## Memorandum

*To:* *Water Supply Availability Work Group*

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*Subject:* *DRAFT Arkansas Water Plan Update Water Supply Availability Methodology*

# 1.0 Introduction

The update to the Arkansas Water Plan (AWP) will involve several major steps including:

1. A description of regional water resources and the socioeconomic characteristics of the different areas of the state.

2. A quantification of current and future water needs (also referred to as water demand or demand), including consideration of water and wastewater infrastructure (this will provide an answer to the question – *How much water do we need?*).

3. An assessment of surface and groundwater supply availability, including water quality considerations (this will provide an answer to the question – *How much water do we have?*).

4. Once information on water demand and supply is obtained, an assessment will be completed to determine if there are any shortfalls or gaps between demand and supply.

5. Finally, a set of recommendations will be developed to address the state's current and future water resource shortfalls. These recommendations may include recommended projects or other non-structural and policy actions.

The remainder of this document will focus on the proposed methodology for quantifying the water supply available to meet current and future water supply needs (item three above). The AWP Update requires assessment of current and future water supply availability in order to develop strategies to meet supply needs while ensuring the health, safety, and prosperity of the citizens of Arkansas and the protection of fish and wildlife. The topics presented include:

- Groundwater supply availability
- Surface water supply availability
- Water quality for both surface water and groundwater
- Fish and wildlife flows

During the AWP Update demand and water supply availability information will be summarized at the Water Resources Planning Region level as shown in Figure 1 at the end of this memorandum. The Water Resources Planning Regions allow for consideration of local and regional issues as the Arkansas Natural Resources Commission (ANRC) updates their Water Plan.

Arkansas is a riparian reasonable use state with some legislation to deal with emerging issues. Riparian use of water is a property right. Riparian land touches a lake, stream, river, or other watercourse. Riparian landowners may use water on the property, but can be limited if their use unreasonably harms another riparian's use. No permission or permit is required from the government before a riparian owner uses water. In Arkansas, the reasonable use theory is applied to groundwater. A landowner may use water on land with a well as long as that use does not unreasonably harm another groundwater user. The ANRC Rules for the Utilization of Surface Water provide a mechanism for nonriparian owners to divert excess surface water to nonriparian land upon approval of the ANRC if the water will be applied to reasonable and beneficial use and the diversion will cause no significant adverse environmental impact.[1]

For groundwater supply availability and surface water availability the physical and legal availability of these supplies will need to be assessed. Physical availability is the actual or observed streamflow or observed groundwater yield at a gage location. Legal availability takes into account the regulatory or legal impacts on physically available supplies. Examples of legal availability in Arkansas include excess surface water and surface water allocation during time of shortage.

Infrastructure availability or gaps are not included in this methodology memorandum. This will be included in the AWP Update when considering future funding needs and potentially as part of the gap analysis.

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[1] Arkansas Natural Resources Commission Rules for the Utilization of Surface Water Title 3 (Effective 2009) 304.1 and 305.7.

# 2.0 Groundwater Availability

Figure 2 at the end of this memorandum represents an overview of the hydrogeology of Arkansas. The Interior Highlands is a mountainous region of consolidated rock formations, which encompass about 31,000 square miles of northwestern Arkansas. Groundwater in the Interior Highlands occurs primarily in fractures, solution openings, and along bedding planes. The Gulf Coastal Plain encompasses approximately 27,000 square miles in southern and eastern Arkansas. This area consists of unconsolidated strata of primarily clay, silt, sand, and gravel. Several of the layers are composed of sand and gravel and function as high yielding aquifers. The two most significant aquifers in the Gulf Coastal Plain are the Alluvial Aquifer and the Sparta Sand aquifer. Other significant water-bearing units include the Cockfield aquifer that is tapped for municipal supplies in southeastern Arkansas, the Wilcox aquifer that is an important source of fresh water in the eastern and northeastern part of the state, and the Nacatoch Sand aquifer that is the source for several municipal supplies in southwest and in extreme northeast Arkansas.[2]

The 1990 Water Plan recommended that critical groundwater areas be identified and pursuant to Act 154 of 1991, the ANRC designates a critical area after notice and public hearings based upon monitoring and scientific review. The critical area is defined based on significant groundwater declines and/or water quality degradation. Boundaries are configured based on the natural hydrogeologic boundary of the aquifer.

This section focuses on the proposed approach for quantifying the groundwater supply available to meet current and future water supply demands. The methodologies described in this document will provide a means of maintaining consistency in approach with previous and ongoing studies on groundwater availability by the United States Geological Survey (USGS) and provide for a collaborative process that will meet the goal of understanding future supply availability. This analysis will rely on the Mississippi Embayment Regional Aquifer Study (MERAS) developed by the USGS to assess groundwater conditions under current and future water use scenarios (Figure 3). This effort is also closely linked to the demand forecasting effort that will provide the demand projections used to assess future groundwater use and resulting supply availability. When appropriate, linkages to the demand forecasting effort are highlighted in this document.

## 2.1 Assess Present and Future Groundwater Availability in the Alluvial and Sparta Sand Aquifers

Most groundwater pumping in Arkansas occurs in the Alluvial and Sparta Sand Aquifers (see Figure 2 at end of this document). Historically, these aquifers have been studied extensively by many parties, including the USGS with the recent development of their MERAS model. This task assumes that the most recent update of the USGS predictive groundwater model (MERAS) will be utilized in this study.

[2] 1990. Arkansas Water Plan Executive Summary. Arkansas Natural Resources Commission.

### 2.1.1 Assess Current Groundwater Conditions

Current groundwater conditions will be simulated using the existing MERAS numerical groundwater model as provided by USGS. The MERAS model simulates groundwater conditions for the time period between 1870 and 2007, although the simulation period may be extended in the updated model. The end of the simulation will be used to represent current aquifer conditions.

Water balance information will be compiled including pumping inputs, recharge, and flow to and from rivers and streams. Simulated water levels will be reviewed to ascertain patterns both spatially and temporally. No modifications will be made to model input files (e.g., water use and groundwater pumping as defined by USGS will be utilized). This task will include the following steps:

1. Review any available updated MERAS model documentation. Existing reports, including the 2009 USGS Scientific Investigations Report[3] and other reports documenting the development and calibration of the MERAS model have been reviewed. If additional documentation is provided as part of the groundwater model update, this material will be reviewed prior to use of the model.

2. Run model simulation and process model results.

3. Summarize model results. Information will be summarized by county over the length of the simulation period for the following model output:

   - Pumping, recharge, and boundary conditions (inflow/outflow at boundaries)

   - Water elevation maps (contoured water levels) and water level hydrographs (time histories) for selected wells at which monitoring data is available

   - Available groundwater in storage

This task will serve as a baseline to compare to other water use scenarios in terms of changes in water levels and available aquifer storage. Time histories of aquifer water levels will also be used to compare against future simulations to determine potential water levels trends.

### 2.1.2 Assess Future Groundwater Conditions

Future groundwater conditions will be simulated using the MERAS model by incorporating water use projections from the concurrent demand study. Model files will be updated to reflect future projections of groundwater pumping. Recharge inputs and other boundary conditions will

[3] USGS, The Mississippi Embayment Regional Aquifer Study (MERAS): Documentation of a Groundwater-Flow Model Constructed to Assess Water Availability in the Mississippi Embayment, Scientific Investigations Report, 2009.

remain the same to isolate the impact of changes in pumping. It is assumed that the range of recharge from precipitation included in the existing model sufficiently represents the range of future recharge.

