Oklahoma Comprehensive Water Plan

OCWP

West Central
Watershed Planning Region
Report

Version 1.1

Oklahoma Water Resources Board

The objective of the Oklahoma Comprehensive Water Plan is to ensure a dependable water supply for all Oklahomans through integrated and coordinated water resources planning by providing the information necessary for water providers, policy-makers, and end users to make informed decisions concerning the use and management of Oklahoma's water resources.

This study, managed and executed by the Oklahoma Water Resources Board under its authority to update the Oklahoma Comprehensive Water Plan, was funded jointly through monies generously provided by the Oklahoma State Legislature and the federal government through cooperative agreements with the U.S. Army Corps of Engineers and Bureau of Reclamation.

Oklahoma Comprehensive Water Plan

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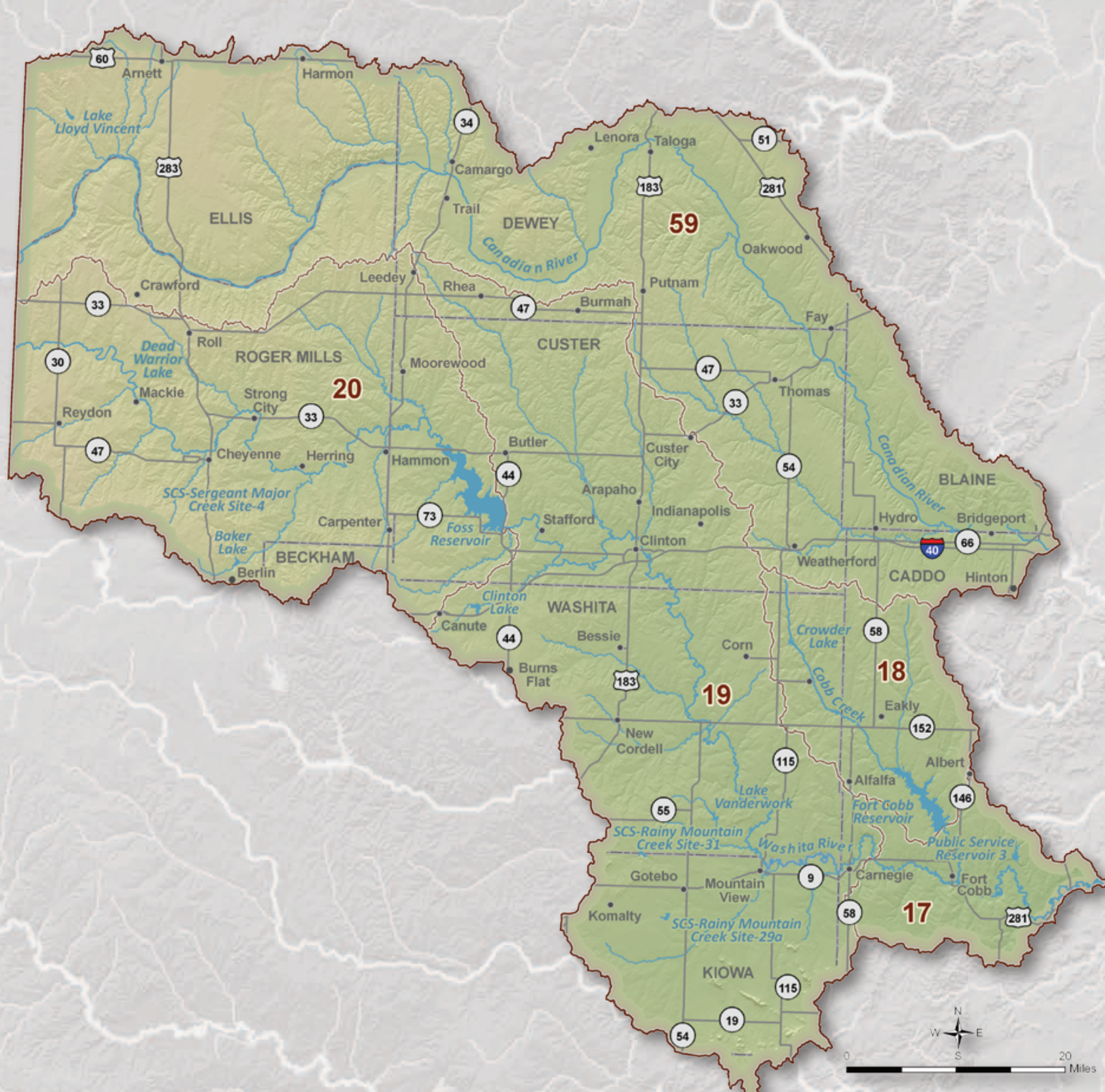
The online version of this 2012 OCWP Watershed Planning Region Report (Version 1.1) includes figures that have been updated since distribution of the original printed version. Revisions herein primarily pertain to the seasonality (i.e., the percent of total annual demand distributed by month) of Crop Irrigation demand. While the annual water demand remains unchanged, the timing and magnitude of projected gaps and depletions have been modified in some basins. The online version may also include other additional or updated data and information since the original version was printed.

Oklahoma Comprehensive Water Plan

West Central Watershed Planning Region



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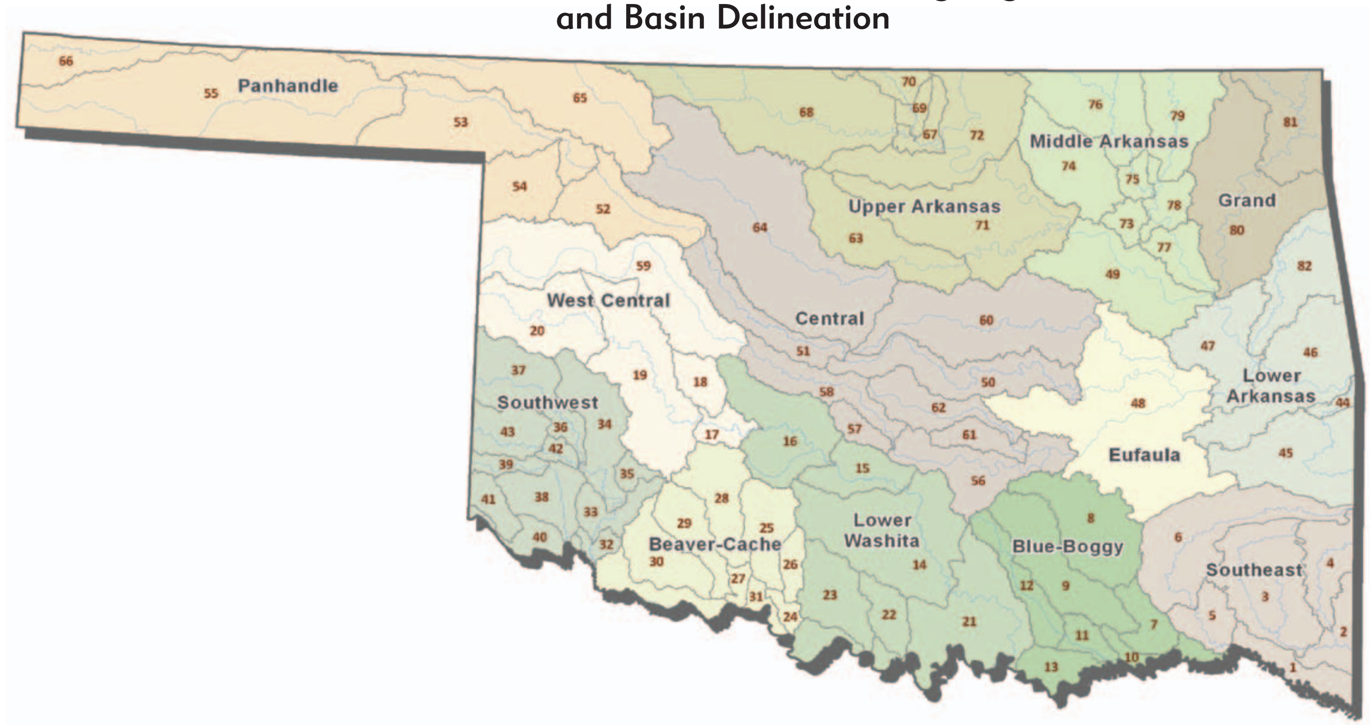


Introduction

The Oklahoma Comprehensive Water Plan (OCWP) was originally developed in 1980 and last updated in 1995. With the specific objective of establishing a reliable supply of water for state users throughout at least the next 50 years, the current update represents the most ambitious and intensive water planning effort ever undertaken by the state. The *2012 OCWP Update* is guided by two ultimate goals:

1. Provide safe and dependable water supply for all Oklahomans while improving the economy and protecting the environment.

2. 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.

In accordance with the goals, the *2012 OCWP Update* has been developed under an innovative parallel-path approach: inclusive and dynamic public participation to build sound water policy complemented by detailed technical evaluations.

Also unique to this update are studies conducted according to specific geographic boundaries (watersheds) rather than political boundaries (counties). This new strategy involved dividing the state into 82 surface water basins for water supply availability analysis (see the OCWP *Physical Water Supply Availability Report*). Existing watershed boundaries were revised to include a United States Geological Survey (USGS) stream gage at or near the basin outlet (downstream boundary), where practical. To facilitate consideration of regional supply challenges and potential solutions, basins were aggregated into 13 distinct Watershed Planning Regions.

The primary factors in the determination of reliable future water supplies are physical supplies, water rights, water quality, and infrastructure. Gaps and depletions occur when demand exceeds supply, and can be attributed to physical supply, water rights, infrastructure, or water quality constraints.

This Watershed Planning Region report, one of 13 such documents prepared for the *2012 OCWP Update*, presents elements of technical studies pertinent to the West Central Region. Each regional report presents information from both a regional and multiple basin perspective, including water supply/demand analysis results, forecasted water supply shortages, potential supply solutions and alternatives, and supporting technical information.

As a key foundation of OCWP technical work, a computer-based analysis tool, "Oklahoma H2O," was created to compare projected demands with physical supplies for each basin to identify areas of potential water shortages.

Integral to the development of these reports was the Oklahoma H2O tool, a sophisticated database and geographic information system (GIS) based analysis tool created to compare projected water demand to physical supplies in each of the 82 OCWP basins statewide. Recognizing that water planning is not a static process but rather a dynamic one, this versatile tool can be updated over time as new supply and demand data become available, and can be used to evaluate a variety of "what-if" scenarios at the basin level, such as a change in supply sources, demand, new reservoirs, and various other policy management scenarios.

Primary inputs to the model include demand projections for each decade through 2060, founded on widely-accepted methods and peer review of inputs and results by state and federal agency staff, industry representatives, and stakeholder groups for each demand sector. Surface water supply data for each of the 82 basins is based on 58 years of publicly-available daily streamflow gage data collected by the USGS. Groundwater resources were characterized using previously-developed assessments of groundwater aquifer storage and recharge rates.

Additional and supporting information gathered during development of the *2012 OCWP Update* is provided in the *OCWP Executive Report* and various OCWP supplemental reports. Assessments of statewide physical water availability and potential shortages are further documented in the OCWP *Physical Water Supply Availability Report*. Statewide water demand projection methods and results are detailed in the OCWP *Water Demand Forecast Report*. Permitting availability was evaluated based on the OWRB's administrative protocol and documented in the OCWP *Water Supply Permit Availability Report*. All supporting documentation can be found on the OWRB's website.

Regional Overview

The West Central Watershed Planning Region includes five basins (numbered 17-20 and 59 for reference). The region encompasses 5,262 square miles in western Oklahoma, spanning all of Custer County and parts of Ellis, Dewey, Roger Mills, Blaine, Beckham, Washita, Kiowa, Comanche, Caddo, and Canadian Counties.

The region is in the Central Lowland physiography province. The terrain varies from rough, marked with high sand hills and deep erosion in the north, to lush pasture and rolling river bottoms.

The climate of the region is generally mild with average monthly temperatures varying from 59°F to 64°F. Annual average precipitation ranges from 22 inches in the west to 28 inches in the east. Annual evaporation ranges from 62 to 65 inches per year.

The largest cities in the region include Weatherford (2010 population 10,833), Clinton (9,033), and New Cordell (2,915). The greatest demand is from Crop Irrigation water use.

By 2060, this region is projected to have a total demand of 110,300 acre-feet per year (AFY), an increase of 30,620 AFY (38%) from 2010.

West Central Regional Summary

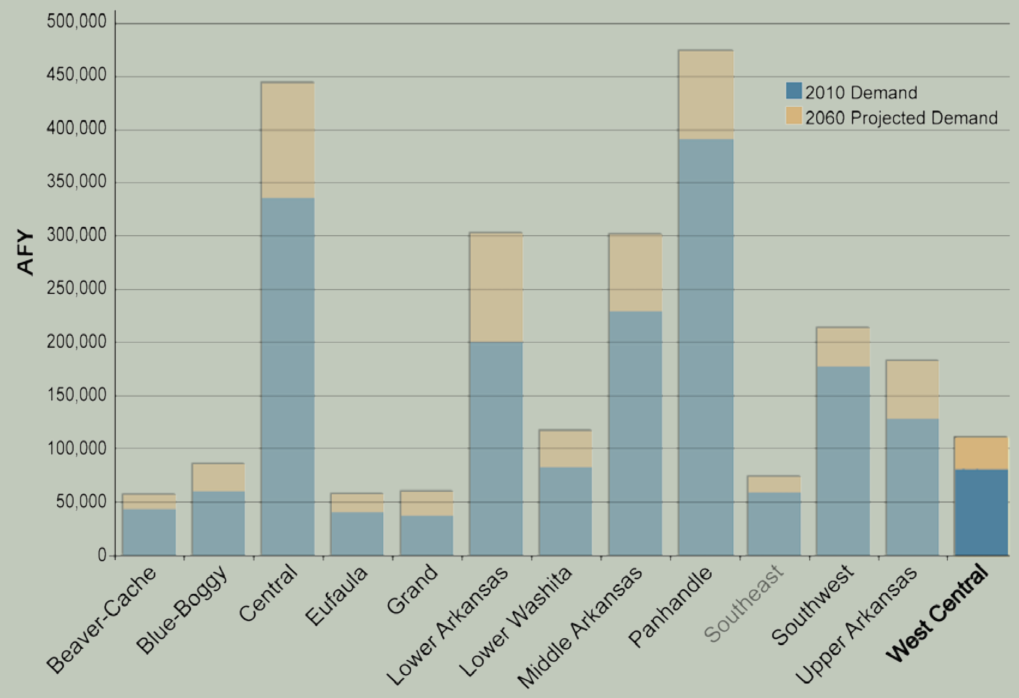
Synopsis

- The West Central Watershed Planning Region relies primarily on bedrock groundwater, and to a lesser extent, surface water supplies (including reservoirs) and alluvial aquifers.
- It is anticipated that water users in the region will continue to rely on these sources to meet future demand.
- Surface water supplies will be typically insufficient to meet demand in several basins.
- Groundwater storage depletions may lead to higher pumping costs, the need for deeper wells, and changes to well yields or water quality.
- To reduce the risk of adverse impacts on water supplies, it is recommended that gaps and storage depletions be decreased where economically feasible.
- Additional conservation could reduce surface water gaps, alluvial groundwater storage depletions, and bedrock groundwater storage depletions.
- Aquifer storage and recovery could be considered to store variable surface water supplies, increase alluvial or bedrock groundwater storage, and reduce adverse effects of localized storage depletions in Basins 18 and 20.
- Use of additional groundwater supplies and/or developing new small reservoirs could mitigate gaps without major impacts to groundwater storage.

West Central Region Demand Summary

Current Water Demand:	79,679 acre-feet/year (4% of state total)
Largest Demand Sector:	Crop Irrigation (68% of regional total)
Current Supply Sources:	16% SW 15% Alluvial GW 69% Bedrock GW
Projected Demand (2060):	110,304 acre-feet/year
Growth (2010-2060):	30,620 acre-feet/year (38%)

Current and Projected Regional Water Demand



The West Central Region accounts for about 4% of the state's total water demand. The largest demand sector is Crop Irrigation (68% of the regional total).

Water Resources & Limitations

Surface Water

Surface water is used to meet about 16% of the region's demand. Basins 17, 19, and 59 are projected to have surface water supply shortages in the future. The region is supplied by two major rivers: the Washita River and the Canadian River. Historically, the rivers and creeks in the region have periods of low to no flow in any month of the year due to seasonal and long-term trends in precipitation. Large reservoirs have been built on several rivers to provide public water supply, flood control, and recreation. Major reservoirs in the West Central Region include Fort Cobb (supplies the Fort Cobb Master Conservancy District) and Foss (supplies the Foss Master Conservancy District).

Relative to other regions, surface water quality in the region ranges from poor to good. Multiple rivers, creeks, and lakes, including the major rivers, are impaired for Agricultural use (Crop Irrigation demand sector) and Public and Private Water Supply (Municipal and Industrial demand sector) due to high levels of total dissolved solids (TDS), sulfates, and chlorophyll-a. These impairments are scheduled to be addressed through the Total Maximum Daily Loads (TMDL) process, but the use of these supplies may be limited in the interim.

Surface water in the Washita River (Basins 17, 18, 19, and 20) is fully allocated, limiting diversions to existing permitted amounts. Basin 59, containing the Upper Canadian River, is expected to have available surface water for new permitting to meet local demand through 2060.

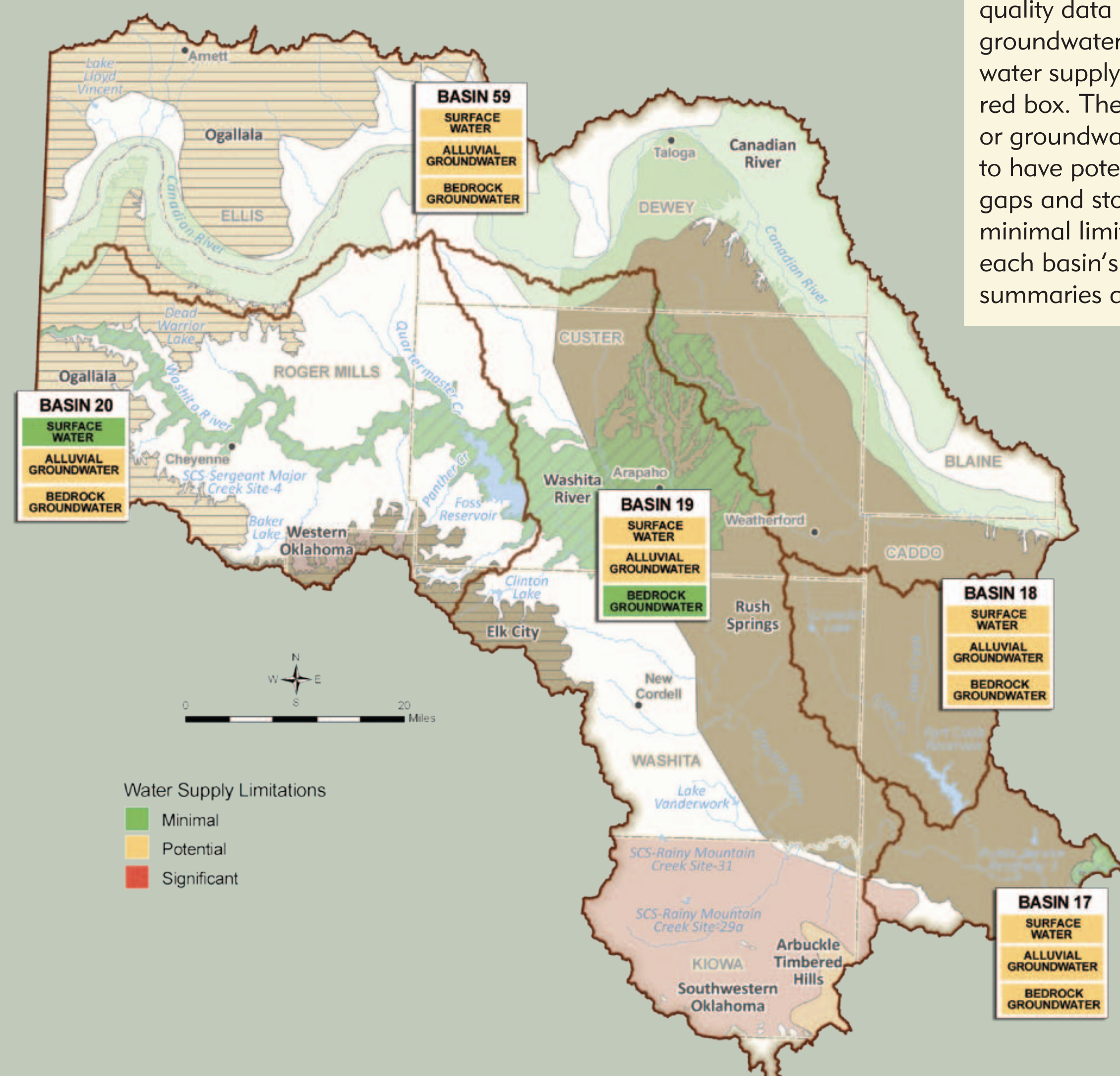
Alluvial Groundwater

Alluvial groundwater is used to meet 15% of the demand in the region. The majority of currently permitted alluvial groundwater withdrawals in the region are from the Washita River aquifer and the Canadian River aquifer. If alluvial groundwater continues to supply a similar portion of demand in the future, storage depletions from these aquifers are likely to occur throughout the year, although these projected depletions will be small to moderate relative to the amount of water in storage. The largest storage depletions are projected to occur in the summer. The availability of permits is not expected to constrain the use of alluvial groundwater supplies to meet local demand through 2060.

Bedrock Groundwater

Bedrock groundwater is used to meet 69% of the demand in the region. Currently permitted and projected withdrawals are primarily from the Rush Springs aquifer, Ogallala aquifer, and non-delineated minor aquifers. The Rush Springs aquifer has about 67 million acre-feet (AF) of groundwater storage in the region. Additionally, the Ogallala aquifer has about 5.8 million AF of groundwater storage in the region. Bedrock aquifer storage depletions are likely to occur throughout the year, but will be largest in the summer months. These depletions are small relative to the amount of water in storage, but may lead to adverse impacts on pumping costs, yields, and/or water quality. The availability of permits is not expected to constrain the use of bedrock groundwater supplies to meet local demand through 2060.

Water Supply Limitations
West Central Region



Water Supply Limitations

Surface water limitations are determined based on physical availability, water supply availability for new permits, and water quality. Groundwater limitations are determined based on the total size and rate of storage depletions in major aquifers. Groundwater permits are not expected to constrain the use of groundwater through 2060; insufficient statewide groundwater quality data are available to compare basins based on groundwater quality. Basins with the most significant water supply challenges statewide are indicated by a red box. The remaining basins with surface water gaps or groundwater storage depletions were considered to have potential limitations (yellow). Basins without gaps and storage depletions are considered to have minimal limitations (green). Detailed explanations of each basin's supplies are provided in individual basin summaries and supporting data and analysis.

Water Supply Options

To quantify physical surface water gaps and groundwater storage depletions through 2060, use of local supplies was assumed to continue in the current (2010) proportions. Surface water, alluvial groundwater, and bedrock groundwater supplies are expected to continue to supply the majority of demand in the region.

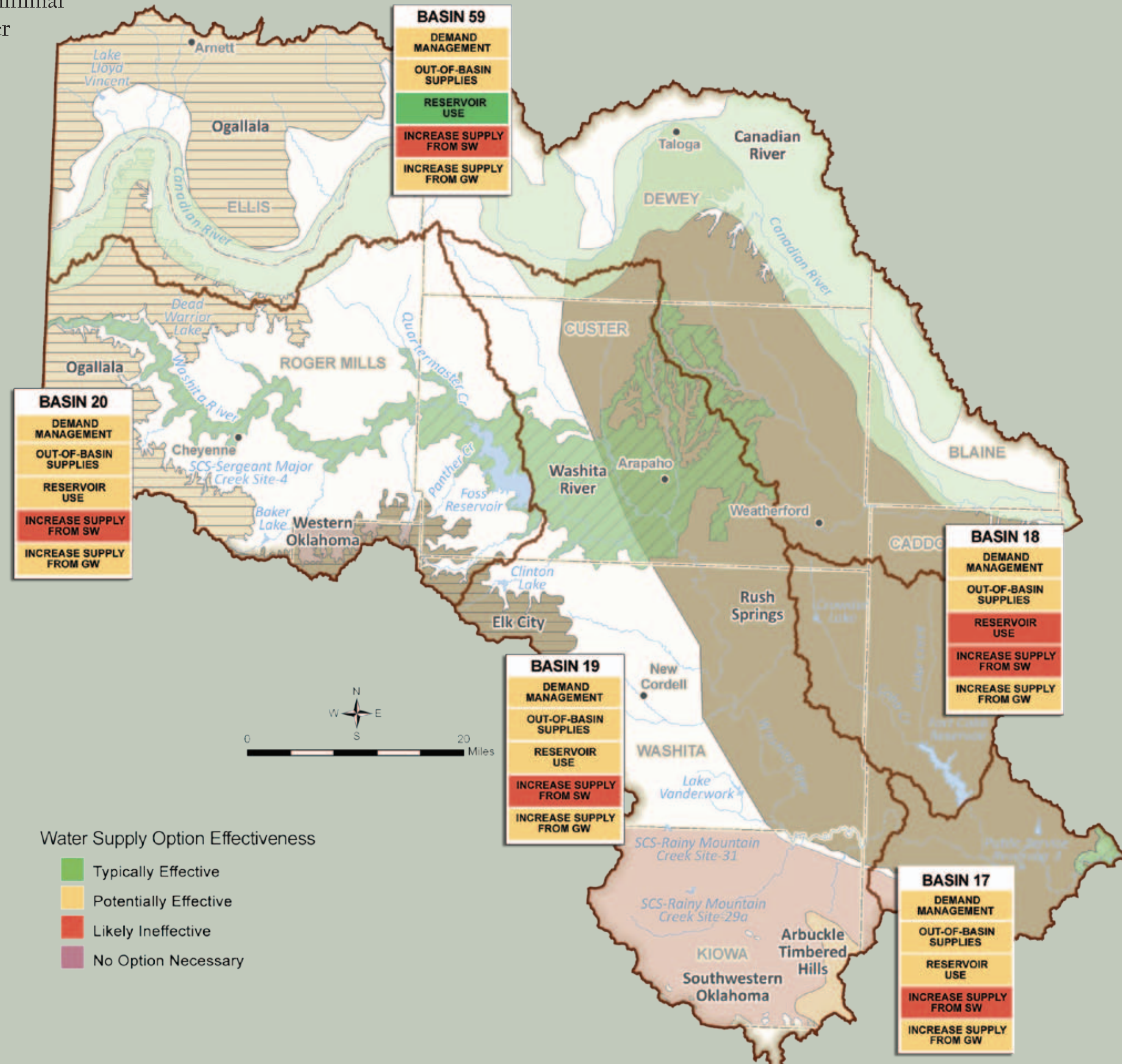
Users that rely on surface water, without significant reservoirs, are projected to have physical surface water supply shortages (gaps) in the future. Alluvial and bedrock groundwater storage depletions are also projected in the future. Therefore, additional long-term water supplies should be considered.

Water conservation could aid in reducing projected gaps and groundwater storage depletions or delaying the need for additional infrastructure. Moderately expanded permanent conservation activities, primarily from increased irrigation efficiency and increased conservation by public water suppliers, could eliminate groundwater storage depletions in Basins 20 and 59 and reduce gaps and depletions in other basins. Further reductions could occur from substantially expanded conservation activities. These measures would require a shift from crops with high water demand (e.g., corn for grain and forage crops) to low water demand crops such as sorghum for grain or wheat for grain, along with increased efficiency and increased public water supplier conservation. Due to extended dry periods and predominant use of groundwater supplies, temporary drought management measures alone will likely be an ineffective water supply option.

New small reservoirs (50 AF or less of storage) could enhance the dependability of surface water supplies and could decrease gaps. Basin 59 has unallocated streamflow and could develop larger reservoirs to decrease local and potentially regional gaps and storage depletions. The OCWP *Reservoir Viability Study* evaluated the potential for reservoirs throughout the state and identified five potentially viable reservoir sites in the region. These water sources could provide additional supplies to mitigate the region's groundwater storage depletions. However, due to the distance from these reservoirs to demand points in each basin, this water supply option may not be cost-effective for many users.

The projected growth in surface water could instead be supplied in part by increased use of groundwater. This may result in minimal increases in projected groundwater storage depletions.

Water Supply Option Effectiveness
West Central Region



Effectiveness of water supply options in each basin in the West Central Region. This evaluation was based upon results of physical water supply availability analysis, existing infrastructure, and other basin-specific factors.

Water Supply

Physical Water Availability

Surface Water Resources

Surface water has historically satisfied about 16% of the demand in the West Central Region. The region's major streams include the Upper Washita and the Upper Canadian. Many streams in this region have historically experienced periods of very low flows, although periodic flooding events can also occur.

The Canadian River, located in the northern area of the region, consists of a long mainstem beginning in Texas and stretching across much of the state of Oklahoma, with 160 miles of the mainstem located in Basin 59. There are no major tributaries to the Canadian River located in the region.

The headwaters of the Washita River are located in Texas with the mainstem flowing through the southern and eastern portion of the West Central Region; 530 miles of the Washita River mainstem are located in Oklahoma with 250 miles in the West Central Region. Major tributaries in the West Central region include Cobb Creek (20 miles).

As important sources of surface water in Oklahoma, reservoirs and lakes help provide dependable water supply storage, especially when streams and rivers experience periods of low seasonal flow or drought.

In the West Central Region, streamflow is generally low. Existing reservoirs in the region increase the dependability of surface water supply for many public water systems and other users. Reservoirs in the region with water supply yield include: Fort Cobb, built in 1959 on Cobb Creek by the Bureau of Reclamation; Foss, built in 1961 on the Upper Washita by the Bureau of Reclamation; and Clinton, built on the Washita River by the City of Clinton in 1931. Other reservoirs in the region include Crowder, Dead Warrior, and Sportsman. There are many other small Natural Resources Conservation Service (NRCS) and municipal and privately owned lakes in the region that provide water for public water supply, agricultural water supply, flood control, and recreation.

Reservoirs
West Central Region

Reservoir Name	Primary Basin Number	Reservoir Owner/Operator	Year Built	Purposes[1]	Normal Pool Storage	Water Supply		Irrigation		Water Quality		Permitted Withdrawals	Remaining Water Supply Yield to be Permitted
						Storage	Yield	Storage	Yield	Storage	Yield		
					AF	AF	AFY	AF	AFY	AF	AFY	AFY	AFY
Clinton	19	City of Clinton	1931	WS, R	3,980	---	---	---	---	---	---	---	---
Crowder	18	State of Oklahoma	1959	FC, R	2,094	---	---	---	---	---	---	---	---
Dead Warrior	20	City of Cheyenne	1959	FC, R	977	---	---	0	0	0	0	0	---
Fort Cobb	18	Bureau of Reclamation	1959	FC, WS, FW, R	80,010	78,350	18,000	0	0	0	0	18,000	0
Foss	20	Bureau of Reclamation	1961	IR, FC, WS, FW, R	256,220	165,480	18,000	0	0	0	0	17,634	366

No known information is annotated as "---"

1 *The "Purposes" represent the use(s), as authorized by the funding entity or dam owner(s), for the reservoir storage when constructed.*

WS=Water Supply, R=Recreation, HP=Hydroelectric Power, IR=Irrigation, WQ=Water Quality, FW=Fish & Wildlife, FC=Flood Control, LF=Low Flow Regulation, N=Navigation, C=Conservation, CW=Cooling Water

Surface Water Resources
West Central Region

Reservoirs may serve multiple purposes, such as water supply, irrigation, recreation, hydropower generation, and flood control. Reservoirs designed for multiple purposes typically possess a specific volume of water storage assigned for each purpose.

Water Supply Availability Analysis

For OCWP physical water supply availability analysis, water supplies were divided into three categories: surface water, alluvial aquifers, and bedrock aquifers. Physically available surface water refers to water currently in streams, rivers, lakes, and reservoirs.

The range of historical surface water availability, including droughts, is well-represented in the Oklahoma H2O tool by 58 years of monthly streamflow data (1950 to 2007) recorded by the U.S. Geological Survey (USGS). Therefore, measured streamflow, which reflects current natural and human created conditions (runoff, diversions and use of water, and impoundments and reservoirs), is used to represent the physical water that may be available to meet projected demand.

The estimated average and minimum annual streamflow in 2060 were determined based on historic surface water flow measurements and projected baseline 2060 demand (see Water Demand section). The amount of streamflow in 2060 may vary from basin-level values, due to local variations in demands and local availability of supply sources. The estimated surface water supplies include changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure. Permitting, water quality, infrastructure, non-consumptive demand, and potential climate change implications are considered in separate OCWP analyses. Past reservoir operations are reflected and accounted for in the measured historical streamflow downstream of a reservoir. For this analysis, streamflow was adjusted to reflect interstate compact provisions in accordance with existing administrative protocol.

The amount of water a reservoir can provide from storage is referred to as its yield. The yield is considered the maximum amount of water a reservoir can dependably supply during critical drought periods. The unused yield of existing reservoirs was considered for this analysis. Future potential reservoir storage was considered as a water supply option.

Groundwater supplies are quantified by the amount of water that an aquifer holds ("stored" water) and the rate of aquifer recharge. In Oklahoma, recharge to aquifers is generally from precipitation that falls on the aquifer and percolates to the water table. In some cases, where the altitude of the water table is below the altitude of the stream-water surface, surface water can seep into the aquifer.

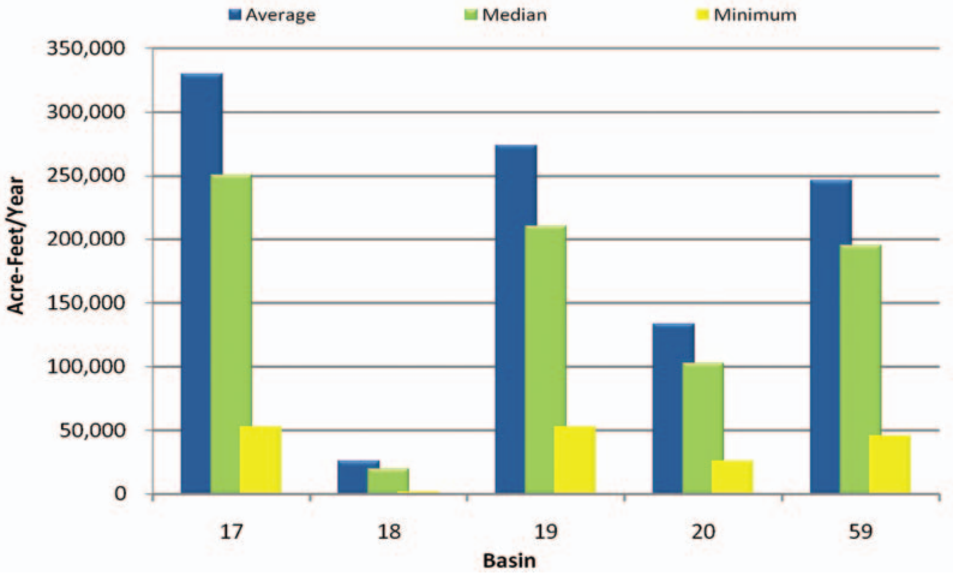
For this analysis, alluvial aquifers are defined as aquifers comprised of river alluvium and terrace deposits, occurring along rivers and streams and consisting of unconsolidated deposits of sand, silt, and clay. Alluvial aquifers are generally thinner (less than 200 feet thick) than bedrock aquifers, feature shallow water tables, and are exposed at the land surface, where precipitation can readily percolate to the water table. Alluvial aquifers are considered to be more hydrologically connected with streams than are bedrock aquifers and are therefore treated separately.

Bedrock aquifers consist of consolidated (solid) or partially consolidated rocks, such as sandstone, limestone, dolomite, and gypsum. Most bedrock aquifers in Oklahoma are exposed at land surface either entirely or in part. Recharge from precipitation is limited in areas where bedrock aquifers are not exposed.

For both alluvial and bedrock aquifers, this analysis was used to predict potential groundwater depletions based on the difference between the groundwater demand and recharge rate. While potential storage depletions do not affect the permit availability of water, it is important to understand the extent of these depletions.

More information is available in the OCWP *Physical Water Supply Availability Report* on the OWRB website.

Surface Water Flows (1950-2007)
West Central Region



Surface water sources supply about 16% of the demand in the West Central Region. While the region's average physical surface water supply exceeds projected surface water demand in the region, gaps can occur due to seasonal, long-term hydrologic (drought), or localized variability in surface water flows.

Estimated Annual Streamflow in 2060
West Central Region

Streamflow Statistic	Basins				
	17	18	19	20	59
	AFY				
Average Annual Flow	309,900	23,500	259,000	121,400	174,300
Minimum Annual Flow	40,200	0	43,800	19,700	4,400

Annual streamflow in 2060 was estimated using historical gaged flow and projections of increased surface water use from 2010 to 2060.

Groundwater Resources

Four major bedrock aquifers–the Elk City, Ogallala, Arbuckle-Timbered Hills, and Rush Springs–underlie the West Central Watershed Planning Region, along with two major alluvial aquifers–the Canadian River and Washita River.

The Elk City aquifer is comprised of fine-grained, friable sandstone with a maximum thickness of about 185 feet. Wells commonly yield 25 to 300 gallons per minute (gpm) of water for irrigation, domestic, and industrial purposes.

Withdrawing groundwater in quantities exceeding the amount of recharge to the aquifer may result in aquifer depletion and reduced storage. Therefore, both storage and recharge were considered in determining groundwater availability.

The Ogallala aquifer, the most prolific aquifer in the state, underlies only the western portion of Basins 20 and 59. The Ogallala consists predominantly of semi-consolidated sediment layers. The depth to water ranges from less than 10 feet to more than 300 feet below the land surface and the saturated thickness ranges from nearly zero to almost 430 feet. The Ogallala commonly yields 500 to 1,000 gpm and can yield up to 2,000 gpm in thick, highly permeable areas. Due primarily to significant crop irrigation use, groundwater is pumped out of the aquifer at rates significantly exceeding recharge, causing declining water levels throughout much of the aquifer. However, in areas of Roger Mills County, water levels have increased. The equal proportionate share has been set at 1.4 AF/acre for the portion of the aquifer underling Ellis and Dewey Counties, but a study has not been completed for the portion of the Ogallala underlying Roger Mills. Water quality of the aquifer is generally very good. However, local areas, water quality has been impaired by high concentrations of nitrate.

