Arkansas Groundwater Summit Proceedings

June 21-22, 2022
Lonoke, AR

NATURAL RESOURCES
DIVISION

Arkansas Department of Agriculture
Natural Resources Division

10421 West Markham Street
Little Rock, AR 72205

Asa Hutchinson
Governor

Wes Ward
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Arkansas Department of Agriculture
Natural Resources Division
Groundwater Protection and Management Section Staff

Blake Forrest, P.G.	**Geology Supervisor**
Jacob Harvey	**Constructor Inspector**
Jackie Broach	**Administrative Analyst**
Mike Guess	**Statistician**
Christy Steward	**Environmental Program Coordinator**
Myles Morton	**Engineer Technician**
Corbin Cannon	**Professional Geologist**

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Table of Contents

List of Appendices

November 4, 2022

PROCEEDINGS OF THE 2022 ARKANSAS GROUNDWATER SUMMIT
June 21-22, 2022

1.0 Introduction

The 2014 Arkansas Water Plan (AWP) was developed as an update to previous water use plans (1975 and 1990) to accommodate emerging issues of supply and quality as well as forecasting water demands. On June 21 and 22, 2022, the Arkansas Conservation Partnership, in conjunction with the Arkansas Association of Conservation Districts and the Arkansas Department of Agriculture Natural Resources Division (NRD), conducted the Arkansas Groundwater Summit for those involved in studying groundwater resources in Arkansas as well as those who work directly with producers in the state to update each other on how they are currently working within the 2014 AWP guidelines. Those in attendance consisted of the following:

- Agricultural Council of Arkansas
- Arkansas Association of Conservation Districts
    - Boone County Conservation District
    - Lee County Conservation District
- Arkansas Economic Development Institute
- Arkansas Game and Fish Commission
- Arkansas Geological Survey
- Arkansas Department of Agriculture Natural Resources Division (NRD)
- Arkansas Department of Energy and Environment Division of Environmental Quality (DEQ)
- Bayou Meto Water Management District
- Delta Plastics
- Ducks Unlimited
- FTN Associates, Ltd.
- Garver Engineering
- Grand Prairie Farming & Water Company
- Mississippi Department of Environmental Quality
- The Nature Conservancy
- Natural State Consulting
- Riceland Foods

- United States Army Corps of Engineers (USACE)
- United States Department of Agriculture (USDA)
  - Agricultural Research Service
  - Farm Service Agency
  - Natural Resources Conservation Service (NRCS)
- United States Geological Survey, Lower Mississippi-Gulf (USGS LMG) Water Science Center
- University of Arkansas
  - Department of Geosciences (Hydrology)
  - Division of Agriculture
- University of Arkansas at Little Rock
- University of Arkansas at Pine Bluff
- University of Memphis
- USA Rice
- White River Irrigation District

On the first day of the summit, various local, state, and federal agencies provided overviews of their current and future research, monitoring and water management activities in the critical groundwater area of eastern Arkansas (where the Sparta and Mississippi River Valley alluvial aquifers exist). Panel discussions were held with various members of irrigation districts, industry, and conservation districts. A printout of the agenda for the summit is provided in Appendix A. A summary of each presentation and panel discussion is presented in Sections 2 - 4, and printouts of presentation slides are shown in Appendix B (technical presentations), Appendix C (current projects panel 1), and Appendix D (current projects panel 2).

On the second day of the summit, attendees were divided into two facilitated discussion groups to brainstorm ideas related to three questions and to pursue consensus on next steps. The session ended with each breakout group summarizing their discussion and identifying consensus recommendations. These discussions and recommendations are summarized in Section 5.

2.0 Technical Presentations (Day 1)

2.1 2021 Arkansas Groundwater Protection and Management Report – Blake Forrest, NRD

Groundwater issues in the state of Arkansas were recognized by the Legislature with the passing of the Groundwater Protection and Management Act of 1991 (15-22-9). This legislation accomplished the following:

i. Ordered the establishment of a comprehensive groundwater protection program that included the following:
   a. Assessment and monitoring of groundwater resources,
   b. Establishment of groundwater criteria and standards, and
   c. Management of groundwater, including issuance of water rights, protection of groundwater quality, and establishment of an education and information program.

ii. Created the Critical Groundwater Area designation, which functions as follows:
   a. Applies to areas identified by the NRD to have groundwater depletion or quality degradation, and
   b. Serves as a non-regulatory designation that seeks to increase conservation efforts through expanded benefits through various state and federal programs.

NRD produces a groundwater protection and management report annually in accordance with this act. As identified by NRD, critical groundwater areas include the Grand Prairie, Cache, and Boeuf-Tensas study areas, as well as portions of south Arkansas. These areas are within the Mississippi River Valley alluvial aquifer (MRVAA) and Sparta aquifer, where intense groundwater withdrawals occur in the state. NRD has also installed monitoring wells in order to study aquifers in these areas (35 MRVAA, 6 Sparta, 1 Cockfield, 2 Boone, and 1 Roubidoux).

NRD ultimately compiles data obtained from the monitoring wells and publishes an annual groundwater protection report. Emphasis is put on the MRVAA and Sparta aquifer due to intensive groundwater use. Data is collected in the spring (pre-irrigation) and fall (post-irrigation) to determine highest and lowest levels during the year. Of the 1,169 water level measurements collected across the state in 2021, 828 were in the MRVAA and Sparta aquifer (456 in the spring and 372 in the fall). Maps showing 2021 measurements of water levels and depth to water (distance to water level from the ground surface) highlight the cones of depression in the Cache and Grand Prairie study areas; these are consistent with previous years' maps. These cones of depression correspond well with hydrographs from wells in these study areas, where declines are shown over time since approximately 2004. Hydrographs for two wells in the Grand Prairie study area, however, indicate a slight rise in groundwater levels since 2015.

The groundwater report also contains a percent saturated map (calculated using water levels and aquifer thickness), which indicates that a cluster of wells in Prairie County, Arkansas, is now below 30% saturated. Wells in the Cache region (specifically in Cross County, Arkansas) are also less than 30% saturated. Maps not included in the report indicate that groundwater level declines started in the 1970s, with the greatest declines in Arkansas County. By the 1990s, the first significant cone of depression appeared in the Cache study area. By 2000, the cone of depression in the Grand Prairie expanded and the Cache cone of depression expanded considerably more.

Efforts to collect data in the areas of interest have been sporadic over time, but collaborations with other agencies have allowed NRD to facilitate more data collection. The table below summarizes average water level changes for various time periods in the MRVAA. All of the average water levels rose over the 5 and 10-year periods, although there were many individual wells where water levels declined.

Study area(s) within MRVAA	Time period	Number of wells*	Average change in water level (ft)	Number of wells showing decline
All	Spring 2021 - Fall 2021	372	-2.80	328
	2020 - 2021	410	-0.64	238
	2016 - 2021	278	+1.43	85
	2011 - 2021	210	+1.05	80
Cache	2011 - 2021	59	+0.91	26
Grand Prairie	2011 - 2021	80	+0.82	34
St. Francis	2011 - 2021	28	+2.24	2
Boeuf-Tensas	2011 - 2021	41	+0.94	17

* Includes only the wells with data at beginning and end of time period.

Sparta Aquifer

Sampling efforts in the Sparta aquifer included a total of 549 water level measurements in 2021, with 242 measurements collected in the spring. Measurements were taken primarily in the South Arkansas and Grand Prairie study areas; data is sparse in the Cache, St. Francis, and Boeuf-Tensas study areas. The 2021 monitoring data shows significant cones of depression in the South Arkansas study area and the Grand Prairie study area (primarily Jefferson and Arkansas counties).

The depth to water map shows depressed water levels in Arkansas and Prairie counties and highlights the historical cone of depression in Jefferson County, which extends to Lincoln, Drew, and Cleveland counties. Union and Columbia counties historically have the worst drawdown in the state; however, hydrographs within the cone of depression show significant increases in water levels over the last 10+ years due to the Ouachita River diversion program. This program helped industries that were using only Sparta water to switch to surface water, and the aquifer has since recovered significantly since the program began in the early 2000s. In the Grand Prairie study area, hydrographs for several wells indicate that the depth to water has generally leveled off in recent years.

The table below summarizes average water level changes for various time periods in the Sparta aquifer. All of the average water levels rose except in the Cache study area.

Study area(s) within Sparta aquifer	Time period	Number of wells*	Average change in water level (ft)	Number of wells showing decline
All	2020 - 2021	139	+0.58	64
	2016 - 2021	155	+6.55	39
	2011 - 2021	182	+6.59	51
South Arkansas	2011 - 2021	52	+12.31	10
Grand Prairie	2011 - 2021	62	+7.00	18
Cache	2011 - 2021	22	-3.50	19
St. Francis	2011 - 2021	7	+3.08	0

* Includes only the wells with data at beginning and end of time period.

NRD established its Water-Use Registration Program in 1985 as part of its efforts for groundwater management. There are over 55,000 surface water and groundwater withdrawal sites. Non-domestic users are required to report water usage for each well that has withdrawals of at least 50,000 gallons per day (35 gallons per minute) and surface water users that withdraw 1 acre-foot or more also have to report. These data are reported annually and stored in a site-specific database. The most recent data from 2018 indicated that 6,517 million gallons per day (MGD) of water from the MRVAA and 68.7 MGD from the Sparta were being used for irrigation. Water use in the MRVAA (3,374 MGD) exceeds sustainable yields and irrigation water use in the Sparta accounts for 78% of the estimated sustainable yield of 87 MGD (this does not include industrial and municipal uses). This indicates that users are likely withdrawing more than what is sustainable.

NRD has a Groundwater Conservation Tax Credit Program where state income tax credits are issued for the completion of on-farm groundwater conservation projects. These projects can include reservoirs, land leveling, surface water conversion, and water meters. Producers can apply for these tax credits at conservation district county offices. In 2021, 75 projects were approved that included 15 impoundments, 43 land leveling projects, 10 surface water conversions, and 7 water meter installations. These projects tended to be in the Cache and St. Francis study areas with a few in the Grand Prairie study area.

2.2 System-Scale Science to Support Water Resources: the USGS Mississippi Alluvial Plain (MAP) Project - Wade Kress and Drew Westerman, USGS LMG Water Science Center

The USGS LMG Water Science Center maintains the following real-time sites in Arkansas: surface water (194), groundwater (36), and water quality (48 surface water and 9 groundwater). These sites are part of a city, state, and federal effort to provide data for anyone who wants to use it. The Lower Mississippi-Gulf (LMG) Water Science Center (including Arkansas, Tennessee, Mississippi, Alabama, and Louisiana) operates approximately 90 real-time water level gages.

The LMG has approximately 7,000 surface water sites and 50,000 groundwater sites in Arkansas alone that are reported by users through the USGS water use reporting tool online. These data are primarily located in the Mississippi Alluvial Plain (MAP), primarily for irrigation uses. Real-time, quality data is of the utmost importance for predictive models to answer questions of sustainability and availability. One study within the MRVAA used data available from summer of 2021 and compared it to data collected in spring of 2022 to see how much water levels had rebounded since the previous irrigation season. One use of data is the USGS StreamStats application that can calculate peak flow statistics, low flow statistics, or other hydrologic values in a specific watershed.

The LMG is currently studying the MAP from a system-scale perspective where their approach includes team-based workflows, an integrated suite of models for decision support, and iterative and co-produced models. The MAP project has component modeling teams working on and developing the following models: hydrogeologic framework, water use, water budget, surface water, groundwater level, and water quality. Each of these component models are discussed briefly below. Each of these teams are responsible for data (observation networks and mapping), modeling, and product development. Each team also provides data to support a "living" hydrologic model for decision support (MODFLOW 6 groundwater flow model). These data are used by the regional Mississippi Embayment model as well as inset models for the Grand Prairie and Cache study areas of Arkansas, Mississippi delta region, and Shellmound, Mississippi. These models are iterative in that the USGS is creating a monitoring, mapping, modeling, and forecasting data worth cycle. They are also co-produced because these models require USGS to work alongside partners and stakeholders in each component.

The water budget model used for the MAP project is the Soil Water Balance (SWB). The SWB model is a physics-based model that uses land use, soils, flow direction, and climate data. It uses the Thornthwaite-Mather method to determine how much water infiltrates into the soil vs direct runoff, how much of the water makes it into plants, what the plants' water needs are, how much water is available, and how much is excess that becomes deep percolation (net infiltration) below the rooting zone. SWB can be run at various horizontal spatial resolutions to provide data for large regional models (1-km grid for the Mississippi Embayment) as well as high-resolution inset models (study in Shellmound, Mississippi to evaluate groundwater transfer and injections). The first version of the SWB for MAP was developed for the Mississippi Embayment and was then expanded to the Gulf Coast (and incorporated PEST ++ in model calibration) for version 2. The model provides daily estimates of evapotranspiration, runoff, net infiltration, and estimated irrigation. Daily water budget data can be aggregated to monthly values for input in groundwater flow models.

The water use model utilizes data from an extensive network of flow meters that are used to evaluate aquaculture and irrigation water use. The Mississippi voluntary metering network provides water use data for more than 2000 flow meters in the Delta. An extensive network also exists that comprises almost 100 continuous meters in Missouri, Arkansas, Mississippi, Tennessee, and Louisiana that is supported by NRD, MDEQ, Louisiana Department of Transportation and Development (LA DOTD), and the MAP project. These data are used to develop crop-specific irrigation sites. The MAP water use model is called the Aquaculture and Irrigation Water Use Model (AIWUM). The first version is a process-based model, scripted in Python, developed to replicate a GIS-based approach. AIWUM is also a grid-based model that provides estimates of aquaculture and irrigation water use. AIWUM 1.0 uses cropland data, crop-specific irrigation rates, and Moderate Resolution Imaging Spectroradiometer (MODIS) irrigated lands data. The second version of AIWUM is a random forest machine-learning model. This version of AIWUM allows USGS to take advantage of continuous water use data and climate variables. This model is currently in the early stages of development, but it is already able to produce results that are comparable to AIWUM 1.0.

The surface water model, also called the Mississippi Embayment Regional Aquifer Study (MERAS) model, uses a stream flow routing package in MODFLOW to route surface water through the model. Streams are a key source of leakage to the alluvial aquifer and to improve the groundwater model as well as the understanding of stream gain and loss in important areas, there is a need to enhance the surface water representation in the MERAS model. A few challenges of surface water modeling include: simple rainfall-runoff models tend to perform poorly in low-gradient systems (e.g., the MAP) and detailed physics-based routing tends to be too computationally intensive for decades of simulation. The MAP team modeled surface water flows using a random forest machine-learning algorithm. This model provides monthly estimates of discharge at any gaged or non-gaged locations within the model domain. Surface water is then routed using the MODFLOW stream-flow routing (SFR) package. The stream network has greatly enhanced with this algorithm and has improved USGS's ability to evaluate stream flow gains and losses in the MERAS model.

For the water quality model, as part of the MAP project, a partnership has been developed with the USGS National Water Quality program to develop a machine-learning model for the Mississippi Embayment. The model has used water quality datasets from state, federal, and local cooperators to develop a boosted regression tree (BRT) machine-learning model as well as create continuous water quality predictions of arsenic, chloride, manganese, and specific conductance across the MRVAA and the middle and lower Claiborne aquifers. The MAP team extended this machine learning model to make continuous water quality predictions of specific conductance across the MAP at multiple depths. This iteration of the model incorporated data from airborne geophysical surveys; the surveys improved model performance at depth. Model outputs can be used to determine where water resources may be limited for irrigation and drinking water uses due to elevated salinity.

The MAP groundwater modeling team has developed a cubist machine-learning model to predict monthly mean groundwater levels relatively quickly and to quantify uncertainty without sophisticated, time-intensive groundwater flow models. The model output is used to evaluate status and trends of the aquifer; it is also used to evaluate monitoring networks and to develop potentiometric surface maps. Groundwater levels for the MAP are collected by multiple local, state, and federal agencies. Frequency of data collection ranges from annual, semi-annual, quarterly, to continuous. The statistical model framework uses discrete and continuous water level data. The USGS was able to provide feedback to each group (i.e., state, local, and federal agencies) in order to optimize temporal frequency of groundwater level data collection in the MAP. This was to determine a target window of time to collect maximum (recovery) and minimum (drawdown) water levels in each state. The machine-learning model is also able to provide mapping products that help to quantify status and trends of the aquifer and evaluate the groundwater flow model.

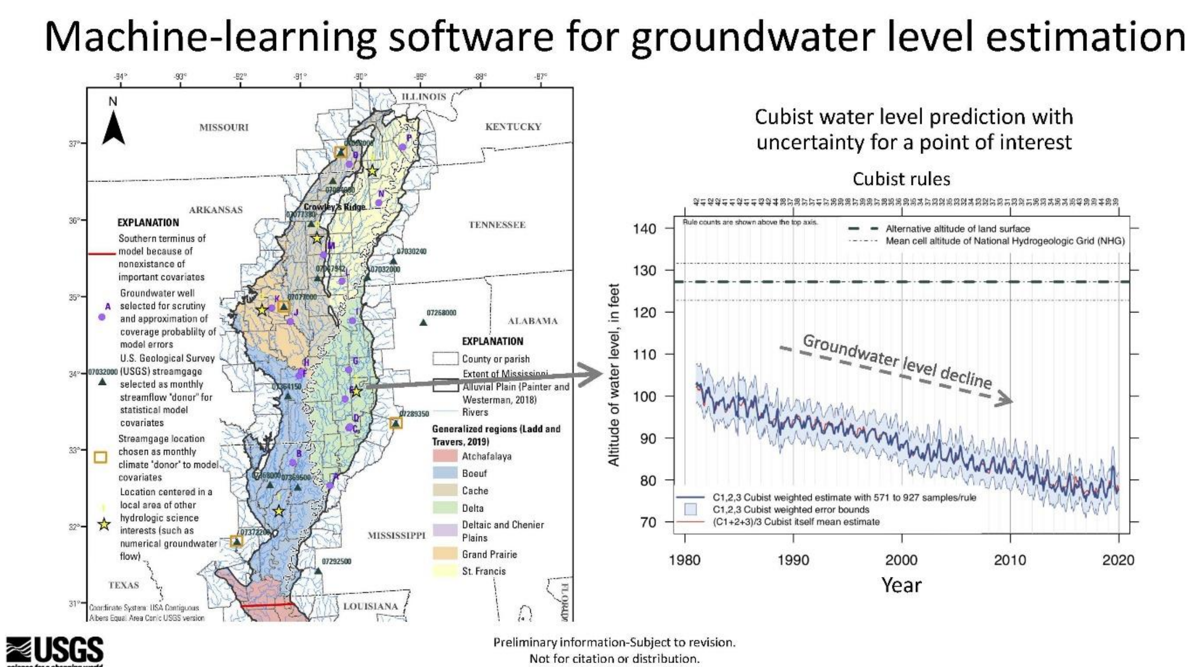
The MAP hydrogeologic framework model improves previous models by utilizing large-scale airborne geophysical surveys. In 2018, the USGS performed a high-resolution survey in Shellmound, Mississippi, to support a managed aquifer recharge project. From 2018 to 2020, USGS also collected data using helicopter (resolve) and fixed wing (tempest) aircraft throughout the MAP study area. This area includes Cape Girardeau, Missouri, to the confluence of the Red River in Louisiana. In 2021, the USGS collected data along selected rivers and along the Mississippi River levee system to evaluate groundwater-surface water interaction. In 2021, the USGS extended data collection to the Gulf of Mexico as well as to the east and west to cover the recharge zones for the Sparta aquifer. They also mapped the Chicot aquifer system for a project funded by the LA DOTD.

The airborne systems collect three types of data: radiometric (measures the upper 20-30 cm), resistivity (from 1-300 m below land surface), and magnetic (used to map deep basement structure). The USGS found that the shallow resistivity layers correlate with surficial geology, intermediate depths were found to be mostly resistive within the MRVAA, and deep resistivity layers correlate well with subcropping tertiary formations. The derived products from these surveys for hydrologic model input include base MRVAA elevation, confining unit thickness and extent, river connectivity, and base aquifer connectivity. Resistivity data has also created facies classes for the MAP.

The decision support model that USGS created integrates groundwater flow models and economic valuation. This model provides updated tools for water resource managers and other stakeholders to quantify the groundwater resources and plan responses to future conditions (development, conservation, mitigation, climate change, etc.). This model also incorporates recent modeling advances (SWB, SFRmaker, MODFLOW 6, and PEST++iES) and new data and analyses from the MAP project (airborne electromagnetic [AEM] surveys, waterborne streambed electrical resistivity surveys, water use metering and estimation, machine learning estimation of stream inflows, and SWB model of the Mississippi Embayment). The model itself is built through a series of scripts where each of the teams provides annual data updates and that data is pulled through the workflow. This allows the MAP project to quickly update the regional-scale model or inset models. The regional model for the Mississippi Embayment (1 km resolution and three layers) is used to provide boundary conditions while the inset models focus on specific areas (500 m resolution and approximately 20 layers). The MAP project has also better automated and harmonized inset model construction by developing and using MODFLOW setup and other Python tools.

The AEM surveys have produced approximately 80,000+ line- kilometers of frequency and time-domain data, which helps investigate both upper 2-5 meters and depths of up to 300 meters. The resistivity data can ultimately be used as a proxy for hydraulic conductivity, which helps determine aquifer properties. The challenges with modeling this data include the following: (1) more data means more model cells, (2) data does not provide absolute values of resistivity (K), (3) large quantities of data are daunting to incorporate into models, and (4) boundary conditions are very important. The AEM data, however, is suitable for mapping discrete structures such as layers in aquifers (e.g., confining units). Another advance to the model is the SWB, which provides physics-based estimates of runoff in addition to net infiltration. The SWB can also be used to estimate water use based on crop demand.

The figure below shows an example of groundwater level decline and a component of the modeling that is used to simulate groundwater levels.



2.3 NRCS Groundwater Conservation Efforts - Gary Bennett, USDA-NRCS

The NRCS has developed groundwater conservation efforts in response to groundwater withdrawals in eastern Arkansas exceeding sustainable yields. These efforts include NRCS strategic priorities, partnerships, impact assessment, and programs. One of the strategic priorities that NRCS has outlined is addressing climate change via climate-smart agriculture, forestry, and renewable energy. Another strategic priority is advancing racial justice, equity, and opportunity. NRCS has also utilized their Environmental Quality Incentives Program (EQIP) to help farmers in Arkansas.

Over the past 7 years, NRCS has entered into cooperative and contribution agreements with partners to advance irrigation technical assistance. These agreements have allowed NRCS to provide more than $5.5 million in federal funding in support of addressing groundwater decline. Mike Hamilton and NRCS, through a contribution agreement with the University of Arkansas Division of Agriculture Cooperative Extension Service (UAEX), created an irrigation water management (IWM) program. This program has facilitated the creation of a total of 10 IWM technician positions since 2015 and NRCS has invested, through 2025, a total of $3.8 million to fully fund these technicians. These technicians can perform a wide variety of tasks: create soil moisture sensors for use on farms, perform demonstrations on conservation irrigation practices, create IWM plans, create irrigation designs using computerized hole selections, and use soil moisture sensors to schedule irrigation.

The NRCS has partnered with the University of Arkansas Division of Agriculture to hold an annual irrigation yield contest called “Most Crop per Drop” where IWM is implemented. The winner of the contest is determined by having the highest water use efficiency (WUE), where the yield is divided by the total water use of rain plus irrigation. This contest is strongly supported by volunteer efforts of NRCS field offices and cooperative extension agents who serve as supervisors of the contest. Another partnership NRCS has in Arkansas is with Dr. Runkle from the University of Arkansas where the primary objectives of the project are to advance technical knowledge of certain water management conservation practices by determining water use and harvest yield on rice production using different conservation practices (alternative wetting and drying, multiple inlet rice irrigation, and furrow irrigation), determining evapotranspiration rates from rice fields, and determining greenhouse gas emissions and land-atmosphere exchange of carbon dioxide, methane, and nitrous oxide.

The NRCS has partnered with Delta Plastics to work on the Pipe Planner software. This purpose of this project is to address the resource concern of inefficient use of irrigation water associated with traditional row crop and rice irrigation practices to enable Pipe Planner to advance. The advancements allow Pipe Planner to be more convenient, attractive, and valuable to users with better record keeping and reporting tools. NRCS is also involved with NRD in financially assisting those participating in NRD's programs through the expanded use of monitoring equipment such as flow meters to enhance water conservation. The NRCS is also involved with the Grand Prairie ($64.4 million) and Bayou Meto ($55.7 million) surface-water irrigation projects.

The NRCS uses impact assessments as part of their groundwater conservation efforts. These assessments include source water protection, cover crops, reservoirs, and IWM. The 2018 Farm Bill provided language for source water protection (SWP) through targeting agricultural practices. Through this bill, the NRCS will identify local priority areas, provide incentives for practices that relate to water quality and quantity and protect drinking water sources while also benefiting producers, and provide at least 10% of funds available for conservation programs nationwide. Targeted areas would be designated by 12-digit hydrologic unit codes (HUCs). These areas could be designated for water quality or quantity emphasis.

The Arkansas NRCS, since 2017, has partnered with the Arkansas Soil Health Alliance, Arkansas Association of Conservation Districts, UAEX, and others to promote and demonstrate soil health conservation practices. Through this partnership, NRCS has been able to host multiple field days demonstrating conservation practices that promote soil health. In 2022, Arkansas was a pilot for EQIP Cover Crop Initiative (CCI) and continued to carry out EQIP and Conservation Stewardship Programs (CSP). For the past 3 fiscal years that have been under the 2018 Farm Bill, there has been a 38% increase in the number of fields in cover crops which resulted in an increase of approximately 43,000 acres in the practice. Conservation crop rotation, conservation tillage, nutrient management, irrigation water management have also been planned and implemented as companion practices for cover crops.

The NRCS has utilized on-farm reservoirs as part of their impact assessments. Those producers who implement reservoirs can see improvements in water conservation as indicated through the work that NRCS has done from 2016 to 2020. Another impact assessment as part of their IWM practices is computerized hole selection (CHS) for irrigation pipes. CHS has been shown to produce water savings of 20-25%. Another IWM method is sensors and surge irrigation, which can produce 20-50% water savings. NRCS estimated that over one million acre-feet in water could be saved annually if all farmers would convert to current ratios of furrow irrigated rice (FIR, about 17% of total rice acres) or alternative wetting and drying (AWD, about 3% of total rice acres) through IWM. FIR has also been found to reduce approximately 50% of methane losses; AWD has been shown to reduce approximately 70% of methane losses.

The NRCS utilizes a multi-system approach to their programs. The Arkansas Groundwater Initiative (AGWI) has provided over $9.3 million in dedicated funding for the past 3 fiscal years to address declining water levels in the MRVAA through EQIP. This initiative uses a tiered approach to funding and the focus of the project was the conversion of irrigation source water from groundwater to surface water and improving water conservation through IWM. Ultimately, NRCS has funded approximately: $40.4 million in IWM, $37.8 million in reservoirs, and $38.6 million in tailwater recovery pits for a total of almost $117 million for the past 3 years.

2.4 Center for Water Sustainability - Michael Clay, USACE Memphis District

The Center for Water Sustainability (CWS) is a regionally focused effort, specifically the Upper Mississippi Embayment (UME) region. The CWS uses the following approach: compile existing information (data, studies, and initiatives), define the problem(s), identify overlaps with other agencies, and design and construct prioritized solutions. Ultimately, the goals of the CWS are to think on a large geographic scale (entire UME), leverage existing efforts to the maximum extent possible, and create a sustainable path forward.

In partnership with CWS, the USGS has the following approaches to address problems in the UME: utilize data and models from the MERAS 3.0 model and catalogue potential approaches developed by local, state, federal, and academic stakeholders. The USGS used mapped products (geophysical surveys) to identify streams within areas where groundwater had been depleted to build weirs to enhance recharge in that area. The USGS has also worked on diverting excess surface waters to disconnected river bends while studying aquifer recharge in areas with sandy and gravel layers near reservoirs.

The USGS has also been using groundwater for flow augmentation where they were looking at the installation of groundwater pumping and extraction systems in areas with high groundwater flow to extract groundwater and pump it into streams with critical low-flow conditions in order to maintain ecological systems. Another approach that USGS has taken is groundwater transfer and injection built upon a study done in Shellmound, Mississippi, where USGS was looking at pumping Tallahatchie River water into areas with cones of depressed groundwater in Mississippi. The last approach that USGS has taken is using on-farm managed aquifer recharge (MAR) infiltration technologies, built upon existing pilot MAR technology, to utilize infiltration vaults integrated with existing conservation practices to maximize aquifer recharge. USGS assessed the associated permitting, construction, operation, maintenance, and hydrologic impact factors of integrated infiltration technologies that increase recharge to the Mississippi River Valley alluvial aquifer.

3.0 Current Projects Panel Discussion 1 – Moderated by Megan Perkins (Day 1)

3.1 Ed Swaim, Bayou Meto Water Management District

The Bayou Meto Water Management District (BMWMD) is focused on resilience, especially in extreme weather. Reducing frequent flood loss, stopping habitat degradation from extended inundation, prevention of public groundwater supply depletion, and avoidance of reduction of irrigated crop acreage are all goals of BMWMD. Over $150 million of work has been done on planning, engineering, and environmental clearances. Other work has included acquiring land rights, and building two pump stations, several miles of canals, and one bridge. Currently, 3.3 miles of canal are under construction.

The current needs of BMWMD are to stay on schedule to finish phase one and to acquire additional funding to keep moving east with the project. American Rescue Plan money is needed to move past Indian Bayou. In this area, the Mississippi River Valley alluvial aquifer has a very low saturated thickness. As a result, BMWMD is working with federal and state agencies to construct more pump stations to deliver water to farmers within the district.

3.2 Chris Henry, University of Arkansas

The University of Arkansas Rice Research and Extension Center in Stuttgart, Arkansas, works on various projects that include promoting irrigation water management practices (extension), performing research field experiments, and developing new technologies (research and extension). This extension center has developed a mobile application called “Rice Irrigation” where users can develop an irrigation plan using a mapping function within the application. These plans provide irrigators with the size of pipe needed, number of rolls, pipe thickness, length of pipe needed, and gate settings for each levee or paddy. This application has saved 340 billion gallons of water for the 563 registered users so far.

Technological developments that the team at the Rice Research and Extension Center have achieved include pump timers and a circulator pump. The pump timer can automatically stop and start based on rainfall. The circulator pump (or pit-less tailwater pump) can be used for no-till or cover crop irrigation and is climate-friendly because it reduces methane as well as nitrous oxide emissions (due to conserving nitrogen). The extension center has also created the “Most Crop per Drop” contest, which tests the skill of participants in achieving the maximum and economically acceptable yield with the least amount of supplemental irrigation. Water use efficiency is calculated by dividing yield (bushels per acre, or BPA) by the total water use of rain plus irrigation.

The contest outlines that minimum yields include 60 BPA for soybeans, 180 BPA for rice, and 200 BPA for corn. Contestants are recognized on social media and winners will receive up to $95,000 in prizes. As a result of this contest, water use efficiency has increased over time (since the start of the contest in 2018) and the adoption of IWM technology (which includes moisture sensors, computerized hole selection, and surge irrigation) is increasing in the contest. The water savings from the water user database vs the irrigation contest saw reductions in water used for rice, soybeans, and corn. Dr. Chris Henry and his team have also created the soil moisture sensor school where farmers can learn how to use the Rice Irrigation application and how they can incorporate it into their operations. There is also a certification program through the school called the National Master Irrigator Initiative.

3.3 Dennis Carmen, White River Irrigation District

The White River Irrigation District (WRID) is a legally formed water district and has been in operation since 1984. The 15 board members are elected by farmers and the water district holds no taxing authority. The ultimate goal of the WRID is to become financially sustainable by delivering affordable water. This water district has an area of 300,000 acres in project lands and 250,000 acres of this area is irrigated cropland. Approximately 350 on-farm reservoirs have been built with tailwater recovery systems, pumps, and pipelines. The WRID wants to build more of these on-farm reservoirs, and their process to build the reservoirs is as follows: (1) use a phased approach, (2) build canals, (3) install pipelines, (4) start water delivery, (5) generate income, and (6) repeat with the next phase.

Currently, these construction projects are funded through the NRCS, NRD, and the USACE. Dennis Carmen is involved in ensuring the project stays at or under budget. One way to achieve this is by providing flexibility in design options for storage and conveyance systems. Another way is stockpiling necessary materials for construction (such as steel pipes). The WRID performs much of the construction, which helps keep the budget down. The construction projects in this irrigation district consist of six phases (the first phase started in 2022) and will alternate between construction of canals and pipelines in each of the phases. Project costs reflect water usage activities: $26 per acre-foot for operation and maintenance, $27 per acre-foot for debt financing, $53 per acre-foot for first foot, and $26 per acre-foot per second foot.

3.4 Mike Hamilton, UAEX

Mike Hamilton with the UAEX works on Discovery Farms Irrigation, which is funded through a grant from the Nature Conservancy. Initially, the project was looking at the start-up and shut-off of irrigation pumps, but every pump start-up could be different. Mike wanted to introduce automation into his setup by changing the risers. The farm plots that were chosen to study (and to introduce automation to) in Discovery Farms had multi-parameter samplers that allowed Mike and his team to monitor these locations more carefully. The risers that were changed required a blowout valve to avoid bursting the polypipe. This setup will be the model for future farms across the state of Arkansas.

To determine if the operation was working correctly, a solar powered security camera with a SIM card and 360-degree rotation was installed. This allows him to zoom in and pan around to monitor the farm remotely. Mike also uses a drone to collect topographic reference points (approximately 11.44 reference points per square foot or half a million reference points per acre). Drones can be outfitted with various sensors that are useful for farmers, such as topographic mapping and thermal imaging. This information can be used to measure areas, determine slopes and elevation changes, create irrigation designs such as multi-inlet rice irrigation (MIRI), and determine flows needed for increased irrigation efficiency.

3.5 Question & Answer Session for Panel Discussion 1

Question 1 (For Dr. Chris Henry or Mike Hamilton): Looking at all the conservation practices, what does it mean for a producer on a large-scale from a financial standpoint?

Answer 1: Energy savings pay for the technology. For example, corn profits are $20-40 more per acre because of reductions in energy and increases the yield.

Answer 2: Reducing irrigation based on actual sensors reduces irrigation time, which reduces diesel, and this also frees up time.

Question 2 (For Dr. Chris Henry): What will the retail price of pit-less tailwater pump be?

Answer: It is not known at this time, but currently working on factoring in cost-share programs. It is also difficult to anticipate how much materials would be. Estimated price may be $15,000-$25,000, but farmers may pay only $5,000.

4.0 Current Projects Panel Discussion 2 – Moderated by Amanda Mathis (Day 1)

4.1 Jason Milks, The Nature Conservancy

The Nature Conservancy (TNC) in Little Rock has programmatic responsibilities in various areas including east Arkansas, west Mississippi, and northeast Louisiana. TNC is the largest conservation network in the world and connects conservation efforts for the best solutions and science possible. Ultimately, Jason Milks wants to answer how we get to those solutions.

Corporations will typically reach out to TNC in order to implement conservation practices. As one example, Jason reached out to various state and federal entities for Kellogg and they were able to obtain and implement timers for irrigation on their farms, which saved billions of gallons of water. TNC can also appeal to global markets.

Industry pressure could be very helpful in implementing sustainable water use at the farm level and for investment into large projects, like the irrigation projects.

4.2 Josh Hankins, Rice Stewardship Partnership

USA Rice is a global advocate for the unified rice industry and its headquarters is in Washington D.C. where teams may work on domestic promotion, lobbying, and a wide variety of other tasks. Around 2014, USA Rice started allocating funds to sustainability and conservation through a partnership with Ducks Unlimited. This came out of the BP oil spill to ensure that migratory birds were still able to move south in 2010. The partnership includes six major rice-growing states with two representatives per state; these representatives are part of a steering committee. This partnership created the 2014 Farm Bill provision for rice conservation, which secured funding for the program (rice conservation partnership program or RCPP).

USA Rice started IWM practices in 2015 with assistance from NRCS. USA Rice, for Arkansas alone, has secured $28 million for rice farmers under the Farm Bill provisions. This funding is very competitive, so Arkansas would have likely not gotten the funding without this partnership. Ducks Unlimited has recently applied for $10 million in surface water conversion. USA Rice wants to continue advocating for Arkansas.

4.3 Matt Lindsey, Delta Plastics

Delta Plastics produces 90% of the pipe used for irrigation (furrow and flooded field) in the mid-South. Delta Plastics has also developed the application “Pipe Planner,” which is used to calculate the exact hole size to punch in polypipe at each furrow and helps equalize pressure along the pipe. This allows plants at different locations along the pipe to receive the same amount of water at the same time, which has been shown to reduce water consumption by 25%. Delta Plastics provides in-house training on “Pipe Planner,” which is also online.

“Pipe Planner,” since its release in 2014, has thousands of users that have enrolled about 2 million acres of land (1 million acres in Arkansas alone). The counties in Arkansas with a majority of users include Mississippi, Craighead, Poinsett, Cross, and Arkansas. Delta Plastics is also partnered with USA Rice in a USDA RCPP as an in-kind contributor. One of the goals for “Pipe Planner” is to get some application programming interfaces (APIs) to connect with other programs and data sources. Ultimately, Delta Plastics wants sustainable water usage in tandem with “Pipe Planner.”

4.4 Adam Shea, Riceland Foods

Riceland is a farmer-owned cooperative that was established in 1921. Currently, Riceland has 5,500 members in Arkansas and Missouri that handle rice and soybeans. It is also the largest rice milling and marketing cooperative in the world that has 22 drier locations (procurement facilities), 7 rice mills, and 1 soybean crushing plant. Their cooperative structure gives them a unique position in the agriculture supply chain in that they fit in multiple sectors. This allows them to be transparent from “farm to table.”

In 2020, Riceland started their sustainability initiative “Ingrain Good” after they received pressure to rebrand their packaging. Within their initiative they recognize their cycle of life: water is required to grow rice, rice feeds ducks and other migratory waterfowl, and ultimately the ducks depend on flooded rice fields to provide habitat as well as other essentials for their migration. Data validation is important to Riceland because it allows them to highlight the good today, shows what opportunities can be created for a better tomorrow, provides transparency as well as proof of sustainability, and allows them to narrow their focus.

Riceland’s goal is to promote and implement sustainable irrigation to reduce water usage in rice production by more than 250 billion gallons by 2025. Their focus is on water because of its importance to rice production as well as the apparent trend of declining groundwater levels in their operational areas. Water also offers diversity across multiple sustainability indicators. Riceland wants to promote sustainable practices for all their farmers, but incorporation of these practices is 100% voluntary. One of these practices is Alternative Wetting and Drying (AWD), of which Riceland is seeing an increase in adoption. About 50% of

Riceland's members have invested in a tailwater recovery system, which allows users to capture excess water and reuse it in subsequent irrigation cycles.

Riceland has also seen a 40% increase in adoption of more efficient irrigation methods since 2019 that include furrow irrigated rice (row rice), multiple inlet rice irrigation (MIRI), and zero-grade irrigation. Riceland ultimately wants to identify sustainable practices that not only make a positive impact on the environment, but generate value for Riceland and their members. There exists a data gap, however, where Riceland needs farm-level information that they don't have. As a solution, they are partnering with Arva Intelligence, which is a company that provides a software and data repository that allows Riceland to aggregate and access farm level data. Arva Intelligence is also working alongside the cooperative on Riceland's Carbon Ready Program.

4.5 Blake Forrest, Arkansas NRD Tax Credit Program

The NRD Groundwater Conservation Tax Credit Program is part of the Title 14 Water Resource Conservation and Incentives Act. The purpose is to encourage water users to invest in practices that reduce groundwater usage by utilizing surface water and improving irrigation efficiency. This currently applies to reservoir or impoundment construction, installation or restoration; land leveling; conversion to surface water; and water meters. Eastern Arkansas is considered to be a critical groundwater area for the conservation tax credit, but producers in counties outside of this portion of Arkansas can still apply.

Pre-approval prior to initiating work is required for reservoirs, land leveling, and conversion to surface water, but not for water meters. It is also a requirement for a professional engineer (PE) or NRCS staff member to sign off on the project plan, and applicants will have 5 years to complete their approved project. The income tax credit can be claimed as soon as approval is received. Upon completion of the project, the site has to be inspected by a PE or NRCS staff member. All projects must be maintained for a minimum of 10 years following the issuance of completion. Users can also transfer their tax credits to another user. Unfortunately, this program has not been utilized to its full potential.

4.6 Question & Answer Session for Panel Discussion 2

Question 1 (For Adam Shea): Is there any information on how programs are marketed to help inform end consumers of the programs and conservation efforts?

Answer: The marketing team would likely be able to answer this question better. One example is Riceland was able to use a QR code on the rice packaging and had a video of someone discussing these conservation efforts.

Question 2 (For Jason Milks): Are there any data on cost savings to the producers when it comes to implementing timers?

Answer: Different ways to collect data have been explored, but NRCS has not felt comfortable collecting a lot of personal data even though farmers are typically eager to share data. NRCS did not set out to understand the economic impact of this particular conservation practice, they were interested in water savings.

There were a few questions that were asked regarding the Groundwater Conservation Tax Credit Program that have not been included here.

5.0 Facilitated Discussions (Day 2)

The following three questions were presented to each of the two facilitated discussion groups:

Given the changes in climate, market, conservation practices, and other factors since the 2014 AWP, and anticipated in future, the 2022 Arkansas Groundwater Summit wanted to address **gaps, overlaps, conflicts, and opportunities** in:

1. Measuring water availability and use, including monitoring surface and groundwater and metering irrigation wells in the Delta?

   NRD monitors several hundred wells annually in multiple aquifers. They access 17 real-time groundwater level gages, 23 real-time water use meters, 40 static water use meters, and 44 real-time stream gages (surface water) throughout the state.

2. Conserving irrigation water use, including increased irrigation water use efficiency, drought resistant cultivars, incentives or need for regulations in the Delta?

   State tax credits and irrigation projects will help greatly. NRCS is making considerable investments into conservation in the critical groundwater areas (CGAs). No regulations are needed at this time.

3. Implementing conjunctive water management practices, including water transfers, in the Delta? The 2014 AWP stated, “Groundwater use should supplement surface water use, rather than being the primary irrigation water source.”

   Irrigation projects have received some funding and provide surface water to surrounding farms, reducing groundwater dependence in those areas if the water is affordable.

Sections 5.1 – 5.3 summarize the group discussions for these three questions.

5.1 Discussion for Question 1

Question 1 - Addressing **gaps, overlaps, conflicts, and opportunities** in: Measuring water availability and use, including monitoring surface and groundwater and metering irrigation wells in the Delta?

Gaps:

- Need for metered data that’s reported more frequently rather than just annually.
  - USGS prefers monthly data for modeling
  - Water use data tends to be estimated when self-reporting, which reduces the accuracy of the data.
  - The law requires any well deeper than 200 feet or completed in a “sustaining aquifer” to have a flow meter installed.
  - Water use reporting asks the user if the well is metered and requests the meter reading at report time.

- There are little to no studies that assess the needs and impacts of metering irrigation wells. Is a large-scale farm easier to meter because of more funding and more staff to maintain and manage the meters and irrigation plan?
- This could be a good research opportunity.

- There is currently no accessible method to determine cost estimates for irrigation water management practices.
  - This could demonstrate potential savings for end users.
  - There is also no simple method to provide cost estimates for implementing conservation technology.
- Self-reporting that is more accessible to farmers.
  - Reporting is currently done through local conservation districts. A lack of data has occurred due to staff turnover and offices being closed during the pandemic.
  - Consider an online reporting tool.
- Need to address where reservoirs and other irrigation water management structures exist spatially.
  - How much water are in these structures?
  - Who's using this water? Other farmers?
  - Currently difficult to determine how much water is being diverted from surface water for irrigation. Surface water withdrawals over 1 acre-foot are required to be reported annually to the Water Use Program. How much is seeping through for aquifer recharge?
  - This is a possible research and modeling project.
- How do you create a long-term program for multi-state data sharing?
  - More collaboration is needed across state lines.
- Network of monitoring wells
  - There are inconsistencies in readings of irrigation wells and it is often difficult to read.

Overlaps:

- Programs in different agencies (state/federal) are trying to address the same issues. Communication and working together is imperative.

Conflicts:

- Management and maintenance of technology.
  - Who is responsible financially for these efforts? Who is responsible for data management?
    Producers are responsible for maintaining equipment. Reported data is the State's responsibility to manage. NRD contracts with USGS to host the data and data retrieval system.
- Privacy concerns in regards to where the data is coming from spatially.
  - The State expects that producers will want anonymity in reporting.
  - Remote reading could cause privacy concerns.
  - If your well or surface withdrawal site is registered, NRD currently has information.

- Producers do not want to be regulated; therefore, it is anticipated that a major point of contention and pushback will be from producers to stay autonomous and not be metered to avoid regulation later.
  - Marketing meters to producers will be a difficult task.
- Policies implementing meters.
  - May negatively affect smaller farms with fewer resources (financial, staff).

Opportunities:

- Expand current groundwater conservation tax program to incentivize more metered readings for accuracy.
  - Should payments for users that provide meter readings be differed?
  - Should there be a full subsidy for adding meters to wells? No cost to farmer?
  - Suggested that smart meters should be prioritized so that data is collected automatically in real-time to save time/money on labor and reduce reporting error.
- Long-term program for collaboration on data sharing will encourage agencies and users to work together.
- Irrigation technician training program could increase the amount of irrigation technicians; could be a valuable resource for farmers.
- Communication with farmers in regard to metering.
  - Why it's good for the State and helpful for water conservation of the aquifer.
  - Why it's necessary for longevity of operations. The aquifer is being depleted and changes must occur anyway.
  - How it could start benefiting them in the short term.
    - Build trust with farmers and ensure data won't be used against them.
    - Fully utilize Irrigation Water Management Technicians to bridge the gap between producers and the larger groundwater issue.

5.2 Discussion for Question 2

Question 2 - Addressing **gaps, overlaps, conflicts, and opportunities** in: Conserving irrigation water use, including increased irrigation water use efficiency, drought resistant cultivars, incentives or need for regulations in the Delta?

Gaps:

- Information exists for the efficiency and effectiveness of some conservation practices, but not all available methods have been studied thoroughly.
- Need to create trust among producers, industries, and agencies.
  - There is an opportunity to frame the "problem" as an "opportunity."
- Need to convince producers to decommission insufficient-yielding acreage to use as holding ponds for irrigation tailwater recovery.
- Lack of real-time trustworthy data.
  - Pay for meters and soil moisture sensors.
  - Better data needed for management and education. If ever forced to regulate, data would be critical.

Water use reporting can be improved.

1. Require meter reading to be reported on wells with meters.
2. Remove the “same as last year” clause from the law.

- Need some kind of entity to standardize management of data over entire watersheds.
  - Need more funding for financial assistance to implement conservation practices.

Overlaps: No overlaps were identified in group discussions.

Conflicts:

- Communication, especially about costs of new inputs to increase efficiency (reservoirs or piping, etc.), will be a point of conflict.
  - It will be difficult to encourage farmers to change their methodology and will be difficult to demonstrate why they should change if there is not an immediate economic benefit.
- Water management practices need to be maintained and managed to be effective.
  - Farmers do not want formal regulation or management.

Opportunities:

- Create some kind of framework for large corporations to fund conservation efforts to meet sustainability goals.
  - This also can be used as a marketing tool for corporations to market sustainably produced products.
- Provide standards to producers to incentivize maximum efficiency.
  - Something similar to the “Most Crop per Drop” contest and expand to the region (multiple states).
- Seek funding opportunities to add monitoring wells.
- Educating farmers on conservation practices as well as implementation of crop rotation, increased cover crops, and reduced tillage.
  - Pump timers can also be included in this; how will this save them time?
- Use conservation districts and cooperative extension offices for farmer outreach.
  - Users typically trust these entities.
- How will conservation efforts impact farmer’s bottom line?
  - In regard to long-term savings and crop yields.
  - Marketing needs to be based on how conservation practices affect farmers financially.
- Prepare some kind of analysis for a “what if” scenario where withdrawals become unsustainable (where some kind of regulation or cost to withdraw would have to be implemented) and how it would affect a farmer’s operation.
  - Ultimately, how would this affect their production (financially)?
  - Could be used as an incentive to conserve water.

- Educate consumers on the need for sustainable practices to add additional market pressure for consumer-facing stakeholders, such as large corporations that buy Arkansas products.
  - This can be used for financial assistance to farmers to implement irrigation water management tools.

5.3 Discussion for Question 3

Question 3 - Addressing **gaps, overlaps, conflicts, and opportunities** in: Implementing conjunctive water management practices, including water transfers, in the Delta? The 2014 AWP stated, "Groundwater use should supplement surface water use, rather than being the primary irrigation water source."

Gaps:

- Not everyone has access to surface water, so groundwater use may be the only viable option.

Overlaps: No overlaps were identified in group discussions.

Conflicts:

- Water rights issues – Arkansas is a riparian state
  - Non-riparian permits are available.
  - Cost of surface water – is it more or less expensive to use surface water?
  - Availability of water to farmers that don't have riparian access.
- Multi-state and multi-user issue
  - Municipalities, wetlands, environment, irrigation, etc., all require access to water.
  - Multi-state compact requirements for water supply (Red River Compact, Arkansas River Compact).
- Water storage
  - Timing of precipitation vs need for irrigation.
  - Reservoirs take acres out of production and take up space.
- Should there be a limitation to the number of wells?
  - Support irrigation districts, private industry, and public-private partnerships.

Opportunities:

- Need meters for Sparta confined aquifer.
- Need to present this issue as a larger problem to the public and legislators.

5.4 Conclusions from Facilitated Discussions

The following are key recommendations from the facilitated discussions and from a survey that was sent out after the meeting:

- Work together.
  - Increase frequency of data collection and ensure the data is the highest quality possible to guide decision making and measuring success.
  - Specify what “sustainable” means and identify milestones by which progress towards sustainability can be measured so that producers are not hesitant to participate due to the expectation that the goalposts will shift.
  - Identify and catalog existing reservoirs and other conservation efforts.
  - Identify the overlaps and differences in needs between small and large farms.
  - NRD and USGS work together to update the existing water use database. Build stronger relationships between farmers, regulatory agencies, and industry partners, conservation districts, and Cooperative Extension.
  - Expand the monitoring well network.
  - Coordinate and communicate implementation of conservation practices between producers and various entities.
  - Invest in conjunctive water use such as irrigation projects.
  - Host an annual groundwater summit that pulls all partners and interests together.
- Have a sense of urgency.
  - Inform water users on the benefits of voluntary reporting of accurate data. Focus should be on education first and regulation as a last resort.
- Build trust with producers.
  - Privacy needs to be ensured, where only the necessary information is obtained.
    - Users may be hesitant to share data if sensitive information could potentially be shared.
  - Incentives need to be created and communicated to get producers to report. Ensure reporting compliance and penalize if necessary.
- Continue marketing education on conservation practices for producers.
  - Focus on practical and financial benefits of on-farm technology adoption and expansion/update, particularly smart meters (especially real-time), pump timers, and other water conservation technologies.
  - Incentives such as the tax credit program and opportunities such as irrigation technician training should continue being marketed to producers to implement conservation practices.
  - Communicate success stories of conservation practices.
  - Correct misinformation when possible.
  - Leverage public opinion as a means of encouraging brands to be more sustainable.
    - Brands may be more willing to fund conservation practices for their producers if the consumer wants sustainably sourced goods.
- Develop a producer-involved working group.
  - In coordination with producers, develop a clear policy for use of producers’ data by government agencies and others.

- Determine a realistic sustainable level of water use with researchers and producers.
- Hold frequent integrated meetings to keep everyone up to date and help maintain goals.
- Identify sources of funding.

APPENDIX A

Agenda for 2022 Arkansas Groundwater Summit

GROUNDWATER SUMMIT – DAY 1

June 21, 2022
Arkansas Rural Water Association Headquarters
240 Dee Dee Lane, Lonoke, AR 72086

9 a.m.	**Welcome** **Wes Ward, Arkansas Department of Agriculture** **Mike Sullivan, State Conservationist, USDA-NRCS** **Jerry Don Clark, Arkansas Association of Conservation Districts**	
9:30 a.m.	**2021 Arkansas Groundwater Protection and Management Report** **Blake Forrest, Natural Resources Division – Arkansas Department of Agriculture**	
10:15 a.m.	**Break**	
10:30 a.m.	**System-Scale Science to Support Water Resources: the USGS Mississippi Alluvial Plain (MAP) Project** **Wade H. Kress and Drew Westerman, US Geological Survey – Lower Mississippi-Gulf Water Center**	
11:15 a.m.	**NRCS Groundwater Conservation Efforts** **Gary M. Bennett, P.E., USDA-NRCS Arkansas**	
12:00 p.m.	**Lunch – Sponsored by the Arkansas Conservation Partnership**	
1:00 p.m.	**Center for Water Sustainability** **Brett A. Dunagan, USACE Memphis District**	
1:45 p.m.	**Current Projects Panel Discussion 1** **Ed Swaim, Bayou Meto Water Management District** **Chris Henry, University of Arkansas** **Dennis Carmen, White River Irrigation District** **Mike Hamilton, University of Arkansas – Extension**	**Moderator, Megan Perkins**
3:00 p.m.	**Break**	
3:20 p.m.	**Current Projects Panel Discussion 2** **Jason Milks, The Nature Conservancy** **Josh Hankins, Rice Stewardship Partnership** **Matt Lindsey, Delta Plastics** **Adam Shea, Riceland Foods** **Blake Forrest, Arkansas NRD Tax Credit Program**	**Moderator, Amanda Mathis**
4:45 p.m.	**Day 1 Roundup and Plan for Day 2**	
5:00 p.m.	**Social Hour - Sponsored by USA Rice-Ducks Unlimited Rice Stewardship Partnership**	
6:00 p.m.	**Dinner on your own**	

GROUNDWATER SUMMIT – DAY 2

June 22, 2022
Arkansas Rural Water Association Headquarters
240 Dee Dee Lane, Lonoke, AR 72086

8:30 a.m.	**Opening – FTN Associates** **"Things that went Bump in the Night"** **Explanation of procedures for Day 2** **Divide into discussion groups**
9:00 a.m.	**Group Discussion**
10:00 a.m.	**Break**
10:15 a.m.	**Group Discussion**
11:15 a.m.	**Bring everyone back together and share thoughts from individual groups**
11:45 a.m.	**Next steps and concluding remarks** **What is ACP going to do with this info** **Availability of conference proceeding** **Thank everyone for participating**
11:50 a.m.	**Summit Ends**

APPENDIX B

Printouts of Slides for Technical Presentations

2021 Arkansas Groundwater Protection and Management Report

Blake Forrest, Arkansas Department of Agriculture Natural Resources Division

ARKANSAS DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES DIVISION

Groundwater Protection & Management

Overview

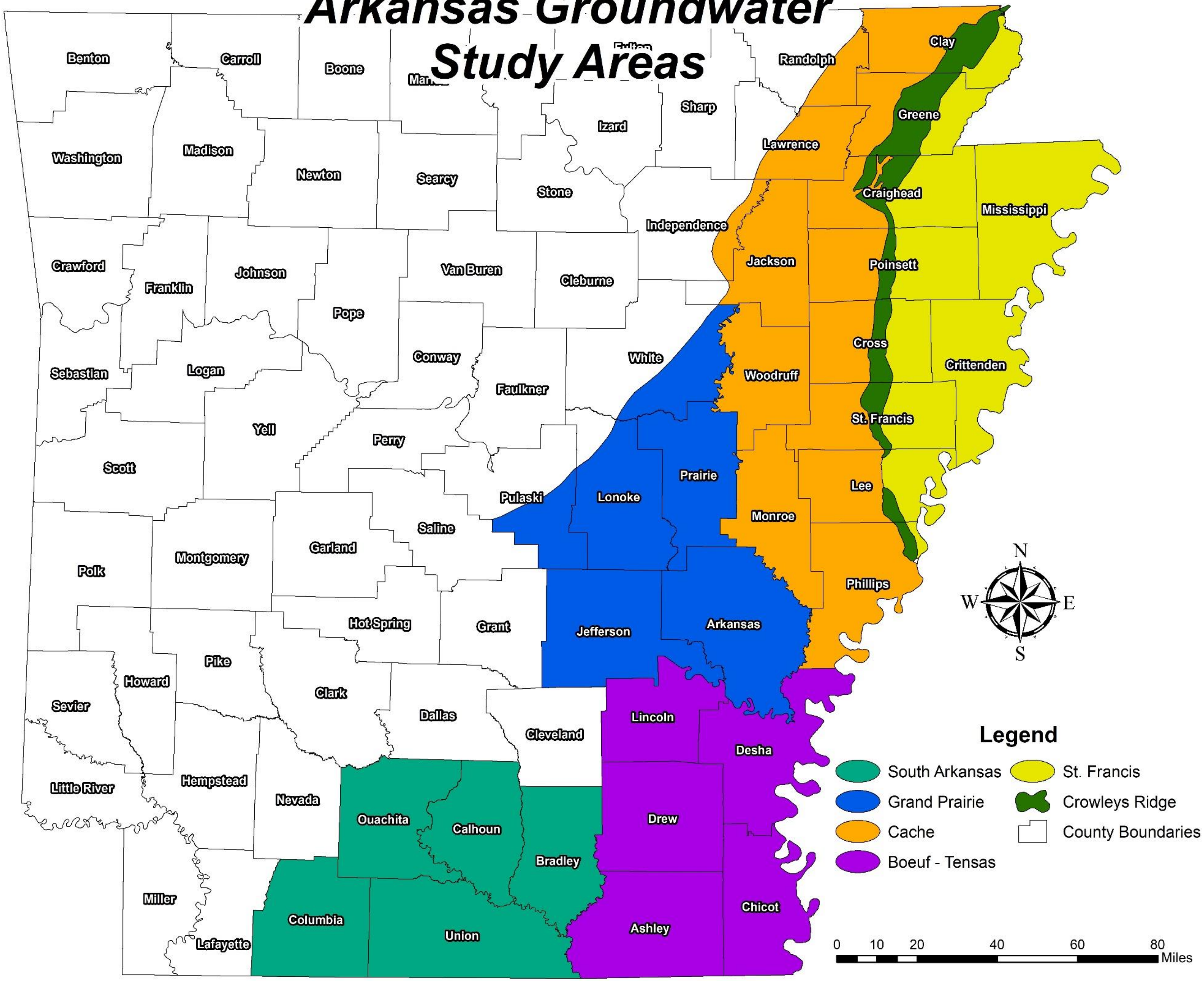
The State of Arkansas acknowledged its groundwater issues with the passing of the Groundwater Protection and Management Act of 1991, or 15-22-9. This act:

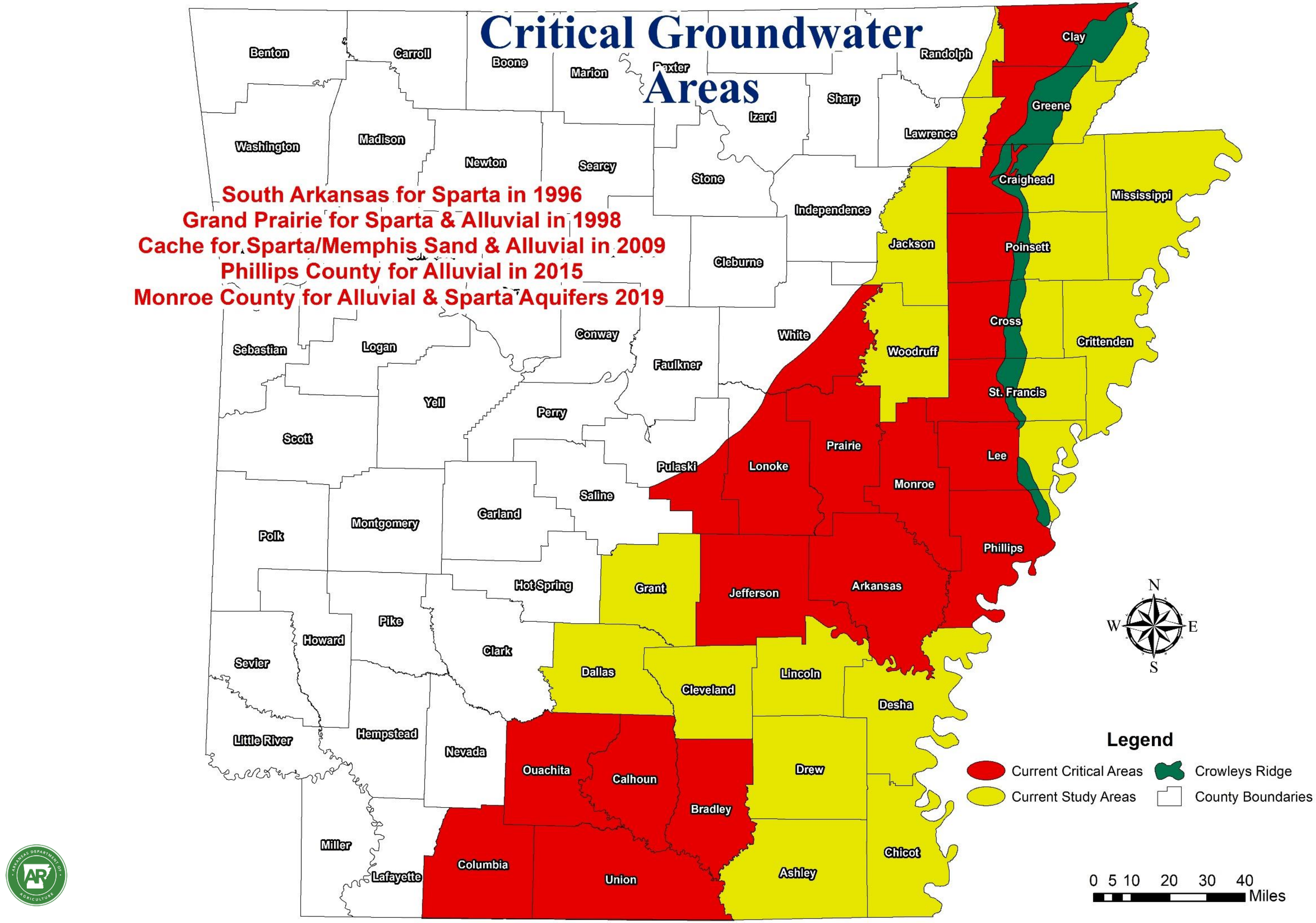
- Ordered the establishment of a comprehensive groundwater protection program that includes:
  1. Assessment and monitoring of groundwater resources
  2. Establishment of groundwater criteria and standards
  3. The management of groundwater; including the issuance of water rights, protection of groundwater quality, and establishment of an education and information program.

