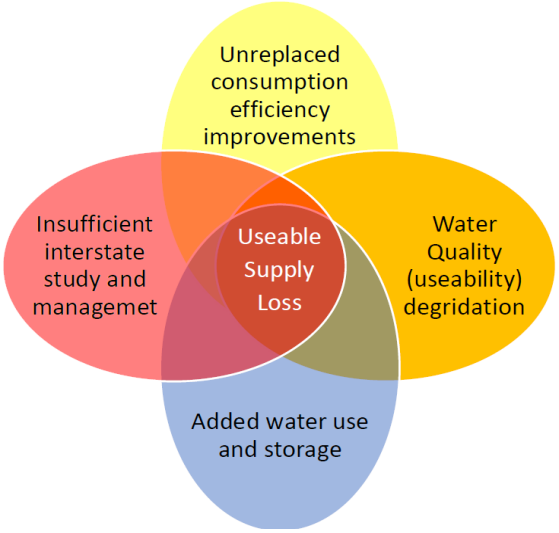


Figure 14, Source of Usable Interstate Supply Loss

Authority for GMD3 Interstate Water Management activities include without limit:

- K.S.A. 82a-1020 declaring the purposes of the GMD Act and the established right of water users to determine their destiny regarding water use;
- K.S.A. 82a-1029 adopting the official groundwater management program for the district area;
- K.S.A. 82a-1028(g), (i) and (m) [referenced in earlier sections of the management program].

Compacts. Two interstate compacts involving the GMD3 area are in place with administrative bodies staffed by officials from Kansas and respective sister states. Each compact administrative body is a forum for the states to pursue "interstate comity." Each compact administrative body provides a portal and forum for GMD3 communications to express common interests and concerns. GMD3 will provide advice and assistance in development of needed interstate agreements consistent with the management program. No compact exists to protect the Cimarron River basin historical water supply to the district. There also is no groundwater compact to govern

lateral flows into Kansas and surface water runoff pulse flows and the associated aquifer recharge. Sustained underflow and surface runoff supplies are important considerations for successful partnerships to secure and improve the future area water supply.

Interstate aquifer management coordination. Interstate resource management coordination is appropriate activity under the management program. The OHP Aquifer, Arkansas River, and Cimarron River basin are closed to new appropriations of water in Kansas, but not in neighboring states. This raises concerns that new appropriations in those states may reduce water supply to Kansas. The governing body of GMD3 sought to provide information to official proceedings in Colorado and were not allowed even though Colorado law provides "any person" may be heard.

1. GMD3 will encourage multi-state attention on shared water resources to exchange the best evidence of safe supply and use conditions that reduce water speculation and detrimental assumptions where additional supplies may not exist , causing greater water risk for members and interstate partners.

2. GMD3 will encourage interstate partnerships and collaborative efforts to manage and restore the quantity and usability of existing water sources, including participation in state water administration in each state where permissible, and work with landowners of properties both inside and outside the district and state.

Interstate Water Management Support Fund. Kansas requires study resources that are not always available for timely investigations (January 22, 2018 and October 11, 2018 letters from GMD3 board to KWO). There are recognized interstate water management questions across Kansas that may emerge with little prior notice to manage agency budgets. The lack of sufficient state funding dedicated for interstate water management support unnecessarily places Kansas at significant disadvantage and in a subordinate role in addressing interstate questions of future water supply significance. The ability to gather information on short notice is needed to promote good working partnerships with sister states. A dedicated funding source outside regular agency budget process will improve Kansas's ability to secure future water supplies.

Federal Reclamation Assistance. A Basin Study grant with Reclamation and interstate partner participation can provide leadership in a multi-year and multi-state partner cooperative effort. This is a commitment of collaboration and does not involve exchange of cash. Contaminated water entering the state from Colorado is impairing the local supply of water sufficient for human and agricultural use. Climate projections indicate the problem will get worse. Nearly 100% of the contaminated flows are applied on fields or percolate into SW Kansas aquifers. The Basin Study requires Colorado participation, and will build on the prior GMD3 Basin Plan of Study in 2015 in keeping with 2019 session SR1729 and HR6018. Basin Studies are collaborative studies, cost-shared with non-Federal partners to evaluate the impacts of climate change and ensure sustainable, usable water supply by identifying strategies to address imbalances in water supply and demands. The Basin Study will be a technical assessment and will not make statements of policy or future commitments by Reclamation or partners.

Additional policy for water development. Water leaves Kansas annually at an estimated amount of more than eight times the groundwater used annually in Kansas. A VISION - STATEWIDE PHASE III Study as referenced in January 2018 letter from GMD3 board to KWO seeks to identify suitable areas for transfer of water to available Kansas aquifer storage space. The Kansas Water Vision looks to develop an interconnected water storage computer model for all eastern

Kansas basins with federal water supply reservoirs. The Vision looks to update a mid-1980s Kansas Water Office plan to interconnect reservoirs across multiple basins to move water to higher demand and increase overall yield, management, and marketing of Kansas water. The 2016 session SSub for HB 2059 proposed additions to the Kansas Water appropriations processes to create a path not currently available for proposing development of waters otherwise lost to the state. The bill and the KDA compromise language are still needed policy for Kansas. The Water Authority accepted a three-part proposal from a special study team and included $200,000 in its FY 2019 recommendations to the Governor and Legislature. No legislative action occurred, and the study team is no longer available. A task force review of current policy and needs is requested as presented at the April 2019 KWA meeting by the Upper Ark RAC. The search for an appropriate path for Kansas study continues to be a Kansas Water Plan priority need.

Department of Interior federal study assistance. GMD3 will evaluate and seek federal assistance through further implementation of the augmentation study authority of Public Law 90-537 of 1968. The text of the law reads "the Secretary of the Interior shall conduct full and complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States." It also requires periodic progress reports to Congress. That has not been done. Augmentation from floodwater east of the High Plains should be considered with multi-state leadership for transportation of water west. In 2015 there was at one point a combined 1,132,550 AF in flood pools of Milford, Tuttle and Perry Reservoirs that was safely evacuated away from Kansas. When a KDA lost value estimate is applied to that lost water for when irrigated land goes dry in GMD3, the unrealized value of the wasted flood water to replace Ogallala dry-up in that case was $2,989,900,000, based on $3,960 lost value per acre at 18 in./acre. An "If and When" transfer of bulk water evacuated to aquifer storage before surface reservoir spills would conserve water and add great value to address Kansas's unmet water demands and GMD3 storage needs.

GMD3 Models, Research and Development Activities

Groundwater management requires specialized model tools. Models that are used by the district in management program activities include models of district groundwater reservoirs, wells, surface water resources, and economy. They are necessary management tools. It is critical to the success of the district management program to create and update models based on the most up to date information available. Each model is a tool designed to represent a simplified version of reality. The reliability of the tools depends on how well the model approximates field conditions. Some extreme events or conditions may be beyond the calibration of a model. Wise application of model data can account for this. The following research and development activities have been identified without limit to the management program activities:

1. **Resources for new models and model updates.** GMD3 will work with state and other partners to use and improve important analytical and numerical models that elevate the district groundwater knowledge base and improve water application evaluations and management activities for GMD3 members and partners.

2. **GMD3 area Ogallala/High Plains Aquifer model update.** The KGS groundwater model for the GMD3 area is slated to begin updating in 2021. GMD3 will partner with the KGS, KWO,

DWR and others to complete a successful update project. Additional data is needed for improving the model function and utility. They include:

a. Index well measurements of groundwater exchange between formations.
b. Groundwater gage measurements of recharge benefits from surface water flow.
c. Groundwater gage measurements of lateral flow and quality or usability.
d. Data needed for improved model calibration.
e. Graphical user interface tools to connect members to model information.
f. Critical well evaluation and water project supply information tools.
g. GMD3 Upper and Lower Ark GMA boundaries and conjunctive use tools.
h. OHP Aquifer water use and recharge estimate tools.

3. **Additional aquifer data.** New aquifer information and data developed by GMD3 will be shared with state and other partners to assist in the development of the best possible models. This information may include, but is not limited to, member test hole contributions, flowmeter and well tests, and use evaluation information. New information benefits the recalibration of supply and economic models as tools needed for implementing the management program.

4. **Economy and water valuation models.** Economic and valuation models are a critical source of information used to advise and assist management program activities. GMD3 will look to develop and update economic models to include without limit: water value projections of the Docking Institute Study of 2000, long term opportunity cost projection of Apparat Analytics LLC., evaluation of major water marketing and transfer benefits with state, reclamation and other partners, past and existing federal law authorizations of the High Plains Study and the Colorado River Project Act (Public Law 90-537), evaluation of Cost Depletion Allowance under federal tax code, and other needed economic studies.
5. **Managed Groundwater Reservoir Recharge**. Managed groundwater reservoir recharge activity may involve both projects that use natural infrastructure and delivery activity and projects using artificial or constructed infrastructure and delivery. GMD3 will encourage both natural and artificial project feasibility investigations and collaborative means to increase the amount and/or usability of water inventories. Application of groundwater recharge flows in classified streams should prevent "statistically significant increase[s] in the concentration of any chemical or radiological contaminant or infectious microorganism in groundwater resulting from surface water infiltration or injection" (K.A.R. 28-26-28d(b)(5) and 28-16-28e(c)(5)).

6. **Water importation**. Western Kansas and the Great Plains region offers the nation a large food production area with a growing economy, but the region is facing aquifer decline, unmet demand and dry-up. Other western states face similar issues. A transfer of water across Kansas would solve this issue for the MGD3 area and other western states. Transient water with little of negative value in eastern water sheds should be considered for transport and conservation storage into available reservoirs in the west to promote economic growth and eliminate risk in the west, while adding flood protection in the east.

   Importation of water from other areas under conditions of surplus local supply seem to be technically feasible under present declining energy cost projections if the right to move the water can be resolved. Some problems are legal in nature and deal with issues such as inter/intra basin transfers. GMD3 will take a leadership role with partner agencies and organizations to continue the long-range planning and study for projects which may become

economically feasible and wise under future water value returns and which offer potential for added water importation into southwest Kansas to meet future resource service needs.

7. **Water exports**. The Board shall involve itself with any proposed direct exportation of groundwater from the district to any area or location outside the district to ensure that all management program purposes are met and to seek opportunities to meet the needs for present and future water supply in adjoining areas. Exported water use may be evaluated to consider assessing higher user fees than for in-district uses or for net use between imported supplies and those exported out of state.

