



POTENTIAL HEALTH EFFECTS OF MUNICIPAL WATER REUSE IN KANSAS

Kansas Health Impact Assessment Project



OCTOBER 2017



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This report, *Potential Health Impacts of Municipal Water Reuse in Kansas*—further on referred to as the KHI Municipal Water Reuse HIA—is intended to be an accessible and informative resource for Kansas policymakers, municipalities, municipal utility staff and others as they make decisions about water resource planning in Kansas. This report describes potential health effects associated with municipal water reuse to inform decision-making that maximizes potential health benefits and mitigates potential health risks that could result from water reuse.

Acknowledgements

This project is supported by a grant from the Kansas Health Foundation (KHF) through an initiative called “Improving Health Through Access to and Consumption of Water.”

Over the course of this project, the Kansas Health Institute’s (KHI) Health Impact Assessment Team—further on referred to as the KHI HIA Team—received valuable input and participation from various stakeholders including local municipalities and municipal utility representatives, state agency officials, representatives of water-related organizations, state legislators, academic researchers, and other KHF grantees. We would like to thank them for dedicating their time, energy and expertise to the project.

The KHI HIA Team extends a special thank-you to two groups of people without which this project would not have been possible: the Full HIA Team and the Technical Advisory Panel. Both groups were created to support and guide the implementation of the HIA. The Full HIA Team was created to identify the focus and scope of the project and consisted of representatives from the Kansas Department of Health and Environment (KDHE), Kansas Water Office (KWO), Kansas Municipal Utilities (KMU) and the University of Kansas (KU). Each member of this team was also key in providing data, context and expertise on issues of water, wastewater and water reuse in Kansas. The purpose of the Technical Advisory Panel was to serve as a sounding board to ensure that the project’s focus, goals and recommendations were feasible and sensible from a local perspective. The Technical Advisory Panel was made up of representatives from municipalities and municipal utilities across Kansas, including Garden City, Hays, Russell, South Hutchinson, Salina and Johnson County, as well as representatives from the Kansas Rural Water Association. A special thank-you goes to Fred Jones, water resource manager for the City of Garden City, and Toby Dougherty, city manager for the City of Hays, for their engagement and assistance in deploying community surveys in those two locations.

Finally, the authors thank Kansas Health Institute (KHI) colleagues who provided feedback throughout the HIA process: Kari M. Bruffett, director of policy, and Steve Corbett, Ph.D., senior analyst. We also thank Sheena Smith, M.P.P., former KHI analyst, for her preliminary work on the project.

Disclaimer

The authors of this report are responsible for the facts and accuracy of the information presented. Any findings, conclusions or recommendations expressed in this HIA report are those of the authors and do not necessarily reflect the view of the project’s funder, the Full HIA Team, the Technical Advisory Panel, or any other stakeholders who provided their perspectives during the process.

The Kansas Health Institute does not endorse or oppose any local decisions related to water reuse projects. KHI delivers credible information and research to support informed decision-making that includes health as one of its priorities. The Kansas Health Institute is a nonprofit, nonpartisan health policy and research organization based in Topeka. KHI was established in 1995 with a multi-year grant from the Kansas Health Foundation.

Water Reuse: The Kansas Water Vision

The Kansas Water Vision, “A Long-Term Vision for the Future of Water Supply in Kansas,” was developed by the Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), and the Kansas Water Authority (KWA), in response to Governor Sam Brownback’s 2013 call-to-action.¹ The Water Vision focuses on several areas, including water conservation, water management, technology and crop varieties, and additional sources of water supply. The Water Vision calls for an evaluation of the sources and potential uses of lower-quality water as a strategy for additional sources of water supply.² It is within this strategy that water reuse is likely to be considered. The Kansas Health Institute (KHI) conducted a health impact assessment (HIA) to examine how municipal water reuse might positively or negatively affect the health of Kansas residents.

An HIA is a practical tool that assesses the health impacts of policies, strategies and initiatives in sectors that are not commonly thought of in relation to health, such as transportation and housing. The overall goal of an HIA is to inform decision-makers of potential positive and negative health effects of proposed policy decisions. The HIA provides evidence-based findings about health impacts and identifies recommendations to maximize health benefits and mitigate health risks.

This HIA focuses on municipal water reuse in Kansas. Municipal water reuse involves the utilization of highly treated municipal wastewater for beneficial purposes. The term “water reuse” is generally used synonymously with water reclamation and water recycling. The goals of the HIA were to: 1) add to the data collection and research on public health impacts related to the access, promotion and consumption of water in Kansas; 2) identify options and provide evidence-based recommendations to enhance potential positive impacts on health and mitigate potential negative health impacts that could result from water reuse; and 3) build HIA sustainability in Kansas by continuing to introduce this tool to state and local decision-makers.

To assess the potential health effects of municipal water reuse in Kansas, the KHI HIA Team reviewed existing literature, analyzed data, and gathered

stakeholder input from multiple groups, such as representatives of local municipal utilities, environmental groups, state personnel involved in water regulation, and water professionals from states with widespread reuse, among others.

Research Questions

The assessment of health effects was guided by several research questions related to water reuse, including:

How will municipal water reuse in Kansas affect the following factors?

- Water availability
- Community sustainability
- Water quality
- Community perception of water quality
- Consumption of beverages other than municipal tap water
- Costs and utility rates
- Guidance and regulations

How will changes in these factors affect health?

Throughout the report, special attention was given to populations that could be disproportionately affected by decisions to reuse municipal water.

Summary of Findings and Recommendations

Following are brief summaries of the findings from each of the identified issue areas. *Figure 1* (page 5) outlines the projected impacts along with the magnitude, direction and quality of evidence for each impact. The findings were developed based on literature and data. Additionally, to maximize the potential positive health effects and mitigate the potential negative health effects associated with the water reuse in Kansas, the KHI HIA Team—with input from stakeholders—developed a set of recommendations to inform future decisions related to water reuse.

Key recommendations are listed below the findings for each issue area. The recommendations listed

are those that were identified as high priority by the stakeholders based on the criteria of feasibility, responsiveness to findings, and whether implementation of the recommendation is likely to produce a meaningful result. The full list of findings and recommendations is available in *Appendix C*, page 75.

Water Availability and Community Sustainability:

Water reuse has the potential to increase the water available for community use, which in turn, could increase community sustainability. However, the magnitude of these increases in the context of overall water use may be relatively small as community sustainability is influenced by many factors, of which water availability is just one. There are social, economic and environmental factors that contribute to the resilience of communities in the face of changes to water availability. Potential health impacts of increased community sustainability include reduced stress and improved individual and community mental health.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- Water utility managers could consider managing water reuse and water conservation in collaboration with other partners;
- Researchers could consider quantifying the social, economic and environmental consequences of water reuse in areas of water scarcity in Kansas;
- Policymakers/legislators could consider encouraging water reuse as a strategy for additional supply through recommendations and/or financial incentives; and
- Municipalities could consider participating in processes for ongoing, long-term water planning.

Water Quality: Reused water quality may increase, decrease, or stay the same in comparison to current drinking water quality. While current technology can be used to treat water to any quality required, the quality of reused water depends on the availability of funds and on the intended end use. Non-potable reused water

is treated to a lower standard by design, while indirect and direct potable reused water typically undergo advanced treatment and quality controls. In general, the reviewed literature suggests that the quality of reused water has not harmed human or environmental health. Nevertheless, the risk of system failure remains, and such an event could result in exposure to contaminants and potential illness. There is also uncertainty about the contaminants of emerging concern. There is not adequate evidence to conclude how prevalent they are and whether they present a risk to health.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- The Kansas Department of Health and Environment (KDHE) could consider establishing consistent requirements for signage to limit public contact with lower-quality, non-potable reused water; and
- KDHE and municipalities could consider working together to identify and adhere to standards, processes and best practices for ensuring the quality of reused water.

Community Perception of Water Quality: While perception varies from community to community, the perception of reused water quality is generally lower than that of current drinking water. There are several components of this perception. The first is what has been referred to as the “yuck” factor, or psychological aversion to treated wastewater. Another is trust in public officials, experts and technology. The public’s perception of the quality of the water is generally lower for all reuse types, and the acceptability of water reuse declines as the potential for human contact with the water increases. A community’s acceptance of water reuse depends on multiple factors, such as the extent of communication, outreach and meaningful engagement of the public. Communication efforts can improve acceptability of water reuse, while issues such as the “yuck” factor and lack of trust in local government could decrease a community’s perception of the quality of reused water. The primary health implications of a decrease in community perception of water quality were found in the switch from drinking tap water to bottled water or sugary beverages.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- Kansas municipalities could consider implementing targeted outreach and educational campaigns about reuse, including information about the social and environmental costs and benefits, institutional structures, regulatory systems and alternate solutions;
- Kansas municipalities could consider demonstrating the utility's trustworthiness by maintaining compliance with the Safe Drinking Water Act standards; and
- State agencies that are involved in water education could consider educating and communicating with the public about water reuse.

Consumption of Beverages Other Than Municipal Tap Water: A decrease in the perception of water quality could impact the purchase and consumption of beverages other than municipal water, such as bottled water or sugary beverages. There is a common perception that bottled water is of higher quality than municipal drinking water, although some evidence points to the opposite. Health impacts of increased sugary beverage consumption include impacts on oral health and chronic conditions such as obesity and diabetes. Purchasing beverages that are more expensive than municipal water could also have negative financial implications for populations that are economically disadvantaged as it could decrease the availability of funds for other essential needs. Some racial and ethnic minority groups may be more likely to consume bottled water and sugary beverages as a result of low trust in the quality of the municipal drinking water, and therefore may be at higher risk of negative health impacts.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- Municipalities could consider improving community perception of drinking water by communicating early and often, and building/maintaining transparency and trust with the community; and

- Local public health agencies could consider engaging in health promotion strategies to highlight the health benefits of water consumption over other beverages such as sodas, juices and other sugary drinks.

Costs and Utility Rates: Water reuse projects are associated with a variety of initial and ongoing costs related to infrastructure, operations and maintenance. The costs may depend on the type of reuse, the desired water quality, and the method and distance of water distribution. Reusing water in smaller communities may be more expensive on a per-capita basis, but in some cases, water reuse may be less costly than the development of other new water sources. Due to water reuse, utility rates could increase, decrease or stay the same. Changes in utility rates may depend on the costs of reuse, availability of alternate funding sources, and the community's perception of and demand for reused water. Increases in utility rates could negatively impact the health of individuals who are already paying a higher percentage of their income on water and wastewater bills, including those who are low-income, elderly, and those served by small and rural community water systems. Because of the importance of water and wastewater service, keeping these utilities turned on could require trade-offs with other necessities such as food, medical expenses, and heating and cooling.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- Kansas municipalities could consider working with partners to share the costs and benefits of reuse infrastructure (e.g., industry partners, neighboring municipalities);
- Kansas municipalities could consider balancing the most cost-effective reuse option with community acceptability;
- Kansas municipalities could consider pricing water to account for scarcity by increasing the rate for high-volume users; and
- Kansas municipalities could consider implementing affordability programs for low-income individuals, such as lifeline rates, payment plans, bill discounts, leak repair assistance programs, among others.

Guidance and Regulations: As more Kansas communities pursue water reuse, new guidance and regulations for water reuse projects are likely to be developed in Kansas. Regulations in states with current or planned widespread water reuse include requirements for water quality, public access, monitoring and reporting. Because most water reuse regulations exist to protect the public's health and the environment, the successful implementation of the regulations may have a beneficial effect on health. However, it is possible that the regulations will help to maintain, rather than improve upon, the current state of health in Kansas, since current federal regulations, such as the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA), are set to ensure the safety of water for health and the environment.

Recommendations to maximize any potential health benefits and mitigate any potential health risks include:

- KDHE could consider incorporating best practices into any new regulatory guidance. Best practices include:

- Maintaining public health as a top priority;
- Preventing cross-connections (actual or potential contact between potable and non-potable water supplies);
- Marking all non-potable components;
- Having a proactive public information program;
- Having a monitoring and surveillance program;
- Training utility staff members on reuse;
- Establishing construction and design standards; and
- Ensuring physical separation of potable and non-potable water lines.

Additional best practices may be found in *Guidelines for Water Reuse* from the U.S. Environmental Protection Agency (EPA).

The following table summarizes potential health impacts associated with water reuse in Kansas for each of the areas studied (Figure 1). See Figure 2, page 7, for the legend that corresponds to Figure 1.

Figure 1. Summary of Health Impacts of Municipal Water Reuse in Kansas

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Water Availability†	Increase	Increase	Increase	Increase	Beneficial	Most/All	Communities with lower water security; Water-dependent industries or amenities	Possible	**
Community	Increase	Increase	Increase	Increase	Beneficial	Most/All	Those without the resources to relocate or seek services elsewhere	Possible	****
Water Quality	Mixed	N/A	No change/ Increase	Mixed	Neutral^	N/A	N/A	N/A	****

Figure 1. Continued

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Non-potable [§]	Decrease	N/A	No change	Decrease	Neutral to Adverse	Few	Individuals with a compromised immune system or other health-related issues	Unlikely	N/A
Indirect potable ^Δ	Increase	N/A	Mixed	Increase	Neutral	N/A	N/A	N/A	N/A
Direct potable [#]	No change/ Increase	N/A	No change/ Increase	No change/ Increase	Neutral [^]	N/A	N/A	N/A	N/A
Community Perception of Water Quality ^{††}	Decrease	N/A	Decrease	Decrease	See "Consumption of beverages other than municipal water" below				****
Consumption of beverages other than municipal water	Increase	N/A	Increase	Increase	Adverse	Some	Some racial and ethnic minority groups; Low-income populations; Individuals with a compromised immune system	Possible	****
Costs of Reuse	Increase	N/A	Increase	Increase	See "Utility Rates" below				****
Utility Rates	Mixed	N/A	Increase	Mixed	Neutral to Adverse	Some	Low-income; Elderly; Those from small/rural community water systems	Possible	**
Regulations	Increase	N/A	Increase	Increase	Neutral to Beneficial	Most/All	Communities with water reuse	Likely	**

Note: See Legend, Figure 2, page 7.

† = Relates to communities with lower water security. The health impact would not be applicable to communities who are water secure, because they will have access to other water resources.

^ = As of December 2016, research does not indicate that there have been any outbreaks of illness connected to direct potable or other types of reuse. However, concerns remain about the potential risks of human error or system breakdown and associated impacts on health given the source and end use of the reused water.

§ = Non-potable reuse is: "All water reuse applications that do not involve potable reuse, including the use of water for car washing, irrigation, industrial cooling, etc."

Δ = Indirect potable reuse is: "Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes drinking water treatment."

= Direct potable reuse is: "The introduction of reclaimed water directly into a drinking water treatment plant, either co-located or remote from the advanced wastewater treatment system."

†† = Despite a perception that reused water quality is lower than that of the current/traditional municipal water supply, acceptability may vary by type of reuse. Non-potable reuse may have highest acceptability, whereas direct potable reuse has the lowest acceptability.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure 2. Legend: Health Impacts for Kansas

CRITERIA	DESCRIPTION
Direction – Projects the direction of change based on the proposed rule.	Increase – Literature (data) achieves consensus that this indicator might increase. Decrease – Literature (data) achieves consensus that this indicator might decrease. Mixed – Literature (data) lacks consensus about this indicator’s potential direction. No effect – Literature (data) suggests that this indicator might remain unchanged.
Expected Health Impact – Indicates whether the health impact is beneficial or adverse.	Beneficial – Change may improve health. Adverse – Change may impair health. Uncertain – Unknown how health may be impacted. Mixed – Change may be positive as well as negative. None – No identified effect on health.
Magnitude – Indicates how widely the health effects would be spread within a population or across a geographical area.	Few – Few or very few people, such as specific individuals or households. Some – Less than half of the population of a given community. Many – More than half of the population of a given community. Most/All – Nearly the entire community or regional impact.
Distribution – Describes the population most likely to be affected by changes in the health factor or outcome.	The populations that are projected to be impacted.
Likelihood – The chance that a given exposure will occur.	Likely – There is a high chance that impacts will occur as a result of municipal water reuse. Possible – There is some chance that impacts will occur as a result of municipal water reuse. Unlikely – There is a low chance that impacts will occur as a result of municipal water reuse. Uncertain – It is unclear if impacts will occur as a result of municipal water reuse.
Quality of Evidence – The strength of the quality of evidence (literature only) to support the judgements made when characterizing the impacts.	**** – Strong literature. ** – Sufficient literature. N/A – Quality of evidence wasn't separately assessed for this health factor/ outcome.

Source: KHI Municipal Water Reuse HIA, 2017.

The HIA Process

The National Research Council defines the HIA process in six main steps:

1. **Screening:** Identify upcoming policy decisions and determine the value and purpose of HIA.
2. **Scoping:** Identify potential health indicators and research methods.
3. **Assessment:** Analyze identified potential health impacts.
4. **Recommendations:** Determine options to mitigate identified potential negative health impacts and maximize identified potential positive health impacts.
5. **Reporting:** Share findings with stakeholders, including decision-makers.
6. **Monitoring and Evaluation:** Monitor/evaluate actual future health impacts resulting from policy changes, and assess the HIA process, results and lessons learned.

To date, the KHI Municipal Water Reuse HIA has included the first five steps. A monitoring plan has been prepared for the purpose of tracking future impacts resulting from local and state water reuse projects. Its implementation, however, will depend on the future availability of resources. Due to time and resource constraints, a formal evaluation of the HIA process and outcomes was not completed for this project.

Step 1 — Screening

Screening determines whether an HIA is feasible, timely, and would add value to the decision-making process.

In 2015, the Kansas Health Foundation (KHF) released a grant opportunity called “Improving Health Through Access to and Consumption of Water.” The Kansas Health Institute (KHI) reviewed the Kansas Water Vision document to identify potential projects, plans or policies included in the Vision document that might be a good fit for an HIA. KHI conducted an environmental scan by reviewing legislative efforts and state-level plans, and had conversations with organizations involved

in developing the Water Vision to understand whether the identified issues would benefit from an HIA. The identified strategy, “Evaluate the sources and potential uses of lower-quality water,” was determined as a good fit for an HIA project due to the number, variety and size of potential health impacts.

The KHI Municipal Water Reuse HIA Project aimed to broaden the scope of current and future discussions beyond contamination of the water supply to include considerations such as financial impacts or impacts on community sustainability which could impact health. After additional meetings with the Kansas Department of Health and Environment (KDHE), Kansas Water Office (KWO) and Kansas Municipal Utilities (KMU), it was determined that the project would provide valuable information about the health risks and benefits of water reuse, as well as recommendations for moving forward.

Step 2 — Scoping

Scoping determines what issues will be studied, which populations will be included in the study, and the methods that will be used to conduct the HIA.

The potential areas of focus (health factors, such as financial impacts or community sustainability and health outcomes, such as chronic and infectious diseases) were identified in collaboration with key stakeholders, including individuals from municipal utilities, KDHE, KWO and KMU.

After an initial meeting with stakeholders, the KHI HIA Team developed and disseminated a scoping survey to the Full HIA Team and the Technical Advisory Panel to assist in prioritizing the key areas to be studied during the HIA. The survey questions asked respondents to provide their perspectives on the potential impacts—including health effects—of municipal water reuse. The results were reviewed with the Full HIA Team and the Technical Advisory Panel.

The KHI HIA Team used the survey results and feedback to inform the final scope of the study. Although the survey results were not representative of all sectors that may be impacted

by water reuse, they provided useful information that helped the KHI HIA Team identify the major issues related to the topic.

Based on the results of the survey and preliminary research, the KHI HIA Team identified several issues for further research, including water availability, community sustainability, water quality, community perception of water quality, costs of reuse, utility rates, and regulations. These issues, and their connections to health, are depicted in the project's pathway diagram. See *Figure 4*, page 20.

Step 3 — Assessment

The assessment step includes analysis of potential health impacts.

This study used multiple methods—including a review of relevant literature, interviews with stakeholders, and secondary data analysis—to identify and estimate potential health impacts of municipal water reuse.

Literature Review

The KHI HIA Team completed systematic and non-systematic literature reviews. In November 2016, a KHI researcher searched PubMed, ScienceDirect, and Google Scholar, limiting results to journal articles, dissertations, master's theses and research reports. Additional inclusion and exclusion criteria are discussed in *Appendix E*, page 88, and were used to review the titles and abstracts of 1,511 total hits.

Abstract and title review left 63 papers, which were read to identify their relevance to research questions. In addition, each article was deductively coded to identify the study location, data sources and timing of collection, study design, limitations, results and policy recommendations. An additional 27 articles were identified through non-systematic searches.

The study findings were reviewed and sorted into the following content areas: water availability and community sustainability, water quality, perception of water quality, consumption of beverages other than municipal water, costs and utility rates, and regulations.

In order to describe the quality of the articles included in the literature review, articles included in the review were scored based on whether they were published in peer-reviewed journals, their funding source, and analytic methods using 12 criteria developed by the KHI HIA Team (see *Appendix E*, page 88). Scores allocated each article into one of three categories based on its quality score (poor, good and excellent).

The KHI HIA Team determined the strength of evidence for each HIA content area based on the scores of the articles included in it. The strength of evidence was then summarized using a system that awarded a star for each of the following criteria:

1. Five or more articles of any quality;
2. 10 or more articles of any quality;
3. 50 percent or more articles with good or better quality;
4. 75 percent or more articles with good or better quality; and
5. 50 percent or more articles with excellent quality.

A total of five stars were possible if the articles for the content area met each of the listed criteria. Using a sixth criteria, a star could be removed if less than 75 percent of articles lacked the same result (findings were inconsistent). For detailed information about the literature search protocol, see *Appendix E*, page 88.

Data Analysis

In order to examine the identified health impacts of water reuse, the KHI HIA Team used available secondary data to examine the current status of the issues and possible impacts. Secondary data analysis was based on data provided by federal, state, and local agencies, including per capita water use, water quality monitoring, and utility rates, among others. In order to assess the possible impacts of reuse on water availability, per-capita water use rates and municipal discharges were analyzed. To examine the distribution of a variety of components related to community sustainability, an index was developed using data from a variety

of sources (see *Appendix F*, page 92). To summarize current rates of compliance with water quality monitoring requirements, water quality reporting data was reviewed. To assess the possible impacts of changes in utility rates for certain population groups, utility rates, water usage and household income information were examined.

Additionally, the KHI HIA Team created maps to demonstrate the distribution of community sustainability indicators and sub-components as well as the distribution of the impacts of increases in utility rates. The maps were created using ArcGIS 10.2 mapping software and are based on several data sources. These maps show the counties where potential vulnerable populations may exist, and can be used to further assess aspects of community sustainability, or to consider means for mitigating any negative impacts due to utility rate increases. For detailed information about data sources and methods, see *Appendix F*, page 92.

Key-Informant Interviews

To provide a deeper understanding of issues surrounding water reuse in Kansas, the KHI HIA Team conducted key-informant interviews with selected stakeholders in Kansas and one of the states (Texas) that has widespread water reuse. The interviews provided additional context and background surrounding each topic, but were not used to develop the key findings.

The KHI HIA Team identified potential interviewees by reviewing public comments, contacting organizations that may have been knowledgeable or impacted by the issue, and through recommendations from stakeholders. Additionally, the KHI HIA Team used a respondent-driven sampling technique whereby interviewees suggested other knowledgeable individuals to interview. The key-informant questions were approved by the KDHE Institutional Review Board (IRB).

A total of 14 interviews were conducted. The interviewees came from a variety of sectors, including municipalities who had and had not implemented reuse, state-level task force, environmental groups, regulators, businesses and

others. Interviews were conducted via telephone and in person. Interviews were semi-structured with a standard set of questions asked of each stakeholder. Interviewees provided perspectives on areas studied in the HIA including water availability and community sustainability, water quality, perception of water quality, consumption of beverages other than municipal water, costs and utility rates, and regulations (see *Appendix G*, page 98, for the key-informant questionnaire).

In some cases, questions were modified slightly depending on applicability to the interviewee's organization and role, and unique follow-up questions were sometimes asked to provide clarity to responses or for additional information. Interviewees were also asked to provide suggestions for recommendations to decision-makers as reuse projects are implemented.

Interviews were voluntary and confidential. Interviewees were allowed to skip questions or sections of the interview. The interviews took an average of one hour to complete, but the length was dependent upon the extent of the answers given by each interviewee. Once complete, interviews were analyzed using inductive coding to identify common themes in interview responses.

Community Perception Surveys

To capture broader community perspectives regarding water reuse and water quality, two community surveys were implemented in cities with a history of water reuse: Hays and Garden City. The city of Hays started irrigating with reused water in the 1970's with a golf course. Today, approximately 24 percent of wastewater is treated and reused to irrigate 141 acres. Garden City has been working with community partners to encourage water reuse for agricultural and industrial purposes. Currently, the city has an arrangement with a local electric provider to reuse water.

In 2015, the city also committed to purchase treated wastewater from the Dairy Farmers of America milk drying plant that is under construction in Garden City. The treated water may be used to irrigate agricultural crops and city

parks, or for other non-potable uses that would offset the use of existing potable ground water supplies. To the knowledge of the KHI HIA Team, neither city has baseline data available about community perceptions of water reuse. The goal of the surveys was to supplement information collected through key-informant interviews and to provide information to decision-makers in these cities about the survey respondents' perceptions of water reuse. The surveys consisted of 19 questions in three sections:

1. Community household water and water consumption behavior;
2. Community experience and perspectives on the use of the recycled water; and
3. Demographics.

Both surveys were approved by the KDHE Institutional Review Board, and the Hays survey underwent additional review by the Fort Hays State University IRB prior to distribution to university staff.

The surveys used a convenience sample, meaning that the surveys were distributed to individuals who were close at-hand, and that all available subjects were invited to participate, rather than randomly selecting specific participants. The surveys were shared with representatives of each of the municipalities, and were then distributed to various community entities, including the city manager's office, city hall, local health department, hospital, library, and other community-based groups. These organizations were asked to share an anonymous survey link with residents and to distribute hard copies of the survey to community members for whom the internet is not easily accessible.

Paper surveys were returned to the designated local organization and were then scanned or mailed to KHI to be entered into the online survey tool. The Garden City staff translated the survey into Spanish and Somali to capture perspectives from individuals who were non-English speakers. The Garden City survey received 154 total responses, and the Hays survey received 248.

Municipal Utility Staff Survey

To capture perspectives regarding water reuse from individuals with direct experience in managing a public water supply or wastewater treatment plant, a separate survey was distributed to municipal utility superintendents and managers. The survey included four sections:

1. The organization's water reuse efforts;
2. Public perception regarding water reuse;
3. Recommendations for local and state agencies and elected officials; and
4. Demographics.

The survey was approved by the KDHE IRB. KHI worked with Kansas Municipal Utility (KMU) to distribute the survey.

The survey was sent to a total of 178 individuals, and 72 total responses were received, which was a 40 percent response rate.



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Step 4 — Recommendations

Recommendations are a way to suggest action that can enhance positive health effects and mitigate potential negative health effects related to the proposed plan, project or policy.

The recommendations for the KHI Municipal Water Reuse HIA came from two primary sources. Some came from policy recommendations made in the research articles of the literature review, while others were developed by the Full HIA Team and/or the Technical Advisory Panel based on their expert feedback.

The recommendations were prioritized based on the following criteria:

- **Feasibility** — *Is the recommendation practical given the political environment, and are the costs reasonable for implementation?*
- **Responsive to predicted impacts** — *Does the recommendation address the identified findings?*
- **Magnitude of impact** — *To what extent is implementation of this recommendation likely to produce a meaningful result?*

The full list of recommendations included 75 recommendations, 16 of which were prioritized by project stakeholders (see *Appendix C*, page 75).

Step 5 — Reporting

Reporting includes the distribution of findings to decision-makers and others involved with the HIA.

The HIA results are summarized in this report, which is designed primarily for municipalities and water utility personnel, as well as decision-makers at the state level. However, we anticipate that this report will be used by stakeholders from a variety of backgrounds. To ensure that readers of this report have a clear understanding of the terms used throughout, a glossary is included in *Appendix D* on page 83. The report findings and recommendations will be shared in a variety of ways (e.g., presentations at conferences, in-person discussions, on the KHI website, Kansas media outlets, and other printed materials) with members of relevant organizations and participants in the project.

Step 6 — Monitoring

The KHI HIA Team has developed a monitoring plan to measure the outcomes of decisions to reuse water and to track the potential effects on health and/or the determinants of health (e.g., community sustainability). The plan includes measures that could be tracked in communities where a decision to reuse water is made. Additionally, the plan suggests agencies and statewide methods for monitoring broader changes and suggests appropriate actions for state and local decision-makers to take to mitigate potential negative health effects (see *Appendix H*, page 116).

Limitations

Literature

Limitations were divided into two categories: those that related to the literature search and those of identified studies. Those related to the search included search engine algorithms, which may have missed relevant articles. Researchers attempted to address this by searching multiple engines. In terms of the search engines used, the algorithm used by Google Scholar is unknown, resulting in poor replicability. Despite these limitations, Google Scholar was selected because it is known to provide more results than other search engines, often from higher-ranked journals.

Searching Google Scholar is also considered acceptable for a systematic review as long as it is

not the only database used.³⁴ Another limitation to note is the potential for publication bias. Publication bias occurs because studies that result in limited or negative findings are less likely to be published in the peer-reviewed journals than studies with positive findings. Gray literature (not peer-reviewed) was included to help offset this bias. Literature was also only analyzed by one researcher, however, the literature review process was agreed upon by the project team and other KHI staff members.

Limitations also include those of identified studies. First, only a small number of articles were found for some topics, indicating little knowledge about these topics. In addition, replication studies are needed to confirm most studies' results. Research was often based on case studies, not generalizable, and unable to establish causality.

Data

This study uses population-level data to explore patterns and correlations between issues. Population-level observational studies (sometimes referred to as ecological studies) are useful for exploring patterns or generating hypotheses, but are limited in their ability to fully explore associations or prove causal relationships. Additionally, many measures included in this

analysis, (including per capita water use, utility rates, and measures of community sustainability) are likely to be influenced by many factors in addition to the presence or absence of water reuse projects.

Stakeholder Engagement

Community engagement is a core component of an HIA. While this HIA offered key stakeholders an opportunity to participate in the assessment process, some declined, and their knowledge and perspectives are, therefore, absent in the analysis. Perspectives from individuals who might be directly affected by water reuse were gathered through a convenience sample survey in two communities, but it is likely that there was some response bias and that some individuals in these communities may not have been adequately represented in this process. Additionally, the perspectives of the survey respondents in these two communities may not be representative of perspectives from all communities in Kansas or of those that are likely to reuse water. A more extensive, probability-based sample is required to make generalizable statements regarding Kansans' perspectives on water issues, including reuse.

Overview of Reuse

There are many different types of water reuse, and a variety of entities that can reuse water. Households, municipalities and industrial operations all have opportunities to engage in water reuse. At a household level, water reuse typically involves the reuse of graywater (water from sinks, showers or washing machines) or the collection of rainwater for watering lawns and landscaping, but usually does not involve additional treatment of the water. The Kansas Department of Health and Environment (KDHE) developed guidelines for household graywater reuse in 2014.⁵

Municipalities and industrial entities often reuse water on a larger scale, investing resources into treating wastewater to standards that are indicated by the intended use of the reused water. There are many examples of this type of reuse throughout the country, and interest is growing for water reuse in Kansas. However, there is no standard framework of guidelines or recommendations for municipal or industrial reuse in Kansas, rather, the guidelines are developed on a case-by-case basis.

This HIA focuses on water reuse at the municipal level, that is, treated municipal wastewater (also referred to as effluent) that is to be used for a beneficial purpose. There are four broad types of water reuse: indirect potable reuse, direct potable reuse, de facto potable reuse, and non-potable reuse. A municipality's reused water may be used by the municipality, sold to a local industry or business, or sold to municipal water customers. The terms "recycled water" and "reclaimed water" are used interchangeably with "reused water."

Non-potable water reuse is the most common form of planned reuse in the United States today, and is commonly used for the irrigation of public spaces and agriculture, or for industrial purposes.¹⁵ ¹⁶ It is common across several regions of the U.S., but is extensively used in California, Texas, Arizona and Florida.¹⁷ Direct and indirect potable water reuse occurs on a limited basis throughout the U.S. Its use is most common in the more arid regions of the country, such as the West, Southwest and some parts of the Southeastern U.S.

In Kansas, there are 118 wastewater treatment plants (WWTPs) with permits that allow water reuse.