- Created the Critical Groundwater Area designation
  - Applies to area identified by the NRD to have groundwater depletion or quality degradation
  - A non-regulatory designation that seeks to increase conservation efforts through expanded benefits through various State and Federal programs

- The NRD produces the Groundwater Protection and Management Report annually in accordance with this act

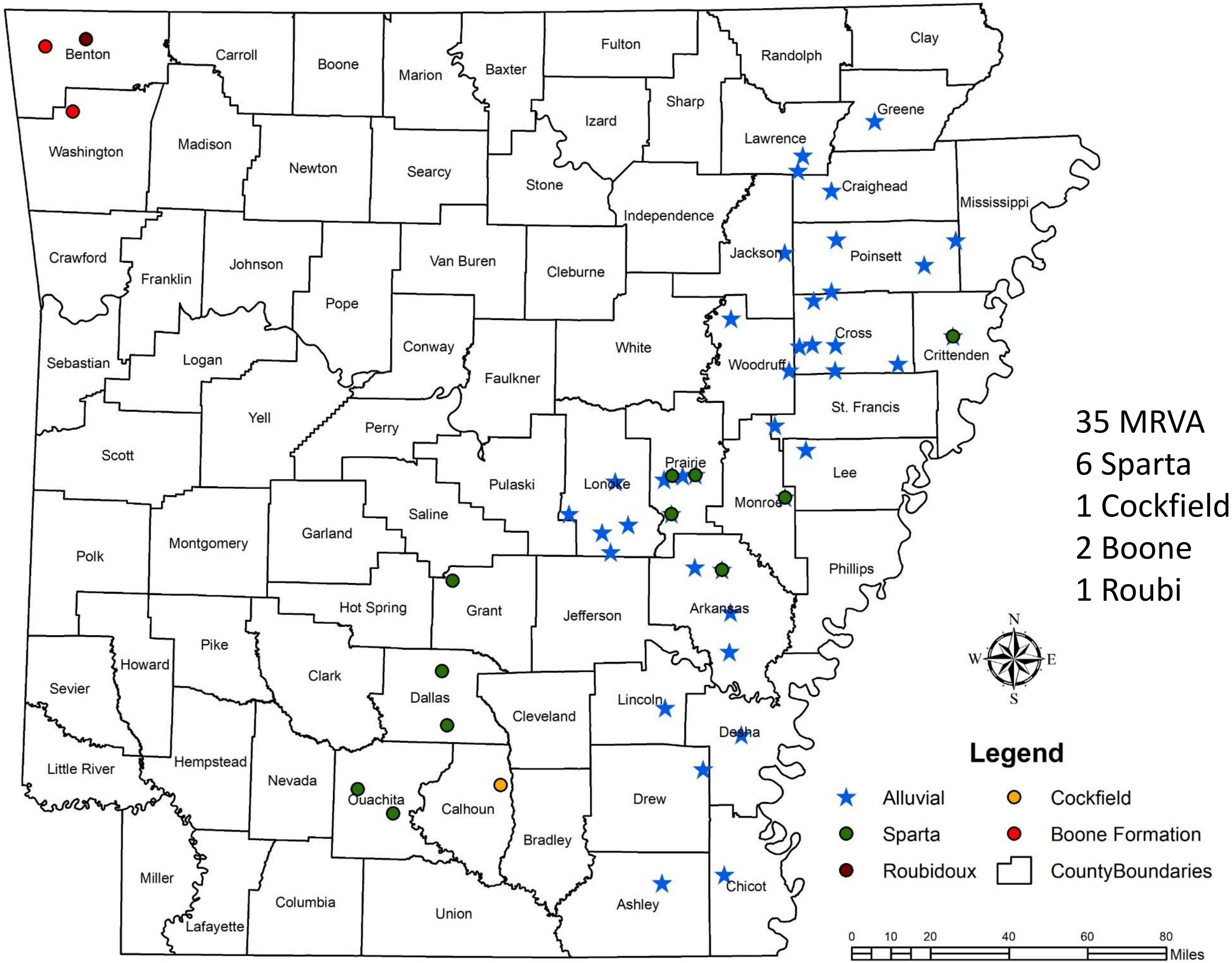
Arkansas Groundwater Study Areas





Critical Groundwater Areas
South Arkansas for Sparta in 1996
Grand Prairie for Sparta & Alluvial in 1998
Cache for Sparta/Memphis Sand & Alluvial in 2009
Phillips County for Alluvial in 2015
Monroe County for Alluvial & Sparta Aquifers 2019
Benton
Carroll
Boone
Marion
Baxter
Randolph
Clay
Sharp
Izard
Lawrence
Greene
Washington
Madison
Newton
Searcy
Stone
Craighead
Mississippi
Independence
Jackson
Poinsett
Cleburne
White
Cross
Crittenden
Sebastian
Logan
Conway
Faulkner
Woodruff
St. Francis
Yell
Perry
Scott
Prairie
Lee
Pulaski
Lonoke
Monroe
Saline
Garland
Montgomery
Polk
Phillips
Hot Spring
Grant
Jefferson
Arkansas
Pike
Howard
Clark
Sevier
Dallas
Lincoln
Cleveland
Desha
Little River
Hempstead
Nevada
Ouachita
Calhoun
Bradley
Drew
Miller
Columbia
Union
Ashley
Chicot
Lafayette
N
W
E
S
Legend
Current Critical Areas
Crowleys Ridge
Current Study Areas
County Boundaries
0 5 10 20 30 40
Miles

ANRC 319 Monitoring Well Locations



35 MRVA
6 Sparta
1 Cockfield
2 Boone
1 Roubi

2021 Groundwater Protection and Management Report

- Summary of the groundwater monitoring efforts of the NRD and its partners
- Focus on the Mississippi River Valley Alluvial aquifer and the Sparta aquifer
- Data collected in spring (pre-irrigation) and fall (post-irrigation) to gauge the aquifer at its highest and lowest levels during the year

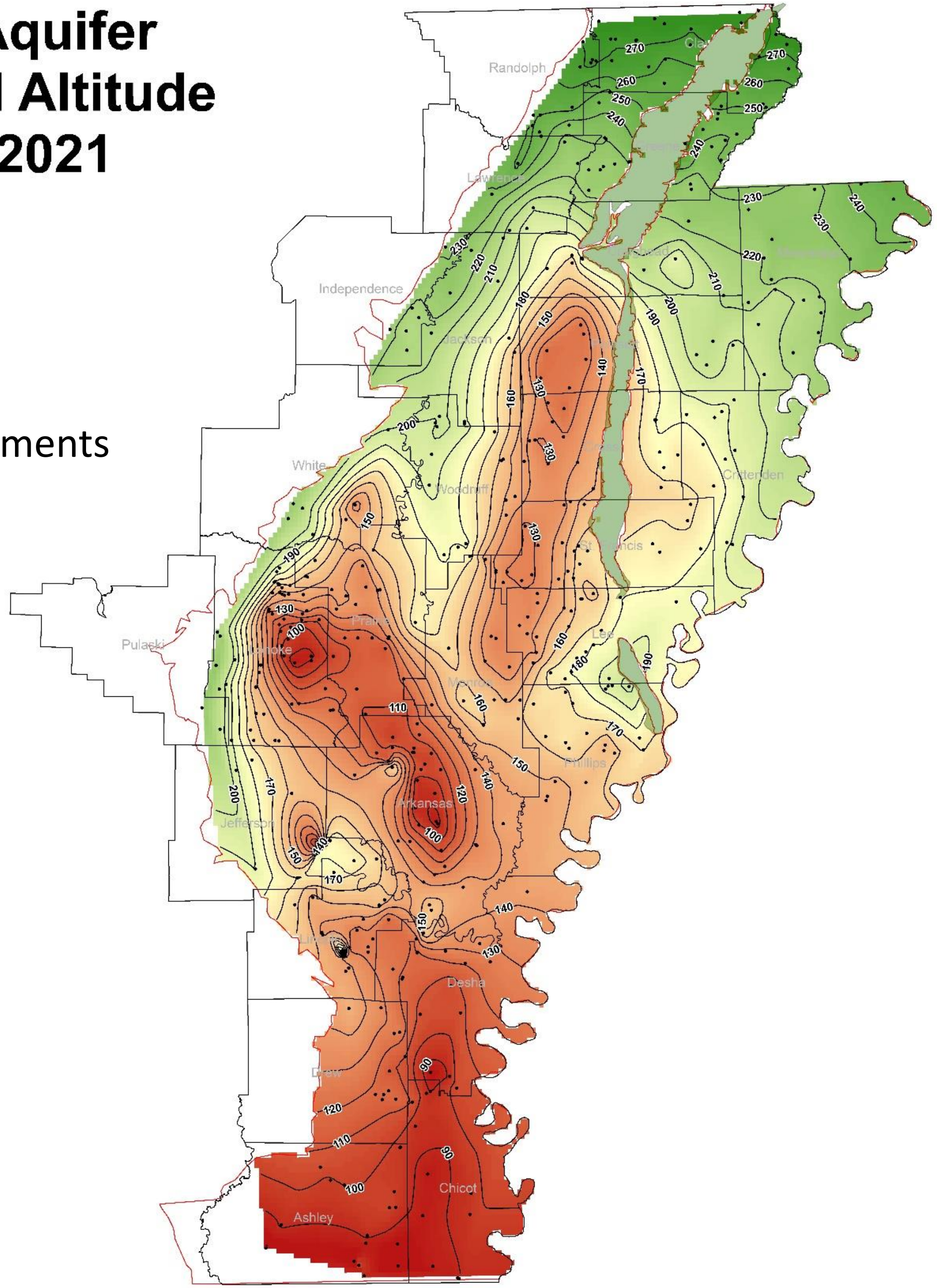
Mississippi River Valley Alluvial Aquifer

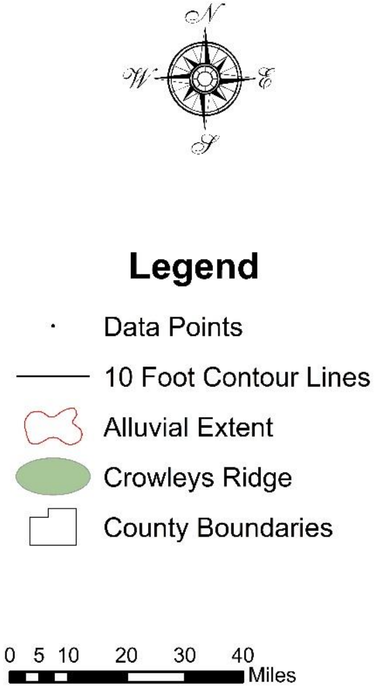
- 1169 water level measurements in in the MRVA in 2021
- Spring 2021: 456 wells measured
- Fall: 372 wells measured

Year	Spring data (wells)	Fall data (wells)	1 year change map (wells)
2021	456	372	410
2020	555	373	232
2019	335	83	165

Alluvial Aquifer Water Level Altitude Spring 2021

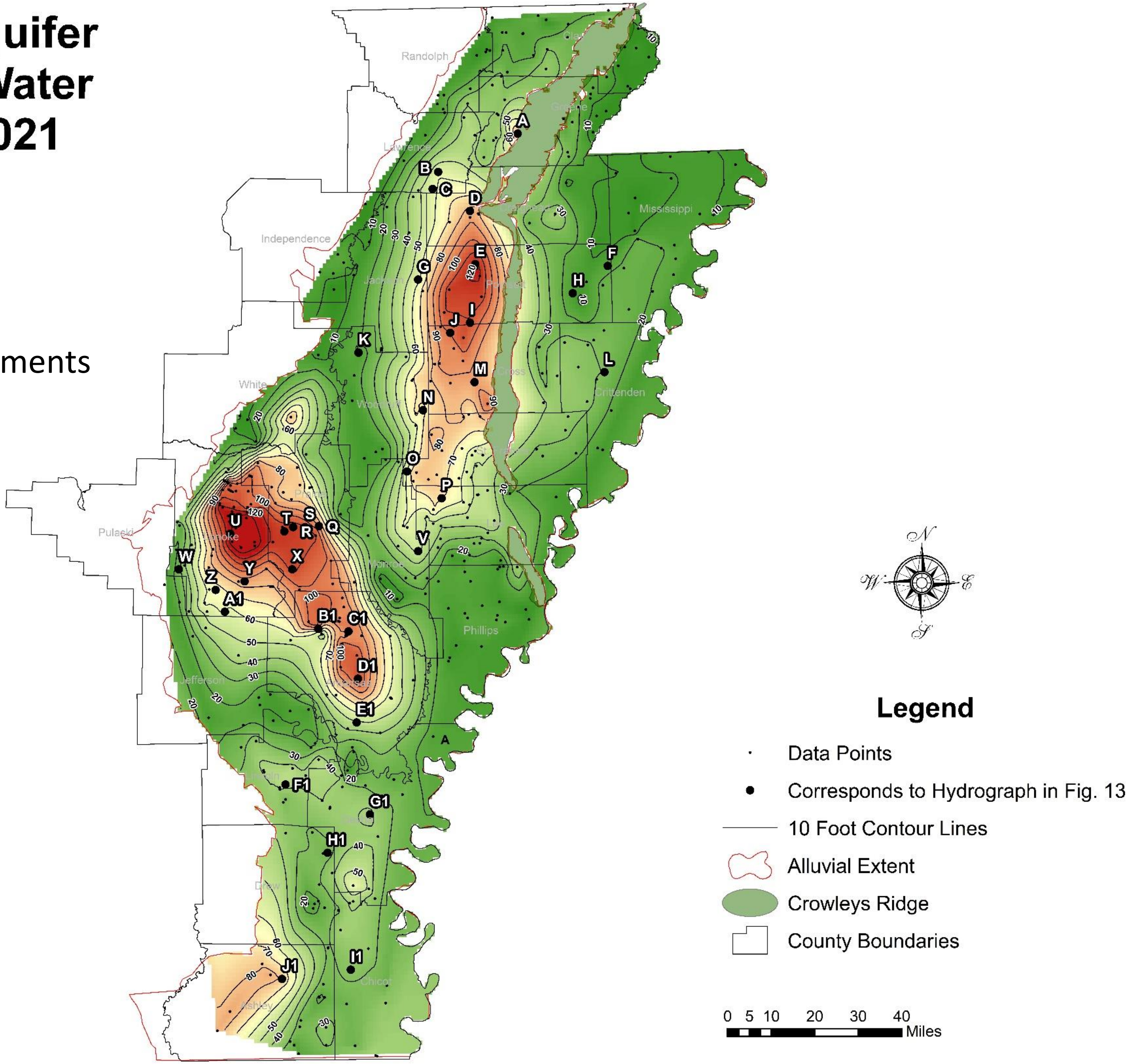
➢ 456 well measurements

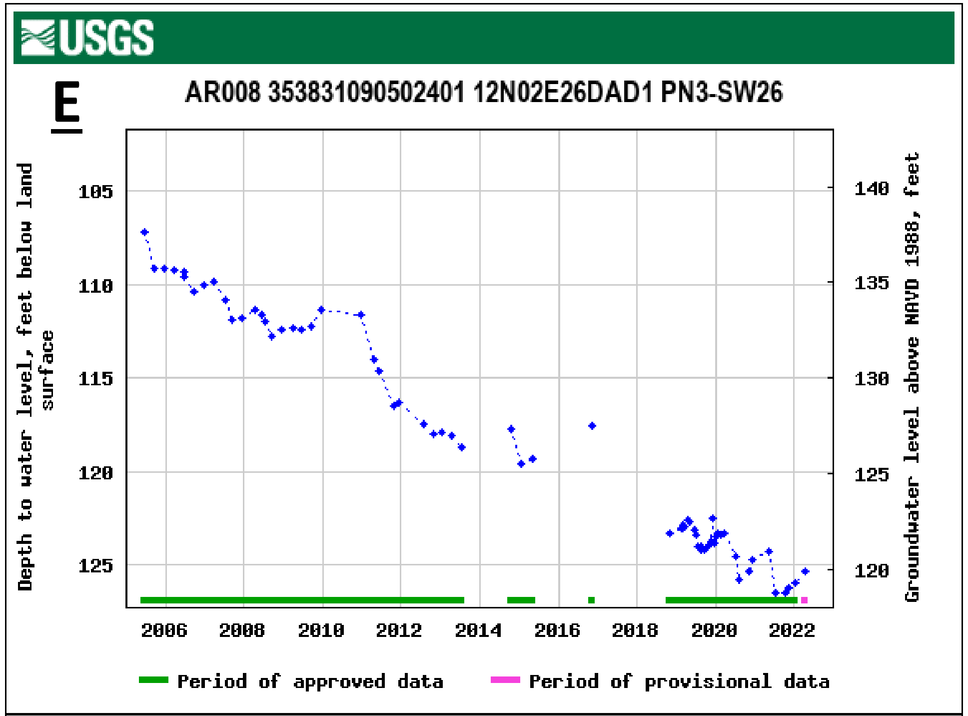


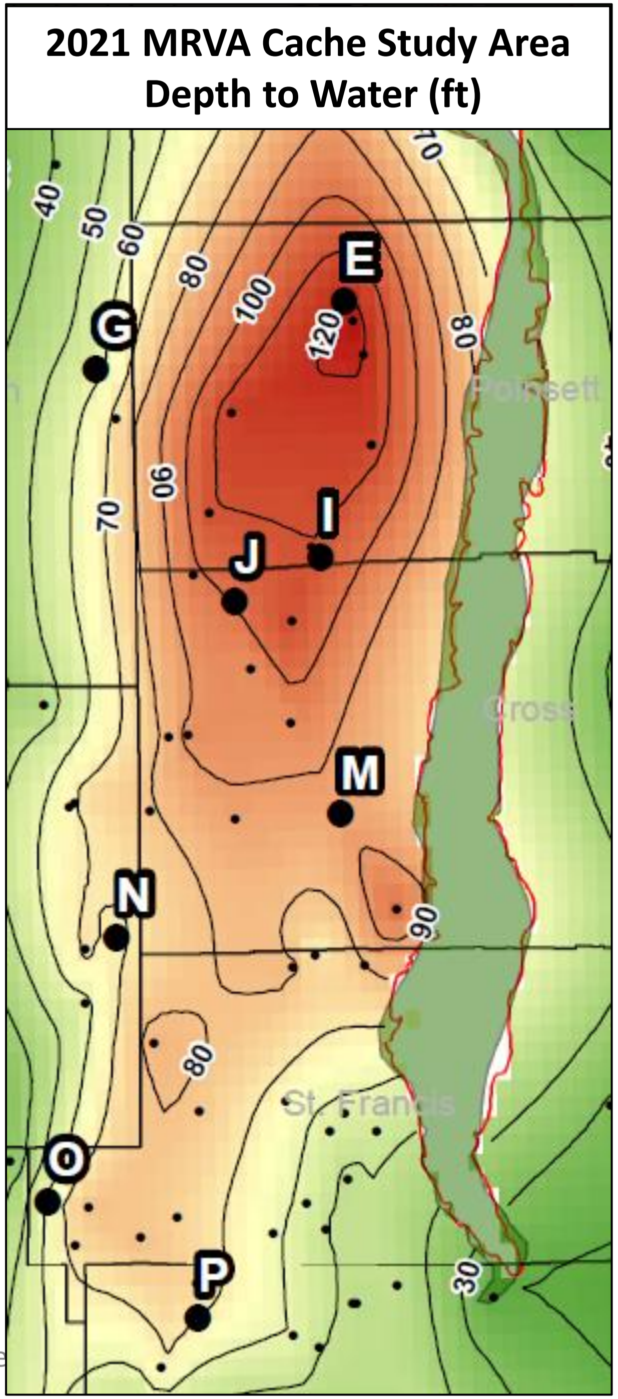


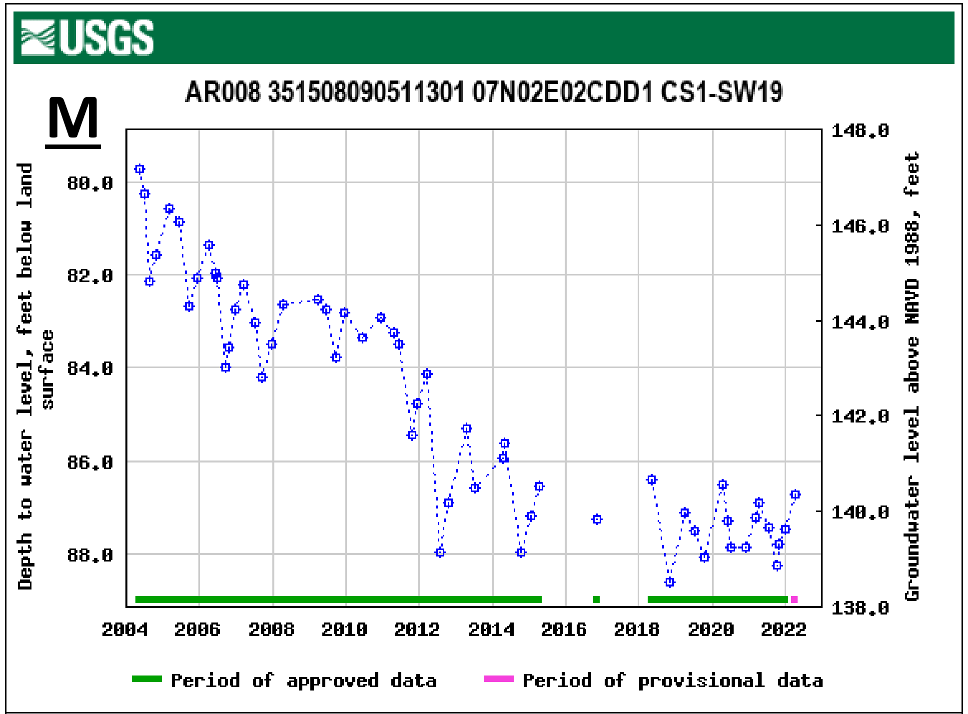
Alluvial Aquifer Depth to Water Spring 2021

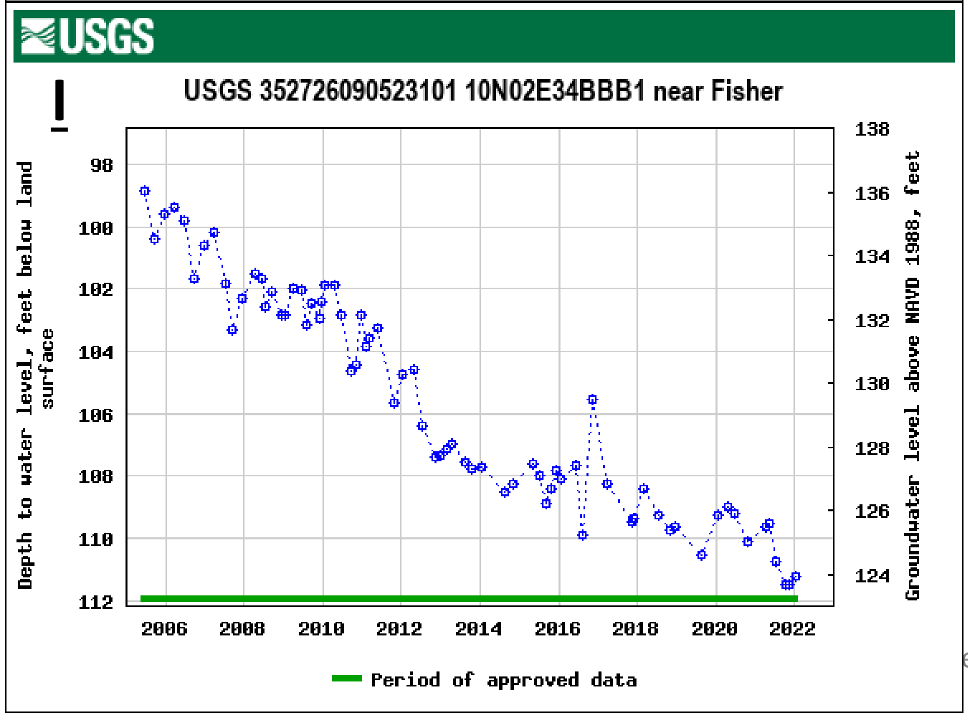
- 456 well measurements

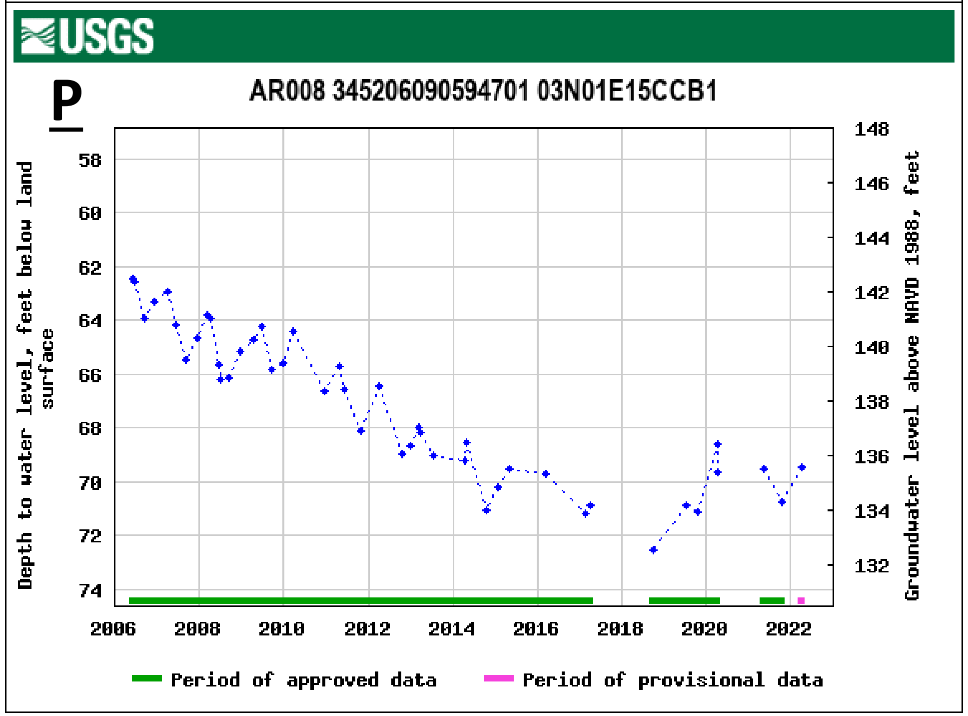


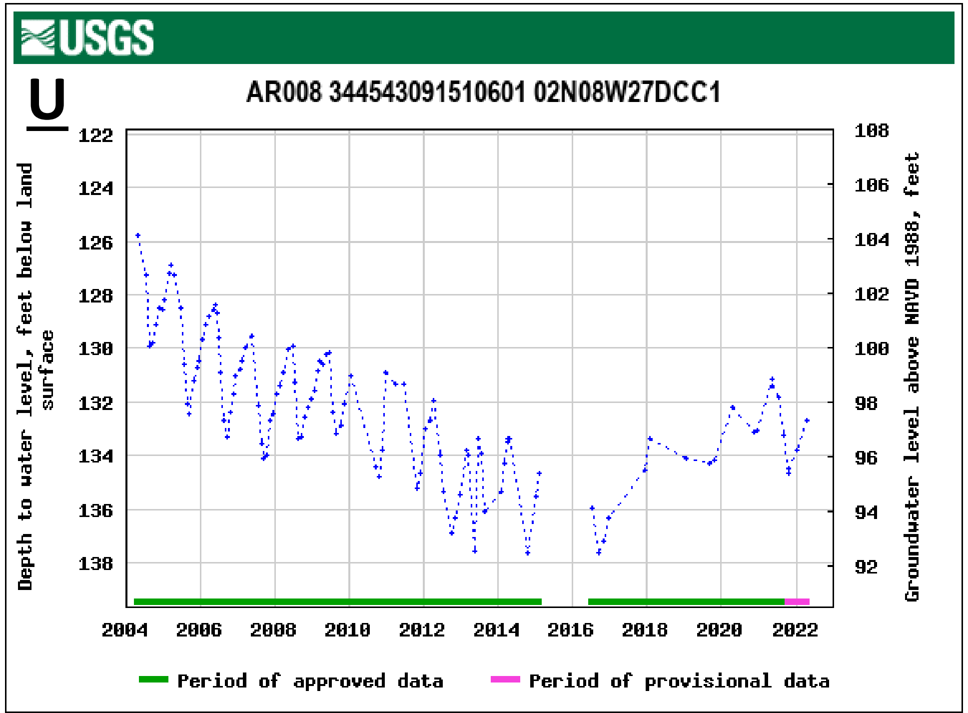

USGS
E
AR008 353831090502401 12N02E26DAD1 PN3-SW26
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
105
110
115
120
125
140
135
130
125
120
2006
2008
2010
2012
2014
2016
2018
2020
2022
Period of approved data
Period of provisional data

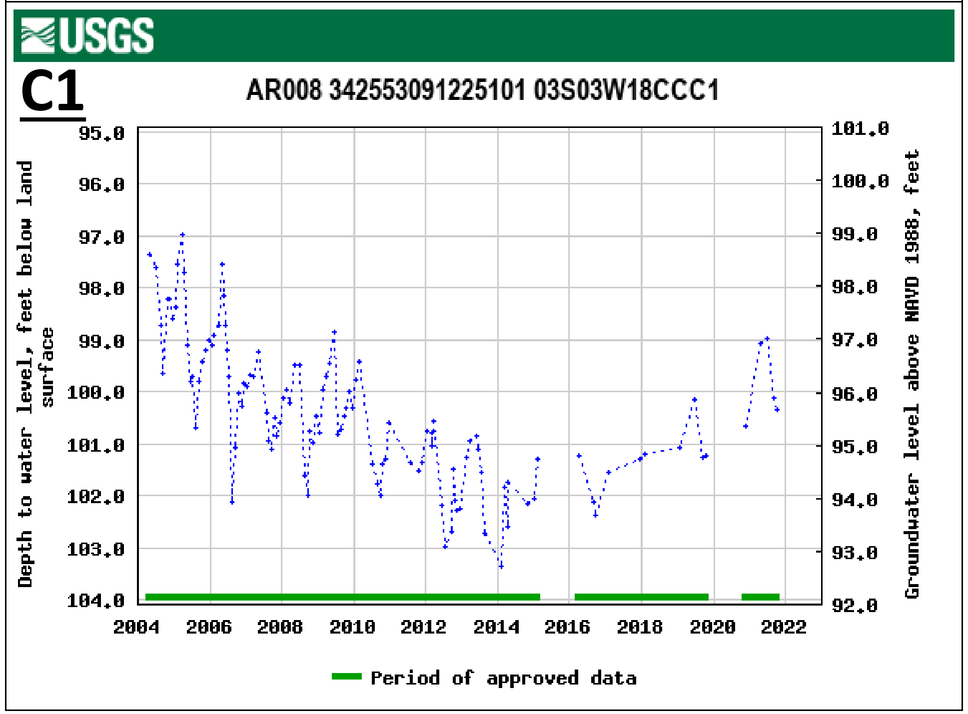

2021 MRVA Cache Study Area
Depth to Water (ft)
E
G
I
J
M
N
O
P
40
50
60
70
80
90
100
120
80
90
80
30
Poinsett
Cross
St. Francis

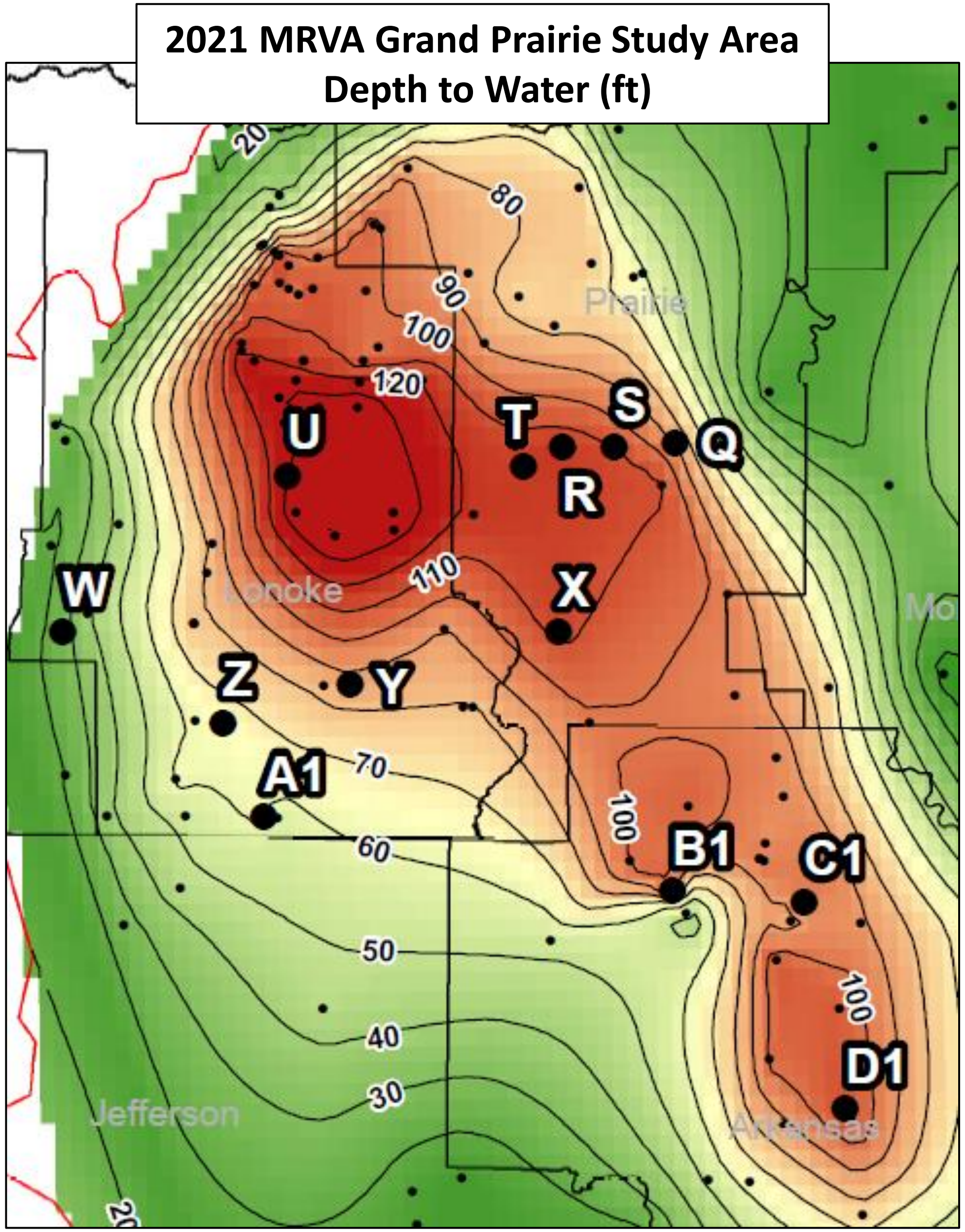

USGS
M
AR008 351508090511301 07N02E02CDD1 CS1-SW19
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
80.0
82.0
84.0
86.0
88.0
148.0
146.0
144.0
142.0
140.0
138.0
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Period of approved data
Period of provisional data


USGS
I
USGS 352726090523101 10N02E34BBB1 near Fisher
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
98
100
102
104
106
108
110
112
138
136
134
132
130
128
126
124
2006
2008
2010
2012
2014
2016
2018
2020
2022
Period of approved data


USGS
P
AR008 345206090594701 03N01E15CCB1
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
58
60
62
64
66
68
70
72
74
148
146
144
142
140
138
136
134
132
2006
2008
2010
2012
2014
2016
2018
2020
2022
Period of approved data
Period of provisional data

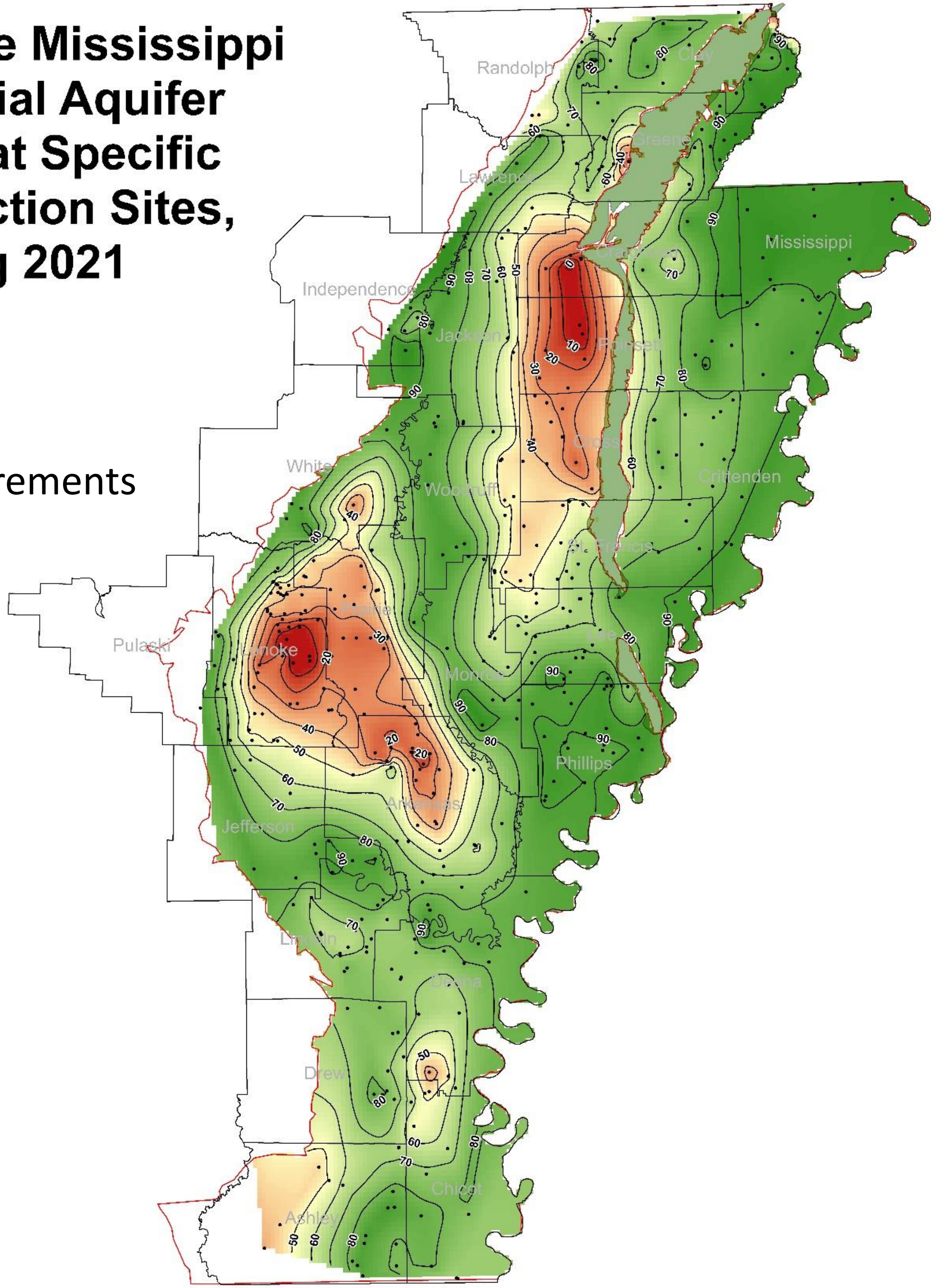

USGS
U
AR008 344543091510601 02N08W27DCC1
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
122
124
126
128
130
132
134
136
138
108
106
104
102
100
98
96
94
92
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
Period of approved data
Period of provisional data

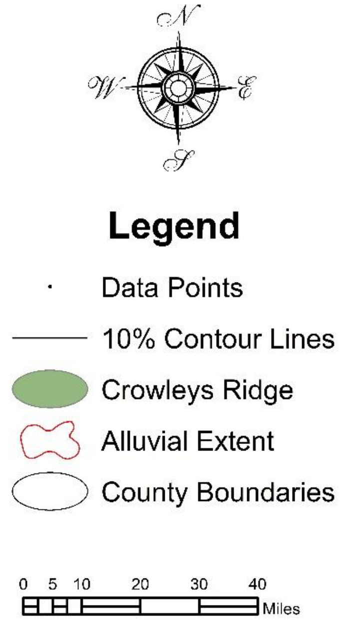

USGS
C1
AR008 342553091225101 03S03W18CCC1
Depth to water level, feet below land surface
Groundwater level above NAVD 1988, feet
95.0
96.0
97.0
98.0
99.0
100.0
101.0
102.0
103.0
104.0
101.0
100.0
99.0
98.0
97.0
96.0
95.0
94.0
93.0
92.0
2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
Period of approved data


2021 MRVA Grand Prairie Study Area
Depth to Water (ft)
U
T
S
Q
R
X
W
Z
Y
A1
B1
C1
D1
20
80
90
100
120
110
70
60
50
40
30
100
100
Prairie
Lonoke
Jefferson
Arkansas

Percent of the Mississippi River Alluvial Aquifer Saturated at Specific Data Collection Sites, Spring 2021

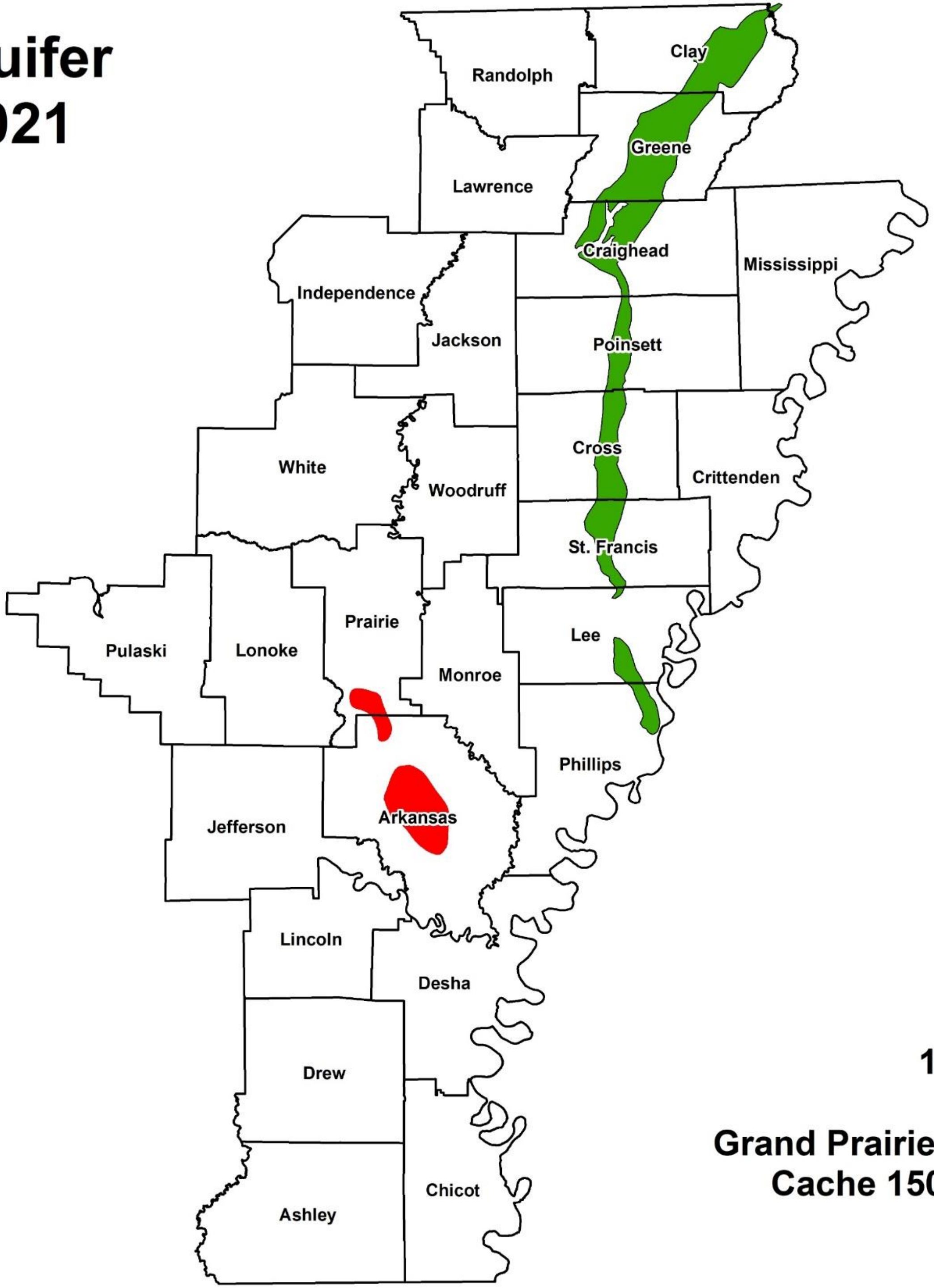
- 456 well measurements





Based on USGS MERAS model aquifer thickness, and Spring 2021 water level measurements.