8. **Federal Farm Programs**. Innovation and local authority implementation are essential for effective use by district farmers and ranchers to continue producing more food and fiber with less water. Federal farm bill research and other programs provide significant support to the implementation of the GMD3 management program for members and partners.

   a. GMD3 will participate in farm bill development in implementing policies to preserve and enhance water conservation for the district. Water conservation programs should incentivize and reward measurable water conservation. Using historic water usage apart from credit for conserve-to-preserve water conservation accounting may incentivize maximum water use prior to enrollment, which is action contrary to the management program. Those who already work to steward Type (2) groundwater conservation in their declining supply have a greater burden to achieve added conservation that should be properly valued in addressing resource concerns.
   b. GMD3 will advocate for flexibility in the use of field level crop bases to encourage conservation of water use over program elements that economically force members to continue high water use to preserve crop bases.

9. **The Conservation Reserve Enhancement Program (CREP)**. As of September 30, 2017, a total of 112 state CREP contracts on 18,659 acres have been approved by the State of Kansas (with the addition of 385 acres this year). These contracts have resulted in the permanent retirement of 37,999 acre-feet of annual water appropriation on 135 water rights from 166 wells, mostly in GMD3. The contracts represent a total of $1,210,511 in state sign-up payments to producers over the past ten years. These payments are matched by annual rental payments to producers from FSA totaling about $2,191,213 in FY2017.

10. **State water conservation incentive programs.** GMD3 will continue to encourage and develop additional partner activities in state sponsored water conservation incentive programs made available to members and investigate opportunities to leverage management program activities with incentivized conservation activities that further the purposes of the management program for district members.

11. **Regional Conservation Partnership Program** (**RCPP**). The GMD3 RCPP promotes coordination of NRCS conservation activities with GMD3 and other partners that offer value-added contributions to on-farm, watershed, and regional natural resource concerns. Through RCPP, NRCS seeks to co-invest with GMD3 and other partners to implement projects that demonstrate innovative solutions to conservation challenges and provide measurable improvements and outcomes tied to the resource concerns of the management program.

12. **Brackish water use technology and feasibility.** Brackish water or briny water is water more saline than fresh water, but less saline than seawater. In GMD3, it may occur in deep geologic

formations or in Arkansas River surface water from Colorado or in Cimarron river flows from the district into Oklahoma. Brackish waters are viewed recently as potential and viable resources to alleviate water scarcity and overcome water budget deficits for some project uses. Kansas law requires that such water sources be evaluated in each water right application (K.S.A. 82a- 711) where " …*the chief engineer shall not approve any application submitted for the proposed use of fresh water in any case where other waters are available for such proposed use and the use thereof is technologically and economically feasible*." The evaluation of various desalination technologies will be explored with reclamation and other partners for options to develop district surface and groundwater supply.

13. **Private well safe drinking water study.** High radionuclide and other mineralization pollutants in some groundwater supply areas of the district require study to determine the best management practices to secure safe drinking water. Programs that will adequately safeguard the health, safety and welfare of district members will be supported, working with state water agency partners that include KDHE, KDA, KWO and KGS.

14. **Strategic local area planning.** GMD3 support of planning efforts by local authorities and their targeted interests in water related economic development and environmental protection activities is an important activity to effectively implement the management program. Coordination with other local government units provides efficiency of resource management in support of members and the leadership of cities, counties, and special districts.

15. **Water reuse information assistance.** The first use of water is the use authorized and reported under water rights, so little comprehensive data is available on water reuse in the district. The management program supports the efficient first use and appropriate reuse of water resources for irrigation or other uses. Efforts to increase water use value through reuse is an important response to dwindling local supplies and increasing water costs. Water reuse should not be used to increase overall water use without offsetting usable appropriated water rights, as reuse reduces return flow to the aquifer. GMD3 will work to develop methods for tracking the extent of water reuse and assist in developing feasibility and researching water recycling projects or as required by grant opportunities.

16. **Data Collection and exchange.** GMD3 collects data regularly for use in addressing water quantity and quality concerns. Land ownership records and socioeconomic and use value studies are considered as necessary to implement the groundwater management program and Board initiatives. District datasets and those of water management partners are exchanged to address mutual concerns. Such cooperative efforts with partner organizations will assure an efficient use of GMD3 manpower, technical, and financial resources.

17. **Smart Device Applications.** GMD3 will support efforts to improve data base access through application tools needed to provide field sensor information for use by member water managers. Significant opportunity exists to serve the water project manager with smart device application tools for near real time decisions and the records they need to adopt and account for practices that save water and costs. GMD3 supports the use of applications that provide water allocation, climate, soil moisture, crop, and financial information to the producer. GMD3 also works to provide water use information from similar projects in the region to producers.

GMD3 Water Quality Protection Assistance

Water quality affects water usability and public health, safety, and welfare for Kansas citizens, including members of GMD3. GMD3 will monitor, implement, and address the following water quality activities in coordination with partners:

1. **Existing Pollution Problems.** Known pollution problems that pose a direct threat to the usability of groundwater supply within the district will be researched and evaluated by staff, in conjunction with KDHE programs and/or other partners to seek adequate mitigation and/or remediation for improving and protecting supply conditions. Where identified concerns exist, staff will present its recommendations to the Board for consideration of advisable action.

2. **Contamination risk.** The water quality protection activity of GMD3 will work with member and business interests to identify the major sources of water usability depletion and address concerns in targeted areas to minimize water risk from contamination of district groundwater or surface water supply. A practical resource for careful land use considerations can be referenced at: http://www.kdheks.gov/nps/downloads/nwpwqppfrm_2017.pdf. Practical assistance to members and industry will harmonize actual conditions with enforceable water policies. The special saltwater intrusion rule in Seward and Meade counties is an example of subsurface well construction assistance. Management program activities will advance drinking water quality monitoring and supply protection with recommended triggering events for drinking water well inspection and for testing water quality.

3. **Oil and gas industry water use and supply risk**. GMD3 should consider accessing data on historical oil and gas activity in the district for review of information with appropriate state officials to screen for inter-aquifer groundwater connection that can create freshwater drains to deeper, less fresh formations. Opportunities for new technology-based water treatment will be evaluated.

4. **Abandoned water wells and test holes**. With about 1/4th of non-domestic wells idle per annum, GMD3 will assist KDHE Bureau of Water in their implementation of the Groundwater Exploration and Protection Act and permitting of temporarily abandoned water wells and assist members in the management of wells and boreholes. GMD3 will advise and assist member to manage well equities, groundwater protection, monitoring well data collection opportunities and on-site safety concerns.

5. **Groundwater gage network**. GMD3 will continue to develop a district monitoring well network and obtain water samples to be analyzed for water usability depletion. GMD3 has worked with partners to establish Stateline groundwater gages that provide quantity and quality data to support interstate supply management. GMD3 continues work to set up a network of observation wells in areas where additional data is needed to support the management program and water risk concerns.

6. **Ark River and other high rate of recharge areas.** Significant need exists to address the water quality issues of the Ark River basin and other key recharge areas affecting both drinking water safety and agribusiness productivity. In-state, interstate, and federal partnerships are needed to address interstate poor-quality surface inflows into GMD3 that are impacting and threatening public and private water supply wells and land resources along the Arkansas River corridor and over the OHP Aquifer. Additional protection of the fresh groundwater in the region is critical for safe drinking water and for municipal, industrial, and agricultural uses. Kansas 2019 legislative resolutions HR6018 and SR1729 passed seeking congressional action and interstate cooperation to mitigate this major multi-state contaminated basin concern. GMD3 will participate in study and project activity to address the 2019 resolutions and control of aquatic nuisance species.

Figure 15, Warning sign, Groundwater Protection Area

7. **Uranium, Radium and Radon.** According to the KGS, radon and its immediate parent radium largely occur where uranium is present in rocks, soil, or ground water. All rocks contain small amounts of uranium. Uranium can also be present as a solid attached to mineral coatings on sand and silt (image at right). Uranium is very soluble and easily weathered into solution—like dissolved salt or sugar. Some groundwater in the district is known to have naturally occurring uranium and radium. Where these occur, close cousin Radon may also occur (Felmlee and Cadigan, 1979). For more information, see: http://www.kgs.ku.edu/Publications/PIC/pic25.html

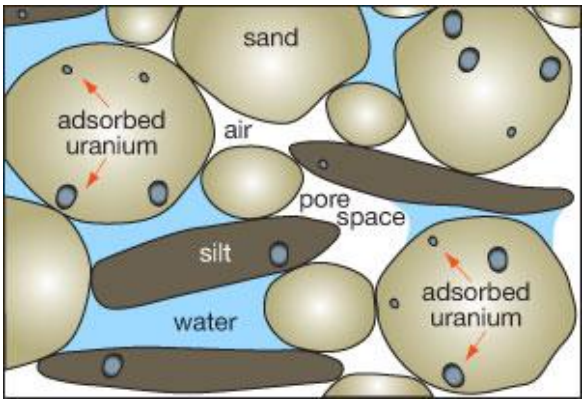


Figure 16, Aquifer Uranium occurrence, KGS Public Information Circular 25

GLOSSARY OF TERMS AND DEFINITIONS

Acre-foot: a water measurement unit one acre by one foot in size consisting of 325,851 gallons.

Alluvium: the gravel, sand, silt, and clay and similar unconsolidated material deposited in comparatively recent geologic time by a stream.

Appropriation right: a real property right to use water, acquired after June 1st, 1945, under the provisions of article 7 of chapter 82a of the Kansas Statutes Annotated and acts amendatory thereof and supplemental thereto, to divert from a definite water supply a maximum quantity of water at a specific rate of diversion or less for a specific use made of water, provided such water is available in excess of the requirements of all vested rights and appropriation rights of earlier date that relate to such supply in preference to all appropriations of later date. K.S.A. 82a-701 (f).

Aquatic nuisance species: animals and plants not native to Kansas that can threaten lake and river ecology, harm native or desirable species, affect water quality and interfere with economy.

Aquifer: any geological formation (a group or a part of a formation) capable of yielding water in sufficient quantities that it can be extracted for beneficial purposes. K.S.A. 82a-1021(a) (1).

Aquifer, Confined: an aquifer which is bounded above and below by formations of impermeable or relatively impermeable material.

Aquifer, Unconfined: An aquifer in an unconfined state has entirely different storage properties than an aquifer in the confined or artesian state. For a groundwater reservoir to be classified as unconfined, it must be shown that it is not confined by impermeable material and its water table cannot be confined from the effects of atmospheric pressure. Unconfined Dakota aquifer system in GMD3 means that portion of the Dakota aquifer system not overlain by Graneros shale.

Aquifer, Ogallala/High Plains: The Ogallala/High Plains (OHP) aquifer, which includes the Ogallala aquifer, is the primary source of water for western Kansas and is economically the important groundwater supply. See http://www.kgs.ku.edu/Publications/Bulletins/TS22/index.html

Augmentation: a water augmentation plan is a procedure for replacing water to a stream system whose flows are overly depleted by the consumption of water.

Bedrock: a general term for solid rock that lies beneath soil, loose sediments, or other generally unconsolidated material.

Conservation, Aquifer Maintenance: Type (2) water conservation activity preserves or recharges underground reservoir storage for future wise use.