Water Reuse Terms

Water Reuse: The process of converting wastewater into water that can be used for beneficial purposes. *The term water reuse is generally used synonymously with water reclamation and water recycling.*⁶

Graywater: Domestic wastewater composed of wash water from sinks (sometimes excluding kitchen sinks), showers or washing machines. Graywater does not include toilet wastewater.⁷

Treated wastewater (effluent): Sewage or other wastewater that is treated and discharged.⁸

Potable reuse: Planned augmentation of a drinking water supply with reclaimed water.⁹

Direct Potable Reuse (DPR): The introduction of wastewater that has been treated and purified to potable, or drinking water, standards into the traditional drinking water system.^{10 11}

Indirect Potable Reuse (IPR): Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer, such as an aquifer, reservoir

or wetlands, that precedes drinking water treatment.¹²

Non-potable Reuse: All water reuse applications that do not involve potable reuse, including the use of water for car washing, irrigation industrial cooling, etc.¹³

De Facto Reuse: A situation where reuse of treated wastewater is practiced but is not officially recognized or formally engineered (e.g., a drinking water supply intake located downstream from a wastewater treatment plant discharge point).¹⁴

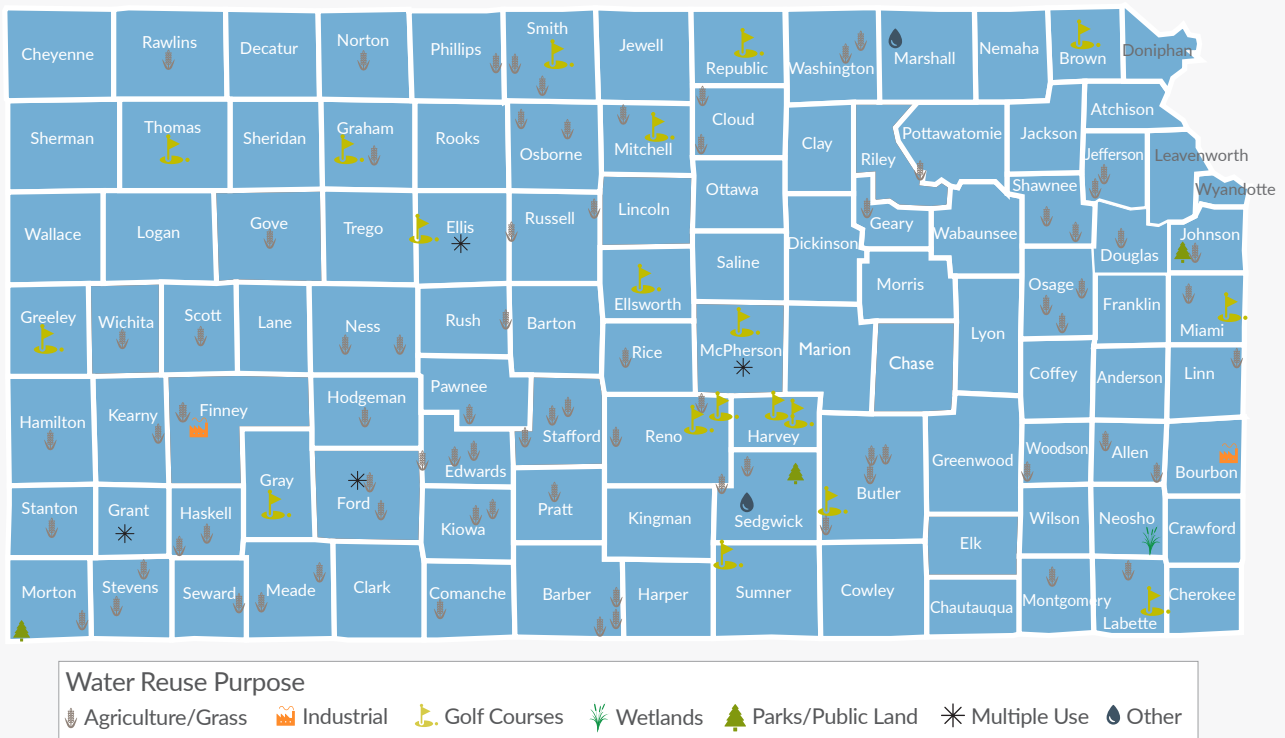
Figure 3 shows the locations of water reuse efforts in Kansas for which permits were issued. These are primarily for non-potable reuses such as irrigation of parks, golf courses and crops not for human consumption. There are additional examples of water reuse in Kansas that are not implemented by municipal WWTPs, such as industrial reuse facilities.

Currently in Kansas, there are no sites implementing direct potable reuse, however, during the drought of

“Effluent reuse for irrigation, for public amenities or for agricultural is the most common...because the regulations for that type of reuse are the lowest.”

– Kansas Municipality

Figure 3. Locations of Water Reuse Efforts in Kansas for Which Permits Were Issued



Source: KHI Municipal Water Reuse HIA, 2017.

the 1950s, Chanute, Kansas, implemented the first example of a direct potable reuse project in the U.S. Reuse was discontinued after rain replenished the surface water supply.

While there are no current examples of intentional potable water reuse, de facto reuse is likely to be occurring in Kansas. De facto reuse occurs as an upstream community releases their treated wastewater into rivers and reservoirs. Through the natural movement of water, it is then taken up by downstream communities into water treatment plants.¹⁸ De facto reuse is more common than any other type of potable reuse, but the exact extent

to which it occurs is not well understood.^{19 20} By some estimates, discharge from wastewater treatment plants may account for 82 to 121 percent of average river flows during times of drought or seasonal times of low flow.²¹ In Kansas, some communities have minimum discharge requirements for the purpose of maintaining stream flow to protect the environment and/or the water rights of downstream communities.²² In these cases, it is likely that de facto reuse is being practiced. As discharges from wastewater treatment plants grow with the population, and as the likelihood of drought and extreme weather events increase, the proportion of river flow attributable to discharge is expected to continue to grow.²³

Kansas State-Level Agencies Involved in Water Issues

In Kansas, there are several state agencies that play a role in the planning, coordination and regulation of water. The three primary agencies include the Kansas Department of Health and Environment (KDHE), the Kansas Department of Agriculture (KDA) and the Kansas Water Office (KWO). All three of these agencies have distinct roles and responsibilities related to water. Although KDHE and KDA have activities and responsibilities outside of water issues, water is an important part of their work.

KDHE's primary water-related role is the implementation of federal regulations including the Clean Water Act and the Safe Drinking Water Act, both of which are described below.²⁴ The role of KDA is the management of the Kansas Water Appropriation Act, including water rights and conservation.²⁵ The role of KWO is planning and coordination for a variety of water issues, including the Kansas Water Vision, described below. One other entity, the Kansas Water Authority (KWA), which consists of 13 voting members appointed by the governor or legislative leadership, makes recommendations to the governor, the Kansas Legislature and the director of the Kansas Water Office.

The Kansas Water Vision

In 2013, Kansas Governor Sam Brownback called on KWO and KDA to develop a long-term vision for water in Kansas, noting that, "Water is a finite resource and without further planning and action we will no longer be able to meet our state's current needs, let alone growth."²⁶ With leadership from KWO, KDA and KWA, the Vision was developed with input from stakeholders across Kansas.

The identified vision is that, "*Kansans act on a shared commitment to have the water resources necessary to support the state's social, economic and natural resource needs for current and future generations.*"²⁷ The vision document, entitled, *A Long-Term Vision for the Future of Water Supply in Kansas*, includes four primary themes, which

are: water conservation, water management, technology and crop varieties, and additional sources of supply. Within each theme, several strategies are identified which will advance progress toward the vision.

One of the strategies identified within the theme of additional sources of supply is to "evaluate the sources and potential uses of lower-quality water."²⁸ It is within this proposed strategy that municipal water reuse is likely to be considered. The Water Vision is an important policy document that provides an impetus for examining reuse in Kansas. In addition to this local context, there are existing federal regulations that may impact water reuse at the municipal level.

Federal Water Regulations

Clean Water Act

The federal Clean Water Act (CWA) was originally established by Congress in 1948 and was substantially reorganized and expanded to its current form in 1972.²⁹ The CWA is the law that regulates the quality of the nation's surface waters (i.e., rivers, lakes and streams) and is the basis of regulating discharges into surface waters from entities including wastewater treatment plants (WWTPs).³⁰ Each facility that discharges water into surface water must have a National Pollutant Discharge Elimination System (NPDES) permit.³¹

Compliance for NPDES permits is monitored largely by the states. In Kansas, KDHE is the entity responsible for overseeing implementation of the CWA, including monitoring NPDES compliance and developing the contaminant thresholds indicated in the permits.³² Kansas wastewater treatment plants that are currently involved in reuse have specific water quality and monitoring requirements included in their NPDES permits, which are set on a case-by-case basis by KDHE.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health through regulation of public drinking

water supply, including protecting sources of drinking water and treatment and distribution systems.³³ The SDWA regulates public water supply (PWS) systems, whose purpose is the provision of piped water for human consumption. This includes municipal (e.g., city) water supplies as well as rural water supplies. In Kansas, a PWS must have at least 10 service connections, or serve at least 25 individuals daily, at least 60 days of the year.³⁴ As of the end of 2015, there were 998 total public water supplies in Kansas.³⁵

The U.S. Environmental Protection Agency (EPA) sets tap water standards with the purpose of maintaining consistent quality in the nation's tap water supply.³⁶ The EPA currently regulates 88 primary contaminants in the National Primary Drinking Water Regulations (NPDWR).³⁷ The EPA defines a contaminant as: "any physical, chemical, biological or radiological substance or matter in water." The EPA also states that, "drinking water may reasonably be expected to contain at least small amounts of some contaminants. Some contaminants may be harmful if consumed at certain levels in drinking water, while others may be harmless. The presence of contaminants does not necessarily indicate that the water poses a health risk."³⁸

The EPA uses a several-step process to identify the standards for contaminants in the NPDWR. First, EPA identifies contaminants in the water supply that may adversely affect public health. It then identifies the level below which there is no expected adverse health effect. This is the Maximum Contaminant Level Goal (MCLG) (see sidebar for definitions). Considering available treatment technology and costs, a Maximum Contaminant Level (MCL) is set, which is the enforceable limit of a contaminant. If no evidence is available to suggest the correct level for an MCLG or an MCL, or if no technology is available to detect a contaminant, the EPA sets a treatment technique—or TT—which is a required method intended to remove the contaminants.³⁹ The EPA also provides Secondary Maximum Contaminant Levels for the 15 contaminants on the list of National Secondary Drinking Water Regulations. These are non-enforceable guidelines for contaminants in drinking water that do not pose

a risk to human health, but that may have cosmetic, aesthetic or technical implications.⁴⁰

The list of potential contaminants that are under exploration for inclusion in the NPDWR are called the Candidate Contaminant List (CCL). These contaminants are not subject to any current regulations, but may require future regulation under the SDWA.⁴¹ The CCLs may be contaminants of emerging concern (CEC). CECs include pharmaceuticals and personal care products that are increasingly being detected in surface water.⁴² These CECs may be an issue both for dischargers—wastewater treatment plants—and public water suppliers.

Definitions of Safe Drinking Water Act (SDWA) Standards⁴³

Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

Treatment Technique (TT): A required process intended to reduce the level of a contaminant in drinking water.

Maximum Residual Disinfectant Level Goal (MRDLG): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Maximum Residual Disinfectant Level (MRDL): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

Definitions of Safe Drinking Water Act (SDWA) Standards, continued

Candidate Contaminant List (CCL): The drinking water CCL is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, but are known or anticipated to occur in public water systems. Contaminants listed on the CCL may require future regulation under the SDWA. SDWA requires EPA to publish the CCL every five years.⁴⁴

Contaminant of Emerging Concern (CEC): Any synthetic or naturally occurring chemical or any microorganism that is not commonly

monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. In some cases, release of emerging chemical or microbial contaminants to the environment has likely occurred for a long time, but may not have been recognized until new detection methods were developed. In other cases, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants.⁴⁵



*Four states overlook in White Cloud, Kansas (Missouri, Nebraska and Iowa).
Copyrighted photo by Larry Schwarm*

Analysis of Health Impacts

The HIA's pathway diagram (*Figure 4*, page 20) provides the visual links between the proposal for water reuse and potential resulting health effects. The diagram illustrates direct impacts, upstream and downstream impacts and health outcomes. A direct impact is an immediate change that is likely to happen as a result of implementing a water reuse project. These can then lead to impacts that can be considered either more "upstream" or "downstream," depending on how directly they are linked to the ultimate health outcome.

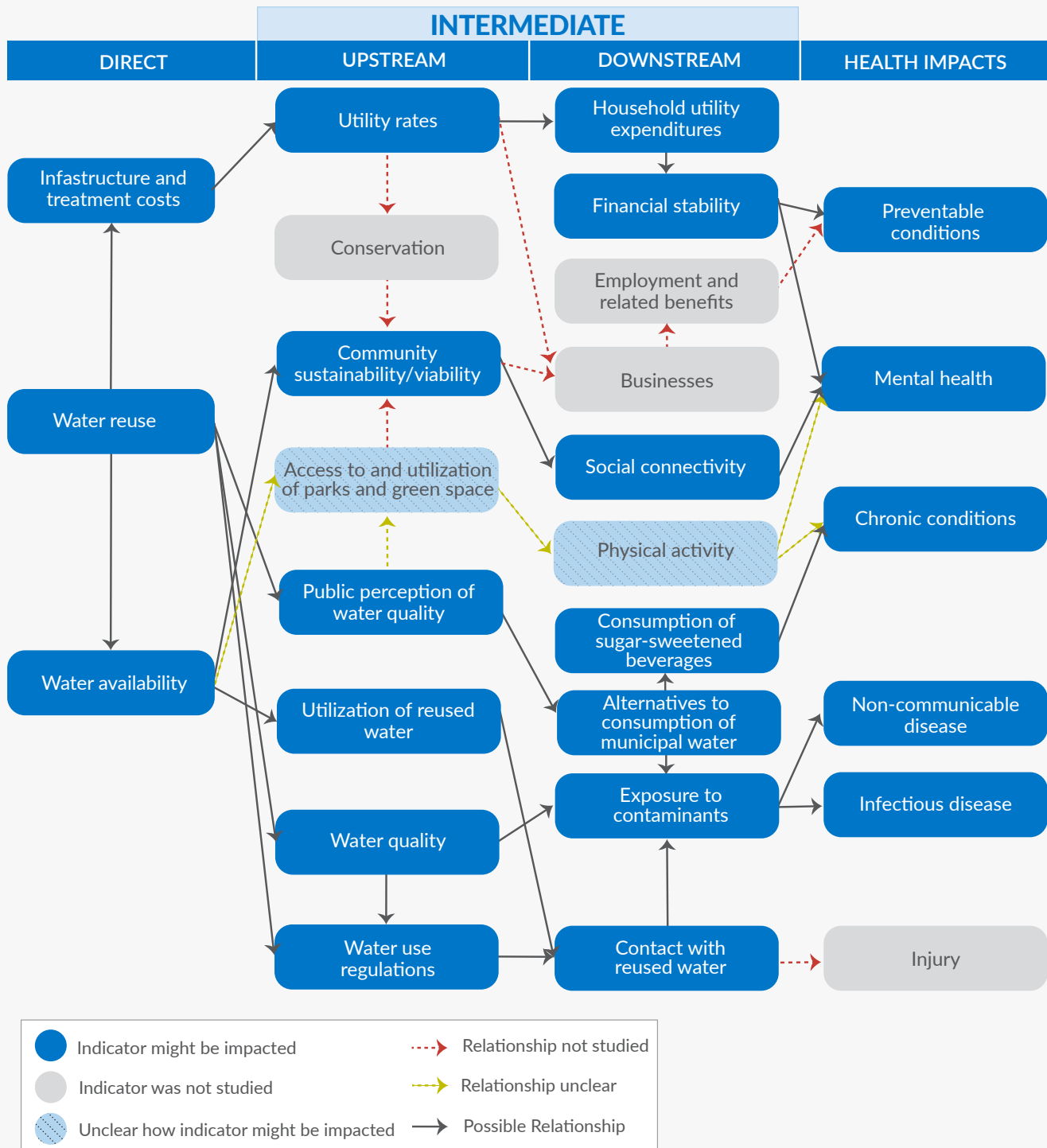
Upstream factors are likely to be further removed from health outcomes than downstream factors. It is important to note that water reuse could directly and indirectly impact areas beyond the ones described in the pathway diagram below. Additionally, the pathway diagram does not describe a specific direction of impact. For example, the treatment of effluent could lead to

an increase, decrease, or a maintenance of the current infrastructure and treatment costs. The research questions were designed to consider all possibilities in this regard.

The pathway diagram is used to develop research questions that examine the potential connections between the issues outlined in the diagram. The research questions are organized into issue-specific topics based on the direct and upstream impacts. The following sections describe the findings related to each of the issue areas, as well as the recommendations that have been developed in response to the findings. As a note, community perception of water quality did not have any health impacts, except through consumption of beverages other than municipal water. However, given the importance placed on the community's perception, as well as the plethora of information about that subject, the two topics are presented in separate sections.

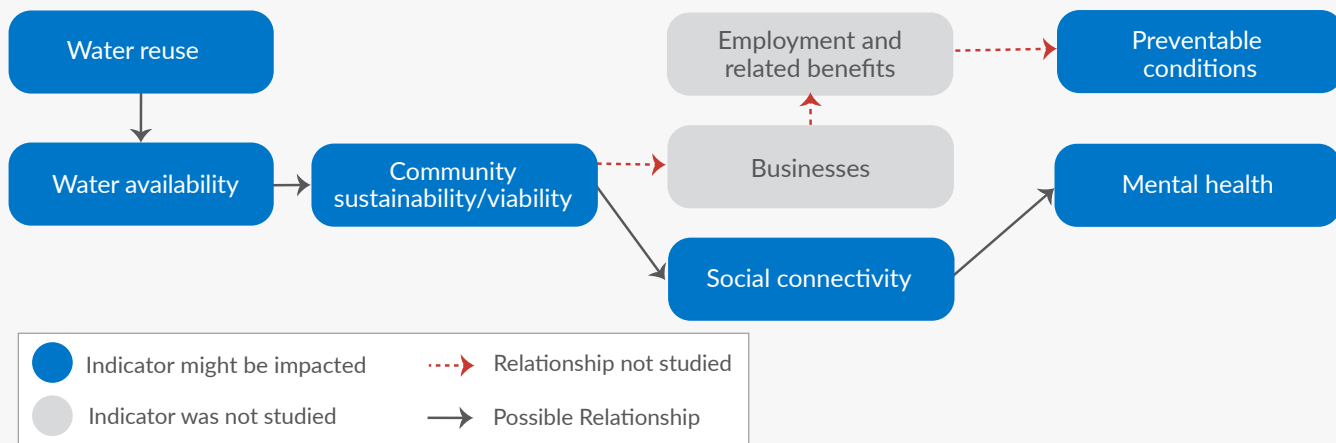


Figure 4. Pathway Diagram: How Municipal Water Reuse May Impact Health



Source: KHI Municipal Water Reuse HIA, 2017.

Figure 5. How Water Reuse May Affect Water Availability and Community Sustainability and Associated Health Impacts



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

Water Availability

- Implementation of water reuse has the potential to increase the water available for community use.
- Because reuse introduces a new source into the water portfolio of a community, it either increases or prevents a decrease in the amount of water available. However, the magnitude of the increase in water availability for municipal uses would depend on the scale and scope of water reuse projects, and is likely relatively small compared to overall water use.
- There are potential health benefits to an increase in water availability. Not only does an increase in the quantity of water impact the quality of that water, the availability of water may impact the long-term economic, social, and environmental sustainability of communities.

Community Sustainability

- Communities may experience an increase in long-term sustainability as a result of increases in water availability. Due to the small potential change in overall water availability due to reuse, the potential increase in community sustainability may be small.

RECOMMENDATIONS

Water Availability

Municipalities could consider:

- Creating long-term water plans.
- Collaborating with local, regional and state partners to manage water resources.
- Partnering with the Kansas Association for Conservation and Environmental Education (KACEE) to continue and expand the delivery of water festival curriculum to educate students about the sources and value of water, and to include water reuse in the curriculum.
- Partnering with engineering firms with expertise in reuse, and exploring reuse as part of water source development.
- Building awareness that water is a limited resource (e.g., incentivizing use of water-efficient technologies, media campaigns, educational activities).
- Utilizing water resources for public benefit, such as maintaining or enhancing parks and green spaces.
- Reviewing the top 10 water users (industrial, commercial customers that are using large quantities of water) and working with them to identify water needs and potential interest in reuse.

FINDINGS

- Water is essential for Kansas communities, and some may be at risk for extreme water scarcity which would make it difficult for communities to survive. There is documentation of the role of water scarcity in driving people from agricultural communities to urban centers.
- However, there are many components of community sustainability, of which, water availability is just one. There are social, economic, and environmental factors that contribute to the resilience of communities in the face of changes to water availability. Communities that are most resilient and sustainable are those that can draw upon strengths in the social, economic and environmental realms.
- An increase in community sustainability has been linked to individual and overall mental health.

RECOMMENDATIONS

- Characterizing available wastewater quantity and quality, and understanding regulations and the potential for reuse.
- Assessing the long-term availability of water for the community. Water reuse can be considered as a potential solution to water supply issues, along with other options. This decision should be made with considerations for social, environmental, political and economic feasibility.
- Reaching out to other communities that have conducted reuse and learning about their approach/experience.

Water utility managers could consider:

- Collaborating with community members, policymakers and scientists to develop workable solutions to water scarcity.
- Managing water reuse and water conservation in collaboration with other partners.

Researchers could consider:

- Quantifying the social, economic and environmental consequences of water reuse in areas of water scarcity in Kansas.
- Developing a locally tailored measure of water resource sustainability and groundwater stress.

Policymakers/legislators could consider:

- Encouraging water reuse as a strategy for additional supply through recommendations and/or financial incentives.

Community Sustainability

Municipalities could consider:

- Participating in processes for ongoing, long-term water planning.
- Developing robust processes for monitoring elements of community sustainability.
- Focusing on strengthening the social, economic, and environmental aspects of the community as part of an overall approach to resilience.

Note: See Appendix C, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background and Current Conditions

Water has been a driving force in the settlement choices of humans since the beginning of civilization. Humans have settled by water due to its necessity for the sustenance of human life, the maintenance of crops and livestock, and its role in transporting people and goods in the days before trains, planes and highways. Availability of water continues to be critically important for communities today.

The water sources that Kansans use are diverse, and the nature of the availability of water varies greatly between western and eastern Kansas. The availability of water is critical to the agriculture industry, which is key to the economy in Kansas, especially western Kansas. A strong economy and clean, reliable water sources are two of the components of a sustainable community.

Water Availability

In eastern Kansas, higher levels of precipitation (more than 40 inches per year in some places) and available surface water characterize relatively stable water resources.⁴⁶ Concerns about the amount of available water supply in eastern Kansas have focused on sedimentation of the reservoirs in the region and work is ongoing to restore the capacity of these reservoirs by dredging, streambank stabilization and other strategies.⁴⁷

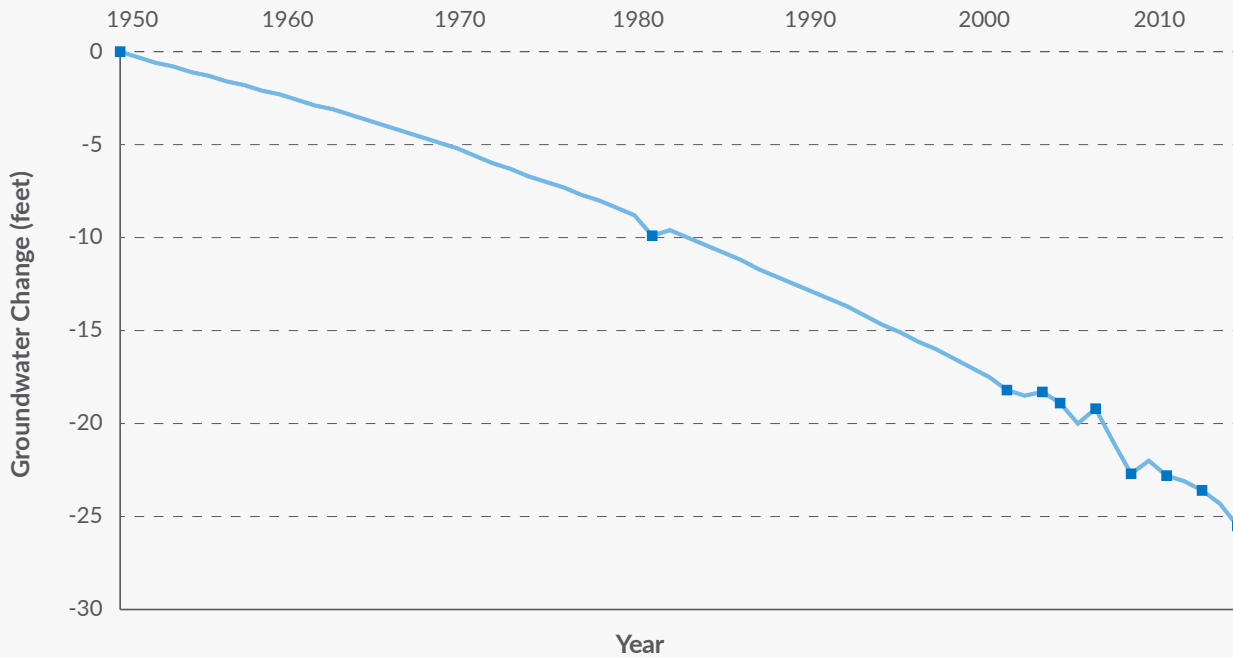
In western Kansas, precipitation and surface water are rare and scarce. Some portions of western Kansas receive, on average, fewer than 18 inches of rain per year, and surface water maps show few perennial streams.⁴⁸ The primary source of water supply is the High Plains or Ogallala aquifer, which underlies most of the region. To supply the abundant agricultural activity in

the region, groundwater is pumped from the aquifer. Due to its vast size, the aquifer at one time seemed to be limitless, and was treated like a limitless resource.⁴⁹ As a result, the aquifer has experienced dramatic declines in its water levels from the time that it was first developed as a water source until the present day.⁵⁰ Large-volume pumping in the area has led to declining water levels and there is a growing realization that current use of the aquifer is depleting it more quickly than it can recharge.⁵¹

In Kansas, the water level has declined an average of more than 25 feet since 1950, with higher declines in certain areas.⁵² *Figure 6*, page 24, shows the area-weighted water levels (in feet) for the High Plains aquifer in Kansas. Without changes to use patterns, groundwater use will soon outstrip the available supply. The Kansas Geological Survey (KGS) has estimated that in some parts of western Kansas, the available groundwater resources are effectively exhausted, and in others, less than 25 years of supply remain.⁵³ There are many variables that impact the amount of life left in the aquifer, however, communities with little groundwater left to draw from may need to look to alternate sources of water to supply their communities in the future.

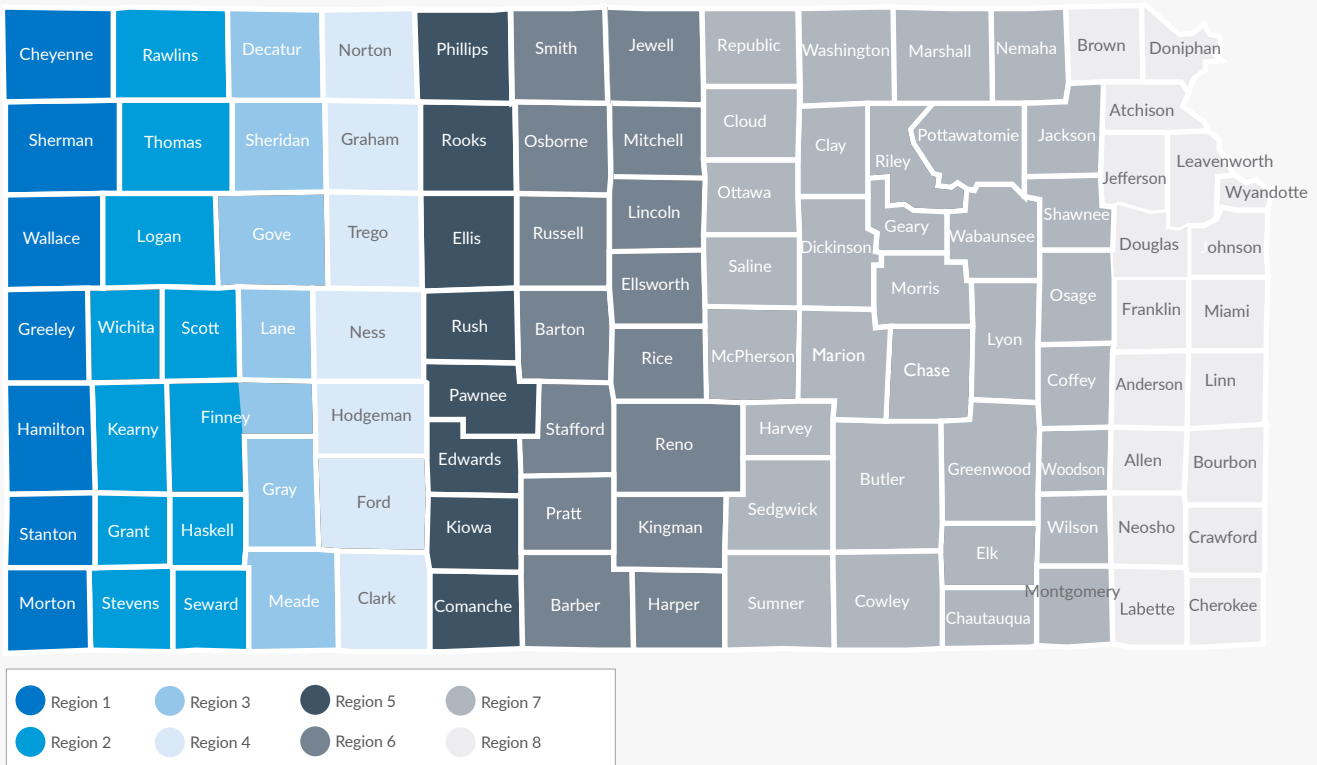
Despite the concerns about declining water resources in western Kansas, the area has a higher per-capita use of water among municipal suppliers than the eastern half of the state. Contributing to this are the dry conditions and little rain which lead to high evaporative demand and higher amounts of water needed for lawn watering and gardening.⁵⁴ An inverse relationship exists between annual rainfall and per capita water use, with water use decreasing and rainfall increasing from west to east. See *Figure 8* (page 25) for details on water use and precipitation by region (regions compiled by the Kansas Water Office, *Figure 7*, page 24).

Figure 6. High Plains (Ogallalla) Aquifer: Kansas Area-Weighted Changes, Pre-development (-1950) to 1980, 2000-2013



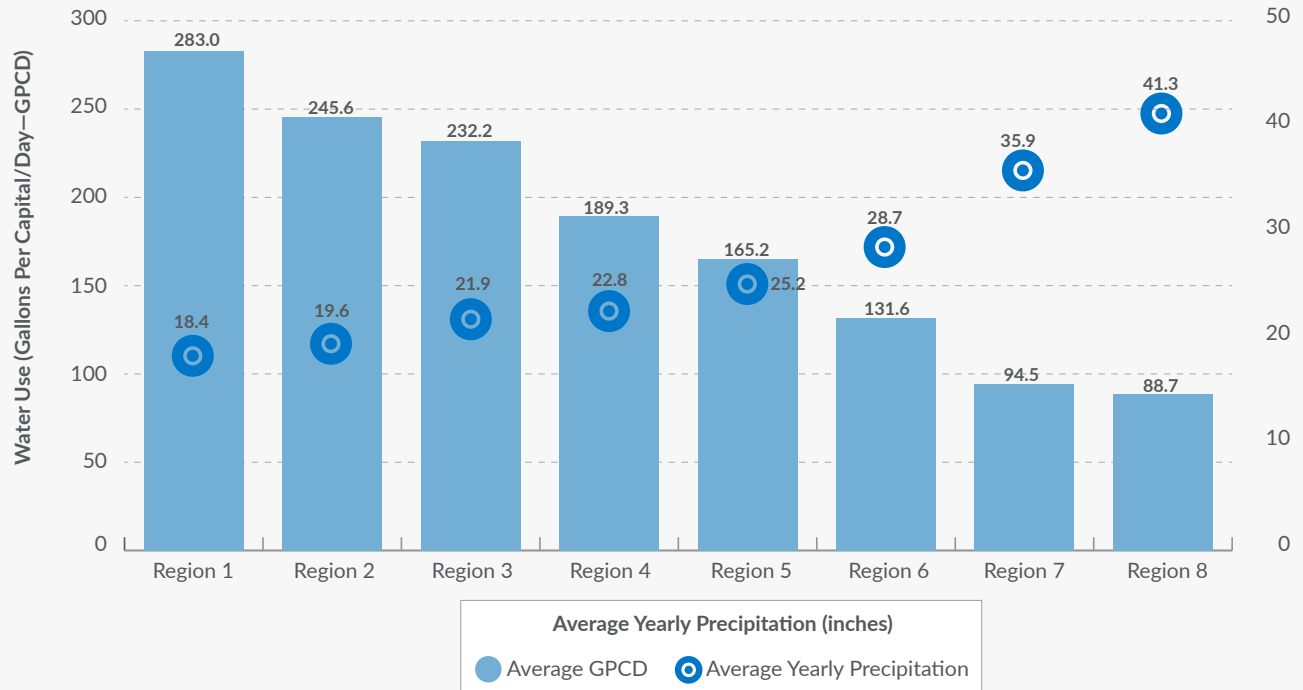
Source: U.S. Geological Survey, High Plains Aquifer Water-Level Monitoring Study, 2014.

Figure 7. Kansas Water Office Regions, 2012



Source: Kansas Water Office, 2012.

Figure 8. Relationship Between Average Water Use and Average Precipitation in Kansas, 2010-2014



Source: KHI analysis of data from the Kansas Water Office and the High Plains Regional Atlas, 2010-2014.

The data in the figure above only include water use for individuals served by a public water system, meaning that they exclude individuals who rely on private wells for household water (about 5 percent of Kansans) and privately owned irrigation wells.⁵⁵

Because the communities in western Kansas rely so heavily on agriculture as the primary industry, any threats to the availability of water to support agriculture could impact the very existence of these communities. Agricultural entities, particularly irrigators, have the biggest impact on water use, as more than 85 percent of the water used in Kansas is used for agriculture.⁵⁶ However, to ensure adequate supplies of water to the community, municipalities are working to understand and plan for future changes to water availability. Water reuse is one strategy that may be used to address water availability

issues, and water availability has been cited as a “major impetus” of a community’s decision to reuse water.⁵⁷

Community Sustainability

There are many components that contribute to the sustainability and resilience of communities. One way to understand the future sustainability of a community is to examine population trends. Many of the communities of western Kansas have been experiencing population declines for the past several decades. Between 2000 and 2014, the far-western Kansas regions 1, 2 and 3 saw population declines of 10.8 percent, 4.0 percent, and 7.9 percent, respectively. Between 2014 and 2024, they are expected to decline an additional 10.4, 5.5 and 11.6 percent (Figure 9, page 26).

