

**PRELIMINARY
ENGINEERING REPORT
PHASE 1**

SUNFLOWER H2O INITIATIVE

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SECTION 1: INTRODUCTION

The Sunflower H2O Initiative (Sunflower) is a consortium (Consortium) of rural communities and water districts in south central Kansas and northern Oklahoma that are working together to address common water issues. Public water supply systems across the Nation are facing ever increasing challenges in meeting Safe Drinking Water Act (SDWA) requirements. This is especially difficult for small, rural water systems that have low and fixed income populations. Exploring opportunities for partnering among systems is one approach to meeting these challenges. The Kansas Department of Health and Environment (KDHE) encourages partnering in problem-solving among water systems through their Regional Public Water Supply Planning Grant Program. KDHE has awarded Sunflower (through the Sunflower RC&D Area, Inc.) a planning grant to support this multi-state regional water initiative.

In recognizing the common need and inherent efficiencies in combining efforts, these entities have formed the Sunflower H2O Initiative with the intent of identifying the most cost effective manner of developing and delivering the needed water supply. This study has been authorized by the consortium with the following primary objectives:

- Prepare a water needs assessment for participating entities (i.e. Water Story). This assessment will be prepared utilizing information collected by the consortium for each of the participating entities. This information will be combined to provide an overall needs assessment for the region.
- Prepare an immediate needs assessment for entities within the region that are in need of immediate water supply improvements due to insufficient quantity, existing administrative orders, or potential administrative orders. These identified entities will be reviewed and preliminary recommendations made.
- Conceptual plans for both a proposed ground water supply and a proposed surface water supply for the region will be prepared. These conceptual designs will include overall layout maps including potential supplies, transmission piping, and any required major facilities such as booster pump stations and elevated water storage tanks.
- A proposed scope for future phases of this study will be prepared. This scope will include a proposed cost for these future study phases based on what is currently understood regarding this project.

SECTION 2: WATER NEEDS ASSESSMENT/ (WATER STORY)

As the Consortium came together through sharing information on their individual system water challenges, the idea of the “water story” was identified. The individual system water stories are critical to this study as they will help identify key issues facing the systems. Both short and long-term challenges and needs will emerge. When combined, they produce a regional perspective that will identify widespread needs, challenges, and most importantly, opportunities for partnerships. This study is particularly timely with respect to the emerging global climate change impacts to water resources management.

2.1 DESCRIPTION OF STUDY AREA

The study area consists of six counties in Kansas (Barber, Comanche, Harper, Kingman, Kiowa, and Pratt) and three counties in Oklahoma (Alfalfa, Grant, and Woods) with a total population of about 55,000 (Figure 2). There are over 60 public water supply systems in the region. The area is predominantly a rural agricultural economy but oil and gas exploration plays an important role in the region. Recent census data continue to show an overall out-migration pattern with an aging remaining population. Agri-tourism is a growing source of income for the region as local farmers/ranchers diversify their business assets. There are opportunities for higher education within the region at two campuses and several communities have developed small industrial centers to attract new business and industry. Critical to opportunities for future growth of this region will be a dependable supply of good quality water.

The Ninnescah, Chikaskia, Medicine Lodge, Cimarron, and Salt Fork of the Arkansas River flow through the study region. There are only two major surface water reservoirs in the study area - Cheney Lake and Great Salt Plains Lake. Cheney Lake serves as a portion of the water supply for the City of Wichita while Great Salt Plains Lake is utilized for recreation, fish and wildlife opportunities. Due to high mineral content, Great Salt Plains Lake is not suitable for public water supply purposes.

Groundwater is virtually the sole source of public water supply in the study region. Alluvium and terrace deposits of the major river basins provide sources of groundwater in the region along with the High Plains, Cedar Hills Sandstone, and Rush Springs Sandstone bedrock aquifers. Other minor aquifers also contribute to the area’s water supply.

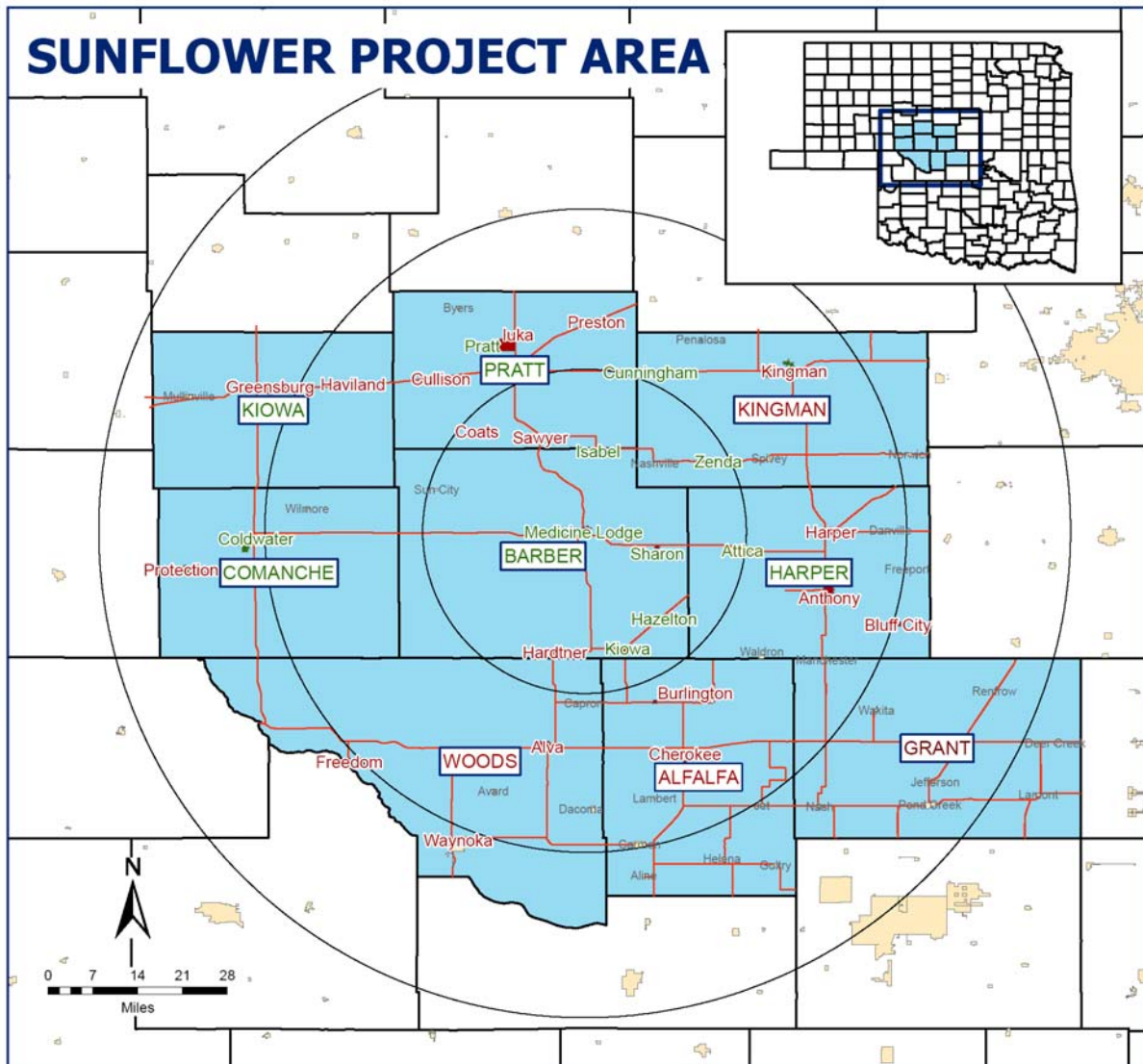


Figure 2: Study Region

2.2 LOCAL WATER STORIES

The following local water stories are presented by State, County, and then by the individual public water supply systems within each County. Not all existing systems within the study area have submitted water story information for inclusion in this phase of study. This will be a living document, so that new and updated water stories may be added as the project progresses.

2.2.1 STATE OF KANSAS

The State of Kansas (from a Sioux word meaning “people of the south wind”) has the following demographic characteristics:

- Land area of 81,814 square miles
- Year 2000 population of 2,688,418

- Year 2040 projected population of 3,545,675
- 32.9 persons per square mile
- 13% of population is 65 years in age and over
- 1,037,891 households
- \$41,664 median household income
- 11.1% of the population below poverty level

Information regarding water systems in the Kansas portion of the region is presented below.

2.2.1.1 Barber County

The county has the following demographic characteristics:

- Land area of 1,134 square miles
- Year 2000 population of 5,307
- 4.7 persons per square mile
- 21.2% of population is 65 years in age and over
- 2,235 households
- \$36,075 median household income
- 10.9% of the population below poverty level

The Kansas Water Office (KWO) State Water Plan projects Barber County population to decline to about 4,706 people by the year 2040.

The following water systems are located in Barber County.

- **Barber County Rural Water District (RWD) #1:** The District serves a population of about 75 persons and purchases treated water (about 5.5 million gallons per year) from Medicine Lodge and Barber County RWD #3 (which serves as their emergency backup supply). The District forecasts growth of service population to around 130 persons and demand to about 6.5 million gallons per year by the year 2040. Inhibiting the potential to grow is the fact that this is an old drip type water system that delivers water to customer's cisterns/holding tanks. The RWD needs to update the pressure system but the cost for such an update is of great concern to its customers. RWD #1 is very interested in exploring regional partnership opportunities to address their water system needs.
- **Barber County RWD #2:** The District serves a population of about 325 persons from a groundwater well field. They currently provide about 4.7 million gallons per year to their system members. Emergency backup supply comes from the City of Kiowa. The District forecasts growth of service population to around 360 persons and demand to about 18 million gallons per year by the year 2040.
- **Barber County RWD #3:** The District serves a population of about 180 persons from a groundwater well field. They currently provide about 6.6 million gallons per year to their system members. They have no emergency backup supply. The KWO forecasts essentially a no growth scenario for the District; therefore, their water demand would not be expected to

grow much beyond their current 6.6 million gallons per year. RWD #3 is concerned about potential contamination to their well field, impacts of drought on water availability, lack of a backup supply, along with ongoing system maintenance/improvement issues.

- **City of Isabel:** The City serves a population of about 105 persons from a groundwater well field. In recent years, they have been providing about 5.5 million gallons per year to their system members. Wells are their emergency backup supply. The KWO forecasts essentially a no growth scenario for the City; therefore, their water demand would not be expected to grow much beyond their current 5.5 million gallons per year. The City is a participant in this study and interested in exploring regional opportunities to meet future needs. They also have ongoing needs to do line replacements, meters, submersible pumps, valves and casings.
- **City of Kiowa:** The City serves a population of about 965 persons from a groundwater well field. In recent years, they have been providing about 76 million gallons per year to their system members, that includes providing water supply to the City of Hazelton and its population of approximately 135 persons. The City system also serves as an emergency backup supply to Barber County RWD #2. The City has old, out of service wells that currently serve as an emergency source of water. The City has undertaken an engineering study of their system including projecting water needs through the year 2040. In this study, an option is also included to connect the City of Sharon to the City system as an emergency water source for Sharon. With this in mind, the average daily demand for the combined Kiowa-Hazelton-Sharon system would be approximately 86.6 million gallons per year in the year 2040. Maximum daily demands push this total to about 157.7 million gallons per year in the year 2040. The City of Kiowa is concerned about vulnerability of their well field to pollution, the poor condition of their water transmission line, and impacts to their fixed income customers (estimated at over 50% of their customer base) of future rate increases to meet system challenges. With this in mind, the City is interested in exploring regional partnerships in addressing these problems.
- **City of Medicine Lodge:** The City serves a population of about 2,150 persons from a groundwater well field. They also provide water to Barber County RWD #1 and their population of about 75 persons. The City and the RWD currently consume about 290 million gallons per year from their well field. The City's 2002 Comprehensive Plan projected a population increase of 350 people by the year 2020. This would result in a potential City population of approximately 2800 persons and a water demand of 377.6 million gallons per year by the year 2040.

The City is making a concentrated effort to enhance potential for business growth through expansion of existing firms and promoting location of prospective businesses to Medicine Lodge. In support of this effort, the City has recently completed US Highway 160 (US-160) improvements, a water system and sewer plant upgrade, swimming pool project, local street improvements and other recreational facility improvements, all totaling about \$5.5 Million. Several new projects are planned including raw water line improvements, a new airport project, City Hall expansion, potential implementation of the Main Street Program, hike/bike trails, and potential development of a business/industrial park.

This vision for the future is contingent on access to dependable quantities of good quality water. While there is currently adequate water to handle some growth, the City is concerned that their well system will soon become inadequate to meet future needs. Additionally, the City is considered low to moderate income due to 54% of its population being below the State's moderate income threshold. They are also concerned that as their aquifer continues to decline, water quality will deteriorate and result in higher levels of treatment cost. Therefore, the City is interested in exploring opportunities for new/additional sources of water supply. In this regard, they would like to investigate opportunities for surface water development within a regional treatment and distribution system. The City believes it is strategically located within the Consortium region and may be a potential project site for a surface water impoundment location and regional water treatment/distribution system.

- **City of Sharon:** The City of Sharon serves a population of about 240 people from a groundwater well field. They have been providing about 12.3 million gallons per year to their system members. They have no identified emergency supply source. KWO population projections indicate a stable population level through the year 2040 which would likely result in no significant change in the City's water demand. In the short term, the City will continue with their well field and perform improvements as needed. In the longer term, the City is interested in opportunities for regional water supplies as a backup to their well field.
- **City of Hardtner:** The City of Hardtner serves a population of about 190 people from groundwater. No data were provided regarding their water story.
- **City of Hazelton:** The City of Hazelton serves a population of about 140 people from groundwater (purchased). No data were provided regarding their water story.