Conservation, Use Efficiency: Type (1) water conservation activity increases valued output per unit of consumed water adds present economic value and benefits as wise use.

Conserve-to-preserve factor: a calculation of added future supply that separates non-use of inaccessible or depleted water supply from choice that maintains a groundwater reservoir by reduced demand or replenished storage.

Critical well: A water supply well having high risk of excessive yield decline and water right impairment within 25 years.

Demand management: cost-effective strategies that assist members and the hydrological community in managing water risk through.

District: the Southwest Kansas Groundwater Management District No. 3, Garden City, KS.

DOC: the Division of Conservation and state conservation commission of KDA, Manhattan, KS.

Domestic use: the use of water by any person or by a family unit or household for household purposes, or for the watering of livestock, poultry, farm and domestic animals used in operating a farm, and for the irrigation of lands not exceeding a total of two (2) acres in area for the growing of gardens, orchards and lawns. K.S.A. 82a-701(c).

DWR: the Division of Water Resources, Kansas Department of Agriculture, Manhattan, KS, with local field office administrative areas containing part of the District officed in Garden City and Stafford, Kansas.

Eligible voter: A natural person 18 years of age or older, or a public or private corporation, municipality or any other legal or commercial entity that: (A) Is a landowner that owns, of record, any land, or any interest in land, comprising 40 or more contiguous acres located within the boundaries of the district and not within the corporate limits of any municipality; or (B) withdraws or uses groundwater from within the boundaries of the district in an amount of one acre-foot or more per year. Most domestic users are assumed to use

GEP Act: Groundwater Exploration and Protection Act body of well contractor, well construction and groundwater protection law administered by KDHE.

GMD Act: the Kansas groundwater management body of law described in K.S.A. 82a-1020 et seq., and amendments thereto, which provides member water users a say in the management of local supplies of groundwater for the future through their plans and projects that are consistent with the adopted management program.

GMD3: Southwest Kansas Groundwater Management District No. 3, officed in Garden City, KS representing all or parts of a 12-county hydrological community of interest in the southwest part of the state.

Groundwater: water below the surface of the earth.

Groundwater Gage: a well that is used to gage and collect data on the water quantity and quality of a local groundwater source of supply.

Groundwater Reservoir: a specific subsurface water-bearing or water depleted aquifer stratum able to receive inflow recharge water.

Hydrogeologic: those factors that deal with subsurface waters and related geologic aspects of surface waters.

Hydrogeologic parameters: numerical parameters that describe the hydrogeologic characteristics of an aquifer such as porosity, permeability, and transmissivity.

Hydrogeology: the part of geology concerned with the functions of water in modifying the earth, especially by erosion and deposition, geology of groundwater with particular emphasis on the chemistry and movement of water.

Hydrologic: of or pertaining to hydrology, that is the science dealing with water, its properties, phenomena, and distribution.

Hydrologic Community of Interest: An area of natural and constructed water infrastructure that interrelate in quality and quantity to affect existing and future water use and supply.

IGUCA: Intensive Groundwater Use Control Area per the GMD Act. (K.S.A. 82a-1036).

K.A.R.: Kansas Administrative Regulations - Standards, statements of policy or general orders of general application and having the effect of law, issued or adopted by a state agency to implement or interpret legislation enforced or administered by such state agency or official, or to govern the organization or procedure of such state agency (K.S.A. 77-415 (4)).

KCC: Kansas Corporation Commission, Topeka, Kansas.

KDA: Kansas Department of Agriculture, Manhattan, Kansas.

KDHE: Kansas Department of Health and Environment., Topeka, Kansas

KDWP&T: Kansas Department of Wildlife, Parks & Tourism, Topeka, Kansas.

KGS: Kansas Geological Survey, Lawrence, Kansas.

K.S.A.: Kansas Statutes Annotated - laws passed by the Kansas Legislature and Governor.

KSU: Kansas State University, Manhattan, Kansas.

KU: Kansas University, Lawrence, Kansas.

KWAA: Kansas Water Appropriation Act, K.S.A. 82a- 701 et seq., and amendments thereto, which protects both the people's right to use Kansas water and the state's supplies of groundwater and surface water for the future. The body of law is administered by the Kansas Department of Agriculture's Division of Water Resources, which issues permits to appropriate water, regulates usage, and keeps records of all water rights in the state.

KWO/KWA: Kansas Water Office and Water Authority with duties of water planning, State Water Plan Storage and Water Assurance from federal reservoirs.

LEMA: Local Enhanced Management Area formed under K.S.A. 82a-1041 of the GMD Act .

Member of GMD3: An eligible voter on District matters described in K.S.A. 82a-1021(a)(5).

Method: Orderliness of thought and behavior to make progress and drive change.

Navigable Stream: According to the Land Title Institute (2001), navigability (For Title Purposes) means a body of water existing naturally at the time of statehood that was used or is susceptible of being used in its ordinary condition for commerce, navigation, fisheries, and more recently in other general statewide public uses such as canoeing, swimming, and related uses.

Normal high-water mark: This is the line normally seen where high water has left debris, sand and gravel during its ordinary annual cycle, but generally absent in the Arkansas River across SW Kansas due to the distribution or elimination of annual flow cycles by man's water use activities.

Overpumping: common or slang expression referring to the unlawful pumping of groundwater in excess of the amount previously authorized by a state water right, permit or state order.

POC: Proof-Of-Concept is a small realization of an idea in order to demonstrate some elements in principle with the aim of verifying one or more concepts have practical potential.

Public Interest: Based on declarations and purposes of the GMD Act (82a-1020 et seq.), the management program document and recommendations of the elected governing body of GMD3, also known as the Board of directors, are considered the local formal expression of public interest relative to groundwater management issues and associated endeavors within the district.

Pulse flow: Rain-dependent stream (ephemeral) flow after an upstream precipitation or reservoir release event that recharges groundwater storage unless interrupted or intercepted.

RAC: Regional Advisory Committee of volunteer members appointed by the KWO/KWA to advise the agency.

Recharge: infiltration of surface water or rainfall into aquifer storage.

Return flow: surface and subsurface water that leaves the field following irrigation.

Revised Management Program: A document containing information as to the groundwater management program undertaken by the district, adopted and revised as needed to update the nature and methods for addressing groundwater supply problems of the district (K.S.A.82a-1028).

Saturated Thickness: the thickness of the portion of one or more hydraulically connected aquifers in which all pores, or voids, are filled with water. In an unconfined aquifer this is the distance between the water level and the base confining layer of the aquifer system.

Static Water Level: the depth below land surface at which the top of the groundwater is found when not affected by recent pumping drawdown effects.

Standby well: a groundwater source security well as a condition documented on the water right of a primary well to be used only when catastrophic failure of the primary well occurs and repairs are under way.

Waste of water: Any act or omission that causes loss of usable water supply or use in excess of reasonable needs or exceeds the water right to appropriate waters of the state and prejudicially and unreasonably affects the management program public interest.

Water Balance: A method of determining the amount of water in a storage area by accounting for inflow to, outflow from, and changes in storage.

Water Usability Depletion: Pollution alteration of the physical, thermal, chemical, or biological quality of, or the contamination of any water into or within the District, that renders the groundwater harmful to humans, animals, vegetation, or property or impairs the usefulness or public enjoyment of the water for any lawful or reasonable use.

Waters of the state: All surface and subsurface waters naturally occurring within the borders of the state or forming part of the border between Kansas and an adjoining states.

Water risk: The four elements of water-related risk, which are: 1) physical usable supply, 2) replenishment, 3) regulations, and 4) reputation.

WCA: water conservation area (K.S.A. 82a-745) formed through a temporary agreed-to plan that is consistent with GMD3 rules and management program.

APPENDIX

Kansas water law and planning legislation history notes.

Selected from work by **John Peck** who provides a water rights and planning history outline in his writing on drought concern and Kansas water law: ***Legal Responses to Drought in Kansas,*** Kansas Law Review, Vol. 62, No. 1141, 2014, University of Kansas - School of Law.

Legislation

A. Pre-1945 water statutes: Drought not mentioned specifically, but perhaps can be inferred as one of the background reasons for some legislation:

1. 1866 (irrigation companies empowered to construct canals)
2. 1886 (stream water may be used for irrigation by appropriation, and first in time is first in right)
3. 1889 (ditch and canal companies empowered to condemn water rights)
4. 1891 (waters west of 99th meridian to be devoted first to irrigation use, subject to domestic, 2nd to industrial use; irrigation districts may be created)
5. 1899 (irrigation companies empowered to condemn to aid in establishing reservoirs, lakes, or ponds for water storage)
6. 1917 (Kansas Water Commission established to investigate problems of, *inter alia*, domestic water supply and irrigation; to establish river gaging stations; to make general plan for development of river basins; repealed 1927)
7. 1919 (Division of Irrigation created in State Board of Agriculture (BOA), under control of commissioner of irrigation; duties of commissioner included gathering data, visiting sites, and making quarterly reports to BOA)
8. 1927 (legislature abolished Water Commission and Division of Irrigation; Division of Water Resources (DWR) created to take over duties) [chief engineer position created]
9. 1933 (Chief Engineer made head of DWR)

B. The 1945 Water Appropriation Act: Activity related to and resulting from 1930s drought: Richard Pfister, WATER RESOURCES AND IRRIGATION, PART IV OF ECONOMIC DEVELOPMENT IN SOUTHWESTERN KANSAS, KU School of Business (March 1955)

1. 1940 (Governor appointed committee and held conference to study problems and make recommendations; committee report recognized need for a state plan to control the water resources)
2. 1941 (legislature repeals part of 1886 Act and established administrative procedures for handling applications for water appropriations)
3. 1944 (*State ex rel. Peterson v. Kansas State Board of Agriculture*, 158 Kan. 603, 149 P.2d 604 (1944) (affirmed common law doctrine of absolute ownership for groundwater; concluded that the chief engineer had been given no power over groundwater allocation))
4. 1944 (Governor appoints committee to study state water law, which produces "The Appropriation of Water for Beneficial Purposes: A Report to the Governor" (Dec. 1944) recommending adoption of Doctrine of Prior Appropriation)
5. 1945 (legislation adopts the Water Appropriation Act (WAA)) [Now all Kansas water rights to follow one doctrine and unused water is dedicated to the people of the state subject to beneficial appropriation as provided in WAA]
6. 1956 (clarify water rights as changeable real property that must tolerate reasonable economic effects between users)

7. 1972 GMD Act (legislature dedicates local groundwater management rights)
8. 1978 (legislature restrict all non-domestic use without first obtaining state permission and adds Intensive Groundwater Use Control Area provision in GMD Act)
9. 1986 (mandated annual water use reports by March 1st each year subject to fines)
10. Water right management tools developed since then.
    [2012: Local Enhanced Management Areas (LEMA's) allowed]
    [2012: Eliminating forfeiture of groundwater rights for non-use in closed areas]
    [2015: Water Conservation Areas (WCA's) allowed]
    [2015: Requirement for chief engineer to give due consideration of past management and voluntary conservation in new conservation programs.]