Alluvial Aquifer
1970 to 2021



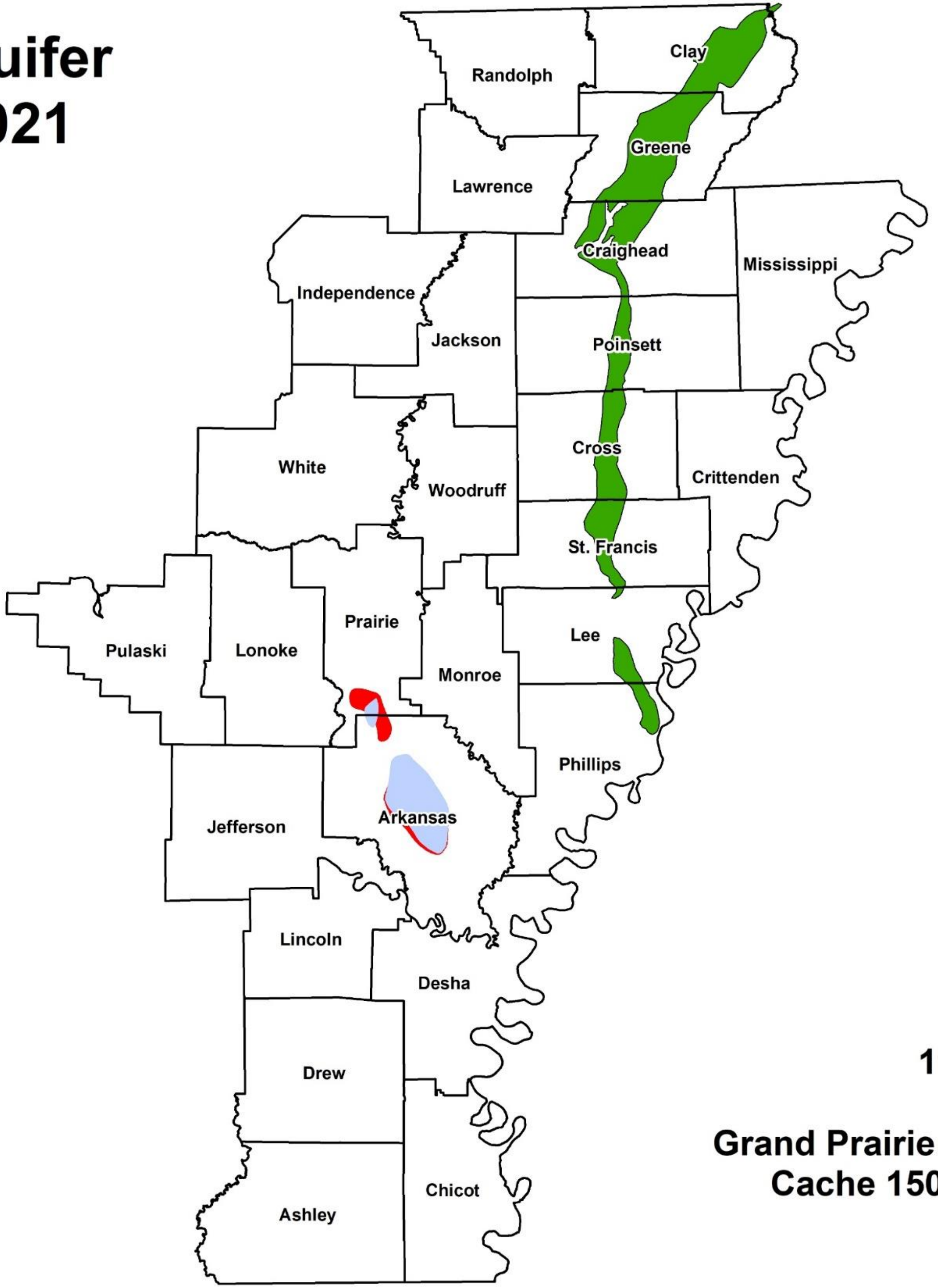
Legend

1970

1970

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer 1970 to 2021



Legend

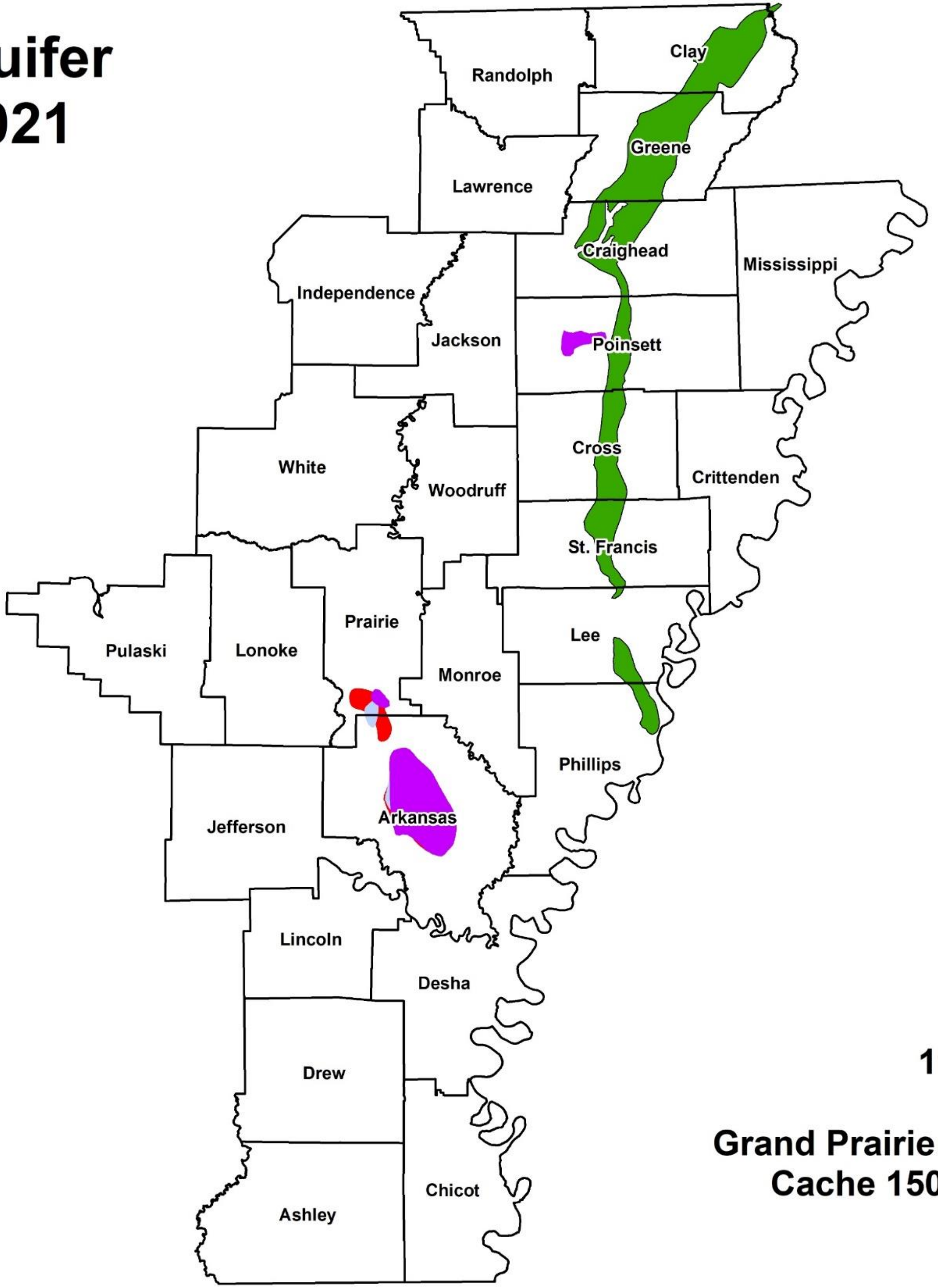
1970

1980

1980

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer 1970 to 2021



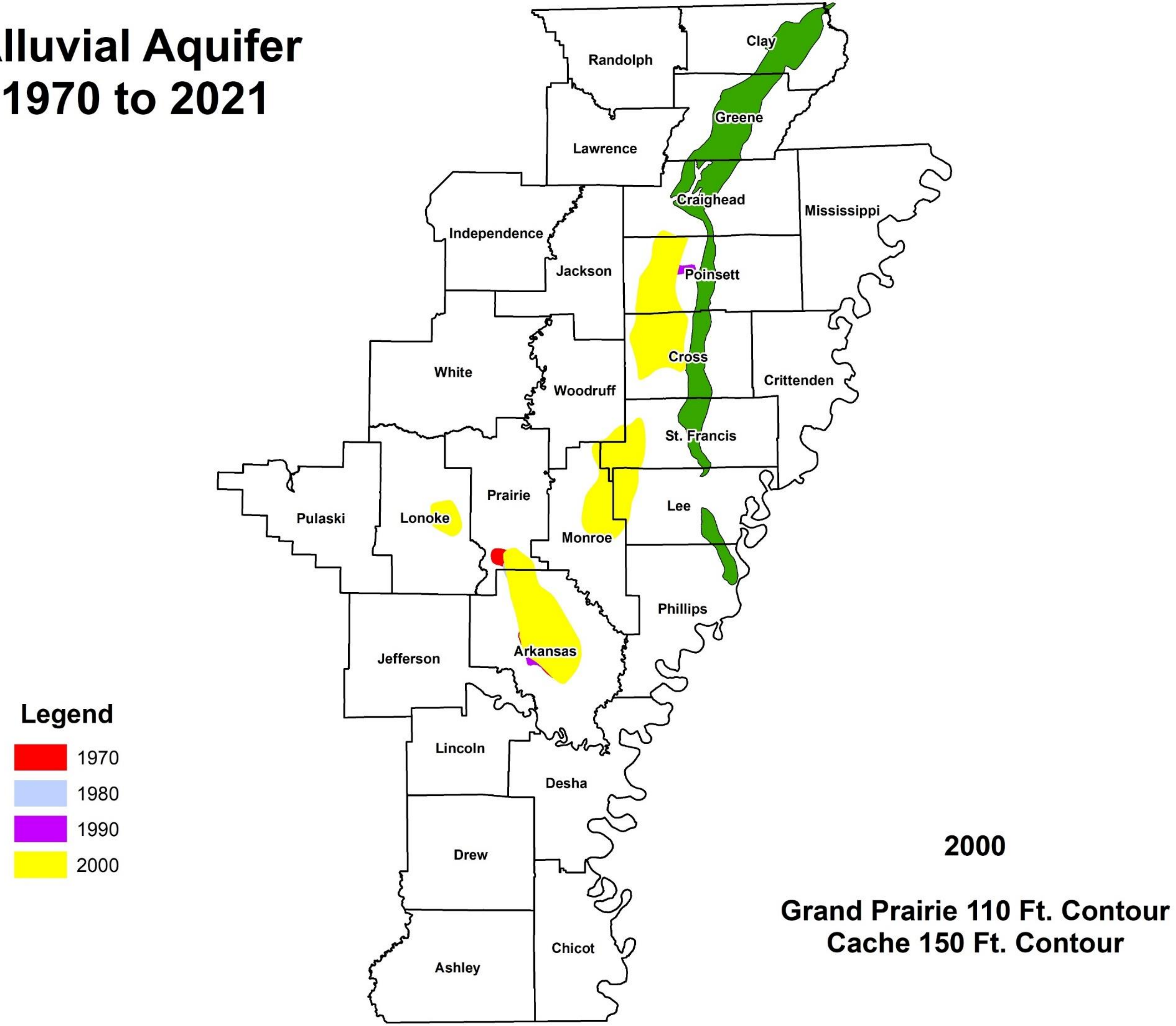
Legend

- 1970
- 1980
- 1990

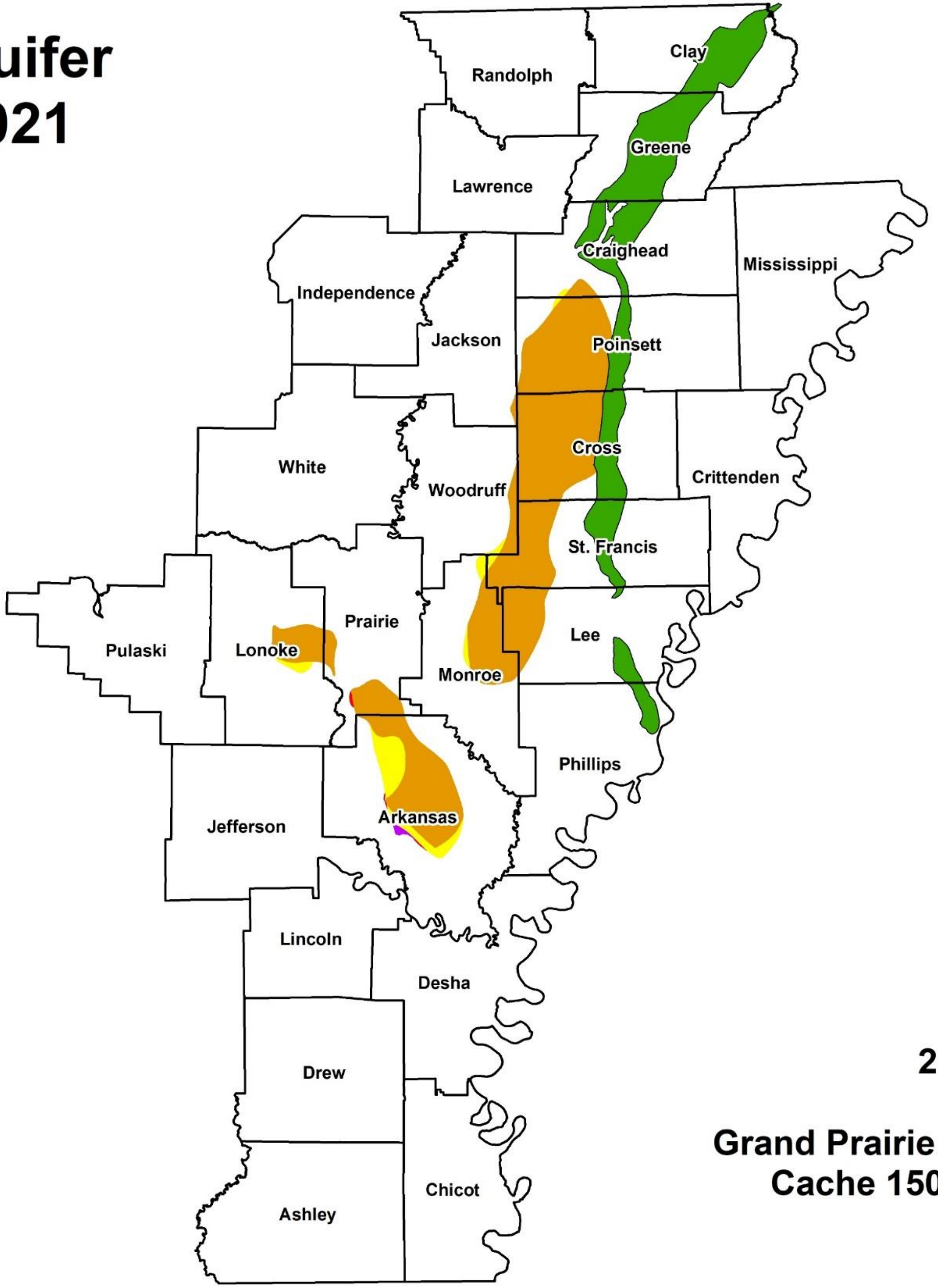
1990

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer
1970 to 2021



Alluvial Aquifer
1970 to 2021



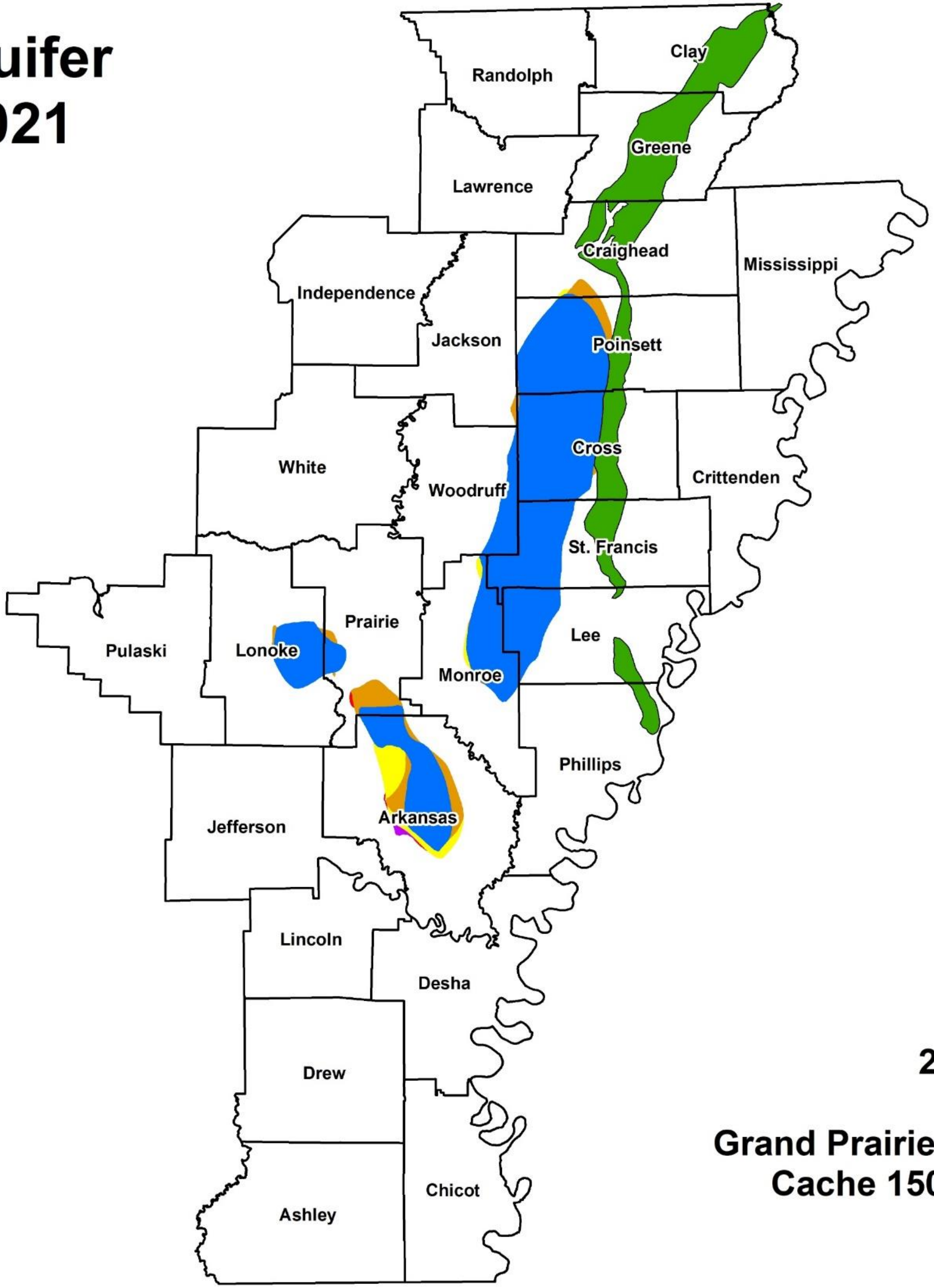
Legend

- 1970
- 1980
- 1990
- 2000
- 2010

2010

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer 1970 to 2021



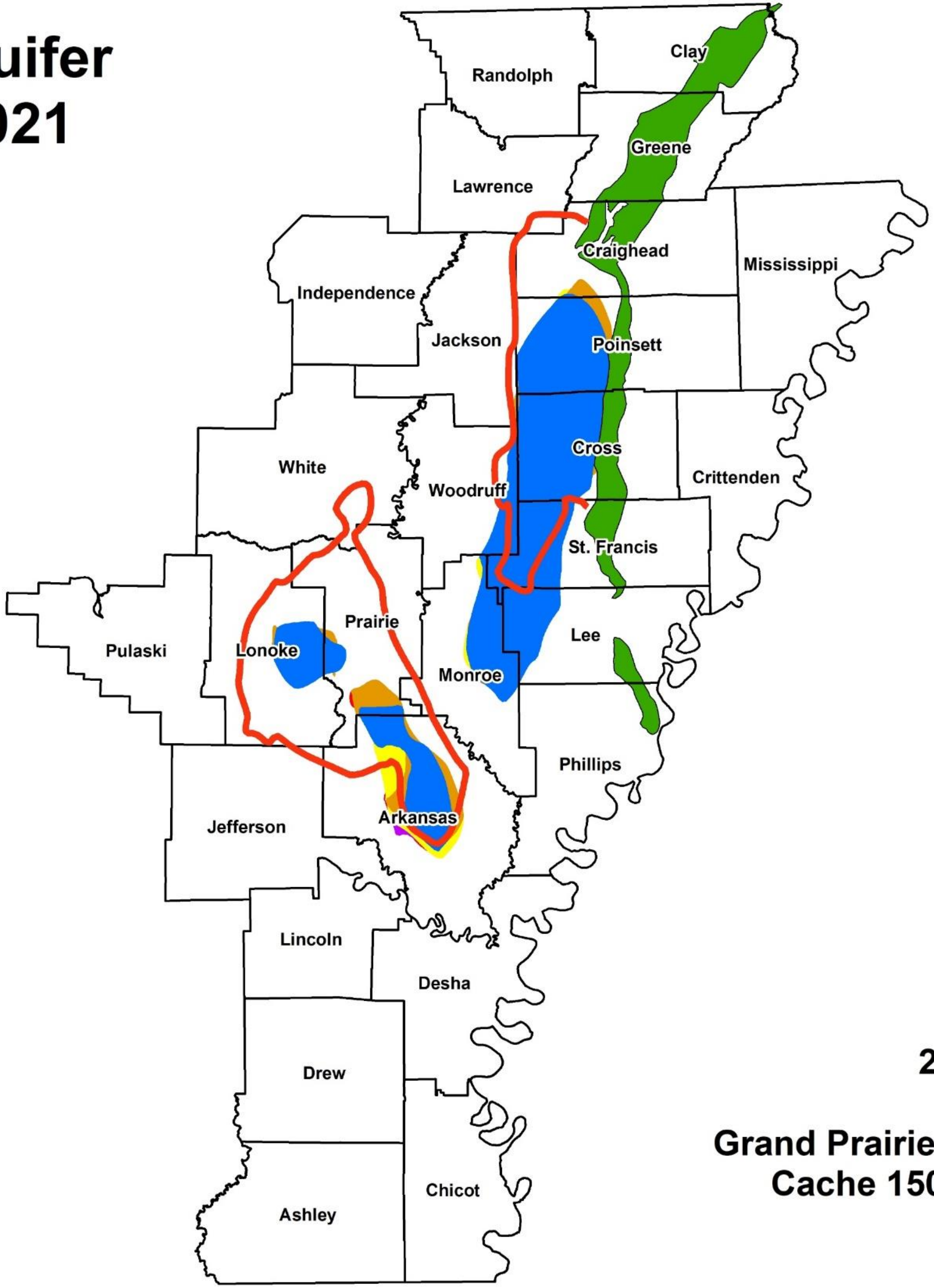
Legend

- 1970
- 1980
- 1990
- 2000
- 2010
- 2021

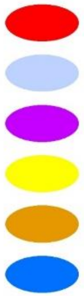
2021

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer
1970 to 2021



Legend



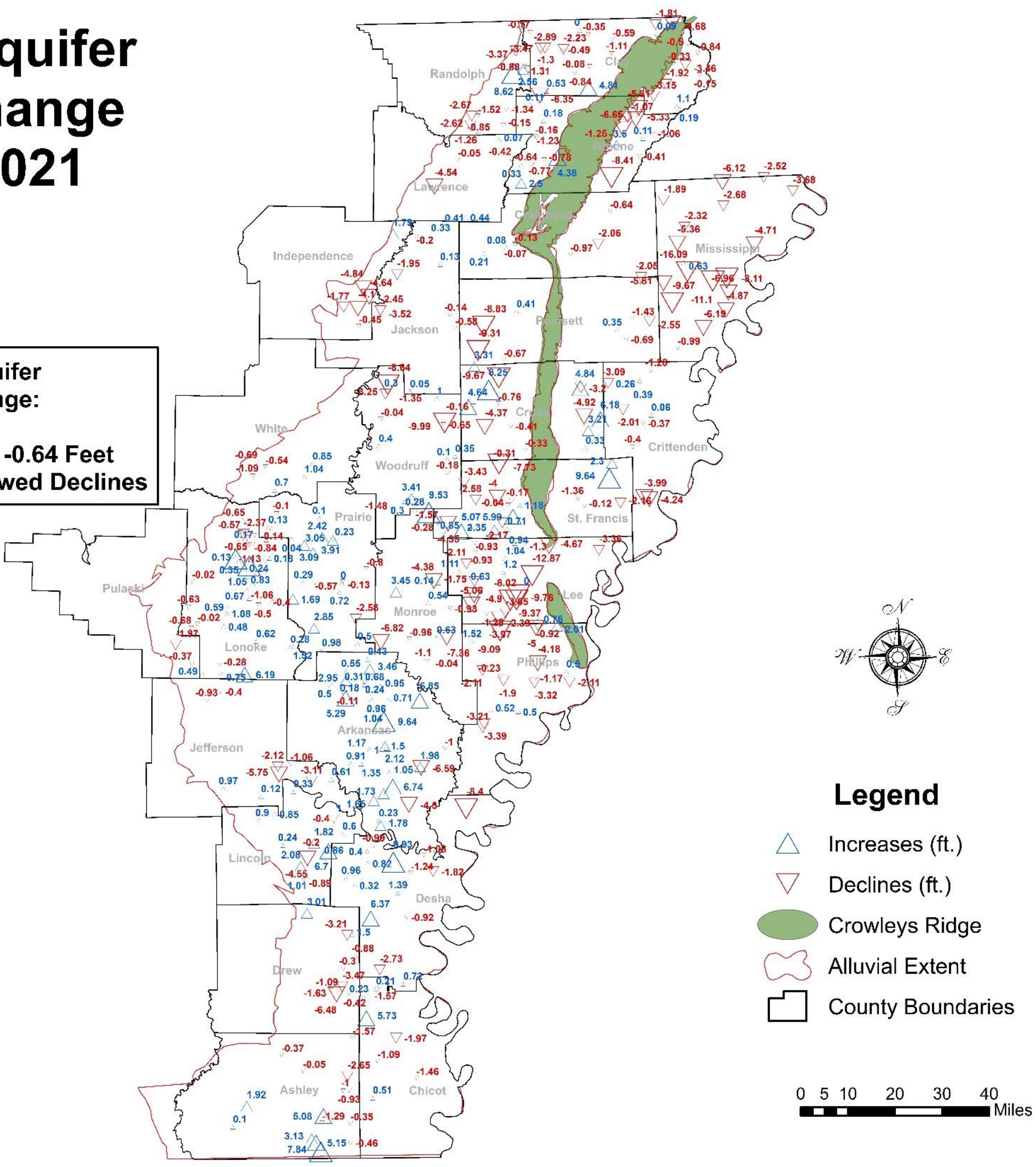
2021

Grand Prairie 110 Ft. Contour
Cache 150 Ft. Contour

Alluvial Aquifer 1 Year Change 2020 - 2021

**Alluvial Aquifer
1 Year Change:**

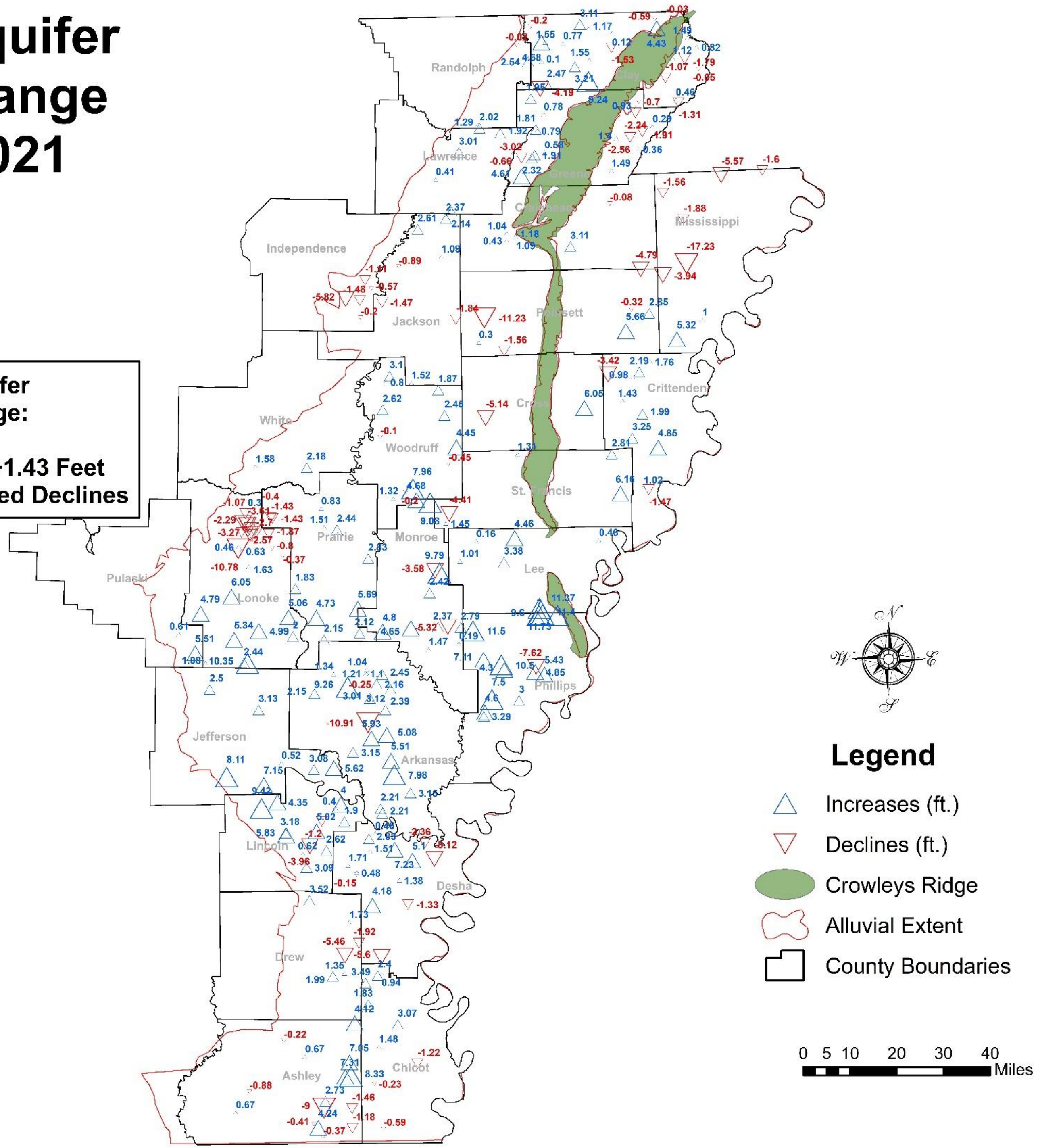
**Average Change: -0.64 Feet
238 of 410 Wells Showed Declines**



Alluvial Aquifer
5 Year Change
2016 - 2021

Alluvial Aquifer
5 Year Change:

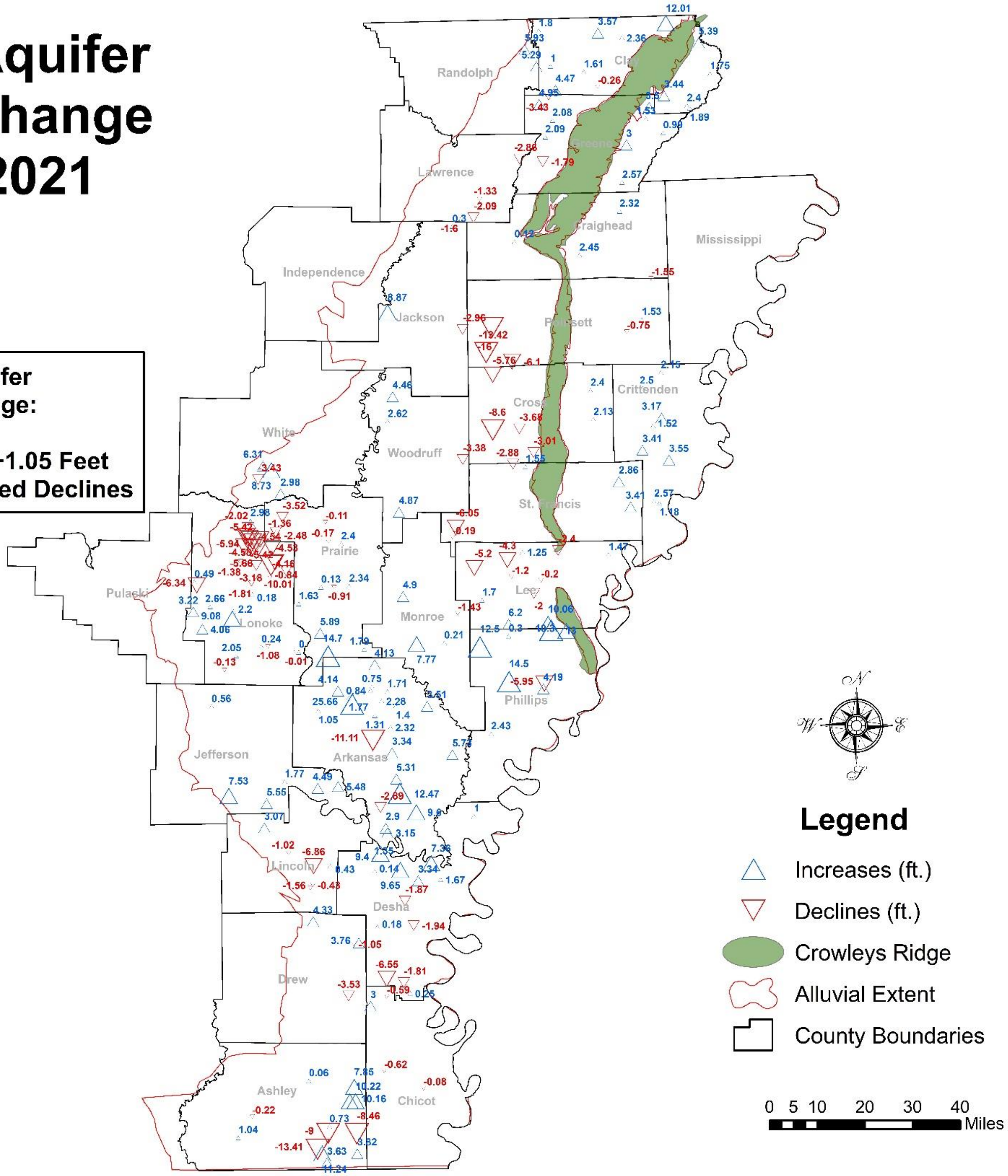
Average Change: +1.43 Feet
85 of 278 Wells Showed Declines



Alluvial Aquifer
10 Year Change
2011 - 2021

Alluvial Aquifer
10 Year Change:

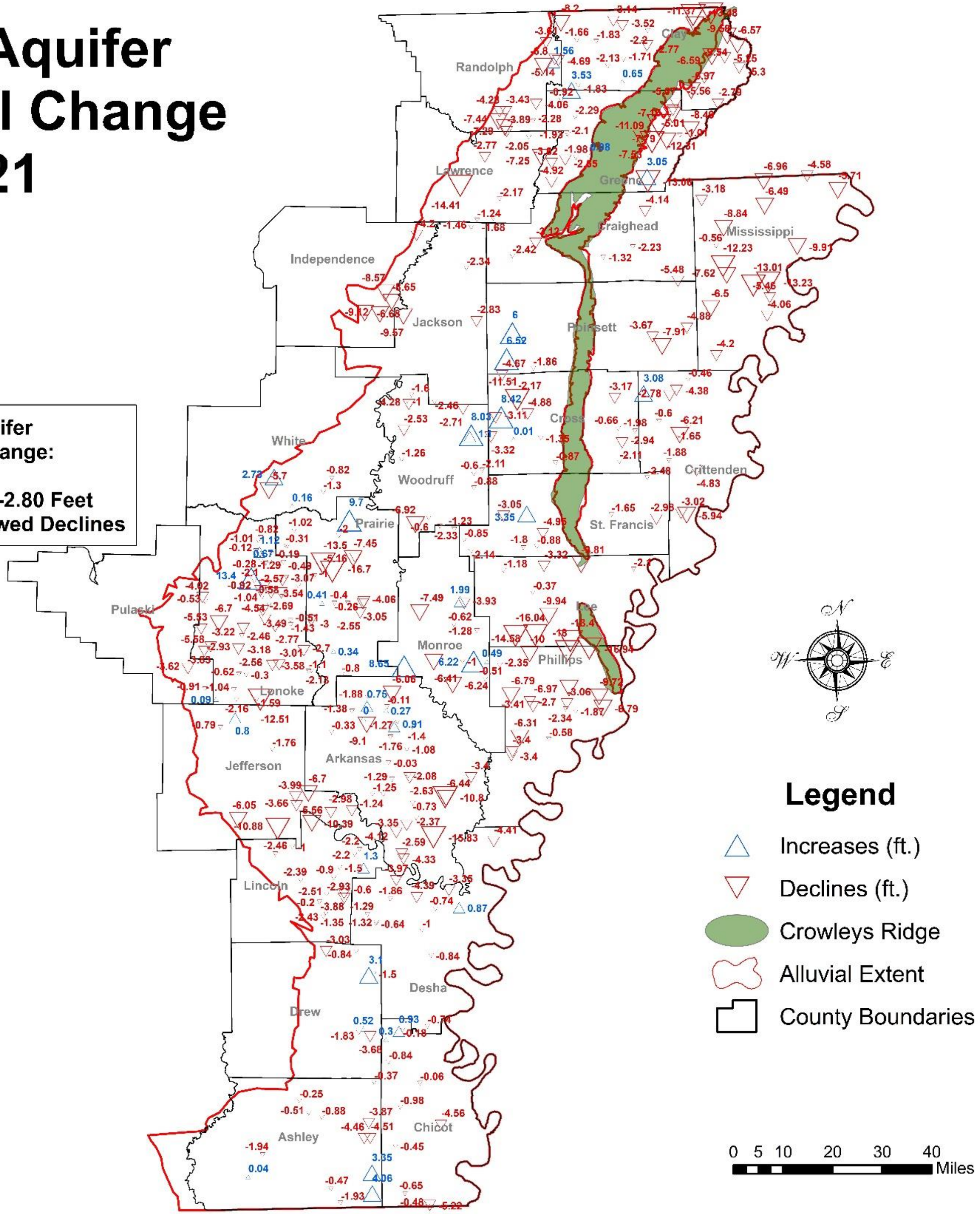
Average Change: +1.05 Feet
80 of 210 Wells Showed Declines



Alluvial Aquifer Spring/Fall Change 2021

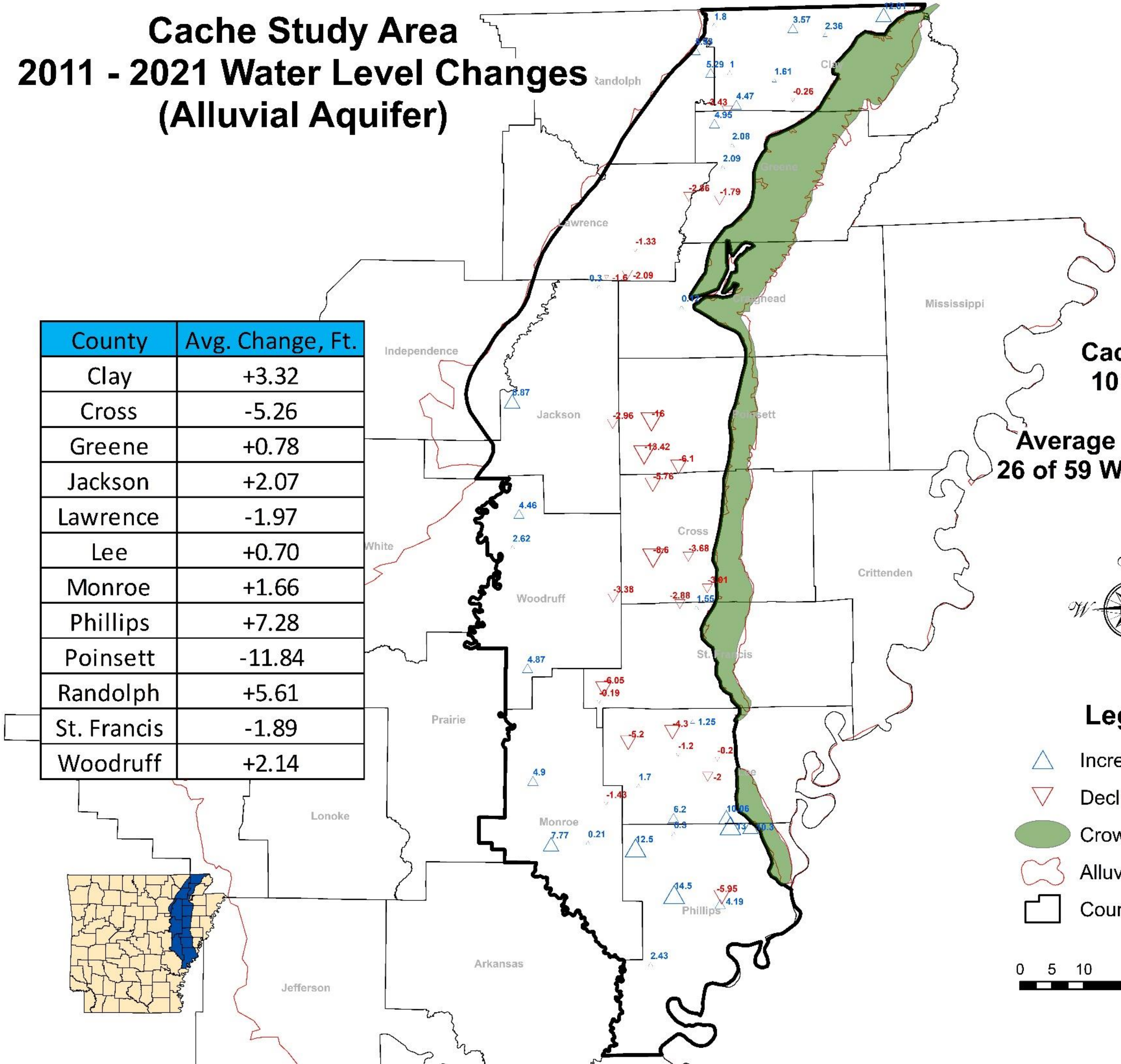
Alluvial Aquifer Spring/Fall Change:

Average Change: -2.80 Feet
328 of 372 Wells Showed Declines



Cache Study Area
2011 - 2021 Water Level Changes
(Alluvial Aquifer)

County	Avg. Change, Ft.
Clay	+3.32
Cross	-5.26
Greene	+0.78
Jackson	+2.07
Lawrence	-1.97
Lee	+0.70
Monroe	+1.66
Phillips	+7.28
Poinsett	-11.84
Randolph	+5.61
St. Francis	-1.89
Woodruff	+2.14



Cache Study Area
10 Year Change:

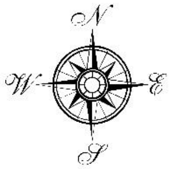
Average Change: +0.91 Feet
26 of 59 Wells Showed Declines

Grand Prairie Study Area
2011 - 2021 Water Level Changes
(Alluvial Aquifer)

Grand Prairie Study Area
10 Year Change:

Average Change: +0.82 Feet
34 of 80 Wells Showed Declines

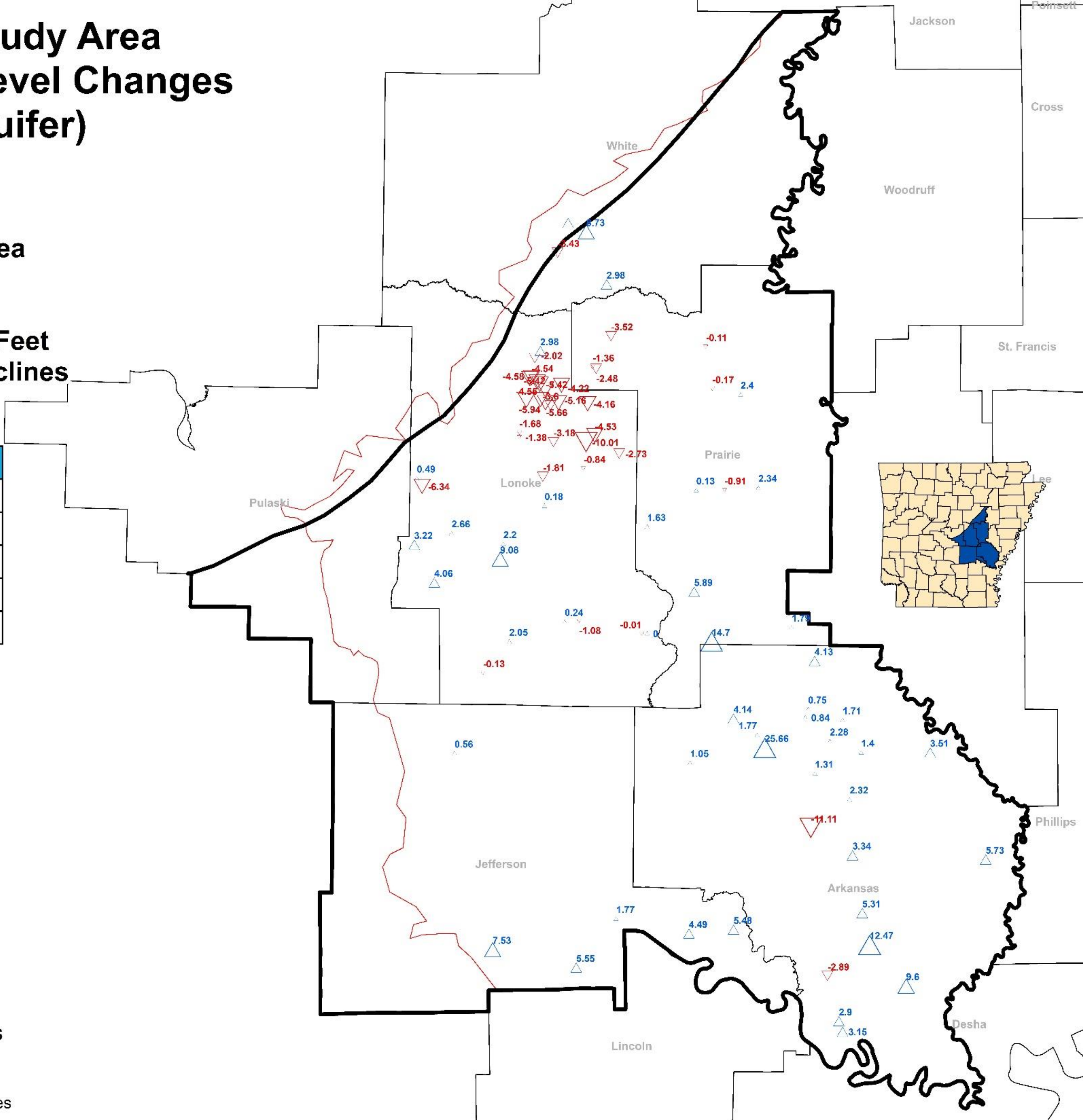
County	Avg. Change, Ft.
Arkansas	+3.61
Jefferson	+4.23
Lonoke	-1.89
Prairie	+1.56
White	+3.65



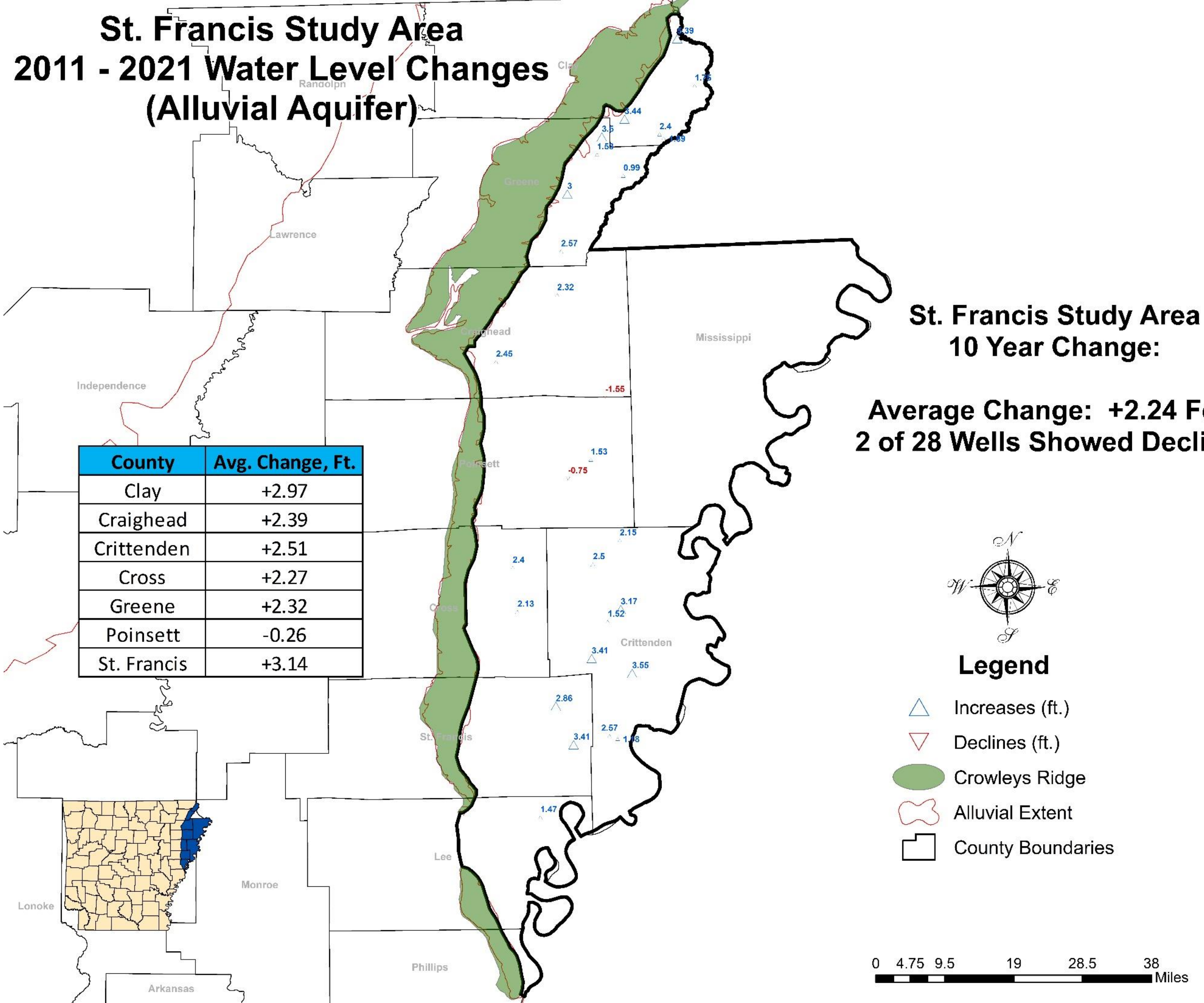
Legend

- Increases (ft.)
- Declines (ft.)
- Alluvial Extent
- County Boundaries

0 3.25 6.5 13 19.5 26 Miles



St. Francis Study Area
2011 - 2021 Water Level Changes
(Alluvial Aquifer)



County	Avg. Change, Ft.
Clay	+2.97
Craighead	+2.39
Crittenden	+2.51
Cross	+2.27
Greene	+2.32
Poinsett	-0.26
St. Francis	+3.14

St. Francis Study Area
10 Year Change:

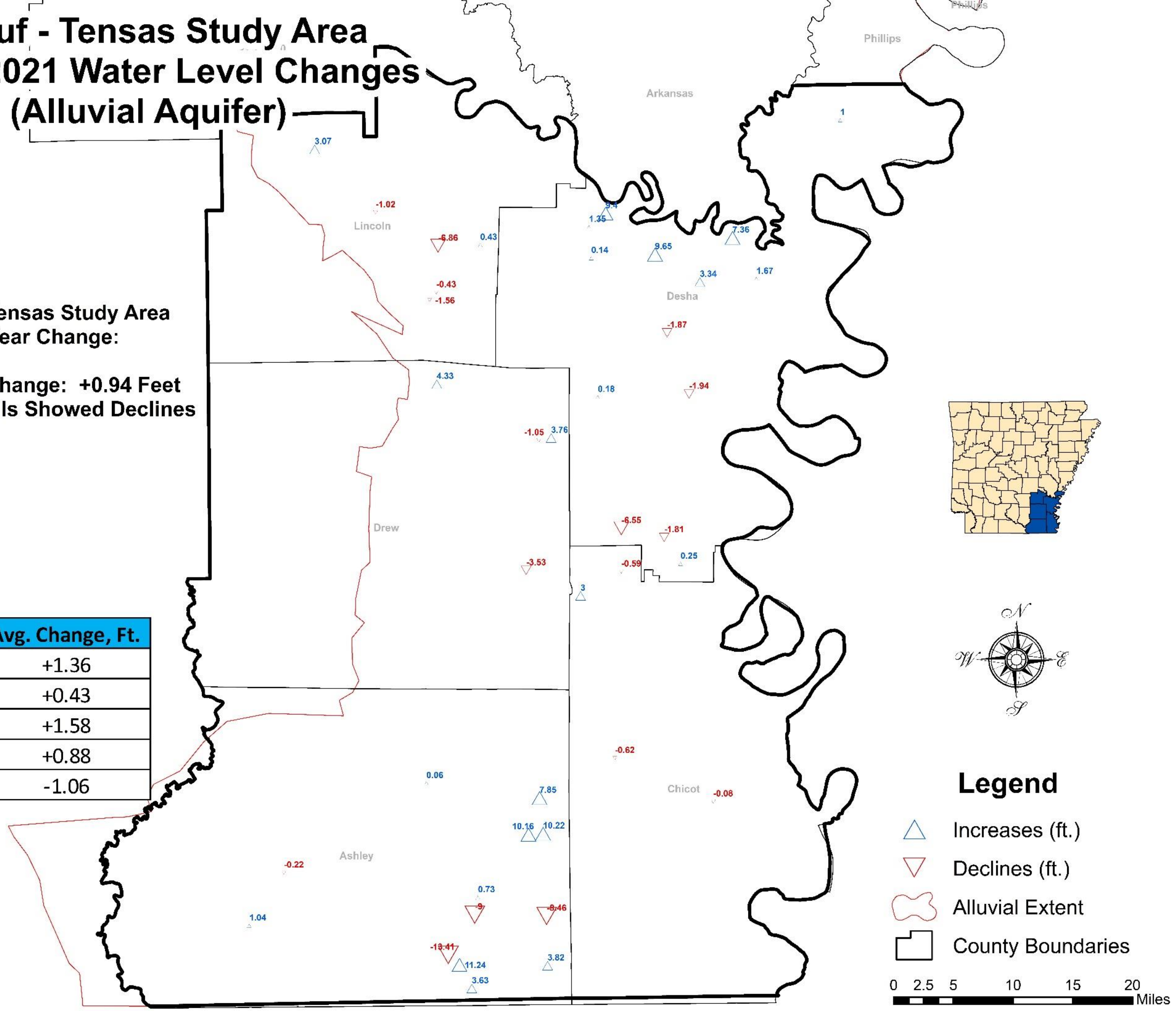
Average Change: +2.24 Feet
2 of 28 Wells Showed Declines

Boeuf - Tensas Study Area
2011 - 2021 Water Level Changes
(Alluvial Aquifer)

Boeuf - Tensas Study Area
10 Year Change:

Average Change: +0.94 Feet
17 of 41 Wells Showed Declines

County	Avg. Change, Ft.
Ashley	+1.36
Chicot	+0.43
Desha	+1.58
Drew	+0.88
Lincoln	-1.06

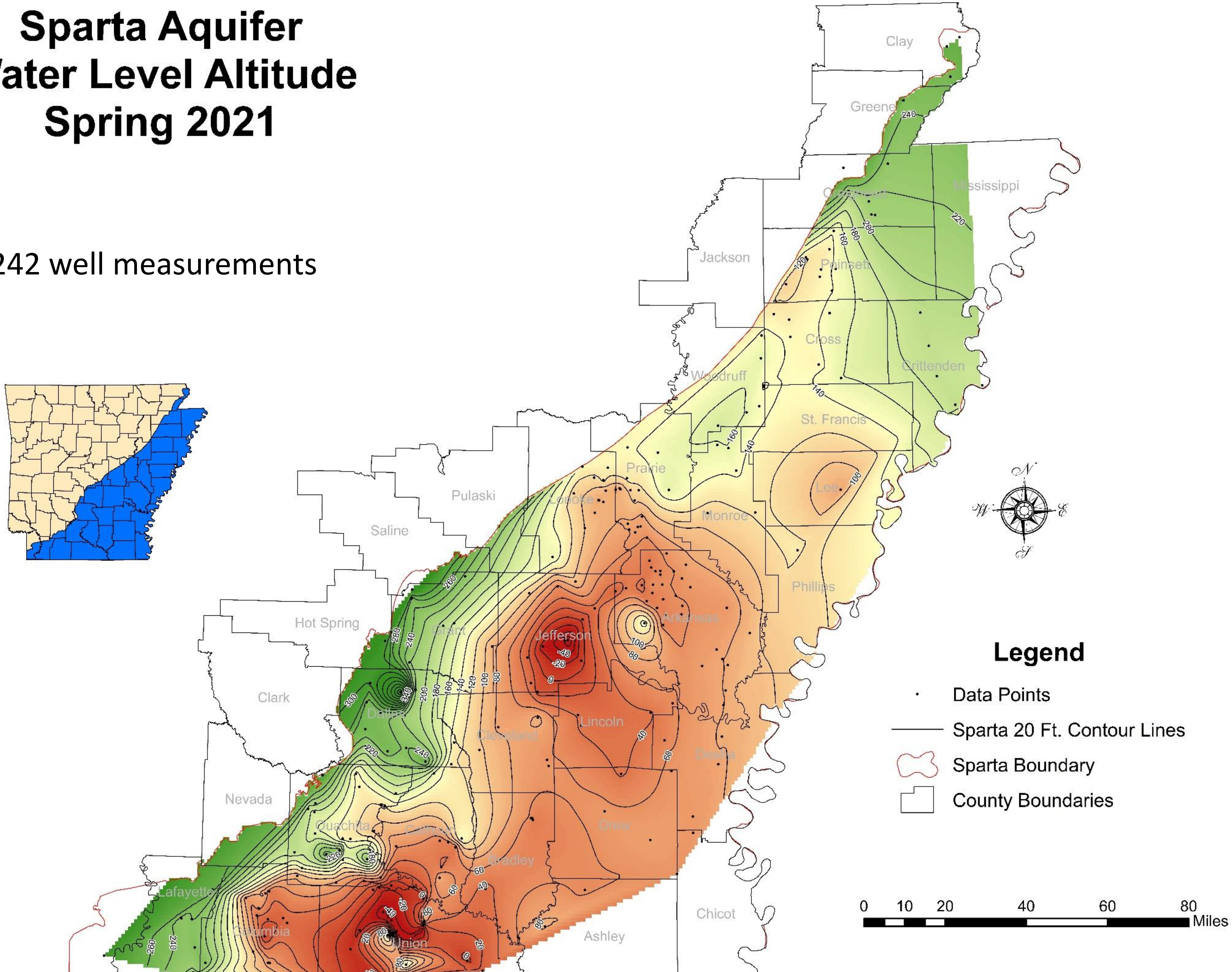


Sparta Aquifer

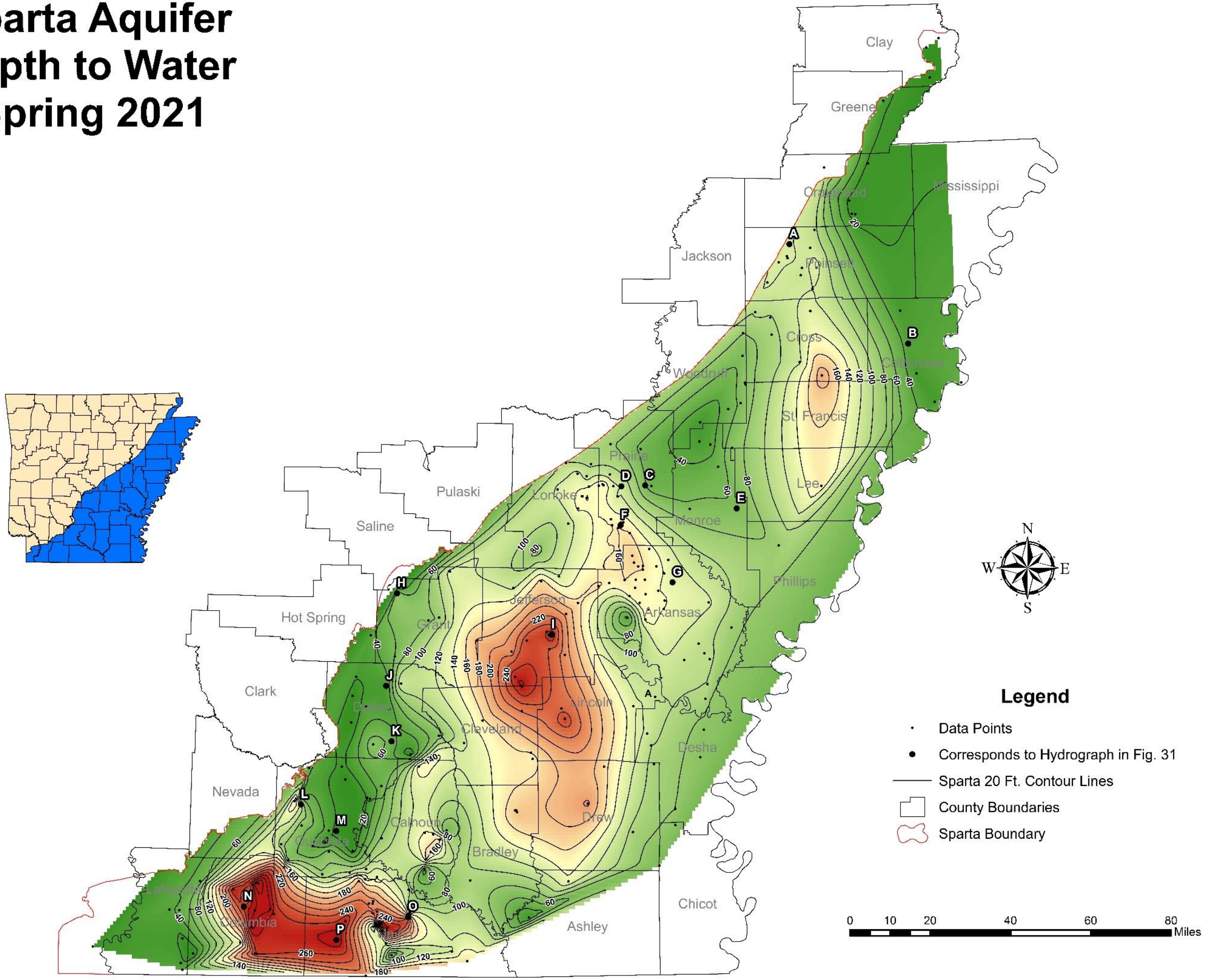
- 549 total number of measurements collected in 2021
- 242 different wells measured in spring 2021

Sparta Aquifer Water Level Altitude Spring 2021

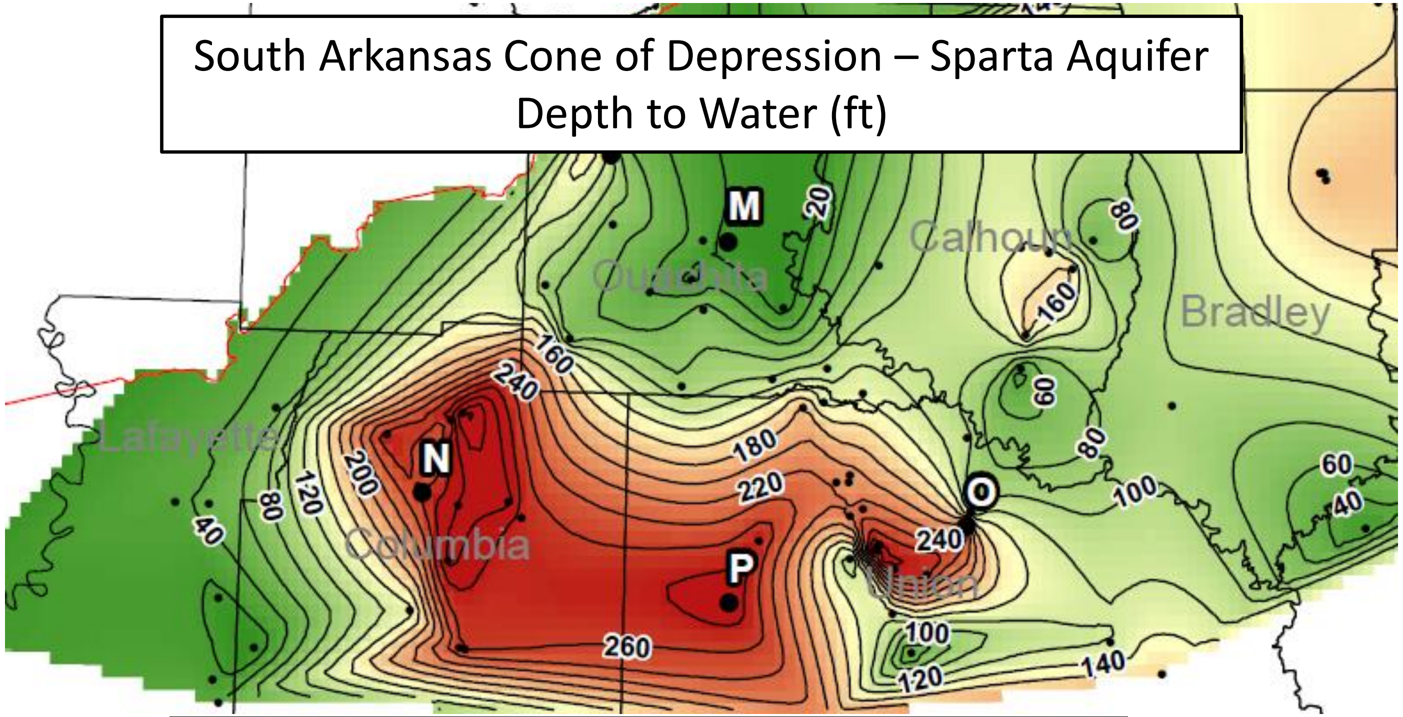
242 well measurements

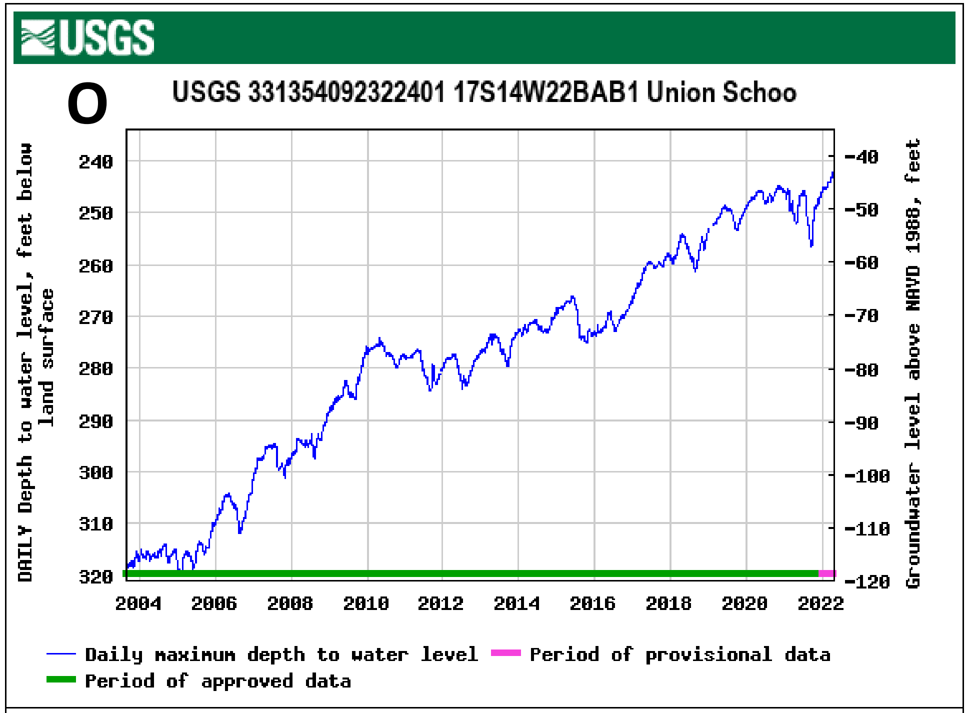


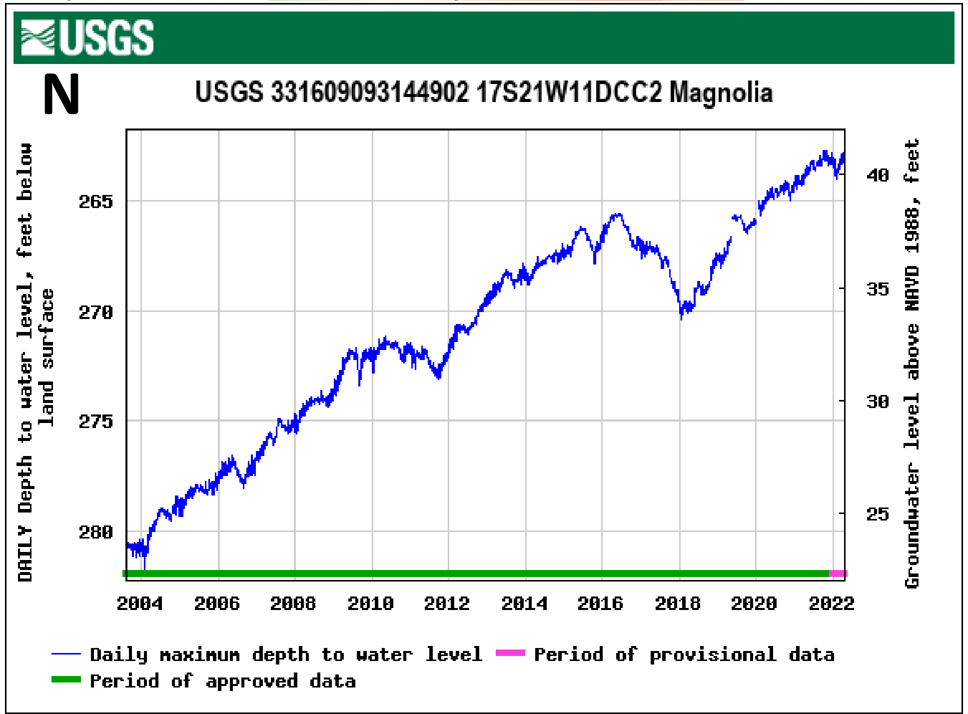
Sparta Aquifer Depth to Water Spring 2021

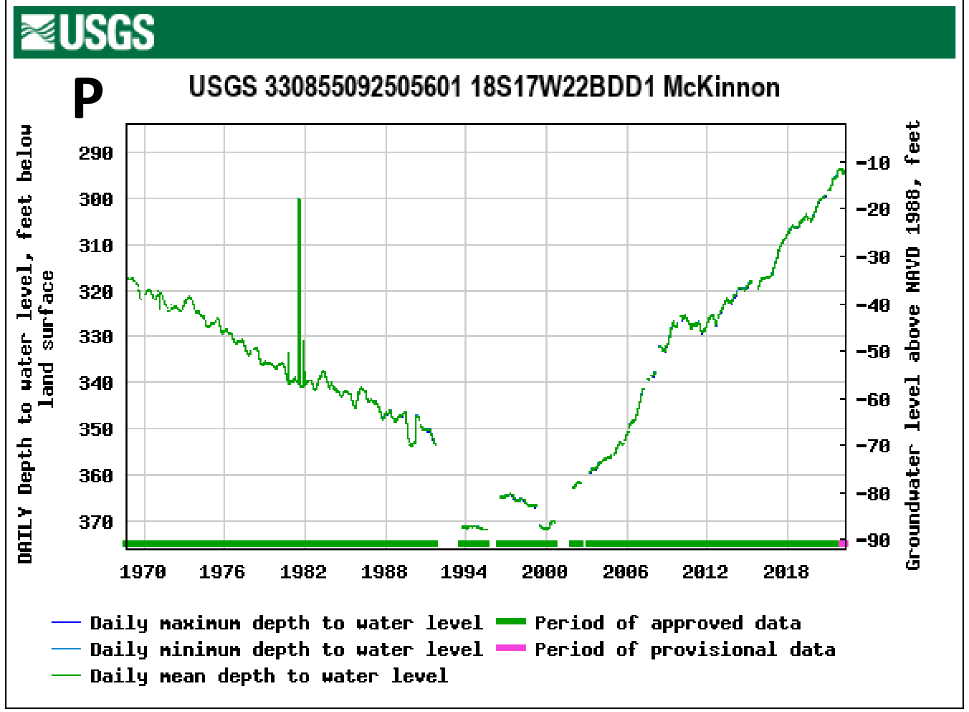


South Arkansas Cone of Depression – Sparta Aquifer Depth to Water (ft)

