FINAL

Alternatives for Sustainability of Crop Irrigation in the East Arkansas Water Resources Planning Region

Arkansas Natural Resources Commission
Arkansas Water Plan Update

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Acronyms

AF	acre-feet
AFY	acre-feet per year
ANRC	Arkansas Natural Resources Commission
AWP	Arkansas Water Plan
East Arkansas Region	East Arkansas Water Resources Planning Region
EIB	Economic Information Bulletin
FRIS	Farm and Ranch Irrigation Survey
gpm	gallons per minute
MAF	million acre-feet
NASS	National Agricultural Statistics Service
NRCS	Natural Resources Conservation Service
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture

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Section 1

Background

The alternatives for sustainability of crop irrigation in eastern Arkansas were developed in response to the decline in groundwater levels over the last several decades. Through state water policy, Arkansas has long advocated the concept of conservation, education, and the conjunctive use of sustainable groundwater and excess surface water. A "no action" alternative is not considered viable for Arkansas, but was included in this report because it provides valuable information as to the harmful results of such an approach. The two other alternatives, conservation and conversion to surface water, are appropriate to meet the future water use goals of Arkansas.

1.1 Arkansas Groundwater Protection Strategy

Arkansas groundwater protection and management policy has long advocated the wise use of groundwater, and conservation, recognizing the holistic view of the water resources system, including stream recharge from groundwater. The policy of sustainable pumping is foremost in groundwater protection. Sustainable pumping maintains 50 percent saturated thickness or a 30-foot minimum saturated thickness and identifies the maximum drawdown available from the aquifer for agricultural purposes. It must be noted that aquifer drawdown causes adverse impacts to water users and the aquifer system itself, well before water levels reach the 30-foot minimum level.

The Arkansas goal of a sustainable yield pumping strategy has great merit for the state. However, in the future, the agricultural economy of eastern Arkansas will rely more and more on the development of excess surface water. Arkansas currently uses the equivalent of only about 9 percent of the water that falls on land surface as precipitation. In fact, eastern Arkansas water users do not have the available water use facilities and capability to use more than a small amount of the state's excess surface water.

Arkansas water policy has evolved in response to significant groundwater level declines observed in the eastern Arkansas alluvial plain and southern Arkansas Gulf Coastal Plain region. Water law has been developed by working closely with Arkansas water users and with a strong underlying desire to reach the necessary goals of a sustainable yield by voluntary, incentive-based methods.

The previous versions of the Arkansas Water Plan (AWP) (1975 and 1990) advocated conservation, education, and the development of excess surface water as the primary means of groundwater protection in the state. In February of 1991, the Arkansas Ground Water Protection and Management Act was signed into law. This law provided the Arkansas Soil and Water Conservation Commission, now the Arkansas Natural Resources Commission (ANRC), with authority to designate critical groundwater areas. To achieve a sustainable yield pumping rate from groundwater in Arkansas, excess surface water must be utilized to meet demands. Without this surplus water, the only option identified by groundwater flow modeling (Czarnecki 2008) is to voluntarily reduce, or restrict, pumping from an estimated 25,000 of the 49,558 registered irrigation wells in eastern Arkansas, as described in Alternative 1.

The AWP from 1990 has guided water policy toward conservation, education, and the use of excess surface water in a conjunctive use pumping strategy with a goal of meeting water needs without adversely impacting instream flow or the sustainable yield of groundwater. It must be noted that the implementation of this policy, especially with respect to the use of excess surface water, has progressed quite slowly. Therefore, the withdrawal of groundwater remains at a rate that is not sustainable and water levels continue to decline at a critical rate throughout much of the state. Union County has succeeded in using excess surface water in place of groundwater and has seen water levels in the Sparta aquifer recover, which is demonstrable proof that this policy is extremely successful. However, this water use strategy has not yet been fully implemented in other parts of Arkansas.

Historically, the ANRC has been an advocate of voluntary conservation programs as a proper response to water resources depletion issues. At the February 18, 1999 meeting of the ANRC, Commissioner Neal Anderson of Lonoke made a motion for a unanimous vote by the ANRC to "encourage continued voluntary conservation efforts pursuant to the AWP and the Arkansas Ground Water Protection and Management Act, and opposes any efforts to enhance the regulatory powers available to it under the Ground Water Protection and Management Act." The motion passed as stated and was termed Resolution 99-2. In so doing, the ANRC established precedent of opposing water use allocation, and indirectly, of support for the policy of development of excess surface water to meet water needs. This action emphasized the ANRC commitment made to individuals in the agricultural areas of the state, that it would not invoke water use regulation, but would continue to support conservation, education, and the use of excess surface water to reach our state's water resources goals.

As Arkansas water resources policy and law continue to develop, important issues must be considered. These issues will work to the benefit of Arkansas if they are framed with good science and knowledge of the complex hydrology of this state. Any effective water policy will continue to recognize and build on the process of the AWP, relying on conservation, education, and the conjunctive use of groundwater and excess surface water, both within sustainable levels that protect all water users and water use needs. Future water policy in Arkansas must recognize that the state's aquifers are still being pumped at a rate that is above sustainable levels. Current groundwater use trends rely on stream capture late during the irrigation season when base flow to streams is extremely vulnerable with respect to instream flow needs. The 1990 AWP advocated the use of excess surface water, which would provide alternate agricultural water supply during the "wet season" when Arkansas has a great abundance of surface water flow through its stream channels and over its floodplains. During such periods of high flow, surface water is available for capture and on-farm storage, therefore protecting the instream flow needs during the more vulnerable times of the year. Alternative 3 in this report analyzes the costs of implementing the conjunctive use of surface water and groundwater.

In the absence of such alternative water supply, agricultural practices will have to adapt to reduced groundwater availability. In areas of the most significant groundwater decline, litigation between water users is expected to occur. At some point in the future, there may be increased interest in a legislated solution, such as state changing the definition of excess surface water or issuance of permits for groundwater use.

1.2 Critical Groundwater Areas

On February 20, 1991, the General Assembly of the State of Arkansas enacted the Arkansas Groundwater Protection and Management Act (Arkansas Code sec. 15-22-901 et seq.). This Act provided the ANRC with additional groundwater protection and management authority to designate critical groundwater use areas, establish the authority for withdrawals, establish groundwater rights, set fees, and provide a mechanism for local groundwater management. As a result of this action, the ANRC began updating the AWP on a yearly basis focusing on groundwater protection concerns. This is accomplished through annual data collection and analysis from a statewide monitoring network of approximately 1,200 wells. This information is presented in an annual report and includes recommendations to the ANRC concerning critical groundwater areas.

Critical groundwater area criteria are evaluated by ANRC staff each year to determine if water levels are declining or if water quality is becoming degraded. The specific criteria include water levels declining at a rate of one foot per year or more, water levels declining to below the top of the formation (below 50 percent saturated thickness for an unconfined aquifer), and water quality becoming degraded. These criteria were selected by a group of geologists and hydrologists in Arkansas who had extensive background working with groundwater programs. Agencies represented included the ANRC, Arkansas Geological Survey, Arkansas Department of Environmental Quality, Arkansas Department of Health, and the U.S. Geological Survey. Each criterion was selected based on observation of hydrologic trends in areas where cones of depression had developed, and a long-term history of water level declines. Other factors considered are groundwater flow model projections and the safe yield of the aquifer.