Kansas Water Planning Acts

1. 1917 (Kansas Water Commission established to investigate problems of, *inter alia*, domestic water supply and irrigation; to establish river gaging stations; to make general plan for development of river basins; repealed 1927)
2. 1955 (Kansas Water Resources Board and executive director established)
    a. Charged with working on and working out a state water plan of water resources development.
    b. Background: "The State of Kansas had no sooner recovered from the spectacular floods of 1951 when it plunged into one of the most severe droughts in Kansas history from 1952 through 1956. This sequence of disasters led to legislative creation of the Kansas Water Resources Board in 1955 as a move to try to do something to avert or at least alleviate future crises through aggressive planning.

3. 1963 (State Water Plan Act, 82a-901 *et seq.)*
4. 1981 (Kansas Water Resources Board replaced by the Kansas Water Authority, the Kansas Water Office, and the director of the Kansas Water Office)
5. 1984 (State Water Resource Planning Act: major amendments to K.S.A. 82a-901a, *et seq.*)
6. 1985 (K.S.A. 82a-906 amended to provide dynamic planning process, under which KWO presents annual water plan and recommendations to the legislature)

End of Legislation History notes.

Maps and groundwater model information

The following maps provide map that inform management program activity.

The High Plains Aquifer Atlas can be found at:
http://www.kgs.ku.edu/HighPlains/HPA_Atlas/Water%20Rights%20and%20Water%20Use/index.html

The most recent GMD3 groundwater model information can be found at the following urls:

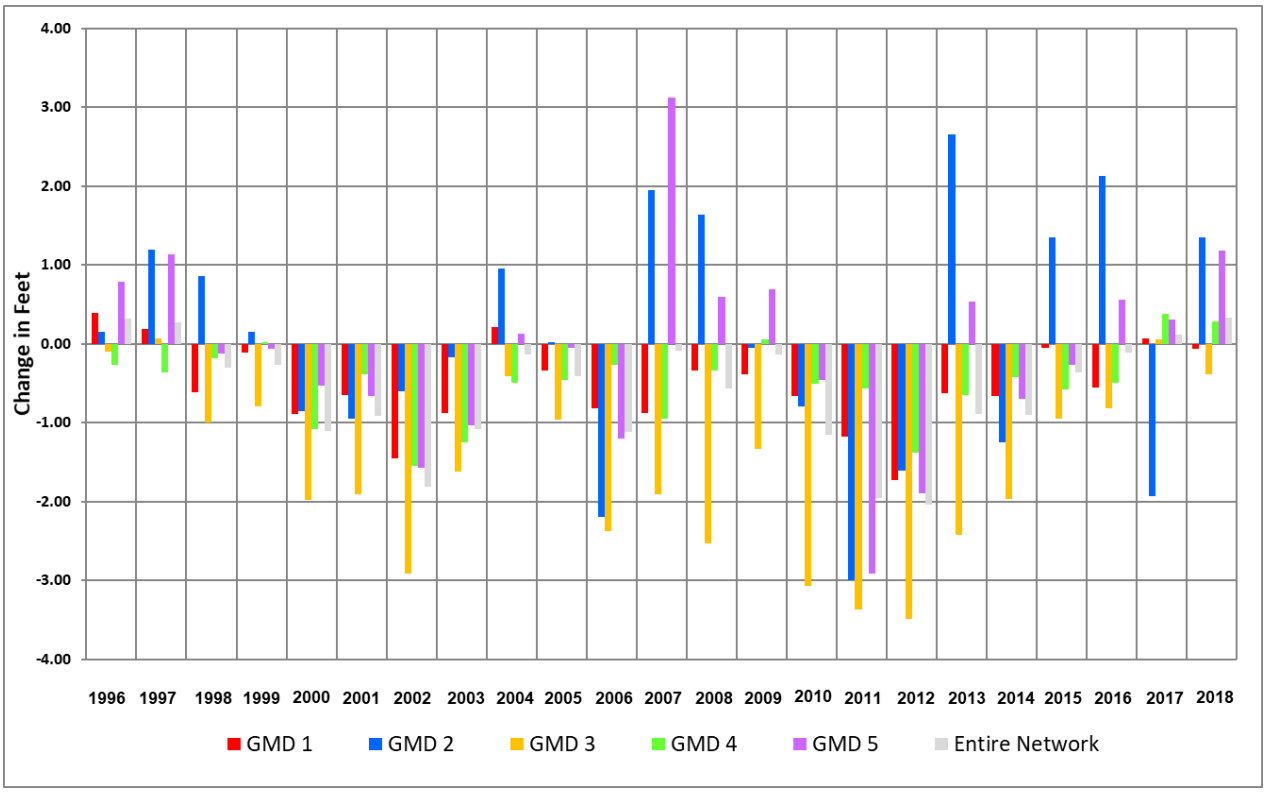
GMD3 Ground-Water Model: http://www.kgs.ku.edu/Hydro/Publications/2010/OFR10_18/

GMD3 Model Future Scenarios: http://www.kgs.ku.edu/Hydro/Publications/2012/OFR12_3/

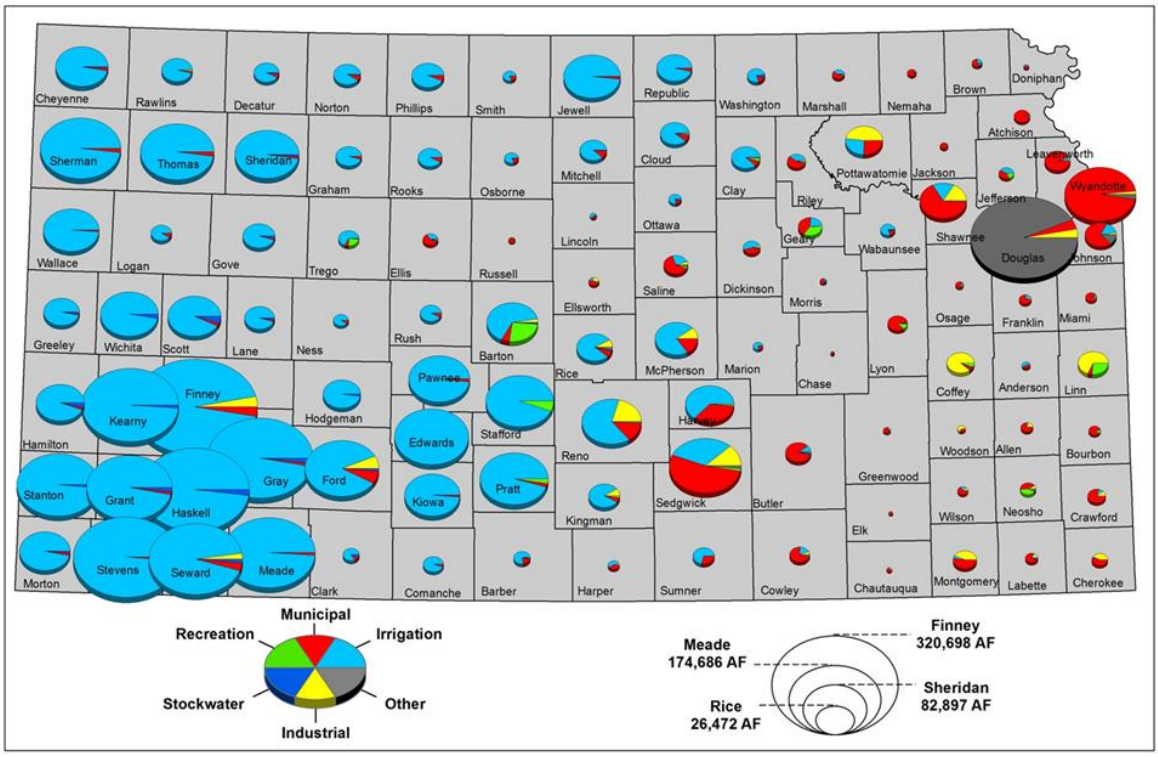
Potential economic impacts of water-use changes in Southwest Kansas:
http://www.tandfonline.com/doi/abs/10.1080/19390459.2013.811855

Section level percent decline in storage (since 1950) of the OHP Aquifer in GMD3.
Source: KGS, http://www.kgs.ku.edu/Publications/pic18/index.html

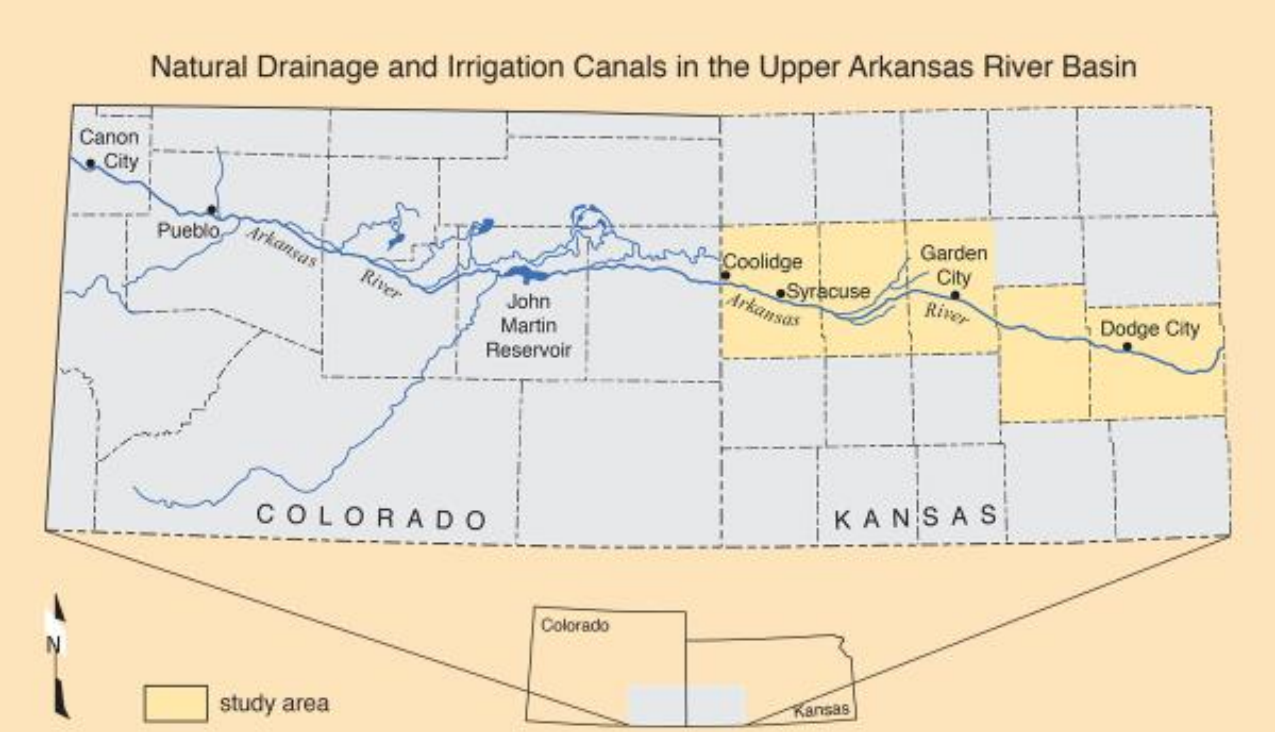
Saturated Thickness of the Ogallala/High Plains Aquifer, 2015.Source: KGS,
http://www.kgs.ku.edu/Publications/pic18/index.html



