Oklahoma Comprehensive Water Plan
2012 Update

Water Demand Forecast Report Addendum

Conservation and Climate Change

August 2011

This study was funded through an agreement with the Oklahoma Water Resources Board under its authority to update the Oklahoma Comprehensive Water Plan, the state's long-range water planning strategy, due for submittal to the State Legislature in 2012. Results from this and other studies have been incorporated where appropriate in the OCWP's technical and policy considerations. The general goal of the OCWP is to ensure reliable water supplies for all Oklahomans through integrated and coordinated water resources planning and to provide information so that water providers, policy-makers, and water users can make informed decisions concerning the use and management of Oklahoma's water resources.

Prepared by CDM under a cooperative agreement between the
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Introduction

In support of IDIQ Task Order Number 1 (W912BV-09-D-1001) for the development of the Oklahoma Comprehensive Water Plan (OCWP), Task 1A.8, Demand Projection Report, this report addendum serves as a supplement to the October 2009, Oklahoma Comprehensive Water Plan. This addendum includes refinements to demand projections based on Task 1A.5, Assessment of Conservation, and Task 2D.8, Investigate Climate Change "What if" Scenarios. This technical document describes the process of data collection and adoption of a reliable methodology for the assessment of both conservation and climate change scenarios. Additionally, new county-level demands are expressed as a result of each of these scenarios.

The demand for water is critical and is increasing due to population and economic growth. Rising demand combined with uncertainty of future supplies under potential climate change creates a critical need to maximize the use of an important and limited resource.

The demand forecast produced in Task 1 has been allocated to watershed basins to characterize any differences between water supply and water demand, thus identifying areas of potential water surplus and shortfalls, or gaps. This is in accordance with Task 2 of the OCWP Programmatic Work Plan. This report does not include information on the basin-level forecasts. Those forecasts are documented in the Demand/Supply Gap report.

Section 2
Conservation

2.1 Introduction

In support of task order W912BV-09-D-1001 for the development of the Oklahoma Comprehensive Water Plan (OCWP), Task 1A.5, Assessment of Conservation, CDM developed the proposed conservation scenarios that are applied to the previously developed baseline forecast for the Municipal and Industrial (M&I) and self-supplied residential and agriculture sectors of the OCWP. Demand scenarios with conservation were developed based on patterns of current conservation and factors affecting future conservation activities occurring throughout the state. These factors include cost-effectiveness of potential programs, ease of implementation, and acceptance by both the citizens of Oklahoma and water provider decision makers.

Water conservation is being recognized as an important tool in managing water resources. In addition to providing decreased cost to water providers and reductions in customer water bills, the water saved through conservation programs has been shown to help reduce or avoid the demand for water restrictions during periods of drought. Conservation can be implemented on both the demand and supply/distribution side of water management. Distribution conservation involves the effective management of system water losses through metering, analysis of water use, and leak detection in order to identify sources of non-revenue water. Municipal and industrial supply side conservation techniques reduce water demand by changing consumer behavior through: implementing education programs, promoting the use of water efficient appliances through voucher, rebates or plumbing codes, and employing conservation pricing (Sturm and Thornton). Agricultural supply side conservation reduce water demand through activities such as implementation of irrigation systems with increased efficiencies and production of crops with decreased water requirements.

Reductions in water demand diminish the amount of water required by end users while supply side leak detection reduces water loss in a system. Both approaches can reduce the volume of water utilities produce, helping decrease operation and maintenance expenses. Reduced water demand from conservation also prolongs the lifespan of current supplies; allowing utilities to defer, down size, or even eliminate costly investment in new facilities and water supplies (Maddaus 1999). Customers also benefit from conservation through reduced water and energy utility bills. Reductions in energy use for residential customers largely come from conserving hot water used by household appliances. Heating water for washing machines, dishwashers, and showers is the biggest water related energy use for residential users as well as many commercial users (Teliinghuisen 2009). Other significant benefits that are difficult to quantify can include lower discharge of treated wastewater into receiving waters, more water available for the environment, and the creation of water conservation jobs (Maddaus 1999). Within this section of this addendum, a brief cost-benefit analysis of conservation activities will be addressed. Conservation costs evaluated will include costs to customers, and costs to utilities including capital and operation and maintenance, administration and implementation.

CDM evaluated the impact of statewide expansion of a number of basic conservation activities to all Oklahoma water providers as well as implementation of a statewide water efficient indoor plumbing code ordinance that improves upon the current U.S. standards. Agricultural conservation activities evaluated included dryland production, increased irrigation efficiencies, and crop shifting. Conservation scenarios were developed through a combination of the activities.

2.2 Residential and Public-Supply Industrial Conservation

In order to provide useful and realistic conservation scenarios for the OCWP, and to assess the potential for conservation in Oklahoma, a comprehensive analysis was conducted identifying current conservation activities occurring at the provider-level throughout the state. Information on conservation activities were gathered from available resources including:

- Provider survey administered in May 2008 by OWRB with assistance from the Oklahoma Rural Water Association (ORWA) and the Oklahoma Municipal League (OML)
- Water provider websites
- Water provider conservation, supply, and drought response plans (as available)
- Oklahoma Water Resources Research Institute (OWRRI) 2009 Annual Report
- 2010 Oklahoma Academy Town Hall Water Final Report
- 2009 Alternative Water Conservation Policy Tools for Oklahoma Water Systems (conducted by OSU)
- 2002 U.S. Army Corps of Engineers (USACE) State of Oklahoma Water Resource Database

One of the main goals of this study is to build on current successful conservation activities which are being implemented by individual water providers in the state. In order to achieve this goal, the conservation matrix was utilized as an essential tool for determining potential future conservation activities. Analysis of the matrix database resulted in percentages of water providers currently practicing specific conservation activities for a given county. Analysis of the matrix revealed that water providers in Edmond and Norman are implementing progressive water conservation activities including educational programs for children and adults, a conservation website complete with water saving tips, leak detection measures, commercial and residential meters, water supply plan, water conservation plan, drought management plan, reclaimed water use for irrigation purposes, an increasing tiered rate water billing structure (often referred to as conservation rates), and summer watering schedules. These fundamental programs were used to form the basis of future conservation goals throughout the state. Thus, it is logical that a realistic assessment of potential conservation savings includes these fundamental activities and builds accordingly.

2.2.1 Conservation Activities

For the purpose of this report, conservation activities are actions performed in an effort to save water. These actions can include behavioral changes or installation of conservation devices used to conserve water. These activities can be implemented at a variety of levels including the state level, by the water provider, or by the water customer. Estimated water savings associated with the following conservation activities can be viewed in **Appendix A** at the end of this report.

Passive Conservation

In order to achieve an accurate estimate of current conservation savings throughout the state, passive conservation savings must be taken into account. Passive conservation involves water savings that are the direct result of state and federal implementation of plumbing codes requiring individuals to install water efficient plumbing fixtures. Prior to 1980, most toilets used 5.0 gallons per flush (gpf). After 1980, toilets installed in new and remodeled homes were primarily 3.5 gpf toilets. In 1994, however, as a result of the U.S. Energy Policy Act (Energy Act) of 1992, national plumbing codes mandated a maximum flush rate of 1.6 gpf (also called Ultra Low Flow Toilets or ULFT) for new and remodeled homes. Standards were also set for faucets (2.5 gallons per minute (gpm)), showerheads (2.5 gpm), and urinals (1.0 gpf). It is estimated that the Energy Act will reduce indoor water use in the average home from 121 to 55 gallons per day (gpd) by 2026 (Vickers 1993).

Passive conservation savings apply to the public-supplied residential (PSR), public-supplied nonresidential (PSNR), and self-supplied residential (SSR) sectors. PSNR savings were estimated using employment data from the 2000 Census, while PSR and SSR savings were estimated using housing data from the 2000 Census ("year structure build"), as well as data on the average replacement rates of toilets and other indoor fixtures. Passive conservation savings and new demands with such savings were calculated on a county basis. Savings are a result of older, less efficient fixtures being replaced with maximum rate fixtures, as well as installation of maximum rate fixtures in new construction.

The methodology for estimating passive savings for the PSR and SSR builds upon the Vicker's assumption that the Energy Act will reduce indoor water use in the average home from 121 gpd in 1994 to 55 gpd by 2026. Indoor use estimate is interpolated from 1994 to 2026. Savings are then estimated from 2007, which is the base year of the forecast (i.e., the water use factors developed for the baseline forecast were generally developed using 2007 data). Per household savings are multiplied by the number of housing units in the county to determine the total savings, as shown in Equation 1 through Equation 3.

$$Sp_Y^C = (H_Y^C \times Sph_Y^C \times 365) \div 325{,}851 \qquad \text{Equation 1}$$

$$Sph_Y^C = IU_Y^C - IU_{Y2007}^C \qquad \text{Equation 2}$$

$$IU_Y^C = \left\{\left((55 - 121) \div (2026 - 1994)\right) * (y - 1994)\right\} + 121 \qquad \text{Equation 3}$$

Where as:

Sp_Y^C = Passive savings in county (C) in year (Y) in acre-fee per year (AFY)
H_Y^C = Households in county (C) in year (Y)
Sph_Y^C = Savings per household in county (C) and year (Y)
IU_Y^C = Average indoor use per household in county (C) and year (Y)

For the public-supplied nonresidential sector, passive savings from the Energy Act were calculated based on an estimated 30 percent reduction in nonresidential employee sanitary water use by the year 2030 (North Carolina 2009). Based on pre-1994 plumbing fixture standards, average domestic water use per employee is estimated at 39 gallons per employee per day (ged). Percent savings are interpolated between 0 percent in 1994 to 30 percent in 2030. Savings are then estimated from the decrease in employee sanitary use between 1994 and 2030. Then, savings are multiplied by the number of employees in the county to determine the total savings. Specifics on how savings are estimated are shown in Equation 4 through Equation 6.

$$\mathrm{Sp}_{\mathrm{Y}}^{\mathrm{C}} = (\mathrm{E}_{\mathrm{Y}}^{\mathrm{C}} \times \mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} \times 365) \div 325{,}851 \qquad \textbf{Equation 4}$$

$$\mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{DU}_{\mathrm{Y}}^{\mathrm{C}} - \mathrm{DU}_{\mathrm{Y2007}}^{\mathrm{C}} \qquad \textbf{Equation 5}$$

$$\mathrm{DU}_{\mathrm{Y}}^{\mathrm{C}} = \big((0\% - 30\%) \div (2030 - 1994)\big) * (\mathrm{y} - 1994) + 39 \qquad \textbf{Equation 6}$$

Where as:

Sp_Y^C = Passive savings in county (C) in year (Y) in AFY
E_Y^C = Employment in county (C) in year (Y)
Spe_Y^C = % Savings per employee in county (C) and year (Y)
DU_Y^C = Average domestic use per employee in county (C) and year (Y)

Both monetary and water savings resulting from the Energy Policy Act are increasingly significant as new fixtures replace older, less efficient models. Additionally, replacement with efficient fixtures will reduce the load on wastewater systems and decrease energy demand.

Residential demand reductions from installation of low flow toilets and showerheads lead to significant savings for consumers with very low costs. Installation of a low flow toilet is estimated to save a household of four approximately 60 gallons of water per day, or 22,000 gallons of water per year over a standard 5.0 gpf toilet. Installation of a high efficiency showerhead and faucet aerator will save an average of 7,800 gallons of water per year for the average household. Reductions in shower water also saves energy based on the energy it requires to heat water. Based on a combined water/wastewater price of $4.00/1000 gallons, these small changes can lead to nearly $120 in annual savings per household from water use alone. Additionally, customers can expect decreases in energy bills based on decreases in the amount of energy utilized to heat water. The cost to the customer to install efficient fixtures is low in comparison to the overall benefits. The cost of a toilet replacement ranges from $60-$230/unit dependant on the model and installation. Low flow faucet aerators cost approximately $5-$10, while a low flow showerhead ranges in cost from $8-$50. Given the average lifespan of these fixtures, reduced utility bills generally far out way the costs to the customer.

In addition to monetary savings by the customer, there are also significant savings to water providers based on a decrease in demand. The American Water Works Association (AWWA) reviewed the impacts of implementing national efficiency standards forecasting water production levels from a 1999 baseline. Their results revealed per unit volume of water produced, the cost of savings to utilities was $210 per million gallons (MG) of water saved and $1,000 per MG saved for the community (Dickinson and Maddaus 2001).

Commercial and Residential Metering with Reduction in System Losses

Metering is a fundamental tool of water conservation that benefits both the supplier and the customer. Through a universal metering program, water use is measured on a per unit basis; which requires the installation of individual water meters. When customers are metered and billed for their actual water use, customers can experience a direct consequence of higher overall costs of water. A water bill which varies based on the amount of water used allows customers to realize the actual value of utility-provided water (California 2005). According to U.S. Environmental Protection Agency

(EPA) Water Conservation Plan Guidelines (2004) as well as additional sources, connection metering can lead to a 20 percent reduction in customer end use (Inman and Jeffrey 2006). Metering efforts include the metering of new construction projects, installing meters at existing customer sites, and replacing poorly operating meters (A&N 2005). Analysis of current water conservation activities throughout the state via the CDM conservation matrix, indicates that approximately 74 percent of water utilities meter their customers and approximately 78 percent of the population in Oklahoma is currently metered.

Equations 7 and 8 are used to estimate county-level savings from metering unmetered customers. Savings from metering were applied to public supply residential and nonresidential customers, although the assumed reductions differ for the sectors. Data were collected regarding which water providers are currently metering their customers. Based on the population serviced by the providers, the percent was calculated for the population serviced that is not metered for each county.

$$\mathrm{Sm}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{Rm} \times \mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}} \times \left(\%\mathrm{Um}^{\mathrm{C}} - \%\mathrm{Um}^{\mathrm{T}}\right) \qquad \textbf{Equation 7}$$

$$\%\mathrm{Um}^{\mathrm{C}} = \sum\nolimits_{\mathrm{C}} \mathrm{Ump} \div \sum\nolimits_{\mathrm{C}} \mathrm{D} \qquad \textbf{Equation 8}$$

Where as:

Sm_Y^C = Savings from metering unmetered customers in county (C) and year (Y)

$M\&I_Y^C$ = M&I baseline demand in county (C) and year (Y)

$\%Um^C$ = Percent of population unmetered in county (C)

$\%Um^T$ = Target percent of population unmetered (if current percent unmetered is greater than target percent unmetered)

Rm = Reduction in demand from metering unmetered customers

$\sum_C Ump$ = Sum of population served unmetered in county (C)

$\sum_C D$ = Sum of population served in county (C) where metering status is known

Program costs to the customer to install meters at single-family residence may be incurred in new construction; however, costs to retrofit water meters at homes are generally paid by the water supplier. Water supplier program costs may include staff time to develop meter programs, meter and installations costs, administration, contractors, and marketing. Costs may vary from supplier to supplier and are reported to range from $250 to $750 per meter for purchase and installation (Bishop and Weber 1995). The Denver Water Department concluded that the average cost per installed meter was $425, including purchase, installation, repair of deteriorating lines, and public education (Denver 1993). Costs for new construction may be lower ($175) and are often passed on to the customer (A&N 2005). Costs for installing retrofits depend on the size of the meter and range from $500-$1000 for single family dwellings and $500-$3000 for multifamily dwellings and commercial connections (A&N 2005).

Metering customers and leak detection are conservation activities that are closely related, because water loss auditing can be more adequately conducted once a utility customer base is fully metered. Water losses occur in two distinctly different manners. Apparent losses occur due to customer meter inaccuracies, billing system data errors and unauthorized consumption. These losses cost utilities revenue and distort data on customer consumption patterns. Losses also occur as real losses or water that escapes the water distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use. Non-revenue water (NRW) represents the difference between water production and revenue-generating (billed) consumption. This difference includes authorized unmetered use, apparent losses and real losses.

Analysis of current water conservation efforts in Oklahoma indicates that approximately 70 percent of water utilities have some type of leak detection program. Additionally, Oklahoma water providers are reporting NRW losses at 5-15 percent, with a statewide average at 14 percent.

For OCWP conservation analysis, reduction in real losses at the county-level is assumed. Analysis of real loss reduction mirrors the recommendations for the OCWP provided by the Oklahoma Academy for State Goals Town Hall Report (Town Hall Report) which mentions "setting maximum loss levels".

For leak detection and loss reduction, the weighted average county NRW percent calculated for the baseline forecast is reduced to a target percentage for all counties. If the weighted average is less than or equal to the target percentage, then the NRW will remain equal to the baseline. New NRW volume was calculated based on the reduced percent resulting in water savings using Equation 9.

$$\mathrm{Sl}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}} - \left\{\left[\mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}} \times \left(1 - \mathrm{NRW}_{\mathrm{B}}^{\mathrm{C}}\right) \times \left(\frac{\mathrm{NRW}_{\mathrm{R}}^{\mathrm{C}}}{1 - \mathrm{NRW}_{\mathrm{R}}^{\mathrm{C}}}\right)\right] + \left[\mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}} \times \left(1 - \mathrm{NRW}_{\mathrm{B}}^{\mathrm{C}}\right)\right]\right\}$$

Equation 9

Where as:

Sl_Y^C = Savings from leak reduction (reducing system losses) in county (C) and year (Y)
$M\&I_Y^C$ = M&I baseline demand in county (C) and year (Y), includes NRW volume
NRW_B^C = Baseline (B) NWR percent for county (C)
NRW_R^C = Reduced (R) NWR percent for county (C)

Water saved from leakage recovery acts as a new supply and is often the best source for new water resources for systems facing water shortages. Adequate leak detection efforts can lead to a substantial amount of water savings. For example, a one-inch crack in a distribution main at 100 pounds per square inch can leak 57 gpm. Leak detection efforts increase the level of service provided to customers by improving the reliability of water supplies, improving public health protection, and reducing the liability of water suppliers.

A comprehensive nationwide review of water loss reduction programs revealed that the average cost to utilities of leak detection programs was $420 per acre foot saved. The analysis showed that the program costs vary from utility to utility, ranging from $318-$658 per acre foot saved (Sturm and Thornton). One study found that leak detection measures cost an average of $150-$500 per mile of pipeline surveyed (California 2005). A general guideline is that distribution side conservation programs are cheaper when the volume of real losses is high. The lower the volume of real losses, the more effort required to reduce them. In the same study, average avoided retail costs were reported as $1,030 per acre foot (Sturm and Thornton).

Conservation Water Rates

An increasing tiered rate structure, or conservation pricing, is an advanced pricing method used to allocate costs by the quantity of water used. The concept is meant to compel customers to implement water conservation strategies in order to reduce water use and, as a result, reduce their overall cost of water. The most effective rate structure is one in which the cost per unit of water increases as the customer uses more water. This helps water providers to achieve an overall goal of reduced daily peak and seasonal peak usage and overall reduced system demand. According to the USEPA Conservation Plan Guidelines (2004), an increasing block-rate structure can lead to a 5 percent overall reduction in end use. Analysis of current water conservation activities indicates that less than 20 percent of Oklahoma water providers implement conservation pricing. Analysis of such a program is congruent with the Town Hall Report, which indicates the need for appropriately structured, market-based pricing to encourage less water usage.

Close examination of the conservation matrix revealed apparent trends in conservation pricing. Chi-squared was applied to test for the dependence between utility size and conservation pricing. The dataset utilized in this test was comprised of 773 water utilities with known pricing structures and an estimated number of households serviced (households serviced is population serviced in 2007 divided by 2.5 persons per household). Chi-squared analysis concluded that the likelihood of implementing conservation pricing is dependent upon utility size. Water utilities servicing 400 households or less are less likely to implement conservation pricing. The results of this test were used in the development of water conservation scenarios, as discussed in the Conservation Scenarios section of this addendum.

Savings from baseline demand from implementing conservation rates are applied to the target population currently not experiencing a conservation pricing structure within a given county, as shown in Equation 10. The percent of population associated with non-conservation pricing structures was estimated from data collected in the conservation matrix and using Equation 11. Implementing conservation pricing is assumed to reduce residential demand by 5 percent (USEPA 2004). Conservation rates are assumed to apply to the PSR customer base. Conservation rate pricing could also have an effect on commercial and industrial customers, however, recent studies have found savings in this sector to be more variable (California 2005). Given the lack of research on the effects of conservation pricing on the non-residential sector, conservation rate savings will only be applied to the PSR sector in this study.

$$\mathrm{Sr}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{Rr} \times \mathrm{PSR}_{\mathrm{Y}}^{\mathrm{C}} \times \left(\%\mathrm{Ur}^{\mathrm{C}} - \%\mathrm{Ur}^{\mathrm{T}}\right) \qquad \textbf{Equation 10}$$

$$\%\mathrm{Ur}^{\mathrm{C}} = \sum_{\mathrm{C}} \mathrm{Urp} \div \sum_{\mathrm{C}} \mathrm{D} \qquad \textbf{Equation 11}$$

Where as:

Sr_Y^C = Savings from implementing conservation rate structures in county (C) and year (Y)

PSR_Y^C = PSR baseline demand in county (C) and year (Y)

$\%Ur^C$ = Percent of population served not in conservation rate structure in county (C)

$\%Ur^T$= Target percent of population served not in conservation rate structure (if current percent is greater than target percent)

Rr = Reduction in demand from implementing conservation rate structure

$\sum_C Urp$ = Sum of population served not in conservation rate structure in county (C)

$\sum_C D$ = Sum of population served in county (C) where conservation rate structure status is known

The savings associated with conservation rates are based on customers' responses to increased utility bills. One study reviewing 30 different utilities found the average range of water savings per participant ranged from 55,2188 gallons to negative 6,394 gallons (a increase in water use) with the average participant saving 14,355 gallons, a saving of 4.8 percent (Little and Gallup). Costs to the customers ranged from negative -$22 to $6 per AF saved, with an average cost of negative $3 per AF saved (Little and Gallup). Average cost to the utilities was also low at $0.82 per connection (Little and Gallup). The primary cost associated with implementing rate structures (not including metering) is dedication of staff to design and implement proper rate structures consistent with utility objectives.

Community Education and Information

Customer education is a critical component of any water conservation program and nearly all water conservation efforts are dependent on public awareness and an understanding of the need for conservation (Butler and Howarth 2004). In addition to communicating water savings habits, the effectiveness of additional conservation measures is enhanced by educational programs. While educational savings are difficult to estimate, providing information which changes water use habits can produce considerable water savings. EPA Conservation Plan Guidelines (2004) and additional sources estimate a 3-5 percent reduction in end use as a result of information and education programs (Inman and Jeffrey 2006)

Education programs can be aimed at any age level and often times can be implemented into school curriculums. The City of Norman, for example, is leading the way with a program in which thousands of flyers and bookmarks with water conservation tips are sent home with students several times a year. Community-wide education can focus on a variety of topics including tips for indoor and outdoor water conservation, water-wise landscaping, and general water education. This information can be distributed by means of water bill inserts, brochures, media campaigns, websites, and public exhibitions. According to data collection efforts, 34 percent of water utilities in Oklahoma implement some form of water conservation educational programs.

Savings from implementing an educational program are applied to the percent of baseline demand currently not targeted by a provider-implemented water conservation education program within a given county, as shown in Equation 12. The percent of population not targeted by a water conservation educational program was estimated from data collected in the conservation matrix and using Equation 13. Targeting a population with a water conservation educational program is assumed to reduce PSR, PSNR, and SSR sector demand by 3-5 percent, depending on the program and the sector.

$$\mathrm{Se}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}} - \left(\%\mathrm{Ue}^{\mathrm{C}} \times \mathrm{Re} \times \mathrm{M\&}I_{\mathrm{Y}}^{\mathrm{C}}\right) \qquad \textbf{Equation 12}$$

$$\%\mathrm{Ue}^{\mathrm{C}} = \sum_{\mathrm{C}} \mathrm{Uep} \div \sum_{\mathrm{C}} \mathrm{D} \qquad \textbf{Equation 13}$$

Where as:

Se_Y^C = Savings from implementing conservation education program in county (C) and year (Y) in AFY

$M\&I_Y^C$ = M&I baseline demand in county (C) and year (Y)

$\%Ue^C$ = Percent of population not targeted by conservation education program in county (C)
Re = Reduction in demand from implementing conservation education program
$\sum_C Uep$ = Sum of population not targeted by conservation education program in county (C)
$\sum_C D$ = Sum of population in county (C) where conservation education program status is known

The cost of an education program will depend on the scale and methods used to reach the targeted population. Both of these factors relate back to utility specific goals and objectives of the program. Free educational curriculum and materials on conservation are readily available but staff time is needed to establish objectives, a target audience, and an appropriate approach and method of outreach. For a basic print media and bill stuffer campaign an annual budget of $10,000 should be sufficient for a small agency with fewer than 5,000 hook ups, for a larger agency with connections around 25,000 an annual budget should be around $50,000 (Colorado WaterWise 2010). A mixed media approach with billboards, web, and radio spots require a larger budget. Television is the most expensive media outlet and is usually only employed by large utility providers. In one review of Portland metropolitan area water suppliers, education programs cost $123 per AF saved ($364 per MG) (RWCP 2004). In another study by the American Water Works Association, youth education programs cost 5 to 57 cents per household per year with an average cost of 24 cents per household (Mirvis and Clark 1998).

Implementation of a High Efficiency Indoor Water Use Ordinance

Mandating minimum plumbing and building code requirements can be a key avenue to advancing water efficiency in indoor plumbing fixtures statewide. Such requirements can apply to indoor water using fixtures and equipment including toilets, urinals, showerheads and faucets, clothes washers and dishwashers. **Table 1** shows the allowed water use rates under the Energy Policy Act for commonly used plumbing fixtures. Water use rates from high efficiency (HE) fixtures currently on the market are also shown.

Table 1: Plumbing Fixture Water Use Rates

Fixture	Maximum Flow Rate Mandated by Energy Policy Act (1992)	Maximum Flow Rate Available
Toilet	1.6 gpf*	1.0-1.28 gpf
Urinal	1.0 gpf	0.5 gpf
Faucet	2.5 gpm**	1.0-2.2 gpm
Showerhead	2.5 gpm	2.0 gpm

*gallons per flush (gpf)
**gallons per minute (gpm)

California, Georgia, and Texas have adopted statewide high efficiency (HE) plumbing fixture programs. Additionally, many counties and cities throughout the U.S. have adopted similar programs. While implementing and enforcing new plumbing requirements can be a laborious task for cities, counties, and states, significant water savings are already being accomplished by those implementing these standards. For example, toilets are by far the main source of water use in the average home, accounting for nearly 30 percent of indoor water consumption. Replacement of older, inefficient toilets can save consumers nearly 11 gallons per toilet every day (EPA 2010). As a local example, if all homes in Oklahoma County have a 1.28 rather than a 1.6 gpf toilet in 2060, savings for that county alone could reach an estimated 1,350 acre-feet.[1]

For the purpose of the OCWP, CDM estimated water savings from the implementation of a statewide ordinance of new indoor water use efficiency standards. The assumption behind such an ordinance is the requirement of high efficiency fixtures in all new construction and in alterations of existing buildings, thus less efficient plumbing fixtures would become phased out in future years. Implementation of an ordinance may take several years, therefore, savings are estimated based on a 2015 implementation date.

Residential water use savings are estimated with Equations 14 through 16, similar to the passive conservation methodology. Based on Table 1, indoor residential water use will, on average, decrease by 10 gallons per household per day through combined savings from implementation of a high efficiency water use ordinance. The program is assumed to reduce indoor residential fixture water use starting in 2015 and achieve 10 gallon per household per day reduction in 2045 (savings are in addition to passive conservation savings). Interpolated savings are multiplied by the number of households in a county to arrive at total savings.

$$\mathrm{Sh}_{\mathrm{Y}}^{\mathrm{C}} = (\mathrm{H}_{\mathrm{Y}}^{\mathrm{C}} \times \mathrm{Sph}_{\mathrm{Y}}^{\mathrm{C}} \times 365) \div 325{,}851 \qquad \textbf{Equation 14}$$

$$\mathrm{Sph}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{IUh}_{\mathrm{Y}}^{\mathrm{C}} - \mathrm{IUh}_{\mathrm{Y}2015}^{\mathrm{C}} \qquad \textbf{Equation 15}$$

$$\mathrm{IU}_{\mathrm{Y}}^{\mathrm{C}} = \big((1-10) \div (2045-2015)\big) * (\mathrm{y}-2015) \qquad \textbf{Equation 16}$$

Where as:

$\mathrm{Sh}_{\mathrm{Y}}^{\mathrm{C}}$ = Savings from HE plumbing code in county (C) in year (Y) in AFY

$\mathrm{H}_{\mathrm{Y}}^{\mathrm{C}}$ = Households in county (C) in year (Y)

$\mathrm{Sph}_{\mathrm{Y}}^{\mathrm{C}}$ = Savings per household in county (C) and year (Y)

$\mathrm{IU}_{\mathrm{Y}}^{\mathrm{C}}$ = Average indoor savings per household in county (C) and year (Y)

Savings from high efficiency (HE) plumbing codes will also impact the nonresidential sector and are estimated using Equation 17 through 19. According to 2008 Watersmart Guidelines, installation of high efficiency model plumbing fixtures in businesses can improve domestic water use efficiency by 20 percent (East Bay 2008). Based on this figure, domestic use water savings per employee are interpolated from 0 to 20 percent from 2015 to 2045. These 20 percent savings result in a five gallon per employee per day water reduction (in addition to passive savings) by 2045. Per employee water savings are then multiplied by the number of employees per county to determine county-wide nonresidential water savings.

$$\mathrm{Sh}_{\mathrm{Y}}^{\mathrm{C}} = (\mathrm{E}_{\mathrm{Y}}^{\mathrm{C}} \times \mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} \times 365) \div 325{,}851 \qquad \textbf{Equation 17}$$

$$\mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} = \mathrm{Wpe}_{\mathrm{Y}}^{\mathrm{C}} \times \%\mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} \qquad \textbf{Equation 18}$$

$$\%\mathrm{Spe}_{\mathrm{Y}}^{\mathrm{C}} = \big((0\% - 20\%) \div (2045-2015)\big) * (\mathrm{y}-2015) \qquad \textbf{Equation 19}$$

[1] Assumptions: 2060 households estimated at 373,390; 2 toilets per household; 5 flushes per toilet per day.

Where as:

Sh_Y^C = Savings from HE plumbing code in county (C) and year (Y) in AFY

E_Y^C = Employment in county (C) and year (Y)

$\%Spe_Y^C$ = % Savings per employee in county (C) and year (Y)

Spe_Y^C = Savings per employee in county (C) and year (Y) in gallons

Wpe_Y^C = Average domestic water use per employee in county (C) and year (Y)

2.2.2 Conservation Scenarios

The five conservation activities described above are combined in a logical and consistent manner to develop two conservation scenarios for Oklahoma. Using these scenarios, the potential reduction in demand is estimated at the county level. Scenarios were constructed with input from OWRB members and the Utility Superintendant for Water and Wastewater at Edmond Public Utilities. Scenario I, ***Moderately Expanded Conservation***, is an analysis of passive savings combined with expanded metering, leak detection, conservation pricing, and education programs. Scenario II, ***Substantially Expanded Conservation***, is an analysis of more aggressive levels of the Scenario I programs with the addition of the high efficiency ordinance. Both scenarios are described in detail, as follows, and results are provided. Estimated water demands by county resulting from each of these scenarios can be viewed in Appendix B at the end of this report.

Scenario I: Moderately Expanded Conservation

The moderately expanded conservation scenario, or Scenario I, is a combination of conservation programs which are most likely to be implemented by water purveyors in Oklahoma based on costs and ease of implementation. In this scenario, savings are included from passive conservation. Additionally, savings from metering are calculated based on a minimum metering implementation percentage of 90 percent of providers in each county. Counties with metering implementation percentage currently at or above 90 percent were not changed and no future potential savings from metering are calculated for those counties.

Also in Scenario I, leak detection methods are assumed to decrease NRW in each county to 12 percent. Those counties with NRW currently at or below 12 percent were left unchanged and no future potential NRW savings are assumed.

Savings for conservation rates were based on urban and rural populations in each county. As described in the conservation activities portion of this document, implementation of conservation pricing is dependent on the population served by utilities. Analysis of this data shows that high population areas are more likely to implement conservation pricing. Data were collected from the United States Department of Agriculture's Economic Research Service (USDA-ERS) in order to classify Oklahoma counties as high population, urbanizing population, and rural population areas (USDA-ERS). For Scenario I, counties with high population metropolitan areas are assumed to have the highest potential conservation pricing implementation percentage at 60 percent. Counties without metropolitan areas, but with urban populations greater than 2,500 are assumed to implement conservation pricing to 40 percent of its public water supply customers. Rural counties are assumed to implement conservation pricing to only 20 percent of its public water supply customers.

Educational programs under this scenario are assumed to be expanded to educational water bill inserts and a website with water conservation tips. These measures are assumed to decrease water demand by an average of 3 percent for customers not currently targeted by these educational materials (Baumann et. al 1998).

In summary, Scenario I is based on the following assumptions:

- Passive conservation will be achieved by 2026 for PSR, 2030 for PSNR
- 90 percent of water providers in each county will metering their customers, unless current metered percentage is greater than 90 percent
- NRW will be reduced to 12 percent, where applicable
- Conservation pricing will be implemented by 20 percent of purveyors in rural counties, 40 percent in mostly urban counties, and 60 percent in counties with high metropolitan populations
- Educational programs will be implemented by all providers, which includes billing inserts and conservation tip websites to reduce demands by 3 percent

Scenario II: Substantially Expanded Conservation

The substantially expanded conservation scenario involves a set of robust yet achievable conservation programs for Oklahoma water purveyors.

In this scenario, potential savings are included from both passive conservation and implementation of a high efficiency plumbing code ordinance. Savings from metering are calculated for 100 percent statewide implementation.

Additionally, leak detection techniques are expected to decrease NRW to 10 percent in those counties with NRW currently above this threshold. Conservation rates were assumed to be implemented by 100 percent of all counties with high population metropolitan areas, 80 percent implementation in urban counties, and 60 percent in rural counties.

Educational programs in this scenario are expected to reduce demands by 5 percent in counties not currently utilizing water conservation educational programs. This aggressive decrease in water demands is expected based on implementation of mass media campaigns and educational programs encouraging water conservation in addition to the water bill inserts and website with conservation tips encouraged in Scenario I (Inman and Jeffrey 2006).

In summary, Scenario II is based on the following assumptions:

- Passive conservation
- Implementation of metering by all purveyors statewide
- NRW reduction to 10 percent where applicable

- Conservation rate implementation by 60 percent of purveyors in rural counties, 80 percent in mostly urban counties, and 100 percent in counties with high metro populations
- Water conservation education programs include school educational programs and media campaigns in addition to billing inserts and a conservation tip website to reduce demands by 5 percent
- Implementation of a high efficiency plumbing code ordinance

Results

Estimates were developed for county water demand M&I and self supply residential savings for each of the above scenarios. New demands were calculated for 2020-2060 in ten-year increments by calculating the total savings for each program and subtracting the savings from corresponding baseline demands. Table 2 provides the statewide M&I with self supply residential demand forecast summary for the baseline demands as well as estimated demands for Scenario 1 and Scenario 2. The moderately expanded conservation scenario is predicted to decrease statewide residential and non-residential demand by 18 percent by the year 2060, while the substantially expanded scenario is predicted to decrease demand by 27percent by 2060.