Once a critical area designation is recommended, the ANRC conducts public hearings in accordance with the Administrative Procedure Act. These hearings are held in each critical area county, and where requested by interested parties. Comments are taken in oral or written form and evaluated by the staff. After consideration or these comments, the ANRC decides on whether or not it is appropriate to designate the proposed area as critical. Once in place, the ANRC is able to focus resources in the critical area and provide greater protection and management of the resource. Critical area designation is a positive step toward groundwater protection, which emphasizes prevention and a coordinated effort focusing on conservation and education programs. Groundwater modeling efforts are enhanced, and additional monitoring is conducted.

Regulation is not automatic with critical area designation. This is a separate process requiring another round of analysis, reporting, and public hearings. The ANRC has always hoped to protect our state's valuable groundwater resources through conservation programs and the development of excess surface water to sustain future water use needs.

Since enactment of the Arkansas Groundwater Protection and Management Act, the ANRC has designated three critical groundwater areas in Arkansas. The first critical groundwater area was delineated in 1996, in a five county area in South Arkansas, for the Sparta Sand formation. The second area was designated in 1998 for a six county area surrounding the Grand Prairie in East-Central Arkansas for the alluvial and Sparta Sand formations, and the latest critical area was designated in 2009 for the Cache area west of Crowley's Ridge for both the alluvial and Sparta/Memphis aquifers. The designation of a critical groundwater area allows federal, state, and local groups to work together in providing a managed and protected resource for current and future water users by focusing on conservation and education. Critical area designation also allows state and federal agencies to focus on cost share and tax incentives for conservation projects within those areas. Critical area designation does not involve regulation of water use or well drilling. It is a proactive action, which focuses on the prevention and mitigation of problems associated with groundwater level declines and groundwater quality degradation. The most effective tools, which the state is currently using, are education programs, conservation tax incentives, and the development of alternative surface water supplies and a conjunctive use strategy.

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Section 2

Introduction and Summary Findings

2.1 Introduction

Under Arkansas state law, the ANRC is responsible for preparing and periodically updating a statewide water resources planning document. The previous update of the AWP was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP to be completed in 2014. The update to the AWP involves several major steps including the quantification of current and future demands (Water Demand Forecast Report, AWP Appendix E) and water availability (Water Availability Report, AWP Appendix C) and the gaps between them (Gap Analysis Report, AWP Appendix F). The Gap Analysis Report quantifies projected gaps between water availability and water demand. The Gap Analysis Report projects a significant groundwater gap in 2050 in the East Arkansas Water Resources Planning Region (East Arkansas Region) that is a significant shortfall between the projected groundwater needs and sustainable groundwater supply.

While the best available information and consistent methodology was used in developing the AWP, projections into the future require many assumptions and result in inherent uncertainty. While this is necessary and appropriate for statewide planning-level analyses, additional, more detailed feasibility- and design-level studies are required for regional and local scale projects. In particular, within the East Arkansas Region, a more detailed analysis of water availability and crop irrigation demands within the major basins is particularly important. This is especially true in northeast Arkansas (for example in the St. Francis River Basin) where regional stakeholders have identified issues with projected crop acreage and historical water use reporting that may be artificially increasing projected crop irrigation water requirements. Also, concerns regarding a lower than expected projected availability of groundwater in the region have been documented. Recognizing areas where there is a lack of reliable and verifiable data is an important goal of the AWP. However, data issues aside, there is no disputing that portions of the East Arkansas Region will have a significant groundwater gap if alternative strategies for supply and demand management are not implemented.

Input received during the Issues and Recommendations Working Group Meetings held from January through March of 2014 resulted in the identification of a need to evaluate, on a reconnaissance level, potential alternatives to address the groundwater gap in the East Arkansas Region. This report presents an analysis of no action and of two alternative management strategies for addressing the water supply gaps and the estimated range of potential benefits of their implementation from a water supply standpoint.

- **Alternative 1: No Action** – Develops an estimate of the impact to agriculture in the East Arkansas Region should no action be taken to meet the groundwater gap. While a "No Action" alternative is not realistic, it is included in this analysis as a baseline for comparison to other actionable alternatives. In fact, many solutions are currently being implemented across the state that positively contributes to sustaining Arkansas's water resources and their associated economic benefits.

- **Alternative 2: Irrigation Conservation Measures** – Presents potential conservation measures that have been used both in Arkansas and elsewhere, the range of water savings that have been achieved, and the potential range of impacts on the identified gap achievable by conservation.
- **Alternative 3: Surface Water Infrastructure for Irrigated Agriculture** – Presents a reconnaissance level range of costs to implement a combination of on-farm surface water infrastructure and imported surface water from mainstem diversions to irrigated cropland to address the gap.

2.2 Summary Findings

As noted above, the purpose of this report is to evaluate three alternatives for maintaining sustainability by addressing the groundwater supply gap identified in the Gap Analysis Report (AWP Appendix F). The following is a summary of the findings developed within this report.

2.2.1 Alternative 1: No Action

The Gap Analysis Report projects a 2050 gap in groundwater supply of approximately 7,260,000 acre-feet per year (AFY) for the East Arkansas Region. The No Action Alternative assumes no changes in groundwater water supply demands. The No Action Alternative results in a 2050 supply shortfall equivalent to the projected groundwater gap: 7,260,000 AFY. If this gap is not addressed by conservation and surface water supply projects, approximately 3,800,000 acres of existing and projected farm acreage will have inadequate water supply.

2.2.2 Alternative 2: Irrigation Conservation Measures

Potential water savings for crop irrigation from conservation measures were developed based upon reasonable projections of increased irrigation efficiency. This analysis suggests that there could be a reduction of 12 to 22 percent in 2050 groundwater demand, resulting in water savings of 1,360,000 to 2,450,000 AFY. This would shrink the projected 2050 groundwater gaps by 34 to 19 percent. Fortunately, farmers are installing water conservation practices. The AWP update recommends increased incentives to accelerate and increase adoption rates.

2.2.3 Alternative 3: Surface Water Infrastructure for Irrigated Agriculture

The conversion from groundwater to surface water irrigation represents the greatest potential to address the projected 2050 groundwater supply gap. Conversion to surface water irrigation is assumed to include small scale on-farm tail water recovery/rain water capture and large, regional projects such as the Grand Prairie Area Demonstration Project or Bayou Meto Water Management Project that import surface water to individual farms. To close the 2050 groundwater gap in the East Arkansas Region, approximately 3,800,000 acres would have to be converted from groundwater to surface water if **no** other measures are employed.

There is sufficient excess surface water on an average annual basis within the East Arkansas Region to close the groundwater gap. However, at the major basin scale, there are some basins that do not have sufficient surface water to balance the groundwater demand. For these major basins, inter-basin transfers from areas with surplus surface water will be required to eliminate the projected 2050 groundwater gap completely.