The Arbuckle-Timbered Hills aquifer underlies a small portion of Basin 19. Availability of groundwater in the Limestone Hills is erratic due to faulting and folding. Most wells are 500 feet or deeper and wells and springs yield as much as 100 gpm. Water from the Limestone Hills area is generally very hard and fluoride concentrations typically exceed the drinking water standard, limiting use for public supply.

Areas without delineated aquifers may have groundwater present. However, specific quantities, yields, and water quality in these areas are currently unknown.

The Rush Springs aquifer is a fine-grained sandstone aquifer with some shale, dolomite, and gypsum. Thickness of the aquifer ranges from 200 to 300 feet. Wells commonly yield 25 to 400 gpm. The water tends to be very hard, requiring water softening to address aesthetic issues for public water supply use. In some areas nitrate and sulfate concentrations exceed drinking water standards, limiting its use for drinking water. The aquifer underlies portions of Basins 17, 18, 19, and 59.

The Washita River aquifer consists of silt and clays grading into fine to course sand. The formation deposits average 70 feet in thickness. Wells in this formation range from 200 gpm to 500 gpm. The water is hard to very hard and of a generally calcium magnesium bicarbonate type, and TDS values are usually less than 1,000 mg/L. The aquifer underlies portions of Basins 17, 19, 20, and 59.

The Canadian River aquifer consists of clay and silt downgrading to fine- to coarse-grained sand with lenses of basal gravel. Formation thicknesses range from 20 to 40 feet in the alluvium with a maximum of 50 feet in the terrace deposits. Yields in the alluvium range between 100 and 400 gpm and between 50 and 100 gpm in the terrace. The water is a very hard calcium bicarbonate type with TDS concentrations of approximately 1,000 mg/L. However, the water is generally suitable for most municipal and industrial uses. The aquifer underlies a small portion of Basins 19, 20, and 59.

Minor aquifers in the region include the Southwestern Oklahoma, Western Oklahoma, and non-delineated groundwater sources. Minor aquifers may have a significant amount of water in storage and high recharge rates, but generally low yields of less than 50 gpm. Groundwater from minor aquifers is an important source of water for domestic and stock water use for individuals in outlying areas not served by rural water systems, but may not have sufficient yield for high-volume users.

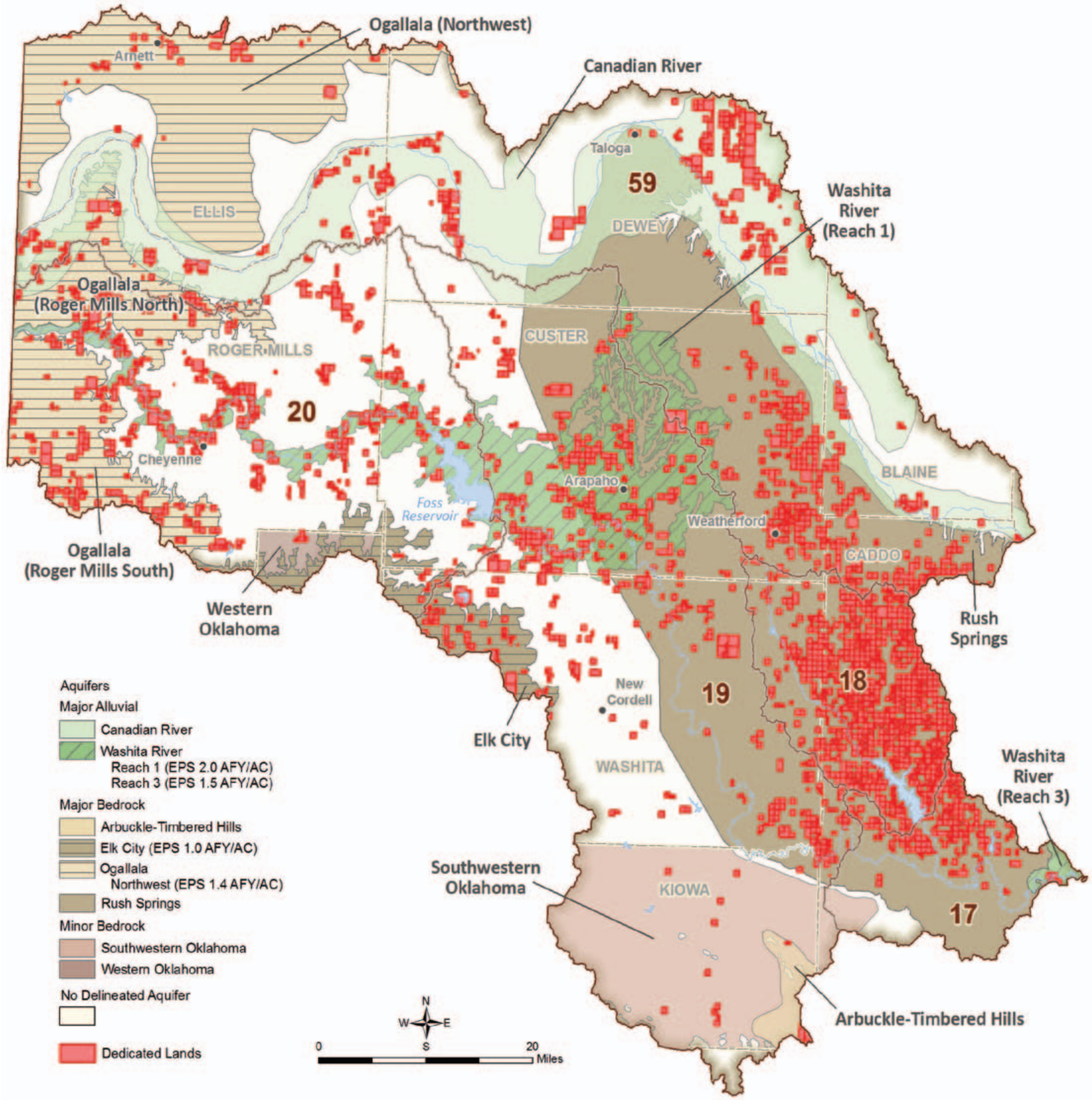
Permits to withdraw groundwater from aquifers (groundwater basins) where the maximum annual yield has not been set are "temporary" permits that allocate 2 AFY/acre. The temporary permit allocation is not based on storage, discharge or recharge amounts, but on a legislative (statute) estimate of maximum needs of most landowners to ensure sufficient availability of groundwater in advance of completed and approved aquifer studies. As a result, the estimated amount of Groundwater Available for New Permits may exceed the estimated aquifer storage amount. For aquifers (groundwater basins) where the maximum annual yield has been determined (with initial storage volumes estimated), updated estimates of amounts in storage were calculated based on actual reported use of groundwater instead of simulated usage from all lands.

Groundwater Resources
West Central Region

Aquifer			Portion of Region Overlaying Aquifer	Recharge Rate	Current Groundwater Rights	Aquifer Storage in Region	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	Inch/Yr	AFY	AF	AFY/Acre	AFY
Arbuckle-Timbered Hills	Bedrock	Major	1%	0.3-0.6	3,300	79,000	temporary 2.0	34,600
Canadian River	Alluvial	Major	15%	2.0	28,000	1,829,000	temporary 2.0	954,000
Elk City	Bedrock	Major	2%	2.8	8,600	809,000	1.0	69,600
Ogallala	Bedrock	Major	14%	0.9	65,500	5,795,000	1.4 to temporary 2.0	846,000
Rush Springs	Bedrock	Major	32%	0-1.8	348,100	67,329,000	temporary 2.0	1,729,800
Washita River	Alluvial	Major	8%	2.7-3.2	66,300	2,982,000	1.5-2.0	453,200
Southwestern Oklahoma	Bedrock	Minor	7%	2.25	0	654,000	temporary 2.0	483,100
Western Oklahoma	Bedrock	Minor	1%	NA	300	NA	temporary 2.0	50,200
Non-Delineated Groundwater Source	Alluvial	Minor			7,100			
Non-Delineated Groundwater Source	Bedrock	Minor			50,100			

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources
West Central Region



Major bedrock aquifers in the West Central Region include the Arbuckle-Timbered Hills, Elk City, Ogallala, and Rush Springs. Major alluvial aquifers in the region include the Canadian River and Washita River. Major bedrock aquifers are defined as those that have an average water well yield of at least 50 gpm; major alluvial aquifers are those that yield, on average, at least 150 gpm.

Permit Availability

For OCWP water availability analysis, "permit availability" pertains to the amount of water that could be made available for withdrawals under permits issued in accordance with Oklahoma water law.

If water authorized by a stream water right is not put to beneficial use within the specified time, the OWRB may reduce or cancel the unused amount and return the water to the public domain for appropriation to others.

Projections indicate that there will be surface water available for new permits through 2060 in Basin 59. There is no surface water available for new permits in Basins 17, 18, 19, and 20 in the West Central Region in 2060. For groundwater, each aquifer's equal proportionate share (EPS) determines the amount of water available for permits. Equal proportionate shares in the West Central Region range from 1 AFY per acre to 2 AFY per acre. Projections indicate that there will be groundwater available for new permits through 2060 in all basins in the West Central Region.

Surface Water Permit Availability

Oklahoma stream water laws are based on riparian and prior appropriation doctrines. Riparian rights to a reasonable use of water, in addition to domestic use, are not subject to permitting or oversight by the OWRB. An appropriative right to stream water is based on the prior appropriation doctrine, which is often described as "first in time, first in right." If a water shortage occurs, the diverter with the older appropriative water right will have first right among other appropriative right holders to divert the available water up to the authorized amount.

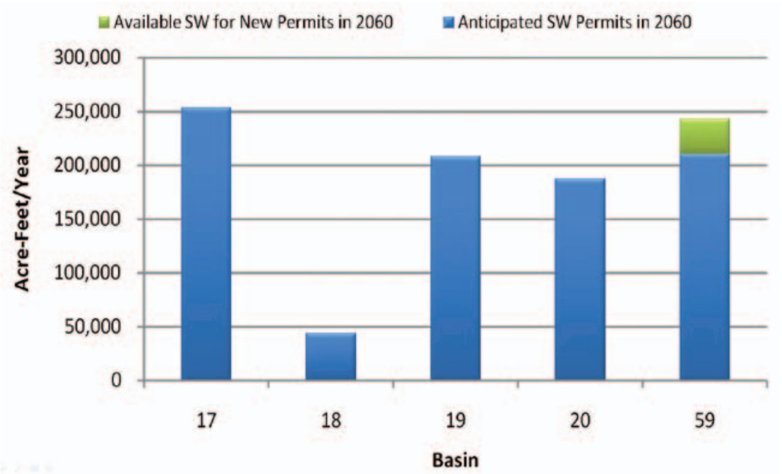
To determine surface water permit availability in each OCWP planning basin in 2060, the analysis utilized OWRB protocol to estimate the average annual streamflow at the basin's outlet point, accounting for both existing and anticipated water uses upstream and downstream, including legal obligations, such as those associated with domestic use and interstate compact requirements.

Groundwater Permit Availability

Groundwater available for permits in Oklahoma is generally based on the amount of land owned or leased that overlies a specific aquifer. For unstudied aquifers, temporary permits are granted allocating 2 AFY/acre. For studied aquifers, an "equal proportionate share" (EPS) is established based on the maximum annual yield of water in the aquifer, which is then allocated to each acre of land overlying the groundwater basin. Once an EPS has been established, temporary permits are then converted to regular permits and all new permits are based on the EPS.

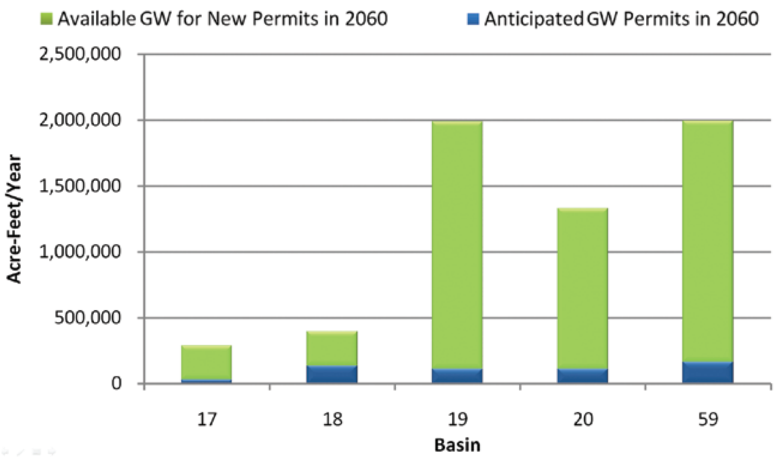
For OCWP analysis, the geographical area overlying all aquifers in each basin was determined and the respective EPS or temporary permit allocations were applied. Total current and anticipated future permit needs were then calculated to project remaining groundwater permit availability.

Surface Water Permit Availability
West Central Region



Projections indicate that there will be surface water available for new permits through 2060 in Basin 59. There is no surface water available for new permits in Basins 17, 18, 19, and 20 in the West Central Region.

Groundwater Permit Availability
West Central Region



Projections indicate that there will be groundwater available for new permits through 2060 in all basins in the West Central Region.

Water Quality

Water quality of the West Central Watershed Planning Region is defined by two major river systems, the Canadian and Washita Rivers, and numerous local water supply/ flood control reservoirs. The majority of the region is contained within the Central Great Plains (CGP) ecoregion, with some Southwestern Tablelands (SWT) influence in the far northwestern corner. It is bordered by the Cross Timbers ecoregion and other CGP ecoregions, but their influence is minimal and will not be addressed.

The region is dominated ecologically by the Rolling Red Hills ecoregion. The area has steep hilly relief and breaks, with intermixed gypsum karst features. It is dominated by rangeland with predominately mixed/short grass prairies and lowland wooded areas. It extends from the western border through over three quarters of the region's geographical area and is drained by the Canadian and Washita Rivers, represented by stations at McClure and Cordell. Streams throughout the area are mostly sand or sand/silt bottom with low/ moderate gradients and incised banks. Flood control/water supply lakes include Foss, Clinton, and Vanderwork. Salinity is high with mean conductivity values ranging from 1,860 (McClure) to 2,250 uS (Taloga). The Canadian has similar mean concentrations for chloride (500 ppm) and sulfate (490 ppm). However, the Washita is sulfate-dominated, with means ranging from 842 (McClure) to near 1,000 ppm (Cordell), while chloride averages around 65 ppm. Reservoir salinity is variable. Conductivity at Vanderwork (1,700 uS) and Foss (2,100 uS) are comparable to the Washita. However, conductivity of 525 uS at Clinton is low. In the Canadian drainage, total nitrogen and phosphorus mean concentrations are low at values of 0.90 and 0.09 ppm. However, the Washita River is eutrophic and higher, with mean total nitrogen and phosphorus concentrations ranging from 1.61 and 0.16 (McClure) to 2.00 and 0.34 ppm (Cordell). Lakes are phosphorus limited and eutrophic (Foss) to hyper-eutrophic (Clinton, Vanderwork). With a mean turbidity of 15 NTU, water clarity is very good in the Canadian River. Conversely, clarity is poor in the Washita drainage with mean turbidities of 56 (McClure) and 61 NTU (Cordell). Lake clarity is poor to good, with average Secchi depths of 23 cm (Clinton) to near 100 cm (Vanderwork). Ecological diversity is low throughout both drainages due to salinity, habitat degradation, and sedimentation.

The remaining quarter of the region is characterized mostly by the Cross Timbers Transition (CTT), and to a lesser extent, the Pleistocene Sand Dunes. The CTT is a hybrid mix of rough plains covered by prairie grasses and oak/ elm and cedar forests, with cropland/rangeland as major land uses. Streams are typically rockier. Along the northern Canadian River, the Pleistocene Sand Dunes have more permeable sandy soils, interlaced with

Lake Trophic Status

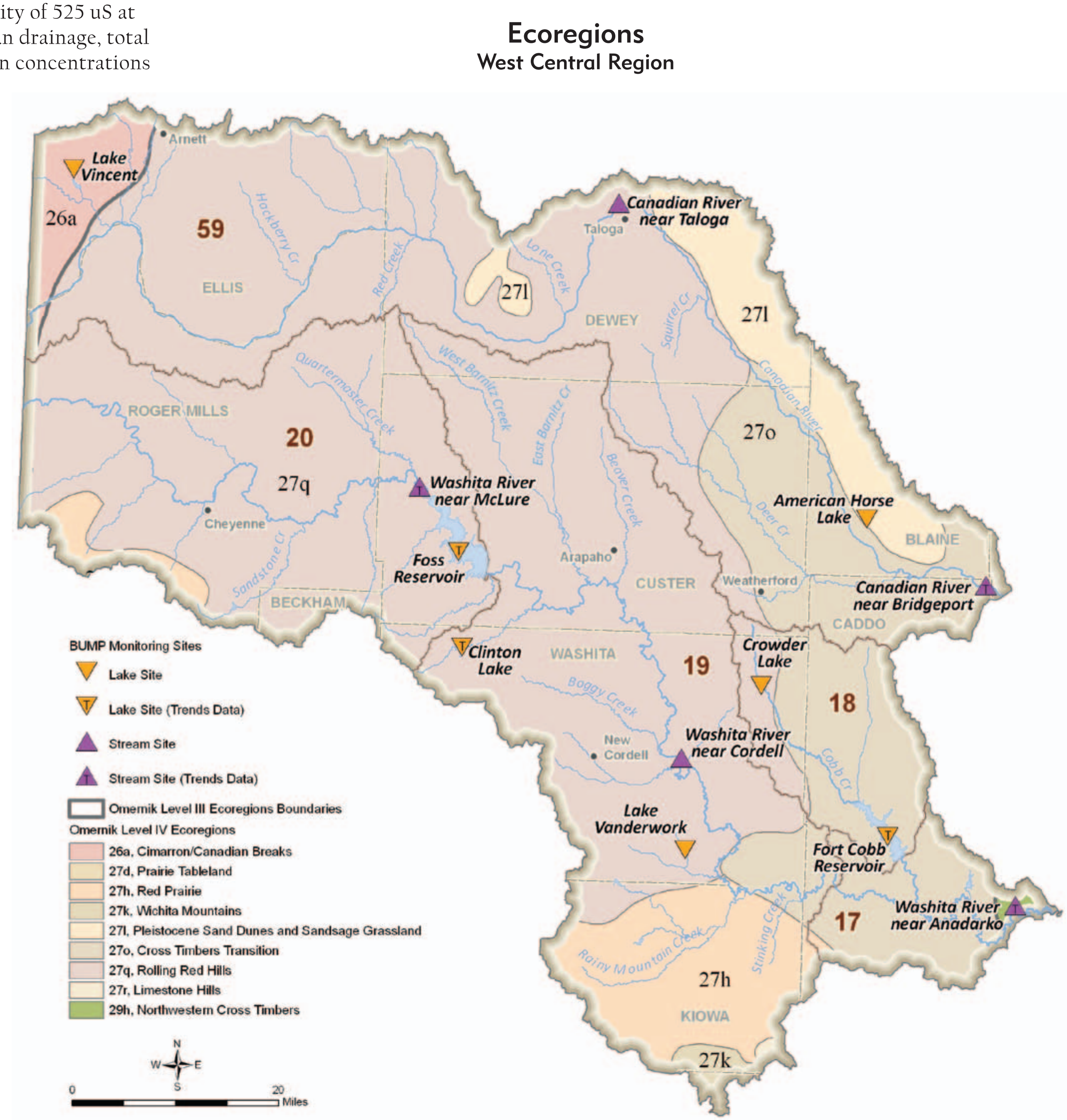
A lake's trophic state, essentially a measure of its biological productivity, is a major determinant of water quality.

Oligotrophic: Low primary productivity and/or low nutrient levels.

Mesotrophic: Moderate primary productivity with moderate nutrient levels.

Eutrophic: High primary productivity and nutrient rich.

Hypereutrophic: Excessive primary productivity and excessive nutrients.



The West Central Planning Region is dominated by the ecoregions of the Central Great Plains with some Southwestern Tablelands influence in the northwest corner. Surface water quality ranges from poor to good depending on drainage and location.

springs and inter-dune wetlands, with stream substrates to the Rolling Red Hills. The area is characterized by the Washita and Canadian drainages and water supply/flood control lakes, including Fort Cobb, American Horse, and Crowder Lakes. Salinity decreases in a trend that will continue east. River mean conductivity is 1,380 (Canadian) to 1,675 uS (Washita). Lake conductivity of around 225 (American Horse) to 500 uS (Fort Cobb) is analogous to the Cross Timbers. Crowder remains high at around 900 uS. Total nitrogen (1.24 ppm) and phosphorus (0.22 ppm) mean concentrations increase along the Canadian. On the Washita, total nitrogen decreases to 1.62 ppm, while total phosphorus remains stable at 0.36 ppm. Both rivers are hyper-eutrophic. Likewise, Fort Cobb and Crowder have high nutrient concentrations and are eutrophic to hyper-eutrophic. Unique for the CGP, American Horse is oligotrophic, with low nutrient concentrations of 1.00 (nitrogen) and 0.05 ppm (phosphorus), Water clarity is fair to poor with turbidity means of 40 (Canadian) and 75 NTU (Washita). Lake clarity is average to good, with mean Secchi depths of 58 (Fort Cobb) to 118 cm (American Horse). Ecological diversity increases due to lower salinity but is still impacted by habitat degradation and sedimentation.

Finally, the Cimarron/Canadian Breaks ecoregion of the SWT extends into the far northwestern corner. It is characteristically rugged, with a variety of hills, buttes, canyons, and escarpments, underlain by sandstone/siltstone. Numerous springs support a variety of ecosystems in lowland areas. Lake Vincent has moderately high salinity (conductivity = 825 uS). Vincent is mesotrophic, with

Water Quality Standards Implementation
West Central Region

The Oklahoma Conservation Commission has begun a watershed implementation project on Fort Cobb Lake to address the sources of the lake's impairments, including sediment, nutrient, and bacterial pathogens. The Oklahoma Department of Environmental Quality has completed TMDL studies on Bear Creek, Commission Creek, Deer Creek, Willow Creek, and Canadian River.

Water Quality Standards and Implementation

The Oklahoma Water Quality Standards (OWQS) are the cornerstone of the state's water quality management programs. The OWQS are a set of rules promulgated under the federal Clean Water Act and state statutes, designed to maintain and protect the quality of the state's waters. The OWQS designate beneficial uses for streams, lakes, other bodies of surface water, and groundwater that has a mean concentration of Total Dissolved Solids (TDS) of 10,000 milligrams per liter or less. Beneficial uses are the activities for which a waterbody can be used based on physical, chemical, and biological characteristics as well as geographic setting, scenic quality, and economic considerations. Beneficial uses include categories such as Fish and Wildlife Propagation, Public and Private Water Supply, Primary (or Secondary) Body Contact Recreation, Agriculture, and Aesthetics.

The OWQS also contain standards for maintaining and protecting these uses. The purpose of the OWQS is to promote and protect as many beneficial uses as are attainable and to assure that degradation of existing quality of waters of the state does not occur.

The OWQS are applicable to all activities which may affect the water quality of waters of the state, and are to be utilized by all state environmental agencies in implementing their programs to protect water quality. Some examples of these implementation programs are permits for point source (e.g. municipal and industrial) discharges into waters of the state; authorizations for waste disposal from concentrated animal feeding operations; regulation of runoff from nonpoint sources; and corrective actions to clean up polluted waters.

More information about OWQS and the latest revisions can be found on the OWRB website.

Water Quality Impairments

A waterbody is considered to be impaired when its quality does not meet the standards prescribed for its beneficial uses. For example, impairment of the Public and Private Water Supply beneficial use means the use of the waterbody as a drinking water supply is hindered. Impairment of the Agricultural use means the use of the waterbody for livestock watering, irrigation or other agricultural uses is hindered. Impairments can exist for other uses such as Fish and Wildlife Propagation or Recreation.

The Beneficial Use Monitoring Program (BUMP), established in 1998 to document and quantify impairments of assigned beneficial uses of the state's lakes and streams, provides information for supporting and updating the OWQS and prioritizing pollution control programs. A set of rules known as "use support assessment protocols" is also used to determine whether beneficial uses of waterbodies are being supported.

In an individual waterbody, after impairments have been identified, a Total Maximum Daily Load (TMDL) study is conducted to establish the sources of impairments—whether from point sources (discharges) or non-point sources (runoff). The study will then determine the amount of reduction necessary to meet the applicable water quality standards in that waterbody and allocate loads among the various contributors of pollution.

For more detailed review of the state's water quality conditions, see the most recent versions of the OWRB's BUMP Report, and the Oklahoma Integrated Water Quality Assessment Report, a comprehensive assessment of water quality in Oklahoma's streams and lakes required by the federal Clean Water Act and developed by the ODEQ.

Water Quality Impairments
West Central Region

Regional water quality impairments are based on the 2008 *Oklahoma Integrated Water Quality Assessment Report*. Excessive levels of nutrients and turbidity are producing impacts. Groundwater from the Rush Springs aquifer has nitrate and sulfate concentrations that exceed drinking water standards in some areas, limiting its use for drinking water.

comparatively low nitrogen (0.60 ppm) and phosphorus (0.02 ppm). Water clarity is good with a Secchi Depth of 68 cm and can be excellent in streams. Ecological diversity is fair but remains impacted by salinity.

Although a statewide groundwater water quality program does not exist in Oklahoma, various aquifer studies have been completed, and data are available from municipal authorities and other sources.

The West Central region is underlain by several major and minor bedrock and alluvial aquifers. In most western Oklahoma alluvial aquifers, water quality is good, and except for hardness and localized nitrate problems, the water is appropriate for domestic, irrigation, industrial and municipal use.

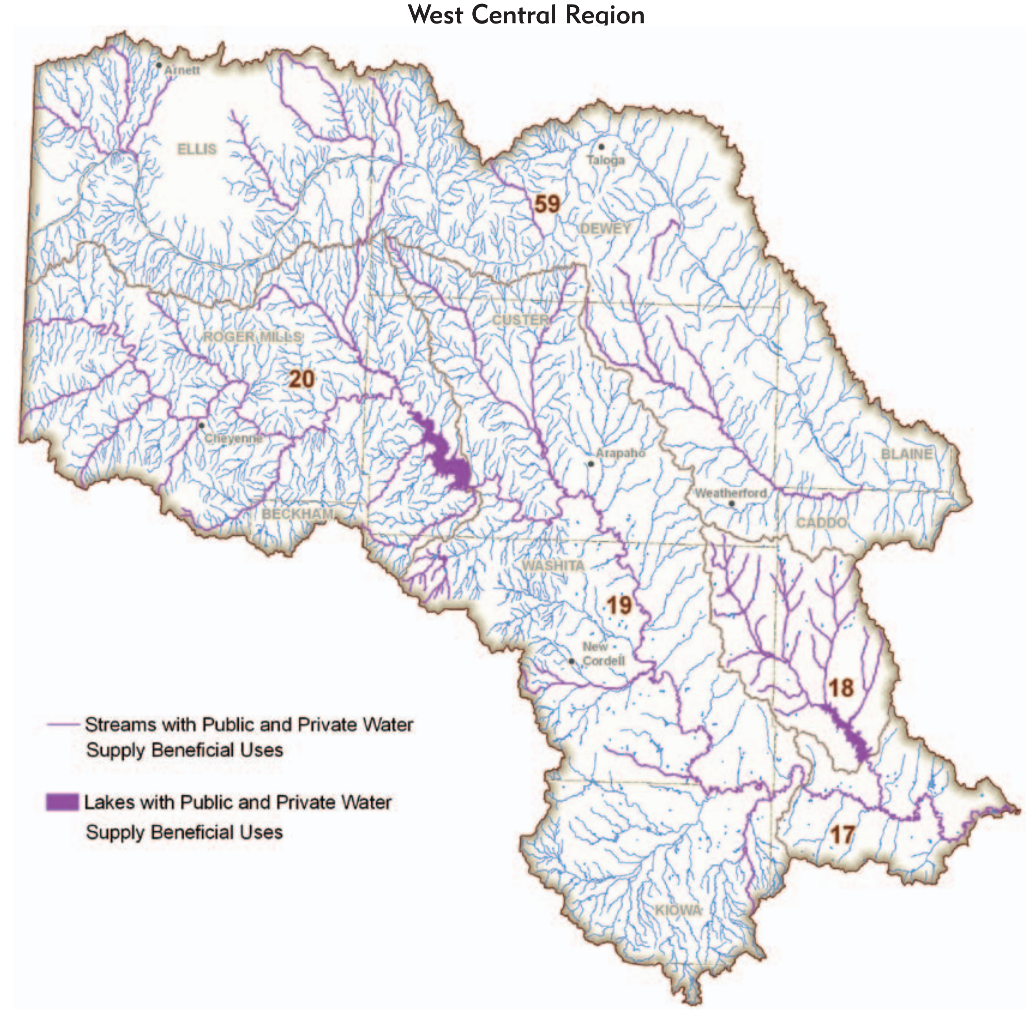
Major bedrock aquifers in the region include the Ogallala, Elk City, Rush Springs Sandstone and Arbuckle-Timbered Hills Group. The Ogallala aquifer extends into the northwestern portion of the region. Water quality of the aquifer is generally very good and can be used for most purposes. The Elk City aquifer lies along a portion of the southern border of the region and is comprised of fine-grained and very friable sandstone. Water is generally considered suitable for most purposes. The Rush Springs Sandstone extends into the east and central portion of the region. Although comparatively hard, most of the water derived from it is suitable for most uses, with total dissolved solids (TDS) values generally less than 500 ppm. However, chloride, sulfate, and nitrate concentrations exceed drinking water standards in some areas. Lastly, the Arbuckle-Timbered Hills Group extends into the southern tip of the region and is characteristic of the Limestone Hills area. It sometimes contains hydrogen sulfide gas and is very hard, calcium bicarbonate water, with total dissolved solids ranging from 195 to 940 ppm. Where permeability is high, water in the Arbuckle-Timbered Hills Group may be suitable for industrial use. Because fluoride concentrations generally range from 1.6 to 17 ppm and exceed drinking water standards, public water supply use is limited.

Surface Waters with Designated Beneficial Use for Agriculture

West Central Region

Surface Waters with Designated Beneficial Use for Public/Private Water Supply

West Central Region



Surface Water Protection

The Oklahoma Water Quality Standards (OWQS) provide protection for surface waters in many ways.

Appendix B Areas are designated in the OWQS as containing waters of recreational and/or ecological significance. Discharges to waterbodies may be limited in these areas.

Source Water Protection Areas are derived from the state's Source Water Protection Program, which analyzes existing and potential threats to the quality of public drinking water in Oklahoma.

The **High Quality Waters** designation in the OWQS refers to waters that exhibit water quality exceeding levels necessary to support the propagation of fishes, shellfishes, wildlife, and recreation in and on the water. This designation prohibits any new point source discharges or additional load or increased concentration of specified pollutants.

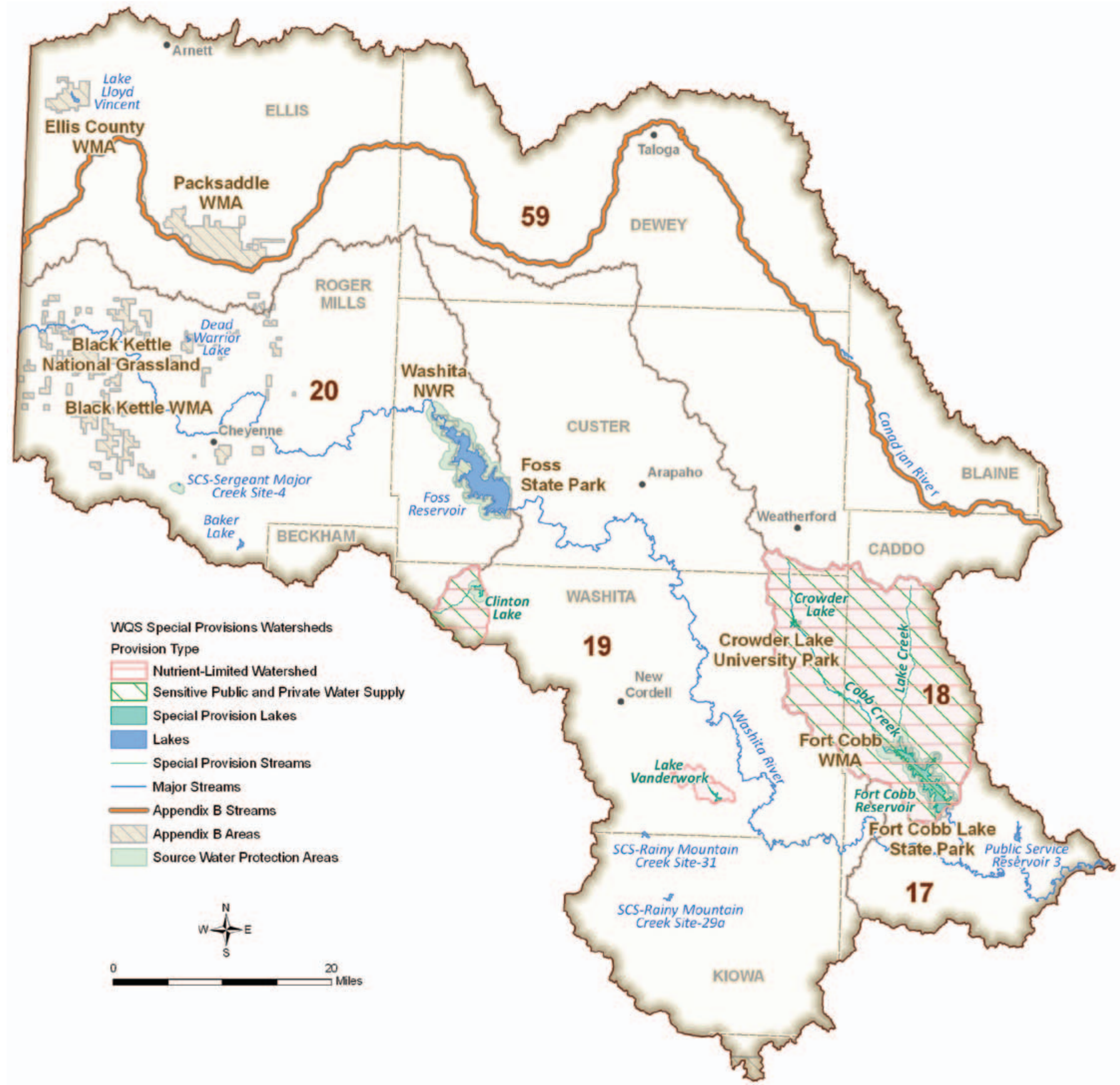
The **Sensitive Water Supplies (SWS)** designation applies to public and private water supplies possessing conditions making them more susceptible to pollution events, thus requiring additional protection. This designation restricts point source discharges in the watershed and institutes a 10 μg/L (micrograms per liter) chlorophyll-a criterion to protect against taste and odor problems and reduce water treatment costs.

Outstanding Resource Waters are those constituting outstanding resources or of exceptional recreational and/or ecological significance. This designation prohibits any new point source discharges or additional load or increased concentration of specified pollutants.

Waters designated as **Scenic Rivers** in Appendix A of the OWQS are protected through restrictions on point source discharges in the watershed. A 0.037 mg/L total phosphorus criterion is applied to all Scenic Rivers in Oklahoma.

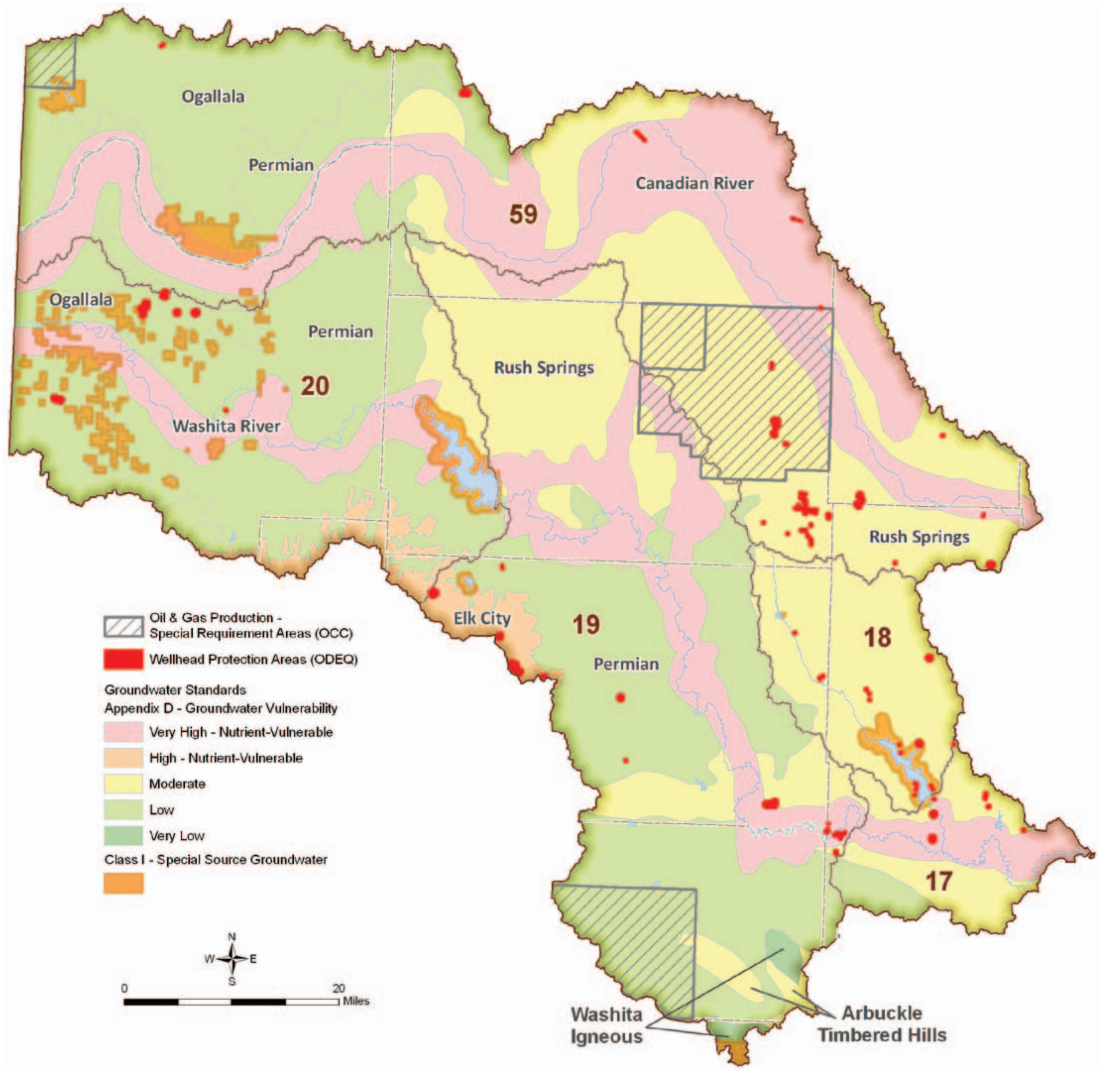
Nutrient-Limited Watersheds are those containing a waterbody with a designated beneficial use that is adversely affected by excess nutrients.