Table 2: Statewide Water Demands with Savings from Conservation Scenarios (AFY)

	2020	2030	2040	2050	2060
Baseline	679,648	717,161	750,844	782,137	813,928
Scenario I	585,746	588,269	615,650	641,026	666,806
Scenario II	547,251	538,908	554,837	571,788	594,646
Change from Baseline (AFY)					
Scenario I	93,902	128,891	135,194	141,111	147,122
Scenario II	132,397	178,253	196,007	210,348	219,283

As shown, for 2030 the range of impacts is estimated to be 128,891 AFY and 178,253 AFY for moderately expanded and substantially expanded conservation, respectively. The range of impacts for 2060 is estimated to be 147,122 AFY and 219,283 AFY for moderately expanded and substantially expanded conservation, respectively.

Figure 1 illustrates the estimated savings for the years 2030 and 2060 statewide by program for Scenario I and Scenario II. Savings from Scenario I are estimated to reach nearly 150,000 AFY of water by 2060. In Scenario II, more aggressive programs and the addition of a high efficiency ordinance brings estimated water savings to nearly 220,000 AFY by 2060.

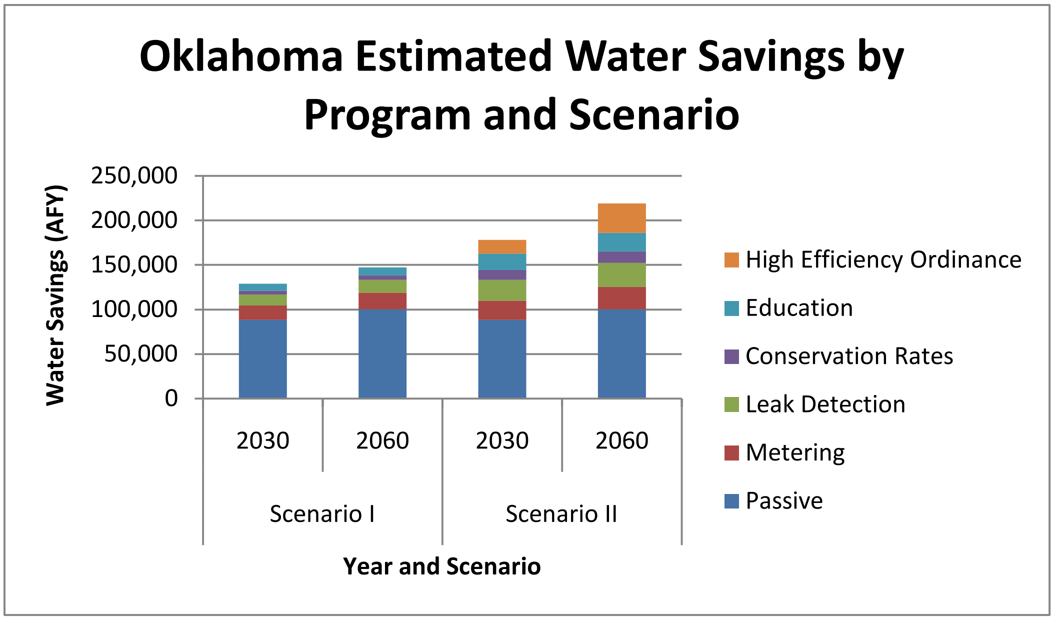

Figure 1: Oklahoma Estimated Water Savings by Program and Scenario

Figure 2 illustrates the estimated decrease in statewide M&I and self supply residential demand by sector in 2060 with implementation of moderately expanded conservation or substantially expanded conservation.

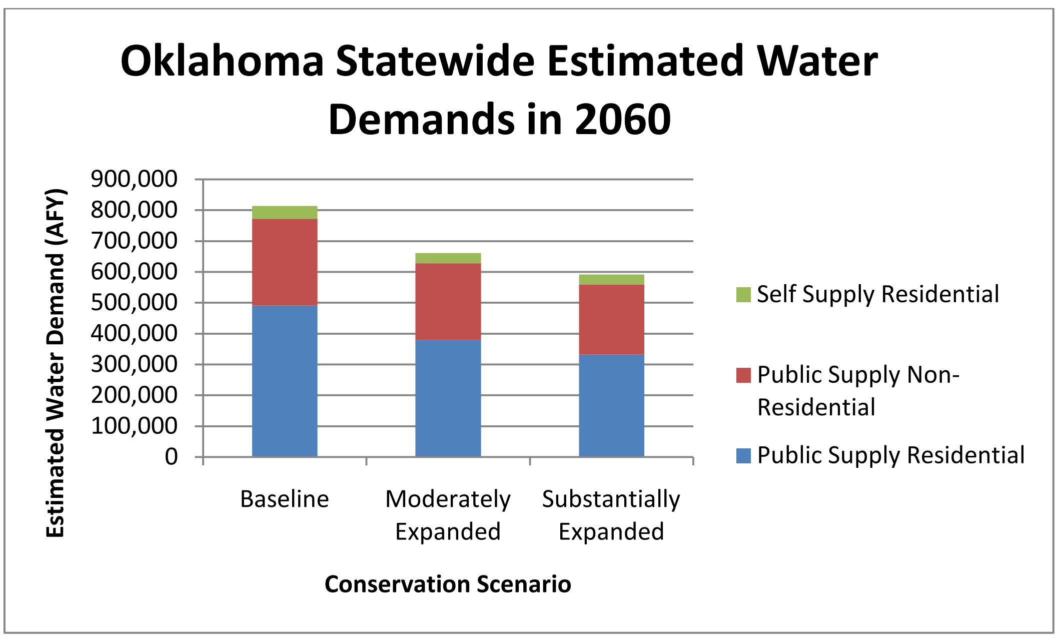

Figure 2: Oklahoma Statewide Estimated Water Demands under Conservation Scenarios in 2060

Cost-Benefit Analysis

The immediate benefits to utilities from reducing water demand derive from the inputs associated with forgoing production of a unit of water. The major inputs include: electricity, chemicals, labor, and water analysis. These inputs or costs are here on referred to as *direct operational costs*. In order to determine the benefits of reductions in water demands, a review of water treatment plant production and of municipal budgets in Oklahoma was completed. The results of this data review suggest that the cost of delivering a MG of treated groundwater range from $157 - $550 per MG, and for surface water sources from $330 – $1,100 per MG. (Groundwater sources typically cost less to produce compared to surface water sources which require more extensive treatment.) Analysis of water budgets and water production from Stillwater, Ardmore, and Edmond suggested the average direct operational production cost of $354 per MG for groundwater sources and $696 per MG for surface water sources. Water production and the associated cost for each utility mentioned above can be seen in Table 3.

Table 3: Water Production Costs

City Utility and Source	Direct Operational Costs ($)	Production (MG)	Direct Operational Cost per Unit Production ($/MG)
Ardmore Surface Water	$878,565	2,659	$330
Ardmore Groundwater	$41,398	263	$157
Stillwater Surface Water*	$1,406,228	2,135	$659
Edmond Surface Water	$2,235,563	2,032	$1,100
Edmond Groundwater	$881,419	1,603	$550

*Note Stillwater's water production is from surface water sources only.

Analysis of residential and non-residential public supplied water demands in 2060 under Scenario I resulted in statewide savings of 139,935 AF of water. Under Scenario II public supplied statewide savings of 209,396 AF were realized. Additionally, 2005 USGS Water Use Data indicates that 82 percent of withdrawals in Oklahoma are from surface water sources. Based on this assumption, under Scenario I 114,746 AF of the statewide savings are derived from surface water and 25,188 AF from ground water sources. For Scenario II the amount of water saved from surface and groundwater sources would be 171,705 AF and 37,691 AF respectively. Utility savings from conservation can be determined by multiplying the direct operational cost by the amount of water saved from each scenario. Under Scenario I, statewide savings associated with reducing water production in the public-supplied M&I subsector is roughly $26.0 million dollars for surface water sources and $2.9 million dollars for groundwater. Under Scenario II the statewide savings for reducing surface water production increases to $39.0 million dollars and for groundwater the savings increase to $4.3 million dollars.

The conservation programs mentioned under Scenarios I and II reduce the overall water production by water utilities, but not all of the programs reduce the volume of water treated by wastewater treatment (WWT) plants. Supply side conservation programs reduce actual water losses in the distribution system but do not reduce the amount of wastewater generated. Non-revenue water escapes the distribution system never reaching WWT plants; therefore savings associated with leak detection do not impact wastewater flows. However, demand side conservation programs that modify water use behavior can reduce the amount of treated wastewater. These programs include metering, conservation rates, education, high efficiency plumbing codes, and passive conservation.

To determine the reductions of wastewater treated by WWT plants, only the public-supplied residential subsector water use was considered. While demand reductions in the public-supplied non-residential subsector would also have a direct effect on wastewater, not enough information is available to determine the amount of wastewater produced by this subsector. For planning purposes, it is assumed that all self-supplied residential wastewater is treated by private septic systems, while public-supplied residences have local sewer services, and that all non-consumptive public-supplied water use is dispensed through municipal sewer systems. In public-supplied residences, all water saved from high efficiency plumbing codes and passive conservation is associated with indoor use and is assumed to reduce or abate wastewater treatment. Therefore, these two programs are assumed to have a 100 percent wastewater impact factor. Other behavioral/supply conservation programs like education, metering, and conservation rates reduce indoor and outdoor water use. Consequently, not all the water saved from these programs can be linked to reductions in wastewater treatment. CDM assumes 25 percent of the water associated with these three programs is indoor use and therefore a wastewater saving impact factor of 25 percent is assigned for these programs.

Analysis of water savings attributable to these five programs in 2060 resulted in a total saving of 103,223 AFY under Scenario I and 141,218 AFY under Scenario II for the public-supplied residential subsector. By multiplying the savings associated with each of the five conservation programs with their respective impact factors and summing the products, the total reduction of treated waste water could be determined. The reduction of treated wastewater was 83,377 AFY (27,180 MG) for Scenario I and 107,567 AFY (107,567 MG) for Scenario II. As with water production facilities, the cost directly related to treating a quantity of wastewater is coupled with the four direct operational costs. A review of the three previously mentioned municipal budgets and corresponding WWT plants suggests the per unit cost of treating one MG of wastewater is $358-$975. The average per unit cost of wastewater treatment in these three cities was $681 per MG of wastewater and was assumed to be the average unit cost of wastewater treatment throughout Oklahoma. By multiplying the per unit cost of wastewater treatment with the estimated reduction of wastewater, the result is the wastewater savings associated with the conservation programs. Scenario I had reduced wastewater flows of 27,180 MG of water resulting in monetary savings of nearly $18.5 million ($681 per MG * 27,180MG = $18,509,824). Under Scenario II, wastewater savings of 35,051 MG results in a monetary saving of about $23.9 million ($681 per MG*35,051 MG = $23,869,429) to the water utilities. A summary of statewide savings related to water production and wastewater treatment can be seen in Table 4.

Table 4: Statewide Water Conservation Savings from Reduced Water Production and Wastewater Treatment in 2060

	Surface Water	Groundwater	Wastewater	Total
Scenario I	$26,036,731	$2,903,100	$18,510,151	$47,449,981
Scenario II	$38,961,078	$4,344,167	$23,880,443	$67,185,689

Another significant benefit of water conservation is the reduction of energy needed to produce water. Water and energy resources are highly collaborated and form a water-energy nexus. The basic concept of the water-energy nexus is that it takes water to produce energy and energy is used in the distribution and treatment of water. A reduction in water demand reduces the energy needed to provide water and reductions in energy demand reduce the need for water use (withdrawal and consumption) in power production facilities.

Approximately four percent of all energy consumption in the United States is used for water distribution and treatment (EPRI 2002). Energy is required to pump water from its source, to a treatment plant, to a customer, and finally to a wastewater facility. Eighty-five percent of the energy involved in the initial treatment and distribution of water is for pumping requirements (Hamilton et. al 2009). It takes anywhere from 540-3,000 kilowatt hours (KWh) to pump a MG of water from its original source and treat it (Arora and Lechevallier 1998; Hamilton et al. 2009; Elliot et al. 2003). Groundwater sources typically require 30 percent more electricity than surface water on a per unit basis due to increased pumping requirements (EPRI 2002). Based on several studies citing national average energy costs, CDM assumes the energy costs of surface water production in Oklahoma to be 1,400 KWh per MG of water, for groundwater 1,800 KWh per MG (Elliot et al. 2003; EPRI 2002; Hamilton et al. 2009). These figures represent the amount of energy imbedded in publicly supplied water. It should be noted that the variation in the energy intensity of water is high and depends on several factors including: the age of distribution system, depth and distance water has to be transported, and quality of water before and after initial treatment.

Using the water savings derived from the two conservation scenarios and the energy intensity of water for each water source, the amount of energy saved for each conservation scenario can be determined. As mentioned previously, 82 percent of public-supplied water in Oklahoma is derived from surface water sources while 18 percent is derived from groundwater sources. Assuming the energy intensity of pumping and distributing surface water and groundwater sources is 1,400 KWh per MG and 1,800 KWh per MG, respectively, the energy saved in conserving 139,935 AF (45,598 MG) of water would be 67,119,686 KWh or 67.12 gigawatt hours (GWh). Similarly, under Scenario II a savings of 209,396 AF (68,232 MG) of water would result in the abatement of 100,437,163,682 KWh or 100.44 GWh of electricity. The calculation to determine the amount of energy saved from reducing water production is shown below in Equation 20.

$$ES_{\mathrm{scy}} = VS_{\mathrm{scy}} \times (sP \times sI + gP \times gI) \quad \textbf{Equation 20}$$

Where:

ES_{scy} =Energy saved associated with reductions in water demand of public supply systems from conservation scenario (sc) in year (y)
VS_{scy} =Volume of water saved from scenario (sc) in year (y)
sP = Percent of water derived from surface water sources in Oklahoma (82%)
sI = Intensity of energy in production of surface water (1,400 KWh per MG)
gP = Percent of water derived from groundwater sources in Oklahoma (18%)
gI= Intensity of energy in production of groundwater (1,800 KWh per MG)

Energy is also saved by reducing the amount of wastewater that needs to be treated. The amount of energy required to recover and treat wastewater range from 955-2,500 KWh per MG depending on the treatment technique (Hamilton et al. 2009; EPRI 2002). The most common treatment technique is activated sludge with an average energy requirement of 1,300 KWh/MG treated. This energy requirement is assumed to be the energy cost of wastewater treatment in Oklahoma. As previously stated, the amount of wastewater abated from conservation Scenarios I and II is 27,180 MG and 35,051MG respectively. The energy intensity in treating a MG of wastewater is assumed to be 1,300 KWh. Therefore, the amount of electricity saved from abatement of wastewater treatment is 35.33-45.57 GWh of energy depending on the conservation scenario.

The amount of energy saved from conserving water is the sum of energy saved from initial water production and wastewater treatment. For Scenario I, the statewide reduction in energy demands is 102.45 GWh and for Scenario II it is 146.00 GWh.

Water is required throughout the production lifespan of energy. It is used in the extraction of fuel sources in mining, drilling, or in the case of bio-fuels, agricultural operations. Water is also needed in the production of energy in thermoelectric power generation to cool equipment and produce steam. In the U.S., thermoelectric power generation accounts for approximately 40 percent of all freshwater withdrawals (Goldstein 2008). The consumption and withdrawal rates of water depend on numerous factors including the type of heat source, prime mover, and cooling system (Goldstein 2008). In Oklahoma, over 93 percent of electricity produced is derived from thermoelectric plants using natural gas or coal derived products as their primary fuel source (EIA 2010). Based on CDM's analysis of 58 power production plants in Oklahoma and USGS 2005 estimates of water use for thermoelectric power, CDM assumed 775 gallons of water are withdrawn for every megawatt hour of electricity (MWh) produced (OCWP 2011 Update Water Demand Forecast Report October 2009). Consumptive use of water in thermoelectric power plants was assumed to be 480 gallons per MWh (Wolfe, 2008).

As stated previously, the savings derived from the conservation scenarios resulted in Oklahoma water utilities reducing water production and wastewater treatment by 72,766 MG to 103,282 MG in 2060. This results in a reduction in power demand of 102.45-146.00 GWh for both water production and wastewater treatment for Scenario I and II respectively. The water withdrawals and consumptive use required for thermoelectric power generation is assumed to be 775 G per MWh and 480 G per MWh respectively. If 93 percent of all energy production is derived from thermoelectric plants, then the reduction in water withdrawals associated with the decrease in power production range from 71.9 MG for Scenario I and 102.5 MG for Scenario II. The decrease in consumptive use associated with this power reduction is 45.7-65.2 MG. The calculations used to derive consumptive use and water withdraws saved from reduced power production are shown below in Equation 21 and Equation 22.

$$WSW_{\text{scy}} = ES_{\text{scy}} \times wI \times eP \qquad \textbf{Equation 21}$$

$$WSC_{\text{scy}} = ES_{\text{scy}} \times CI \times eP \qquad \textbf{Equation 22}$$

Where:

WSW_{scy} = Volume of water withdrawal saved from reductions in energy demand for scenario (sc) in year(y)

WSC_{scy} = Volume of water consumption saved from reductions in energy demand for scenario (sc) in year(y)
ES_{scy} = Amount of electricity saved from reductions in water demands for scenario (sc) in year (y)
wI = Intensity of water withdrawals for power production (775 G per MWh)
CI = Intensity of water consumption for power production (480 G per MWh)
eP = Percent of energy produced by thermoelectric plants using natural gas and coal (93%)

Table 5 provides a summary of potential water and energy savings from each conservation scenario.

Table 5: Statewide Water and Energy Savings Derived From Conservation Scenarios in 2060

Scenario	Water Saved From Conservation	Energy Saved From Water Conservation	Water Saved From Energy Reductions	
	MG	GWh	Consumptive Use (MG)	Withdrawals (MG)
Scenario I	45,598	102	46	72
Scenario II	68,232	146	65	103

2.3 Agricultural Conservation

In order to provide useful and realistic conservation scenarios, CDM conducted a comprehensive review of current and future potential conservation measures and trends associated with agricultural irrigation in Oklahoma. The conservation scenarios provided herein were developed based on patterns of current conservation and factors affecting future conservation activities including trends in regional irrigation practices, recent improvements of water conveyance systems, ease and cost effectiveness to farmers, and farming economics.

A comprehensive review of available data and academic research was undertaken to inform the development of useful and realistic scenarios of potential agriculture conservation in Oklahoma. Information on current and historic agricultural practices was gathered from the sources listed below. Much of this data was collected and reviewed for development of the OCWP baseline agriculture forecast.

- USDA Farm and Ranch Irrigation Survey (FRIS) for Oklahoma
- USDA Census of Agriculture
- USGS Water Use for Oklahoma
- NRCS Irrigation Handbook

In Oklahoma, agriculture irrigation was the largest source of water withdraws in 2007; accounting for 40.5 percent of all withdrawals. Agricultural water demand is driven by numerous factors including the acreage and type of crop irrigated, irrigation system (i.e., surface, sprinkler, and micro-irrigation), seasonal rainfall, water availability, and fuel and commodity prices. Water savings can be achieved through a number of methods including: implementing more efficient irrigation methods and improving deficit irrigation techniques, shifting from water intensive to water efficient crops, and shifting to dryland production. These activities have differing economic, environmental, and political impacts and have various likelihoods of implementation, as discussed in the following sections.

2.3.1 Conservation Activities

The following section provides an overview of potential conservation activities performed to save water. A summary of estimated savings from these activities is provided in Appendix A at the end of this report.

Dryland Production

Dryland production is the shift from irrigation dependent crops to rainfall dependent crops. Essentially, this reduces irrigation demands to zero and a detailed analysis of water demands under dryland production is not required for the OCWP. Dryland production, however, is a viable future alternative in certain regions and discussion of this alternative is warranted.

The likelihood of dryland production in Oklahoma is dependent upon numerous, interrelated factors and varies by region. This type of farming is shown to have economic impacts that may reduce the level of implementation. Dryland production produces significant decreases in crop yield. In Nebraska, dryland farming of the region's most popular crops had average yields 35 percent less than irrigated crop yields, and this difference would be even greater under drought conditions (Lamphear 2005). In the Southern High Plains of Texas, irrigation provides a 150 percent yield increase over dryland farming (Colaizzi et al. 2004).

It can be assumed that farmers across the State are not likely to shift to dryland production where irrigation systems are currently in place unless faced with severe water shortages, high pumping costs, or implementation of policies that provided incentives to do so. Almas et al. (1998) has shown through an economic optimization model that irrigated acres will significantly decrease in Cimarron, Texas, and Beaver Counties by 2060 due to groundwater declines. Thus, in Panhandle counties, transition from irrigation to dryland farming is a viable (and likely) future outcome.

Irrigation Efficiency

Improvements in irrigation system deliveries reduces on-farm system losses and thus reduces the amount of water applied to the irrigation scheme. There are three main types of irrigation systems, each with unique efficiencies and options for improvement: sprinkler, surface, and micro-irrigation. The field application efficiencies of these systems assumed for the baseline forecast are 85 percent, 64 percent, and 89 percent, respectively. Future conditions of system efficiency vary by type of system, as discussed below.

Sprinkler Irrigation

Sprinkler systems irrigate by spraying pressurized water over the field through above ground piping structures. According to the 2005 USGS Water Use Survey, 81 percent of all irrigated acres in Oklahoma are irrigated by sprinkler systems. There are numerous types of sprinkler systems on the market with varying levels of efficiency. A low pressure center pivot system with drop down nozzles increases efficiency over standard sprinkler systems by reducing evaporation losses. An example of this type of system is the Low Energy Precision Application (LEPA) system. LEPA is a highly efficient sprinkler system and is reported to have irrigation efficiencies ranging from 85 percent to 95 percent (Lynne and Morris 2006, Sloggett and Dickason, Aillery et al. 2009, Schneider 2000). LEPA can be used on low pressure linear move and center pivot sprinkler irrigation systems and applies water on the soil surface or at crop height (NRCS 2010).

Use of high efficient low pressure sprinkler systems in the West has been expanding (Aillery et al. 2009). A review of the FRIS shows that the percent area of irrigated lands using low pressure sprinkler systems grew by 8 percent from 1998-2003 and by 12 percent from 2003-2008. By 2008, 77 percent of the irrigated lands in Oklahoma were using low pressure sprinkler systems, with the majority being center pivot systems (USDA FRIS 1998, 2003, 2008).

Continued growth of LEPA sprinkler systems is expected. A study of irrigation technology adaption in the Central Plains suggested LEPA systems would grow by 27 percent by 2015 (Aillery and Schaible 2003). Other studies of irrigation technology adaption compared the potential use of six irrigation systems under four groundwater supply scenarios, and concluded that LEPA was the preferred irrigation method in all four scenarios (Feng and Segarra 1994). LEPA operational costs were also found not to be binding and the authors suggested LEPA could feasibly be used on all irrigated acreage within the study region (Feng and Segarra 1994).

Thus, it is reasonable to assume implementation of LEPA for all sprinkler systems, increasing application efficiency to 90 percent. This is a 5 percent increase in sprinkler system field application efficiency from the baseline forecast.

Surface Irrigation

Surface irrigation, also referred to as flood or furrow irrigation, relies on gravity to distribute water across the surface of a field. In Oklahoma, 18 percent of all irrigated acres are irrigated by surface irrigation methods (2005 USGS Water Use Survey). Surface irrigation has the lowest field application efficiency of the three irrigation methods due to seepage losses of the conveyance system and application method. Regions with large areas of surface irrigation tend to have low weighted efficiencies and could have a high potential for agricultural water conservation improvements. However, it should be noted that surface water irrigation has a higher return flow and lower consumptive use ratio when compared to other irrigation methods. Thus, true savings in consumptive demands should be carefully considered. That is, shifting away from surface irrigation may reduce water withdrawals, but will not change the consumptive water requirements of the crop.

Historically in Oklahoma, shifts from surface to sprinkler irrigation systems have occurred but this trend is slowing. According to the USGS Water Use Survey data from 1995-2000, 10 percent of the irrigated acres in Oklahoma experienced a shift from surface to sprinkler systems. From 2000-2005, this trend slowed to 3.8 percent. Analysis of the FRIS data showed similar findings in the state; with a large initial shift of surface to sprinkler systems followed by a significant decrease in this trend from 2003-2008. A recent reduction in growth of surface to sprinkler systems is a trend observed throughout the western states (Aillery et al. 2009). The implication is that farmers most likely to shift away from surface irrigation may have already done so. Additional transitions away from surface irrigation may require greater incentives.

Water conservation can be achieved in regions with surface irrigation by improving the efficiency of surface systems. There are two regions in Oklahoma where surface irrigation systems are used extensively: the southwest counties Harmon, Jackson, Tillman, and Kiowa, and the southeast counties McCurtain and Leflore.

McCurtain County has only 421 acres of irrigated land, yet all of the irrigated water in McCurtain is delivered by surface irrigation systems (USDA FRIS 1998). Leflore County has 9,398 acres of irrigated land with the majority of the irrigated land used for soybean and spinach production. In Leflore County, 72 percent of irrigated water is applied through surface irrigation systems (USDA FRIS 1998). It is assumed that McCurtain and Leflore counties in the southeast are unlikely to take measures to improve system losses. These counties are in a humid, surface water rich area of the state and there is little incentive for irrigation improvements.

Harmon, Jackson, Tillman, and Kiowa counties have relatively large areas of land using surface irrigation methods. In Jackson County, 88 percent of the 55,120 acres irrigated is irrigated by surface water methods. Most of the surface water is provided by the Lugert-Altus Irrigation District (LAID) (Mull 2002). The LAID is the only large scale irrigation district in the state that primarily uses surface water and open conveyance canals. According to Mull (2002), only 2 percent of the 270 miles of LAID canals are lined or piped resulting in an average delivery efficiency of 65 to 72 percent.

The district has received funding from the Bureau of Reclamation (BOR) and other sources to upgrade its irrigation delivery system by expanding its remote monitoring and automation sites, improving flow measurements, and replacing and rehabilitating farm turnouts. The project is expected to save 8,000-10,000 acre feet (AF) of water per year (Mull 2002, Smith 2005). If an average of 9,000 AF of water saving is realized, then the delivery efficiency for the system would increase to approximately 80 percent.

Improvement in the conveyance efficiency of the LAID, through improvements to delivery infrastructure and installment of tailwater recovery pits, is reflected in surface irrigation efficiency assumptions for Harmon, Jackson, Kiowa and Tillman counties. Thus, for this region, the field application efficiency of surface irrigation is assumed to increase to 80 percent, which is an increase of 16 percent from the baseline forecast.

Micro-Irrigation

Micro-irrigation is a highly efficient form of irrigation using low pressure application of water onto the soil surface near the plant or below the soil surface at the plant root zone. There are different methods and types of micro-irrigation (spray, mist, drip) which have reported application efficiencies ranging from 85 percent to 95 percent (Aillery and Schaible 2006, Lynne and Morris 2006). An analysis of the USDA and USGS surveys shows slow growth of the number of acres irrigated by micro-irrigation from 1995-2008 in Oklahoma. Micro-irrigated acres represent less than 1 percent of total irrigated acres.

Micro-irrigation is used with some vegetables and widely used with perennial crops such as orchards and vineyards (Aillery and Schaible 2006). There have been attempts to expand the use of micro-irrigation using sub-surface drip irrigation (SDI) for field crops with mixed results. Based on the current crop production in Oklahoma, slow system adoption, and unverified feasibility of system use with most field crops; the expansion of acreage using micro-irrigation methods is expected to be minimal and insignificant, particularly in regions with unreliable water supplies. The southwest area of Oklahoma is the only region where micro-irrigation is expected to expand.

Mr. Tom Buchanan, manager of the LAID, cites that the four counties of southwest Oklahoma will most likely see an increase in micro-irrigation due to the increased use of SDI to irrigate cotton and possibly corn. Cotton is an important regional crop and can be successfully irrigated by SDI systems. SDI has been adopted by commercial cotton growers in Texas since the mid 1980s where it has been documented to slightly outperform LEPA and other spray systems in term of lint yields, lint quality, and water use efficiency (Almas et al. 1999). SDI has also has been applied to corn production but with less success. Studies in western Kansas compared profitability of irrigating corn with SDI to irrigation by center pivot sprinklers. SDI was found to have less net returns on large fields but was found to be more profitable on smaller corn fields ranging from 13-25 hectares (O'Brien et al. 1998). These findings were highly dependent on the price and assumed life span of SDI systems. The use of SDI to irrigate corn is likely to increase when its reliability and longevity is established, the cost of SDI systems and installment decreases, and potential benefits are realized (O'Brien et al. 1998).

Conversion of surface irrigation to SDI is assumed for the four county region of southwest Oklahoma for 10 percent of total irrigated acres. No additional conversion to micro-irrigation will be assumed for the remaining areas of the state.

Crop Shifting

Different crops require varying amounts of irrigation water to supplement the gap between crop consumptive needs and rainfall. Water requirements are based on crop response to water inputs. Corn has a high yield response to water inputs and, compared to other crops, continues to improve yield with additional water (Dumler 2004). Other crops, such as grain sorghum and wheat, have lower yield responses (Dumler 2004). Their yields per unit of irrigation are not as high as corn, particularly at high levels of irrigation; conversely their yields are not as negatively affected by water deficits. Additionally, less water responsive crops need less irrigation to reach their maximum yield potential (Dumler 2004).

Shifting from high water demanding /responsive crops to less water demanding crops reduces the amount of irrigation required per acre. Water intensive crops include alfalfa, pasture grass, and corn for grain. Cotton and peanuts are mid-level water demanding, while wheat, soybeans, and corn silage are less demanding (NRCS 2010, Dumler 2004, Lin and Pfeiffer 2010). Limiting the acreage of high water demanding crops can reduce the amount of water required for irrigation in a given year. With proper management and knowledge, crop shifting can reduce the amount of irrigated water required per acre of crop. Crop shifting has been used as a water conservation tool in other states. In a simulated crop mix in Idaho, 10 percent of the alfalfa and silage corn was shifted into barley with a fallow or potato rotation and resulted in a 7 percent decrease in statewide water consumption (Contor and Pelot 2008).

For crop shifting, it is assumed that all acres of corn for grain, and forage crops including alfalfa and pasture grass shift to grain for sorghum. While is it highly unlikely that all water intensive crop production will stop, this assumption allows for analysis of full implementation of the "what-if" scenario.

2.3.2 Conservation Scenarios

For analysis of potential agriculture conservation water savings for the OCWP, two conservation scenarios were developed for examining impacts of improved irrigation efficiencies and crop shifting. The scenarios correspond to work completed for the M&I sector. In order to allow adequate time to implement these activities, the scenarios are assumed to be implemented beginning in 2015. However, the actual implementation date may shift to a later or earlier date depending upon factors including budgeting issues, supply and demand, and future weather conditions. County-level results of the conservation scenarios are input into the "Gap Tool" to determine if the levels of conservation are effective in reducing or eliminating modeled water supply gaps. The assumptions for the scenarios are provided below, followed by the resulting statewide savings. Estimated savings by county can be found in Appendix B at the end of this document.

Scenario I: Moderately Expanded Conservation

- The field application efficiency of surface irrigation systems for Harmon, Jackson, Tillman, and Kiowa counties will increase to 80 percent beginning in 2015.
- In Harmon, Jackson, Tillman, and Kiowa counties, 10 percent of the land irrigated by surface irrigation will shift to micro-irrigation beginning in 2015.
- All sprinkler systems will have a field application efficiency of 90 percent beginning in 2015, representing implementation of LEPA nozzles on existing sprinkler systems.
- No improvement in surface irrigation for McCurtain and Leflore counties.
- While water withdrawals will be reduced through irrigation efficiency improvements, the consumptive use fraction of water withdrawals will increase (i.e., consumptive volume is expected to remain the same, explained in more detail in the "Results and Discussion" section in this report).
- Water saved through conservation activities is not applied to a water scheme elsewhere, such as expanding the number of irrigated acres, thus achieving true conservation.

Scenario II: Substantially Expanded Conservation

- All assumptions from Scenario I are applicable.
- All acres of corn for grain and forage crops including alfalfa and pasture grass shift to grain for sorghum beginning in 2015.

Results and Discussion

Statewide results of the agriculture conservation scenario demand analysis are shown in Table 6. Under Scenario I, savings of about 67,600 AFY in 2060, or 7.5 percent are achieved from the baseline scenario. These savings are achieved through improved irrigation efficiency. Under Scenario

II, savings of about 196,500 AFY in 2060, or 22 percent are achieved from the baseline scenario. These savings are achieved through improved irrigation efficiency and shifting to less water intensive crops. The crop shift assumption accounts for savings of about 128,900 AFY in 2060, or about 65 percent of the Scenario II savings. Less extreme assumptions about crop shifting (e.g., half of crops shift) would result in a reduction of the Scenario II savings.

Table 6: Statewide Demand Projections and Water Savings for Agriculture Conservation Scenarios in AFY

	2020	2030	2040	2050	2060
Baseline	775,661	806,112	836,562	859,932	897,464
Scenario I	716,070	744,512	772,953	794,781	829,837
Scenario II	608,146	631,340	654,535	672,335	700,923
Savings from Baseline					
Scenario I	59,591	61,600	63,609	65,151	67,628
Scenario II	167,514	174,771	182,028	187,597	196,541

Figure 3, below illustrates estimated statewide water demands for the agricultural subsector in 2060

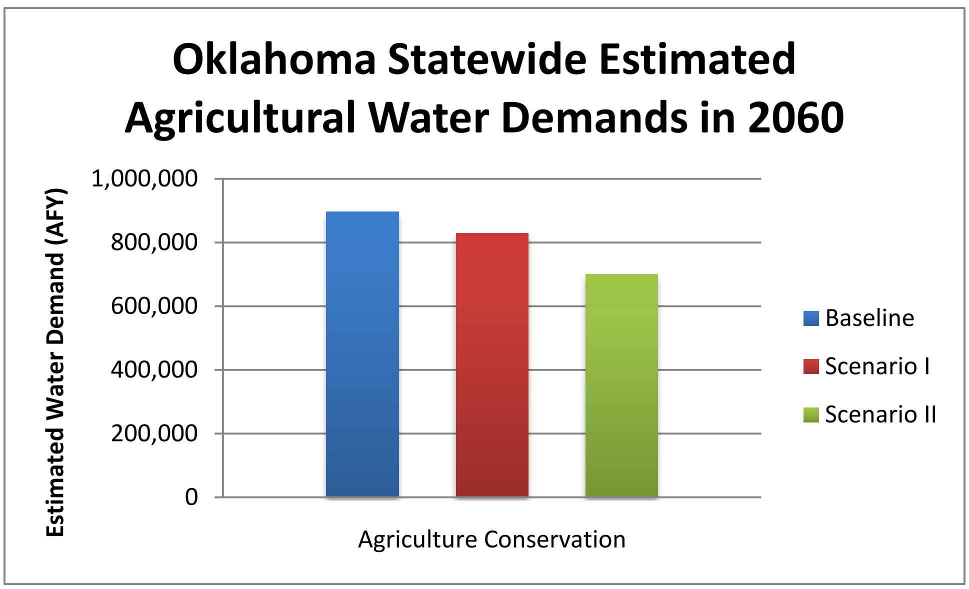

Figure 3. Oklahoma Statewide Estimated Agricultural Water Demands in 2060.