Figure 9. Historical Population Trends and Population Predictions in Kansas, 1980–2064

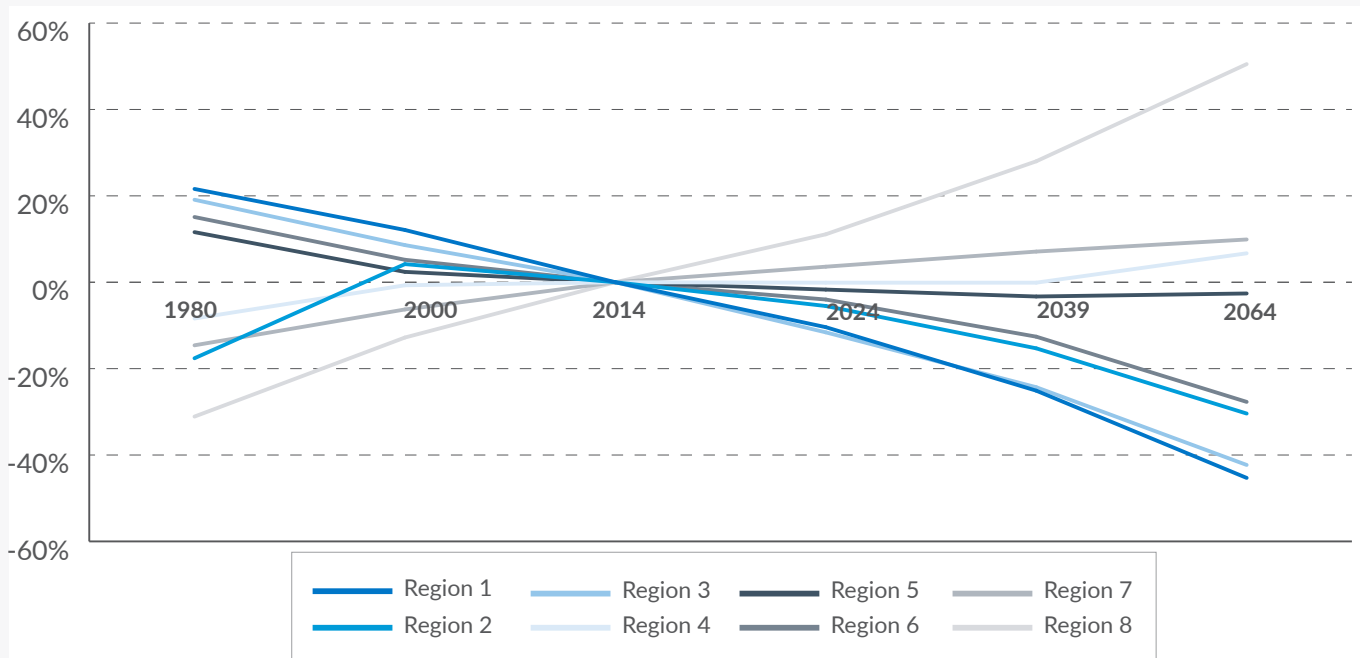
REGION	2000 (Actual Population)	PERCENT CHANGE 2000–2014	2014 (Actual Population)	2024 (Estimated Population)	PERCENT CHANGE 2014–2024
Region 1	21,780	-10.8%	19,434	17,406	-10.4%
Region 2	107,086	-4.0%	102,812	97,132	-5.5%
Region 3	22,043	-7.9%	20,300	17,935	-11.6%
Region 4	52,605	0.7%	52,988	52,932	-0.1%
Region 5	58,671	-2.3%	57,311	56,340	-1.7%
Region 6	175,892	-5.0%	167,121	160,416	-4.0%
Region 7	1,217,302	6.7%	1,299,056	1,345,413	3.6%
Region 8	1,033,445	14.7%	1,185,299	1,316,570	11.1%
Kansas	2,688,824	8.0%	2,904,321	3,064,144.398	5.5%

Source: Wichita State Center for Economics and Business Development Research, 2016.

In 50 years, by 2064, Regions 1-3 and 6 are expected to have population declines of more than 25 percent compared to 2014 levels (Figure 10).

Though there is some level of uncertainty in predicting population trends, the availability of water for business, recreation and home use may play a role in the sustainability of these Kansas

Figure 10. Population Trends 1980–2014 and Projections 2014–2064 in Kansas



Source: U.S. Census Bureau, 2016, and Wichita State Center for Economics and Business Development Research, 2016.

communities, and research suggests that water scarcity may contribute to migration away from rural areas.⁵⁸

What We Learned from Literature

The implementation of water reuse projects has the potential to increase the water available for a community to use. Water reuse is often implemented in response to the decreasing availability of a community or water system's historic water supply.⁵⁹ It is difficult to quantify the amount of water made available to communities through reuse because each water reuse project has its own impetus, design and capacity. However, water reuse does appear to preserve existing sources of water and can support some of the demand, reducing stress on freshwater sources.⁶⁰

Many water resource professionals believe that reused water is an important and underutilized component of a sustainable water resource management portfolio.⁶¹ Water reuse has also been called the “most significant of demand management strategies,” due to its ability to reduce withdrawals from traditional water sources.⁶² There is additional uncertainty on the impact of climate changes on infrastructure, water availability and water quality.⁶³ Movement to include reused water in the municipal water supply may provide additional security in the form of a diversified water source portfolio.⁶⁴

In the U.S., there are areas that are experiencing growth in water demand that is outpacing water availability. Researchers estimate that in 2025, 2.4 billion people will live under high water stress conditions worldwide.⁶⁵ Regionally, in the U.S., areas experiencing water stress are found in California, Texas, and portions of the Midwest, Southeast and Mid-Atlantic.⁶⁶ There are also predictions that the Great Plains region is likely to experience increased drought by the end of the twenty-first century.⁶⁷

Rural areas experiencing this increasing demand, without a sizable tax base to respond with infrastructure investment, are at increased risk of reaching a point where there is not enough water to meet both agricultural and domestic water demands.^{68,69} This can result in population decline in these areas. There is documentation of the role

of water scarcity in driving people from historically agricultural regions and lifestyles to urban centers, which can have consequences for social disruption and the breakdown of traditional institutions and coping mechanisms.^{70,71}

A change in water availability has socioeconomic, cultural, and environmental consequences, and there are community and population characteristics that are indicative of greater vulnerability and resilience to water scarcity.^{72,73} Resilience can be defined as an attribute that characterizes a system's ability to cope with stress, and is determined by physical and ecological features as well as social systems through which resources are regulated and perceived.^{74,75}

Water-resilient communities have several common characteristics, which include social, economic and preparedness factors.⁷⁶ Social factors include social connectivity within the community and the diversity of social contact beyond the community.⁷⁷ Further, greater amounts of social capital or trust can influence the ability of a community to come together and work collectively.⁷⁸ Community member characteristics can also be a predictor of resilience. Communities with members that are described as leaders or “initiators” show a greater ability to respond to water scarcity, perhaps due to their ability to learn, network and respond quickly.^{79,80}

Economics play a part in the ability of communities to finance solutions, therefore, wealthy communities may be more resilient to water scarcity.⁸¹ The way in which water is valued in a community can also be indicative of resilience. For example, if water is only valued in terms of its utility, rather than through a more diverse set of values, such as cultural identity, the community is less likely to be proactive rather than reactive regarding water security.⁸² Finally, the presence of a water or a drought plan, as well as the ability to monitor droughts, the development of indices and participation in regional or state water planning can be indicative of a community's preparedness for responding to a water crisis.^{83,84}

The determinants of health such as education, health care and infrastructure can also play a part in both vulnerability and resilience, which emphasizes the importance of taking a broad approach when responding preemptively to water scarcity.⁸⁵

The effects of decreased water availability are not experienced equally. Certain groups of individuals within a given community may be disproportionately impacted by decreased water availability, and certain communities will likely experience the effects of water scarcity more acutely than others. Within a community, those most likely to experience the effects of water scarcity are those that are currently vulnerable, including the very young and old, outdoor laborers, pregnant women, those who are socially and physically isolated, and those living in poverty.^{86,87} Those without the resources or diversity of skill to migrate to more water-prosperous regions may be trapped in vulnerable areas.⁸⁸

Communities that may be more vulnerable to the effects of water scarcity vary by region, livelihood and resources.^{89,90,91} Low-income communities may be less capable of adapting to the challenges presented by lower water availability due to lack of resources for investing in infrastructure, or institutions to manage or mobilize these types of resources.^{92,93} Rural communities may also be more vulnerable to water scarcity due to the extent to which their economies are tied to water-intensive agriculture and the limited tax base available to generate funds for investing in new or improved water sources.⁹⁴

Researchers have linked non-potable water reuse with the health benefits of protection against water scarcity.⁹⁵ Changes in water availability may create conflict and result in stress experienced by community members. One author found that abnormally high and low levels of rainfall, both of which interrupt normal agricultural practices, are a predictor of social or interpersonal conflict.⁹⁶ Disruption of the necessary resources to continue an agricultural business may influence a decision to abandon farming and move to a more urban area, which can lead to the disruption of historic social or cultural norms, and can increase social tension and stress.^{97,98}

The literature also introduces the concept of “place,” and defines it as a sense of human relationship with an environment.⁹⁹ A disruption of this sense of place may have consequences for individual mental health and community health.^{100,101}

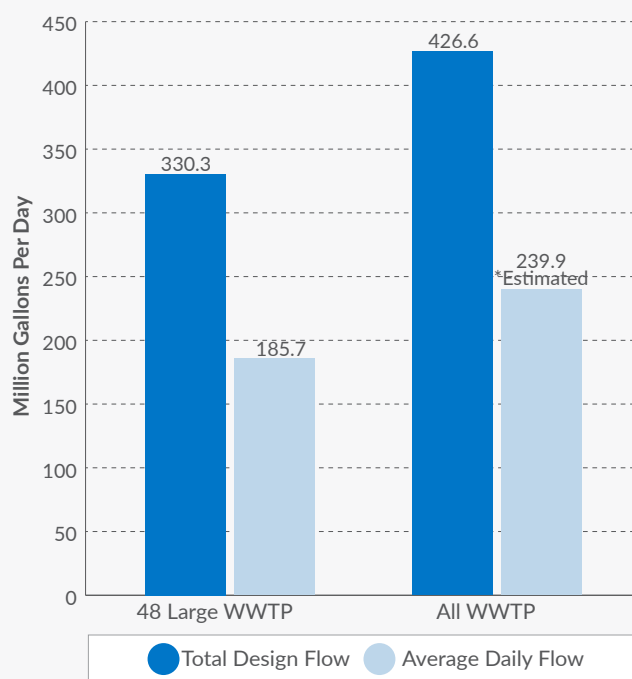
What We Learned from Data

Reuse and Availability

In Kansas, there are currently 118 permits, issued by the Kansas Department of Health and Environment (KDHE), that allow wastewater treatment plants (WWTPs) to reuse effluent for beneficial purposes. The primary use of the wastewater is for irrigation of agricultural crops or grass, and/or golf courses, parks and public lands. The total discharge capacity of these permits is 51.7 million gallons per day (MGD). Most of these WWTPs, however, are seasonal or infrequent dischargers, and the actual amount of water reused is not known.

For 48 of the largest WWTPs in Kansas, the design flow is 330.3 MGD and the actual average daily discharge is 185.7 MGD, which is approximately 56 percent of the total design flow. For all Kansas WWTPs with design flow information available, the total capacity is 426.6 MGD. Using the assumption that all Kansas WWTPs discharge at a similar

Figure 11. Design Flow Capacity and Average Daily Flow for Kansas Wastewater Treatment Plants (WWTPs), 2016



Source: KHI analysis of data from KDHE, Bureau of Water, 2016.

proportion of capacity, it can be estimated that the total average daily discharge for all WWTPs with available design flow is 239.9 MGD (Figure 11, page 28).

In 2014, the total municipal water use in Kansas was 373.2 MGD.¹⁰² Comparing the total estimated daily flows from wastewater treatment plants to the total amount of water used by the public water suppliers in Kansas, treated effluent could represent up to approximately 64 percent of municipal water use.

However, it is important to put municipal water reuse into context: only 10 percent of water used in Kansas is for municipal purposes, therefore, municipal water reuse may be only a small part of an overall strategy to ensure water availability for a community or region.

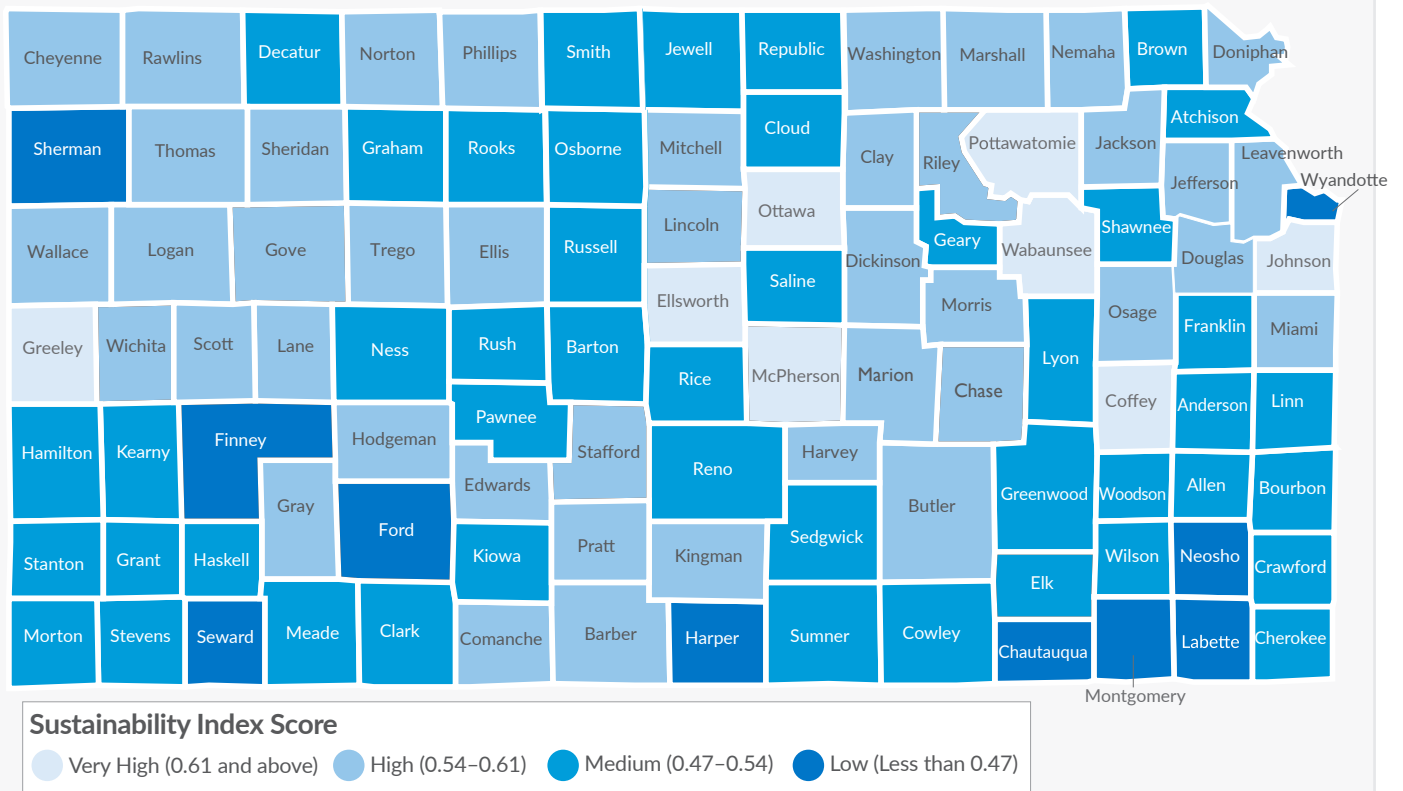
Despite the limitations, this estimation provides an approximate idea of the potential volume of new

water supply that could be provided by treating and reusing municipal wastewater.

Community Sustainability

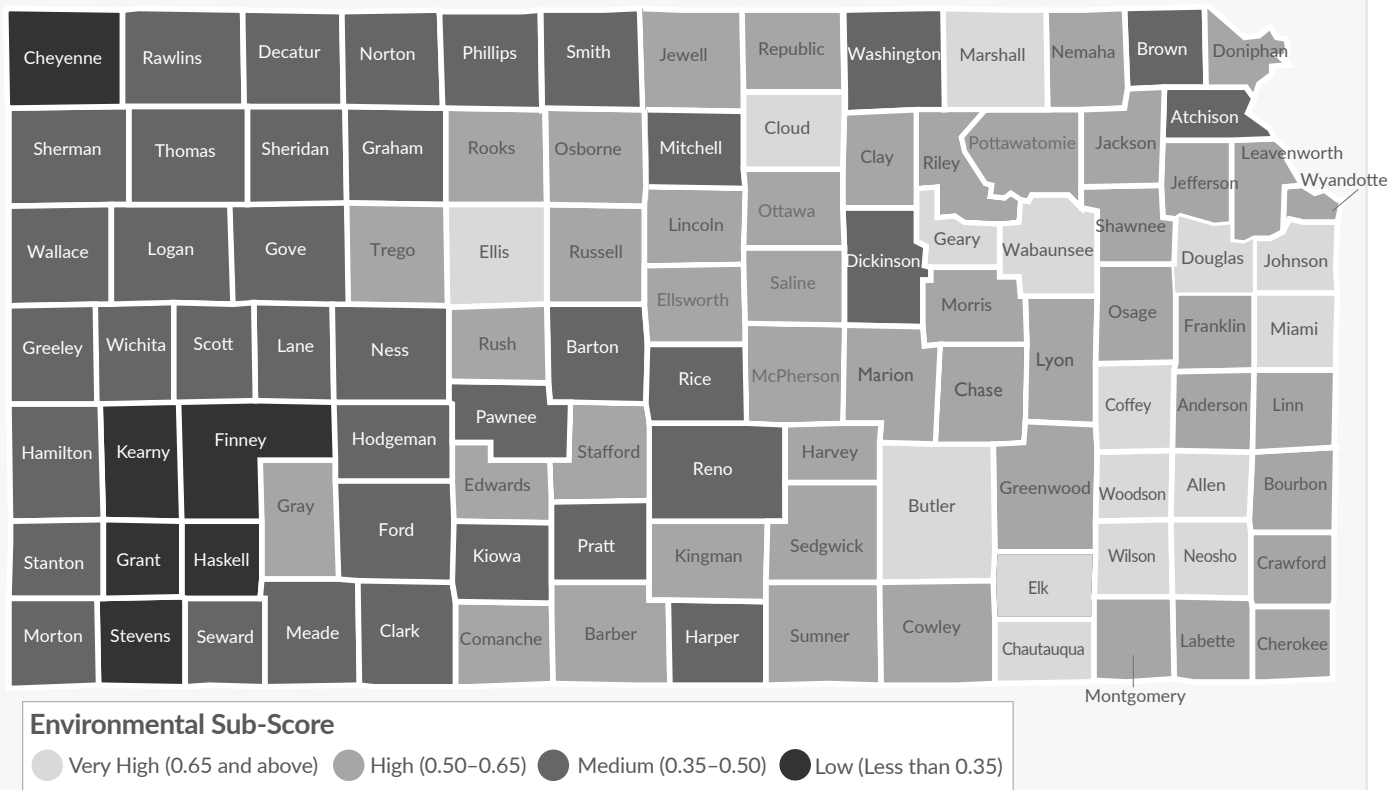
Based on the literature’s findings that community sustainability has social, economic and environmental components, a community sustainability index was created to understand these elements of community sustainability in Kansas.^{103 104} The index was based on national and international indices of community sustainability and sustainable development, but was tailored to information available at a county level in Kansas, and specific to the topic of water. Appendix F, page 92, has a list of indicators and methods used to create this index. Higher scores indicate greater resilience or community sustainability. The index was divided into three sub-scores: environmental, economic, and social. Because this HIA is focused on water issues, the environmental aspects of

Figure 12. Community Sustainability Index in Kansas



Source: Multiple sources. See Figure F-1, page 93.

Figure 13. Community Sustainability Index, Environmental Sub-Score



Source: Multiple sources. See Figure F-1, page 93.

community sustainability are of particular interest. The environmental sub-index includes measures of water use, precipitation, drought, water stress and water quality. Figures 12 (page 29) and 13 illustrate the overall community sustainability index and the environmental sub-score.

These indices can be used by communities and decision-makers who are committed to examining the components of community sustainability and understanding their strengths and areas for improvement. Efforts to plan for resilience may be informed by this understanding.

What We Learned from Stakeholders

The interviewees agreed that the amount of water available is a key driver for water reuse efforts. The increasing concern with water availability can also move a community from non-potable to direct

potable reuse. However, several interviewees noted that not all communities have a clear picture about how much water is available to them from different sources. They felt that this was particularly true for communities that rely on groundwater. To address this issue, interviewees suggested conducting regular assessments of water sources. Interviewees also recommended informing community members about water

“Reduced water availability will slow the economy down...and at some point, the community will go away or be significantly smaller than it is now.”

—Key Informant

“Increased access or increased supply to drinking water is one of the critical issues to having a community that is sustainable.”

—Key Informant

availability issues through community outreach and education.

In a survey of water utility superintendents and managers, the most frequently selected factor leading to the decision to implement a reuse project in the community was a commitment to conservation. Of 11 respondents who indicated having a current reuse project, six selected conservation as one of the primary drivers.

The majority of the interviewees agreed that water reuse projects would increase the amount of water available to Kansas communities as they will provide a new source of water as well as supplement the existing sources. However, the magnitude of this increase would depend on the scale and scope of the reuse projects. Participants also mentioned that communities that reuse water may experience benefits, while communities located downstream might have access to less water. To address this issue, interviewees suggested strengthening regional collaboration and exploring the feasibility of creating comprehensive regional water plans or systems.

All participants agreed that water is essential for Kansas communities. They noted that some communities might run out of water in the future, and that a lack of water would make it difficult for communities to survive. Areas that might be dramatically affected include agriculture—especially crops that require irrigation—and businesses that use water to sustain their operations.

Furthermore, the interviewees noted that the decline of these businesses due to water scarcity may result in loss of Kansas residents to other states. In addition, several interviewees suggested that out-of-state businesses are less likely to locate

in Kansas communities if water is not available to adequately support their operations. This could have a dramatic impact on jobs and communities' livelihoods. As one interviewee said, “There won't be jobs, and without jobs people won't be staying here.”

Conclusion

Based on available literature and data, implementation of water reuse has the potential to increase the water available for community use (Figure 14, page 32). The literature, data and stakeholder feedback all pointed toward an increase in water availability as a result of water reuse. Because reuse introduces a new source into the water portfolio of a community, it either increases or prevents a decrease in the amount of water available. However, the magnitude of the increase in water availability for municipal uses would depend on the scale and scope of water reuse projects, and should also be put into context of overall water use in Kansas.

Currently, municipal water use represents about 10 percent of water use, and is even lower in more water-scarce regions of the state. Therefore, municipal water reuse represents a relatively small potential increase in overall water available for a community.

Additionally, based on available literature and data, communities may experience an increase in long-term sustainability due to increases in water availability. Because of the small potential change in overall water availability due to reuse, the potential increase in community sustainability may also be small. Literature, data and stakeholder feedback all pointed toward an increase in community sustainability as a result of an increase in water availability. The stakeholders agreed that water is essential for Kansas communities, and that some may be at risk for extreme water scarcity, which would make it difficult for those communities to survive.

Indeed, existing research documents the role of water scarcity in driving people from agricultural communities to urban centers. However, there are many components of

community sustainability, of which water availability is just one. There are social, economic and environmental factors that contribute to the resilience of communities in the face of changes to water availability. Communities that are most resilient and sustainable are those that can draw upon strengths in the social, economic and environmental realms. In Kansas, the presence or absence of these factors vary from community to community.

There are potential health benefits to increases in water availability and community sustainability. Not only can an increase in the quantity of water impact the quality of that water, the availability of water may impact the long-term economic, social and environmental sustainability of communities. Potential health impacts of increased community sustainability include reduced stress and interpersonal conflict, and improved individual and community mental health.

Figure 14. Impact of Water Reuse on Water Availability, Community Sustainability and Related Health Impacts

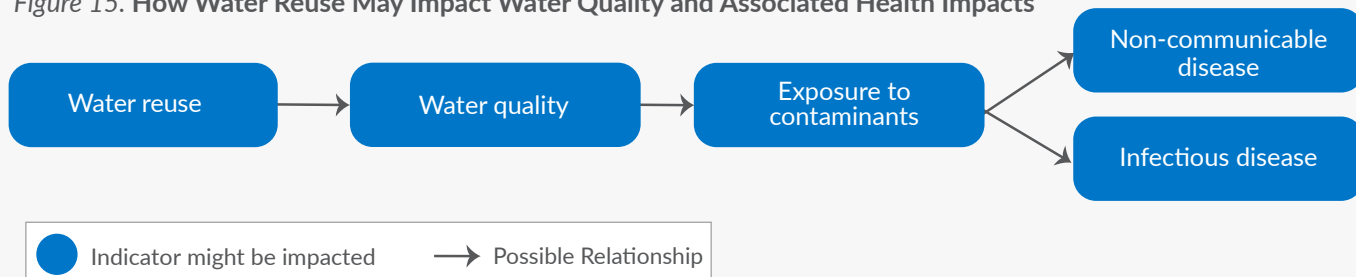
Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Water Availability [†]	Increase	Increase	Increase	Increase	Beneficial	Most/All	Communities with lower water security; Water-dependent industries or amenities	Possible	**
Community Sustainability [†]	Increase	Increase	Increase	Increase	Beneficial	Most/All	Those without the resources to relocate or seek services elsewhere	Possible	****

Note: See Legend, Appendix B, page 74.

† = Relates to communities with lower water security. The health impact would not be applicable to communities who are water secure, because they will have access to other water resources.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure 15. How Water Reuse May Impact Water Quality and Associated Health Impacts



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

- Water quality may increase, decrease or stay the same compared to current drinking water quality. The direction of change depends on the type of reuse that is implemented.
- With current technology, water can be treated to any quality required by the desired end-use within the boundaries of available funds.
- Reused water quality depends on the type of reuse. Non-potable reused water is treated to a lower standard and is therefore of lower quality overall. Water treated for indirect and direct potable purposes is highly treated and may be of equal or better quality than current drinking water.
- Potential risks associated with the reuse of water include contaminants of emerging concern, such as personal care products, pharmaceuticals and disinfectant byproducts.

RECOMMENDATIONS

Municipalities could consider:

- Reviewing water and wastewater treatment plans with regulatory agencies to ensure that they are appropriate for the intended use.
- Investing in professional development to maintain knowledge of the most current technology available for wastewater treatment and water reuse.
- Assuring sufficient operational monitoring and adherence to quality requirements for water and wastewater.
- Pilot testing/bench scale testing for reuse within the current framework to ensure expected quality is achieved.
- Developing local plans to test for different viruses or other contaminants that might be of concern in the water reuse project.

KDHE could consider:

- Establishing a task force to address contaminants of emerging concern in reuse and the traditional water supply on an ongoing basis.
- Establishing consistent requirements for signage to limit public contact with lower-quality, non-potable reused water.

Academic and research organizations could consider:

- Conducting and communicating research related to the quality of reused water.

FINDINGS

RECOMMENDATIONS

KDHE and municipalities could consider:

- Working together to identify and adhere to standards, processes and best practices for ensuring the quality of reused water.

Note: See Appendix C, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background and Current Conditions

In the late 1800s, scientists, doctors and municipalities began to realize that the practice of discharging wastewater into the same surface waters that were used for drinking water was causing illness in the population. John Snow's famous identification of the Broad Street Pump as a source of cholera transmission in London in 1854 was the beginning of common understanding that ingesting contaminated water could cause illness.¹⁰⁵

In 1885, the Kansas State Board of Health was formed, in large part due to concerns about drinking water quality.¹⁰⁶ In 1887, the Board recommended that the Topeka Water Treatment Plant be moved upstream from pollution sources or that much deeper wells be constructed, indicating that the cost of construction should not be a deterrent to this improvement since "the welfare of the water works company is not to be weighed against the public health, the lives of company is not to be weighed against the public health, the lives of our people, and their right to enjoy pure water."¹⁰⁷

In the years that followed, Dr. Samuel Crumbine, as the secretary of the Kansas State Board of Health, worked to pass the Kansas Water and Sewage Law in 1907, and later the first national standards for drinking water, the 1914 U.S. Public Health Service Drinking Water Standards.^{108 109}

Water standards such as these have been used to keep drinking water safe and to keep the harmful contaminants of wastewater away from the public water supply. The Clean Water Act (CWA) and Safe Drinking Water Act (SDWA), described on pages

16–17, are the laws that currently govern source water and drinking water quality in the United States.

As part of the SDWA, each public water system (PWS) is required to develop and share with the public an annual *Consumer Confidence Report* (CCR) outlining the sources and quality of the tap water provided to customers.¹¹⁰ Additionally, the state is required to prepare a summary report of the water system compliance within the state. Annual reports from the Kansas Department of Health and Environment (KDHE) are available on their website.

According to the 2015 SDWA annual compliance report, 111 (11.1 percent) of the 998 public water systems in Kansas incurred at least one health-based violation during the 2015 calendar year. The overall health-based compliance rate for public water systems was 88.9 percent. Additionally, 94.0 percent of the total population served by a public water system was served by one without a health-based violation.

For wastewater treatment plants that engage in reuse, National Pollutant Discharge Elimination System (NPDES) permits include maximum limits for coliform and chlorine residuals, which are set by KDHE. The wastewater treatment plants are required to monitor the quality of the reused water. However, monitoring data for these permits was not available at the time of this report.

What We Learned from Literature

With existing technology, wastewater can be treated to a quality beyond potable water

standards (Figure 16).^{111 112 113} Additionally, given frequent community reluctance to accept water reuse, reuse facilities often hold themselves to stricter quality standards and monitoring techniques.¹¹⁴ In 2007 and again in 2013, reviews of water reuse literature resulted in the conclusion that there has been no evidence of disease outbreaks or public health problems resulting from the use of reclaimed water in the U.S.¹¹⁵ Because clean and sustainable water sources are necessary for life, water quality concerns are often raised when using reclaimed water; however, in general, the reviewed literature suggests that the quality of reused water has not harmed human or environmental health.^{116 117 118}

Reuse has the potential to improve source water quality since fewer large, nutrient-rich, and potentially pollutant-laden wastewater deposits are put back into the freshwater sources.¹¹⁹ Additionally, because de facto reuse is often the status quo, engineered reuse can provide a higher quality, reliable and sustainable water supply to communities.¹²⁰ Some have concluded that the health risk of reusing water does not exceed the current risk when a water intake station is located downstream from a wastewater treatment outflow site.¹²¹

As communities conduct long-range water planning, some are anticipating that raw water quality will be degraded in the future by climate

change, including “increased temperatures, sediment, nutrient and pollutant loadings from heavy rainfall, coastal flooding, increased concentration of pollutants during droughts, and disruption of treatment facilities during floods.”¹²² In the face of these potential events, reuse could provide the water utilities with access to a water supply that is of a dependable quantity, and for which the quality is closely monitored and reliable.

Given the origin of reused water, there are often questions raised regarding the quality of water available through reuse.¹²³ Concerns include the cleanliness of the water after treatment processes and the potential for breakdown within the treatment system.¹²⁴ Common quality concerns include biochemical oxygen demand, total suspended solids, phosphorous, nitrogen, fecal coliform, chlorine residuals, heavy metals and pathogens.¹²⁵ Some cite viruses as a particular concern due to the difficulty in removing them from water by standard treatment processes, however, the same study tested reused water and did not detect any viruses that are known to be pathogenic to humans.¹²⁶

The research says that contaminant removal efficiency and type of contaminants found in water can vary from system to system, by treatment type, and even simply by time of

Figure 16. Water Quality and Levels of Treatment



Note: * Level of treatment depends on the reuse application. Treatment technologies are available to achieve any desired level of water quality.

Source: United States Environmental Protection Agency, *Water Quality Guidelines*, 2012.

sample due to the variation experienced in inflow loads.^{127 128} Additionally, even those who conclude that water can be treated to any required purity standard concede that there will always be residual contaminants in the reused water, though the extent to which those contaminants can have health impacts is not always clear.¹²⁹

Additional concern exists for contaminants of emerging concern, such as pharmaceuticals and personal care products. The risk of these contaminants to human health is not fully understood due to a frequent absence of information on appropriate concentrations and the expense and difficulty of both assessing their presence in water and removing it.¹³⁰

In some studies, water utility managers have cited “flawed or unevenly applied regulations and standards” as well as potential “liability over the unknown long-term health effects of chemical contaminants” as major challenges to water reuse.¹³¹ The long-term effect of exposures to this wide mixture of unregulated chemicals is unknown.¹³² Some are also concerned about the effect of the advanced water treatment itself due to the presence of disinfectant byproducts in water.¹³³

One such byproduct is N-nitrosodimethylamine (NDMA). Thought to be a human carcinogen, NDMA was found in the water that had been treated for groundwater recharge (i.e., indirect potable reuse) in Orange County, California, in the year 2000.¹³⁴ However, rather than serving as a warning to other communities considering reuse, the incident in Orange County is often held up as a best practice case study. The water quality monitoring mechanisms were able to identify the issue in a timely manner and steps were immediately taken to correct the issue before there was any effect on human health.

Non-potable reuse, because it is designed to be a lower-quality water, requires the installation of new infrastructure referred to as “purple pipe.” This purple pipe exists to move the lower-quality water from the treatment plant to the point-of-use. It is important for this water to be kept and transported separately from the traditional water distribution system, because

the purple pipe water is not treated to drinking water standards. Inadvertent consumption of the water from purple pipes could result in illness.¹³⁵ However, a review of literature associated with dual distribution systems noted that there have been no documented negative health effects as a result of non-potable reuse in the U.S.¹³⁶

A common objection to indirect potable reuse is that it is resource-intensive to treat water to high, or near potable standards and add it to bodies of water that are frequently dirtier, only for it to be redrawn and retreated. However, indirect potable reuse allows for a buffer period due to the time elapsed between treated wastewater’s discharge into the environment and its subsequent uptake for drinking water treatment.

This time lapse allows for additional monitoring and dilution of residual contaminants. Should a breakdown in the treatment system occur, the lag time allows for the issue to be addressed before detrimental health consequences are experienced.¹³⁷ Additionally, it has been found that risks to human health due to indirect potable reuse are equal to or less than those associated with many traditional water sources.¹³⁸

Direct potable reuse is often associated with greater risk because of the lack of travel time through the environmental buffer that occurs in indirect potable reuse.¹³⁹ However, studies that have examined the risk of direct potable reuse projects have determined that direct potable reuse projects may provide equal or better protection against contaminants than other water sources.¹⁴⁰

A water quality study of a direct potable reuse project in Wichita Falls, Texas, found that the reused water quality was, “in nearly every way superior to the raw surface water with which it is being blended.”¹⁴¹ The operations manager in Wichita Falls also noted that there had been no cases of illness associated with the city’s reuse of wastewater.¹⁴² However, the need for redundant processes to protect health in the event of a crisis remains.¹⁴³

What We Learned from Stakeholders

(Overall) “It will be as good or better at a minimum.” – Key Informant

The majority of interviewees thought that water treated for reuse would be the same quality or better than water they receive from more traditional sources. They suggested that with existing technology, any desired quality can be reached. Several individuals also noted that water quality will depend on the size of the investment. On the other hand, one interviewee said that the reused wastewater for non-potable purposes may not be “as good of a quality as the water we drink or the water we pull out of the ground.” This interviewee also suggested that more sophisticated treatment is required in order to treat it to the same or better quality.

When asked about the impact of non-potable reuse efforts on water quality, several thought that water quality will depend on its original source, treatment system and desired quality. In general, interviewees do not seem to have concerns about non-potable water quality. However, two participants noted that reused water might be high in nitrates and may also contain compounds that could accumulate in soil and plants.