Surface Water Protection Areas
West Central Region



Because Lake Thomas is a public water supply reservoir and has a relatively small watershed, it could potentially benefit from a SWS designation. This designation could provide protection from new or increased loading from point sources in the watershed. This additional protection would also provide limits for algae (chlorophyll-a) that can cause taste and odor problems and increased treatment costs.

Groundwater Protection Areas
West Central Region



Various types of protection are in place to prevent degradation of groundwater and levels of vulnerability. The Elk City, Canadian River, and Washita River aquifers have been identified as very highly vulnerable.

Groundwater Protection

The Oklahoma Water Quality Standards (OWQS) sets the criteria for protection of groundwater quality as follows: "If the concentration found in the test sample exceeds [detection limit], or if other substances in the groundwater are found in concentrations greater than those found in background conditions, that groundwater shall be deemed to be polluted and corrective action may be required."

Wellhead Protection Areas are established by the Oklahoma Department of Environmental Quality (ODEQ) to improve drinking water quality through the protection of groundwater supplies. The primary goal is to minimize the risk of pollution by limiting potential pollution-related activities on land around public water supplies.

Oil and Gas Production Special Requirement Areas, enacted to protect groundwater and/or surface water, can consist of specially lined drilling mud pits (to prevent leaks and spills) or tanks whose contents are removed upon completion of drilling activities; well set-back distances from streams and lakes; restrictions on fluids and chemicals; or other related protective measures.

Nutrient-Vulnerable Groundwater is a designation given to certain hydrogeologic basins that are designated by the OWRB as having high or very high vulnerability to contamination from surface sources of pollution. This designation can impact land application of manure for regulated agriculture facilities.

Class 1 Special Source Groundwaters are those of exceptional quality and particularly vulnerable to contamination. This classification includes groundwaters located underneath watersheds of Scenic Rivers, within OWQS Appendix B areas, or underneath wellhead or source water protection areas.

Appendix H Limited Areas of Groundwater are localized areas where quality is unsuitable for default beneficial uses due to natural conditions or irreversible human-induced pollution.

NOTE: The State of Oklahoma has conducted a successful surface water quality monitoring program for more than fifteen years. A new comprehensive groundwater quality monitoring program is in the implementation phase and will soon provide a comparable long-term groundwater resource data set.

Water Quality Trends Study

As part of the *2012 OCWP Update*, OWRB monitoring staff compiled more than ten years of Beneficial Use Monitoring Program (BUMP) data and other resources to initiate an ongoing statewide comprehensive analysis of surface water quality trends.

Reservoir Trends: Water quality trends for reservoirs were analyzed for chlorophyll-a, conductivity, total nitrogen, total phosphorus, and turbidity at sixty-five reservoirs across the state. Data sets were of various lengths, depending on the station's period of record. The direction and magnitude of trends varies throughout the state and within regions. However, when considered statewide, the final trend analysis revealed several notable details.

- Chlorophyll-a and nutrient concentrations continue to increase at a number of lakes. The proportions of lakes exhibiting a significant upward trend were 42% for chlorophyll-a, 45% for total nitrogen, and 12% for total phosphorus.
- Likewise, conductivity and turbidity have trended upward over time. Nearly 28% of lakes show a significant upward trend in turbidity, while nearly 45% demonstrate a significant upward trend for conductivity.

Stream Trends: Water quality trends for streams were analyzed for conductivity, total nitrogen, total phosphorus, and turbidity at sixty river stations across the state. Data sets were of various lengths, depending on the station's period of record, but generally, data were divided into historical and recent datasets and analyzed separately and as a whole. The direction and magnitude of trends varies throughout the state and within regions. However, when considered statewide, the final trend analysis revealed several notable details.

- Total nitrogen and phosphorus are very different when comparing period of record to more recent data. When considering the entire period of record, approximately 80% of stations showed a downward trend in nutrients. However, if only the most recent data (approximately 10 years) are considered, the percentage of stations with a downward trend decreases to 13% for nitrogen and 30% for phosphorus. The drop is accounted for in stations with either significant upward trends or no detectable trend.
- Likewise, general turbidity trends have changed over time. Over the entire period of record, approximately 60% of stations demonstrated a significant upward trend. However, more recently, that proportion has dropped to less than 10%.
- Similarly, general conductivity trends have changed over time, albeit less dramatically. Over the entire period of record, approximately 45% of stations demonstrated a significant upward trend. However, more recently, that proportion has dropped to less than 30%.

Typical Impact of Trends Study Parameters

Chlorophyll-a is a measure of algae growth. When algae growth increases, there is an increased likelihood of taste and odor problems in drinking water as well as aesthetic issues.

Conductivity is a measure of the ability of water to pass electrical current. In water, conductivity is affected by the presence of inorganic dissolved solids, such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Conductivity in streams and rivers is heavily dependent upon regional geology and discharges. High specific conductance indicates high concentrations of dissolved solids, which can affect the suitability of water for domestic, industrial, agricultural, and other uses. At higher conductivity levels, drinking water may have an unpleasant taste or odor or may even cause gastrointestinal distress. High concentration may also cause deterioration of plumbing fixtures and appliances. Relatively expensive water treatment processes, such as reverse osmosis, are required to remove excessive dissolved solids from water. Concerning agriculture, most crops cannot survive if the salinity of the water is too high.

Total Nitrogen is a measure of all dissolved and suspended nitrogen in a water sample. It includes kjeldahl nitrogen (ammonia + organic), nitrate, and nitrite nitrogen. It is naturally abundant in the environment and is a key element necessary for growth of plants and animals. Excess nitrogen from polluting sources can lead to significant water quality problems, including harmful algal blooms, hypoxia, and declines in wildlife and habitat.

Total Phosphorus is one of the key elements necessary for growth of plants and animals. Excess phosphorus leads to significant water quality problems, including harmful algal blooms, hypoxia, and declines in wildlife and habitat. Increases in total phosphorus can lead to excessive growth of algae, which can increase taste and odor problems in drinking water as well as increased costs for treatment.

Turbidity refers to the clarity of water. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity. Increases in turbidity can increase treatment costs and have negative effects on aquatic communities by reducing light penetration.

Reservoir Water Quality Trends
West Central Region

Parameter	Clinton Lake (1995-2004)	Fort Cobb Lake (1995-2009)	Foss Lake (1996-2005)
Chlorophyll-a (mg/m3)	↑	↓	↑
Conductivity (us/cm)	↑	↑	NT
Total Nitrogen (mg/L)	↑	NT	NT
Total Phosphorus (mg/L)	NT	NT	↓
Turbidity (NTU)	NT	↓	↑

Increasing Trend ↑ **Decreasing Trend** ↓ NT = No significant trend detected

Trend magnitude and statistical confidence levels vary for each site. Site-specific information can be obtained from the OWRB Water Quality Division.

Notable concerns for reservoir water quality include the following:

- Significant upward trend for chlorophyll-a on Clinton and Foss reservoirs.
- Significant upward trend for conductivity on Clinton and Fort Cobb reservoirs.
- Significant upward trend for total nitrogen on Clinton Reservoir.

Stream Water Quality Trends
West Central Region

Parameter	Canadian River near Bridgeport		Washita River near Anadarko		Washita River near McClure	
	All Data Trend (1948-1993, 1999-2009)[1]	Recent Trend (1999-2009)	All Data Trend (1964-1993, 1999-2009)1	Recent Trend (1999-2009)	All Data Trend (1969-1993, 1998-2009)[1]	Recent Trend (1998-2009)
Conductivity (us/cm)	NT	↓	↑	NT	↑	↓
Total Nitrogen (mg/L)	↓	↑	↓	↑	NT	↑
Total Phosphorus (mg/L)	↓	↑	↓	NT	↓	↑
Turbidity (NTU)	↑	NT	↑	↓	↑	↑

Increasing Trend ↑ **Decreasing Trend** ↓ NT = No significant trend detected

Trend magnitude and statistical confidence levels vary for each site. Site-specific information can be obtained from the OWRB Water Quality Division.

[1]Date ranges for analyzed data represent the earliest site visit date and may not be representative of all parameters.

Notable concerns for stream water quality include the following:

- Significant upward trend for recent nutrient data throughout the region.
- Significant upward trend for period of record turbidity throughout the region.

Water Demand

The West Central Region's water needs account for about 4% of the total statewide demand. Regional demand will increase by 38% (30,620 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be from the Crop Irrigation sector, with significant growth also coming from the Oil and Gas sector.

Crop Irrigation demand is expected to remain the largest demand sector in the region, accounting for 62% of the 2060 demand. Currently, 5% of the demand from this sector is supplied by surface water, 14% by alluvial groundwater, and 81% by bedrock groundwater. Predominant irrigated crops in the West Central Region include pasture grasses and wheat.

Municipal and Industrial demand is projected to account for approximately 11% of the total 2060 demand. Currently, 52% of the demand from this sector is supplied by surface water, 5% by alluvial groundwater, and 43% by bedrock groundwater.

Oil and Gas demand is projected to account for approximately 11% of the 2060 demand. Currently, 59% of the demand from this sector is supplied by surface water, 13% by alluvial groundwater, and 29% by bedrock groundwater.

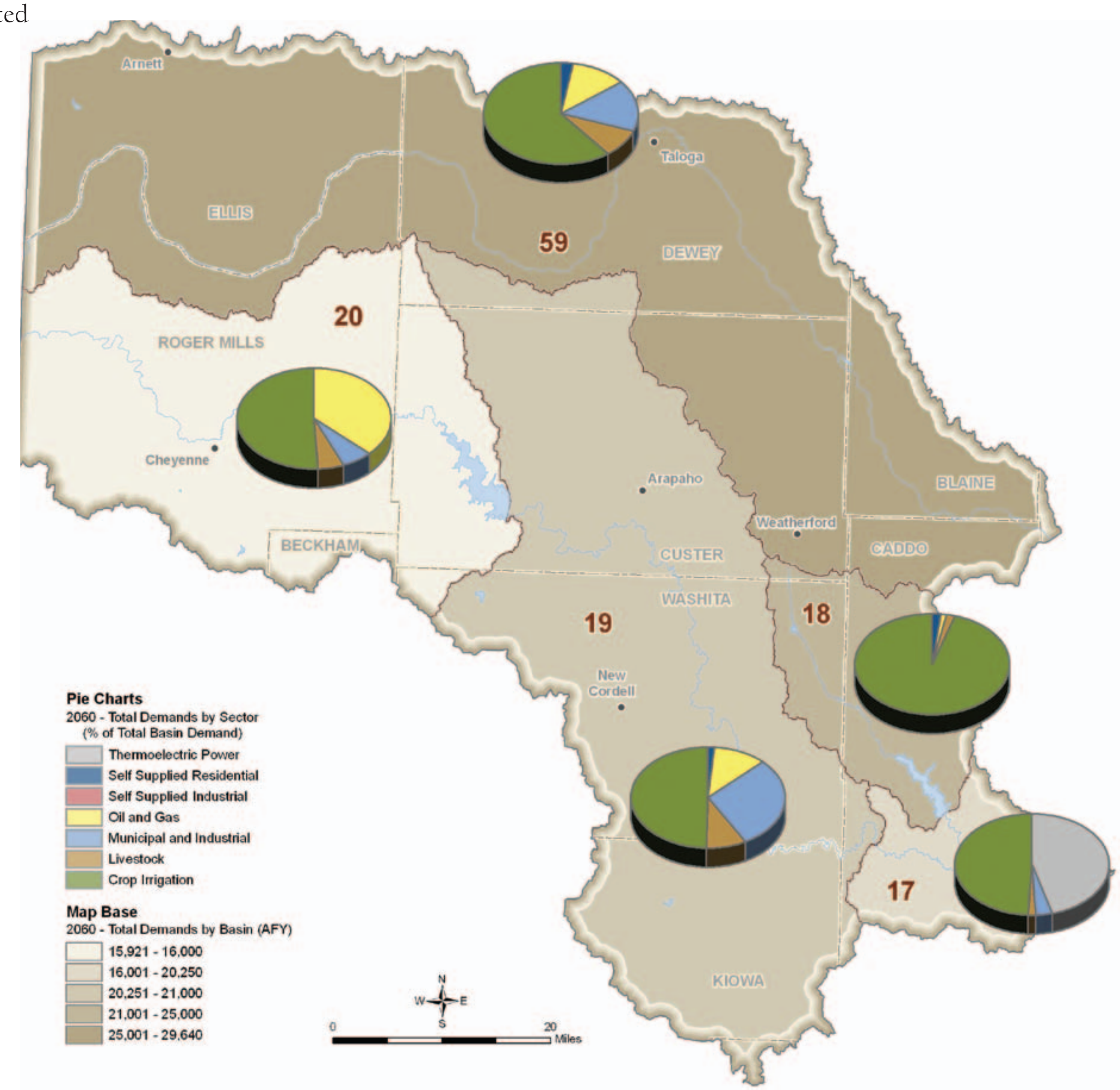
Thermoelectric Power demand is projected to account for approximately 8% of the 2060 demand. The Public Service Company of Oklahoma's Southwestern plant and the Western Farmers Electric Cooperative's Anadarko plant are large users of water for thermoelectric power generation in the region. Currently, 61% of the demand from this sector is supplied by surface water, 37% by alluvial groundwater, and 2% by bedrock groundwater.

Livestock demand is projected to account for 6% of the 2060 demand. Currently, 6% of the demand from this sector is supplied by surface water, 19% by alluvial groundwater, and 75% by bedrock groundwater. Livestock use in the region is predominantly for cattle for cow-calf production, followed distantly by hogs.

Self-Supplied Residential demand is projected to account for 2% of the 2060 demand. Currently, 33% of the demand from this sector is supplied by alluvial groundwater and 67% by bedrock groundwater.

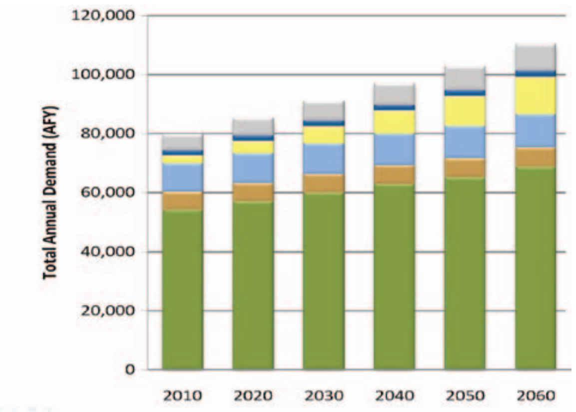
There is minimal Self-Supplied Industrial demand in the region.

Total 2060 Water Demand by Sector and Basin
(Percent of Total Basin Demand)
West Central Region

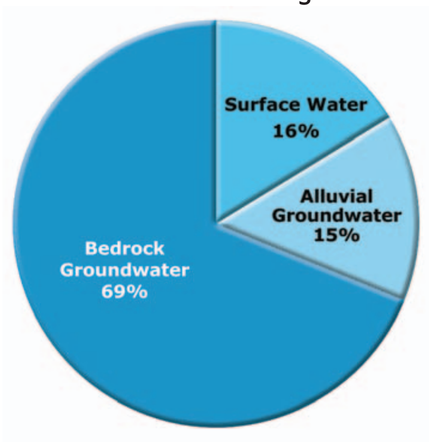


Crop Irrigation demand is expected to remain the largest demand sector in the region, accounting for 62% of the total regional demand in 2060.

Total Water Demand by Sector
West Central Region



Supply Sources Used to Meet Current Demand (2010)
West Central Region



The West Central Region's water needs account for about 4% of the total statewide demand. Regional demand will increase by 38% (30,620 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be in the Crop Irrigation sector, with significant growth also coming from the Oil & Gas sector.

Total Water Demand by Sector
West Central Region

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	54,160	6,090	9,800	2,610	20	1,820	5,180	79,680
2020	57,080	6,180	10,210	4,060	20	1,880	5,780	85,220
2030	60,000	6,280	10,530	5,690	20	1,940	6,440	90,900
2040	62,920	6,370	10,840	7,660	20	1,990	7,190	97,000
2050	65,170	6,460	11,120	9,950	30	2,040	8,020	102,780
2060	68,770	6,560	11,380	12,540	30	2,090	8,950	110,300

Water Demand

Water demand refers to the amount of water required to meet the needs of people, communities, industry, agriculture, and other users. Growth in water demand frequently corresponds to growth in population, agriculture, industry, or related economic activity. Demands have been projected from 2010 to 2060 in ten-year increments for seven distinct consumptive water demand sectors.

Water Demand Sectors

- **Thermoelectric Power:** Thermoelectric power producing plants, using both self-supplied water and municipal-supplied water, are included in the thermoelectric power sector.
- **Self-Supplied Residential:** Households on private wells that are not connected to a public water supply system are included in the SSR sector.
- **Self-Supplied Industrial:** Demands from large industries that do not directly depend upon a public water supply system are included in the SSI sector. Available water use data and employment counts were included in this sector.
- **Oil and Gas:** Oil and gas drilling and exploration activities, excluding water used at oil and gas refineries (typically categorized as self supplied industrial users), are included in the oil and gas sector.
- **Municipal and Industrial:** These demands represent water that is provided by public water systems to homes, businesses, and industries throughout Oklahoma, excluding water supplied to thermoelectric power plants.
- **Livestock:** Livestock demands were evaluated by livestock group (beef, poultry, etc.) based on the 2007 Agriculture Census.
- **Crop Irrigation:** Water demands for crop irrigation were estimated using the 2007 Agriculture Census data for irrigated acres by crop type and county. Crop irrigation requirements were obtained primarily from the Natural Resource Conservation Service Irrigation Guide Reports.

OCWP demands were not projected for non-consumptive or instream water uses, such as hydroelectric power generation, fish and wildlife, recreation and instream flow maintenance. Projections, which were augmented through user/stakeholder input, are based on standard methods using data specific to each sector and OCWP planning basin.

Projections were initially developed for each county in the state, and then allocated to each of the 82 basins. To provide regional context, demands were aggregated by Watershed Planning Region. Water shortages were calculated at the basin level to more accurately determine areas where shortages may occur. Therefore, gaps, depletions, and options are presented in detail in the basin summaries and subsequent sections. Future demand projections were developed independent of available supply, water quality, or infrastructure considerations. The impacts of climate change, increased water use efficiency, conservation, and non-consumptive uses, such as hydropower, are presented in supplemental OCWP reports.

Present and future demands were applied to supply source categories to facilitate an evaluation of potential surface water gaps and alluvial and bedrock aquifer storage depletions at the basin level. For this baseline analysis, the proportion of each supply source used to meet future demands for each sector was held constant at the proportion established through current, active water use permit allocations. For example, if the crop irrigation sector in a basin currently uses 80% bedrock groundwater, then 80% of the projected future crop irrigation demand is assumed to use bedrock groundwater. Existing out-of-basin supplies are represented as surface water supplies in the receiving basin.

Public Water Providers

There are more than 1,600 Oklahoma water systems permitted or regulated by the Oklahoma Department of Environmental Quality (ODEQ); 785 systems were analyzed in detail for the *2012 OCWP Update*. The public systems selected for inclusion, which collectively supply approximately 94 percent of the state's current population, consist of municipal or community water systems and rural water districts that were readily identifiable as non-profit, local governmental entities. This and other information provided in the OCWP will support provider-level planning by providing insight into future supply and infrastructure needs.

The West Central Region includes 37 of the 785 public supply systems analyzed for the *2012 OCWP Update*. The Public Water Providers map indicates the approximate service areas of these systems. (The map may not accurately represent existing service areas or legal boundaries. In addition, water systems often serve multiple counties and can extend into multiple planning basins and regions.)

In terms of population served (excluding provider-to-provider sales), the five largest systems in the region, in decreasing order, are Weatherford, Clinton, Caddo Co RWD #3, New Cordell Utility Authority, and Burns Flat PWS. Together, these five systems provide service for about 62 percent of the population served by public water providers in the region.

Demands upon public water systems, which comprise the majority of the OCWP's Municipal and Industrial (M&I) water demand sector, were analyzed at both the basin and provider level. Retail demand projections detailed in the Public Water Provider Demand Forecast table were developed for each of the OCWP providers in the region. These projections include estimated system losses, defined as water lost either during water production or distribution to residential homes and businesses. Retail demands do not include wholesaled water.

OCWP provider demand forecasts are not intended to supersede water demand forecasts developed by individual providers. OCWP analyses were made using a consistent methodology based on accepted data available on a statewide basis. Where available, provider-generated forecasts were also reviewed as part of this effort.

Public Water Providers
West Central Region

Population and Demand Projection Data

Provider level population and demand projection data, developed specifically for OCWP analyses, focus on retail customers for whom the system provides direct service. These estimates were generated from Oklahoma Department of Commerce population projections. In addition, the 2008 OCWP Provider Survey contributed critical information on water production and population served that was used to calculate per capita water use. Population for 2010 was estimated and may not reflect actual 2010 Census values. Exceptions to this methodology are noted.

Public Water Providers/Population Served

West Central Region

Provider	SDWIS ID[1]	County	Retail Per Capita (GPD)[2]	Population Served					
				2010	2020	2030	2040	2050	2060
ARAPAHO	OK3002004	Custer	85	856	899	932	964	997	1,019
ARNETT	OK2002305	Ellis	222	507	497	497	486	486	497
BESSIE	OK3007504	Washita	63	196	196	206	206	215	215
BRIDGEPORT	OK2000804	Caddo	321	109	119	119	119	129	129
BURNS FLAT PWS	OK2007505	Washita	125	2,525	2,607	2,676	2,717	2,785	2,827
BUTLER	OK3002001	Custer	77	358	367	387	406	416	425
CADDO CO RWD #3	OK2000816	Caddo	300	5,453	5,684	5,863	6,039	6,218	6,378
CAMARGO RWD #2	OK2002202	Dewey	207	150	150	150	150	150	150
CANUTE	OK2007503	Washita	97	534	554	564	573	583	593
CARNEGIE	OK2000805	Caddo	132	1,612	1,679	1,737	1,785	1,843	1,891
CHEYENNE	OK1010803	Roger Mills	186	778	778	778	778	778	778
CLINTON	OK1010828	Custer	299	9,057	9,482	9,870	10,266	10,557	10,818
CORN PWA	OK2007501	Washita	144	597	616	636	646	665	675
CUSTER CITY PWS	OK2002009	Custer	204	405	424	433	453	462	472
CUSTER CO RWD #3	OK2002040	Custer	106	997	1,045	1,087	1,131	1,163	1,191
DEWEY CO RWD #1	OK2002201	Dewey	139	129	126	126	126	129	131
EAKLY DEV CORP	OK2000808	Caddo	135	276	286	296	306	315	325
FORT COBB	OK2000810	Caddo	141	673	703	722	742	762	782
FORT COBB MCD (WHOLESALER ONLY)	None	Caddo	0	0	0	0	0	0	0
FOSS	OK2007508	Washita	110	27	29	29	29	31	31
FOSS RESERVOIR MCD (WHOLESALER ONLY)	OK1010829	Custer	0	0	0	0	0	0	0
FRONTIER DEV AUTH	OK3002011	Custer	95	915	959	998	1,038	1,068	1,093
GOTEBO	OK3003801	Kiowa	245	266	266	276	276	286	286
HAMMON	OK3006503	Roger Mills	88	469	469	469	469	469	469
HINTON	OK2000809	Caddo	138	2,193	2,292	2,361	2,430	2,499	2,568
HYDRO PWA	OK2000812	Caddo	208	1,068	1,123	1,150	1,191	1,219	1,246
LEEDEY	OK3002201	Dewey	294	205	205	205	205	211	211
MOUNTAIN VIEW PWA	OK2003805	Kiowa	60	874	874	884	894	915	925
NEW CORDELL UTILITY AUTH	OK2007502	Washita	101	2,933	3,032	3,111	3,161	3,230	3,279
ROGER MILLS RWS & SWMD #1	OK2006502	Roger Mills	148	300	300	300	300	300	300
ROGER MILLS RWD #2 (RED STAR)	OK2006505	Roger Mills	351	800	800	800	800	800	800
ROGER MILLS RWS & SWMD #3	OK2006501	Roger Mills	50	179	179	179	179	179	179
TALOGA	OK2002207	Dewey	207	197	192	192	192	197	202
THOMAS	OK2002001	Custer	87	1,261	1,319	1,377	1,434	1,473	1,511
VICI	OK2002203	Dewey	161	750	727	727	727	738	762
WASHITA CO RWD #2	OK2007511	Washita	175	1,126	1,161	1,191	1,208	1,237	1,258
WEATHERFORD	OK2002002	Custer	151	10,138	10,614	11,050	11,487	11,817	12,108

1 SDWIS - Safe Drinking Water Information System
2 RED ENTRY indicates date was taken from 2007 Water Rights Database. GPD=gallons per day.

Projections of Retail Water Demands

Each public water supply system has a "retail" demand, defined as the amount of water used by residential and non-residential customers within that provider's service area. Public-supplied residential demands include water provided to households for domestic uses both inside and outside the home. Non-residential demands include customer uses at office buildings, shopping centers, industrial parks, schools, churches, hotels, and related locations served by a public water supply system. Retail demands do not include wholesale water to other providers.

Municipal and Industrial (M&I) demand is driven by projected population growth and specific customer characteristics. Demand forecasts for each public system are estimated from average water use (in gallons per capita per day) multiplied by projected population. Oklahoma Department of Commerce 2002 population projections (unpublished special tabulation for the OWRB) were calibrated to 2007 Census estimates and used to establish population growth rates for cities, towns, and rural areas through 2060. Population growth rates were applied to 2007 population-served values for each provider to project future years' service area (retail) populations.

The main source of data for per capita water use for each provider was the 2008 OCWP Provider Survey conducted by the OWRB in cooperation with the Oklahoma Rural Water Association and Oklahoma Municipal League. For each responding provider, data from the survey included population served, annual average daily demand, total water produced, wholesale purchases and sales between providers, and estimated system losses.

For missing or incomplete data, the weighted average per capita demand was used for the provider's county. In some cases, provider survey data were supplemented with data from the OWRB water rights database. Per capita supplier demands can vary over time due to precipitation and service area characteristics, such as commercial and industrial activity, tourism, or conservation measures. For the baseline demand projections described here, the per capita demand was held constant through each of the future planning year scenarios. OCWP estimates of potential reductions in demand from conservation measures are analyzed on a basin and regional level, but not for individual provider systems.

Public Water Providers Demand Forecast

West Central Region

Provider	SDWIS ID[1]	County	Demand 2010 (AFY)	2020	2030	2040	2050	2060
ARAPAHO	OK3002004	Custer	82	86	89	92	95	97
ARNETT	OK2002305	Ellis	126	123	123	121	121	123
BESSIE	OK3007504	Washita	14	14	15	15	15	15
BRIDGEPORT	OK2000804	Caddo	39	43	43	43	46	46
BURNS FLAT PWS	OK2007505	Washita	354	365	375	380	390	396
BUTLER	OK3002001	Custer	31	32	33	35	36	37
CADDO CO RWD #3	OK2000816	Caddo	1,832	1,910	1,970	2,029	2,090	2,143
CAMARGO RWD #2	OK2002202	Dewey	35	35	35	35	35	35
CANUTE	OK2007503	Washita	58	60	61	62	63	64
CARNEGIE	OK2000805	Caddo	238	248	257	264	272	279
CHEYENNE	OK1010803	Roger Mills	162	162	162	162	162	162
CLINTON	OK1010828	Custer	3,031	3,173	3,303	3,436	3,533	3,620
CORN PWA	OK2007501	Washita	96	100	103	104	108	109
CUSTER CITY PWS	OK2002009	Custer	92	97	99	103	105	108
CUSTER CO RWD #3	OK2002040	Custer	118	124	129	134	138	141
DEWEY CO RWD #1	OK2002201	Dewey	20	20	20	20	20	20
EAKLY DEV CORP	OK2000808	Caddo	42	43	45	46	48	49
FORT COBB	OK2000810	Caddo	106	111	114	117	120	123
FORT COBB MCD (WHOLESALER ONLY)	None	Caddo	0	0	0	0	0	0
FOSS	OK2007508	Washita	3	4	4	4	4	4
FOSS RESERVOIR MCD (WHOLESALER ONLY)	OK1010829	Custer	0	0	0	0	0	0
FRONTIER DEV AUTH	OK3002011	Custer	97	102	106	110	114	116
GOTEBO	OK3003801	Kiowa	73	73	76	76	79	79
HAMMON	OK3006503	Roger Mills	46	46	46	46	46	46
HINTON	OK2000809	Caddo	339	354	365	375	386	397
HYDRO PWA	OK2000812	Caddo	248	261	267	277	283	290
LEEDEY	OK3002201	Dewey	68	68	68	68	70	70
MOUNTAIN VIEW PWA	OK2003805	Kiowa	59	59	59	60	61	62
NEW CORDELL UTILITY AUTH	OK2007502	Washita	332	343	352	358	366	371
ROGER MILLS RWD # 2 (RED STAR)	OK2006505	Roger Mills	315	315	315	315	315	315
ROGER MILLS RWS & SWMD #1	OK2006502	Roger Mills	50	50	50	50	50	50
ROGER MILLS RWS & SWMD #3	OK2006501	Roger Mills	10	10	10	10	10	10
TALOGA	OK2002207	Dewey	46	44	44	44	46	47
THOMAS	OK2002001	Custer	123	129	134	140	144	147
VICI	OK2002203	Dewey	135	131	131	131	133	137
WASHITA CO RWD #2	OK2007511	Washita	221	228	233	237	243	247
WEATHERFORD	OK2002002	Custer	1,711	1,791	1,865	1,938	1,994	2,043

1 SDWIS - Safe Drinking Water Information System

Public Water Providers Wholesale Transfers

West Central Region

Provider	SDWIS ID[1]	Sales			Purchases		
		Sells To	Emergency or Ongoing	Treated or Raw or Both	Purchases from	Emergency or Ongoing	Treated or Raw or Both
ARAPAHO	OK3002004				City of Clinton	O	T
BESSIE	OK3007504				Foss Reservoir Washita RWD 2	O O	T T
BUTLER	OK3002001				Foss Reservoir MCD (via Hobart)	O	T
CADDO CO RWD #3	OK2000816	Gotebo Cyril Lawton		T T T			
CLINTON	OK1010828	City of Arapaho	O	T	Foss Reservoir MCD	O	T
CUSTER CITY PWS	OK2002009	Custer Co RWD #3	O	T			
CUSTER CO RWD #3	OK2002040				Custer City PWS	O	T
FORT COBB MCD	None	Anadarko WTP (Basin 16, Lower Washita Region) Chickasha (Basin 16, Lower Washita Region)	O O	R R			
FOSS RESERVOIR MCD	OK1010829	Butler Clinton Bessie Hobart Frontier Dev Auth New Cordell Utility Auth	O O O O O O	T T T T T T			
FRONTIER DEV AUTH	OK3002011				Hobart (Southwest Region) Foss Reservoir MCD	O	T
GOTEBO	OK3003801				Caddo Co RWD #3	O	T
HAMMON	OK3006503				Beckham Co RWD #3	O	T
LEEDEY	OK3002201				Roger Mills RWD #2 (Red Star)	O	T
NEW CORDELL UTILITY AUTH	OK2007502				Foss Reservoir MCD		
ROGER MILLS RWD #2 (RED STAR)	OK2006505	Leedey	O	T			
WASHITA CO RWD #2	OK2007511	Bessie	O	T			

1 SDWIS - Safe Drinking Water Information System

Wholesale Water Transfers

Some providers sell water on a "wholesale" basis to other providers, effectively increasing the amount of water that the selling provider must deliver and reducing the amount that the purchasing provider diverts from surface and groundwater sources. Wholesale water transfers between public water providers are fairly common and can provide an economical way to meet demands. Wholesale quantities typically vary from year to year depending upon growth, precipitation, emergency conditions, and agreements between systems.

Water transfers between providers can help alleviate costs associated with developing or maintaining infrastructure, such as a reservoir or pipeline; allow access to higher quality or more reliable sources; or provide additional supplies only when required, such as in cases of supply emergencies. Utilizing the 2008 OCWP Provider Survey and OWRB water rights data, the Wholesale Water Transfers table presents a summary of known wholesale arrangements for providers in the region. Transfers can consist of treated or raw water and can occur on a regular basis or only during emergencies. Providers commonly sell to and purchase from multiple water providers.

Provider Water Rights

Public water providers using surface water or groundwater obtain water rights from the OWRB. Water providers purchasing water from other suppliers or sources are not required to obtain water rights as long as the furnishing entity has the appropriate water right or other source of authority. Each public water provider's current water right(s) and source of supply have been summarized in this report. The percentage of each provider's total 2007 water rights from surface water, alluvial groundwater, and bedrock groundwater supplies was also calculated, indicating the relative proportions of sources available to each provider.

A comparison of existing water rights to projected demands can show when additional water rights or other sources and in what amounts might be needed. Forecasts of conditions for the year 2060 indicate where additional water rights may be needed to satisfy demands by that time. However, in most cases, wholesale water transfers to other providers must also be addressed by the selling provider's water rights. Thus, the amount of water rights required will exceed the retail demand for a selling provider and will be less than the retail demand for a purchasing provider.

In preparing to meet long-term needs, public water providers should consider strategic factors appropriate to their sources of water. For example, public water providers who use surface water can seek and obtain a "schedule of use" as part of their stream water right, which addresses projected growth and consequent increases in stream water use. Such schedules of use can be employed to address increases that are anticipated to occur over many years or even decades, as an alternative to the usual requirement to use the full authorized amount of stream water in a seven-year period. On the other hand, public water providers that utilize groundwater should consider the prospect that it may be necessary to purchase or lease additional land in order to increase their groundwater rights.

Public Water Provider Water Rights and Withdrawals (2010)

West Central Region

Provider	SDWIS ID[1]	County	Permitted Quantity	Source: Permitted Surface Water	Source: Permitted Alluvial Groundwater	Source: Permitted Bedrock Groundwater
			AFY	Percent		
ARAPAHO	OK3002004	Custer	---	---	---	---
ARNETT	OK2002305	Ellis	516	0%	0%	100%
BESSIE	OK3007504	Washita	---	---	---	---
BRIDGEPORT	OK2000804	Caddo	320	---	---	100%
BURNS FLAT PWS	OK2007505	Washita	447	0%	0%	100%
BUTLER	OK3002001	Custer	---	---	---	---
CADDO CO RWD #3	OK2000816	Caddo	4,793	0%	0%	100%
CAMARGO RWD #2	OK2002202	Dewey	320	0%	0%	100%
CANUTE	OK2007503	Washita	153	0%	0%	100%
CARNEGIE	OK2000805	Caddo	839	0%	0%	100%
CHEYENNE	OK1010803	Roger Mills	434	100%	0%	0%
CLINTON	OK1010828	Custer	2,178	76%	0%	24%
CORN PWA	OK2007501	Washita	236	0%	0%	100%
CUSTER CITY PWS	OK2002009	Custer	443	0%	0%	100%
CUSTER COUNTY RWD #3	OK2002040	Custer	400	0%	100%	0%
DEWEY CO RWD #1	OK2002201	Dewey	320	0%	72%	28%
EAKLY DEV CORP	OK2000808	Caddo	232	0%	0%	100%
FORT COBB	OK2000810	Caddo	215	0%	0%	100%
FORT COBB MCD (WHOLESALER ONLY)	None	Caddo	18,000	100%	0%	0%
FOSS	OK2007508	Washita	459	0%	100%	0%
FOSS RESERVOIR MCD (WHOLESALER ONLY)	OK1010829	Custer	17,634	100%	0%	0%
FRONTIER DEV AUTH	OK3002011	Custer	---	---	---	---
GOTEBO	OK3003801	Kiowa	51	0%	100%	0%
HAMMON	OK3006503	Roger Mills	368	0%	100%	0%
HINTON	OK2000809	Caddo	1,974	0%	0%	100%
HYDRO PWA	OK2000812	Caddo	324	0%	0%	100%
LEEDEY	OK3002201	Dewey	---	---	---	---
MOUNTAIN VIEW PWA	OK2003805	Kiowa	226	0%	0%	100%
NEW CORDELL UTILITY AUTH	OK2007502	Washita	2,371	0%	0%	100%
ROGER MILLS RWS & SWMD #1	OK2006502	Roger Mills	100	0%	100%	0%
ROGER MILLS RWD #2 (RED STAR)	OK2006505	Roger Mills	1130	0%	0%	100%
ROGER MILLS RWS & SWMD #3	OK2006501	Roger Mills	138	0%	0%	100%
TALOGA	OK2002207	Dewey	341	0%	16%	84%
THOMAS	OK2002001	Custer	1,133	0%	0%	100%
VICI	OK2002203	Dewey	717	0%	0%	100%
WASHITA CO RWD #2	OK2007511	Washita	640	0%	0%	100%
WEATHERFORD	OK2002002	Custer	4,446	0%	0%	100%

1 SDWIS - Safe Drinking Water Information System

OCWP Provider Survey
West Central Region

Town of Arapaho (Custer County)
Current Source of Supply
Primary source: City of Clinton
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace portion of distribution system lines; add storage.

Town of Arnett (Ellis County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: replace well motors; add main shut-off valves.
Long-Term Needs
Infrastructure improvements: replace water main lines.

Town of Bessie (Washita County)
Current Source of Supply
Primary sources: Foss Reservoir, Washita County RWD 2
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Bridgeport (Caddo County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells;
Infrastructure improvements: add storage.

Town of Burns Flat PWS (Osage County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replacement or rehabilitation of town's infrastructure.