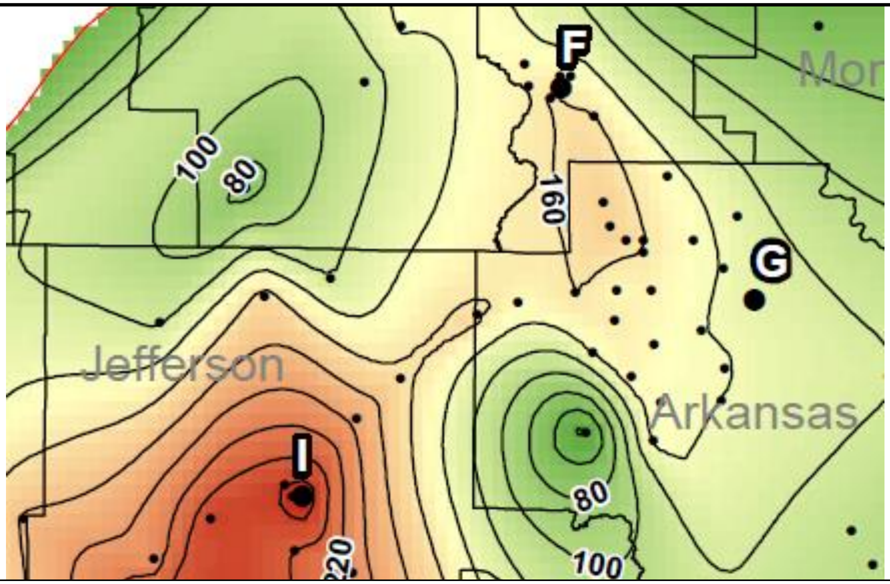


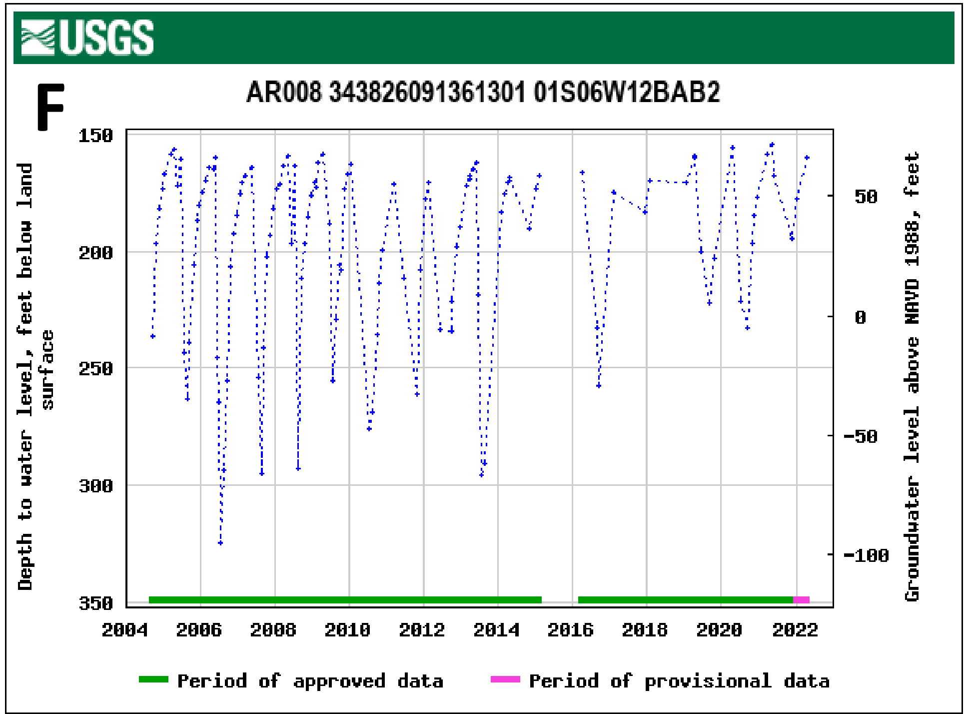


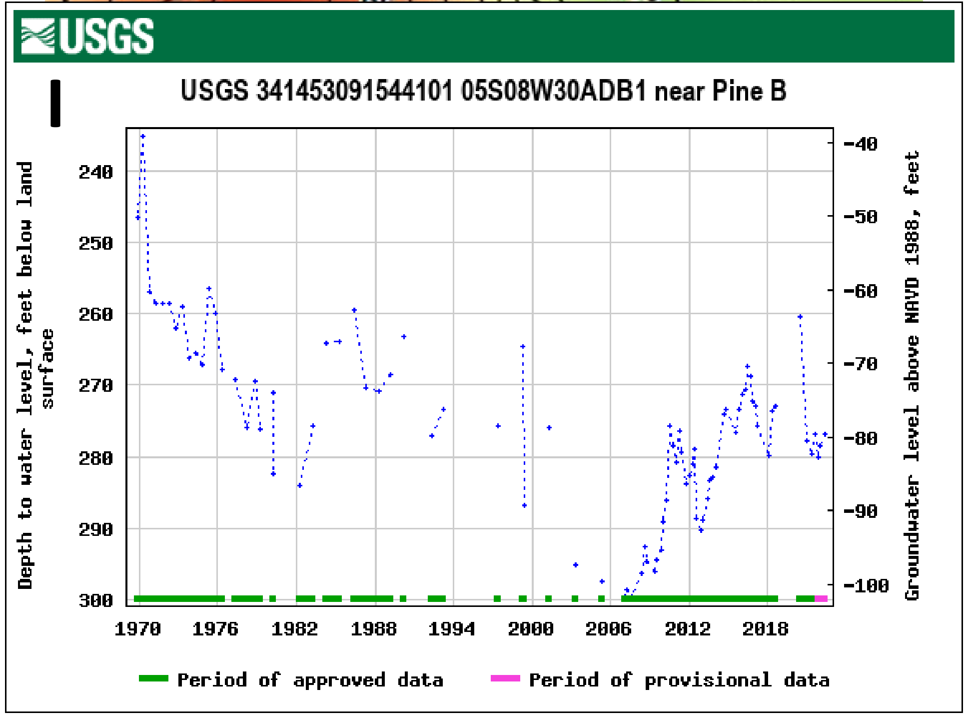


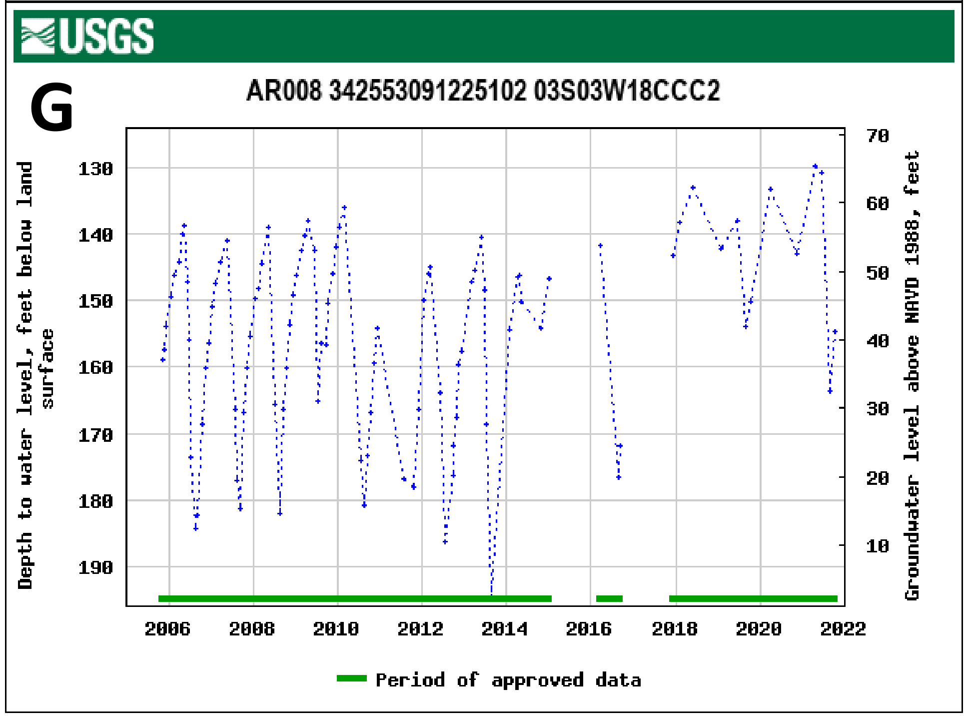


2021 Grand Prairie Cone of Depression – Sparta Aquifer Depth to Water (ft)





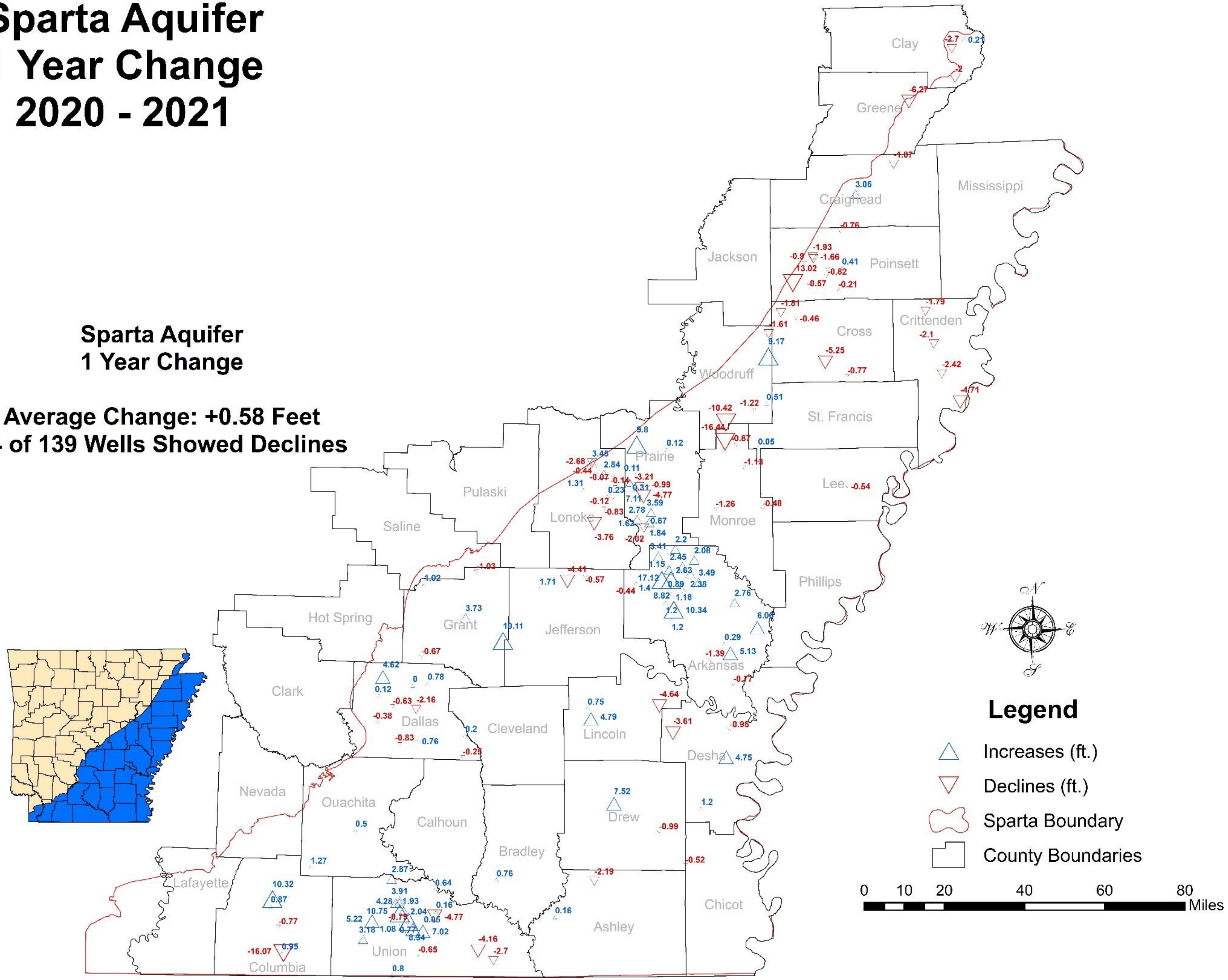




Sparta Aquifer
1 Year Change
2020 - 2021

Sparta Aquifer
1 Year Change

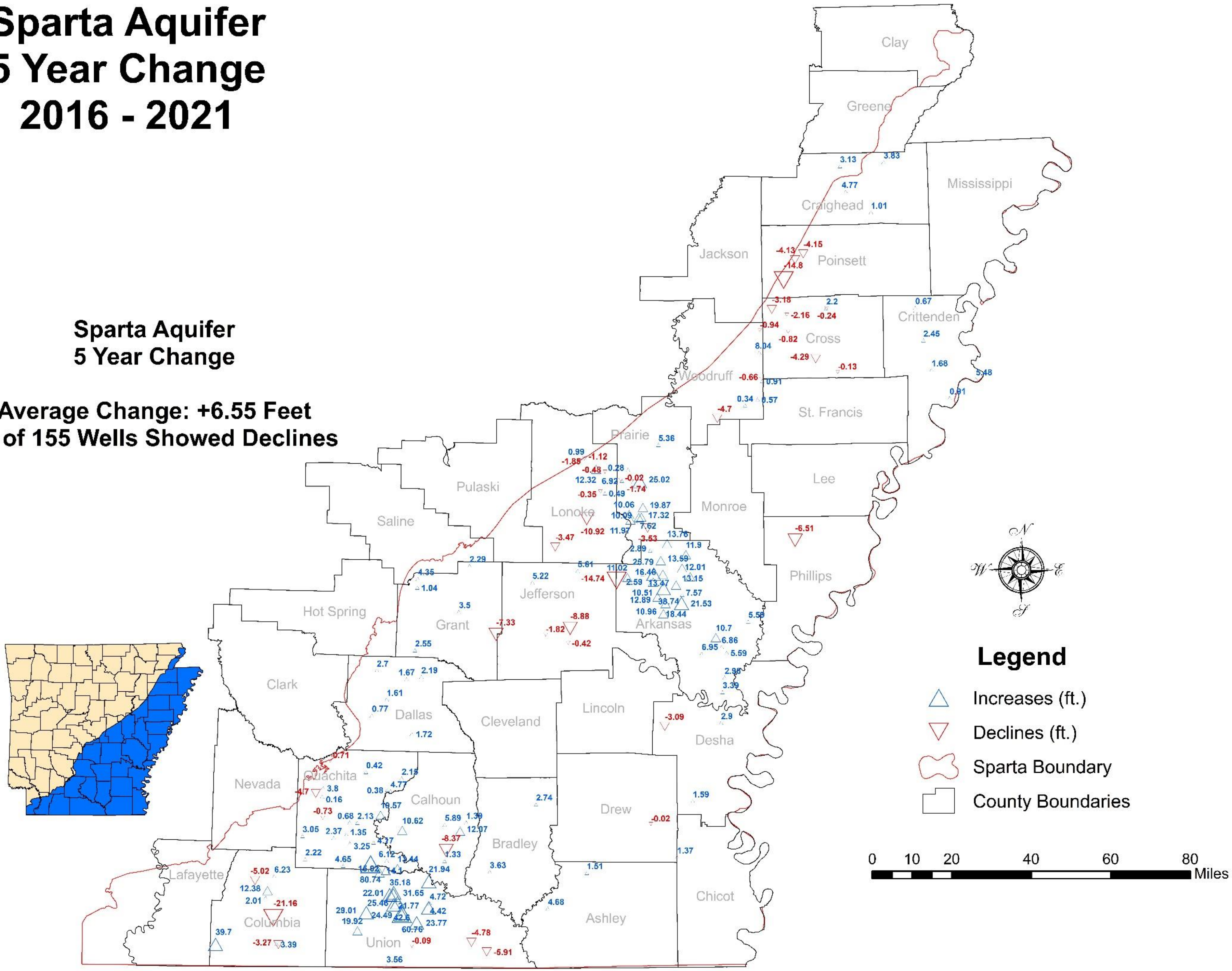
Average Change: +0.58 Feet
64 of 139 Wells Showed Declines



Sparta Aquifer
5 Year Change
2016 - 2021

Sparta Aquifer
5 Year Change

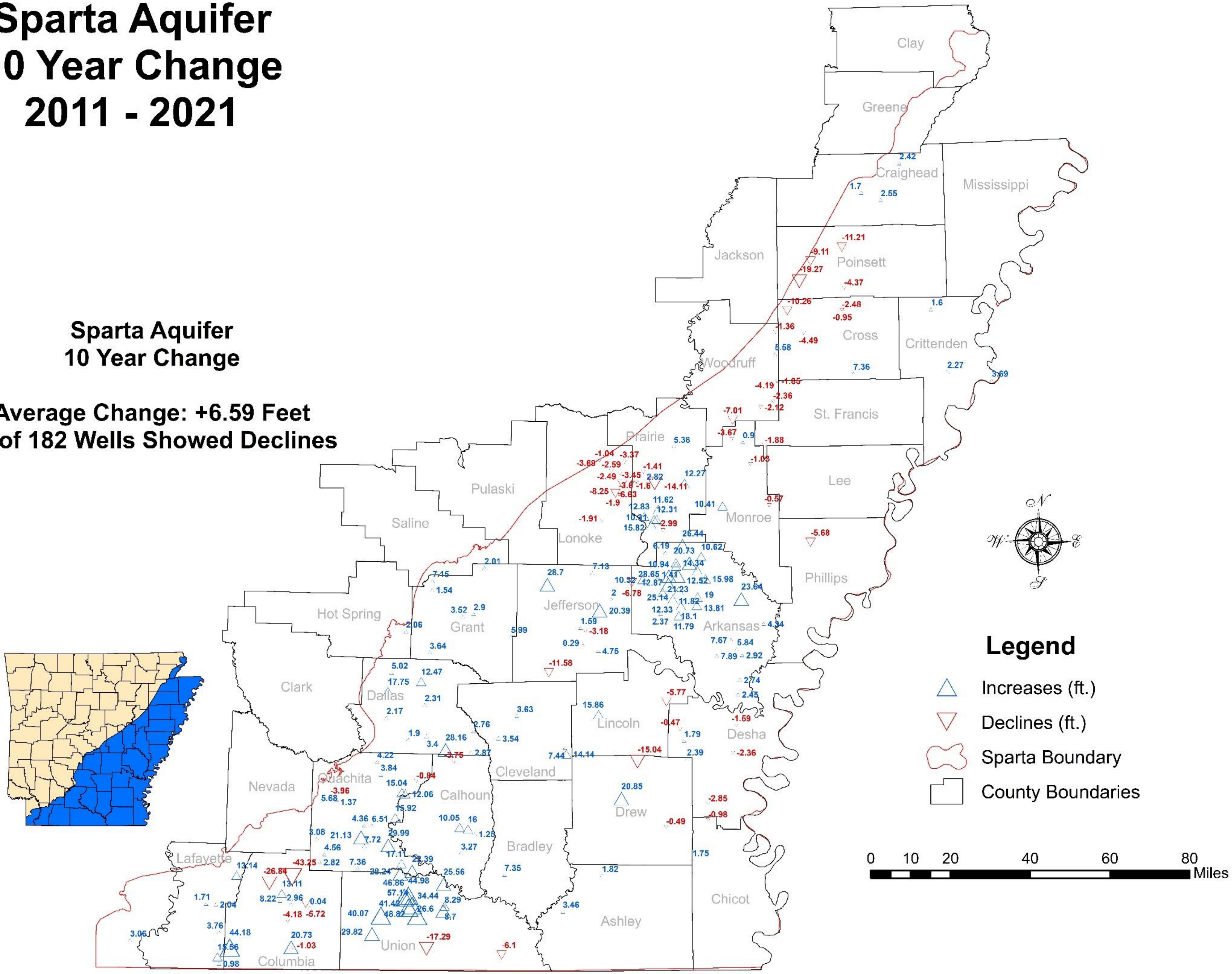
Average Change: +6.55 Feet
39 of 155 Wells Showed Declines



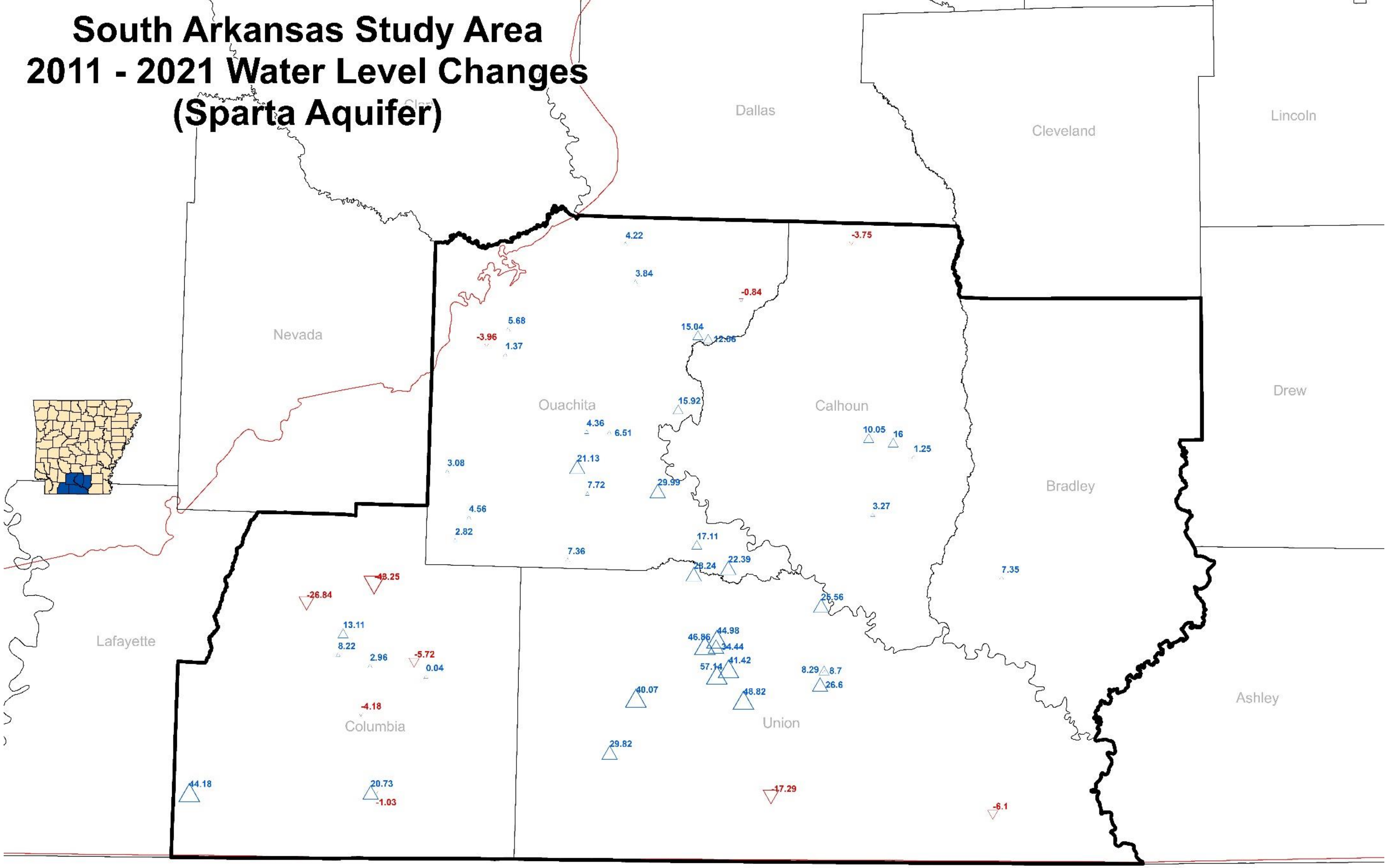
Sparta Aquifer
10 Year Change
2011 - 2021

Sparta Aquifer
10 Year Change

Average Change: +6.59 Feet
51 of 182 Wells Showed Declines



South Arkansas Study Area
2011 - 2021 Water Level Changes
(Sparta Aquifer)



County	Avg. Change, Ft.
Bradley	+7.35
Calhoun	+5.36
Columbia	+0.75
Ouachita	+9.02
Union	+28.00

South Arkansas Study Area
10 Year Change:

Average Change: +12.31 Feet
10 of 52 Wells Showed Declines

0 2.5 5 10 15 20 Miles

Legend

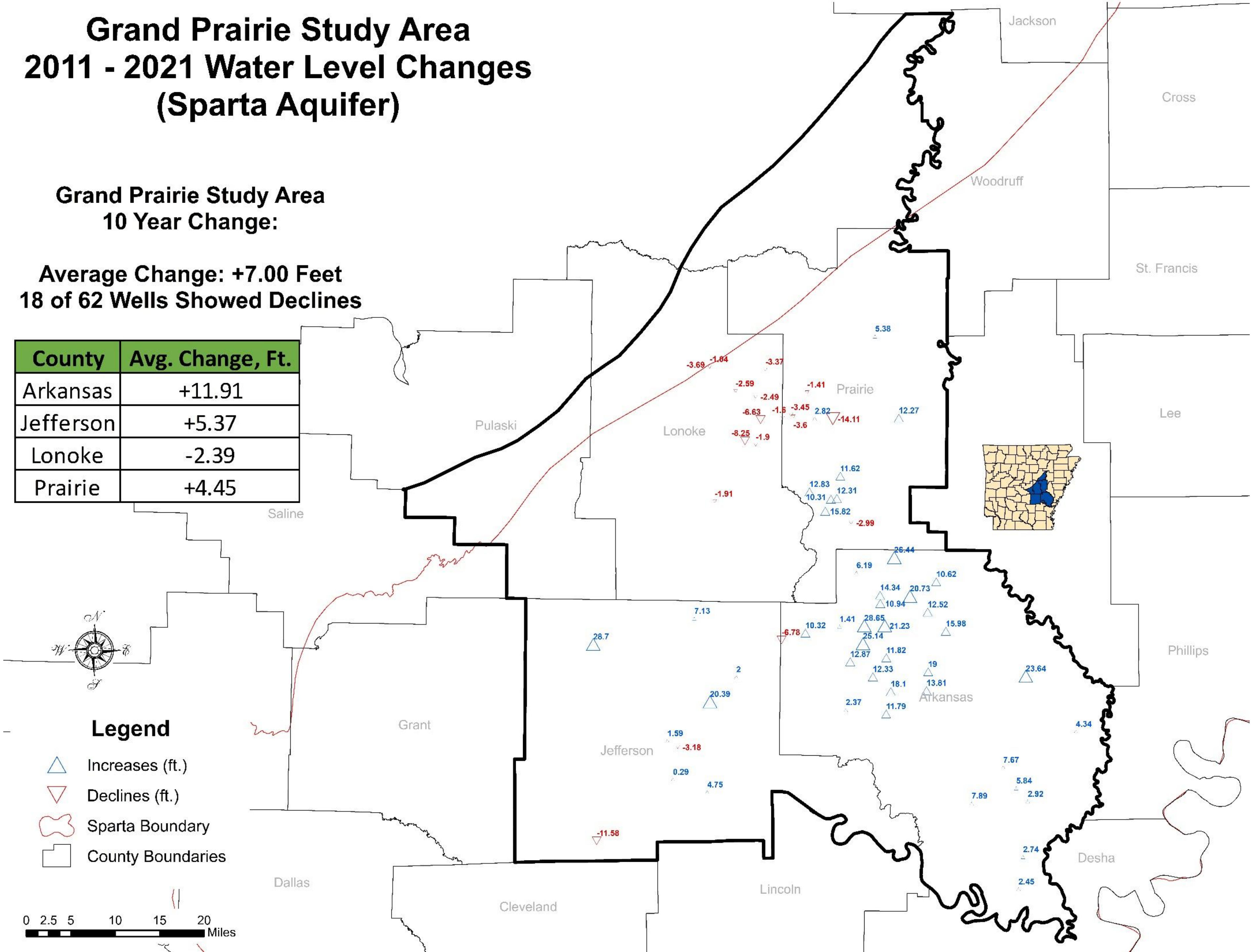
- Increases (ft.)
- Declines (ft.)
- Sparta Boundary
- County Boundaries

Grand Prairie Study Area
2011 - 2021 Water Level Changes
(Sparta Aquifer)

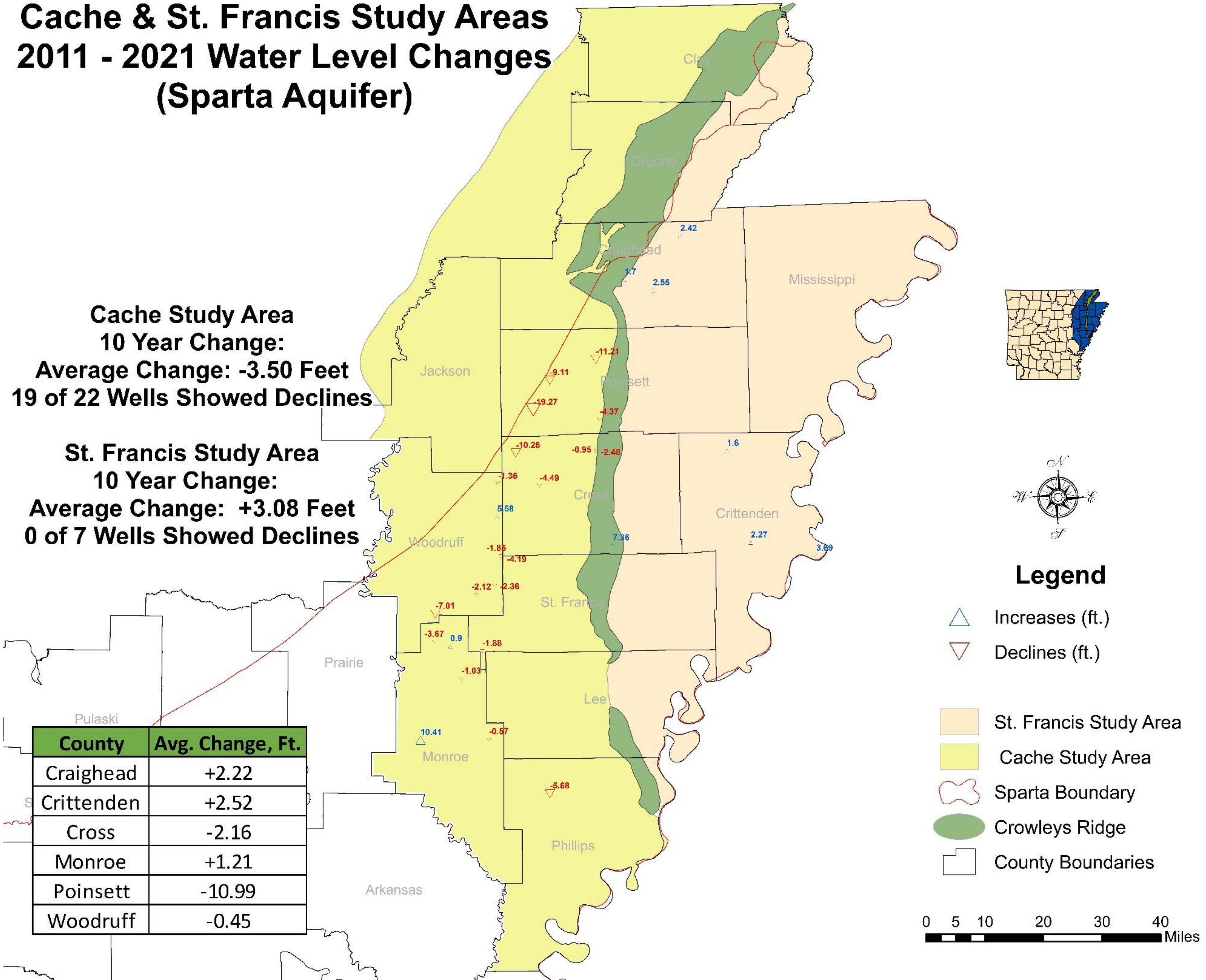
Grand Prairie Study Area
10 Year Change:

Average Change: +7.00 Feet
18 of 62 Wells Showed Declines

County	Avg. Change, Ft.
Arkansas	+11.91
Jefferson	+5.37
Lonoke	-2.39
Prairie	+4.45



Cache & St. Francis Study Areas 2011 - 2021 Water Level Changes (Sparta Aquifer)



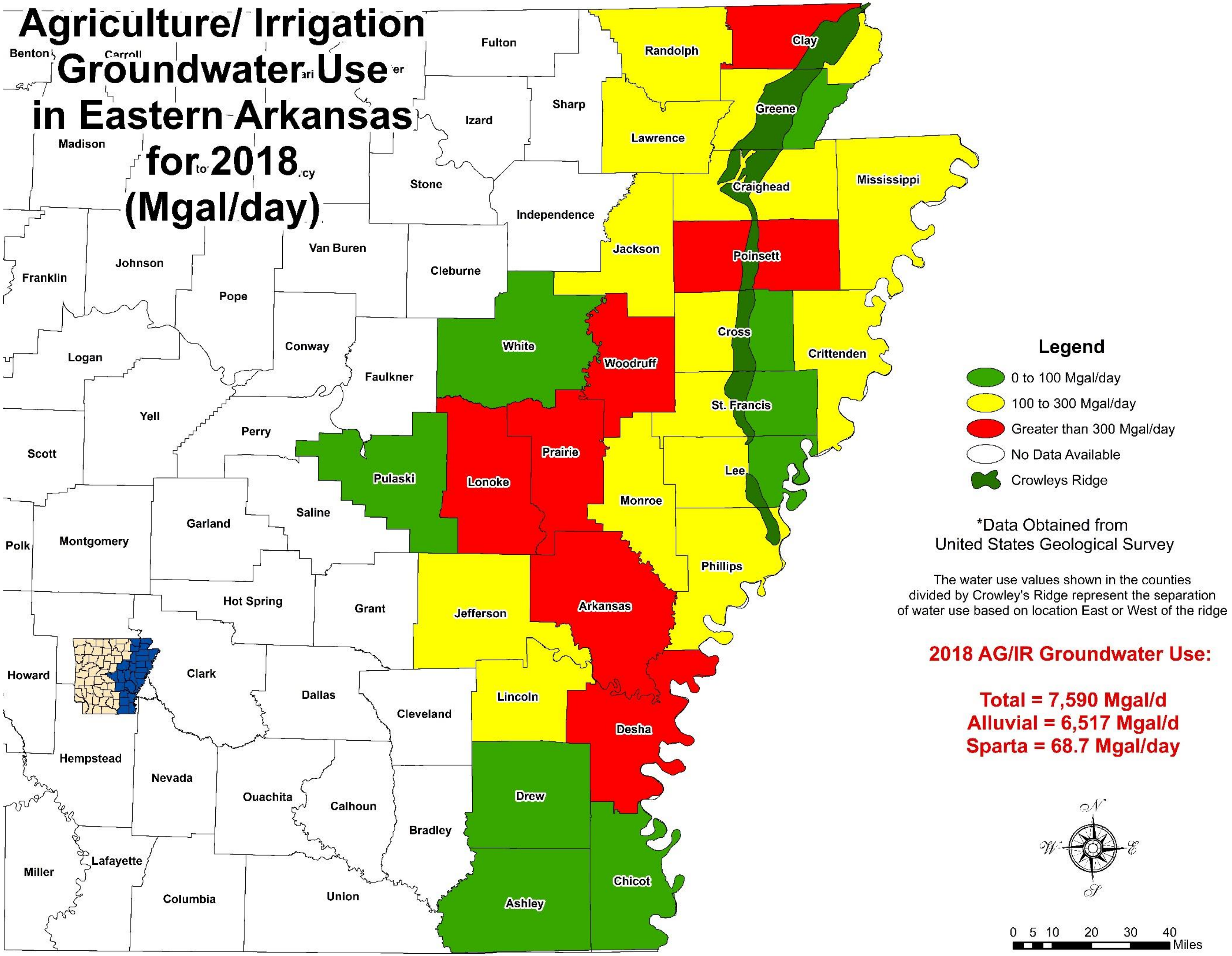
Cache Study Area
10 Year Change:
Average Change: -3.50 Feet
19 of 22 Wells Showed Declines

St. Francis Study Area
10 Year Change:
Average Change: +3.08 Feet
0 of 7 Wells Showed Declines

County	Avg. Change, Ft.
Craighead	+2.22
Crittenden	+2.52
Cross	-2.16
Monroe	+1.21
Poinsett	-10.99
Woodruff	-0.45

Water-use Registration Program

- Established in 1985
- Over 55,000 surface water and groundwater withdrawal sites
- Any non-domestic user of groundwater that has the potential to withdraw at least 50,000 gpd (35 gpm) must report annual water usage
- Any user of surface water that withdraws 1 acft or more must report
- Data reported annually and stored in a site-specific database


Agriculture/ Irrigation Groundwater Use in Eastern Arkansas for 2018 (Mgal/day)
Legend
0 to 100 Mgal/day
100 to 300 Mgal/day
Greater than 300 Mgal/day
No Data Available
Crowleys Ridge
*Data Obtained from United States Geological Survey
The water use values shown in the counties divided by Crowley's Ridge represent the separation of water use based on location East or West of the ridge
2018 AG/IR Groundwater Use:
Total = 7,590 Mgal/d
Alluvial = 6,517 Mgal/d
Sparta = 68.7 Mgal/day
Benton
Carroll
Madison
Fulton
Sharp
Izard
Stone
Independence
Randolph
Clay
Greene
Lawrence
Craighead
Mississippi
Jackson
Poinsett
Van Buren
Cleburne
Franklin
Johnson
Pope
Logan
Conway
Faulkner
White
Woodruff
Cross
Crittenden
St. Francis
Yell
Perry
Scott
Pulaski
Lonoke
Prairie
Monroe
Lee
Saline
Garland
Polk
Montgomery
Phillips
Hot Spring
Grant
Jefferson
Arkansas
Howard
Clark
Dallas
Cleveland
Lincoln
Desha
Hempstead
Nevada
Ouachita
Calhoun
Bradley
Drew
Chicot
Miller
Lafayette
Columbia
Union
Ashley
N
W
E
S
0 5 10 20 30 40
Miles

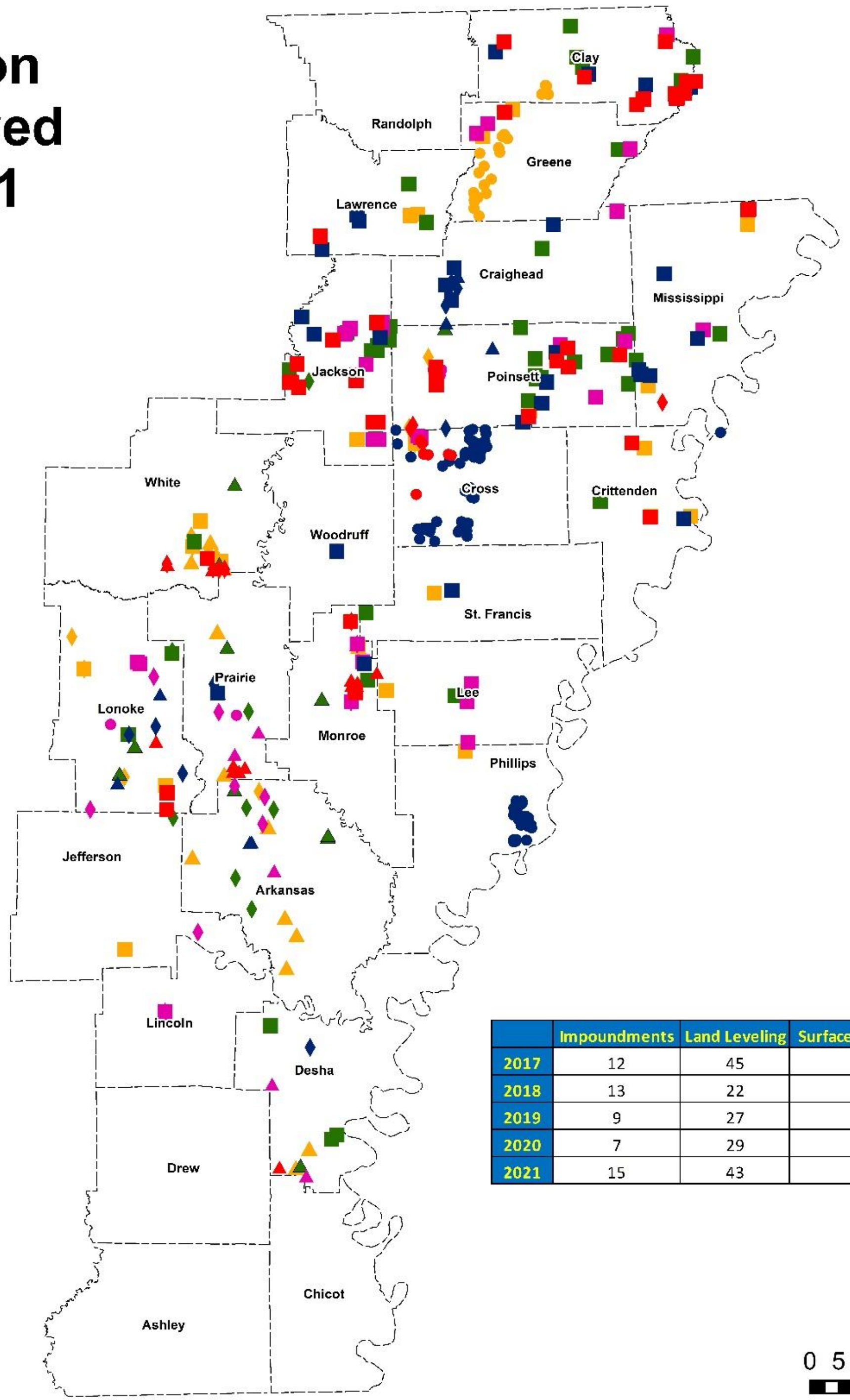
Groundwater Conservation Tax Credit Program

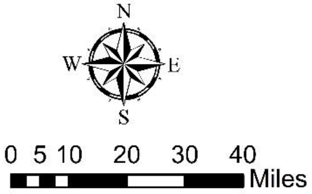
- Issues State income tax credit for the completion of on-farm groundwater conservation projects

- Conservation Project types:
  - Reservoirs
  - Land leveling
  - Surface water conversion
  - Water meters

- Easily applied for at the Conservation District county office

Water Conservation Tax Credits Approved from 2017 to 2021





Project Type:

- Water Meters
- Impoundments
- Land Leveling
- Surface Water Conversions

Year:

Red - 2021
Blue - 2020
Pink - 2019
Yellow - 2018
Green - 2017

	Impoundments	Land Leveling	Surface Water Conversions	Water Meter Installations	Total
2017	12	45	8	0	**65**
2018	13	22	15	23	**73**
2019	9	27	12	9	**57**
2020	7	29	10	80	**126**
2021	15	43	10	7	**75**

Questions?

Blake Forrest, P.G.
Groundwater Section Supervisor
Natural Resources Division

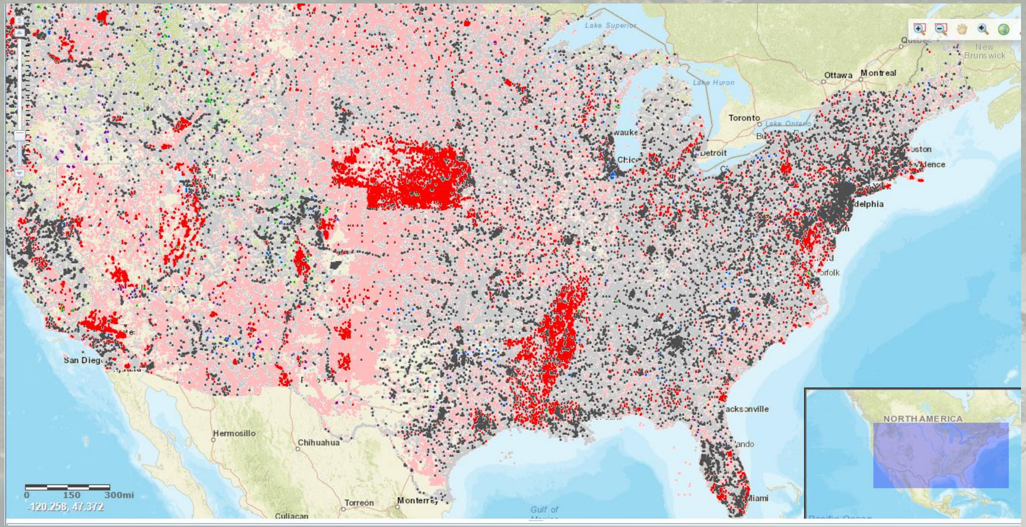
blake.forrest@agriculuture.arkansas.gov

System-Scale Science to Support Water Resources: the USGS Mississippi Alluvial Plain (MAP) Project

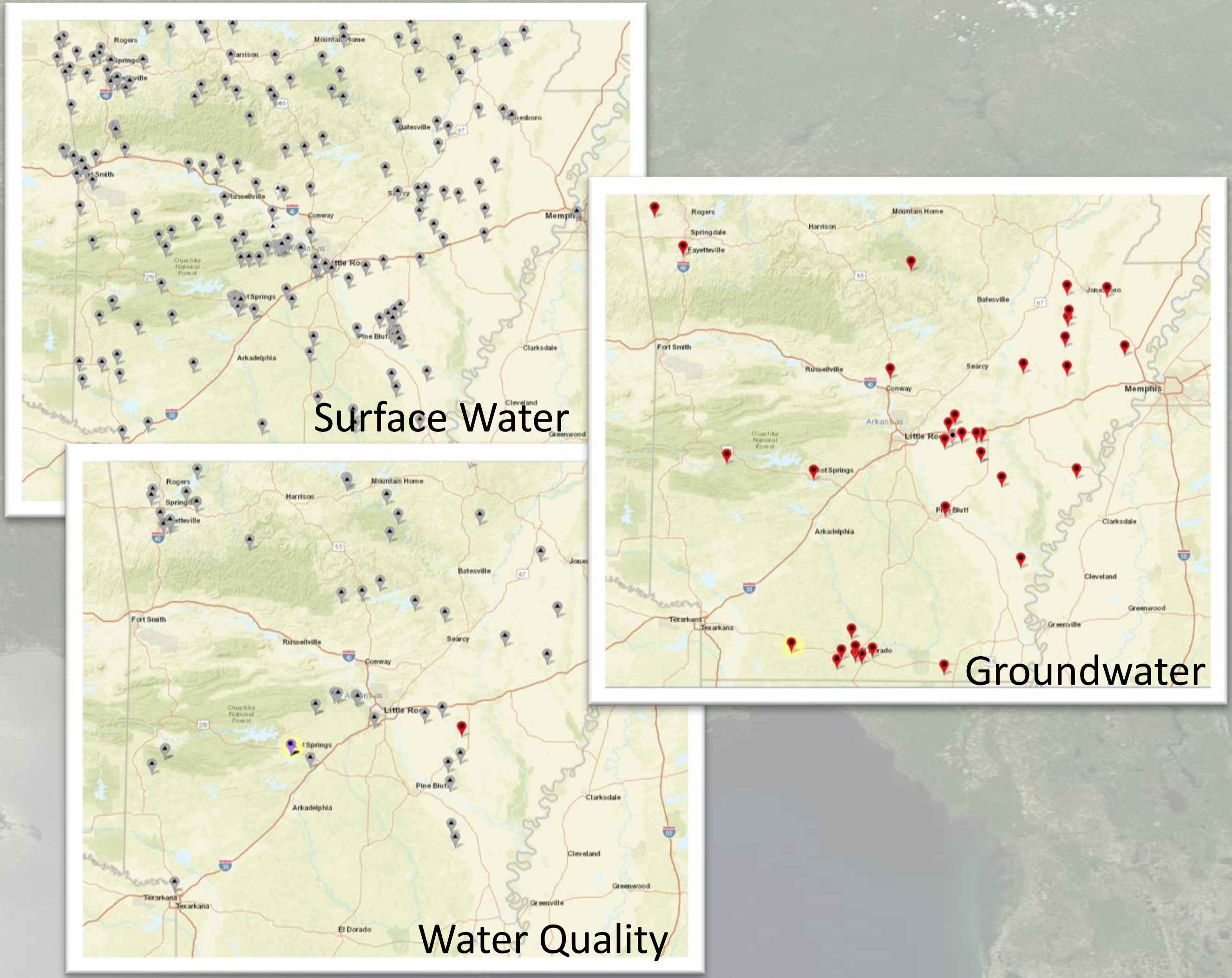
Wade H. Kress and Drew Westerman, US Geological Survey – Lower Mississippi-Gulf Water Center

Arkansas Data

- Surface Water Real-Time Sites: 194
- Groundwater Real-Time Sites: 36
- Water Quality Real-Time Sites: 57
    - 48 surface water; 9 groundwater



nwis mapper

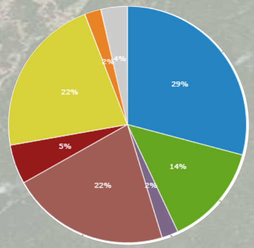


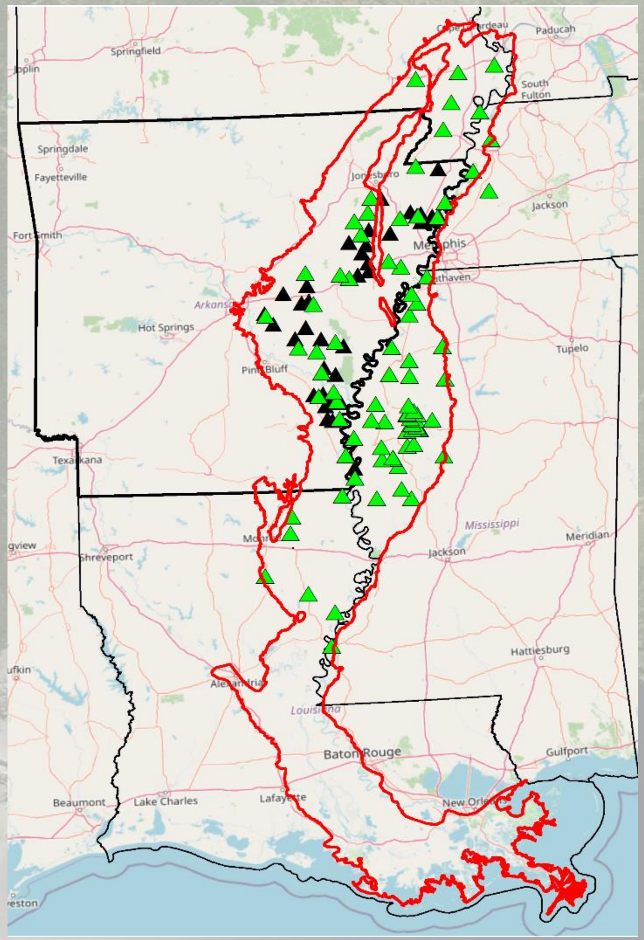
Google: usgs lmg

usgs.gov/centers/lmg-water

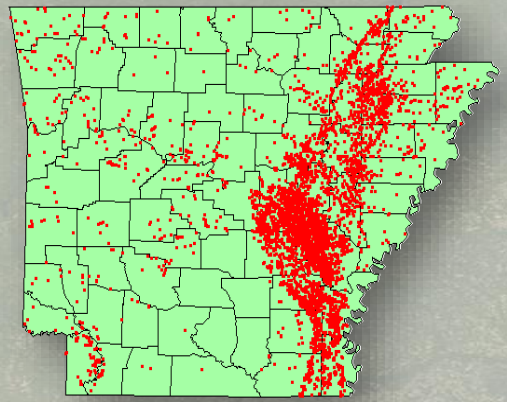
Water-Use Network

- LMG operates ~90 real-time water-use gages
- Web-based water-use reporting
- Water-use data are critical for modeling

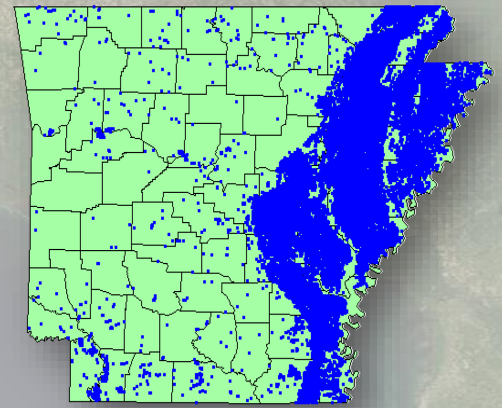




Surface water sites: 7,000+

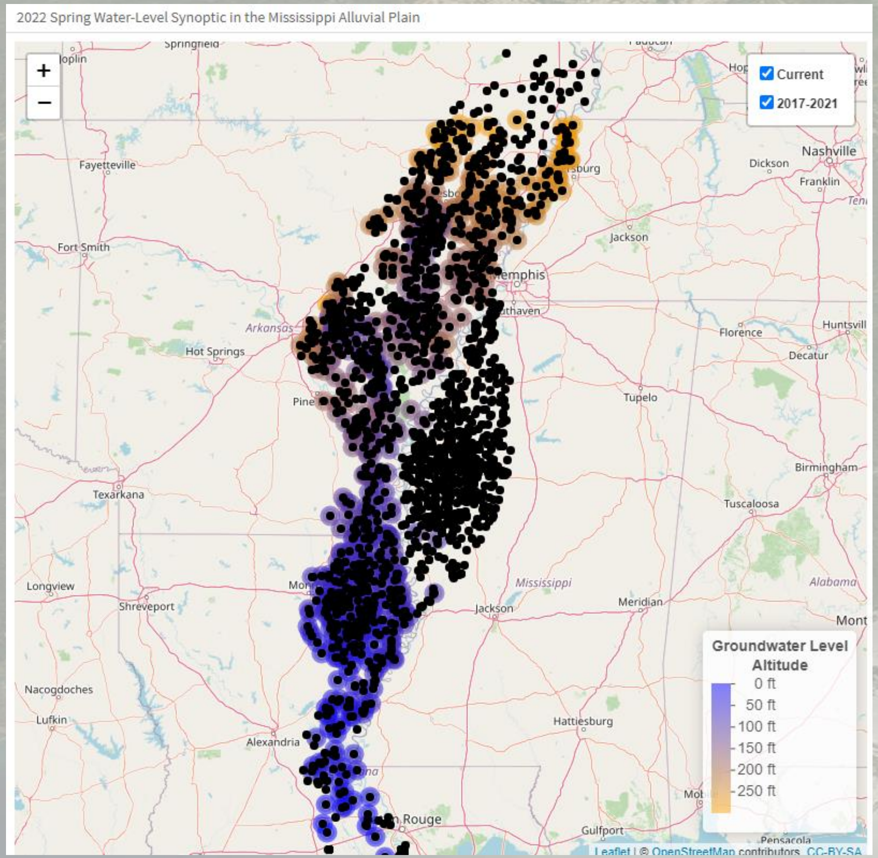


Groundwater sites: 50,000+



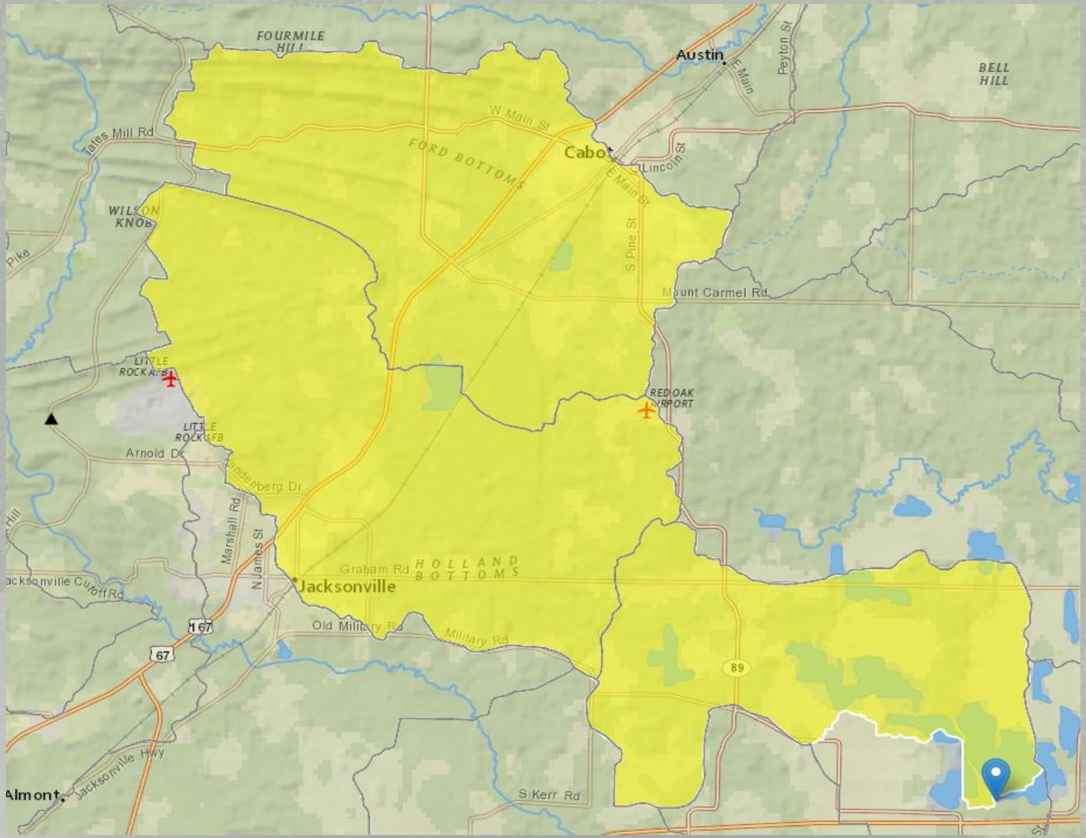
Data and Applications

MAP – Groundwater Levels



Spring – AR ~350; Overall ~600

AR StreamStats



Bayou Two Prairie Watershed @Lonoke

System-scale science to support water resources:

the USGS Mississippi Alluvial Plain (MAP) Project

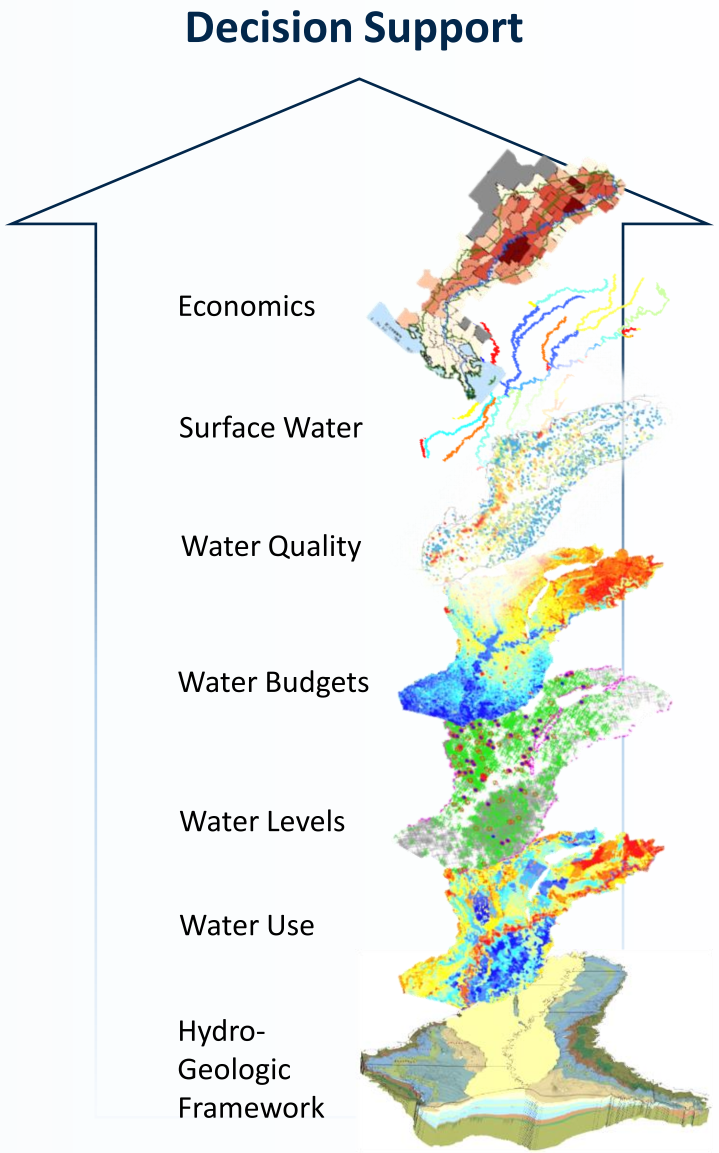
Wade H. Kress, Associate Center Director,
Lower Mississippi-Gulf Water Science Center

U.S. Department of the Interior
U.S. Geological Survey

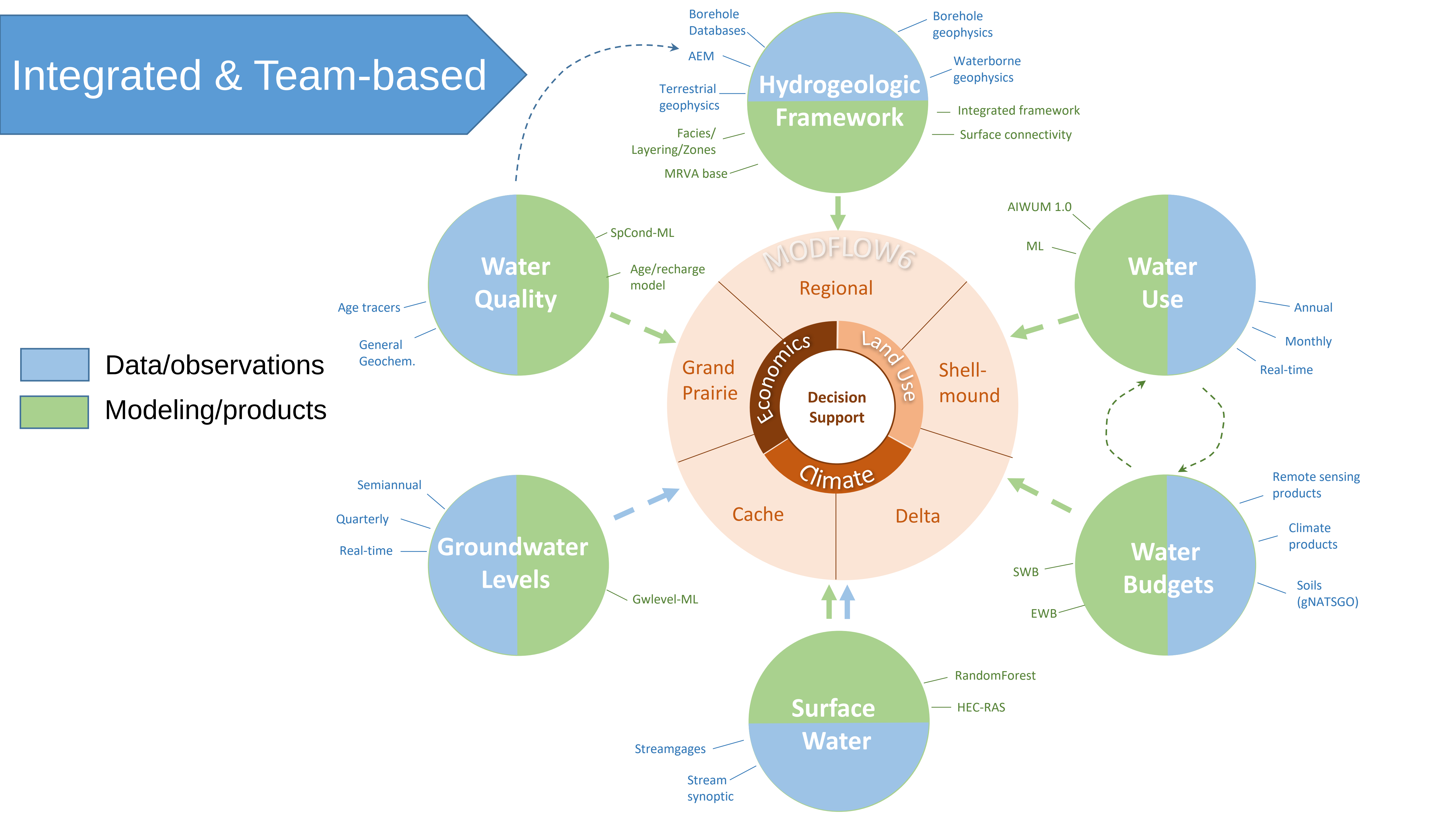
USGS science for a changing world

MAP Approach

- **Team-based** workflows
- **Integrated** suite of models for decision support
- **Iterative** & Coproduced

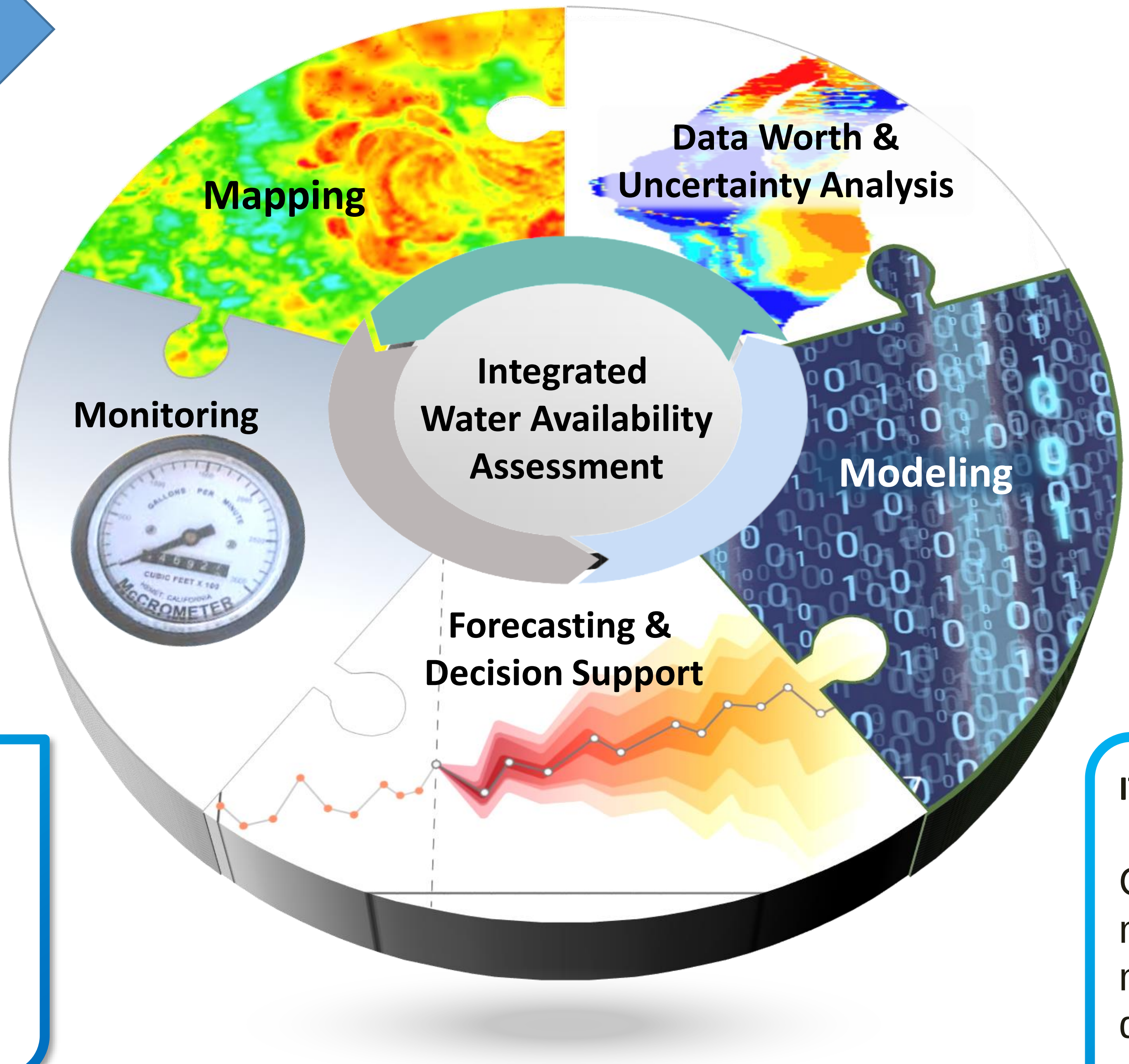


Integrated & Team-based



Iterative

- Groundwater Levels
- Stream Gages
- Water Use
- Evapotranspiration
- Water Quality
- Precipitation



- Regional Groundwater
- Inset Groundwater
- Surface Water (ML/Process)
- Water Quality
- Water Budgets

CO-PRODUCED:

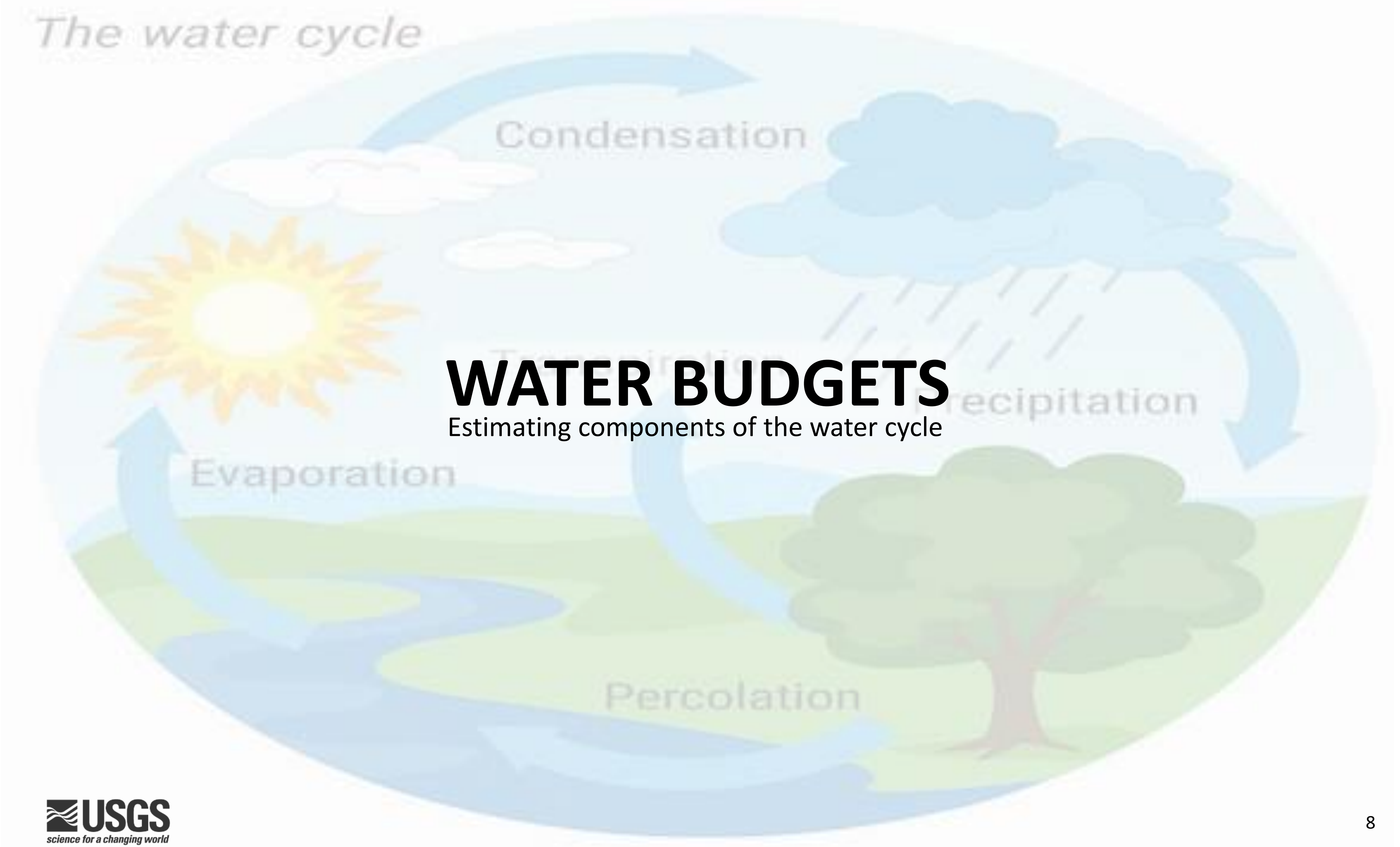
Working alongside partners and stakeholders in each component.