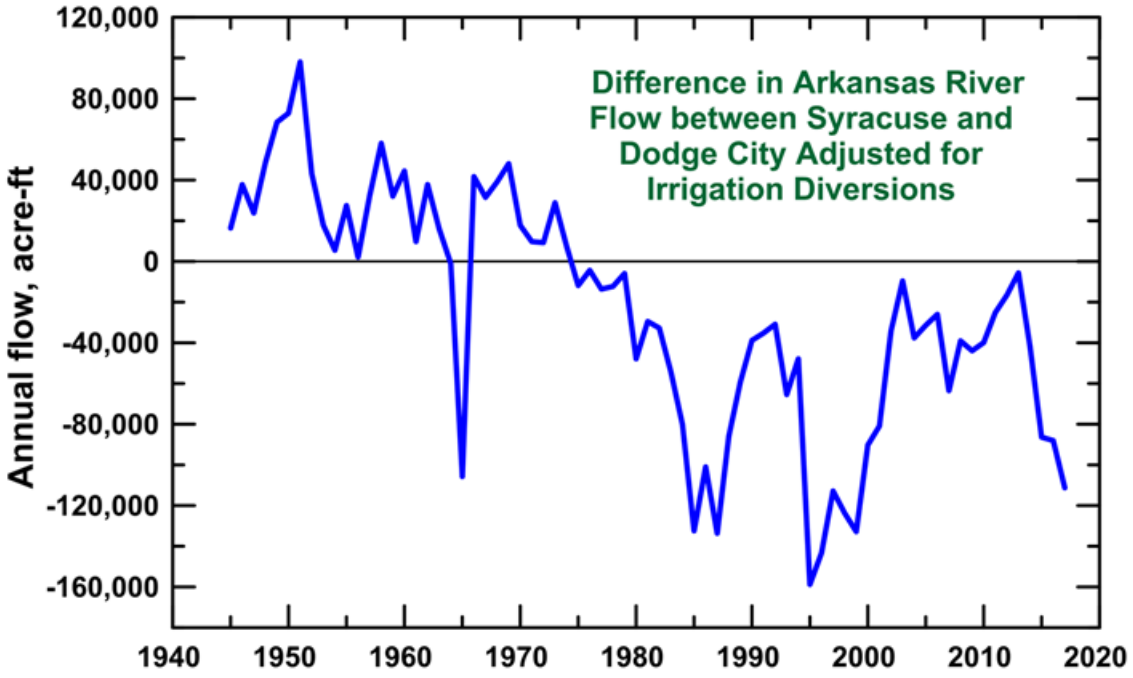
Average change results above are based only on the cooperative network (KGS and KDA-DWR) and do not include sub-regional networks from the KDA-DWR, KGS, or local GMDs. 2019 water levels are provisional data.



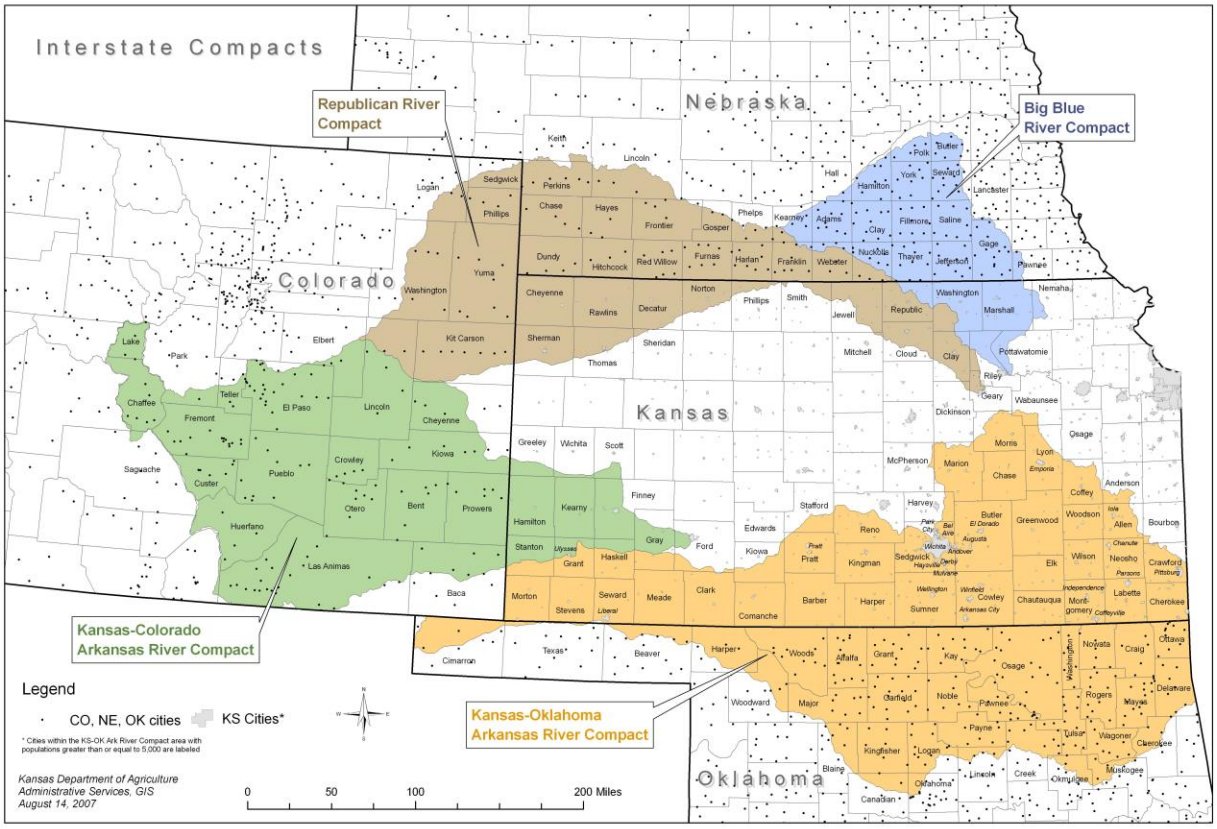
Average annual reported water uses 1995 to 2014 are influenced by precipitation patterns and available groundwater. “Other” use is primarily flow through hydropower. Source: KGS.

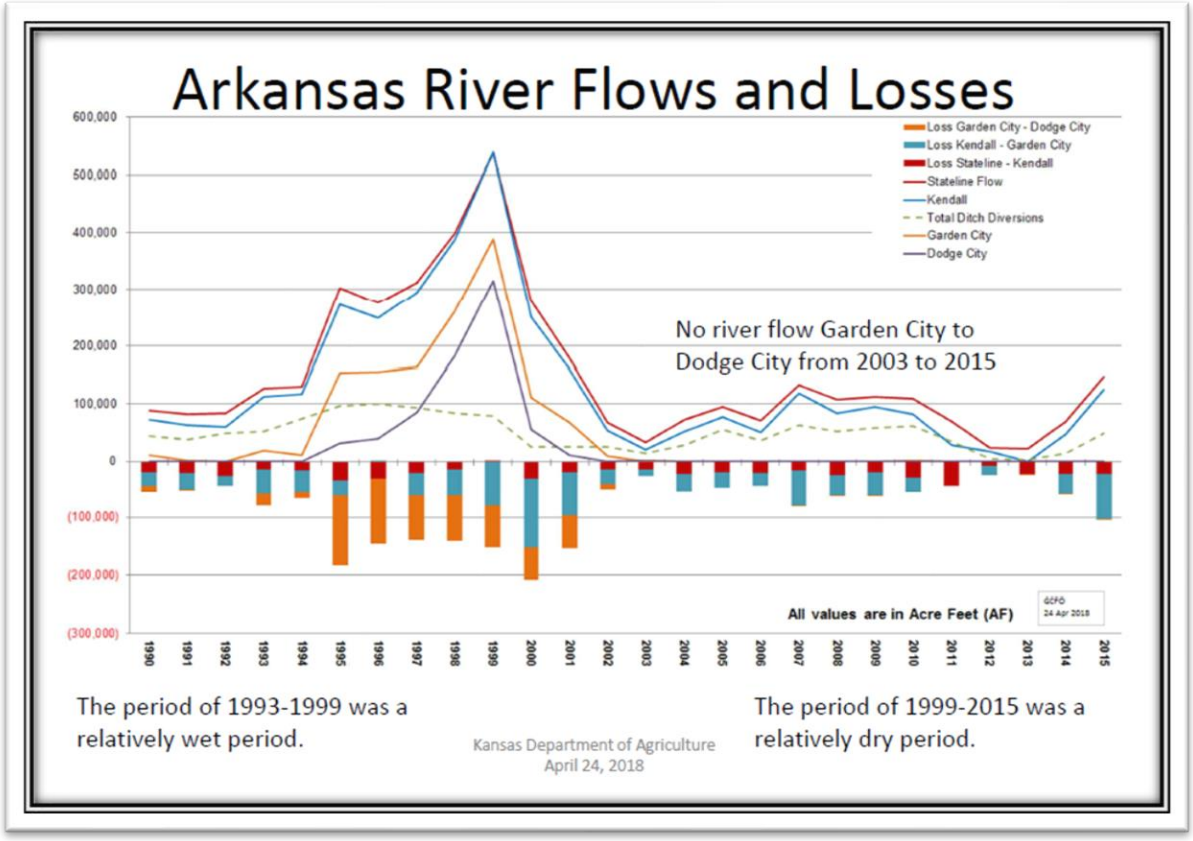


Evapotranspiration in the area of irrigation diversions and reservoirs in eastern Colorado substantially decreases the river flow before it enters Kansas. A smaller extent of irrigation ditches also divert river water in the GMD3 area.