Demand forecasts will be developed for all demand sectors of water use through 2050, at 10-year intervals from 2010 through 2050 (Figure 4). The demand forecasts will be used to create model input files to replace the specified pumping in the MERAS model. This task will include the following steps:

1. Develop model files from the water demand projections that are being produced in the demand study. It is assumed that a range of demand projections (high and low demand, etc.) may be investigated. Water use will be estimated for each county based on projected growth in various demand sectors, changes in land use, and current and projected unit water use, among other variables. The current pumping allocation approach in MERAS uses site-specific information from the water use database for pumping assignments for the simulation period of 1998 and on. Prior to that, historic water use data was aggregated to the county level then distributed amongst individual wells. To maintain consistency with the USGS modeling efforts and to utilize the county-level demand information, the same approach of distributing county-level pumping estimates will be utilized in this study. Also, although demand projections will be developed through 2050, at 10-year intervals from 2010 through 2050, for the purposes of this study the demand projections will be interpolated to create demand datasets for each year of the simulation.

**Available Water Use Data**
Historical water withdrawal data are used to establish baseline levels of demand by water use sector for developing demand forecasts. In Arkansas, water withdrawal permits are required for all surface water users withdrawing 1 acre-foot (AF) or more per year and all groundwater users with the potential to pump 50,000 gallons per day (gpd) under the Water-Use Registration Program. This program is under the purview of the Arkansas Natural Resources Commission (ANRC). Withdrawal data are reported by registered users annually for the approximately 6,100 surface water withdrawal sites and 49,000 groundwater withdrawal sites. Reported withdrawals are stored in the Water-Use Database (WUDBS), which is managed by the U.S. Geological Survey (USGS) through a cooperative agreement with ANRC. This database contains monthly water withdrawal volumes by registered user. Key data fields include the diverter name, location of withdrawal, and industry type.

**Figure 4 Overview of Available Water Use Data**

2. Run groundwater model simulation(s) based on variable demand projection scenarios and process model results.

3. Summarize model results. Again, information will be summarized by county over the length of the simulation period for the following model output:

    - Pumping, recharge, and boundary conditions (inflow and outflow at boundaries)

- Water elevation maps (contoured water levels) and water level hydrographs (time histories) for selected wells at which monitoring data is available

- Available groundwater in storage

The MERAS model includes all major rivers and tracks both flow in the various reaches of each river and flow between the river and the underlying aquifers (baseflow). The USGS has noted some uncertainty in the simulation of streamflow and the model results show under prediction of streamflows less than 1,000 cubic feet per second (cfs) and over prediction of streamflows greater than 100 cfs. Therefore, only relative changes in streamflow and baseflow due to changes in groundwater pumping or increases in surface water diversions will be assessed using the MERAS model. This relative measure of change in surface water/groundwater interaction could provide guidance on the impact of future groundwater demands or future river diversion projects.

### 2.1.3 Coordination with ANRC Groundwater Protection and Management Program Activities

The ARNC has historically collaborated with the USGS in developing models and collecting information about the groundwater resources in Arkansas. The ANRC is currently working with the USGS to update the "Aquifers of Arkansas" report. The modeling scenarios that will be included in the Aquifers of Arkansas update are:

- USGS Scenario 1 uses optimized pumping totals (from the USGS sustainable yield models) for each county within Arkansas distributed to Alluvial and Sparta Sand Aquifer wells.

- USGS Scenario 2 uses the average pumping for each model cell of the Alluvial Aquifer from 2000 to 2005 to represent recent pumping amounts as inputs to the model.

- USGS Scenario 3 includes drawdown constraints equal to an altitude of approximately 50 percent of the predevelopment saturated thickness of the alluvial aquifer (one of the current water level criteria for an unconfined aquifer as a Critical Ground-Water Area (Arkansas Natural Resources Commission, 2012).

All three scenarios will utilize a steady-state version of the MERAS model. Scenario 1 simulates use of a single optimized pumping distribution into the future. Scenario 2 represents current conditions of the aquifer using a steady-state, rather than long-term, simulation. This scenario could be directly compared to the end of the original MERAS simulation (which ends in 2007, or later based on the ongoing model update effort) that simulated as part of the scenarios presented below. Scenario 3 assesses the impact of incorporating aquifer drawdown thresholds. The coordination described above is focused on water quantity. See section 4.2 of this memorandum for a discussion on groundwater quality.

## 2.2 Assess Present and Future Groundwater Availability in Aquifers West of the Alluvial and Sparta Sand Aquifers

Numerical groundwater models are not available for aquifers to the west of the Alluvial and Sparta Sand Aquifers, so the assessment of available groundwater in these aquifers will rely on available information on the water balances of these aquifers including estimates of yield.

### 2.2.1 Assess Baseline Groundwater Conditions

This task will involve the compilation of information on baseline or current groundwater conditions in Western Arkansas aquifers. This information will include water levels, pumping and water use, geology, some estimate of recharge and perhaps loss from aquifers through inter-aquifer flows and other information that could be used to support a planning-level water balance and estimate of yield for these aquifers. Where information is available, an assessment of whether current use of an aquifer would cause long-term drawdown impacts will be made.

### 2.2.2 Assess Future Groundwater Conditions

Based on future water use projections developed by the demand forecast effort, a comparison will be made between future demand projections and current availability of groundwater in Western Arkansas. The amount of detail incorporated in these assessments is dependent on the amount of available information.

## 2.3 Evaluate Groundwater Drawdown Thresholds and Impact on Supply Need

This task will include analysis similar in concept to USGS studies that identified the sustainable yield of the Alluvial and Sparta Sand Aquifers. In addition to using the current definition of water level thresholds, this task will assess other definitions of groundwater withdrawal thresholds and the impact of each on groundwater availability and the corresponding supply needs

### 2.3.1 Simulate Future Water Use Under Various Aquifer Thresholds

A range of alternative thresholds allow a cost/benefit analysis associated with different potential management end points for Alluvial and Sparta Sand Aquifers. This would support assessment of technical, legal, and political constraints and needs for each alternative management alternative or solution.

These thresholds could include:

- Current ANRC target level used to attain sustainable yield: minimum water elevation equal to half the aquifer thickness in an unconfined aquifer and the top of formation in a confined aquifer.

- Lower thresholds: minimum water elevation equal to one-quarter the aquifer thickness in an unconfined aquifer and the top of formation in a confined aquifer.

- Economic-based thresholds: minimum water elevation equal to a computation of aquifer transmissivity and pumping rate from the model cell that would approximate a limit to what a sunk well could economically produce from a given aquifer and based on certain economic assumptions.

- Develop a mining related alternative that would estimate the length of time to deplete the resource at current and/or future withdrawal levels. This alternative would not use a threshold but would assess how long current use would take to drawdown the aquifers to an accepted minimum saturated thickness. Studies such as Richard C. Peralta's assessment of drought-related target minimums of saturated thickness in the Arkansas Grand Prairie Aquifer will be reviewed as part of this effort.

### 2.3.2 Compare Results of Simulations with Various Aquifer Thresholds

Table 1 below shows an example of one potential output from this analysis (fictitious numbers used for illustrative purposes), a comparison of how groundwater withdrawal threshold impact the availability of groundwater and the resulting groundwater supply need in each scenario.