2.2.1.2 Comanche County

The county has the following demographic characteristics:

- Land area of 788 square miles
- Year 2000 population of 1,967
- 2.5 persons per square mile
- 24.4% of population is 65 years in age and over
- 872 households
- \$31,775 median household income
- 9.8% of the population below poverty level.

The KWO State Water Plan projects Comanche County population to decline to about 1,453 by the year 2040.

The following water systems are located in Comanche County.

- **City of Coldwater:** The City of Coldwater serves a population of about 770 people from a groundwater well field. They have been providing about 68 million gallons per year to their system members. They have no specific emergency source of supply. KWO population projections indicate a stable to slightly declining population level through the year 2040 which could result in no significant change in the City's water demand. In the short term, the City needs to do some line replacements. In the longer term, the City is interested in opportunities for regional water supplies as a backup to their well field.
- **Comanche County RWD #1:** Comanche County RWD #1 serves about 70 people from groundwater (purchased). No data has been provided regarding their water story.
- **Comanche County RWD #2:** Comanche County RWD #2 serves about 125 people from groundwater. No data has been provided regarding their water story.
- **City of Protection:** The City of Protection serves about 540 people from groundwater. No data has been provided regarding their water story.

2.2.1.3 Harper County

The county has the following demographic characteristics:

- Land area of 801 square miles
- Year 2000 population of 6,536
- 8.2 persons per square mile
- 22.5% of population is 65 years in age and over
- 2,773 households
- \$32,411 median household income
- 11.9% of the population below poverty level.

The KWO state water plan projects Harper County population to decline to about 5,072 by the year 2040.

The following water systems are located in Harper County.

- **City of Anthony:** The City of Anthony serves a population of about 2,300 people from a groundwater well field. They have been providing about 187 million gallons per year to their system members. They have no specific emergency source of supply. KWO population projections indicate a stable to slightly declining population level through the year 2040 which could result in no significant change in the City's water demand. The City is concerned in the short term about water loss from the 18" water line from their well field. They also have three water tanks that will be in need of rehabilitation or replacement. They are also concerned about nitrate contamination of their well field in both the short and long term. This leads to the need for a treatment plant and their interest in a regional water system in the future.

- **City of Attica:** The City of Attica serves a population of about 600 people from a groundwater well field. They have been providing about 47 million gallons per year to their system members. They have no specific emergency supply. KWO population projections indicate a stable to slightly declining population level through the year 2040 which could result in no significant change in the City's water demand. However, the City believes their 2040 water demand could approach 55 million gallons per year. The City is concerned about pollution threats to their groundwater supply and having adequate quantities available in future years to support growth and economic development opportunities. This leads to their interest in a regional water supply system for the future.
- **City of Bluff City:** The City of Bluff City serves about 80 people from groundwater. No data has been provided regarding their water story.
- **Harper County RWD #1:** The District serves about 50 people from groundwater (purchased). No data has been provided regarding their water story.
- **Harper County RWD #2:** The District serves about 800 people with groundwater purchased from the City of Anthony. They are providing about 29 million gallons per year to their system members. They have no specific source of emergency supply. KWO water demand projections for the District are stable through the year 2040. The District sees opportunity for growth in their service area. They are concerned about pollution of their groundwater source from nitrates. They are also concerned about increasing regulatory requirements and how their system's fixed income customer base will be able to afford higher costs of water. With this in mind, the District is interested in regional water system opportunities that can provide a dependable, high quality and affordable source of water for the future.
- **Harper County RWD #4:** The District serves a population of about 320 people from groundwater (purchased). No data has been provided regarding their water story.
- **Harper County RWD #5:** The District serves a population of about 500 people from groundwater purchased from the City of Harper. They have been providing about 18 million gallons per year to their system members. They have no specific emergency supply source. KWO projects a slightly increasing demand for water through the year 2040. The District is generally concerned about maintaining the ability to provide a dependable, high quality source of water to their customers that is affordable. It is in this regard that the District is interested in regional water system opportunities.
- **City of Harper:** The City of Harper serves a population of about 1,500 from a groundwater well field. They have been providing about 104 million gallons per year to their system members. They have no specific emergency supply source. KWO projects a stable to slightly decreasing demand for water through the year 2040. However, the City believes there is opportunity for growth in demand from new business development and resulting housing needs. The City is concerned about nitrate pollution threatening their well field. It is in this regard that the City is interested in regional water system opportunities.

2.2.1.4 Kingman County

The county has the following demographic characteristics:

- Land area of 863 square miles
- Year 2000 population of 8,673 people
- 10 persons per square mile
- 19.9% of population is 65 years in age and over
- 3,371 households; \$40,174 median household income
- 10.5% of the population below poverty level

The KWO State Water Plan projects Kingman County population to decline to about 7,729 people by the year 2040.

- **City of Cunningham:** The City of Cunningham serves a population of about 480 persons from a groundwater well field. They currently provide about 30 million gallons per year to their system members. They have no specific emergency water supply source. KWO projects stable to slightly declining population for the City; therefore, their water demand would not be expected to grow much beyond their current 30 million gallons per year. They are concerned that if there is significant new growth, their infrastructure is undersized. They are also concerned about contamination to and adequacy of their well field to meet future demands. With this in mind, the City is interested in evaluating regional water system opportunities.
- **Kingman County RWD #1:** The District serves a population of about 250 persons from groundwater (purchased). No data has been provided regarding their water story.
- **City of Kingman:** The City serves a population of about 3,200 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Norwich:** The City serves a population of about 520 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Spivey:** The City serves a population of about 80 persons from groundwater (purchased). No data has been provided regarding their water story.
- **City of Zenda:** The City serves a population of about 120 persons from a groundwater well field. They have been supplying as much as 7 million gallons per year to their customers in recent years. KWO projects water demand to increase to about 7.8 million gallons per year by the year 2040. The City believes that growth will cause increased demands on their system. They are concerned about adequate availability of water to meet these projected growing demands along with pollution threats to their well field. In this regard, the City is interested in exploring options for regional water supply solutions to meet future needs in an affordable manner.

2.2.1.5 Kiowa County

The county has the following demographic characteristics:

- Land area of 722 square miles
- Year 2000 population of 3,278 people
- 4.5 persons per square mile
- 21.8% of population is 65 years in age and over
- 1,365 households
- \$35,829 median household income
- 11.6% of the population below poverty level

The KWO State Water Plan projects Kiowa County population to decline to about 3,055 by the year 2040.

The following water systems are located in Kiowa County.

- **City of Greensburg:** Prior to the devastating tornado of 2007, the City served a population of about 1,400 persons from a groundwater well field. Understandably, the City has not submitted a water story due to their tornado recovery efforts.
- **City of Haviland:** The City serves a population of about 575 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Mullinville:** The City serves a population of about 260 persons from a groundwater well field. No data has been provided regarding their water story.

2.2.1.6 Pratt County

The county has the following demographic characteristics:

- Land area of 735 square miles
- Year 2000 population of 9,647 people
- 13.1 persons per square mile
- 18.1 % of population is 65 years in age and over
- 3,963 households
- \$37,882 median household income
- 10.8% of the population below poverty level

The KWO State Water Plan projects Pratt County population to decline to about 9,440 people by the year 2040.

The following water systems are located in Pratt County.

- **City of Coats:** The City serves a population of about 110 persons from a groundwater well field. No data has been provided regarding their water story.

- **City of Cullison:** The City serves a population of about 100 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Iuka:** The City serves a population of about 185 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Pratt:** The City serves a population of about 6,450 persons from a groundwater well field. In recent years, the City has provided up to about 604 million gallons per year to their system customers. Backup wells serve as their emergency supply source. The KWO forecasts a slightly increasing population for the City which would result in a somewhat increased water demand. Protecting their well field from contamination is of primary concern to the City. They also believe there is opportunity for significant demand growth due to energy production. This will put pressure on their well field to meet demands of as much as 800 million gallons per year by the year 2040. With all this in mind, the City is interested in exploring regional water supply opportunities to meet future demands.
- **City of Preston:** The City serves a population of about 160 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Sawyer:** The City serves a population of about 120 persons from a groundwater well field. No data has been provided regarding their water story.

2.2.2 STATE OF OKLAHOMA

The State of Oklahoma (which means “land of the red people” in Choctaw language) has the following demographic characteristics:

- Land area of 68,667 square miles
- Year 2000 population of 3,450,654
- Year 2040 projected population of 4,400,600
- 50.3 persons per square mile
- 13.2% of population is 65 years in age and over
- 1,342,293 households
- \$37,109 median household income
- 14% of the population below poverty level

Information regarding water systems in the Oklahoma portion of the region is presented below.

2.2.2.1 Alfalfa County

The county has the following demographic characteristics:

- Land area of 866 square miles
- Year 2000 population of 6,105 people
- 7 persons per square mile

- 20.2% of population is 65 years in age and over
- 2,199 households
- \$30,857 median household income
- 13.5% of the population below poverty level

The Oklahoma Water Resources Board (OWRB) projects Alfalfa County population to decline to about 5,900 people by the year 2040.

The following water systems are located in Alfalfa County.

- **Alfalfa County RWS&SWMD #1:** The District serves a population of about 550 persons from a groundwater well field. No data has been provided regarding their water story.
- **Alfalfa County RWS&SWMD #1 North:** The District serves a population of about 600 persons from a groundwater well field. No data has been provided regarding their water story.
- **Aline Public Works Authority (PWA):** Aline PWA serves a population of about 215 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Burlington:** The City serves a population of about 155 persons from groundwater (purchased). No data has been provided regarding their water story.
- **Town of Carmen:** The Town serves a population of about 410 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Cherokee:** The City serves a population of about 1,630 persons from a groundwater well field. No data has been provided regarding their water story.
- **Goltry PWA:** Goltry PWA serves a population of about 270 persons from a groundwater well field. No data has been provided regarding their water story.
- **Helena PWA:** Helena PWA serves a population of about 440 persons from a groundwater well field. No data has been provided regarding their water story.
- **Town of Jet:** The Town serves a population of about 230 persons from a groundwater well field. No data has been provided regarding their water story.

2.2.2.2 Grant County

The county has the following demographic characteristics:

- Land area of 1,000 square miles
- Year 2000 population of 5,144 people
- 5.1 persons per square mile

- 20.3% of population is 65 years of age and over
- 2,089 households
- \$32,319 median household income
- 12.3% of the population below poverty level

The OWRB State Water Plan projects Grant county population to increase to about 5,300 people by the year 2040.

The following water systems are located in Grant County:

- **Town of Deer Creek:** The Town serves a population of about 150 persons from a groundwater well field. No data has been provided regarding their water story.
- **Grant County RWD #1:** The District serves a population of about 100 persons from groundwater purchased from the Town of Manchester. They currently supply about seven million gallons per year to their system members. They have no specific emergency backup supply. The OWRB forecasts slightly increasing population in the County through the year 2040 so the District's water demand may grow somewhat beyond current usage. The District is concerned about ongoing maintenance of their 62 miles of pipeline. They are also interested in exploring regional water supply and distribution options that might make sense for their District members.
- **Town of Jefferson:** The Town serves a population of about 30 persons from groundwater (purchased from the City of Medford). They supply an estimated 1.5 million gallons per year to their customers. They have no specific emergency backup supply other than their tie in to the City of Medford. The OWRB forecasts slightly increasing population in the County through the year 2040 so the Town's water demand may grow somewhat beyond current usage. The Town is interested in exploring regional water supply and distribution options that might make sense for their system.
- **Town of Lamont:** The Town serves a population of about 470 from a groundwater well field. They have no specific emergency backup supply other than their existing well field. The OWRB forecasts slightly increasing population in the County through the year 2040, so the Town may experience growth that will increase their water demand somewhat. The Town is concerned about short and long-term maintenance and replacement of their overall system including lines, towers, tanks and treatment plant components. It is in this regard that they are interested in exploring regional water supply and distribution options that could make sense for their system customers.
- **Manchester PWA:** Manchester PWA serves a population of about 105 persons from a groundwater well field. No data has been provided regarding their water story.

- **City of Medford:** The City serves a population of about 1,170 persons from a groundwater well field. They currently provide about 239 million gallons per year to their customers. They have no specific emergency backup supply other than their existing well field. The OWRB forecasts slightly increasing population in the County through the year 2040, so the City may experience growth that will increase their water demand beyond current levels. The City is concerned that their well levels have been steadily declining over recent years. With this in mind, they are interested in regional water supply and distribution opportunities that may complement their existing system.
- **Nash PWA:** Nash PWA serves a population of about 220 persons from a groundwater well field. No data has been provided regarding their water story.
- **City of Pond Creek:** The City serves a population of about 900 persons from a groundwater well field. They currently provide about 94 million gallons per year to their customers. They have no specific emergency backup supply other than their existing well field. The OWRB forecasts slightly increasing population in the County through the year 2040, so the City may experience some growth in demand for water beyond their current levels. They are concerned about oil well exploration activities in their well field area and potential for pollution of the aquifer. Even though the City's wells continue to meet customer demands, they are interested in exploring options for regional sources of supply and distribution that may benefit the system in the future.
- **R&C Water Corporation:** R&C serves a population of about 400 persons from groundwater purchased from the City of Medford. They currently provide about 29 million gallons per year to their system customers. They have no specific emergency backup supply other than their service tie to Medford. The OWRB forecasts slightly increasing population in the County through the year 2040, so R&C may experience some growth in demand for water beyond their current levels. R&C is interested in exploring regional sources of supply and distribution that may make sense for their system in the future.
- **SW Water Inc.:** SW Water, Inc. serves a population of about 200 persons from groundwater purchased from the City of Pond Creek. No data has been provided regarding their water story.
- **Wakita Utilities Authority (UA):** Wakita UA serves a population of about 420 persons from a groundwater well field. No data has been provided regarding their water story.