Town of Butler (Custer County)
Current Source of Supply
Primary source: Foss MCD
Short-Term Needs
Infrastructure improvements: replace distribution system lines.
Long-Term Needs
None identified.

Caddo County RWD 3
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: drill additional wells.
Long-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: add storage.

Camargo RWD 2 (Dewey County)
Current Source of Supply
Primary source: groundwater.
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: none identified.

Town of Canute (Washita County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: treatment plant expansion and upgrades.
Long-Term Needs
None identified.

Town of Carnegie (Caddo County)
Current Source of Supply
Primary source: groundwater
Emergency source: Caddo County RWD 3
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: add storage.

Town of Cheyenne (Roger Mills County)
Current Source of Supply
Primary source: Cheyenne City Lake
Short-Term Needs
Infrastructure improvements: replace water main line to town.
Long-Term Needs
None identified.

City of Clinton (Custer County)
Current Source of Supply
Primary sources: Clinton Lake, Foss MCD
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: add storage.

Corn PWA (Washita County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace lines from wells to town.

Custer City PWS (Custer County)
Current Source of Supply
Primary source: Rush Springs aquifer, purchased water
Short-Term Needs
None identified.
Long-Term Needs
New wells and infrastructure improvements.

Custer County RWD 3
Current Source of Supply
Primary source: Rush Springs aquifer, Custer City PWS.
Short-Term Needs
None identified.
Long-Term Needs
New wells and other infrastructure improvements.

Dewey County RWD 1
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: redrill existing wells.

Eakly Development Corp. (Caddo County)
Current Source of Supply
Primary source: Rush Springs aquifer
Short-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: replace distribution system lines.
Long-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: add water main lines.

Town of Fort Cobb (Caddo County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.

Fort Cobb Reservoir MCD (Custer County)
Current Source of Supply
Primary source: Fort Cobb Reservoir
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Provider Supply Plans

In 2008, a survey was sent to 785 municipal and rural water providers throughout Oklahoma to collect vital background water supply and system information. Additional detail for each of these providers was solicited in 2010 as part of follow-up interviews conducted by the ODEQ. The 2010 interviews sought to confirm key details of the earlier survey and document additional details regarding each provider's water supply infrastructure and plans. This included information on existing sources of supply (including surface water, groundwater, and other providers), short-term supply and infrastructure plans, and long-term supply and infrastructure plans.

In instances where no new source was identified, maintenance of the current source of supply is expected into the future. Providers may or may not have secured the necessary funding to implement their stated plans concerning infrastructure needs, commonly including additional wells or raw water conveyance, storage, and replacement/upgrade of treatment and distribution systems.

Additional support for individual water providers wishing to pursue enhanced planning efforts is documented in the Public Water Supply Planning Guide. This guide details how information contained in the OCWP Watershed Planning Region reports and related planning documents can be used to formulate provider-level plans to meet present and future needs of individual water systems.

OCWP Provider Survey
West Central Region

Town of Foss (Washita County)
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.

Foss Reservoir MCD (Custer County)
Current Source of Supply
Primary source: Foss Reservoir
Short-Term Needs
Rehabilitation of intake structure and tanks; replace pumps.
Long-Term Needs
None identified.

Frontier Development Authority (Custer County)
Current Source of Supply
Primary source: Foss MCD
Short-Term Needs
Infrastructure improvements: refurbish storage tanks.
Long-Term Needs
None identified.

Town of Gotebo (Kiowa County)
Current Source of Supply
Primary source: Caddo County RWD 3
Short-Term Needs
Infrastructure improvements: replace distribution system lines.
Long-Term Needs
None identified.

Town of Hammon (Roger Mills County)
Current Source of Supply
Primary source: Beckham County RWD 3
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: refurbish storage tower.

Town of Hinton (Caddo County)
Current Source of Supply
Primary source: Rush Springs aquifer
Short-Term Needs
New supply source: drill additional wells.
Long-Term Needs
None identified.

Hydro PWA (Caddo County)
Current Source of Supply
Primary source: Rush Springs aquifer
Short-Term Needs
New supply source: drill additional well.
Long-Term Needs
New supply source: drill additional wells.

Town of Leedey (Dewey County)
Current Source of Supply
Primary source: Roger Mills RWD 2
Short-Term Needs
Infrastructure improvements: replace distribution system lines.
Long-Term Needs
Infrastructure improvements: replace distribution system lines.

Mountain View PWA (Kiowa County)
Current Source of Supply
Primary source: Rush Springs aquifer
Short-Term Needs
New supply source: drill additional wells.
Long-Term Needs
New supply source: drill additional wells.

New Cordell Utility Authority (Washita County)
Current Source of Supply
Primary sources: Elk City Sandstone aquifer, Foss Reservoir
Short-Term Needs
Infrastructure improvements: new pump system.
Long-Term Needs
Infrastructure improvements: increase line capacity from Foss Reservoir.

Roger Mills RWD 2 (Red Star)
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.
Infrastructure improvements: add storage; replace or add distribution lines.

Roger Mills RWS & SWMD 1
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
Infrastructure improvements: replace distribution lines.
Long-Term Needs
Infrastructure improvements: replace & add distribution lines.

Roger Mills RWS & SWMD 3
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
Infrastructure improvements: replace distribution lines, pumps & valves.
Long-Term Needs
Infrastructure improvements: add storage.

Town of Taloga (Dewey County)
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Thomas (Custer County)
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: drill additional wells.

Town of Vici (Dewey County)
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace water main lines.

Washita County RWD 2
Current Source of Supply
Primary sources: groundwater
Short-Term Needs
New supply source: drill additional wells.
Long-Term Needs
Infrastructure improvements: replace water main lines; replace distribution system lines.

City of Weatherford (Custer County)
Current Source of Supply
Primary sources: Rush Springs aquifer
Short-Term Needs
New supply source: drill additional wells.
Long-Term Needs
None identified.

Infrastructure Cost Summary
West Central Region

Provider System Category[1]	Infrastructure Need (millions of 2007 dollars)			
	Present-2020	2021-2040	2041-2060	Total Period
Small	$62	$324	$74	$460
Medium	$37	$101	$85	$223
Large	$0	$0	$0	$0
Reservoir[2]	$0	$4	$87	$91
Total	$99	$429	$246	$774

1 Large providers are defined as those serving more than 100,000 people, medium systems as those serving between 3,301 and 100,000 people, and small systems as those serving 3,300 or fewer people.

2 The "reservoir" category refers specifically to rehabilitation projects.

- Approximately $774 million is needed to meet the projected drinking water infrastructure needs of the West Central region over the next 50 years. The largest infrastructure costs are expected to occur between 2021 and 2040.
- Distribution and transmission projects account for more than 85% of the providers' estimated infrastructure costs, followed distantly by water treatment projects.
- Small providers have the largest overall drinking water infrastructure costs.
- Projects involving rehabilitation of existing reservoirs comprise approximately 12% of the total costs.

Drinking Water Infrastructure Cost Summary

As part of the public water provider analysis, regional cost estimates to meet system drinking water infrastructure needs over the next 50 years were prepared. While it is difficult to account for changes that may occur within this extended time frame, it is beneficial to evaluate, at least on the order-of-magnitude level, the long-range costs of providing potable water.

Project cost estimates were developed for a selection of existing water providers, and then weighted to determine total regional costs. The OCWP method is similar to that utilized by the EPA to determine national drinking water infrastructure costs in 2007. However, the OCWP uses a 50-year planning horizon while the EPA uses a 20-year period. Also, the OCWP includes a broader spectrum of project types rather than limiting projects to those eligible for the Drinking Water State Revolving Fund program. While estimated costs for new reservoirs are not included, rehabilitation project costs for existing major reservoirs were applied at the regional level.

More information on the methodology and cost estimates is available in the OCWP *Drinking Water Infrastructure Needs Assessment by Region* report.

Water Supply Options

Limitations Analysis

For each of the state's 82 OCWP basins, an analysis of water supply and demand was followed by an analysis of limitations for surface water, bedrock groundwater, and alluvial groundwater use. Physical availability limitations for surface water were referred to as gaps. Availability limitations for alluvial and bedrock groundwater were referred to as depletions.

For surface water, the most pertinent limiting characteristics considered were (1) physical availability of water, (2) permit availability, and (3) water quality. For alluvial and bedrock groundwater, permit availability was not a limiting factor through 2060, and existing data were insufficient to conduct meaningful groundwater quality analyses. Therefore, limitations for major alluvial and bedrock aquifers were related to physical availability of water and included an analysis of both the amount of any forecasted depletion relative to the amount of water in storage and rate at which the depletion was predicted to occur.

Methodologies were developed to assess limitations and assign appropriate scores for each supply source in each basin. For surface water, scores were calculated weighting the characteristics as follows: 50% for physical availability, 30% for permit availability, and 20% for water quality. For alluvial and bedrock groundwater scores, the magnitude of depletion relative to amount of water in storage and rate of depletion were each weighted 50%.

The resulting supply limitation scores were used to rank all 82 basins for surface water, major alluvial groundwater, and major bedrock groundwater sources (see Water Supply Limitations map in the regional summary). For each source, basins ranking the highest were considered to be "significantly limited" in the ability of that source to meet forecasted demands reliably. Basins with intermediate rankings were considered to be "potentially limited" for that source. For bedrock and alluvial groundwater rankings, "potentially limited" was also the baseline default given to basins lacking major aquifers due to typically lower yields and insufficient data. Basins with the lowest rankings were considered to be "minimally limited" for that source and not projected to have any gaps or depletions.

Based on an analysis of all three sources of water, the basins with the most significant limitations ranking were identified as "Hot Spots." A discussion of the methodologies used in identifying Hot Spots, results, and recommendations can be found in the *OCWP Executive Report*.

Primary Options

To provide a range of potential solutions for mitigation of water supply shortages in each of the 82 OCWP basins, five primary options were evaluated for potential effectiveness: (1) demand management, (2) use of out-of-basin supplies, (3) reservoir use, (4) increasing reliance on surface water, and (5) increasing reliance on groundwater. For each basin, the potential effectiveness of each primary option was assigned one of three ratings: (1) typically effective, (2) potentially effective, and (3) likely ineffective (see Water Supply Option Effectiveness map in the regional summary). For basins where shortages are not projected, no options are necessary and thus none were evaluated.

Demand Management

"Demand management" refers to the potential to reduce water demands and alleviate gaps or depletions by implementing conservation or drought management measures. Demand management is a vitally important tool that can be implemented either temporarily or permanently to decrease demand and increase available supply. "Conservation measures" refer to long-term activities that result in consistent water savings throughout the year, while "drought management" refers to short-term measures, such as temporary restrictions on outdoor watering. Municipal and industrial conservation techniques can include modifying customer behaviors, using more efficient plumbing fixtures, or eliminating water leaks. Agricultural conservation techniques can include reducing water demand through more efficient irrigation systems and production of crops with decreased water requirements.

Two specific scenarios for conservation were analyzed for the OCWP—moderate and substantial—to assess the relative effectiveness in reducing statewide water demand in the two largest demand sectors, Municipal/Industrial and Crop Irrigation. For the Watershed Planning Region reports, only moderately expanded conservation activities were considered when assessing the overall effectiveness of the demand management option for each basin. A broader analysis of moderate and substantial conservation measures statewide is discussed below and summarized in the "Expanded Options" section of the *OCWP Executive Report*.

Demand management was considered to be "typically effective" in basins where it would likely eliminate both gaps and storage depletions and "potentially effective" in basins where it would likely either reduce gaps and depletions or eliminate either gaps or depletions (but not both). There were no basins where demand management could not reduce gaps and/or storage depletions to at least some extent; therefore this option was not rated "likely ineffective" for any basin.

Out-of-Basin Supplies

Use of "out-of-basin supplies" refers to the option of transferring water through pipelines from a source in one basin to another basin. This option was considered a "potentially effective" solution in all basins due to its general potential in eliminating gaps and depletions. The option was not rated "typically effective" because complexity and cost make it only practical as a long-term solution. The effectiveness of this option for a basin was also assessed with the consideration of potential new reservoir sites within the respective region as identified in the Expanded Options section below and the OCWP *Reservoir Viability Study*.

Reservoir Use

"Reservoir Use" refers to the development of additional in-basin reservoir storage. Reservoir storage can be provided through increased use of existing facilities, such as reallocation of existing purposes at major federal reservoir sites or rehabilitation of smaller NRCS projects to include municipal and/or industrial water supply, or the construction of new reservoirs.

The effectiveness rating of reservoir use for a basin was based on a hypothetical reservoir located at the furthest downstream basin outlet. Water transmission and legal or water quality constraints were not considered; however, potential constraints in permit availability were noted. A site located further upstream could potentially provide adequate yield to meet demand, but would likely require greater storage than a site located at the basin outlet. The effectiveness rating was also largely contingent upon the existence of previously studied reservoir sites (see the Expanded Options section below) and/or the ability of new streamflow diversions with storage to meet basin water demands.

Reservoir use was considered "typically effective" in basins containing one or more potentially viable reservoir sites unless the basin was fully allocated for surface water and had no permit availability. For basins with no permit availability, reservoir use was considered "potentially effective," since diversions would be limited to existing permits. Reservoir use was also considered "potentially effective" in basins that generate sufficient reservoir yield to meet future demand. Statewide, the reservoir use option was considered "likely ineffective" in only three basins (Basins 18, 55, and 66), where it was determined that insufficient streamflow would be available to provide an adequate reservoir yield to meet basin demand.

Increasing Reliance on Surface Water

"Increasing reliance on surface water" refers to changing the surface water-groundwater use ratio to meet future demands by increasing surface water use. For baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions. Increasing the use of surface water through direct diversions without reservoir storage or releases upstream from storage provides a reliable supply option in limited areas of the state and has potential to mitigate bedrock groundwater depletions and/or alluvial groundwater depletions. However, this option largely depends upon local conditions concerning the specific location, amount, and timing of the diversion.

Due to this uncertainty, the pronounced periods of low streamflow in many river systems across the state, and the potential to create or augment surface water gaps, this option was considered "typically ineffective" for all basins. The preferred alternative statewide is reservoir use, which provides the most reliable surface water supply source.

Increasing Reliance on Groundwater

"Increasing reliance on groundwater" refers to changing the surface water-groundwater use ratio to meet future demands by increasing groundwater use. Supplies from major aquifers are particularly reliable because they generally exhibit higher well yields and contain large amounts of water in storage. Minor aquifers can also contain large amounts of water in storage, but well yields are typically lower and may be insufficient to meet the needs of high volume water users. Site-specific information on the suitability of minor aquifers for supply should be considered prior to large-scale use. Additional groundwater supplies may also be developed through artificial recharge (groundwater storage and recovery), which is summarized in the "Expanded Options" section of the *OWRB Executive Report*.

Increased reliance on groundwater supplies was considered "typically effective" in basins where both gaps and depletions could be mitigated in a measured fashion that did not lead to additional groundwater depletions. This option was considered "potentially effective" in basins where surface water gaps could be mitigated by increased groundwater use, but would likely result in increased depletions in either alluvial or bedrock groundwater storage. Increased reliance on groundwater supplies was considered "typically ineffective" in basins where there were no major aquifers.

Expanded Options

In addition to the standard analysis of primary options for each basin, specific OCWP studies were conducted statewide on several more advanced though less conventional options that have potential to reduce basin gaps and depletions. More detailed summaries of these options are available in the *OWRB Executive Report*. Full reports are available on the OWRB website.

Expanded Conservation Measures

Water conservation was considered an essential component of the "demand management" option in basin-level analysis of options for reducing or eliminating gaps and storage depletions. At the basin level, moderately expanded conservation measures were used as the basis for analyzing effectiveness. In a broader OCWP study, summarized in the *OCWP Executive Report* and documented in the OCWP *Water Demand Forecast Report Addendum: Conservation and Climate Change*, both moderately and substantially expanded conservation activities were analyzed at a statewide level for the state's two largest demand sectors: Municipal/Industrial (M&I) and Crop Irrigation. For each sector, two scenarios were analyzed: (1) moderately expanded conservation activities, and (2) substantially expanded conservation activities. Water savings for the municipal and industrial and crop irrigation water use sectors were assessed, and for the M&I sector, a cost-benefit analysis was performed to quantify savings associated with reduced costs in drinking water production and decreased wastewater treatment. The energy savings and associated water savings realized as a result of these decreases were also quantified.

Artificial Aquifer Recharge

In 2008, the Oklahoma Legislature passed Senate Bill 1410 requiring the OWRB to develop and implement criteria to prioritize potential locations throughout the state where artificial recharge demonstration projects are most feasible to meet future water supply challenges. A workgroup of numerous water agencies and user groups was organized to identify suitable locations in both alluvial and bedrock aquifers. Fatal flaw and threshold screening analyses resulted in identification of six alluvial sites and nine bedrock sites. These sites were subjected to further analysis that resulted in five sites deemed by the workgroup as having the best potential for artificial recharge demonstration projects.

Where applicable, potential recharge sites are noted in the "Increasing Reliance on Groundwater" option discussion in basin data and analysis sections of the Watershed Planning Region reports. The site selection methodology and results for the five selected sites are summarized in the *OCWP Executive Report*; more detailed information on the workgroup and study is presented in the OCWP *Artificial Aquifer Recharge Issues and Recommendations* report.

Marginal Quality Water Sources

In 2008, the Oklahoma Legislature passed Senate Bill 1627 requiring the OWRB to establish a technical workgroup to analyze the expanded use of marginal quality water (MQW) from various sources throughout the state. The group included representatives from state and federal agencies, industry, and other stakeholders. Through facilitated discussions, the group defined MQW as that which has been historically unusable due to technological or economic issues associated with diverting, treating, and/or conveying the water. Five categories of MQW were identified for further characterization and technical analysis: (1) treated wastewater effluent, (2) stormwater runoff, (3) oil and gas flowback/produced water, (4) brackish surface and groundwater, and (5) water with elevated levels of key constituents, such as nitrates, that would require advanced treatment prior to beneficial use.

A phased approach was utilized to meet the study's objectives, which included quantifying and characterizing MQW sources and their locations for use through 2060, assessing constraints to MQW use, and matching identified sources of MQW with projected water shortages across the state. Feasibility of actual use was also reviewed. Of all the general MQW uses evaluated, water reuse—beneficially using treated wastewater to meet certain demand—is perhaps the most commonly applied elsewhere in the U.S. Similarly, wastewater was determined to be one of the most viable sources of marginal quality water for short-term use in Oklahoma. Results of the workgroup's study are summarized in the *OCWP Executive Report*; more detailed information on the workgroup and study is presented in the OCWP *Marginal Quality Water Issues and Recommendations* report.

Potential Reservoir Development

Oklahoma is the location of many reservoirs that provide a dependable, vital water supply source for numerous purposes. While economic, environmental, cultural, and geographical constraints generally limit the construction of new reservoirs, significant interest persists due to their potential in meeting various future needs, particularly those associated with municipalities and regional public supply systems.

As another option to address Oklahoma's long-range water needs, the OCWP *Reservoir Viability Study* was initiated to identify potential reservoir sites throughout the state that have been analyzed to various degrees by the OWRB, Bureau of Reclamation (BOR), U.S. Army Corps of Engineers (USACE), Natural Resources Conservation Service (NRCS), and other public or private agencies. Principal elements of the study included extensive literature search; identification of criteria to determine a reservoir's viability; creation of a database to store essential information for each site; evaluation of sites; Geographic Information System (GIS) mapping of the most viable sites; aerial photograph and map reconnaissance; screening of environmental, cultural, and endangered species issues; estimates of updated construction costs; and categorical assessment of viability. The study revealed more than 100 sites statewide. Each was assigned a ranking, ranging from Category 4 (sites with at least adequate information that are viable candidates for future development) to Category 0 (sites that exist only on a historical map and for which no study data can be verified).

This analysis does not necessarily indicate an actual need or specific recommendation to build any potential project. Rather, these sites are presented to provide local and regional decision-makers with additional tools as they anticipate future water supply needs and opportunities. Study results present only a cursory examination of the many factors associated with project feasibility or implementation. Detailed investigations would be required in all cases to verify feasibility of construction and implementation. A summary of potential reservoir sites statewide is available in the *OCWP Executive Report*; more detailed information on the study is presented in the OCWP *Reservoir Viability Study*. Potential reservoir development sites for this Watershed Planning Region appear on the following table and map.

Reservoir Project Viability Categorization

Category 4: Sites with at least adequate information that are viable candidates for future development.

Category 3: Sites with sufficient data for analysis, but less than desirable for current viability.

Category 2: Sites that may contain fatal flaws or other factors that could severely impede potential development.

Category 1: Sites with limited available data and lacking essential elements of information.

Category 0: Typically sites that exist only on an historical map. Study data cannot be located or verified.

Potential Reservoir Sites (Categories 3 & 4)

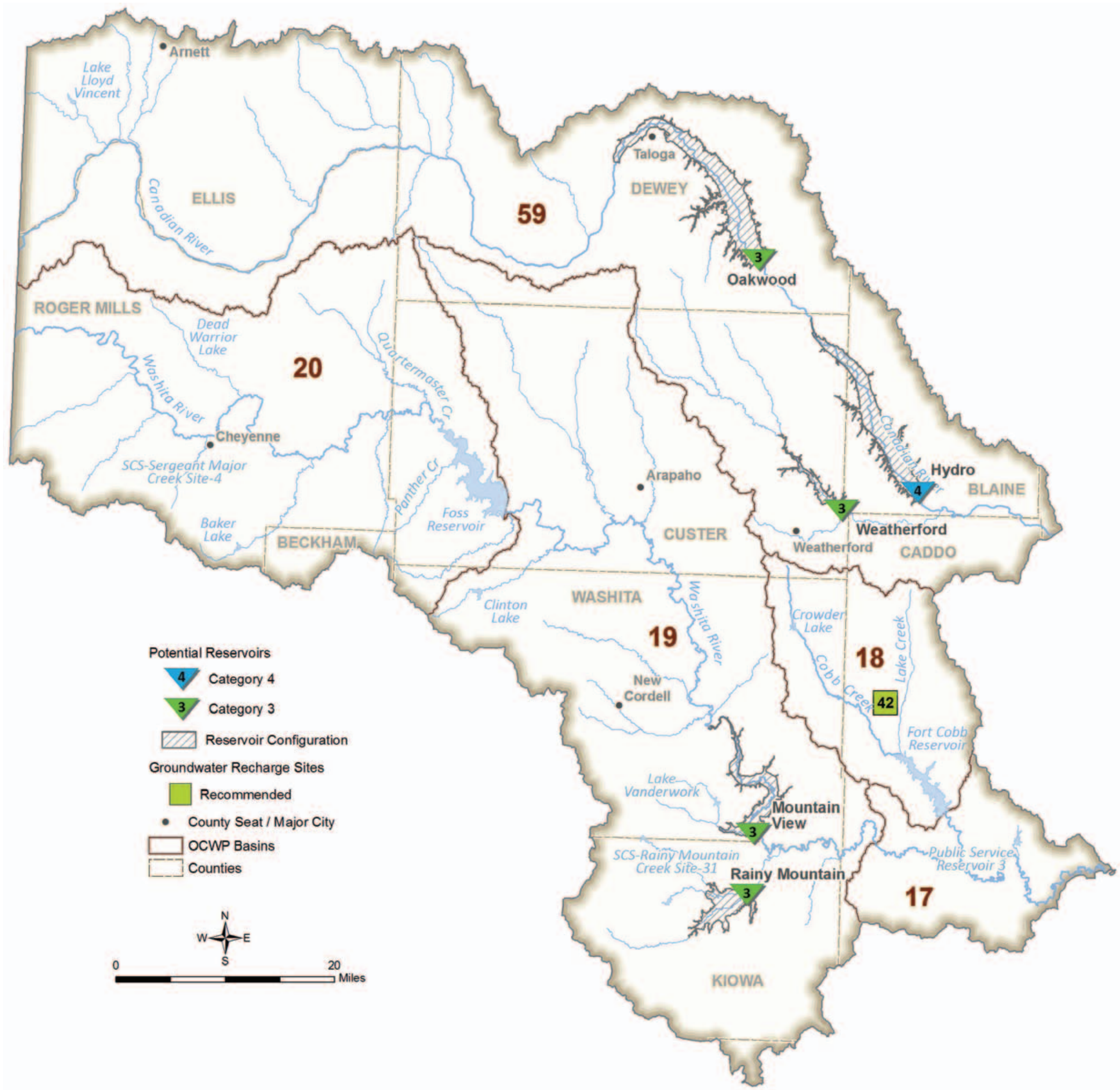
West Central Region

Name	Category	Stream	Basin	Purposes[1]	Total Storage	Conservation Pool			Primary Study		Updated Cost Estimate[2] (2010 dollars)
						Surface Area	Storage	Dependable Yield	Date	Agency	
					AF	Acres	AF	AFY			
Hydro	4	Canadian River	59	WS, R, FW	700,000	20,400	700,000	114,934	1973	Bureau of Reclamation	$744,954,000
Mountain View	3	Washita River	19	R, FC, FW, WS	344,000	9,388	150,000	50,000	1973	Bureau of Reclamation	$162,176,000
Oakwood	3	Canadian River	59	WS, FW, R	680,000	22,800	680,000	100,000	1981	Bureau of Reclamation	$710,907,000
Rainy Mountain	3	Rainy Mountain Creek and Sugar Creek	19	FC, WS, FW, R	211,200	6,739	65,000	5,000	1973	Bureau of Reclamation	$113,201,000
Weatherford	3	Deer Creek	59	WS, R, FW, FC	162,933	2,751	43,475	14,500	1973	Bureau of Reclamation	$120,434,000

1 WS=Water Supply, R=Recreation, HP=Hydroelectric Power, IR=Irrigation, WQ=Water Quality, FW=Fish & Wildlife, FC=Flood Control, LF=Low Flow Regulation, N=Navigation, C=Conservation, CW=Cooling Water

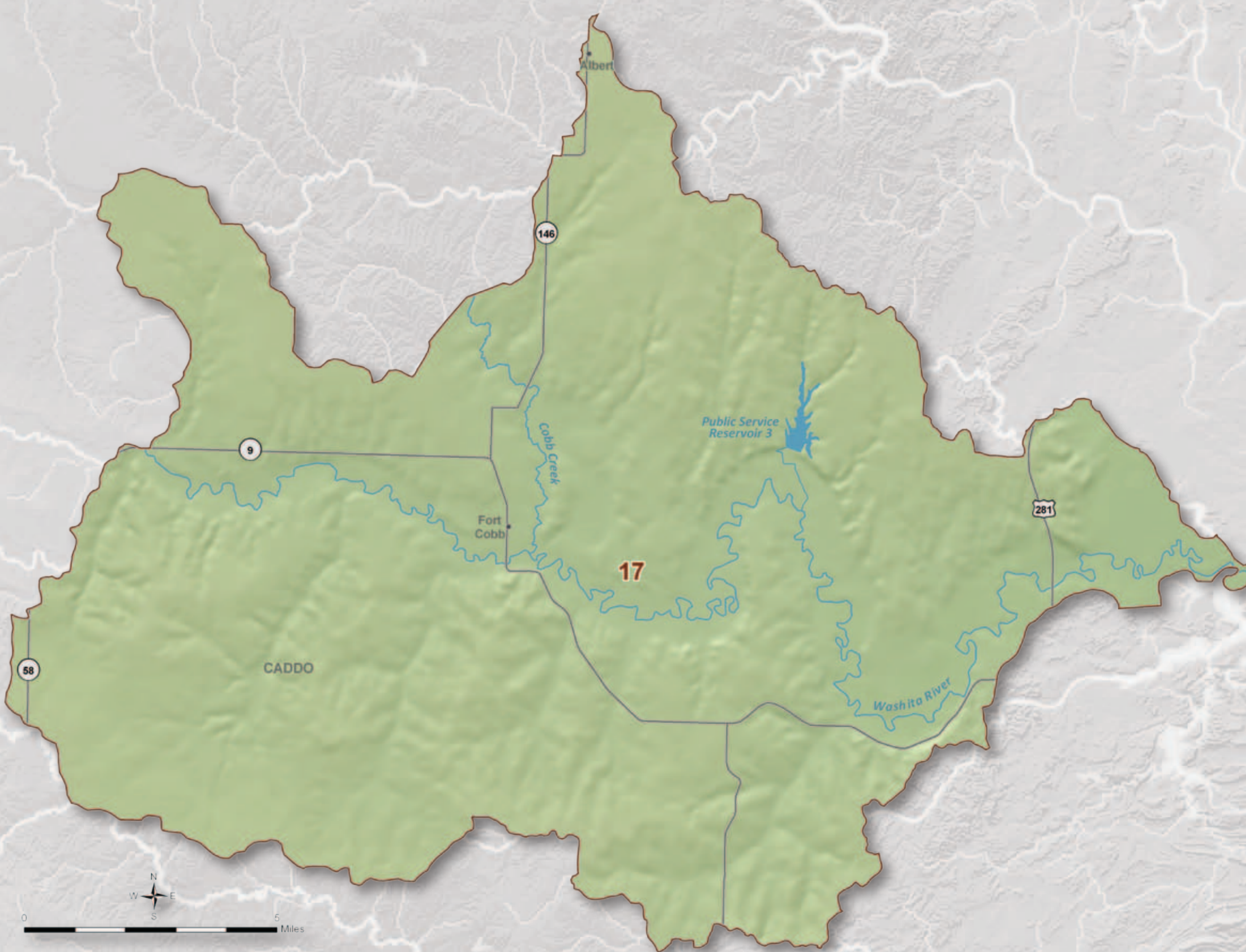
2 The majority of cost estimates were updated using the costs as estimated in previous project reports combined with the USACE Civil Works Construction Cost Index System (CWCCIS) annual escalation figures to scale the original cost estimates to present-day cost estimates. These estimated costs may not accurately reflect current conditions at the proposed project site and are meant to be used for general comparative purposes only.

Expanded Water Supply Options
West Central Region



Data & Analysis
West Central Watershed Planning Region

Basin 17



Basin 17 Summary

Synopsis

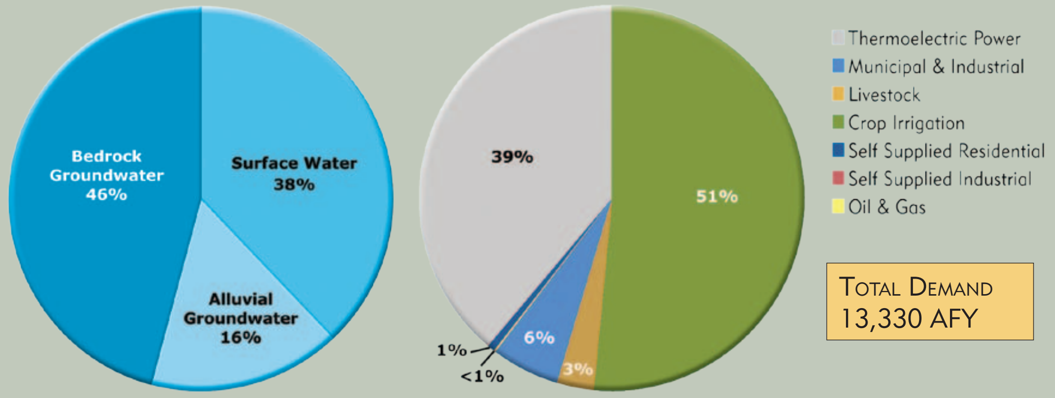
- Most water users are expected to continue to rely primarily on the basin's alluvial and bedrock aquifers or out-of-basin supplies.
- By 2020, surface water gaps may occur during summer months with low streamflows.
- Water quality is a potential concern for surface water users.
- Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.
- Alluvial and bedrock groundwater storage depletions may occur by 2020, but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that storage depletions and gaps be decreased where economically feasible.
- Additional conservation could mitigate surface water gaps and reduce the adverse effects of storage depletions.
- Use of dependable groundwater supplies and/or developing additional small reservoir storage could mitigate surface water gaps. These supply sources could be used without major impacts to groundwater storage.

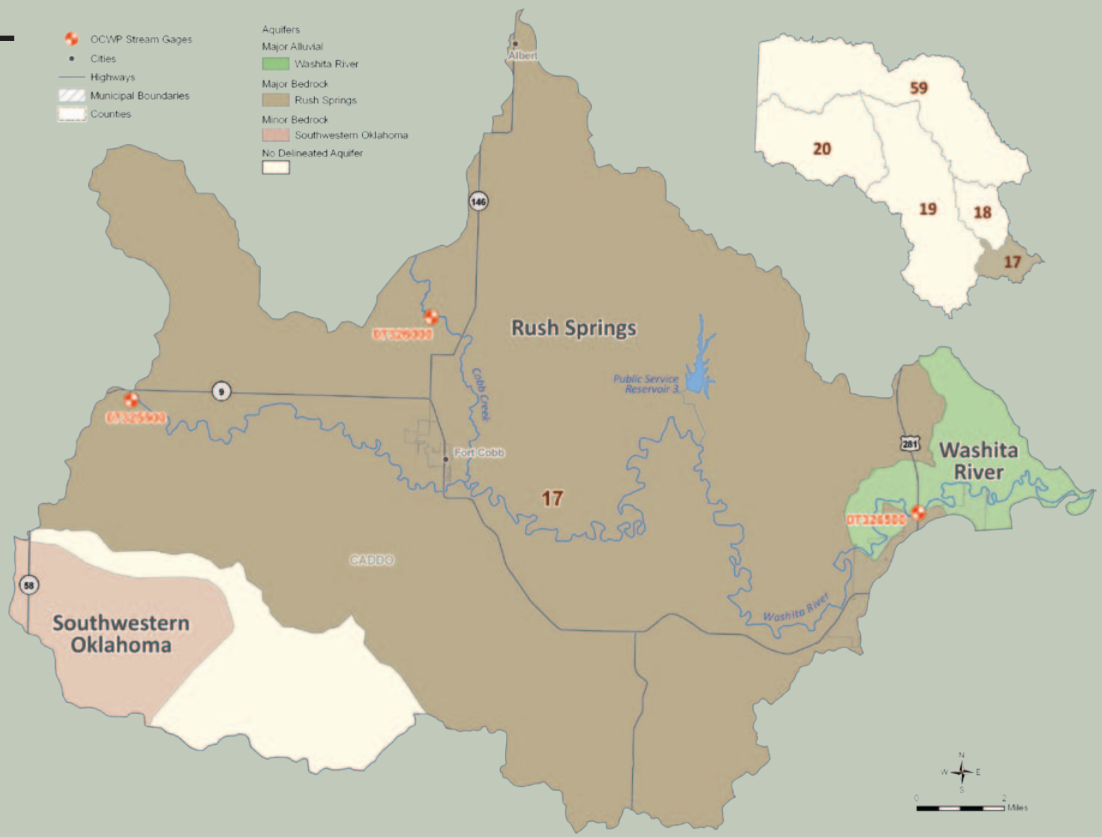
Basin 17 accounts for about 17% of the water demand in the West Central Watershed Planning Region. About 51% of the basin demand is in the Crop Irrigation demand sector. Thermoelectric Power (39%) is the second-largest demand sector. Surface water and out-of-basin supplies currently satisfy about 38% of the total water demand in the basin. Groundwater satisfies about 62% of the total water demand in the basin (46% bedrock aquifer and 16% alluvial). The peak summer month total water demand in Basin 17 is about 5 times the winter demand, which is similar to the overall statewide pattern.

Historically, the flows of the Washita River at Anadarko are typically greater than 9,000 AF/month. However, the river can have prolonged periods of low flow in any month of the year. The Fort Cobb Master Conservancy District currently supplies water out-of-region to the City of Anadarko, Western Farmers Electric Cooperative's Anadarko power plant, and the City of Chickasha in Basin 16 (Lower Washita Watershed Planning Region), and is expected to continue to do so in the future. The Public Service Company of Oklahoma has a power generating plant in Basin 17 and receives its water from Ft. Cobb Reservoir (through the City of Anadarko), as well as from a smaller reservoir on Leeper Creek and from the Rush Springs aquifer. Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts. Relative to other basins in the state, the surface water quality in Basin 17 is considered poor. However, individual lakes and streams may have acceptable water quality.

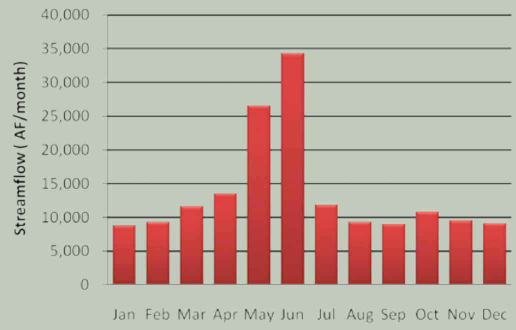
Future development of additional groundwater supplies is expected to be mostly from the Crop Irrigation and Thermoelectric demand sectors. The Rush Springs and Washita River aquifers have a combined total of approximately 4.8 million acre-feet of water in storage in the basin. There are no significant basin-wide groundwater quality issues. However, localized areas with high levels of nitrate and fluoride have been found in the Rush Springs aquifer and may occur in Basin 17. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060.

Current Demand by Source and Sector
West Central Region, Basin 17

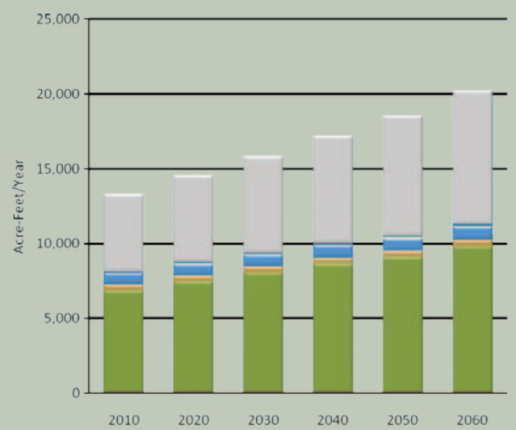




Median Historical Streamflow at the Basin Outlet
West Central Region, Basin 17



Projected Water Demand
West Central Region, Basin 17



The projected 2060 water demand of 20,230 AFY reflects a 6,900 AFY increase (52%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Crop Irrigation and Thermoelectric Power demand sectors.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and groundwater storage depletions may occur by 2020. Surface water gaps will be up to 440 AFY by 2060. Alluvial groundwater storage depletions will be up to 180 AFY by 2060. Surface water gaps and alluvial groundwater storage depletions will occur in spring and summer and will have a 9% probability of occurring in at least one month of these seasons by 2060. Bedrock groundwater storage depletions will be 1,570 AFY on average in 2060 and occur in the spring and summer. Projected annual alluvial and bedrock storage depletions are minimal relative to volume of water stored in the major aquifers underlying the basin. However, localized depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Options

Water users are expected to continue to rely primarily on groundwater supplies. To reduce the risk of adverse impacts to the basin's water users, storage depletions and gaps should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could reduce gaps and storage depletions. Due to the low probability of gaps, temporary drought management could be effective at reducing surface water use and subsequent gaps. Temporary drought management activities are not expected to be needed for groundwater demand, since groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could be developed to supplement the basin's water supplies and mitigate gaps. The Fort Cobb Master Conservancy District (MCD) is expected to continue to meet the demand of its users in the basin and in the Lower Washita Watershed Planning Region. Fort Cobb MCD is currently fully allocated; therefore, the district may not be able to meet additional future needs or demands. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region. Alternative sources of out-of-basin supplies may not be cost-effective compared to using the abundant in-basin groundwater resources for users not supplied by the MCD.