(Non-potable) “I don’t think that non-potable reuse has any significant impact on the water utility.” – Key Informant

Opinions were mixed regarding the impact of indirect potable reuse efforts on water quality. Several interviewees suggested that water quality would depend on how it is treated and on the original source. Three out of 14 participants noted that the quality should be good. In particular, they suggested that the benefit would be realized through nutrient reduction and water treatment before it is injected into an aquifer or reservoir. On the other hand, three out of 14 interviewees were concerned about the presence of pathogens

and the potential to do something that could have negative impacts on an aquifer or other water body.

(Indirect potable) “The concern is that you don’t do something that will negatively impact the aquifer or resource that was not polluted prior to the introduction of the reused water.”

– Key Informant

Overall, interviewees said that the direct potable reuse efforts will have the same level of quality or higher and would increase availability of treated water. However, several individuals recognized cost implications of treating water to these high standards. Furthermore, one interviewee also noted that direct potable reuse might have a positive impact on groundwater quality as it would help to reduce demand.

(Direct potable) “If it is treated to the highest for direct potable reuse, there is no reason for there to be negative health effects.” – Key Informant

The majority of interviewees thought that reuse would not impact exposure to contaminants. Several stressed the importance of reliable treatment processes in eliminating any potential risks for contaminants. Availability of technology and funding were cited as two key “safeguards” for preventing any potential issues and reaching high quality of water. One stakeholder also discussed a lack of clarity regarding current practice of treating contaminants of emerging concern that might be present in water and the impact of this issue on reuse, while another stakeholder cited public perception of reuse as the biggest issue.

The interviewees offered several strategies that can be implemented to ensure that water quality remains adequate if reuse is initiated. For instance, they suggested conducting bench scale testing at the sites considering reuse, and developing ongoing local plans to test for different viruses

or other contaminants of emerging concern. Staying current with the industry trends, putting mechanisms in place and adhering to standards were referenced as essential foundation for ensuring adequate quality of water.

Conclusion

Based on the literature, water quality may increase, decrease, or stay the same compared to current drinking water quality. For non-potable reuse, the quality may be lower, and for direct and indirect potable reuse, the water quality could be the same or higher (*Figure 17, page 39*).

Literature and stakeholders both expressed that with current technology, water can be treated to any quality required by the desired end-use within the boundaries of available funds. Reused water can also serve as a source of water of known and consistent quality. However, the quality of reused water depends on the type of use.

In practice, non-potable reuse is usually of lower quality than current drinking water standards, but this is by design. This is likely a more appropriate match between quality and end-use. However, restrictions are necessary to limit public contact with the water while it is being used for irrigation or other purposes. Water reused for non-potable purposes may contain viral particles, bacteria, nitrates or other compounds that could accumulate in the environment.

Water reused for indirect potable purposes is usually treated to a quality higher than the water it is being discharged into. It is also treated

more than the current standards for effluent discharge into rivers, lakes and streams. The level of treatment of water prior to discharge may depend on a variety of factors including the length of travel time through the environmental buffer. Water reused for direct potable purposes is frequently treated to a standard greater than current drinking water regulations in order to alleviate any negative perceptions about the quality of reused water.

Potential risks associated with the reuse of water include contaminants of emerging concern, such as personal care products, pharmaceuticals and disinfectant byproducts. The detection and removal of these trace contaminants is expensive and difficult.

Because clean and sustainable water sources are necessary for life, water quality concerns are often raised when using reclaimed water; however, in general, the reviewed literature suggests that the quality of reused water has not harmed human or environmental health. Nevertheless, as with all water systems, the risk of system failure remains, and such an event could result in exposure to and potential illness from a number of wastewater contaminants including biochemical oxygen demand, total suspended solids, phosphorous, nitrogen, fecal coliform, heavy metals and pathogens. There is also uncertainty about the health consequences of contaminants of emerging concern. Risks should be assessed in the context of other risks associated with new and existing water sources and treatment types.

Figure 17. Impact of Water Reuse on Water Quality and Associated Health Impacts.

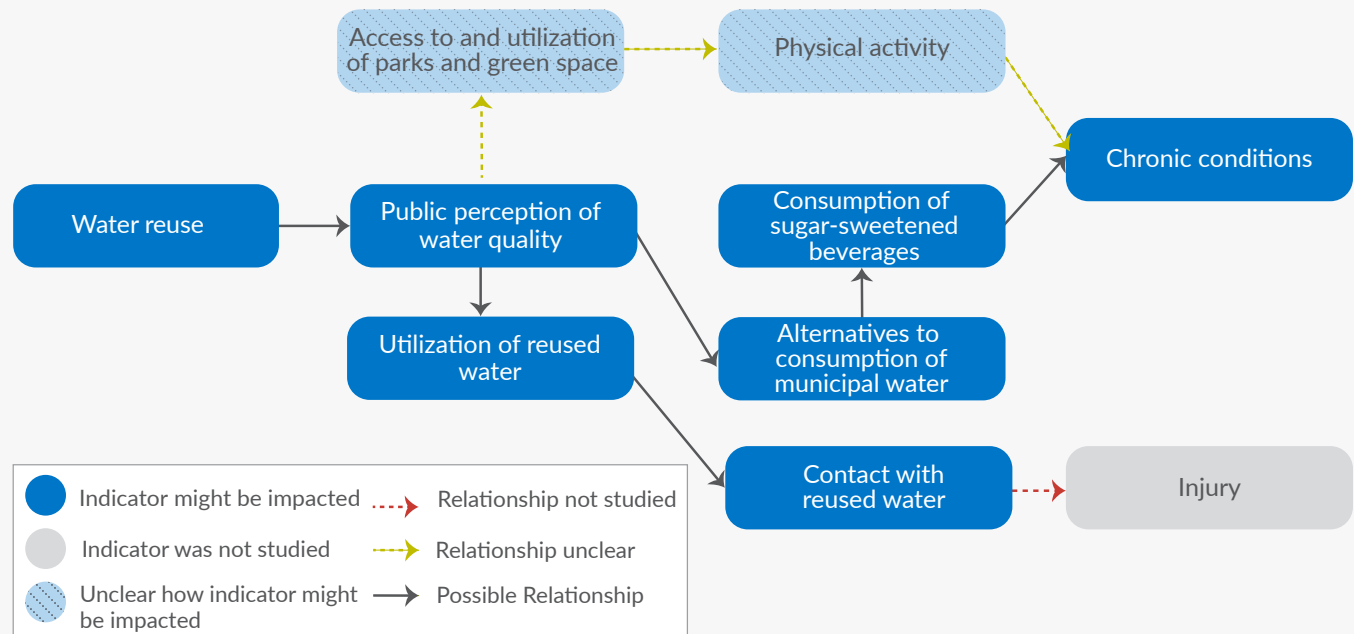
Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Water Quality	Mixed	N/A	No change/ Increase	Mixed	Neutral [^]	N/A	N/A	N/A	****
Non-potable	Decrease	N/A	No change	Decrease	Neutral to Adverse	Few	Individuals with a compromised immune system or other health-related issues	Unlikely	****
Indirect potable	Increase	N/A	Mixed	Increase	Neutral	N/A	N/A	N/A	N/A
Direct potable	No change/ Increase	N/A	No change/ Increase	No change/ Increase	Neutral [^]	N/A	N/A	N/A	N/A

Note: See Legend, Appendix B, page 74.

[^] = As of December 2016, research does not indicate that there have been any outbreaks of illness connected to direct potable or other types of reuse. However, concerns remain about the potential risks of human error or system breakdown and associated impacts on health given the source and end-use of the reused water.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure 18. How Water Reuse May Impact Perception of Reused Water Quality



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

- The community’s perception of reused water quality is lower than that of current drinking water.
- Reused water is typically perceived to be a lower-quality product by the community. There are several components of this perception, including the often cited “yuck” factor, which is an aversion to using formerly soiled water, as well as the public’s trust of the system’s ability to ensure health and safety.
- Regardless of actual water quality, the acceptability of water is lower as the potential for human contact with the water increases.
- A positive community response to water reuse may depend, in part, on how important the community perceives the project to be, as well as other various factors, including trust in local government and treatment technologies, reasonable costs, an emphasis on water conservation, environmental benefits, protecting health and recognition that water is a limited, valuable resource.

RECOMMENDATIONS

Kansas Municipalities could consider:

- Implementing targeted outreach and education campaigns about reuse, including information about the social and environmental costs and benefits, institutional structures, regulatory systems and alternate solutions.
- Seeking out and incorporating feedback from community members and leaders about reuse.
- Demonstrating the utility’s trustworthiness by maintaining compliance with the Safe Drinking Water Act standards.
- Developing emergency intervention and monitoring plans to capture and respond to any breakdowns in the treatment system.
- Framing potable reuse as recycling or an improvement over de facto reuse.
- Requiring public relations and communication training for water and wastewater utility managers.
- Developing vocabulary and imagery that lends positive connotation to reuse.

FINDINGS

- The primary health implications of a decrease in community perception of water quality were found in the switch from drinking tap water to bottled water or other sugary beverages (see the section on *Consumption of Beverages Other Than Municipal Water*, beginning on page 48).

RECOMMENDATIONS

- Providing information about current water quality and treatment mechanisms, more frequently than the annual *Consumer Confidence Report (CCR)*.
- Providing information about wastewater treatment quality, including seeking out independent laboratory verification of wastewater quality, and the sharing of annual financial audits.
- Educating and providing information to the city council about water supply and water reuse.
- Regularly educating the public about their water supply, water quantity, water quality and how water reuse projects can positively impact their city's environment.
- Taking steps to assess the community's perception of and acceptability towards various types of water reuse (e.g., community survey).

State agencies that are involved in water education could consider:

- Educating and communicating with the public about water reuse.

Note: See Appendix C, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background & Current Conditions

There is little current information available regarding Kansans' perceptions of their own drinking water and of water reuse issues. However, a 2007 survey conducted by university researchers from Kansas, Missouri, Iowa and Nebraska examined Kansans' perceptions of water issues.¹⁴⁴ A random sample of 215 Kansans were surveyed. The study found that 85.0 percent of those surveyed believed that their water was safe to drink, and 61.8 percent were satisfied with their drinking water.¹⁴⁵

All respondents (100 percent) felt that clean drinking water for residents was extremely or very important.¹⁴⁶ More than one-third of respondents

believed that it was the responsibility of local government to protect water quality, and another third indicated that it was the state's responsibility to do so.¹⁴⁷

Respondents rated their local government the highest when asked whether certain groups were fulfilling their responsibility to protect local waters. Over one-third (38.2 percent) of respondents thought local government was doing "very well," while other responsible parties—including the state and federal governments, individual citizens and the community—scored lower.¹⁴⁸ However, many respondents also indicated that they did not know whether each entity was meeting expectations.¹⁴⁹

Over half (58.1 percent) of the respondents to the survey indicated that they wanted to learn more about drinking water and human health, and that

their primary sources of information about water quality were from newspapers and television.¹⁵⁰

While the survey did not ask specifically about water reuse, it did ask questions related to conservation. Just under half of respondents felt that their local government did not put enough emphasis on environmental issues, and about a third wanted to know more about conservation.¹⁵¹

These survey results, while several years old, provide a basis for understanding communities' perceptions of water quality in Kansas. This information can serve as a baseline.

What We Learned from Literature

The public's perception of the quality, safety and acceptability of reused water has often been cited as a major hindrance to widespread water reuse.^{152 153} Addressing any negative perceptions is important for communities interested in reusing municipal wastewater, and there are examples of projects that have been suspended or abandoned due to public opposition.^{154 155}

In general, the public is concerned about potential risks associated with reused water. The public's concern has several components. There is a general distaste for connecting water to sewage, a perceived risk to public health, a potential for system failure, a concern about the chemical and biological composition of reused water, and interest in considering environmental implications of water reuse.^{156 157} In addition to these specific concerns, the magnitude of concern generally increases as the project moves from hypothetical to concrete, and as the proposed project brings reused water into closer contact with humans.^{158 159 160 161 162}

A positive community response to water reuse projects may be more likely if the community perceives the project to be promoting water conservation, providing environmental benefits, protecting human health, and treating and distributing a limited, valuable resource in a cost-effective manner.¹⁶³ In practice, reused water is often treated beyond the established quality

standard to make the water more acceptable and palatable to the community.¹⁶⁴ Public opinion, intention to use and willingness to pay for reused water can also be impacted positively or negatively by public communication (e.g., signage, symbols and terminology) and the media.¹⁶⁵

The public's perception of water quality is likely rooted in more than just the technically established water quality. The "yuck" factor is the term water professionals have used to describe the "visceral reaction of displeasure and disdain" in the public's perception of water reuse.¹⁶⁶ It has been described as an "intractable" barrier to the implementation of water reuse.¹⁶⁷

Some describe the "yuck" factor as being influenced by the physical nearness of a person to the reused water.¹⁶⁸ Others have found that the impetus for water reuse may play a part; when water reuse is implemented as a means for managing wastewater, rather than to supply needed water, public perception problems are more common.¹⁶⁹

Still others discuss the idea that if something is where it does not socially or culturally belong, it is perceived to be dirty, regardless of actual pathogenic status.¹⁷⁰ The idea that municipal sewage and usable water have anything in common can be distasteful.¹⁷¹ However, recent literature has moved away from this psychological reaction to water reuse and instead has shown the social, cultural and political origin of the public's perception of water quality and acceptability of reuse.^{172 173 174 175 176}

Research shows that the source of concern may also lie with the public's trust or confidence in water utility managers and local elected officials.^{177 178} This poses a challenge to reuse projects, since studies show that confidence in public agencies and officials is declining.^{179 180} In some areas, there may be a perception that public officials do not hold the interest of the public as the highest priority, but that instead, business interests may be guiding decisions regarding the management of water and the implementation of new projects, such as reuse.¹⁸¹

Trust in university researchers and the medical community may be higher than for public officials.

However, on water issues, the public tends to trust its own judgment the most. This opinion is frequently based on the taste or appearance of tap water.^{182 183} Further, some studies suggest that technical experts may have a different perspective of the risk of reusing water than the public. Technical experts, having invested their time, education and career in understanding and supporting complex water systems, may have a greater confidence in the ability of those systems to clean water consistently. This can complicate the reaching of consensus on acceptable water solutions between utilities and the community.¹⁸⁴

A 2014 survey of water utility consumers in Oklahoma also found that when survey respondents saw contaminant-specific information, they were less likely to find water reuse acceptable, even when the data showed that the water was meeting quality standards. Researchers hypothesized that this could be that they trusted their own perception more than the data, or that the data reminded them of the risk of contamination presented by reusing water.¹⁸⁵

In addition to a psychological disgust and the public's trust in public agencies and officials, other influences on perception of water reuse include the intended use, regulation, drought conditions and experience with and knowledge about the reused water.^{186 187} Other important components of reused water acceptability include cost of treatment and distribution, awareness of water supply problems, and confidence in water reuse technology.^{188 189 190}

The literature does not appear to reach consensus on the influence of age, gender or educational attainment on acceptability of water reuse.¹⁹¹ ¹⁹² However, studies note the importance of recognizing that public perception of reuse can vary from community to community, depending on local context.¹⁹³ As such, these generalized assumptions about drivers of community perception may not be applicable in every community.

The intended end-use for the reused water is a key predictor of acceptability. Though technology exists to treat water beyond the established standard for drinking water, water reuse projects become less acceptable to communities as human exposure increases.¹⁹⁴ As intended use moves from irrigation, to other non-potable uses, to indirect

potable uses, to direct potable uses, acceptability of reuse decreases.^{195 196 197 198 199 200 201} Generally, non-potable reuse projects are deemed acceptable, and irrigation has been found to be the most acceptable use for reclaimed water.^{202 203} Direct potable reuse is generally the least acceptable intended use for reclaimed water.

Drought conditions in a specific geographical area may also influence the level of support for reused water. In a national survey on perception of water reuse, it was found that generally, the highest support for reclaimed water use was found in U.S. Environmental Protection Agency (EPA) regions with a Palmer Drought Severity Index (PDSI) that indicates drought conditions.²⁰⁴

There is also evidence that water scarcity may increase willingness to pay for reclaimed water.²⁰⁵ Further, in some areas of the U.S., such as the Southwest, water reuse is ubiquitous, so a sense of acceptability may exist due to familiarity. Indirect potable reuse was found to be “contemplated, planned, or practiced in every major municipality in the Southwest.”²⁰⁶ Studies show that those with knowledge about or positive experience with water reuse are more likely to support its use.^{207 208} However, there is no evidence that familiarity with non-potable uses encourages the acceptability of potable uses.²⁰⁹

Successful reuse projects have utilized several strategies. These strategies include:

- Outreach and education;
- Incorporating feedback from citizen's advisory committees, focus groups and community leaders;
- Establishing a track record of high water quality;
- Demonstrating the utility's trustworthiness;
- Installing high-quality equipment and laboratory practices; and
- Developing emergency intervention and quality monitoring plans.²¹⁰

Other successful practices include naming the project something that is understandable to

the community and has positive connotations, and having water utilities' management directly involved in community outreach and communication.²¹¹ Some have suggested that educational outreach should focus on the prevalence of de facto reuse which is frequently the status quo.²¹²

The literature suggests taking steps to foster the public's trust prior to a reuse project when there is not a contentious decision to be made or a crisis at hand. This may instill in the public a sense of confidence in the utility's competence that can translate to future efforts. Possible steps to take include building communication channels—through the media—when there is not an ongoing crisis.²¹³ Recent events in Flint, Michigan, underscore the difficulty of establishing trust once it is lost.^{214 215}

Reuse projects that have not been successful in gaining the public's confidence also have some commonalities. They typically did not allow for meaningful public participation in planning and decision-making, and utilities are not likely to gain the public's trust if they have a history of withholding information from the public.²¹⁶ Some projects have floundered when they have relied on an elected official to serve as the face or voice of the project. If a reuse project is unpopular, the politician may abandon the project as elections approach, perhaps confirming to the public that the project should be abandoned.²¹⁷

There does not appear to be an “easy” way to garner public support for water reuse; therefore, a top challenge for a water reuse project is the education, outreach and information-sharing required to garner public support.²¹⁸ ²¹⁹ The literature repeatedly emphasizes the importance of engaging the public early, often and meaningfully.^{220 221 222} There are three forms for community involvement in water reuse:

- A reuse project is initiated by the public;
- The public participates in the planning of a reuse project initiated by the local government; or
- The public is presented with a situation where there are no other feasible alternatives.²²³

The important distinction is differentiating between information-sharing and meaningful engagement. Several indicators have been proposed to capture this important distinction. One proposed indicator for public participation is percentage of users that feel they are “aware of and responsible for” the reuse project.²²⁴ Other proposed metrics of engagement include whether the public is provided with general information, an assessment of interest in conservation programs and reuse, whether there is an active educational campaign, the availability of and participation in workshops, and whether training is required for use of non-potable water.²²⁵

To engage meaningfully and maintain public confidence, researchers recommend managing information with all stakeholders in mind, promoting communication and public dialogue, and ensuring a “fair and sound” decision-making process.²²⁶ Additionally, decision-makers need access to information about the public's attitude towards water reuse, and should use this information to determine reuse strategies.²²⁷

Outreach related to reuse should be managed carefully, as some studies have found that individuals previously unsupportive of water reuse may become even less supportive if they feel they are trying to be tricked or coerced into supporting the project.²²⁸ Other studies examined water utilities that approached water reuse acceptability by providing technical information. This approach was often inadequate as consumers are interested in a broader range of information, such as social and environmental costs, risk comparisons and alternatives, and regulatory and institutional structures in place for monitoring.²²⁹

What We Learned from Stakeholders

The interviewees said that public perception of water reuse impacts whether a community decides to implement water reuse projects. The interviewees agreed that the public is not familiar with water reuse. This lack of knowledge could result in an increase in safety concerns. Interviewees acknowledged the role of education and transparency in building community's trust and buy-in for water reuse efforts. Several interviewees

suggested including the public in conversations regarding water reuse as early as possible and on an ongoing basis.

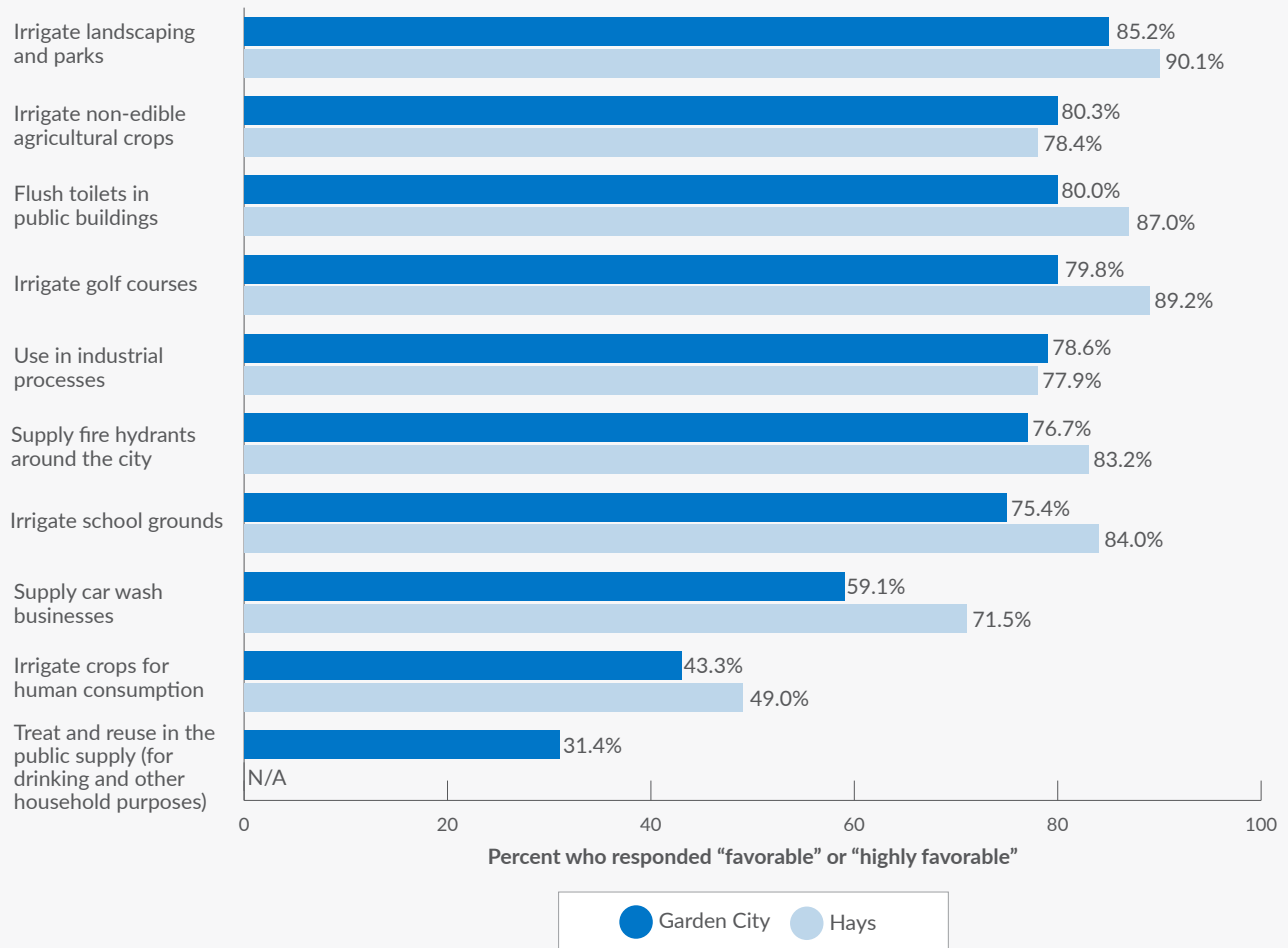
Interviewees anticipated that the public would not have issues with non-potable reuse as they would not feel as directly impacted. However, several stakeholders believed that some individuals might still be resistant to the idea of reuse and stressed the need to educate. They believed that communication and education could shape the community's perspectives.

In a survey of community members in Garden City and Hays, respondents were generally supportive of current and potential reuse efforts. In Garden City, 69.9 percent indicated that they were supportive

or highly supportive of current efforts, and 72.3 percent indicated that they would be supportive or highly supportive of additional reuse in the future. In Hays, 91.8 percent indicated support for current efforts and 87.0 percent indicated support for future efforts.

When asked whether they would be supportive of various types of reuse, respondents generally found a variety of non-potable reuses to be favorable—more than two-thirds indicating favorable or highly favorable. Irrigation of landscaping and parks rated the highest, while irrigation of crops for human consumption and treatment for potable reuse were rated the lowest (the Hays survey did not include potable reuse in the question). See *Figure 19*.

Figure 19. Percent of Survey Respondents Indicating “Favorable” or “Highly Favorable” for Various Reuse Types in Garden City and Hays, Kansas



Source: Community Surveys in Hays and Garden City, 2017.

“Generally it would be very easy to achieve a high level of confidence in the non-potable reuse, a little less easy to get the confidence in indirect potable reuse, and then progressively more difficult as you’re talking about direct potable reuse.” – Key Informant

“When people have a concern, the best thing we can do is to try to give them good information. I think the community knowing that you’re giving them the complete story is very important.” – Key Informant

Conclusion

Treating wastewater for beneficial purposes can influence the public’s perception of municipal water quality, and based on available literature, it was found that the community’s perception of reused water quality is generally lower than that of current drinking water (Figure 20, page 47). There are several components of this perception, including the often cited “yuck” factor, which is an aversion to using formerly soiled water, as well as the public’s trust of the system’s ability to ensure health and safety.

Public trust is the degree to which constituents trust local officials and water managers to operate water reuse facilities competently, communicate openly regarding water quality, and the integrity of these officials to make decisions without undue influence from business or other interests. The public may trust their own judgement, often based on taste or appearance of water, more than the expertise of public agencies, public officials or researchers.

Regardless of the measured water quality, the acceptability of water is lower as the potential for human contact with the water increases, and objections to water reuse typically increases as the level of human contact increases. Stakeholders felt

that the acceptability of non-potable uses would be high, but that community members may be resistant to other uses such as indirect or direct potable reuse.

A positive community response to water reuse may depend, in part, on how important the community perceives the project to be, as well as other factors, including the cost of the project, an emphasis on water conservation, the perceived threat of drought, environmental benefits, protecting health and recognition that water is a limited, and a valuable resource. Communication, outreach and meaningful engagement of the public have also been shown to increase familiarity with and support for reuse projects, and can also have impacts on the community’s trust of public officials.

Finally, perception can vary greatly between communities, so caution should be exercised in applying these findings to a specific community, and the literature encourages taking steps to understand local perspectives of water use.

The primary health implications of a decrease in community perception of water quality were found in the switch from drinking tap water to bottled water or other sugary beverages (described in the following section).

Figure 20. Impacts of Water Reuse on Community Perception of Water Quality

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Community Perception of Water Quality ^{††}	Decrease	N/A	Decrease	Decrease	See section on consumption of beverages other than municipal water. (Page 48)			****	

Note: See Legend, Appendix B, page 74. The decrease in perception of water quality relates to all three types of reuse (non-potable, indirect potable and direct potable). However, changes in consumption of municipal water and other beverages may be more likely when indirect or direct potable reuse is practiced.

† † = Despite a perception that reused water quality is lower than that of the current/traditional municipal water supply, acceptability may vary by type of reuse. Non-potable reuse may have highest acceptability, whereas direct potable reuse has the lowest acceptability.

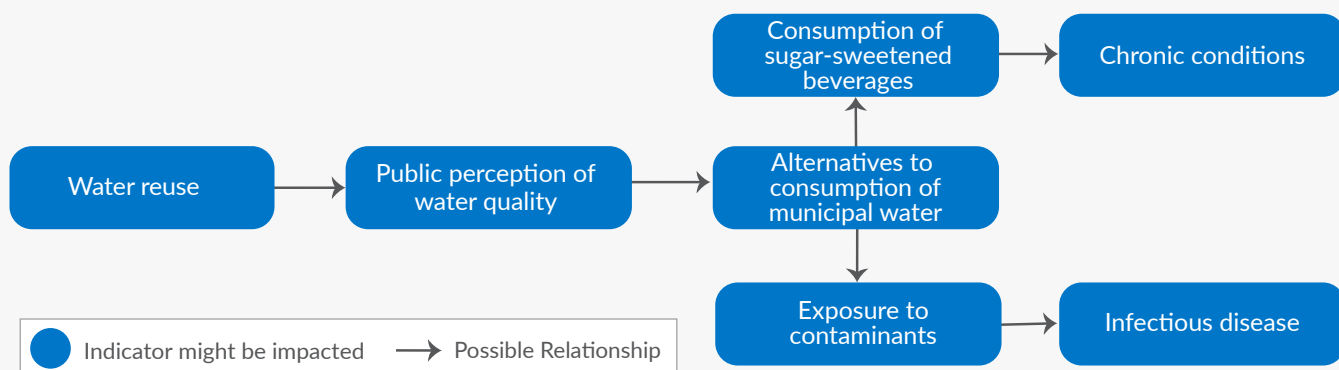
Source: KHI Municipal Water Reuse HIA, 2017.

“The concept of reusing water is somewhat foreign to people and may cause them to question the safety of the water supply.”

– Key Informant



Figure 21. How Water Reuse May Impact Consumption of Beverages Other than Municipal Water (e.g. bottled water or sugary beverages)



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

- Changes in the perception of water quality would impact the purchase and consumption of beverages other than municipal water, such as bottled water or sugary beverages.
- There is often a perception that bottled water is of higher quality than municipal drinking water, whereas in fact, some evidence points to the opposite. Bottled water is not regulated the same as drinking water, and the presence of some contaminants may be higher than in municipal water.
- The potential health impacts of a switch to bottled water include impacts on oral health—particularly for children—due to missing out on a fluoridated municipal water supply.
- An increase in sugary beverage consumption may also lead to an increase in tooth decay and chronic conditions such as obesity and diabetes.

RECOMMENDATIONS

Water regulators could consider:

- Pursuing similar quality, monitoring and reporting requirements on bottled water as municipal water supplies.

Municipalities could consider:

- Increasing public awareness of the impact of bottled water consumption on oral health, household budgets and the environment.
- Improving community perception of drinking water by communicating early and often and building/maintaining transparency and trust with the community.

Local public health agencies could consider:

- Engaging in health promotion strategies to highlight the health benefits of water consumption over other beverages such as sodas, juices and other sugary drinks.

FINDINGS

- Racial and ethnic minority groups, such as Latinos and African Americans, may be more likely to consume bottled water and sugary beverages as a result of low trust in the quality of the municipal drinking water.
- Economically disadvantaged populations may be at higher risk for negative financial implications of purchasing beverages that are more expensive than municipal water.

RECOMMENDATIONS

Note: See Appendix C, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background and Current Conditions

According to 2013 Behavioral Risk Factor Surveillance System (BRFSS) data, 19.3 percent of Kansas adults consume soda once or more per day, and 73.8 percent of Kansas adults reported consuming any sugary drink (e.g., pop, soda or other fruit juice/ beverage) at least once in the past month. This percentage differs by race/ethnicity, annual household income and age.^{230 231}

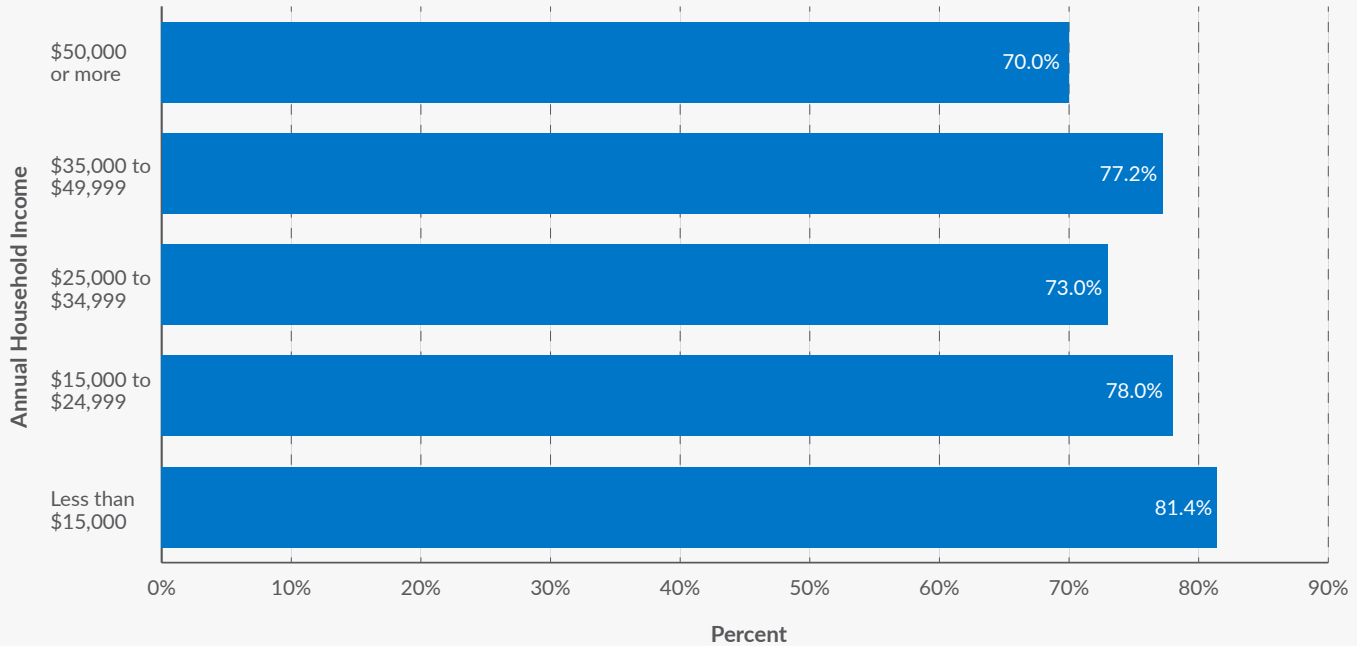
Hispanic Kansans are more likely to have consumed a sugary drink in the past month compared to non-Hispanics (85.3 percent versus 72.7 percent, respectively). Black or African American individuals also report higher sugary drink consumption (84.4 percent) than White individuals (72.1 percent).²³²

Sugary drink consumption is higher among those with lower incomes compared with those with the highest annual household income, and is also higher among young adults compared to older adults (Figures 22 and 23, page 50).²³³

19.3% of Kansas adults consume a soda beverage once or more a day.