2.2.2.3 Woods County

The county has the following demographic characteristics:

- Land area of 1,286 square miles
- Year 2000 population of 9,089 people
- 7.1 persons per square mile
- 19.5% of population is 65 years of age and over
- 3,684 households
- \$31,195 median household income

- 13.5% of the population below poverty level

The OWRB State Water Plan projects Woods County population to increase to about 9,400 people by the year 2040.

The following water systems are located in Woods County.

- **City of Alva:** The City serves a population of about 5,290 persons from a groundwater well field. They currently provide about 428 million gallons per year to their customers. Storage tanks serve as their emergency backup source of water but no alternative source of water other than their well field. The OWRB forecasts slightly increasing population in the County through the year 2040, so the City may experience increased water demand. The City expects demand to increase to about 525 million gallons per year by the year 2040 due to development of an industrial park and additional residential construction. They also anticipate that other systems may look to them for water purchase opportunities. The City is concerned about water quality – both pollution threats to their well field and increasing regulatory standards for treatment. They are also concerned about the ability to acquire additional water rights as their system grows. In this regard, the City is interested in exploring regional water supply and distribution opportunities that make sense for their system in the future.
- **Dacoma PWA:** Dacoma PWA serves a population of about 150 persons from groundwater (purchased from the City of Alva). No data has been provided regarding their water story.
- **Freedom Municipal Authority (MA):** The Freedom MA serves a population of about 275 persons from groundwater (purchased from Woodward County RWD #1). No data has been provided regarding their water story.
- **Waynoka UA:** The Waynoka UA serves a population of about 1,000 persons from a groundwater well field. They currently provide about 57 million gallons per year to their customers. They have no emergency backup source of supply other than their current well field. The OWRB forecasts slightly increasing population in the County through the year 2040, so the UA may see some increasing demand for water beyond their current levels. The UA expects demand to increase to about 66 million gallons per year by the year 2040 due to new industrial recruitment activities and a growing recreational industry spurred by Little Sahara State Park. The UA is concerned about increasing regulatory requirements along with pollution threats (nitrates) to their well field. They also have operation, maintenance and replacement issues with the old lines in their distribution system. They maintain a reverse osmosis treatment plant to deal with their nitrate issue. With these current challenges in mind, the UA is interested in exploring regional water supply and distribution options that might make sense for their system in the future.

- **Woods County RWD #1:** The RWD serves a population of about 425 persons from groundwater (purchased from the City of Alva). They currently provide about 28 million gallons per year to their customers. They have no emergency backup source of supply other than their tie-in to the City of Alva. The OWRB forecasts slightly increasing population for the County through the year 2040, so the RWD may see some increasing demand for water beyond current levels. The District is concerned about water quality threats to their source of supply in the future. In this regard, they are interested in exploring opportunities for regional water supply and distribution options that could make sense for their system in the future.
- **Woods County RWD #2:** The RWD serves a population of about 40 persons from groundwater (purchased). No data has been provided regarding their water story.
- **Woods County RWD #3:** The RWD serves a population of about 460 from groundwater (purchased from the City of Alva and Waynoka UA). They currently provide an estimated 23 million gallons per year to their customers. They have no emergency backup supply other than their tie-in to the Alva and Waynoka systems. The OWRB forecasts slightly increasing population growth in the County through the year 2040, so the RWD may experience some increase in water demand beyond current levels. The District is concerned about the quality of their water along with ongoing operation, maintenance and replacement of their system components. The RWD is interested in exploring opportunities for regional water supply and distribution options that make sense for their system in the future.

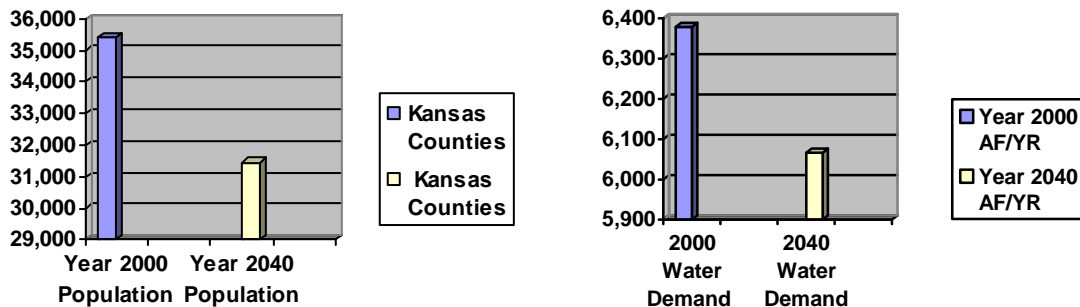
SECTION 3: REGIONAL POPULATION / WATER DEMAND PROJECTIONS

A critical component in any water resources planning project is a reasonable projection of future population and resulting water requirements. These projections provide important information for planning timely infrastructure improvement projects such as expansion of water supply, treatment and distribution facilities. The Consortium is fortunate that the KWO and the OWRB have recently performed population/water demand projections for the study region.

3.1 STATE OF KANSAS POPULATION / WATER DEMAND PROJECTIONS

The KWO State Water Plan indicates that the population of Sunflower's six county region in Kansas will decline from 35,408 persons in the year 2000 to about 31,455 persons by the year 2040.

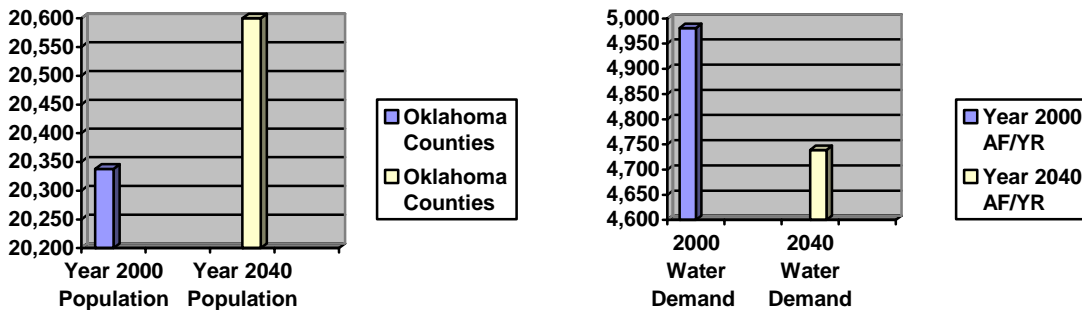
The KWO State Water Plan also indicates that the public water supply demand in Sunflower's six county region in Kansas will decline from about 6,378 acre-feet per year in the year 2000 to about 6,066 acre-feet per year by the year 2040.



3.2 STATE OF OKLAHOMA POPULATION / WATER DEMAND PROJECTIONS

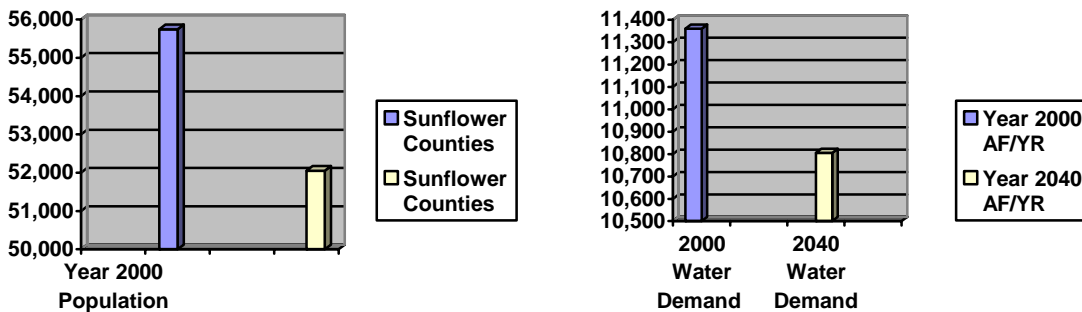
The OWRB State Water Plan indicates that the population of Sunflower’s three county region in Oklahoma will increase from 20,338 persons in the year 2000 to about 20,600 persons by the year 2040.

The OWRB State Water Plan also indicates that the public water supply demand in Sunflower’s three county region in Oklahoma will decline from about 4,981 acre-feet per year in the year 2000 to about 4,739 acre-feet per year by the year 2040.



3.3 SUNFLOWER H2O POPULATION / WATER DEMAND PROJECTIONS

The results of the respective KWO and OWRB State Water Plan projections indicate that the Sunflower H2O study region is forecasted to have an overall population decline of 55,746 people from the year 2000 to about 52,055 people in the year 2040. Additionally, water demand is forecasted for an overall decline from about 11,359 acre-feet per year from the year 2000 to about 10,805 acre-feet per year by the year 2040.



3.4 SUMMARY OF DEMAND ISSUES

The following identifies key issues that the Consortium water stories and the overall study have revealed.

3.4.1 SHORT-TERM ISSUES

- All systems are groundwater sourced.
- Many systems are experiencing pollution/contamination threats to their well fields. These threats include nitrates and oil field activities.
- Some systems are experiencing consistent water level declines in their well fields.
- Considerable day-to-day operation, maintenance, and replacement issues.
- Few systems have emergency back-up water sources.
- Rural systems are spread thin, but experience demand for new connections.
- Economic development opportunities may vanish due to availability of water (bio-fuels industry, etc).
- The recent relatively brief drought episodes stressed many systems.
- Increasingly stringent SDWA requirements are becoming more difficult for some systems to meet.
- Potential transition of Oklahoma Groundwater and Stream Water Laws to a conjunctive use management system and its potential impacts to existing water rights.

3.4.2 LONG-TERM ISSUES

- Projected slightly declining population.
- Opportunities for growth and economic prosperity hinge on the availability of adequate quantities of good quality water (bio-fuels industry, agri-tourism, etc).
- Challenges of a study area population with 20% over the age of 65 and on fixed or limited incomes.
- Median household incomes below the state averages, which challenges opportunities to increase system revenues.
- Very low population densities near 10% of state averages, which results in costly rural delivery settings.
- Continuing pollution threats to groundwater sources from the critical local economic engines of oil and gas exploration and agriculture.
- Total dependency on what may ultimately be fragile groundwater resources, particularly during prolonged drought periods.
- No non-groundwater source emergency back up water sources.
- Critical need to balance sources of water between groundwater and surface water resources.
- The region is “due” from a climatological perspective for a multi-year drought that will critically stress the water resources infrastructure of the region.
- Potential negative impacts of global warming of longer dry spells and less general, but more intense, rains that could result in less recharge of the aquifers.

SECTION 4: IMMEDIATE NEEDS ASSESSMENT

As a part of this study we have been asked to prepare an immediate needs assessment for the entities involved in the study area. The purpose of this assessment is to identify entities within the region that are in need of immediate water supply improvements due to insufficient quantity, existing administrative orders, or potential administrative orders. Once these entities have been identified general recommendations will be presented that if possible will tie into the overall conceptual plan for the region. These recommendations will also describe future steps that each entity will need to take to implement these recommendations.

4.1 ENTITIES WITH CURRENT ADMINISTRATIVE ORDERS

To determine which entities within the region are currently under administrative order information from the Kansas Department of Health and Environment and the Oklahoma Department of Environmental Quality was reviewed. From this research the following information was found:

Communities which have exceeded standards for Nitrates

Kansas

Harper Co. No. 4
Freeport
Norwich

Oklahoma

Waynoka

Communities which have encountered Disinfection Bi-Product Violations

Kansas

Harper
Anthony

All of these communities are currently receiving water from local ground water supplies. The community of Waynoka, Oklahoma is currently operating a reverse osmosis system to treat for nitrates. It is assumed that their last violation in 2002 is now being resolved with this R/O process.

The three Kansas entities receiving nitrate violations are Harper Co. No. 4, Freeport, and Norwich. Each of these communities are utilizing ground water without a treatment process other than disinfection with free chlorine. These communities all fall within the eastern portion of Harper County and the southeastern portion of Kingman County.

The two communities in Kansas which have disinfection bi-product violations are Harper and Anthony. Anthony also sells water to Harper Co. No. 2. These entities have also indicated a concern of future nitrate issues, and are located in eastern Harper County.

With the communities of Harper, Anthony, Norwich, Freeport, Harper Co. No. 4, and Harper Co. No. 2 all located in relatively close proximity to one another, an overall solution to the nitrate and disinfection bi-product issues may be feasible and meet future proposed improvements for the overall regional supply solution.

Our recommendation would be to incorporate the existing water supply wells of both Harper and Anthony, which lie to the northwest of Harper, into a new well field to serve a portion of the currently proposed regional system. This new well field would currently be sized to serve these proposed entities with the ability to add wells in the future to serve the larger regional system. A reverse osmosis treatment plant would be constructed in this area to treat this proposed raw water supply to remove nitrates and also reduce hardness caused by calcium carbonate. This plant would initially be designed to serve the existing entities in question with the ability to expand this treatment process for the future needs of the regional system in this area. This potential supply could then be provided to these 6 entities through new pipelines designed for the ultimate future use of the regional system.