ITERATIVE:

Creating a monitoring,mapping, modeling, forecasting, data worth *cycle*.

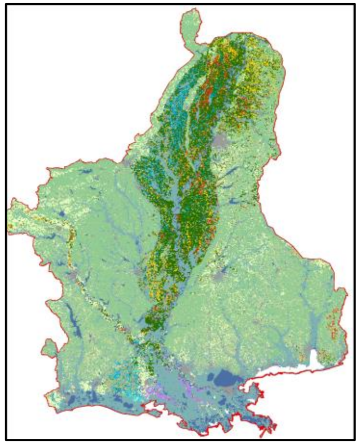
WATER BUDGETS

Estimating components of the water cycle

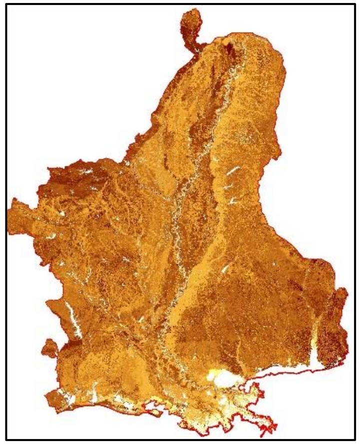


SWB data flow

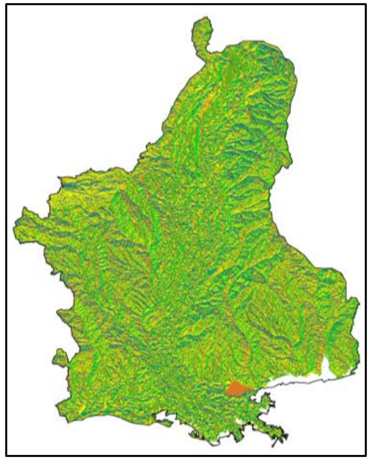
Land Use



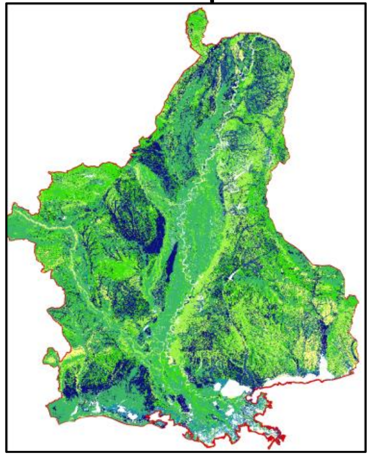
Available Water Capacity



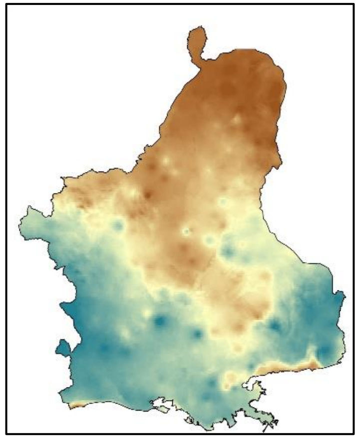
Flow Direction

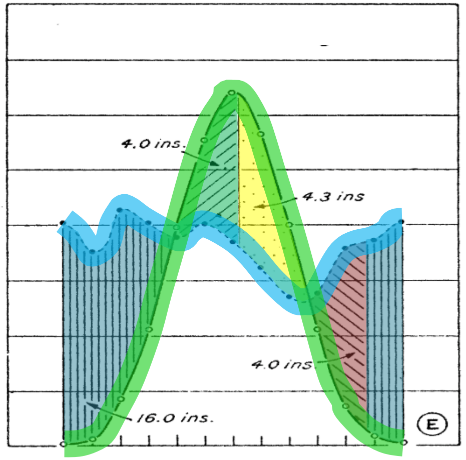


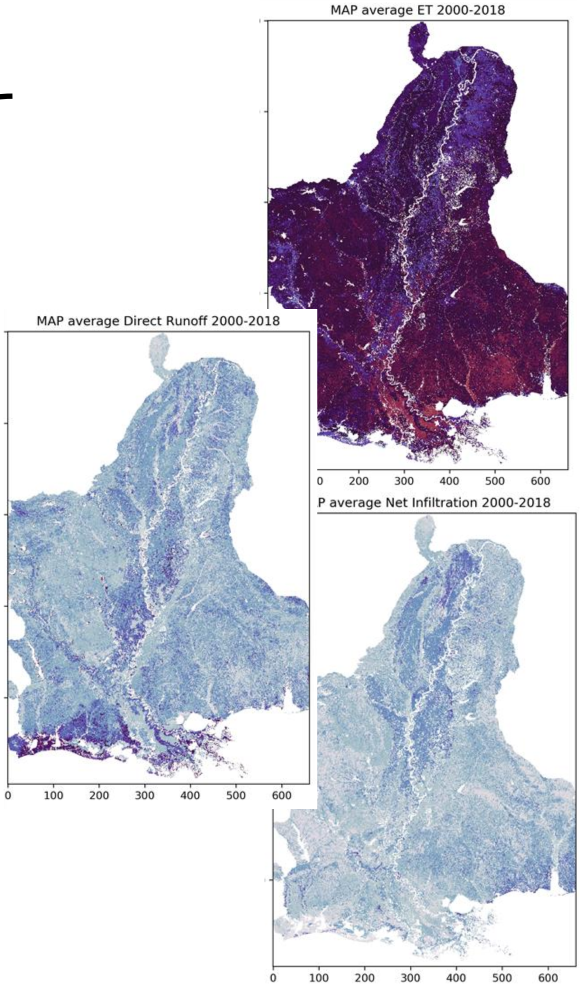
Hydrologic Soils Group



DayMet, PRISM, or other gridded PRECIPITATION, AIR TEMPERATURE



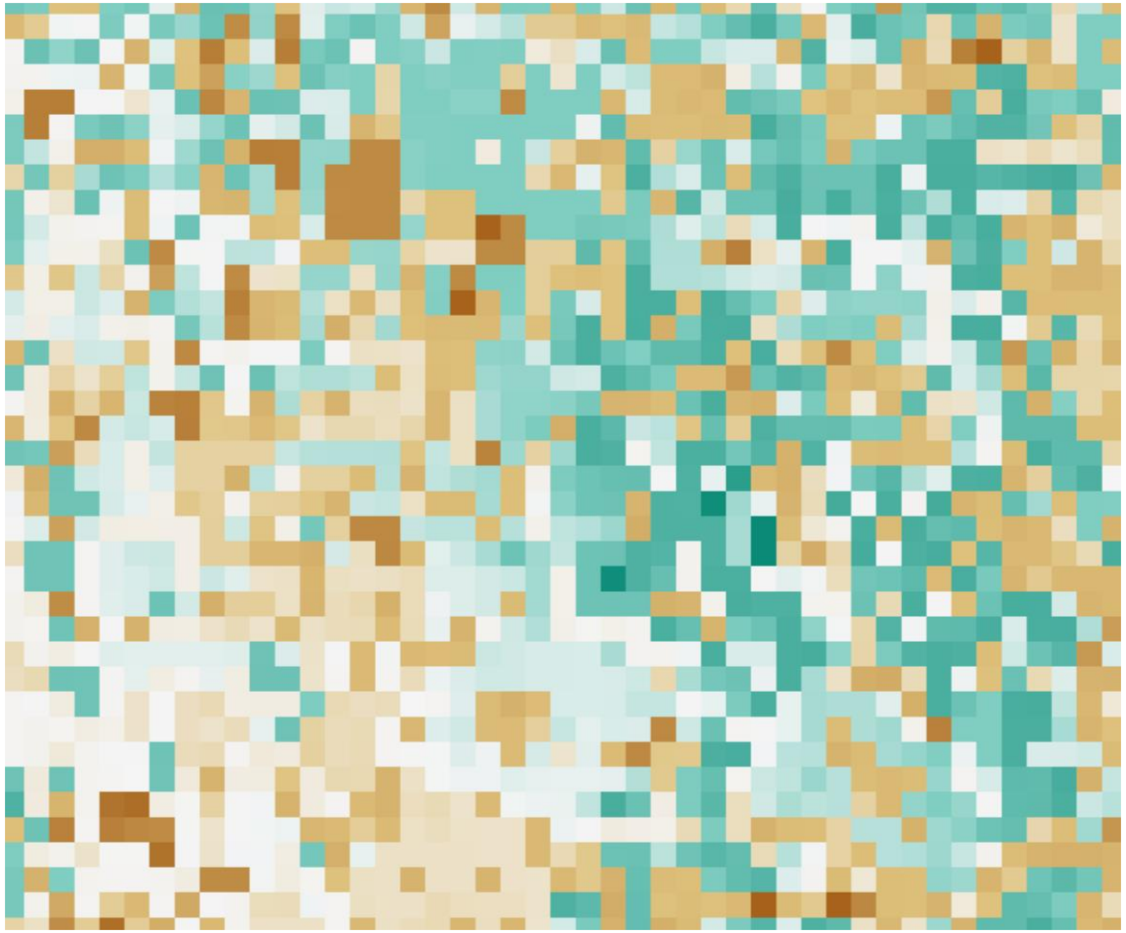




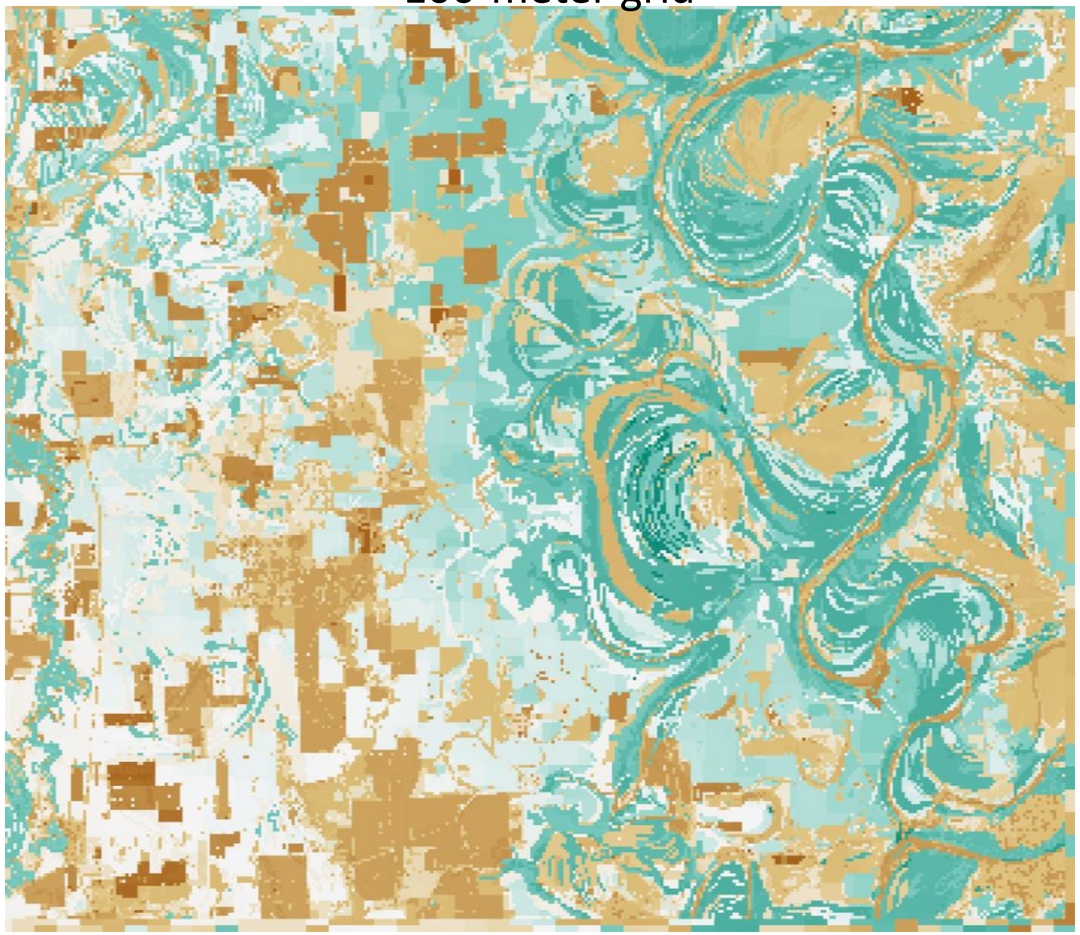
- net infiltration
- actual ET
- direct runoff
- rejected recharge
- irrigation water requirement
- Interception

Running SWB for different areas of interest and different grid cell resolutions is easily done

1000-meter grid

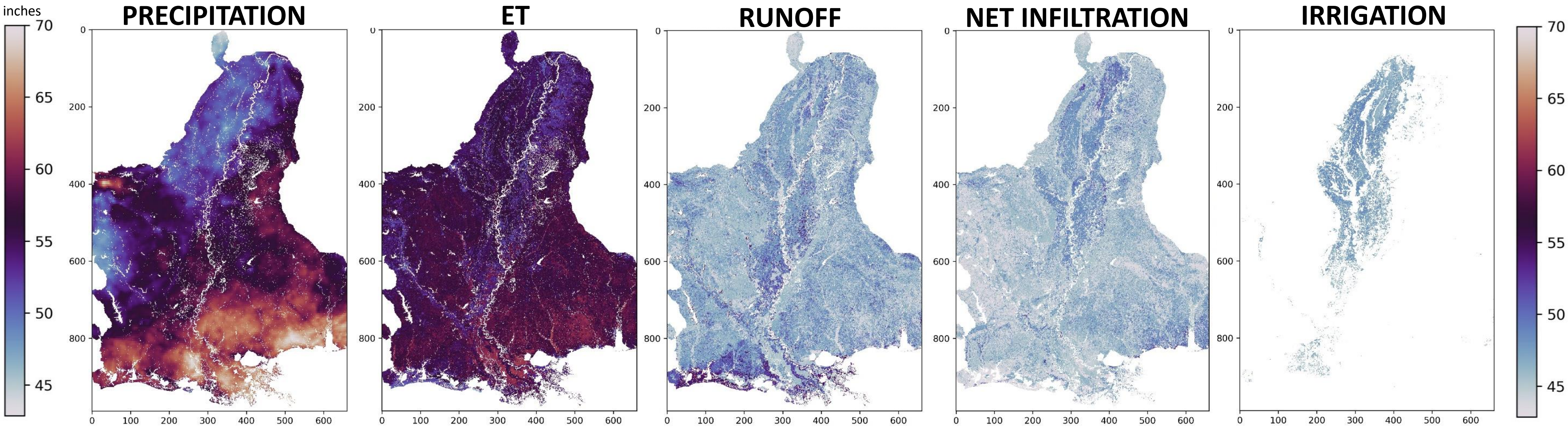


100-meter grid



SWB inset model for Shellmound, Mississippi

Soil Water Balance model



Average precip 2000-2028

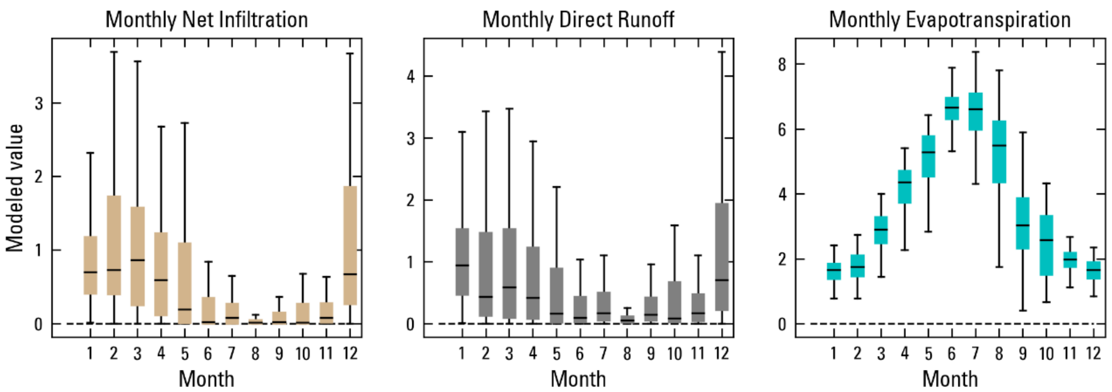
Average ET 2000-2028

Average runoff 2000-2028

Average net infiltration 2000-2028

Average irrigation 2000-2028

MAP Monthly water balance terms

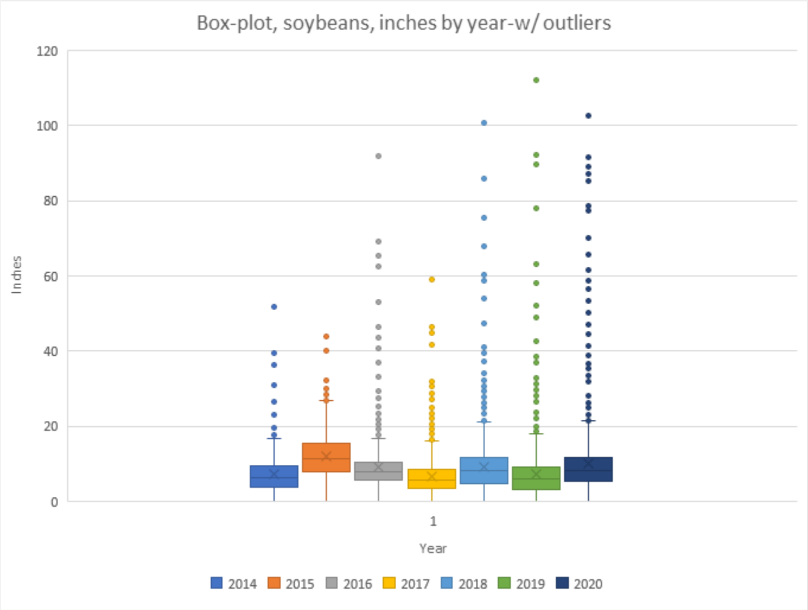


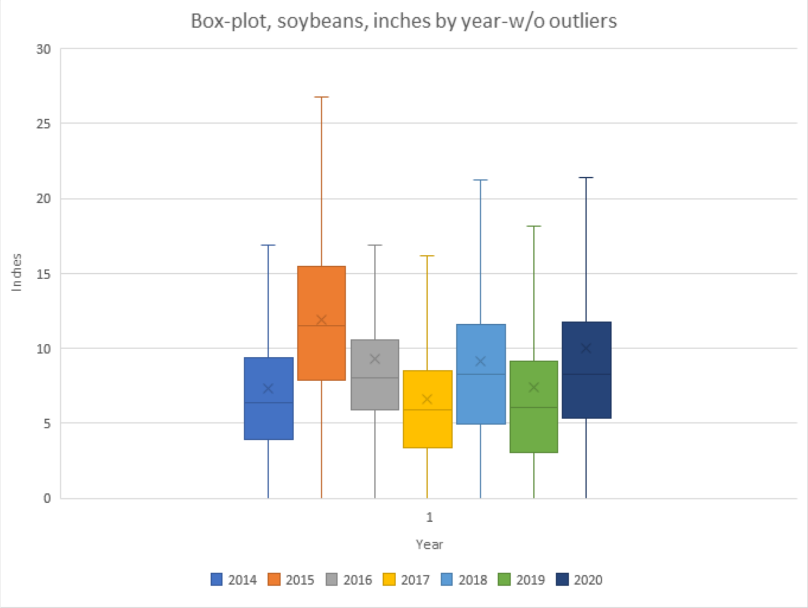
WATER USE

Measuring and modeling irrigation water use

WATER USE MODELS METERED WATER USE DATA

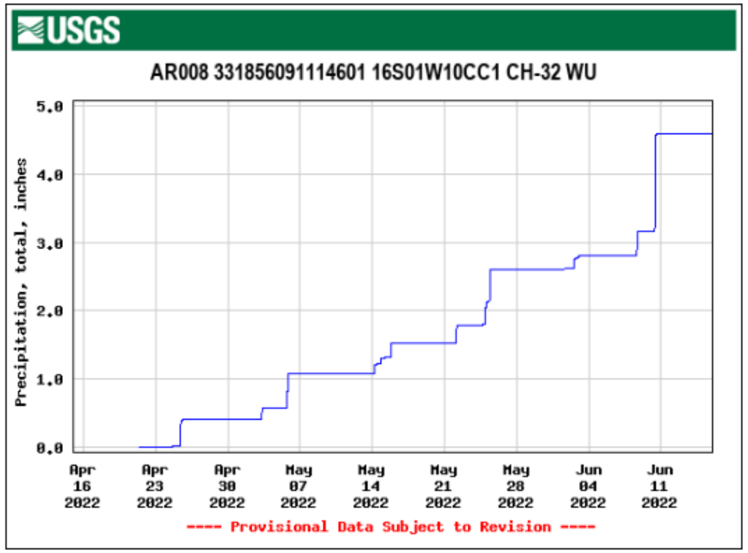
VMP



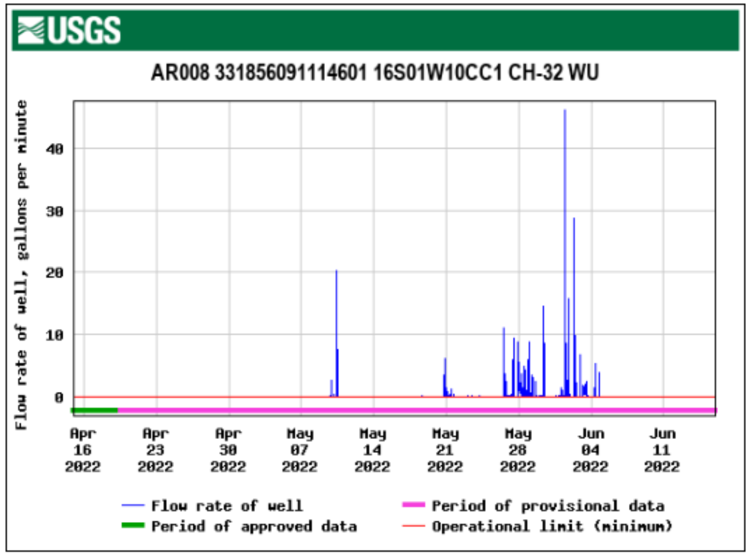


Metered Data Source	Temporal Resolution	Number of sites	Year Started	Strength	Weakness
MDEQ Voluntary Metering Program (VMP)	1 per year	1762 (2020) in MS	2014	• Order of magnitude broadest crop coverage • Spatial coverage • Longest term--since 2014	• 1 value per year • Voluntary, requires QC • Data release availability
USGS Real-time (RT)	Sub-hourly	92 (2020) in LMG-WSC	2018	• Sub hourly and online • Professionally maintained QC	• Very few sites relative to the number fields.

- Water use meter network continues to be improved. 2021 and 2022 saw the addition of rainfall gages at select real-time metering sites.



RT



AIWUM DEVELOPMENT From AIWUM 1.0–1.1–2.2

AIWUM
1.0 (1999–2017)
1.1 (1999–2019)

- **Regression of metered data and application to zone-categorized, non-metered locations,**
- **Yearly Outputs and Monthly Outputs**

AIWUM 1.0–1.1 Model Inputs	Source/Model	Resolution (m)
Agricultural acres	USDA/Cropland Data Layer	30 meters
Crop-specific irrigation rates	Yazoo Mississippi Delta (YMD) Joint Water Management District / Mississippi Department of Environmental Quality (MDEQ) / USGS Real-time Flow Meter	Point
Climate (precipitation and temperature)	Parameter-Elevation Regressions on Independent Slopes Model [PRISM]	800 meters
Irrigated lands	The Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture Dataset for the United States (MIrAD-US)	250 meters

AIWUM
2.0 (2014–2020)

- **Machine learning**
- **Yearly Outputs.**
- **Monthly Outputs in development**

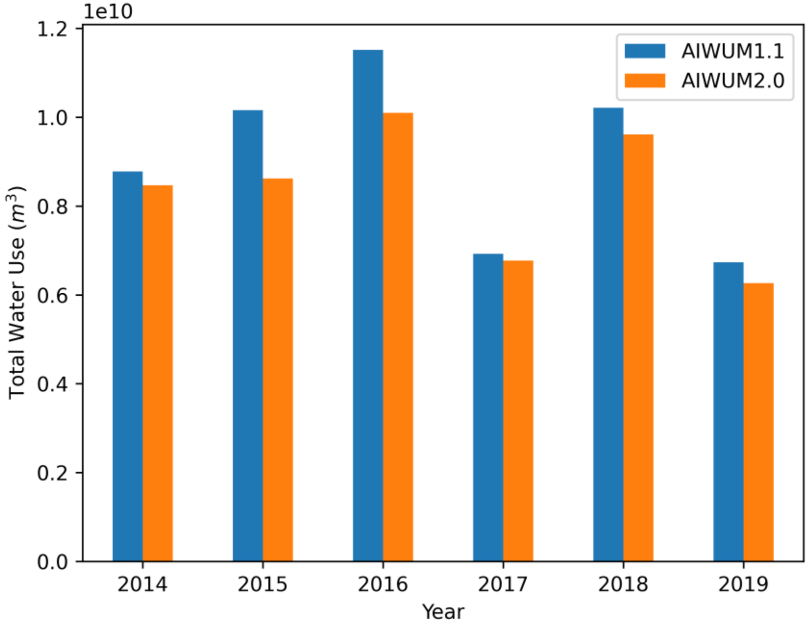
AIWUM 2.0 Model Inputs	Source/Model	Resolution (m)
Latitude	Flowmeter	Point
Longitude	Flowmeter	Point
Crop Type	USDA/Cropland Data Layer	30
Precipitation	Parameter-Elevation Regressions on Independent Slopes Model [PRISM]	800
Maximum Temperature	Parameter-Elevation Regressions on Independent Slopes Model [PRISM]	800
Evapotranspiration	SSEBop	1000
Surface Runoff	TerraClimate	~4000
Soil Moisture	TerraClimate	~4000
Infiltration Rate (derived from HSG)	USGS/Soil Water Balance Model	1000
Irrigation	USGS/Soil Water Balance Model	1000
Crop-specific irrigation rates	Mississippi Department of Environmental Quality (MDEQ)	Point

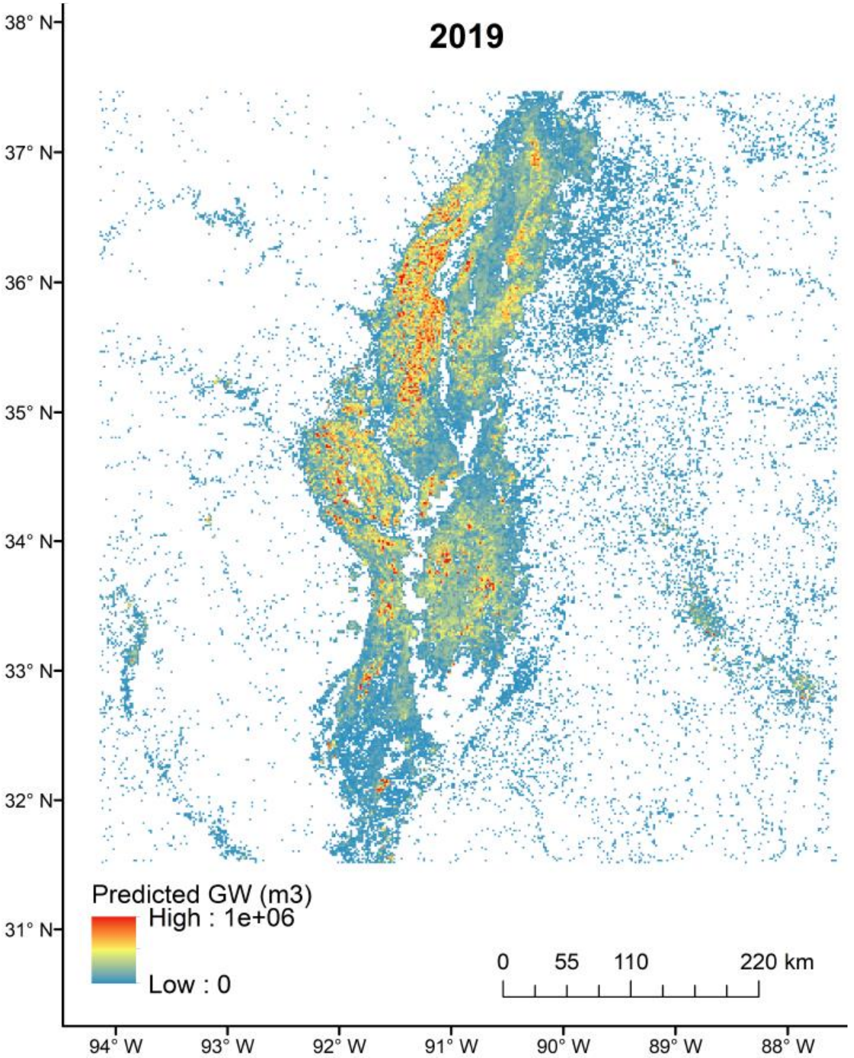
AIWUM 2.0 DEVELOPMENT

- AIWUM 2.0 machine learning framework uses Distributed Random Forests or DRF available through the Light Gradient Boosting Machine (LightGBM) package (Ke et al., 2017)
- Allows better representation continuous water use and climate data
- AIWUM 2.0 continues to be refined. Current results are an improvement over AIWUM 1.1
  - *R^2 increased*
  - RMSE and MAE have *decreased*

Model Comparison Results, Yearly Predictions

Model	R^2	RMSE (m)	MAE (m)
AIWUM 1.1	0.275	0.148	0.096
AIWUM 2.0 (test data)	0.516	0.137	0.092





This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government may be held liable for any damages resulting from the authorized or unauthorized use of the information.

SURFACE WATER

Measuring and modeling surface water discharge

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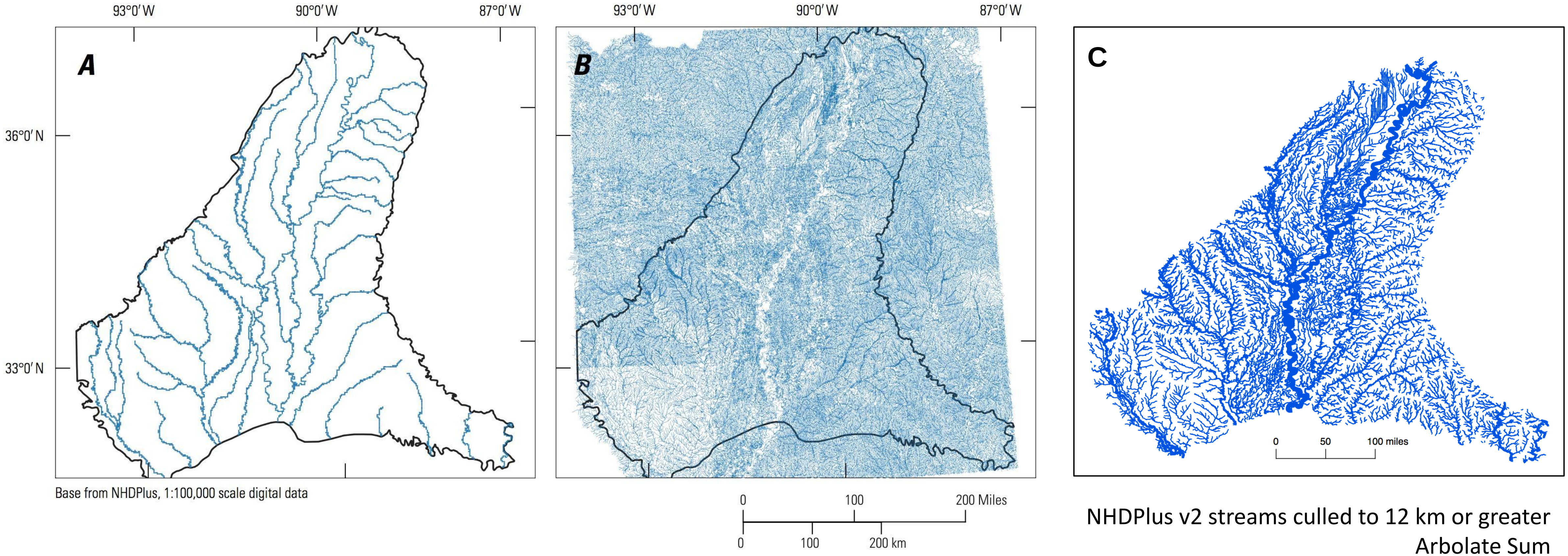
SFR in the MERAS model



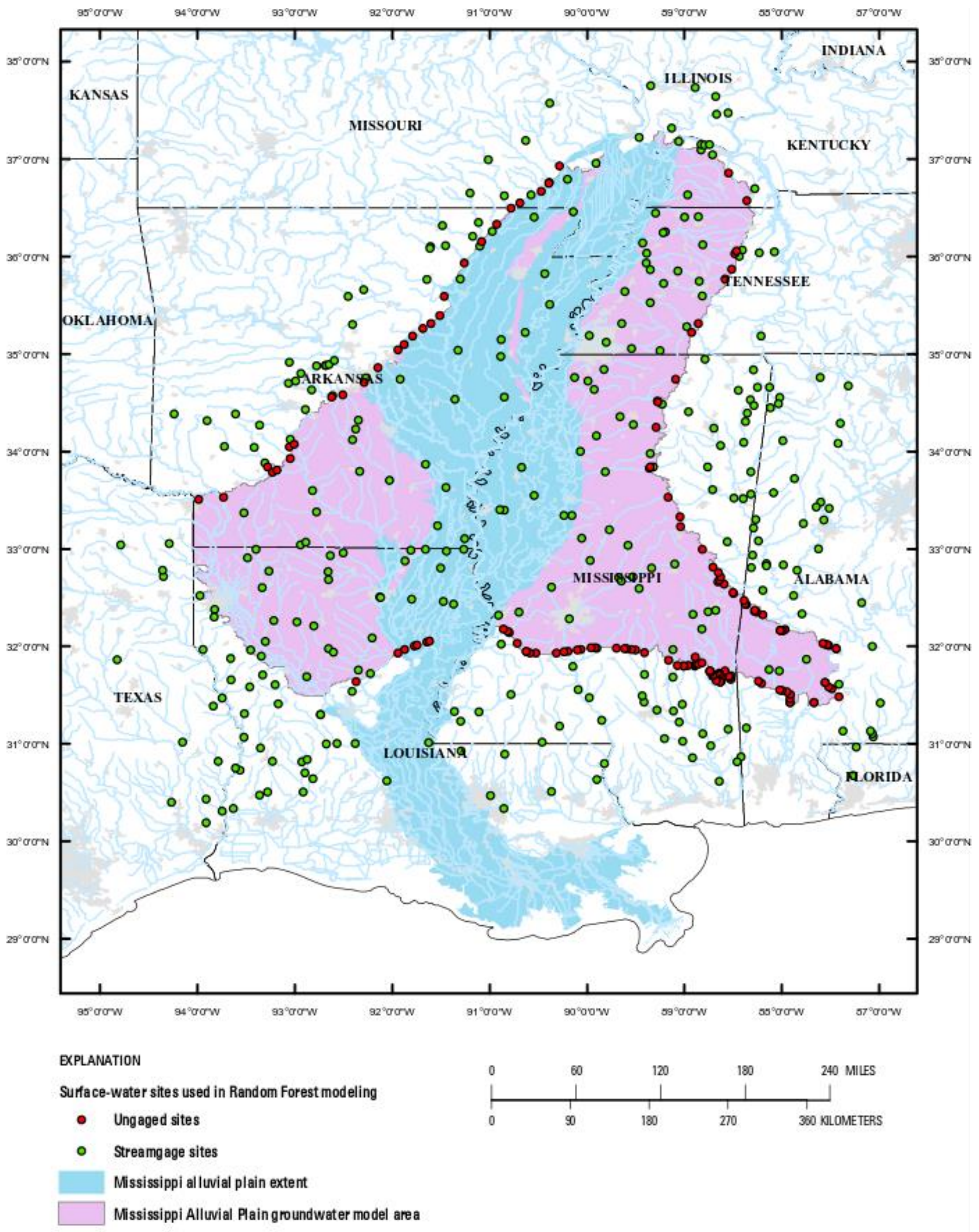
NHDPlus v2 streams culled to 12 km or greater Arbolate Sum

- Increase stream density to improve surface water representation in groundwater model

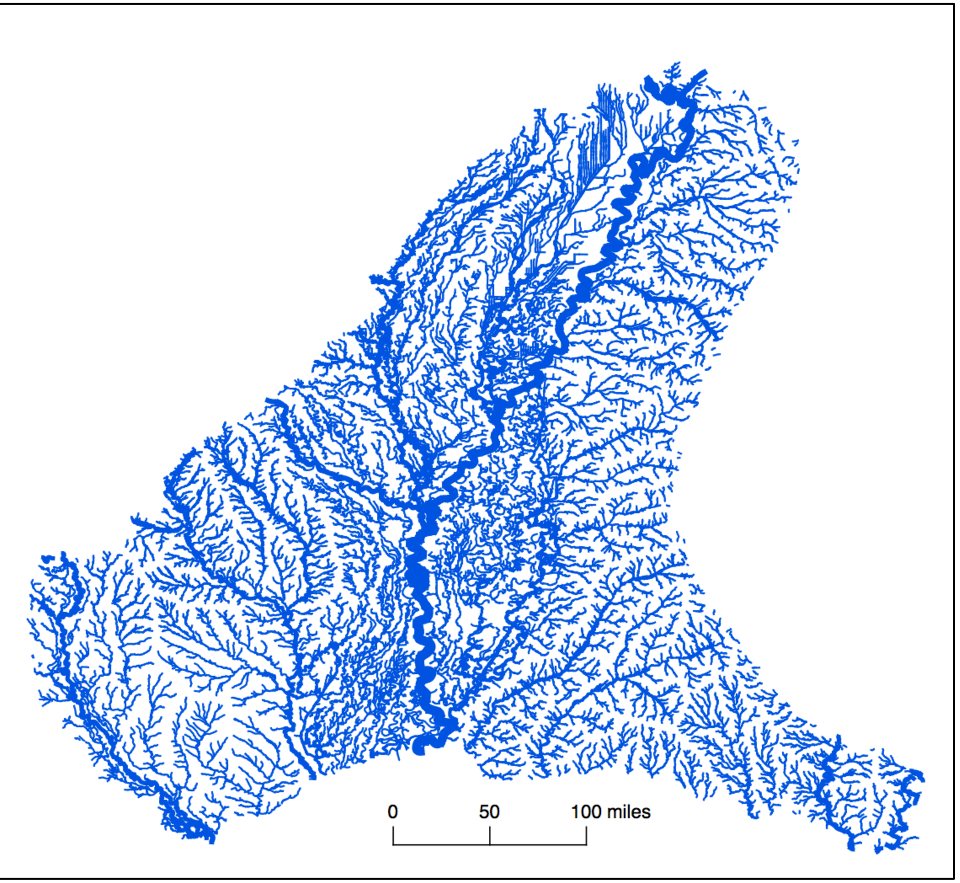
Estimating ungaged flows

- Meet groundwater models needs
  - Boundary conditions for SFR
  - Fill in data gaps at gages
  - Flow estimates for calibration & parameter adjustment

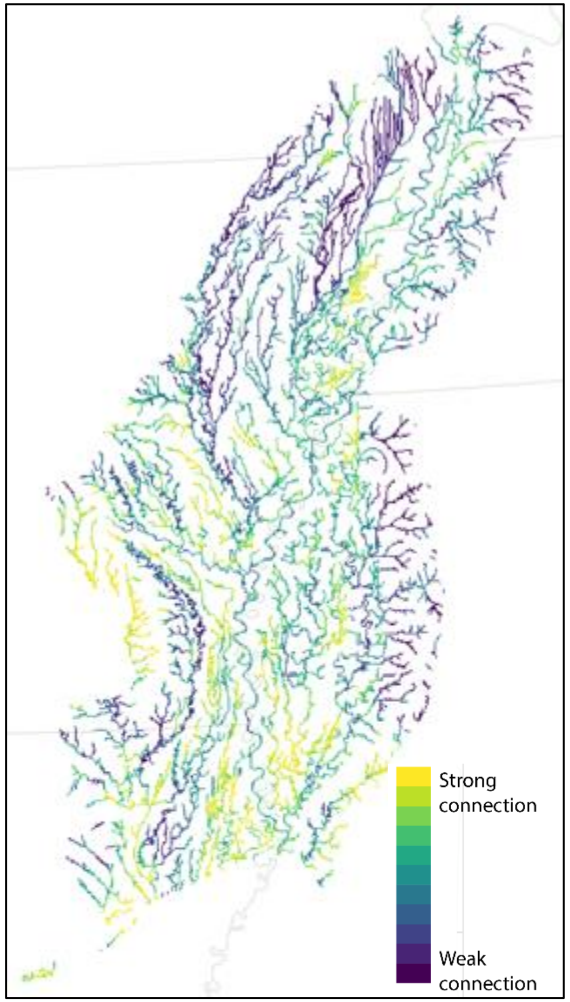
- Statistical modeling approach
  - Automated methods to prepare inputs, develop, and run model
  - Flexibility to use new information
    - Climate data
    - Expanded gage network



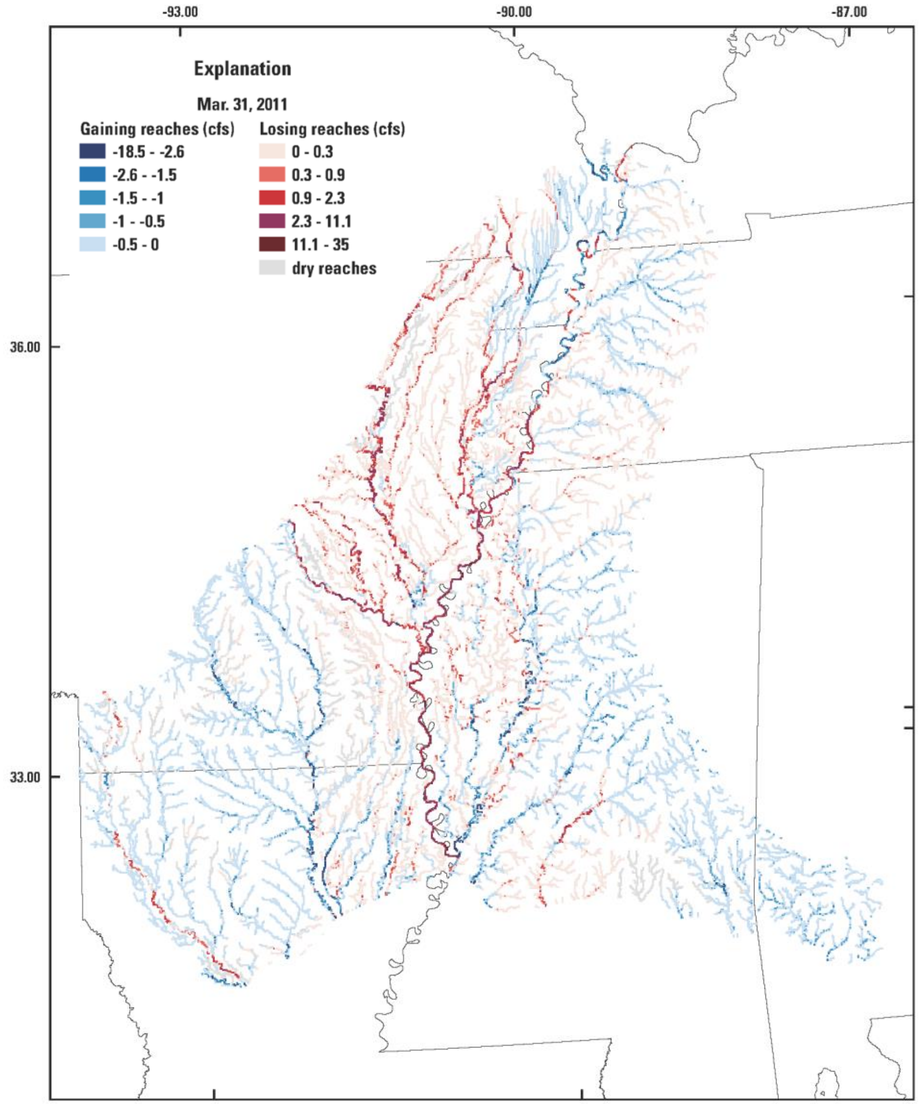
SFR results



NHDPlus v2 streams culled to 12 km or greater Arbolate Sum



Airborne derived stream connectivity



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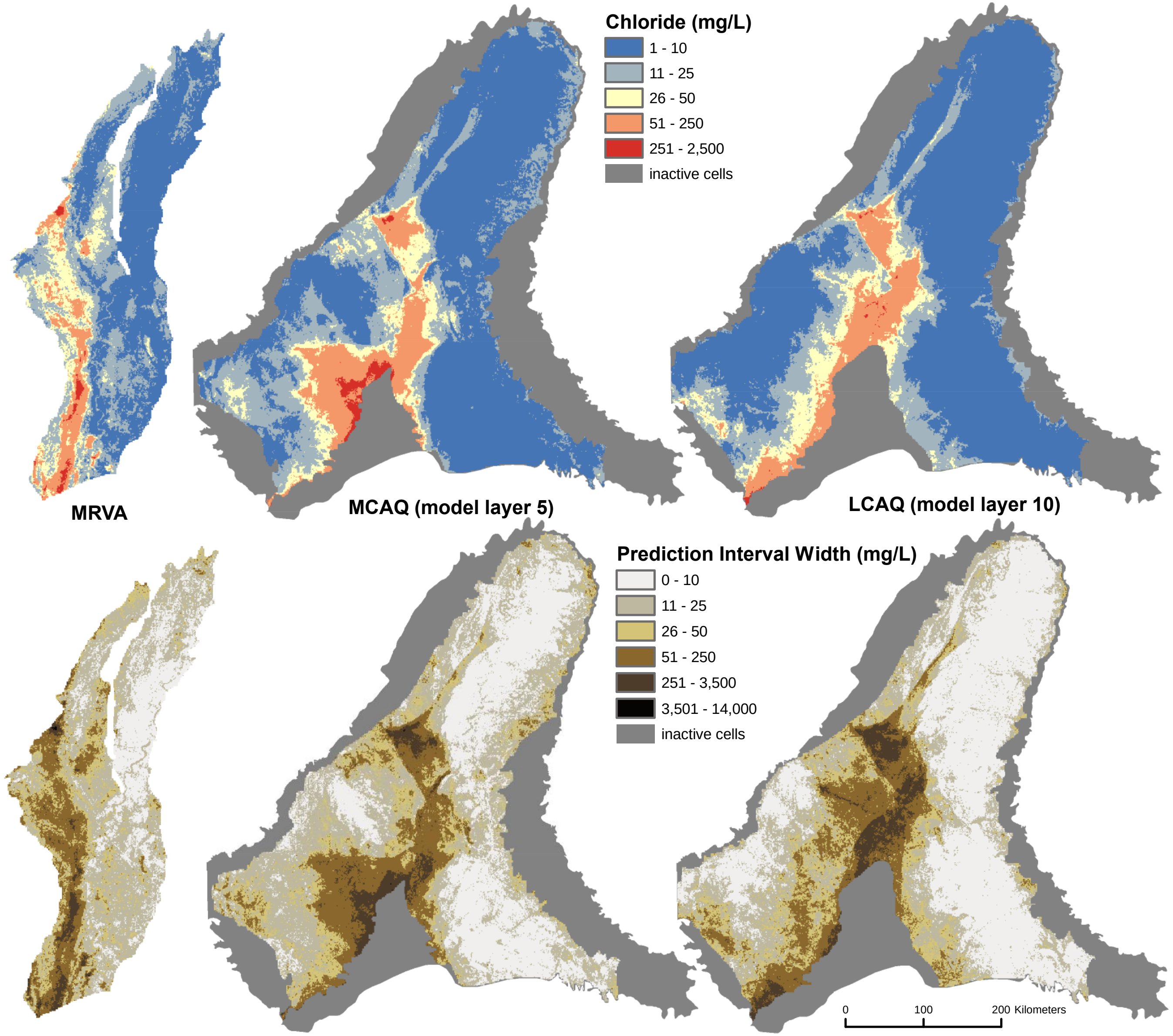
WATER QUALITY

Measuring and modeling water quality constituents

Water Quality - Chloride Model

Boosted Regression Tree modeling of chloride concentration throughout the Mississippi Embayment

- Machine learning approach
- Embayment aquifers
- Constituents include Chloride, Specific Conductance, As, Mn



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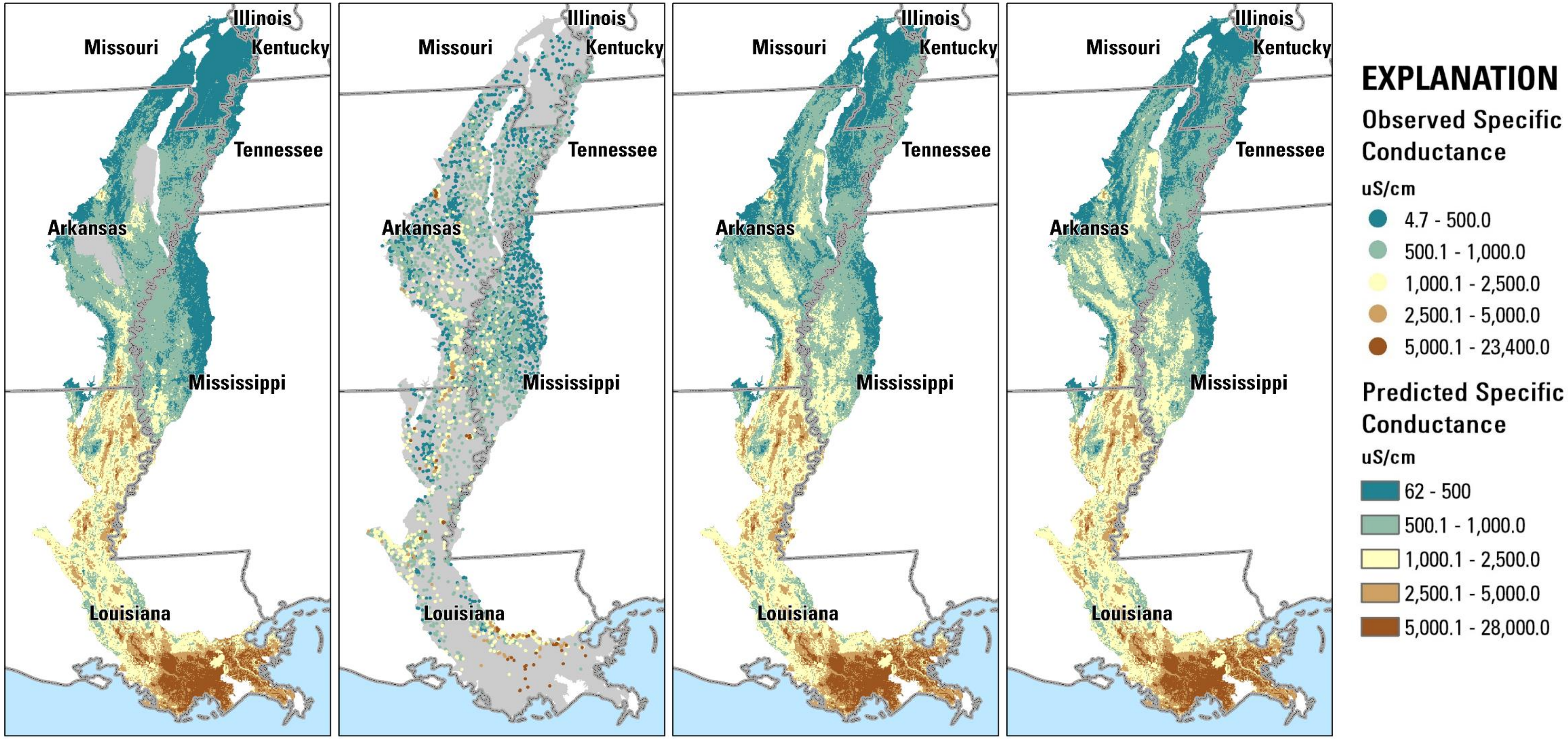
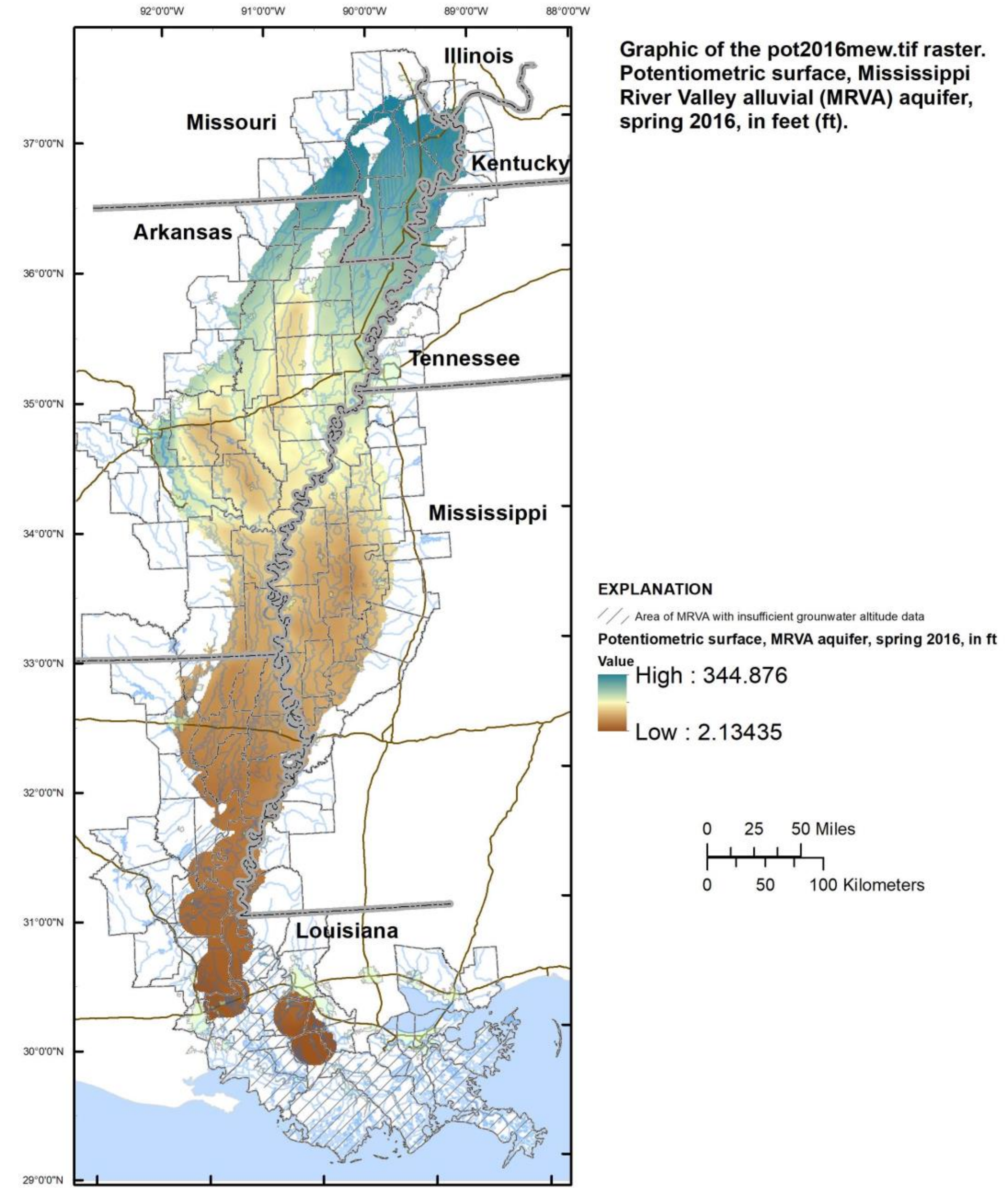
Machine learning model for water quality estimation



75 feet **200 feet** **300 feet**

GROUNDWATER LEVELS

Collecting groundwater level data, publishing updates, and developing tools



Base from U.S. Geological Survey digital data, 1:1,000,000 and 1:2,000,000 variously dated
Highways from National Highway Planning Network, various scales, 2014
Urban areas from U.S. Census Bureau, 1:500,000, 2016
Albers_NHG projection
Standard parallels 45 30'N and 29 30'N, central meridian 96 00'N World Geodetic Survey of 1984

Current extent of Mississippi River Valley alluvial aquifer (Painter and Westerman, 2018)
Regions in the Mississippi River Valley alluvial aqufier (Ladd and Travers, 2019)