**Table 1 Example Potential Output from Groundwater Scenario Analysis**

| Simulation Name | Aquifer Thresholds Used | Total Pumping Available in 2050 | Total Anticipated Water Use in 2050 | Groundwater Supply Need in 2050 |
|---|---|---|---|---|
| Current | No minimum aquifer thresholds | 60 MGD | 61 MGD | 1 MGD |
| USGS Assumptions | USGS Thresholds | 50 MGD | | 11 MGD |
| Low Thresholds | Low Thresholds | 55 MGD | | 6 MGD |
| Economic | Economic-based Thresholds | 59 MGD | | 2 MGD |
| Mining | None | 45 MGD | | 16 MGD |

# 3.0 Surface Water Availability

Through consultation with ANRC, a preliminary map presenting the watersheds to be evaluated with respect to surface water supply has been developed (Figure 5 at the end of this document). The major river basins are generally consistent with the 1990 AWP. Surface water availability will be developed based on physical watershed boundaries shown in Figure 5. Water demand data at the county and Water Resources Planning Region level will be evaluated and adjusted as appropriate for application in the calculations related to surface water physical and legal availability. The remainder of section includes discussion on:

- Physical availability of surface water
- Safe Yield
- Excess surface water
- Allocation during time of shortage
- U.S. Army Corp of Engineers (USACE) projects
- Interstate compacts

## 3.1 Physical Availability of Surface Water

The basis of the surface water availability analysis for the AWP Update will be existing streamflow data. Streamflow data are collected by the USGS and the USACE. Streamflow data collection sites within each river basin will be selected based on the availability of adequate data and relevance to the required calculations. Additional consideration will be given to those stations used in the 1990 AWP. If additional sources of data are identified and are available (e.g., operational data for the Huxtable Pumping Station on the St. Francis River), relevant data will be incorporated into the analysis for streamflow.

In order to characterize historical hydrologic conditions and variability, streamflow data will be summarized using a variety of statistical metrics. These will likely include annual and monthly mean and median flows, minimum and maximum flows, standard deviations, and a range of percentile values. Monthly timeseries plots, summarizing the full period of record, may also be developed to better visualize historical variability and drought periods. The data synthesized in this task will be used to characterize physical availability of surface water throughout the state. This is different than the legal availability of water but will be just as critical to the analysis of water supply gaps and alternatives during subsequent tasks of the Water Plan Update.

For basins or subbasins where significant data gaps exist in the gage records, numerical techniques will be applied to estimate streamflows to the extent necessary. Techniques that may be utilized include the area ratio method and the MOVE.2 ("Maintenance of Variance Extension") statistical extension method. Both rely on the selection and use of a "surrogate" gage from a nearby basin with similar land cover features and a more complete data record. The area ratio method applies drainage area ratios to surrogate gage records to estimate flows for the study basin. MOVE.2 is a statistical flow record extension technique that fills missing data in a streamflow record (y) based on the flow at a surrogate gage (x) while preserving the statistics in basin (y).

## 3.2 Safe Yield of Streams and Rivers

A.C.A. § 15-22-301 requires the ANRC to define the safe yield of streams and rivers in Arkansas. The safe yield of a stream or river is defined as the amount of water that is available, or potentially available, on a dependable basis that could be used as a surface water supply.[4] In the 1990 Water Plan, the amount of water available on a dependable basis was defined by ANRC as the discharge that has been equaled or exceeded 95 percent of the time for the available period of record. The 1990 Water Plan explained that this is what streamflow can be expected on a dependable basis but that not all of this flow is available for use. The 1990 plan identified minimum streamflows and as part of the safe yield calculations the minimum flows were not available for use. Minimum stream flows are further discussed in Section 5.0 of this memorandum.

[4] 1990. Arkansas Water Plan. Arkansas Natural Resources Commission.

For the current plan update, it is proposed that the definition of safe yield be reviewed and that if changes are needed based on the review that they be established during the AWP Update. Assuming the definition for safe yield remains unchanged, calculations can be made in the future for safe yield at specific locations using the same methodology as the 1990 AWP, but with an updated gaged flow record.

## 3.3 Excess Surface Water

If a person does not already possess a riparian right to use a stream, they can apply for a non-riparian permit. A non-riparian permit allows an individual to use water that is not adjacent to their land. However, before approving a non-riparian application, the ANRC must first determine that excess surface water exists. In 1985, the General Assembly defined "excess surface water" to be 25 percent of that amount of water available on an average annual basis above the amount required to satisfy existing and projected needs. These needs include:[5]:

1. Existing riparian rights as of June 28, 1985
2. The water needs of federal water projects existing on June 28, 1985
3. The firm yield of all reservoirs in existence on June 28, 1985
4. Maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation
5. Future water needs of the basin of origin as projected in the state water plan

Excess surface water estimates were established in the 1990 AWP. These estimates will be updated with data collected since the last Water Plan Update (see Section 5.0 of this memorandum for a discussion on how fish and wildlife flows will be included in these updated estimates). Excess surface water will be estimated on an annual average basis. The amount of water available on an average annual basis for selected streams and rivers will be determined based on data from streamflow gaging stations located throughout the state. A preliminary selection of gaging stations has been made that generally includes, but is not limited to, those used for the 1990 AWP. The gages were selected based on their relevance within specific watersheds and on a preliminary assessment of available periods of record. Additional gages were selected for specific subbasins identified for analysis (e.g., the Kings River watershed in the Upper White River Basin). It is anticipated that as the analyses proceed, additional gages may be used and that some of the preliminarily selected gages may be deleted.

Average monthly streamflows will be calculated from the available data and aggregated to determine average annual flow. Entire periods of record may not be used in cases where significant changes to the flow regime in a basin have occurred (e.g., impoundment and stream regulation such as in the Upper White River Basin). When appropriate, consistent periods of record will be used to calculate average annual flows for subbasins within a major river watershed (e.g., the Saline River within the Ouachita River Basin). However, it is recognized that

[5] A.C.A. § 15-22-304 and A.C.A. § 15-22-202.

there will likely be cases when the periods of record are not consistent and analyses will have to be performed on a case-by-case basis. If data gaps exist, they will be resolved using the methods described above in the physical availability section of this memorandum.

To determine the excess surface water in a given basin (except the White River Basin), the average annual yield will be adjusted to account for the following:

- Existing uses
- Instream Flows:
  - Fish and wildlife flows (see section 5.0)
  - Water quality
  - Aquifer recharge requirements
  - Navigation
- Future demands as determined through demand forecasts in the AWP Update

After accounting for the above the remaining yield will be multiplied by 25 percent to estimate excess surface water.

For the White River Basin, A.C.A. § 15-22-304 (e) states: the transfer amount shall not exceed on a monthly basis an amount which is fifty percent (50%) of the monthly average of each individual month of excess surface water.

## 3.4 Allocation during Time of Shortage

Whenever a shortage of water in any stream or part of a stream exists to the extent that there is insufficient water to meet the requirements of all water needs, the ANRC may allocate available water among the competing water uses so that each use obtains an equitable apportion of the amount of water available. This process may also be initiated by a third party. A third party, deprived of usage or fearful that competing water users may impair his usage, may petition the Commission for allocation of available water supplies for a specific stream. Prior to allocation, the Commission must determine that a water shortage exists or is imminent. This condition of stream shortage is also known as the "allocation level" because this is the stream stage that triggers the Commission's power to apportion the water among users. [6]

As part of the AWP Update, it is not anticipated that "allocation levels" will be established. Because allocation during time of shortage is a legal availability issue it is important that stakeholders and public understand this concept A.C.A. § 15-22-217 (allocation during shortages) was recently revised by the Arkansas Legislature. The Commission will amend their Rules for the Utilization of Surface Water Title 3 based on these revisions. The revised statute is:

[6] 2011. Water Law in Arkansas. Arkansas Natural Resources Commission.

15-22-217. Allocation during shortages.