Our recommendation would also be that the consortium take the lead in establishing this initial supply, treatment facility, and transmission lines. This would allow the Sunflower group to begin selling water to these individual entities as a wholesale water supplier.

The first step in achieving this project would be to have a preliminary engineering report prepared specifically addressing these issues. The report should describe the available design alternatives and prepare probable construction costs for each alternative making a recommendation of the best available option. This design report would then be used to make application to either the SRF Program or funds available through USDA Rural Development.

4.2 ENTITIES NOT UNDER ADMINISTRATIVE ORDER WITH EXISTING ISSUES

No other entities within this regional area are currently under administrative orders for water supply or distribution violations. However, within the water stories a majority of the entities responding have indicated concerns about possible future contamination of their ground water supplies. The majority of these concerns revolved around nitrate levels in existing wells. Our recommendation would be to initially have a monitoring regiment established by placing monitoring wells around supply areas where this concern exists. This will allow each entity to determine if the potential for contamination is eminent or if these locations can continue to wait and monitor contamination levels.

Other communities within the study area have indicated a need for internal system improvements to continue providing a high quality of service to their patrons. These communities include:

Barber Co. No. 1	District operates an old style drip system.
City of Isabel	Ongoing needs for line replacement, meters, and pumps.
City of Coldwater	Ongoing need for line replacement.
City of Anthony	Water loss in 18" Trans. Main, and 3 tanks need rehab.
Grant Co. No. 1	Maintenance concerns for existing waterlines.
Town of Lamont	Maintenance issues with waterline, tanks, and treatment.
City of Medford	City concerned with declining well levels.
Woods Co. No. 3	Concerned about ongoing O&M issues with system.

Barber Co. No. 1 currently serves 40 customers equating to approximately 75 people. This system is currently operated as an old style drip system that fills cisterns at each individual residence which is in turn pumped into the home. As a regional system develops we would propose replacing waterlines within this system to provide adequate flows to individual customers. The District could also purchase storage from a future elevated water storage tank proposed for this area within the regional wholesale system. This scenario would limit required internal improvements.

The City of Isabel, Kansas has expressed a need for internal line replacement, meter replacement, submersible pump maintenance, and valve replacement. These issues all generally fall under normal operation and maintenance of a water system. Our recommendation would be to have an overall system analysis performed identifying these issues specifically and prioritizing these projects. Once anticipated project costs are determined specific funding options can be reviewed to determine the availability of grant and loan funds.

The City of Coldwater, Kansas has also indicated a short term need for waterline replacement. This will require the same process as above for hiring a firm to prepare a preliminary engineering report specifically for this community. Once the extent of the needed waterline replacement is determined proposed project costs and funding can be determined.

The City of Anthony, Kansas has expressed a short term concern with water loss in the cities existing 18" transmission line running from the city to their well field. If the cities potential nitrate issues cause them to proceed with treatment as described previously, there is the possibility that this existing transmission line will be replaced as a part of the overall project. If this treatment option does not proceed a PER will be required designating funding options for the project.

Grant Co. No. 1 in Oklahoma has expressed concerns about ongoing maintenance issues in the district's 62 miles of waterline. To address this we would recommend that the district have a preliminary engineering report prepared. This report should analyze deficiencies within the system and recommend improvements. From this opinions of probable construction costs could be created. From these costs and income information provided by the district funding options could be evaluated.

The Town of Lamont, Oklahoma serves a population of approximately 470 people. The city has expressed concerns about long term maintenance and replacement of their overall system including waterlines, tanks, and treatment plant components. We would propose that the city hire a firm to perform an overall system analysis to detail these specific issues generating probable construction costs for these projects allowing a funding package to be prepared.

The City of Medford, Oklahoma has raised concerns regarding water levels at their existing well field. This may be a circumstance where monitoring wells could be installed to determine the extent of this drawdown. Once this area is determined the city can continue to monitor, and may need to consider an additional well site outside of this area to allow pumping from the existing well field to be decreased. If the existing wells can continue to be pumped until a regional supply is developed additional wells may not be required.

Woods Co. No. 3 in Oklahoma has also expressed concerns regarding long term operation and maintenance issues with the district. Again, these issues should be reviewed in a detailed PER of the system highlighting specific issues and potential project costs. With these costs available funding opportunities can be reviewed.

SECTION 5: CONCEPTUAL REGIONAL SYSTEM LAYOUTS

For this study phase conceptual design plans have been prepared for the regional area based on the water needs assessment. For this study two conceptual designs have been prepared. The first design assumes a surface water supply as a source for the entire study region. The second design layout assumes a surface water supply as a source for central regions of the area where ground water is not as prevalent and pocket ground water supplies where available. These conceptual designs include overall layout maps included in Appendix D. On these maps areas of potential ground and surface water supplies will be generally located. These maps will also include potential transmission piping layouts and any required major facilities such as booster pump stations and elevated water storage tanks.

During the conceptual design phase a cursory review of potential environmental impacts to the project area were reviewed. Ultimately a full environmental assessment of the project area will be required. The assessment could include archeological surveys, reviews of riparian habitats and wetlands, and reviews of endangered species in the project area. During a cursory review it would appear that impacts from pipeline installation would be minimal because the majority of these lines would be installed along existing road right-of-ways. Attempts would also be made to located tanks and booster pumping facilities in areas where these conflicts could be minimized. New water supplies such as wells are many located in areas of environmental concern so some mitigation measures may be required for these facilities. The creation of a new reservoir will certainly require additional scrutiny and design aspects will most certainly be impacted based on these environmental requirements.

5.1 CONCEPTUAL SURFACE WATER SUPPLY

To begin the process of a conceptual design layout for a surface water supply for this regional we first need to try and establish a general location for this potential supply. It is not the intent of this study to size a potential surface water impoundment, determine the adequacy of the underlying soils, or to evaluate stream flow data. These factors will be evaluated in a future Phase 2 detailed design study. The intent of this study is to locate a potential surface water supply in a general area basing the location on adequate topography, general elevation of the location (allowing other regional areas to take advantage of gravity flow), and previously prepared Bureau of Reclamation studies (Technical Memorandum, Sub-Appraisal Investigation, Kiowa and Amber Dam and Reservoir Sites, Kansas, June 1988).

The general location for the potential surface water impoundment was selected as site falling within a 10 mile radius of Medicine Lodge, Kansas. The reason for this initial location was based on the following factors; topography of the area allows for a reservoir of reasonable size, the general elevation of this location will allow for a transmission system to take advantage of the significant elevation drop across the study region to the south and east creating the need for less pumping and longer transmission runs, and finally the positive findings from the 1988 Bureau of Reclamation study.

Once a potential surface water location is determined, the next step is to evaluate demands throughout the region. The water needs assessment provides us with the current annual water demand of 11,359 acre-feet or an average of 10.1 million gallons per day (mgd). This demand

figure is for service to 100% of the proposed study area. Assuming initial signups to be far less than this we will use this current 100% demand figure as our basis for ultimate design.

To model a system under extreme conditions, a peak day demand is imposed on the system. Therefore, a peak day factor must be determined to convert the average day demand to the peak day demand. Based on monthly peaking factors provided in the individual water stories near 1.5, we have assumed a daily peaking factor for this region of 1.8.

With these design criteria determined, it is now necessary to distribute these demands across the study area. This was done by taking the current total population of the area (55,746 people) and assigning people to regions based on current township and municipal populations from 2000 census data. This distribution allowed water demands to be proportioned across the region.

Transmission piping was then laid out across the area connecting major population centers leaving connection points to serve rural areas. It is assumed that this regional system will operate as a wholesale provider allowing connection points for larger wholesale customers not individual residential services. It is the intention that this regional system will supply a clean potable source of water to areas so that rural water systems can be formed providing service to these individual customers. Initial transmission lines were sized to provide a minimum of 25 psi at any point in the system. Booster pump stations and elevated water storage tanks were also located as required to increase hydraulic gradelines and provide storage equivalent to a 6 hour control volume plus a peak equalization volume equivalent to one average day usage for the largest community within the region. For the conceptual layout, a maximum pressure of 150 psi was used at any point in the system. Additional pumping may be required at some individual connection points which is not shown in the conceptual layout.

The attached map for the conceptual surface water supply located in Appendix D shows this transmission line routing and sizes listing booster pump station locations and elevated water storage tanks. Future studies will further detail these layouts field checking routing, specifically sizing pumps and tanks, and providing estimates of probable construction costs.

5.2 CONCEPTUAL SURFACE WATER/GROUND WATER SUPPLY

The conceptual design for a part surface water and part ground water supply begins in much the same way as the surface water design. We begin by establishing the location of the water supplies. In this case the surface water supply will remain the same. The ground water supply locations have been established based on locations where appropriations are available and where current ground water supplies exist.

For this scenario 3 ground water supply locations have been established. The first is in the bedrock formations of northern Comanche County, the second in the bedrock formations of southern Kingman County, and the third in the alluvial formations of southern Woods County near Waynoka.

The benefit of supplementing the surface water supply with ground water is two fold. First it allows for peak demand requirements from any one source to be decreased reducing the required transmission lines sizes required from a single source. Secondly, it provides some redundancy to the system by having multiple supply sources.

It is assumed that the surface water supply in this scenario will serve Pratt, Barber, Alfalfa, and Grant counties. The ground water supply in northern Comanche county will serve Comanche and Kiowa counties. The ground water supply in Kingman will serve Kingman and Harper counties. While the ground water supply in southern Woods county, will serve Woods county alone.

Transmission line sizing, booster pump locations, and elevated water storage tank sizes and locations were determined using the same criteria used in the previous conceptual design. The layout map for this layout can also be found at the back of this report in Appendix D As previously stated future studies will further detail these layouts field checking routing, specifically sizing pumps and tanks, and providing estimates of probable construction costs.

For informational purposes a sole ground water supply solution was not pursued due to the overall quantities of water required. Based on preliminary investigations, wells of the size anticipated in this region to produce 11,359 acre-feet annually would not be available to provide this entire quantity. To account for this the surface/ground water conceptual design was developed.

5.3 GENERAL TREATMENT PROCESSES

At this time no raw water analysis has been performed for any of the potential water supply locations. For this reason recommending treatment processes for these locations is not possible. However, we have included information on general treatment processes for both surface and ground water to provide a sample of processes which may be ultimately pursued.

5.3.1 Water Quality

There are several raw water quality parameters (turbidity, iron, manganese, total organic carbon, pH, alkalinity, hardness, temperature, etc.) that are analyzed in a surface water source to aid in determining the type of treatment process. The water quality discussion for Pomona Lake is based on information gathered from the Kansas Department of Health and Environment. It is anticipated that the raw water quality of a proposed treatment facility on the lake will be similar to that collected by KDHE. The water quality discussion for the Kansas River is based on information gathered from the Douglas Co. RWD No. 3 water treatment facility, which uses the Kansas River alluvial as the water source. It is anticipated that the source water quality will be similar to that experienced at the RWD No. 3 treatment facility.

Turbidity indicates the amount of suspended and/or colloidal material that is present in the source water. Without proper removal of these particles and adequate disinfection contact times, microbial contaminants such as *Giardia* and *Cryptosporidium* may pass into the distribution system. Pomona Lake source water turbidities are anticipated to range from as low

as 3 to 5 NTU to as high as 50 to 60 NTU, with typical daily readings of 10 to 15 NTU. These are typical values that can be expected with a surface water lake/reservoir. The Kansas River source turbidities are anticipated to range from as low as 10 to 20 NTU to as high as 400 to 500 NTU, with typical daily readings of 25 to 35 NTU. As discussed in Section 6, the combined filtered water turbidity must not exceed 1 NTU at any time or exceed 0.3 NTU in 95% of the monthly samples.

The presence of soluble iron and/or manganese in the source water can result in a discoloration (reddish brown to black tint) of the treated water, if not properly removed in the treatment process. The secondary maximum contaminant levels (MCLs) for iron and manganese are 0.3 mg/L and 0.05 mg/L. It is anticipated that source water iron and manganese concentrations will typically range from 0.1 mg/L to 0.3 mg/L and 0.02 to 0.15 mg/L, respectively. It is likely there will be times during lake-turnover events (primarily in spring and fall) in which the iron and manganese concentrations will exceed 1 mg/L and 0.75 mg/L, respectively.

Total organic carbon (TOC) is a measure of the organic matter found in the source water. When free chlorine is added to water with organic matter, the free chlorine combines with the organic matter to form disinfection by-products (THMs and HAAs) which are regulated in the Stage 1 and Stage 2 D/DBP Rule. By removing TOC prior to the addition of free chlorine or incorporating a disinfectant that does not combine with the organic matter (chlorine dioxide, ozone, or ultraviolet light), a system can reduce the likelihood of THM and/or HAA formation. It is anticipated that both the Pomona Lake and Kansas River source water TOC will range from 4.0 to 6.0 mg/L. TOC removal requirements are based on the source water TOC and source water alkalinity. Treatment processes can be designed to obtain a substantial reduction in THM and HAA formation. This is a function of achieving adequate chlorine contact time within the chlorine contact basins. This can allow primary disinfection with free chlorine after the clarification process, in which approximately 25% to 35% TOC removal is achieved. If free chlorine is utilized as the primary disinfectant, it should be added after the clarification step of the process.

The alkalinity and pH of water indicate the tendency of the water to be corrosive. The corrosivity of finished water is regulated based on concentrations of lead and copper at taps within the distribution system. While it is important to know the alkalinity and pH of the source water for various reasons within the treatment process, it is critical that treatment process produce non-corrosive finished water that is distributed within the distribution system.