The agri-business sector is a crucial part of the economy in Oklahoma. One analysis concluded that agriculture, agri-business, and agricultural support activities provide over 17 percent of the state's employment, over 343,000 jobs (Battelle 2007). The market value of agricultural goods sold has increased from $1.6 billion in 1974 to $4.2 billion in 2005 (inflation adjusted) (Battelle 2007). Other studies have shown the direct agricultural contribution (agricultural production and processing) to Oklahoma's Gross State Product (GSP) was $3.2 billion in 2000 (Woods 2003). Accounting for indirect and induced contributions increases this to $7.4 billion dollars or 7.6 percent of the GSP (Woods 2003). Irrigated agriculture claims a large percentage of this economic activity statewide, and may claim an even larger percentage in some regions. Given the economic and societal importance of agriculture in Oklahoma, the impacts and drivers of water conservation in the agriculture sector should be considered carefully.

Strong evidence in the literature suggests that increases in irrigation efficiencies through technology adoption or management activities does not always equate to water savings or reduced water use. This can happen when farmers use the water savings to expand irrigated acreage or apply the saved water to an existing irrigation scheme. Farmers with more efficient irrigation systems can increase overall consumptive use by expanding acreage of irrigated crops or increasing irrigation per acre through an increase of yields or by shifting to more water intensive crops (Petterson and Upendram 2007, Goldern and Petterson 2006, Lin and Pfeiffer 2010). In Kansas, federal and state programs have given assistance to farmers to upgrade irrigation technologies in order to reduce withdraws of the Ogallala aquifer (Goldern and Petterson 2006, Lin and Pfeiffer 2010). Compared to standard center pivot systems, systems with high efficient drop nozzles did not reduce groundwater extraction but increased it. A one percent increase in the percentage of acres irrigated with dropped nozzles resulted in a 1.7 percent increase in water extracted per farmed acre (Lin and Pfeiffer 2010). The increase in groundwater extraction was attributed to shifts in cropping patterns to more water intensive crops (Lin and Pfeiffer 2010). In western Kansas, producers were also found to shift from a water efficient crop (sorghum) to a water intensive crop (corn) after a simulated conversion from surface irrigation systems to center pivots (Petterson and Upendram 2007). Others have argued that a similar irrigation conversion leads to increases in irrigated acreage with minimal crop shifting, depending on the type of technology adoption and crop grown (Goldern and Petterson 2006).

Exactly how increased efficiencies can lead to increased water use is debatable. However, reductions in overall consumptive use (including what is required by the crop and that lost to evaporation) is the only sure way water savings at the basin level can be realized. Investments in cost sharing programs to increase adoption of efficient irrigation systems were found to be less effective at reducing consumptive use per dollar invested than a water buyout program, and in certain situations the cost sharing program increased consumptive use (Goldern and Petterson 2006). Care needs to be given when supporting a policy that will increase efficiency and needs to consider whole basin effects. Adoption of efficient irrigation technology does have benefits to the producer and is still an important part of water conservation, but should be implemented with goal-oriented conservation policies that consider net reductions in consumptive use.

Correspondence with Mr. Tom Buchanan at the LAID indicates that reduction in irrigation waste water will most likely result in increased irrigated acres. He believes that irrigation water recovered from reduced seepage or runoff will eventually be used to expand irrigation in the surrounding areas. In general, the region’s amount of irrigated cropland is limited by the amount of water available. Given the assumptions outlined in Scenario I, enough water would be conserved in the four-county area of southwest Oklahoma to irrigate approximately 22,000 more acres.[2]

The true water savings associated with irrigation efficiency and crop shifting would likely only be realized given economic incentives. That is, the most likely way to see a change from what is

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[2] 22,000 acres is derived using the assumption that water saved through the conservation activities outlined in scenario 1 is applied to additional potential farmland, in order to expand the number of irrigated acres. This number is calculated by taking the amount of saved water from conservation in each county and dividing it by the county specific weighted Crop Irrigation Requirement (Wt CIR), The amount of additional land irrigated for the four counties are summed together to get 22,000 acres.

described above is if some type of economic incentive is in place to both reduce water use within the current irrigation infrastructure and limit growth. These incentives could be from a number of state and federal entities.

The factors that impact adoption of water conservation actions, particularly technology adoption, are complex and site specific. The high initial capital requirements of new irrigation systems often impede farmers from adopting more efficient systems. Even when systems are proven to be economically profitable in the long term, many farmers do not have the financial resources for such an investment, this is particularly true of smaller farming operations (Aillery and Schaible 2006). The cost of water is also an important driver in regards to water conservation. The cost of water to agriculture producers is often low relative to the cost of providing water and the opportunity costs of non-agriculture users. This reduces the incentive to adopt water conservation measures and it has been shown that producers with high water cost are more likely to adopt conservation measures (Aillery and Schaible 2006). The reliability of water supplies also influences adoption of conservation actions. Junior water right holders will often buffer against possible late-season shortages by overwatering during peak-flows, additionally the threat of losing the rights of water saved from potential conservation actions limits the incentive to conserve (Aillery and Schaible 2006). Often water saved by conservation measures is not available for market transfers and so is used to expand irrigation or improve yields. In one survey by the U.S. Department of Commerce the potential loss of water rights was found to be a critical concern to 20 percent of irrigators when considering water conservation (Aillery and Schaible 2006). Water right policies can also impede development of an operational water market which could otherwise compensate farmers for unused or saved water.

2.4 Summary of Statewide Conservation

In an effort to assess the impacts of public supply and self supply residential, public supply non-residential, and agriculture conservation statewide, CDM combined conservation scenarios to provide statewide water conservation savings. Scenario I from the M&I sector, agricultural sector, and thermoelectric withdrawals were combined to produce statewide estimates for a moderately expanded conservation scenario. Additionally, Scenario II from the M&I sectors, agricultural sector, and thermoelectric withdrawals were combined to produce estimates of a statewide substantially expanded conservation scenario. Table 7 provides a summary of demand projections and water savings resulting from these conservation scenarios. In 2030, the range of impact is 184,400 to 345,400, or 12.4 percent to 23.2 percent decrease in statewide water demands. In 2060, the range of impact is 207,500 to 405,938 or 12.4 percent to 32.1 percent decrease. Figure 4 provides an illustration of the variation in statewide demands in 2060 with baseline, scenario I and scenario II demands. Figure 5 illustrates statewide savings for scenario I and scenario II in 2030 and 2060.

Table 7: M&I and Agriculture Combined Statewide Demand Projections and Water Savings for Conservation Scenarios in AFY

	2020	2030	2040	2050	2060
Baseline	1,455,309	1,523,273	1,587,406	1,642,069	1,711,392
Scenario I	1,301,816	1,332,781	1,388,603	1,435,807	1,496,643
Scenario II	1,155,397	1,170,248	1,209,372	1,244,123	1,295,569
Savings from Baseline					
Scenario I	153,493	190,492	198,803	206,262	214,749
Scenario II	299,912	353,025	378,034	397,946	415,823

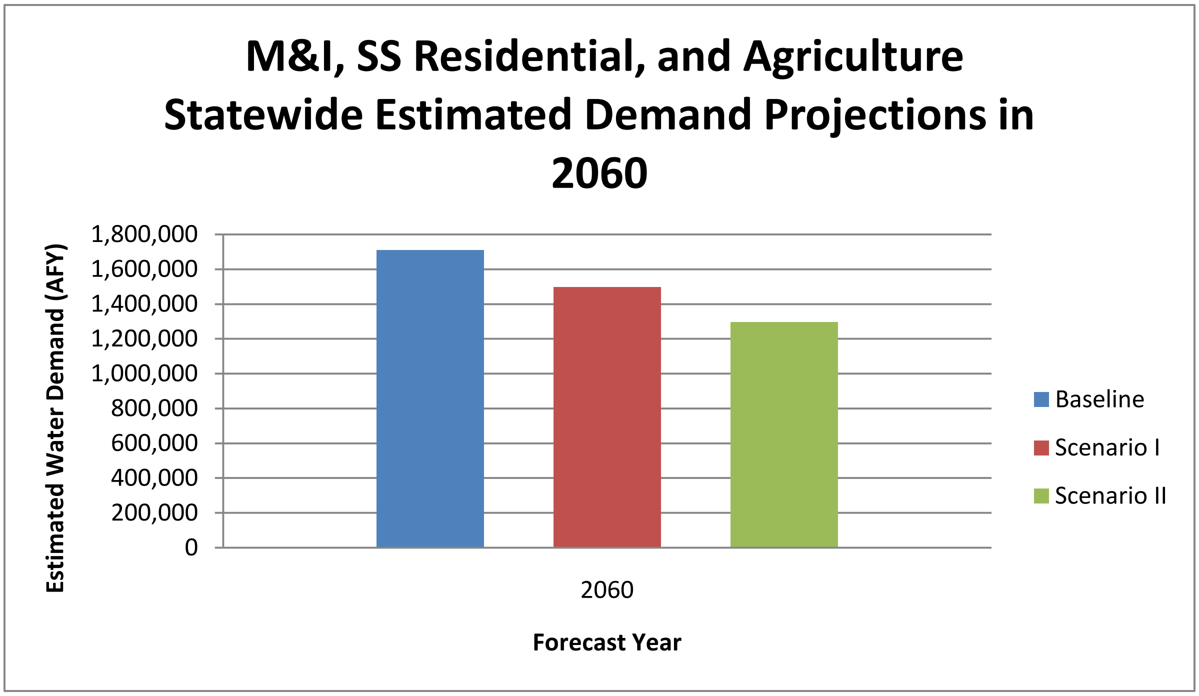


Figure 4: Combined PS Residential, PS Non-residential, SS Residential, and Agriculture Statewide Estimated Demand Projections in 2060.

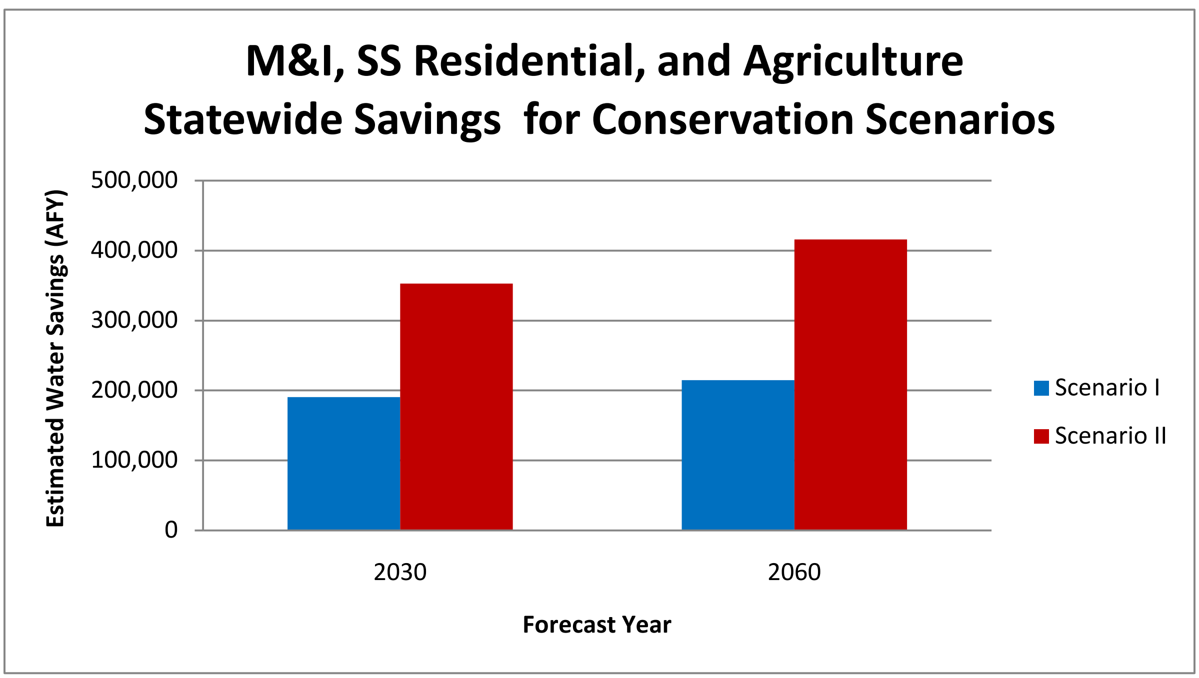


Figure 5: Combined PS Residential, PS Non-Residential, SS Residential, and Agriculture Statewide Estimated Water Savings in 2030 and 2060.

Section 3
Climate Change

3.1 Introduction

In support of IDIQ Task Order Number 1 (W912BV-09-D-1001) for the development of the Oklahoma Comprehensive Water Plan (OCWP), Task 2D.8, Investigate Climate Change "What if" Scenarios, this portion of the addendum provides a summary of the preliminary demand forecasts under selected climate change scenarios. Included is a brief description of the global climate change scenario data developed in related OCWP work by AMEC, the steps taken by CDM to transform the climate data, and how corresponding demand scenarios were developed for the Municipal and Industrial (M&I) and Irrigated Agriculture sectors.

3.2 Climate Change Scenario Analysis and Selection

Definition of future climate change scenarios is derived from contemporary climate simulation information. Climate simulation models have been developed and applied to estimate global and/or continental climatic conditions during the 21th century. These climate simulations must then be downscaled to the Oklahoma region.

According to a recent report by the U.S. Bureau of Reclamation, review of current downscaled climate projections over Oklahoma suggests that the southern Great Plains are likely to be warmer in the future, although the rate of warming varies. Projections of precipitation differ from model to model and range between drier and wetter than historical conditions (Bureau of Reclamation, 2010).

In order to assess the potential implication of surface water availability under climate change conditions, AMEC developed five climate change scenarios based on ensembles of climate projection models: Q1, Q2, Q3, Q4, and C. These five scenarios were developed for two different projection horizons: 2030 and 2060. AMEC also provided one dataset representing historical average conditions. The general implications of the five climate scenarios are shown in Figure 6. Q1 is a hot and dry scenario; Q4 is a warm wet scenario; Q2 and Q3 are interim scenarios; and "C" is the central tendency of Q1-Q4. There is slight variation in the scenarios from basin to basin, as further discussed below.

The AMEC methodology for developing climate projections closely followed that applied by the U.S. Bureau of Reclamation as part of their "ensemble hybrid-delta" method (BOR, 2010). Projections were developed based on differences in regional mean annual temperature and precipitation compared to the historical baseline. Q1 represents the ensemble projection developed from the set of individual projections with predicted mean annual temperature changes greater than the median projected change (upper half) and predicted mean annual precipitation changes less than the median projected change (lower half) (i.e. hot and dry). Similarly, Q2 is developed from the lower half of both the temperature and precipitation change; Q3 from the upper half of both temperature and precipitation change (hot and wet); and Q4 from the lower half of temperature change and upper half of precipitation change (warm and wet). The C scenario represents the pool of projections from the interquartile range of change projections: 25th to 75th percentile of both temperature and precipitation change. For each of the five scenarios, and each month, climate adjustment factor distributions were calculated based on differences between the ensemble pools of data and the historical baseline data set. These adjustment factors were then applied to the historical timeseries data set to incorporate climate change impacts associated with the given planning horizon, while maintaining historical patterns of month to month variability.

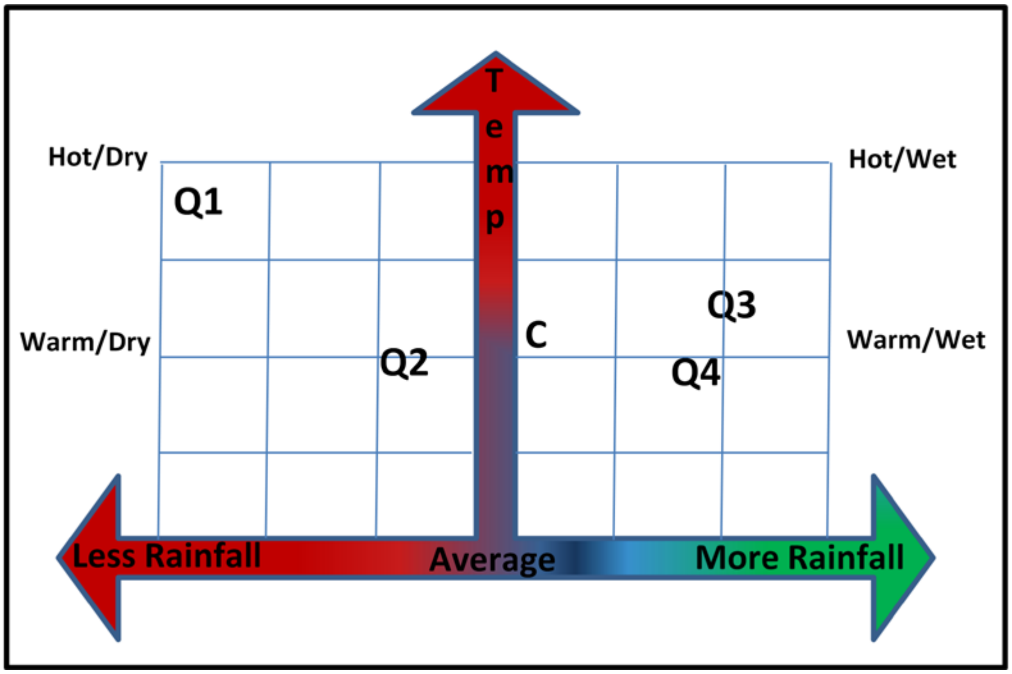


Figure 6: Climate Scenario Implications

Before analysis on the climate change scenario data could occur, the data had to be transformed to a usable format. The data were delivered to CDM in 11 folders, one for each of the five climate scenarios and planning horizon forecast (2030 and 2060) plus the historical dataset. Each climate scenario folder contained 82 text files representing OCWP planning basins with daily precipitation, wind speed, maximum and minimum temperature for 58 years from January 1, 1950 to December 31, 2007. A macro was developed by CDM to convert each of the text files into a Microsoft Excel file.

For demand forecast use, the basin for each county (for M&I projections) and agriculture station were identified and those basin data were imported into a Microsoft Access database. The basin that made up the largest area of a given county was designated as that county's primary basin and was used to represent the climate conditions for that county. Forty-nine of the 82 basins were identified as primary basins. The basin Excel files were imported into Access, thus creating a climate database. Queries were performed for quality assurance and control to ensure that every required Excel file was imported without duplicates.

From Access, a set of queries was applied to the selected climate database to transform the climate data into a usable format for input into the M&I and Irrigated Agricultural demand models, as follows:

- Converted the date column from bunched format (e.g., 19500101) to months and years (e.g., 01, 1950)

- Organized daily data into monthly data for each year and basin/scenario combination, daily precipitation values were summed for each month, and the daily temperatures and wind speed were converted to monthly values
- Averaged the monthly climate values for each month across all years to get the monthly means of the climate variables for each basin/scenario combination

The monthly climate data for the 77 counties and 11 stations were exported into an Excel file. The temperature units were converted from Celsius to Fahrenheit, precipitation from millimeters to inches, and wind speed from meters per second to miles per hour.

Climate Scenario Selection

Rather than create demand forecasts for each possible climate scenario, CDM analyzed the climate scenario data to confirm that Q1 and Q4 would bracket a range of potential climate change conditions. The climate scenario analysis was performed for Q1-Q4 and "C" scenarios using the 2060 planning horizon for five counties, four corners and a central location in Oklahoma. Results of the analysis are shown in **Figure 7** through **Figure 11** for the five locations.

The difference or Delta (Δ) in annual precipitation between the historical and climate scenarios was determined for each selected county. The Δ for average maximum temperatures in August was also determined for these scenarios. The temperature and precipitation Δ represents departure of the climate scenario from historic climate.

Inspection of Figure 2 through Figure 6 confirms that Q1 represents the hottest/driest scenario across Oklahoma. Likewise, Q4 represents the mildest change in temperature with a slight increase in precipitation, or a warm/wet scenario. These two scenarios do indeed have the largest variation in climate (of the scenarios evaluated here) and represent the extreme ends of predicted climate change and were thus selected for demand forecast sensitivity analysis. **Appendix C** provides precipitation and temperature variables by county for the historical dataset, Q1 (herein referred to as Hot/Dry), and Q4 (herein referred to as Warm/Wet). The statewide change in precipitation and temperature for the climate scenarios are shown in **Figure 12** and **Figure 13**, respectively.

Figure 7: Northwest Region Scenario Comparison

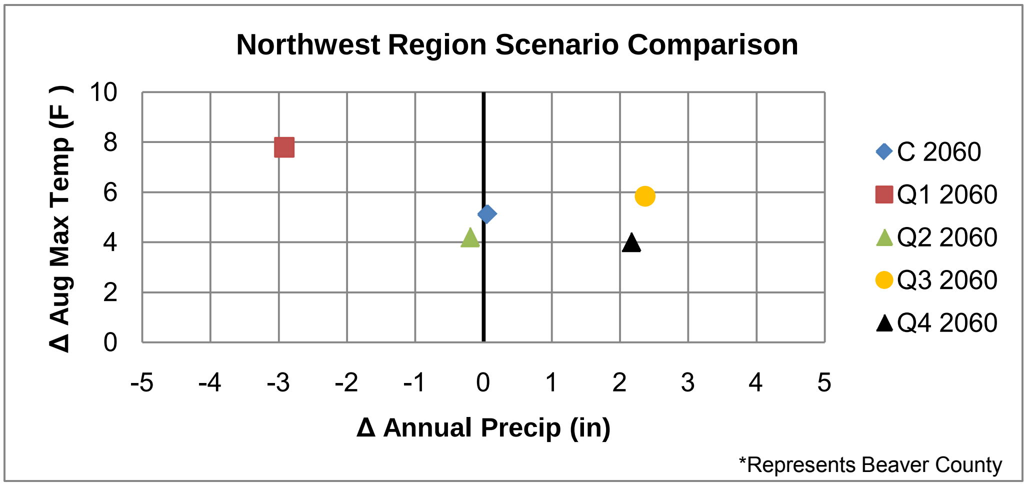


Figure 8: Southwest Region Scenario Comparison

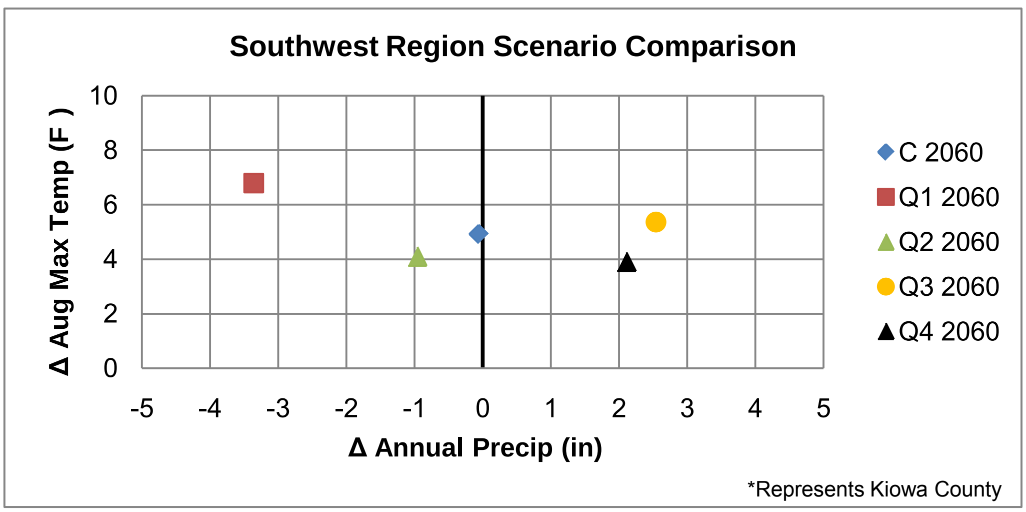


Figure 9: Northeast Region Scenario Comparison

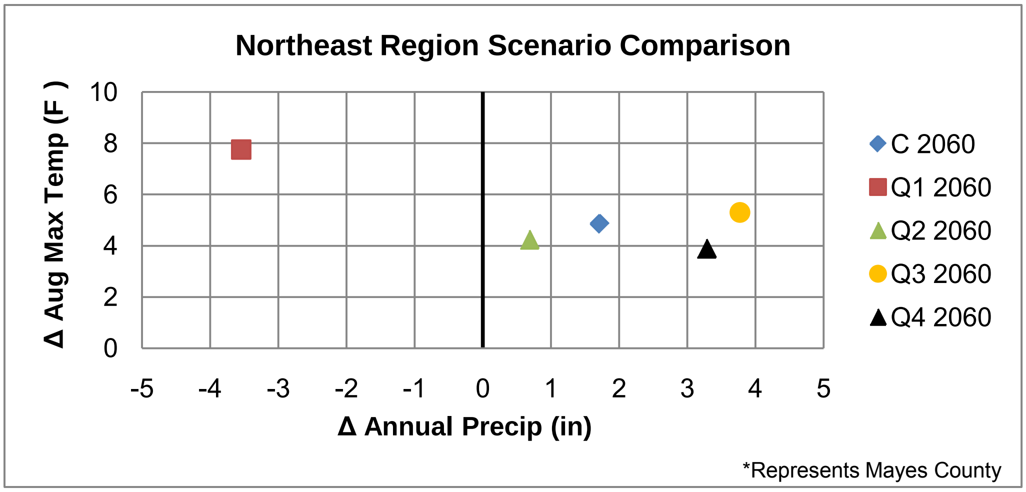


Figure 10: Central Region Scenario Comparison

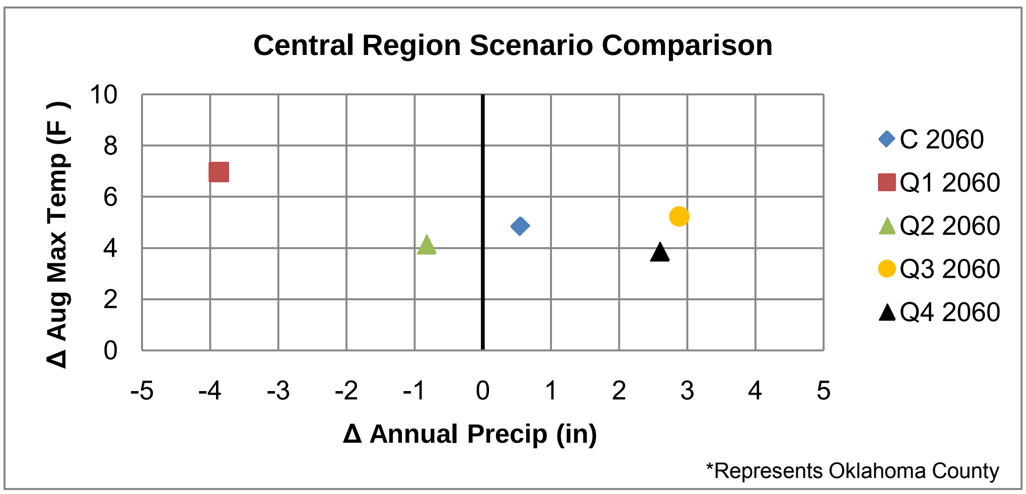


Figure 11: Southeast Region Scenario Comparison

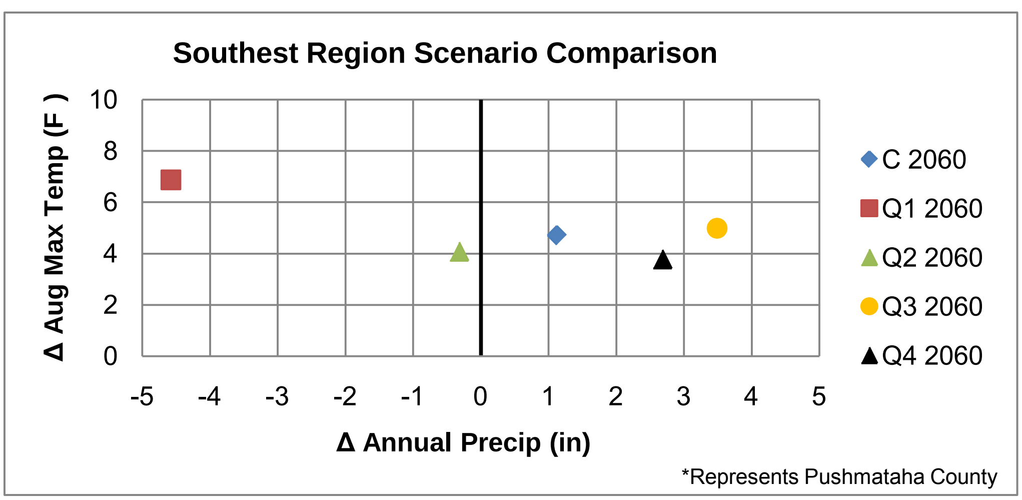


Figure 12: Change in 2060 Annual Precipitation (inches) from Historical Average for Scenarios Q1 and Q4

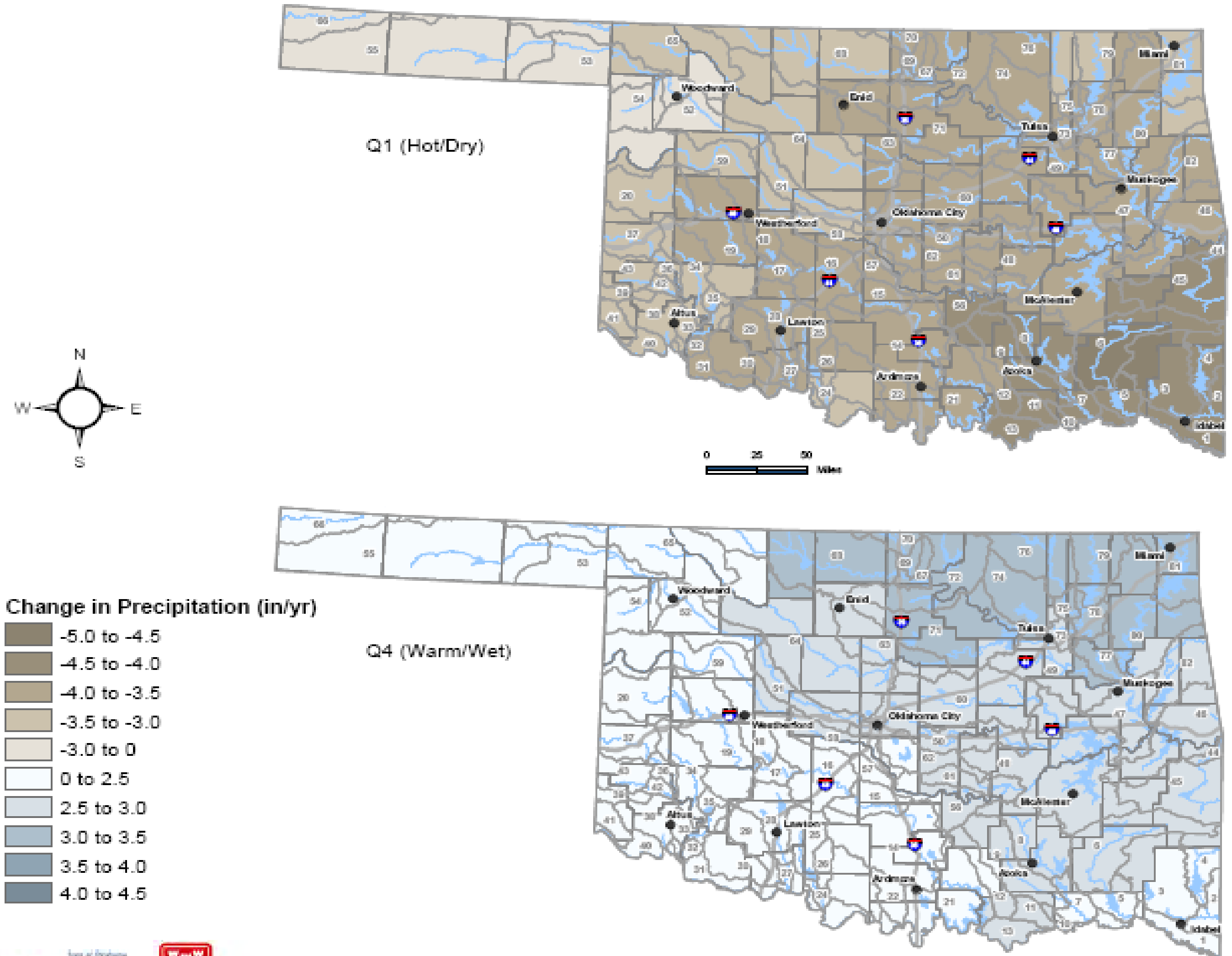
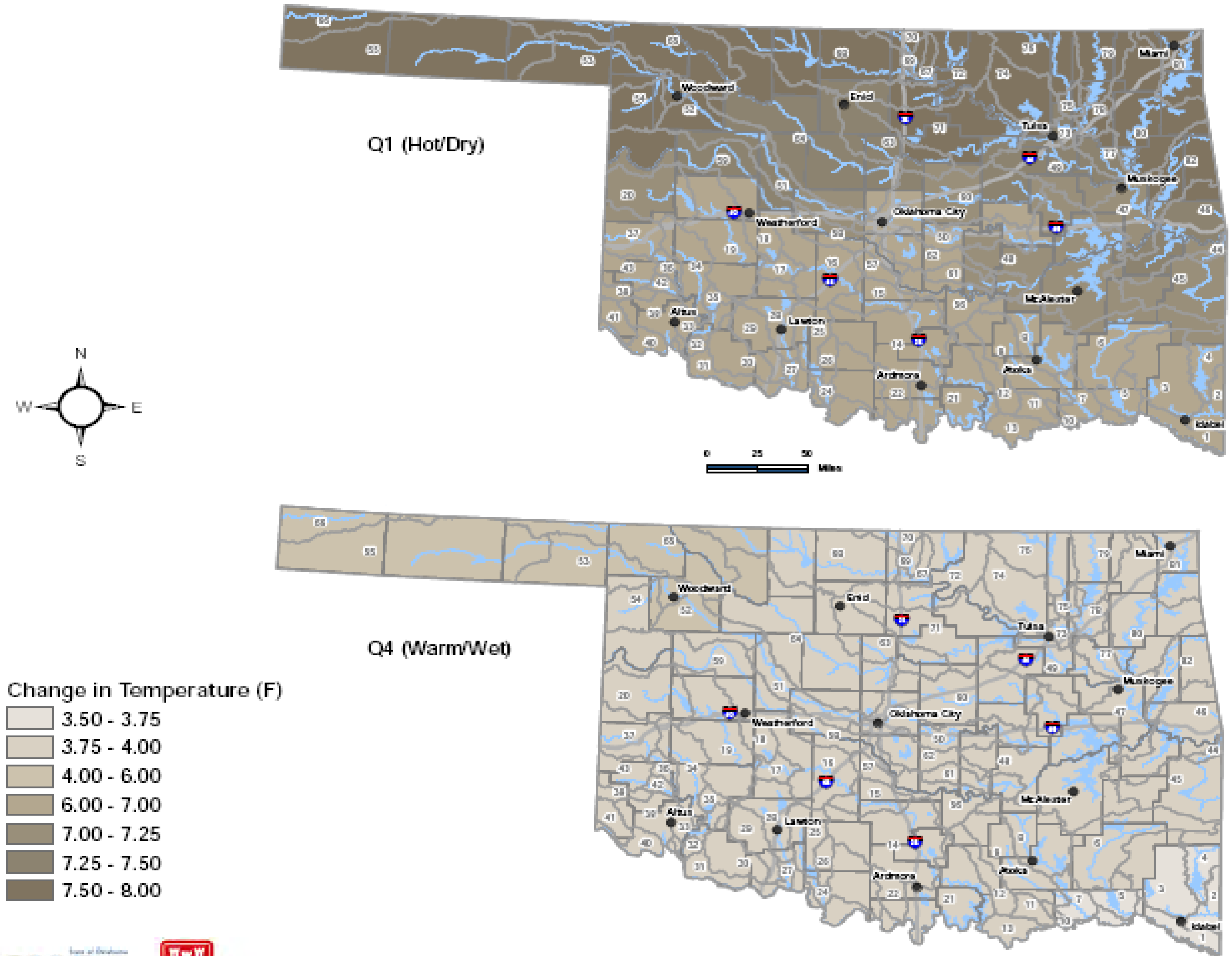


Figure 13: Change in 2060 Maximum Temperature in August (º Fahrenheit) from Historical Average for Scenarios Q1 and Q4



3.3 M&I Model and Results

Statistical results of the OCWP Climate Demand Model were used to model the impacts of climate change on M&I water demand (CDM Deliverable, "OCWP Weather Production Model Revised Final TM"). The Climate Demand Model was developed using regression analysis and assessed the relationship between weather and monthly water demand. These relationships are expressed as elasticities, or the percent change in monthly water production given a percent change in monthly weather.