(a) (1) ~~Whenever~~ If a shortage of water in ~~any~~ <u>a</u> stream or part ~~thereof~~ <u>of a stream</u> exists to the extent that there is not sufficient water in the stream to meet the requirements of all water needs, on its own initiative or on the petition of any a person affected by the shortage of water and after notice and hearing, the Arkansas Natural Resources Commission may allocate the available water from the stream among the uses of water affected by the shortage of water in a manner that each of the needs affected by the shortage of water may obtain an equitable portion of the available water.

<u>(2) (A) Subject to the preferences and reserved uses stated in this section, if the commission allocates water under subdivision (a)(1) of this section, the commission shall give preference for water uses and types of water diversions as stated in this subdivision (a)(2).</u>

<u>(B) The commission shall allocate water for water uses in the following order of priority:</u>

<u>(i) Agriculture;</u>
<u>(ii) Industry;</u>
<u>(iii) Minimum streamflow;</u>
<u>(iv) Hydropower; and</u>
<u>(v) Recreation</u>

(b) In allocating water ~~in such a case~~ <u>under this section</u>, the commission may consider the use that each person involved is to make of the water allocated to that person.

(c) In making ~~such~~ allocations of water <u>under this section</u>, reasonable preferences shall be given to different uses, in the following order of preference:

(1) Sustaining life;
(2) Maintaining health; and
(3) Increasing wealth.

(d) Water needs shall include domestic and municipal water supply needs, agricultural and industrial water needs, and navigational, recreational, fish and wildlife, and other ecological needs.

(e) The following priorities shall be reserved ~~prior to~~ <u>before</u> allocation <u>under this section</u>:

(1) Domestic and municipal domestic; and
~~(2) Minimum streamflow; and~~
~~(3)~~ <u>(2)</u> Federal water rights.

## 3.4 U.S. Army Corps of Engineers Projects

An updated summary of USACE reservoir projects in the state will be prepared, including a summary of the current allocation status for each project. A narrative will be included that describes the general process required for reallocation of storage.

## 3.5 Interstate Compacts

The surface water availability analyses conducted as part of the Water Plan Update will need to consider Interstate Compacts. Following is a summary of the state's interstate compact agreements.

***Arkansas River Compact***

The Arkansas River Compact is an interstate compact negotiated and signed by the states of Arkansas and Oklahoma. The area involved is "the Arkansas River Basin immediately below the confluence of the Grand-Neosho River with the Arkansas River near Muskogee, Oklahoma, to a point immediately below the confluence of Lee Creek with the Arkansas River near Van Buren, Arkansas, together with the drainage basin of Spavinaw Creek in Arkansas, but excluding that portion of the drainage basin of the Canadian River above Eufaula Dam". The compact has multiple purposes in including to provide for an equitable apportionment of the waters of the Arkansas River between the states of Arkansas and Oklahoma and to promote their orderly development.

The apportionment of the waters of the Arkansas River Basin is defined in Article IV of the compact. This article provides for each state’s rights to develop and use the waters of particular sub-basins, with limitations that the annual yield (as defined in the compact) shall not be depleted beyond specific percentages.

The annual yield of the interstate compact areas is to be determined by December 31 of each year. The flows are calculated on an annual basis and included in the Arkansas Compact Commission report. If depletion of the flows is greater than that specified in the compact, steps are to be taken to assure that 60 percent of the current runoff be delivered to the downstream state.

***Red River Compact***

Arkansas is part of the Red River Compact, which is an interstate compact agreement among the states of Arkansas, Oklahoma, Texas and Louisiana. One purpose of the compact is to promote comity among these participating states by cooperating in the equitable apportionment and development of the water in the river basin as provided by the agreement. There are five defined reaches in the Red River Basin. Various watersheds in Arkansas are included in parts of Reaches II, III and IV (need to include map of compact area and reaches). The area covered by the compact includes essentially all watersheds in Arkansas located south of the Arkansas River watershed boundary.

The compact provides specific criteria for the apportionment of water in each reach to the various states. According to Article II, Section 2.01 of the compact, each affected state may use the water allocated to it by the compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to availability of water in accordance with the apportionments made by the compact.

In the previous update of the AWP, it was recognized that the amount of water required to satisfy compact requirements could not be quantified for multiple reasons. The first reason is that for certain reaches compact compliance is based on a percentage of total runoff in a basin. Runoff, as defined in the compact, includes flow in the streams and water that has been diverted from the streams for other uses. The amount of water that is diverted from streams is not accurately quantified (on a real-time basis), therefore, the amount of runoff in the basins is unknown. Another reason the compact requirements cannot be quantified is because the requirements are based on the previous week's runoff and diversions. Therefore, the compact requirements change from week to week, depending on the runoff available in a basin the previous week. Using average weekly discharge for the period of record would give an idea of the weekly discharges that could be expected at a specific location (where such data is available). However, the compact requirements cannot be determined using these data since the requirements are based on a percentage of the actual weekly runoff for a basin.

# 4.0 Surface Water and Groundwater Quality

The update of the AWP requires updating the quantification of the availability of surface water of useable quality in order to achieve a future that sustainably supports the state's water needs while ensuring the health, safety, and prosperity of the citizens of Arkansas and the protection of fish and wildlife.

This section presents the general methodology by which surface water and groundwater quality will be characterized.

## 4.1 Surface Water Quality

The first element discussed is current water quality, followed by characterization of long-term trends in water quality and water quality changes since the previous Water Plan Update. Finally, characterization of water quality issues is discussed.

### 4.1.1 Current Surface Water Quality

The characterization of water quality outlined in this paper is intended to contribute to quantification of water availability; it is necessary that available water be of a useable quality. The basic approach will be to use existing water quality assessments and studies to characterize current water quality conditions associated with available water quantities being determined for the Water Plan Update. Priorities for both water quality protection and water quality restoration will be identified and characterized. The 2008 state-wide biennial integrated water quality monitoring and assessment report and impaired waters list (303(d) list) prepared by Arkansas Department of Environmental Quality (ADEQ) will be the primary source utilized. This is the most current year for which approved documents are available. The results of the biennial water quality assessment are organized by ADEQ Planning Segments in the report. It should not be difficult to summarize this ADEQ water quality information from the watersheds evaluated for available water supply, and  the Water Resources Planning Regions.

Water supply and demand assessments are presented by sectors of use. Information from the ADEQ biennial water quality assessment and impaired waters list will be presented in terms of the designated uses, similar to the sectors of use being used to evaluate water quantity, that are impaired by water quality conditions. Stream reaches assessed by ADEQ and those with impaired and unimpaired designated uses will be displayed on maps (GIS layers provided by ADEQ and ANRC). In addition, information about ADEQ water quality classification and designated use attainment will be summarized in tables, including the pollutants believed to be causing impairments, and identified sources of those pollutants.

Information on water quality from a number of other sources will also be included. The ANRC nonpoint source priority watersheds for restoration will be identified and discussed in terms of water quality, attainment of designated uses, pollutants, and pollutant sources. Total Maximum Daily Loads (TMDLs) that have been, or are being prepared will also be discussed – this information is available from both ADEQ and the Environmental Protection Agency. Active fish consumption advisories, which affect the recreation use sector, will be identified. Surface water that are subject to the Arkansas Department of Health source water protection program will also be identified. Finally, recent or ongoing surface water quality-related studies (including those conducted by ADEQ, USGS, ANRC, and universities) identified by work group members, that meet plan criteria for scale and data quality will be discussed, as well as active nine-element watershed water quality management plans and watershed organizations working with work group members to address water quality issues.