The reconnaissance-level range of costs to convert to surface water supplies (either on-farm or water imported from a river) to close the 2050 groundwater supply gap, exclusive of any other measures, could entail a capital expenditure in the range of $3.4 to $7.8 billion in 2014 dollars.

It should also be noted that approximately 15 percent of this acreage conversion is underway through the Grand Prairie Area Demonstration Project and Bayou Meto Water Management Project. These are some of the proactive steps that have been taken by water resource managers within the state.

To provide a context in which to view the cost of conversion to surface water, the contribution of agriculture to the Arkansas economy should be highlighted. Based on the 2012 Census of Agriculture for Arkansas, the market value of all harvested irrigated cropland was $2 billion. The total farm production expenses for irrigated cropland were $1.3 billion, which represents income for farm suppliers, labor, and related industries. These figures do not include the economic impact of the "supply chain" going into the farm, or the "post-production" agricultural economy (grain mills, shipping, food processors, etc.).

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Section 3

Alternative 1: No Action

Alternative 1, No Action is an analysis of the impacts of doing nothing to address the projected year 2050 Groundwater Supply Gap for the East Arkansas Region. The Gap Analysis Report (AWP Appendix F) identified a 2050 gap, or shortfall, between supply and demand for groundwater in the East Arkansas Region of 7,260,000 AFY. This section of the Alternatives Analysis defines the projected impact on irrigated acreage that would result from not pursuing measures to address this supply shortfall. It is recognized that this assumption is inherently unrealistic, as farmers are taking action to conserve water. The purpose of looking at the consequences of "No Action" is to show the extent of the production loss if we do not continue these positive efforts.

3.1 Current Conditions

The regions for the AWP are shown below on **Figure 3-1**. The East Arkansas Region includes all, or portions, of seven major river basins. It encompasses approximately the eastern one-fourth of the state; however, the region accounts for 92 percent of the state's agricultural acreage. There are currently approximately 4.6 million acres under irrigation in the East Arkansas Region with approximately 4 million of those acres irrigated by groundwater. The AWP Water Demand Forecast Report (AWP Appendix E) estimates that by 2050 the East Arkansas Region's agricultural acreage will be roughly 5.4 million acres. The AWP has estimated a groundwater supply gap of approximately 7,260,000 AFY in the year 2050; that is, the demand for groundwater as an irrigation source will exceed the sustainable supply by 7,260,000 AFY. If no action is taken to address this shortfall, there will be insufficient groundwater to irrigate some lands currently under irrigation and all those projected to be developed between now and 2050. The following section estimates that acreage for which there will be insufficient groundwater for irrigation if no action is taken. Note that this is a calculation of acreage and does not indicate or suggest where this acreage would be located in the East Arkansas Region.

3.2 Analysis of Acreage Impacted by No Action

In order to appreciate the impact of the supply gap on current and future agricultural activity in the East Arkansas Region, it is necessary to convert the water supply shortage from water supply to equivalent acres impacted. Average crop irrigation application rates (acre-feet [AF] per acre) were estimated for each major basin based on the previously determined county-based application rates from the AWP Water Demand Forecast Report (AWP Appendix E).

A key assumption in the AWP Water Demand Forecast Report (see Section 11.4) is that most farms in Arkansas are efficient in their water application rates; apply water when crops need it, and in the amounts that they need for plant growth requirements. In other words, none of the pumped or applied water returns to a stream or aquifer. This assumption, which was based on literature review and discussions with irrigators, means that application rates represent the consumptive use of water. The application rates were used to assess the irrigation water demand.

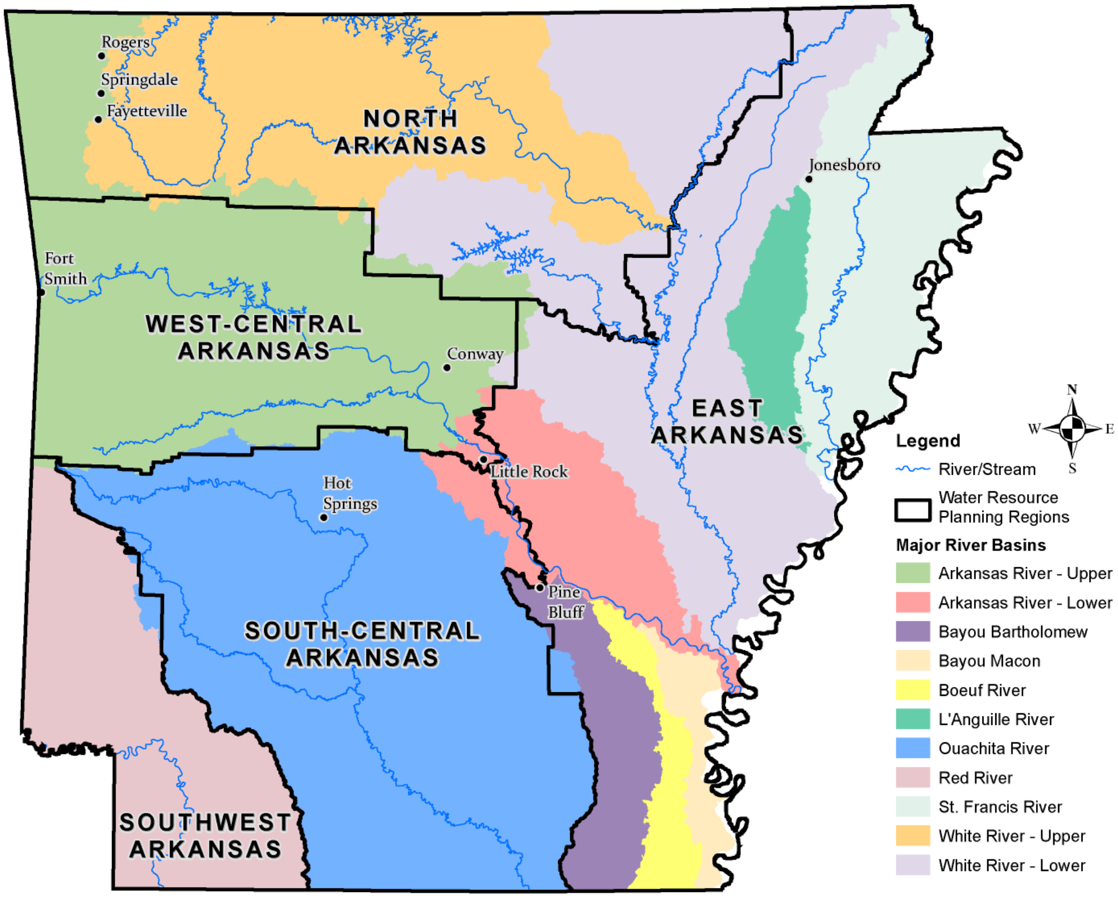

Figure 3-1. Water Resource Planning Regions and Major River Basins of the Arkansas Water Plan

The groundwater gap was estimated from the imbalance between projected supply and demand as described in the AWP Gap Analysis Report (AWP Appendix F). The application rates were then divided into the projected 2050 groundwater gap (AF) to produce the number of acres that could not be irrigated due to a reduced supply of groundwater. The results of this analysis, on a per-basin and total acreage basis, are presented below in **Table 3-1** (Table 3-1 is representative of the East Arkansas Region only). This analysis assumes that the Grand Prairie Area Demonstration Project and Bayou Meto Water Management Project are not implemented. When implemented, approximately 15 percent of the estimated acreage without groundwater would be supplied by imported surface water.