Variation in both monthly average daily maximum temperature and monthly total precipitation were found to have statistically significant relationships with water production. The elasticities for maximum temperature and precipitation can be used to adjust monthly water production estimates for the potential shifts in maximum temperature and precipitation. The formula to estimate monthly water demand under climate change for a given scenario is shown in **Equation 23**.

$$QC_{my}^{c} = QB_{my}^{c} \times \left(\frac{mtC_{m}^{c}}{mtH_{m}^{c}}\right)^{emt_{m}} \times \left(\frac{pC_{m}^{c}}{pH_{m}^{c}}\right)^{ep_{m}}$$

Equation 23

Where:

QC_{my}^{c} = Climate adjusted total production for county (c) in month (m) and year (y)
QB_{my}^{c} = Baseline total production for county (c) in month (m) and year (y)
mtC_{m}^{c} = Estimated average maximum daily temperature under climate change for county (c) in month (m)
mtH_{m}^{c} = Historical average maximum daily temperature for county (c) in month (m)
emt_{m} = Elasticity of maximum temperature in month (m)
pC_{m}^{c} = Estimated monthly precipitation under climate change for county (c) in month (m)
pH_{m}^{c} = Historical average precipitation for county (c) in month (m)
ep_{m} = Elasticity of precipitation in month (m)

*Note that the term $\left(\frac{\mathrm{mtC_m^c}}{\mathrm{mtH_m^c}}\right)$ represents the Delta (Δ) in temperature and that $\left(\frac{\mathrm{pC_m^c}}{\mathrm{pH_m^c}}\right)$ represents the Delta (Δ) in precipitation.

M&I Results

Estimates were developed for county M&I demand under climate change scenarios using Equation 23, the baseline M&I demand, elasticities from the Weather Production Model, and average monthly weather data from the climate scenarios. **Table 8** provides the statewide M&I demand forecast summary for the Hot/Dry and Warm/Wet climate scenarios as well as the difference from the baseline forecast. The change in M&I county demand from baseline under climate change scenarios are displayed in **Figure 14**. The county M&I forecast under climate change is provided in tabular form in **Appendix D**.

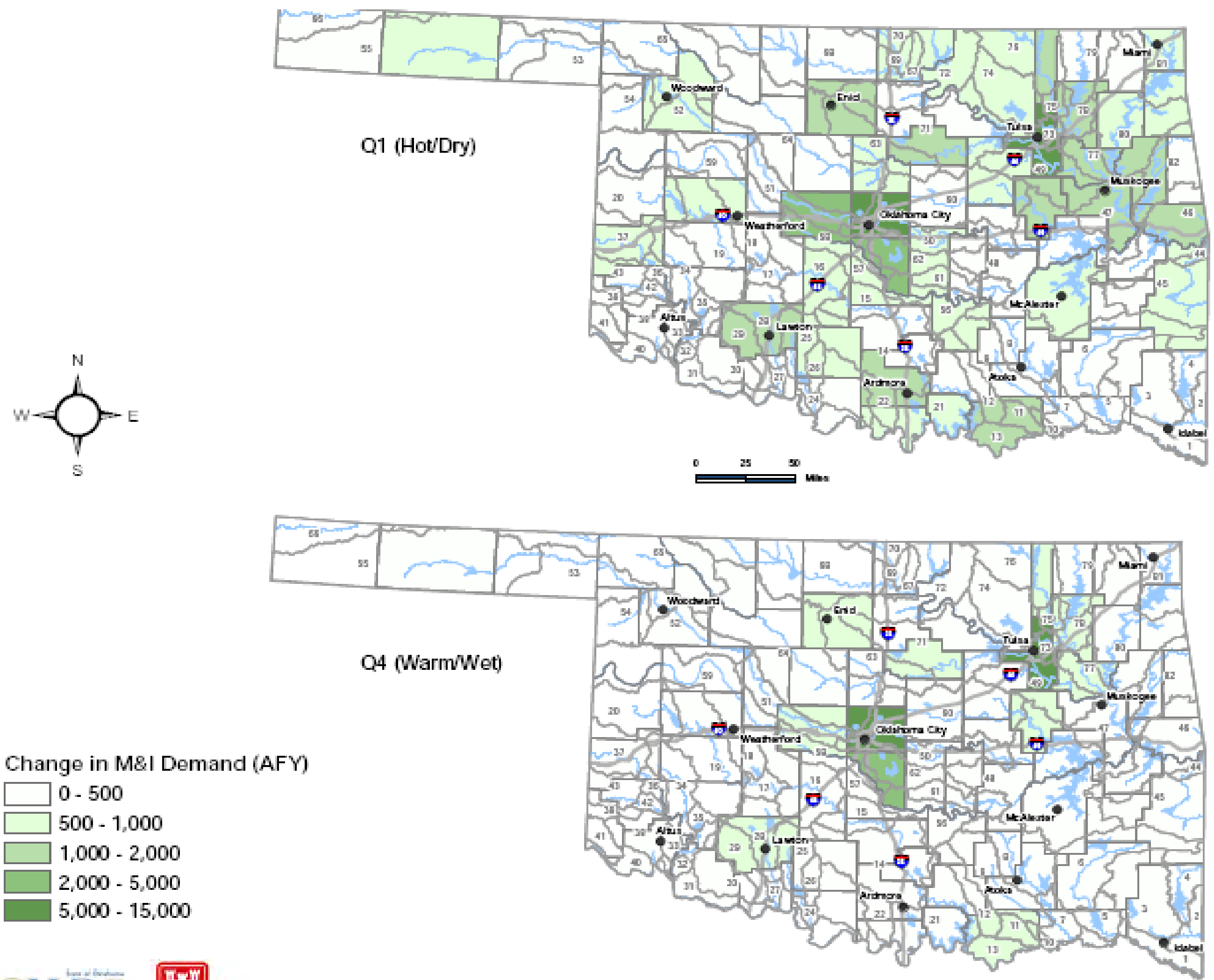
As expected, the 2060 Hot/Dry scenario produces the largest increase in M&I demand with a 9.5 percent increase from baseline. The Warm/Wet 2060 scenario produces an M&I demand increase of 4.2 percent. Demands for the Hot/Dry and Warm/Wet scenarios in 2030 are estimated to increase from the baseline forecast by 5.3 and 2.5 percent, respectively.

Table 8: Statewide M&I Demand Forecast Under Climate Change in AFY*

Year	Baseline	Hot/Dry	Warm/Wet
2007	583,901	n/a	n/a
2030	682,391	718,747	699,119
2060	772,773	846,029	805,398
Change from Baseline			
2030	n/a	36,356	16,727
2060	n/a	73,256	32,625
Percent Increase from Baseline			
2030	n/a	5.30%	2.50%
2060	n/a	9.50%	4.20%

*AFY= acre-feet per year

Figure 14: Change in M&I Water Demand (AFY) from Baseline for Scenarios Q1 and Q4



3.4 Irrigated Agriculture Model and Results

Climate change is assumed to impact only the Crop Irrigation demand and no change is assessed for the Livestock demand sector. Modeling climate change impacts on agriculture demand required adaptation and use of the model developed for the OCWP baseline forecast. The model considers a county's number of acres to be irrigated in the future, relative crop mix, monthly irrigation requirements for each crop, and losses due to irrigation system inefficiencies. The baseline forecast used monthly irrigation requirements for crops at 11 stations throughout Oklahoma, as reported in the NRCS Irrigation Guide Report, Oklahoma Supplement (Natural Resource Conservation Service, 2006).

For the climate change scenario forecast, it was assumed that the number of irrigated acres, relative mix of crops, and irrigation efficiencies would remain constant from the baseline forecast. Irrigation crop requirements by station are assumed to change given climate change scenarios.

Crop irrigation requirements under climate change were estimated using Irrigation Water Requirement, Penman-Monteith (IWRpm) program developed by the NRCS. The FAO Penman-Monteith (PM) method available in IWRpm is citied as providing the most accurate results, even with missing input data, and is the standard method used by the American Society of Civil Engineers (ASCE). Thus, CDM selected this method within IWRpm to estimate irrigation crop requirements under climate change scenarios.

The NRCS Irrigation Guide data utilized in the baseline forecast were developed using the Blaney-Criddle (BC) method. However, communications with NRCS employees indicated that the BC method is no longer the most desired choice in estimating plant water requirements. The FAO PM method will ultimately produce differing results, even if all other variables are held constant (including climate). In order to distinguish the changes in demand that occur solely from climate change and to minimize changes that may occur from differing methodologies, IWRpm was used to estimate irrigation requirements under historical average weather conditions and under climate change scenarios. The difference between historical average and climate change estimates of irrigation requirements created using IWRpm was then applied to the baseline irrigation requirements, as shown in Equation 24.

$$NC_s^m = \frac{(NB_s^m \times NCFAO_s^m)}{NHFAO_s^m}$$

Equation 24

Where:

NC_s^m = Net irrigation water requirement for input into demand model for month (m) and station (s)

NB_s^m = Net irrigation water requirement from the baseline model for month (m) and station (s)

$NCFAO_s^m$ = Net irrigation water requirement for a given climate scenario computed by IWRpm for month (m) and station (s)

$NHFAO_s^m$ = Net irrigation water requirement for historical average weather computed by IWRpm for month (m) and station (s)

The IWRpm program requires the development of a climate and crop database with the inputs derived from local conditions, where possible. The following sections describe how these databases were developed.

IWR Databases

The FAO PM method uses monthly climate data including: mean maximum and minimum temperatures, mean maximum and minimum relative humidity, mean wind speed, and solar radiation climate data. Solar radiation is not a required input and values of zero were entered for solar radiation and actual duration of sunshine. The scenarios selected for the irrigation model were limited to the Hot/Dry and Warm/Wet scenarios. As mentioned, data were also developed for historical average conditions.

Local weather conditions for the 11 stations were entered into the IWR climate database. For each station four copies were created with the same general station information and were named after the different station/climate scenario separating the 2030 and 2060 planning horizons. For each station/climate scenario the respective monthly precipitation, maximum and minimum temperatures, and wind data were entered into the climate database using the edit function. These values originated from the previously mentioned averaged monthly station data file. Mean monthly relative humidity was obtained from the Oklahoma Agweather and Oklahoma Mesonet website (AgWeatherMesonet). Humidity was considered not to vary with the climate change scenarios and remained constant for each of the climate scenarios.

The same list of crops used in the baseline forecast of the agricultural irrigation demand model was used to develop the crop database in IWRpm, excluding spinach and sod/turf. The list varies slightly by station but includes alfalfa, corn grain, corn silage, cotton, pasture grass, grain sorghum, peanuts, potatoes, soybeans, sunflower, wheat, and watermelons. Each crop required a designated crop coefficient Kc value from the program's FAO Table 12, as well as a crop growing stage value including Fs1, Fs2, and Fs3 values. The majority of the default settings for the final data entry and Kc computation were used, the exception was selecting the Sub-humid minimum relative humidity option. The default settings were similar to conditions found in Oklahoma and the IWRpm documentation suggested only changing the settings when specific local conditions were available (Dalton, 2006).

Once the crop and climate databases were established, the main IWRpm program was used to determine the crops' monthly irrigation requirements for each station/climate combination. The resulting monthly irrigation requirements IWRpm were then input into an Excel spreadsheet. Once the monthly irrigation requirements were in Excel, the final net irrigation requirements under climate change scenarios were developed using Equation 24.

Finally, the adjusted net irrigation water requirements under climate change by crop and station were input into the agriculture irrigation demand model by scenario (see baseline forecast documentation for methodology). The models were used to estimate climate scenario irrigation water demand for each county for the 2030 and 2060 planning horizons.

Irrigated Agriculture Results

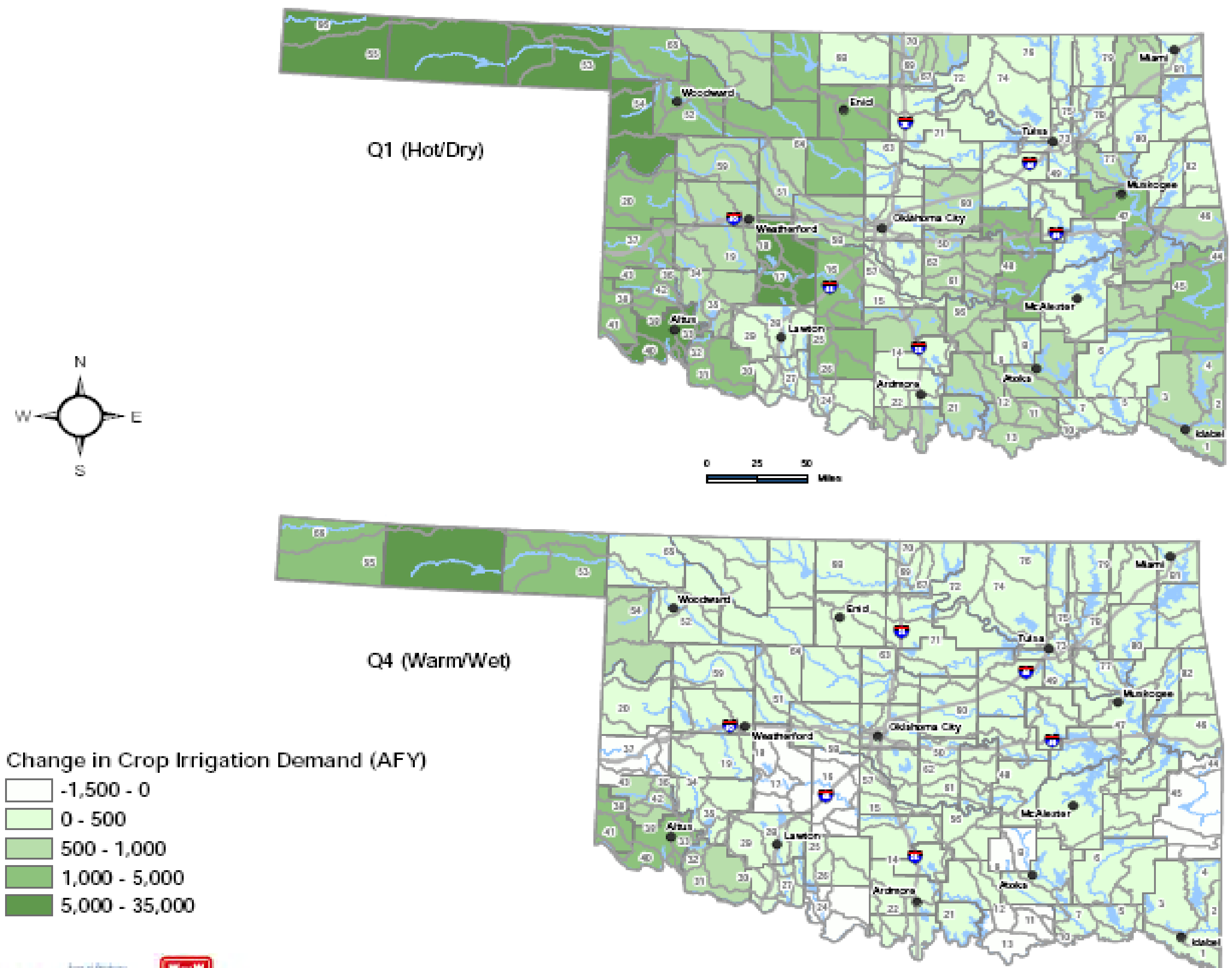
Table 9 provides a statewide summary of Irrigated Agriculture demand under baseline, Hot/Dry, and Warm/Wet conditions. County-level irrigation demands under climate change are provided in tabular form in Appendix D. Figure 15 provides the statewide change in Irrigated Agriculture demand from baseline for each scenario.

As shown, the range of increase for 2030 is 17,000 and 86,000 AFY, or 2.2 to 10.7 percent. The upper-end of the range doubles in 2060 to 143,000 AFY under the Hot/Dry scenario. This is an increase of 16.0 percent from the baseline forecast.

Table 9: Statewide Irrigated Agriculture Demand Forecast Under Climate Change in AFY

Year	Baseline	Hot/Dry	Warm/Wet
2007	736,074	n/a	n/a
2030	806,112	892,221	823,622
2060	897,464	1,041,032	926,557
Change from Baseline			
2030	n/a	86,109	17,511
2060	n/a	143,567	29,093
Percent Increase from Baseline			
2030	n/a	10.70%	2.20%
2060	n/a	16.00%	3.20%

Figure 15: Change in Agriculture Irrigation Water Demand (AFY) from Baseline for Scenarios Q1 and Q4



3.5 Combined Impacts

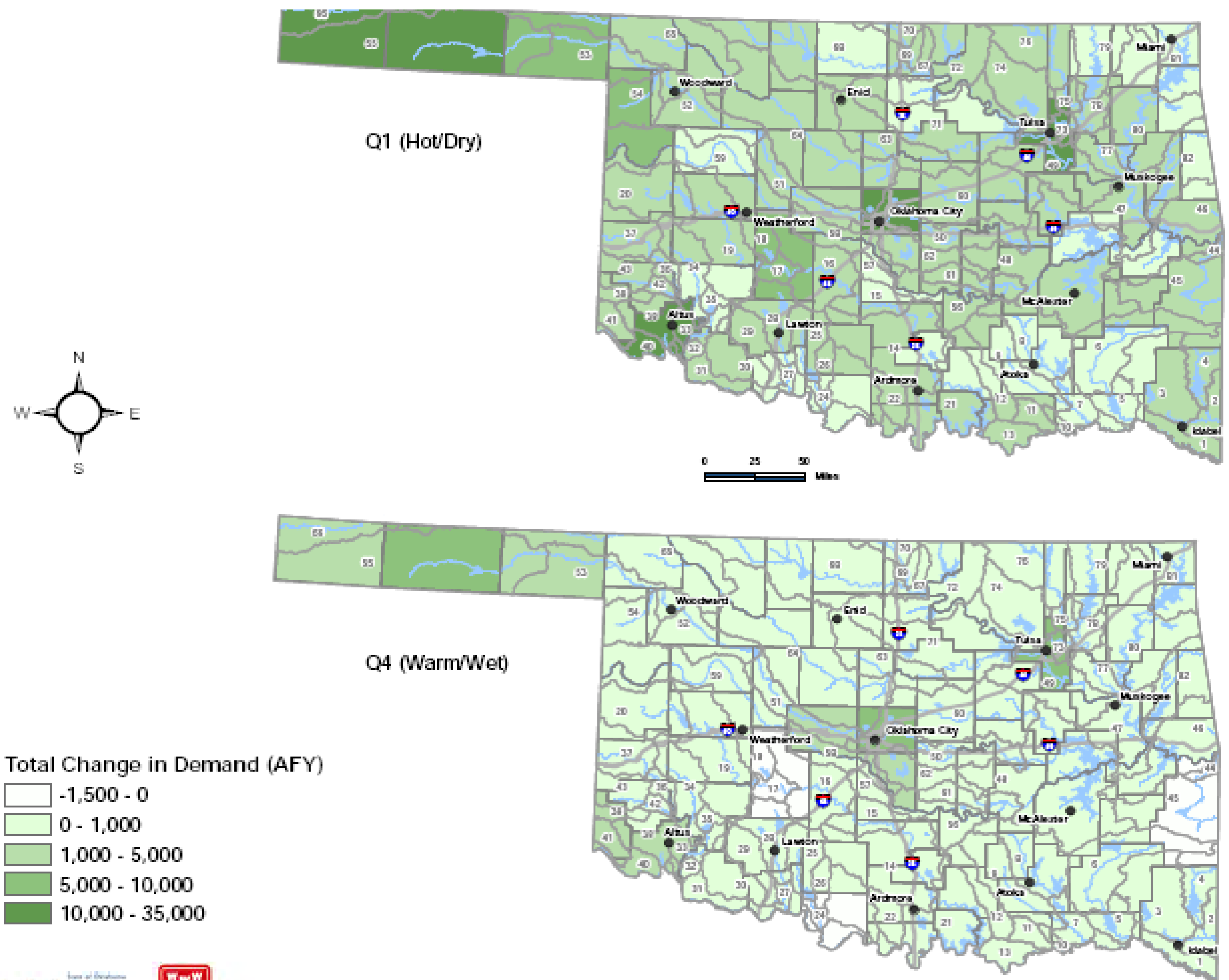
Table 10 provides the combined M&I and Irrigated Agriculture impacts from climate change scenarios. For 2030, the range of impact is estimated to be between 34,200 and 122,400 AFY, or 2.3 to 8.2 percent. For 2060, the range of impacts is estimate to be between 61,700 and 216,800 AFY, or 3.7 to 13.0 percent increases from baseline water demand estimates. Under the 2060 Warm/Wet scenario, M&I demand accounts for 60 percent of the variation. Conversely, under the 2060 Hot/Dry scenario, irrigated agriculture accounts for 66 percent of the variation.

Figure 16 displays the combined impacts from M&I and Irrigated Agriculture under climate change for the Hot/Dry and Warm/Wet scenarios. Areas with large quantities of irrigated agriculture and areas with high concentrations of population are estimated to experience the greatest increases in demand from potential climate change.

Table 10: Combined M&I and Irrigated Agriculture Demand Impacts Under Climate Change in AFY

Year	Baseline	Hot/Dry	Warm/Wet
2007	1,319,975	n/a	n/a
2030	1,488,503	1,610,968	1,522,741
2060	1,670,238	1,887,061	1,731,955
Change from Baseline			
2030	n/a	122,465	34,238
2060	n/a	216,823	61,718
Percent Increase from Baseline			
2030	n/a	8.20%	2.30%
2060	n/a	13.00%	3.70%

Figure 16: Combined Agriculture and M&I Changes in Water Demand (AFY) from Baseline for Scenario Q1 and Q4



Section 4
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Appendices

Appendix A
County Water Savings in AFY by Sector for Conservation Scenario I and Conservation Scenario II

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Adair	Public Supply Residential	Passive	283	391	283	391
		Metering	232	320	264	364
		Leak Detection	55	76	89	123
		Conservation Rates	0	0	19	27
		Education Programs	27	37	45	62
		High Efficiency Plumbing Standards	0	0	38	100
		Subtotal	597	824	739	1,068
	Public Supply Non-Residential	Passive	56	77	56	77
		Metering	136	188	155	214
		Leak Detection	32	44	53	72
		Education Programs	0	0	16	22
		High Efficiency Plumbing Standards	0	0	20	56
		Subtotal	224	309	300	442
	Self Supply Residential	Passive	203	280	203	280
		Education Programs	0	0	16	23
		High Efficiency Plumbing Standards	0	0	27	71
		Subtotal	203	280	247	374
	Irrigated Agriculture	Irrigation Savings	84	122	437	634
	Total County Conservation Savings		1,109	1,536	1,722	2,518
Alfalfa	Public Supply Residential	Passive	90	93	90	93
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Conservation Rates	4	4	18	19
		Education Programs	19	20	32	33
		High Efficiency Plumbing Standards	0	0	13	24
		Subtotal	113	117	152	168
	Public Supply Non-Residential	Passive	11	12	11	12
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Education Programs	0	0	5	5
		High Efficiency Plumbing Standards	0	0	4	9
		Subtotal	11	12	20	25
	Self Supply Residential	Passive	16	17	16	17
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	2	4
		Subtotal	16	17	22	24
	Irrigated Agriculture	Irrigation Savings	330	405	437	634
	Total County Conservation Savings		471	550	631	852

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Atoka	Public Supply Residential	Passive	296	389	296	389
		Metering	0	0	0	0
		Leak Detection	107	140	174	229
		Conservation Rates	53	70	116	152
		Education Programs	54	71	90	118
		High Efficiency Plumbing Standards	0	0	40	99
		Subtotal	509	670	714	987
	Public Supply Non-Residential	Passive	35	46	35	46
		Metering	0	0	0	0
		Leak Detection	21	27	34	44
		Education Programs	0	0	10	14
		High Efficiency Plumbing Standards	0	0	13	33
		Subtotal	55	73	91	137
	Self Supply Residential	Passive	78	103	78	103
		Education Programs	0	0	12	16
		High Efficiency Plumbing Standards	0	0	11	26
		Subtotal	78	103	101	145
	Irrigated Agriculture	Irrigation Savings	93	130	1,521	1,865
	Total County Conservation Savings		735	975	2,427	3,133
Beaver	Public Supply Residential	Passive	49	52	49	52
		Metering	0	0	3	3
		Leak Detection	0	0	0	0
		Conservation Rates	0	0	0	0
		Education Programs	5	5	9	9
		High Efficiency Plumbing Standards	0	0	7	13
		Subtotal	54	57	68	77
	Public Supply Non-Residential	Passive	13	14	13	14
		Metering	0	0	2	3
		Leak Detection	0	0	0	0
		Education Programs	0	0	4	4
		High Efficiency Plumbing Standards	0	0	5	10
		Subtotal	13	14	25	31
	Self Supply Residential	Passive	47	49	47	49
		Education Programs	0	0	4	5
		High Efficiency Plumbing Standards	0	0	7	13
		Subtotal	47	49	58	66
	Irrigated Agriculture	Irrigation Savings	1,823	1,973	537	755
	Total County Conservation Savings		1,938	2,093	688	929

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Beckham	Public Supply Residential	Passive	387	482	387	482
		Metering	0	0	17	21
		Leak Detection	0	0	0	0
		Conservation Rates	0	0	0	0
		Education Programs	109	136	182	227
		High Efficiency Plumbing Standards	0	0	53	123
		Subtotal	496	618	639	853
	Public Supply Non-Residential	Passive	87	108	87	108
		Metering	0	0	9	11
		Leak Detection	0	0	0	0
		Education Programs	0	0	58	72
		High Efficiency Plumbing Standards	0	0	31	78
		Subtotal	87	108	185	269
	Self Supply Residential	Passive	43	54	43	54
		Education Programs	0	0	11	14
		High Efficiency Plumbing Standards	0	0	6	14
		Subtotal	43	54	60	82
	Irrigated Agriculture	Irrigation Savings	484	484	10,235	11,078
	Total County Conservation Savings		1,111	1,265	11,119	12,283
Blaine	Public Supply Residential	Passive	240	300	240	300
		Metering	245	306	293	365
		Leak Detection	0	0	0	0
		Conservation Rates	0	0	0	0
		Education Programs	69	86	115	143
		High Efficiency Plumbing Standards	0	0	33	76
		Subtotal	554	692	680	885
	Public Supply Non-Residential	Passive	31	39	31	39
		Metering	57	71	68	85
		Leak Detection	0	0	0	0
		Education Programs	0	0	16	20
		High Efficiency Plumbing Standards	0	0	11	28
		Subtotal	89	111	127	173
	Self Supply Residential	Passive	24	30	24	30
		Education Programs	0	0	7	8
		High Efficiency Plumbing Standards	0	0	3	8
		Subtotal	24	30	34	46
	Irrigated Agriculture	Irrigation Savings	362	362	1,181	1,181
	Total County Conservation Savings		1,029	1,194	2,022	2,284

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Bryan	Public Supply Residential	Passive	746	943	746	943
		Metering	0	0	31	39
		Leak Detection	82	104	231	292
		Conservation Rates	0	0	38	48
		Education Programs	132	167	220	279
		High Efficiency Plumbing Standards	0	0	101	241
		Subtotal	961	1,214	1,368	1,842
	Public Supply Non-Residential	Passive	164	208	164	208
		Metering	0	0	14	17
		Leak Detection	37	46	103	130
		Education Programs	0	0	59	74
		High Efficiency Plumbing Standards	0	0	59	150
		Subtotal	201	254	399	579
	Self Supply Residential	Passive	56	71	56	71
		Education Programs	0	0	9	11
		High Efficiency Plumbing Standards	0	0	8	18
		Subtotal	56	71	73	100
	Irrigated Agriculture	Irrigation Savings	974	1,010	686	686
	Total County Conservation Savings		2,192	2,550	2,525	3,207
Caddo	Public Supply Residential	Passive	319	347	319	347
		Metering	117	128	169	183
		Leak Detection	0	0	0	0
		Conservation Rates	14	15	66	71
		Education Programs	49	53	82	89
		High Efficiency Plumbing Standards	0	0	44	89
		Subtotal	500	544	679	779
	Public Supply Non-Residential	Passive	67	73	67	73
		Metering	46	50	66	72
		Leak Detection	0	0	0	0
		Education Programs	0	0	19	21
		High Efficiency Plumbing Standards	0	0	24	53
		Subtotal	113	123	177	219
	Self Supply Residential	Passive	213	232	213	232
		Education Programs	0	0	29	32
		High Efficiency Plumbing Standards	0	0	30	59
		Subtotal	213	232	272	323
	Irrigated Agriculture	Irrigation Savings	2,051	2,502	1,728	1,791
	Total County Conservation Savings		2,877	3,400	2,857	3,113

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Canadian	Public Supply Residential	Passive	2,031	2,357	2,031	2,357
		Metering	1,587	1,842	1,851	2,148
		Leak Detection	0	0	41	48
		Conservation Rates	0	0	240	279
		Education Programs	267	310	445	516
		High Efficiency Plumbing Standards	0	0	278	601
		Subtotal	3,886	4,509	4,887	5,949
	Public Supply Non-Residential	Passive	245	285	245	285
		Metering	579	671	675	783
		Leak Detection	0	0	15	17
		Education Programs	0	0	97	113
		High Efficiency Plumbing Standards	0	0	89	206
		Subtotal	824	956	1,121	1,404
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	375	412	5,528	6,743
	Total County Conservation Savings		5,085	5,876	11,536	14,096
Carter	Public Supply Residential	Passive	953	1,104	953	1,104
		Metering	0	0	0	0
		Leak Detection	109	126	245	284
		Conservation Rates	25	29	150	174
		Education Programs	88	102	147	170
		High Efficiency Plumbing Standards	0	0	131	282
		Subtotal	1,175	1,361	1,626	2,014
	Public Supply Non-Residential	Passive	213	247	213	247
		Metering	0	0	0	0
		Leak Detection	66	77	150	173
		Education Programs	0	0	54	62
		High Efficiency Plumbing Standards	0	0	77	178
		Subtotal	280	324	494	661
	Self Supply Residential	Passive	4	5	4	5
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	1	1
		Subtotal	4	5	5	7
	Irrigated Agriculture	Irrigation Savings	156	162	1,186	1,301
	Total County Conservation Savings		1,615	1,853	3,310	3,983

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Cherokee	Public Supply Residential	Passive	900	1,207	900	1,207
		Metering	60	80	180	242
		Leak Detection	205	276	335	449
		Conservation Rates	18	24	138	185
		Education Programs	135	181	225	302
		High Efficiency Plumbing Standards	0	0	121	308
		Subtotal	1,317	1,767	1,898	2,693
	Public Supply Non-Residential	Passive	157	210	157	210
		Metering	27	36	82	110
		Leak Detection	93	125	152	204
		Education Programs	0	0	61	82
		High Efficiency Plumbing Standards	0	0	57	152
		Subtotal	277	372	508	758
	Self Supply Residential	Passive	176	236	176	236
		Education Programs	0	0	22	30
		High Efficiency Plumbing Standards	0	0	24	60
		Subtotal	176	236	222	327
	Irrigated Agriculture	Irrigation Savings	91	103	339	352
	Total County Conservation Savings		1,862	2,478	2,968	4,129
Choctaw	Public Supply Residential	Passive	196	211	196	211
		Metering	0	0	0	0
		Leak Detection	28	30	47	50
		Conservation Rates	16	18	34	37
		Education Programs	26	28	43	46
		High Efficiency Plumbing Standards	0	0	27	54
		Subtotal	266	286	347	397
	Public Supply Non-Residential	Passive	42	45	42	45
		Metering	0	0	0	0
		Leak Detection	25	27	42	45
		Education Programs	0	0	23	25
		High Efficiency Plumbing Standards	0	0	15	32
		Subtotal	66	71	122	147
	Self Supply Residential	Passive	89	96	89	96
		Education Programs	0	0	10	11
		High Efficiency Plumbing Standards	0	0	12	24
		Subtotal	89	96	112	131
	Irrigated Agriculture	Irrigation Savings	64	89	468	529
	Total County Conservation Savings		486	542	1,048	1,204