Small reservoirs (less than 50 AF) could be used to meet the demand of surface water users or groundwater users experiencing adverse effects of localized storage depletions. Because surface water in the basin is fully allocated, substantial permit issues must be resolved in order to construct larger reservoirs.

Increased reliance on surface water supplies through direct diversions, without reservoir storage, will likely increase surface water gaps. Also, surface water in the basin is fully allocated. Therefore, this water supply option is not recommended.

Increased reliance on groundwater supplies could be used to offset future demands on surface water, but would increase groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in Basin 17's portion of the Rush Springs aquifer and Washita River aquifer but may increase localized adverse impacts to users.

Water Supply Limitations
West Central Region, Basin 17

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Potential

Minimal Potential Significant

Water Supply Option Effectiveness
West Central Region, Basin 17

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Potentially Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Potentially Effective

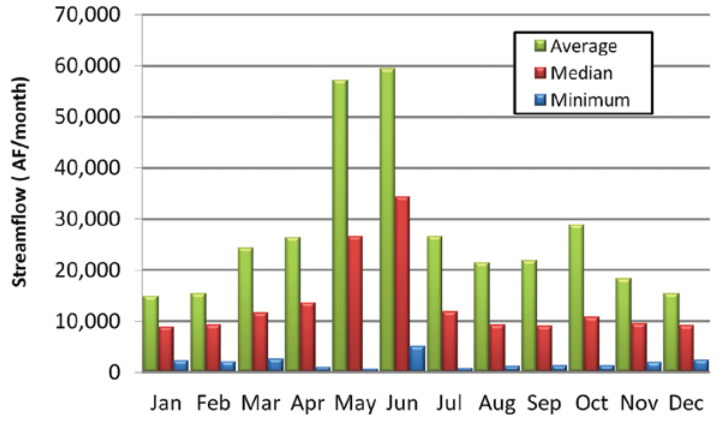
Typically Effective Potentially Effective Likely Ineffective No Option Necessary

Basin 17 Data & Analysis

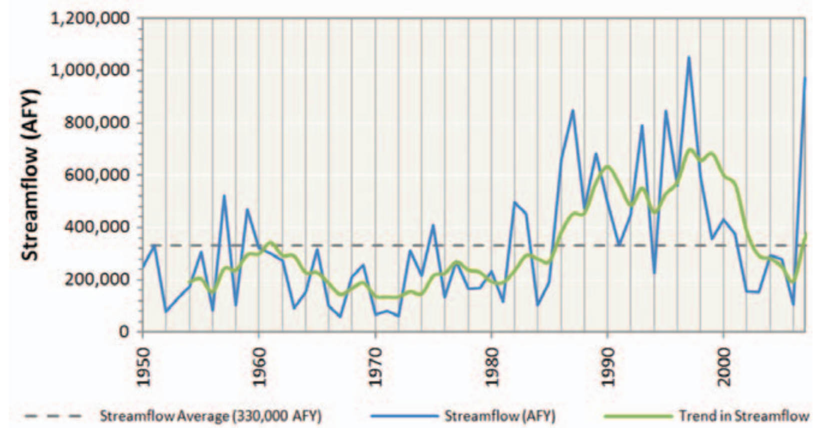
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the potential range of future surface water supplies. The Washita River at Anadarko had a prolonged period of below-average streamflow from the early 1960s to the early 1980s, corresponding to a period of below-average precipitation. The mid 1980s through the mid 2000s had a prolonged period of above average streamflow and precipitation, demonstrating hydrologic variability in the basin.
- The median flow in the Washita River at Anadarko is greater than about 9,000 AF/month throughout the year and greater than 26,000 AF/month in May and June. Historically, Basin 17 can have periods of low flow in any month of the year, except June.
- Relative to other basins in the state, the surface water quality in Basin 17 is considered poor. However, individual lakes and streams may have acceptable water quality.
- There are no significant reservoirs in the basin.

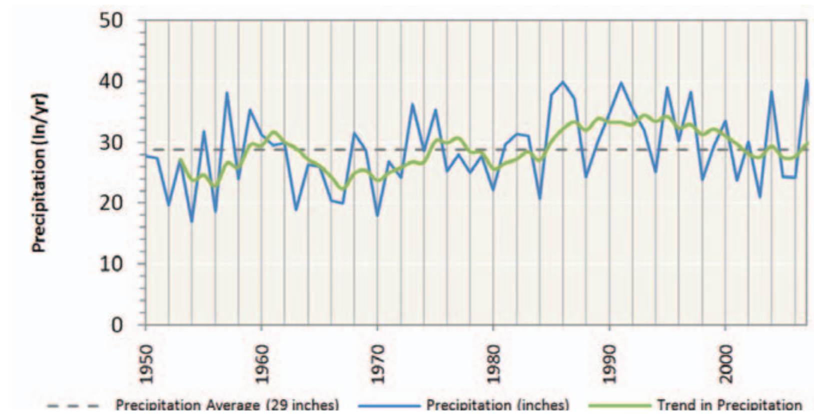
Monthly Historical Streamflow at the Basin Outlet
West Central Region, Basin 17



Historical Streamflow at the Basin Outlet
West Central Region, Basin 17



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

West Central Region, Basin 17

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Washita River	Alluvial	Major	5%	3,300	254,000	2.0	10,800
Rush Springs	Bedrock	Major	82%	25,800	4,517,000	temporary 2.0	194,300
Southwestern Oklahoma	Bedrock	Minor	6%	0	17,000	temporary 2.0	12,800
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	0	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	400	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of current groundwater rights in Basin 17 are from the Rush Springs aquifer, which has about 4.5 million AF of storage, underlies 82% of the basin, and receives an estimated 18,000 AFY of recharge to the basin. There are also water rights in the Washita River aquifer and non-delineated minor bedrock aquifers in Basin 17.
- There are no significant groundwater quality issues in the basin.

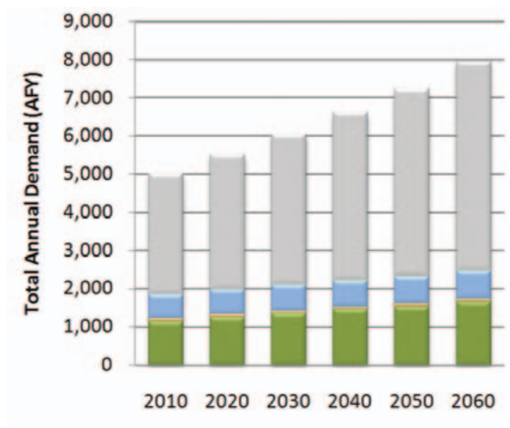
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

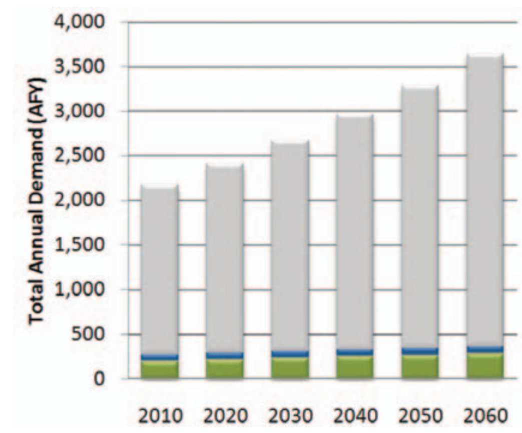
Water Demand

- Water demand in Basin 17 accounts for about 17% of the total demand in the West Central Region and will increase by 52% (6,900 AFY) from 2010 to 2060. The majority of the demand over this period will be from the Crop Irrigation demand sector. However, the largest growth in demand will be from the Thermoelectric Power Demand Sector.
- Surface water and out-of-basin supplies are used to meet 38% of the total demand in Basin 17 and its use will increase by 58% (2,930 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use during this period will be from the Thermoelectric Power demand sector.
- Alluvial groundwater is used to meet 16% of the total demand in Basin 17 and its use will increase by 68% (1,470 AFY). The majority of alluvial groundwater use and growth in alluvial groundwater use during this period will be from the Thermoelectric Power demand sector.
- Bedrock groundwater is used to meet 46% of the total demand in Basin 17 and is expected to increase by 41% (2,500 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use during this period will be from the Crop Irrigation demand sector.

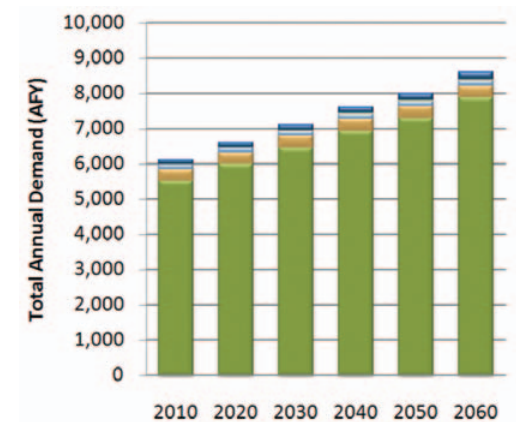
Surface Water Demand by Sector
West Central Region, Basin 17



Alluvial Groundwater Demand by Sector
West Central Region, Basin 17



Bedrock Groundwater Demand by Sector
West Central Region, Basin 17

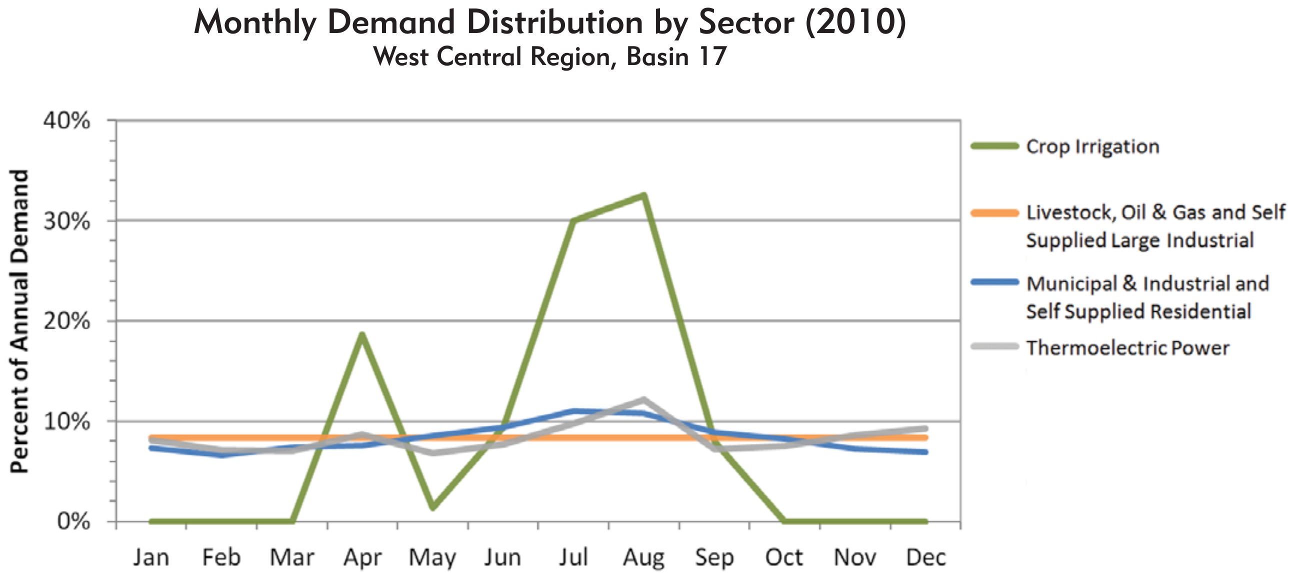


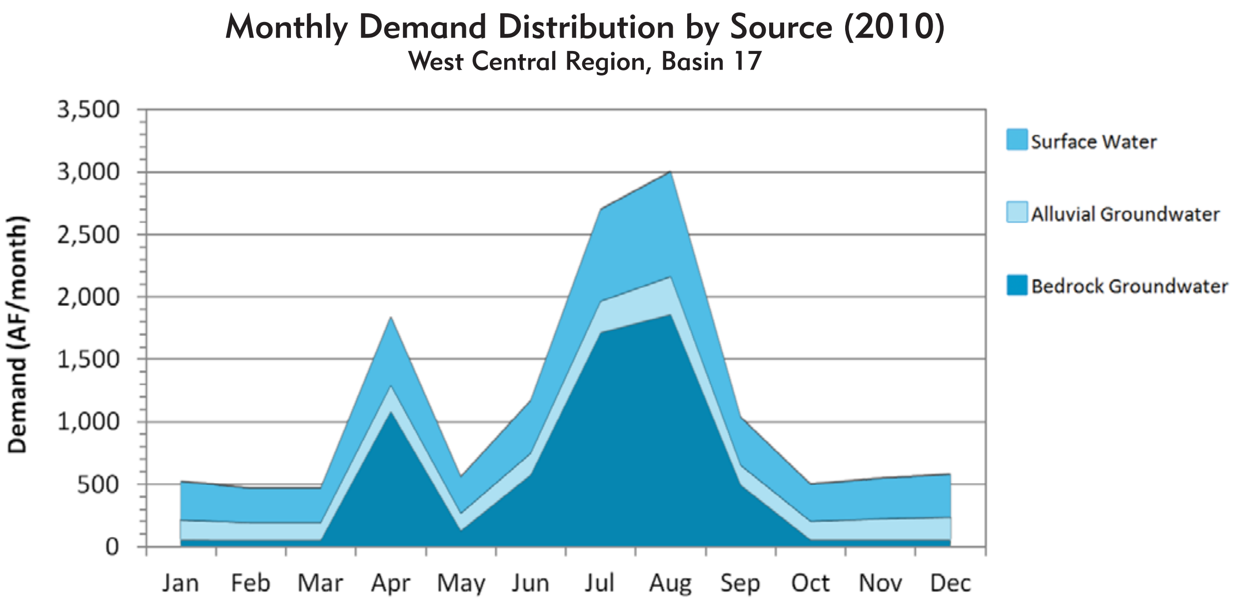
Total Demand by Sector
West Central Region, Basin 17

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	6,870	410	760	20	0	90	5,180	13,330
2020	7,460	410	790	20	0	90	5,780	14,550
2030	8,050	410	820	30	0	90	6,440	15,840
2040	8,640	410	840	40	0	90	7,190	17,210
2050	9,090	410	870	50	0	100	8,020	18,540
2060	9,820	410	890	60	0	100	8,950	20,230

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 50% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power has its highest demand in the summer and winter. The other demand sectors have a more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month demand in Basin 17 is 5 times the monthly winter demand, which is similar to the overall statewide pattern. Monthly surface water demand peaks in the summer at 2.4 times the monthly winter demand. Alluvial groundwater use in the peak summer month is 1.7 times the monthly winter use. Monthly bedrock groundwater demand peaks in the summer at about 38 times the monthly winter demand.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and groundwater depletions are projected to occur by 2020.
- There will be a 9% probability of surface water gaps occurring in at least one month of the year by 2060. Gaps in Basin 17 may occur during the spring and summer, peaking in size during the summer. Gaps in 2060 will be up to 30% (390 AF/month) of the surface water demand in the peak summer month and as much as 25% (210 AF/month) of the peak spring month's surface water demand.
- There will be a 9% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions in Basin 17 may occur in spring and summer, peaking in size during the summer. Alluvial groundwater storage depletions in 2060 will be up to 30% (150 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 26% (90 AF/month) of the peak spring month's alluvial groundwater demand.
- Bedrock groundwater storage depletions in Basin 17 will occur during the summer. Bedrock groundwater storage depletions in 2060 will be 30% (790 AF/month) of the bedrock groundwater demand on average in the peak summer month and as much as 4% (60 AF/month) of the peak spring month's bedrock groundwater demand.
- Projected annual alluvial and bedrock groundwater storage depletions are minimal relative to the volume of water stored in Basin 17's portion of the Washita River and Rush Springs aquifers. However, localized depletions may adversely impact well yields, water quality and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
West Central Region, Basin 17

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	210	165	3%
Jun-Aug (Summer)	390	320	5%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 17

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	90	75	3%
Jun-Aug (Summer)	150	120	5%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
West Central Region, Basin 17

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	30	10	360	2%	2%
2030	70	30	600	2%	2%
2040	110	50	900	2%	2%
2050	160	60	1,140	7%	7%
2060	440	180	1,570	9%	9%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 17

Months (Season)	Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	60
Jun-Aug (Summer)	790
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

West Central Region, Basin 17

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/ Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	440	180	1,570	9%	9%
Moderately Expanded Conservation in Crop Irrigation Water Use	420	170	1,230	9%	9%
Moderately Expanded Conservation in M&I Water Use	420	180	1,550	9%	9%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	380	160	1,230	9%	9%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	180	80	850	5%	5%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

West Central Region, Basin 17

Reservoir Storage	Diversion
AF	AFY
100	900
500	2,800
1,000	5,200
2,500	12,300
5,000	19,100
Required Storage to Meet Growth in Demand (AF)	1,400
Required Storage to Meet Growth in Surface Water Demand (AF)	400

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation demand sectors could reduce the size of gaps and bedrock storage depletions by about 14% and alluvial groundwater storage depletions by about 11%. Due to the low probability of gaps, temporary drought management could be effective at reducing surface water use and subsequent gaps when they do occur. Temporary drought management activities may not be needed for groundwater demand, since the groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies may be developed to supplement the basin's water supplies and mitigate gaps. The Fort Cobb Master Conservancy District (MCD) in Basin 18 is expected to continue to meet the demand of its users in the basin as well as that of Anadarko, Western Farmers Electric Cooperative and the City of Chickasha in Basin 16 of the Lower Washita Region. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region: Mountain View and Rainy Mountain in Basin 19 and Hydro, Oakwood, and Weatherford in Basin 59. However, out-of-basin supplies may not be cost effective for some users compared to using the abundant in-basin groundwater resources.

Reservoir Use

Small reservoirs (less than 50 AF) could reduce surface water gaps or adverse effects of localized storage depletions. The surface water in Basin 17 has been fully allocated, therefore, substantial permit issues must be resolved in order to construct a new large reservoir storage. However, if permittable, a new river diversion and 400 AF of storage at the basin outlet could meet the growth in surface water demand from 2010 to 2060. The use of multiple reservoirs in the basin or reservoirs upstream of the basin outlet may increase the size of storage necessary to mitigate future gaps and depletions.

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, would increase gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on groundwater supplies could be used to offset future demands on surface water, but would increase groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in Basin 17's portion of the Rush Springs aquifer and Washita River aquifer. However, increased depletions may adversely impact well yields, water quality and pumping costs. A shift from surface water to alluvial groundwater could potentially decrease the size of surface water gaps, but may not decrease the probability of remaining surface water gaps due to the interconnection between the supply sources.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
West Central Watershed Planning Region

Basin 18

Basin 18 Summary

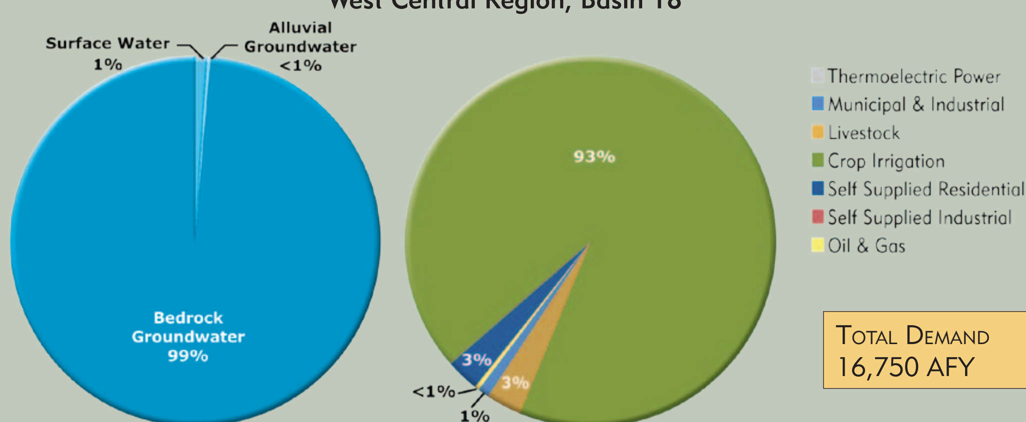
Synopsis

- Water users are expected to continue to rely primarily on the Rush Springs aquifer.
- Water quality is a potential concern for surface water users.
- Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.
- Increased use of Fort Cobb Reservoir could meet all surface water demands in the basin. However, Fort Cobb Reservoir is fully allocated to users outside the basin and has pending applications on file; therefore, existing and pending water rights would need to be taken into consideration for future planning purposes.
- Bedrock groundwater storage depletions may occur by 2020, but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that storage depletions be decreased where economically feasible.
- Additional conservation could reduce the adverse effects of bedrock depletions.
- Aquifer recharge and recovery could be considered to store variable surface water supplies, increase alluvial groundwater storage, and reduce adverse effects of localized storage depletions.

Basin 18 accounts for about 21% of the water demand in the West Central Watershed Planning Region. About 93% of the demand is in the Crop Irrigation demand sector. Surface water satisfies about 1% of the total demand in the basin. Groundwater satisfies about 99% of the total demand. The peak summer month demand in Basin 18 is about 54 times the winter demand, which is much more pronounced than the overall statewide pattern.

Current Demand by Source and Sector

West Central Region, Basin 18

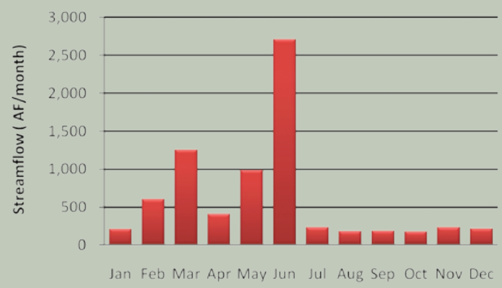


TOTAL DEMAND
16,750 AFY

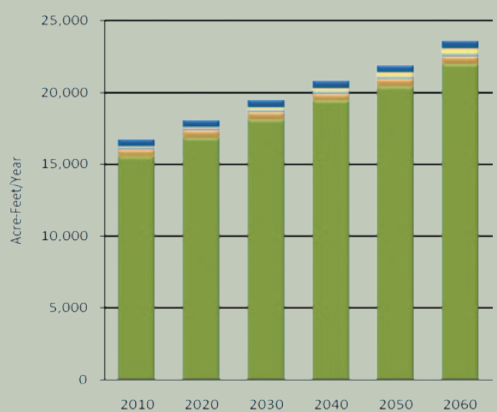
Water Resources

West Central Region, Basin 18

Median Historical Streamflow at the Basin Outlet
West Central Region, Basin 18



Projected Water Demand
West Central Region, Basin 18



Fort Cobb Reservoir, located at the basin outlet, contains 78,350 AF of water supply storage which yields 18,000 AFY of dependable yield to the Fort Cobb Master Conservancy District. The District supplies water out-of-region to the City of Anadarko, Western Farmers Electric Cooperative, and the City of Chickasha in Basin 16 (Lower Washita Watershed Planning Region). The reservoir is expected to continue to provide water supplies to its users in the future. Crowder Lake, located in the northwest portion of the basin, provides flood control and recreation for the State of Oklahoma, but does not provide water supplies. Historically, the flow in Cobb Creek near Fort Cobb, Oklahoma is typically lower than 250 AF/month from July to January. However, the river can have prolonged periods of low flow in any month of the year. Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts. Relative to other basins statewide, the surface water quality is in Basin 18 is poor. Public and Private Water Supply is restricted in Crowder Lake and Fort Cobb due to high chlorophyll-a levels. However, individual lakes and streams may have acceptable water quality.

The Rush Springs aquifer underlies the entire basin and has approximately 10.5 million acre-feet of water stored in the basin. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060.

There are no significant basin-wide groundwater quality issues. However, localized areas with high levels of nitrate and fluoride have been found in the overall Rush Springs aquifer and may occur in Basin 18.

The projected 2060 water demand of 23,580 AFY reflects a 6,830 AFY increase (41%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Crop Irrigation demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, bedrock groundwater storage depletions may occur by 2020. Bedrock storage depletions will be 5,290 AFY on average in 2060. Bedrock storage depletions are expected to occur during the spring and summer. Projected annual bedrock storage depletions are minimal relative to the volume of water stored in the Rush Springs aquifer underlying the basin. However, localized storage depletions may adversely impact yields, water quality, or pumping costs. No alluvial groundwater depletions were evaluated due to minimal increases in projected alluvial demand in this basin.

There are no surface water gaps expected in the basin under 2060 demand conditions. Fort Cobb Reservoir is capable of providing dependable water supply to its existing users, and with new infrastructure, could supply sufficient water to meet all of Basin 18's future surface water demand

Water Supply Limitations
West Central Region, Basin 18

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Potential

Minimal Potential Significant

Water Supply Option Effectiveness
West Central Region, Basin 18

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Likely Ineffective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Potentially Effective

Typically Effective Potentially Effective
Likely Ineffective No Option Necessary

during periods of low streamflow. However, the reservoir is currently fully allocated. Existing water rights would need to be taken into consideration for future planning purposes.

Options

Water users are expected to continue to rely primarily on groundwater supplies. To reduce the risk of adverse impacts to the basin's water users, storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could reduce storage depletions. Temporary drought management activities may not be needed for this basin since the storage in bedrock aquifers could continue to provide supplies during droughts.

Out-of-basin supplies may be developed to supplement the basin's water supplies and/or reduce storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region. However, out-of-basin supplies may not be cost-effective for all users based on the availability of groundwater resources.

Increased reliance on the Fort Cobb Master Conservancy District could provide dependable water supplies. Additional reservoir storage is not expected to provide effective water supplies in the future. Substantial permit issues must be resolved in order to construct new reservoir storage.

Increased reliance on surface water supplies through direct diversion, without reservoir storage, may increase surface water gaps. Also, surface water in the basin is fully allocated. Therefore, this water supply option is not recommended.

Increased reliance on groundwater supplies could be used to meet future demands on surface water and alluvial groundwater, but would increase groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in the basin's portion of the Rush Springs aquifer.

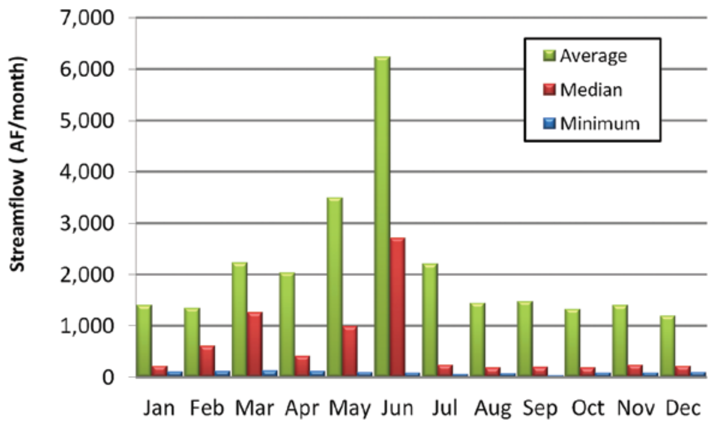
The Aquifer Recharge Workgroup identified a site near Eakly (site # 42) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the upper Washita River to recharge the Rush Springs aquifer.

Basin 18 Data & Analysis

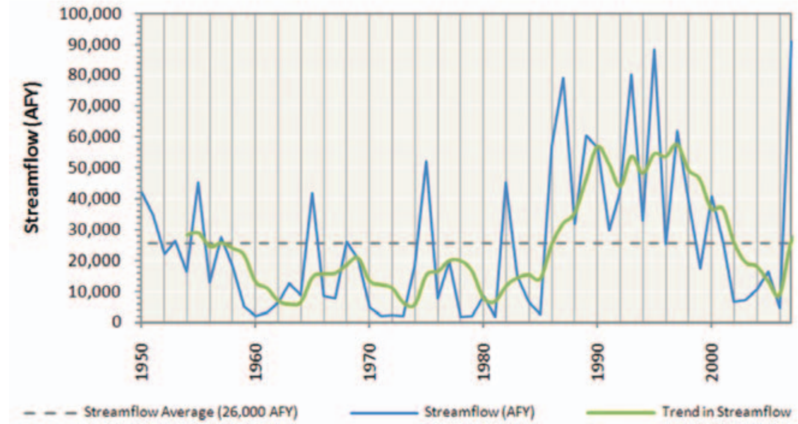
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the potential range of future surface water supplies. Cobb Creek, near Fort Cobb, had a prolonged period of below-average streamflow from the mid-1960s to the mid-70s, partially corresponding to periods of below average precipitation. The late 1980s through the early 2000s had a prolonged period of above average streamflow and precipitation, demonstrating the basin's hydrologic variability.
- The median streamflow in Cobb Creek near Fort Cobb is lower than 250 AF/month from July to January. Additionally, Basin 18 can undergo frequent periods of low flow in any month of the year.
- Relative to other basins in the state, the surface water quality is in Basin 18 is poor. However, individual lakes and streams may have acceptable water quality.
- Fort Cobb Reservoir, located at the basin outlet, provides 18,000 AFY of dependable water supply to the Fort Cobb Master Conservancy District users. The District provides water to out-of-basin users and is expected to provide additional supplies to its users in the future. Crowder Lake is operated by the State of Oklahoma for flood control and recreation. It is not expected to provide additional supplies in the future.

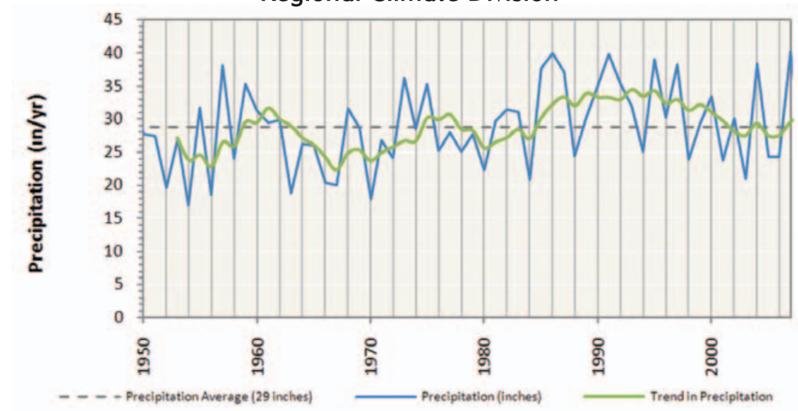
Monthly Historical Streamflow at the Basin Outlet
West Central Region, Basin 18



Historical Streamflow at the Basin Outlet
West Central Region, Basin 18



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

West Central Region, Basin 18

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Rush Springs	Bedrock	Major	100%	137,100	10,473,000	temporary 2.0	178,400
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	0	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	0	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- Water rights in the Rush Springs aquifer are used to meet 99% of Basin 18's demand. The aquifer has more than 10.4 million AF of storage and underlies the entire basin. There is approximately 30,000 AFY of recharge to the Rush Springs aquifer in Basin 18.
- There are no significant groundwater quality issues in the basin.

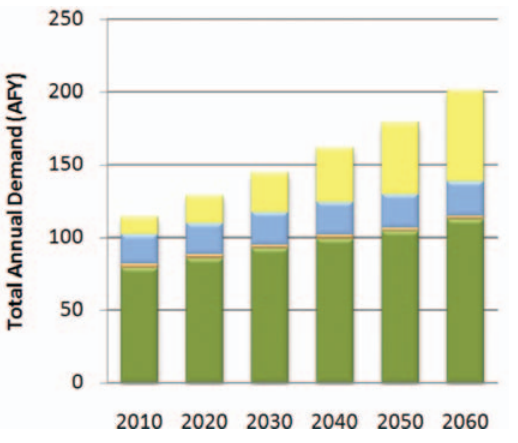
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

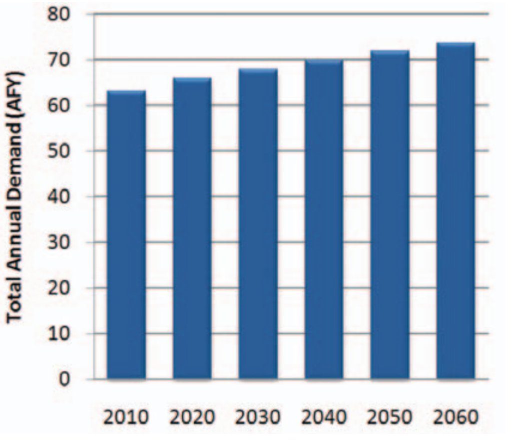
Water Demand

- Basin 18's water demand accounts for about 21% of the total demand in the West Central Region and will increase by 41% (6,830 AFY) from 2010 to 2060. The majority of the demand and growth in demand during this period will be from the Crop Irrigation demand sector.
- Surface water is used to meet 1% of the demand in Basin 18 and its use will increase 90 AFY from 2010 to 2060. The majority of surface water use during this period will be in the Crop Irrigation sector. The majority of growth in surface water use from 2010 to 2060 will be from the Oil and Gas demand sector.
- Alluvial groundwater use for the Self-Supplied Residential demand sector is less than 1% of the demand in Basin 18 and its use will increase by 17% (10 AFY) from 2010 to 2060. The increase in alluvial groundwater demand from 2010 to 2060 is minimal on a basin-scale.
- Bedrock groundwater is used to meet 99% of the total demand in the basin and its use will increase by 41% (6,730 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use during this period will be from the Crop Irrigation sector.

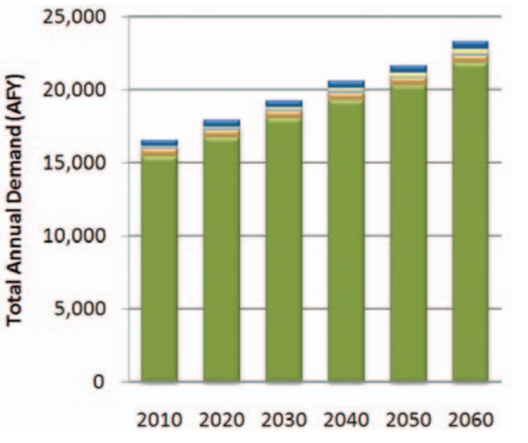
Surface Water Demand by Sector
West Central Region, Basin 18



Alluvial Groundwater Demand by Sector
West Central Region, Basin 18



Bedrock Groundwater Demand by Sector
West Central Region, Basin 18



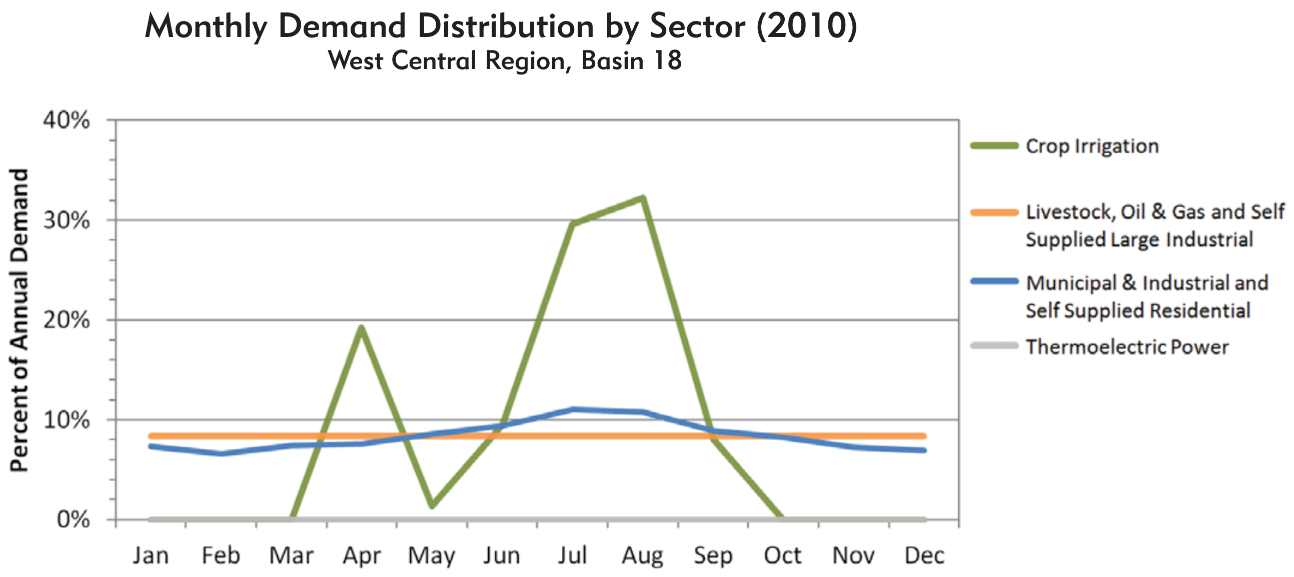
Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

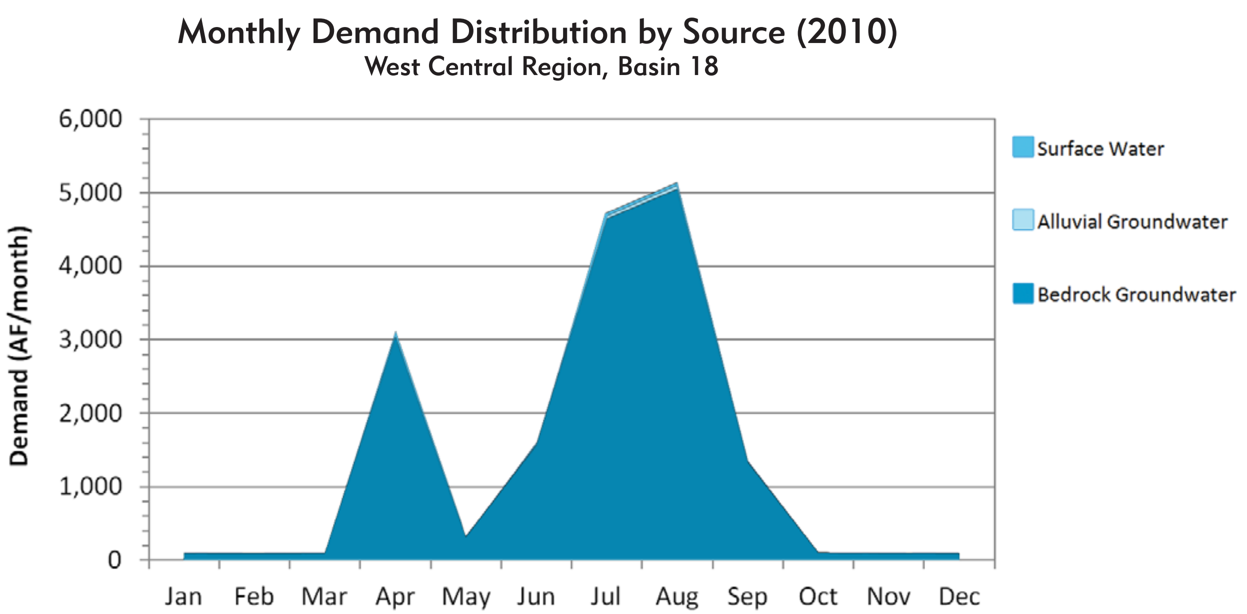
Total Demand by Sector
West Central Region, Basin 18

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	15,520	520	160	70	0	480	0	16,750
2020	16,810	520	160	110	0	500	0	18,100
2030	18,100	520	170	160	0	520	0	19,470
2040	19,390	520	170	220	0	530	0	20,830
2050	20,380	520	180	280	0	550	0	21,910
2060	21,960	520	180	360	0	560	0	23,580

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 50% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have a more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 18 is 54 times the winter demand, which is much more pronounced than the overall statewide pattern. The peak summer month surface water demand is 10.5 times the monthly winter demand. Alluvial groundwater demand in the peak summer month is 1.5 times the monthly winter demand. Bedrock groundwater demand in the peak summer month is about 58 times the monthly winter demand.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, bedrock groundwater depletions are projected to occur by 2020. No surface water gaps are expected in this basin through 2060. Alluvial groundwater depletions were not evaluated in detail due to the minimal increase in demand from 2010 to 2060.
- Fort Cobb Reservoir is capable of providing dependable water supplies to its existing users, and with new infrastructure, could be used to meet all of Basin 18's future surface water demand during periods of low streamflow. However, Ft. Cobb is fully allocated and existing water rights would need to be considered.
- Bedrock groundwater storage depletions in Basin 18 may occur in spring and summer, peaking in size during the summer. Projected annual storage depletions are minimal relative to the amount of water stored in the basin's portion of the Rush Springs Aquifer. However, localized storage depletions may occur and adversely affect well yields, water quality and/or pumping costs. Bedrock groundwater storage depletions in 2060 will be 29% (2,100 AF/month) of the bedrock groundwater demand on average in the peak summer month, and 29% (1,260 AF/month) of the bedrock groundwater demand on average in the peak spring month.