### 4.1.2 Surface Water Quality Changes

#### *4.1.2.1 Long-term Trends*

The ADEQ and USGS have maintained a number of water quality monitoring stations on streams and in lakes with data records that go back at least to the 1970s. These long-term stations will be identified through evaluation of station periods of record, and discussions with ADEQ and USGS staff. Water quality records for Arkansas lakes and rivers from other sources, such as the USACE and universities, with data for 30 years or more will also be identified. Long-term trends will be evaluated only at water quality stations with 30 years of data or more that are located closest to the sites (i.e. flow gages) where available surface water quantity is being updated (see Figure 5 and Section 3.0). Where available, data from more than one source (e.g. ADEQ and USGS) will be evaluated. The selected water quality stations will be shown on maps.

Time series of long-term data records from the selected stream and lake water quality monitoring stations will be plotted and analyzed for trends. Depending on the character of the data, the trend analysis may consist of simple linear regressions, or seasonal Kendall tests. The water quality parameters that will be evaluated are dissolved oxygen (fish and wildlife use), nutrients (fish and wildlife use), bacteria (domestic and recreation uses), and sediment (fish and wildlife, non-domestic, commercial and industrial, and navigation uses).

Work group member's water quality trend studies of 10 years or longer in waterbodies being evaluated for available water quantity will be identified. Results from any of these studies that meet plan criteria for scale and data quality will be discussed and/or referenced.

#### *4.1.2.2 Changes since Previous Water Plan Update*

Changes in water quality since the previous Water Plan Update will be evaluated based on data from the water quality stations selected for long-term trend analysis, and information reported in the ADEQ 2008 statewide biennial integrated water quality monitoring and assessment report. The baseline year for water quality at the time of the previous Water Plan Update will be 1982. In addition, available work group member studies of water quality changes during the period from 1982 to 2012 that meet plan criteria for scale and data quality will be summarized. Information on possible causes for any observed changes will be gleaned from resources such as TMDLs, ADEQ, 2008 statewide biennial integrated water quality monitoring and assessment report, ANRC nonpoint source management plan, and special studies that meet plan criteria for scale and data quality.

This assessment will also include a discussion of ADEQ listings of water body impairments during the period from 1982 through 2008, provided information on historic 303(d) lists can be obtained from ADEQ. During this period, the water quality assessment and impairment determination methodologies used by ADEQ have evolved and changed. A summary of changes that have occurred in the protocols for assessing and classifying water body water quality since the previous Water Plan Update will be provided. This will include a discussion of the increased importance of assessment of benthic communities.

The number of segments and/or miles of streams and number of lakes listed as impaired for each assessment year will be listed in a table, along with the use(s) impaired, the pollutant(s) identified as causing the impairment, and any source(s) of the pollutant(s) identified. This information may also be presented in graphs. In addition, for each assessment period, the number of new impairments, old or continued impairments, and removed impairments will be identified. Reasons for the removal of stream segments or lakes from the list of impaired water bodies will also be identified. The influence of changes in methodology of impairment determination on the comparability of the numbers and types of water quality impairments reported will be included in the discussion of the impairments over time.

### 4.1.3 Surface Water Quality Issues

#### *4.1.3.1 Existing*

Discussion of existing water quality issues in each Water Resources Planning Region will grow out of the discussion of current water quality. Water quality issues will be categorized in terms of the use sector(s) impacted and whether associated pollutants might be attributed to point and/or nonpoint sources..

Sources for information on water quality issues will include:

- The ADEQ 2008 statewide biennial integrated water quality monitoring and assessment report and 303(d) list
- TMDLs
- The ANRC nonpoint source watershed prioritization
- The ANRC Nonpoint Source Management Plan
- Land use
- Nine-element watershed water quality management plans
- Watershed organizations working with work group members to address water quality
- Natural Resources Conservation Service (NRCS) programs priorities
- The Arkansas Game and Fish Commission (AGFC) wildlife action plan
- Fish consumption advisories

- The Arkansas Department of Health source water protection program
- ADEQ special waterbody classifications
  - Extraordinary Resource Waters
  - Ecologically Sensitive Waters
  - Natural and Scenic Waterways
- The presence of threatened or endangered species
- The presence of wildlife refuges
- U.S. Fish and Wildlife programs priorities
- Arkansas Natural Heritage programs priorities

#### *4.1.3.2 Changes Since Previous Water Plan Update*

Surface water quality issues identified for the Water Resources Planning Region(s) in the previous Water Plan Update will be summarized and compared to the existing issues discussed above. Drivers of any changes in surface water quality issues will be identified and discussed. In addition, if any issues identified in the previous Water Plan Update are still considered an issue, reasons behind this situation will also be identified and discussed.

#### *4.1.3.3 Emerging*

Existing information known to work group members will be reviewed to identify any emerging water quality issues that could affect surface water availability over the next five years. These issues will be discussed in terms of the water resources and the use sectors that could be affected.

## 4.2 Groundwater Quality

Groundwater Quality is being assessed as part of the Aquifers of Arkansas Study described in Section 2.1.3 of this memorandum. This information will be included in the AWP Update. As part of this study water quality data from approximately 8,000 groundwater sites in Arkansas will be used to produce statistical analyses and spatial distribution maps for chemical constituents associated with 16 aquifer systems in Arkansas. Approximately 7,000 water quality sites will be extracted from the ANRC and USGS database. Data will be collected irrespective of dates and included major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate) and selected trace metals (iron, manganese, and arsenic). Approximately 1,000 water quality sites will be extracted from the ADEQ database. The ADEQ in Little Rock, Arkansas, operates a water quality laboratory; groundwater samples collected by the ADEQ Water Division are analyzed by U.S. Environmental Protection Agency (USEPA) approved methods with data stored at their Little Rock office. The ADEQ additionally has participated and currently participates in the USGS Standard Reference Sample project for numerous years, which evaluates and improves the performance of participating laboratories.

The major physiographic provinces of the state were reviewed and based on this review water quality information will be summarized for 16 aquifers in the state (Table 2). Problems arose at times in the strict assignment of aquifers by the physiographic provinces. For example, an original outline for eastern and southern Arkansas into the Mississippi Alluvial Plain and West Gulf Coastal Plain sections would have resulted in several aquifers, including the Sparta, Cockfield, and other aquifers, being discussed in two separate sections as their extent overlaps both provinces. As such, the higher order Coastal Plain Province will be used as the basis for assignment of most aquifers in this part of the state. Additionally, the west half of the state resides within the Interior Highlands Division, which contains two provinces, each with two associated sections: the Ozarks Plateaus Province (Springfield-Salem Plateaus and Boston Mountains sections) and the Ouachita Province (Arkansas Valley and Ouachita Mountains sections). The Atoka Formation, which is a well-known formation in the Boston Mountains and hydrologically part of the Western Interior Plains confining system, also extends into the Ouachita Mountains. For this analysis, all formations that are found in both the Boston Mountains and Ouachita Mountains sections will be incorporated with the Ouachita Mountains where south of the Arkansas River and with the Boston Mountains where north of the river.