If no action is taken to address the groundwater supply gap, over 80 percent of the acreage, or 3.8 million acres, projected for irrigation in the East Arkansas Region will be without irrigation in 2050. Considering that approximately 4 million acres in the region are currently irrigated by groundwater and the projected acreage for groundwater irrigation is 4.8 million acres, the majority of acres without irrigation (3 million acres) in 2050 will be acreage that is currently irrigated. In effect, if no action is taken, irrigated acreage in 2050 will be reduced to approximately 1.6 million acres or 30 percent of total current irrigated acreage (Table 3-1).

Table 3-1. Summary of Projected Impacts to Groundwater Irrigated Acres in the East Arkansas Region Under No Action Alternative

Major Surface Water Basins	Projected Total 2050 Irrigated Acres	Projected 2050 Irrigated Acres - Groundwater	Projected 2050 Groundwater Gap (AF)	Average Irrigation Application Rate (in.)	Average Irrigation Application Rate (AF/acre)	If no action taken, Reduction in Groundwater Irrigated Acres	If no action taken, % Reduction in Groundwater Irrigated Acres	If no action taken, Remaining Groundwater Irrigated Acres	If no action taken, % Remaining Groundwater Irrigated Acres
Arkansas River - Lower	500,589	351,908	595,150	25.4	2.1	281,095	80%	70,812	20%
Arkansas River - Upper	2,602	1,508	21	24.9	2.1	10	1%	1,498	99%
Bayou Bartholomew	235,381	203,422	143,820	20.0	1.7	86,221	42%	117,200	58%
Bayou Macon	226,579	172,773	278,741	21.4	1.8	156,596	91%	16,177	9%
Boeuf River	246,571	192,373	317,880	20.4	1.7	187,106	97%	5,267	3%
L'Anguille River[1]	399,714	371,467	926,718	26.8	2.2	414,652	112%	-43,185	-12%
Ouachita River	21,119	18,672	114	21.5	1.8	64	0%	18,608	100%
St. Francis River	1,651,781	1,585,872	1,897,109	21.7	1.8	1,049,126	66%	536,746	34%
White River - Lower	2,134,331	1,866,034	3,100,257	23.0	1.9	1,615,765	87%	250,269	13%
Total	**5,418,669**	**4,764,029**	**7,259,810**	**22.8**	**1.9**	**3,790,635**	**80%**	**973,394**	**20%**

[1] Some percentages may be slightly larger than 100% (or less than 0%) due to area-weighting procedure utilized to convert county level irrigated acreages to the major basin level

It is apparent that a No Action Alternative will result in significant impact to the agricultural sector of the Arkansas economy. **Table 3-2** shows the contribution of agriculture to the Arkansas economy. Based on the 2012 Census of Agriculture for Arkansas, the market value of all harvested irrigated cropland was $2 billion. The total farm production expenses for irrigated cropland were $1.3 billion, which represents income for farm suppliers, labor, and related industries. These figures do not include the economic impact of the "supply chain" going into the farm, or the "post-production" agricultural economy (grain mills, shipping, slaughter houses, food processors, etc.).

Table 3-2. Market Value of Agricultural Products on Arkansas Farms

	All Farms	Non-irrigated Farms	Any Land Irrigated	All Harvested Cropland Irrigated
Number of Farms	45,071	39,987	5,084	2,324
Acres	13,810,786	7,366,731	6,444,055	2,487,520
Irrigated Acres	4,803,902	-	4,803,902	2,337,808
Harvested Cropland	7,316,469	1,423,836	5,892,633	2,336,259
Market Value of Ag Products ($million)	$9,775.758	$4,971.073	$4,804.685	$2,018.349
Average Per Farm	$216,897	$124,317	$945,060	$868,481
Total Farm Production Expenses ($million)	$7,701.266	$4,520.945	$3,180.321	$1,329.250
Average Per Farm	$ 170,870	$ 113,060	$ 625,555	$ 571,966

Source: 2012 Census of Agriculture, Arkansas - Table 11.

It should be recognized that farmers and other Arkansas water resource managers have noted the potential impact of no action and have taken proactive steps in the form of several projects planned, partially funded, and/or implemented to address the groundwater gap. These projects – the Grand Prairie Area Demonstration Project, the Plum Bayou project, the Bayou Meto Water Management Project, the Point Remove Wetland Reclamation and Irrigation Project, and the Little Red River Irrigation District Agricultural Water Enhancement Program Project – will reduce the projected groundwater gap by approximately 15 percent and are discussed in Alternative 3.

Section 4

Alternative 2: Irrigation Conservation Measures

Alternative 2, Irrigation Conservation Measures, develops reconnaissance level estimates of potential water savings from shifting current irrigation technologies to more efficient technologies. The intent of this analysis is to estimate the potential for conservation to reduce the identified groundwater supply gap and, as such, utilizes generalized data from various sources to estimate potential savings ranges that might be achieved by conservation measures. Two hypothetical scenarios are presented in an effort to bracket the potential water supply savings that might result from implementation of conservation technologies.

4.1 Current Conditions

The U.S. Department of Agriculture (USDA) Economic Research Service report *Water Conservation in Irrigated Agriculture: Trends and Challenges in the Face of Emerging Demands* (Economic Information Bulletin- [EIB] #99, 2012) states that "According to the 2008 Farm and Ranch Irrigation Survey (FRIS), at least half of irrigated crop acreage across the United States continues to be irrigated with less efficient irrigation application systems and most irrigators do not make use of less water-intensive on-farm water management practices" (page 33).

Crop irrigation technologies have different levels of efficiency that represent the difference between the amount of water applied and the amount of water required by the crop. The primary irrigation technologies reported in the USDA FRIS are pressure, gravity, and drip. Pressure systems include center pivot systems and other sprinkler technologies, while gravity systems include furrow irrigation and flooding techniques. Each of the primary irrigation methods includes multiple application technologies, each with their own efficiency levels. For example, furrow irrigation efficiency can be improved with the installation of surge valves, while flood irrigation can be improved with multiple inlet designs and zero-grade leveling. **Table 4-1** gives a comparison of application efficiency levels, as an example.

The applicability of irrigation technologies varies by crop and field conditions. Flood irrigation technologies are typically used for rice, sprinkler (pivot) and furrow irrigation technologies are used for row crops, and drip irrigation for vegetables. The efficiency of an application technology varies by crop, soil type, slope of field, length of row, scheduling practices, and other variables that may vary from one farm to another. For example, application rates in Arkansas for rice with contour irrigation systems range from 16 inches to 56 inches (Henry et al., publication pending, page 10). Furthermore, the irrigation system must match the physical field and soil conditions in order to be applicable and efficient. Zero-grade leveled fields can result in 40 percent water savings for rice irrigation; however, not all fields have physical characteristics appropriate for zero-grade leveling.