Surface Water Gaps by Season (2060 Demand)
West Central Region, Basin 18

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	0	0	0%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 18

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	0	0	0%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
West Central Region, Basin 18

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	0	0	970	0%	0%
2030	0	0	2,110	0%	0%
2040	0	0	3,170	0%	0%
2050	0	0	3,980	0%	0%
2060	0	0	5,290	0%	0%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 18

Months (Season)	Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	1,260
Jun-Aug (Summer)	2,100
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

West Central Region, Basin 18

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	0	0	5,290	0%	0%
Moderately Expanded Conservation in Crop Irrigation Water Use	0	0	4,310	0%	0%
Moderately Expanded Conservation in M&I Water Use	0	0	5,250	0%	0%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	4,280	0%	0%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	2,890	0%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

West Central Region, Basin 18

Reservoir Storage	Diversion
AF	AFY
100	400
500	1,100
1,000	1,700
2,500	2,300
5,000	2,700
Required Storage to Meet Growth in Demand (AF)	Insufficient Surface Water Supplies
Required Storage to Meet Growth in Surface Water Demand (AF)	0

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could reduce bedrock storage depletions by about 19%. Temporary drought management activities may not be needed for this basin since the storage in bedrock aquifers could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out -of-basin supplies could increase the available supply and mitigate bedrock groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region: Mountain View and Rainy Mountain in Basin 19 and Hydro, Oakwood, and Weatherford in Basin 59. However, out-of-basin supplies may not be cost-effective for all users based on the availability of groundwater resources.

Reservoir Use

Increased reliance on the Fort Cobb Master Conservancy District could supplement water supplies. However, Fort Cobb is fully allocated and future use would be subject to the provisions of existing water rights. A new river diversion and small reservoirs (less than 50 AF) could be used to alleviate groundwater depletions; however, as the basin is fully allocated, substantial permit issues would need to be resolved to construct new reservoir storage. In addition, there is insufficient streamflow to meet the bedrock groundwater demand in the basin. Therefore, additional reservoir storage is not expected to be effective.

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and surface water in the basin is fully allocated. Therefore, this water supply option is not recommended.

Increasing Reliance on Groundwater

Virtually all demand in the basin is currently on bedrock groundwater supplies. Increased reliance on bedrock groundwater supplies could mitigate the adverse effects of localized gaps or alluvial groundwater storage depletions, but would increase bedrock storage depletions. Any increases in groundwater storage depletions would be minimal relative to the volume of water in the portion of the Rush Springs aquifer underlying the basin. However, the increased storage depletions would occur and could adversely affect well yields, water quality, and/or pumping costs. The OCWP Aquifer Recharge Workgroup identified a site near Eakly (site # 42) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the upper Washita River to recharge the Rush Springs aquifer.

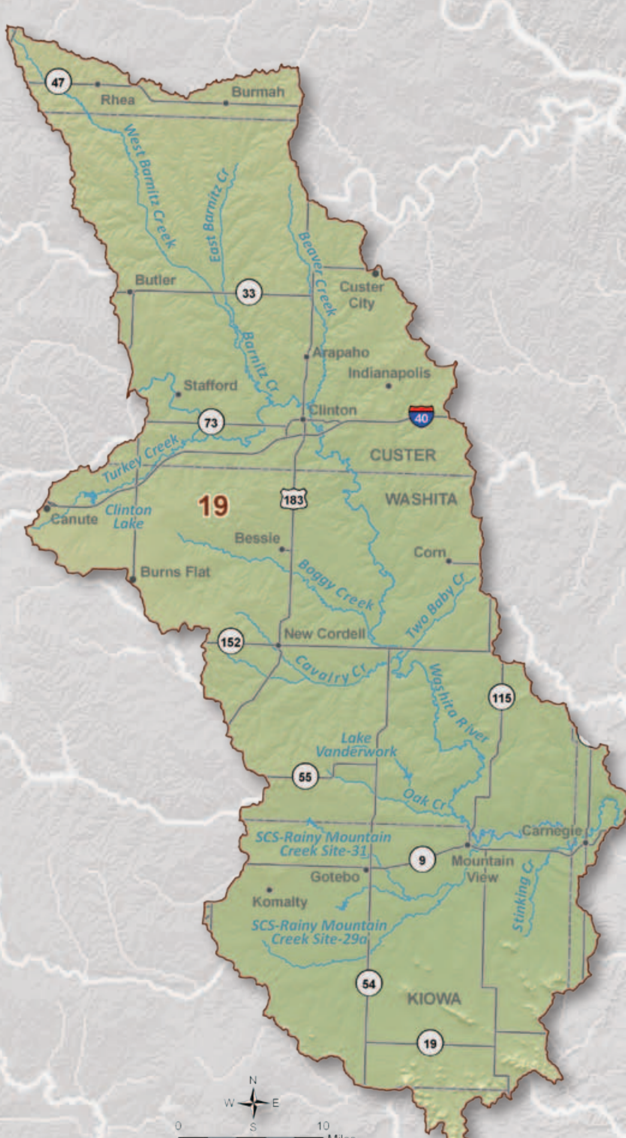
Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
West Central Watershed Planning Region

Basin 19



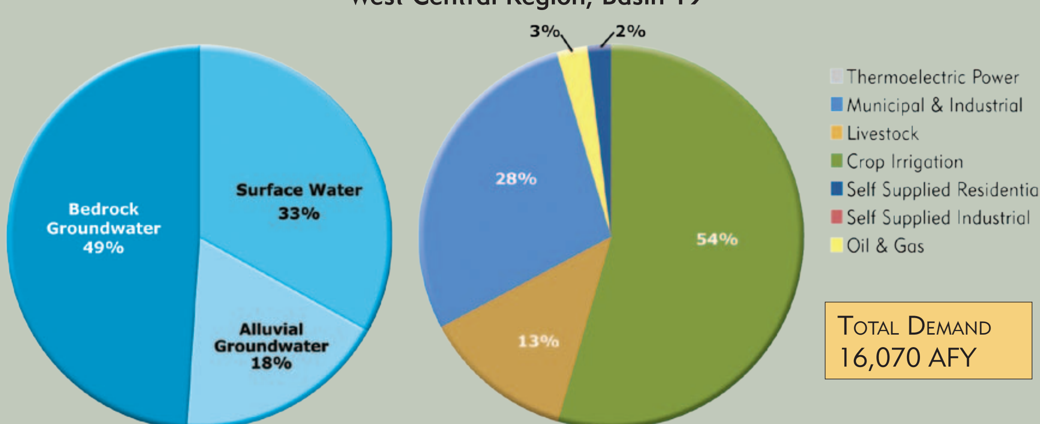
Basin 19 Summary

Synopsis

- Water users are expected to continue to rely primarily on groundwater supplies and surface water supplies from the Foss Reservoir Master Conservancy District.
- By 2020, there is a low probability of surface water gaps from increased demands on the Washita River during low flow periods.
- Water quality is a potential concern for surface water users.
- Surface water in the basin is fully allocated, limiting diversions to existing amounts.
- Alluvial groundwater storage depletions may occur by 2020, but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- It is recommended that surface water gaps and groundwater storage depletions be decreased where economically feasible.
- Additional conservation could mitigate surface water gaps and reduce the adverse effects of alluvial groundwater storage depletions.
- Increased use of Foss Master Conservancy District supplies could mitigate surface water gaps. Foss Reservoir is almost fully allocated; therefore, any future use of this source would need to take into consideration existing water rights.
- Use of additional groundwater supplies and/or developing additional small reservoir storage could mitigate surface water gaps. These supply sources could be used without major impacts to groundwater storage.

Basin 19 accounts for about 20% of the water demand in the West Central Watershed Planning Region. About 54% of the demand is from the Crop Irrigation demand sector. Municipal and Industrial (28%) is the second largest demand sector. Surface water satisfies about 33% of the total demand in the basin. Groundwater satisfies about 67% of the total demand (18% alluvial and 49% bedrock). The peak summer month demand in Basin 19 is

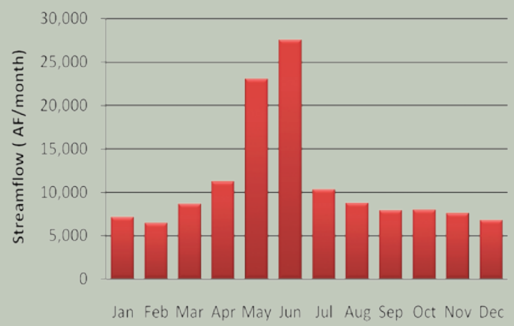
Current Demand by Source and Sector
West Central Region, Basin 19



Water Resources
West Central Region, Basin 19

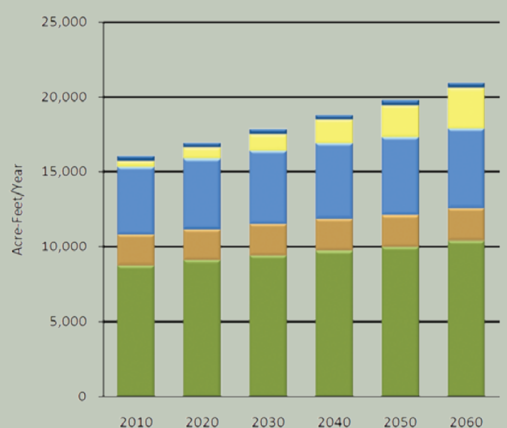
Median Historical Streamflow at the Basin Outlet

West Central Region, Basin 19



Projected Water Demand

West Central Region, Basin 19



about 6 times the winter demand, which is more pronounced than the overall statewide pattern.

The Foss Reservoir Master Conservancy District (Basin 20) is currently providing out-of-basin supply to public water providers in Basin 19 (Clinton, Bessie, and Cordell) and Basin 34 (Hobart in the Southwest Watershed Planning Region). Clinton Lake, located on Turkey Creek, also provides water supply to the City of Clinton. Historically, the flow of the Washita River at Carnegie, Oklahoma is typically greater than 6,000 AF/month. However, the river can have prolonged periods of low flow in any month of the year. Compared to basins statewide, the surface water quality in Basin 19 is considered poor. Out-of-basin supply from Foss Reservoir in Basin 20 is highly mineralized and requires desalinization or advanced treatment technology prior to municipal use. Clinton Lake is impaired for Public and Private Water Supply due to high chlorophyll-a levels. The Washita River and several creeks (Stinking Creek, Rainy Mountain Creek, Boggy Creek, and Barnitz East and West Creeks) are impaired for Agricultural uses due to high levels of chloride. Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.

The Washita River and Rush Springs aquifers have approximately 32 million acre-feet of groundwater stored in the basin. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. There are no significant basin-wide groundwater quality issues. However, localized areas with high levels of nitrate and fluoride have been found in the overall Rush Springs aquifer and may occur in Basin 19. The projected 2060 water demand of 20,930 AFY reflects a 4,860 AFY increase (30%) over the 2010 demand. The majority of the demand will be in the Crop Irrigation demand sector.

The majority of growth in demand will be in the Oil and Gas demand sector, which currently has a small demand.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. Surface water gaps will be up to 280 AFY and have a 9% probability of occurring in at least one month of the year by 2060. Surface water gaps in Basin 19 may occur in the spring, summer and fall. Alluvial groundwater gaps will be up to 170 AFY and have a 9% probability of occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions in Basin 19 may occur in spring, summer, and fall, peaking in size during the summer. Alluvial groundwater storage depletions are minimal compared to the storage in the Washita River aquifer. However, localized storage depletions may adversely impact well yields, water quality, and/or pumping costs. No bedrock groundwater depletions are expected in Basin 19.

Water Supply Limitations

West Central Region, Basin 19

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal · Potential · Significant

Water Supply Option Effectiveness

West Central Region, Basin 19

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective · Potentially Effective · Likely Ineffective · No Option Necessary

Options

Water users are expected to continue to rely primarily on groundwater supplies. To reduce the risk of adverse impacts to the basin's water users, storage depletions and gaps should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could reduce gaps and storage depletions. Due to the low probability of gaps, temporary drought management would likely be effective in reducing demand and subsequent gaps. Temporary drought management activities may not be needed for alluvial groundwater uses, since the storage could continue to provide supplies during droughts.

Out-of-basin supplies may be developed to supplement the basin's limited water supplies and eliminate gaps. Foss Master Conservancy District (MCD) is expected to continue to meet the demand of the public water providers that they are currently serving. Foss MCD is currently fully allocated; therefore, any future use of this source would need to take into consideration existing water rights. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified three potentially viable out-of-basin sites in the West Central Watershed Planning Region: Hydro, Oakwood, and Weatherford, all in Basin 59. Out-of-basin supplies may not be cost-effective relative to using the abundant in-basin groundwater resources for some users.

New small reservoirs could reduce surface water gaps and storage depletions. The OCWP *Reservoir Viability Study* identified two potentially viable sites in Basin 19: Mountain View and Rainy Mountain. However, substantial permit issues must be resolved in order to construct new larger reservoirs and further mitigate gaps and storage depletions.

Increased reliance on surface water supplies through direct diversion, without reservoir storage, will likely increase surface water gaps and the basin is fully allocated. Therefore, this water supply option is not recommended.

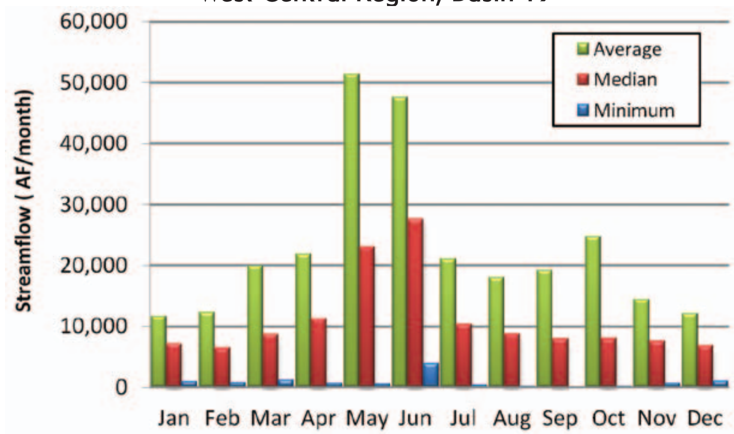
Increased reliance on groundwater supplies could be used to meet future demands on surface water and alluvial groundwater, but would increase groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in the basin's portion of the Rush Springs aquifer or Washita River aquifer.

Basin 19 Data & Analysis

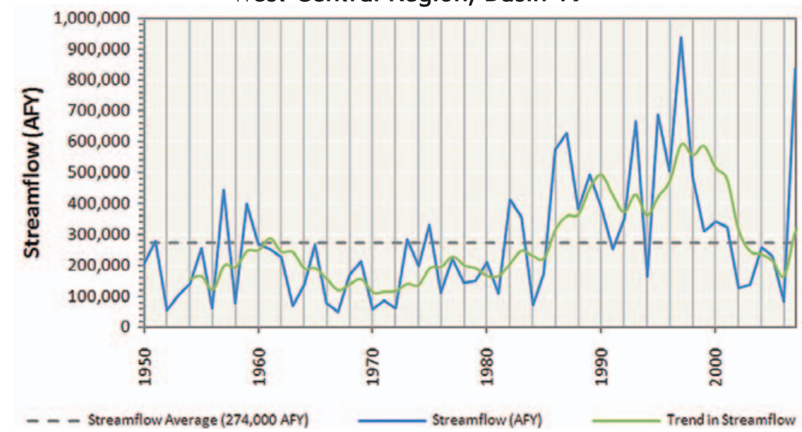
Surface Water Resource

- Historical streamflow from 1950 through 2007 was used to estimate the potential range of future surface water supplies. The Washita River at Carnegie had a prolonged period of below-average streamflow from the mid 1960s to the early 1970s, corresponding to a below-average precipitation period. The mid 1980s through the early 2000s had a prolonged period of above-average streamflow and precipitation, demonstrating hydrologic variability in the basin.
- The median flow in Basin 19 is greater than 6,000 AF/month throughout the year. The Washita River at Carnegie can have periods of low flow in any month of the year.
- Relative to other basins statewide, the surface water quality in Basin 19 is considered poor. However, individual streams may have acceptable water quality.
- Clinton Lake has a normal pool of 3,980 AF and provides water supplies to the City of Clinton. The water supply yield is unknown; therefore, the ability of this reservoir to provide future water supplies could not be evaluated.

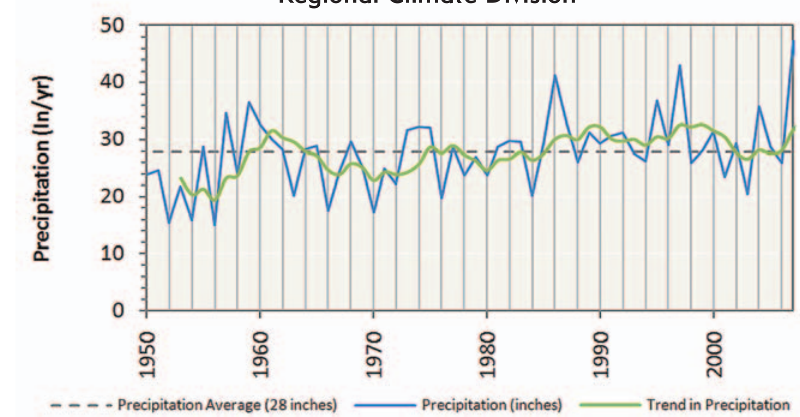
Monthly Historical Streamflow at the Basin Outlet
West Central Region, Basin 19



Historical Streamflow at the Basin Outlet
West Central Region, Basin 19



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

West Central Region, Basin 19

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	1%	0	42,000	1.0	25,600
Arbuckle-Timbered Hills	Bedrock	Major	2%	3,300	79,000	temporary 2.0	34,600
Elk City	Bedrock	Major	4%	7,700	482,000	1.0	32,100
Rush Springs	Bedrock	Major	39%	67,700	30,420,000	temporary 2.0	722,000
Washita River	Alluvial	Major	15%	25,900	1,508,000	2.0	261,500
Southwestern Oklahoma	Bedrock	Minor	23%	0	637,000	temporary 2.0	470,300
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	9,000	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	2,400	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 19 are from the Washita River and Rush Springs aquifers. The Rush Springs aquifer underlies approximately 39% of the basin and has more than 30 million AF of groundwater storage with an estimated 68,000 AFY of recharge. The Washita River aquifer underlies 15% of Basin 19 and has about 1.5 million AF of storage in the basin. There are also water rights in the Elk City and Arbuckle-Timbered Hills aquifers, as well as from non-delineated groundwater sources.
- There are no significant groundwater quality issues in the basin; however, localized areas with high levels of nitrate and fluoride have been found in the Rush Springs aquifer and may be present in Basin 19.

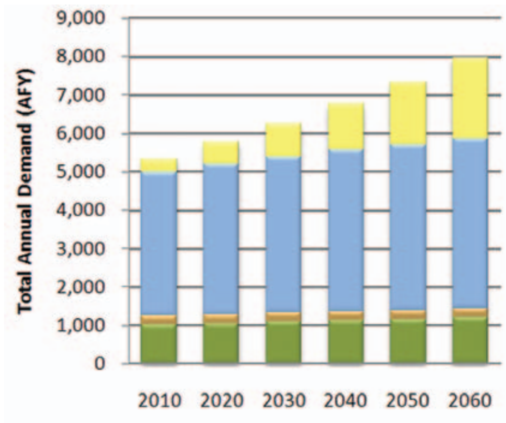
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

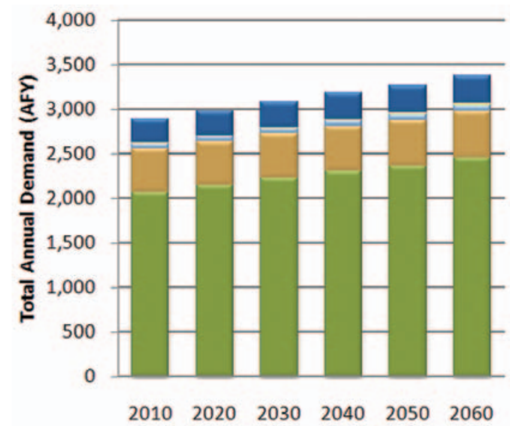
Water Demand

- Basin 19's water needs account for about 20% of the demand in the West Central Region and will increase by 30% (4,860 AFY) from 2010 to 2060. The majority of the demand over this period will be from the Crop Irrigation demand sector. The majority of growth in demand will be in the Oil and Gas demand sector, which currently has a small demand.
- Surface water is used to meet 33% of the total demand in Basin 19 and its use will increase by 49% (2,630 AFY) from 2010 to 2060. The majority of surface water use over this period will be in the Municipal and Industrial demand sector. The majority of growth in surface water use will be from the Oil and Gas demand sector.
- Alluvial groundwater is used to meet 18% of the total demand in Basin 19 and its use will increase by 17% (490 AFY). The majority of alluvial groundwater use and growth in alluvial groundwater use will be from the Crop Irrigation demand sector.
- Bedrock groundwater is used to meet 49% of the total demand in Basin 19 and its use will increase by 22% (1,740 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use will be from the Crop Irrigation demand sector.

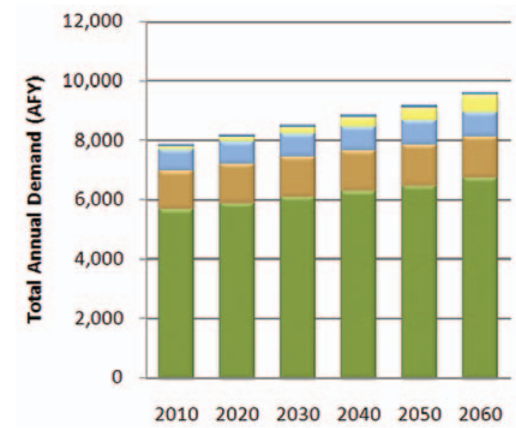
Surface Water Demand by Sector
West Central Region, Basin 19



Alluvial Groundwater Demand by Sector
West Central Region, Basin 19



Bedrock Groundwater Demand by Sector
West Central Region, Basin 19



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

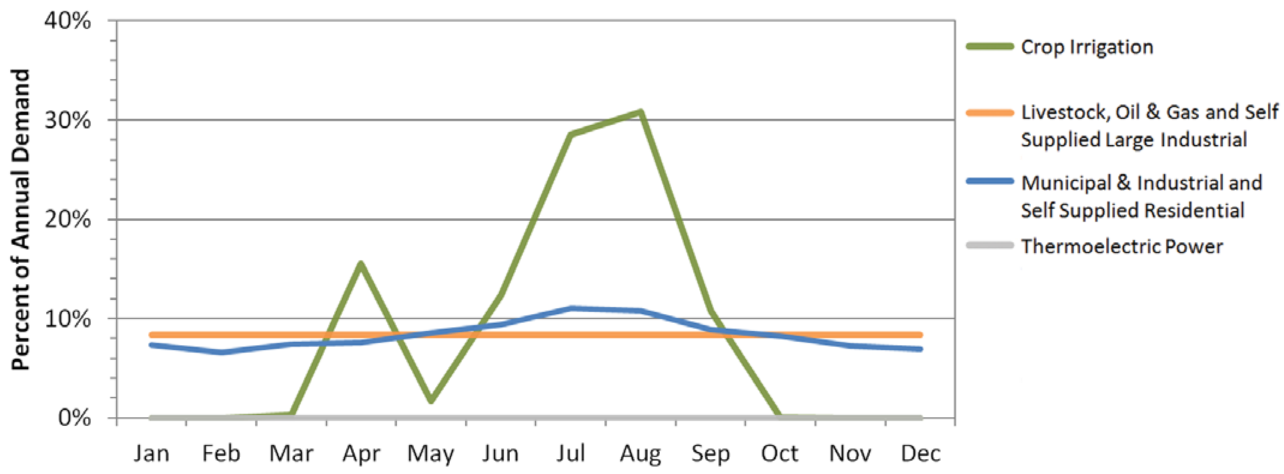
Total Demand by Sector
West Central Region, Basin 19

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	8,760	2,040	4,530	430	0	310	0	16,070
2020	9,080	2,070	4,740	720	0	320	0	16,930
2030	9,410	2,090	4,910	1,100	0	340	0	17,850
2040	9,730	2,110	5,070	1,550	0	350	0	18,810
2050	9,980	2,140	5,200	2,080	0	350	0	19,750
2060	10,390	2,160	5,320	2,700	0	360	0	20,930

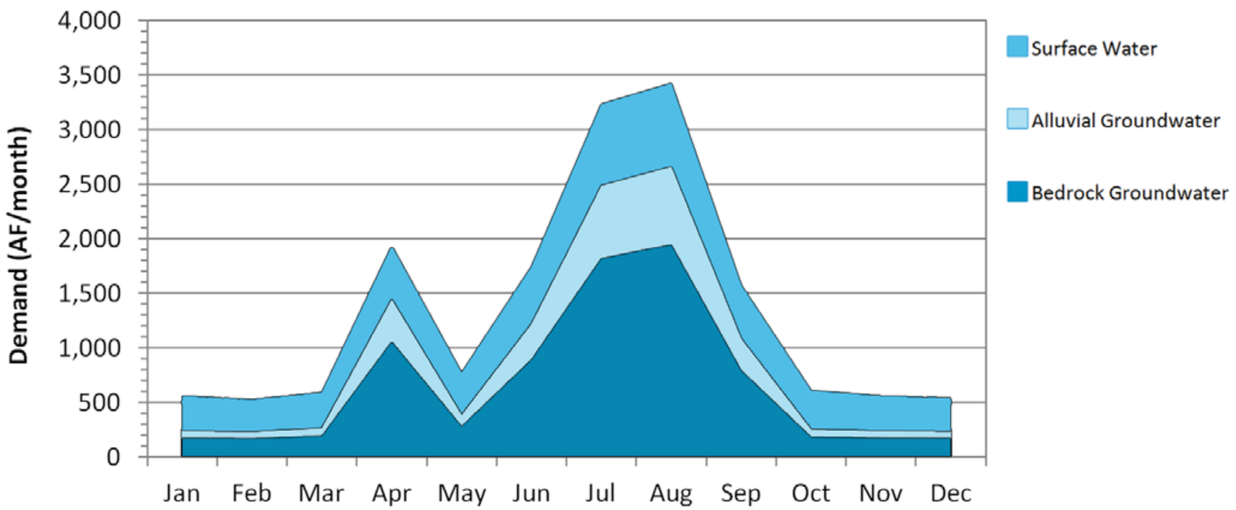
Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.

Monthly Demand Distribution by Sector (2010)
West Central Region, Basin 19



Monthly Demand Distribution by Source (2010)
West Central Region, Basin 19



Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 50% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have a more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 19 is 6 times the winter demand, which is more pronounced than the overall statewide pattern. The peak summer month surface water demand is 2.4 times the monthly winter demand. Alluvial and bedrock groundwater demand in the peak summer month is 11 times the monthly winter demand.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. No bedrock groundwater depletions are expected in Basin 19.
- There will be a 9% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps in Basin 19 may occur in the spring, summer and fall. Surface water gaps in 2060 will be up to 24% (170 AF/month) of the peak spring month's surface water demand, and as much as 21% (150 AF/month) of the peak fall month's surface water demand.
- There will be a 9% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions in Basin 19 may occur in spring, summer, and fall, peaking in size during the summer. Alluvial groundwater storage depletions in 2060 will be up to 12% (100 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 21% (70 AF/month) of the peak fall month's alluvial groundwater demand.
- Alluvial groundwater storage depletions are minimal compared to the groundwater storage in the Washita River aquifer. However, localized storage depletions may occur and adversely affect well yields, water quality and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)

West Central Region, Basin 19

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	170	170	2%
Jun-Aug (Summer)	130	70	5%
Sep-Nov (Fall)	150	90	3%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

West Central Region, Basin 19

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	100	100	2%
Jun-Aug (Summer)	100	50	5%
Sep-Nov (Fall)	70	40	3%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

West Central Region, Basin 19

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY		Percent		
2020	30	10	0	2%	2%
2030	60	40	0	3%	3%
2040	110	70	0	5%	3%
2050	180	120	0	9%	7%
2060	280	170	0	9%	9%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

West Central Region, Basin 19

Months (Season)	Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

West Central Region, Basin 19

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	280	170	0	9%	9%
Moderately Expanded Conservation in Crop Irrigation Water Use	240	140	0	9%	9%
Moderately Expanded Conservation in M&I Water Use	160	100	0	9%	7%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	120	70	0	5%	5%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	50	30	0	3%	3%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

West Central Region, Basin 19

Reservoir Storage	Diversion
AF	AFY
100	900
500	2,600
1,000	4,500
2,500	9,000
5,000	14,100
Required Storage to Meet Growth in Demand (AF)	1,100
Required Storage to Meet Growth in Surface Water Demand (AF)	300

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could reduce surface water gaps and alluvial groundwater storage depletions by about 58%. Due to the low probability of gaps, z drought management is recommended to reduce surface water use and subsequent gaps. However, reductions would likely not affect the Oil and Gas sector and aquifer storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies may be developed to supplement the basin's limited water supplies and mitigate gaps. Foss Reservoir Master Conservancy District (MCD) currently provides out-of-basin supplies to the Cities of Clinton, Bessie, Butler, and Cordell. The MCD is expected to continue to meet the demand of these providers. Foss MCD is currently almost fully allocated; therefore, any future use of this source would need to take into consideration existing water rights. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified three out-of-basin sites: Hydro, Oakwood and Weatherford, all in Basin 59. However, out-of-basin supplies may not be cost-effective for some users due to abundant in-basin groundwater resources.

Reservoir Use

Small reservoirs (less than 50 AF) could be used to reduce surface water gaps or localized storage depletions. Surface water in Basin 19 is fully allocated; therefore substantial permit issues must be resolved in order to construct larger reservoirs. If permittable, a new river diversion and an additional 1,100 AF of reservoir storage at the basin outlet could supply the entire increase in demand from 2010 to 2060. The use of multiple reservoirs in the basin or reservoirs upstream of the outlet may increase the storage required to mitigate future gaps and depletions. The OCWP *Reservoir Viability Study* also identified Mountain View and Rainy Mountain Reservoirs as potentially viable sites in Basin 19. These sites would provide much more water than needed for the basin but might present opportunities for regional or inter-regional supply options.

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversion, without reservoir storage, will increase gaps. The surface water in the basin is fully allocated. Therefore, this water supply option is not recommended.

Increasing Reliance on Groundwater

Increased reliance on groundwater could mitigate surface water gaps but would increase groundwater storage depletions. Increases in depletions would be minimal relative to the volume of water stored in the basin's portion of the Rush Springs aquifer or Washita River aquifer. However, increased depletions may adversely impact well yields, water quality and pumping costs. A shift from surface water to alluvial groundwater can potentially decrease the size of surface water gaps but may not decrease the probability of additional surface water gaps due to the interconnection between the supply sources.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Data & Analysis
West Central Watershed Planning Region

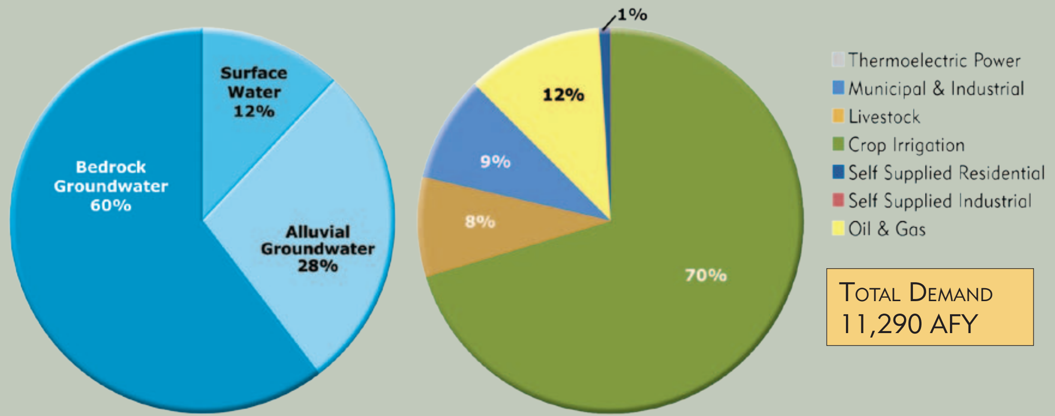
Basin 20

Basin 20 Summary

Synopsis

- Water users are expected to continue to rely primarily on groundwater supplies.
- By 2020, there is a low probability that alluvial groundwater use will exceed recharge rates and thus draw from aquifer storage each year.
- Groundwater storage depletions will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- Foss Reservoir is capable of providing dependable water supplies to its existing out-of-basin users and could be used to meet a portion of Basin 20's future surface water demand during periods of low streamflow. However, Foss Reservoir is currently almost fully allocated; therefore, any future use of this source would need to take into consideration existing water rights.
- Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.
- To reduce the risk of adverse impacts on water supplies, it is recommended that storage depletions be decreased where economically feasible.
- Aquifer recharge and recovery could be considered to store variable surface water supplies, increase alluvial groundwater storage, and reduce adverse effects of localized storage depletions.
- To mitigate localized gaps for surface water users without access to Foss Reservoir, dependable groundwater supplies and/or developing new small reservoirs could be used as alternatives. These supply sources could be used without major impacts to groundwater storage.

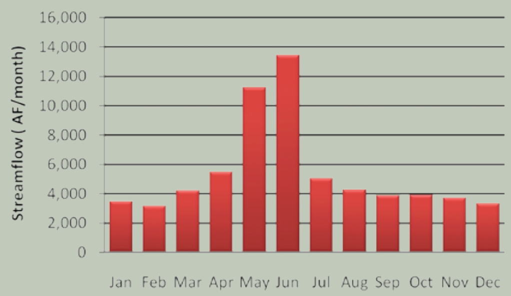
Current Demand by Source and Sector
West Central Region, Basin 20



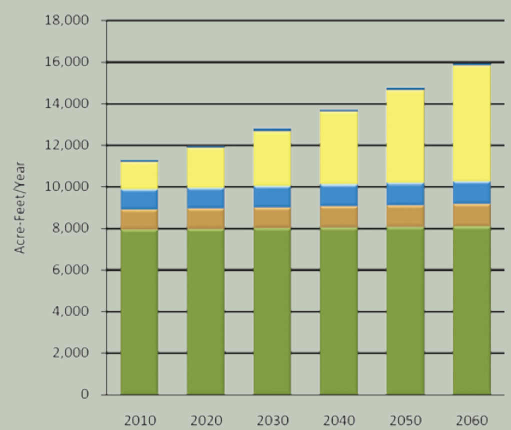
Basin 20 accounts for 14% of the water demand in the West Central Watershed Planning Region. About 70% of the demand is in the Crop Irrigation demand sector. Oil and Gas (12%) is the second-largest demand sector. Surface water satisfies about 12% of the total demand in the basin. Groundwater is used to satisfy about 88% of the basin's demand (60% bedrock and 28% alluvial). The peak summer month demand in Basin 20 is about 10 times the winter demand, which is more pronounced than the overall statewide pattern.