Taste and odor in the source water is a common problem experienced by surface water treatment facilities. A conventional treatment process that is adding potassium permanganate, chlorine (or chlorine dioxide), or powdered activated carbon (PAC) into the source water has the ability to remove the taste and odor. While the Pomona Lake and Kansas River source water will likely have taste and odor issues, it is anticipated that the treatment process will incorporate chemical feed systems for other source water quality concerns that will remove the taste and odor.

The hardness of water is the sum of the concentrations of multivalent ions, particularly calcium and magnesium. Hardness is generally classified in the following categories: 1) Soft - 0 to 75 mg/L as CaCO₃ 2) Moderate - 75 to 150 mg/L as CaCO₃ 3) Hard - 150 to 300 mg/L as CaCO₃ 4) Very Hard - above 300 mg/L as CaCO₃. Generally, surface water sources have hardness

concentrations ranging from 120 to 200 mg/L as CaCO₃. Since these concentrations are typically considered acceptable in the finished water, most surface water treatment facilities are not designed for softening the water. It is anticipated that softening will not be required with the Pomona Lake source water, but will be required for treatment of the Kansas River source water. Treatment for hardness in a conventional treatment process will generally consist of lime softening which causes the CaCO₃ to precipitate out of solution. Membrane filtration plants can deal with hardness issues by filtering the water through a membrane to remove CaCO₃. This process of filtration is described in more detail in Section 6.3.2.2.

5.3.2 Treatment Processes

5.3.2.1 Clarification

There are several types of clarification systems that could be utilized with the Pomona Lake source water and the Kansas River source water. The processes discussed in this section include: 1) Superpulsators, 2) ballasted sand clarification (ACTIFLO®), and 3) adsorption clarifiers. There are other clarification treatment alternatives (Claricones, solids contact basins, etc.) that could be considered prior to final design. The design of the selected process shall comply with the Kansas Department of Health and Environment (KDHE) design standards.

Pre-sedimentation basins can be incorporated into the treatment process in which source waters experience periodic turbidity spikes and/or increased amounts of grit, mud, leaves, or other debris. The pre-sedimentation basins provide an area in which some of the particles within the source water and any debris are settled out, thus generally providing a more consistent quality of water to the clarification portion of the process. With more mild turbidity spikes expected at a Pomona Lake treatment facility, it is not recommended that a pre-sedimentation basin be constructed with the Pomona Lake source, unless the intake is constructed near a creek/river inlet to the lake that may result in considerably higher turbidity spikes. With the potential for the Kansas River source water to have more frequent turbidity spikes and increased debris if surface water is utilized, it is recommended that a pre-sedimentation basin be considered. If the Kansas River source is taken from the alluvial of the river pre-sedimentation would not be required. Further discussion relative to pre-sedimentation as it pertains to the specific clarification process can be found in the following discussions.

5.3.2.2 Superpulsator

The Superpulsator clarifier takes advantage of previously flocculated sludge to aid in the clarification process. As the process water flows upward through the existing sludge blanket, the blanket acts as a flocculation filter. Newly formed floc particles in the process water deposit on the surface of the existing sludge. Thus, the existing sludge particles grow in size at a higher rate, producing a heavier, faster-settling floc. To help keep the sludge blanket uniform, the sludge blanket is periodically “pulsed” in the clarifier. During pulses, the bed expands uniformly and during subsiding flow, the bed settles uniformly. The pulsating blanket can be likened to a coiled spring. The blanket is compressed by the force of gravity and extended by the counter force of the friction of the water on the particles. It tends to expand more and more as the upward velocity increases. The pulsating flow results in a homogenous sludge blanket throughout the clarifier, with no stratification and no short circuiting, maintaining effective

contact between the water and the sludge. The sludge is periodically blown down (similar to other clarification systems) to on-site sludge lagoons.

The manufacturer of the pulsating clarifiers indicates that they typically size the units for a rise rate of 1.5 to 2.5 gpm/sq ft. The installation of Type U baffles is required to achieve the higher loading rates. According to the manufacturer, a sudden increase in turbidity (spike) would not be a problem for the Superpulsator, as long as the coagulant feed system was adjusted accordingly within a reasonable amount of time. However, an event leading to the increased amount of grit, mud, leaves, and other debris could affect the performance of the clarifier. With the potential for higher turbidity spikes and increased amount of debris with the Kansas River surface water source, it is recommended that a presedimentation basin be constructed to handle such events. Extra space and construction costs are associated with this basin. The presedimentation basin could be by-passed during normal flows. However, it would likely be utilized most of the time to provide potassium permanganate contact for iron and manganese oxidation (dependent on the distance between the treatment facility and the intake facility).

5.3.2.3 Ballasted-Sand Clarification

The ballasted-sand clarification process under consideration is manufactured by Krueger and is called the ACTIFLO process. The process contains the following steps: 1) raw water is treated in the “coagulation tank” with a coagulant to destabilize suspended solids and colloidal matter, 2) a polymer and microsand are added to the “injection tank” to initiate floc formation, 3) gentle mixing in the “maturation tank” allows the bridging of the destabilized suspended solids to the microsand, and 4) the fully-formed ballasted flocs enter the settling portion of the process (which incorporates tube settlers) in which the floc is rapidly settled out. The sand-sludge slurry that settles in the sedimentation tank is pumped to a hydrocyclone for separation whenever the process is operational. This system does not periodically perform a sludge blowdown since it is continuously drawing sludge from the sedimentation tank while the process is operational. The hydrocyclone recycles the microsand into the treatment process while the lighter density sludge is discharged at the top of the hydrocyclone and sent to final disposal (sludge lagoons).

The ACTIFLO process achieves the mixing, flocculation, and sedimentation of a conventional clarification process, however, due to the microsand enhanced flocculation and sedimentation with tube settlers, this process achieves clarification at a substantially higher loading rate. A conventional process that incorporates rapid mix, flocculation, and sedimentation would have the sedimentation portion of the process sized for a loading rate of 1.0 gpm/sq.ft without tube settlers and 2.0 gpm/sq.ft. with tube settlers. The ACTIFLO system is rated for loading rates upwards of 20 to 25 gpm/sq.ft. The result is a substantially smaller footprint for clarification equipment/basins to process the same amount of water.

The ACTIFLO process has been installed in applications in which the source water turbidity is likely to experience spikes. Since this process adds microsand into the process water, the process is more forgiving when turbidities fluctuate and it does not require immediate chemical adjustments. If the spike event lasts for a period of time, coagulant and/or polymer dosage adjustments may be required. In terms of turbidity removal, a pre-sedimentation basin is likely not required ahead of the ACTIFLO process. However, depending on the relationship of the

treatment facility to the intake facility, other water quality parameters may dictate that a pre-sedimentation/contact basin be installed.

5.3.2.4 Adsorption Clarifiers

Adsorption/contact clarification resembles filtration more than clarification, in that granular media is used in the process. Chemically dosed raw water enters the clarifier and flows upward or downward (depending on the proprietary process selected) through the granular media. Some manufacturers utilize a buoyant media that is held in place by an upper screen. Other manufacturers use a media heavier than water that must be supported by a media-retaining system similar to gravity filters. Contact flocculation and clarification occur as the coagulated particles move through the bed of media, causing the particles to be retained on the media. The process is enhanced by repeated contact with previously trapped solids on the media until the media becomes clogged. At that point, the media must be backwashed to remove the retained particles. This process is most effective with source water having low solids (turbidity), color, iron, and manganese. High-solids and/or high-color waters that require high coagulant dosages quickly clog the medium and result in excessive backwashing. Standard loading rates range from 8 to 10 gpm/sq. ft., although the manufacturer indicated the process has been operated up to 15 gpm/sq. ft. The process does not function properly if the loading rate is below 5 gpm/sq. ft. In terms of raw water turbidity, the manufacturer indicated that the adsorption clarifier could handle a continuous flow of 30 ntu, with spikes up to 100 ntu, without causing excessive backflushing. However, the time between backflushing each clarifier is a function of the amount of solids in the raw water, so elevated turbidity in the raw water is going to reduce the operation time between backflushes and increase the amount of water being sent to the washwater recovery basin. Given the fairly consistent quality of water from Pomona Lake, the need for pre-sedimentation would not be a requirement, but would provide a consistent quality of water to the adsorption clarifiers. With the potential for turbidity spikes on the Kansas River, a pre-sedimentation basin would be required to lower the turbidity of the process water reaching the adsorption clarifiers.

The manufacturer indicated that the backwashing rate is typically operated at a rate of 10 gpm/sq. ft. The system can be flushed at a higher rate, which would decrease the amount of time the backwash would occur. If a two-train system is installed (each approximately 210 sq. ft., capable of processing 2100 gpm/each) it is anticipated the volume of waste produced per backflush is approximately 23,000 gallons, which will be directed to either a reclaim basin or sludge lagoons. Depending on the process water quality entering the adsorption clarifier, the backflushing could occur approximately every 6 to 12 hours of operation, per train. The adsorption clarifiers have a three-step backflushing process: 1) inlet flow is stopped and air is added until the media expands by 50%, (usually take approximately 1 to 3 minutes), 2) raw water and air are used simultaneously for 3 to 5 minutes to remove the captured solids from the media (approximately 10,500 gallons waste produced), and 3) the air is shut off, and a filter-to-waste step occurs for approximately 4 to 6 minutes to compact the bed prior to putting the unit on-line (approximately 12,600 gallons waste produced). It should be noted that the water used for backflushing is raw water, not finished water from the clearwell.

5.3.3 Filtration

Filtration in a water treatment facility is the passage of water through a porous medium to remove suspended solids. Filtration provides a second barrier (disinfection is considered the primary barrier) to the transmission of waterborne disease. Filtration can assist disinfection significantly by reducing the load on the disinfection process and increasing the disinfection efficiency. The most common process utilized for filtering drinking water is conventional media filtration. Membranes have been in the water treatment industry for many years, primarily for removal of dissolved solids (reverse osmosis and nanofiltration). Membrane filtration for the removal of suspended solids (microfiltration and ultrafiltration) has been gaining popularity over the past 10 to 20 years. Both conventional media and membrane filtration will be discussed in the following sections.

5.3.3.1 Conventional Media Filtration

Conventional media filters are the most common form of filtration utilized in water treatment plants throughout the United States. The amount and type of media installed determines the classification of the filter. Classifications include single media, dual media, and mixed media. KDHE design standards indicate typical loading rates for these classifications are as follows: 1) 3.0 gpm/sq. ft. for single media, 2) 4.0 gpm/sq. ft. for dual media, and 3) 5.0 gpm/sq. ft. for mixed media. A single media filter incorporates at least 27 inches of silica sand or 42 inches of anthracite. A dual media filter incorporates a minimum of 18 inches of anthracite and a minimum of 12 inches of sand. The mixed media filter incorporates 16.5 inches of anthracite, 9 inches of silica sand, and 4.5 inches of garnet or ilmenite sand. The overall media depth in the dual and mixed media filters must be a minimum of 30 inches. A majority of the conventional media filters installed throughout the United States are dual or mixed media.

5.3.3.2 Membrane Filtration

Membrane filtration utilizes hollow-fiber membranes as the porous medium to filter the clarified water. There are two systems available that have differing methods of achieving the filtration process. The first process is utilizing a feed pump to force the water through the membrane surface at a relatively low pressure (25 to 45 psi). These are commonly known as pressurized membranes. The modules/submodules (varying terminologies between the different manufacturers) enclose a bundle of hollow-fiber membranes in which a portion of the process flow is filtered. Each skid has many modules/submodules to treat the desired flow. The second process flows the clarified water into an open tank and utilizes a vacuum to draw the water through the membrane surface. Membrane submodules hang into the open tank and are submerged (commonly referred to as immersed/submerged membranes) to allow the vacuum to draw the water from the tank. Each open tank has many submodules that treat the desired flow. As is the case with all membranes, as the water temperature decreases the amount of water that can be filtered through the membranes also decreases.

5.3.4 Disinfection

The surface water treatment rule (SWTR), the long term one enhanced surface water treatment rule (LT1ESWTR), and the long term two enhanced surface water treatment rule (LT2ESWTR) seek to prevent waterborne diseases caused by microorganisms in the source water. Disease-

causing microbes are present at varying concentrations in most surface waters. The SWTR established that water systems filter and disinfect water from surface water sources to reduce the occurrence of unsafe levels of these microbes.

Most surface water treatment facilities have a primary disinfectant and a secondary disinfectant. The primary disinfectant is utilized to achieve the disinfection contact time (CT) requirements within the treatment process as required by the SWTR. Typical disinfectants utilized for primary disinfection include free chlorine (most common), chlorine dioxide, ozone, and ultraviolet (UV) light. All of the primary disinfectants are strong oxidants, thus limiting the amount of contact time required at a given dosage. The secondary disinfectant is utilized to maintain a residual in the distribution system. Typical disinfectants include free chlorine and chloramines (ammonia combined with free chlorine). Chloramines have a distinct advantage over free chlorine as a secondary disinfectant in that there is minimal formation of regulated disinfection bi-products (DBPs) when in contact with organic matter and chloramines have a very persistent residual. However, a disadvantage is the potential for formation of nitrifying bacteria, which feeds on the ammonia and can cause rapid degradation of the chlorine residual. Each primary disinfectant will be discussed further in the following sections. The type of primary disinfectant(s) selected will be a function of process selected as well as any source water *Cryptosporidium* testing data that is available at the time of design.