Table 4-1. Example of Irrigation System Efficiency Levels

Irrigation System	Attainable Efficiencies
Surface Irrigation	
Basin	80-90%
Border	70-85%
Furrow	60-75%
Sprinkler Irrigation	
Hand Move or Portable	65-75%
Traveling Gun	60-70%
Center Pivot and Linear Move	75-90%
Solid Set or Permanent	70-80%
Trickle Irrigation	
With Point Source Emitters	75-90%
With Line Source Products	70-85%

Source: California State University, Fresno, January 1988

The USDA EIB-#99 reports that average irrigation costs in eastern United States is about $65 - $75 per acre (page 24). Henry et al. (publication pending) report that the cost of rice irrigation in Arkansas averages about $44 per acre in fields with surface water sources and about $75 per acre in fields with groundwater sources.

4.2 Crop Irrigation in Arkansas

Information on irrigated acres by crop type by county was collected during the development of the agricultural irrigation water demand forecast. The USDA FRIS collects detailed information on irrigation practices. This information is available at the state level but is not statistically valid at the county level. The FRIS data for Arkansas indicates the number of acres irrigated by Pressure (sprinkler), Gravity (furrow and flood), and Drip methods by crop. The data also show the number of statewide acres irrigated by technological subsets of Pressure, Gravity, and Drip methods, but these data are not cross-tabulated by crop. Discussions with both University of Arkansas Extension Service and USDA-National Agricultural Statistics Service (NASS) - Little Rock personnel confirmed that information on irrigation technologies by crop by county is not available.

Average crop irrigation application rates were estimated for each county and major crop as part of the estimation of crop irrigation water demand for the AWP. The distribution statistics of these application rates are shown in **Table 4-2**. As noted above, application rates for similar crops with similar irrigation technologies can exhibit a wide range of application rates due to field conditions, soil types, crop cultivars, climatic conditions, and management decisions. In addition, the data used in the AWP crop irrigation estimates are averaged by county and crop type from reported information that may vary in accuracy and in the number of data points per county. (For example, the statewide average application rate for rice derived from the available data is higher than is typically used.) The county average application rates range in value from the minimum to the maximum values shown in Table 4-2 for each crop. These extremes may be anomalies due to unique conditions within the respective county or data reporting discrepancies. However, half of the average county application rates are between the range determined by the 25th and 75th percentile values.

Table 4-2. Distribution of County Application Rates by Crop

	Total Inches				Total AF			
	Corn	Cotton	Rice	Soybeans	Corn	Cotton	Rice	Soybeans
No. of Counties	37	25	33	37	37	25	33	37
Maximum	30.55	30.17	47.58	32.32	2.55	2.51	3.96	2.69
75th Percentile	20.45	17.95	37.22	18.55	1.70	1.50	3.10	1.55
Average	16.21	15.61	34.50	14.82	1.35	1.30	2.87	1.23
25th Percentile	12.00	12.67	31.32	11.30	1.00	1.06	2.61	0.94
Minimum	2.62	7.81	13.49	1.00	0.22	0.65	1.12	0.08

The approach used to estimate potential water savings from on-farm water use efficiency for Alternative 2 is based upon the data shown in Table 4-2. Two hypothetical scenarios are evaluated.

4.3 Definition and Evaluation of Scenarios

The following paragraphs define the two hypothetical scenarios and evaluate each for potential irrigation conservation savings.

4.3.1 Reasonable Scenario

The first scenario evaluated is a "Reasonable" scenario that assumes any county with above average application rates will be able to improve crop irrigation efficiency and achieve the average application rate shown in Table 4-2 by crop. This assumes that about half of the reporting counties will lower their application rate for each crop type. Such efficiency gains may come about through technological changes (e.g., using surge valves for furrow irrigation) or from behavioral changes (e.g., shifting to more efficient monitoring of soil conditions and irrigation scheduling).

Results of this scenario in which half the counties are assigned the average application rates are summarized in **Table 4-3** and show that water requirements for corn irrigation would be reduced about 19 percent, soybeans about 17 percent, and cotton and rice about 9 percent. Total estimated savings based upon projected 2050 irrigated acres in the AWP analysis would be about 1.36 million acre-feet (MAF) of water. This estimate is derived by changing the application rate of crops by county; thus the estimated savings can be tabulated by county, sub-basin, or region.

Table 4-3. Estimated Potential Savings from Shifts in Average Application Rates

	2010	2020	2030	2040	2050
Estimated AF for Irrigation – Baseline					
Corn	424,580	434,441	447,014	451,515	452,749
Cotton	647,302	660,702	664,449	652,777	655,296
Rice	5,483,710	5,718,125	5,888,561	5,912,304	5,919,475
Soybeans	3,164,959	3,678,422	3,976,103	4,047,725	4,059,670
Total	**9,720,550**	**10,491,691**	**10,976,126**	**11,064,321**	**11,087,190**
Estimated AF for Irrigation - Average Application Rate*					
Corn	342,338	349,574	360,206	363,692	364,519
Cotton	581,027	595,498	603,098	593,600	595,577
Rice	5,009,635	5,228,404	5,384,852	5,407,192	5,413,756
Soybeans	2,570,122	3,014,302	3,285,910	3,345,209	3,354,655
Total	**8,503,122**	**9,187,778**	**9,634,066**	**9,709,693**	**9,728,508**

Table 4-3. Estimated Potential Savings from Shifts in Average Application Rates

	2010	2020	2030	2040	2050
Estimated Reduction in AF - Average Application Rate*					
Corn	82,242	84,867	86,808	87,823	88,230
Cotton	66,275	65,204	61,351	59,178	59,719
Rice	474,074	489,721	503,709	505,112	505,719
Soybeans	594,837	664,120	690,192	702,516	705,015
Total	**1,217,428**	**1,303,913**	**1,342,060**	**1,354,628**	**1,358,682**
Estimated Percent Reduction - Average Application Rate*					
Corn	19.4%	19.5%	19.4%	19.5%	19.5%
Cotton	10.2%	9.9%	9.2%	9.1%	9.1%
Rice	8.6%	8.6%	8.6%	8.5%	8.5%
Soybeans	18.8%	18.1%	17.4%	17.4%	17.4%
Total	**12.5%**	**12.4%**	**12.2%**	**12.2%**	**12.3%**

Counties with crop application rate higher than average shift to average rate for crop.

The costs associated with improved efficiency are not determined in this high-level assessment. However, it is assumed that the costs of implementing irrigation efficiencies can be regained through higher yields; lower energy and labor costs; and federal, state, and conservation district incentive programs.

Youts and Eisenhauer discuss the benefits of surge irrigation in Fundamentals of Surge Irrigation (University of Nebraska-Lincoln Extension, 2008). They indicate that surge irrigation can provide lower labor costs, reduce run-off, and improve irrigation performance without the expense of center pivot irrigation technology. Proper field leveling and irrigation scheduling is important for improved efficiency. Because some furrow irrigators "apply more than twice the amount of water that a crop can use" the water, labor, and fuel savings from a surge system can pay for itself in "just a few years" (Youts and Eisenhauer, 2008, p. 2).