Foss Reservoir, located at the basin outlet, supplies almost 18,000 AFY of dependable yield to the Foss Master Conservancy District, which provides water out-of- basin to public water providers in Basin 19 (Clinton, Bessie, and Cordell) and Basin 34 (Hobart in the Southwest Watershed Planning Region). The Conservancy District is expected to provide additional water supplies to its out-of-basin members in the future, and Foss Reservoir may also supply a small amount of water in-basin. The water in Foss Reservoir is highly mineralized and requires desalinization or advanced treatment technology prior to municipal use. Dead Warrior Lake provides flood control and recreation to the City of Cheyenne and is not expected to provide water supplies in the future. Historically, the flows of the Washita River below Foss Dam are typically greater than 3,000 AF/month. However, the river can have prolonged periods of low flow in any month of the year. Surface water in the basin is fully allocated, limiting diversions to existing permitted amounts. Relative to basins statewide, the surface water quality in Basin 20 is considered fair. Quartermaster Creek is impaired for Agricultural use due to high turbidity levels.

Median Historical Streamflow at the Basin Outlet
West Central Region, Basin 20



Projected Water Demand
West Central Region, Basin 20



The Washita River and Ogallala aquifers have approximately 2.8 million acre-feet of water stored in the basin. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. There are no significant basin-wide groundwater quality issues. However, localized areas with high levels of nitrate have been found in the overall Ogallala aquifer and may occur in Basin 20.

The projected 2060 water demand of 15,910 AFY reflects a 4,620 AFY increase (41%) over the 2010 demand. The majority of the demand over this period will be in the Crop Irrigation demand sector. However, almost all of the of growth in demand from 2010 to 2060 will be in the Oil and Gas demand sector.

Gaps and Depletions

Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2020. No surface water gaps or bedrock groundwater depletions are expected in Basin 20 through 2060. Foss Reservoir is capable of providing dependable water supplies to its existing out-of-basin users and could be used supply a small amount of water to Basin 20 in the future. However, Foss Reservoir is almost fully allocated; therefore, any future use of this source would need to take into consideration existing water rights. Alluvial groundwater gaps will be up to 240 AFY and have a 9% probability of occurring in at least one month of the year by 2060. Projected alluvial groundwater storage depletions are minimal relative to the volume of water in storage. However, localized depletions may adversely affect yields, water quality, and pumping costs.

Options

Water users are expected to continue to rely primarily on groundwater supplies and potentially Foss Reservoir (Foss Reservoir Master Conservancy District currently supplies water primarily to out-of-basin users). To reduce the risk of adverse impacts to the basin's water users, storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial and Crop Irrigation sectors could mitigate bedrock groundwater storage depletions. Temporary drought management activities may not be needed for this basin since the storage in aquifers could continue to provide supplies during droughts and reductions would likely not affect the Oil and Gas demand sector.

Out-of-basin supplies could be developed to mitigate storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region: Mountain View and Rainy Mountain in Basin 19 and Hydro, Oakwood, and Weatherford

Water Supply Limitations
West Central Region, Basin 20

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal Potential Significant

Water Supply Option Effectiveness
West Central Region, Basin 20

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective Potentially Effective
Likely Ineffective No Option Necessary

in Basin 59. However, out-of-basin supplies may not be cost-effective relative to using in-basin groundwater resources.

Small reservoirs (less than 50 AF) could be used to reduce surface water gaps from users without access to Foss Reservoir and to mitigate adverse effects of localized groundwater storage depletions. Basin 19 is fully allocated; therefore substantial permit issues must be resolved in order to construct larger reservoirs.

Increased reliance on surface water supplies through direct diversion, without reservoir storage, may cause surface water gaps and the basin is fully allocated. Therefore, this water supply option is not recommended.

Increased reliance on groundwater supplies could be used to meet future demands on surface water, but would increase groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in the basin's portion of the Ogallala or Washita River aquifers.

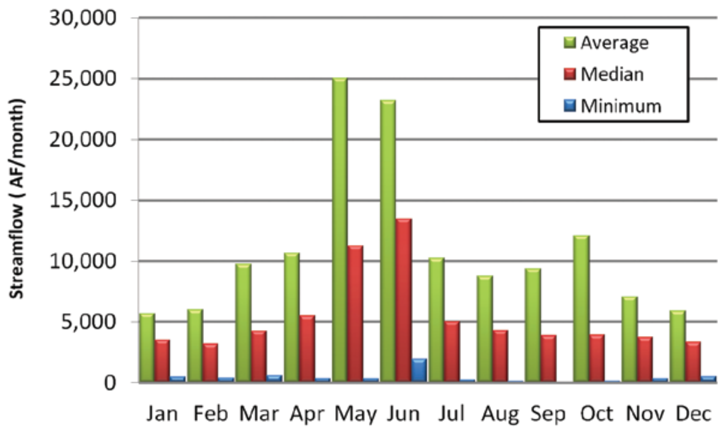
The Aquifer Recharge Workgroup identified a site near Reydon (site # 40) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the Washita River to recharge the Ogallala aquifer. However, since Basin 20 is fully allocated, permit issues would need to be resolved before new water withdrawals could be considered.

Basin 20 Data & Analysis

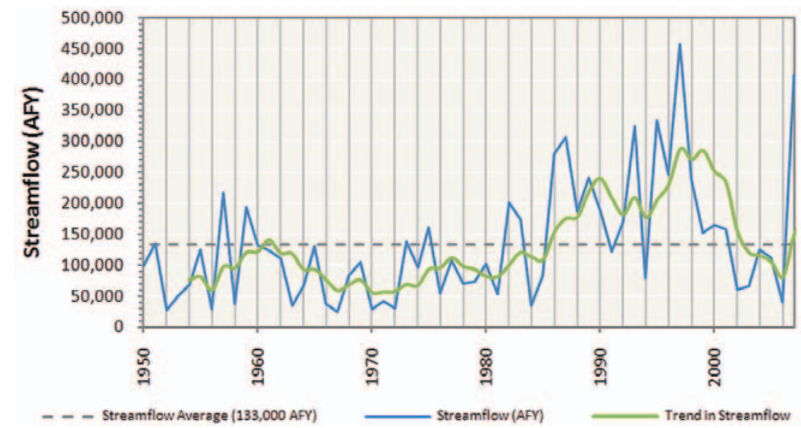
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the potential range of future surface supplies. The Washita River below Foss Dam had a prolonged period of below-average streamflow from the mid 1960s to the mid 1970s, corresponding to a period of below-average precipitation. The mid 1980s through the early 2000s had a prolonged period of above average streamflow and rainfall, demonstrating the basin's hydrologic variability.
- The median flow in Basin 20 is greater than 3,000 AF/month throughout the year and greater than 11,000 AF/month in May and June. However, the Washita River below Foss Dam can have periods of low flow in any month of the year.
- Relative to other basins statewide, the surface water quality in Basin 20 is fair.
- Foss Reservoir, located at the basin outlet, supplies 18,000 AFY of dependable yield to the Foss Reservoir Master Conservancy District. The reservoir is expected to provide additional water supplies to its out-of-basin users in the future. Dead Warrior Lake provides flood control and recreation to the City of Cheyenne and is not expected to provide future supplies.

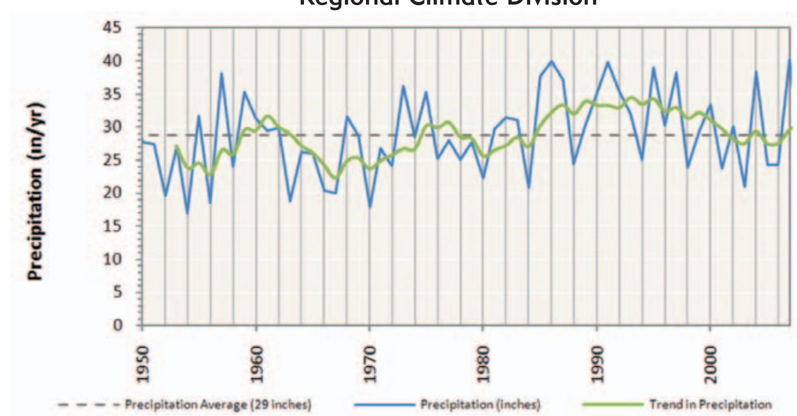
Monthly Historical Streamflow at the Basin Outlet
West Central Region, Basin 20



Historical Streamflow at the Basin Outlet
West Central Region, Basin 20



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

West Central Region, Basin 20

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	2%	0	53,000	1.0	17,000
Washita River	Alluvial	Major	13%	37,100	1,209,000	2.0	118,200
Elk City	Bedrock	Major	5%	900	327,000	1.0	37,500
Ogallala	Bedrock	Major	25%	43,600	1,617,000	2.0	294,900
Western Oklahoma	Bedrock	Minor	4%	300	0	temporary 2.0	50,200
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	37,700	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	0	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 20 are from the Washita River aquifer, Ogallala aquifer, and non-delineated groundwater sources, primarily in the Cloud Chief and Doxey geological formations. There is an estimated 21,000 AFY of recharge to major bedrock aquifers in Basin 20.
- There are no significant groundwater quality issues in the basin; however, localized areas with high levels of nitrate have been found in the Ogallala aquifer and may occur in Basin 20.

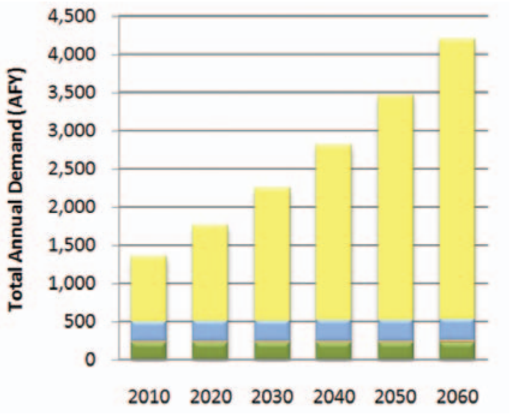
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

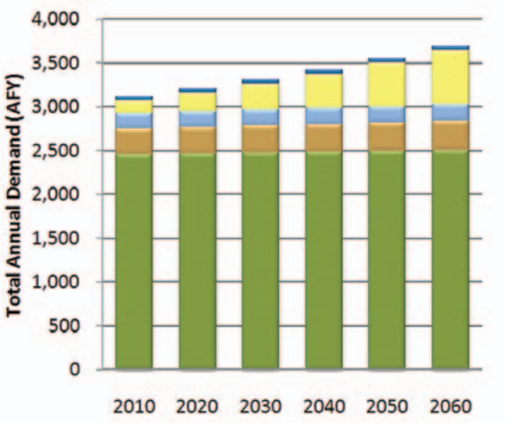
Water Demand

- Basin 20's water needs account for about 14% of the demand in the West Central Region and will increase by 41% (4,620 AFY) from 2010 to 2060. The majority of the demand during this period will be in the Crop Irrigation demand sector. However, the majority of the of growth in demand from 2010 to 260 will be from the Oil and Gas demand sector.
- Surface water is used to meet 12% of the total demand in Basin 20 and its use will more than triple by 2060. The majority of surface water use and growth in surface water use from 2010 to 2060 will be from the Oil and Gas demand sector.
- Alluvial groundwater is used to meet 28% of the total demand in Basin 20 and its use will increase by 19% (580 AFY) from 2010 to 2060. The majority of alluvial groundwater use during this period will be in the Crop Irrigation demand sector. However, the majority of the of growth in alluvial groundwater use from 2010 to 2060 will be from the Oil and Gas demand sector.
- Bedrock groundwater is used to meet 60% of the total demand in Basin 20 and its use will increase by 18% (1,230 AFY) from 2010 to 2060. The majority of bedrock groundwater use during this period will be in the Crop Irrigation demand sector. However, the majority of the of growth in bedrock groundwater use from 2010 to 2060 will be from the Oil and Gas demand sector.

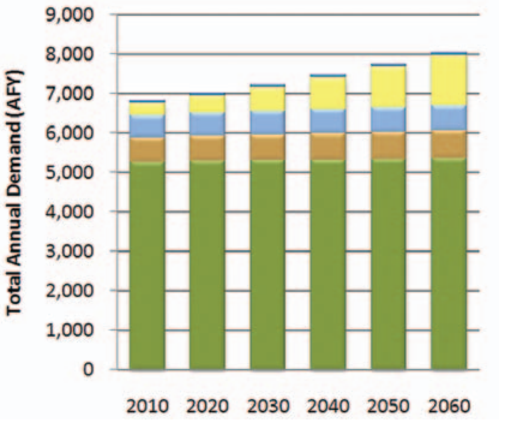
Surface Water Demand by Sector
West Central Region, Basin 20



Alluvial Groundwater Demand by Sector
West Central Region, Basin 20



Bedrock Groundwater Demand by Sector
West Central Region, Basin 20



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

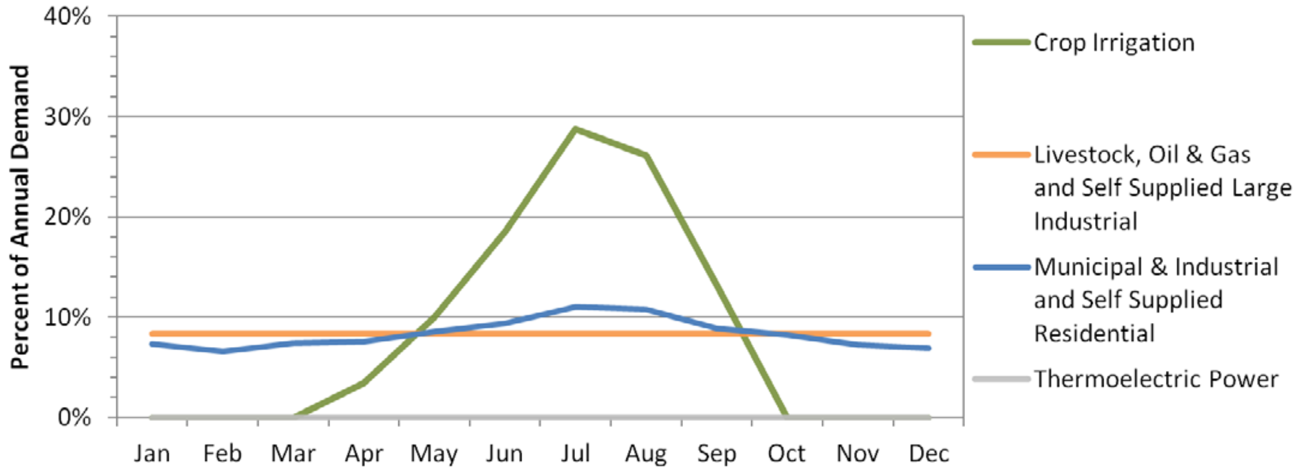
Total Demand by Sector
West Central Region, Basin 20

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	7,940	940	1,000	1,310	0	100	0	11,290
2020	7,970	960	1,030	1,920	0	100	0	11,980
2030	8,000	990	1,050	2,640	0	100	0	12,780
2040	8,020	1,020	1,070	3,490	0	100	0	13,700
2050	8,040	1,050	1,080	4,470	0	100	0	14,740
2060	8,080	1,070	1,100	5,560	0	100	0	15,910

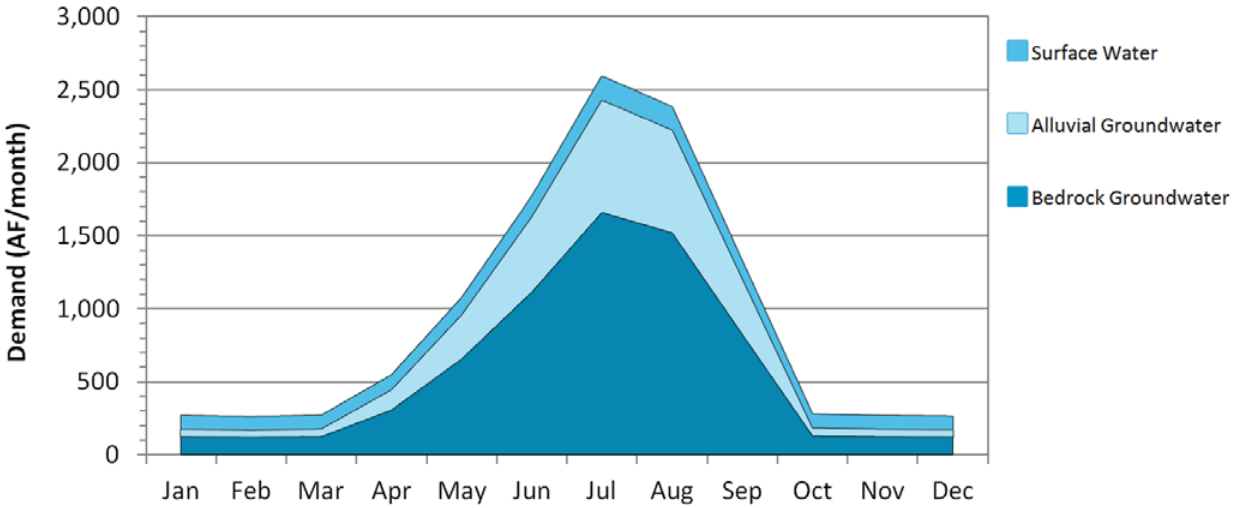
Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.

Monthly Demand Distribution by Sector (2010)
West Central Region, Basin 20



Monthly Demand Distribution by Source (2010)
West Central Region, Basin 20



Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 50% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 20 is about 10 times the monthly winter demand, which is more pronounced than the overall statewide pattern. Monthly surface water use peaks in the summer at about 1.8 times the monthly winter use. Alluvial and bedrock groundwater demand in the peak summer month is about 14 times the monthly winter demand.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2020.
- There will be a 9% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. These depletions in Basin 20 may occur during the spring, summer, and fall. Alluvial storage depletions in 2060 will be up to 14% (110 AF/month) of the alluvial groundwater demand in the peak summer month and as much as 56% (100 AF/month) of the peak spring month's alluvial demand.
- No bedrock groundwater storage depletions are expected in Basin 20 through the 2060 planning horizon.
- Projected annual storage depletions are minimal relative to the amount of water stored in major alluvial and bedrock aquifers in Basin 20. However, localized storage depletions may adversely affect well yields, water quality, or pumping costs.

Surface Water Gaps by Season (2060 Demand)

West Central Region, Basin 20

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	0	0	0%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

West Central Region, Basin 20

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	100	100	2%
Jun-Aug (Summer)	110	50	5%
Sep-Nov (Fall)	130	80	3%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

West Central Region, Basin 20

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	0	20	0	0%	2%
2030	0	40	0	0%	3%
2040	0	80	0	0%	7%
2050	0	170	0	0%	7%
2060	0	240	0	0%	9%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

West Central Region, Basin 20

Months (Season)	Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

West Central Region, Basin 20

Conservation Activities [1]	2060 Gap/Storage Depletion			Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	0	240	0	0%	9%
Moderately Expanded Conservation in Crop Irrigation water use	0	220	0	0%	9%
Moderately Expanded Conservation in M&I water use	0	240	0	0%	9%
Moderately Expanded Conservation in Crop Irrigation and M&I water use	0	210	0	0%	9%
Substantially Expanded Conservation in Crop Irrigation and M&I water use	0	80	0	0%	7%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

West Central Region, Basin 20

Reservoir Storage	Diversion
AF	AFY
100	1,200
500	3,700
1,000	5,200
2,500	8,000
5,000	11,800
Required Storage to Meet Growth in Demand (AF)	800
Required Storage to Meet Growth in Surface Water Demand (AF)	300

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded conservation activities are expected to have a 13% reduction on alluvial groundwater storage depletions. Temporary drought management activities may not be needed, since reductions would likely not affect the Oil and Gas demand sector and aquifer storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could be developed to mitigate storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified five potentially viable out-of-basin sites in the West Central Watershed Planning Region: Mountain View and Rainy Mountain in Basin 19 and Hydro, Oakwood, and Weatherford in Basin 59. However, out-of-basin supplies may not be cost-effective relative to using in-basin groundwater resources.

Reservoir Use

Small reservoirs (less than 50 AF) could mitigate groundwater depletions. Surface water in Basin 20 has been fully allocated, which is expected to severely limit the size and location options of new reservoirs and substantial permit issues must be resolved in order to construct larger reservoirs. If permittable, a new river diversion and an additional 800 AF of reservoir storage at the basin outlet could supply the entire increase in demand from 2010 to 2060. The use of multiple reservoirs in the basin or reservoirs upstream of the basin outlet may increase the size of storage necessary to mitigate future gaps and storage depletions.

Increasing Reliance on Surface Water

Increasing the surface water use, without reservoir storage, will likely cause localized gaps and is not recommended.

Increasing Reliance on Groundwater

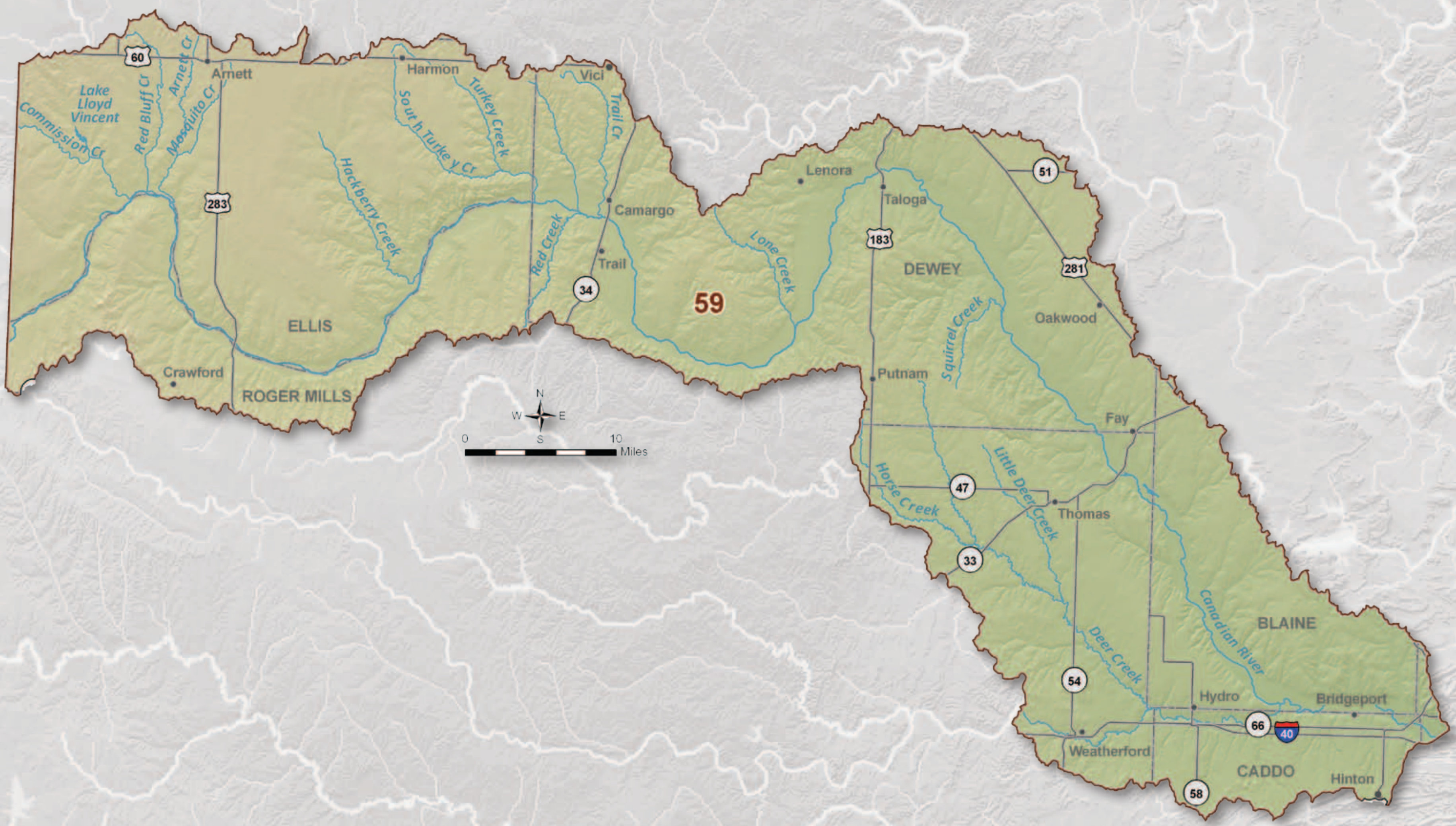
Increased reliance on groundwater supplies could mitigate localized surface water gaps, but would increase the amount of groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in major aquifers in the basin. However, increased storage depletions may adversely impact well yields, water quality, and/or pumping costs. The Aquifer Recharge Workgroup identified a site near Reydon (site # 40) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the Washita River to recharge the Ogallala Aquifer.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Data & Analysis
West Central Watershed Planning Region

Basin 59

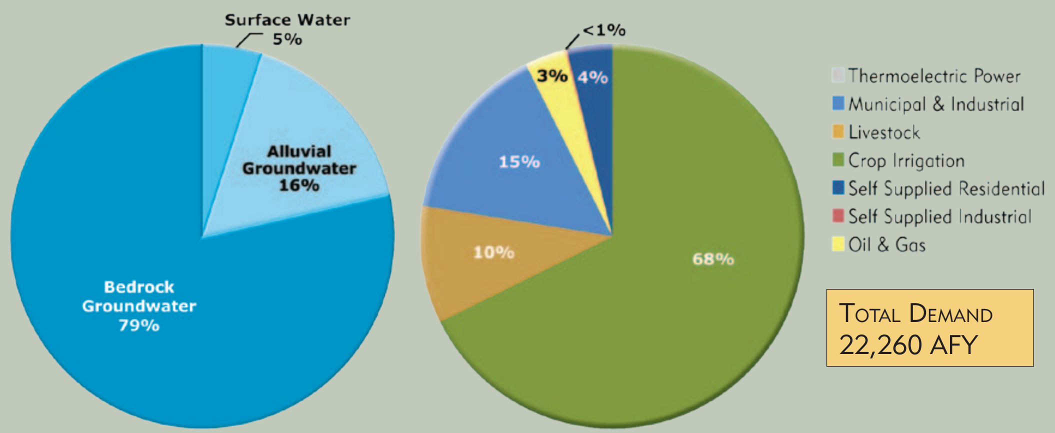


Basin 59 Summary

Synopsis

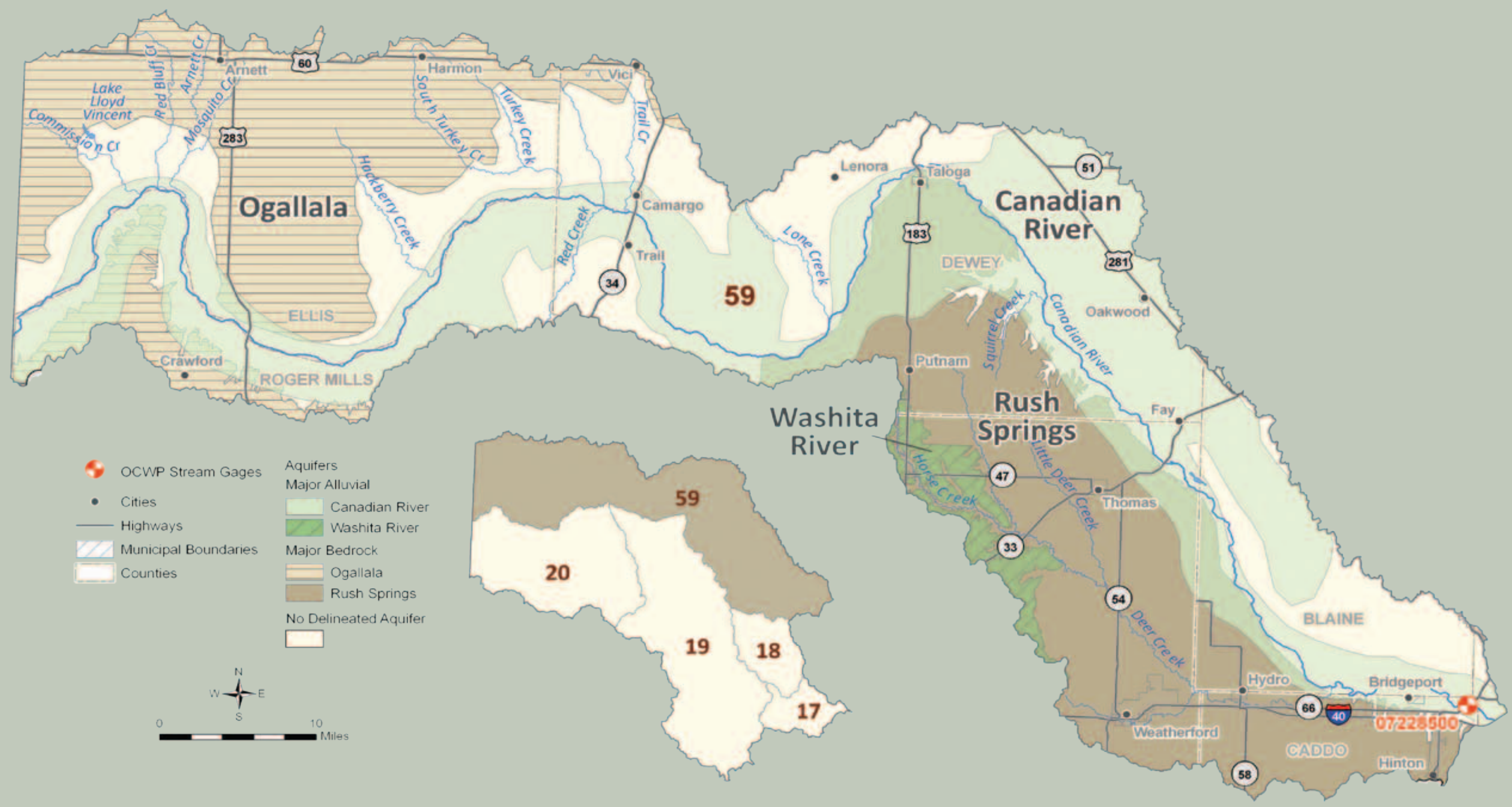
- Most water users are expected to continue to rely primarily on alluvial and bedrock aquifers.
- By 2020, surface water gaps may occur during summer months with low streamflows.
- Alluvial groundwater storage depletions may occur by 2020 and bedrock groundwater storage depletions may occur by 2060, but the depletions will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that storage depletions and gaps be decreased where economically feasible.
- Additional conservation could reduce surface water gaps and potentially mitigate bedrock groundwater storage depletions.
- Use of additional groundwater supplies and/or developing new small reservoirs could mitigate gaps without having major impacts to groundwater storage.

Current Demand by Source and Sector
West Central Region, Basin 59



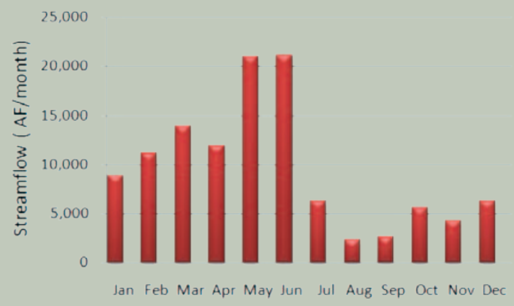
Basin 59 accounts for about 28% of the water demand in the West Central Watershed Planning Region. About 68% of the demand is from the Crop Irrigation demand sector. Municipal and Industrial (15%) is the second-largest demand sector. Surface water satisfies about 5% of total demand in the basin. There are no significant reservoirs in this basin. Groundwater satisfies about 95% of the total demand in the basin (16% alluvial and 79% bedrock). The peak summer month demand in Basin 59 is about 10 times the winter demand, which is more pronounced than the overall statewide pattern.

Historically, the flows of the Canadian River at Bridgeport are typically greater than 2,000 AF/month. However, the river can have prolonged periods of low flow in any month of the year. Upstream development and future in-basin development are expected to reduce the historical streamflow in this basin. Relative to basins statewide, the surface water quality is in Basin 59 is considered fair. A portion of the Canadian River and its tributaries are impaired for Agricultural uses due to high levels of TDS, chlorides, and sulfates.



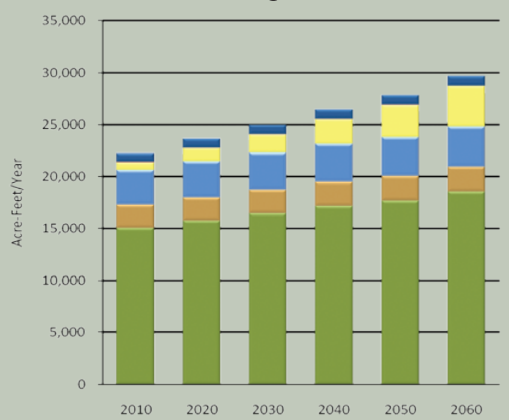
Median Historical Streamflow at the Basin Outlet

West Central Region, Basin 59



Projected Water Demand

West Central Region, Basin 59



The Canadian River, Rush Springs, and Ogallala aquifers have approximately 28 million acre-feet of water stored in the basin. There are no significant basin-wide groundwater quality issues. However, localized areas with high levels of nitrate have been found in the overall Rush Springs and Ogallala aquifers and may occur in Basin 59. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060.

The projected 2060 water demand of 29,640 AFY reflects a 7,380 AFY increase (33%) over the 2010 demand. The majority of the demand over this period will be in the Crop Irrigation demand sector. However, almost all of the growth in demand from 2010 to 2060 will be in the Oil and Gas demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020 and bedrock groundwater storage depletions may occur by 2060. Surface water gaps in Basin 59 may occur throughout the year. Surface water gaps will be up to 910 AFY and will have a 57% probability of gaps occurring in 2060. Alluvial groundwater storage depletions in Basin 59 may occur throughout the year, peaking in size during the summer. Alluvial groundwater storage depletions will be up to 1,310 AFY and will have a 57% probability of occurring in 2060. Bedrock groundwater storage depletions will occur in the summer and will be 40 AFY on average by 2060. Projected annual storage depletions are minimal relative to the volume of water stored in the major aquifers underlying the basin. However, localized storage depletions may adversely affect well yields, water quality and/or pumping costs.

Options

Most water users are expected to continue to rely primarily on groundwater supplies. To reduce the risk of adverse impacts on water supplies, it is recommended that storage depletions and gaps be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial demand sector could reduce gaps and mitigate bedrock groundwater storage depletions. Temporary drought management activities may not be needed in this basin since reductions would likely not affect the Oil and Gas demand sector and aquifer storage could continue to provide Crop Irrigation supplies during droughts.

Out-of-basin supplies may be developed to supplement the basin's water supplies and reduce or mitigate gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified two potentially viable out-of-basin sites in

Water Supply Limitations

West Central Region, Basin 59

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal Potential Significant

Water Supply Option Effectiveness

West Central Region, Basin 59

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective Potentially Effective
Likely Ineffective No Option Necessary

the region. However, due to the availability of the basin's groundwater resources and the geographically dispersed nature of the Crop Irrigation and Oil and Gas demand sectors, out-of-basin supplies may not be cost-effective for many users in the basin.

New small reservoirs (less than 50 AF) could reduce surface water gaps or adverse effects of localized storage depletions. The OCWP *Reservoir Viability Study* identified three potentially viable sites in Basin 59. A new river diversion and an additional 7,000 AF of reservoir storage at the basin outlet could provide dependable water supplies for all growth in demand through 2060.

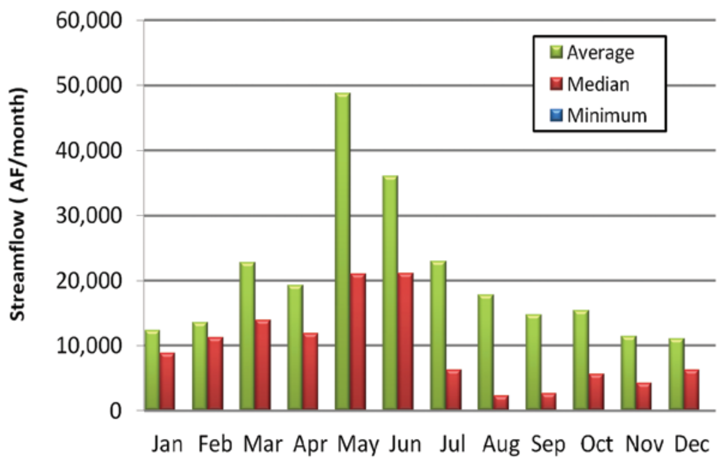
Increased reliance on groundwater supplies could mitigate surface water gaps but would increase the amount of groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in major aquifers underlying the basin.

Basin 59 Data & Analysis

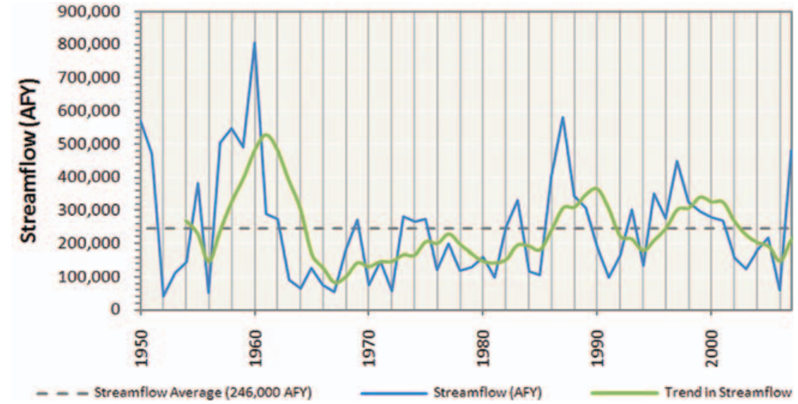
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Canadian River at Bridgeport has undergone long periods of below-average streamflow from the early 1960s to the mid 1970s corresponding to a period of below-average precipitation. From the mid 1990s to the early 2000s, the basin went through a period of above-average flow and precipitation, demonstrating hydrologic variability in the basin.
- The median monthly streamflow is greater than 2,000 AF/month throughout the year and greater than 10,000 AF/Month from February through June. However, the Canadian River at Bridgeport can have periods of low to no flow in any month of the year. Upstream compact obligations could affect streamflow in the future.
- Relative to other basins statewide, the surface water quality in Basin 59 is considered fair.
- There are no significant reservoirs in the basin.