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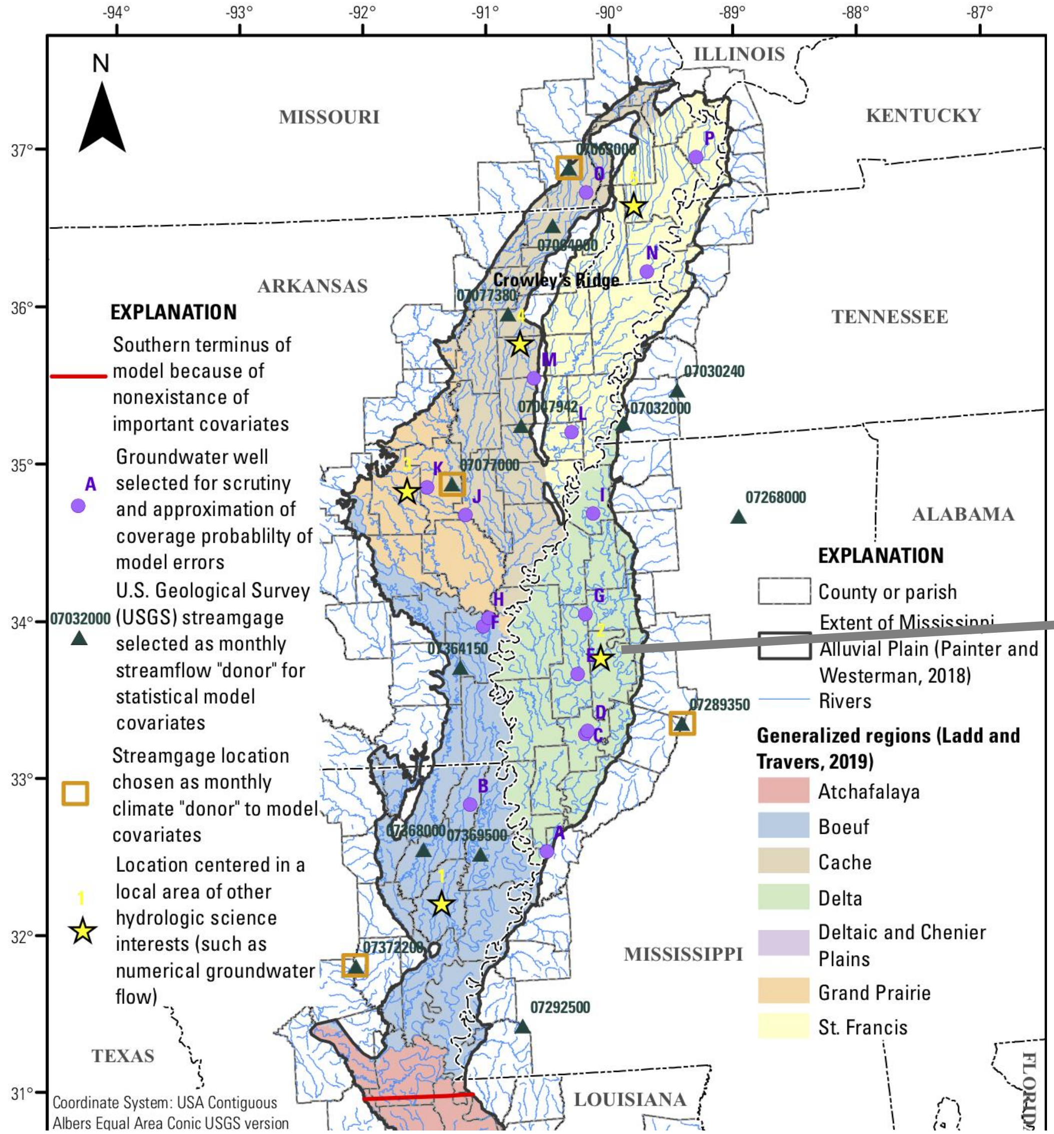
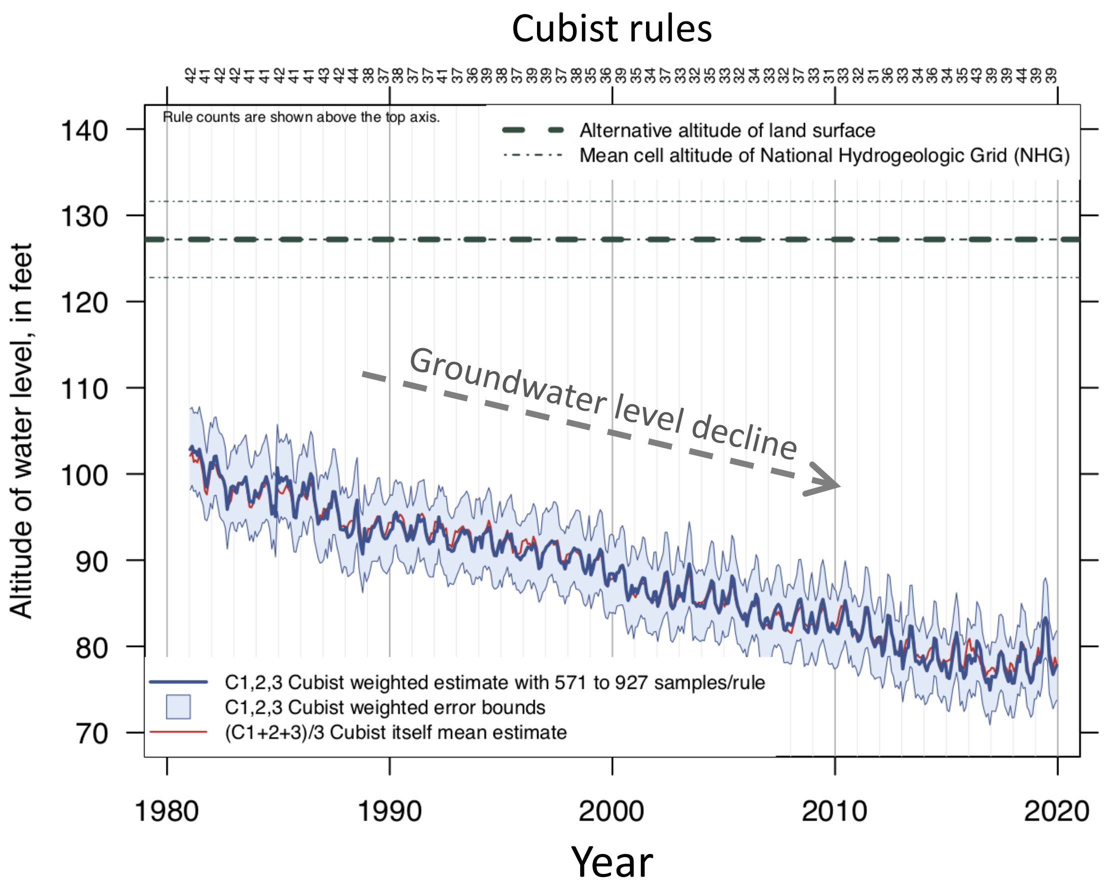
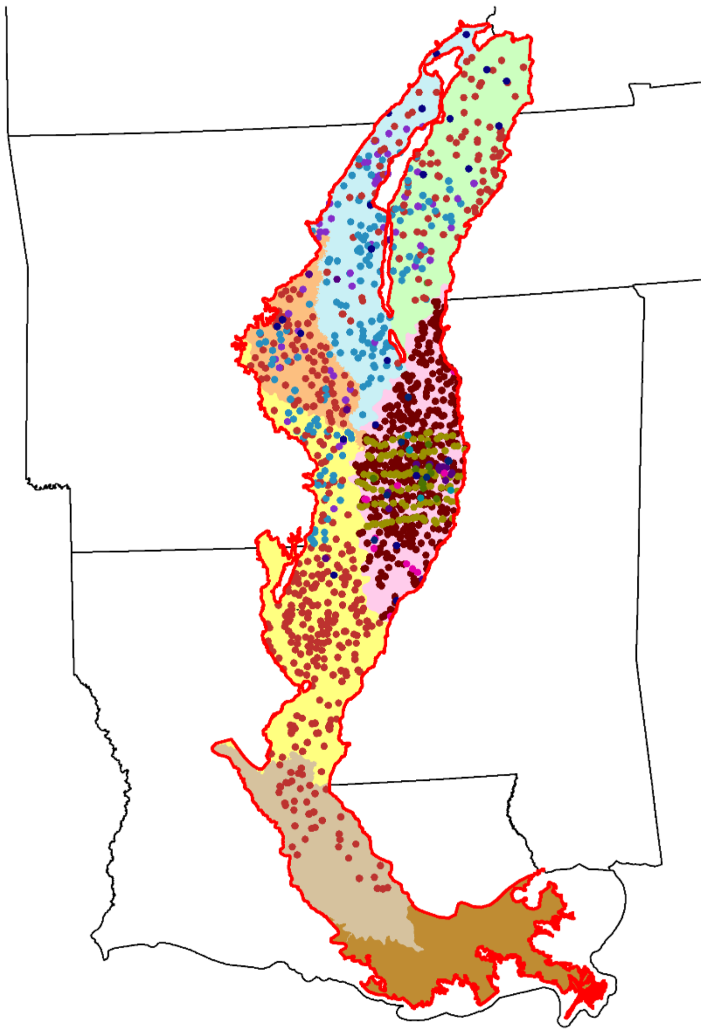
Machine-learning software for groundwater level estimation

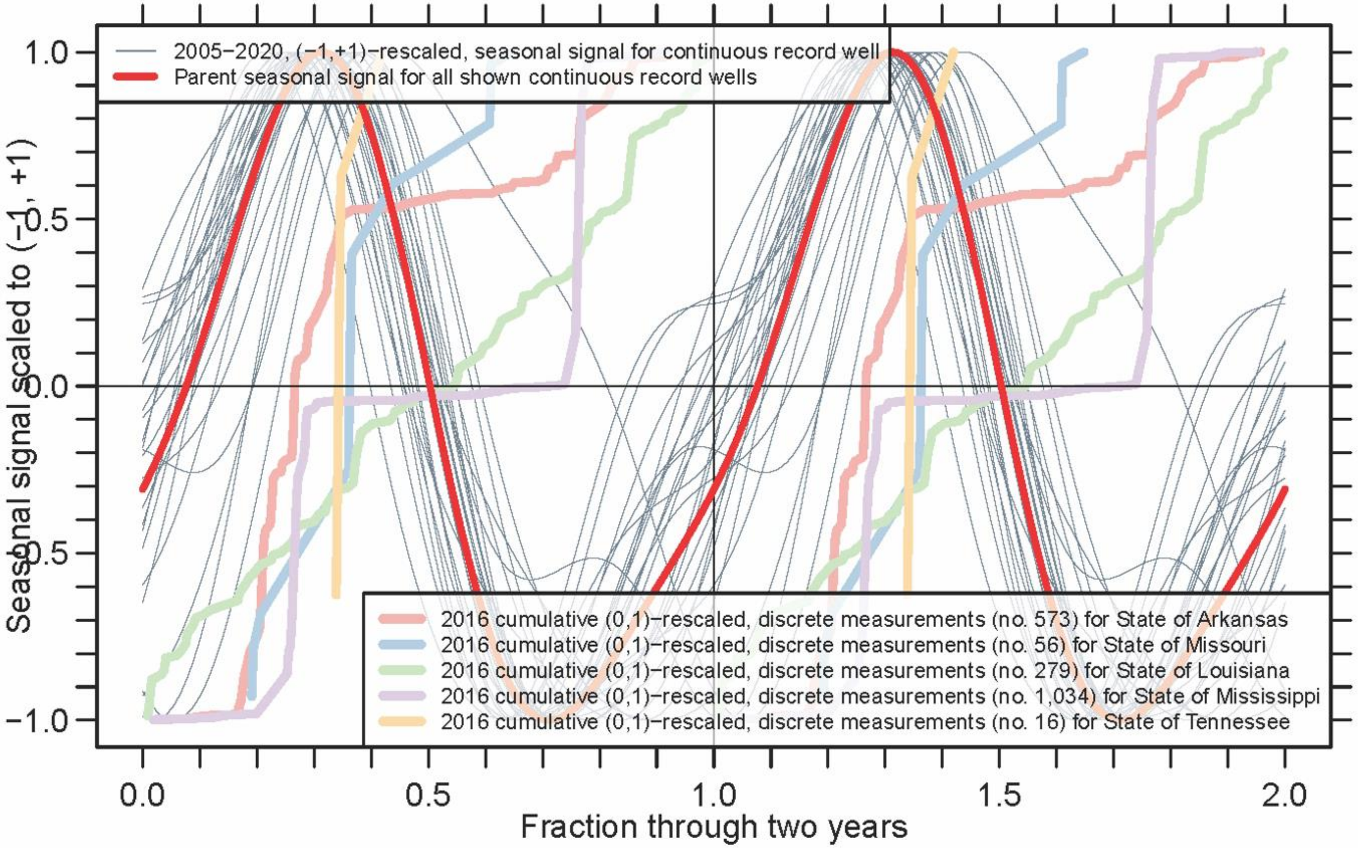


Cubist water level prediction with uncertainty for a point of interest



Status of the Groundwater



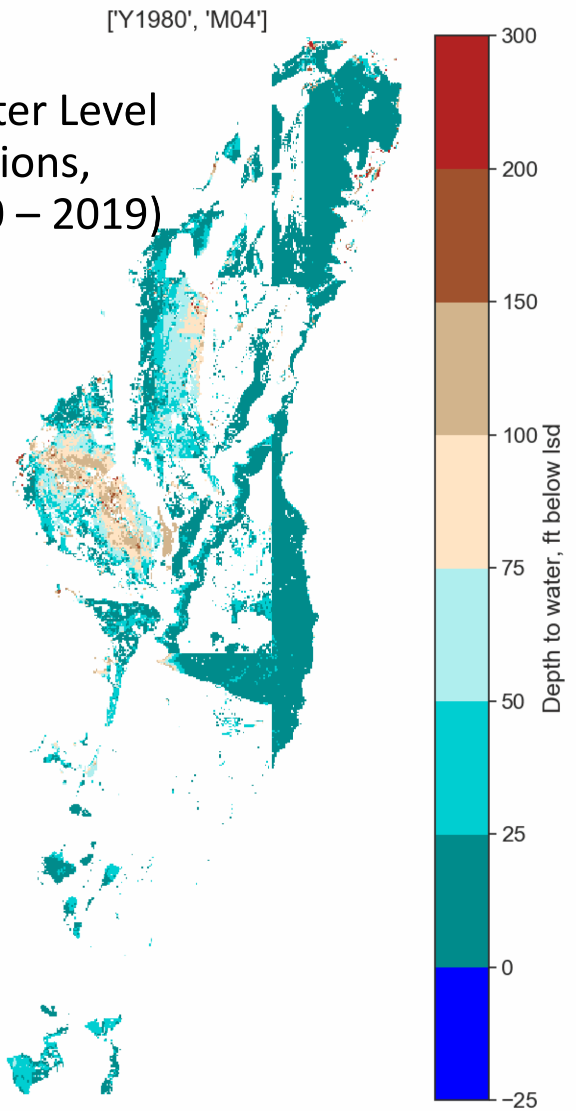


8 different agencies including county, university, state, and federal

USGS science for a changing world

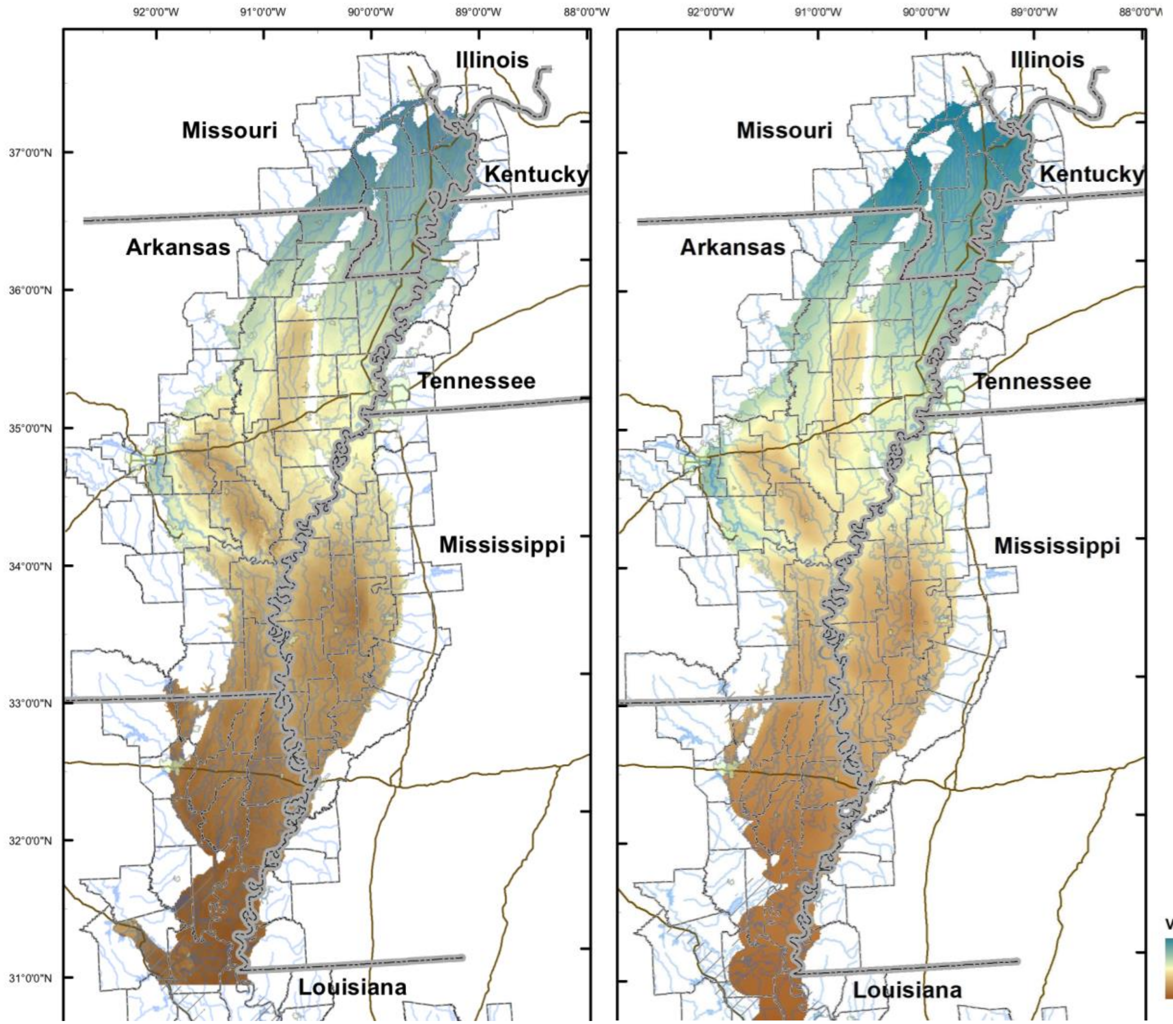
Machine-learning software for groundwater level estimation

Cubist Water Level Predictions, April (1980 – 2019)



Cubist prediction

McGuire et al. (2019) "Spring 2016" (Jan-May maxima)



Potentiometric surface

Preliminary information-Subject to revision.
Not for citation or distribution.

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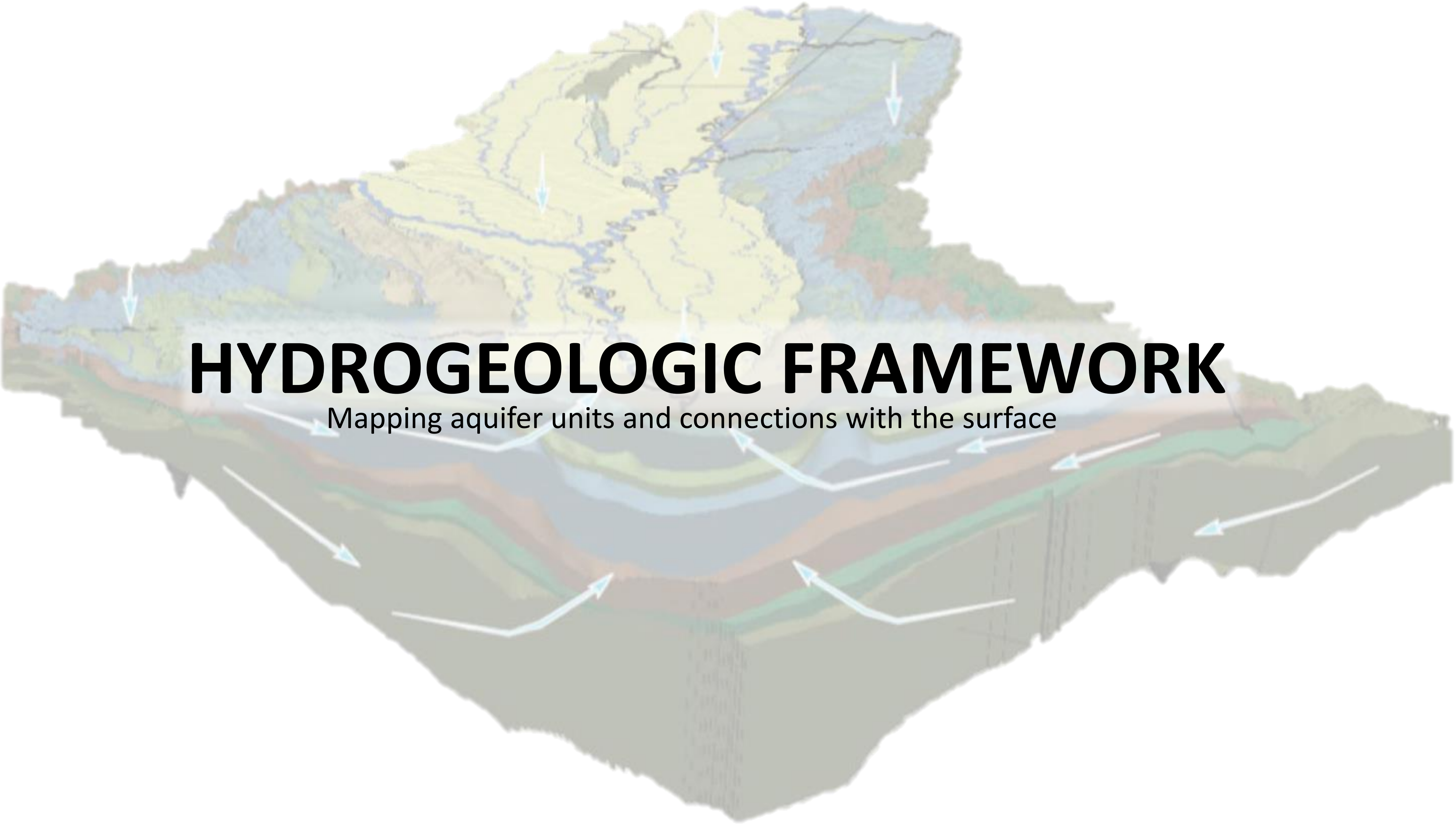


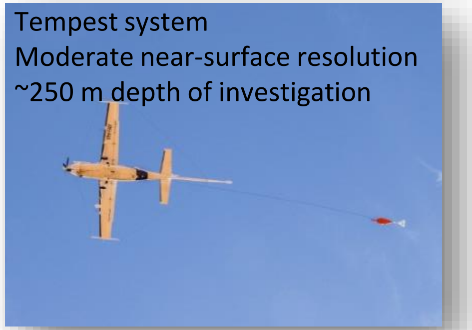
HYDROGEOLOGIC FRAMEWORK

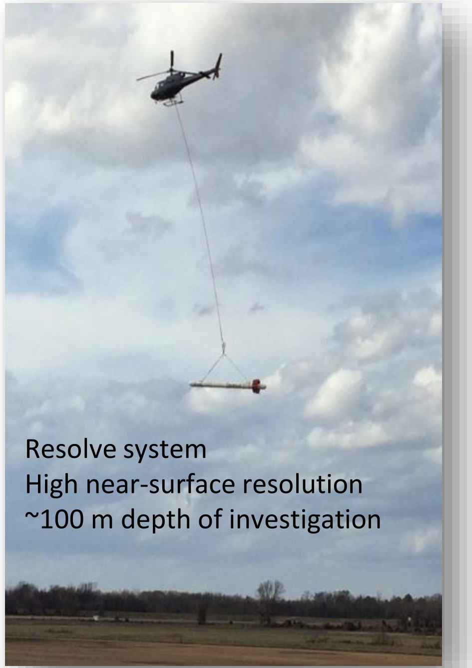
Mapping aquifer units and connections with the surface

http://arcg.is/01nraa

MAP AEM surveys

Largest integrated AEM effort for water resource+ mapping in CONUS
Total completed + planned ~80,000+ line-km



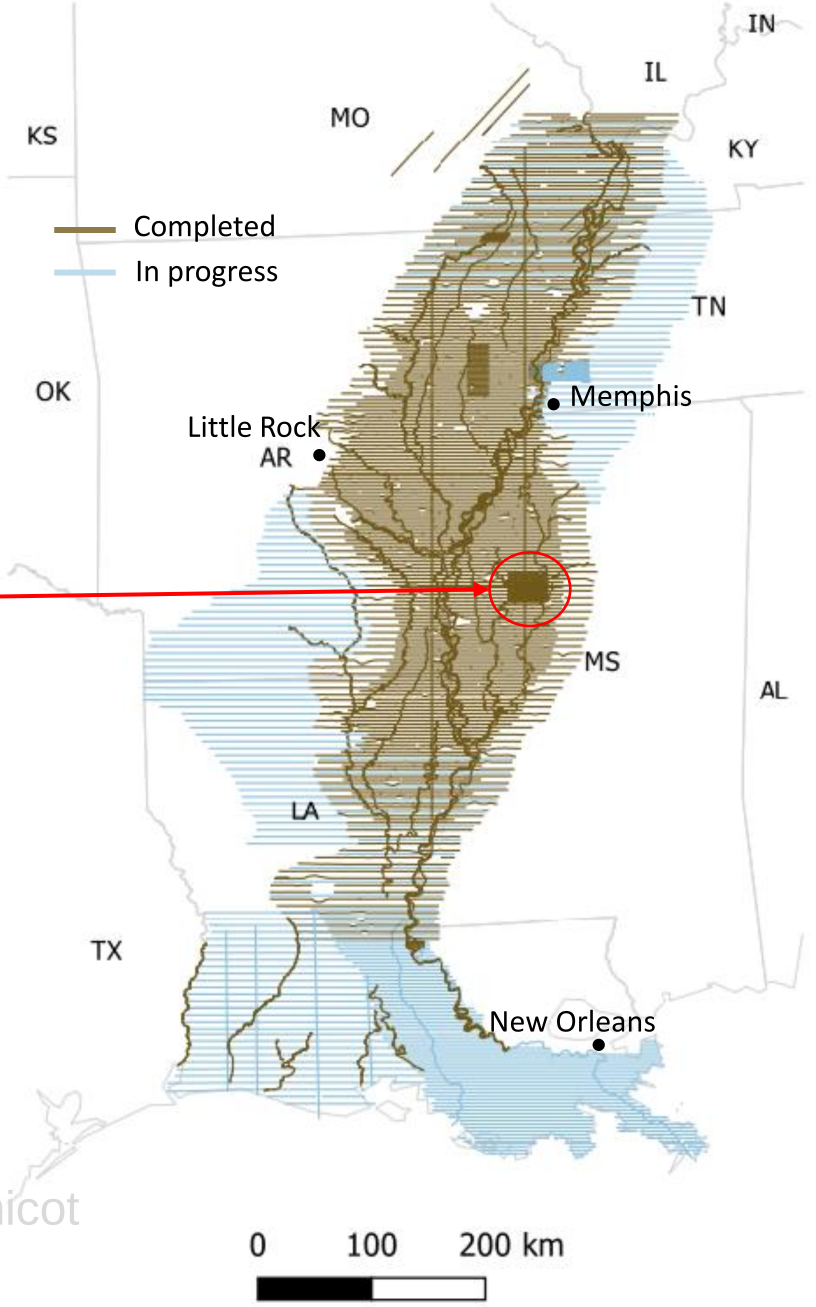


2018: Shellmound high-res survey
- 250-1000 m spacing; managed aquifer recharge

2018-2020: Regional Resolve & Tempest surveys
- 3-6 km spacing + rivers

Spring 2021: Resolve rivers & infrastructure
- MAP + Chicot Rivers
- US Army Corps of Engineers levees

Summer 2021: Regional Tempest extension
- Extending to the gulf coast, recharge areas, and Chicot aquifer



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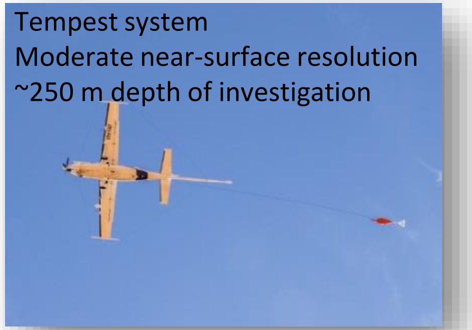

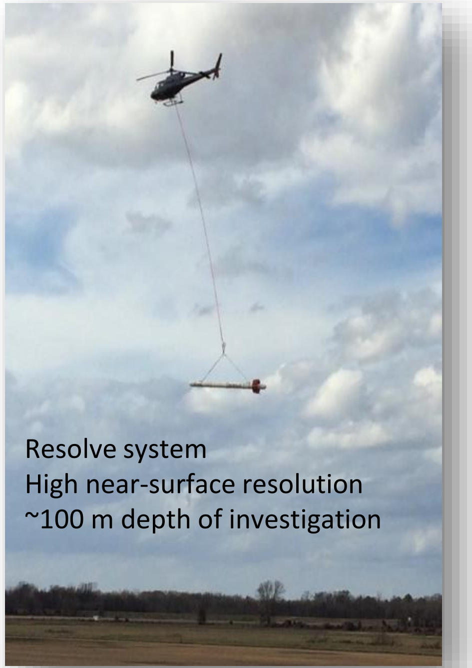

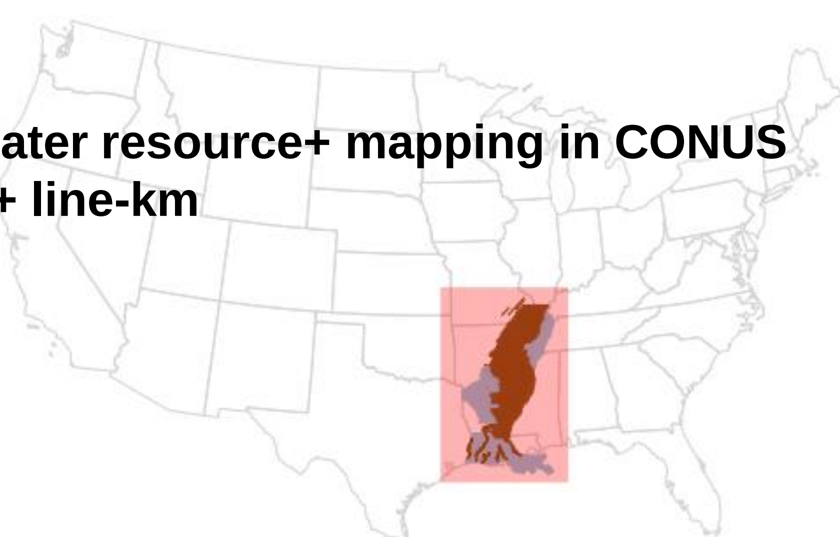

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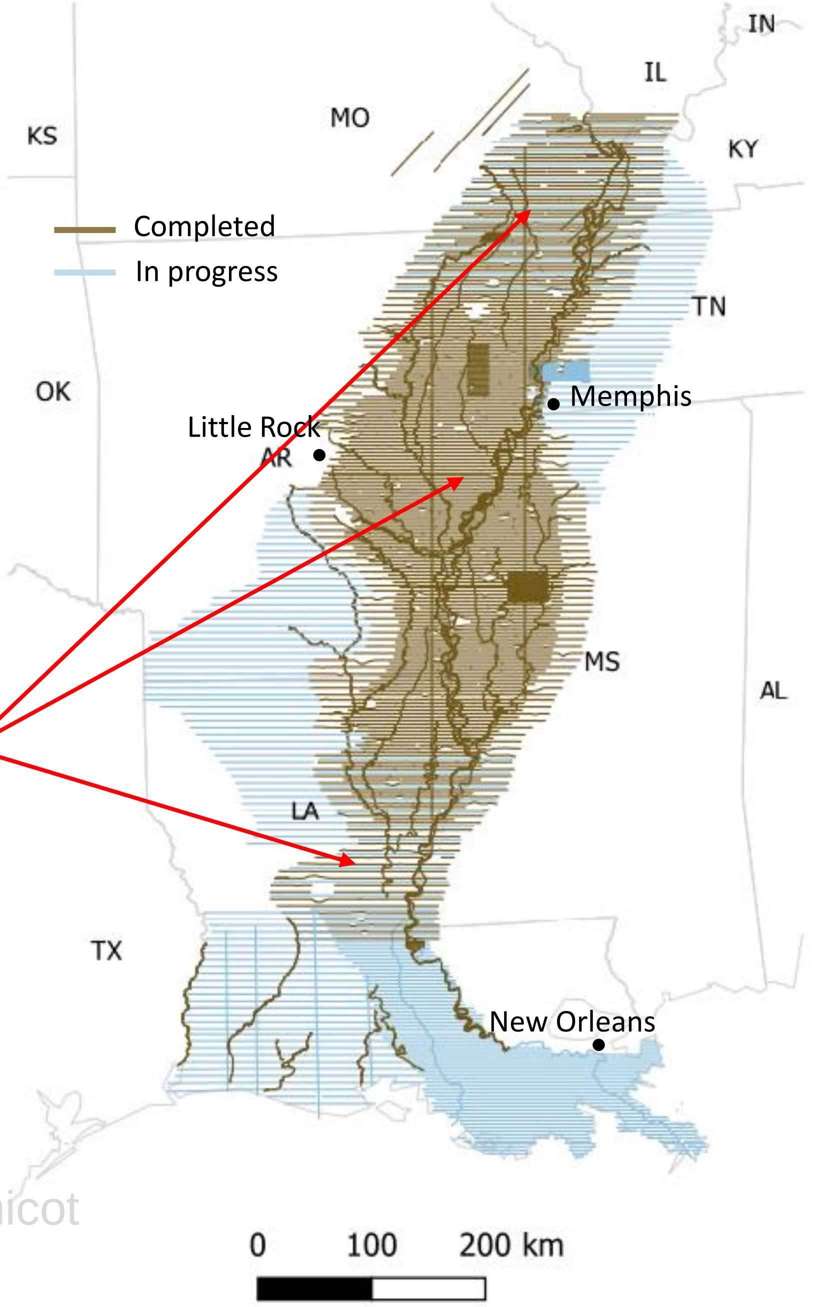

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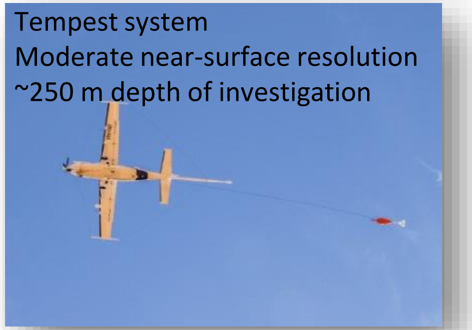
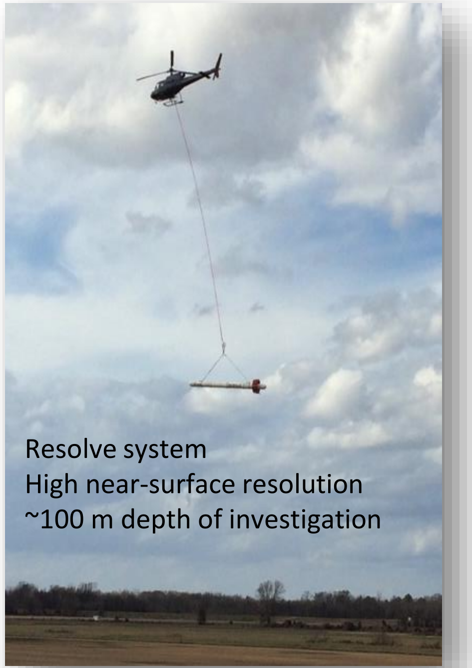

Tempest system
Moderate near-surface resolution
~250 m depth of investigation

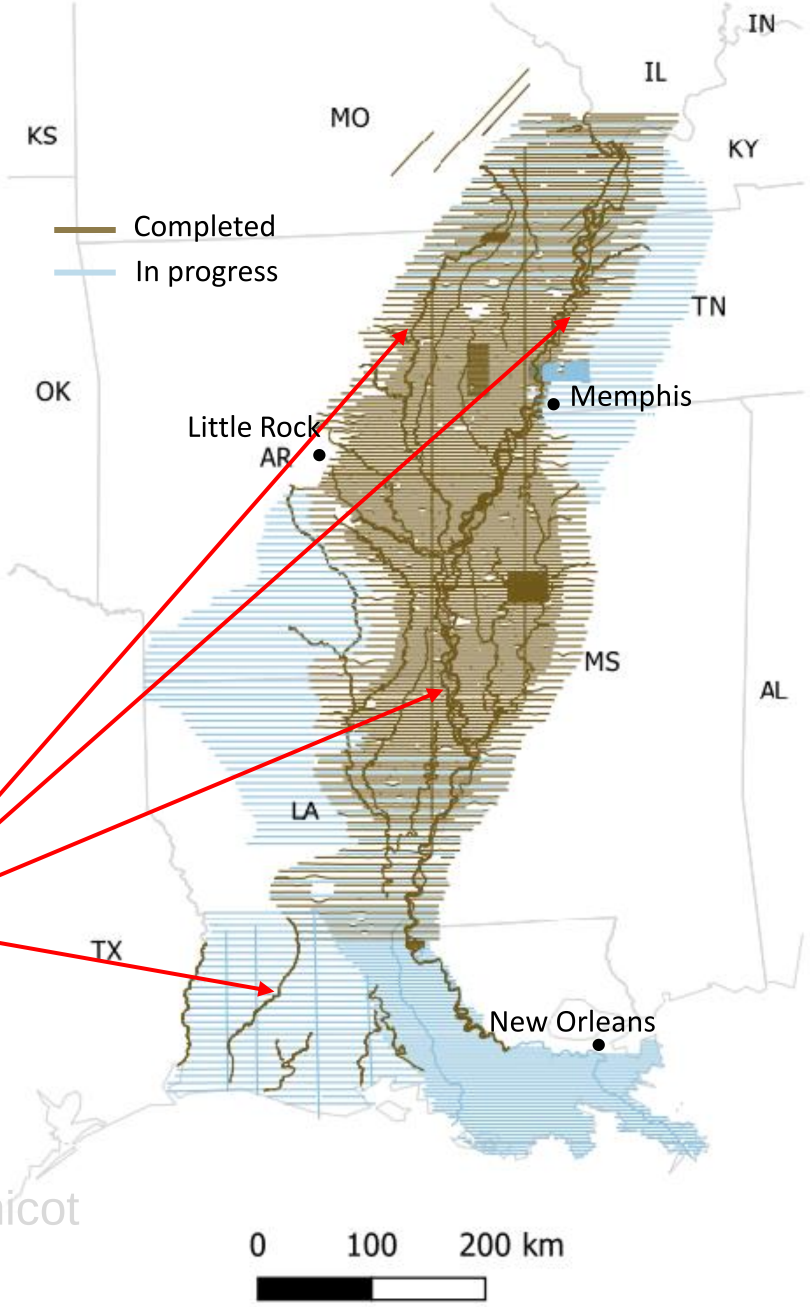

Resolve system
High near-surface resolution
~100 m depth of investigation

2018: Shellmound high-res survey
- 250-1000 m spacing; managed aquifer recharge

2018-2020: Regional Resolve & Tempest surveys
- 3-6 km spacing + rivers

Spring 2021: Resolve rivers & infrastructure
- MAP + Chicot Rivers
- US Army Corps of Engineers levees

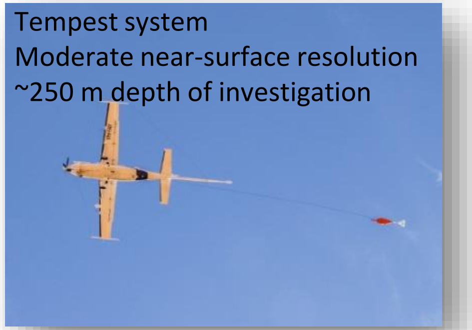
Summer 2021: Regional Tempest extension
- Extending to the gulf coast, recharge areas, and Chicot aquifer

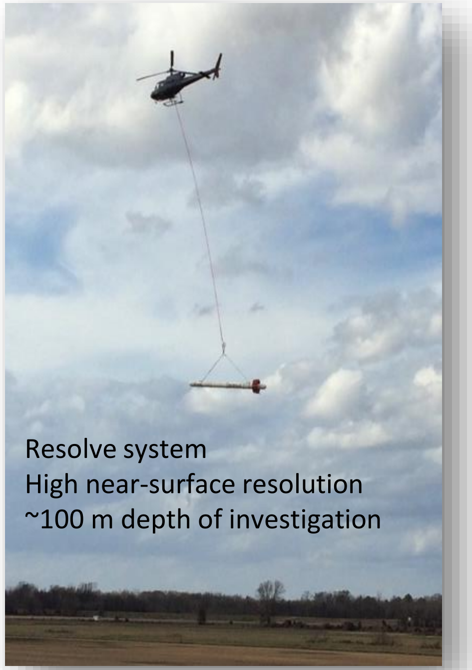


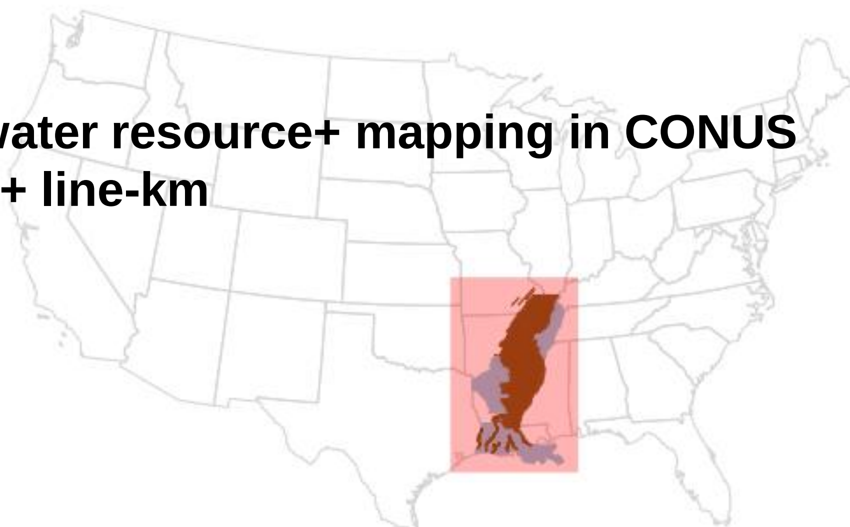
http://arcg.is/01nraa

MAP AEM surveys

Largest integrated AEM effort for water resource+ mapping in CONUS
Total completed + planned ~80,000+ line-km





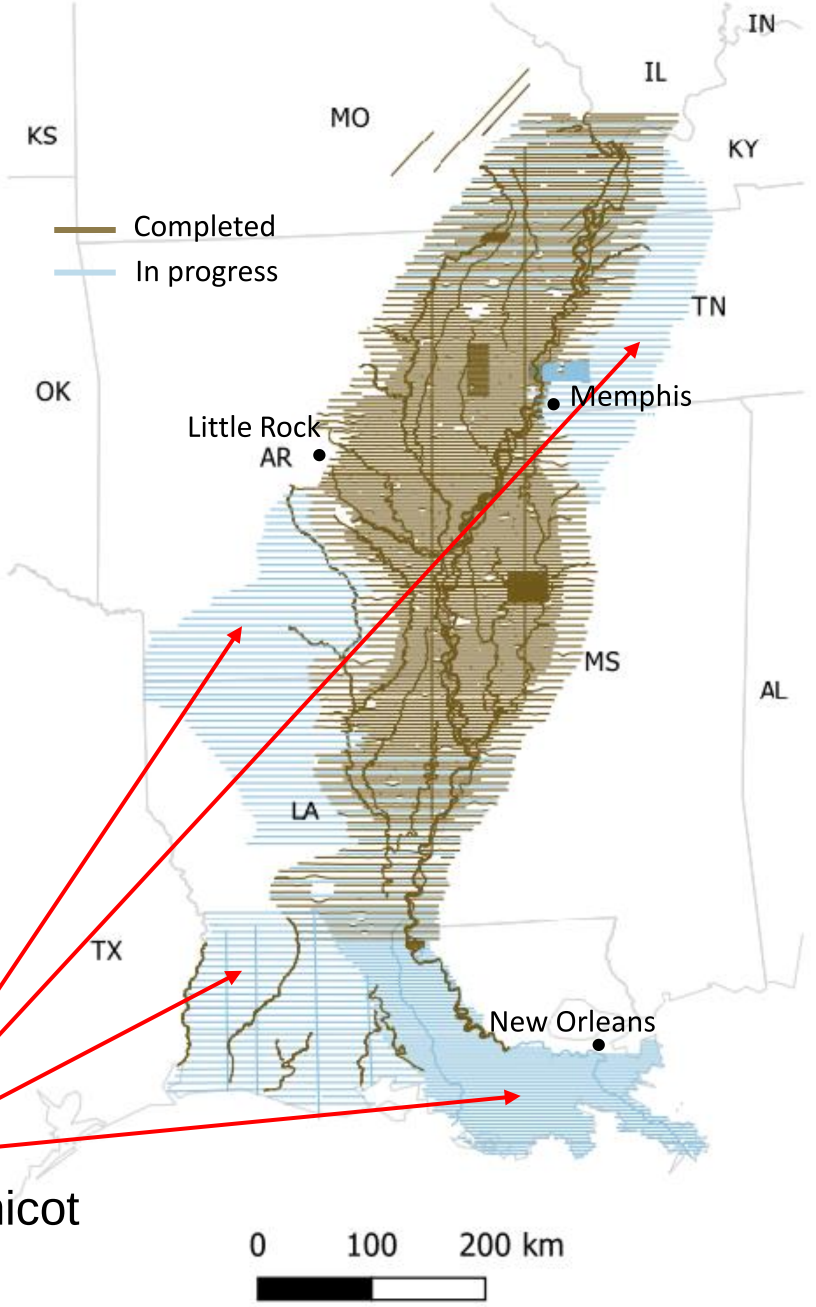


2018: Shellmound high-res survey
- 250-1000 m spacing; managed aquifer recharge

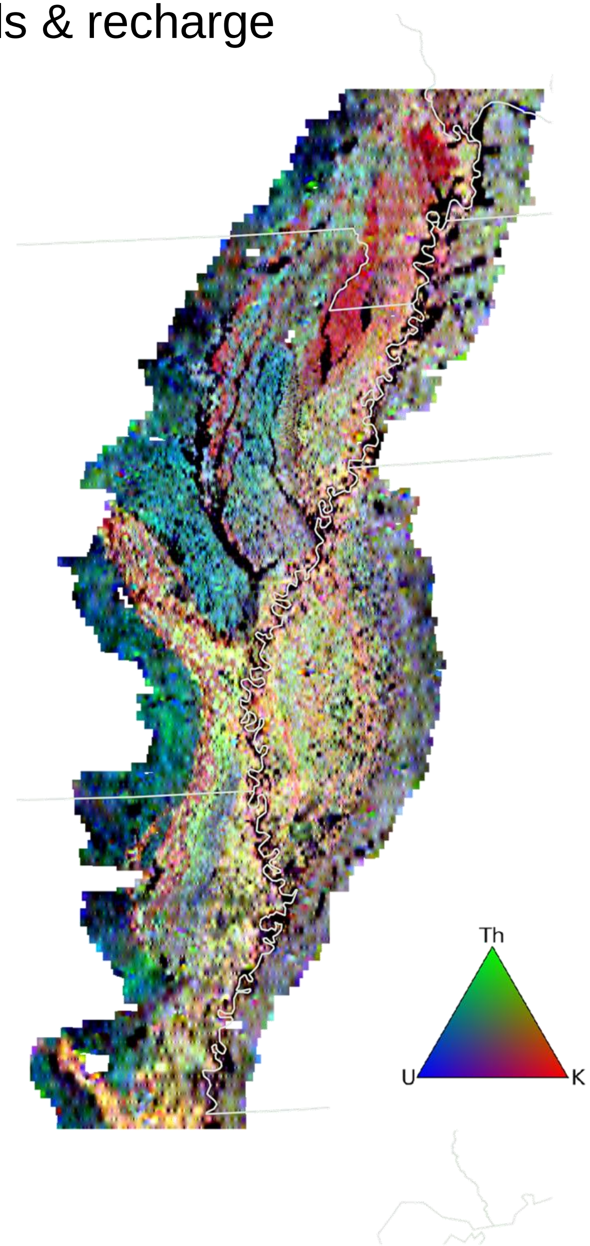
2018-2020: Regional Resolve & Tempest surveys
- 3-6 km spacing + rivers

Spring 2021: Resolve rivers & infrastructure
- MAP + Chicot Rivers
- US Army Corps of Engineers levees

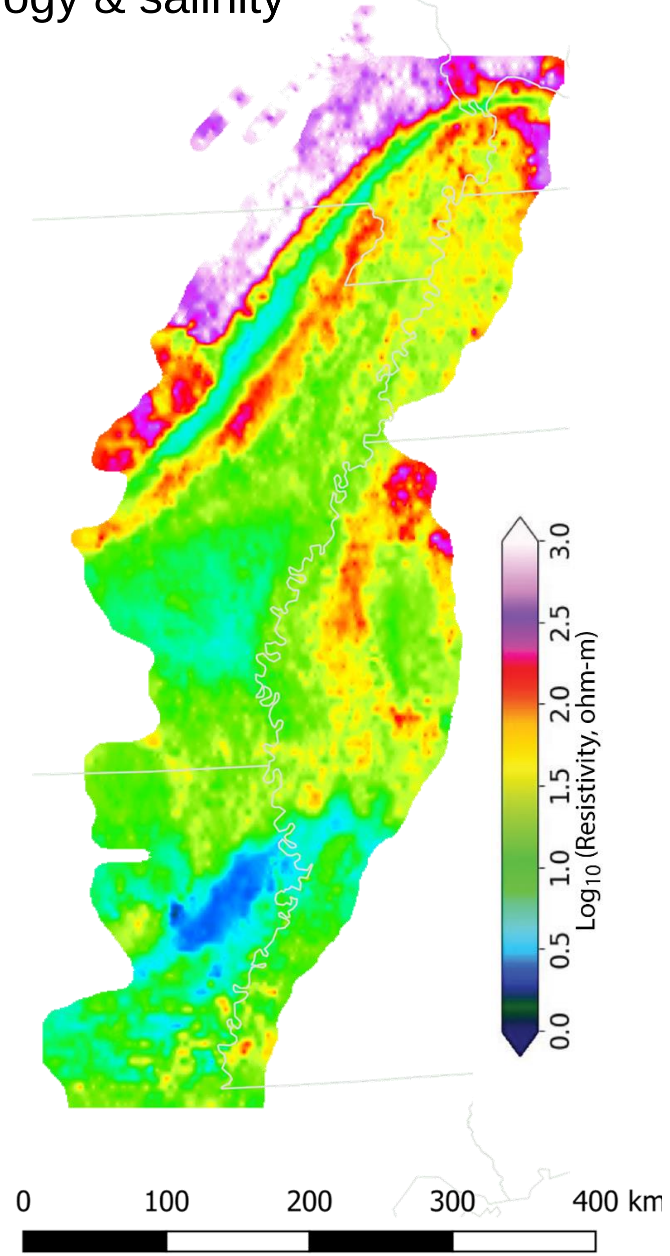
Summer 2021: Regional Tempest extension
- Extending to the gulf coast, recharge areas, and Chicot aquifer



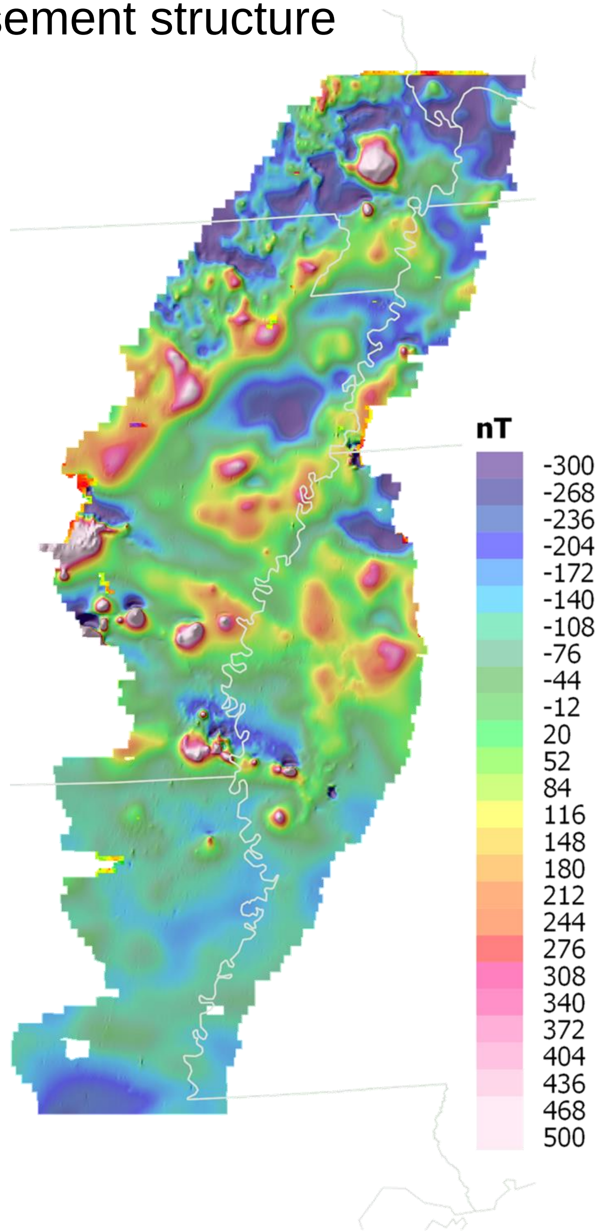
Radiometric
Upper 20-30 cm
Soils & recharge



Resistivity
1-300 m
Lithology & salinity



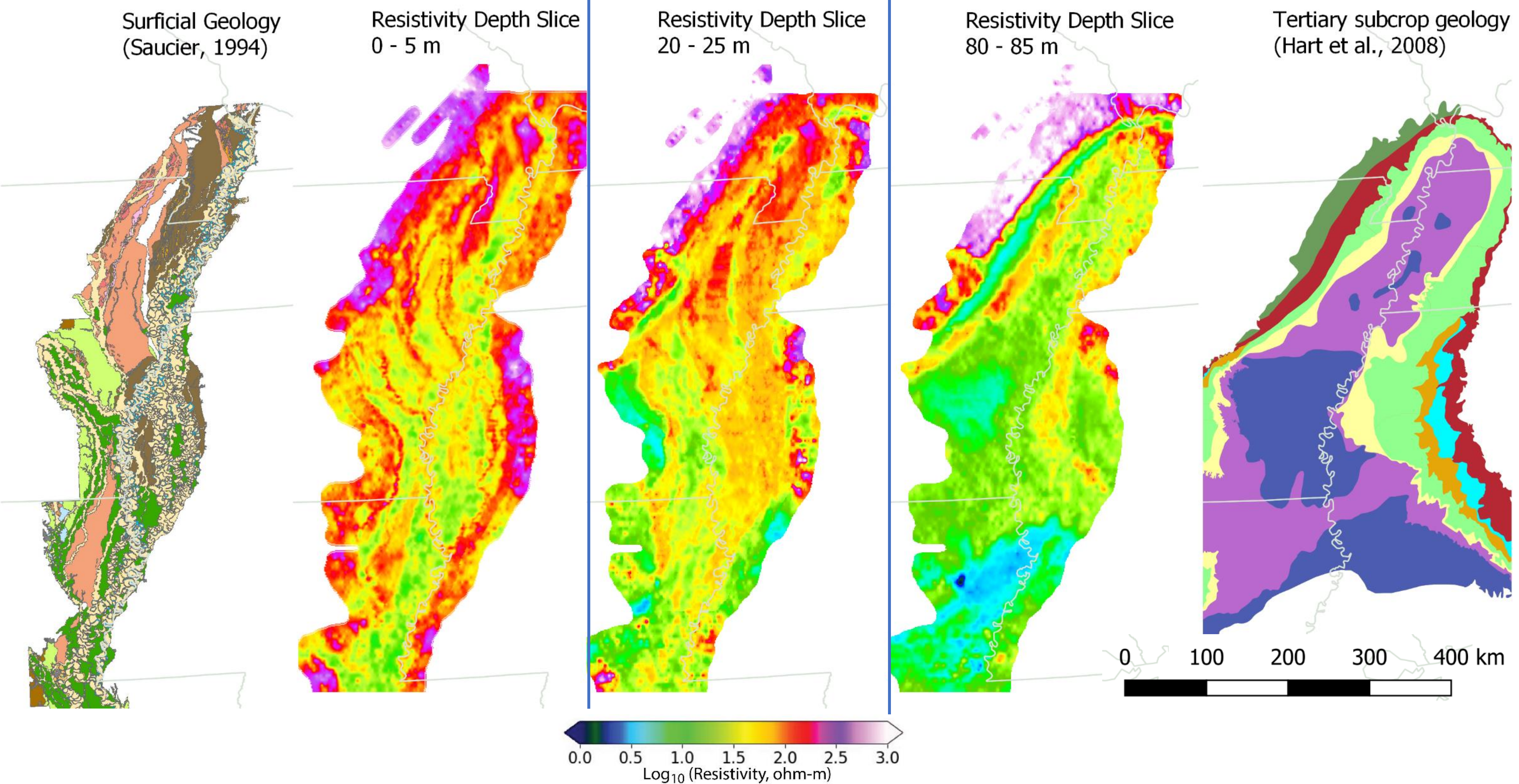
Magnetic
100 m - kms
Basement structure



Shallow resistivity layers correlate with surficial geology

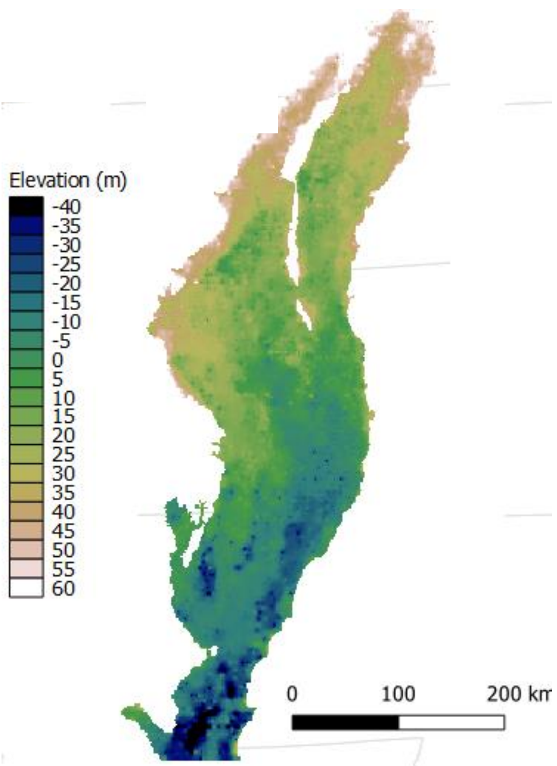
Intermediate depths mostly resistive, within the MRVA aquifer

Deep resistivity layers correlate with subcropping Tertiary formations

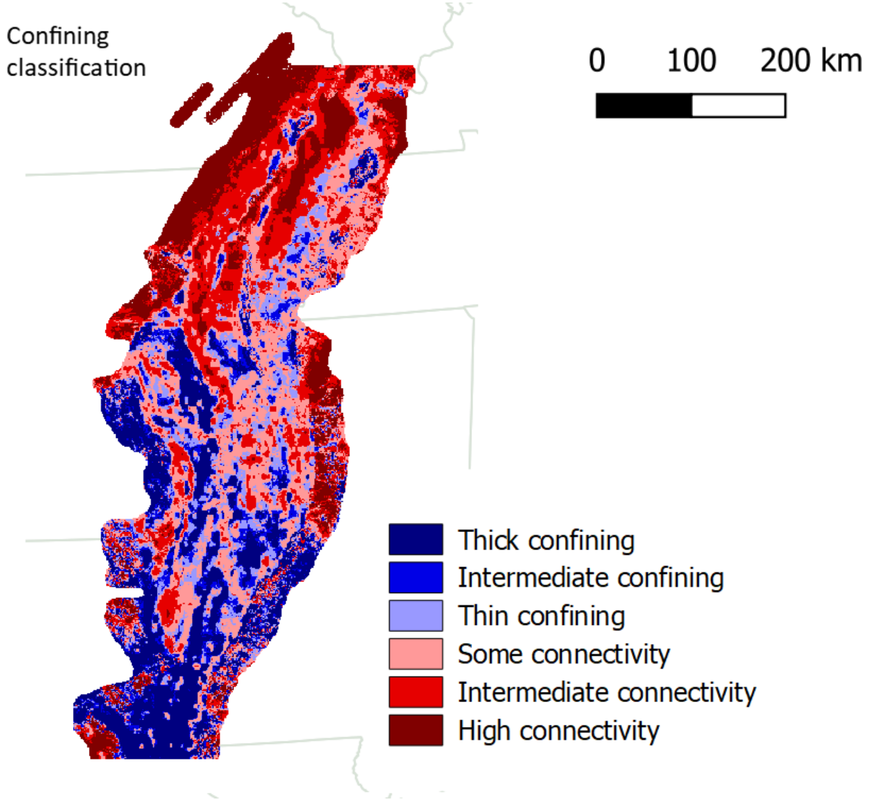


Derived products for hydrologic model inputs

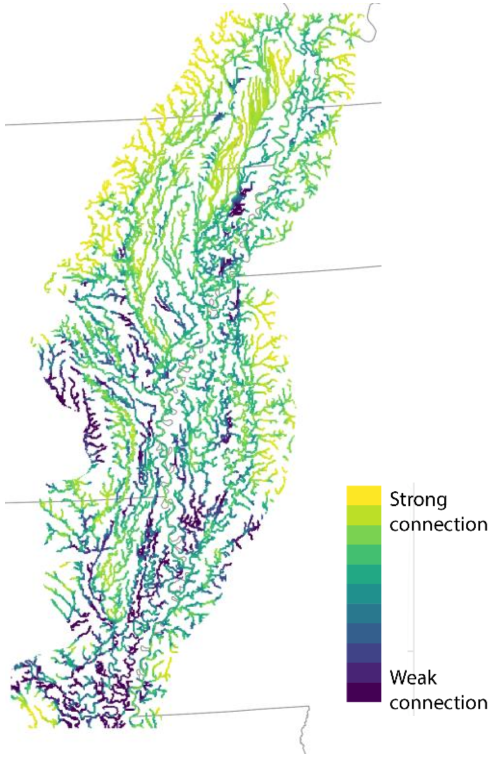
Base MRVA elevation



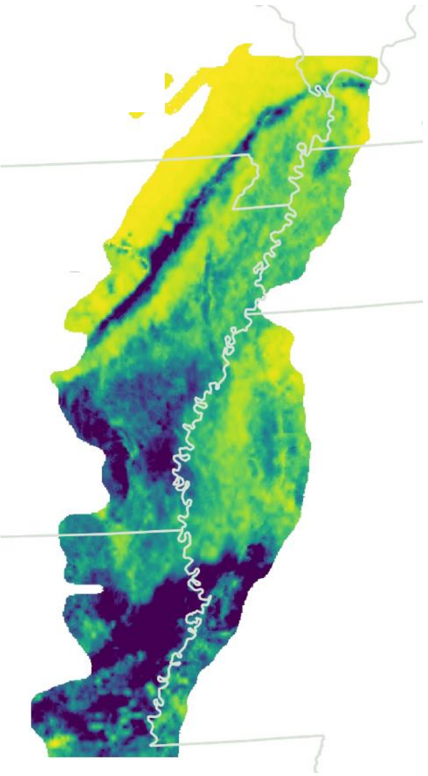
Confining unit thickness & extent



River connectivity

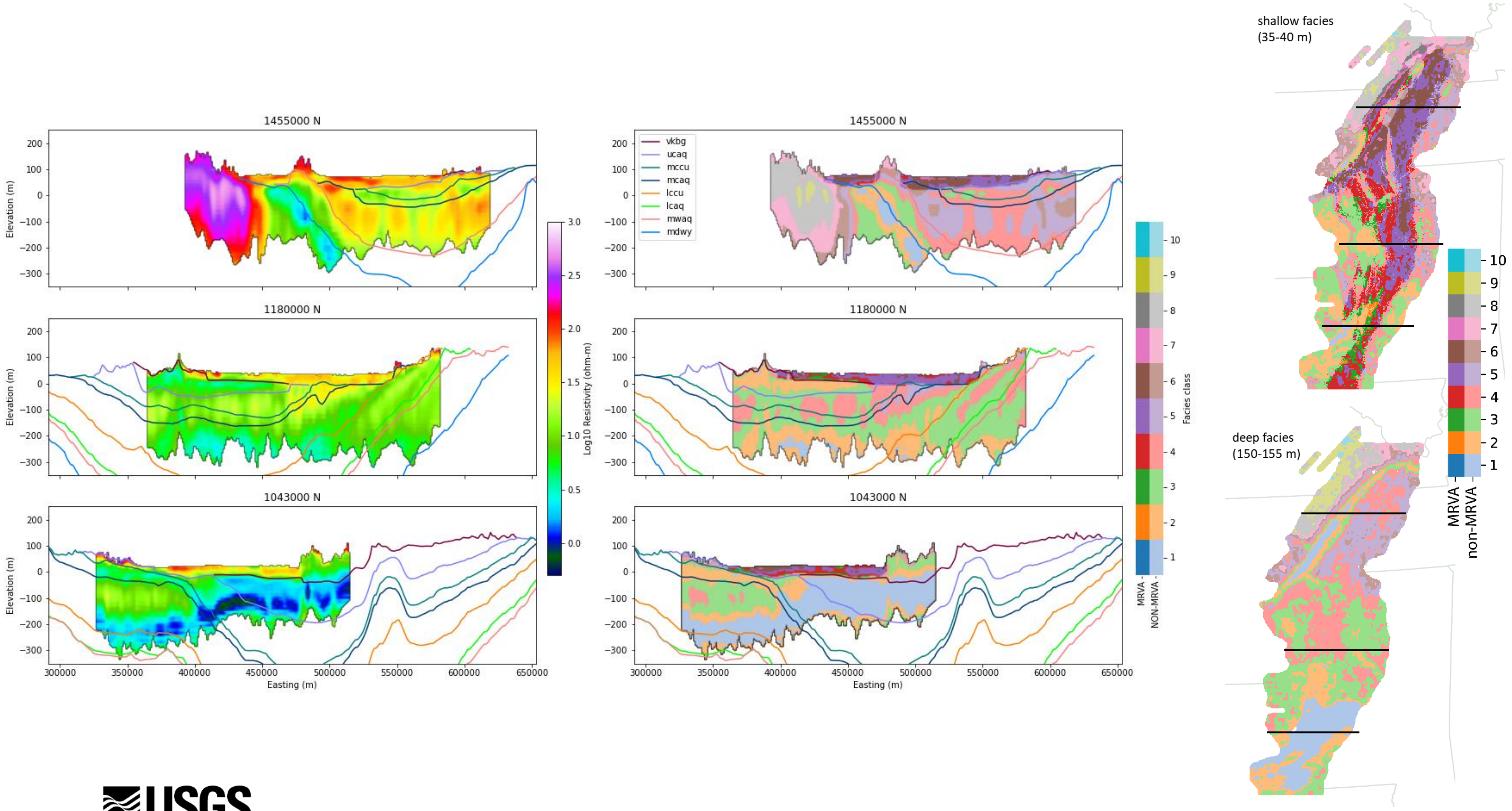


Base aquifer connectivity



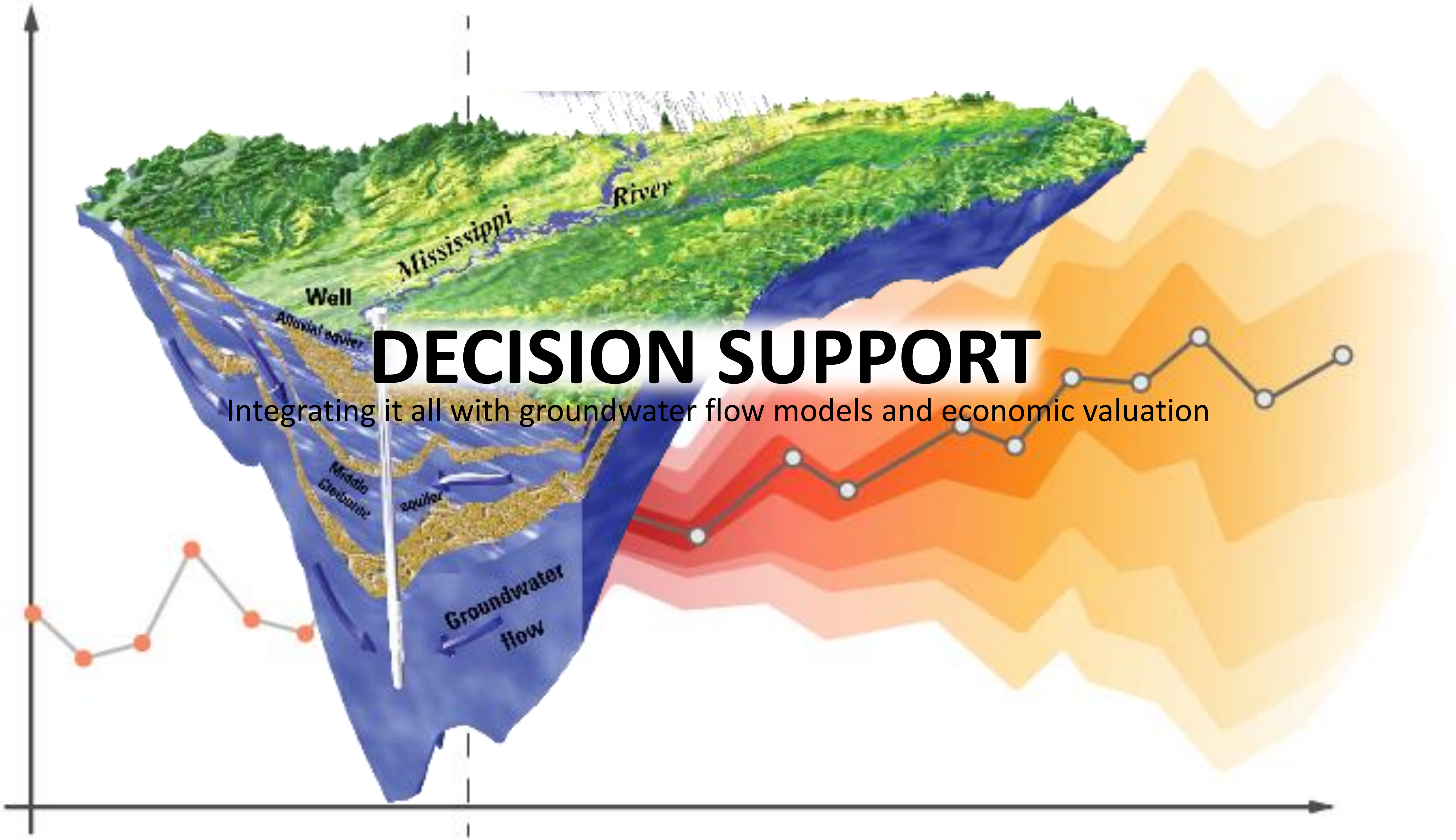
James & Minsley, 2021
Minsley et al., in revision

From resistivity to facies class



DECISION SUPPORT

Integrating it all with groundwater flow models and economic valuation



Decision Support Model

- Provide updated tool for water resource managers and other stakeholders to quantify the groundwater resource and responses to future conditions (development, conservation, mitigation, climate change, etc.)