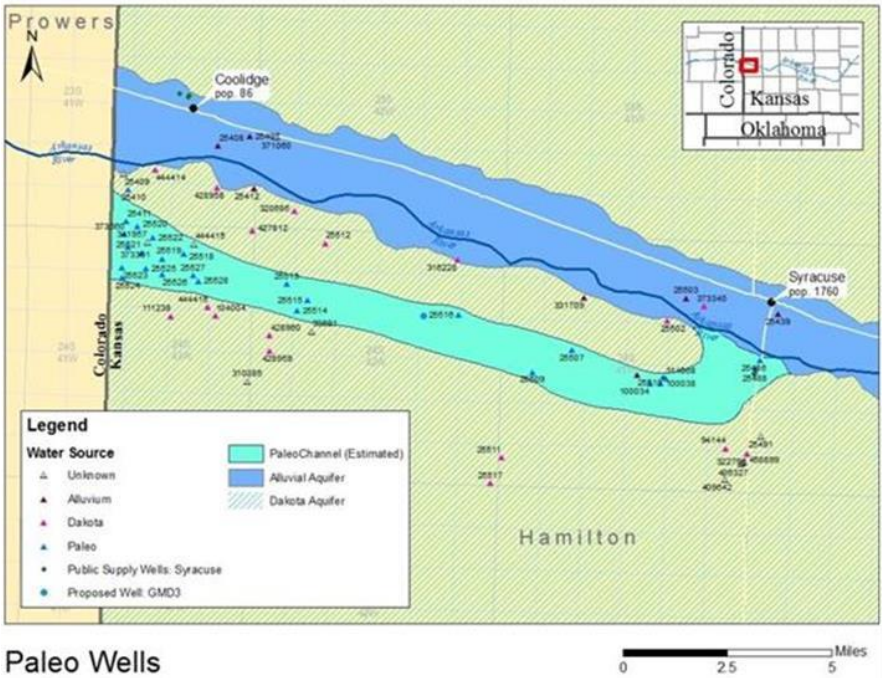


Before the mid-1970s, the Arkansas River nearly always gained flow (represented by positive values on the graph) between the area of ditch diversions and Dodge City. Now the river recharges the HPA, with recharge exceeding 100,000 acre-ft during years of higher flows. We've created a closed basin (KGS 2018). GMD3 has identified this hydrology setting to be surface water natural storage into available groundwater reservoir space.





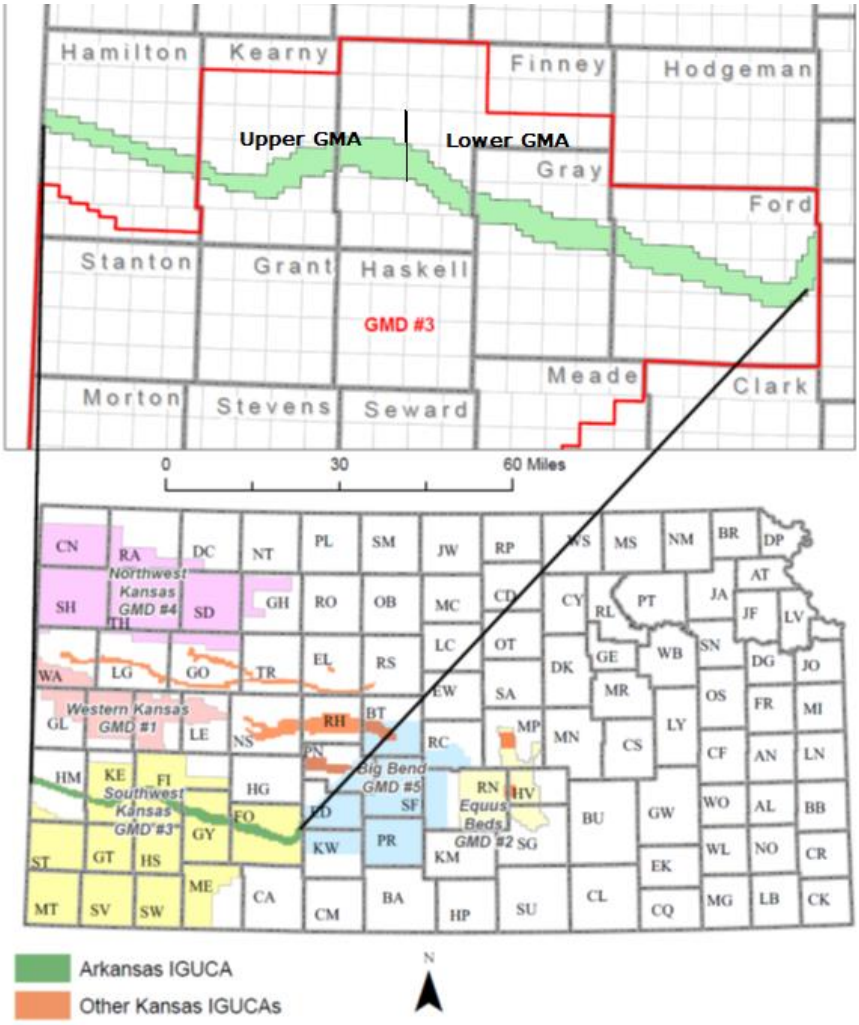
Arkansas River flow/loss chart. Source: DWR



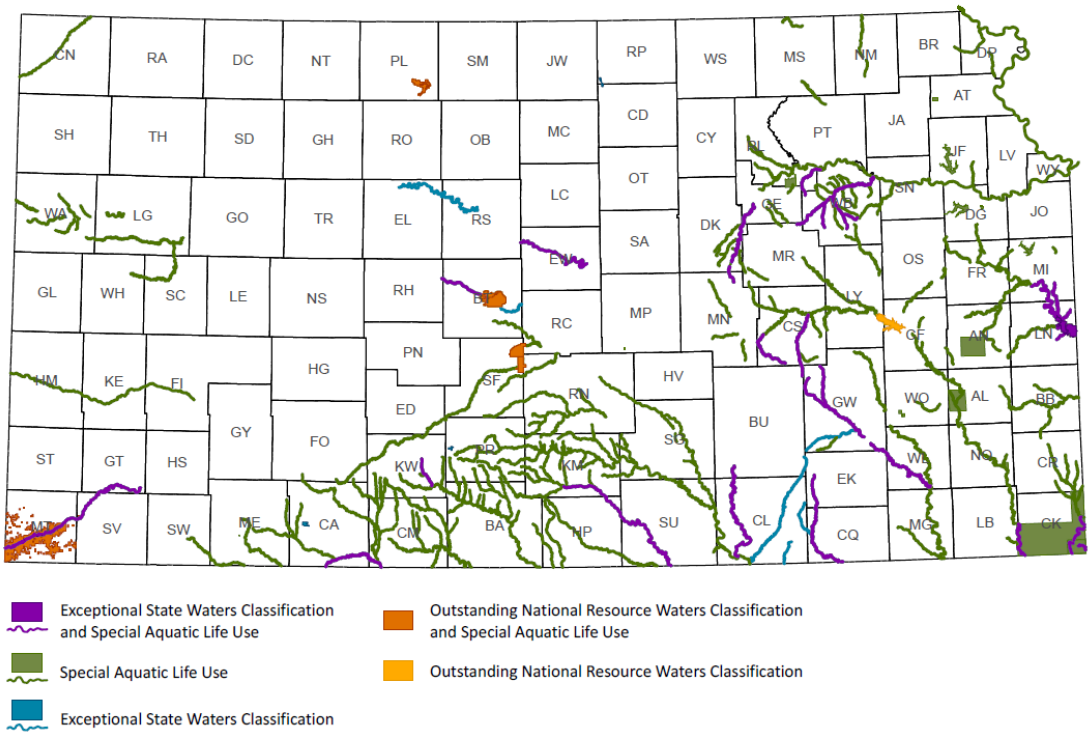
Paleo Wells

Hamilton County palio-river channel freshwater aquifer source of drinking water and river water quality mitigation to be managed.

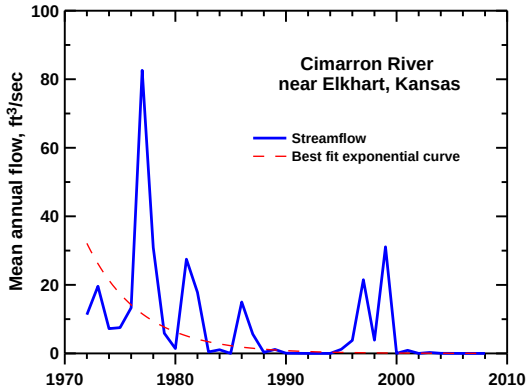
Ark River IGUCA



High Value Surface Water Designations within Kansas



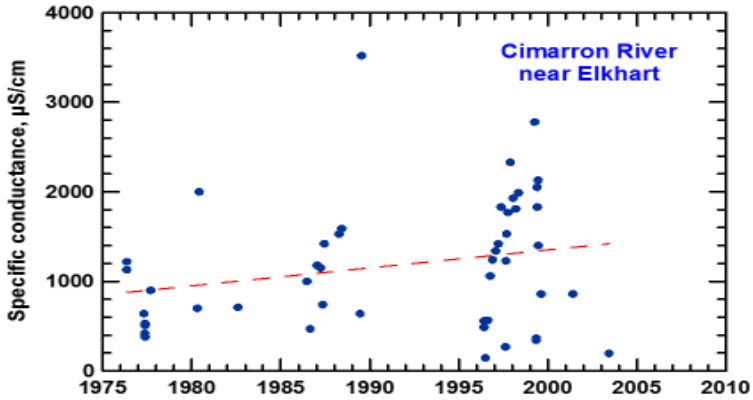
Map showing Exceptional State Waters and Outstanding National Resource Waters of the Cimarron River and National Grassland. Source: KDHE, 2010



Cimarron River entering Kansas in Morton County

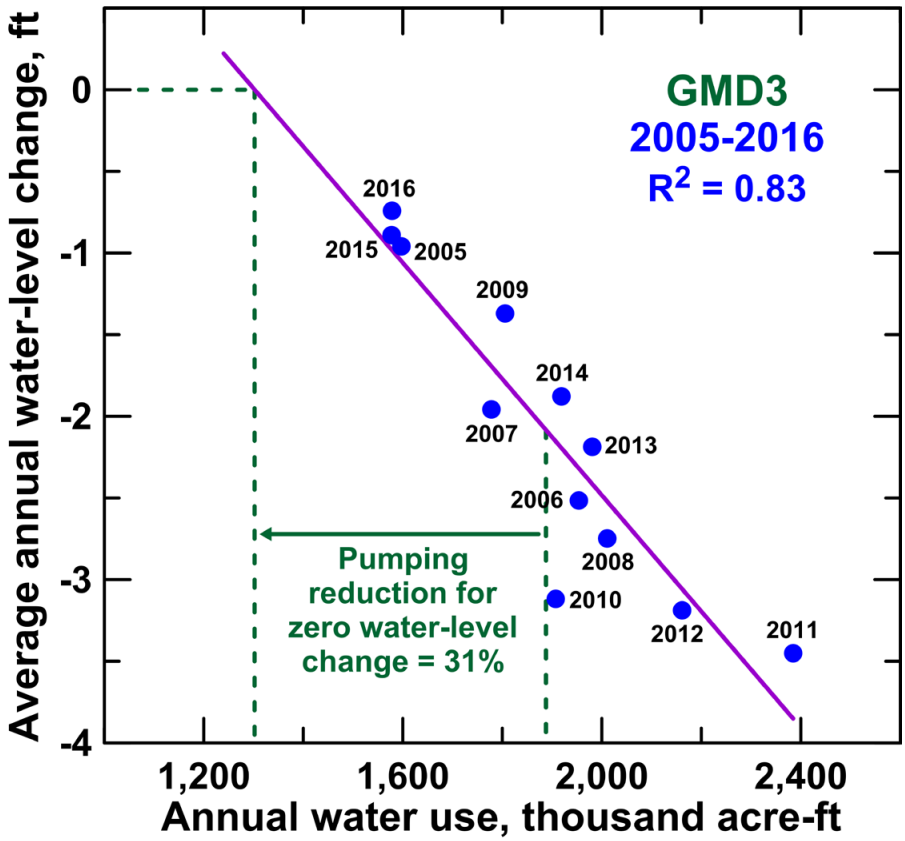
Water use in the Cimarron River valley upstream of the Kansas Stateline has decreased flow and increased salinity of the river system entering Kansas. The river no longer flows except occasionally.