**Table 2 Number of groundwater sites with groundwater quality data for all aquifers in Arkansas**

| Aquifer System | Physiographic Province | Physiographic Section | Water quality Sites |
|---|---|---|---|
| Coastal Plain Alluvium | Coastal Plain | Mississippi Alluvial and West Gulf Coastal Plain | 4,061 |
| Sparta Formation | | | 1,626 |
| Jackson Group | | | 68 |
| Cockfield Formation | | | 257 |
| Carrizo Sand | | | 12 |
| Cane River Formation | | | 45 |
| Wilcox Formation | | | 170 |
| Nacatoch Sand | | | 143 |
| Tokio Formation | | West Gulf Coastal Plain | 165 |
| Trinity Formation | | | 38 |
| Ozan Formation | | | 14 |
| Western Interior Plains Confining System | Ozark Plateaus | Boston Mountains | 287 |
| Springfield Plateau | | Springfield-Salem Plateaus | 95 |
| Ozark Plateau | | | 131 |
| Ouachita Mountains | Ouachita Province | Ouachita Mountains | 162 |
| Arkansas River Valley Alluvium | | Arkansas Valley | 680 |

General water quality for all aquifer systems will be summarized as part of the ground water quality assessment. Water quality requirements can vary widely depending on the use, rather it be industrial, municipal supply, irrigation or other uses. In assessing water quality, water quality data associated primarily with drinking water use will be compared to the USEPA drinking water standards (USEPA, 2009). These standards include a wide array of inorganic and organic constituents. Because only a limited set of inorganic constituents will be reviewed for this assessment, drinking water standards will be discussed only for these constituents. The Federal drinking water standards include maximum contaminant levels (MCLs) that are enforceable standards (for municipal and community supply systems) and are based on adverse health effects, health advisories that are nonregulatory estimates of acceptable drinking water levels for a chemical substance based on health effects information (often leads to development of an MCL), and secondary drinking water regulations that are non-enforceable Federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water (USEPA, 2009). Primary drinking water standards, health advisories, and secondary drinking water regulations for the constituents reviewed in this report are found in Table 3. More detailed information can be found in the above-referenced 2009 publication[7].

[7] http://water.epa.gov/drink/contaminants/upload/mcl-2.pdf

**Table 3 Water Quality Constituents to be Considered in Groundwater Quality Assessment**

| Major Inorganic Chemistry | | Trace Metals | Field Parameters |
|---|---|---|---|
| Calcium | Sodium | Iron | pH |
| Magnesium | Potassium | Manganese | Specific Conductance |
| Chloride | Sulfate | Arsenic | |
| Bicarbonate | Silica | | |
| Dissolved Solids | Nitrate | | |
| Hardness | | | |

# 5.0 Fish and Wildlife Flows

As discussed in Section 3.0 above, fish and wildlife flows are considered in determining safe yield, excess surface water, and allocation during shortage.

In the 1990 Water Plan, the calculation of safe yield recognized minimum streamflow for fish and wildlife at 10 percent of the average seasonal flow for the lowest flow season (July-October). For excess surface water calculations, the Arkansas Method was used to determine seasonal fish and wildlife streamflows. During allocation or a time of shortage, additional consideration of minimum streamflow criteria would be established on a site-specific basis.

Minimum streamflow is defined as the lowest daily mean discharge that will satisfy minimum instream flow requirements. Minimum streamflows are established for the purpose of protecting instream flow needs, particularly during low-flow conditions which may occur naturally or because of significant water withdrawal from the streams. The minimum streamflow also represents a critical low flow condition below which some minimum instream need will not be met. The minimum streamflow is not a target level or a flow that can be maintained for an extended period of time without serious environmental consequences. Because of the critical low flow conditions which may exist at the minimum streamflow level, allocation of water based on the establishment of water-use priorities should be in effect long before this point is reached. Allocation of water should help to maintain streamflow above the established minimum discharge.

The Instream Flow Council has identified four levels of instream flow or fish and wildlife flow protection that are summarized in Table 4 below.[8] The riverine components referenced in the table below include hydrology, biology, geomorphology, water quality, and connectivity.

**Table 4 Level of Flow Protection as Identified by Instream Flow Council**

| Level of Protection | Definition |
|---|---|
| Full instream flow protection | No allowances for additional water withdrawals and/or flow manipulations would be |

[8] 2009. International Instream Flow Program Initiative: A Status Report of State and Provincial Fish and Wildlife Agency Instream Flow Activities and Strategies for the Future. Instream Flow Council. http://www.instreamflowcouncil.org/docs/IIFPI-final-report-with-covers.pdf

| | |
|---|---|
| | permitted for streams in this category. Management is essentially confined to a hands-off strategy. |
| Comprehensive ecologically based instream flow management | Flow recommendation based on all five riverine components that varies with the season of year (intra-annual) and with the water supply or watershed condition (inter-annual). |
| Partial ecologically based instream flow management | Flow requirements are determined on the basis of one or more of the five riverine components. |
| Threshold level instream flow protection | A minimum, or baseline, instream flow protection that results in considerably less than the average natural flow remaining in the channel. |

Comparing the 1990 Water Plan with Table 4, the minimum flow used for safe yield calculations most closely correlates with threshold level protection. The safe yield calculation incorporates a modified Tennant method or 10 percent of average seasonal flow to establish a minimum streamflow. Excess streamflow calculations utilized the Arkansas Method, which considered hydrology, biology, geomorphology, and water quality.[9] Based on review of the Arkansas Method, its level of protection most closely correlates to partial ecologically based instream flow management and comprehensive ecologically based instream flow management as described in Table 4.

For allocations during shortage, minimum streamflows are developed on a site-specific basis, given that localized conditions can vary widely within an ecoregion or hydrologic basin. Before establishing minimum streamflows for any stream, ANRC must first notify and accept comments from the Arkansas Game and Fish Commission, the Arkansas Pollution Control and Ecology Commission, and any other interested state boards and commissions.

In 2009, the Commission adopted minimum streamflow rules for the main stem of the White River.[10] In 1990, the Commission adopted minimum streamflow rules for the mainstem of the Arkansas River.

A Fish and Wildlife Flows Subgroup of the Water Availability Work Group has met three times in person and once via conference call to discuss fish and wildlife flow and the AWP Update. Based on these discussions, the group has proposed the following next steps for addressing fish and wildlife flows:

- For excess surface water calculations that will be completed for the AWP Update, the Arkansas Method will be utilized. These calculations will be required to be completed by fall of 2013.

- The Subgroup will evaluate alternative methods for calculating or establishing minimum streamflows as described under existing procedures. If potential improvements to current

[9] 1987. THE STATUS OF THE INSTREAM FLOW ISSUE IN ARKANSAS, 1987. Filipek, S.P., W.E. Keith, and J. Giese. Proceedings Arkansas Academy off Science, Vol.41, 1987.
[10] 2011. Water Law in Arkansas. Arkansas Natural Resources Commission.

methodologies are identified, the group will provide recommendations on how such improvements could be incorporated when establishing minimum streamflows in the future.

Specifically the group will:

- Develop resource mapping based on available GIS datasets from AGFC and Arkansas Natural Heritage Commission that provide an overview of the state's stream and lake based ecological resources.
- Evaluate the Arkansas Method to assess whether it adequate for use excess surface water calculations in the future and recommend other methodologies if appropriate.
- Evaluate and assess methods for establishing minimum instream flows or threshold protection levels as identified in Table 2 that could be applied during allocation during time of shortage or in future estimates of safe yield.
- Develop recommendations for improving implementation of non-riparian permits that that consider fish and wildlife flow issues associated with scale and seasonality.
- Potentially "pilot" implementation of other fish and wildlife methods in areas of the state where surface water availability has been a concern.

A workshop was held on for March 27, 2013 that addressed some of the next steps described above. The meeting summary will be provided to the Water Supply Availability Work Group members and the distributed through the Water Plan Update website.