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Cimarron	Public Supply Residential	Passive	30	32	30	32
		Metering	0	0	0	0
		Leak Detection	20	22	33	35
		Conservation Rates	0	0	0	0
		Education Programs	18	19	30	32
		High Efficiency Plumbing Standards	0	0	4	8
		Subtotal	68	72	97	107
	Public Supply Non-Residential	Passive	7	7	7	7
		Metering	0	0	0	0
		Leak Detection	4	4	6	6
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	2	5
		Subtotal	10	11	18	22
	Self Supply Residential	Passive	22	23	22	23
		Education Programs	0	0	11	12
		High Efficiency Plumbing Standards	0	0	3	6
		Subtotal	22	23	36	41
	Irrigated Agriculture	Irrigation Savings	4,015	4,948	342	473
	Total County Conservation Savings		4,115	5,054	494	642
Cleveland	Public Supply Residential	Passive	4,571	5,033	4,571	5,033
		Metering	0	0	0	0
		Leak Detection	727	801	1,400	1,541
		Conservation Rates	0	0	59	65
		Education Programs	360	396	600	661
		High Efficiency Plumbing Standards	0	0	628	1,284
		Subtotal	5,659	6,230	7,258	8,584
	Public Supply Non-Residential	Passive	704	775	704	775
		Metering	0	0	0	0
		Leak Detection	277	305	534	588
		Education Programs	0	0	137	151
		High Efficiency Plumbing Standards	0	0	254	560
		Subtotal	982	1,081	1,630	2,074
	Self Supply Residential	Passive	259	285	259	285
		Education Programs	0	0	18	19
		High Efficiency Plumbing Standards	0	0	36	73
		Subtotal	259	285	312	377
	Irrigated Agriculture	Irrigation Savings	83	115	17,669	21,776
	Total County Conservation Savings		6,982	7,710	26,869	32,811

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Coal	Public Supply Residential	Passive	97	136	97	136
		Metering	0	0	9	13
		Leak Detection	21	30	34	48
		Conservation Rates	0	0	0	0
		Education Programs	4	6	7	10
		High Efficiency Plumbing Standards	0	0	13	35
		Subtotal	122	172	160	242
	Public Supply Non-Residential	Passive	11	16	11	16
		Metering	0	0	3	4
		Leak Detection	6	9	10	15
		Education Programs	0	0	1	2
		High Efficiency Plumbing Standards	0	0	4	11
		Subtotal	18	25	30	47
	Self Supply Residential	Passive	37	52	37	52
		Education Programs	0	0	1	2
		High Efficiency Plumbing Standards	0	0	5	13
		Subtotal	37	52	43	67
	Irrigated Agriculture	Irrigation Savings	36	36	168	232
	Total County Conservation Savings		212	284	400	589
Comanche	Public Supply Residential	Passive	2,361	2,570	2,361	2,570
		Metering	2,072	2,256	2,322	2,528
		Leak Detection	0	0	206	224
		Conservation Rates	331	361	581	633
		Education Programs	44	47	73	79
		High Efficiency Plumbing Standards	0	0	325	656
		Subtotal	4,807	5,233	5,868	6,690
	Public Supply Non-Residential	Passive	393	428	393	428
		Metering	1,031	1,122	1,155	1,257
		Leak Detection	0	0	103	112
		Education Programs	0	0	22	24
		High Efficiency Plumbing Standards	0	0	142	309
		Subtotal	1,424	1,550	1,814	2,130
	Self Supply Residential	Passive	46	50	46	50
		Education Programs	0	0	1	1
		High Efficiency Plumbing Standards	0	0	6	13
		Subtotal	46	50	53	64
	Irrigated Agriculture	Irrigation Savings	172	205	168	170
	Total County Conservation Savings		6,449	7,039	7,904	9,054

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Cotton	Public Supply Residential	Passive	117	124	117	124
		Metering	60	64	71	75
		Leak Detection	18	19	29	31
		Conservation Rates	0	0	3	3
		Education Programs	16	17	26	28
		High Efficiency Plumbing Standards	0	0	16	32
		Subtotal	211	223	262	292
	Public Supply Non-Residential	Passive	14	15	14	15
		Metering	35	37	41	43
		Leak Detection	10	11	17	18
		Education Programs	0	0	9	9
		High Efficiency Plumbing Standards	0	0	5	10
		Subtotal	58	62	85	95
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	43	60	594	710
	Total County Conservation Savings		312	345	942	1,097
Craig	Public Supply Residential	Passive	31	40	31	40
		Metering	0	0	21	27
		Leak Detection	61	78	99	128
		Conservation Rates	14	18	49	64
		Education Programs	54	69	89	115
		High Efficiency Plumbing Standards	0	0	4	10
		Subtotal	160	205	295	384
	Public Supply Non-Residential	Passive	60	77	60	77
		Metering	0	0	11	15
		Leak Detection	33	42	53	68
		Education Programs	0	0	29	37
		High Efficiency Plumbing Standards	0	0	22	56
		Subtotal	92	119	175	253
	Self Supply Residential	Passive	2	2	2	2
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	0	1
		Subtotal	2	2	5	6
	Irrigated Agriculture	Irrigation Savings	63	144	55	77
	Total County Conservation Savings		316	471	529	721

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Creek	Public Supply Residential	Passive	1,183	1,350	1,183	1,350
		Metering	0	0	96	109
		Leak Detection	216	246	351	401
		Conservation Rates	63	71	189	216
		Education Programs	147	168	245	280
		High Efficiency Plumbing Standards	0	0	163	345
		Subtotal	1,608	1,835	2,227	2,700
	Public Supply Non-Residential	Passive	163	186	163	186
		Metering	0	0	46	53
		Leak Detection	105	119	170	195
		Education Programs	0	0	71	81
		High Efficiency Plumbing Standards	0	0	59	135
		Subtotal	268	306	511	650
	Self Supply Residential	Passive	135	153	135	153
		Education Programs	0	0	14	16
		High Efficiency Plumbing Standards	0	0	19	39
		Subtotal	135	153	167	209
	Irrigated Agriculture	Irrigation Savings	24	31	294	677
	Total County Conservation Savings		2,035	2,325	3,199	4,235
Custer	Public Supply Residential	Passive	453	497	453	497
		Metering	273	299	350	383
		Leak Detection	37	41	122	133
		Conservation Rates	24	27	101	111
		Education Programs	115	126	192	211
		High Efficiency Plumbing Standards	0	0	63	127
		Subtotal	903	989	1,280	1,461
	Public Supply Non-Residential	Passive	107	118	107	118
		Metering	143	156	183	200
		Leak Detection	19	21	64	70
		Education Programs	0	0	60	66
		High Efficiency Plumbing Standards	0	0	39	85
		Subtotal	269	295	453	539
	Self Supply Residential	Passive	66	72	66	72
		Education Programs	0	0	15	16
		High Efficiency Plumbing Standards	0	0	9	18
		Subtotal	66	72	90	107
	Irrigated Agriculture	Irrigation Savings	266	280	77	99
	Total County Conservation Savings		1,504	1,637	1,900	2,206

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Delaware	Public Supply Residential	Passive	699	957	699	957
		Metering	149	204	226	309
		Leak Detection	130	178	212	291
		Conservation Rates	56	77	133	182
		Education Programs	105	144	176	240
		High Efficiency Plumbing Standards	0	0	94	244
		Subtotal	1,140	1,562	1,538	2,224
	Public Supply Non-Residential	Passive	84	116	84	116
		Metering	61	84	92	126
		Leak Detection	53	73	87	119
		Education Programs	0	0	43	59
		High Efficiency Plumbing Standards	0	0	30	84
		Subtotal	199	272	337	504
	Self Supply Residential	Passive	278	381	278	381
		Education Programs	0	0	36	49
		High Efficiency Plumbing Standards	0	0	37	97
		Subtotal	278	381	351	527
	Irrigated Agriculture	Irrigation Savings	53	53	778	821
	Total County Conservation Savings		1,669	2,268	3,005	4,076
Dewey	Public Supply Residential	Passive	60	62	60	62
		Metering	0	0	18	19
		Leak Detection	15	15	35	36
		Conservation Rates	9	9	27	28
		Education Programs	27	28	45	47
		High Efficiency Plumbing Standards	0	0	8	16
		Subtotal	111	116	194	209
	Public Supply Non-Residential	Passive	11	12	11	12
		Metering	0	0	5	5
		Leak Detection	4	4	9	10
		Education Programs	0	0	7	7
		High Efficiency Plumbing Standards	0	0	4	9
		Subtotal	15	16	37	43
	Self Supply Residential	Passive	20	20	20	20
		Education Programs	0	0	8	8
		High Efficiency Plumbing Standards	0	0	3	5
		Subtotal	20	20	30	34
	Irrigated Agriculture	Irrigation Savings	264	264	267	267
	Total County Conservation Savings		410	417	528	553

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Ellis	Public Supply Residential	Passive	47	47	47	47
		Metering	0	0	0	0
		Leak Detection	19	19	31	31
		Conservation Rates	1	1	12	12
		Education Programs	17	17	28	28
		High Efficiency Plumbing Standards	0	0	7	12
		Subtotal	84	84	125	130
	Public Supply Non-Residential	Passive	9	9	9	9
		Metering	0	0	0	0
		Leak Detection	6	6	9	9
		Education Programs	0	0	5	5
		High Efficiency Plumbing Standards	0	0	3	7
		Subtotal	15	15	27	30
	Self Supply Residential	Passive	26	26	26	26
		Education Programs	0	0	8	8
		High Efficiency Plumbing Standards	0	0	4	7
		Subtotal	26	26	37	40
	Irrigated Agriculture	Irrigation Savings	1,527	1,932	929	929
	Total County Conservation Savings		1,651	2,056	1,118	1,129
Garfield	Public Supply Residential	Passive	1,085	1,151	1,085	1,151
		Metering	0	0	11	11
		Leak Detection	306	324	498	528
		Conservation Rates	177	188	356	378
		Education Programs	28	30	47	50
		High Efficiency Plumbing Standards	0	0	151	294
		Subtotal	1,596	1,693	2,148	2,412
	Public Supply Non-Residential	Passive	230	244	230	244
		Metering	0	0	5	5
		Leak Detection	139	148	227	241
		Education Programs	0	0	13	14
		High Efficiency Plumbing Standards	0	0	83	176
		Subtotal	369	391	557	679
	Self Supply Residential	Passive	28	30	28	30
		Education Programs	0	0	1	1
		High Efficiency Plumbing Standards	0	0	4	8
		Subtotal	28	30	33	38
	Irrigated Agriculture	Irrigation Savings	74	74	11,179	14,145
	Total County Conservation Savings		2,066	2,187	13,917	17,274

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Garvin	Public Supply Residential	Passive	432	457	432	457
		Metering	34	36	98	103
		Leak Detection	109	115	177	188
		Conservation Rates	0	0	42	44
		Education Programs	77	81	128	135
		High Efficiency Plumbing Standards	0	0	60	117
		Subtotal	651	690	936	1,045
	Public Supply Non-Residential	Passive	84	89	84	89
		Metering	19	20	56	59
		Leak Detection	62	66	101	107
		Education Programs	0	0	44	46
		High Efficiency Plumbing Standards	0	0	30	64
		Subtotal	165	175	315	366
	Self Supply Residential	Passive	78	83	78	83
		Education Programs	0	0	12	12
		High Efficiency Plumbing Standards	0	0	11	21
		Subtotal	78	83	101	116
	Irrigated Agriculture	Irrigation Savings	112	182	1,144	1,144
	Total County Conservation Savings		1,006	1,129	2,496	2,670
Grady	Public Supply Residential	Passive	688	790	688	790
		Metering	38	44	109	125
		Leak Detection	121	139	197	227
		Conservation Rates	0	0	38	44
		Education Programs	99	113	164	189
		High Efficiency Plumbing Standards	0	0	94	201
		Subtotal	945	1,086	1,291	1,576
	Public Supply Non-Residential	Passive	125	144	125	144
		Metering	25	28	71	81
		Leak Detection	78	90	128	147
		Education Programs	0	0	64	73
		High Efficiency Plumbing Standards	0	0	45	104
		Subtotal	228	262	432	549
	Self Supply Residential	Passive	310	356	310	356
		Education Programs	0	0	38	43
		High Efficiency Plumbing Standards	0	0	43	91
		Subtotal	310	356	391	491
	Irrigated Agriculture	Irrigation Savings	627	627	336	546
	Total County Conservation Savings		2,111	2,331	2,450	3,161

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Grant	Public Supply Residential	Passive	73	77	73	77
		Metering	2	2	13	14
		Leak Detection	18	19	30	31
		Conservation Rates	0	0	7	7
		Education Programs	17	18	28	29
		High Efficiency Plumbing Standards	0	0	10	20
		Subtotal	109	115	160	178
	Public Supply Non-Residential	Passive	10	11	10	11
		Metering	1	1	4	5
		Leak Detection	6	6	10	10
		Education Programs	0	0	6	6
		High Efficiency Plumbing Standards	0	0	4	8
		Subtotal	17	18	34	40
	Self Supply Residential	Passive	12	13	12	13
		Education Programs	0	0	2	3
		High Efficiency Plumbing Standards	0	0	2	3
		Subtotal	12	13	16	19
	Irrigated Agriculture	Irrigation Savings	100	100	1,657	1,657
	Total County Conservation Savings		238	246	1,868	1,894
Greer	Public Supply Residential	Passive	112	118	112	118
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Conservation Rates	17	18	34	35
		Education Programs	25	27	42	44
		High Efficiency Plumbing Standards	0	0	16	30
		Subtotal	154	162	204	228
	Public Supply Non-Residential	Passive	14	15	14	15
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Education Programs	0	0	6	7
		High Efficiency Plumbing Standards	0	0	5	11
		Subtotal	14	15	25	32
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	553	900	340	340
	Total County Conservation Savings		721	1,077	569	599

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Harmon	Public Supply Residential	Passive	53	58	53	58
		Metering	0	0	0	0
		Leak Detection	24	26	39	42
		Conservation Rates	0	0	14	15
		Education Programs	21	23	35	38
		High Efficiency Plumbing Standards	0	0	7	15
		Subtotal	98	106	148	168
	Public Supply Non-Residential	Passive	8	9	8	9
		Metering	0	0	0	0
		Leak Detection	4	4	7	7
		Education Programs	0	0	4	4
		High Efficiency Plumbing Standards	0	0	3	6
		Subtotal	12	13	21	26
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	4,194	4,525	2,191	3,569
	Total County Conservation Savings		4,303	4,645	2,360	3,763
Harper	Public Supply Residential	Passive	42	44	42	44
		Metering	51	52	66	68
		Leak Detection	26	26	42	43
		Conservation Rates	0	0	6	6
		Education Programs	21	21	35	36
		High Efficiency Plumbing Standards	0	0	6	11
		Subtotal	140	144	197	208
	Public Supply Non-Residential	Passive	12	12	12	12
		Metering	15	15	19	20
		Leak Detection	8	8	12	13
		Education Programs	0	0	6	6
		High Efficiency Plumbing Standards	0	0	4	9
		Subtotal	34	35	54	60
	Self Supply Residential	Passive	18	18	18	18
		Education Programs	0	0	7	8
		High Efficiency Plumbing Standards	0	0	2	5
		Subtotal	18	18	28	31
	Irrigated Agriculture	Irrigation Savings	607	713	5,645	6,092
	Total County Conservation Savings		799	910	5,923	6,389

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Haskell	Public Supply Residential	Passive	176	239	176	239
		Metering	0	0	0	0
		Leak Detection	31	42	50	68
		Conservation Rates	0	0	0	0
		Education Programs	27	37	45	61
		High Efficiency Plumbing Standards	0	0	24	61
		Subtotal	233	317	294	428
	Public Supply Non-Residential	Passive	40	54	40	54
		Metering	0	0	0	0
		Leak Detection	26	35	42	57
		Education Programs	0	0	23	31
		High Efficiency Plumbing Standards	0	0	14	39
		Subtotal	65	89	118	181
	Self Supply Residential	Passive	137	186	137	186
		Education Programs	0	0	18	24
		High Efficiency Plumbing Standards	0	0	18	47
		Subtotal	137	186	173	258
	Irrigated Agriculture	Irrigation Savings	167	202	4,712	5,534
	Total County Conservation Savings		602	794	5,297	6,401
Hughes	Public Supply Residential	Passive	294	387	294	387
		Metering	171	225	204	269
		Leak Detection	58	76	94	123
		Conservation Rates	12	16	46	60
		Education Programs	51	67	84	111
		High Efficiency Plumbing Standards	0	0	40	99
		Subtotal	585	770	762	1,050
	Public Supply Non-Residential	Passive	30	39	30	39
		Metering	49	65	59	78
		Leak Detection	17	22	27	36
		Education Programs	0	0	15	19
		High Efficiency Plumbing Standards	0	0	11	28
		Subtotal	96	126	141	200
	Self Supply Residential	Passive	22	29	22	29
		Education Programs	0	0	3	4
		High Efficiency Plumbing Standards	0	0	3	7
		Subtotal	22	29	28	40
	Irrigated Agriculture	Irrigation Savings	298	471	910	1,099
	Total County Conservation Savings		1,000	1,395	1,841	2,389

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Jackson	Public Supply Residential	Passive	469	511	469	511
		Metering	0	0	42	46
		Leak Detection	114	124	186	203
		Conservation Rates	44	48	111	121
		Education Programs	100	109	167	182
		High Efficiency Plumbing Standards	0	0	65	131
		Subtotal	728	793	1,040	1,193
	Public Supply Non-Residential	Passive	105	114	105	114
		Metering	0	0	22	24
		Leak Detection	61	66	99	108
		Education Programs	0	0	54	58
		High Efficiency Plumbing Standards	0	0	38	83
		Subtotal	166	181	318	388
	Self Supply Residential	Passive	21	22	21	22
		Education Programs	0	0	4	4
		High Efficiency Plumbing Standards	0	0	3	6
		Subtotal	21	22	27	32
	Irrigated Agriculture	Irrigation Savings	20,947	22,164	1,430	2,261
	Total County Conservation Savings		21,861	23,160	2,815	3,874
Jefferson	Public Supply Residential	Passive	111	119	111	119
		Metering	103	111	116	124
		Leak Detection	21	23	35	37
		Conservation Rates	0	0	12	13
		Education Programs	4	4	7	7
		High Efficiency Plumbing Standards	0	0	15	30
		Subtotal	239	257	295	331
	Public Supply Non-Residential	Passive	12	13	12	13
		Metering	31	33	35	37
		Leak Detection	6	7	10	11
		Education Programs	0	0	1	1
		High Efficiency Plumbing Standards	0	0	4	9
		Subtotal	49	53	62	71
	Self Supply Residential	Passive	3	3	3	3
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	1
		Subtotal	3	3	3	3
	Irrigated Agriculture	Irrigation Savings	20	25	22,559	23,869
	Total County Conservation Savings		311	337	22,919	24,275

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Johnston	Public Supply Residential	Passive	230	307	230	307
		Metering	189	252	222	295
		Leak Detection	56	74	91	121
		Conservation Rates	1	1	33	44
		Education Programs	27	36	45	60
		High Efficiency Plumbing Standards	0	0	31	78
		Subtotal	503	669	652	904
	Public Supply Non-Residential	Passive	30	40	30	40
		Metering	66	87	77	102
		Leak Detection	19	26	31	42
		Education Programs	0	0	9	12
		High Efficiency Plumbing Standards	0	0	11	29
		Subtotal	115	153	159	226
	Self Supply Residential	Passive	2	3	2	3
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	1
		Subtotal	2	3	3	4
	Irrigated Agriculture	Irrigation Savings	109	171	31	38
	Total County Conservation Savings		729	996	844	1,172
Kay	Public Supply Residential	Passive	831	890	831	890
		Metering	585	627	675	723
		Leak Detection	153	164	250	267
		Conservation Rates	0	0	45	48
		Education Programs	116	124	193	206
		High Efficiency Plumbing Standards	0	0	115	227
		Subtotal	1,685	1,805	2,109	2,362
	Public Supply Non-Residential	Passive	186	200	186	200
		Metering	492	527	568	608
		Leak Detection	129	138	210	225
		Education Programs	0	0	97	104
		High Efficiency Plumbing Standards	0	0	67	144
		Subtotal	807	865	1,129	1,281
	Self Supply Residential	Passive	43	46	43	46
		Education Programs	0	0	5	5
		High Efficiency Plumbing Standards	0	0	6	12
		Subtotal	43	46	54	63
	Irrigated Agriculture	Irrigation Savings	255	255	467	730
	Total County Conservation Savings		2,790	2,970	3,758	4,436

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Kingfisher	Public Supply Residential	Passive	222	288	222	288
		Metering	0	0	28	36
		Leak Detection	70	91	115	149
		Conservation Rates	19	25	60	78
		Education Programs	28	37	47	61
		High Efficiency Plumbing Standards	0	0	30	73
		Subtotal	340	440	502	685
	Public Supply Non-Residential	Passive	60	77	60	77
		Metering	0	0	20	25
		Leak Detection	50	65	81	105
		Education Programs	0	0	20	26
		High Efficiency Plumbing Standards	0	0	21	56
		Subtotal	109	142	202	289
	Self Supply Residential	Passive	86	112	86	112
		Education Programs	0	0	9	12
		High Efficiency Plumbing Standards	0	0	12	29
		Subtotal	86	112	107	153
	Irrigated Agriculture	Irrigation Savings	484	550	452	452
	Total County Conservation Savings		1,020	1,244	1,263	1,579
Kiowa	Public Supply Residential	Passive	177	186	177	186
		Metering	0	0	6	6
		Leak Detection	28	30	46	48
		Conservation Rates	0	0	11	11
		Education Programs	25	26	41	43
		High Efficiency Plumbing Standards	0	0	25	48
		Subtotal	230	242	306	343
	Public Supply Non-Residential	Passive	23	24	23	24
		Metering	0	0	3	3
		Leak Detection	16	16	25	27
		Education Programs	0	0	14	14
		High Efficiency Plumbing Standards	0	0	8	17
		Subtotal	39	40	74	86
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	640	691	1,988	2,258
	Total County Conservation Savings		909	973	2,368	2,687

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Latimer	Public Supply Residential	Passive	177	209	177	209
		Metering	0	0	9	11
		Leak Detection	59	70	96	114
		Conservation Rates	35	41	69	82
		Education Programs	52	61	87	102
		High Efficiency Plumbing Standards	0	0	24	53
		Subtotal	322	381	462	571
	Public Supply Non-Residential	Passive	38	45	38	45
		Metering	0	0	4	5
		Leak Detection	26	31	43	51
		Education Programs	0	0	23	27
		High Efficiency Plumbing Standards	0	0	14	33
		Subtotal	65	77	122	161
	Self Supply Residential	Passive	25	30	25	30
		Education Programs	0	0	6	8
		High Efficiency Plumbing Standards	0	0	3	8
		Subtotal	25	30	35	45
	Irrigated Agriculture	Irrigation Savings	103	186	1,306	1,408
	Total County Conservation Savings		515	673	1,926	2,185
Le Flore	Public Supply Residential	Passive	855	1,014	855	1,014
		Metering	263	311	364	432
		Leak Detection	173	206	283	335
		Conservation Rates	116	137	218	258
		Education Programs	138	164	230	273
		High Efficiency Plumbing Standards	0	0	117	259
		Subtotal	1,544	1,832	2,066	2,571
	Public Supply Non-Residential	Passive	125	148	125	148
		Metering	124	147	173	205
		Leak Detection	82	97	134	159
		Education Programs	0	0	65	77
		High Efficiency Plumbing Standards	0	0	45	107
		Subtotal	331	393	541	696
	Self Supply Residential	Passive	125	149	125	149
		Education Programs	0	0	17	20
		High Efficiency Plumbing Standards	0	0	17	38
		Subtotal	125	149	160	207
	Irrigated Agriculture	Irrigation Savings	198	198	568	1,029
	Total County Conservation Savings		2,198	2,571	3,335	4,502

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	2060	Scenario II Savings (AFY) 2030	2060
Lincoln	Public Supply Residential	Passive	296	358	296	358
		Metering	69	84	101	122
		Leak Detection	54	65	88	106
		Conservation Rates	8	10	40	48
		Education Programs	47	57	79	96
		High Efficiency Plumbing Standards	0	0	40	91
		Subtotal	474	574	643	821
	Public Supply Non-Residential	Passive	71	86	71	86
		Metering	51	61	74	90
		Leak Detection	40	48	65	78
		Education Programs	0	0	35	42
		High Efficiency Plumbing Standards	0	0	26	62
		Subtotal	161	195	270	358
	Self Supply Residential	Passive	357	432	357	432
		Education Programs	0	0	49	59
		High Efficiency Plumbing Standards	0	0	49	110
		Subtotal	357	432	454	601
	Irrigated Agriculture	Irrigation Savings	199	199	976	976
	Total County Conservation Savings		1,191	1,400	2,344	2,756
Logan	Public Supply Residential	Passive	552	702	552	702
		Metering	505	643	599	762
		Leak Detection	160	203	260	331
		Conservation Rates	61	78	155	197
		Education Programs	93	118	155	197
		High Efficiency Plumbing Standards	0	0	75	179
		Subtotal	1,370	1,743	1,795	2,367
	Public Supply Non-Residential	Passive	70	89	70	89
		Metering	129	164	153	195
		Leak Detection	41	52	67	85
		Education Programs	0	0	24	30
		High Efficiency Plumbing Standards	0	0	25	64
		Subtotal	240	305	339	463
	Self Supply Residential	Passive	247	314	247	314
		Education Programs	0	0	35	45
		High Efficiency Plumbing Standards	0	0	33	80
		Subtotal	247	314	315	439
	Irrigated Agriculture	Irrigation Savings	111	111	1,042	1,042
	Total County Conservation Savings		1,968	2,473	3,491	4,311

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Love	Public Supply Residential	Passive	447	533	447	533
		Metering	327	389	380	452
		Leak Detection	90	107	147	175
		Conservation Rates	0	0	38	45
		Education Programs	57	68	95	113
		High Efficiency Plumbing Standards	0	0	61	136
		Subtotal	921	1,097	1,168	1,454
	Public Supply Non-Residential	Passive	88	105	88	105
		Metering	348	414	404	481
		Leak Detection	96	114	156	186
		Education Programs	0	0	61	72
		High Efficiency Plumbing Standards	0	0	32	76
		Subtotal	531	633	740	919
	Self Supply Residential	Passive	16	19	16	19
		Education Programs	0	0	2	2
		High Efficiency Plumbing Standards	0	0	2	5
		Subtotal	16	19	20	26
	Irrigated Agriculture	Irrigation Savings	205	285	471	471
	Total County Conservation Savings		1,673	2,034	2,399	2,871
Major	Public Supply Residential	Passive	92	96	92	96
		Metering	53	56	65	68
		Leak Detection	4	4	17	18
		Conservation Rates	0	0	0	0
		Education Programs	8	8	13	13
		High Efficiency Plumbing Standards	0	0	13	24
		Subtotal	157	164	200	219
	Public Supply Non-Residential	Passive	21	22	21	22
		Metering	39	41	48	50
		Leak Detection	3	3	12	13
		Education Programs	0	0	6	6
		High Efficiency Plumbing Standards	0	0	8	16
		Subtotal	63	66	94	106
	Self Supply Residential	Passive	38	39	38	39
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	5	10
		Subtotal	38	39	46	52
	Irrigated Agriculture	Irrigation Savings	726	733	655	909
	Total County Conservation Savings		984	1,002	995	1,287

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Marshall	Public Supply Residential	Passive	408	620	408	620
		Metering	0	0	13	20
		Leak Detection	78	119	127	193
		Conservation Rates	37	57	83	127
		Education Programs	69	104	114	174
		High Efficiency Plumbing Standards	0	0	54	158
		Subtotal	592	900	800	1,293
	Public Supply Non-Residential	Passive	75	114	75	114
		Metering	0	0	12	18
		Leak Detection	70	106	114	173
		Education Programs	0	0	61	93
		High Efficiency Plumbing Standards	0	0	27	82
		Subtotal	144	220	289	480
	Self Supply Residential	Passive	19	28	19	28
		Education Programs	0	0	3	4
		High Efficiency Plumbing Standards	0	0	2	7
		Subtotal	19	28	24	40
	Irrigated Agriculture	Irrigation Savings	254	277	2,780	2,808
	Total County Conservation Savings		1,010	1,426	3,892	4,620
Mayes	Public Supply Residential	Passive	839	1,054	839	1,054
		Metering	63	79	156	196
		Leak Detection	159	200	259	325
		Conservation Rates	93	117	186	234
		Education Programs	104	131	174	218
		High Efficiency Plumbing Standards	0	0	114	269
		Subtotal	1,258	1,580	1,728	2,296
	Public Supply Non-Residential	Passive	111	139	111	139
		Metering	25	32	62	78
		Leak Detection	64	80	104	130
		Education Programs	0	0	42	53
		High Efficiency Plumbing Standards	0	0	40	101
		Subtotal	200	251	359	501
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	78	96	331	361
	Total County Conservation Savings		1,536	1,928	2,417	3,158

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	2060	Scenario II Savings (AFY) 2030	2060
McClain	Public Supply Residential	Passive	559	762	559	762
		Metering	0	0	0	0
		Leak Detection	138	189	226	307
		Conservation Rates	122	166	203	277
		Education Programs	122	166	203	277
		High Efficiency Plumbing Standards	0	0	75	195
		Subtotal	941	1,283	1,266	1,818
	Public Supply Non-Residential	Passive	77	105	77	105
		Metering	0	0	0	0
		Leak Detection	47	64	76	104
		Education Programs	0	0	41	56
		High Efficiency Plumbing Standards	0	0	28	76
		Subtotal	124	169	222	341
	Self Supply Residential	Passive	170	232	170	232
		Education Programs	0	0	32	43
		High Efficiency Plumbing Standards	0	0	23	59
		Subtotal	170	232	224	334
	Irrigated Agriculture	Irrigation Savings	163	171	410	504
	Total County Conservation Savings		1,398	1,855	2,122	2,997
McCurtain	Public Supply Residential	Passive	489	532	489	532
		Metering	270	293	332	361
		Leak Detection	106	115	173	188
		Conservation Rates	57	62	119	130
		Education Programs	29	31	48	52
		High Efficiency Plumbing Standards	0	0	68	136
		Subtotal	950	1,034	1,228	1,398
	Public Supply Non-Residential	Passive	98	106	98	106
		Metering	137	149	168	183
		Leak Detection	54	58	88	95
		Education Programs	0	0	14	16
		High Efficiency Plumbing Standards	0	0	35	77
		Subtotal	288	313	403	477
	Self Supply Residential	Passive	141	153	141	153
		Education Programs	0	0	7	8
		High Efficiency Plumbing Standards	0	0	19	39
		Subtotal	141	153	167	200
	Irrigated Agriculture	Irrigation Savings	0	0	307	323
	Total County Conservation Savings		1,378	1,500	2,105	2,397

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
McIntosh	Public Supply Residential	Passive	470	644	470	644
		Metering	76	104	122	167
		Leak Detection	78	106	126	173
		Conservation Rates	0	0	9	12
		Education Programs	44	60	74	101
		High Efficiency Plumbing Standards	0	0	63	164
		Subtotal	667	915	863	1,260
	Public Supply Non-Residential	Passive	44	61	44	61
		Metering	26	36	42	58
		Leak Detection	27	37	44	60
		Education Programs	0	0	15	21
		High Efficiency Plumbing Standards	0	0	16	44
		Subtotal	98	134	162	244
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	38	38	364	644
	Total County Conservation Savings		803	1,087	1,389	2,148
Murray	Public Supply Residential	Passive	278	350	278	350
		Metering	92	117	138	175
		Leak Detection	46	59	96	122
		Conservation Rates	0	0	27	35
		Education Programs	54	68	90	113
		High Efficiency Plumbing Standards	0	0	38	89
		Subtotal	470	593	667	884
	Public Supply Non-Residential	Passive	53	66	53	66
		Metering	37	47	55	70
		Leak Detection	19	23	39	49
		Education Programs	0	0	22	27
		High Efficiency Plumbing Standards	0	0	19	48
		Subtotal	108	136	187	260
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	18	42	137	138
	Total County Conservation Savings		597	772	991	1,282

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Muskogee	Public Supply Residential	Passive	1,206	1,297	1,206	1,297
		Metering	175	188	314	337
		Leak Detection	0	0	0	0
		Conservation Rates	97	105	237	254
		Education Programs	179	193	299	322
		High Efficiency Plumbing Standards	0	0	167	331
		Subtotal	1,658	1,783	2,223	2,542
	Public Supply Non-Residential	Passive	270	291	270	291
		Metering	99	106	178	191
		Leak Detection	0	0	0	0
		Education Programs	0	0	102	109
		High Efficiency Plumbing Standards	0	0	98	210
		Subtotal	369	397	647	801
	Self Supply Residential	Passive	129	138	129	138
		Education Programs	0	0	18	20
		High Efficiency Plumbing Standards	0	0	18	35
		Subtotal	129	138	165	193
	Irrigated Agriculture	Irrigation Savings	466	466	40	91
	Total County Conservation Savings		2,622	2,784	3,074	3,627
Noble	Public Supply Residential	Passive	188	202	188	202
		Metering	5	6	26	28
		Leak Detection	11	12	33	36
		Conservation Rates	5	5	25	27
		Education Programs	30	32	50	54
		High Efficiency Plumbing Standards	0	0	26	52
		Subtotal	240	258	348	398
	Public Supply Non-Residential	Passive	41	44	41	44
		Metering	4	5	21	22
		Leak Detection	9	10	27	29
		Education Programs	0	0	24	26
		High Efficiency Plumbing Standards	0	0	15	32
		Subtotal	55	59	128	154
	Self Supply Residential	Passive	30	32	30	32
		Education Programs	0	0	4	4
		High Efficiency Plumbing Standards	0	0	4	8
		Subtotal	30	32	38	45
	Irrigated Agriculture	Irrigation Savings	68	68	1,599	1,599
	Total County Conservation Savings		392	417	2,113	2,195

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Nowata	Public Supply Residential	Passive	235	318	235	318
		Metering	54	73	76	103
		Leak Detection	38	51	62	83
		Conservation Rates	22	30	45	60
		Education Programs	30	40	50	67
		High Efficiency Plumbing Standards	0	0	32	81
		Subtotal	379	513	499	713
	Public Supply Non-Residential	Passive	19	25	19	25
		Metering	14	20	20	28
		Leak Detection	10	14	17	22
		Education Programs	0	0	8	11
		High Efficiency Plumbing Standards	0	0	7	18
		Subtotal	43	58	70	104
	Self Supply Residential	Passive	16	22	16	22
		Education Programs	0	0	2	2
		High Efficiency Plumbing Standards	0	0	2	6
		Subtotal	16	22	20	30
	Irrigated Agriculture	Irrigation Savings	34	64	357	357
	Total County Conservation Savings		473	657	947	1,204
Okfuskee	Public Supply Residential	Passive	187	202	187	202
		Metering	0	0	0	0
		Leak Detection	37	40	60	65
		Conservation Rates	0	0	14	15
		Education Programs	33	35	54	59
		High Efficiency Plumbing Standards	0	0	26	51
		Subtotal	256	277	341	392
	Public Supply Non-Residential	Passive	22	24	22	24
		Metering	0	0	0	0
		Leak Detection	14	15	23	25
		Education Programs	0	0	12	13
		High Efficiency Plumbing Standards	0	0	8	17
		Subtotal	36	39	65	79
	Self Supply Residential	Passive	20	22	20	22
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	3	6
		Subtotal	20	22	26	31
	Irrigated Agriculture	Irrigation Savings	126	158	234	435
	Total County Conservation Savings		438	495	665	936