5.3.4.1 Free Chlorine

The use of free chlorine for meeting the disinfection requirements of the SWTR is common in many water treatment plants throughout the United States. Free chlorine is relatively inexpensive and is a strong disinfectant of *Giardia* and viruses. Significant disadvantages are: 1) it is a significantly less effective disinfectant for *Cryptosporidium* and 2) increased formation of DBPs in the finished water if naturally occurring organic matter is present in the source water when the free chlorine is applied. DBP formation is increased in warm water and/or systems with large contact times (either excessive contact time within the treatment process or contact time in the distribution system), and decreased in cold water and/or systems with reduced contact times (specific chlorine contact tank in treatment process or elimination of free chlorine in the distribution system by converting to chloramines). The two forms of DBPs that are regulated are trihalomethanes (THMs) and haloacetic acids (HAAs).

5.3.4.2 Chlorine Dioxide

Chlorine dioxide is a disinfectant that is gaining popularity in the water treatment industry primarily due to the fact that it does not form THMs and HAAs in significant amounts. It is a very strong oxidant whose properties are not adversely affected by a higher pH, as is the case with free chlorine. Similar to chlorine, chlorine dioxide exerts a demand when it is first applied to a water supply, which must be overcome to maintain a persistent residual. While it is gaining popularity, there are still some concerns that there are organic by-products of chlorine dioxide that are not yet understood, and it may have some undesirable reaction products. Inorganic by-products of chlorine dioxide reactions are chlorite ion, chloride ion, and chlorate ion. If chlorine dioxide is fed within the treatment process, Stage 1 of the DBPR requires that daily samples be collected at the entrance to the distribution system and analyzed for chlorine dioxide and chlorite, which cannot exceed 0.8 mg/L and 1.0 mg/L, respectively. If daily

sampling is exceeded for either parameter, additional testing must be completed in the distribution system. Monthly sampling for chlorite is required within the distribution system.

5.3.4.3 Ozone

Ozone is a powerful oxidant commonly used to treat surface water containing organic matter. Ozone can accomplish several things simultaneously such as metal oxidation, taste and odor control, organics oxidation, and C*T credit. Ozonation of raw water should be considered if the source water has relatively high concentrations of total organic carbon (>5 mg/L) and the concentration of chlorinated disinfection by-products is approaching the regulatory limits for these compounds. Ozonation does not result in the addition of solids that must be disposed, and will oxidize metal ions, taste and odor compounds, natural organic matter (NOM), and synthetic organic carbons (SOCs). Research has shown that pre-oxidizing raw water with ozone before coagulation/flocculation enhances floc formation and shortens settling time. The chemical nature of the organic matter becomes more polar by the ozonation process, whereby the organics can be coagulated and settled more easily. On top of these potential gains, ozone also disinfects and can gain the plant additional C*T credit without the addition of chlorine. However, as with most disinfectants, ozone can produce DBPs, most notably bromates, aldehydes, and ketones. Of these, only the concentration of bromate is strictly regulated. Ozone does not, however, provide a long-lasting residual concentration that can be carried into the distribution system. A secondary disinfectant (free or combined chlorine) must be utilized to maintain a residual in the distribution system. It should be noted, that if the source water *Cryptosporidium* testing (LT2ESWTR) classifies the source water in Bins 2, 3, or 4, extra consideration should be given to ozone.

5.3.4.4 Ultraviolet (UV) Light

In general, germicidal ultraviolet (UV) radiation results in a photochemical reaction that effectively inactivates microorganisms by inhibiting their ability to replicate. Contrary to chemical disinfectants, germicidal UV radiation does not immediately inactivate the organism, but it introduces genetic interference that inhibits the organism's ability to undergo cellular division, preventing replication. If an organism cannot replicate, ingestion of the organism will not result in infection. This disinfecting ability of germicidal UV radiation without altering the chemical composition of the water makes UV disinfection an attractive option that bypasses some of the drawbacks of chemical disinfection. Presently, no definitive proof exists that UV radiation of water produces undesirable by-products or undermines any other treatment step under normal operating conditions.

Unlike chemical disinfectants, the effectiveness of ultraviolet radiation is not significantly affected by environmental conditions. Commercial UV units are installed into a pipeline carrying filtered water to be disinfected. A typical commercial UV unit comprises a power supply system, housing, UV lamp(s) in a quartz sleeve, controls and sensors, and possibly a lamp wiper to reduce fouling. Manufacturers of commercial UV units may offer both low-pressure and medium-pressure systems. The 'low' and 'medium' pressure designation refers to the pressure of the mercury vapor inside the lamp. Low-pressure systems emit nearly monochromatic UV light at 253.7 nm and medium-pressure systems emit a broad range of UV light throughout the ultraviolet spectrum. Medium-pressure systems are used in treatment plants with higher flow rates. While low-pressure lamps are electrically more efficient than

medium-pressure lamps, medium-pressure lamps produce a greater UV output per lamp. Thus, medium-pressure UV systems can be expected to use fewer lamps, take up less space, and require less maintenance. The reduced number of lamps allows medium-pressure UV systems to cost-effectively incorporate automatic cleaning mechanisms to remove fouling that accumulates on lamp sleeves during operation.

Ultraviolet (UV) light is used in the wastewater industry and is gaining popularity in the water treatment industry. Since it is new to the water treatment industry, appropriate applied dosages and contact times are continually under investigation. At the time of final design, additional research into the viability of UV light as the primary disinfectant should be conducted. It should be noted, that if the source water *Cryptosporidium* testing (LT2ESWTR) classifies the source water in Bins 2, 3, or 4, extra consideration should be given to UV light.

SECTION 6: WHAT COMES NEXT?

With the Phase 1 study nearing completion the obvious question that comes to everyone's mind is "What Comes Next?". How do we move forward from a conceptual design to ultimately having a regional multi-state system.

There are 2 short answers to that question and they are:

- * Secure Funding for future study phases.
- * Prepare a Phase 2 Design Study

6.1 FUNDING

It is recommended that the Consortium approach KDHE, KWO, OWRB, and the Oklahoma Department of Environmental Quality (ODEQ) about opportunities for funding assistance to initiate these studies. Both the states of Kansas and Oklahoma have active water planning processes underway. They may be able to provide cost matching financial assistance to obtain study assistance from federal water partners such as the USACE, BOR, NRCS, and others. Such an approach will leverage the study funds to the maximum extent, and even more importantly, have the critical State and Federal water agencies engaged in partnering with the Sunflower H2O Initiative.

Currently the Sunflower H2O Initiative has received a matching grant from the Kansas Department of Health and Environment to complete the Phase 1 study. This current grant is a \$12,500 grant requiring a \$12,5000 match from the consortium. The state has indicated that additional funds for additional studies may be available at the same levels. We would also recommend approaching the Oklahoma Department of Environmental Quality to determine if similar funds may be available.

The Bureau of Reclamation was designated as the administrator of the Rural Water Supply Act of 2006. The intended purpose of this act is to streamline the congressional authorization process for large regional water projects in the 17 BOR states, in which Kansas and Oklahoma are included. Qualifying projects will be selected for an "Appraisal Investigation" to identify the need for a regional solution. From those appraisal investigations, the Secretary of the Interior will then select certain projects for a "Feasibility Study". This second study will contain a greater level of detail regarding the actual development of the project. From these studies, the Secretary of the Interior will then select projects to be recommended to Congress for authorization. Once authorized by Congress, these projects will then be eligible for annual appropriations for development costs.

The Rural Water Supply Act of 2006 authorized \$15 million annually for the development of appraisal and feasibility level studies. To date, the funding has not been appropriated for the studies to commence. Once funding has been appropriated the act provides for grant up to \$200,000 and a 50% match for funds above \$200,000 for each level of study.

This act became public law 109-451 on December 22, 2006, but the rules and criteria for each of the study phases have not yet been promulgated. Funds will not be appropriated until this has

been completed. Therefore, it appears that the earliest opportunity for acquiring study funds through the program will be fiscal year 2009. The progression of this program will continue to be watched closely for future opportunities. A copy of Public Law 109-451 is included in Appendix A.

An additional option for funding the remaining study phases would be to apply through the Kansas and Oklahoma congressional delegation for a State & Tribal Assistance Grant or STAG. These grants are earmark requests and require congressional approval, typically in a funding bill. With this type of grant there is a 45% cost share requirement. That means, for example, that a \$1 million project would involve a maximum of \$550,000 in STAG Grant funds with the remainder coming from other sources. This type of funding could also be utilized for the immediate need projects working in conjunction with USDA Rural Development loan and grant funds or the state revolving loan program for the matching funds.

6.2 FUTURE STUDY PHASES

This phase of the Sunflower Initiative Water Needs Assessment is a first “snapshot” of the water setting in the study region. Many challenges exist and some will require creative thinking on the part of the Consortium. Further detailed analysis is needed to more clearly identify short and long term options. The following identifies some potential opportunities for the Consortium to further explore.

- Evaluate opportunities for further regionalization of existing resources/systems.
- Evaluate opportunities for regional transmission, treatment, and distribution of water from currently available surface impoundments.
- Evaluate opportunities to develop regional groundwater well fields.
- Evaluate opportunities to migrate to a surface water based supply with groundwater resources reserved for peak demands and drought conditions.
- Evaluate potential for construction of new and/or modification of existing surface water impoundments:
 - Bureau of Reclamation (BOR) dam sites
 - US Army Corps of Engineers (USACE) dam sites
 - Natural Resources Conservation Service (NRCS) dam sites
 - Other non-federal dam sites

A phase 2 design study will be a continuation of this study. It will continue to refine and detail alternatives for a proposed regional project. The following items are a list of potential scope items that would appear in a phase 2 report. These items may vary depending on the funding option used and its specific criteria.

1. Area meetings to describe the upcoming process and need for community participation.
2. Meet with potential funding agencies regarding the project to receive comment and buy in to the project approach.
3. Send out mailings requesting additional demand and infrastructure information. Meet with individual communities as needed.
4. Determine the extent of Rural potential.

5. Detailed analysis of water needs specifying location and hydraulic delivery requirements.
6. Detailed analysis of potential water supplies to determine potential quantity and quality available.
7. Field check potential transmission line routings based on supply locations and demand delivery points for various alternatives.
8. Hydraulic Analysis for sizing of transmission lines for various alternatives.
9. Preliminary design of elevated tank and booster pump stations for various alternatives.
10. Prepare preliminary project Development Estimates for each design.
11. Formulate Preliminary Environmental Issues.
12. Explore various types of governing bodies and provide advantages and disadvantages to each.
13. Identify process for gaining approval to transport water between the states of Kansas and Oklahoma.
14. Establish preliminary phasing boundaries for the potential projects.
15. Establish a preliminary rate structure.
16. Present findings to the consortium and potential funding agencies.

This is a tentative scope for a proposed second phase of this study process. This second phase will continue to present multiple alternatives for this proposed regional project. We anticipate a detailed scoping meeting with the consortium to finalize the items described above, but a detailed analysis of the type listed for the potential 9 county region would require a fee ranging from \$175,000 to \$225,000 for the scope as listed. We look forward to continuing this project with the Sunflower H2O consortium, and are excited about the potential for regional water in south central Kansas and north central Oklahoma.

APPENDIX A

**PUBLIC LAW 109-451
RECLAMATION WATER SUPPLY ACT OF 2006**

APPENDIX B

**CLIMATE CHANGE AND ITS IMPACTS FOR WATER
RESOURCES PLANNING**

CLIMATE CHANGE AND ITS IMPLICATIONS FOR WATER RESOURCES PLANNING

The Intergovernmental Panel on Climate Change recently issued a landmark report [*Climate Change 2007: The Physical Basis - Summary for Policymakers* (IPCC, February 2007 Geneva, Switzerland)] concluding that it is very likely that hot extremes, heat waves, and heavy (short intensity) precipitation events will continue to become more frequent on a global scale. The report states there is strong observational evidence and results from modeling that indicate, at least over the last 50 years, human activities are a major contributor to climate change and global warming. Annual precipitation is projected to decrease across the southwestern United States, especially during the summer. Warmer temperatures will cause more evaporation in summer resulting in less available soil moisture. These drier conditions will lead to episodes of extreme heat, particularly across the southwest. It is projected that typical drought episodes may transform into a more prolonged 1930s and 1950s drought scenarios. The warmer/drier weather could increase the risk for and intensity of wildfires. It is important to keep in mind that climate model projections are uncertain because the impact depends on our socio-economic responses to climate change.

It is important to put this climate change information in context with what the Consortium has experienced recently. Figure 1 provides a climatological perspective of rainfall in the north central climate division of Oklahoma for the period 1895-2006, and is representative of the study region as a whole. It is clear that the Sunflower area has enjoyed a recent, prolonged wet period whose duration has lasted some 15-20 years versus the more normal 8-12 year wet cycle. Additionally, the magnitude of the recent wet cycle has been greater (more annual precipitation) than any other wet cycle during the period of record, and is similar in magnitude to the droughts of the 1910s, 1930s, and 1950s. The bottom line is, the Consortium should approach this study from the perspective that their recent "memory" of rainfall conditions is far and away from what would be considered "normal." In fact, recent rainfall history has been abnormally high. Furthermore, the Consortium may indeed be conducting this long-range planning effort in the early stages of a much more prolonged period of dry weather should the climate change forecasts prove accurate.