- Incorporate recent modeling advances (SWB, SFRmaker, MODFLOW 6, PEST++ iES)

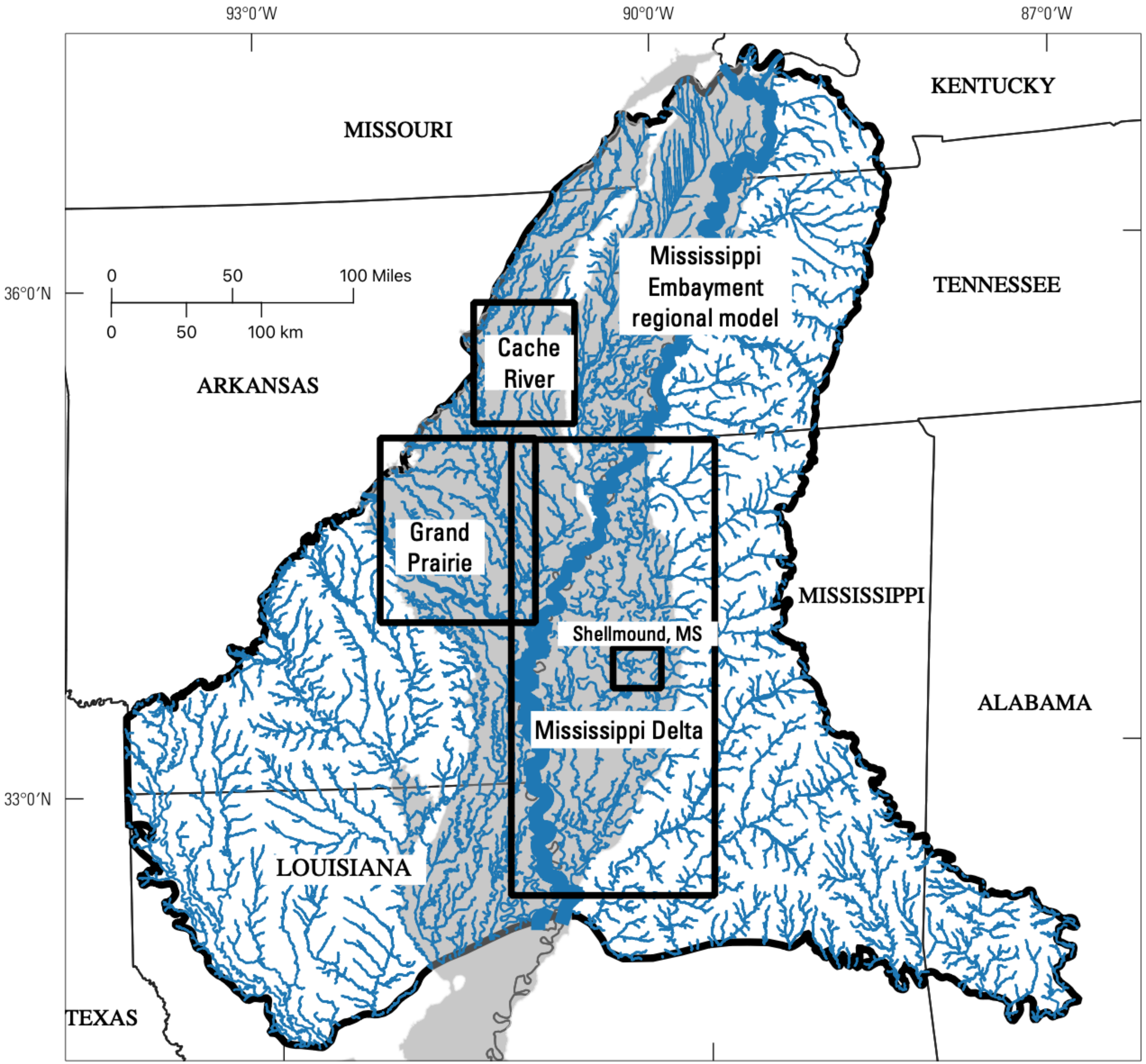
- Incorporate new data and analyses from Mississippi Alluvial Plain (MAP) Project
  - Airborne electromagnetic (AEM) survey
  - Waterborne streambed electrical resistivity surveys
  - Water use metering and estimation
  - Machine learning estimation of stream inflows
  - Soil Water Balance Code (SWB) model of the Embayment

- ”Living” model

(MSU Ag Communications/File Photo)

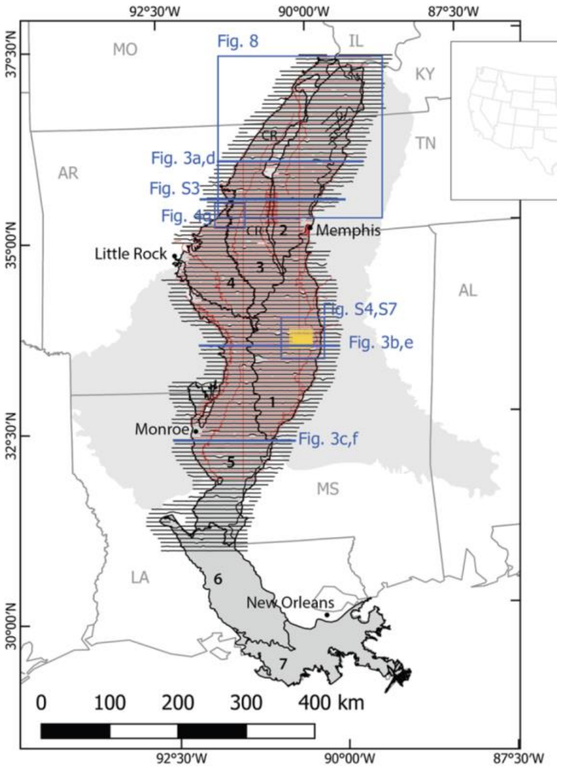
Approach

- Major model inputs developed at regional scale by dedicated teams on the MAP project
- Simplified, fast running regional model (1 km resolution, 3 layers) to provide boundary conditions
- Inset models focusing on specific areas (500m res. ~20 layers)
- Automate/harmonize inset model construction by developing/using Modflow-setup (https://github.com/aleaf/modflow-setup) and other python tools
- Key advances
    - Airborne electromagnetic survey
    - Soil Water Balance Code (SWB)
    - PEST++ iES & pyEMU



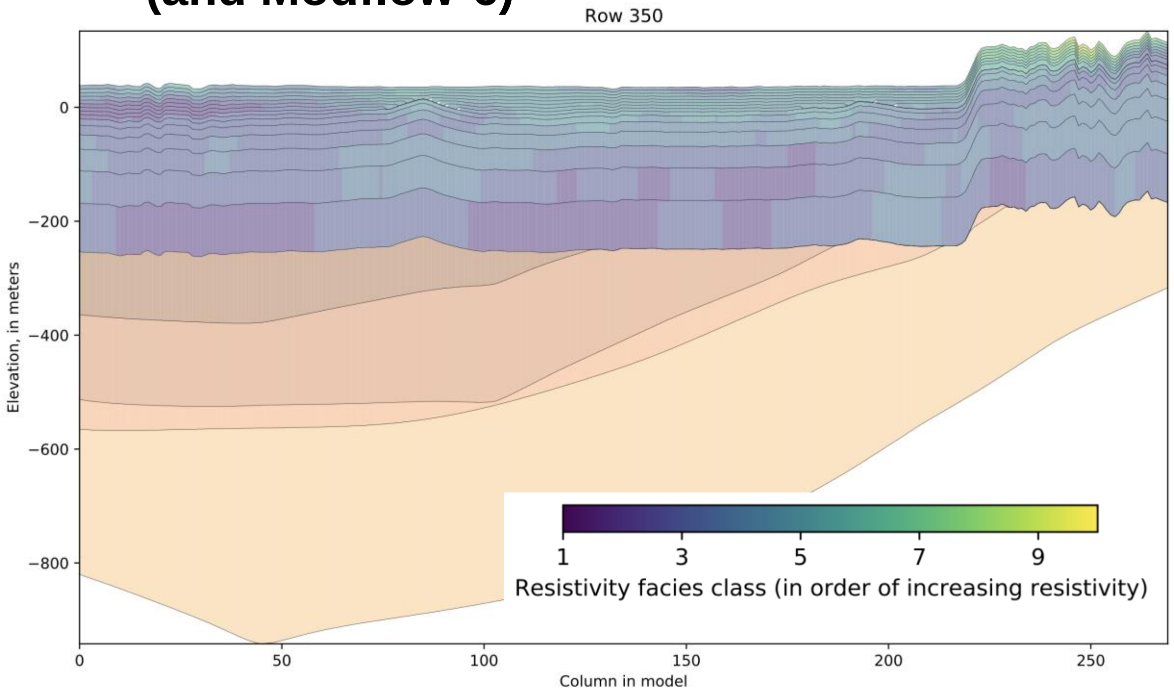
USGS

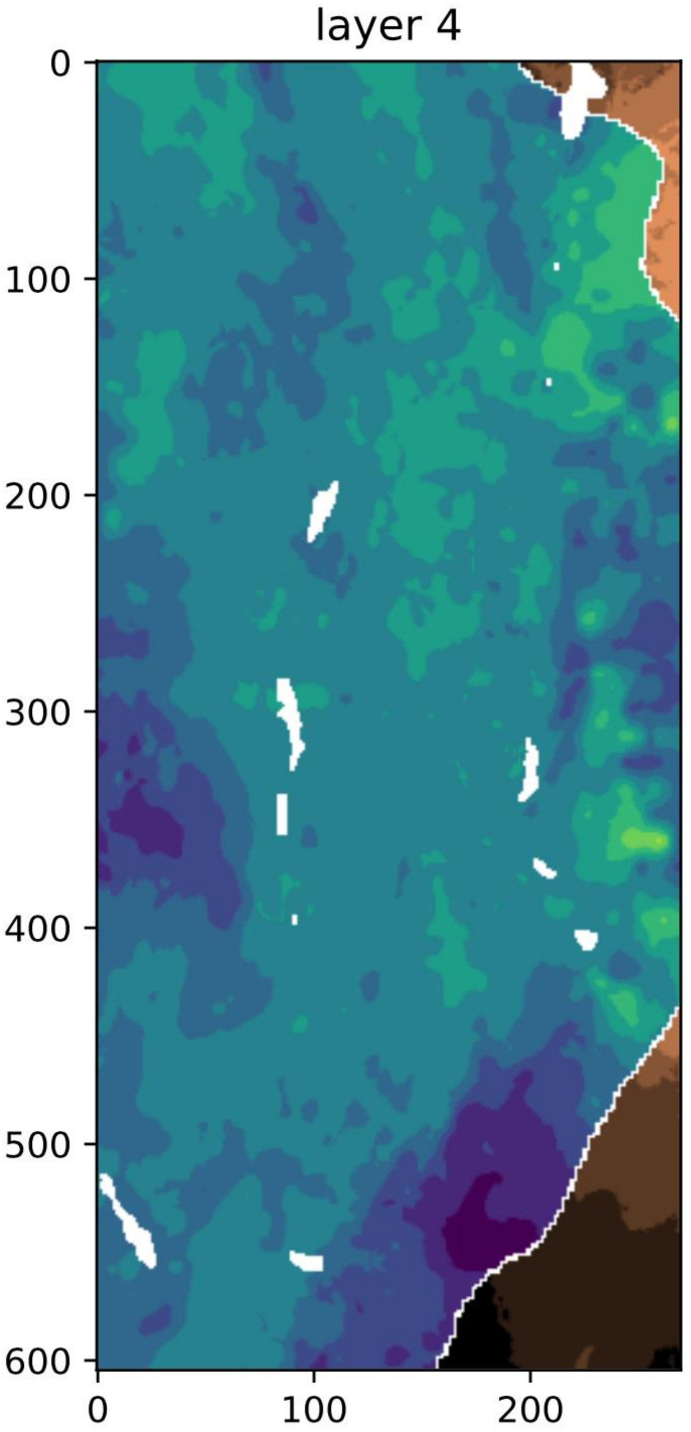
Key advance: AEM survey



(Minsley et al, 2021)

(and Modflow-6)



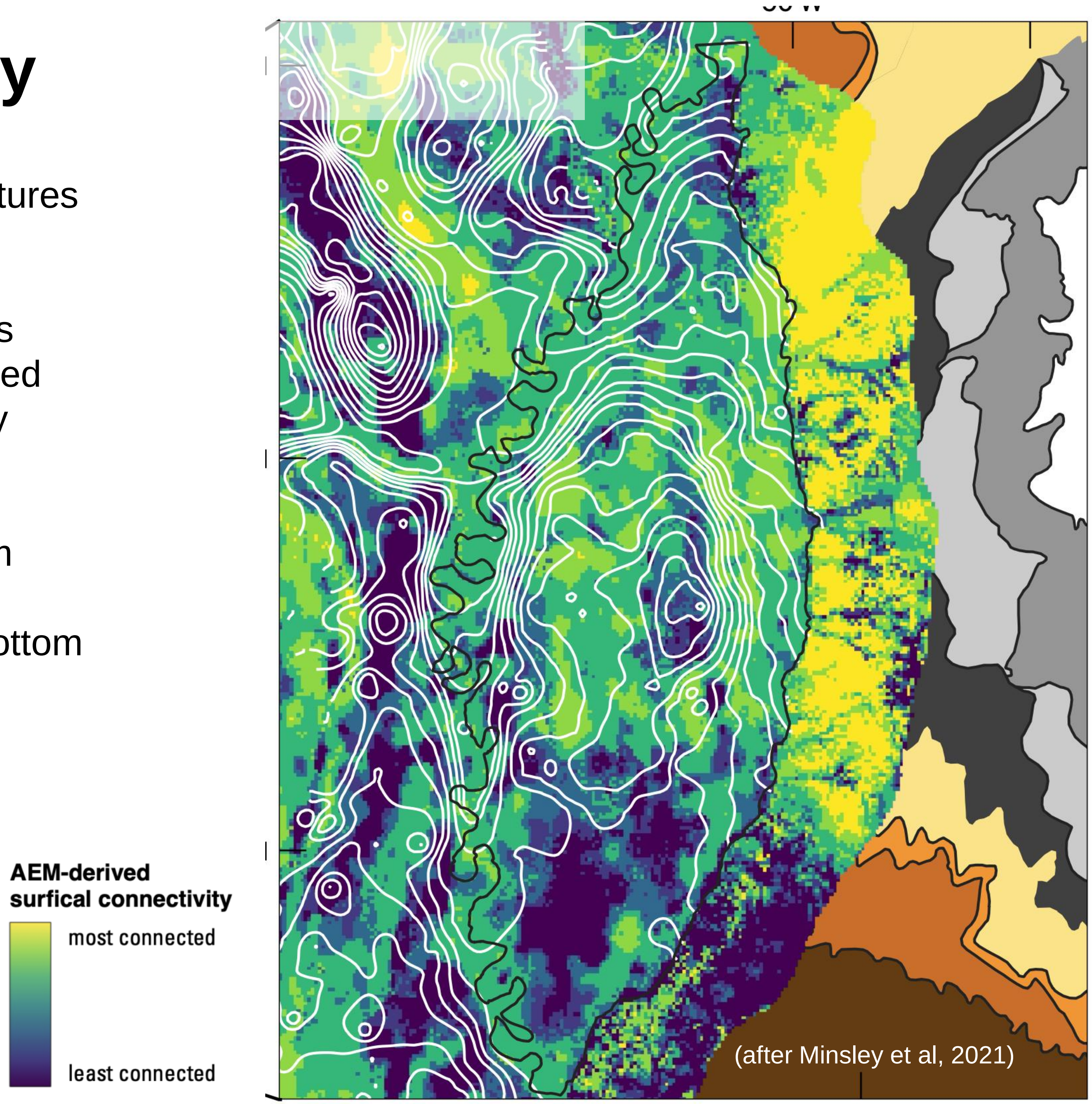


- ~80,000+ line-km
- Frequency and time-domain to investigate both upper 2-5 meters and depths up to 300 meters
- Resistivity can be proxy for hydraulic conductivity
- Challenges:
  - more data = more model cells;
  - doesn't provide absolute values of K
  - How to use all of this information in the model?
  - Boundary conditions are also important

USGS

Key advance: AEM survey

- Best application is mapping discrete structures such as layer surfaces
- In this case, the surficial confining unit was classified spatially (on a scale of 1-6), based on the thickness of low electrical resistivity layers in the upper 15 m
  - Traditional methods based on soil classifications only consider top 1-2 m
- AEM results were also used to map the bottom surface of the surficial confining unit

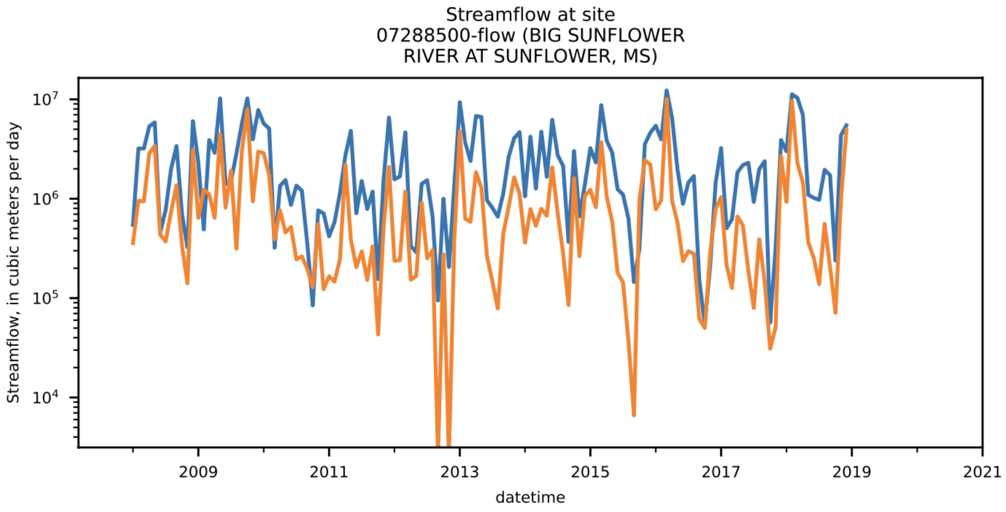


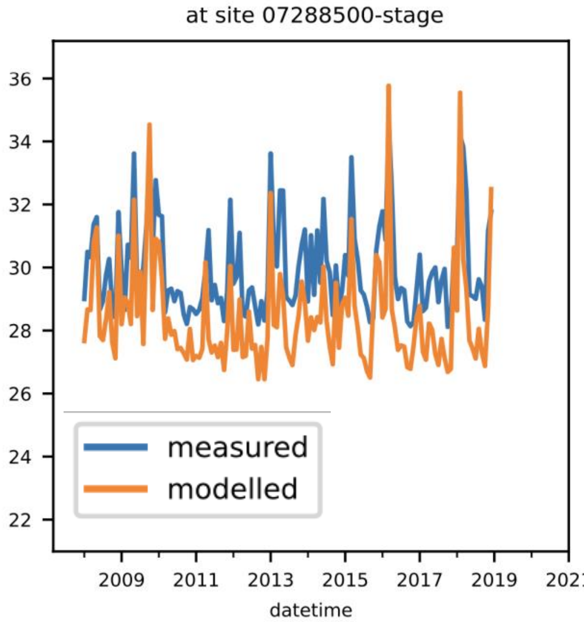
USGS

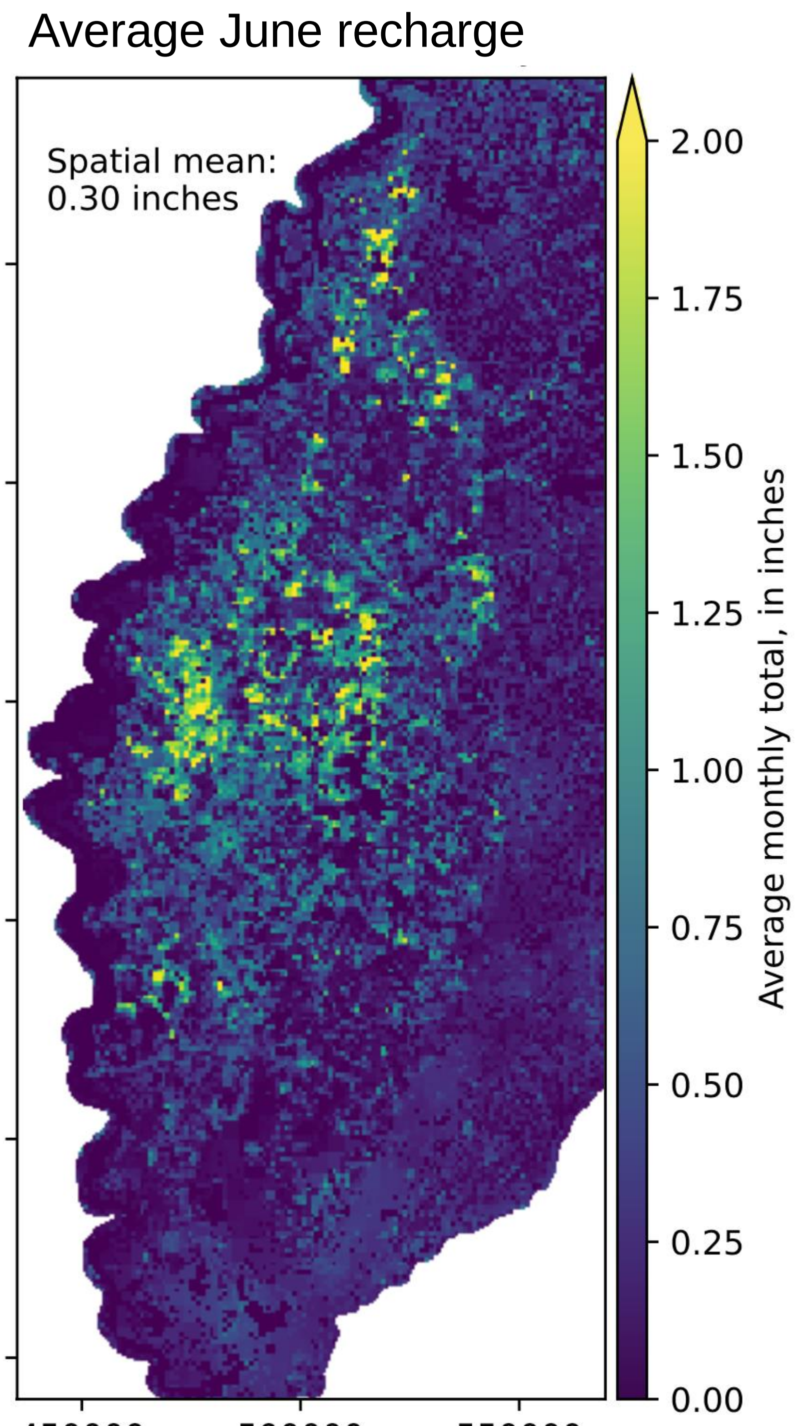
Key advance: Soil water balance code (SWB)

- MS Delta streams are important boundary conditions, but dominated by non-GW flow components

- SWB provides physics-based estimates of runoff in addition to net infiltration estimates
  - NHDPlus has the information to route each SWB pixel to an SFR reach
  - With monthly timesteps, detailed characterization of runoff is not as important
- SWB can also estimate water use based on crop demand





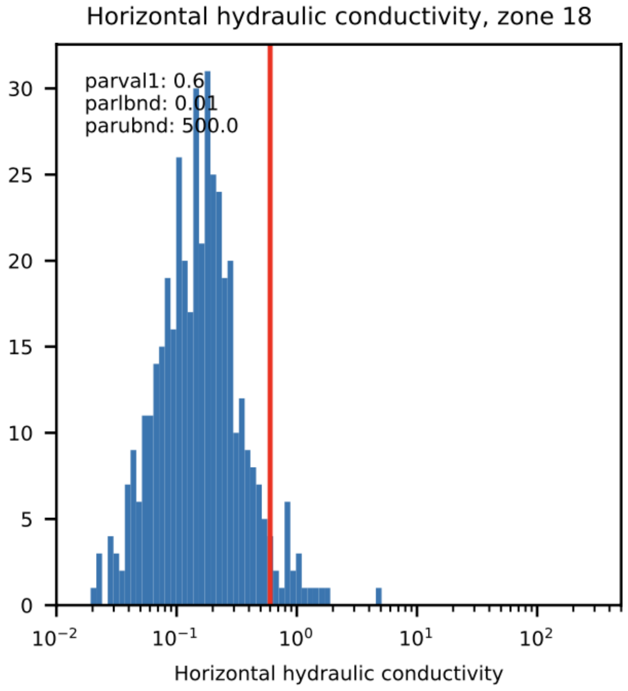


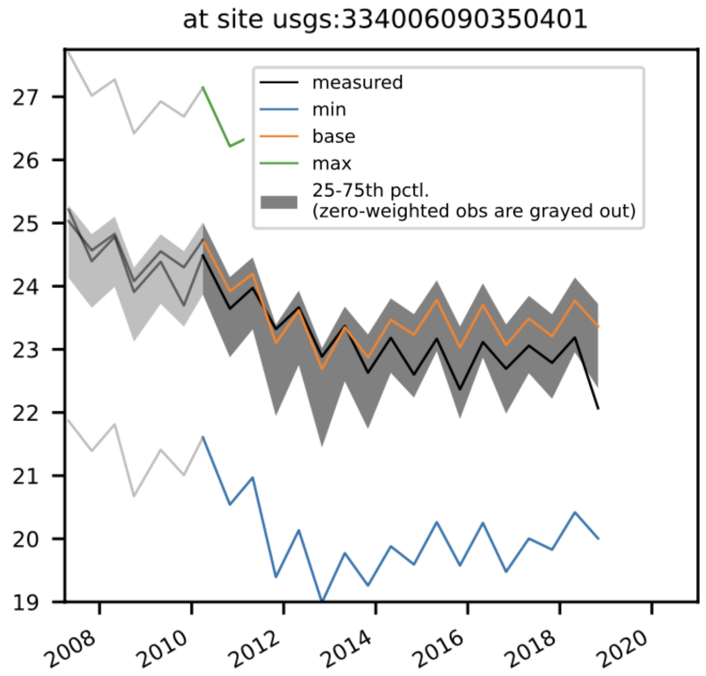
USGS

Key advance: PEST++ iterative ensemble smoother (iES) & pyEMU for history matching

- **"Jacobians for nothing, uncertainty for free"**
  - Gauss Levenburg Marquardt approach
  - Ensemble is used to approximate Jacobian matrix
  - 1000s of parameter changes can be tested with 100s of runs
  - ~2 iterations to reach a solution

- **Challenges/limitations**
  - New paradigm (black box at some level)
  - Information overload (pyEMU can help with this)
  - Results are best with a good starting point (prior) and multi-scale parametrization (White et al, 2021)
  - Only explores model parameter uncertainty





USGS

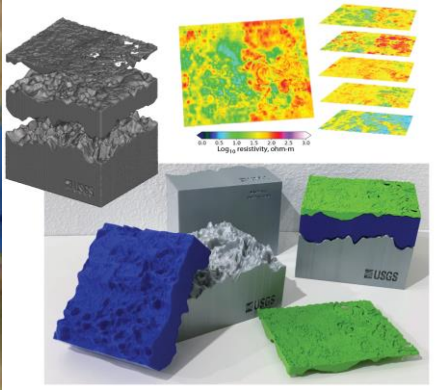
Summary

MAP project is a System-scale project to support water resource management

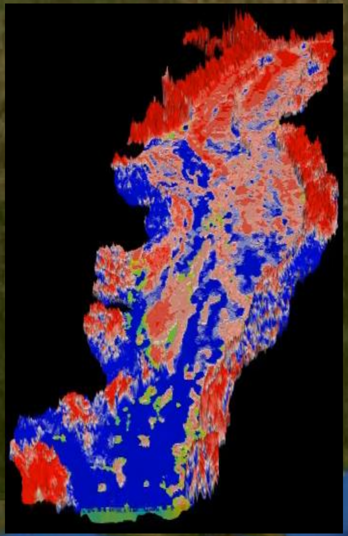
MAP project has demonstrated capability for integrated data collection, mapping, modeling research and application in a basin-scale interdisciplinary study with multiple stakeholders

https://www2.usgs.gov/water/lowermississippigulf/map/regional_SM.html
MAP regional geonarrative

https://www2.usgs.gov/water/lowermississippigulf/map/shellmound_SM.html
MAP Shellmound geonarrative



Shellmound 3D printed model



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Article | Open Access | Published: 22 June 2021

Airborne geophysical surveys of the lower Mississippi Valley demonstrate system-scale mapping of subsurface architecture

Burke J. Minsley, J. R. Rigby, Stephanie R. James, Bethany L. Burton, Katherine J. Knierim, Michael D. M. Pace, Paul A. Bedrosian & Wade H. Kress

Communications Earth & Environment **2**, Article number: 131 (2021) | Cite this article

1716 Accesses | **20** Altmetric | Metrics

https://www.nature.com/articles/s43247-021-00200-z

NRCS Groundwater Conservation Efforts

Gary M. Bennett, P.E., USDA-NRCS Arkansas

United States Department of Agriculture

2022 Arkansas Groundwater Summit

NRCS Groundwater Conservation Efforts

Gary M. Bennett, PE
State Conservation Engineer
USDA/NRCS – Arkansas

Arkansas

Natural Resources Conservation Service

nrcs.usda.gov/

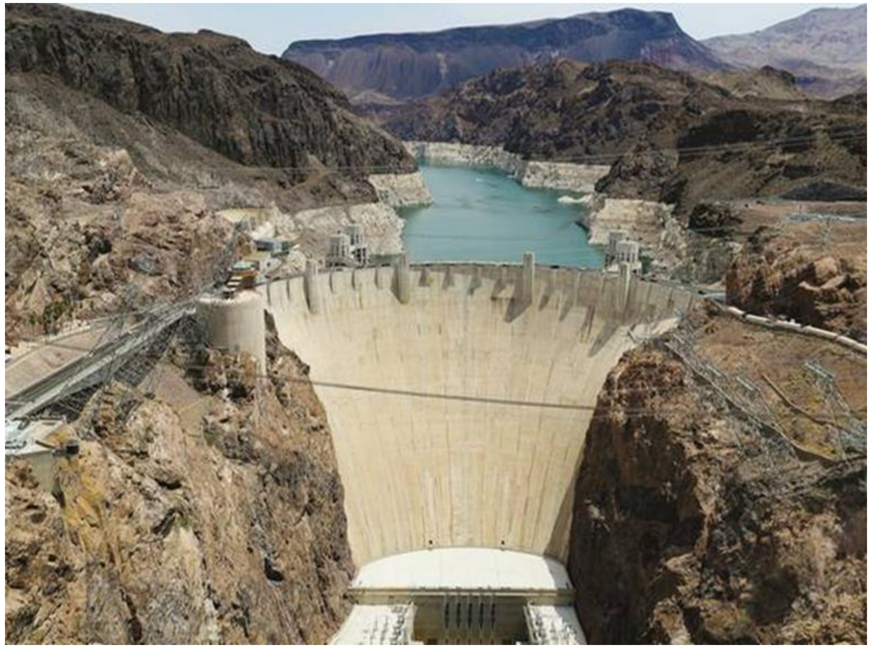
Current Groundwater use Gap

- Reported agricultural-irrigation water use in 2018 estimates that a total of 7,590 Mgal/d of groundwater was used for irrigation

- Estimated sustainable yield of the alluvial aquifer is 3,374 Mgal/d

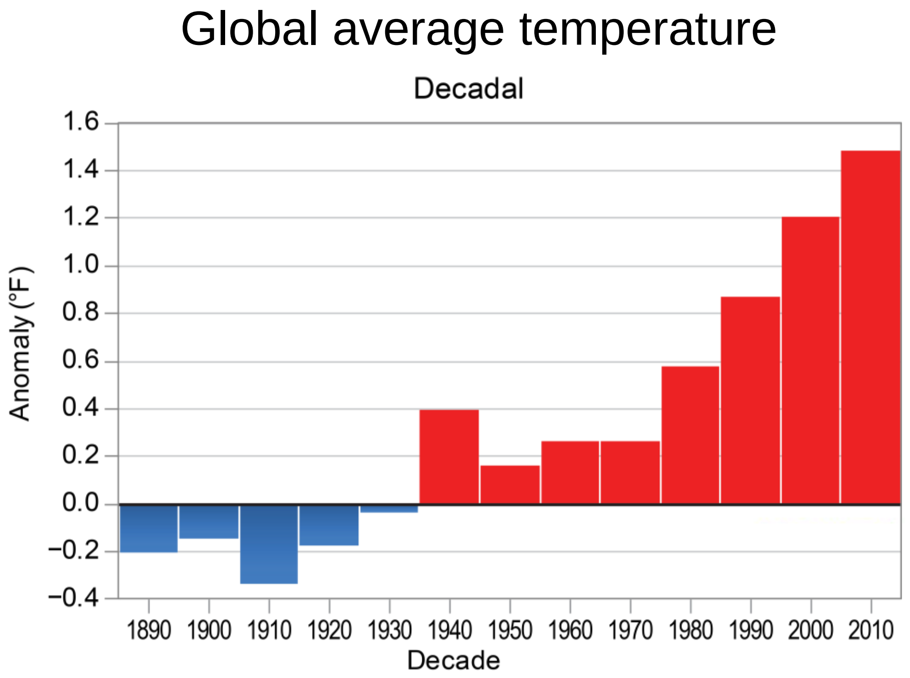
NRCS Groundwater Conservation Efforts

- NRCS Strategic Priorities
- Partnerships
- Impact Assessment
- Programs



NRCS Strategic Priorities

Addressing Climate Change via Climate-Smart Agriculture, Forestry, and Renewable Energy



https://science2017.globalchange.gov/chapter/1/

NRCS Strategic Priorities

Advancing Racial Justice, Equity, and Opportunity

Partnerships

7 year - $5.5 million addressing GW decline

- IWM – Mike Hamilton
- IWM Technicians
- Most Crop Per Drop Contest – Dr. Henry/UA
- Rice Water Use – Dr. Runkle/UA
- Pipe Planner – Delta Plastics
- Other

Grand Prairie / Bayou Meto Irrigation Projects

~ $120 million when complete

IWM – Mike Hamilton
shared position between Extension and NRCS

- Started in 2015
- renewed 3 times
- agreement with UADA Cooperative Extension Service
- **Over life of project**
  - **$490,000 Federal**
  - **$490,000 UADA**

IWM- Irrigation Technicians

2015: 4 positions, 3-year 50/50 contribution agreement with ANRC

2018: Added 4 more, fully funded by NRCS

2019: Added 2 more, fully funded by NRCS

2022: Recently announced to fund ANRC's proposal for 10 IWM technicians through 2025

10 IWM Technicians
NRCS investment through 2025 will total $3.8+ million

IWM- Irrigation Technicians

Since 2018 prepared an additional 532 IWM Plans / 155,000 acres

Over 2500 irrigation designs using CHS / 250,000 acres.

Determined flow from an additional 1000 irrigation wells

Over 150 demonstrations using soil moisture sensors

Growers adopting soil moisture sensors crossed over beyond contracted acres to well over 1000 additional fields

Most Crop per Drop Contest
Implementing IWM

Farmer Chad Render:
Corn & Soybean Winner

Dr. Chris Henry

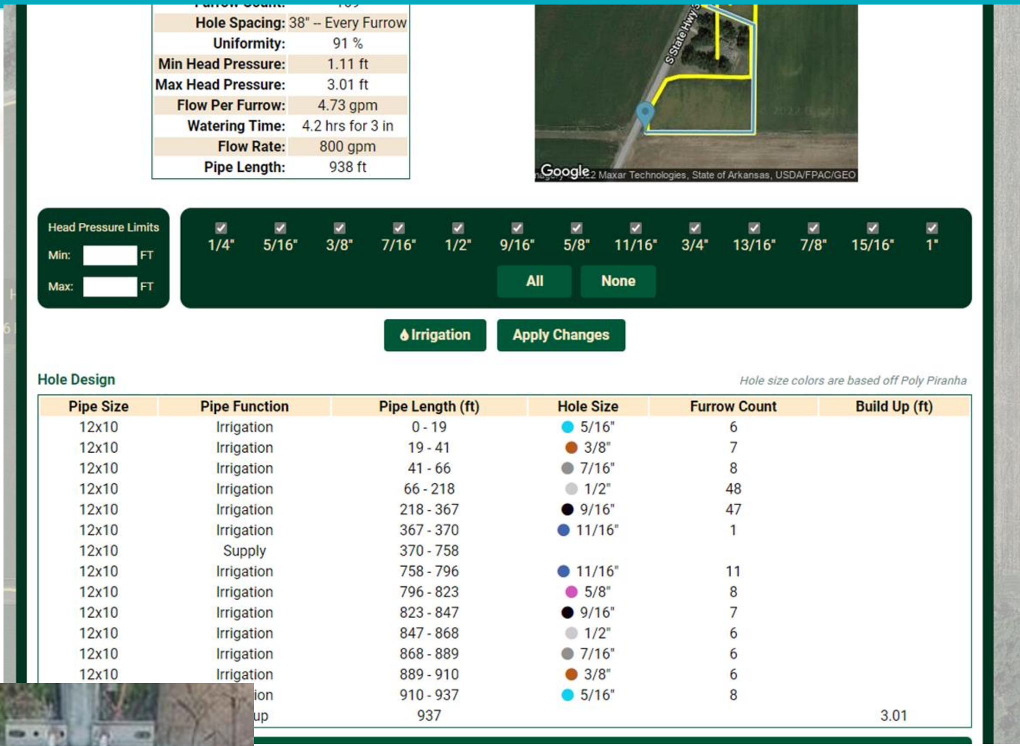
Computerized Hole Selection (CHS)

WUE = Yield / (Irrigation + Rainfall

Other Partnerships

UA – Dr. Runkle

Objectives:
Water use/yield data
ET rates
GHG emissions
$331,415 in funding



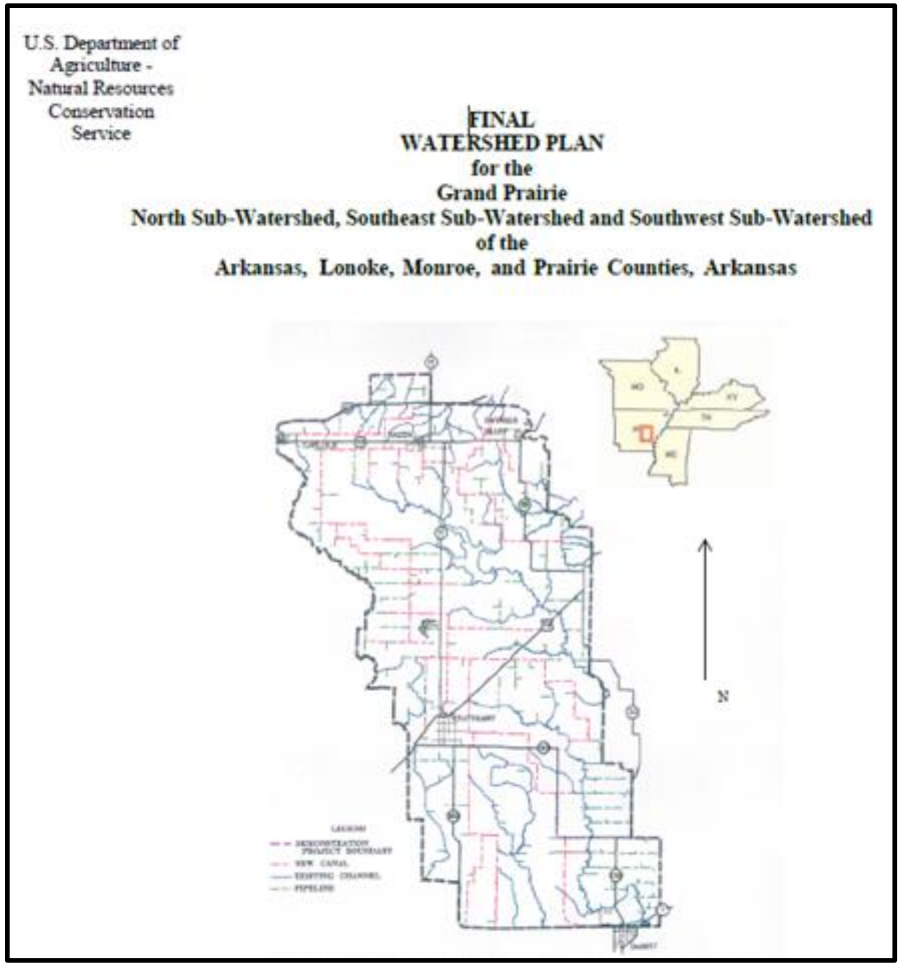
Pipe Size	Pipe Function	Pipe Length (ft)	Hole Size	Furrow Count	Build Up (ft)
12x10	Irrigation	0 - 19	5/16"	6	
12x10	Irrigation	19 - 41	3/8"	7	
12x10	Irrigation	41 - 66	7/16"	8	
12x10	Irrigation	66 - 218	1/2"	48	
12x10	Irrigation	218 - 367	9/16"	47	
12x10	Irrigation	367 - 370	11/16"	1	
12x10	Supply	370 - 758			
12x10	Irrigation	758 - 796	11/16"	11	
12x10	Irrigation	796 - 823	5/8"	8	
12x10	Irrigation	823 - 847	9/16"	7	
12x10	Irrigation	847 - 868	1/2"	6	
12x10	Irrigation	868 - 889	7/16"	6	
12x10	Irrigation	889 - 910	3/8"	6	
	ion	910 - 937	5/16"	8	
	up	937			3.01

Delta Plastics

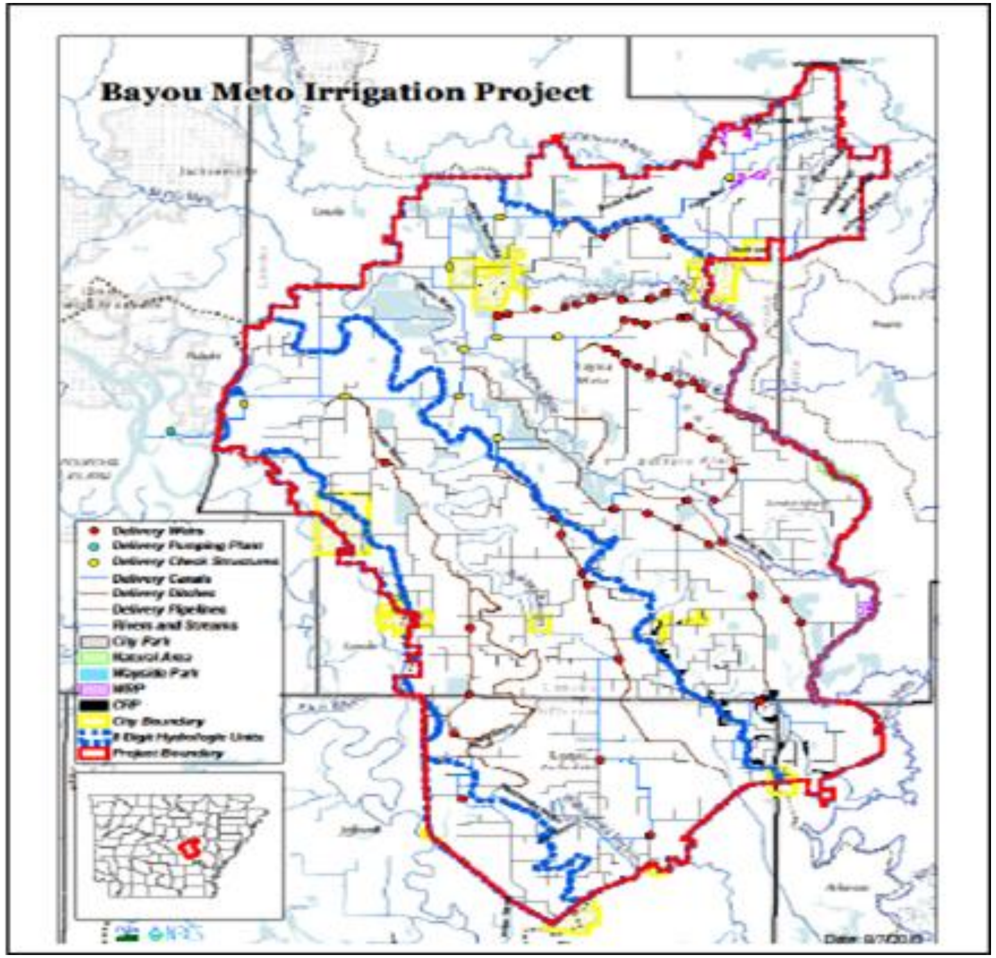
Enhancing Pipe Planner App,
$150,000

ADA-NRD – Flow Meters, $100,000

Grand Prairie / Bayou Meto Irrigation Projects



White River (Grand Prairie) – $48.3 million through PL-566 for construction, $64.4 million when complete



Bayou Meto – $41.8 million through PL-566 for construction, $55.7 million when complete

Impact Assessment

- Source Water Protection
- Cover Crops
- Reservoirs
- IWM

Source Water Protection (SWP) Language in the 2018 Farm Bill

- **Identify local priority areas for drinking water protection in each state in collaboration with State Technical Committees and community water systems**

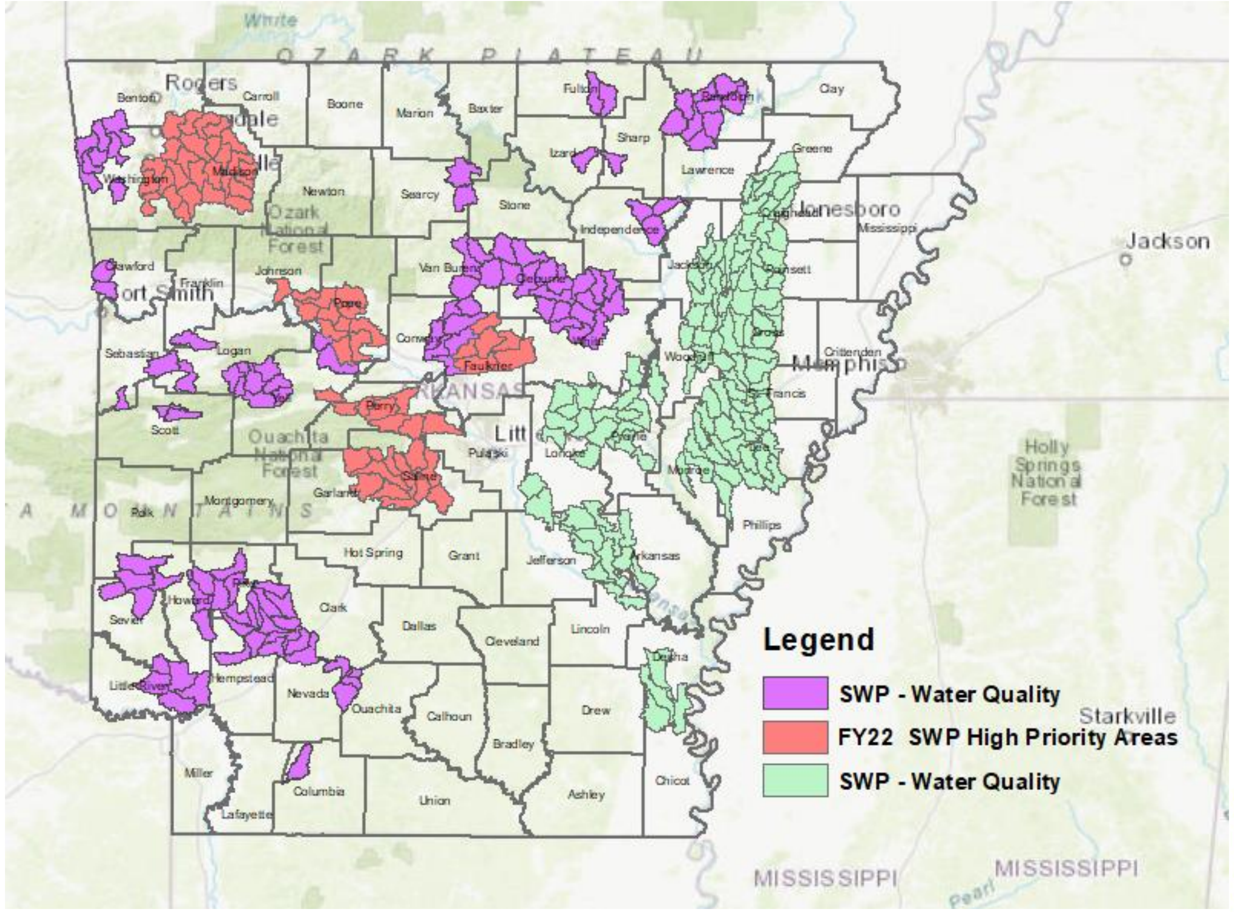
- **Provide increased incentives for practices that relate to water quality and quantity and protect drinking water sources while also benefitting producers**

- **Nation-wide dedicate at least 10% of funds available for conservation programs (with the exception of CRP), each year beginning in FY 2019 through FY 2023, to be used for source water protection**

Source Water Protection

For Arkansas

- The map shows targeted areas for Water Quality (purple & orange) and Water Quantity (green).
- Watersheds within the Arkansas Groundwater Initiative were designated as the targeted Water Quantity area.
- High Priority Areas (orange) within the Water Quality area received additional ranking criteria and incentive on some practices



United States Department of Agriculture

Source Water Protection

Year	Conservation Program Funding	SWP Practices & Easements within EPA Source Water HUCs	Percent SPW Practices of Conservation Program Funding
	(millions)	(millions)	(percent)
2019	$ 117.5	$ 25.1	18.6
2020	$ 103.9	$ 14.5	11.4
2021	$ 95.1	$ 13.0	11.3

Preliminary data showing contracts that intersect EPA Source Water Protection Areas.

Natural Resources Conservation Service

nrcs.usda.gov/

Soil Health and Cover Crops

- Since 2017, Arkansas NRCS has partnered with the Arkansas Soil Health Alliance, Arkansas Association of Conservation Districts, University of Arkansas Extension and others to promote and demonstration soil health conservation practices.
- Through this partnership we have hosted multiple field days that have demonstrated conservation practices that improve soil health.

Cover Crops

FY19	372 Fields on 34,310 acres	1.64 M in FA
FY20	433 Fields on 42,486 acres	2.05 M in FA
FY21	517 Fields on 78,198 acres	2.67M in FA

In 2022 Arkansas was a pilot for the EQIP Cover Crop Initiative (CCI) and continued to carry out EQIP and CSP Programs. Thus fare in FY22 we have obligated 5.25 M in FA for cover crops.

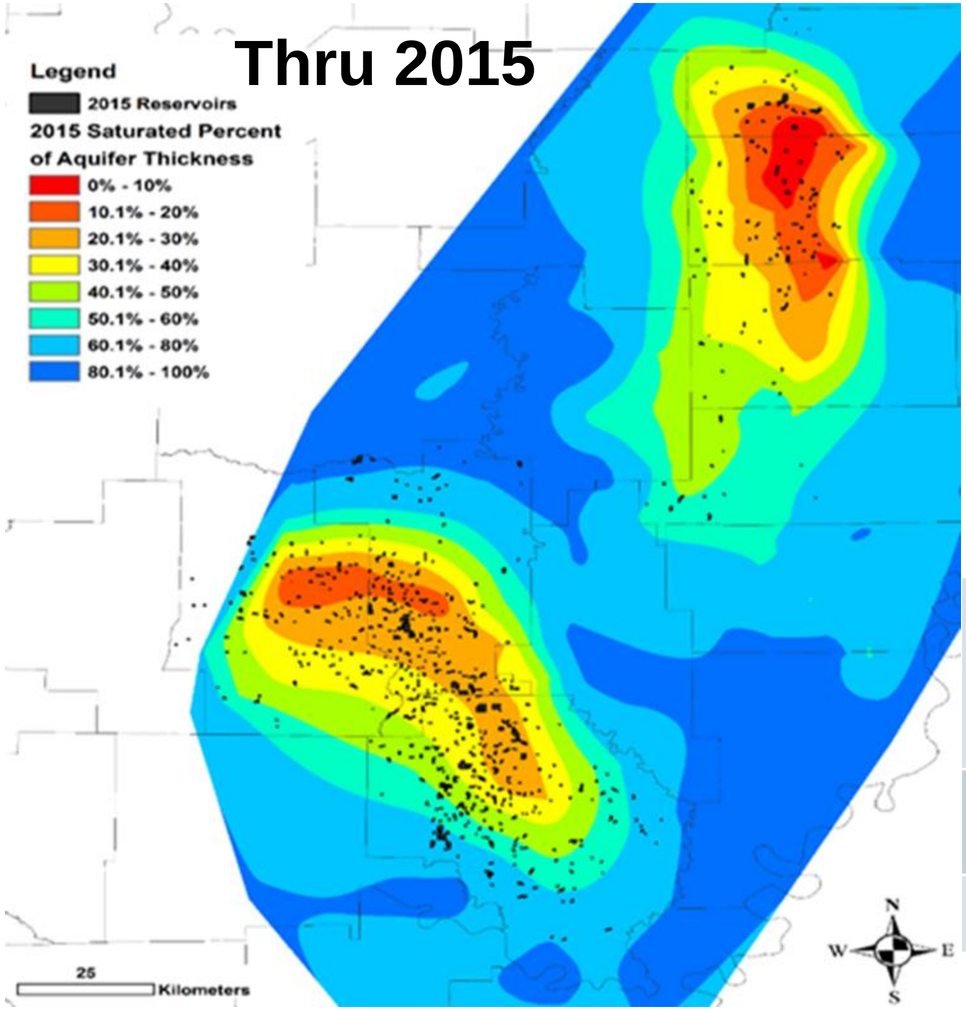
Soil Health and Cover Crops

Additional soil health practices have been planned and implemented as companion practice to cover crops for soil health.