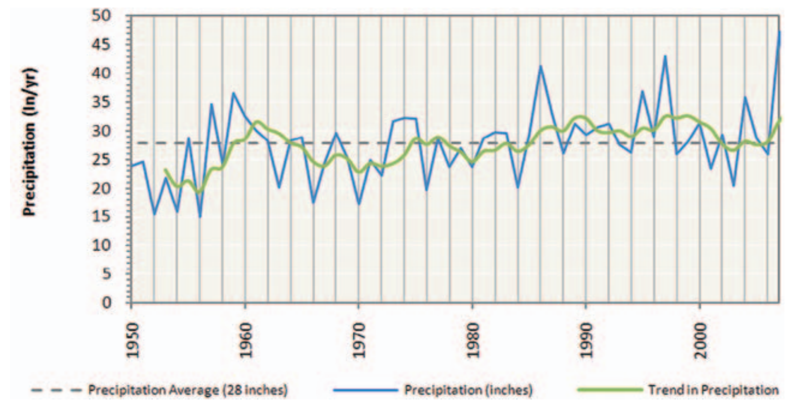
Monthly Historical Streamflow at the Basin Outlet
West Central Region, Basin 59



Historical Streamflow at the Basin Outlet
West Central Region, Basin 59



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

West Central Region, Basin 59

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	38%	28,000	1,734,000	1.0	911,400
Ogallala	Bedrock	Major	22%	21,900	4,178,000	2.0	551,100
Rush Springs	Bedrock	Major	29%	117,500	21,919,000	temporary 2.0	635,100
Washita River	Alluvial	Major	2%	0	11,000	2.0	62,700
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	4,300	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	4,300	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

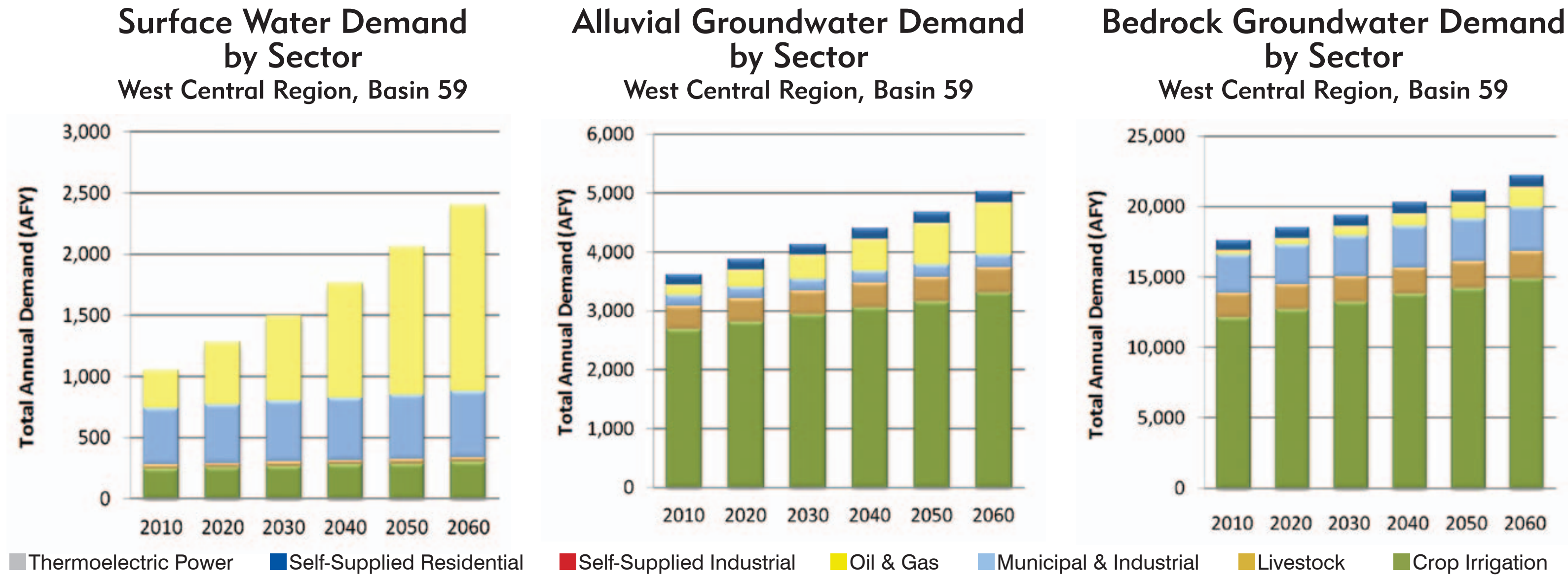
- The majority of water rights in Basin 59 are from the Rush Springs aquifer. There are also substantial water rights in the Canadian River and Ogallala aquifers. There is an estimated 66,000 AFY of recharge to major bedrock aquifers in the basin. There are also about 8,600 AFY of water rights from non-delineated groundwater sources.
- There are no significant groundwater quality issues in the basin; however, localized areas with high levels of nitrate have been found within the overall Rush Springs and Ogallala aquifers and may occur in Basin 29.

Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

Water Demand

- Basin 59's water demand accounts for about 28% of the West-Central Region's total demand and will increase by 33% (7,380 AFY) from 2010 to 2060. The majority of demand and growth in demand during this period will be from the Crop Irrigation demand sector. Substantial growth in demand will also occur from the Oil and Gas demand sector.
- Surface water is used to supply 5% of the total demand in the basin and its use will double in the next 50 years. The largest growth in surface water use from 2010 to 2060 will be in the Oil and Gas demand sector.
- Alluvial groundwater is used to supply 16% of the total demand in Basin 59 and its use will increase by 39% (1,410 AFY) from 2010 to 2060. The majority of alluvial groundwater use during this period will be from the Crop Irrigation demand sector. The largest growth in alluvial groundwater use from 2010 to 2060 will be in the Oil and Gas demand sector.
- Bedrock groundwater is used to supply 79% of the total demand in Basin 59 and its use will increase by 26% (4,620 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use during this period will be from the Crop Irrigation demand sector.



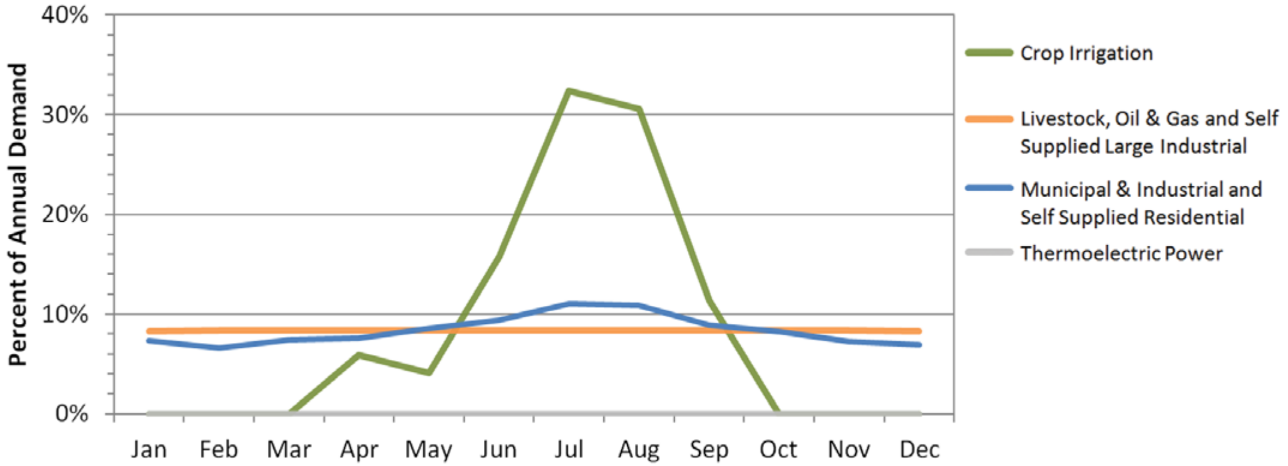
Total Demand by Sector
West Central Region, Basin 59

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	15,070	2,190	3,350	780	20	850	0	22,260
2020	15,760	2,230	3,480	1,290	20	870	0	23,650
2030	16,450	2,270	3,580	1,760	20	890	0	24,970
2040	17,140	2,310	3,690	2,370	20	920	0	26,450
2050	17,670	2,350	3,790	3,070	30	940	0	27,850
2060	18,520	2,390	3,880	3,860	30	960	0	29,640

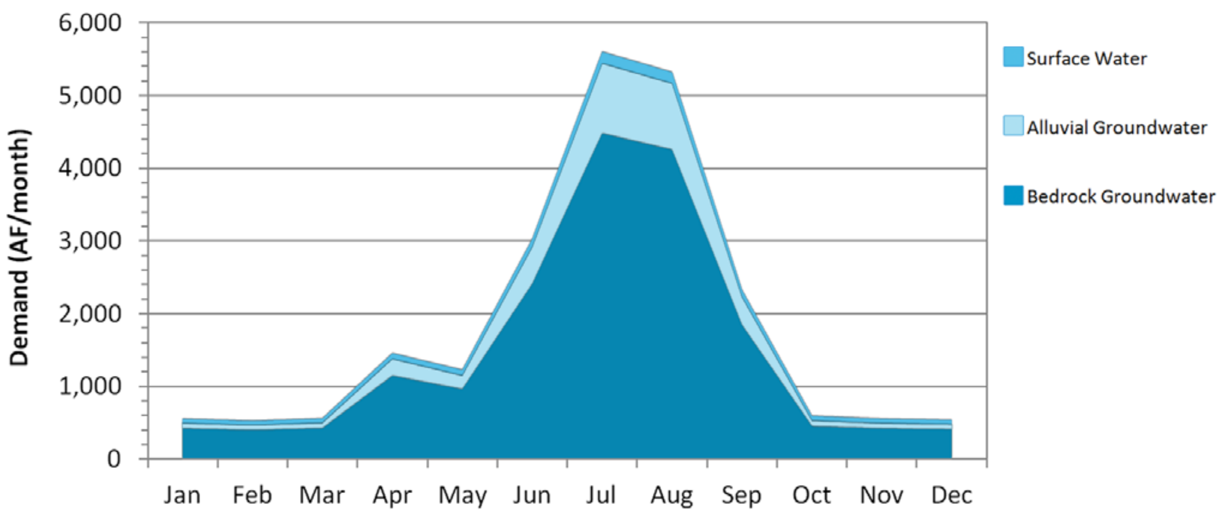
Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.

Monthly Demand Distribution by Sector (2010)
West Central Region, Basin 59



Monthly Demand Distribution by Source (2010)
West Central Region, Basin 59



Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 50% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 59 is 10 times the winter demand, which is more pronounced than the overall statewide pattern. Monthly surface water demand peaks in the summer at 2.6 times the monthly winter demand. Alluvial and bedrock groundwater demand in the peak summer month is over 10 times the monthly winter demand.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions are expected by 2020, and bedrock groundwater storage depletions are expected by 2060.
- Surface water gaps in Basin 59 may occur throughout the year. Surface water gaps in 2060 will be up to 26% (60 AF/month) of the surface water demand in the peak summer month, and as much as 59% (100 AF/month) of the peak winter month's surface water demand. There will be a 57% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer months.
- Alluvial groundwater storage depletions in Basin 59 may occur throughout the year, peaking in size during the summer. These depletions in 2060 will be up to 19% (230 AF/month) of the alluvial groundwater demand in the peak summer month and as much as 57% (80 AF/month) of the peak winter month's alluvial groundwater demand. There will be a 57% probability of alluvial depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during summer months.
- Bedrock groundwater storage depletions in Basin 59 will occur during the summer. Bedrock groundwater storage depletions in 2060 will be 1% (40 AF/month) of the bedrock groundwater demand on average in the peak summer month.
- Projected annual alluvial and bedrock storage depletions are minimal relative to the amount of water in storage in the aquifer. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
West Central Region, Basin 59

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF	AF	Percent
Dec-Feb (Winter)	100	90	29%
Mar-May (Spring)	100	80	14%
Jun-Aug (Summer)	60	60	47%
Sep-Nov (Fall)	100	60	34%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 59

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF	AF	Percent
Dec-Feb (Winter)	80	80	29%
Mar-May (Spring)	120	110	14%
Jun-Aug (Summer)	230	220	47%
Sep-Nov (Fall)	150	80	34%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
West Central Region, Basin 59

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AF			Percent	
2020	110	280	0	50%	53%
2030	280	470	0	53%	53%
2040	460	710	0	53%	53%
2050	660	990	0	55%	55%
2060	910	1,310	40	57%	57%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
West Central Region, Basin 59

Months (Season)	Storage Depletion[1]
	AF
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	40
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

West Central Region, Basin 59

Conservation Activities [1]	2060 Gap/Storage Depletion			Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	910	1,310	40	57%	57%
Moderately Expanded Conservation in Crop Irrigation water use	900	1,250	0	57%	57%
Moderately Expanded Conservation in M&I water use	770	1,310	0	57%	57%
Moderately Expanded Conservation in Crop Irrigation and M&I water use	760	1,250	0	55%	57%
Substantially Expanded Conservation in Crop Irrigation and M&I water use	740	920	0	53%	53%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

West Central Region, Basin 59

Reservoir Storage	Diversion
AF	AFY
100	100
500	700
1,000	1,400
2,500	3,400
5,000	6,300
Required Storage to Meet Growth in Demand (AF)	7,000
Required Storage to Meet Growth in Surface Water Demand (AF)	1,200

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial demand sector could reduce the size of surface water gaps by about 11% and mitigate bedrock groundwater storage depletions. Additional conservation activities are expected to have a small effect on alluvial groundwater storage depletions. Temporary drought management activities may not be needed in this basin since reductions would likely not affect the Oil and Gas sector and aquifer storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

New out-of-basin supplies could be used to augment supplies and meet demand. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified two potentially viable out-of-basin sites in the West Central Watershed Planning Region: Mountain View and Rainy Mountain in Basin 19. However, due to the basin's groundwater resources and the geographically dispersed nature of the Crop Irrigation and Oil and Gas sectors, out-of-basin supplies may not be cost-effective for many users.

Reservoir Use

New reservoir storage could reduce surface water gaps or adverse effects of localized storage depletions. A new river diversion and an additional 7,000 AF of reservoir storage at the basin outlet could supply all the increase in demand from 2010 to 2060. The use of multiple reservoirs in the basin or reservoirs upstream of the basin outlet may increase the size of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* identified Hydro, Oakwood and Weatherford Reservoirs as potentially viable sites in Basin 59. These sites would provide much more water than needed for the basin, but might present opportunities for regional or inter-regional supply options.

Increasing Reliance on Surface Water

Increased reliance on surface water supplies through direct diversion, without reservoir storage, will increase surface water gaps. Therefore, this water supply option is not recommended.

Increasing Reliance on Groundwater

Increased reliance on groundwater supplies could mitigate surface water gaps, but would increase the amount of groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water in storage in Basin 59's portion of the Rush Springs aquifer, the Canadian River aquifer, and the Ogallala aquifer. However, increases in localized depletions may occur and adversely impact users in the basin. A shift from surface water to alluvial groundwater could potentially decrease the size of surface water gaps, but may not decrease the probability of remaining surface water gaps due to the interconnection between the supply sources.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Glossary

Acre-foot: volume of water that would cover one acre of land to a depth of one foot; equivalent to 43,560 cubic feet or 325,851 gallons.

Alkalinity: measurement of the water's ability to neutralize acids. High alkalinity usually indicates the presence of carbonate, bicarbonates, or hydroxides. Waters that have high alkalinity values are often considered undesirable because of excessive hardness and high concentrations of sodium salts. Waters with low alkalinity have little capacity to buffer acidic inputs and are susceptible to acidification (low pH).

Alluvial aquifer: aquifer with porous media consisting of loose, unconsolidated sediments deposited by fluvial (river) or aeolian (wind) processes, typical of river beds, floodplains, dunes, and terraces.

Alluvial groundwater: water found in an alluvial aquifer.

Alluvium: sediments of clay, silt, gravel, or other unconsolidated material deposited over time by a flowing stream on its floodplain or delta; frequently associated with higher-lying terrace deposits of groundwater.

Appendix B areas: waters of the state into which discharges may be limited and that are located within the boundaries of areas listed in Appendix B of OWRB rules Chapter 45 on Oklahoma's Water Quality Standards (OWQS); including but not limited to National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges. Appendix B may include areas inhabited by federally listed threatened or endangered species and other appropriate areas.

Appropriative right: right acquired under the procedure provided by law to take a specific quantity of water by direct diversion from a stream, an impoundment thereon, or a playa lake, and to apply such water to a specific beneficial use or uses.

Aquifer: geologic unit or formation that contains sufficient saturated, permeable material to yield economically significant quantities of water to wells and springs.

Artificial recharge: any man-made process specifically designed for the primary purpose of increasing the amount of water entering into an aquifer.

Attainable uses: best uses achievable for a particular waterbody given water of adequate quality.

Background: ambient condition upstream or upgradient from a facility, practice, or activity that has not been affected by that facility, practice or activity.

Basin: see Surface water basin.

Basin outlet: the furthest downstream geographic point in an OCWP planning basin.

Bedrock aquifer: aquifer with porous media consisting of lithified (semi-consolidated or consolidated) sediments, such as limestone, sandstone, siltstone, or fractured crystalline rock.

Bedrock groundwater: water found in a bedrock aquifer.

Beneficial use: (1) The use of stream or groundwater when reasonable intelligence and diligence are exercised in its application for a lawful purpose and as is economically necessary for that purpose. Beneficial uses include but are not limited to municipal, industrial, agricultural, irrigation, recreation, fish and wildlife, etc., as defined in OWRB rules Chapter 20 on stream water use and Chapter 30 on groundwater use. (2) A classification in OWQS of the waters of the State, according to their best uses in the interest of the public set forth in OWRB rules Chapter 45 on OWQS.

Board: Oklahoma Water Resources Board.

Chlorophyll-a: primary photosynthetic plant pigment used in water quality analysis as a measure of algae growth.

Conductivity: a measure of the ability of water to pass electrical current. High specific conductance indicates high concentrations of dissolved solids.

Conjunctive management: water management approach that takes into account the interactions between groundwaters and surface waters and how those interactions may affect water availability.

Conservation: protection from loss and waste. Conservation of water may mean to save or store water for later use or to use water more efficiently.

Conservation pool: reservoir storage of water for the project's authorized purpose other than flood control.

Consumptive use: a use of water that diverts it from a water supply.

Cultural eutrophication: condition occurring in lakes and streams whereby normal processes of eutrophication are accelerated by human activities.

CWSRF: see State Revolving Fund (SRF).

Dam: any artificial barrier, together with appurtenant works, which does or may impound or divert water.

Degradation: any condition caused by the activities of humans resulting in the prolonged impairment of any constituent of an aquatic environment.

Demand: amount of water required to meet the needs of people, communities, industry, agriculture, and other users.

Demand forecast: estimate of expected water demands for a given planning horizon.

Demand management: adjusting use of water through temporary or permanent conservation measures to meet the water needs of a basin or region.

Demand sectors: distinct consumptive users of the state's waters. For OCWP analysis, seven demand sectors were identified: thermoelectric power, self-supplied residential, self-supplied industrial, oil and gas, municipal and industrial, livestock, and crop irrigation.

Dependable yield: the maximum amount of water a reservoir can dependably supply from storage during a drought of record.

Depletion: a condition that occurs when the amount of existing and future demand for groundwater exceeds available recharge.

Dissolved oxygen: amount of oxygen gas dissolved in a given volume of water at a particular temperature and pressure, often expressed as a concentration in parts of oxygen per million parts of water. Low levels of dissolved oxygen facilitate the release of nutrients from sediments.

Diversion: to take water from a stream or waterbody into a pipe, canal, or other conduit, either by pumping or gravity flow.

Domestic use: in relation to OWRB permitting, the use of water by a natural individual or by a family or household for household purposes, for farm and domestic animals up to the normal grazing capacity of the land whether or not the animals are actually owned by such natural individual or family, and for the irrigation of land not exceeding a total of three acres in area for the growing of gardens, orchards, and lawns. Domestic use also includes: (1) the use of water for agriculture purposes by natural individuals, (2) use of water for fire protection, and (3) use of water by non-household entities for drinking water purposes, restroom use, and the watering of lawns, provided that the amount of water used for any such purposes does not exceed five acre-feet per year.

Drainage area: total area above the discharge point drained by a receiving stream.

DWSRF: see State Revolving Fund (SRF).

Drought management: short-term measures to conserve water to sustain a basin's or region's needs during times of below normal rainfall.

Ecoregion (ecological region): an ecologically and geographically defined area; sometimes referred to as a bioregion.

Effluent: any fluid emitted by a source to a stream, reservoir, or basin, including a partially or completely treated waste fluid that is produced by and flows out of an industrial or wastewater treatment plant or sewer.

Elevation: elevation in feet in relation to mean sea level (MSL).

Equal proportionate share (EPS): portion of the maximum annual yield of water from a groundwater basin that is allocated to each acre of land overlying the basin or subbasin.

Eutrophic: a water quality characterization, or "trophic status," that indicates abundant nutrients and high rates of productivity in a lake, frequently resulting in oxygen depletion below the surface.

Eutrophication: the process whereby the condition of a waterbody changes from one of low biologic productivity and clear water to one of high productivity and water made turbid by the accelerated growth of algae.

Flood control pool: reservoir storage of excess runoff above the conservation pool storage capacity that is discharged at a regulated rate to reduce potential downstream flood damage.

Floodplain: the land adjacent to a body of water which has been or may be covered by flooding, including, but not limited to, the one-hundred year flood (the flood expected to be equaled or exceeded every 100 years on average).

Fresh water: water that has less than five thousand (5,000) parts per million total dissolved solids.

Gap: an anticipated shortage in supply of surface water due to a deficiency of physical water supply or the inability or failure to obtain necessary water rights.

Groundwater: fresh water under the surface of the earth regardless of the geologic structure in which it is standing or moving outside the cut bank of a definite stream.

Groundwater basin: a distinct underground body of water overlain by contiguous land having substantially the same geological and hydrological characteristics and yield capabilities. The area boundaries of a major or minor basin can be determined by political boundaries, geological, hydrological, or other reasonable physical boundaries.

Groundwater recharge: see Recharge.

Hardness: a measure of the mineral content of water. Water containing high concentrations (usually greater than 60 ppm) of iron, calcium, magnesium, and hydrogen ions is usually considered "hard water."

High Quality Waters (HQW): a designation in the OWQS referring to waters that exhibit water quality exceeding levels necessary to support the propagation of fishes, shellfishes, wildlife, and recreation in and on the water. This designation prohibits any new point source discharge or additional load or increased concentration of specified pollutants.

Hydraulic conductivity: the capacity of rock to transmit groundwater under pressure.

Hydrologic unit code: a numerical designation utilized by the United States Geologic Survey and other federal and state agencies as a way of identifying all drainage basins in the U.S. in a nested arrangement from largest to smallest, consisting of a multi-digit code that identifies each of the levels of classification within two-digit fields.

Hypereutrophic: a surface water quality characterization, or "trophic status," that indicates excessive primary productivity and excessive nutrient levels in a lake.

Impaired water: waterbody in which the quality fails to meet the standards prescribed for its beneficial uses.

Impoundment: body of water, such as a pond or lake, confined by a dam, dike, floodgate, or other barrier established to collect and store water.

Infiltration: the gradual downward flow of water from the surface of the earth into the subsurface.

Instream flow: a quantity of water to be set aside in a stream or river to ensure downstream environmental, social, and economic benefits are met (further defined in the OCWP *Instream Flow Issues & Recommendations* report).

Interbasin transfer: the physical conveyance of water from one basin to another.

Levee: a man-made structure, usually an earthen embankment, designed and constructed to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

Major groundwater basin: a distinct underground body of water overlain by contiguous land and having essentially the same geological and hydrological characteristics and from which groundwater wells yield at least fifty (50) gallons per minute on the average basinwide if from a bedrock aquifer, and at least one hundred fifty (150) gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the OWRB.

Marginal quality water: waters that have been historically unusable due to technological or economic issues associated with diversion, treatment, or conveyance.

Maximum annual yield (MAY): determination by the OWRB of the total amount of fresh groundwater that can be produced from each basin or subbasin allowing a minimum twenty-year life of such basin or subbasin.

Mesotrophic: a surface water quality characterization, or "trophic status," describing those lakes with moderate primary productivity and moderate nutrient levels.

Million gallons per day (mgd): a rate of flow equal to 1.54723 cubic feet per second or 3.0689 acre-feet per day.

Minor groundwater basin: a distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and which is not a major groundwater basin.

Nitrogen limited: in reference to water chemistry, where growth or amount of primary producers (e.g., algae) is restricted in a waterbody due in large part to available nitrogen.

Non-consumptive use: use of water in a manner that does not reduce the amount of supply, such as navigation, hydropower production, protection of habitat for hunting, maintaining water levels for boating recreation, or maintaining flow, level and/or temperature for fishing, swimming, habitat, etc.

Nonpoint source (NPS): a source of pollution without a well-defined point of origin. Nonpoint source pollution is commonly caused by sediment, nutrients, and organic or toxic substances originating from land use activities. It occurs when the rate of material entering a waterbody exceeds its natural level.

Normal pool elevation: the target lake elevation at which a reservoir was designed to impound water to create a dependable water supply; sometimes referred to as the top of the conservation pool.

Normal pool storage: volume of water held in a reservoir when it is at normal pool elevation.

Numerical criteria: concentrations or other quantitative measures of chemical, physical or biological parameters that are assigned to protect the beneficial use of a waterbody.

Numerical standard: the most stringent of the OWQS numerical criteria assigned to the beneficial uses for a given stream.

Nutrient-impaired reservoir: reservoir with a beneficial use or uses impaired by human-induced eutrophication as determined by a Nutrient-Limited Watershed Impairment Study.

Nutrient-Limited Watershed (NLW): watershed of a waterbody with a designated beneficial use that is adversely affected by excess nutrients as determined by a Carlson's Trophic State Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of the OWQS.

Nutrients: elements or compounds essential as raw materials for an organism's growth and development; these include carbon, oxygen, nitrogen, and phosphorus.

Oklahoma Water Quality Standards (OWQS): rules promulgated by the OWRB in Oklahoma Administrative Code Title 785, Chapter 45, which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.

Oligotrophic: a surface water quality characterization, or "trophic status," describing those lakes with low primary productivity and/or low nutrient levels.

Outfall: a point source that contains the effluent being discharged to the receiving water.

Percolation: the movement of water through unsaturated subsurface soil layers, usually continuing downward to the groundwater or water table (distinguished from Seepage).

Permit availability: the amount of water that could be made available for withdrawals under permits issued in accordance with Oklahoma water law.

pH: the measurement of the hydrogen-ion concentration in water. A pH below 7 is acidic (the lower the number, the more acidic the water, with a decrease of one full unit representing an increase in acidity of ten times) and a pH above 7 (to a maximum of 14) is basic (the higher the number, the more basic the water). In Oklahoma, fresh waters typically exhibit a pH range from 5.5 in the southeast to almost 9.0 in central areas.

Phosphorus limited: in reference to water chemistry, where growth or amount of primary producers (e.g., algae) is restricted in a waterbody due in large part to the amount of available phosphorus.

Physical water availability: amount of water currently in streams, rivers, lakes, reservoirs, and aquifers; sometimes referred to as "wet water."

Point source: any discernible, confined and discrete conveyance, including any pipe, ditch, channel, tunnel, well, discrete fissure, container, rolling stock or concentrated animal feeding operation from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture.

Potable: describing water suitable for drinking.

Primary Body Contact Recreation (PBCR): a classification in OWQS of a waterbody's use; involves direct body contact with the water where a possibility of ingestion exists. In these cases, the water shall not contain chemical, physical or biological substances in concentrations that irritate the skin or sense organs or are toxic or cause illness upon ingestion by human beings.

Primary productivity: the production of chemical energy in organic compounds by living organisms. In lakes and streams, this is essentially the lowest denominator of the food chain (phytoplankton) bringing energy into the system via photosynthesis.

Prior groundwater right: comparable to a permit, a right to use groundwater recognized by the OWRB as having been established by compliance with state groundwater laws in effect prior to 1973.

Provider: private or public entity that supplies water to end users or other providers. For OCWP analyses, "public water providers" included approximately 785 non-profit, local governmental municipal or community water systems and rural water districts.

Recharge: the inflow of water to an alluvial or bedrock aquifer.

Reservoir: a surface depression containing water impounded by a dam.

Return water or return flow: the portion of water diverted from a water supply that returns to a watercourse.

Reverse osmosis: a process that removes salts and other substances from water. Pressure is placed on the stronger of two unequal concentrations separated by a semi-permeable membrane; a common method of desalination.

Riparian water right (riparian right): the right of an owner of land adjoining a stream or watercourse to use water from that stream for reasonable purposes.

Riverine: relating to, formed by, or resembling a river (including tributaries), stream, etc.

Salinity: the concentration of salt in water measured in milligrams per liter (mg/L) or parts per million (ppm).

Salt water: any water containing more than five thousand (5,000) parts per million total dissolved solids.

Saturated thickness: thickness below the zone of the water table in which the interstices are filled with groundwater.

Scenic Rivers: streams in "Scenic River" areas designated by the Oklahoma Legislature that possess unique natural scenic beauty, water conservation, fish, wildlife and outdoor recreational values. These areas are listed and described in Title 82 of Oklahoma Statutes, Section 1451.

Sediment: particles transported and deposited by water deriving from rocks, soil, or biological material.

Seepage: the movement of water through saturated material often indicated by the appearance or disappearance of water at the ground surface, as in the loss of water from a reservoir through an earthen dam (distinguished from Percolation).

Sensitive sole source groundwater basin or subbasin: a major groundwater basin or subbasin all or a portion of which has been designated by the U.S. Environmental Protection Agency (EPA) as a "Sole Source Aquifer" and serves as a mechanism to protect drinking water supplies in areas with limited water supply alternatives. It includes any portion of a contiguous aquifer located within five miles of the known areal extent of the surface outcrop of the designated groundwater basin or subbasin.

Sensitive Water Supplies (SWS): designation that applies to public and private water supplies possessing conditions that make them more susceptible to pollution events. This designation restricts point source discharges in the watershed and institutes a 10 μg/L (micrograms per liter) chlorophyll-a criterion to protect against taste and odor problems and reduce water treatment costs.

Soft water: water that contains little to no magnesium or calcium salts.

State Revolving Fund (SRF): fund or program used to provide loans to eligible entities for qualified projects in accordance with Federal law, rules and guidelines administered by the EPA and state. Two separate SRF programs are administered in Oklahoma: the Clean Water SRF is intended to control water pollution and is administered by OWRB; the Drinking Water SRF was created to provide safe drinking water and is administered jointly by the OWRB and ODEQ.

Storm sewer: a sewer specifically designed to control and convey stormwater, surface runoff, and related drainage.

Stream system: drainage area of a watercourse or series of watercourses that converges in a large watercourse with defined boundaries.

Stream water: water in a definite stream that includes water in ponds, lakes, reservoirs, and playa lakes.

Streamflow: the rate of water discharged from a source indicated in volume with respect to time.

Surface water: water in streams and waterbodies as well as diffused over the land surface.

Surface water basin: geographic area drained by a single stream system. For OCWP analysis, Oklahoma has been divided into 82 surface water basins (also referenced as "planning basins").

Temporary permit: for groundwater basins or subbasins for which a maximum annual yield has not been determined, temporary permits are granted to users allocating two acre-feet of water per acre of land per year. Temporary permits are for one-year terms that can be revalidated annually by the permittee. When the maximum annual yield and equal proportionate share are approved by the OWRB, all temporary permits overlying the studied basin are converted to regular permits at the new approved allocation amount.

Terrace deposits: fluvial or wind-blown deposits occurring along the margin and above the level of a body of water and representing the former floodplain of a stream or river.

Total dissolved solids (TDS): a measure of the amount of dissolved material in the water column, reported in mg/L, with values in fresh water naturally ranging from 0-1000 mg/L. High concentrations of TDS limit the suitability of water as a drinking and livestock watering source as well as irrigation supply.

Total maximum daily load (TMDL): sum of individual wasteload allocations for point sources, safety reserves, and loads from nonpoint source and natural backgrounds.

Total nitrogen: for water quality analysis, a measure of all forms of nitrogen (organic and inorganic). Excess nitrogen can lead to harmful algae blooms, hypoxia, and declines in wildlife and habitat.

Total phosphorus: for water quality analysis, a measure of all forms of phosphorus, often used as an indicator of eutrophication and excessive productivity.

Transmissivity: measure of how much water can be transmitted horizontally through an aquifer. Transmissivity is the product of hydraulic conductivity of the rock and saturated thickness of the aquifer.

Tributary: stream or other body of water, surface or underground, that contributes to another larger stream or body of water.

Trophic State Index (TSI): one of the most commonly used measurements to compare lake trophic status, based on algal biomass. Carlson's TSI uses chlorophyll-a concentrations to define the level of eutrophication on a scale of 1 to 100, thus indicating the general biological condition of the waterbody.

Trophic status: a lake's trophic state, essentially a measure of its biological productivity. The various trophic status levels (Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic) provide a relative measure of overall water quality conditions in a lake.

Turbidity: a combination of suspended and colloidal materials (e.g., silt, clay, or plankton) that reduce the transmission of light through scattering or absorption. Turbidity values are generally reported in Nephelometric Turbidity Units (NTUs).

Vested stream water right (vested right): comparable to a permit, a right to use stream water recognized by the OWRB as having been established by compliance with state stream water laws in effect prior to 1963.

Waste by depletion: unauthorized use of wells or groundwater; drilling a well, taking, or using fresh groundwater without a permit, except for domestic use; taking more fresh groundwater than is authorized by permit; taking or using fresh groundwater so that the water is lost for beneficial use; transporting fresh groundwater from a well to the place of use in such a manner that there is an excessive loss in transit; allowing fresh groundwater to reach a pervious stratum and be lost into cavernous or otherwise pervious materials encountered in a well; drilling wells and producing fresh groundwater there from except in accordance with well spacing requirements; or using fresh groundwater for air conditioning or cooling purposes without providing facilities to aerate and reuse such water.

Waste by pollution: permitting or causing the pollution of a fresh water strata or basin through any act that will permit fresh groundwater polluted by minerals or other waste to filter or intrude into a basin or subbasin, or failure to properly plug abandoned fresh water wells.

Water quality: physical, chemical, and biological characteristics of water that determine diversity, stability, and productivity of the climax biotic community or affect human health.

Water right: right to the use of stream or groundwater for beneficial use reflected by permits or vested rights for stream water or permits or prior rights for groundwater.

Wastewater reuse: treated municipal and industrial wastewater captured and reused commonly for non-potable irrigation and industrial applications to reduce demand upon potable water systems.

Water supply: a body of water, whether static or moving on or under the surface of the ground, or in a man-made reservoir, available for beneficial use on a dependable basis.

Water supply availability: for OCWP analysis, the consideration of whether or not water is available that meets three necessary requirements: physical water is present, the water is of a usable quality, and a water right or permit to use the water has been or can be obtained.

Water supply options: alternatives that a basin or region may implement to meet changing water demands. For OCWP analysis, "primary options" include demand management, use of out-of-basin supplies, reservoir use, increasing reliance on surface water, and increasing reliance on groundwater; "expanded options" include expanding conservation measures, artificial aquifer recharge, use of marginal quality water sources, and potential reservoir development.

Water table: The upper surface of a zone of saturation; the upper surface of the groundwater.

Waterbody: any specified segment or body of waters of the state, including but not limited to an entire stream or lake or a portion thereof.

Watercourse: the channel or area that conveys a flow of water.

Waters of the state: all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state.

Watershed: the boundaries of a drainage area of a watercourse or series of watercourses that diverge above a designated location or diversion point determined by the OWRB.

Well: any type of excavation for the purpose of obtaining groundwater or to monitor or observe conditions under the surface of the earth; does not include oil and gas wells.

Well yield: amount of water that a water supply well can produce (usually in gpm), which generally depends on the geologic formation and well construction.

Wholesale: for purposes of OCWP Public Water Provider analyses, water sold from one public water provider to another.

Withdrawal: water removed from a supply source.

AF: acre-foot or acre-feet

AFD: acre-feet per day

AFY: acre-feet per year

BMPs: best management practices

BOD: biochemical oxygen demand

cfs: cubic feet per second

CWAC: Cool Water Aquatic Community

CWSRF: Clean Water State Revolving Fund

DO: dissolved oxygen

DWSRF: Drinking Water State Revolving Fund

EPS: equal proportionate share

FACT: Funding Agency Coordinating Team

gpm: gallons per minute

HLAC: Habitat Limited Aquatic Community

HQW: High Quality Waters

HUC: hydrologic unit code

M&I: municipal and industrial

MAY: maximum annual yield

mgd: million gallons per day

µS/cm: microsiemens per centimeter (see specific conductivity)

mg/L: milligrams per liter

NLW: nutrient-limited watershed

NPS: nonpoint source

NPDES: National Pollutant Discharge Elimination System

NRCS: Natural Resources Conservation Service

NTU: Nephelometric Turbidity Unit (see "Turbidity")

OCWP: Oklahoma Comprehensive Water Plan

ODEQ: Oklahoma Department of Environmental Quality

O&G: Oil and Gas

ORW: Outstanding Resource Water

OWQS: Oklahoma Water Quality Standards

OWRB: Oklahoma Water Resources Board

PBCR: Primary Body Contact Recreation

pH: hydrogen ion activity

ppm: parts per million

RD: Rural Development

REAP: Rural Economic Action Plan

SBCR: Secondary Body Contact Recreation

SDWIS: Safe Drinking Water Information System

SRF: State Revolving Fund

SSI: Self-Supplied Industrial

SSR: Self-Supplied Residential

SWS: Sensitive Water Supply

TDS: total dissolved solids

TMDL: total maximum daily load

TSI: Trophic State Index

TSS: total suspended solids

USACE: United States Army Corps of Engineers

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

WLA: wasteload allocation

WWAC: Warm Water Aquatic Community

Water Quantity Conversion Factors

Initial Unit \ Desired Unit	CFS	GPM	MGD	AFY	AFD
CFS	—	450	.646	724	1.98
GPM	.00222	—	.00144	1.61	.00442
MGD	1.55	695	—	1120	3.07
AFY	.0014	.62	.00089	—	.00274
AFD	.504	226	.326	365	—

EXAMPLE: Converting from MGD to CFS. To convert from an initial value of 140 MGD to CFS, multiply 140 times 1.55 to come up with the desired conversion, which would be 217 CFS (140 X 1.55 = 217).

CFS: cubic feet per second
GPM: gallons per minute
MGD: millions gallons per day
AFY: acre-feet per year
AFD: acre-feet per day
1 acre-foot: 325,851 gallons

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