County	Sector	Conservation Activity	Scenario I Savings (AFY)		Scenario II Savings (AFY)	
			2030	2060	2030	2060
Oklahoma	Public Supply Residential	Passive	13,907	14,920	13,907	14,920
		Metering	0	0	69	74
		Leak Detection	1,047	1,124	2,529	2,714
		Conservation Rates	1,540	1,652	2,895	3,106
		Education Programs	1,805	1,936	3,008	3,227
		High Efficiency Plumbing Standards	0	0	1,921	3,807
		Subtotal	18,299	19,632	24,329	27,849
	Public Supply Non-Residential	Passive	4,089	4,387	4,089	4,387
		Metering	0	0	70	75
		Leak Detection	1,064	1,142	2,571	2,758
		Education Programs	0	0	1,834	1,968
		High Efficiency Plumbing Standards	0	0	1,477	3,169
		Subtotal	5,153	5,529	10,041	12,357
	Self Supply Residential	Passive	284	305	284	305
		Education Programs	0	0	32	34
		High Efficiency Plumbing Standards	0	0	39	78
		Subtotal	284	305	355	417
	Irrigated Agriculture	Irrigation Savings	302	302	736	921
	Total County Conservation Savings		24,038	25,768	35,460	41,543
Okmulgee	Public Supply Residential	Passive	792	934	792	934
		Metering	77	90	290	342
		Leak Detection	363	428	592	698
		Conservation Rates	133	157	347	409
		Education Programs	190	224	316	373
		High Efficiency Plumbing Standards	0	0	109	238
		Subtotal	1,555	1,834	2,445	2,994
	Public Supply Non-Residential	Passive	98	115	98	115
		Metering	13	15	48	57
		Leak Detection	60	71	98	115
		Education Programs	0	0	31	37
		High Efficiency Plumbing Standards	0	0	35	83
		Subtotal	170	201	310	408
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	59	59	551	551
	Total County Conservation Savings		1,784	2,094	3,306	3,952

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Osage	Public Supply Residential	Passive	757	859	757	859
		Metering	589	669	741	841
		Leak Detection	258	293	420	477
		Conservation Rates	34	39	185	210
		Education Programs	124	141	207	234
		High Efficiency Plumbing Standards	0	0	104	219
		Subtotal	1,762	2,000	2,414	2,840
	Public Supply Non-Residential	Passive	58	66	58	66
		Metering	102	116	128	145
		Leak Detection	45	51	73	83
		Education Programs	0	0	21	24
		High Efficiency Plumbing Standards	0	0	21	48
		Subtotal	205	232	301	366
	Self Supply Residential	Passive	132	150	132	150
		Education Programs	0	0	18	21
		High Efficiency Plumbing Standards	0	0	18	38
		Subtotal	132	150	169	209
	Irrigated Agriculture	Irrigation Savings	47	72	343	343
	Total County Conservation Savings		2,146	2,454	3,227	3,758
Ottawa	Public Supply Residential	Passive	520	621	520	621
		Metering	517	618	585	699
		Leak Detection	116	138	189	226
		Conservation Rates	0	0	6	7
		Education Programs	102	122	170	203
		High Efficiency Plumbing Standards	0	0	71	158
		Subtotal	1,255	1,499	1,541	1,914
	Public Supply Non-Residential	Passive	112	134	112	134
		Metering	383	458	434	518
		Leak Detection	86	103	140	167
		Education Programs	0	0	76	90
		High Efficiency Plumbing Standards	0	0	41	97
		Subtotal	582	695	802	1,007
	Self Supply Residential	Passive	143	170	143	170
		Education Programs	0	0	24	28
		High Efficiency Plumbing Standards	0	0	20	43
		Subtotal	143	170	186	242
	Irrigated Agriculture	Irrigation Savings	33	44	148	228
	Total County Conservation Savings		2,012	2,408	2,677	3,391

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Pawnee	Public Supply Residential	Passive	250	317	250	317
		Metering	26	32	70	88
		Leak Detection	75	95	122	155
		Conservation Rates	48	61	92	117
		Education Programs	66	84	110	139
		High Efficiency Plumbing Standards	0	0	34	81
		Subtotal	465	589	677	897
	Public Supply Non-Residential	Passive	35	44	35	44
		Metering	7	9	20	25
		Leak Detection	21	27	34	44
		Education Programs	0	0	19	24
		High Efficiency Plumbing Standards	0	0	12	32
		Subtotal	63	80	120	168
	Self Supply Residential	Passive	99	125	99	125
		Education Programs	0	0	22	28
		High Efficiency Plumbing Standards	0	0	13	32
		Subtotal	99	125	134	185
	Irrigated Agriculture	Irrigation Savings	10	18	108	144
	Total County Conservation Savings		636	812	1,039	1,393
Payne	Public Supply Residential	Passive	1,651	1,918	1,651	1,918
		Metering	0	0	0	0
		Leak Detection	283	328	461	535
		Conservation Rates	145	169	311	362
		Education Programs	63	73	104	121
		High Efficiency Plumbing Standards	0	0	225	489
		Subtotal	2,142	2,488	2,752	3,426
	Public Supply Non-Residential	Passive	343	399	343	399
		Metering	0	0	0	0
		Leak Detection	217	253	354	412
		Education Programs	0	0	48	56
		High Efficiency Plumbing Standards	0	0	124	288
		Subtotal	561	651	870	1,154
	Self Supply Residential	Passive	182	211	182	211
		Education Programs	0	0	6	7
		High Efficiency Plumbing Standards	0	0	25	54
		Subtotal	182	211	212	272
	Irrigated Agriculture	Irrigation Savings	75	76	10	18
	Total County Conservation Savings		2,958	3,426	3,844	4,869

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Pittsburg	Public Supply Residential	Passive	898	1,027	898	1,027
		Metering	0	0	74	84
		Leak Detection	196	224	319	365
		Conservation Rates	94	107	208	238
		Education Programs	142	162	236	270
		High Efficiency Plumbing Standards	0	0	124	262
		Subtotal	1,328	1,520	1,858	2,247
	Public Supply Non-Residential	Passive	162	185	162	185
		Metering	0	0	44	50
		Leak Detection	116	133	190	217
		Education Programs	0	0	84	96
		High Efficiency Plumbing Standards	0	0	59	134
		Subtotal	278	319	538	683
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	173	208	157	159
	Total County Conservation Savings		1,780	2,046	2,553	3,088
Pontotoc	Public Supply Residential	Passive	608	665	608	665
		Metering	0	0	53	58
		Leak Detection	0	0	52	57
		Conservation Rates	49	53	127	139
		Education Programs	113	124	189	207
		High Efficiency Plumbing Standards	0	0	84	170
		Subtotal	770	843	1,113	1,296
	Public Supply Non-Residential	Passive	178	195	178	195
		Metering	0	0	36	40
		Leak Detection	0	0	35	39
		Education Programs	0	0	77	85
		High Efficiency Plumbing Standards	0	0	64	141
		Subtotal	178	195	391	499
	Self Supply Residential	Passive	107	118	107	118
		Education Programs	0	0	18	19
		High Efficiency Plumbing Standards	0	0	15	30
		Subtotal	107	118	140	167
	Irrigated Agriculture	Irrigation Savings	177	305	609	730
	Total County Conservation Savings		1,233	1,461	2,252	2,692

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Pottawatomie	Public Supply Residential	Passive	959	1,115	959	1,115
		Metering	507	590	580	674
		Leak Detection	0	0	0	0
		Conservation Rates	0	0	0	0
		Education Programs	35	41	59	68
		High Efficiency Plumbing Standards	0	0	132	285
		Subtotal	1,502	1,746	1,729	2,142
	Public Supply Non-Residential	Passive	201	234	201	234
		Metering	454	528	518	603
		Leak Detection	0	0	0	0
		Education Programs	0	0	32	37
		High Efficiency Plumbing Standards	0	0	73	169
		Subtotal	655	761	824	1,042
	Self Supply Residential	Passive	414	482	414	482
		Education Programs	0	0	14	16
		High Efficiency Plumbing Standards	0	0	57	123
		Subtotal	414	482	485	621
	Irrigated Agriculture	Irrigation Savings	147	202	831	1,432
	Total County Conservation Savings		2,718	3,191	3,869	5,237
Pushmataha	Public Supply Residential	Passive	238	318	238	318
		Metering	62	84	80	107
		Leak Detection	29	39	48	64
		Conservation Rates	4	6	22	29
		Education Programs	11	15	19	25
		High Efficiency Plumbing Standards	0	0	32	81
		Subtotal	346	462	438	625
	Public Supply Non-Residential	Passive	33	44	33	44
		Metering	37	49	47	63
		Leak Detection	17	23	28	38
		Education Programs	0	0	7	9
		High Efficiency Plumbing Standards	0	0	12	32
		Subtotal	87	116	126	184
	Self Supply Residential	Passive	36	48	36	48
		Education Programs	0	0	1	2
		High Efficiency Plumbing Standards	0	0	5	12
		Subtotal	36	48	43	63
	Irrigated Agriculture	Irrigation Savings	46	46	496	682
	Total County Conservation Savings		514	673	1,103	1,554

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Roger Mills	Public Supply Residential	Passive	48	48	48	48
		Metering	6	6	15	15
		Leak Detection	16	16	26	26
		Conservation Rates	0	0	1	1
		Education Programs	8	8	14	14
		High Efficiency Plumbing Standards	0	0	7	12
		Subtotal	78	78	111	116
	Public Supply Non-Residential	Passive	8	8	8	8
		Metering	2	2	5	5
		Leak Detection	5	5	9	9
		Education Programs	0	0	3	3
		High Efficiency Plumbing Standards	0	0	3	5
		Subtotal	15	15	26	29
	Self Supply Residential	Passive	13	13	13	13
		Education Programs	0	0	2	2
		High Efficiency Plumbing Standards	0	0	2	3
		Subtotal	13	13	16	18
	Irrigated Agriculture	Irrigation Savings	391	393	260	264
	Total County Conservation Savings		497	499	414	427
Rogers	Public Supply Residential	Passive	1,603	1,998	1,603	1,998
		Metering	161	200	400	499
		Leak Detection	315	393	575	717
		Conservation Rates	106	132	345	430
		Education Programs	226	281	376	469
		High Efficiency Plumbing Standards	0	0	217	510
		Subtotal	2,410	3,005	3,517	4,624
	Public Supply Non-Residential	Passive	240	300	240	300
		Metering	57	71	141	176
		Leak Detection	111	139	203	253
		Education Programs	0	0	80	99
		High Efficiency Plumbing Standards	0	0	87	216
		Subtotal	408	509	751	1,044
	Self Supply Residential	Passive	115	144	115	144
		Education Programs	0	0	14	17
		High Efficiency Plumbing Standards	0	0	16	37
		Subtotal	115	144	145	198
	Irrigated Agriculture	Irrigation Savings	98	120	3,320	3,336
	Total County Conservation Savings		3,032	3,778	7,733	9,202

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Seminole	Public Supply Residential	Passive	373	405	373	405
		Metering	0	0	0	0
		Leak Detection	48	53	79	86
		Conservation Rates	14	16	43	46
		Education Programs	33	36	56	60
		High Efficiency Plumbing Standards	0	0	52	103
		Subtotal	469	509	601	700
	Public Supply Non-Residential	Passive	71	77	71	77
		Metering	0	0	0	0
		Leak Detection	54	59	88	95
		Education Programs	0	0	37	40
		High Efficiency Plumbing Standards	0	0	26	56
		Subtotal	125	136	222	269
	Self Supply Residential	Passive	73	80	73	80
		Education Programs	0	0	6	6
		High Efficiency Plumbing Standards	0	0	10	20
		Subtotal	73	80	89	106
	Irrigated Agriculture	Irrigation Savings	103	146	221	269
	Total County Conservation Savings		770	870	1,133	1,345
Sequoyah	Public Supply Residential	Passive	844	1,055	844	1,055
		Metering	375	468	520	649
		Leak Detection	247	308	402	502
		Conservation Rates	94	118	239	299
		Education Programs	183	229	306	382
		High Efficiency Plumbing Standards	0	0	115	269
		Subtotal	1,744	2,178	2,426	3,156
	Public Supply Non-Residential	Passive	94	118	94	118
		Metering	85	106	118	148
		Leak Detection	56	70	91	114
		Education Programs	0	0	42	52
		High Efficiency Plumbing Standards	0	0	34	85
		Subtotal	236	294	380	517
	Self Supply Residential	Passive	17	22	17	22
		Education Programs	0	0	3	4
		High Efficiency Plumbing Standards	0	0	2	5
		Subtotal	17	22	23	31
	Irrigated Agriculture	Irrigation Savings	97	111	538	764
	Total County Conservation Savings		2,093	2,605	3,366	4,468

County	Sub-Sector	Conservation Activity	Scenario I 2030	Scenario I 2060	Scenario II 2030	Scenario II 2060
Stephens	Public Supply Residential	Passive	674	706	674	706
		Metering	0	0	28	30
		Leak Detection	189	198	308	323
		Conservation Rates	66	69	177	185
		Education Programs	149	156	249	261
		High Efficiency Plumbing Standards	0	0	94	180
		Subtotal	1,079	1,130	1,531	1,686
	Public Supply Non-Residential	Passive	142	149	142	149
		Metering	0	0	17	18
		Leak Detection	113	119	184	193
		Education Programs	0	0	89	93
		High Efficiency Plumbing Standards	0	0	51	108
		Subtotal	255	268	484	561
	Self Supply Residential	Passive	122	127	122	127
		Education Programs	0	0	23	24
		High Efficiency Plumbing Standards	0	0	17	33
		Subtotal	122	127	161	184
	Irrigated Agriculture	Irrigation Savings	198	309	1,002	1,564
	Total County Conservation Savings		1,654	1,834	3,178	3,994
Texas	Public Supply Residential	Passive	446	667	446	667
		Metering	0	0	0	0
		Leak Detection	146	219	239	357
		Conservation Rates	65	97	151	226
		Education Programs	17	25	28	42
		High Efficiency Plumbing Standards	0	0	58	170
		Subtotal	675	1,009	923	1,462
	Public Supply Non-Residential	Passive	73	109	73	109
		Metering	0	0	0	0
		Leak Detection	42	62	68	101
		Education Programs	0	0	5	7
		High Efficiency Plumbing Standards	0	0	26	79
		Subtotal	115	171	172	297
	Self Supply Residential	Passive	67	100	67	100
		Education Programs	0	0	2	3
		High Efficiency Plumbing Standards	0	0	9	25
		Subtotal	67	100	77	128
	Irrigated Agriculture	Irrigation Savings	10,803	11,017	43,868	44,736
	Total County Conservation Savings		11,659	12,296	45,040	46,623

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Tillman	Public Supply Residential	Passive	138	148	138	148
		Metering	15	16	36	39
		Leak Detection	15	16	38	41
		Conservation Rates	0	0	2	2
		Education Programs	32	34	53	57
		High Efficiency Plumbing Standards	0	0	19	38
		Subtotal	199	214	286	324
	Public Supply Non-Residential	Passive	20	22	20	22
		Metering	5	5	12	13
		Leak Detection	5	5	12	13
		Education Programs	0	0	10	11
		High Efficiency Plumbing Standards	0	0	7	16
		Subtotal	30	32	63	75
	Self Supply Residential	Passive	12	13	12	13
		Education Programs	0	0	2	3
		High Efficiency Plumbing Standards	0	0	2	3
		Subtotal	12	13	17	19
	Irrigated Agriculture	Irrigation Savings	1,533	1,594	43,868	44,736
	Total County Conservation Savings		1,775	1,854	44,233	45,155
Tulsa	Public Supply Residential	Passive	11,644	12,487	11,644	12,487
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Conservation Rates	0	0	1,015	1,089
		Education Programs	616	660	1,026	1,100
		High Efficiency Plumbing Standards	0	0	1,607	3,186
		Subtotal	12,259	13,147	15,292	17,862
	Public Supply Non-Residential	Passive	3,314	3,554	3,314	3,554
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Education Programs	0	0	428	459
		High Efficiency Plumbing Standards	0	0	1,197	2,567
		Subtotal	3,314	3,554	4,939	6,580
	Self Supply Residential	Passive	181	194	181	194
		Education Programs	0	0	9	9
		High Efficiency Plumbing Standards	0	0	25	49
		Subtotal	181	194	214	253
	Irrigated Agriculture	Irrigation Savings	445	487	2,444	2,541
	Total County Conservation Savings		16,199	17,382	22,889	27,237

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Wagoner	Public Supply Residential	Passive	1,360	1,661	1,360	1,661
		Metering	119	146	298	364
		Leak Detection	305	373	497	608
		Conservation Rates	61	75	240	293
		Education Programs	83	101	138	169
		High Efficiency Plumbing Standards	0	0	185	424
		Subtotal	1,928	2,355	2,719	3,519
	Public Supply Non-Residential	Passive	68	83	68	83
		Metering	16	19	39	48
		Leak Detection	40	49	66	80
		Education Programs	0	0	11	13
		High Efficiency Plumbing Standards	0	0	25	60
		Subtotal	124	152	209	285
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	466	466	531	581
	Total County Conservation Savings		2,519	2,973	3,459	4,386
Washington	Public Supply Residential	Passive	946	987	946	987
		Metering	75	79	233	243
		Leak Detection	269	280	438	457
		Conservation Rates	158	164	315	329
		Education Programs	26	27	43	45
		High Efficiency Plumbing Standards	0	0	132	252
		Subtotal	1,474	1,538	2,109	2,313
	Public Supply Non-Residential	Passive	183	191	183	191
		Metering	44	46	136	142
		Leak Detection	157	164	256	267
		Education Programs	0	0	15	16
		High Efficiency Plumbing Standards	0	0	66	138
		Subtotal	384	400	656	753
	Self Supply Residential	Passive	0	0	0	0
		Education Programs	0	0	0	0
		High Efficiency Plumbing Standards	0	0	0	0
		Subtotal	0	0	0	0
	Irrigated Agriculture	Irrigation Savings	48	73	1,326	1,326
	Total County Conservation Savings		1,906	2,011	4,091	4,392

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Washita	Public Supply Residential	Passive	178	188	178	188
		Metering	32	34	47	50
		Leak Detection	0	0	11	12
		Conservation Rates	0	0	12	13
		Education Programs	12	12	20	21
		High Efficiency Plumbing Standards	0	0	25	48
		Subtotal	222	234	293	331
	Public Supply Non-Residential	Passive	22	23	22	23
		Metering	19	20	28	30
		Leak Detection	0	0	7	7
		Education Programs	0	0	7	7
		High Efficiency Plumbing Standards	0	0	8	17
		Subtotal	41	43	71	84
	Self Supply Residential	Passive	41	44	41	44
		Education Programs	0	0	2	3
		High Efficiency Plumbing Standards	0	0	6	11
		Subtotal	41	44	49	57
	Irrigated Agriculture	Irrigation Savings	310	346	218	328
	Total County Conservation Savings		613	667	632	801
Woods	Public Supply Residential	Passive	146	153	146	153
		Metering	493	514	548	571
		Leak Detection	93	97	152	159
		Conservation Rates	0	0	12	13
		Education Programs	59	61	98	102
		High Efficiency Plumbing Standards	0	0	20	39
		Subtotal	791	825	976	1,036
	Public Supply Non-Residential	Passive	29	30	29	30
		Metering	87	91	97	101
		Leak Detection	17	17	27	28
		Education Programs	0	0	10	11
		High Efficiency Plumbing Standards	0	0	11	22
		Subtotal	133	139	174	192
	Self Supply Residential	Passive	23	24	23	24
		Education Programs	0	0	8	8
		High Efficiency Plumbing Standards	0	0	3	6
		Subtotal	23	24	33	37
	Irrigated Agriculture	Irrigation Savings	210	247	830	929
	Total County Conservation Savings		1,157	1,234	2,013	2,194

County	Sector	Conservation Activity	Scenario I Savings (AFY) 2030	Scenario I Savings (AFY) 2060	Scenario II Savings (AFY) 2030	Scenario II Savings (AFY) 2060
Woodward	Public Supply Residential	Passive	308	327	308	327
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Conservation Rates	79	84	157	167
		Education Programs	23	24	38	41
		High Efficiency Plumbing Standards	0	0	43	83
		Subtotal	409	435	546	618
	Public Supply Non-Residential	Passive	89	95	89	95
		Metering	0	0	0	0
		Leak Detection	0	0	0	0
		Education Programs	0	0	13	14
		High Efficiency Plumbing Standards	0	0	32	69
		Subtotal	89	95	135	178
	Self Supply Residential	Passive	67	72	67	72
		Education Programs	0	0	5	5
		High Efficiency Plumbing Standards	0	0	9	18
		Subtotal	67	72	81	95
	Irrigated Agriculture	Irrigation Savings	423	423	1,364	1,598
	Total County Conservation Savings		989	1,025	2,126	2,489

Appendix B
County Water Demands in AFY for Baseline (No Conservation), Conservation Scenario I and Conservation Scenario II

Table B1: Public Supplied M&I and Self Supplied Residential in AFY

County	Baseline Demands		Scenario I Demands		Scenario II Demands	
	2030	2060	2030	2060	2030	2060
Adair	3,535	4,878	2,511	3,465	2,250	2,995
Alfalfa	997	1,031	857	886	803	813
Atoka	4,435	5,837	3,793	4,991	3,529	4,568
Beaver	1,114	1,169	999	1,048	964	994
Beckham	5,941	7,403	5,315	6,622	5,057	6,198
Blaine	3,142	3,922	2,475	3,090	2,301	2,819
Bryan	10,244	12,951	9,026	11,412	8,405	10,430
Caddo	5,121	5,570	4,295	4,671	3,992	4,248
Canadian	18,000	20,884	13,290	15,419	11,992	13,531
Carter	10,073	11,672	8,614	9,981	7,948	8,990
Cherokee	9,762	13,096	7,992	10,721	7,134	9,319
Choctaw	2,008	2,156	1,586	1,703	1,428	1,481
Cimarron	1,074	1,136	974	1,029	923	966
Cleveland	44,312	48,785	37,413	41,190	35,112	37,750
Coal	1,004	1,412	827	1,164	771	1,056
Comanche	18,934	20,613	12,657	13,779	11,199	11,729
Cotton	821	869	552	584	474	482
Craig	2,824	3,643	2,570	3,316	2,350	2,999
Creek	10,002	11,412	7,991	9,117	7,097	7,853
Custer	6,340	6,948	5,102	5,591	4,517	4,841
Delaware	6,676	9,147	5,060	6,932	4,450	5,893
Dewey	1,403	1,465	1,257	1,313	1,142	1,179
Ellis	991	991	867	867	802	791
Garfield	13,247	14,052	11,254	11,938	10,509	10,923
Garvin	5,503	5,829	4,609	4,882	4,151	4,303
Grady	7,210	8,279	5,726	6,575	5,096	5,664
Grant	833	880	695	734	622	643
Greer	1,049	1,103	881	926	820	843
Harmon	821	894	711	774	652	700
Harper	1,240	1,277	1,048	1,079	962	979
Haskell	2,241	3,049	1,806	2,458	1,657	2,183
Hughes	2,284	3,005	1,581	2,081	1,352	1,716
Jackson	5,254	5,726	4,339	4,729	3,869	4,112
Jefferson	819	879	528	567	459	474
Johnston	2,211	2,943	1,591	2,118	1,398	1,808
Kay	8,470	9,071	5,934	6,356	5,178	5,365
Kingfisher	4,212	5,460	3,677	4,766	3,402	4,334
Kiowa	1,287	1,351	1,018	1,069	907	923
Latimer	2,717	3,212	2,305	2,724	2,098	2,434
Le Flore	8,134	9,648	6,133	7,275	5,367	6,175
Lincoln	4,367	5,286	3,375	4,085	3,000	3,506
Logan	7,664	9,748	5,806	7,386	5,215	6,479
Love	5,534	6,592	4,066	4,844	3,606	4,193
Major	1,222	1,271	964	1,002	882	894

Table B1: Public Supplied M&I and Self Supplied Residential in AFY

County	Baseline Demands		Scenario I Demands		Scenario II Demands	
	2030	2060	2030	2060	2030	2060
Marshall	4,422	6,722	3,666	5,573	3,309	4,909
Mayes	6,526	8,200	5,069	6,369	4,440	5,402
McClain	6,478	8,831	5,243	7,147	4,766	6,338
McCurtain	5,445	5,926	4,067	4,426	3,647	3,851
McIntosh	3,066	4,202	2,301	3,153	2,041	2,698
Murray	3,216	4,059	2,638	3,329	2,362	2,915
Muskogee	11,604	12,480	9,448	10,162	8,569	8,944
Noble	1,953	2,104	1,629	1,755	1,440	1,507
Nowata	1,477	1,995	1,038	1,402	887	1,148
Okfuskee	1,597	1,725	1,285	1,387	1,165	1,224
Oklahoma	137,812	147,856	114,076	122,390	103,087	107,234
Okmulgee	12,415	14,645	10,690	12,610	9,660	11,243
Osage	9,997	11,345	7,899	8,964	7,113	7,930
Ottawa	6,711	8,016	4,732	5,652	4,182	4,853
Pawnee	3,555	4,508	2,929	3,714	2,623	3,258
Payne	15,446	17,946	12,563	14,596	11,612	13,095
Pittsburg	9,150	10,471	7,543	8,632	6,754	7,541
Pontotoc	7,211	7,895	6,155	6,739	5,567	5,933
Pottawatomie	8,297	9,647	5,726	6,658	5,259	5,841
Pushmataha	1,483	1,983	1,015	1,357	876	1,112
Roger Mills	730	730	624	624	576	567
Rogers	16,952	21,134	14,018	17,476	12,539	15,268
Seminole	3,240	3,519	2,573	2,795	2,328	2,444
Sequoyah	9,012	11,256	7,015	8,762	6,184	7,552
Stephens	9,717	10,183	8,261	8,657	7,540	7,752
Texas	6,058	9,056	5,202	7,776	4,886	7,169
Tillman	1,501	1,610	1,259	1,351	1,135	1,191
Tulsa	122,528	131,403	106,774	114,508	102,082	106,708
Wagoner	10,137	12,383	8,085	9,875	7,209	8,578
Washington	12,486	13,021	10,627	11,083	9,721	9,955
Washita	1,331	1,405	1,027	1,084	917	933
Woods	3,582	3,737	2,636	2,749	2,399	2,471
Woodward	6,954	7,393	6,388	6,791	6,192	6,502

Table B2: Agriculture in AFY

County	Baseline Demands 2030	Baseline Demands 2060	Scenario I Demands 2030	Scenario I Demands 2060	Scenario II Demands 2030	Scenario II Demands 2060
Adair	1,518	2,203	1,434	2,080	1,081	1,569
Alfalfa	5,940	7,285	5,610	6,881	4,420	5,421
Atoka	1,666	2,339	1,573	2,209	1,128	1,585
Beaver	34,538	37,383	32,715	35,409	24,303	26,305
Beckham	8,718	8,718	8,234	8,234	7,537	7,537
Blaine	6,517	6,517	6,155	6,155	5,831	5,831
Bryan	17,536	18,178	16,562	17,169	15,808	16,387
Caddo	37,078	45,228	35,027	42,726	31,549	38,484
Canadian	6,818	7,482	6,443	7,071	5,633	6,181
Carter	2,812	2,918	2,656	2,756	2,473	2,566
Cherokee	1,644	1,859	1,553	1,755	1,176	1,330
Choctaw	1,154	1,597	1,090	1,508	812	1,124
Cimarron	73,517	90,606	69,503	85,658	55,848	68,830
Cleveland	1,571	2,178	1,488	2,063	1,403	1,946
Coal	643	650	607	614	474	480
Comanche	3,089	3,688	2,918	3,483	2,495	2,979
Cotton	793	1,110	750	1,050	737	1,033
Craig	1,128	2,599	1,065	2,455	834	1,922
Creek	433	560	409	529	356	460
Custer	4,957	5,232	4,691	4,951	4,179	4,410
Delaware	949	949	897	897	682	682
Dewey	4,752	4,752	4,488	4,488	3,823	3,823
Ellis	27,870	35,263	26,343	33,331	16,691	21,118
Garfield	6,029	6,029	5,956	5,956	4,886	4,886
Garvin	2,298	3,734	2,186	3,552	1,962	3,189
Grady	11,291	11,291	10,664	10,664	9,634	9,634
Grant	1,801	1,801	1,701	1,701	1,461	1,461
Greer	10,445	17,016	9,892	16,116	8,254	13,447
Harmon	27,927	30,137	23,734	25,611	22,282	24,045
Harper	11,759	13,813	11,152	13,100	7,048	8,278
Haskell	3,006	3,633	2,839	3,431	2,097	2,533
Hughes	5,360	8,474	5,063	8,003	3,930	6,212
Jackson	105,813	111,960	84,866	89,796	83,255	88,090
Jefferson	427	523	407	498	396	485
Johnston	2,344	3,662	2,234	3,491	1,876	2,932
Kay	4,690	4,690	4,435	4,435	4,238	4,238
Kingfisher	8,716	9,902	8,232	9,351	6,729	7,643
Kiowa	4,813	5,190	4,173	4,499	3,508	3,782
Latimer	1,846	3,344	1,744	3,158	1,278	2,315
Le Flore	9,985	9,985	9,788	9,788	9,009	9,009
Lincoln	3,575	3,575	3,376	3,376	2,533	2,533
Logan	1,991	1,991	1,880	1,880	1,519	1,519
Love	3,695	5,133	3,490	4,848	3,041	4,223
Major	13,122	13,254	12,396	12,522	10,342	10,447

Table B2: Agriculture in AFY

County	Baseline Demands		Scenario I Demands		Scenario II Demands	
	2030	2060	2030	2060	2030	2060
Marshall	4,952	5,397	4,698	5,119	4,621	5,036
Mayes	1,411	1,735	1,333	1,639	1,002	1,231
McClain	2,969	3,120	2,806	2,949	2,662	2,798
McCurtain	1,756	3,105	1,756	3,105	1,391	2,460
McIntosh	685	690	647	652	548	552
Murray	332	765	314	722	292	674
Muskogee	8,882	8,882	8,416	8,416	7,284	7,284
Noble	1,223	1,223	1,155	1,155	865	865
Nowata	616	1,148	581	1,084	382	712
Okfuskee	2,267	2,836	2,141	2,679	1,531	1,916
Oklahoma	5,537	5,537	5,235	5,235	4,986	4,986
Okmulgee	1,250	1,250	1,191	1,191	907	907
Osage	843	1,302	797	1,229	696	1,073
Ottawa	598	795	565	751	490	652
Pawnee	179	317	169	299	169	299
Payne	1,344	1,360	1,269	1,284	1,187	1,201
Pittsburg	3,299	3,958	3,126	3,751	2,690	3,228
Pontotoc	3,284	5,657	3,107	5,352	2,453	4,225
Pottawatomie	2,639	3,628	2,492	3,426	2,143	2,946
Pushmataha	824	836	778	790	563	572
Roger Mills	9,296	9,342	8,905	8,949	5,976	6,006
Rogers	1,769	2,160	1,671	2,040	1,549	1,890
Seminole	1,847	2,624	1,744	2,478	1,309	1,860
Sequoyah	2,465	2,832	2,369	2,721	2,063	2,370
Stephens	3,564	5,564	3,366	5,255	2,563	4,000
Texas	202,385	206,393	191,583	195,377	158,518	161,657
Tillman	18,661	19,408	17,128	17,813	16,217	16,866
Tulsa	8,012	8,775	7,567	8,287	7,481	8,193
Wagoner	8,392	8,392	7,926	7,926	7,065	7,065
Washington	867	1,306	819	1,234	649	978
Washita	5,571	6,234	5,262	5,888	4,741	5,305
Woods	3,787	4,439	3,577	4,192	2,423	2,840
Woodward	8,026	8,026	7,602	7,602	5,370	5,370

Table B3: Combined Public Supplied M&I, Self Supplied Residential, and Agriculture in AFY

County	Baseline Demands		Scenario I Demands		Scenario II Demands	
	2030	2060	2030	2060	2030	2060
Adair	5,054	7,081	3,945	5,545	3,331	4,564
Alfalfa	6,938	8,317	6,467	7,767	5,223	6,234
Atoka	6,101	8,176	5,366	7,201	4,657	6,153
Beaver	35,652	38,551	33,714	36,458	25,267	27,299
Beckham	14,659	16,121	13,548	14,856	12,594	13,735
Blaine	9,658	10,439	8,630	9,244	8,132	8,650
Bryan	27,781	31,130	25,588	28,580	24,213	26,817
Caddo	42,198	50,797	39,321	47,397	35,541	42,733
Canadian	24,818	28,366	19,733	22,490	17,624	19,712
Carter	12,885	14,590	11,270	12,737	10,421	11,556
Cherokee	11,406	14,955	9,544	12,476	8,310	10,649
Choctaw	3,162	3,753	2,676	3,211	2,240	2,605
Cimarron	74,591	91,742	70,476	86,688	56,771	69,796
Cleveland	45,883	50,964	38,901	43,253	36,515	39,696
Coal	1,646	2,062	1,434	1,778	1,245	1,536
Comanche	22,024	24,301	15,575	17,262	13,694	14,708
Cotton	1,614	1,979	1,301	1,634	1,211	1,515
Craig	3,952	6,242	3,635	5,771	3,184	4,922
Creek	10,435	11,971	8,400	9,646	7,454	8,314
Custer	11,296	12,180	9,793	10,543	8,695	9,252
Delaware	7,626	10,097	5,956	7,829	5,132	6,575
Dewey	6,154	6,217	5,744	5,800	4,965	5,002
Ellis	28,861	36,254	27,209	34,198	17,493	21,909
Garfield	19,276	20,082	17,210	17,894	15,395	15,808
Garvin	7,801	9,564	6,795	8,434	6,113	7,491
Grady	18,501	19,570	16,391	17,240	14,730	15,299
Grant	2,634	2,681	2,396	2,435	2,083	2,104
Greer	11,494	18,119	10,773	17,042	9,075	14,291
Harmon	28,749	31,030	24,445	26,386	22,934	24,745
Harper	13,000	15,089	12,201	14,179	8,010	9,257
Haskell	5,248	6,682	4,646	5,888	3,753	4,716
Hughes	7,644	11,479	6,644	10,084	5,282	7,928
Jackson	111,067	117,685	89,206	94,525	87,123	92,203
Jefferson	1,246	1,402	935	1,065	855	959
Johnston	4,555	6,605	3,825	5,609	3,274	4,740
Kay	13,160	13,761	10,370	10,791	9,417	9,604
Kingfisher	12,929	15,362	11,909	14,118	10,130	11,977
Kiowa	6,101	6,541	5,191	5,568	4,415	4,704
Latimer	4,564	6,555	4,049	5,882	3,376	4,749
Le Flore	18,119	19,633	15,921	17,062	14,375	15,183
Lincoln	7,942	8,861	6,752	7,462	5,533	6,039
Logan	9,654	11,739	7,687	9,266	6,734	7,999
Love	9,229	11,725	7,556	9,691	6,646	8,416
Major	14,344	14,526	13,360	13,524	11,224	11,340