4.3.2 Aggressive Scenario

The second hypothetical scenario is an "Aggressive" scenario in which it is assumed that counties with application rates higher than the 25th percentile shown in Table 4-2 above can improve irrigation efficiency to the level of the 25th percentile. This assumes that about 75 percent of the reporting counties will significantly lower their average application rate for each crop type. As with the "Reasonable" scenario, such efficiency gains may come about through technological changes and/or behavioral changes; however, more education and incentives will be required to affect these changes. Thus, achieving the Aggressive scenario target may require more funding of extension service programs.

Results of this scenario are summarized in **Table 4-4** and show that water requirements for corn irrigation would be reduced about 35 percent, soybeans about 31 percent, cotton about 18 percent, and rice about 16 percent, if such a reduction in application rates can be achieved. Total estimated savings based upon projected 2050 irrigated acres in the AWP analysis would be about 2.45 MAF of water.

Table 4-4. Estimated Potential Savings from Shifts in Application Rates

	2010	2020	2030	2040	2050
Estimated AF for Irrigation – Baseline					
Corn	424,580	434,441	447,014	451,515	452,749
Cotton	647,302	660,702	664,449	652,777	655,296
Rice	5,483,710	5,718,125	5,888,561	5,912,304	5,919,475
Soybeans	3,164,959	3,678,422	3,976,103	4,047,725	4,059,670
Total	**9,720,550**	**10,491,691**	**10,976,126**	**11,064,321**	**11,087,190**
Estimated AF for Irrigation - 25th % Application Rate**					
Corn	277,959	283,829	292,254	294,834	295,447
Cotton	517,608	534,336	544,808	537,100	538,705
Rice	4,611,964	4,814,049	4,960,664	4,980,945	4,986,904
Soybeans	2,159,717	2,536,389	2,762,183	2,807,704	2,814,841
Total	**7,567,247**	**8,168,603**	**8,559,910**	**8,620,584**	**8,635,897**
Estimated Reduction in AF - 25th % Application Rate**					
Corn	146,622	150,612	154,760	156,680	157,302
Cotton	129,694	126,366	119,641	115,677	116,591
Rice	871,745	904,077	927,897	931,359	932,571
Soybeans	1,005,242	1,142,033	1,213,919	1,240,021	1,244,829
Total	**2,153,303**	**2,323,088**	**2,416,217**	**2,443,737**	**2,451,293**
Estimated Percent Reduction - 25th % Application Rate**					
Corn	34.5%	34.7%	34.6%	34.7%	34.7%
Cotton	20.0%	19.1%	18.0%	17.7%	17.8%
Rice	15.9%	15.8%	15.8%	15.8%	15.8%
Soybeans	31.8%	31.0%	30.5%	30.6%	30.7%
Total	**22.2%**	**22.1%**	**22.0%**	**22.1%**	**22.1%**

** Counties with crop application rate higher than 25th percentile shift to 25th percentile rate for crop.

These two hypothetical scenarios are presented to show that on-farm water use can provide significant water savings from improved irrigation efficiency. More information on agricultural irrigation practices by Arkansas farmers is needed to provide a more accurate assessment of the potential conservation savings and the costs to achieve them. A program to collect and assemble actual Arkansas and basin-specific data on conservation and associated costs should be implemented to provide these data in the future. As conservation projects are considered, this accurate, site-specific data would be invaluable to accurately reflect the actual benefits of projects and their accompanying costs.

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Section 5

Alternative 3: Surface Water Infrastructure for Irrigated Agriculture

Alternative 3 assumes that the acreage requiring conversion from groundwater irrigation does not go out of production (as described in Alternative 1) but is instead maintained (and increased from current levels) by converting the irrigated cropland to an alternate source of irrigation water. Examples of source conversion include on-farm rain water impoundment and imported water from large-scale surface water diversion projects, both of which rely on surface water. Other options, as discussed in the No Action Alternative, include dry-land farming and cropland fallowing. These latter options are not part of the Alternative 3 analysis.

The Alternative 3 analysis is presented at the major basin level and considers whether or not enough excess surface water and total available surface water is projected to be available for cropland source conversion. The analysis relies on previous analyses completed in support of the AWP. These include the AWP Water Demand Forecast Report (AWP Appendix E), AWP Water Availability Report (AWP Appendix C), AWP Gap Analysis (AWP Appendix F), and the No Action Alternative (see Alternative 1 of this report). For convenience, critical information from these sources is reproduced here. If additional detail is desired for a specific subject, then the reader is directed to these previous studies.

5.1 Existing and Planned Surface Water Irrigation Projects

This section provides a summary of existing or planned surface irrigation projects in or near the East Arkansas Region. The success of existing projects show that source conversion of irrigated acres is a viable alternative.

5.1.1 Plum Bayou

The Plum Bayou project was completed in 1993 at a cost of $977,000 and serves 14,200 irrigated acres. It consists of 3 pumps with a total capacity of 79,500 gallons per minute (gpm); 3 road crossings; an irrigation canal; 10.5 miles of underground pipelines; and 77 flow meters. The sponsors are Natural Resources Conservation Service (NRCS), ANRC, Lonoke County Conservation District, Pulaski County Conservation District, and the Plum Bayou Irrigation District (USDA 2014). The success of the Plum Bayou project can partially be attributed to the relative low capital cost per acre for conversion ($129/acre), which is a result of efficient and innovative utilization of natural features (versus infrastructure). It is not likely that future surface water irrigation projects would be able to replicate this unique level of cost efficiency.

5.1.2 Point Remove Wetland Reclamation and Irrigation Project

The Point Remove Wetland Reclamation and Irrigation Project was completed in 2006. It provides irrigation water to 14,000 acres of cropland in Pope and Conway counties and winter water for the 6,000-acre Ed Gordon Wildlife Management Area. The project's capital cost was approximately $10 million, including wildlife enhancements. At the time of publication of this report a breakdown between water supply and wildlife enhancement capital costs was not possible. The sponsors are the

Point Remove Wetlands Reclamation and Irrigation District; and Arkansas Game and Fish Commission (USDA 2014).

5.1.3 Grand Prairie Area Demonstration Project

The planned Grand Prairie Area Demonstration Project "consists of a major pumping station and a network of new canals, existing channels, pipelines, and associated channel structures to provide interbasin transfer of surface water" to areas previously irrigated with groundwater (U.S. Army Corps of Engineers [USACE] 1998). The primary withdrawal location is located north of DeValls Bluff on the White River. Approximately 560,000 AF of excess surface water has been permitted for non-riparian use in support of the project (Soller 2014). When complete the project will convert nearly 255,000 acres of irrigated cropland acres from utilizing groundwater as the primary source of water to utilizing excess surface water in an area that includes portions of Arkansas, Prairie, Lonoke, and Monroe counties (USACE 1998). The project includes a distribution system of 102 miles of open canals and 290 miles of buried pipeline to deliver water to farms within the region. An additional 600 on-farm systems including reservoirs, tailwater recovery systems, pipelines, and improved irrigation efficiencies will be implemented. The project components include not just water supply but also conservation and wildlife restoration. The imported water supply portion of the project is projected to cost $400 million for the primary delivery system and another $100 million for on-farm infrastructure (Carman 2014a).