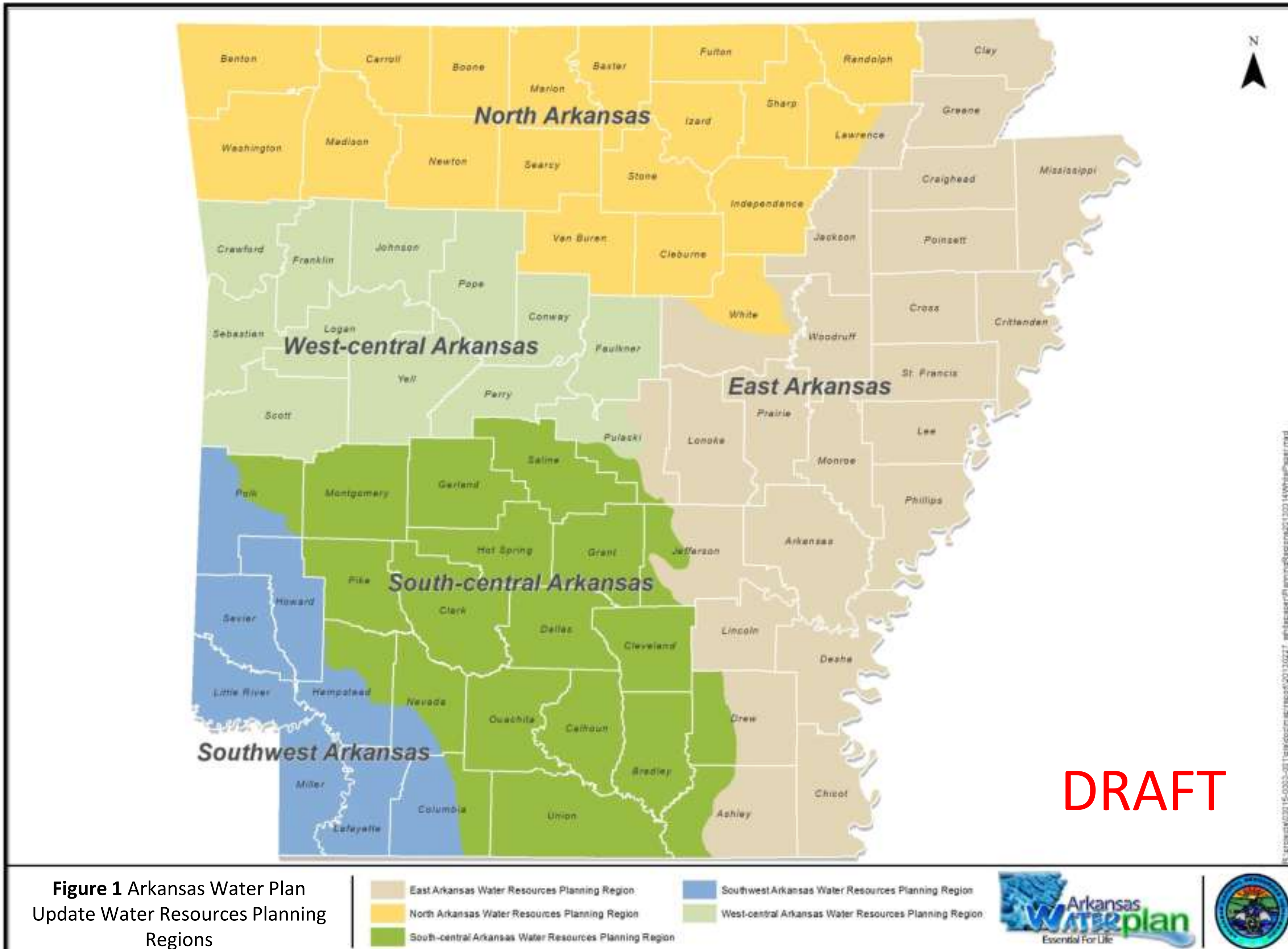


**Figure 1** Arkansas Water Plan Update Water Resources Planning Regions

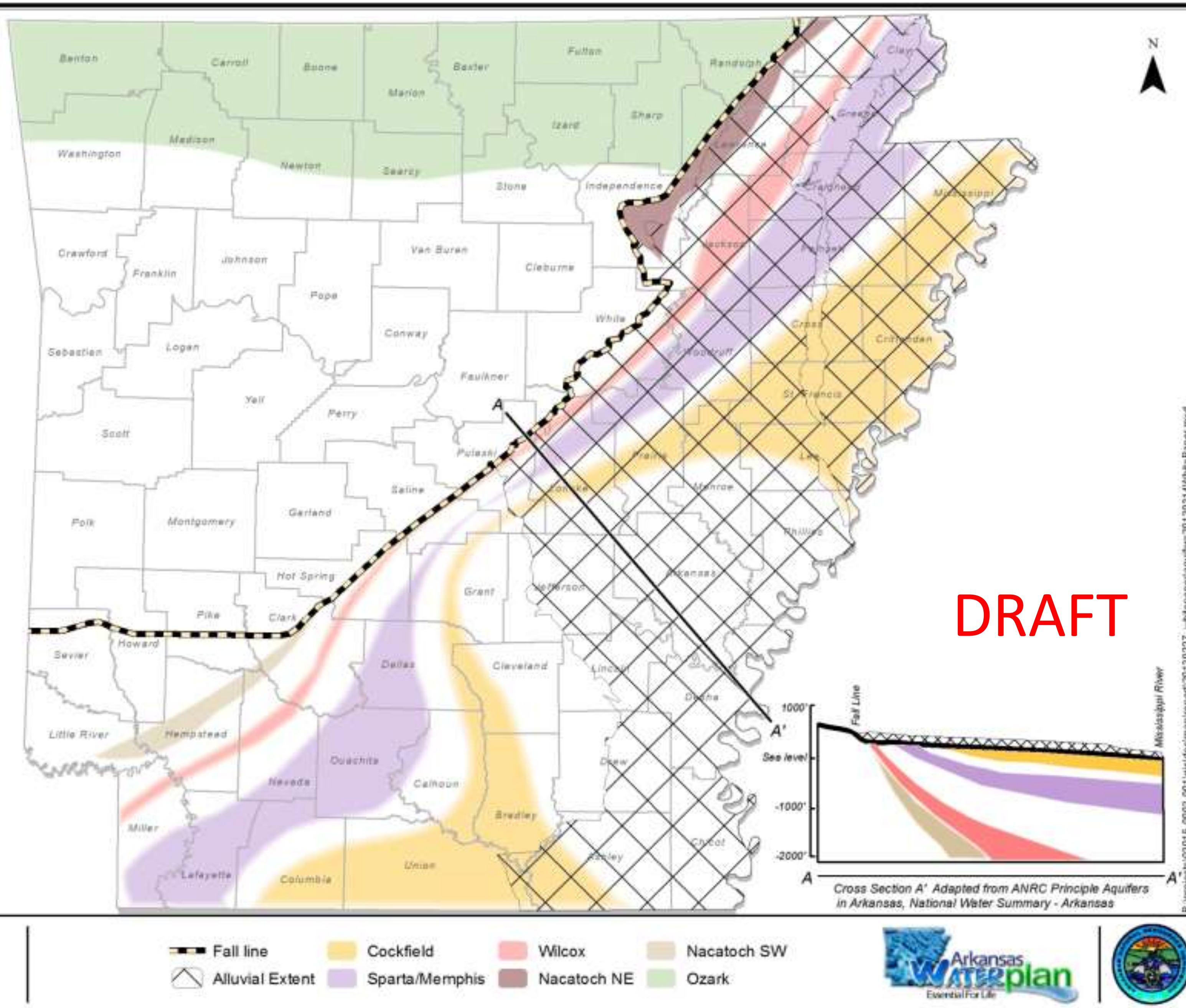


**Figure 2** Major Aquifers in Arkansas

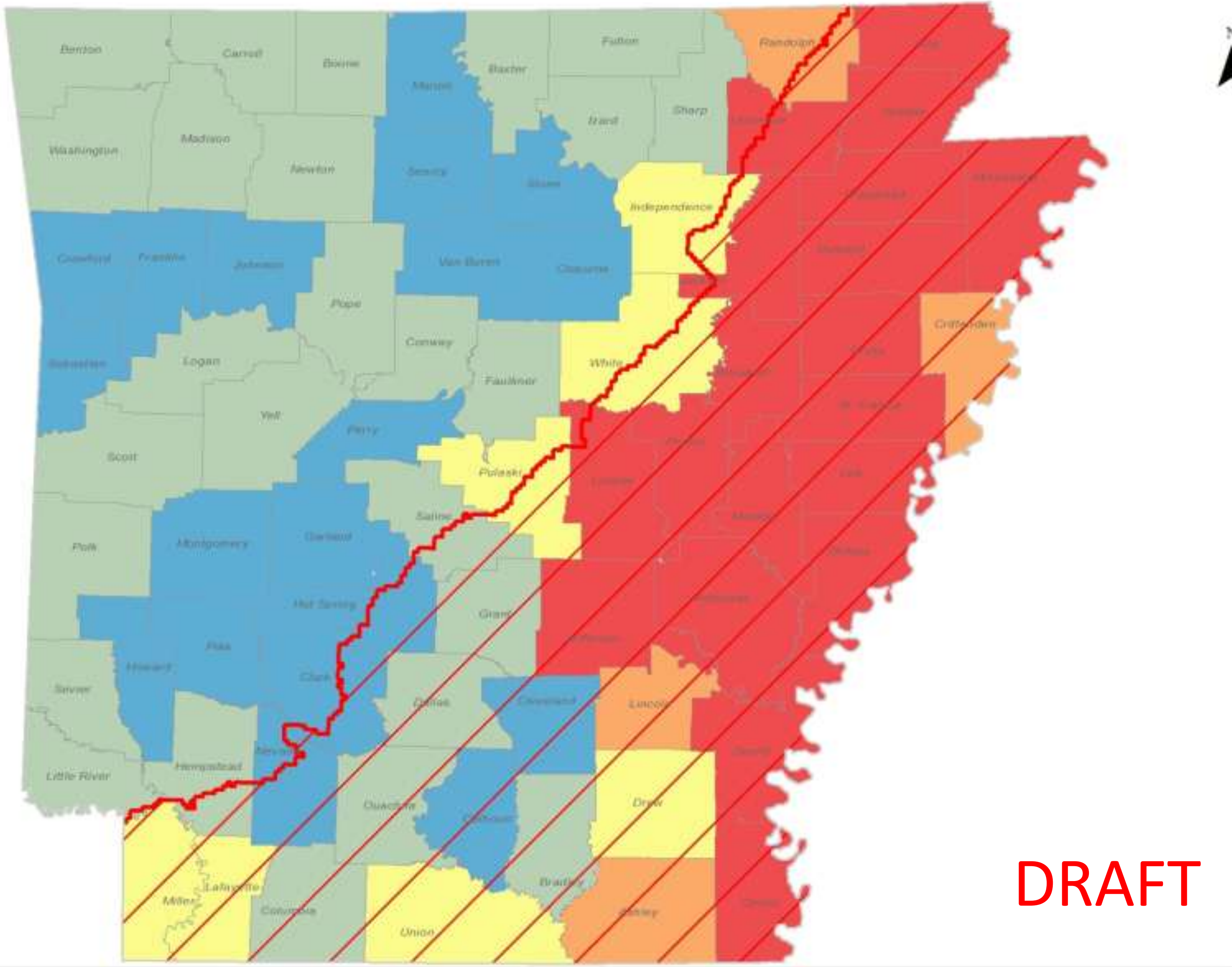


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**Figure 