Table B3: Combined Public Supplied M&I, Self Supplied Residential, and Agriculture in AFY

County	Baseline Demands		Scenario I Demands		Scenario II Demands	
	2030	2060	2030	2060	2030	2060
Marshall	9,374	12,118	8,364	10,693	7,930	9,945
Mayes	7,938	9,935	6,402	8,008	5,441	6,634
McClain	9,447	11,951	8,049	10,096	7,428	9,136
McCurtain	7,201	9,031	5,822	7,530	5,039	6,311
McIntosh	3,752	4,892	2,948	3,805	2,589	3,250
Murray	3,548	4,824	2,951	4,052	2,654	3,589
Muskogee	20,486	21,362	17,865	18,578	15,853	16,227
Noble	3,176	3,326	2,784	2,909	2,305	2,372
Nowata	2,093	3,143	1,620	2,486	1,270	1,861
Okfuskee	3,864	4,561	3,425	4,066	2,696	3,140
Oklahoma	143,349	153,393	119,311	127,625	108,073	112,220
Okmulgee	13,666	15,895	11,882	13,801	10,568	12,150
Osage	10,841	12,647	8,695	10,193	7,809	9,004
Ottawa	7,309	8,811	5,297	6,403	4,672	5,505
Pawnee	3,734	4,825	3,098	4,014	2,793	3,558
Payne	16,790	19,306	13,832	15,880	12,799	14,296
Pittsburg	12,449	14,429	10,669	12,383	9,444	10,769
Pontotoc	10,495	13,552	9,262	12,091	8,020	10,158
Pottawatomie	10,936	13,275	8,218	10,084	7,402	8,787
Pushmataha	2,307	2,819	1,793	2,147	1,439	1,684
Roger Mills	10,026	10,072	9,529	9,573	6,553	6,572
Rogers	18,721	23,293	15,689	19,515	14,088	17,158
Seminole	5,087	6,143	4,317	5,273	3,636	4,304
Sequoyah	11,477	14,088	9,383	11,483	8,247	9,922
Stephens	13,281	15,747	11,627	13,912	10,103	11,752
Texas	208,443	215,449	196,784	203,153	163,403	168,826
Tillman	20,162	21,018	18,387	19,164	17,353	18,058
Tulsa	130,539	140,178	114,340	122,795	109,563	114,901
Wagoner	18,529	20,774	16,010	17,801	14,275	15,644
Washington	13,353	14,328	11,447	12,317	10,370	10,933
Washita	6,902	7,639	6,289	6,972	5,658	6,238
Woods	7,370	8,175	6,213	6,941	4,822	5,311
Woodward	14,980	15,419	13,990	14,394	11,563	11,873

Appendix C
Selected Climate Change Scenario Data

Table C1: Historical Average Weather Variables by County and Month

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Adair	Precip*	2.2	2.5	3.8	4.4	5.7	4.7	3.6	3.3	4.4	3.9	3.8
	Temp**	48.2	53.4	61.8	72	78.7	85.9	91.6	91.6	84	73.8	60.7
Alfalfa	Precip	0.9	1.1	2.3	2.7	4.2	4.4	3.2	3.1	3	2.6	1.7
	Temp	46.5	52.1	61.1	71.9	80.6	90.1	95.6	94.6	85.8	74.7	59.5
Atoka	Precip	2	2.4	3.5	4.4	5.5	4.5	3.2	2.7	4.5	3.8	3.2
	Temp	51.2	56.5	64.6	74	80.6	88.1	93.8	94.2	86.5	76.4	63.5
Beaver	Precip	0.5	0.8	1.6	1.7	3.3	3.4	2.7	2.6	2	1.6	1
	Temp	47.6	52.5	60.5	71.3	79.5	88.7	94.1	93	84.6	73.9	59.3
Beckham	Precip	0.8	1.1	1.8	2.2	4.5	3.8	2.3	2.5	2.8	2.6	1.4
	Temp	50.3	55.5	64.1	74.2	82.1	90.5	95.7	94.7	86.4	75.7	61.7
Blaine	Precip	0.9	1.2	2.2	2.6	4.6	4.2	2.7	2.9	3.1	2.5	1.7
	Temp	48.1	53.4	62.3	72.7	80.9	89.8	95.4	94.6	86.1	75.1	60.4
Bryan	Precip	1.9	2.3	3.4	4.1	5.3	4.5	2.9	2.6	4.4	4	2.9
	Temp	51.8	56.9	65	74.2	80.9	88.5	93.9	94.2	86.6	76.6	63.8
Caddo	Precip	1.1	1.4	2.3	2.9	5.1	4.1	2.6	2.8	3.4	3.2	1.8
	Temp	50	55.5	64.1	74	81.3	89.1	94.6	94.1	86.2	75.7	62.1
Canadian	Precip	0.9	1.2	2.2	2.6	4.8	4.2	2.5	2.8	3.2	2.8	1.7
	Temp	48.2	53.4	62.1	72.2	80.1	88.5	94.1	93.5	85.1	74.3	60.2
Carter	Precip	1.5	1.9	2.8	3.4	5.3	4.1	2.7	2.6	4	3.7	2.3
	Temp	51.6	56.9	65.2	74.6	81.4	88.9	94.5	94.7	86.8	76.6	63.4
Cherokee	Precip	2.2	2.5	3.8	4.4	5.7	4.7	3.6	3.3	4.4	3.9	3.8
	Temp	48.2	53.4	61.8	72	78.7	85.9	91.6	91.6	84	73.8	60.7
Choctaw	Precip	2.7	3.2	4	4.5	5.6	4.2	3.6	2.9	4.4	4.2	4
	Temp	53.6	58.6	66.6	75.3	82	89	94	94.6	87.4	77.6	65
Cimarron	Precip	0.4	0.5	1.1	1.3	2.7	2.7	2.7	2.5	1.7	1.1	0.7
	Temp	48.7	53.1	60.6	70.9	79.5	89.1	93.7	91.7	84	73.6	59
Cleveland	Precip	1.4	1.8	2.8	3.4	5.5	4.4	3	2.8	4	3.6	2.4
	Temp	49.8	55.3	63.8	73.6	80.4	88.1	93.9	93.9	85.8	75.5	62.1
Coal	Precip	2	2.4	3.5	4.4	5.5	4.5	3.2	2.7	4.5	3.8	3.2
	Temp	51.2	56.5	64.6	74	80.6	88.1	93.8	94.2	86.5	76.4	63.5
Comanche	Precip	1.1	1.4	2.2	2.6	5.1	4	2.4	2.6	3.3	3.1	1.8
	Temp	51	56.2	64.7	74.4	81.8	89.9	95.4	95.1	86.8	76.3	62.6

Table C1: Historical Average Weather Variables by County and Month

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Cotton	Precip	1.1	1.4	2.2	2.6	5.1	4	2.4	2.6	3.3	3.1	1.8
	Temp	51	56.2	64.7	74.4	81.8	89.9	95.4	95.1	86.8	76.3	62.6
Craig	Precip	1.9	2.1	3.4	4.1	5.6	4.7	3.4	3.3	4.4	3.8	3.4
	Temp	47.3	52.8	61.6	72	79	86.4	92.1	92.2	84.3	74	60.5
Creek	Precip	1.6	2	3.2	3.9	5.4	4.5	3.3	2.8	4.2	3.6	2.9
	Temp	48.2	53.8	62.4	72.7	79.6	87.3	93.1	93.1	85	74.9	61.4
Custer	Precip	0.9	1.1	2	2.4	4.6	3.9	2.4	2.7	2.9	2.6	1.4
	Temp	49.7	54.9	63.4	73.6	81.5	90.2	95.6	94.8	86.3	75.4	61.3
Delaware	Precip	1.8	2	3.3	3.9	5.5	4.8	3.4	3.3	4.5	3.7	3.4
	Temp	46.6	52.1	61	71.7	78.7	86.2	91.7	91.8	83.9	73.4	60
Dewey	Precip	0.7	1	1.9	2.3	4.5	3.8	2.3	2.7	2.7	2.3	1.4
	Temp	48.1	53.1	61.5	71.9	79.9	88.7	94.4	93.4	84.9	74	59.8
Ellis	Precip	0.6	0.9	1.6	1.9	3.7	3.5	2.4	2.5	2	1.8	1.1
	Temp	47.4	52.2	60.3	71.1	79	87.8	93.4	92.4	84	73.4	59.1
Garfield	Precip	1	1.4	2.5	2.9	5	4.4	3.1	3	3.7	2.9	2
	Temp	47.7	53.1	62	72.6	80.5	89	94.7	94.3	85.8	74.9	60.4
Garvin	Precip	1.5	1.9	2.8	3.4	5.3	4.1	2.7	2.6	4	3.7	2.3
	Temp	51.6	56.9	65.2	74.6	81.4	88.9	94.5	94.7	86.8	76.6	63.4
Grady	Precip	1.1	1.4	2.3	2.9	5.1	4.1	2.6	2.8	3.4	3.2	1.8
	Temp	50	55.5	64.1	74	81.3	89.1	94.6	94.1	86.2	75.7	62.1
Grant	Precip	0.9	1.1	2.3	2.7	4.2	4.4	3.2	3.1	3	2.6	1.7
	Temp	46.5	52.1	61.1	71.9	80.6	90.1	95.6	94.6	85.8	74.7	59.5
Greer	Precip	0.8	1.1	1.7	2.1	4.4	3.8	2.3	2.5	2.8	2.6	1.3
	Temp	52	57.2	66.1	76.2	83.7	91.9	96.9	95.9	87.7	77.2	63.2
Harmon	Precip	0.7	1	1.4	2.1	3.7	3.6	2.2	2.4	2.8	2.4	1.2
	Temp	53.3	58.4	67.2	77.2	84.8	93	97.6	96.6	88.3	78	64.1
Harper	Precip	0.6	0.8	1.7	2	3.6	3.6	2.7	2.8	2.2	1.7	1.1
	Temp	48	53.2	61.6	72.4	80.6	89.7	95.2	94	85.6	74.9	59.9
Haskell	Precip	2.4	2.7	3.8	4.4	5.7	4.4	3.7	2.9	4.3	3.9	4
	Temp	49.7	54.9	63.3	73.4	80.1	87.4	93	92.9	85.4	75.3	62.2
Hughes	Precip	1.9	2.3	3.5	4.2	5.6	4.4	3.5	2.9	4.5	3.8	3.2
	Temp	50.1	55.5	64	73.7	80.3	87.8	93.6	93.7	85.9	75.8	62.6

Table C1: Historical Average Weather Variables by County and Month

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Jackson	Precip	0.9	1.2	1.8	2.2	4.5	3.8	2.3	2.5	2.9	2.7	1.4
	Temp	51.4	56.6	65.3	75.2	83.1	91.6	96.7	95.6	87.3	76.7	62.8
Jefferson	Precip	1.3	1.7	2.3	2.9	4.7	3.8	2.4	2.4	3.4	3.1	1.9
	Temp	54.2	59.3	67.7	76.8	83.8	91.3	96.9	96.7	88.8	78.6	65.4
Johnston	Precip	1.8	2.2	3.1	3.8	5.1	4.3	2.6	2.4	4.1	3.8	2.6
	Temp	52.7	57.7	65.8	74.9	81.7	89.2	94.6	94.9	87.3	77.2	64.3
Kay	Precip	1	1.4	2.6	3.2	4.8	4.6	3.5	3.2	3.8	2.9	2.1
	Temp	46.2	52	61	71.9	79.7	88.2	93.9	93.4	84.9	74.2	59.5
Kingfisher	Precip	0.9	1.2	2.2	2.6	4.6	4.2	2.7	2.9	3.1	2.5	1.7
	Temp	48.1	53.4	62.3	72.7	80.9	89.8	95.4	94.6	86.1	75.1	60.4
Kiowa	Precip	0.8	1.1	1.8	2.2	4.5	3.8	2.3	2.5	2.8	2.6	1.4
	Temp	50.3	55.5	64.1	74.2	82.1	90.5	95.7	94.7	86.4	75.7	61.7
Latimer	Precip	2.7	3	4.2	4.7	6	4.3	4	3	4.4	4	4.3
	Temp	51.3	56.3	64.5	74.2	80.8	88	93.5	93.5	86	76	63.3
Le Flore	Precip	2.7	3	4.2	4.7	6	4.3	4	3	4.4	4	4.3
	Temp	51.3	56.3	64.5	74.2	80.8	88	93.5	93.5	86	76	63.3
Lincoln	Precip	1.3	1.8	2.8	3.5	5.4	4.4	3.2	2.8	4.1	3.4	2.5
	Temp	49.3	54.8	63.4	73.5	80.2	87.9	93.8	93.8	85.7	75.4	61.9
Logan	Precip	1	1.4	2.5	2.9	5	4.4	3.1	3	3.7	2.9	2
	Temp	47.7	53.1	62	72.6	80.5	89	94.7	94.3	85.8	74.9	60.4
Love	Precip	1.8	2.2	3.1	3.8	5.1	4.3	2.6	2.4	4.1	3.8	2.6
	Temp	52.7	57.7	65.8	74.9	81.7	89.2	94.6	94.9	87.3	77.2	64.3
Major	Precip	0.9	1.2	2.2	2.6	4.6	4.2	2.7	2.9	3.1	2.5	1.7
	Temp	48.1	53.4	62.3	72.7	80.9	89.8	95.4	94.6	86.1	75.1	60.4
Marshall	Precip	1.8	2.2	3.1	3.8	5.1	4.3	2.6	2.4	4.1	3.8	2.6
	Temp	52.7	57.7	65.8	74.9	81.7	89.2	94.6	94.9	87.3	77.2	64.3
Mayes	Precip	1.9	2.1	3.4	4.1	5.6	4.7	3.4	3.3	4.4	3.8	3.4
	Temp	47.3	52.8	61.6	72	79	86.4	92.1	92.2	84.3	74	60.5
McClain	Precip	1.3	1.6	2.6	3.3	5.5	4.2	2.9	2.7	3.9	3.3	2.1
	Temp	50	55.5	64	73.9	80.8	88.4	94.3	94.2	86.1	75.7	62.2
McCurtain	Precip	3.1	3.6	4.3	4.6	5.4	4	3.7	2.5	4.1	4.2	4.4
	Temp	53.9	58.8	66.7	75.2	82	89	93.6	94.2	87.3	77.6	65.2

Table C1: Historical Average Weather Variables by County and Month

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
McIntosh	Precip	1.9	2.3	3.5	4.2	5.6	4.4	3.5	2.9	4.5	3.8	3.2
	Temp	50.1	55.5	64	73.7	80.3	87.8	93.6	93.7	85.9	75.8	62.6
Murray	Precip	1.5	1.9	2.8	3.4	5.3	4.1	2.7	2.6	4	3.7	2.3
	Temp	51.6	56.9	65.2	74.6	81.4	88.9	94.5	94.7	86.8	76.6	63.4
Muskogee	Precip	2.1	2.4	3.6	4.3	5.6	4.4	3.5	2.9	4.5	3.9	3.5
	Temp	48.7	54	62.6	72.9	79.8	87.4	93.3	93.3	85.5	75.1	61.8
Noble	Precip	1.2	1.6	2.8	3.3	5.2	4.4	3.3	3	4	3.1	2.2
	Temp	47.8	53.4	62.1	72.8	79.9	87.8	93.7	93.6	85.3	74.9	60.9
Nowata	Precip	1.5	1.8	3.2	3.8	5.4	4.9	3.3	3.2	4.4	3.5	3
	Temp	46.3	52.2	61.2	71.8	79.1	87.1	92.9	92.9	84.7	74	60.2
Okfuskee	Precip	1.4	1.8	2.8	3.5	5.4	4.5	3	2.8	4.1	3.5	2.4
	Temp	49.4	54.9	63.4	73.3	80.1	87.8	93.6	93.6	85.5	75.2	61.8
Oklahoma	Precip	1.4	1.8	2.8	3.5	5.4	4.5	3	2.8	4.1	3.5	2.4
	Temp	49.4	54.9	63.4	73.3	80.1	87.8	93.6	93.6	85.5	75.2	61.8
Okmulgee	Precip	1.9	2.3	3.5	4.2	5.6	4.4	3.5	2.9	4.5	3.8	3.2
	Temp	50.1	55.5	64	73.7	80.3	87.8	93.6	93.7	85.9	75.8	62.6
Osage	Precip	1.3	1.7	3	3.7	5.4	4.7	3.4	3.1	4.2	3.2	2.5
	Temp	47.2	53	61.9	72.6	79.5	87.2	93.1	93.1	84.8	74.3	60.5
Ottawa	Precip	1.8	2	3.3	3.9	5.5	4.8	3.4	3.3	4.5	3.7	3.4
	Temp	46.6	52.1	61	71.7	78.7	86.2	91.7	91.8	83.9	73.4	60
Pawnee	Precip	1.2	1.6	2.8	3.3	5.2	4.4	3.3	3	4	3.1	2.2
	Temp	47.8	53.4	62.1	72.8	79.9	87.8	93.7	93.6	85.3	74.9	60.9
Payne	Precip	1.2	1.6	2.8	3.3	5.2	4.4	3.3	3	4	3.1	2.2
	Temp	47.8	53.4	62.1	72.8	79.9	87.8	93.7	93.6	85.3	74.9	60.9
Pittsburg	Precip	1.9	2.3	3.5	4.2	5.6	4.4	3.5	2.9	4.5	3.8	3.2
	Temp	50.1	55.5	64	73.7	80.3	87.8	93.6	93.7	85.9	75.8	62.6
Pontotoc	Precip	1.6	2	3.1	3.7	5.5	4.3	3	2.8	4.2	3.8	2.6
	Temp	50.8	56.3	64.6	74.1	80.8	88.3	94	94.1	86.3	76.2	63
Pottawatomie	Precip	1.4	1.8	2.8	3.5	5.4	4.5	3	2.8	4.1	3.5	2.4
	Temp	49.4	54.9	63.4	73.3	80.1	87.8	93.6	93.6	85.5	75.2	61.8
Pushmataha	Precip	2.7	3.1	4.1	4.9	6.1	4.4	4	3.1	4.8	4.3	4
	Temp	51.7	56.8	64.9	74	80.4	87.5	93	93.3	85.9	76	63.4

Table C1: Historical Average Weather Variables by County and Month

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Roger Mills	Precip	0.6	1	1.8	2.2	4.3	3.6	2.1	2.5	2.6	2.2	1.3
	Temp	49.4	54.3	62.7	73	80.6	89.1	94.6	93.4	85.2	74.6	60.6
Rogers	Precip	1.7	1.9	3.3	3.9	5.3	4.8	3.3	3	4.2	3.6	3
	Temp	46.4	52.1	60.7	71.3	78.8	86.7	92.5	92.5	84.3	73.9	60.2
Seminole	Precip	1.9	2.3	3.5	4.2	5.6	4.4	3.5	2.9	4.5	3.8	3.2
	Temp	50.1	55.5	64	73.7	80.3	87.8	93.6	93.7	85.9	75.8	62.6
Sequoyah	Precip	2.4	2.7	3.8	4.4	5.7	4.4	3.7	2.9	4.3	3.9	4
	Temp	49.7	54.9	63.3	73.4	80.1	87.4	93	92.9	85.4	75.3	62.2
Stephens	Precip	1.2	1.5	2.4	2.8	5.2	4.1	2.4	2.6	3.5	3.3	2
	Temp	51.7	57	65.5	74.8	82	89.7	95.3	95.1	87.1	76.7	63.4
Texas	Precip	0.4	0.5	1.1	1.3	2.7	2.7	2.7	2.5	1.7	1.1	0.7
	Temp	48.7	53.1	60.6	70.9	79.5	89.1	93.7	91.7	84	73.6	59
Tillman	Precip	1	1.4	2	2.4	4.6	3.8	2.2	2.5	3.1	3	1.7
	Temp	52.5	57.7	66.3	76.1	83.8	92.2	97.5	96.8	88.4	77.8	63.9
Tulsa	Precip	1.6	2	3.2	3.9	5.4	4.5	3.3	2.8	4.2	3.6	2.9
	Temp	48.2	53.8	62.4	72.7	79.6	87.3	93.1	93.1	85	74.9	61.4
Wagoner	Precip	1.8	2	3.3	4	5.4	4.5	3.2	2.9	4.3	3.8	3.2
	Temp	47.9	53.5	62.3	72.6	79.6	87.3	93.1	93	85	74.7	61.2
Washington	Precip	1.3	1.6	3	3.6	5.3	4.9	3.4	3.2	4.1	3.3	2.5
	Temp	46.5	52.4	61.4	72.3	79.4	87.2	93.1	93	84.7	74.1	60.2
Washita	Precip	0.9	1.1	2	2.4	4.6	3.9	2.4	2.7	2.9	2.6	1.4
	Temp	49.7	54.9	63.4	73.6	81.5	90.2	95.6	94.8	86.3	75.4	61.3
Woods	Precip	0.6	0.8	1.7	2	3.6	3.6	2.7	2.8	2.2	1.7	1.1
	Temp	48	53.2	61.6	72.4	80.6	89.7	95.2	94	85.6	74.9	59.9
Woodward	Precip	0.5	0.8	1.6	1.7	3.3	3.4	2.7	2.6	2	1.6	1
	Temp	47.6	52.5	60.5	71.3	79.5	88.7	94.1	93	84.6	73.9	59.3

*Total monthly precipitation in inches

**Average maximum daily temperature in degrees Fahrenheit

Table C2: Climate Scenario Hot/Dry in 2060 Weather Variables by County and Month [Q1]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adair	Precip*	2.3	2.7	4.1	4.8	6	5	3.6	3.7	4.8	3.9	4.2	3.1
	Temp**	51.2	56.7	64.7	74.9	81.9	89.2	95.3	95.4	87.8	78	64.1	53.8
Alfalfa	Precip	0.9	1.3	2.7	2.9	4.5	4.9	3.3	3.5	3.4	2.8	1.9	1.3
	Temp	49.4	55.4	64.1	74.9	83.8	93.1	99.1	98.5	89.7	78.9	62.8	51.6
Atoka	Precip	2	2.6	3.7	4.7	5.8	4.8	3.3	3	4.9	3.9	3.5	2.9
	Temp	54.1	59.7	67.5	77	83.9	91.3	97.4	98	90.3	80.6	66.9	56.8
Beaver	Precip	0.6	0.9	1.9	1.8	3.5	3.9	2.8	2.8	2.2	1.6	1.1	0.9
	Temp	50.4	55.6	63.5	74.3	82.9	91.7	97.6	97	88.6	78.2	62.5	52.1
Beckham	Precip	0.8	1.2	2	2.4	4.8	4.2	2.3	2.6	3.1	2.6	1.5	1.2
	Temp	53.2	58.6	67	77.3	85.3	93.5	99.3	98.6	90.4	80.1	65	55
Blaine	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9	1.4
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7	53
Bryan	Precip	1.9	2.5	3.6	4.4	5.6	4.9	2.9	2.8	4.8	4.1	3.2	2.7
	Temp	54.7	60.1	67.9	77.2	84.2	91.6	97.4	98	90.4	80.8	67.1	57.2
Caddo	Precip	1.1	1.6	2.5	3.1	5.4	4.5	2.6	3	3.8	3.2	2	1.7
	Temp	52.9	58.7	67.1	77	84.6	92.1	98.1	97.9	90.1	80	65.4	55.1
Canadian	Precip	0.9	1.4	2.5	2.8	5.2	4.7	2.5	3	3.6	2.9	1.9	1.4
	Temp	51.1	56.6	65	75.2	83.4	91.5	97.6	97.4	89	78.6	63.5	53.1
Carter	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6	2.2
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7	56.7
Cherokee	Precip	2.3	2.7	4.1	4.8	6	5	3.6	3.7	4.8	3.9	4.2	3.1
	Temp	51.2	56.7	64.7	74.9	81.9	89.2	95.3	95.4	87.8	78	64.1	53.8
Choctaw	Precip	2.7	3.4	4.1	4.8	5.8	4.5	3.6	3.1	4.9	4.3	4.4	3.9
	Temp	56.5	61.8	69.4	78.3	85.2	92.2	97.6	98.3	91.1	81.7	68.4	58.7
Cimarron	Precip	0.4	0.5	1.3	1.3	2.8	3.1	2.8	2.6	1.9	1.2	0.7	0.6
	Temp	51.4	56.1	63.5	74	83.1	92.3	97.1	95.9	88.1	77.9	62.1	52.6
Cleveland	Precip	1.4	2	3	3.7	5.8	4.8	3	3	4.4	3.6	2.6	2.1
	Temp	52.7	58.6	66.7	76.6	83.7	91.1	97.4	97.7	89.7	79.8	65.4	55.1
Coal	Precip	2	2.6	3.7	4.7	5.8	4.8	3.3	3	4.9	3.9	3.5	2.9
	Temp	54.1	59.7	67.5	77	83.9	91.3	97.4	98	90.3	80.6	66.9	56.8
Comanche	Precip	1.1	1.6	2.4	2.8	5.4	4.5	2.5	2.7	3.6	3.2	2	1.7
	Temp	53.9	59.4	67.6	77.5	85.1	92.8	98.9	99	90.8	80.6	65.9	55.8

Table C2: Climate Scenario Hot/Dry in 2060 Weather Variables by County and Month [Q1]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cotton	Precip	1.1	1.6	2.4	2.8	5.4	4.5	2.5	2.7	3.6	3.2	2	1.7
	Temp	53.9	59.4	67.6	77.5	85.1	92.8	98.9	99	90.8	80.6	65.9	55.8
Craig	Precip	1.9	2.3	3.8	4.4	5.9	5.1	3.4	3.7	4.9	3.9	3.7	2.8
	Temp	50.3	56.2	64.6	74.9	82.2	89.7	95.8	96.1	88.2	78.2	63.9	53.2
Creek	Precip	1.7	2.2	3.5	4.1	5.7	4.9	3.3	3.1	4.6	3.8	3.3	2.4
	Temp	51.2	57.1	65.3	75.7	82.8	90.5	96.8	96.9	88.9	79.1	64.8	54
Custer	Precip	0.9	1.3	2.2	2.5	5	4.4	2.4	2.8	3.2	2.7	1.6	1.3
	Temp	52.6	58.1	66.4	76.6	84.8	93.1	99.1	98.7	90.3	79.8	64.6	54.4
Delaware	Precip	1.8	2.2	3.7	4.2	5.8	5.1	3.4	3.7	5.1	3.8	3.7	2.6
	Temp	49.7	55.5	64	74.6	81.9	89.4	95.4	95.7	87.7	77.6	63.4	52.6
Dewey	Precip	0.7	1.2	2.2	2.5	4.8	4.3	2.4	2.9	3	2.4	1.6	1.2
	Temp	51	56.3	64.5	74.9	83.2	91.7	97.8	97.3	88.8	78.3	63.1	52.8
Ellis	Precip	0.6	1	1.9	2	4	4	2.5	2.7	2.3	1.9	1.2	1
	Temp	50.3	55.4	63.3	74.1	82.3	90.8	96.8	96.4	87.9	77.7	62.3	52
Garfield	Precip	1	1.5	2.8	3.1	5.3	4.9	3.1	3.2	4.1	3	2.2	1.6
	Temp	50.6	56.4	65	75.5	83.7	92	98.3	98.2	89.7	79.2	63.7	52.9
Garvin	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6	2.2
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7	56.7
Grady	Precip	1.1	1.6	2.5	3.1	5.4	4.5	2.6	3	3.8	3.2	2	1.7
	Temp	52.9	58.7	67.1	77	84.6	92.1	98.1	97.9	90.1	80	65.4	55.1
Grant	Precip	0.9	1.3	2.7	2.9	4.5	4.9	3.3	3.5	3.4	2.8	1.9	1.3
	Temp	49.4	55.4	64.1	74.9	83.8	93.1	99.1	98.5	89.7	78.9	62.8	51.6
Greer	Precip	0.8	1.2	1.8	2.3	4.7	4.3	2.3	2.7	3.1	2.6	1.4	1.2
	Temp	54.8	60.4	69	79.3	87	94.8	100.4	99.8	91.7	81.6	66.5	56.4
Harmon	Precip	0.7	1.1	1.6	2.2	4	4	2.2	2.5	3	2.4	1.3	1.1
	Temp	56.1	61.6	70.2	80.4	88.2	96	101.1	100.4	92.3	82.3	67.4	57.6
Harper	Precip	0.6	1	2	2.1	3.9	4.2	2.8	3	2.5	1.8	1.3	1
	Temp	50.9	56.4	64.6	75.4	83.9	92.7	98.7	98	89.5	79.2	63.2	52.6
Haskell	Precip	2.4	2.9	4.1	4.8	6	4.7	3.7	3.2	4.7	3.9	4.4	3.2
	Temp	52.7	58.2	66.1	76.3	83.3	90.7	96.7	96.8	89.2	79.5	65.5	55.2
Hughes	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5	2.8
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9	55.7

Table C2: Climate Scenario Hot/Dry in 2060 Weather Variables by County and Month [Q1]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jackson	Precip	0.9	1.3	2	2.4	4.8	4.3	2.3	2.7	3.2	2.7	1.6	1.4
	Temp	54.3	59.8	68.2	78.3	86.4	94.6	100.2	99.5	91.2	81	66.1	56
Jefferson	Precip	1.3	1.8	2.5	3.1	5.1	4.3	2.4	2.6	3.7	3.2	2.1	1.9
	Temp	57	62.5	70.6	79.9	87	94.3	100.3	100.5	92.6	82.9	68.7	59.1
Johnston	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8	2.5
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6	57.8
Kay	Precip	1.1	1.6	3	3.4	5.2	5.1	3.6	3.6	4.3	3.1	2.3	1.6
	Temp	49.2	55.4	64.1	74.8	82.9	91.2	97.5	97.3	88.8	78.4	62.9	51.6
Kingfisher	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9	1.4
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7	53
Kiowa	Precip	0.8	1.2	2	2.4	4.8	4.2	2.3	2.6	3.1	2.6	1.5	1.2
	Temp	53.2	58.6	67	77.3	85.3	93.5	99.3	98.6	90.4	80.1	65	55
Latimer	Precip	2.8	3.1	4.4	5.1	6.3	4.6	4	3.3	4.8	4	4.7	3.7
	Temp	54.3	59.6	67.3	77.1	84	91.3	97.1	97.3	89.7	80.2	66.7	56.7
Le Flore	Precip	2.8	3.1	4.4	5.1	6.3	4.6	4	3.3	4.8	4	4.7	3.7
	Temp	54.3	59.6	67.3	77.1	84	91.3	97.1	97.3	89.7	80.2	66.7	56.7
Lincoln	Precip	1.3	1.9	3.1	3.7	5.8	4.9	3.2	3	4.5	3.5	2.7	2.1
	Temp	52.3	58.1	66.3	76.5	83.5	91	97.4	97.7	89.6	79.7	65.2	54.7
Logan	Precip	1	1.5	2.8	3.1	5.3	4.9	3.1	3.2	4.1	3	2.2	1.6
	Temp	50.6	56.4	65	75.5	83.7	92	98.3	98.2	89.7	79.2	63.7	52.9
Love	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8	2.5
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6	57.8
Major	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9	1.4
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7	53
Marshall	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8	2.5
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6	57.8
Mayes	Precip	1.9	2.3	3.8	4.4	5.9	5.1	3.4	3.7	4.9	3.9	3.7	2.8
	Temp	50.3	56.2	64.6	74.9	82.2	89.7	95.8	96.1	88.2	78.2	63.9	53.2
McClain	Precip	1.3	1.8	2.9	3.5	5.9	4.6	2.8	2.9	4.2	3.4	2.3	2
	Temp	52.9	58.7	67	76.8	84.1	91.5	97.8	98	90	80	65.5	55.1
McCurtain	Precip	3.1	3.7	4.5	4.9	5.6	4.3	3.8	2.8	4.6	4.2	4.7	4.3
	Temp	56.8	61.9	69.4	78.2	85.2	92.3	97.1	97.9	90.9	81.6	68.5	59

Table C2: Climate Scenario Hot/Dry in 2060 Weather Variables by County and Month [Q1]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
McIntosh	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5	2.8
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9	55.7
Murray	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6	2.2
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7	56.7
Muskogee	Precip	2.1	2.5	3.8	4.6	5.9	4.7	3.5	3.1	4.8	4	3.9	2.9
	Temp	51.7	57.3	65.4	75.8	83	90.6	96.9	97.1	89.3	79.3	65.2	54.6
Noble	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5	1.8
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2	53.3
Nowata	Precip	1.6	2	3.6	4.1	5.7	5.3	3.3	3.6	4.9	3.7	3.3	2.3
	Temp	49.3	55.6	64.2	74.7	82.3	90.3	96.6	96.8	88.5	78.2	63.6	52.3
Okfuskee	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7	2.2
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2	54.8
Oklahoma	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7	2.2
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2	54.8
Okmulgee	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5	2.8
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9	55.7
Osage	Precip	1.4	1.9	3.4	3.9	5.8	5.2	3.5	3.5	4.7	3.4	2.8	2
	Temp	50.2	56.4	64.9	75.5	82.7	90.3	96.7	97	88.7	78.6	63.9	52.8
Ottawa	Precip	1.8	2.2	3.7	4.2	5.8	5.1	3.4	3.7	5.1	3.8	3.7	2.6
	Temp	49.7	55.5	64	74.6	81.9	89.4	95.4	95.7	87.7	77.6	63.4	52.6
Pawnee	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5	1.8
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2	53.3
Payne	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5	1.8
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2	53.3
Pittsburg	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5	2.8
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9	55.7
Pontotoc	Precip	1.6	2.2	3.3	4	5.9	4.7	3	3	4.6	3.8	2.8	2.4
	Temp	53.7	59.5	67.5	77.1	84.1	91.4	97.5	98	90.2	80.4	66.3	56.1
Pottawatomie	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7	2.2
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2	54.8
Pushmataha	Precip	2.8	3.2	4.3	5.2	6.4	4.7	4.1	3.3	5.2	4.3	4.4	3.8
	Temp	54.7	60	67.7	77	83.7	90.8	96.6	97.1	89.6	80.2	66.7	57