5.1.4 Bayou Meto Water Management Project

The Bayou Meto Water Management Project is planned to convert nearly 268,000 acres of irrigated acres from groundwater to surface water. Major features of the project include diversion of Arkansas River water, 4 pump stations, 107 miles of canals, and 464 miles of underground pipelines. The project area includes portions of Lonoke, Prairie, Arkansas, and Jefferson counties. The project will also provide increased flood control and enhanced water fowl management. The water supply portion of the project is projected to cost $550 million for the primary delivery system (does not include the cost of any on-farm improvements).

5.1.5 On-Farm Successes

The above success stories provide details related primarily to large-scale imported surface water systems. On-farm improvements that capture and impound rainwater are also critical to the success of eliminating the groundwater gap in the East Arkansas Region. For example, Oliver Farms made improvements to its on-farm systems that allows for the utilization of rainfall and runoff from irrigation water. These improvements included one groundwater well and four surface water relift pumps with a combined capacity of 15,800 gpm. In addition, over 14,500 feet of underground polyvinyl chloride irrigation pipeline was installed along with construction of one tailwater pit and two storage reservoirs. Successful implementation of the on-farm infrastructure has impacted approximately 1,000 acres of cropland that to date has been completely sustained by the new system. The total cost of these on-farm improvements was just under $600,000 resulting in a unit cost of approximately $600 per acre of cropland (Bowie 2014). It is estimated that 500,000 acres across the state have been converted to rain water capture and water reuse utilizing similar systems as Oliver Farms (Delp 2014).

5.2 Analysis for Source Conversion of Irrigated Acres to Surface Water

The No Action Alternative (see Alternative 1) presented a projected groundwater gap of about 7,260,000 AF in 2050 for the East Arkansas Region assuming aquifers are sustainably managed. Alternative 3 builds upon this analysis by assessing if enough *excess surface water or total available surface water* is available to fill the projected 2050 groundwater gap. Definitions for these two surface water availability terms are presented below.

Excess surface water is statutorily defined in A.C.A. § 15-22-304 as:

- Twenty-five percent of that amount of water available on an average annual basis above the amount required to satisfy existing and projected needs. Needs include:
  - Existing riparian rights as of June 28, 1985
  - The water needs of federal water projects existing on June 28, 1985
  - The firm yield of all reservoirs in existence on June 28, 1985
  - Maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation
  - Future water needs of the basin of origin as projected in the AWP

The excess surface water data compilation and calculations are described in detail in the AWP Water Availability Report, Section 3 (AWP Appendix C) and the AWP Gap Analysis Report (AWP Appendix F).

The total available surface water is calculated similarly to excess surface water in that the water to meet the "needs" specified in A.C.A. § 15-22-304 is subtracted, but the 25-percent factor is not applied to the remaining flow. In other words, total available surface water is the amount of physically available surface water after identified existing and future needs have been met. Without subtracting the 25-percent factor, the calculated total available surface water is four times greater than calculated excess surface water. Besides the use of the 25-percent factor, a key differentiator between excess surface water and total available surface water is location of use. Excess surface water quantifies available surface water for non-riparian and transbasin use and development. Total available surface water quantifies available surface water for riparian, non-riparian, and transbasin use and development. The total available surface water data compilation and calculations are described in detail in the AWP Gap Analysis (AWP Appendix F).

Table 5-1 compares the projected 2050 groundwater gap (assuming sustainably managed aquifers) to the excess surface water and total available surface water for each major basin that is contained (or partially contained) within the East Arkansas Region. For convenience, a determination is made that simply classifies each basin as either having "Yes" enough or "No" not enough excess surface water or total available surface water. As shown in Table 5-1, not every basin has enough excess surface water or total available surface water to fill the projected groundwater gap. However, on a whole, the major basins that flow into the East Arkansas Region do have enough excess surface water and total available surface water to meet the gap. It should be noted that the excess surface water and total available surface water quantities shown in Table 5-1 are representative of the entire major basin and that upstream development of surface water resources outside of the East Arkansas Region may reduce the actual amount available for development within the East Arkansas Region. Figure 3-1 highlights the relative location of major basins and planning regions and highlights the overlap. The issue of upstream development limiting future surface water availability within the East Arkansas Region is most prominent in the Arkansas River and White River Basins.

An additional consideration in the question of surface water availability is changing the statutory definition of excess surface water. If excess surface water definition was changed from 25 percent to 33 percent in the East Arkansas Region, the groundwater gaps in all major basins in the East Planning Region could be eliminated. Note that while there would be an adequate amount of water to eliminate the groundwater gap, it would require transbasin imports/exports from the major basins with large amounts of surface water (e.g., the Arkansas River – Lower, White River- Lower, and Ouachita River – Table 5-1) to basins with inadequate surface water (e.g., Bayou Macon, Boeuf River, and L'Anguille River).

Table 5-1. Summary of Excess Surface Water and Total Available Surface Water in the East Arkansas Region

Major Surface Water Basins	Groundwater Gap (AF)	Excess Surface Water (AFY)[2]	Total Available Surface Water (AFY)[2]	Is there enough Excess SW?	Is there enough Total Available SW?
Arkansas River - Lower[1]	595,150	3,307,616	13,230,466	yes	yes
Arkansas River - Upper[1]	21	3,256,854	13,027,414	yes	yes
Bayou Bartholomew	143,820	114,517	458,068	no	yes
Bayou Macon	278,741	27,132	108,529	no	no
Boeuf River	317,880	37,967	207,132	no	no
L'Anguille River	926,718	90,803	363,214	no	no
Ouachita River	114	1,026,619	4,106,478	yes	yes
St. Francis River	1,897,109	670,461	2,681,844	no	yes
White River – Lower[1]	3,100,257	2,131,256	8,525,023	no	yes
Total	7,259,810	7,406,373	29,680,752	yes	yes

1 The Upper and Lower basins are hydrologically connected. Upper basin Excess Surface Water has been removed from Total values to avoid double counting.

2 See the AWP Water Availability Report (AWP Appendix C) and AWP Gap Analysis Report (AWP Appendix F) for more detail.

For Alternative 3, it is assumed that a source conversion would be made either to on-farm rain water capture systems (similar to Oliver Farms) or to imported surface water projects (similar to the Grand Prairie and Bayou Meto projects). Current estimates are that, region-wide, new source water would be split approximately 50/50 between on-farm and imported surface waters in the future (Carman 2014b).

The reconnaissance-level cost estimate presented below used cost data from existing and planned surface water irrigation projects (previously described). Because each surface water irrigation project is unique in terms of required infrastructure capacity and type of infrastructure (on-farm vs. imported surface water), this cost analysis provides a "book end" range – the lowest and highest estimates.