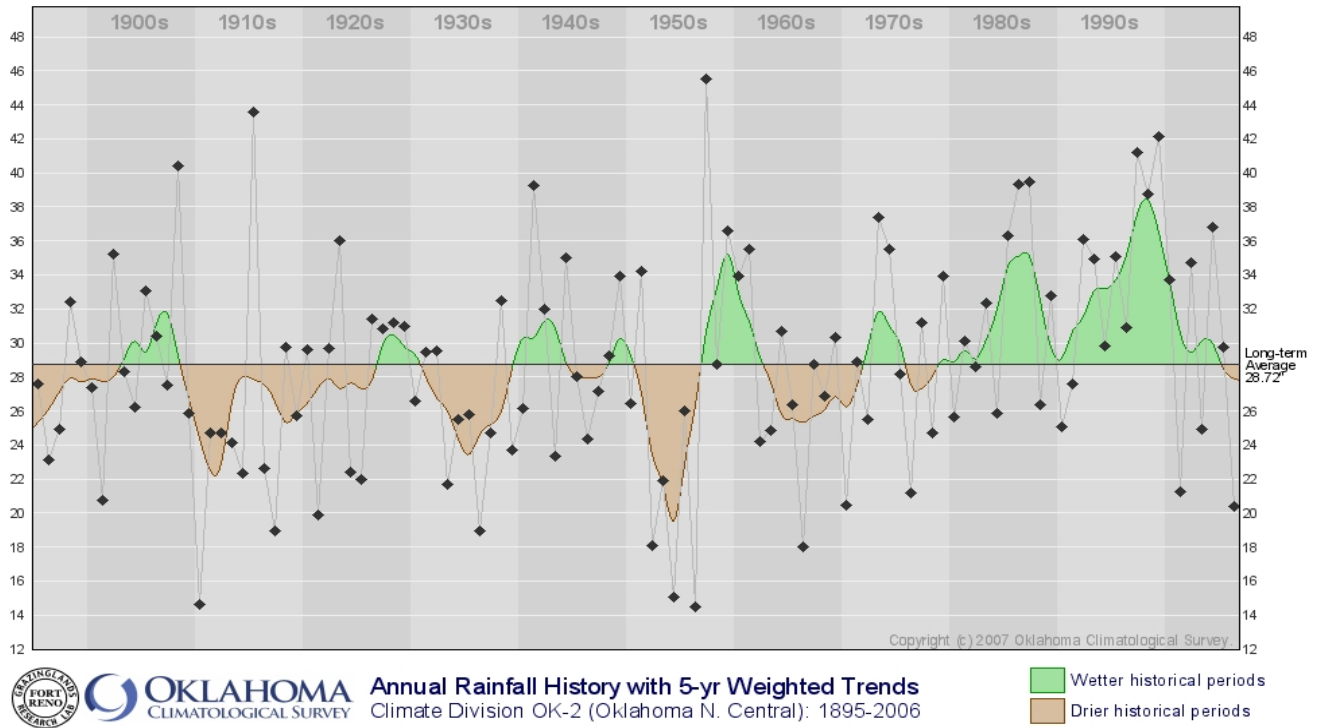


Figure 1: Historical Rainfall

Whatever the perspective is of climate change – be it man-made or part of a normal cycle – the globe is currently warming. That fact means the Consortium members must exercise due diligence to plan, develop, and protect their water resources for the future. In this regard, a “no regrets” strategy offers the best of all alternatives. Should a major climate shift not occur, the benefits of a no regrets strategy would be significant. No one would complain about a more robust and better protected water supply. It is in this light that the Consortium Water Story is developed.

NOTE: This climate change discussion was excerpted, in part, from a recent presentation by Dr. Kenneth Crawford (State Climatologist, Oklahoma Climatological Survey and Regents’ Professor of Meteorology at the University of Oklahoma) to the Oklahoma Water Resources Board.

APPENDIX C

TREATMENT PLANT REGULATIONS

1.0 General

The water quality requirements for any treatment facility are governed by standards regulated by the Safe Drinking Water Act and enforced by the Kansas Department of Health and Environment (KDHE). The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources – rivers, lakes, reservoirs, springs, and groundwater wells. (SDWA does not regulate private wells that serve fewer than 25 individuals.) SDWA authorizes the United States Environmental Protection Agency (USEPA) to set national health-based standards for drinking water in the form of finalized rules to protect against both naturally-occurring and man-made contaminants. Finalized rules of drinking water standards provide two levels of standards to be regulated – primary and secondary standards. Primary Drinking Water Standards are health-related criteria that protect public health by limiting the levels of contaminants in drinking water. The primary contaminants are divided into the following categories: 1) microorganisms, 2) disinfectants and disinfection by-products, 3) inorganic chemicals, 4) organic chemicals, and 5) radionuclides.

Secondary Drinking Water Standards are non-enforceable guidelines that include criteria intended for the control of cosmetic and aesthetic factors. The guidelines are strongly recommended for consideration, but not required for compliance. The parameters included in the secondary standards are aluminum, chloride, color, copper, corrosivity, fluoride, foaming agents, iron, manganese, odor, pH, silver, sulfate, total dissolved solids, and zinc.

Under the SDWA, the USEPA sets legal limits on the levels of certain contaminants in drinking water. The legal limits reflect both the level that protects human health and the level that water systems can achieve using the best available technology. Besides prescribing these legal limits, USEPA rules set water-testing schedules and methods that water systems must follow for compliance. The rules also list acceptable techniques for treating contaminated water. The SDWA gives individual states the opportunity to set and enforce their own drinking water standards, provided these standards are at least as stringent as the USEPA's national drinking water standards.

The USEPA continues to set legal limits of certain contaminants in drinking water and recommend treatment techniques to ensure compliance with federal regulations. Table 1 is a brief review of the regulations that have followed under the SDWA of 1974. The regulations shown in bold in Table 1 represent relatively new USEPA rules that will need to be taken into consideration during design of any water treatment facilities.

Table 1. SDWA Regulatory Schedule *			
Regulation	Date Proposed	Date Final **	Date Effective **
National Interim Primary Drinking Water Regulations (NIPDWR)		12/24/75	6/24/77
NIPDWR Amend No. 1 - Radionuclides		7/9/76	6/24/77
National Secondary Drinking Water Regulations	3/31/77	7/19/79	1/10/81
NIPDWR Amend. No. 2 - TTHMs		11/29/79	Varies (11/81 and 11/83)
NIPDWR Amend. No. 3 - Sodium and Corrosion		8/27/80	2/27/82
NIPDWR Amend. No. 4 - BAT for TTHM		2/28/83	3/30/83
Lead Ban (SDWA 1417)	6/86	6/86	6/86
Phase 1 - Volatile Organic Contaminants (VOC's)	11/85	7/87	1/89
Public Notification Rule	4/87 & 5/99	10/87 & 5/00	Varies
Total Coliform Rule	11/87	6/89	12/90
Surface Water Treatment Rule (SWTR)	11/87	6/89	Varies
Lead and Copper Rule (LCR)	8/88	6/91	Varies
Phase II - 38 Synthetic Organic Chemicals (SOCs) and Inorganic Chemicals (IOCs)	5/89	7/91	7/92
Phase V - 24 Contaminants (SOCs and IOCs)	7/90	7/92	1/94
Information Collection Rule	12/93	5/96	6/96 to 12/00
Contaminant Candidate List (CCL)	10/97	3/98	Varies
Consumer Confidence Report Rule	2/98	8/98	9/98
Stage 1 D/DBPR	7/29/94	12/98	Varies (1/02 and 1/04)
Interim Enhanced Surface Water Treatment Rule	7/29/94	12/98	1/02
Phase III Radionuclide Rule	7/91	12/00	12/03
Arsenic Rule	6/00	1/01	1/06
Filter Backwash Recycling Rule	4/00	6/01	Varies (6/04 and 6/06)
Radon Rule	11/99	(Late 2004)	(Late 2007)
Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)	4/00	1/02	1/05
Ground Water Rule	5/00	(Early 2004)	(2007)
Long-Term 2 Enhanced Surface Water Treatment Rule	9/00	(July 2004)	Varies
Stage 2 D/DBPR	9/00	(July 2004)	Varies

*As of Fall 2003

**All dates after Fall 2003 are estimated.

2.0 Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) seeks to prevent waterborne diseases caused by viruses such as *Legionella*, *Cryptosporidium*, and *Giardia lamblia*. These disease-causing microbes can be present pathogens in surface waters. The rule requires that water systems filter and disinfect water from surface water sources to reduce the occurrence of unsafe levels of these microbes.

As the title suggests, this rule governs water supplies with surface water sources (which it defines as "all water that is open to the atmosphere and subject to surface runoff") and water supplies with ground water under the direct influence of surface water (which is determined based on well depth and proximity to a surface water). This water, which is used by most of the country's large water systems, is in rivers, lakes, and reservoirs. Surface water is particularly susceptible to microbial contamination from sewage treatment plant discharges and runoff from storm water and snow melt. These sources often contain high levels of fecal microbes that originated in livestock wastes or septic systems.

3.0 Applicable USEPA Regulatory Requirements

The Surface Water Treatment Rule (SWTR) is the result of a series of amendments to the National Primary Drinking Water Regulations and was originally promulgated in June of 1989. The SWTR has been amended and filtered water turbidity limitations tightened, which is explained in greater detail later in this section.

The SWTR requires that all public water systems using any surface water or groundwater under the direct influence of surface water must disinfect, and will likely be required to filter, unless certain source water quality requirements and site-specific conditions are met.

Treatment must reliably achieve at least 99.9 percent (3-log) removal and/or inactivation of *Giardia lamblia* cysts and 99.99 percent (4-log) removal and/or inactivation of viruses between the point where the raw water ceases to be subject to surface water runoff at a point prior to delivery to the first customer.

The SWTR established criteria for filtered water systems. Originally, filtered water turbidity was required to be less than 5 NTU at all times, with filtered water turbidity equal to or less than 0.5 NTU in at least 95 percent of the measurements taken each month.

Each system providing filtration must also disinfect to ensure that the total treatment process achieves the log removal and/or inactivation as indicated previously. A conventional filtration process receives 2.5-log *Giardia* and 2.0-log virus removal credits; thus the minimum levels of inactivation by disinfection are 0.5-log *Giardia* and 2.0-log virus. A direct filtration process receives 2.0-log *Giardia* and 1.0-log virus removal credits; thus the minimum levels of inactivation by disinfection are 1.0-log *Giardia* and 3.0-log virus. The controlling parameter (0.5-log *Giardia* vs. 2.0-log virus for conventional or 1.0-log *Giardia* vs. 3.0-log virus for direct filtration) is dependent on water quality parameters such as pH, temperature, disinfectant residual, and disinfectant type.

As indicated previously, the regulations shown in bold in Table 1 represent new USEPA rules that will need to be taken into consideration during final design of any of these treatment facilities. Some of these new regulations are more stringent than what is prescribed in the SWTR. The following sections summarize each of the impacting regulations and discuss their requirements.

3.1 Interim and Long-Term 1 Enhanced Surface Water Treatment Rule (IESWTR & LT1ESWTR)

The presence of microbiological contaminants in drinking water is a health concern due to the potential for water-borne disease outbreaks. Physical removal through treatment is critical to the control of pathogens (such as *Cryptosporidium*) because they are highly resistant to standard disinfection practices.

The Interim Enhanced Surface Water Treatment Rule (IESWTR), published December 1998, is intended to increase the protection of finished drinking water supplies from contamination by *Cryptosporidium* and other microbial pathogens. This rule is applicable to all public water systems using surface water or groundwater under the direct influence of surface water that serve greater than 10,000 people annually. The Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), published in January 2002, extended the IESWTR to small water systems that serve fewer than 10,000 people.

The underlying goal of the Rule is to achieve 2-log removal of *Cryptosporidium* by establishing monitoring standards for filtration systems with individual filter turbidity requirements and specific combined filter effluent turbidity requirements. To meet the requirements of the Rule, systems are required to continuously monitor individual filter turbidity for each filter used in the system. For the purposes of this rule, continuous monitoring means at least every 15 minutes. Systems must keep the results of this monitoring for at least three years. Compliance with the provisions of the IESWTR and LT1ESWTR (combined filter effluent turbidity limits, individual filter turbidity monitoring, *Cryptosporidium* removal requirements) were to be achieved by January 2002, and January 2005, respectively.

Under IESWTR and LT1ESWTR, the allowable combined finished water turbidity limit is 0.3 NTU in at least 95 percent of the measurements taken each month. The turbidity level of the representative samples of a system's filtered water must at no time exceed 1 NTU. The maximum filtered water turbidity at any one time for an individual filter is set at 1.0 NTU. This assures that if each filter is monitored and one filter exceeds 1 NTU, this filter can be inspected. Each filter is monitored because the combined filter effluent turbidity may still be below 0.3 NTU due to dilution by the properly working filters. The troubling filter can then be examined before the final filtered water exceeds the turbidity limit. It should be noted that the individual filter measurements are for informational purposes only. Compliance is based on combined filter turbidity readings. However, if the individual filter turbidity has been exceeded, an "exception report" must be provided to the State, and action to correct the situation must be taken.

The IESWTR and LT1ESWTR also establish disinfection benchmarking in which the water system is required to develop a disinfection profile, unless applicable monitoring demonstrates their disinfection byproduct levels are less than 80% of the new maximum contaminant levels.

If a system is considering a significant change to their disinfection practice and they were required to perform the disinfection profiling, they must develop a disinfection benchmark and receive approval from the State prior to implementing a change to their disinfection practices.