Table C2: Climate Scenario Hot/Dry in 2060 Weather Variables by County and Month [Q1]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Roger Mills	Precip	0.7	1.1	2	2.3	4.6	4.1	2.2	2.7	2.8	2.2	1.4	1.1
	Temp	52.2	57.5	65.6	76.1	83.9	92	98	97.4	89.1	79	63.9	53.8
Rogers	Precip	1.7	2.1	3.6	4.2	5.6	5.2	3.4	3.4	4.7	3.8	3.3	2.5
	Temp	49.4	55.5	63.7	74.3	82	89.9	96.2	96.4	88.2	78.1	63.6	52.6
Seminole	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5	2.8
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9	55.7
Sequoyah	Precip	2.4	2.9	4.1	4.8	6	4.7	3.7	3.2	4.7	3.9	4.4	3.2
	Temp	52.7	58.2	66.1	76.3	83.3	90.7	96.7	96.8	89.2	79.5	65.5	55.2
Stephens	Precip	1.2	1.7	2.6	3	5.6	4.5	2.5	2.7	3.8	3.3	2.2	1.9
	Temp	54.6	60.2	68.4	77.9	85.2	92.6	98.8	98.9	90.9	81	66.7	56.7
Texas	Precip	0.4	0.5	1.3	1.3	2.8	3.1	2.8	2.6	1.9	1.2	0.7	0.6
	Temp	51.4	56.1	63.5	74	83.1	92.3	97.1	95.9	88.1	77.9	62.1	52.6
Tillman	Precip	1	1.6	2.2	2.6	5	4.3	2.2	2.7	3.4	3	1.9	1.6
	Temp	55.4	60.9	69.2	79.2	87.1	95.2	101	100.6	92.3	82.1	67.2	57.2
Tulsa	Precip	1.7	2.2	3.5	4.1	5.7	4.9	3.3	3.1	4.6	3.8	3.3	2.4
	Temp	51.2	57.1	65.3	75.7	82.8	90.5	96.8	96.9	88.9	79.1	64.8	54
Wagoner	Precip	1.9	2.2	3.6	4.3	5.7	4.9	3.3	3.1	4.8	3.9	3.5	2.6
	Temp	50.9	56.8	65.2	75.5	82.9	90.5	96.7	96.9	88.8	78.9	64.6	53.8
Washington	Precip	1.4	1.8	3.4	3.9	5.7	5.3	3.5	3.5	4.6	3.5	2.8	2
	Temp	49.5	55.8	64.4	75.2	82.6	90.3	96.7	97	88.6	78.3	63.5	52.2
Washita	Precip	0.9	1.3	2.2	2.5	5	4.4	2.4	2.8	3.2	2.7	1.6	1.3
	Temp	52.6	58.1	66.4	76.6	84.8	93.1	99.1	98.7	90.3	79.8	64.6	54.4
Woods	Precip	0.6	1	2	2.1	3.9	4.2	2.8	3	2.5	1.8	1.3	1
	Temp	50.9	56.4	64.6	75.4	83.9	92.7	98.7	98	89.5	79.2	63.2	52.6
Woodward	Precip	0.6	0.9	1.9	1.8	3.5	3.9	2.8	2.8	2.2	1.6	1.1	0.9
	Temp	50.4	55.6	63.5	74.3	82.9	91.7	97.6	97	88.6	78.2	62.5	52.1

*Total monthly precipitation in inches

**Average maximum daily temperature in degrees Fahrenheit

Table C3: Climate Scenario Warm/Wet in 2060 Weather Variables by County and Month [Q4]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Adair	Precip*	2.3	2.7	4.1	4.8	6	5	3.6	3.7	4.8	3.9	4.2
	Temp**	51.2	56.7	64.7	74.9	81.9	89.2	95.3	95.4	87.8	78	64.1
Alfalfa	Precip	0.9	1.3	2.7	2.9	4.5	4.9	3.3	3.5	3.4	2.8	1.9
	Temp	49.4	55.4	64.1	74.9	83.8	93.1	99.1	98.5	89.7	78.9	62.8
Atoka	Precip	2	2.6	3.7	4.7	5.8	4.8	3.3	3	4.9	3.9	3.5
	Temp	54.1	59.7	67.5	77	83.9	91.3	97.4	98	90.3	80.6	66.9
Beaver	Precip	0.6	0.9	1.9	1.8	3.5	3.9	2.8	2.8	2.2	1.6	1.1
	Temp	50.4	55.6	63.5	74.3	82.9	91.7	97.6	97	88.6	78.2	62.5
Beckham	Precip	0.8	1.2	2	2.4	4.8	4.2	2.3	2.6	3.1	2.6	1.5
	Temp	53.2	58.6	67	77.3	85.3	93.5	99.3	98.6	90.4	80.1	65
Blaine	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7
Bryan	Precip	1.9	2.5	3.6	4.4	5.6	4.9	2.9	2.8	4.8	4.1	3.2
	Temp	54.7	60.1	67.9	77.2	84.2	91.6	97.4	98	90.4	80.8	67.1
Caddo	Precip	1.1	1.6	2.5	3.1	5.4	4.5	2.6	3	3.8	3.2	2
	Temp	52.9	58.7	67.1	77	84.6	92.1	98.1	97.9	90.1	80	65.4
Canadian	Precip	0.9	1.4	2.5	2.8	5.2	4.7	2.5	3	3.6	2.9	1.9
	Temp	51.1	56.6	65	75.2	83.4	91.5	97.6	97.4	89	78.6	63.5
Carter	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7
Cherokee	Precip	2.3	2.7	4.1	4.8	6	5	3.6	3.7	4.8	3.9	4.2
	Temp	51.2	56.7	64.7	74.9	81.9	89.2	95.3	95.4	87.8	78	64.1
Choctaw	Precip	2.7	3.4	4.1	4.8	5.8	4.5	3.6	3.1	4.9	4.3	4.4
	Temp	56.5	61.8	69.4	78.3	85.2	92.2	97.6	98.3	91.1	81.7	68.4
Cimarron	Precip	0.4	0.5	1.3	1.3	2.8	3.1	2.8	2.6	1.9	1.2	0.7
	Temp	51.4	56.1	63.5	74	83.1	92.3	97.1	95.9	88.1	77.9	62.1
Cleveland	Precip	1.4	2	3	3.7	5.8	4.8	3	3	4.4	3.6	2.6
	Temp	52.7	58.6	66.7	76.6	83.7	91.1	97.4	97.7	89.7	79.8	65.4
Coal	Precip	2	2.6	3.7	4.7	5.8	4.8	3.3	3	4.9	3.9	3.5
	Temp	54.1	59.7	67.5	77	83.9	91.3	97.4	98	90.3	80.6	66.9
Comanche	Precip	1.1	1.6	2.4	2.8	5.4	4.5	2.5	2.7	3.6	3.2	2
	Temp	53.9	59.4	67.6	77.5	85.1	92.8	98.9	99	90.8	80.6	65.9

Table C3: Climate Scenario Warm/Wet in 2060 Weather Variables by County and Month [Q4]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Cotton	Precip	1.1	1.6	2.4	2.8	5.4	4.5	2.5	2.7	3.6	3.2	2
	Temp	53.9	59.4	67.6	77.5	85.1	92.8	98.9	99	90.8	80.6	65.9
Craig	Precip	1.9	2.3	3.8	4.4	5.9	5.1	3.4	3.7	4.9	3.9	3.7
	Temp	50.3	56.2	64.6	74.9	82.2	89.7	95.8	96.1	88.2	78.2	63.9
Creek	Precip	1.7	2.2	3.5	4.1	5.7	4.9	3.3	3.1	4.6	3.8	3.3
	Temp	51.2	57.1	65.3	75.7	82.8	90.5	96.8	96.9	88.9	79.1	64.8
Custer	Precip	0.9	1.3	2.2	2.5	5	4.4	2.4	2.8	3.2	2.7	1.6
	Temp	52.6	58.1	66.4	76.6	84.8	93.1	99.1	98.7	90.3	79.8	64.6
Delaware	Precip	1.8	2.2	3.7	4.2	5.8	5.1	3.4	3.7	5.1	3.8	3.7
	Temp	49.7	55.5	64	74.6	81.9	89.4	95.4	95.7	87.7	77.6	63.4
Dewey	Precip	0.7	1.2	2.2	2.5	4.8	4.3	2.4	2.9	3	2.4	1.6
	Temp	51	56.3	64.5	74.9	83.2	91.7	97.8	97.3	88.8	78.3	63.1
Ellis	Precip	0.6	1	1.9	2	4	4	2.5	2.7	2.3	1.9	1.2
	Temp	50.3	55.4	63.3	74.1	82.3	90.8	96.8	96.4	87.9	77.7	62.3
Garfield	Precip	1	1.5	2.8	3.1	5.3	4.9	3.1	3.2	4.1	3	2.2
	Temp	50.6	56.4	65	75.5	83.7	92	98.3	98.2	89.7	79.2	63.7
Garvin	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7
Grady	Precip	1.1	1.6	2.5	3.1	5.4	4.5	2.6	3	3.8	3.2	2
	Temp	52.9	58.7	67.1	77	84.6	92.1	98.1	97.9	90.1	80	65.4
Grant	Precip	0.9	1.3	2.7	2.9	4.5	4.9	3.3	3.5	3.4	2.8	1.9
	Temp	49.4	55.4	64.1	74.9	83.8	93.1	99.1	98.5	89.7	78.9	62.8
Greer	Precip	0.8	1.2	1.8	2.3	4.7	4.3	2.3	2.7	3.1	2.6	1.4
	Temp	54.8	60.4	69	79.3	87	94.8	100.4	99.8	91.7	81.6	66.5
Harmon	Precip	0.7	1.1	1.6	2.2	4	4	2.2	2.5	3	2.4	1.3
	Temp	56.1	61.6	70.2	80.4	88.2	96	101.1	100.4	92.3	82.3	67.4
Harper	Precip	0.6	1	2	2.1	3.9	4.2	2.8	3	2.5	1.8	1.3
	Temp	50.9	56.4	64.6	75.4	83.9	92.7	98.7	98	89.5	79.2	63.2
Haskell	Precip	2.4	2.9	4.1	4.8	6	4.7	3.7	3.2	4.7	3.9	4.4
	Temp	52.7	58.2	66.1	76.3	83.3	90.7	96.7	96.8	89.2	79.5	65.5
Hughes	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9

Table C3: Climate Scenario Warm/Wet in 2060 Weather Variables by County and Month [Q4]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Jackson	Precip	0.9	1.3	2	2.4	4.8	4.3	2.3	2.7	3.2	2.7	1.6
	Temp	54.3	59.8	68.2	78.3	86.4	94.6	100.2	99.5	91.2	81	66.1
Jefferson	Precip	1.3	1.8	2.5	3.1	5.1	4.3	2.4	2.6	3.7	3.2	2.1
	Temp	57	62.5	70.6	79.9	87	94.3	100.3	100.5	92.6	82.9	68.7
Johnston	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6
Kay	Precip	1.1	1.6	3	3.4	5.2	5.1	3.6	3.6	4.3	3.1	2.3
	Temp	49.2	55.4	64.1	74.8	82.9	91.2	97.5	97.3	88.8	78.4	62.9
Kingfisher	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7
Kiowa	Precip	0.8	1.2	2	2.4	4.8	4.2	2.3	2.6	3.1	2.6	1.5
	Temp	53.2	58.6	67	77.3	85.3	93.5	99.3	98.6	90.4	80.1	65
Latimer	Precip	2.8	3.1	4.4	5.1	6.3	4.6	4	3.3	4.8	4	4.7
	Temp	54.3	59.6	67.3	77.1	84	91.3	97.1	97.3	89.7	80.2	66.7
Le Flore	Precip	2.8	3.1	4.4	5.1	6.3	4.6	4	3.3	4.8	4	4.7
	Temp	54.3	59.6	67.3	77.1	84	91.3	97.1	97.3	89.7	80.2	66.7
Lincoln	Precip	1.3	1.9	3.1	3.7	5.8	4.9	3.2	3	4.5	3.5	2.7
	Temp	52.3	58.1	66.3	76.5	83.5	91	97.4	97.7	89.6	79.7	65.2
Logan	Precip	1	1.5	2.8	3.1	5.3	4.9	3.1	3.2	4.1	3	2.2
	Temp	50.6	56.4	65	75.5	83.7	92	98.3	98.2	89.7	79.2	63.7
Love	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6
Major	Precip	0.9	1.3	2.5	2.8	4.9	4.7	2.8	3.1	3.5	2.7	1.9
	Temp	51	56.7	65.2	75.7	84.1	92.8	98.9	98.5	89.9	79.3	63.7
Marshall	Precip	1.8	2.4	3.3	4.1	5.4	4.7	2.7	2.6	4.5	3.9	2.8
	Temp	55.6	60.9	68.7	78	84.9	92.3	98.1	98.7	91	81.4	67.6
Mayes	Precip	1.9	2.3	3.8	4.4	5.9	5.1	3.4	3.7	4.9	3.9	3.7
	Temp	50.3	56.2	64.6	74.9	82.2	89.7	95.8	96.1	88.2	78.2	63.9
McClain	Precip	1.3	1.8	2.9	3.5	5.9	4.6	2.8	2.9	4.2	3.4	2.3
	Temp	52.9	58.7	67	76.8	84.1	91.5	97.8	98	90	80	65.5
McCurtain	Precip	3.1	3.7	4.5	4.9	5.6	4.3	3.8	2.8	4.6	4.2	4.7
	Temp	56.8	61.9	69.4	78.2	85.2	92.3	97.1	97.9	90.9	81.6	68.5

Table C3: Climate Scenario Warm/Wet in 2060 Weather Variables by County and Month [Q4]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
McIntosh	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9
Murray	Precip	1.5	2	3	3.6	5.7	4.5	2.7	2.7	4.3	3.7	2.6
	Temp	54.5	60.1	68.1	77.6	84.6	92	98	98.5	90.6	80.8	66.7
Muskogee	Precip	2.1	2.5	3.8	4.6	5.9	4.7	3.5	3.1	4.8	4	3.9
	Temp	51.7	57.3	65.4	75.8	83	90.6	96.9	97.1	89.3	79.3	65.2
Noble	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2
Nowata	Precip	1.6	2	3.6	4.1	5.7	5.3	3.3	3.6	4.9	3.7	3.3
	Temp	49.3	55.6	64.2	74.7	82.3	90.3	96.6	96.8	88.5	78.2	63.6
Okfuskee	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2
Oklahoma	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2
Okmulgee	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9
Osage	Precip	1.4	1.9	3.4	3.9	5.8	5.2	3.5	3.5	4.7	3.4	2.8
	Temp	50.2	56.4	64.9	75.5	82.7	90.3	96.7	97	88.7	78.6	63.9
Ottawa	Precip	1.8	2.2	3.7	4.2	5.8	5.1	3.4	3.7	5.1	3.8	3.7
	Temp	49.7	55.5	64	74.6	81.9	89.4	95.4	95.7	87.7	77.6	63.4
Pawnee	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2
Payne	Precip	1.2	1.7	3.1	3.5	5.6	4.9	3.4	3.3	4.4	3.2	2.5
	Temp	50.8	56.7	65.1	75.7	83.1	90.9	97.3	97.5	89.2	79.1	64.2
Pittsburg	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9
Pontotoc	Precip	1.6	2.2	3.3	4	5.9	4.7	3	3	4.6	3.8	2.8
	Temp	53.7	59.5	67.5	77.1	84.1	91.4	97.5	98	90.2	80.4	66.3
Pottawatomie	Precip	1.4	2	3.1	3.8	5.8	4.9	3	3	4.5	3.6	2.7
	Temp	52.4	58.2	66.3	76.3	83.4	90.8	97.2	97.5	89.4	79.5	65.2
Pushmataha	Precip	2.8	3.2	4.3	5.2	6.4	4.7	4.1	3.3	5.2	4.3	4.4
	Temp	54.7	60	67.7	77	83.7	90.8	96.6	97.1	89.6	80.2	66.7

Table C3: Climate Scenario Warm/Wet in 2060 Weather Variables by County and Month [Q4]

County	Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Roger Mills	Precip	0.7	1.1	2	2.3	4.6	4.1	2.2	2.7	2.8	2.2	1.4
	Temp	52.2	57.5	65.6	76.1	83.9	92	98	97.4	89.1	79	63.9
Rogers	Precip	1.7	2.1	3.6	4.2	5.6	5.2	3.4	3.4	4.7	3.8	3.3
	Temp	49.4	55.5	63.7	74.3	82	89.9	96.2	96.4	88.2	78.1	63.6
Seminole	Precip	2	2.4	3.7	4.6	6	4.7	3.5	3.1	4.9	3.9	3.5
	Temp	53.1	58.7	66.8	76.6	83.6	91	97.2	97.5	89.7	80	65.9
Sequoyah	Precip	2.4	2.9	4.1	4.8	6	4.7	3.7	3.2	4.7	3.9	4.4
	Temp	52.7	58.2	66.1	76.3	83.3	90.7	96.7	96.8	89.2	79.5	65.5
Stephens	Precip	1.2	1.7	2.6	3	5.6	4.5	2.5	2.7	3.8	3.3	2.2
	Temp	54.6	60.2	68.4	77.9	85.2	92.6	98.8	98.9	90.9	81	66.7
Texas	Precip	0.4	0.5	1.3	1.3	2.8	3.1	2.8	2.6	1.9	1.2	0.7
	Temp	51.4	56.1	63.5	74	83.1	92.3	97.1	95.9	88.1	77.9	62.1
Tillman	Precip	1	1.6	2.2	2.6	5	4.3	2.2	2.7	3.4	3	1.9
	Temp	55.4	60.9	69.2	79.2	87.1	95.2	101	100.6	92.3	82.1	67.2
Tulsa	Precip	1.7	2.2	3.5	4.1	5.7	4.9	3.3	3.1	4.6	3.8	3.3
	Temp	51.2	57.1	65.3	75.7	82.8	90.5	96.8	96.9	88.9	79.1	64.8
Wagoner	Precip	1.9	2.2	3.6	4.3	5.7	4.9	3.3	3.1	4.8	3.9	3.5
	Temp	50.9	56.8	65.2	75.5	82.9	90.5	96.7	96.9	88.8	78.9	64.6
Washington	Precip	1.4	1.8	3.4	3.9	5.7	5.3	3.5	3.5	4.6	3.5	2.8
	Temp	49.5	55.8	64.4	75.2	82.6	90.3	96.7	97	88.6	78.3	63.5
Washita	Precip	0.9	1.3	2.2	2.5	5	4.4	2.4	2.8	3.2	2.7	1.6
	Temp	52.6	58.1	66.4	76.6	84.8	93.1	99.1	98.7	90.3	79.8	64.6
Woods	Precip	0.6	1	2	2.1	3.9	4.2	2.8	3	2.5	1.8	1.3
	Temp	50.9	56.4	64.6	75.4	83.9	92.7	98.7	98	89.5	79.2	63.2
Woodward	Precip	0.6	0.9	1.9	1.8	3.5	3.9	2.8	2.8	2.2	1.6	1.1
	Temp	50.4	55.6	63.5	74.3	82.9	91.7	97.6	97	88.6	78.2	62.5

*Total monthly precipitation in inches

**Average maximum daily temperature in degrees Fahrenheit

Appendix D
County Results of Climate Change Demand Scenarios in AFY

Table D1 : County Results of M&I Demand Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Adair	2,555	3,526	2,691	3,862	2,617	3,675
Alfalfa	882	912	928	998	902	948
Atoka	3,733	4,913	3,924	5,357	3,825	5,120
Beaver	752	789	793	866	770	821
Beckham	5,562	6,930	5,839	7,547	5,692	7,203
Blaine	2,918	3,642	3,069	3,981	2,984	3,786
Bryan	9,799	12,388	10,291	13,486	10,039	12,903
Caddo	3,578	3,892	3,758	4,241	3,662	4,047
Canadian	18,000	20,884	19,002	22,961	18,454	21,792
Carter	10,048	11,643	10,576	12,726	10,301	12,140
Cherokee	8,760	11,751	9,226	12,871	8,972	12,247
Choctaw	1,667	1,790	1,750	1,946	1,708	1,864
Cimarron	705	746	743	819	723	777
Cleveland	42,804	47,126	45,139	51,651	43,892	49,178
Coal	805	1,132	846	1,234	824	1,180
Comanche	18,717	20,376	19,633	22,158	19,155	21,176
Cotton	821	869	861	945	840	903
Craig	2,739	3,534	2,884	3,871	2,805	3,682
Creek	9,391	10,715	9,880	11,710	9,612	11,152
Custer	5,852	6,414	6,145	6,989	5,988	6,666
Delaware	5,384	7,377	5,671	8,090	5,514	7,689
Dewey	1,146	1,197	1,205	1,308	1,172	1,244
Ellis	730	730	769	801	747	760
Garfield	13,049	13,842	13,780	15,229	13,373	14,441
Garvin	5,014	5,311	5,277	5,804	5,140	5,537
Grady	5,848	6,715	6,166	7,364	5,996	7,006
Grant	752	794	794	875	770	828
Greer	1,049	1,103	1,100	1,199	1,074	1,145
Harmon	821	894	860	970	840	928
Harper	973	1,001	1,024	1,098	995	1,041
Haskell	1,648	2,243	1,738	2,457	1,690	2,340
Hughes	2,178	2,866	2,293	3,134	2,232	2,989
Jackson	5,129	5,590	5,379	6,077	5,248	5,807
Jefferson	807	866	847	943	827	902
Johnston	2,196	2,923	2,304	3,177	2,250	3,043
Kay	8,272	8,860	8,749	9,776	8,479	9,250
Kingfisher	3,529	4,575	3,727	5,034	3,616	4,771
Kiowa	1,287	1,351	1,351	1,472	1,317	1,405
Latimer	2,506	2,961	2,640	3,240	2,569	3,090
Le Flore	7,499	8,895	7,900	9,732	7,688	9,281
Lincoln	2,745	3,322	2,896	3,647	2,814	3,467
Logan	5,883	7,483	6,212	8,232	6,029	7,806
Love	5,455	6,498	5,732	7,083	5,592	6,772
Major	1,013	1,054	1,066	1,152	1,036	1,095

Table D1 : County Results of M&I Demand Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Marshall	4,333	6,586	4,545	7,158	4,438	6,855
Mayes	6,526	8,200	6,871	8,982	6,683	8,543
McClain	5,428	7,400	5,722	8,108	5,565	7,719
McCurtain	4,685	5,099	4,917	5,545	4,800	5,310
McIntosh	3,066	4,202	3,229	4,595	3,142	4,382
Murray	3,216	4,059	3,385	4,437	3,297	4,233
Muskogee	10,898	11,720	11,463	12,800	11,158	12,205
Noble	1,815	1,955	1,918	2,153	1,861	2,041
Nowata	1,412	1,907	1,487	2,089	1,446	1,986
Okfuskee	1,497	1,616	1,573	1,763	1,532	1,681
Oklahoma	136,613	146,570	144,183	160,911	140,120	153,050
Okmulgee	12,415	14,645	13,051	15,971	12,710	15,241
Osage	8,876	10,073	9,342	11,025	9,081	10,481
Ottawa	5,918	7,069	6,234	7,752	6,061	7,368
Pawnee	2,818	3,574	2,965	3,909	2,883	3,717
Payne	14,671	17,045	15,495	18,756	15,035	17,788
Pittsburg	9,150	10,471	9,634	11,449	9,377	10,918
Pontotoc	6,596	7,222	6,954	7,910	6,764	7,536
Pottawatomie	6,848	7,963	7,224	8,734	7,022	8,311
Pushmataha	1,371	1,834	1,443	2,003	1,406	1,913
Roger Mills	626	626	658	684	641	651
Rogers	16,213	20,212	17,066	22,128	16,598	21,049
Seminole	3,002	3,261	3,167	3,577	3,079	3,405
Sequoyah	8,886	11,099	9,367	12,161	9,109	11,583
Stephens	8,866	9,291	9,327	10,152	9,090	9,686
Texas	5,513	8,242	5,807	9,049	5,651	8,582
Tillman	1,418	1,521	1,485	1,650	1,450	1,579
Tulsa	121,517	130,319	127,837	142,428	124,378	135,643
Wagoner	10,137	12,383	10,665	13,538	10,377	12,892
Washington	12,486	13,021	13,144	14,259	12,776	13,552
Washita	1,179	1,244	1,238	1,356	1,206	1,293
Woods	3,224	3,363	3,395	3,687	3,297	3,494
Woodward	6,169	6,558	6,497	7,196	6,313	6,819

Table D2 : County Results of Irrigated Agriculture Demand Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Adair	1,518	2,203	1,705	2,671	1,556	2,288
Alfalfa	5,940	7,285	6,625	8,520	6,073	7,515
Atoka	1,666	2,339	1,891	2,856	1,715	2,421
Beaver	34,538	37,383	37,909	43,869	35,351	38,768
Beckham	8,718	8,718	9,209	9,791	8,630	8,760
Blaine	6,517	6,517	7,548	7,416	6,587	6,688
Bryan	17,536	18,178	18,112	19,158	17,650	17,908
Caddo	37,078	45,228	42,651	51,809	36,508	44,698
Canadian	6,818	7,482	7,513	8,482	6,915	7,643
Carter	2,812	2,918	2,951	3,167	2,850	2,964
Cherokee	1,644	1,859	1,843	2,249	1,684	1,930
Choctaw	1,154	1,597	1,306	1,942	1,188	1,653
Cimarron	73,517	90,606	80,220	105,653	75,532	94,342
Cleveland	1,571	2,178	2,585	2,626	1,608	2,260
Coal	643	650	703	885	649	658
Comanche	3,089	3,688	3,305	4,133	3,118	3,734
Cotton	793	1,110	823	1,180	800	1,119
Craig	1,128	2,599	1,264	3,140	1,155	2,699
Creek	433	560	492	744	454	594
Custer	4,957	5,232	5,640	6,055	5,022	5,368
Delaware	949	949	1,064	1,148	973	986
Dewey	4,752	4,752	5,325	5,556	4,872	4,924
Ellis	27,870	35,263	30,704	41,404	28,474	36,462
Garfield	6,029	6,029	7,124	7,436	6,193	6,249
Garvin	2,298	3,734	2,491	4,303	2,328	3,810
Grady	11,291	11,291	12,171	12,827	11,378	11,328
Grant	1,801	1,801	2,116	2,182	1,833	1,853
Greer	10,445	17,016	11,348	19,646	10,692	17,637
Harmon	27,927	30,137	30,325	34,743	28,651	31,378
Harper	11,759	13,813	12,897	16,211	12,017	14,286
Haskell	3,006	3,633	3,378	4,410	3,080	3,772
Hughes	5,360	8,474	6,201	10,242	5,483	8,796
Jackson	105,813	111,960	114,874	128,722	108,595	116,808
Jefferson	427	523	479	630	436	369
Johnston	2,344	3,662	2,577	4,291	2,407	3,777
Kay	4,690	4,690	5,114	5,393	4,763	4,804
Kingfisher	8,716	9,902	10,949	11,827	8,897	10,205
Kiowa	4,813	5,190	5,355	6,008	4,929	5,380
Latimer	1,846	3,344	2,090	4,068	1,900	3,460
Le Flore	9,985	9,985	14,423	11,609	10,190	9,606
Lincoln	3,575	3,575	4,134	4,513	3,792	3,826
Logan	1,991	1,991	2,216	2,396	2,048	2,071
Love	3,695	5,133	4,134	6,258	3,780	5,276
Major	13,122	13,254	14,746	15,431	13,392	13,682

Table D2 : County Results of Irrigated Agriculture Demand Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Marshall	4,952	5,397	5,243	5,943	5,029	5,505
Mayes	1,411	1,735	1,586	2,105	1,446	1,802
McClain	2,969	3,120	3,266	3,409	2,992	3,159
McCurtain	1,756	3,105	1,971	3,731	1,802	3,210
McIntosh	685	690	838	820	700	717
Murray	332	765	356	871	333	774
Muskogee	8,882	8,882	12,331	10,575	9,077	9,229
Noble	1,223	1,223	1,379	1,486	1,244	1,255
Nowata	616	1,148	692	1,568	630	1,187
Okfuskee	2,267	2,836	2,694	3,881	2,318	2,937
Oklahoma	5,537	5,537	5,733	5,878	5,599	5,614
Okmulgee	1,250	1,250	1,392	1,628	1,279	1,299
Osage	843	1,302	954	1,734	877	1,373
Ottawa	598	795	667	951	612	825
Pawnee	179	317	196	383	183	328
Payne	1,344	1,360	1,408	1,464	1,367	1,386
Pittsburg	3,299	3,958	3,531	4,430	3,335	4,017
Pontotoc	3,284	5,657	3,614	6,637	3,375	5,830
Pottawatomie	2,639	3,628	3,046	4,193	2,711	3,768
Pushmataha	824	836	934	1,019	848	865
Roger Mills	9,296	9,342	10,039	10,686	9,461	9,602
Rogers	1,769	2,160	1,836	2,394	1,782	2,184
Seminole	1,847	2,624	2,136	3,316	1,959	2,809
Sequoyah	2,465	2,832	2,881	3,378	2,521	2,942
Stephens	3,564	5,564	4,011	6,752	3,644	5,652
Texas	202,385	206,393	221,205	240,005	208,035	215,269
Tillman	18,661	19,408	20,306	22,343	19,143	20,211
Tulsa	8,012	8,775	8,226	8,966	8,022	8,794
Wagoner	8,392	8,392	8,947	9,349	8,503	8,570
Washington	867	1,306	1,101	1,713	898	1,374
Washita	5,571	6,234	6,090	7,197	5,669	6,412
Woods	3,787	4,439	4,164	5,218	3,869	4,587
Woodward	8,026	8,026	8,921	9,404	8,209	8,315

Table D3: County Results of M&I and Irrigated Agriculture Demands Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Adair	4,073	5,729	4,396	6,533	4,173	5,963
Alfalfa	6,822	8,197	7,553	9,518	6,975	8,462
Atoka	5,399	7,253	5,815	8,212	5,540	7,541
Beaver	35,291	38,172	38,702	44,735	36,121	39,589
Beckham	14,280	15,648	15,047	17,338	14,322	15,963
Blaine	9,434	10,159	10,617	11,398	9,571	10,474
Bryan	27,335	30,566	28,403	32,645	27,689	30,810
Caddo	40,656	49,120	46,409	56,050	40,170	48,744
Canadian	24,818	28,366	26,514	31,443	25,369	29,435
Carter	12,860	14,561	13,528	15,893	13,151	15,104
Cherokee	10,404	13,610	11,069	15,120	10,657	14,177
Choctaw	2,821	3,387	3,056	3,889	2,896	3,517
Cimarron	74,223	91,352	80,963	106,472	76,255	95,119
Cleveland	44,375	49,304	47,724	54,276	45,500	51,439
Coal	1,447	1,782	1,549	2,119	1,474	1,837
Comanche	21,807	24,065	22,938	26,291	22,274	24,910
Cotton	1,614	1,979	1,684	2,125	1,640	2,023
Craig	3,867	6,133	4,148	7,010	3,960	6,380
Creek	9,825	11,274	10,372	12,454	10,066	11,746
Custer	10,809	11,645	11,785	13,044	11,011	12,035
Delaware	6,334	8,326	6,735	9,238	6,487	8,674
Dewey	5,897	5,948	6,530	6,864	6,044	6,169
Ellis	28,600	35,993	31,473	42,205	29,222	37,222
Garfield	19,078	19,872	20,904	22,665	19,566	20,690
Garvin	7,312	9,045	7,768	10,107	7,468	9,348
Grady	17,139	18,006	18,337	20,191	17,374	18,334
Grant	2,553	2,595	2,911	3,057	2,603	2,681
Greer	11,494	18,119	12,448	20,845	11,766	18,782
Harmon	28,749	31,030	31,185	35,714	29,491	32,306
Harper	12,732	14,814	13,921	17,309	13,012	15,327
Haskell	4,655	5,875	5,115	6,867	4,770	6,113
Hughes	7,538	11,340	8,494	13,376	7,715	11,784
Jackson	110,943	117,550	120,253	134,799	113,843	122,615
Jefferson	1,234	1,389	1,326	1,573	1,263	1,271
Johnston	4,540	6,586	4,881	7,469	4,657	6,820
Kay	12,963	13,550	13,863	15,169	13,242	14,054
Kingfisher	12,246	14,477	14,676	16,861	12,513	14,976
Kiowa	6,101	6,541	6,706	7,479	6,246	6,785
Latimer	4,352	6,305	4,730	7,308	4,469	6,550
Le Flore	17,485	18,880	22,323	21,341	17,878	18,887
Lincoln	6,320	6,897	7,030	8,160	6,606	7,293
Logan	7,874	9,473	8,428	10,628	8,076	9,877
Love	9,150	11,631	9,866	13,342	9,372	12,048
Major	14,135	14,308	15,812	16,583	14,429	14,777

Table D3: County Results of M&I and Irrigated Agriculture Demands Scenarios in AFY

County	Baseline		Hot/Dry		Warm/Wet	
	2030	2060	2030	2060	2030	2060
Marshall	9,284	11,983	9,788	13,101	9,467	12,360
Mayes	7,938	9,935	8,457	11,087	8,129	10,345
McClain	8,397	10,520	8,988	11,517	8,557	10,878
McCurtain	6,441	8,204	6,888	9,275	6,602	8,520
McIntosh	3,752	4,892	4,067	5,415	3,842	5,099
Murray	3,548	4,824	3,742	5,308	3,630	5,007
Muskogee	19,780	20,603	23,793	23,375	20,235	21,434
Noble	3,038	3,177	3,297	3,639	3,104	3,296
Nowata	2,028	3,055	2,178	3,657	2,075	3,174
Okfuskee	3,764	4,453	4,268	5,644	3,850	4,619
Oklahoma	142,150	152,107	149,916	166,789	145,718	158,664
Okmulgee	13,666	15,895	14,443	17,599	13,989	16,540
Osage	9,719	11,374	10,297	12,758	9,958	11,854
Ottawa	6,517	7,864	6,900	8,703	6,673	8,193
Pawnee	2,998	3,891	3,161	4,292	3,066	4,045
Payne	16,015	18,405	16,903	20,220	16,402	19,174
Pittsburg	12,449	14,429	13,165	15,879	12,711	14,935
Pontotoc	9,880	12,879	10,567	14,547	10,139	13,366
Pottawatomie	9,487	11,590	10,270	12,927	9,733	12,078
Pushmataha	2,195	2,670	2,377	3,022	2,253	2,778
Roger Mills	9,922	9,968	10,697	11,370	10,102	10,253
Rogers	17,982	22,372	18,902	24,522	18,379	23,233
Seminole	4,849	5,885	5,303	6,893	5,038	6,214
Sequoyah	11,351	13,931	12,248	15,539	11,630	14,524
Stephens	12,430	14,855	13,338	16,905	12,734	15,337
Texas	207,898	214,635	227,012	249,054	213,686	223,852
Tillman	20,079	20,929	21,791	23,993	20,593	21,790
Tulsa	129,529	139,094	136,063	151,394	132,400	144,436
Wagoner	18,529	20,774	19,613	22,887	18,880	21,462
Washington	13,353	14,328	14,245	15,972	13,674	14,925
Washita	6,750	7,478	7,327	8,553	6,875	7,705
Woods	7,011	7,801	7,559	8,905	7,167	8,082
Woodward	14,194	14,583	15,419	16,601	14,522	15,134