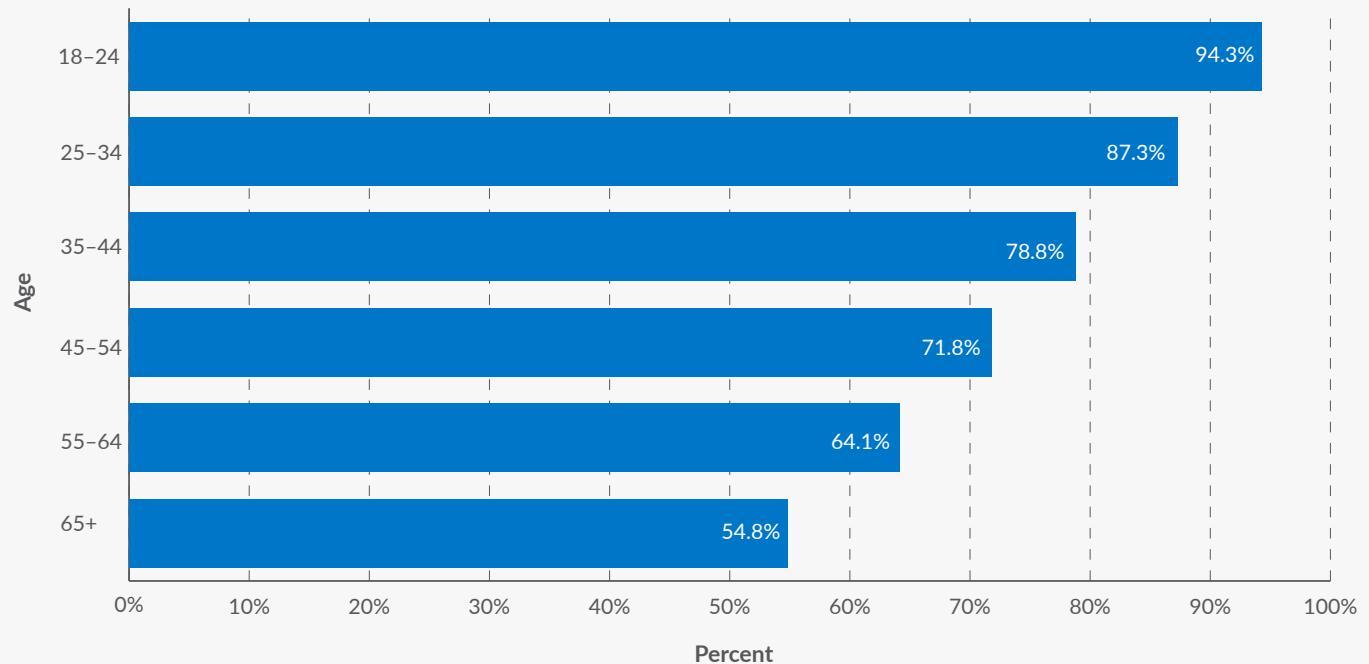


Figure 22. Sugary Drink Consumption by Annual Household Income in Kansas, 2013



Source: Kansas Behavioral Risk Factor Surveillance System (BRFSS), 2013.

Figure 23. Sugary Drink Consumption by Age in Kansas, 2013



Source: Kansas Behavioral Risk Factor Surveillance System (BRFSS), 2013.

What We Learned from Literature

Bottled water consumption has increased in the past decades. From 1997 to 2007, bottled water consumption in the U.S. has doubled.²³⁴ In one community, where an HIA analyzed the effect of a proposed improved water and sanitation system, researchers found that about two-thirds of residents used bottled water for drinking and tap water for other household purposes.²³⁵

Researchers frequently question why bottled water consumption is so common given that, in the U.S., tap water is typically safe to drink and that bottled water is anywhere from 240 to 10,000 times more expensive than tap water.²³⁶ Identified drivers of bottled water consumption include taste, safety, trust, convenience and marketing.^{237 238 239} Taste and other aesthetic features, such as clarity, appear to be a major standard by which people assess the safety and acceptability of tap water.^{240 241 242 243} Studies have found that people list taste as a top reason for their preference of bottled water to tap, and they rate bottled water as tasting better than tap water.^{244 245 246}

Trust has also been found to be an important component of tap water consumption.^{247 248} In one study, trust in the local water treatment facility strongly predicted whether residents purchased bottled water.²⁴⁹ In another study, the more people trusted the local government and water treatment facility, the less likely they were to purchase bottled water.²⁵⁰ Media attention on “trust-destroying events” is thought to heighten public distrust in municipal water and inflate the confidence in bottled water.²⁵¹

The marketing of bottled water as a high-quality, safe product is an important driver of increased consumption.^{252 253} A conclusion drawn by some research is that behavior is driven by the perception of risk, which may be influenced by marketing, rather than objective conclusions reached and written about by scientists.^{254 255 256}

Public water utilities are held to strict requirements for maintaining the quality of municipal water.²⁵⁷ These requirements detail water quality benchmarks and mandatory reporting.²⁵⁸ Each year,

public utilities are required to inform their clients of the quality of their water in a report called the *Consumer Confidence Report*, or CCR.²⁵⁹ Studies have found that consumers read and respond to these reports. One reported violation has been found to increase the likelihood of bottled water consumption by 21.0 percent.²⁶⁰ In other words, hearing of a water quality violation increases the probability of consuming bottled water.²⁶¹

Bottled water does not have the same quality reporting requirements as tap water. In a recent report, the U.S. Governmental Accountability Office found that the bottled water requirements set forth by the U.S. Food and Drug Administration (FDA) are often less stringent than the U.S. Environmental Protection Agency's (EPA) requirement for tap water.²⁶² There is little, if any, evidence to suggest that bottled water is safer than tap water in the U.S., and in some instances, it has been found to have higher levels of contaminants than the EPA allows for standard tap water.^{263 264} Differential reporting requirements have led to greater awareness of tap water quality and an accompanying assumption that it is inferior to bottled water.^{265 266}

Some have concluded that the differential reporting requirements have resulted in a false sense of security in the quality and safety of bottled water.²⁶⁷ In one study, it was found that consumers assumed bottled water was safer because it was more expensive than tap water.²⁶⁸ This point of view assumes that the greater expense of bottled water is due to higher levels of water treatment, when in fact, these expenses are due to bottling, transporting, marketing and company profits.²⁶⁹

In addition to influencing the consumption of bottled water, some have suggested that trust in the safety of tap water is a potential driver of sugary beverage consumption.²⁷⁰ One study conducted with Hispanics in the U.S. found that the likelihood of consuming one or more sugary beverage per day doubled when the participant reported that they did not trust local tap water.²⁷¹

Some populations may be more likely to consume bottled water or sugary beverages because of concerns about water quality. Latinos have higher

rates of consumption of both bottled water and sugary beverages. It is hypothesized that this could be a cultural or community preference that has developed due to community water systems in some Latin American countries that are not well-regulated.²⁷²

Racial and ethnic minority groups consume bottled water and sugary beverages more frequently than White Americans.^{273 274} Young people tend to be more frequent consumers of bottled water and sugary beverages than older people.^{275 276} Households with children consume more bottled water than households without children.²⁷⁷ Additionally, women may consume bottled water at a higher rate than men.²⁷⁸ Income and education are uncertain predictors of bottled water consumption.^{279 280 281 282 283}

There may be implications for chronic disease, oral health, and a household's financial well-being due to increased consumption of bottled water and sugary beverages. If individuals who are not consuming tap water choose to consume sugary beverages instead, there may be a greater likelihood of obesity, poor mental health and type 2 diabetes.²⁸⁴

If the community water supply is supplemented with fluoride, individuals—especially children—may experience poorer oral health outcomes because bottled water often is not fluoridated.²⁸⁵ Additionally, there are financial implications for choosing beverages other than tap water. Bottled water and sugary beverages are both significantly more expensive than municipal drinking water. Bottled water can be as much as 10,000 times more expensive than tap water.²⁸⁶ This could impact budgets for low-income families and may lead to trade-offs with other necessities.

What We Learned from Stakeholders

The majority of interviewees agreed that public perception of water quality would impact the consumption of municipal drinking water. Specifically, the participants noted that concerns regarding safety and quality of water would likely result in a higher purchase of other

beverages (e.g., soda and bottled water). However, several interviewees believed that this situation would change over time as people develop trust and understanding of the reused wastewater.

Additionally, interviewees suggested that the decision to consume bottled water may also be influenced by other factors, such as the “desire to look cool” or the presence of fluoride in public water supplies. The interviewees believed that education about the quality of drinking water and information about reuse can help to address potential residents' concerns.

“If public perception is bad, they just won't use that supply, they will go and purchase bottled water.” – Key Informant

Conclusion

Based on available literature, decreases in the community's perception of water quality could lead to an increase in consumption of bottled water and sugary beverages, which may have an adverse impact on health (*Figure 24*, page 53).

Literature and stakeholders were consistent in concluding that changes in the perception of water quality would impact the purchase and consumption of beverages other than municipal water, such as bottled water or sugary beverages. This is due to a common perception that bottled water is of higher quality than municipal drinking water, whereas in fact, some evidence points to the opposite. Bottled water is not regulated the same as drinking water, and the presence of some contaminants may be higher than in municipal water.

As a result, the Centers for Disease Control and Prevention (CDC) notes that individuals with a compromised immune system should be cautious when purchasing bottled water. Furthermore, racial and ethnic minority groups, such as Latinos and African Americans, may be more likely to consume bottled water and sugary beverages as a result of low trust in the quality of the municipal drinking water.

The literature points to potential health impacts of increased bottled water and sugary beverage consumption, including impacts on oral health—particularly for children—due to missing out on a fluoridated municipal supply of water. An increase in sugary beverage consumption may

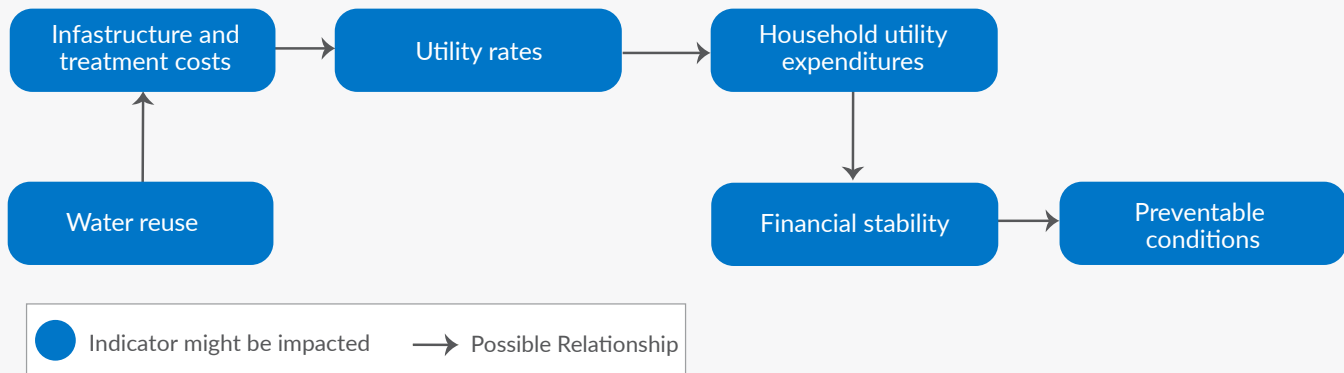
also lead to an increase in tooth decay and chronic conditions such as obesity and diabetes. Economically disadvantaged populations may be at higher risk for negative financial implications of purchasing beverages that are more expensive than municipal water.

Figure 24. Impact of Water Reuse on Consumption of Beverages Other than Municipal Water and Associated Health Impacts

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Consumption of beverages other than municipal water	Increase	N/A	Increase	Increase	Adverse	Some	Some racial and ethnic minority groups; Low-income populations; Individuals with a compromised immune system	Possible	****

Note: See Legend, Appendix B, page 74. While changes in perception of water quality could impact consumption of municipal water and other beverages regardless of the type of reuse, the change in consumption may be more likely when indirect or direct potable reuse is practiced.
Source: KHI Municipal Water Reuse HIA, 2017.

Figure 25. How Water Reuse May Impact Costs and Utility Rates and Associated Health Impacts



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

Costs

- A variety of initial and ongoing costs will be introduced if communities decide to implement water reuse.
- The magnitude of costs may depend on aspects related to the type of reuse, such as desired water quality and the method and distance of water distribution. Due to specialized treatment, expenses associated with potable reuse may be higher than with non-potable reuse.
- In some cases, water reuse may be less costly than the development of other new water sources.

Utility Rates

- Utility rates could increase, decrease or stay the same as a result of water reuse.
- Changes in utility rates may depend on the size of the costs, availability of alternate funding sources, and the community's perception of and demand for reused water.
- If utility rates increase, some populations may experience negative impacts. These include individuals who are low-income, elderly, and those served by small and rural community water systems.

RECOMMENDATIONS

Costs

Kansas municipalities could consider:

- Identifying funding sources that could help cover costs related to reuse, including: the Community Development Block Grant (CDBG), USDA Rural Development, Rural Community Assistance Partnership, and the Midwest Assistance Program (MAP).
- Working together with partners to share the costs and benefits of reuse infrastructure (e.g., industry partners and neighboring municipalities).
- Coordinating between water, wastewater and storm water to plan and finance water reuse projects.
- Including fees on water/wastewater bills to build a pool of funds for financing reuse projects.
- Integrating reuse infrastructure into areas of new development.
- Balancing the most cost-effective reuse option with community acceptability.
- Communicating with industrial partners about the water environment that is supporting their operations and any threats to its sustainability.
- Comparing the costs of reused water to the costs of new source development or the costs to the community of water scarcity.

FINDINGS

These individuals are more likely to already be paying a higher percentage of their current income on water and wastewater bills, and an increase in rates may become unaffordable for them.

- Because of the critical nature of water and wastewater service, keeping these utilities turned on could require that families make trade-offs and go without other necessities such as food, medical expenses, and heating and cooling, among others.

RECOMMENDATIONS

- Investing in infrastructure that is supportive of reuse as aging water infrastructure is replaced. Identifying local sources of funding, including bond financing.
- Ensuring that the project's cost and sale estimates are realistic.

KDHE could consider:

- Prioritizing any state financial support of reuse by using a framework that accounts for access to alternative funding sources.
- Waiving application fees and/or inspection fees for municipalities interested in pursuing water reuse efforts.
- Providing grant funding to municipalities or help municipalities apply for grant funding associated with water reuse.
- Providing a template policy/process for coordination between water and wastewater utilities.
- Working with federal agencies to streamline the process for local funding.
- Dedicating funding to support long-term water planning efforts.
- Allowing the use of loan programs as incentive for private businesses to embark on water reuse efforts, similar to the state revolving loan fund.

Utility Rates

Kansas municipalities could consider:

- Pricing reused water at a lower rate in order to encourage its use, if needed, based on community acceptability.
- Pricing water to account for scarcity by increasing the rate for high-volume users.
- Implementing affordability programs for low-income individuals, such as lifeline rates, payment plans, bill discounts, leak repair assistance programs, and others.
- Requiring staff training for items such as: 1) how to identify causes of and customers experiencing financial hardship, 2) how to communicate with or assist customers experiencing hardship.

Note: See *Appendix C*, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background and Current Conditions

A variety of factors are considered when setting water utility rates. Some of the factors that impact utility rates are the source of water (groundwater or surface water), the type of treatment used, the costs of distribution, and any debt that the utility might incur from financing infrastructure projects.

Additionally, utilities use a variety of pricing structures to set their utility rates. A few of the most common pricing structures are described below.

- **Flat Fee:** Customers are charged a fixed price for water, no matter how much or how little water is used.²⁸⁷
- **Uniform Rate:** Customers are charged the same price-per-unit of water usage, so that the water bill increases with more usage, but there is no difference in the rate per unit for low-use and high-use. Occasionally uniform rates by class are used. For example, residential and non-residential customers may be charged different per-unit rates.²⁸⁸
- **Decreasing Block Rate:** The per-unit charges for water decreases as the amount of water used increases. This pricing structure is akin to buying in bulk, with discounts for customers purchasing larger quantities of a product. In this pricing structure, the first block is charged at one rate, the next block is charged at a lower rate, and so on. The number of blocks may vary based on the utility.²⁸⁹
- **Increasing Block Rate:** The per-unit charges for water increase as the amount of water increases. A block is a quantity of water for which the price per thousand gallons is set. The first “block” is charged at one rate, the next block is charged at a higher rate, and so on. The number of blocks may vary based on the utility. This type of rate structure is used to create a financial incentive for conservation.²⁹⁰

Uniform rates, decreasing block rates, and increasing block rates sometimes also use a multi-component price that involves a fixed charge and an additional cost per unit. Some utilities use seasonal or peak pricing to reward conservation during high-demand periods.²⁹¹ Establishing appropriate fee structures is important to the appropriate and sustainable use of water. Some research shows that consumers respond to price signals more than they do traditional conservation programs, rebates or educational programs.²⁹²

In Kansas, about 57 percent of water utilities use a uniform or flat fee rate structure, about 23 percent use a decreasing block rate, and just 20 percent use an increasing block rate structure.

What We Learned from Literature

Costs

A frequently cited challenge of water reuse is funding the project, and some researchers predict that costs may be an even more critical consideration in the future.^{293 294 295 296} In one survey, water reuse managers were asked to name the greatest barriers to a successful reuse project. Eighty seven percent of respondents cited financial or economic challenges as one of the top barriers.²⁹⁷ Reuse costs are dependent on the scale, treatment technology and water quality needed from the project.^{298 299} Major cost components are the initial costs for infrastructure, such as treatment facilities and distribution pipelines, as well as ongoing costs for operation and maintenance.³⁰⁰

Generally, costs for water reuse projects increase as the desired water quality increases and as the distribution distance increases. By one estimate, installation costs for a dual-distribution pipeline can range from \$1 million to \$3 million per mile.³⁰¹ Another assessment of 16 reuse projects found that the cost of reusing water would range from \$220 per acre-foot (AF) to \$3,400 per AF with a median of \$1,200 per AF.³⁰² Each type of reuse has its own unique costs. Direct potable reuse often requires expensive advanced treatment technology, indirect potable reuse requires the development of an appropriate environmental buffer, and non-potable

reuse may require the installation of separate distribution infrastructure.³⁰³

Despite these high costs, reusing water can be less expensive than importing additional water.^{304 305} Because many of the costs associated with reuse (e.g., dual distribution systems, environmental buffers and infrastructure for advanced treatment) are initial investments, they may have a lower life-cycle cost than the cost of continual transport of water into an area. Historically, the U.S. Environmental Protection Agency (EPA) and others supported water transport over reuse. As treatment technologies have improved, resulting in a higher quality end-product, water reuse often becomes more economically attainable than water transport, and the recommendations of organizations like the EPA have shifted.^{306 307}

In the U.S., many water utilities have infrastructures that are aging and in need of replacement.^{308 309} Some researchers have suggested incorporating water reuse considerations in planning for infrastructure replacement, which may be more cost-effective than replacing infrastructure and investing in reuse separately.^{310 311}

Of local interest, some research indicates that water and wastewater treatment is more expensive on a per capita basis for residents of rural communities compared to larger communities.³¹² One study cites the difficulty that small communities experience in qualifying for federal or state grants or loans.³¹³

Research cites the importance and challenge of developing realistic cost estimates to ensure the success of the reuse project, and there are a variety of approaches that can be taken to make cost projections.³¹⁴ When assessing the costs associated with water infrastructure, it is typical to also consider benefits. One of these benefits may be the potential for economic stability and growth that a secure water supply provides.³¹⁵

As an agricultural state, Kansans know the importance of water to the food supply, and a recent review found that water is a key factor for sustainable food and energy production.³¹⁶ If reuse can help ensure a stable water supply, there may be economic benefits.

One analysis conducted in Minnesota found that water provides \$9.3 billion in farm income each year.³¹⁷ When this is expanded to include all the economic activity generated from this, the value grows to \$55 billion.³¹⁸ Additionally, short-term economic loss due to drought is one strategy used to capture the economic benefit of water to a community's financial well-being.³¹⁹ Historically, the most successful urban economies have consistently made investments in their water infrastructure.³²⁰

Some authors have also noted that the general economic feasibility of water reuse projects is difficult to determine and have called for more research on the topic.^{321 322}

Utility Rates

If a reuse project's costs are substantial enough, they may impact the rates that consumers pay for their water or wastewater utility. The theory behind utility rate setting is complex and requires balancing a variety of considerations.³²³ Rates are expected to be set to cover the cost of infrastructure and ongoing treatment, but it is generally not publicly acceptable to set utility rates at an amount that generates profit.³²⁴ Water is typically priced to reflect the cost of treatment and infrastructure and customer prices may not reflect the scarcity of water or the future cost of infrastructure to secure its availability.³²⁵ Some researchers emphasize the need to price water to reflect that it is a valuable, exhaustible resource.³²⁶ At the same time, water is essential to human life and should not be priced at a point to place an undue financial burden on low-income households.³²⁷

The most common rate system for reused water appears to be offering reclaimed water as a specific percentage of the potable water rate.³²⁸ ³²⁹ Researchers have found that it is sometimes difficult to price reused water at the same rate as potable water, since incentives may be required to promote use.³³⁰ This is not always true though, and it is common for municipalities to conduct a rate study prior to implementing a water reuse system.³³¹ In one such study conducted in Oklahoma, it was found that Oklahomans may

actually be willing to pay an additional \$3.47 per 1,000 gallons for reused water.³³² However, the hypothetical nature of the question may have inflated the amount that those surveyed would be willing to pay.³³³

Some researchers suggest that managing water as a single resource or collaborating at the regional or state level may be one strategy to ensure high-quality water at a consistent, appropriate price point.^{334 335} Researchers also recommend allocating the cost of reuse across the water system in correspondence to where benefits will be felt or costs deferred.³³⁶ This includes allocating costs to those agencies responsible for extending supply or managing wastewater. Other research indicates that rate increases may be acceptable if they are planned for and implemented over several years.³³⁷

The impact of utility rate hikes is likely to be felt most acutely by individuals who are low-income and those who are served by small and rural community water systems. Currently, the EPA sets an affordability threshold for drinking water at 2.5 percent of median household income (MHI), and for wastewater, the threshold is 2.0 percent of MHI.³³⁸

These thresholds are used when considering the estimated cost of new federal rules to small community water and wastewater systems (those serving fewer than 10,000 people). If the estimated costs exceed the threshold, small or rural community water or wastewater systems may use alternate methods to achieve compliance with the new rule.³³⁹ It has been noted that there are some limitations to this approach, including the fact that MHI may not capture income inequality within communities and this approach could mask the ability of poorer residents to pay their utility bills.³⁴⁰ Additionally, since the threshold is applied to the costs for all water systems of a certain size, it could mask differences between systems. Alternatives have been proposed, such as examining affordability at lower household income percentiles (such as the 10th or 20th percentile).³⁴¹

Further, the EPA has never determined a rule unaffordable based on these criteria, which has led some to believe that the threshold is set too high to be a meaningful gauge of unaffordability for

small systems.³⁴² Despite these noted limitations, no changes have been made to the established affordability thresholds.

The primary concern is that higher costs due to rate increases may negatively impact community members. Researchers have noted that rural households tend to spend a larger portion of income on utilities and other necessities than do urban households, and that these families might be forced to choose between paying for medical care, heat, or other necessities that impact health.³⁴³

It has been argued that even though water and wastewater utilities typically cost less than other utilities such as electricity, they trump other costs because shutoffs to these utilities can make homes uninhabitable.³⁴⁴ One article notes that water and wastewater utility costs are a critical component of public health protection for low-income households, and that the utility companies have the responsibility to consider the impacts of rate hikes on consumers in addition to ensuring that water is treated to high standards.³⁴⁵

Multiple resources suggest that implementing affordability programs for water and wastewater is a best practice in the field. The benefit may be felt by the utility as well—some note that public trust in the utility may be improved as a result of affordability policies.^{346 347} There is a variety of assistance programs that can be implemented by water and wastewater utilities, including bill discounts, flexible terms, lifeline rates, temporary assistance and water efficiency programs.³⁴⁸

Some stakeholders have recommended implementation of a national Low-Income Water Assistance Program, or LIWAP, (similarly structured to the Low-Income Heating Assistance Program—LIHEAP), because while there are federal assistance programs for other utility services, there is no such program for water.³⁴⁹ The EPA notes that as of 2016, more than one-quarter of utilities nationwide offer some sort of customer assistance program, while in Kansas, just five of the largest water and wastewater utilities offer such programs.³⁵⁰ Assistance programs may be an important consideration for utilities embarking on reuse in Kansas.

What We Learned from Data

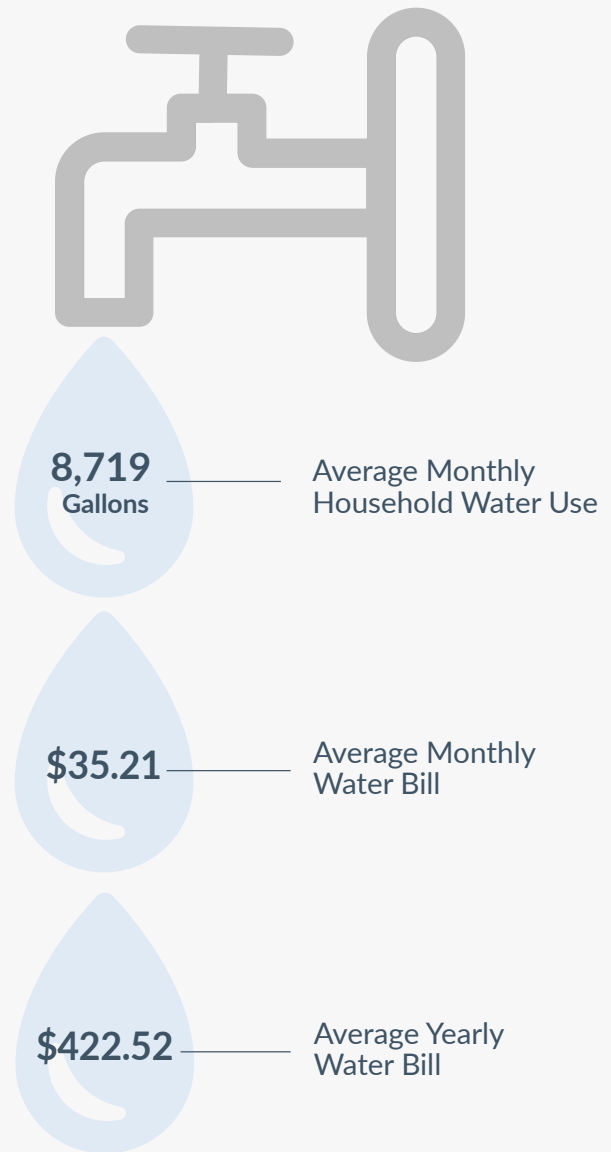
In order to examine drinking water affordability in Kansas, the KHI HIA Team compared the average water utility bill to the MHI at the state and county levels. Water utility bills were estimated using water rates and average per capita daily usage for PWS in Kansas with available data. Using the average household size in Kansas (2.5 persons), the average monthly household water use was calculated to determine the correct rate for each utility, then that rate was applied to the average per capita usage. The average water bill in Kansas is estimated to be approximately \$35 per month, or \$420 per year (Figure 26).

In comparison to other utilities, water bills are typically relatively affordable. For example, in 2015, the average monthly electricity bill in Kansas was \$110.58, which is more than three times the estimated monthly water utility charge.

The Kansas MHI in 2014 was \$52,504. The average estimated annual water bill is about 0.8 percent of the MHI in Kansas, less than the two percent affordability threshold. However, there are disparities in the MHI among various groups of individuals in Kansas, and the impact of utility bills may differ for some sub-populations. Figure 27, page 60, shows the varying percentages of MHI for the average estimated utility bills for sub-populations by race and age.

African Americans, Hispanics, households with adults under 24 years of age and those over age 65 have lower MHI and may be paying a higher percentage of income toward utility bills than other groups. Because water use data were not available by income distribution, this analysis assumes that water use is the same regardless of income.

Figure 26. Average Monthly Household Water Use and Average Water Bills in Kansas, 2010–2014



Source: KHI analysis of data from Kansas Rural Water Association and U.S. Geological Survey, 2010–2014.

Figure 27. Annual Utility Costs as a Percent of Medium Household Income by Race/Ethnicity and Age in Kansas, 2014

Group	Median Household Income, 2014	Annual Utility Cost, as a percent of MHI
All Kansas Households	\$52,504	0.8%
Race/Ethnicity of Householder		
White, non-Hispanic	\$56,010	0.8%
Black/African American	\$32,057	1.3%
Hispanic	\$39,869	1.1%
Age of Head of Household		
15-24	\$27,990	1.5%
25-44	\$57,186	0.7%
45-64	\$64,951	0.7%
65 years and over	\$39,009	1.1%

Source: American Community Survey, 2014 1-year estimates.

Water utility rates can also vary from one location to another. The average MHI and estimated water utility bills were compared at a county level for Kansas. *Figure 28, page 61, shows the differences in the percent of MHI represented by water bills for counties in Kansas.*

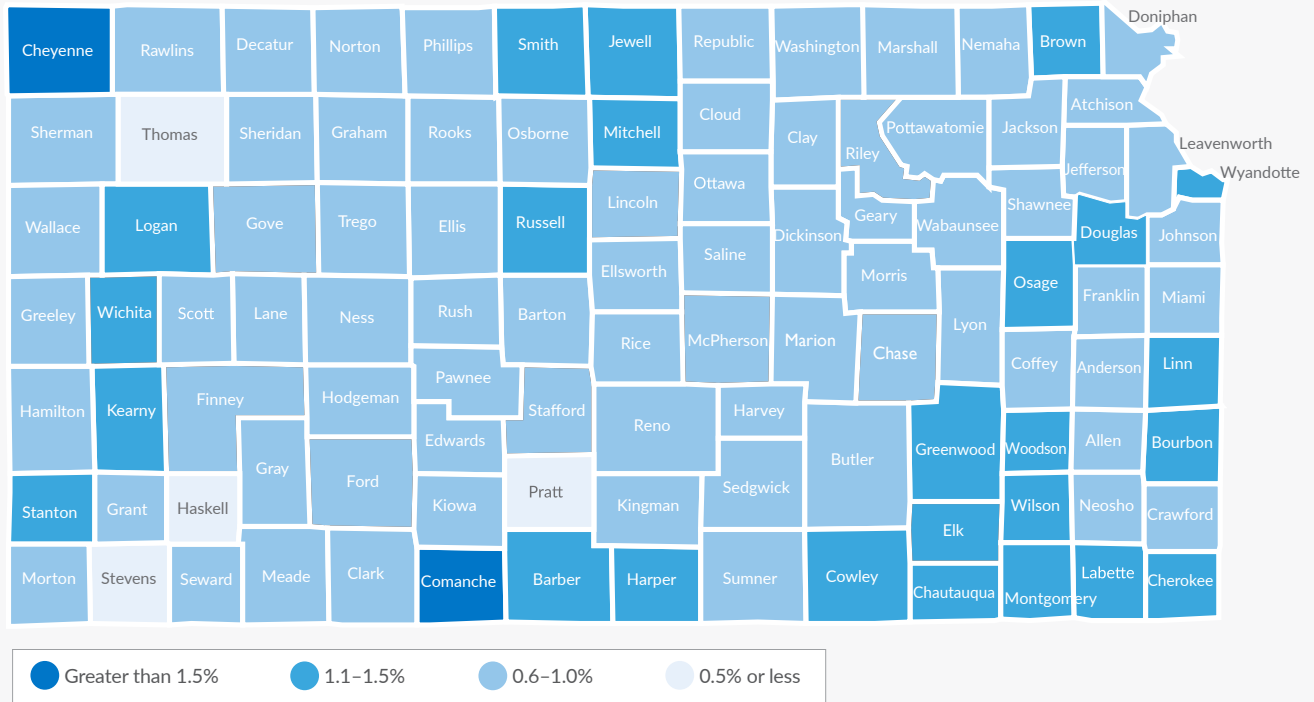
Furthermore, the federal poverty level (FPL) in 2014 for a household of three people was \$19,790. The average yearly water bill of \$420 is about 2.1 percent of FPL. In 2014, 13.6 percent of Kansans were living below the poverty level. Based on the EPA’s affordability criteria, the average yearly water bill would be unattainable for many individuals living below the poverty threshold. Because estimated water utility bills differ by county, the proportion of income that families living below poverty would be paying in

water utilities could also differ. *Figure 29, page 61, shows the estimated average utility bills by county compared to the 2014 FPL.*

If water or wastewater rate increases were required for the implementation of water reuse projects, individuals with low incomes would likely experience greater impact to their household finances than those with higher incomes.

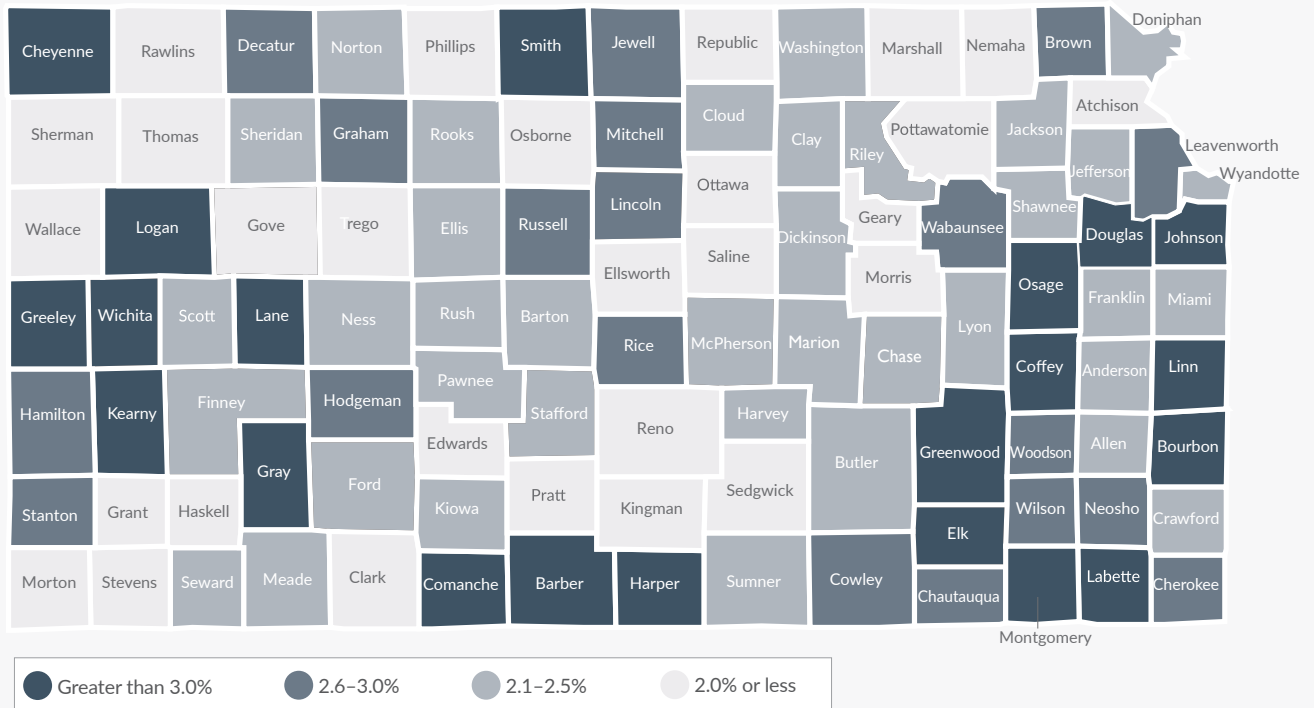
It is important to note that these calculations were made for water utility bills, however, wastewater bills may be impacted due to the decision to reuse water, and are also an important component of determining utility prices for households. Standardized wastewater rates and usage for Kansas were not available at the time of this report.