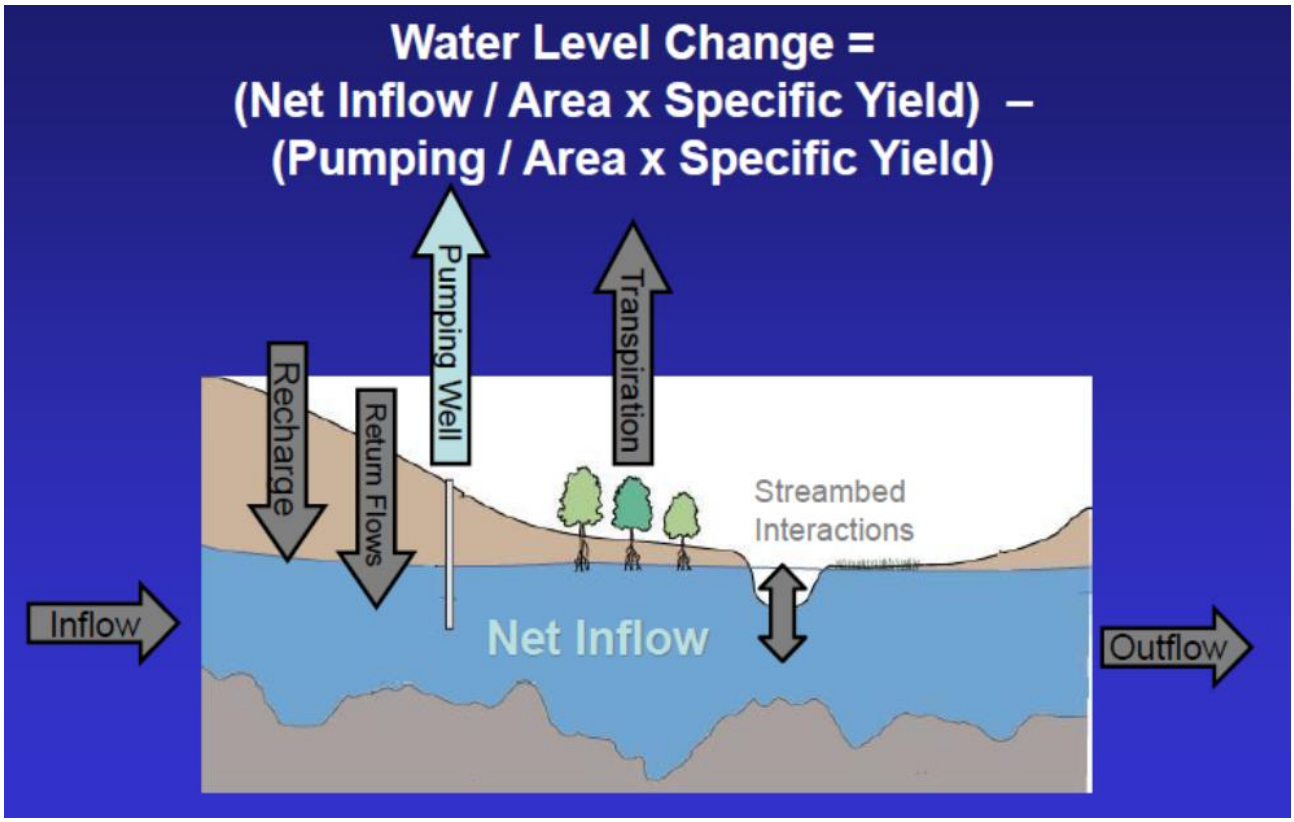
From Kansas Geological Survey Open File Report 2005-27



From Kansas Geological Survey Open File Report 2005-27

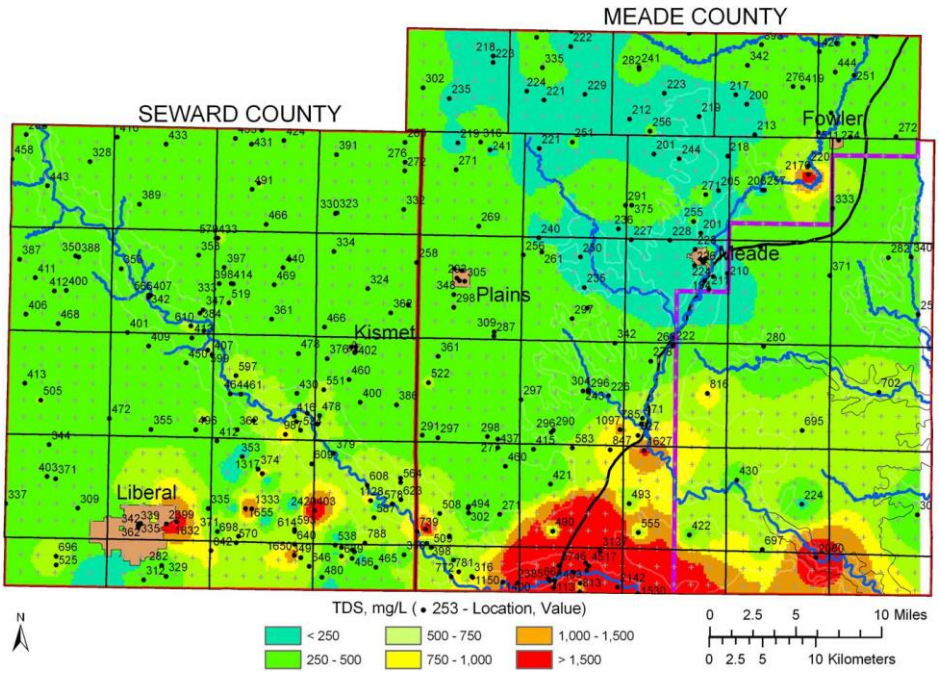
How close to sustainable? Average annual water-level change versus annual water use for GMD3 for 2005–2016. Water-level data are for KGS-DWR cooperative network wells measured each winter during the period. The solid line is the best-fit straight line to the plot. The pumping reduction from the average water use for 2005–2016 to that needed to achieve a zero water-level change is shown by the vertical dashed green lines. From *Status of the High Plains Aquifer in Kansas* | Whittemore, Butler, & Wilson, KGS Technical series 22, 2018. 31% = about 776,000 acre-feet.



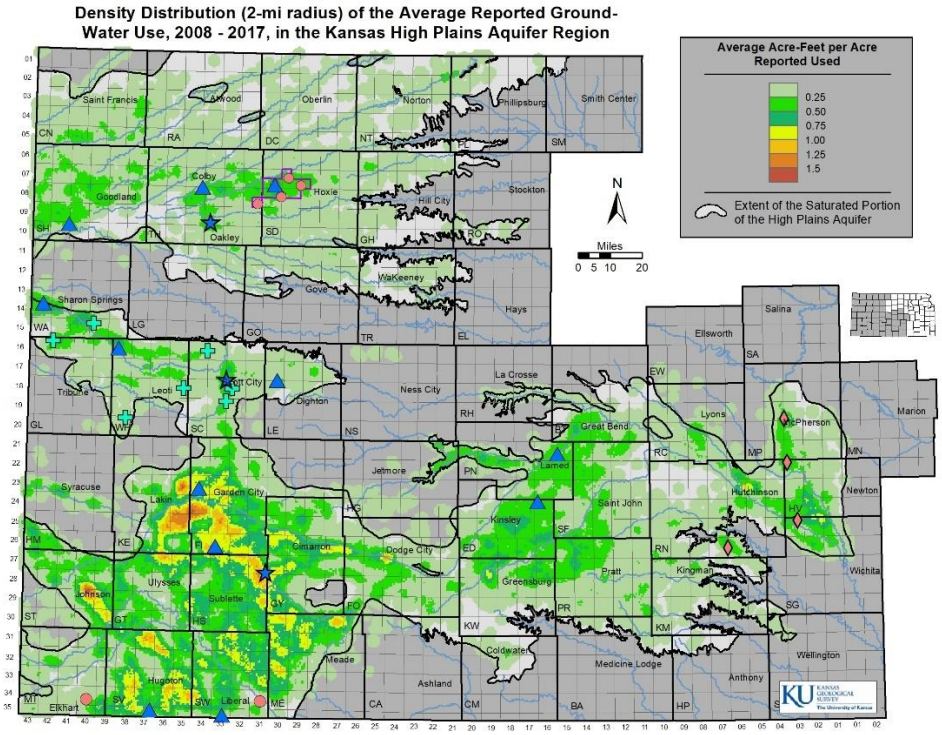


Source: Kansas Geological Survey

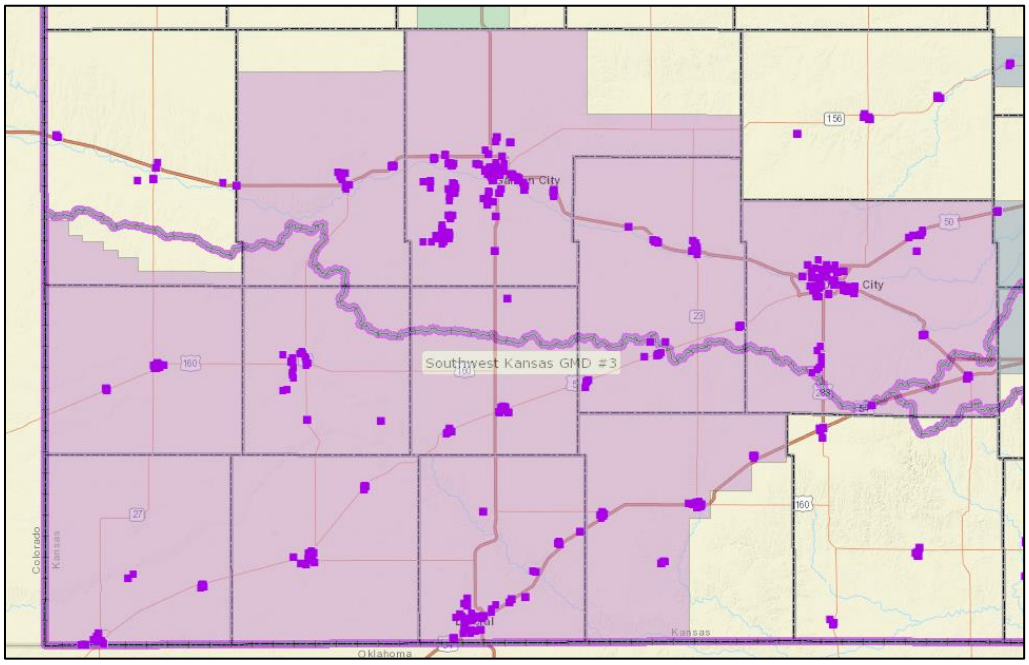
GMD3 Special Rule GMA (Water Quality Control Area)