3.2 Filter Backwash Recycling Rule (FBRR)

The Filter Backwash Recycling Rule (FBRR), finalized June 8, 2001, applies to all Public Water Systems (PWSs) that use surface water, utilize filtration (conventional, direct, or membrane), and recycle spent filter backwash water, sludge thickener supernatant, or other liquids from a dewatering process. The FBRR requires that recycled water from filter backwashing or any recycled water from a dewatering process must be returned to the front end of the entire treatment process for further treatment. Systems may apply to the Primacy Agency (KDHE) for approval to recycle to an alternate point in the treatment process. The FBRR also requires that systems notify the Primacy Agency (KDHE) in writing that their system practices recycling.

Any new water treatment facilities that are designed to recycle water from any dewatering process at the facility must be designed to comply with the FBRR. The design engineer and/or the owner should notify KDHE that the new facility will incorporate the ability to recycle filter backwash or any recycled water from a dewatering process to the head of the treatment plant.

3.3 Stage 1 Disinfectants and Disinfection Byproducts Rule (D/DBPR)

While disinfectants are effective in controlling many microorganisms, they react with natural organic and inorganic matter in source water and distribution systems to form disinfection byproducts (DBPs). Several DBPs have been shown to be carcinogenic in laboratory animals, while others have been shown to cause adverse reproductive or developmental effects in laboratory animals. This rule now applies to all drinking water systems.

The Stage 1 Disinfectants and Disinfection Byproducts Rule (D/DBPR) applies to all community and non-transient, non-community water systems (NTNCWS) that treat their water with a chemical disinfectant. It updates and supercedes the 1979 regulations for total trihalomethanes (TTHMs) and reduces exposure to three disinfectants and many disinfection byproducts. The rule establishes maximum residual disinfectant level goals (MRDLGs) and maximum residual disinfectant levels (MRDLs) for three chemical disinfectants: chlorine, chloramine, and chlorine dioxide. Table 2 summarizes these levels.

Table 2. Maximum Residual Disinfectant Level Goals and Residual Disinfectant Levels			
Disinfectant	MRDLG (mg/L)	MRDL (mg/L)	Compliance Based On:
Chlorine	4.0 (as Cl ₂)	4.0 (as Cl ₂)	annual average
Chloramine	4.0 (as Cl ₂)	4.0 (as Cl ₂)	annual average
Chlorine Dioxide	0.8 (as ClO ₂)	0.8 (as ClO ₂)	daily samples

The Stage 1 D/DBPR also establishes maximum contaminant level goals (MCLGs) and maximum contaminant levels (MCLs) for total trihalomethanes (TTHMs), haloacetic acids (HAA5), chlorite, and bromate, as summarized in Table 3. Analysis for chlorite is only required for systems feeding chlorine dioxide and analysis for bromate is only required for systems feeding ozone. Annual running average of quarterly samples cannot exceed the MCLs for TTHMs and HAA5 at any required compliance sample location.

Table 3. Maximum Contaminant Levels and Contaminant Level Goals			
Constituent	MCLG (mg/L)	MCL (mg/L)	Compliance Based On:
TTHMs	-	0.080	annual running average
Chloroform	-	-	
Bromodichloromethane	0	-	
Dibromochloromethane	0.06	-	
Bromoform	0	-	
HAA5	-	0.060 ¹	annual running average
Dichloroacetic Acid	0	-	
Trichloroacetic Acid	0.3 ²	-	
Monochloroacetic Acid	-	-	
Monobromoacetic Acid	-	-	
Dibromoacetic Acid	-	-	
Chlorite	0.8	1.0	monthly average
Bromate	0	0.010	annual average

¹ the sum of all five cannot exceed MCL

² Although this number is inconsistent with the MCL for all five haloacetic acids, this compound has not been found to be a carcinogen and the listed MCLG has been carried over from previous findings and/or regulations. Dichloroacetic acid is of more concern from a carcinogenic standpoint. The overall MCL of 0.060 mg/L for all HAAs is the regulation that needs to be met to comply with the Stage 1 D/DBPR.

In addition to these maximum levels, water systems that use surface water or groundwater under the direct influence of surface water, and use conventional filtration treatment, are required to remove specified percentages of organic materials, measured as total organic carbon (TOC), that may react with disinfectants to form DBPs. The required removal is summarized in Table 4. Any new treatment facilities that are designed with a conventional filtration treatment process shall incorporate the ability for some TOC removal either through enhanced

coagulation (lowering of pH of raw water), increased alum and ferric coagulant addition, the addition of powdered activated carbon (PAC), or a combination of chemicals that indicate through jar-testing the ability to remove TOC.

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as CaCO ₃)		
	0-60	60-120	> 120
> 2.0 – 4.0	35.0 %	25.0 %	15.0 %
4.0 – 8.0	45.0 %	35.0 %	25.0 %
> 8.0	50.0 %	40.0 %	30.0 %

- 1 Systems meeting at least one of the alternative compliance criteria in the rule are not required to meet the removals in this table.
- 2 Systems practicing softening must meet the TOC removal requirements in the last column to the right.

3.4 Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is an extension of the IESWTR and LT1ESWTR. The LT2ESWTR will apply to all public water systems treating surface water or ground water under the direct influence of surface water. LT2ESWTR requires source water characterization and USEPA bin classification based on source water monitoring. For large systems (serving at least 10,000 people annually), source water samples must be analyzed for *Cryptosporidium*, *E. coli*, and turbidity. Initially, small systems are required to analyze their source water for only *E. coli*. However, *Cryptosporidium* testing may be required if the initial testing indicates levels of *E. coli* exceeding the requirements listed in the LT2ESWTR.

For large systems, source water testing must be conducted over a period of two years and must begin within 6 months of promulgation of LT2ESWTR (expected July 2004). If samples are collected once-per-month, bin classification is based on the highest consecutive twelve month running annual average over the 2-year period. If the system conducts twice-per-month or more frequent sampling over the 2-year period, bin classification is based on the two-year mean of the samples. For small systems source water testing for *E. coli* must be conducted over a period of one year and must begin within 30 months (2 ½ years) after promulgation of LT2ESWTR. The *E. coli* source water sampling must occur every two weeks.

Once the source water testing is complete, the source water is characterized and placed in one of four bin classifications. The bin classifications are as follows:

- Bin #1: Systems with source water *Cryptosporidium* levels below 0.075/L
- Bin #2: Systems with source water *Cryptosporidium* levels between 0.075/L and 1.0/L.
- Bin #3: Systems with source water *Cryptosporidium* levels between 1.0/L and 3.0/L.
- Bin #4: Systems with source water *Cryptosporidium* levels 3.0/L and above.

If the system's source water is placed in Bin No. 1 (lowest bin classification), no additional log treatment for *Cryptosporidium* is required (applies to all filtration processes). If the source water

is treated by conventional, slow sand, or diatomaceous earth filtration and is classified in Bin 2, 3, or 4, the required additional treatment is 1 log, 2 log, or 2.5 log, respectively. If the source water is being treated by direct filtration and is classified in Bin 2, 3 or 4, the required additional treatment is 1.5 log, 2.5 log, or 3 log, respectively.

If the source water testing indicates that additional log treatment is required, the water system must refer to the Microbial Toolbox included in LT2ESWTR to aid in determining the approach to achieving the required log removal. The Toolbox includes guidelines for credit associated with various options (watershed control program, pre-sedimentation basin w/ coagulation, lime softening, bank filtration, membranes, combined filter performance, individual filter performance, bag/cartridge filters, chlorine dioxide, ozone, ultraviolet light) that can be implemented to achieve the required log treatment. For systems with required log treatment of 2, 2.5 and 3, the system must achieve at least 1 log of the additional treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or bank filtration.

It is difficult to predict the *Cryptosporidium* levels that will be experienced within any source water, until testing within the source water occurs.

3.5 Stage 2 Disinfectants and Disinfection Byproducts Rule

Stage 2 D/DBP regulations will be implemented in two phases. Once the Stage 2 D/DBP rules have been promulgated, systems will conduct *Cryptosporidium* and Initial Distribution System Evaluation (IDSE) monitoring and submit the results to the State/Primacy Agency (KDHE). Phase One of Stage 2 D/DBP Rule (referred to as Stage 2A) states that three years after the rule is promulgated (expected July 2004), all systems will be required to comply with the 0.120 mg/L THMs level and 0.100 HAAs standard on a Locational Running Annual Average (LRAA) at sites specified under the Stage 1 D/DBP Rule. Systems must also continue compliance with the 0.080 mg/L THM and 0.060 mg/L HAA requirements for a running annual average as stipulated in Stage 1 D/DBP Rule. Phase Two of Stage 2 D/DBP Rule (referred to as Stage 2B) states that large systems (serving > 10,000) have six years after promulgation and small systems (serving < 10,000) have seven and a half years after promulgation (unless additional *Cryptosporidium* testing is required) to lower the LRAA levels to 0.080 mg/L THM and 0.060 mg/L HAA based on sampling at revised compliance sites determined under the IDSE process. Phase Two compliance requires that the LRAA at each sampling point not exceed the MCL. This allows for a more targeted approach in adhering to the intent of the regulation, which is to protect public health from potentially harmful disinfection byproducts.

3.6 Other Regulations

3.6.1 Arsenic Standards Revision

Arsenic occurs naturally in a variety of organic materials, including rocks, soil, water, air, plants, and animals. Arsenic can be released into the environment through natural activities such as volcanic action, erosion of rocks, and forest fires, and by human actions. Long-term exposure to low concentrations of arsenic in drinking water can lead to skin, bladder, lung, and prostate cancer, as well as cardiovascular disease, diabetes, anemia, and reproductive, developmental, immunological, and neurological effects.

In January 2001, the USEPA promulgated a new arsenic maximum contaminant level (MCL) in drinking water of 10 parts per billion (ppb), lowered from the old MCL of 50 ppb. This new MCL will apply to all community water systems and all systems that serve at least 25 of the same people more than six months per year (such as schools, churches, nursing homes, and factories). These systems are required to notify their consumers if the arsenic levels exceed the new MCL, and take corrective action to lower the arsenic levels in their drinking water. The effective date of the revised arsenic standard rule was February 22, 2002. Compliance with the Rule must be achieved by January 200 it is anticipated that arsenic concentrations in the source water will be below the MCL, however, source water testing should be conducted to determine the concentration of arsenic. If arsenic in the source water is above the MCL, provisions shall be included in the final design for arsenic removal.

3.6.2 Radionuclides Regulation Revision

Exposure to radionuclides from drinking water may result in an increased risk of cancer. The radioactive particles (alpha, beta, and gamma) emitted by radionuclides destabilize nearby atoms as they travel through a cell or other material. In living tissue, this ionization process can damage chromosomes and other parts of the cell. This cellular damage can lead to unnatural reproduction of the cell (*i.e.* cancer), or to the cell's death. Uranium not only has the carcinogenic health effects from its radioactive decay and the decay of its daughter products ("radiotoxicity"), but it can also cause damage to the kidneys. Most drinking water sources in the United States have very low levels of radionuclides, but there are some parts of the country that have levels elevated enough to cause concern.

The USEPA has revised the current radionuclide regulation, which has been in effect since 1977, by requiring new monitoring provisions that will ensure that all customers of community water systems will receive water that meets the maximum contaminant levels. The USEPA also has promulgated a standard for uranium, as required by the 1986 amendments to the Safe Drinking Water Act. The final standards are as shown in Table 5.

Table 5. Final Radionuclide Standards	
Contaminant	Maximum Contaminant Level (MCL)
Combined Radium 226/228	5 pCi/L
(Adjusted) Gross Alpha	15 pCi/L
Beta Particle and Photon Radioactivity	4 mrem/yr
Uranium	30 µg/L

The rule became effective on December 8, 2003, three years after the publication date. All initial monitoring must be complete by December 31, 2007.

3.6.3 Drinking Water Contaminant Candidate List (CCL)

The Safe Drinking Water Act requires that the USEPA establish a list of contaminants to aid in priority setting for the USEPA's drinking water program. Contaminants have been grouped according to those that are priorities for additional research, those that need additional occurrence data, and those that are priorities for rulemaking consideration. On October 6, 1997, the USEPA published a draft of the first drinking water Contaminant Candidate List (CCL).

The current CCL is a list of 60 contaminants which: 1) are not currently subjected to any proposed or promulgated national primary drinking water regulation; 2) are known or anticipated to occur in public water systems; and 3) may require future regulation under SDWA. A proposed rule was issued in June 2002 indicating preliminary finding of nine contaminants that are on the CCL. The contaminants listed were: 1) acanthamoeba, 2) aldrin, 3) dieldrin, 4) hexachlorobutadiene, 5) manganese, 6) metribuzin, 7) naphthalene, 8) sodium, and 9) sulfate. The preliminary regulatory determination was to not regulate any of these contaminants, however, a final rule has not been published to date. The remaining contaminants will be continuously researched, at which time new proposed lists will be released.

3.7 USEPA Rules and Regulations Summary

The USEPA rules and regulations discussed above have been limited to the recent regulations that will impact the final design of any new water treatment facilities. The above discussion should not be taken as an all-inclusive list of compliance criteria, but as a summary of the major rules with which the system will be expected to comply. While contaminants such as arsenic, and radon are likely not a threat to the systems source water, the producing entity should have raw water samples analyzed prior to final design for these compounds to determine the severity of their presence. The drinking water contaminate candidate list should also be reviewed annually and compared with the current raw water and finished water quality analyses.

APPENDIX D

**CONCEPTUAL LAYOUT
SURFACE WATER**

**CONCEPTUAL LAYOUT
SURFACE/GROUND WATER**

CURRENT GROUND WATER MAP