Figure 28. Estimated Average Utility Bills as a Percent of Median Household Income by County in Kansas, 2014



Source: KHI analysis of data from the U.S. Census Bureau, U.S. Geological Survey, and Kansas Rural Water Association.

Figure 29. Estimated Average Utility Bills as a Percent of the Federal Poverty Level by County in Kansas, 2014



Source: KHI analysis of data from the U.S. Census Bureau, U.S. Geological Survey, and Kansas Rural Water Association.

What We Learned from Stakeholders

In general, interviewees agreed that water reuse efforts are associated with various costs. Treatment, infrastructure and engineering were identified as three primary types of costs associated with water reuse. However, interviewees also suggested that these projects may have opportunity costs, and might incur additional costs, including those associated with transporting effluent, testing, system maintenance, staff and legal fees.

Some of these expenses will likely be one-time costs such as infrastructure costs, while some will be ongoing, such as the cost of treatment, energy and staff. The participants noted that the costs would also depend on the type of reuse. For example, one interviewee said that non-potable reuse may require less treatment. In the meantime, he emphasized that the cost savings associated with less treatment might be offset by expenses associated with a separate piping system, which is often required for non-potable reuse projects.

Interviewees were also asked to provide some suggestions they would want communities, local decision-makers or state legislators to consider as they embark on water reuse efforts. One of the suggestions on this issue was to compare the cost of water reuse with the cost of any available new water sources. Additionally, the interviewees recommended considering geographical location, water quality requirements, distribution system needs, energy costs, and potential subsidies or cost-sharing opportunities, among other factors, when deciding to embark on a reuse project.

Most interviewees generally predicted that utility rates associated with water reuse efforts will increase due to capital costs, ongoing treatment and maintenance. However, they anticipated that the level of increase would depend on the type of reuse and overall expenses associated with these efforts. Several interviewees thought that direct potable reuse projects would result in higher costs due to the

type of treatment required and expenses associated with public education and outreach work. The interviewees also noted that an increase in utility rates will likely motivate customers to use less water thus leading to conservation. Moreover, several interviewees felt that water is often underpriced, and current pricing structures offer little incentive to conserve.

In a survey of water utility superintendents and managers, over half of those with current reuse (6 of 11) indicated that their organizations had to invest in additional infrastructure in order to implement the reuse project. However, none indicated that water utility rates had been impacted for the general population, and the most commonly selected method of financing a reuse project was charges to specific users who purchase the reused water.

“The impact to low-income and elderly people will be disproportionate in terms of how much income it takes to have access to water.” – Key Informant

“More than likely utility rates would need to increase or the projects could be paid for some other way.” – Key Informant

“There could be some options where with some industrial users [...] some of the cost to residential users could be offset.” – Key Informant

Conclusion

Based on the literature, costs are likely to increase as a result of implementing water reuse projects, however, utility rates could increase, decrease, or stay the same, resulting in neutral-to-adverse health impacts (Figure 30, page 63).

In general, water reuse projects are associated with a variety of initial and ongoing costs. Major

cost components for water reuse projects include the costs of infrastructure, operations and maintenance. The magnitude of costs may depend on the type of reuse, the desired water quality and the method and distance of water distribution. Due to specialized treatment, expenses associated with potable reuse may be higher than with non-potable reuse. However, in some cases, water reuse may be less costly than the development of other new water sources.

Funding water reuse projects can be challenging because reused water can be perceived to be a lower-quality product, therefore it is difficult to charge the price needed for cost recovery. Reusing water in smaller communities can be more expensive on a per capita basis, and there may be more barriers to securing state or federal loans.

An increase in treatment and infrastructure costs associated with reuse should, theoretically, increase utility rates. However, according to the literature, utility rates could increase, decrease or stay the same as a result of water reuse. Changes

in utility rates may depend on the magnitude of the costs, availability of alternate funding sources, and the community's perception of and demand for reused water. In a survey of Kansas water utility managers and superintendents, of the 11 respondents that indicated current water reuse projects, none indicated that reuse had impacted utility rates for the general population.

If utility rates were to increase, some populations may be more impacted than others. These include individuals who are low-income, elderly, and those served by small and rural community water systems. These individuals are more likely to already be paying a higher percentage of their current income on water and wastewater bills, and an increase in rates may become unaffordable for them. Because of the critical nature of water and wastewater service, keeping these utilities turned on could require that families make trade-offs and go without other necessities such as food, medical expenses and heating and cooling. Going without these essentials could result in negative health impacts.

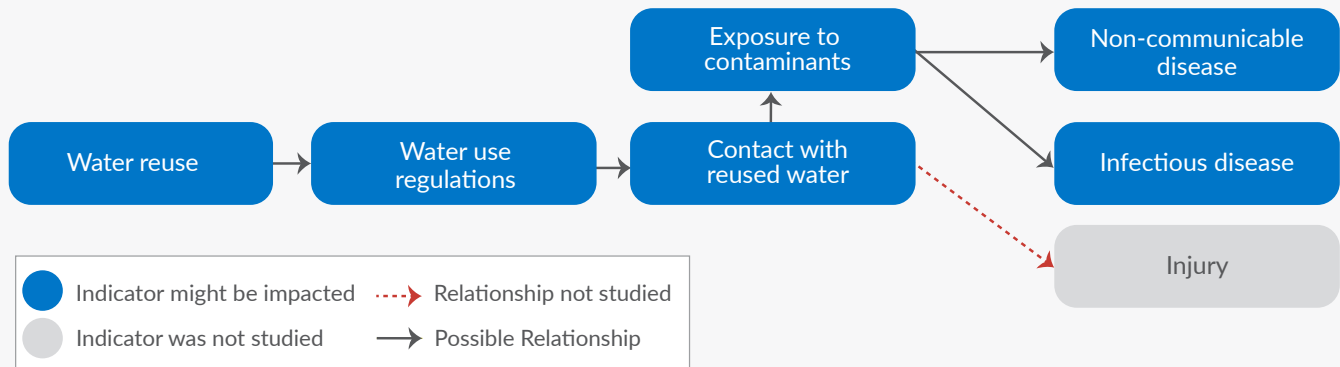
Figure 30. Impact of Water Reuse on Costs and Utility Rates and Associated Health Impacts

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Costs of Reuse	Increase	N/A	Increase	Increase	See "Utility Rates" below				****
Utility Rates	Mixed	N/A	Increase	Mixed	Neutral to Adverse	Some	Low-income; Elderly; Those from small/rural community water systems	Possible	**

Note: See Legend, Appendix B, page 74.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure 31. How Water Reuse May Impact Guidance and Regulations and Associated Health Impacts



Source: KHI Municipal Water Reuse HIA, 2017.

FINDINGS

- Regulations for water reuse will increase as a result of additional reuse projects in the state. However, this change is likely to happen gradually over time.
- A regulatory framework for categorizing and reporting on water reuse is typically implemented in states with widespread water reuse, as well as those considering expanding reuse.
- Regulations for water quality (depending on intended use), public access, monitoring, and reporting are typically included in state water reuse frameworks.
- The successful implementation of any new regulations may have beneficial effects. However, it is possible that the regulations will maintain, rather than improve upon, the current state of health in Kansas.

RECOMMENDATIONS

KDHE could consider:

- Implementing a streamlined permitting process for reuse.
- Developing clear and consistent regulations based on the best-available science and lessons learned from Kansas reuse projects and other states.
- Incorporating best practices into any new regulatory guidance. Best practices include: maintaining public health as a top priority; preventing cross-connections (actual or potential contact between potable and non-potable water supplies); marking all non-potable components; having a proactive public information program; having a monitoring and surveillance program; training utility staff members on reuse; establishing construction and design standards; and ensuring physical separation of potable and non-potable water lines. Additional best practices may be found in the EPA's *Guidelines for Water Reuse* document.
- Developing water reuse guidance and regulations based on the experience from other states, such as California and Texas.

- Giving flexibility to municipalities undertaking reuse projects.
- Making sure that the regulations are as current as possible (align with new evidence, standards).
- Establishing consistent requirements for signage to limit public contact with lower-quality, non-potable reused water.
- Reviewing World Health Organization (WHO) guidelines for water reuse to learn about international best practices.
- Adopting a water policy that takes a holistic approach that considers the physical, social and economic conditions within a watershed, aquifer and river basin context.

Note: See *Appendix C*, page 75, for a detailed list of all of the HIA recommendations and their sources.

Background and Current Conditions

In Kansas, water and wastewater utilities must adhere to regulations for drinking water and wastewater quality—see page 16–17 for descriptions of the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA). However, there is not currently a standardized framework of regulations for water reuse in Kansas.

Wastewater treatment plants that are engaged in reuse have water quality and monitoring requirements for the reused water included in their National Pollutant Discharge Elimination System (NPDES) discharge permits. These requirements are set on a case-by-case basis.

What We Learned from Literature

Water regulations are created to reflect how society values water, uses water and manages it to ensure availability.³⁵² When a community decides to reuse water, new regulations and requirements are introduced.³⁵³ However, current regulations are often considered inadequate to support the

information needed by water resource managers or other stakeholders. The lack of a streamlined regulatory process is frequently cited as a top barrier to the implementation of water reuse projects. Contributing to this may be the fact that regulations for reused water are not federally mandated, but differ by state.^{354 355} Water reuse regulations can include requirements for water quality, types of uses and monitoring. Regulations may also include guidance on minimum discharge requirements, which is more common in areas that rely on surface water and where downstream communities have a right to stated amounts of discharged effluent.³⁵⁶ Additionally, some literature noted that because water utilities are regulated entities, government policies can influence rate setting, subsidizing initial costs and quality testing.³⁵⁷ Other regulatory concerns include the navigation of complicated determinations of authority. In some states, the authority or agency responsible for regulating the quality of reused water may vary by type of reuse project.³⁵⁸

California is one of several states that has been reusing water for many years. Some of California's water reuse regulations include specifications on permit management, reporting, allowable contaminant levels for each type of reuse, signage,

and cross-connection management.³⁵⁹ Standards specific to type of use include differing regulations by the level of contact with the water.

The U.S. Environmental Protection Agency (EPA) also has developed guidelines for water reuse in its report, *Guidelines for Water Reuse*, which was first published in 2004 and updated in 2012.³⁶⁰ Though the guidelines are not federally required, some states use these guidelines for the development of state-level regulations. In order to provide

guidance specific to types of reuse, the EPA has recommended a variety of reuse categories to aid in the development of state-level reuse regulations.³⁶¹

Figure 32 outlines the reuse categories and their descriptions. The table beginning on pages 4–9 of the EPA document, *Guidelines for Water Reuse*, includes more specific details about guidelines for contaminant levels, treatment types, monitoring, and setback distances for each type of reuse.

Figure 32. Reuse Categories in EPA Guidance, 2012

REUSE CATEGORY	DESCRIPTION
Urban Reuse (restricted and unrestricted)	The use of reclaimed water for non-potable applications. Public access may be restricted or unrestricted.
Impoundments (restricted and unrestricted)	The use of reclaimed water in an impoundment. Depending on the water quality, there may or may not be restrictions on body contact with water (e.g., swimming).
Agricultural Reuse (food crops and non-food crops)	The use of reclaimed water to irrigate crops. There are different requirements for crops that are and are not for human consumption.
Environmental Reuse	The use of reclaimed water to create, enhance, sustain, or augment water bodies, including wetlands, aquatic habitats or stream flow.
Industrial Reuse	The use of reclaimed water in industrial applications and facilities, power production and fossil fuel extraction.
Non-Potable Groundwater Recharge	The use of reclaimed water to recharge aquifers that are not used as a potable water source.
Indirect Potable Reuse	Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes normal drinking water treatment.
Direct Potable Reuse	The introduction of reclaimed water directly into a water treatment plant, either co-located or remote from the advanced wastewater treatment system.

Source: U.S. Environmental Protection Agency, 2012.

Other states with established reuse regulations include “classes” to describe the categories of reuse and accompanying requirements. Most are some combination of the categories and requirements listed in the table above.

Regulating reused water for both safety and consistent quality has been raised as a key issue.³⁶² Although water reuse is impacted by existing regulations for water quality, including the CWA and SDWA, researchers note that these regulatory frameworks are not sufficient to

address concerns related to water reuse for potable purposes.³⁶³

As early as 1998, a committee recommended that the EPA develop a list of contaminants that are specific to wastewater that may be important when considering reuse. No such list exists, but some states and localities have taken steps to address this concern locally.³⁶⁴ The California Department of Public Health has received positive reviews for developing a policy that set consistent permitting, nutrient, and contaminant requirements and

established a Blue Ribbon Panel for evaluating contaminants of emerging concern.³⁶⁵

Contaminants of emerging concern are particularly difficult to regulate as few target thresholds have been set, the threat to human health is often not well established, and the expense and expertise associated with monitoring may be prohibitive.³⁶⁶

Non-Potable Reuse Guidelines

Guidelines and regulations for non-potable uses often include restrictions on access to or contact with reused water. Examples include restricting access to golf courses so that they can be watered when not in use, allowing only certain types of recreation (i.e., fishing, but no swimming) in lakes that have reused water of lower quality, and specification for spray irrigation versus subsurface irrigation in parks and ball fields.³⁶⁷ Other requirements for non-potable reuses include setting minimum distances from potable water wells, signage indicating where reused water has been applied, and the requirement to use purple pipes for dual distribution systems.³⁶⁸

Indirect Potable Reuse Guidelines

Groundwater recharge project specifications include contaminant-specific information, a plan for providing alternative water should the system fail, and differential specifications based on the time it takes for water to travel through the environmental buffer.³⁶⁹ The EPA recommends at least two months of travel time through the environmental buffer, in addition to requiring that the water meets drinking water standards, either at the point of injection (for aquifer recharge via injection) or upon reaching the aquifer (for aquifer recharge via infiltration).³⁷⁰ When groundwater is recharged through infiltration, rather than injection, state and local regulations apply, but there are no applicable federal regulations. When injection is used for aquifer recharge, some portions of the SDWA are applicable.³⁷¹

Direct Potable Reuse Guidelines

Developing regulations for direct potable reuse can be a balancing act. While some note that

wastewater treated for direct potable reuse may not differ substantially from current source water quality, especially where de facto reuse is high, it is important for regulations to consider the potential risks that direct potable reuse might introduce.

The EPA did not provide regulatory guidance for direct potable uses, and to date, no state has implemented regulatory standards for direct potable use, rather, these projects are addressed on a case-by-case basis. However, when direct potable reuse is practiced in the United States, water is required to meet the standards set by state and federal entities for drinking water quality, and is often treated to an even higher standard than drinking water. The Texas Water Resources Board developed a resource document regarding direct potable reuse in the state, which provides guidance on costs, treatment types, and regulatory frameworks for direct potable reuse.

Other Recommendations and Best Practices

California's statewide Water Plan includes recommendations to streamline the reuse permitting process, remove funding barriers, support regionalized and integrated water management plans, introduce limits on new demands on the water supply, and prohibit wasteful uses of water.³⁷⁶ The Water Plan's funding recommendations include new financing strategies, such as low-interest loans and grant programs, funding assistance to vulnerable communities, and analysis of user and polluter fees to ensure that existing rate structures place the cost burden on the largest and most detrimental users.³⁷⁷

Recommendations from other sources include simulating emergencies as is done in other situations where there is the potential for a low-likelihood, high-impact system breakdown—such as in the aviation industry or for natural disaster preparedness—to ensure an appropriate, rapid response to crisis. Some have also recommended the creation of an independent federal oversight committee.³⁷⁸

What We Learned from Stakeholders

The majority of stakeholders thought that a regulatory framework would be developed as a result of additional water reuse projects being implemented in Kansas; however, some thought that appropriate regulations already exist to support water reuse. One interviewee noted that it is unlikely that a regulatory framework would be put into place preemptively. When asked about potential recommendations related to regulations, several stakeholders stressed the importance of ensuring that the regulations be kept up-to-date and reflect the best-available evidence. In addition, the interviewees suggested to develop regulations based on the experience and practices of states with a long history of reuse.

“The regulatory requirements will increase with the quantity of reuse.”

– Key Informant

Conclusion

A regulatory framework for categorizing and reporting on water reuse is typically implemented in states with widespread water reuse, as well as in those considering expanding reuse. Regulations and guidance include requirements for water quality (depending on intended end-use), public access, monitoring and reporting. Stakeholders believed that an additional or enhanced regulatory framework would be developed in Kansas, but that it would likely be developed as a response to an increase in water reuse projects. Some stakeholders thought that regulations already exist to support water use.

Because most water reuse regulations exist to protect the public’s health and the environment, the successful implementation of the regulations may have a beneficial effect of health. However, it is possible that the regulations will maintain, rather than improve upon, the current state of health in Kansas.

Based on available information, regulations for water reuse will increase over time as a result of additional reuse projects in the state, which may have a neutral-to-beneficial effect on health (Figure 33).

Figure 33. Impact of Water Reuse on Regulations and Associated Health Impacts

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Regulations	Increase	N/A	Increase	Increase	Neutral to Beneficial	Most/All	Communities with water reuse	Likely	**

Note: See Legend, Appendix B, page 74.

Source: KHI Municipal Water Reuse HIA, 2017.

Reuse, Parks and Physical Activity

One of the impacts included in the initial pathway diagram was the community's access to and utilization of parks and green space as a result of water reuse and perceptions of water reuse. While there was limited literature to indicate whether water reuse impacts parks and green spaces, their availability in a community can impact levels of physical activity.

Below are some issues that could be considered as reuse is implemented.

- Monitoring the extent to which water reuse can increase the availability of parks and green spaces in a community.
- Utilizing reused water to enhance or expand availability of parks and green spaces.
- Educating the public on the quality of the water used in parks and green spaces.

What We Learned from Literature

There is limited research available on the impact of perceived irrigated water quality on the public's utilization of parks and green space. There is some emerging concern about exposure to antibiotic-resistant bacteria in parks or other spaces irrigated with reclaimed water.³⁷⁹ Several suggestions have been made to mitigate these concerns, including utilizing ultraviolet disinfection, altering irrigation schedules to reduce airborne exposure, and discontinuing open air storage of non-potable water between treatment and irrigation.³⁸⁰

However, there are several mediators of park use that are well understood. The perception of low safety has been found to be a barrier to park use.³⁸¹ Park use is also strongly influenced by programming, amenities and the distance of the park from a person's home.^{382 383 384 385} Overall, availability of parks and recreational facilities contribute to

increased physical activity.³⁸⁶ However, only certain types of parks lead to this increase—including trails, golf courses, open spaces and natural settings; while recreation centers, exercise facilities and sports facilities did not indicate an increase the rate of physical activity.³⁸⁷

What We Learned from Data

Of the 118 permits that allow for reuse in Kansas, 24 (approximately 20 percent) of them apply reused water to irrigate public parks, golf courses or ball fields. There is no clear indication, however, that these facilities would not be irrigated if the reused water was not available.

Research has shown that there are many factors that impact participation in physical activity.³⁸⁸ Growing evidence points to the importance of the built environment and policy actions in making opportunities for physical activity accessible to all people. Parks and outdoor spaces are one component of the built environment that provide the opportunity for individuals to be physically active. According to Healthy People 2020, some of the primary factors that are associated with physical activity include: educational attainment, income, age, motivation, self-efficacy, rural residency, access to exercise facility, overweight or obesity status, and perception of poor health.

The KHI HIA Team examined the connection between the number of parks in a community and the population-level rates of physical activity. It was found that the number of parks in a community is significantly positively correlated with adult physical activity in Kansas ($p < .01$), even when controlling for factors that are associated with physical activity, including income, population density, and the perception of poor health. However, educational attainment was most strongly correlated with physical activity, and when it was included in the regression model, the number of parks in a community was no longer significantly correlated with physical activity.

What We Learned from Stakeholders

In general, interviewees suggested that communities would continue using parks and green spaces that have been watered with reused wastewater. The participants noted that some individuals that haven't been educated about the reuse efforts or don't trust the government might initially be hesitant about using parks and green spaces. To address this issue, interviewees suggested educating residents about wastewater treatment and monitoring processes.

“If it goes into a park where you want to take your children out to play at the park, they (people) would need some assurance.” – Key Informant

“Communities that I am aware of take pride in the fact that they implement these types of projects.”

– Key Informant



APPENDICES

*Lab at the Land Institute, south of Salina, Kansas.
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Figure A-1. Summary of Health Impacts of Municipal Water Reuse

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Water Availability†	Increase	Increase	Increase	Increase	Beneficial	Most/All	Communities with lower water security; Water-dependent industries or amenities	Possible	**
Community Sustainability†	Increase	Increase	Increase	Increase	Beneficial	Most/All	Those without the resources to relocate or seek services elsewhere	Possible	****
Water Quality	Mixed	N/A	No change/ Increase	Mixed	Neutral^	N/A	N/A	N/A	****
Non-potable	Decrease	N/A	No change	Decrease	Neutral to Adverse	Few	Individuals with a compromised immune system or other health-related issues	Unlikely	N/A
Indirect potable	Increase	N/A	Mixed	Increase	Neutral	N/A	N/A	N/A	N/A
Direct potable	No change/ Increase	N/A	No change/ Increase	No change/ Increase	Neutral^	N/A	N/A	N/A	N/A
Community Perception of Water Quality††	Decrease	N/A	Decrease	Decrease	See "Consumption of beverages other than municipal water" below				****
Consumption of beverages other than municipal water	Increase	N/A	Increase	Increase	Adverse	Some	Some racial and ethnic minority groups; Low-income populations; Individuals with a compromised immune system	Possible	****

Health Factor or Outcome	Literature Review	Data Analysis	Stakeholder Perspectives	Based on Literature and Data					Literature
				Overall Projection	Expected Health Impact	Magnitude of Impact	Distribution of Impact	Likelihood of Impact	Quality of Evidence
Costs of Reuse	Increase	N/A	Increase	Increase	See "Utility Rates" below				****
Utility Rates	Mixed	N/A	Increase	Mixed	Neutral to Adverse	Some	Low-income; Elderly; Those from small/rural community water systems	Possible	**
Regulations	Increase	N/A	Increase	Increase	Neutral to Beneficial	Most/All	Communities with water reuse	Likely	**

Note: See Legend, *Appendix B*, page 74.

† Relates to communities with lower water security. The health impact would not be applicable to communities who are water secure, because they will have access to other water resources.

^ As of December 2016, research does not indicate that there have been any outbreaks of illness connected to direct potable or other types of reuse. However, concerns remain about the potential risks of human error or system breakdown and associated impacts on health given the source and end-use of the reused water.

† † Despite a perception that reused water quality is lower than that of the current/traditional municipal water supply, acceptability may vary by type of reuse. Non-potable reuse may have highest acceptability, whereas direct potable reuse has the lowest acceptability.

Source: *KHI Municipal Water Reuse HIA, 2017*.

Figure B-1. Legend: Health Impacts for Kansas

CRITERIA	DESCRIPTION
Direction – Projects the direction of change based on the proposed rule.	Increase – Literature (data) achieves consensus that this indicator might increase. Decrease – Literature (data) achieves consensus that this indicator might decrease. Mixed – Literature (data) lacks consensus about this indicator’s potential direction. No effect – Literature (data) suggests that this indicator might remain unchanged.
Expected Health Impact – Indicates whether the health impact is beneficial or adverse.	Beneficial – Change may improve health. Adverse – Change may impair health. Uncertain – Unknown how health may be impacted. Mixed – Change may be positive as well as negative. None – No identified effect on health.
Magnitude – Indicates how widely the health effects would be spread within a population or across a geographical area.	Few – Few or very few people, such as specific individuals or households. Some – Less than half of the population of a given community. Many – More than half of the population of a given community. Most/All – Nearly the entire community or regional impact.
Distribution – Describes the population most likely to be affected by changes in the health factor or outcome.	The populations that are projected to be impacted.
Likelihood – The chance that a given exposure will occur.	Likely – There is a high chance that impacts will occur as a result of municipal water reuse. Possible – There is some chance that impacts will occur as a result of municipal water reuse. Unlikely – There is a low chance that impacts will occur as a result of municipal water reuse. Uncertain – It is unclear if impacts will occur as a result of municipal water reuse.
Quality of Evidence – The strength of the quality of evidence (literature only) to support the judgements made when characterizing the impacts.	**** – Strong literature. ** – Sufficient literature. N/A – Quality of evidence wasn't separately assessed for this health factor/outcome.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure C-1. Key Findings and Recommendations

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
WATER AVAILABILITY		
<ul style="list-style-type: none"> • Implementation of water reuse has the potential to increase the water available for community use. • Because reuse introduces a new source into the water portfolio of a community, it either increases or prevents a decrease in the amount of water available. However, the magnitude of the increase in water availability for municipal uses would depend on the scale and scope of water reuse projects, and is likely relatively small compared to overall water use. • There are potential health benefits to an increase in water availability. Not only does an increase in the quantity of water impact the quality of that water, the availability of water may impact the long-term economic, social and environmental sustainability of communities. 	<p>Municipalities could consider:</p> <ul style="list-style-type: none"> • Creating long-term water plans. – AP • Collaborating with local, regional and state partners to manage water resources. – L • Partnering with the Kansas Association for Conservation and Environmental Education (KACEE) to continue and expand the delivery of water festival curriculum to educate students about the sources and value of water, and to include water reuse in the curriculum. – AP • Partnering with engineering firms with expertise in reuse, and exploring reuse as part of water source development. – AP • Building awareness that water is a limited resource (e.g., incentivizing use of water-efficient technologies, media campaigns and educational activities). – S • Utilizing water resources for public benefit, such as maintaining or enhancing parks and green spaces. – T • Reviewing the top 10 water users (i.e., industrial, commercial customers that are using large quantities of water) and working with them to identify water needs and potential interest in reuse. – S • Characterizing available wastewater quantity and quality, and understanding regulations and the potential for reuse. – S • Assessing the long-term availability of water for the community. Water reuse can be considered as a potential solution to water supply issues, along with other options. This decision should be made with considerations for social, environmental, political and economic feasibility. – S, AP • Reaching out to other communities that have conducted reuse and learning about their approach/experience. – S <p>Water utility managers could consider:</p> <ul style="list-style-type: none"> • Collaborating with community members, policymakers and scientists to develop workable solutions to water scarcity. –AP • Managing water reuse and water conservation in collaboration with other partners.* – L 	<p>Literature indicates that a holistic approach to water management is necessary for communities to manage their water resources. Breaking down silos, and implementing processes for participatory decision-making, problem solving, collaboration, trust-building, information-sharing can help communities to maximize their available water supply and increase resilience to water scarcity.^{389 390 391 392 393}</p> <p>Additionally, communities that use their water resources for public benefit, such as for parks and green spaces, could have positive impacts on physical activity and related health outcomes, such as obesity, heart disease and mental health.³⁹⁴</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
WATER AVAILABILITY CONTINUED		
	<p>Researchers could consider:</p> <ul style="list-style-type: none"> • Quantifying the social, economic and environmental consequences of water reuse in areas of water scarcity in Kansas.* – L • Developing a locally tailored measure of water resource sustainability and groundwater stress. – S <p>Policymakers/legislators could consider:</p> <ul style="list-style-type: none"> • Encouraging water reuse as a strategy for additional supply through recommendations and/or financial incentives.* – S 	
COMMUNITY SUSTAINABILITY		
<ul style="list-style-type: none"> • Communities may experience an increase in long-term sustainability as a result of increases in water availability. Due to the small potential change in overall water availability for reuse, the potential increase in community sustainability may be small. • Water is essential for Kansas communities, and some may be at risk for extreme water scarcity which would make it difficult for communities to survive. There is documentation of the role of water scarcity in driving people from agricultural communities to urban centers. • However, there are many components of community sustainability, of which, water availability is just one. There are social, economic, and environmental factors that contribute to the resilience of communities in the face of changes to water availability. Communities that are most resilient and sustainable are those that can draw upon strengths in the social, economic and environmental realms. • An increase in community sustainability has been linked to individual and overall mental health. 	<p>Municipalities could consider:</p> <ul style="list-style-type: none"> • Participating in processes for ongoing, long-term water planning.* – L • Developing robust processes for monitoring elements of community sustainability. – L • Focusing on strengthening the social, economic and environmental aspects of the community as part of an overall approach to resilience. – L 	<p>Literature indicates that communities whose water utilities engaged in long-term water planning are more resilient in the face of challenges than those without similar plans. Additionally, some key elements of sustainability and successful community adaptation include leadership, information-sharing, and monitoring outcomes of changes to the community and the environment.^{395 396}</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
WATER QUALITY		
<ul style="list-style-type: none"> Water quality may increase, decrease, or stay the same compared to current drinking water quality. The direction of change depends on the type of reuse that is implemented. With current technology, water can be treated to any quality required by the desired end-use within the boundaries of available funds. Reused water quality depends on the type of reuse. Non-potable reused water is treated to a lower standard and is therefore, lower quality overall. Water treated for indirect and direct potable purposes is highly treated and may be of equal or better quality than current drinking water. Potential risks associated with the reuse of water include contaminants of emerging concern, such as personal care products, pharmaceuticals and disinfectant byproducts. 	<p>Municipalities could consider:</p> <ul style="list-style-type: none"> Reviewing water and wastewater treatment plans with regulatory agencies to ensure that they are appropriate for the intended use. – S Investing in professional development to maintain knowledge of the most current technology available for wastewater treatment and water reuse. – L Assuring sufficient operational monitoring and adherence to quality requirements for water and wastewater. – T Pilot testing/bench scale testing for reuse within the current framework to ensure expected quality is achieved. – S/T Developing local plans to test for different viruses or other contaminants that might be of concern in the water reuse project. – S <p>KDHE could consider:</p> <ul style="list-style-type: none"> Establishing a task force to address contaminants of emerging concern in reuse and the traditional water supply on an ongoing basis. – L Establishing consistent requirements for signage to limit public contact with lower-quality, non-potable reused water.* – AP <p>Academic and research organizations could consider:</p> <ul style="list-style-type: none"> Conducting and communicating research related to the quality of reused water. – AP <p>KDHE and municipalities could consider:</p> <ul style="list-style-type: none"> Working together to identify and adhere to standards, processes and best practices for ensuring the quality of reused water. – S 	<p>According to the literature, a standardized and consistent policy for water reuse permitting, water quality, and types of reuse is beneficial for perception of and actual water quality.³⁹⁷</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
COMMUNITY PERCEPTION OF WATER QUALITY		
<ul style="list-style-type: none"> • The community’s perception of reused water quality is lower than that of current drinking water. • Reused water is typically perceived to be a lower-quality product by the community. There are several components of this perception, including the often-cited “yuck” factor, which is an aversion to using formerly soiled water, as well as the public’s trust of the system’s ability to ensure health and safety. • Regardless of actual water quality, the acceptability of reused water is lower as the potential for human contact with the water increases. • A positive community response to water reuse may depend, in part, on how important the community perceives the project to be, as well as other various factors, including trust in local government and treatment technologies, reasonable costs, an emphasis on water conservation, environmental benefits, protecting health, and recognition that water is a limited, valuable resource. • The primary health implications of a decrease in community perception of water quality were found in the switch from drinking tap water to bottled water or other sugary beverages. 	<p>Kansas municipalities could consider:</p> <ul style="list-style-type: none"> • Implementing targeted outreach and education campaigns about reuse, including information about the social and environmental costs and benefits, institutional structures, regulatory systems and alternate solutions.* – L • Seeking out and incorporating feedback from community members and leaders about reuse. – L • Demonstrating the utility’s trustworthiness by maintaining compliance with the Safe Drinking Water Act standards.* – L • Developing emergency intervention and monitoring plans to capture and respond to any breakdowns in the treatment system. – L • Framing potable reuse as recycling or an improvement over de facto reuse. – L • Requiring public relations and communication training for water and wastewater utility managers. – L • Developing vocabulary and imagery that lends positive connotation to reuse. – L • Providing information about current water quality and treatment mechanisms, more frequently than the annual <i>Consumer Confidence Report</i> (CCR). – AP • Providing information about wastewater treatment quality, including seeking out independent laboratory verification of wastewater quality, and the sharing of annual financial audits. – T, AP • Educating and providing information to the city council about water supply and water reuse. – AP • Regularly educating the public about their water supply, water quantity, water quality and how water reuse projects can positively impact their city’s environment. – S • Taking steps to assess the community’s perception of and acceptability towards various types of water reuse (e.g., community survey). – L <p>State agencies that are involved in water education could consider:</p> <ul style="list-style-type: none"> • Educating and communicating with the public about water reuse.* – S 	<p>According to the literature, communicating with the public about reuse is essential to building trust, which impacts the success of a reuse project. In addition to allowing opportunities for feedback on the decision, it was found that providing information about broad social, environmental, and economic impacts of reuse was important to community members.</p> <p>Developing a consistent policy framework also had a positive impact on public perception of water reuse. Additionally, selecting the right words and imagery can help frame reuse in a positive manner and can remove some psychological barriers that may exist for the issue of reuse.^{398 399 400 401 402} It is critical that transparency and good communication are conducted proactively, prior to the implementation of a reuse project, because it is extremely difficult to regain public trust after it has been broken.^{403 404 405}</p> <p>Finally, decision-makers should have information about the community’s perception of water reuse. The literature suggests seeking information about community attitudes regarding various types of reuse.⁴⁰⁶</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
CONSUMPTION OF BEVERAGES OTHER THAN MUNICIPAL WATER		
<ul style="list-style-type: none"> Decreases in the community's perception of water quality could lead to an increase in consumption of bottled water and sugary beverages. Changes in the perception of water quality would impact the purchase and consumption of beverages other than municipal water, such as bottled water or sugary beverages. The potential health impacts of a switch to bottled water include impacts on oral health—particularly for children—due to missing out on a fluoridated municipal water supply. An increase in sugary beverage consumption may also lead to an increase in tooth decay and chronic conditions such as obesity and diabetes. Racial and ethnic minority groups, such as Latinos and African Americans, may be more likely to consume bottled water and sugary beverages as a result of low trust in the quality of the municipal drinking water. There is often a perception that bottled water is of higher quality than municipal drinking water, whereas in fact, some evidence points to the opposite: bottled water is not regulated the same as drinking water, and the presence of some contaminants may be higher than in municipal water. Economically disadvantaged populations may be at higher risk for negative financial implications of purchasing beverages that are more expensive than municipal water. 	<p>Water regulators could consider:</p> <ul style="list-style-type: none"> Pursuing similar quality, monitoring and reporting requirements on bottled water as municipal water supplies. – L <p>Municipalities could consider:</p> <ul style="list-style-type: none"> Increasing public awareness of the impact of bottled water consumption on oral health, household budgets, and the environment. – L Improving community perception of drinking water by communicating early and often and building/maintaining transparency and trust with the community.* – L <p>Local public health agencies could consider:</p> <ul style="list-style-type: none"> Engaging in health promotion strategies to highlight the health benefits of water consumption over other beverages such as sodas, juices and other sugary drinks.* – L 	<p>Literature suggests the need for information to be provided to the public about the health, financial, and environmental impacts of bottled water consumption, together with clear information about the quality of tap water. Literature also points to a need for clear and consistent requirements for bottled water quality, such as those that exist for municipal water supplies.^{407 408}</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
COSTS OF REUSE		
<ul style="list-style-type: none"> • A variety of initial and ongoing costs will be introduced as a result of implementing water reuse. • The magnitude of costs may depend on aspects related to the type of reuse, such as desired water quality and the method and distance of water distribution. Due to specialized treatment, expenses associated with potable reuse may be higher than with non-potable reuse. • In some cases, water reuse may be less costly than the development of other new water sources. 	<p>Kansas municipalities could consider:</p> <ul style="list-style-type: none"> • Identifying funding sources that could help cover costs related to reuse, including: the Community Development Block Grant (CDBG), USDA Rural Development, Rural Community Assistance Partnership, and the Midwest Assistance Program (MAP). – L • Working together with partners to share the costs and benefits of reuse infrastructure (e.g., industry partners, neighboring municipalities).* – AP, S • Coordinating between water, wastewater and stormwater to plan and finance water reuse projects. – AP • Including fees on water/wastewater bills to build a pool of funds for financing reuse projects. – AP • Integrating reuse infrastructure into areas of new development. – L • Balancing the most cost-effective reuse option with community acceptability.* – L • Communicating with industrial partners about the water environment that is supporting their operations and any threats to its sustainability. – L • Comparing the costs of reused water to the costs of new source development or the costs to the community of water scarcity. – L • Investing in infrastructure that is supportive of reuse as aging water infrastructure is replaced. – L • Identifying local sources of funding, including bond financing. – T • Ensuring that the project’s cost and sale estimates are realistic. – L <p>KDHE could consider:</p> <ul style="list-style-type: none"> • Prioritizing any state financial support of reuse by using a framework that accounts for access to alternative funding sources. – L • Waiving application fees and/or inspection fees for municipalities interested in pursuing water reuse efforts. – S • Providing grant funding to municipalities or help municipalities apply for grant funding associated with water reuse. – S • Providing a template policy/process for coordination between water and wastewater utilities. –AP 	<p>Literature suggests that capitalizing on opportunities for investing in infrastructure that allows for reuse, such as when existing infrastructure is already being replaced or when new developments are being built, is an effective strategy for ensuring a cost-effective source of water supply in the future.^{409 410 411}</p> <p>Literature also suggests that a funding allocation mechanism, targeting areas that are vulnerable to water shortages for priority funding of reuse projects, can make a positive impact on the overall water environment.⁴¹²</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
COSTS OF REUSE CONTINUED		
	<ul style="list-style-type: none"> • Working with federal agencies to streamline the process for local funding. – AP • Dedicating funding to support long-term water planning efforts. – AP • Allowing the use of loan programs as incentive for private businesses to embark on water reuse efforts, similar to the state revolving loan fund. – S 	
UTILITY RATES		
<ul style="list-style-type: none"> • Utility rates could increase, decrease or stay the same as a result of water reuse. • Changes in utility rates may depend on the size of the costs, availability of alternate funding sources, and the community's perception of and demand for reused water. • If utility rates did increase, some populations may experience negative impacts. These include individuals who are low-income, elderly, and those served by small and rural community water systems. These individuals are more likely to already be paying a higher percentage of their current income on water and wastewater bills, and an increase in rates may become unaffordable for them. • Because of the critical nature of water and wastewater service, keeping these utilities turned on could require that families make trade-offs and go without other necessities such as food, medical expenses, and heating and cooling, among others. 	<p>Kansas municipalities could consider:</p> <ul style="list-style-type: none"> • Pricing reused water at a lower rate in order to encourage its use, if needed, based on community acceptability. – L • Pricing water to account for scarcity by increasing the rate for high-volume users.* – L • Implementing affordability programs for low-income individuals, such as lifeline rates, payment plans, bill discounts, leak repair assistance programs, and others.* – L • Requiring staff training for items such as: 1) how to identify causes of and customers experiencing financial hardship, 2) how to communicate with or assist customers experiencing hardship. – L 	<p>Literature suggests that pricing reused water at a lower rate may encourage its use and increase the public acceptability of reuse. However, utilities need to remain financially stable, and in order to not increase rates for all customers, the literature recommends higher water pricing for high-volume users.^{413 414 415}</p> <p>Literature also suggests that increases in utility rates may present hardships to some customers, and a variety of sources present recommendations for addressing affordability for potentially vulnerable customers.^{416 417}</p>