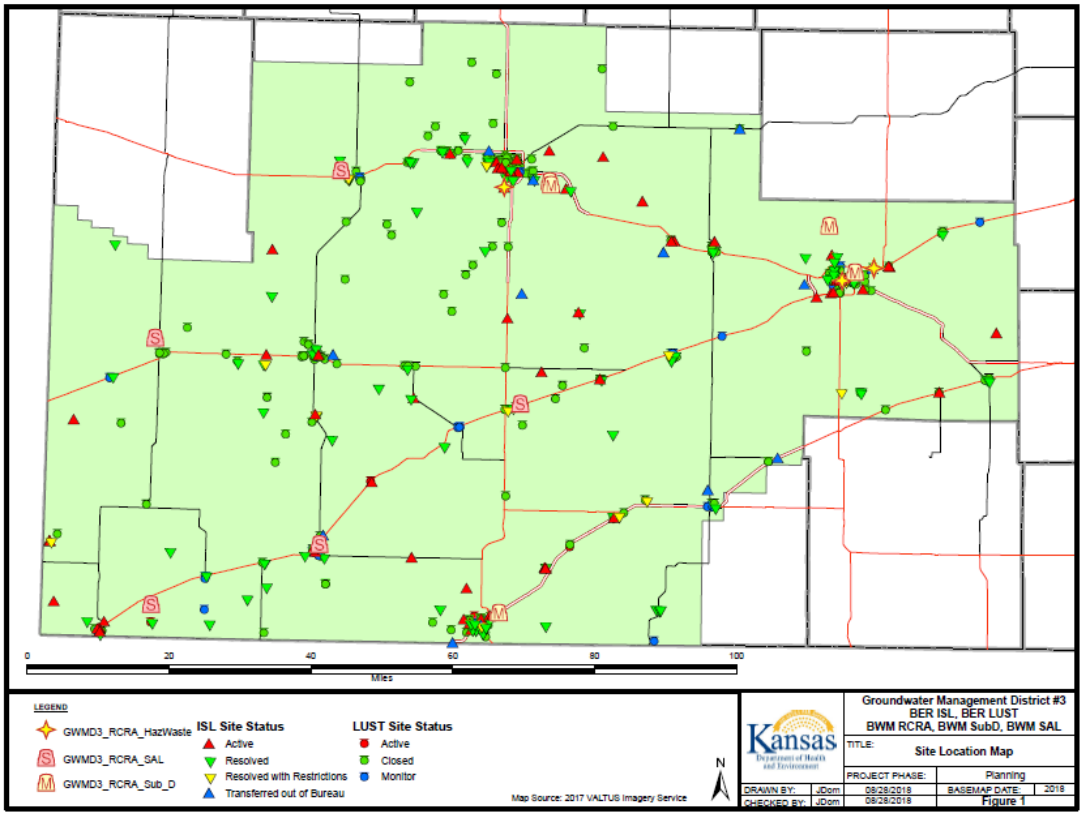
Distribution of chloride concentration in groundwater in groundwater reservoirs in Seward and Meade counties. The blue line extending from northwest to southeast Seward County and through southwest Meade County is the Cimarron River. Most of the blue lines in northern, central, and southeast Meade County are streams that are part of the Crooked Creek drainage basin. The vertical red line is the boundary between Seward and Meade counties. The purple line within Meade County is part of the eastern boundary of GMD3. The black line extending from southwest to northeast Meade County represents the eastern extent of the saturated part of the High Plains Aquifer in the figure. From KGS Open File Report 2005-27.



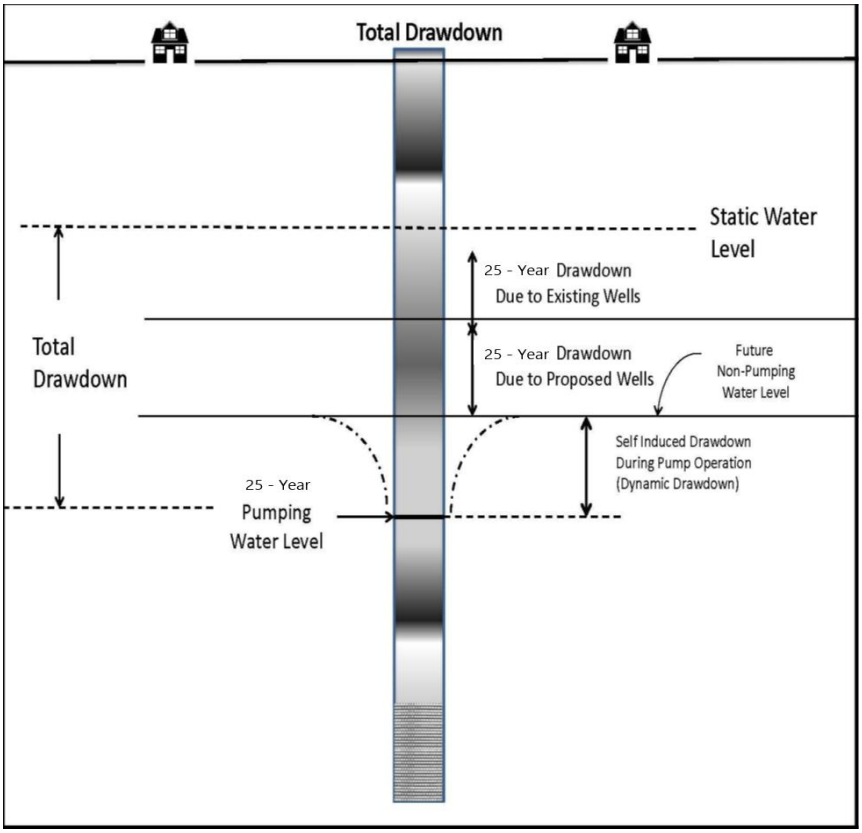
Kansas High Plains Groundwater reservoir detailed pumping density and location of KGS index wells in 2019.



2018 KDHE map of the 67 public water system infrastructure locations within or near GMD3. Map includes the boundary through the district between the Upper Ark and the Cimarron basins. Southeast Ford County includes the upper Rattlesnake Creek basin.



KDHE 2018 map of contaminated sites documented in the Identified Site List (ISL) and Leaking Underground Storage Tanks (LUST). A subset of these are "orphaned sites" with no identified responsible entity for site cleanup, including groundwater remediation.



Illistration (A), Total Drawdown Calculation

(A) is adapted from *Guidelines for the Assessment of Drawdown Estimates for Water Right Application Processing* (New Mexico Office of the State Engineer Hydrology Bureau Report 05-17, May 10, 2017, by Tom Morrison, et. al.). GMD3 may use a 25-year period of pumping to be consistent with GMD3 Board policy on maximum allowable rate of groundwater reservoir depletion.

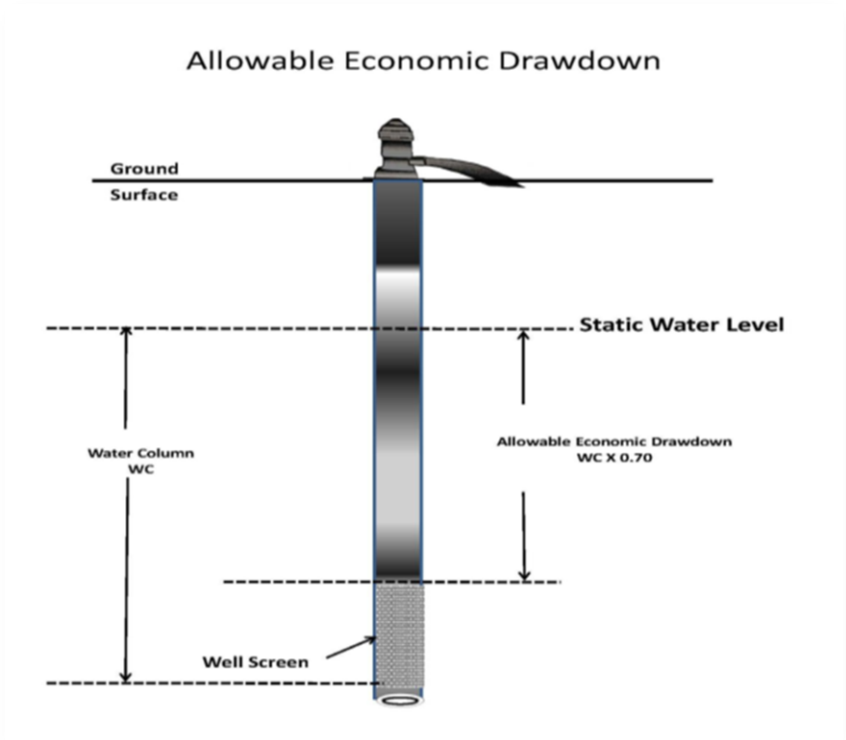


Illustration (B), Allowable Economic Drawdown

(B) is addapted from: *Guidelines for the Assessment of Drawdown Estimates for Water Right Application Processing* (New Mexico Office of the State Engineer Hydrology Bureau Report 05-17, May 10, 2017, by Tom Morrison, et. al.).

- The Theis equation estimates drawdown in the aquifer but not inside of the well casing.
- Dynamic drawdown represents drawdown inside of casing, including well inefficiencies.
- Dynamic drawdown represents fluctuating drawdown as pumps are cycled on and off.

See: http://www.gmd3.org/wp-content/uploads/2019/04/DRAWDOWN-ASSESSMENT-GUIDELINES-for-GMD3-2019.docx