3** MERAS Model Extent and Groundwater Use

MERAS Model Extent

**Groundwater Use in MGD**

- < 1
- 1 - 10
- 10 - 100
- 100 - 200
- > 200

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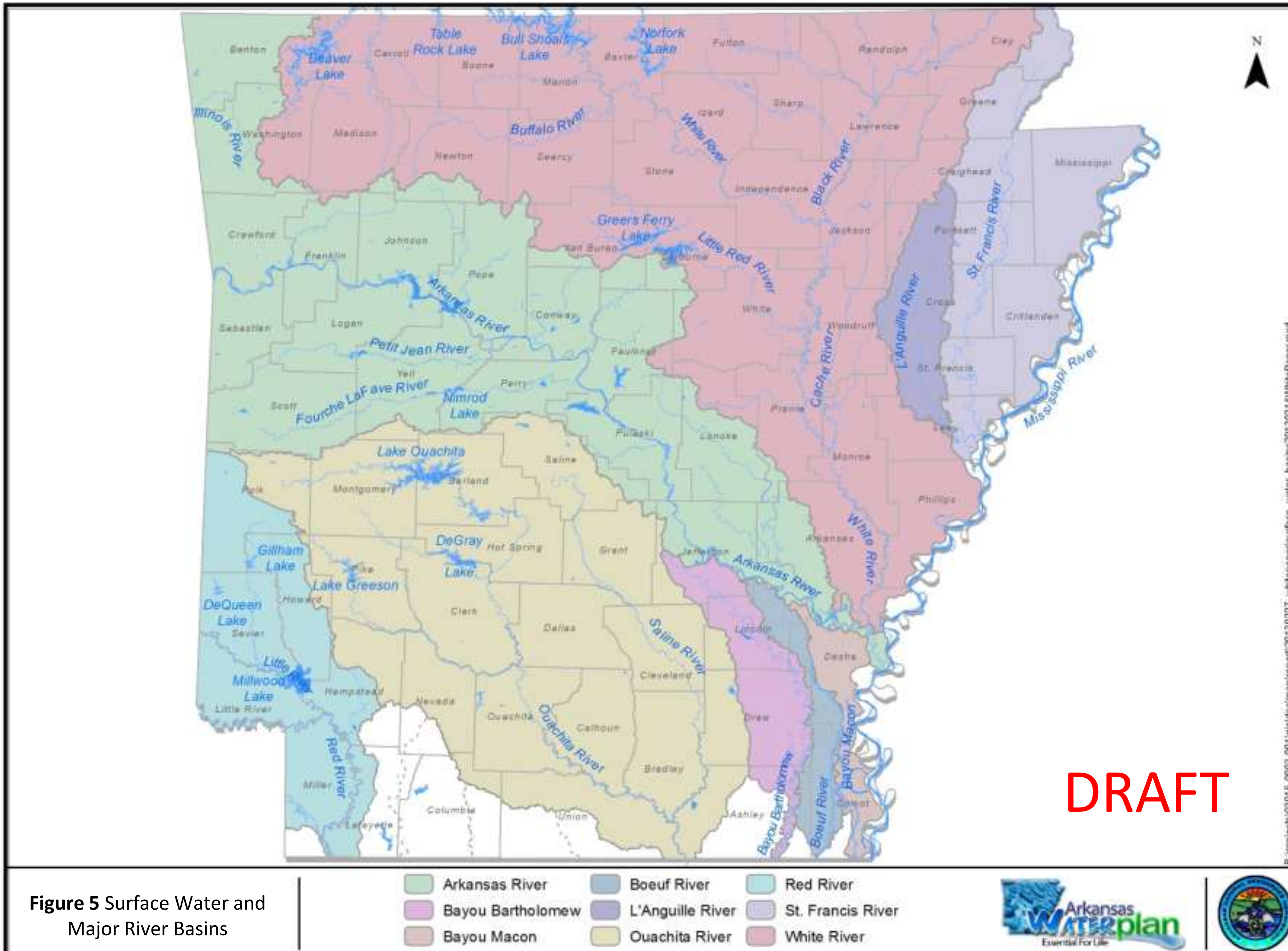


**Figure 5** Surface Water and Major River Basins