KEY FINDINGS	POSSIBLE RECOMMENDATIONS	RATIONALE
REGULATIONS		
<ul style="list-style-type: none"> Regulations for water reuse will increase as a result of additional reuse projects in the state. However, this change is likely to happen gradually over time. A regulatory framework for categorizing and reporting on water reuse is typically implemented in states with widespread water reuse, as well as those considering expanding reuse. Regulations for water quality (depending on intended use), public access, monitoring, and reporting are typically included in state water reuse frameworks. The successful implementation of any new regulations may have beneficial effects. However, it is possible that the regulations will maintain, rather than improve upon, the current state of health in Kansas. 	<p>KDHE could consider:</p> <ul style="list-style-type: none"> Implementing a streamlined permitting process for reuse. – AP Developing clear and consistent regulations based on the best-available science and lessons learned from Kansas reuse projects and peer states. – L Incorporating best practices into any new regulatory guidance. Best practices include: maintaining public health as a top priority; preventing cross-connections (actual or potential contact between potable and non-potable water supplies); marking all non-potable components; having a proactive public information program; having a monitoring and surveillance program for the non-potable system; training staff members for reuse connections; establishing construction and design standards; and ensuring physical separation of potable and non-potable water lines. Additional best practices may be found in the EPA’s <i>Guidelines for Water Reuse</i> document.* – L Developing water reuse guidance and regulations based on the experience from other states, such as California and Texas. – S Giving flexibility to municipalities undertaking reuse projects. – S Making sure that the regulations are as current as possible (align with new evidence, standards). – S Establishing consistent requirements for signage to limit public contact with lower-quality, non-potable reused water. – AP Reviewing WHO guidelines for water reuse to learn about international best practices. – T Adopting water policy that takes a holistic approach that considers the physical, social and economic conditions within a watershed, aquifer and river basin context. – L 	<p>According to the literature, a standardized and consistent policy for water reuse permitting, reused water quality, and types of reuse is beneficial for perception of and actual water quality.^{418 419}</p>

Note: (*) Recommendations that were rated highest by stakeholders are denoted with an asterisk.

L= Recommendation comes from the literature.

AP= Recommendation comes from the Advisory Panel.

T= Recommendation comes from the Full HIA Team.

S= Recommendation comes from other stakeholders, such as the key-informant interviewees.

Source: KHI Municipal Water Reuse HIA, 2017.

Figure D-1. Glossary of Key Terms

KEY TERM OR PHRASE	MEANING	PAGE OF FIRST REFERENCE
EXECUTIVE SUMMARY		
Water Reuse	The process of converting wastewater into water that can be used for beneficial purposes. The term water reuse is generally used synonymously with water reclamation and water recycling. ⁴²⁰	1
HIA METHODOLOGY		
Systematic Literature Review	A literature review that is based on a clearly formulated question, identifies relevant studies based on criteria, appraises the quality of the studies and summarizes the evidence by use of stated methodology. ⁴⁴³	9
Non-Systematic Literature Review	A non-systematic review is a critical assessment and evaluation of some but not all research studies that address an issue. Researchers do not use an organized method of locating, assembling, and evaluating a body of literature on a topic, possibly using a set of specific criteria. ⁴⁴⁴	9
Deductive Coding	A type of coding in which categories and themes are pre-defined, based on an existing framework. ⁴⁴⁵	9
OVERVIEW OF REUSE CONCEPTS & STATUS OF REUSE IN KANSAS		
Effluent	Sewage or other wastewater discharged from an artificial source. ⁴²²	10
Graywater	Domestic wastewater composed of wash water from sinks (sometimes excluding kitchen sinks), showers, or washing machines. Graywater does not include toilet wastewater. ⁴²¹	14
Potable Reuse	Planned augmentation of a drinking water supply with reclaimed water. ⁴²³	14
Direct Potable Reuse	The introduction of reclaimed water directly into a drinking water treatment plant, either co-located or remote from the advanced wastewater treatment system. ⁴²⁴	14
Indirect Potable Reuse	Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes drinking water treatment. ⁴²⁵	14
Non-Potable Reuse	All water reuse applications that do not involve potable reuse, including the use of water for car washing, irrigation, industrial cooling, etc. ⁴²⁶	14
De facto Reuse	A situation where reuse of treated wastewater is practiced but is not officially recognized (e.g., a drinking water supply intake located downstream from a wastewater treatment plant discharge point). ⁴²⁷	14

KEY TERM OR PHRASE	MEANING	PAGE OF FIRST REFERENCE
Environmental Buffer	A water body or aquifer, perceived by the public as natural, which serves to sever the connection between the water and its history. The buffer may provide an opportunity to blend or dilute the reclaimed water, increase the amount of time between when the reclaimed water is produced and it is introduced into the water supply, and decrease the concentration of contaminants. ⁴²⁸	14
Drought	A deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group or environmental sector. ⁴⁶⁰	15
Discharge	The volume of water that passes a given location within a given period of time. Usually expressed in cubic feet per second. ⁴⁸⁸	15
RELEVANT REGULATIONS, POLICIES & CONTEXT		
Clean Water Act (CWA)	The law that regulates the quality of the nation’s surface waters (i.e., rivers, lakes and streams) and is the basis of regulating discharges into surface waters from entities including wastewater treatment facilities. ⁴²⁹	16
Surface Water	Water that is found on the Earth’s surface, such as in a stream, river, lake or reservoir. ⁴³⁰	16
National Pollutant Discharge Elimination System (NPDES)	The program which addresses water pollution by regulating discharges into U.S. waters. Each facility that discharges water into surface water must have a NPDES permit. The permit sets allowable limits for the discharge of certain contaminants. ⁴³¹	16
Safe Drinking Water Act (SDWA)	The law that aims to protect public health through regulation of public drinking water supply, including protecting sources of drinking water and treatment and distribution systems. ⁴³²	16
Public Water Supply (PWS)	A system for the provision to the public of piped water for human consumption. In Kansas, a PWS must have at least 10 service connections or regularly serve an average of at least 25 individuals daily at least 60 days out of the year. ⁴³³	17
National Primary Drinking Water Regulations (NPDWR)	Legally enforceable primary standards and treatment techniques that apply to public water systems. Primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water. ⁴³⁴	17
Contaminant	Any physical, chemical, biological or radiological substance or matter in water. ⁴³⁵	17
Maximum Contaminant Level Goal (MCLG)	The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals. ⁴³⁶	17
Maximum Contaminant Level (MCL)	The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best-available treatment technology and taking cost into consideration. MCLs are enforceable standards. ⁴³⁷	17
Treatment Technique (TT)	A required process intended to reduce the level of a contaminant in drinking water. ⁴³⁸	17
Maximum Residual Disinfectant Level Goal (MRDLG)	The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants. ⁴³⁹	17

KEY TERM OR PHRASE	MEANING	PAGE OF FIRST REFERENCE
Maximum Residual Disinfectant Level (MRDL)	The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants. ⁴⁴⁰	17
Candidate Contaminant List (CCL)	A list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, but are known or anticipated to occur in public water systems. Contaminants listed on the CCL may require future regulation under the Safe Drinking Water Act (SDWA). ⁴⁴¹	17
Contaminant of Emerging Concern (CEC)	Any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. In some cases, release of emerging chemical or microbial contaminants to the environment has likely occurred for a long time, but may not have been recognized until new detection methods were developed. In other cases, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants. ⁴⁴²	17
WATER AVAILABILITY/COMMUNITY SUSTAINABILITY		
Perennial Streams	Rivers or streams that flow all year round except during severe drought. ⁴⁴⁶	23
Aquifer	Underground deposits of permeable rock or sediment (e.g., sand and gravel) from which water can be pumped in usable quantities. ⁴⁴⁷	23
High Plains/Ogallala Aquifer	A regional aquifer system composed of several smaller units that are geologically similar and hydrologically connected. The High Plains aquifer lies beneath parts of eight states in the Great Plains, including 30,800 square miles of western and central Kansas. The Ogallala aquifer is a part of the High Plains aquifer. ⁴⁴⁸	23
Groundwater	Water that flows or seeps downward and saturates soil or rock, supplying springs and wells, or water stored underground in rock crevices and in the pores of geologic materials that make up the Earth's crust. ⁴⁴⁹	23
Aquifer Recharge	Inflow of water to a groundwater reservoir from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Recharge may also be artificial, when water is intentionally put into the aquifer to increase its volume. ⁴⁵⁰	23
Evaporative Demand	The rate of water loss from a wet surface. ⁴⁵¹	23
Community Sustainability	A sustainable community is one that is economically, environmentally and socially healthy and resilient. It meets challenges through integrated solutions rather than through fragmented approaches that meet one of those goals at the expense of the others. And it takes a long-term perspective—one that's focused on both the present and future, well beyond the next budget or election cycle. ⁴⁵²	25
Resilience	An attribute that characterizes a system's ability to cope with stress. ^{453 454}	25
Water Scarcity	The abundance, or lack thereof, of water supply. This is typically calculated as a ratio of human water consumption to available water supply in a given area. ⁴⁵⁶	27
Water Stress	The ability, or lack thereof, to meet human and ecological demand for water. It considers several physical aspects related to water resources, including water scarcity, but also water quality, environmental flows and the accessibility of water. ⁴⁵⁷	27
Social Capital	The value of social networks, partly stemming from the norms of trust and reciprocity that flourish through these networks. ⁴⁵⁸	27

KEY TERM OR PHRASE	MEANING	PAGE OF FIRST REFERENCE
Determinants of Health	The range of personal, social, economic and environmental factors that influence health status are known as determinants of health. ⁴⁵⁹	27
Million Gallons Per Day (MGD)	A rate of flow of water equal to 133,680.56 cubic feet per day, or 1.5472 cubic feet per second, or 3.0689 acre-feet per day. A flow of one million gallons per day for one year equals 1,120 acre-feet (365 million gallons). ⁴⁶¹	28
Wastewater Treatment Plant (WWTP)	Structures or devices that collect, store, stabilize, treat or otherwise control pollutants so that after the discharge, disposal or land application of wastewater treatment sludge or treated wastewater, water pollution will not occur, and the public health and waters of the state will be protected. ⁴⁶²	28
WATER QUALITY		
Consumer Confidence Report (CCR)	Annual reports about the water provided by public water suppliers, including information on detected contaminants, possible health effects and the water's source. ⁴⁶³	34
Potable Water	Water of a quality suitable for drinking. ⁴⁶⁴	34
Water Portfolio	The sources from which a community derives water. ⁴⁵⁵	35
Biochemical Oxygen Demand (BOD)	A measure of oxygen consumed in biological processes that break down organic matter in water. ⁴⁶⁵	35
Total Suspended Solids (TSS)	A measure of the number of small particles suspended in water or wastewater. ⁴⁶⁶	35
Fecal Coliforms	Bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short-term effects, such as diarrhea, cramps, nausea, headaches or other symptoms. They may pose a special health risk for infants, young children and people with severely compromised immune systems. ⁴⁶⁷	35
Chlorine Residual	Chlorine is the most commonly used disinfectant in the U.S. After treatment of water, some chlorine is necessary to provide protection against microbial contaminants. However, in higher concentrations, chlorine can have negative health impacts, such as skin/eye irritation and stomach discomfort. ^{468 469}	34
Pathogens	Disease-causing microorganisms, including pathogenic bacteria, viruses, helminths and protozoans. ⁴⁷⁰	35
Disinfectant Byproducts (DBP)	A group of compounds formed as a result of chemical reactions between disinfectants and other components of water. Some disinfectant byproducts may be carcinogenic. ⁴⁷¹	36
Purple Pipe	Water infrastructure used to transport reused water. The pipes are often colored purple to distinguish them from potable water or wastewater.	36
COMMUNITY PERCEPTION OF WATER QUALITY		
"Yuck" Factor	The visceral reaction of displeasure and disdain to water reuse. ⁴⁷²	42
Palmer Drought Severity Index (PDSI)	A measure of the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. ⁴⁷³	43
CONSUMPTION OF BEVERAGES OTHER THAN MUNICIPAL WATER		
Sugary Beverage or Sugar-Sweetened Beverage	Any liquids that are sweetened with various forms of added sugars. Examples of sugary beverages include, but are not limited to regular soda (not sugar-free), fruit drinks, sports drinks, energy drinks, sweetened waters and coffee and tea beverages with added sugars. ⁴⁷⁴	49

KEY TERM OR PHRASE	MEANING	PAGE OF FIRST REFERENCE
COSTS & UTILITY RATES		
Flat Fee	A utility rate structure in which customers are charged a fixed price for water, no matter how much or how little water is used. ⁴⁷⁵	56
Uniform Rate	A utility rate structure in which customers are charged the same price-per-unit of water usage, so that the water bill increases with more usage, but there is no difference in the rate per unit for low-use and high-use. ⁴⁷⁶	56
Decreasing Block Rate	A utility rate structure in which the per-unit charges for water decrease as the amount of water used increases. A block is a quantity of water for which the price per thousand gallons is set. In this pricing structure, the first block is charged at one rate, the next block is charged at a lower rate, and so on. ⁴⁷⁷	56
Increasing Block Rate	A utility rate structure in which the per-unit charges for water increase as the amount of water increases. A block is a quantity of water for which the price per thousand gallons is set. The first block is charged at one rate, the next block is charged at a higher rate, and so on. An increasing block rate structure is often referred to as conservation pricing. ⁴⁷⁸	56
Seasonal Pricing	A utility rate structure in which water prices rise or fall according to weather conditions and the corresponding demand for water. ⁴⁷⁹	56
Peak Pricing	A utility rate structure in which prices for water are higher during a utility's peak demand periods. ⁴⁸⁰	56
Acre-Foot (AF)	The volume of water required to cover 1 acre of land (43,560 square feet) to a depth of 1 foot. Equal to 325,851 gallons or 1,233 cubic meters. ⁴⁸¹	56
Median Household Income (MHI)	Median annual household income refers to the income level earned by a given household where half of the homes in the sample earn more and half earn less. It is used instead of the average or mean household income because it can give a more accurate picture of actual economic status when the income distribution is skewed. ⁴⁸²	58
Bill Discounts	Reduction in a customer's bill, usually long-term, can be applied to nearly any type of rate structure. ⁴⁸³	58
Lifeline Rates	Customers pay a subsidized rate for a fixed amount of water, which is expected to cover that customer's basic water needs. When water use exceeds the initial fixed amount of water, the rates increase. ⁴⁸⁴	58
Temporary Assistance	Utilities help customers on a short-term or one-time basis to prevent disconnection of service or restore service after disconnection for households facing an unexpected hardship. ⁴⁸⁵	58
Water Efficiency Programs	Utilities subsidize water efficiency measures by providing financial assistance for leak repairs and offering rebates for WaterSense-certified fixtures, toilets and appliances. ⁴⁸⁶	58
GUIDANCE & REGULATIONS		
Cross-Connections	The actual or potential connections between potable and non-potable water supplies. ⁴⁸⁷	64
Subsurface Irrigation	Application of water below the soil surface. ⁴⁸⁹	67
Injection	Wastewater is generally forced (pumped) into the well for dispersal or storage into a designated aquifer. ⁴⁹⁰	67
Infiltration	Flow of water from the land surface into the subsurface. ⁴⁹¹	67

Literature Review Search Protocol and Scoring Methods

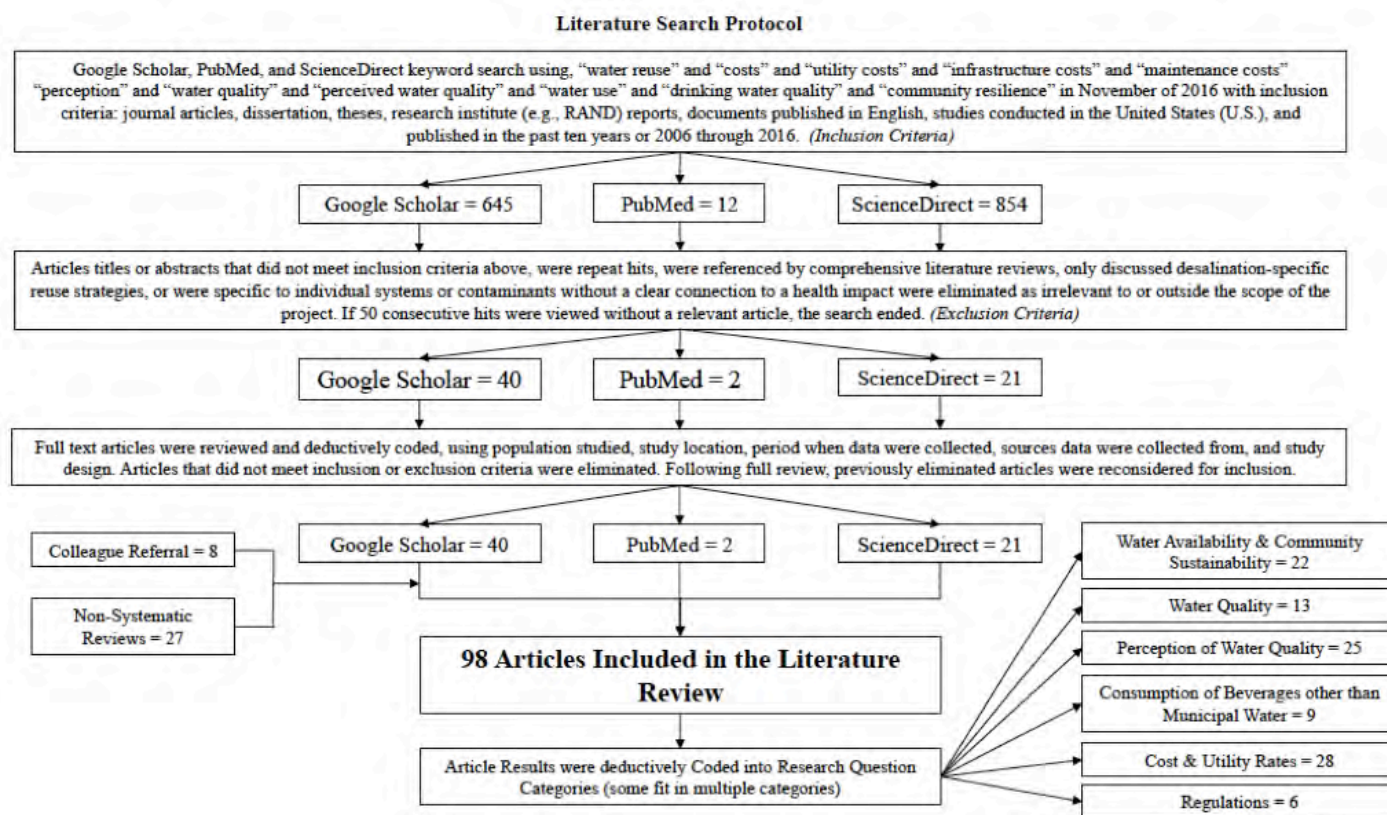
The KHI HIA Team completed systematic and non-systematic literature reviews. In November 2016, a KHI researcher searched PubMed, ScienceDirect, and Google Scholar, limiting results to journal articles, dissertations, masters' theses and research reports. Additional inclusion criteria include articles published in English and studies conducted in the U.S. in the past 10 years.

Exclusion criteria included repeat hits, articles referenced by comprehensive literature reviews, articles that discussed only desalination-specific reuse, or articles that were focused on specific contaminants or an individual system's performance without a clear connection to health.

These additional criteria were used to review the titles and abstracts of 1,511 total hits.

Abstract and title review left 63 papers, which were read to identify their relevance to research questions. In addition, each article was deductively coded to identify the study location, data sources and timing of collection, study design, limitations, results and policy recommendations. An additional 27 articles were identified through non-systematic searches. The study findings were reviewed and sorted into the following content areas: water availability and community sustainability, water quality, perception of water quality, consumption of beverages other than municipal water, costs and utility rates, and regulations. *Figure E-1* illustrates the process through which literature was identified and reviewed.

Figure E-1. Literature Review Search Protocol



Literature Review Framework and Quality of Evidence

Following article identification via the process described on the previous page, each article was read and analyzed by the KHI HIA Team. Articles were described along the following characteristics: author, year, type of literature, and article

identification method, the article population and sample, along with the year of data collection or data source. The study design and accompanying limitations were noted, and a summary was made of the article findings, potential policy notes or recommendations, and any relevant definitions. *Figure E-2* is an example of how the information from one article was organized.

Figure E-2. Summary Table (for analysis and use by the project team)

Author, Year, Type of Literature (e.g., journal vs. gray), and How Identified	Garcia-Cuerva, L., Berglund, E. Z., Binder, A. R., 2016. Science Direct Resources, Conservation and Recycling (journal)
Population and Sample	United States, funded by the National Science Foundation
Years and Data Source	May 2013
Study Design and Limitations	Survey n=2800 with methodology to be representative of the United States. Pearson's Chi Square test of independence compared water concern, conservation, and support of reuse and demographic, socioeconomic info, age, sex, race/ethnicity, marital status, number and age of children, highest level of education achieved, geographical location, metropolitan or rural residency, type of household, household income, home ownership status, household head status and household size for a relationship. (p<0.05)
Findings	<p>"The widespread implementation of water reclamation programs is limited by the social acceptability of reusing wastewater effluent. Public resistance to water reuse may be the result of a lack of knowledge about reclaimed water and the perception of risk associated with health hazards." (Page 107)</p> <p>As discussed in Bixio et al., "uses that involve high human exposure are typically less acceptable than uses that involve low levels of contact, even though the technology required to treat wastewater and convert it to reusable water that surpasses drinking water standards is currently available." (Page 107)</p> <p>"Results show that only a small percentage of participants (6.5 percent) are Water Concerned; 51 percent are Water Conservers; and 43 percent are Reclaimed Water Supporters." (Page 109)</p> <p>The findings here (with contested support from literature) show no difference in acceptance of water reuse based on sex. Water concern and conservation increase with age, but there is no relationship for age and support for water reuse. Highest level of education corresponds to the highest percentage of water concern and reclaimed water supporters (consistent with literature). Significant relationship between community type (rural vs. urban) and support for reclaimed water use. The highest-income group shows the highest percentage of support for reclaimed water use. Geographically—the highest support for reclaimed water use was in EPA regions with PDSI less than -2.0 (with the exception of the Pacific Northwest). (Page 111).</p> <p>For time of study (May 2012–May 2013), Kansas was in the top 10 for lowest average PDSI value (indicating drought). (Page 111)</p> <p>No significant relationship was found between PDSI value (indicating moderate drought) and the percentage of reclaimed water supporters. (Page 112)</p> <p>"Acceptability is inversely proportional to the level of direct exposure, which is consistent with results from previous research." (Page 112)</p>

<p>Policy Recommendations and Notes</p>	<p>Results reported here indicate that a reduced water bill increases the willingness to adopt the use of reclaimed water. Previous research identified that the costs and benefits experienced by residents can affect public acceptability of water reuse (Marks et al., 2002). Demand for reclaimed water has been inhibited by artificially low and subsidized water prices (Woolston and Jaffer, 2005). Low reclaimed water rates could encourage its use and help meet reuse and demand management targets (Woolston and Jaffer, 2005).” (Page 112)</p> <p>Restated in conclusion as... “Results demonstrate that financial incentives influence the willingness of respondents to participate in water reuse programs, and a decrease in the monthly cost of water increased the likelihood that respondents would participate in a reclaimed water program.” (Page 113)</p> <p>“By planning dual distribution systems in areas of new development, the cost of including water reuse in an existing water supply portfolio may become competitive with other supply alternatives. The cost for reclaimed water treatment and distribution may be offset by costs that are delayed or avoided to construct new water infrastructure.” (Page 112)</p> <p>“Tradeoffs will vary according to local and regional land use characteristics and climate conditions, and new analysis should include the cost of new infrastructure and the impacts of financial incentives on acceptability.” (Page 113)</p> <p>“Decision-makers need available and accessible information about public attitudes toward water reuse to select appropriate and sustainable resource management strategies. Implementation of reclaimed infrastructure should focus initially on applications with greater social acceptability, such as street cleaning, car washing, irrigation of parks and athletic fields or toilet flushing.” (Page 113)</p>
<p>Relevant Definitions</p>	<p>“Yuck” factor - The instinctive disgust associated with the idea of recycling sewage and the fear that exposure to reclaimed water is unsafe.” (p 106)</p> <p>“Reclaimed water is the end product of wastewater reclamation that meets water quality requirement for biodegradable materials, suspended matter, and pathogens (Levine and Asano, 2004).” (p 106)</p>

Source: KHI Municipal Water Reuse HIA, 2017.

In order to describe the quality of the articles included in the literature review, articles included in the review were scored based on whether they were published in peer-reviewed journals, their funding source, and analytic methods using 12 criteria developed by the KHI HIA Team. Scores allocated each article into one of three categories based on its quality score (poor, good, and excellent). See *Figure E-3*.

Figure E-3. Literature Review Scoring System

SCORE FOR METHODOLOGY CRITERIA												
1	2	3	4	5	6	7	8	9	10	11	12	Total Score
Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N

1. Conducted by or funded by non-advocacy or non-industry entity;
2. Study was published in a peer-reviewed publication;
3. Findings are directly relevant to the research question;
4. Strong methodology and data analysis techniques, including using either a pre/post or other comparative design and large sample;
5. The study design was grounded in a theoretical framework;
6. Findings were statistically significant at the 0.05 level or better;
7. Covariates were examined;
8. Findings are generalizable to the population of interest;
9. Data consist of more than one time point or are beyond cross-sectional (e.g., longitudinal or with follow-up);
10. Data are not self-reported and/or contain little inter-rater reliability error;
11. Data were collected within the past ten years; and
12. There are few limitations beyond those stated.

Each study should be assessed using the above criteria and assigned a score. Scores that fall within the 1 to 4 range are poor, within the 5 to 8 range are good, and 9 to 12 range are excellent.

Community Sustainability Index Methodology

Background

One of the potential impacts of water reuse prioritized by the Advisory Panel and Full HIA Team was the sustainability of a community. The review of the research focused on community sustainability found that the strength and sustainability of a community is usually characterized by many interrelated components. These components commonly fall into three areas, or pillars: environmental, social and economic. Each of these areas includes many additional components that can be used to characterize the strength of a community's sustainability.

Because of the many components that make up the area of community sustainability, the KHI HIA Team, along with the Full HIA Team, decided that a composite index would be the best approach to capturing and characterizing the sustainability of Kansas communities. A composite index allows the combination of the values of a variety of indicators to capture a broader picture of how a community is performing on a certain concept.

In order to develop such an index, the KHI HIA Team reviewed indices on the topics of community sustainability and water resource availability. The review resulted in two frameworks that were closely related to the concepts that the HIA Team aimed to characterize (i.e., community sustainability components of environmental, social, and economic factors). These two frameworks were the basis for the development of an index for this project.

The first framework was the U.N.'s *Indicators of Sustainable Development: Guidelines and Methodologies*.⁴⁹³ The second was the U.S. Environmental Protection Agency's (EPA) *Indicators and Methods for Constructing a U.S. Human Well-being Index (HWBI) for Ecosystem Services Research*.⁴⁹⁴ While both frameworks were helpful and relevant, neither was able to fully capture the impacts of interest to stakeholders and partners without additional adaptation.

The U.N. framework is primarily used at national and international levels to characterize components of sustainable development. Sustainable development is defined as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."⁴⁹⁵ It has also been defined as, "the simultaneous pursuit of economic prosperity, environmental quality and social equity,"⁴⁹⁶ and is a means of building sustainable communities. Because this index is used for national and international comparison, some of the framework measures were determined not relevant to Kansas, and were excluded from the development of the Community Sustainability Index (CSI) for this project.

Nevertheless, this framework included indicators that were relevant to each of the three pillars of sustainability and were characterized into sub-domains. It also provided specific indicator suggestions with the flexibility to adapt the indicators to local context. Because of this, the framework was the basis of indicator selection. The KHI HIA team reviewed each of the suggested indicators, and if the same or a closely related indicator was available for Kansas counties, it was included in the draft list of indicators.

The second index is a more recently developed index used to characterize the impacts to human well-being from changes to ecosystem services. In contrast to the U.N. framework described above, the HWBI indicators have defined and identified data sources and the index presents methods for calculation. This index also classifies indicators into categories related to the three pillars of sustainability. One limitation of this index is that it does not include measures of the environment itself. For example, to measure the impact of environment on human wellbeing it includes a measure of 'biophilia' (connection to nature).

The geographic level of the indicators included in this index vary. Several are available at the county-level, while many are available only at a regional or state level. The KHI HIA Team was interested only in indicators available at the county level. The KHI HIA team reviewed the indicators in this index and included for consideration those that were available at the county level and were not duplicative of already-identified indicators.

Neither of the frameworks had an already-calculated index at the county level, which was required for this project. However, both were very useful in determining appropriate indicators for this project's CSI.