Unit costs on a price per acre irrigated basis were calculated for existing and planned surface water irrigation projects. Due to a lack of available information on operations and maintenance costs, only capital costs are included. A summary of the existing and planned project capital costs are shown below in **Table 5-2**. The Grand Prairie unit cost of $1,569 per acre includes an approximate 50/50 split between on-farm and imported surface water while the Bayou Meto unit cost of

$2,052 per acre includes only infrastructure associated with imported surface water. Existing projects' capital costs were adjusted to present day dollar values utilizing the Engineering News Record 20-City Construction Cost Index.

Table 5-2. Summary of Capital Costs of Existing and Planned Surface Irrigation Projects

Project	Construction Cost ($M)	Construction Year	2014 Construction Cost ($M)	Current/ Planned Irrigated Acres Converted	$/acre
Grand Prairie[1,2]	400	ongoing	400	255,000	$ 1,569
Bayou Meto[1,3]	550	ongoing	550	268,000	$ 2,052
Plum Bayou[4]	0.98	1993	1.8	14,000	$ 129
Point Remove[4,5]	10	2006	12.6	14,000	$ 900

1 Construction cost is estimated, project is not yet complete
2 Cost includes an approximate 50/50 split between on-farm and imported surface water
3 Cost includes only infrastructure associated with imported surface
4 Construction cost adjusted to $2014 utilizing Engineering News Record Construction Cost Index (20-city)
5 Construction cost includes wildlife enhancement portion of project.

A range of estimated capital costs associated with converting cropland irrigated with groundwater to surface water (either on-farm or imported) is provided in **Table 5-3** by major basin. The Bayou Meto project unit cost of $2,052 per acre served as the basis for the High "Book End" while Point Remove's unit cost of $900 served as the Low "Book End" (see Table 5-2). The Plum Bayou project was not included in the book ends due to its unique configuration and ability to utilize natural features that resulted in an exceptionally low unit cost.

Table 5-3. Summary of Capital Cost for Alternative 3

Major Surface Water Basins (within the East Arkansas Region)	Required Acres Converted to Fill Gap	Low "Book End" Cost ($M)	High "Book End" Cost ($M)
Arkansas River – Lower	281,095	253.0	576.8
Arkansas River – Upper	10	0.0	0.0
Bayou Bartholomew	86,221	77.6	176.9
Bayou Macon	156,596	140.9	321.3
Boeuf River	187,106	168.4	383.9
L'Anguille River[1]	414,652	373.2	850.9
Ouachita River	64	0.1	0.1
St. Francis River	1,049,126	944.2	2,152.8
White River – Lower	1,615,765	1,454.2	3,315.5
Total	**3,790,635**	**3,412**	**7,778**

The estimated range of capital costs presented in Table 5-3 assumes that converted acres required to fill the groundwater gap may come from outside of a particular major basin. This is necessary because, as shown in Table 5-1, there is not sufficient excess surface water or total available surface water projected to be available in each individual basin to meet its own source conversion needs; however, region-wide, there is sufficient excess surface water and total available surface water. Inter-basin water transfer projects would likely move actual costs towards the High "Book End" (or possibly beyond). The "book end" approach also reflects the uniqueness of each potential source conversion project. While current surface water irrigation projects have an approximate split between on-farm and imported surface water, the exact ratio of surface water sources for future projects is unknown at this time.

The range of costs presented in Table 5-3 represents "book ends" for statewide planning purposes. Actual cost will vary depending upon the type of strategies implemented, which reinforces the use of a "book end" approach. Furthermore, all costs are +/- 50 percent due to the high-level planning nature of the analysis.

Consistent with the No Action Alternative (Alternative 1), this analysis estimates that 3.8 million acres of cropland in the East Arkansas Region would have to be converted from groundwater irrigation to surface water irrigation (either on-farm or imported) in order to close the projected water supply gap. The Alternative 3 analysis found that the cost of developing irrigation projects that would maintain projected levels of crop irrigation in the East Arkansas Region would likely fall between $3.4 billion and $7.7 billion. This range of costs represents "book ends" for statewide planning purposes. Actual cost will vary depending upon the type of strategies implemented.

While the alternative cost analysis presented here utilized the best available information, it contains many assumptions and inherent uncertainty. Like other high-level water resources planning studies, these costs will need refined. As project concepts are evolved it will be necessary to conduct additional, more detailed feasibility- and design-level studies. Included in these studies should be a more detailed look at water availability and crop irrigation demands. This is especially true in Northeast Arkansas (ex. St. Francis River Basin) where regional stakeholders have identified existing issues with water demand reporting that may be artificially increasing projected crop irrigation water requirements. Also, concerns regarding a lower than expected projected availability of groundwater have also been documented.

Lastly, it is very likely that the actual solution to the East Arkansas Region's water resources challenges will not be found in a single alternative or strategy, such as Alternative 3. Rather, the actual solution will consist of a portfolio of strategies that may include on-farm and imported surface water projects along with conservation and other strategies not specifically addressed in this report.

Section 6
Conclusions

A 2050 groundwater supply gap of 7,620,000 AFY is projected for the East Arkansas Region. The No Action alternative and two management alternatives to address this gap are evaluated: Irrigation Conservation Measures and Surface Water Infrastructure for Irrigated Agriculture.

The first, No Action, would result in the loss of over 70 percent of the East Arkansas Region total irrigated acres by 2050 resulting in only 1.6 million acres under irrigation in 2050 versus the 4.6 million acres currently irrigated and the 5.4 million acres projected for 2050 should adequate irrigation supplies be available. Essentially, if the No Action Alternative were implemented, over 3.8 million acres of irrigated acres would be fallowed or converted to dryland farming by 2050.

Alternative 2: Irrigation Conservation Measures is estimated to have the potential for reduction of the groundwater supply gap by anywhere from 12 to 22 percent, reducing the gap to a range of 4,810,000 to 5,900,000 AFY in year 2050.

Alternative 3: Surface Water Infrastructure for Irrigated Agriculture by far holds the most promise to positively address the groundwater supply gap. The Water Availability Report (AWP Appendix C) projects that sufficient excess surface water is available to totally satisfy the gap throughout the East Arkansas Region. However, in some major basins surface water is insufficient, either because of the legal designation of excess water, or because there is not enough physical availability of total available surface water. Alternative 3 projects the cost to fully satisfy the groundwater supply gap with projects that convert groundwater irrigated acreage to surface supply in the East Arkansas Region to be between $3.4 and $7.8 billion. This range of costs represents "book ends" for statewide planning purposes. Actual cost will vary depending upon the type of strategies implemented.

It is clear that the projected groundwater supply gap represents a serious challenge to the continued practice of agriculture in the state, and specifically in the East Arkansas Region. No single alternative of those presented will provide a satisfactory solution to the challenges posed by the gap, and the solution most probably lies with hybrid solutions implemented on a major basin or subbasin level combining conservation, conversion to surface water supply, and in some cases fallowing land or converting acreage to dry land farming. The results of the alternative analysis show that there are options available to address the gap and maintain agricultural acreage at or near the projected 2050 levels with careful planning conducted at appropriate scales to provide area-specific solutions.

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Section 7
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