Analysis

Using distribution analysis and mapping techniques, a CSI was developed to illustrate the Kansas counties that might have the greatest resilience, or the presence of factors that contribute to community sustainability. Based on the available data and a review of similar indices, thirty-four measures (listed in *Figure F-1*) were identified to include in the index. Most of the measures used the most recent year of data available, which varied by indicator, but generally ranged from 2009–2016. To provide a standardized approach to quantifying and comparing the index scores, the KHI HIA Team adapted an approach referenced in the EPA's *Human Wellbeing Index (HWBI)*,⁴⁹⁷ which was originally used in the Organization for Economic Cooperation and Development (OECD) *Better Life Index*. This calculation is an approach which converts the original values of the indicators into proportions that range from 0 (worst possible outcome) to 1 (best possible outcome).

For 13 of the 34 identified measures, higher values represented positive contributions to community sustainability. For these measures, the proportion

is calculated using the following formula for each county and indicator, where the lowest and highest values refer to the values for all counties:

$$\frac{(\text{county value} - \text{lowest value})}{(\text{highest value} - \text{lowest value})}$$

For the 21 of 34 measures in which a higher value represented a negative contribution to community sustainability, the following formula was used:

$$1 - \frac{(\text{county value} - \text{lowest value})}{(\text{highest value} - \text{lowest value})}$$

The state's mean value was used as a substitute for missing county-level data points. Higher scores indicate smaller differences between the values of a measure for a specific geographic unit compared to the value for the best-performing county. Lower values indicate larger differences between the values of a measure for a specific geographic unit and the best-performing county.

The measures used in the index were divided into three domains, based on the three components of community sustainability: Social, Environment and Economy.^{498 499} The Social sub-index consists of 14 measures, the Environmental sub-index consists of 11 measures, and the Economy sub-index consists of 9 measures. The means of the calculated proportions for each of the measures included in each domain were used to compile the domain scores.

Figure F-1. Domains, Topics and Measures in the Community Sustainability Index

DOMAIN	TOPIC	MEASURE DESCRIPTION	DATA SOURCE AND YEAR(S) <i>If multiple years, data represent the average for the span of years</i>
Social	Crime	Violent crimes per 1,000 population	Federal Bureau of Investigation, 2012–2014
	Infant Mortality	Infant mortality rate (infant deaths per 1,000 live births)	Kansas Department of Health and Environment, 2011–2015
	Life Expectancy	Life expectancy at birth (females)	Institute for Health Metrics and Evaluation, 2010
	Uninsured	Percent of population under age 65 without health insurance	U.S. Census Bureau (SAHIE), 2014
	Immunizations	Percent of children who are fully immunized at 24 months	Kansas Department of Health and Environment, 2014–2015

DOMAIN	TOPIC	MEASURE DESCRIPTION	DATA SOURCE AND YEAR(S) <i>If multiple years, data represent the average for the span of years</i>
Social	Child Food Insecurity	Percent of children who are food insecure	Feeding America, 2015
	Poor Physical Health Days	Average number of physically unhealthy days reported in the past 30 days	BRFSS, 2015
	Smokers	Percent of adults who are current smokers	BRFSS, 2015
	Suicide	Suicide rate per 100,000	KDHE, 2013-2015
	High School Graduation Rate	High school graduation rate	EDFacts, 2014-2015
	Bachelor's Degree Attainment	Proportion of population age 25+ with a bachelor's degree and above	U.S. Census Bureau, American Community Survey, 2011-2015
	Projected Population Change	Projected population change (percent change over 10 years, 2014-2024)	Center for Economic Development and Business Research, 2016
	Social Dependency	Ratio of elderly persons to adults	U.S. Census Bureau, 2015
	Social Capital	Social Capital Index	University of Pennsylvania, 2009
Environmental	Natural Hazards	Index of vulnerability to natural hazards	University of South Carolina, 2006-2010
	Air Pollution	Average daily density of fine particulate matter	U.S. Centers for Disease Control and Prevention, 2012
	Oil and Gas Production	Barrel equivalents of oil and gas produced	Kansas Geological Survey, 2016
	Clean Energy Production	Wind farm presence	Kansas Department of Commerce, 2016
	Land use	Percent of land area that is used for farming	University of Kansas Institute for Policy & Social Research, 2012
	Per Capita Water Use	Gallons Per Capita Per Day Municipal Water Supply Use	Kansas Water Office, 2010-2014
	Agricultural Water Use	Total water used for agriculture	Kansas Water Office, 2014
	Water Stress	Groundwater stress	World Resources Institute, 2015
	Precipitation	Average annual precipitation	High Plains Regional Climate Center, 1981-2010
	Drought	Average drought conditions (Palmer Drought Severity Index)	National Centers for Environmental Information, 1981-2010
	Water Quality	Presence of a SDWA violation in the past year	KDHE, 2015
Economy	Poverty	Proportion of the population living below the federal poverty level	U.S. Census Bureau, American Community Survey, 2011-2015
	Income Inequality	Ratio of highest to lowest income quintile	U.S. Census Bureau, American Community Survey, 2011-2015

DOMAIN	TOPIC	MEASURE DESCRIPTION	DATA SOURCE AND YEAR(S) <i>If multiple years, data represent the average for the span of years</i>
Economy	Housing Cost	Percent of households spending more than one-third of income on rent and utilities	U.S. Census Bureau, American Community Survey, 2011-2015
	Housing Quality	Percent of households with one or more severe housing problems	U.S. Department of Housing and Urban Development, 2009-2013
	Median Household Income	Median household income	U.S. Census Bureau, American Community Survey, 2011-2015
	Property Values	Taxable property value per capita	Kansas Department of Revenue, 2015
	Tax Revenues	Property tax revenues as a percent of full market property value	Kansas Department of Revenue, 2015
	Unemployment	Percent of the population that is unemployed	U.S. Bureau of Labor Statistics, 2015
	Transportation	Percent of workers who drive alone to work	U.S. Census Bureau, American Community Survey, 2011-2015

Source: KHI Municipal Water Reuse HIA, 2017.

Results

Based on the above indicators and methods, the maximum possible overall CSI score was 1, and the highest overall index score was 0.74. A higher score indicates more resilience, or factors that contribute to community sustainability, whereas a lower score indicates lower sustainability or greater vulnerability to declines in community sustainability. The lowest possible CSI score was 0, and the lowest-performing county had an overall score of 0.38. Scores were broken into four categories based on score.

- Those scoring less than 0.47 were classified as “Low;”
- Those between 0.47 and 0.54 were “Medium;”
- Those between 0.54 and 0.61 were “High;” and
- Those 0.61 and above were considered “Very High.”

Of Kansas counties, 97 out of 105 counties had scores between 0-0.61; those with scores greater than 0.61 included Coffey, Ellsworth, Greeley, Johnson, McPherson, Ottawa, Pottawatomie, and Wabaunsee Counties. See *Figure F-2* for a

breakdown of the CSI scores overall and *Figure F-3* (page 96) for a breakdown of the scores for each sub-index. A map of the overall CSI scores by county can be found in *Figure 12* (page 29).

Figure F-2. Overall Community Sustainability Index Scores

OVERALL CSRI SCORES	NUMBER OF COUNTIES IN RANGE
Low (<0.47)	10
Medium (0.47–0.54)	45
High (0.54–0.61)	42
Very High (≥0.61)	8

Source: KHI Municipal Water Reuse HIA, 2017.

For the sub-indices, counties were classified into four categories based on scores (*Figure F-3*, page 96).

- Scores less than 0.35 were considered “Low;”
- Scores between 0.35 and 0.50 were classified as “Medium;”
- Scores between 0.50 and 0.65 were considered “High;” and
- Scores of 0.65 and above were “Very High.”

Figure F-3. Community Sustainability Index Sub-Scores

Sub-Index Scores	Number of Counties in Range (Environmental Sub-Index, 11 measures)	Number of Counties in Range (Social Sub-Index, 14 measures)	Number of Counties in Range (Economic Sub-Index, 9 measures)
Low (<0.35)	6	0	11
Medium (0.35–0.50)	37	18	50
High (0.50–0.65)	46	74	39
Very High (≥0.65)	16	13	5

Source: KHI Municipal Water Reuse HIA, 2017.

Because this HIA is focused on water issues, the environmental aspects of community sustainability are of particular interest. The environmental sub-index includes measures of water use, precipitation, drought, water stress and water quality. For the environmental sub-index, 16 Kansas counties scored 'Very High' due to their performance on the measures described above (Figure F-3). Based on the analysis, these counties were determined to have environmental characteristics—related to water use, availability and quality—that may indicate resilience, or higher community sustainability.

Limitations

There are a number of limitations to this approach.

First and foremost, community sustainability is a broad and evolving topic with many components that may be difficult or impossible to measure. Because of this, there may be aspects of community sustainability that were not captured in this index. There may also be some aspects of community sustainability that are more important than others. The KHI HIA Team did not attempt to develop weights for the indicators included in this index because of a lack of consensus in the research about the relative importance, and because of the resources that would be required to develop weights for these indicators.

The KHI HIA Team identified a number of indicators relevant to community sustainability, however, not all of the indicators of interest were available at a county level. For some indicators,

data were available for many or most counties in Kansas, but some counties, especially smaller ones, had missing data. To mitigate this limitation, the team adapted the approach described in the EPA HWBI, and used the state's mean value for these missing data points. However, the use of the mean value may not accurately represent the current value for the counties in which there were missing data.

Some of the indicators that were used in this index come from data sources that are several years old because they have not been updated by the data owner or because older data were more reliable or more easily accessible. Despite this limitation, some of these measures were included because of their relevance to the topic. Additionally, many indicators use different years or spans of years. Because of this, the index may not reflect the picture of community sustainability for a specific point in time. Despite this, the index may still serve as a useful resource to provide an overall picture of community sustainability and help to identify needs. Finally, some of the indicators are themselves indices, and are subject to additional limitations of the methods used to calculate them.

While an attempt was made to capture both the local availability and use of environmental resources—including water—in the state, the indicators used may not present the entire picture of water sustainability in each community. The authors recommend further study and the development of a consistent and locally available measure of water resource sustainability.

The number of indicators included in each of the three sub-scores is different due to the availability of data and relevant indicators included in the adapted frameworks. This does not represent an intentional weighting of one sub-score over another, however, it may result in bias toward one or more of the sub-scores in the overall score.

Finally, this index has not been externally validated. It is subject to the knowledge and data access of the KHI HIA Team. There may be additional indicators that would have been helpful in this index that were not included, because of lack of awareness or lack of access to these data.

Figure F-4. Data Sources, Measures and Years

DATA SOURCE	MEASURE AND YEAR
WATER AVAILABILITY/COMMUNITY SUSTAINABILITY	
*See Figure F-1 (page 93) for measures, data sources, and years for items included in the Community Sustainability Index.	
Kansas Department of Health and Environment (KDHE)	Large Public Water Supply Values for: <ul style="list-style-type: none"> • Average Daily Discharges (2016) Public Water Supply Values for: <ul style="list-style-type: none"> • Discharge Capacity (2016)
Kansas Water Office	Kansas County Values for: <ul style="list-style-type: none"> • Percent of total water used by type (2014)
WATER QUALITY	
Kansas Department of Health and Environment (KDHE)	Kansas County Values for: <ul style="list-style-type: none"> • SDWI Health-Based Violations (2015)
CONSUMPTION OF BEVERAGES OTHER THAN MUNICIPAL WATER	
Kansas Behavioral Risk Factor Surveillance System (BRFSS)	Kansas State Values for: <ul style="list-style-type: none"> • Percent of adults who consume sodas at least once per day (2013) • Percent of adults who have consumed a sugary drink in the past month (2013)
COSTS AND UTILITY RATES	
Kansas Rural Water Association	Public Water Supply system values for: <ul style="list-style-type: none"> • Utility rates (2014)
Kansas Water Office	Public Water Supply system values for: <ul style="list-style-type: none"> • Average Gallons Per Capita Per Day (GPCD) of water used (2010-2014)
U.S. Census Bureau, American Community Survey	Kansas State Values for: <ul style="list-style-type: none"> • Median Household Income (2014) Kansas County Values for: <ul style="list-style-type: none"> • Median Household Income (2010–2014)

Source: KHI Municipal Water Reuse HIA, 2017.

Key-Informant Interview Documents and Survey Questionnaires

Health Impact Assessment Key-Informant Informed Consent

Oral Consent

PI Name: Sarah Hartsig, M.S.

Institution: Kansas Health Institute

Hello. My name is Tatiana Lin and I am from the Kansas Health Institute. Today, I would like to talk to you about a research study that is being conducted at KHI. This research study will assess the potential positive and negative health effects that could result from municipal water reuse in Kansas.

We are conducting a health impact assessment (HIA) to inform the implementation of water reuse projects in Kansas and existing regulations in this area. An HIA is a policy tool which combines the best available research, data, and community input in order to project potential positive and negative health impacts of a decision, project or plan.

This work will also address one of the strategies, *Evaluate the Sources and Potential Uses of Lower Quality Water*, included in the Kansas Water Vision, "[A Long-Term Vision for the Future of Water Supply in Kansas](#)," developed by the Kansas Water Office (KWO) in partnership with other state agencies.

We are asking you to participate in this study because you have experience with water-related issues in Kansas. Specifically, we want to capture your perspectives about the potential effects of water reuse initiatives.

The questions we are asking are not personally sensitive or controversial, so we do not anticipate any risks to the study participants. However, we will use the following process to ensure that the information you share with us remains confidential. We need to be able to connect your answers to the interview recording. I will assign you a number and put the number on your questionnaire, but not your name. In a separate document, I will list your name and the assigned number. When all information is analyzed, I will discard the list with your name on it. We also intend to interview up to 15 people and will use aggregate data when reporting on the results of the research. Specific quoted responses will only be attributed to you after you review and give express consent to the quotation.

There are no financial or other direct benefits for participating in this research. However, your perspective as an expert in water-related issues will be critical in informing this research. While your participation is invaluable to the process, it is voluntary. If you agree to participate, our interview will take about an hour. You do not have to answer all the questions and you may stop at any time. There are no right or wrong answers. If *you do not know* or *cannot* recall the *answer* to a *question*, simply say "I do not know."

Permission to Record?

Yes No

Signature

Date

Health Impact Assessment Key-Informant Interview Questionnaire

The Kansas Health Institute is conducting a health impact assessment (HIA) to inform the implementation of water reuse projects in Kansas and existing regulations in this area. An HIA is a policy tool which combines the best available research, data, and community input in order to project potential positive and negative health impacts of a decision, project or plan.

This work will also address one of the strategies, *Evaluate the Sources and Potential Uses of Lower Quality Water*, included in The Kansas Water Vision, "[A Long-Term Vision for the Future of Water Supply in Kansas](#)," developed by the Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), and the Kansas Water Authority (KWA).

We have developed a series of questions to capture your perspectives about potential positive and negative effects of water reuse initiatives.

Do you have any questions about the study? You may ask me now, or contact [Sarah Hartsig](#) at shartsig@khi.org or 785-233-5443.

Interviewee Info

- 1) What is your position at <<organization>>?
- 2) How long have you been in this field?
- 3) Do you work primarily at the state- or local-level?

Part I. Water Reuse in Kansas

We will first start off by asking a few background questions related to water reuse in Kansas. I also would like to share a few definitions that I will reference during our conversation.

- 1) To your knowledge, what projects for **non-potable water reuse** are occurring in Kansas?
 - a) In which communities are these water reuse projects happening?
- 2) To your knowledge, what projects for **indirect potable water reuse** are occurring in Kansas?
 - a) In which communities are these water reuse projects happening?
- 3) To your knowledge, what projects for **direct potable water reuse** are occurring in Kansas?
 - a) In which communities are these water reuse projects happening?
- 4) Are some types of water reuse projects more common than others?

- 5) What factors make it more likely for a community to consider implementing reuse projects?
 - a) For non-potable uses? (e.g., golf course irrigation)
 - b) For indirect potable uses? (e.g., aquifer recharge)
 - c) For direct potable uses? (e.g., drinking)

[For Staff of Local Municipalities Only]

- 6) Has your community implemented a water reuse project? Please choose one of the following answers.
 - Yes
 - No, but considering implementation
 - Neither implemented nor considering implementation

If the answer is “Yes”

- a) What factors led to that decision?
- b) Were there any concerns raised by the community? If so, how were those concerns addressed?

If the answer is “No, but considering implementation”

- a) What water reuse project is your community considering?
- b) What challenges or barriers to implementation do you anticipate?
- c) How are these barriers or challenges being addressed?

If the answer is “Not implemented nor considering to implement”

- a) Why hasn't your community embarked on a water reuse project?
- b) What challenges or barriers to implementation do you anticipate?
- c) How can these barriers or challenges be addressed?

Part II: Health Impacts of the Municipal Water Reuse Efforts

So far we have largely asked a few general questions about water reuse in Kansas, but now I would like you to think more specifically about potential impacts of implementing municipal water reuse projects in Kansas.

- 1) Do you think municipal water reuse projects would have any impacts on Kansans? If so, please explain.

Prompt: How could the impacts that you just mentioned affect the health of Kansas communities?

Prompt: What are some other potential health effects of water reuse efforts?

- 2) What potential **positive impacts** could result from municipal water reuse, if any? Please explain.

Prompt: How could the positive impacts that you just mentioned improve the health of Kansans?

- 3) What **negative impacts** do you anticipate, if any? Please explain.

Prompt: How could the negative impacts that you just mentioned affect the health of Kansans?

- 4) Do you think that implementing municipal water reuse would impact certain people more than others (e.g., youth, elderly, certain racial or ethnic groups, etc.)? If so, please explain. If not, why?

Part III. Key Issues: Pathway Diagram

Preliminary analysis of municipal water reuse identified a few areas that could be impacted if implemented. Now, we would like to get your thoughts on how each area we identified might be impacted, if at all.

- a) How does the amount of water available (more water, less water) in Kansas communities impact their decision to implement water reuse projects? Please explain.
 - b) If water reuse projects were implemented, how could that impact the amount of water available to Kansas communities?
 - c) What might be the long-term impact of water availability to Kansas communities?
- 1) Municipal Water Reuse and Costs
 - a) If a water reuse project is implemented, what type of costs might be associated with the implementation?
 - b) How might costs associated with a water reuse project impact utility rates? Please explain.

If the answer to question (b) is no impact, skip c.

- c) How might changes in utility rates impact households? Please explain.
- 2) Treatment of Water and Quality of Water
 - a) How does water treated for reuse compare to the quality of more traditional water sources?
 - b) How do non-potable (e.g., golf course irrigation) reuse projects impact water quality?
 - 3) How do indirect potable reuse (e.g., aquifer recharge) projects impact water quality?
 - 4) How do direct potable reuse (e.g., drinking) projects impact water quality?
 - 5) How would changes in water quality due to reuse impact exposure to contaminants?

Next, we would like to ask you about public perception regarding water reuse.

- 5) Treatment of Water and Public Perception of Water Reuse

- 6) Does public perception of wastewater reuse impact whether a community decides to implement water reuse projects? Please explain.
- 7) If water reuse projects were implemented, how would the public perceive the quality of water used for non-potable purposes? Please explain.
- 8) If water reuse projects were implemented, how would the public perceive the quality of water used for indirect potable purposes? Please explain.
- 9) If water reuse projects were implemented, how would the public perceive the quality of water used for direct potable purposes? Please explain.
- 10) How might public perception of water quality impact their use of parks and green spaces that have been irrigated with reused water?
- 11) How might public perception of water quality impact the consumption of municipal drinking water? How might that impact the consumption of beverages other than municipal drinking water (i.e., bottled water or sodas)?
- 12) Does water reuse lead to changes in how water use is regulated at the federal, state, or local level? If so, please explain.
- 13) To what extent do existing regulations/guidelines support water reuse efforts in Kansas?
- 14) To what extent do these regulations/guidelines protect the health of Kansans?

Part IV. Closing Questions

- 1) As water reuse projects are being considered and implemented in Kansas:
 - a) What recommendations would you suggest for state agencies?
 - b) What recommendations would you suggest for local agencies?
 - c) What recommendations would you suggest for policymakers? (e.g., local or state elected officials)
 - d) Do you have any recommendations that are specific to improving health and/or protecting health?
 - e) What role, if any, do you see your organization playing related to water reuse efforts in Kansas?
- 2) Is there anything else you would like to add?
- 3) Are there any individuals that you recommend we interview?

Thank you for your time! If you have any questions, please call (785) 233-5443 and ask for Sarah Hartsig.

Community Perception Survey

Dear Community Member: The purpose of this survey is to gather your perceptions about municipal water reuse efforts in *[Garden City/Hays]*. The information gathered in this survey will inform future water reuse efforts in the city and Kansas. Your responses will be compiled with other responses and will never directly identify your individual response. We are gathering some demographic information to ensure that we have gathered feedback from a broad representation of individuals in the community. You can choose to skip questions that you don't feel comfortable answering and you can stop at any time. We thank you for your participation! The survey should take no more than 15 minutes of your time. We ask that you complete the survey no later than **February 28, 2017**. Please contact Tatiana Lin at tlin@khi.org with any questions. Thank you for your time and input!

In this first section, we would like to ask you some general questions about your household water and your water consumption behavior.

From which of the following sources does your household water (i.e., the water you use for drinking/bathing) come? Please choose one.

- Well or other private water source
- Public (municipal) water source

If your water comes from a municipal supply, what is the source of that supply? Please choose one.

- Underground aquifer
- Reservoir, lake, or river
- I am not sure
- N/A

How would you describe the quality of your drinking water?

- Very poor
- Poor
- Acceptable
- Good
- Very good

Please complete the statement that best describes your drinking water consumption. Overall, I drink ...

- Only tap water
- More tap water than bottled water
- Equal amounts of tap water and bottled water
- More bottled water than tap water
- Only bottled water

Recycled water use has been steadily growing in the United States. In this section, we are interested in learning about your experience with and perspectives on the use of the recycled water.

For the following terms, please indicate if you know what the term means, have heard of the term but do not know its meaning, or have not heard of the term at all.

	Have not heard of the term at all	Have heard of the term but don't know its meaning	Know what the term means
Water reuse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potable water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reclaimed water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wastewater	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Graywater	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recycled water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effluent	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Recycled water is defined as wastewater that has been purified so it can be used again for new purposes. Please note that the terms water reuse/recycling are used interchangeably throughout the survey.

In general, how well informed would you consider yourself to be regarding water reuse in *[Garden City/Hays]*?

- Not informed
- Somewhat informed
- Neither informed nor uninformed
- Informed
- Very well informed

[Description of water reuse efforts in Garden City/Hays] Were you aware of these efforts?

- No
- Yes
- Unsure

How do you feel about these water reuse efforts?

- Not supportive at all
- Not supportive
- Neutral
- Supportive
- Highly supportive

In general, how important are water reuse efforts for [Garden City]?

- Not important at all
- Limited importance
- Somewhat important
- Important
- Very Important

Thinking about water reuse more broadly, how much do you favor the use of recycled wastewater for each of the following? If you don't know or have no opinion of a use, please leave it blank.

	Highly Unfavorable	Unfavorable	Neutral	Favorable	Highly Favorable
Irrigate golf courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate landscaping and parks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate school grounds	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate non-edible agricultural crops	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate agricultural crops for human consumption	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use in industrial processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flush toilets in public buildings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supply fire hydrants in the city	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supply car wash businesses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Treat and reuse in the public water supply (for drinking and other household use) <i>This question only asked in Garden City.</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How important are each of the following when choosing a water reuse approach? If you have no opinion of one, please leave blank.

	Not Important at all	Limited Importance	Somewhat Important	Important	Very Important
Protect human health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Extension or preservation of the current water supply	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Energy efficiency of reuse	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Project costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

In your opinion, what is the best method of financing for water reuse projects?

- Through existing water or wastewater utility rates
- Through property taxes
- Through a sales tax
- Through a dedicated water re-use utility
- Through sales of reused water to specific users

In general, how confident are you that decisions regarding water reuse in your community are made with the best interests of the public in mind?

- Not confident at all
- Somewhat confident
- Neutral
- Confident
- Very Confident

If [*Garden City/Hays*] decides to expand water reuse in the future, how supportive would you be?

- Not supportive at all
- Not supportive
- Neutral
- Supportive
- Highly supportive

In order to better understand the results of this survey, we would like to know a little more about the survey participants. Please note that all responses are anonymous.

What is your gender?

- Female
- Male

What is your current age in years?

- Less than 18
- 18-25
- 26-39 years
- 40-54 years
- 55-64 years
- 65 or over

What racial/ethnic group do you most identify with?

- African American/Black
- Asian/Pacific Islander
- Hispanic/Latino
- Native American
- White/Caucasian
- Other _____

What level of education have you completed?

- Less than high school
- High school diploma or GED
- Some college or 2-year degree
- Bachelor's degree
- Graduate degree or higher
- Other

How long have you lived in *[Garden City/Hays]*?

- 0-1 years
- 2-5 years
- 6-10 years
- 11 + years

Municipal Staff Survey

Dear Colleague:

The Kansas Health Institute (KHI) in collaboration with the Kansas Department of Health and Environment (KDHE), the Kansas Water Office (KWO), and the Kansas Municipal Utilities (KMU), is conducting a health impact assessment (HIA) to inform the implementation of water reuse projects in Kansas and existing regulations in this area. An HIA is a policy tool which combines the best

available research, data, and community input in order to project potential positive and negative health impacts of a decision, project or plan. This work will also address one of the strategies, Evaluate the Sources and Potential Uses of Lower Quality Water, included in The Kansas Water Vision, "A Long-Term Vision for the Future of Water Supply in Kansas," developed by the Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), and the Kansas Water Authority (KWA). In order to understand local experience with water reuse projects, we would like to hear from experts and professionals who have been engaged in water-related issues in Kansas. Specifically, KHI and KMU want to capture your perspectives towards water reuse projects. The information gathered in this survey will inform future water reuse efforts in Kansas. Your responses will be compiled with other responses and will never directly identify your individual response. We are gathering some demographic information to ensure that we have gathered feedback from a broad representation of individuals. You can choose to skip questions that you don't feel comfortable answering and you can stop at any time. We thank you for your participation! The survey should take no more than 15 minutes of your time. We ask that you complete the survey no later than January 20, 2017. Please contact Tatiana Lin at tlin@khi.org with any questions. Thank you for your time and input!

In this first section, we would like to ask you some general questions about your organization's water reuse efforts.

Does your organization engage in water reuse efforts? Please choose one.

- Yes
- No
- Not sure

What were the major factors leading to the decision to begin the water reuse project? Please choose all that apply.

- Interested partners
- Commitment to conservation
- Community interest
- Interest from organizational leadership
- Interest from elected officials
- Other _____

What changes did your organization have to make in order to implement water reuse efforts?
Please choose all that apply.

- Hire more staff
- Hire staff with certain expertise
- Update infrastructure
- Secure funding
- Contract with consultant
- Change utility rates
- Not sure
- Other _____

What challenges or barriers to water reuse efforts has your organization encountered, if any?
Please choose all that apply.

- Lack of needed expertise
- Limited staff
- Not enough funding
- Community resistance
- Regulations
- No challenges or barriers experienced
- Other _____

Where does the funding come from for these water reuse efforts? Please choose all that apply.

- Built into the utility rate structure
- Conservation fund
- State revolving loan fund
- Charges to specific users who purchase waste water
- Municipal bond
- Grant
- Other _____

How have water utility rates been impacted by water reuse efforts in your community? Please choose one answer.

- Water utility rates increased
- Water utility rates decreased
- Water utility rates have not been impacted
- Not sure

If “Water utility rates increased” is selected above:

What were some drivers of increased water utility rates due to reuse? Please choose all that apply.

- Increased energy costs as a result of reuse
- Increased infrastructure costs as a result of reuse
- Increased personnel costs
- Increased costs for consultants required to implement reuse
- Other _____

If “Water utility rates decreased” is selected above:

What were some drivers of decreased water utility rates due to reuse? Please list the reasons below.

Has your organization considered embarking on a water reuse project? Please choose one answer.

- Yes, but didn't move forward
- No, but might consider in future
- Not implemented nor considering to implement

What were some barriers or challenges to initiating water reuse efforts? Please choose all that apply.

	For those that you have selected, please describe how each challenge can be addressed.	Challenges
Lack of funding		<input type="checkbox"/>
Community concerns		<input type="checkbox"/>
Lack of infrastructure		<input type="checkbox"/>
Lack of staff expertise		<input type="checkbox"/>
Lack of interest from organizational leadership		<input type="checkbox"/>
Availability of water from other sources		<input type="checkbox"/>
Other		<input type="checkbox"/>

Thinking about water reuse more broadly, how much do you favor the use of recycled wastewater for each of the following?

	Highly Unfavorable	Unfavorable	Neutral	Favorable	Highly Favorable
Irrigate golf courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate landscaping and parks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate school grounds	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate non-edible agricultural crops	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigate agricultural crops for human consumption	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use in industrial processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flush toilets in public buildings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supply fire hydrants in the city	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supply car wash businesses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If your organization decides to expand water reuse in future, how supportive would you be? Please choose one answer.

- Not supportive at all
- Not supportive
- Neutral
- Supportive
- Highly supportive

Next, we would like to ask you about your organization's communication with the public about water/wastewater.

How often does your organization engage with community members about the municipal water or wastewater system? Please choose one answer.

- Never
- Rarely (once per year or less)
- Sometimes (2-3 times a year)
- Often (4 or more times per year)
- All the time (monthly)

How does your organization engage with community members? Please choose all that apply.

- Holds public meetings
- Provides open comment period
- Conducts surveys
- Direct mailing
- Other _____

Has your organization engaged with community members about water reuse efforts? Please choose one answer.

- Yes
- No
- Not sure

What is your community's perception about local water reuse efforts? Please choose one answer.

- Very negative
- Negative
- Neutral
- Positive
- Very positive
- I don't know

Why do you think your community has this perception?

As water reuse projects are being considered and implemented in Kansas.....

- What recommendations would you have for state agencies? Please provide suggestions below.
- What recommendations would you have for local agencies/organizations? Please provide suggestions below.
- What recommendations would you have for elected officials? Please provide suggestions below.

In order to better understand the results of this survey, we would like to know a little more about the survey participants. Please note that all responses are anonymous.

Is your job primarily associated with...

- Wastewater
- Water
- Both (wastewater and water)
- Other _____

What is your gender?

- Female
- Male

What is your current age in years?

- Less than 18
- 18-25
- 26-39 years
- 40-54 years
- 55-64 years
- 65 or over

What racial/ethnic group do you most identify with?

- African American/Black
- Asian/Pacific Islander
- Hispanic/Latino
- Native American
- White/Caucasian
- Other _____

What level of education have you completed?

- Less than high school
- High school diploma or GED
- Some college or 2-year degree
- Bachelors degree
- Graduate degree or higher
- Other _____

How long have you lived in your community?

- 0-1 years
- 2-5 years
- 6-10 years
- 11 + years

Thank you for your responses. Please contact Tatiana Lin at tlin@khi.org with any questions.

Monitoring Plan

The monitoring plan (Figure H-1) provides suggestions on indicators that could be used for tracking the possible impacts of municipal water reuse in Kansas at the state-level, as well as at the county- and municipal-level, where possible. It includes relevant indicators that are already available either by request or from a publicly accessible source, as well as indicators that are not yet available. The plan also suggests how

frequently these indicators should be monitored and the agencies that might be best suited to monitor the information. If a substantial change in these indicators is observed, the monitoring agency could consider further study. If the effects are positive, the monitoring agency could document findings and/or take action to replicate the positive impact, and if negative, the agency could consider efforts to address any negative impacts that could be occurring.

Figure H-1. Monitoring Plan

INDICATOR TO MONITOR	GEOGRAPHY	SOURCE	FREQUENCY	MONITORING AGENCY
WATER AVAILABILITY/COMMUNITY SUSTAINABILITY				
Per-capita water use	Public water suppliers	Kansas Water Office (KWO)	Annually	KWO
Water scarcity	Statewide, regionally and counties	Kansas Geological Survey	Annually	KWO
Water stress	Statewide, regionally and counties	Kansas Geological Survey	Annually	KWO
Population trends	Statewide, regionally and counties	U.S. Census Bureau	Annually	Kansas Department of Health and Environment (KDHE)
WATER QUALITY				
Number of health-based violations of the Safe Drinking Water Act (SDWA)	Public water suppliers and state overall	Annual compliance report	Annually	KDHE
Compliance with contaminant limits for permits that allow reuse	Wastewater treatment plants	Wastewater treatment plants	Monthly	KDHE
Incidence of water-related outbreaks of illness	State and county	KDHE and local health department surveillance	Annually	KDHE
PERCEPTION OF WATER QUALITY				
Percent of adults who think their overall water quality is "good" or "very good"	State and county	Survey of water perceptions in Kansas	Annually	KWO, Kansas Department of Agriculture (KDA)
Percent of adults surveyed who rate a variety of reuses as "favorable" or "highly favorable"	State and county	Survey of water perceptions in Kansas	Annually	KWO, KDA

INDICATOR TO MONITOR	GEOGRAPHY	SOURCE	FREQUENCY	MONITORING AGENCY
Percent of adults who “support” or “strongly support” future reuse efforts	State and county	Survey of water perceptions in Kansas	Annually	KWO, KDA
Percent of adults who are “confident” or “very confident” that overall, decisions about water are made with the public’s best interests in mind	State and county	Survey of water perceptions in Kansas	Annually	KWO, KDA
Percentage of residents that feel they are “aware of and responsible for” water reuse projects in their community	Communities with water reuse	Survey of water perceptions in Kansas	Annually	KWO, KDA
CONSUMPTION OF BEVERAGES OTHER THAN MUNICIPAL WATER				
Percent of adults who have consumed sugary beverages in the past month	State and county	BRFSS	Annually	KDHE
Percent of adults who consume bottled water	State and county	BRFSS state-added question	Annually	KDHE
COSTS AND UTILITY RATES				
Costs of reuse projects	Municipalities	Municipalities	Annually	Municipalities
Impact to water/wastewater utility bills as a result of reuse projects	Public water supplier/wastewater treatment plants	Public water supplier/wastewater treatment plants	Annually	Municipalities
Average water utility bills as a percent of median household income	Public water supplier	Public water suppliers	Annually	Municipalities
Average wastewater utility bills as a percent of median household income	Wastewater treatment plants	Wastewater treatment plants	Annually	Municipalities
REGULATIONS				
Existence of regulatory framework to support reuse	State	KDHE	Annually	KDHE

Source: KHI Municipal Water Reuse HIA, 2017.

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