TA few of these practices are:

- **Conservation Crop Rotation**
- **Conservation Tillage**
- **Nutrient Management**
- **Irrigation Water Management**

Reservoirs



(Yaeger et al., 2017, Applied Engineering in Agriculture, Vol. 33(6)
(Yaeger et al., 2018, Agricultural Water Management, 208: 373-383

Conversion to Surface Water through Surface Storage (2016-2020)

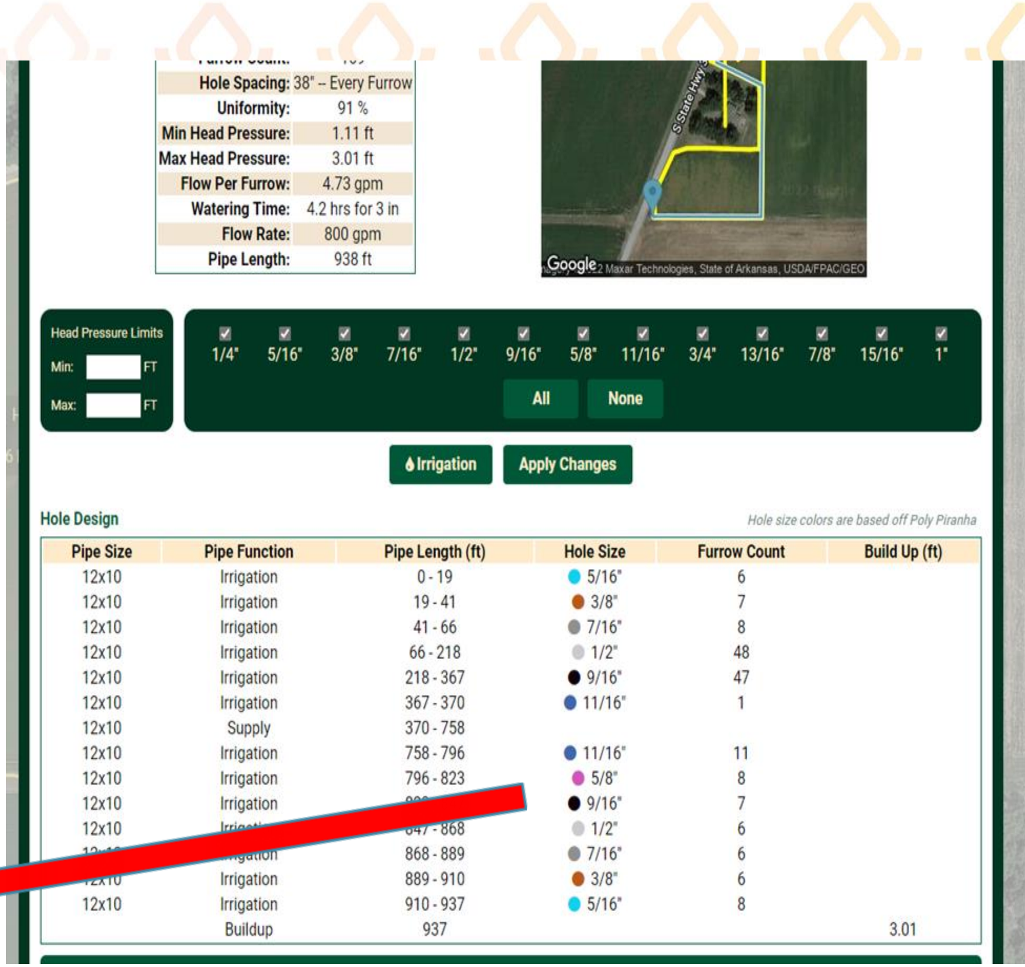
	Certified	Ac-ft of Ground Water Conserved
Tailwater Recovery Pits	148	6,660
Reservoirs	74	29,600


447 Irrigation System, Tailwater Recovery
449 Irrigation Water Management
533 Pumping Plant (recovery)
436 Irrigation Reservoir (embankment)
533 Pumping Plant (delivery)
430 Irrigation Pipeline
464 Irrigation Land Leveling
410 Grade Stabilization Structure
607 Surface Drain, Field Ditch
608 Surface Drain, Main or Lateral
587 Structure for Water Control
436 Irrigation Reservoir (excavated)
443 Irrigation System, Surface and Subsurface

IWM and Computerized Hole Selection (CHS)

CHS – 20-25% water savings!

From technicians data:
250,000 acres X 11” (soybeans) X 20% equals a water demand savings of: ~46,000 acre-foot



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12x10	[illegible]	[illegible] - 868	1/2"	6	
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	Buildup	937			3.01

Natural Resources Conservation Service

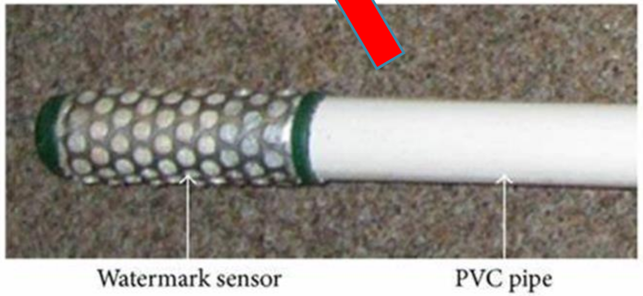
“$5 diesel is an IWMers dream year”! – 2022 IWM Technician

More Irrigation Water Management

Sensors/Surge – 20-50% water savings!

From technicians info:
Over 150 demonstrations using soil moisture sensors

Growers adopting soil moisture sensors crossed over beyond contracted acres to well over 1000 additional fields



USDA United States Department of Agriculture

Rice and IWM

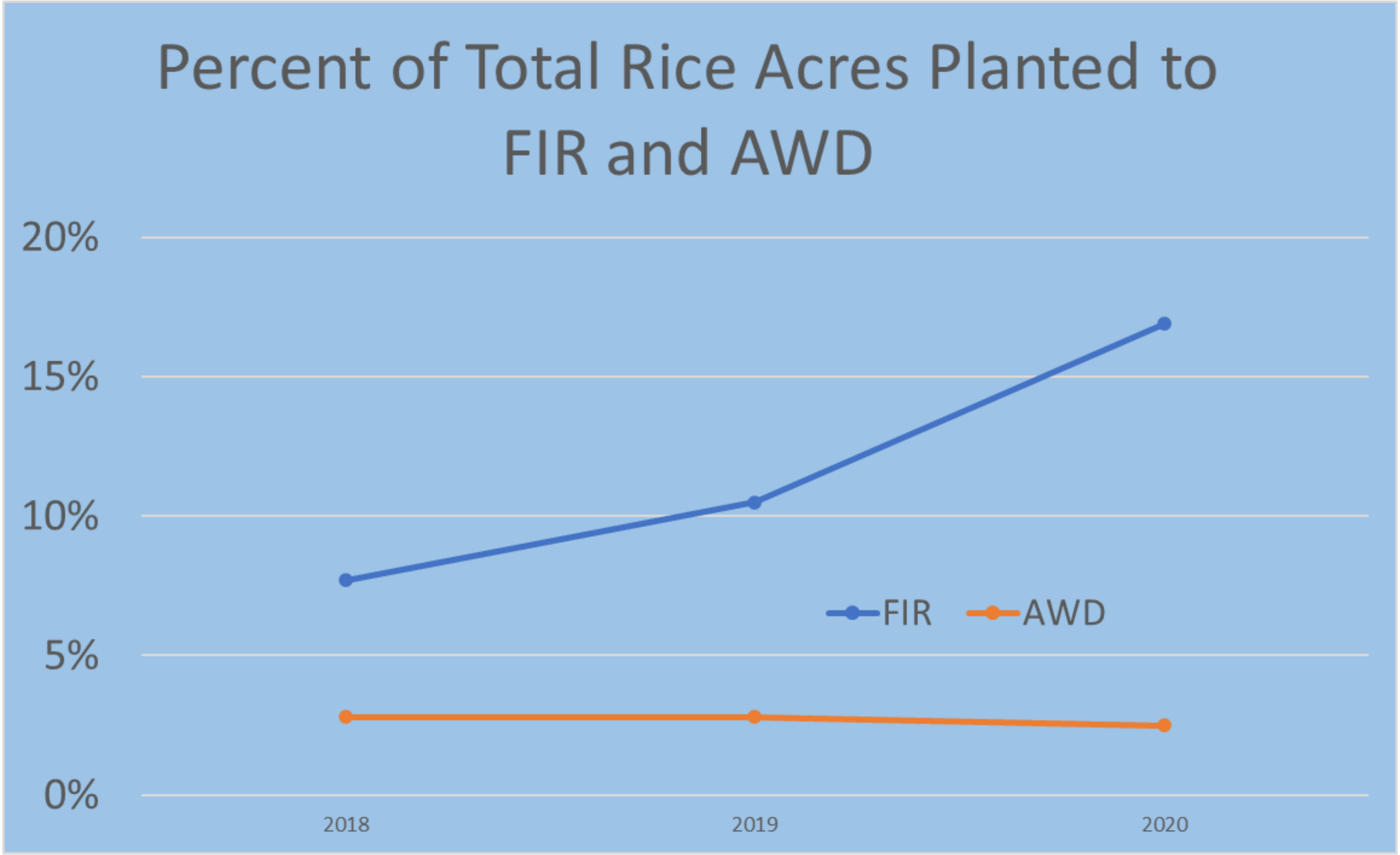
Rice constitutes ~55% of Arkansas Annual Water Demand (4 major crops, 2017-21)

Multiple-inlet rice irrigation (MIRI) - ~20% less water demand vs conventional

FIR - ~ 28% less water demand[1]

AWD - ~ 38% less water demand[1]

[1](Chlapecka et al 2021, Massey et al 2022)



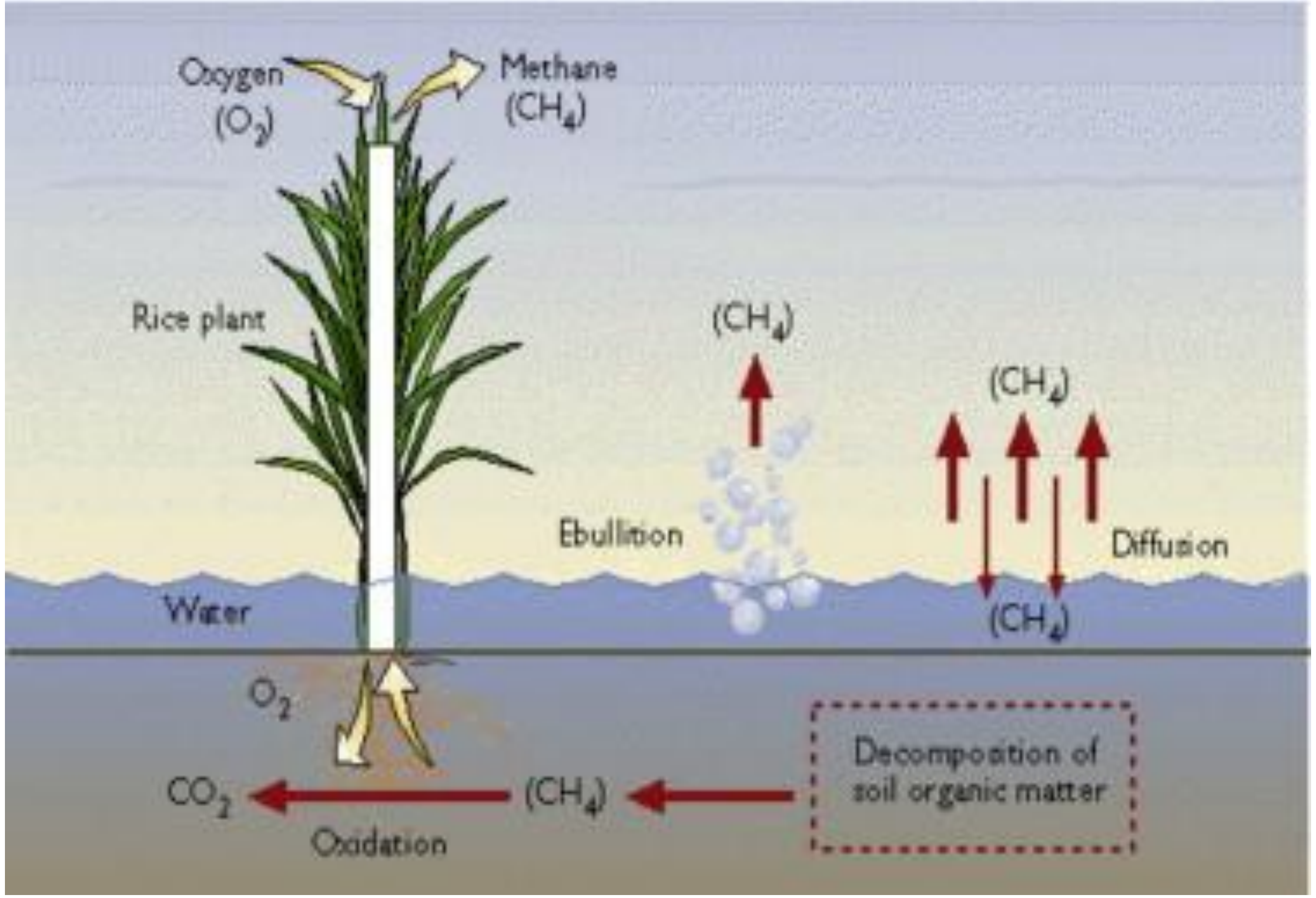
Over One Million Acre-foot savings annually if all farmers would convert to current ratio of FIR or AWD

Rice, IWM and Climate Smart

AWD - ~ 70% reduction in Methane losses

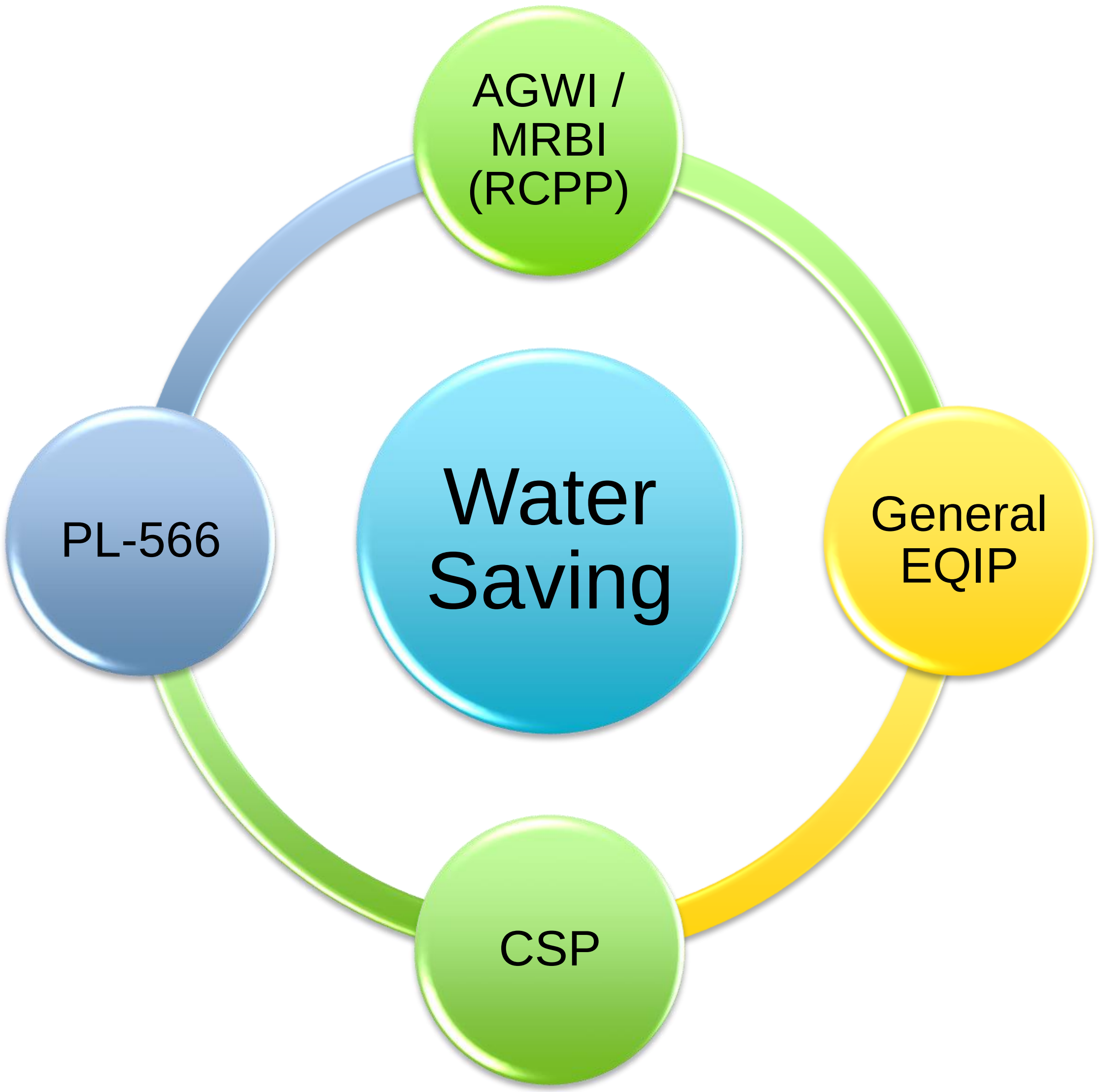
FIR - ~ 50% reduction in Methane losses

Rice constitutes 11% of anthropogenic methane worldwide (IPCC, 2013)



Methane emission from rice cultivation. After Van der Gon and Neue (1996).

Programs - Multi system approach



AGWI Initiative

Arkansas has put $3M in 2019, $3.3M in 2020 and $3M for 2021 in dedicated funding to address declining water levels in the Mississippi River Aquifers through EQIP. Arkansas' special initiative used a tiered approach to funding. Funding requests in Tier 1 was two times the amounted allocated to the initiative.   Only practices that were focused on conversion from groundwater to surface water and improved water conservation through irrigation water management were available for this initiative.

In FY 19 and 20 there were over 300 applications for the entire AGWI area. There were 94 within the higher priority Tier 1 and Tier 2 areas. 10 contracts were signed. This will result in 10 new irrigation storage reservoirs and 15 new tailwater recovery pits adding nearly 6,000 AC.Ft. of storage which will reduce the groundwater demand by at least 9, 000 Ac.Ft. per year or approximately 200,000 Ac.Ft. in the next 20 years

Irrigation Water Management will be conducted over 7000 acres on these contracts resulting in approximately 3500 Ac. Ft. of reduced water usage.

Obligated Dollars for practices 2019-2021

NRCS Financial Obligation			
	2019	2020	2021
449 Irrigation Water Management	$13,330,547.92	$12,854,672.62	$14,376,722.78
436 Irrigation Reservoir	$12,892,461.65	$12,108,064.47	$12,854,664.78
447 Tailwater Recovery	$13,163,646.28	$12,259,032.47	$13,254,874.18

United States Department of Agriculture

2022 Arkansas Groundwater Summit

NRCS Groundwater Conservation Efforts

NRCS Strategic Priorities
Partnerships
Impact Assessment
Programs

Gary M. Bennett, PE
State Conservation Engineer
USDA/NRCS – Arkansas

Arkansas

Natural Resources Conservation Service

nrcs.usda.gov/

Center for Water Sustainability

Brett A. Dunagan, USACE Memphis District

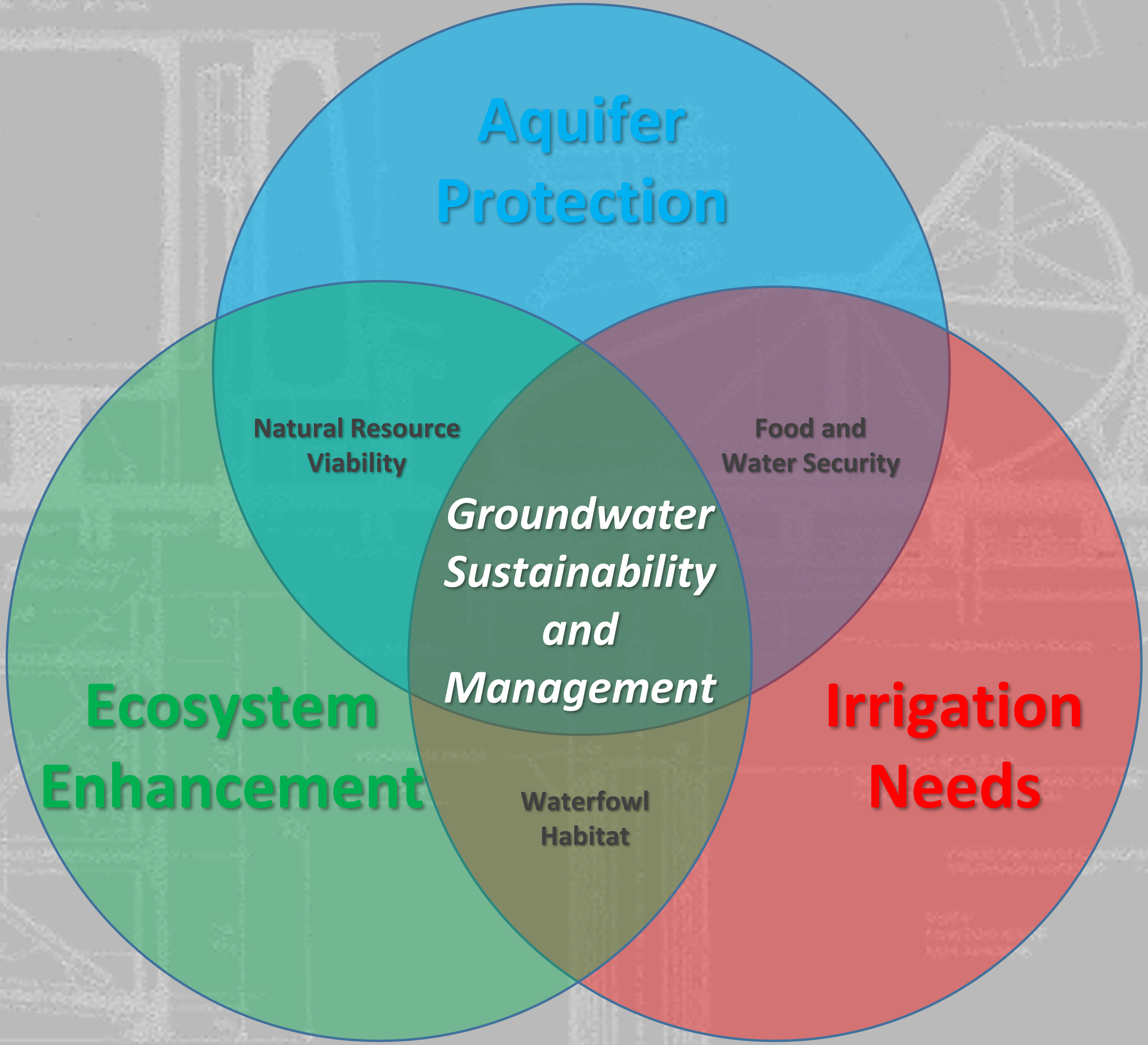
CENTER FOR WATER SUSTAINABILITY

ACP GROUNDWATER SUMMIT

Ron Bingner – Research Leader & Research Agricultural Engineer, WPPRU
USDA-ARS-National Sedimentation Laboratory
Oxford, MS

Wade Kress – Associate Director, Hydrologic Decisions Science Branch
USGS – Lower MS-Gulf Water Science Center
Nashville, TN

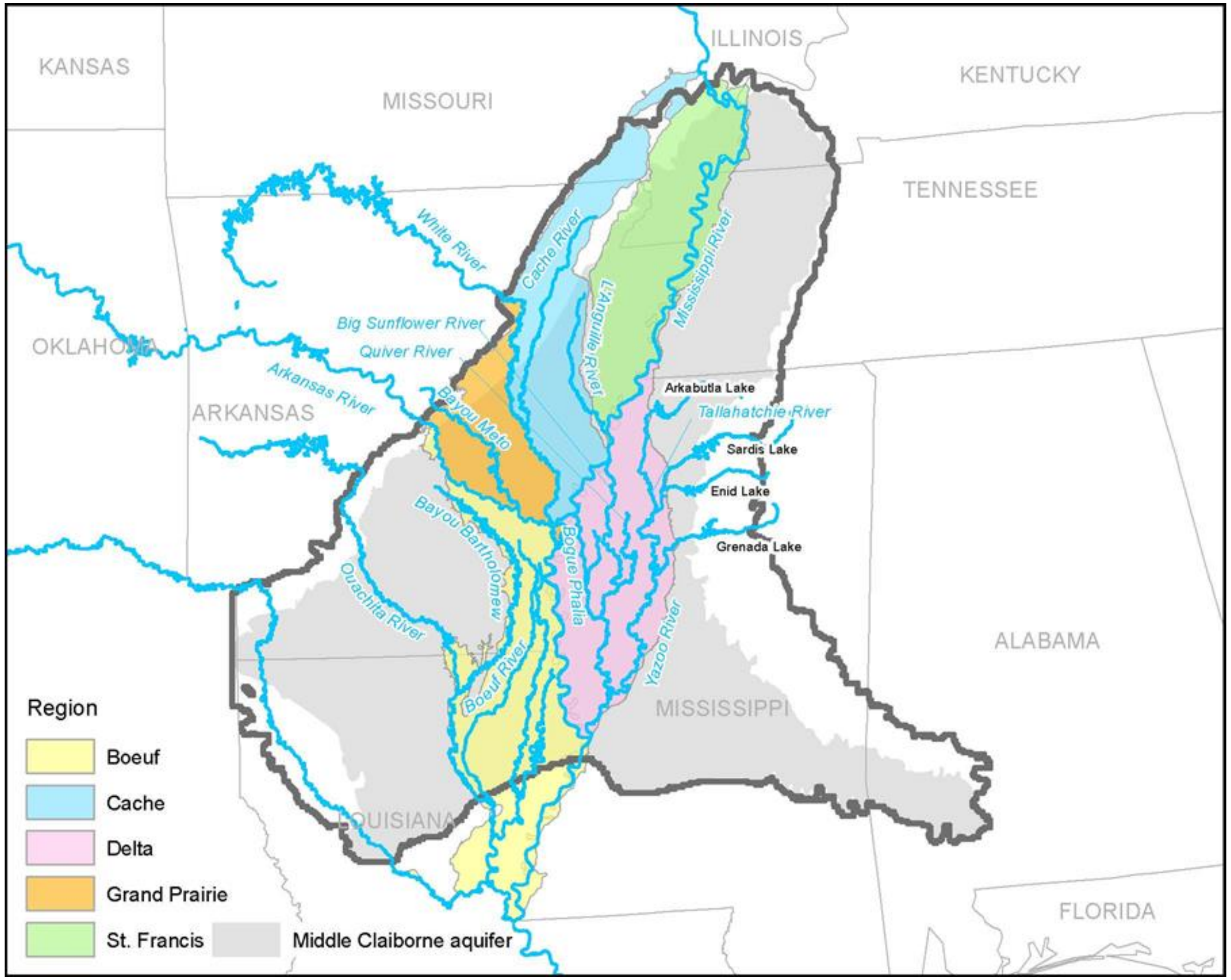
Mike Clay – Chief, Hydraulics & Hydrology Branch
USACE Memphis District
Memphis, TN



JUNE 2022

CWS – "REGIONALLY" FOCUSED

- Not USACE Division focused
- Not Federal Agency focused
- Not State Agency focused
- Not Conservation District focused
- Not Municipal/Utility District focused.
- **UPPER MISSISSIPPI EMBAYMENT (UME) Focused**



HOW DOES THE CWS PROVIDE VALUE

- The CWS provides leadership and serves as a catalyst for implementing a collaborative, regional approach to improve our understanding of GW/SW interactions.
- The CWS serves as a collaborative forum, bringing Governmental and non-Governmental organizations together for regular-recurring dialogue to develop consensus on the best way to understand, protect, preserve, and manage water resources for the benefit of all, leveraging existing local and regional efforts.
- The nucleus of this effort is a shared vision and common objective that leads to goals designed to provide unity of effort and based on current and future needs and implementable solutions

CWS PARTNERS TO DATE

Federal Agencies

US Army Corps of Engineers

USDA United States Department of Agriculture

USGS science for a changing world

State Conservation Agencies

AR Department of Agriculture Natural Resources Division

Mississippi Department of Environmental Quality

TN Department of Agriculture

Missouri Department of Natural Resources

TN Department of Environment & Conservation

Academia

LSU

The University of Memphis

University of Arkansas

Mississippi State University

The University of Mississippi

Regional Conservation Districts

White River Irrigation District

YMD Yazoo Mississippi Delta Joint Water Management District

Bayou Meto Water Management District

GENERAL APPROACH

- Inventory data, studies, and initiatives that already exist
- Develop a definition of the problem(s)
- Find overlap in agencies' missions or commonality in problems
- Develop a definition of the solution(s)
- Design and Construct solutions in prioritized fashion – THE GOAL.

GUIDING PRINCIPLES IN DEVELOPING SOLUTIONS/APPROACHES

- Think large geographic scale – UME wide.
  - How do we determine next steps for the entire UME, not how do we optimize a single approach at a single site.

- Leverage existing data, studies, research, and models to the maximum extent possible.
  - Data collection efforts should be focused on representing a larger area, not knowing exactly what is happening at a single location. Leverage MERAS 3.0.

- Focus on the approaches we have the most confidence will be successful AND that can be evaluated with existing tools.
  - Look to approaches that have existing research or piloting to illustrate the approach's viability.

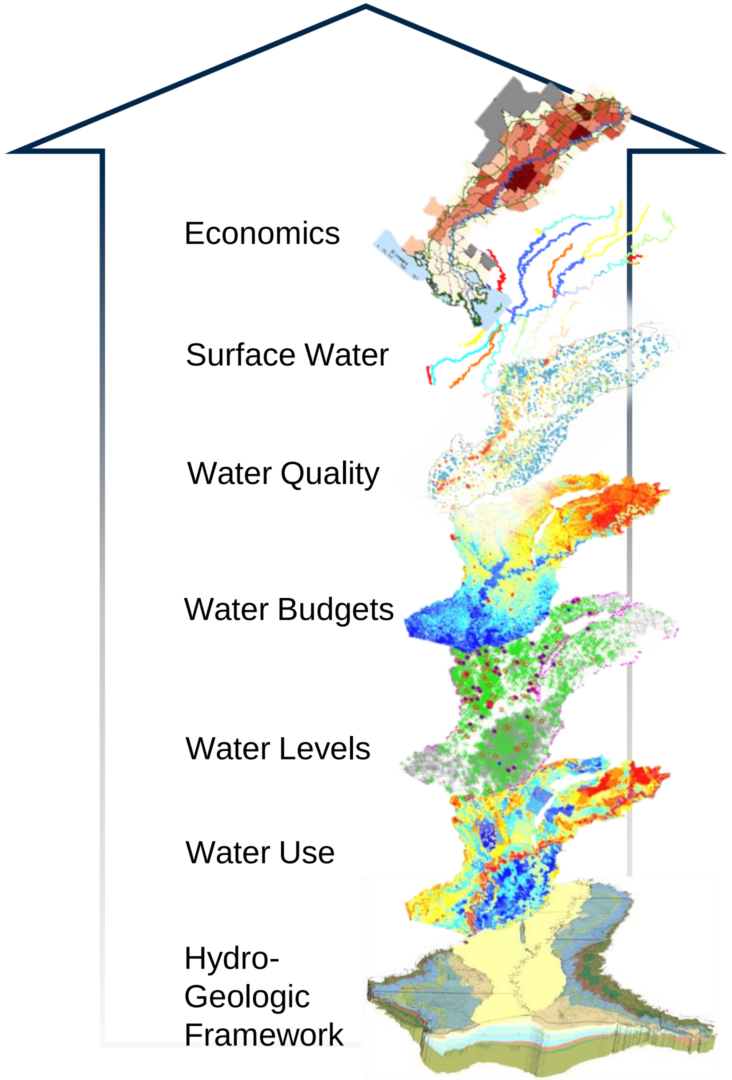
A SUSTAINABLE PATH

1. 729 Watershed Study
2. Focused Pilot Projects
3. 3x3x3 Feasibility Study
4. Large Scale Implementation

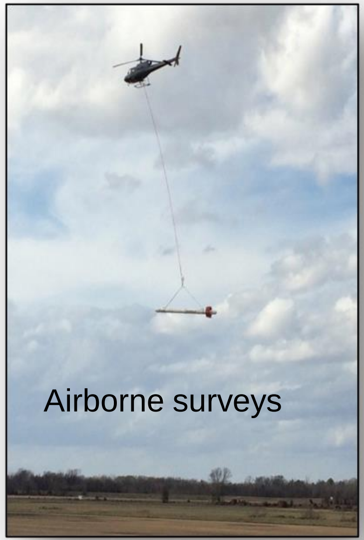
APPROACHES

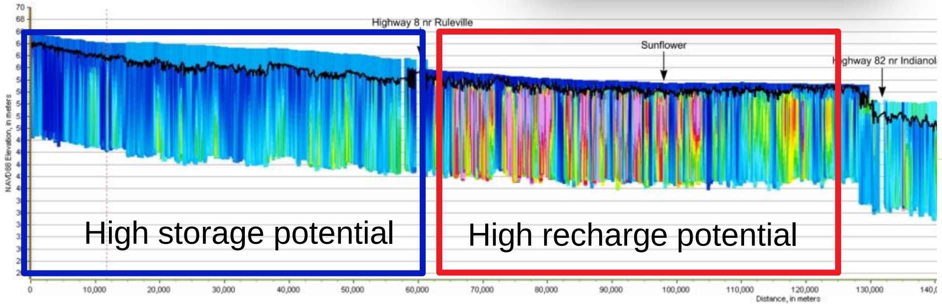
MERAS 3.0 Decision Support System

- Utilize data and models from MERAS 3.0
- Catalogued potential approaches developed by local, state federal, academic stakeholders

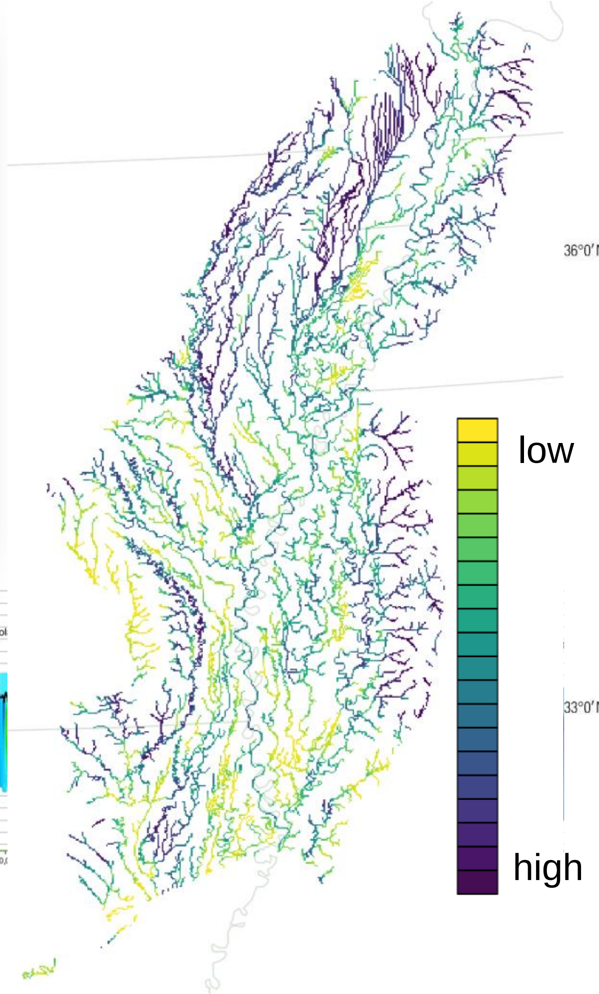


APPROACH I: ENHANCING AQUIFER RECHARGE WITH IN-STREAM WEIRS

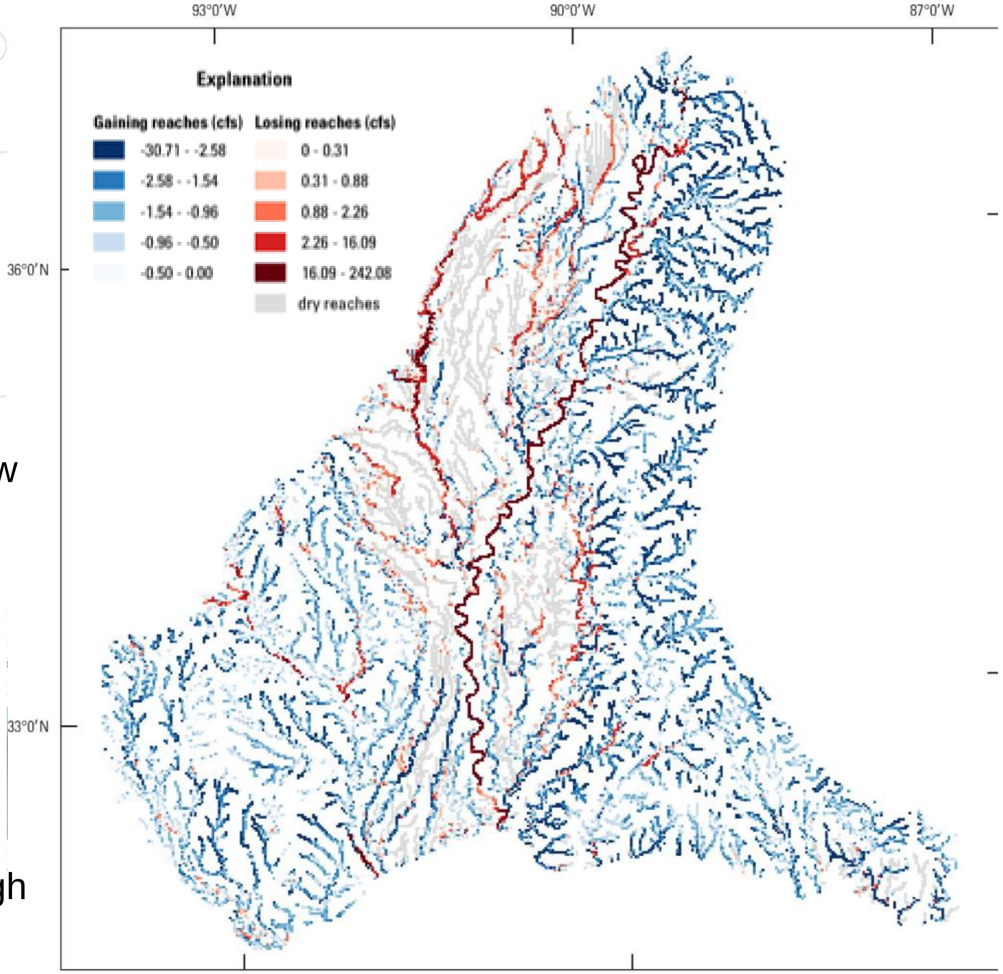




2D resistivity profile from Sunflower River, MS. (high resistivity values) represent coarse sediments (Adams and others, 2019)



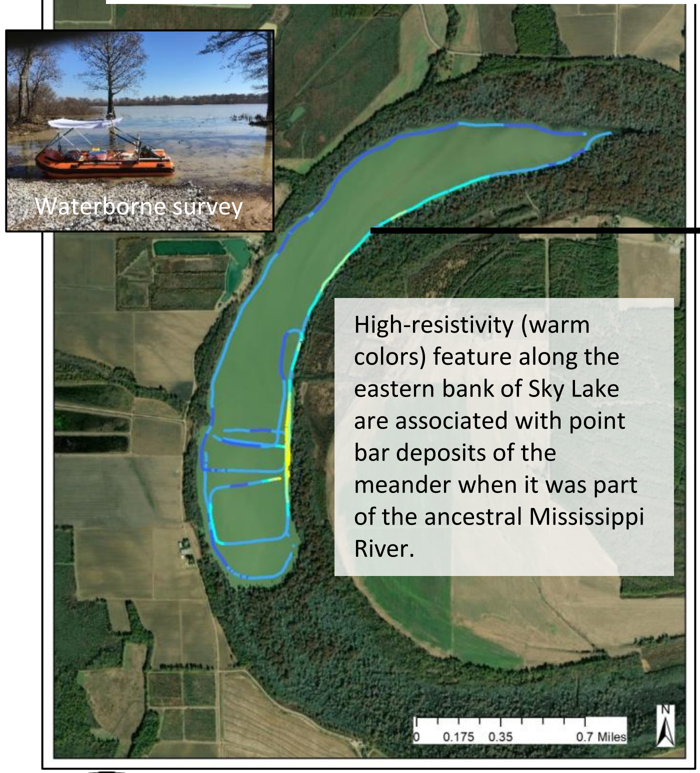
Potential for surface water-groundwater connectivity derived from airborne geophysical data (Minsley *et al*. 2021)



Gaining and losing reaches from MERAS 3.0 hydrologic model

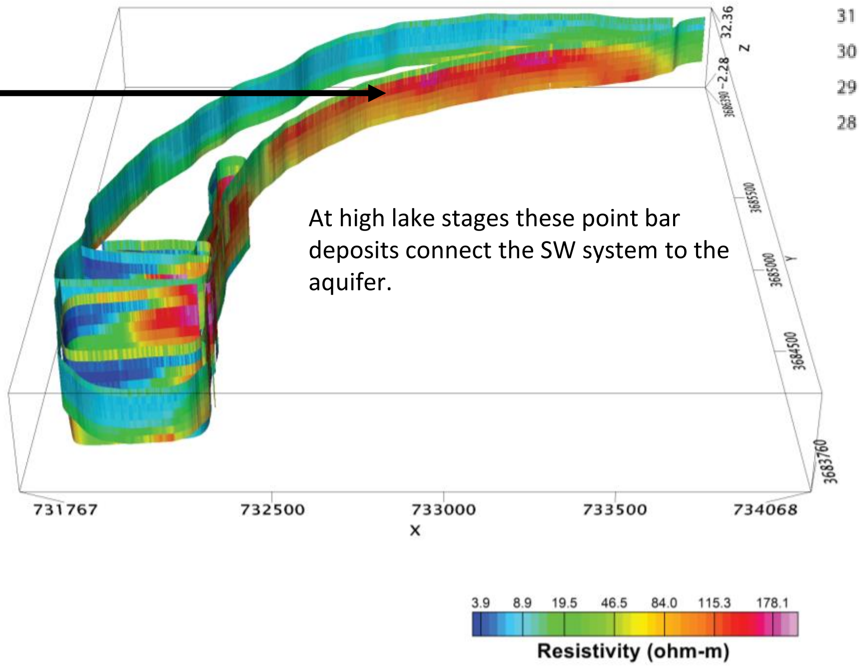
APPROACH II: DIVERSION OF EXCESS SURFACE WATERS TO DISCONNECTED RIVER BENDS

Map showing resistivity profiles (Adams and others, 2019) collected along the banks of Sky Lake, an oxbow lake-wetland system, in northern Humphreys County, MS.



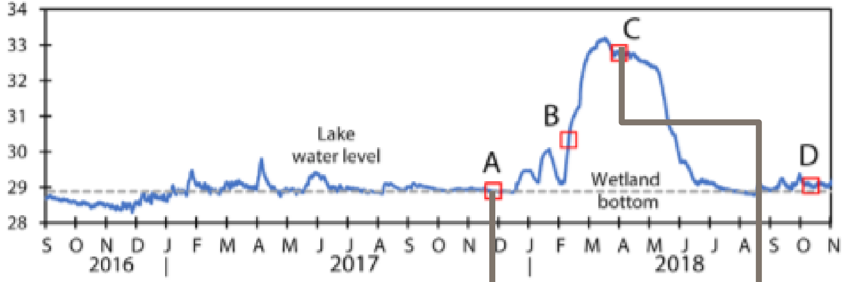
High-resistivity (warm colors) feature along the eastern bank of Sky Lake are associated with point bar deposits of the meander when it was part of the ancestral Mississippi River.

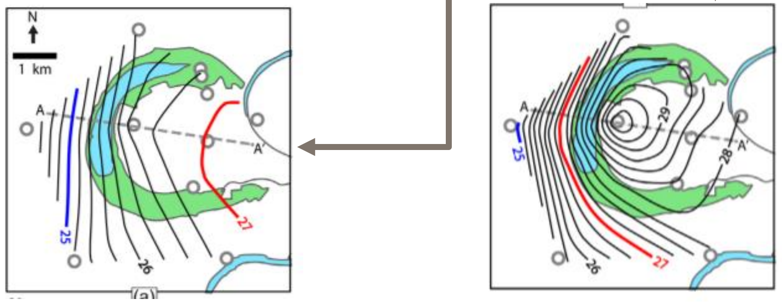
3D view of resistivity data showing point bar deposits (warm colors).



At high lake stages these point bar deposits connect the SW system to the aquifer.

Hydrograph showing lake-stage rise at Sky Lake (from Gratzer and others, 2020).



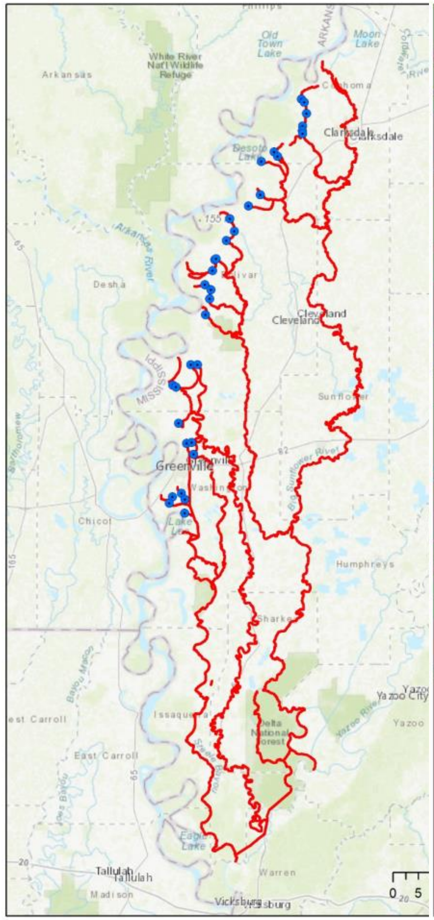


Potentiometric surface maps of the Mississippi River Valley alluvial aquifer beneath Sky Lake illustrating the groundwater response to the rise in lake stage during the spring of 2018.

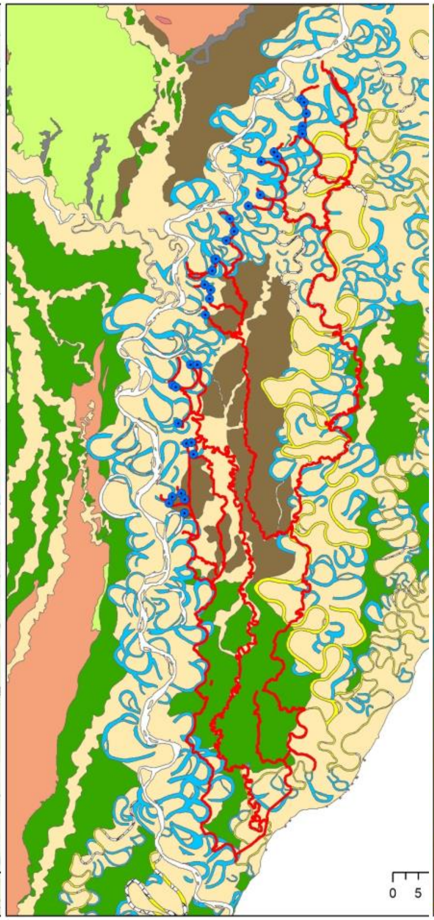
Dr. Davidson (left) and MSc student Michael Gratzer (right) from U of M, collecting GW and SW data at Sky Lake during Spring 2018 high-water event.

APPROACH III: USING GROUNDWATER FOR FLOW AUGMENTATION

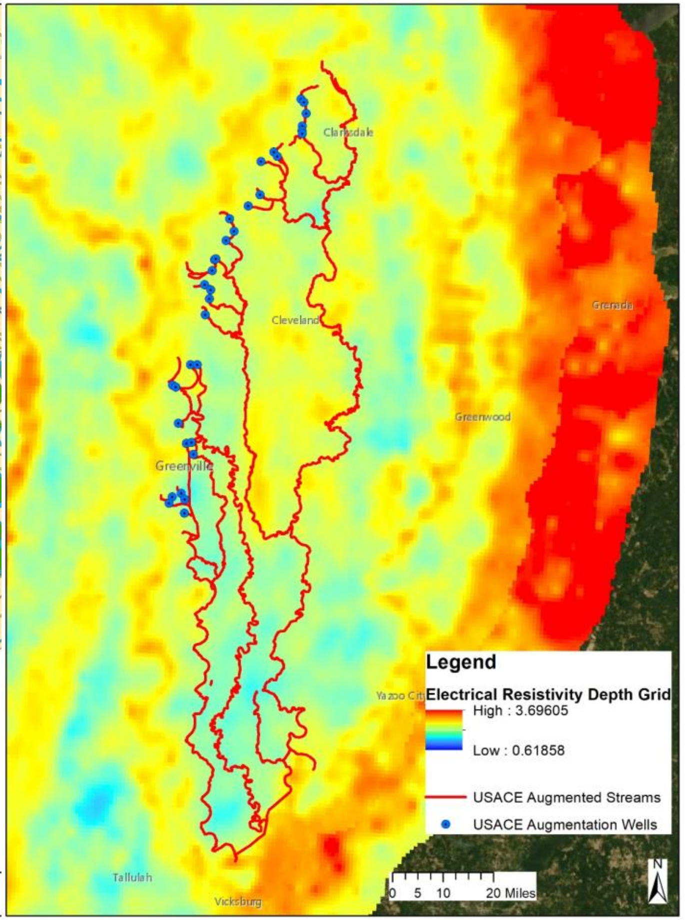
Dry streambeds during the summer months due to lack of base flow for (*A*) Big Sunflower River at Sunflower, Mississippi, and (*B*) Bogue Phalia River near Leland, Mississippi.



Hypothetical augmentation wells



Surficial Geology



Airborne – derived resistivity

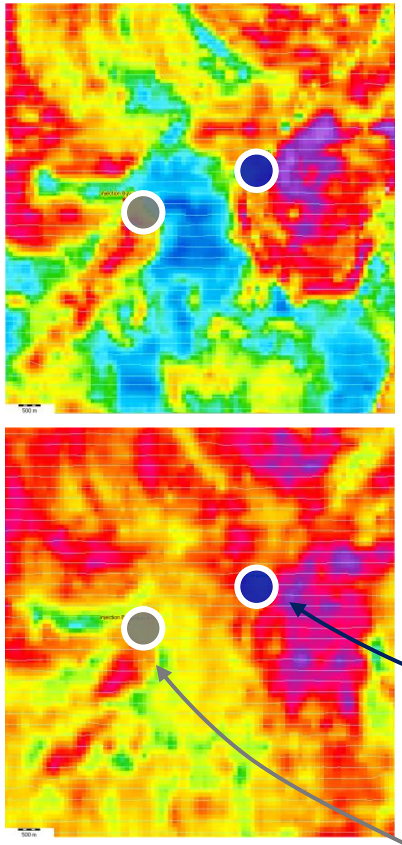
APPROACH IV: GROUNDWATER TRANSFER AND INJECTION

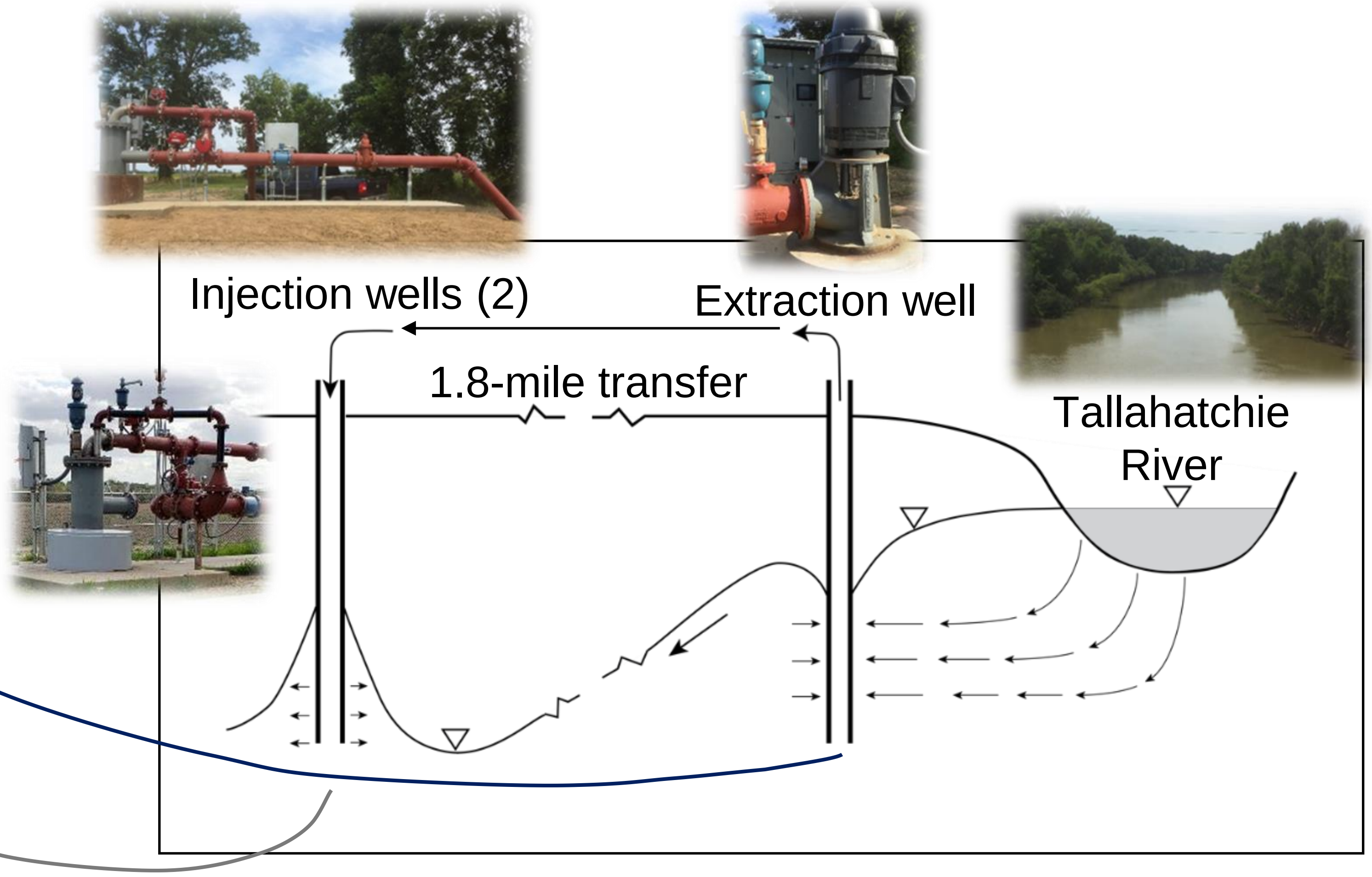
- Build upon the USDA-ARS groundwater injection pilot project at Shellmound, MS.

Depth = 5 m
(above MRVAA)

<u>USGS AEM data</u>:
Higher resistivity (yellow and warmer colors) are more sandy texture sediments.

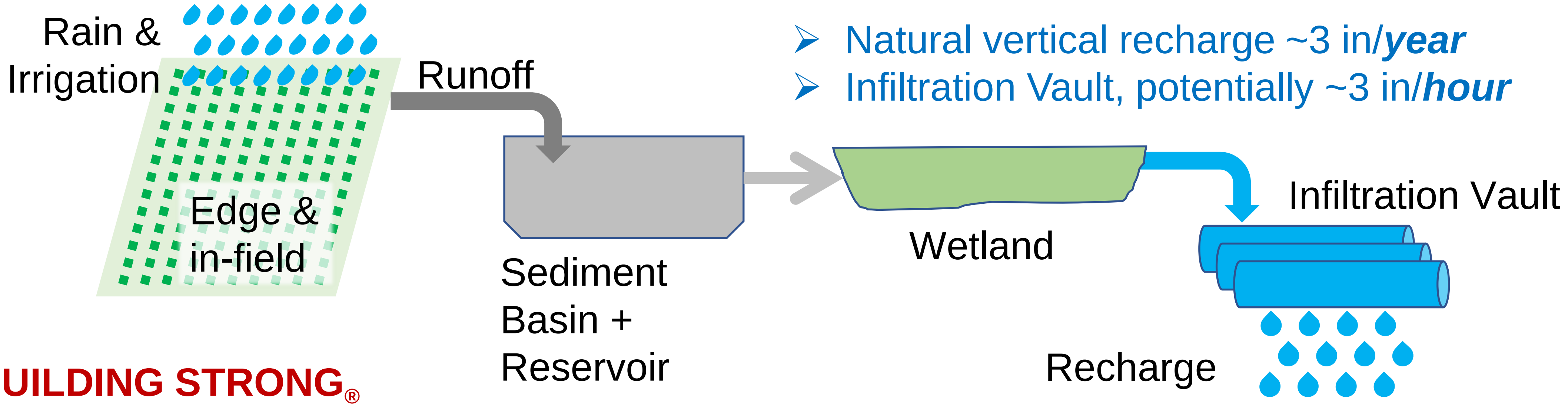
Depth = 25 m
(in MRVAA)





APPROACH V: ON-FARM MANAGED AQUIFER RECHARGE (MAR) INFILTRATION TECHNOLOGIES

- Build upon existing pilot MAR technologies (GTIP, Infiltration galleries) with on-farm technologies utilizing subsurface infiltration
- Assess the associated permitting, construction, operation, maintenance, and hydrologic impact factors of integrated infiltration technologies that increase recharge to the MRVAA



PATH FORWARD

- Join us!
  - Send an email to Brett Dunagan (Brett.A.Dunagan@usace.army.mil)
- 28-JUN-2022
  - Review final Scope of Work for a proposed 729 Watershed Study
- 04-AUG-2022
  - Groundwater Summit in Memphis, TN
  - CWS will present a potential Scope of Work

QUESTIONS?

APPENDIX C

Printouts of Slides for Current Projects Panel 1

Ed Swaim, Bayou Meto Water Management District


BAYOU METO
Water Management District
MARION BERRY PUMP STATION

Resilience-especially in extreme weather

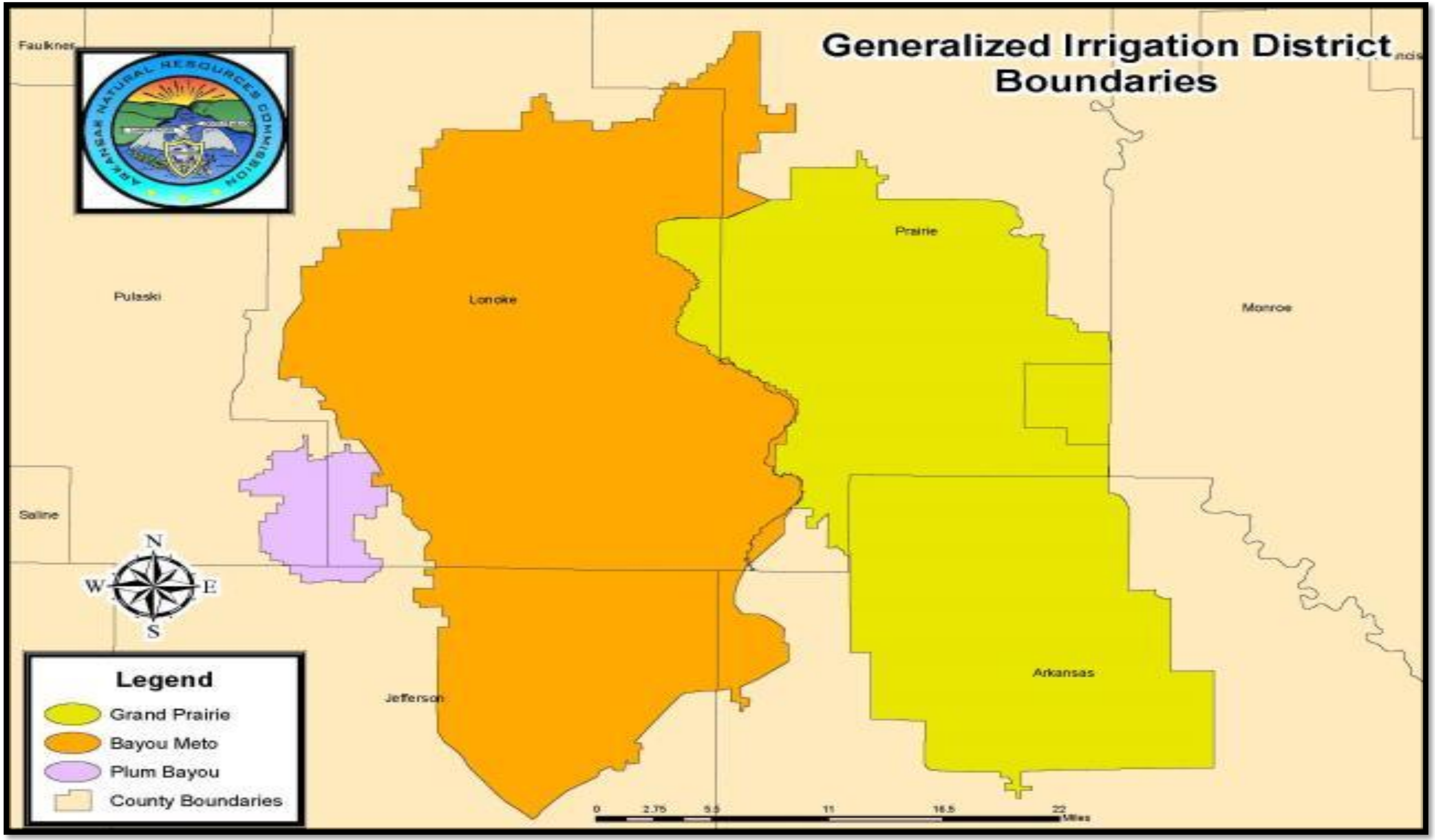
- Reduce frequent flood loss
- Stop habitat death from extended inundation
- Prevent depletion of public groundwater supply
- Avoid reduction of irrigated crop acreage

Over $150 million work done

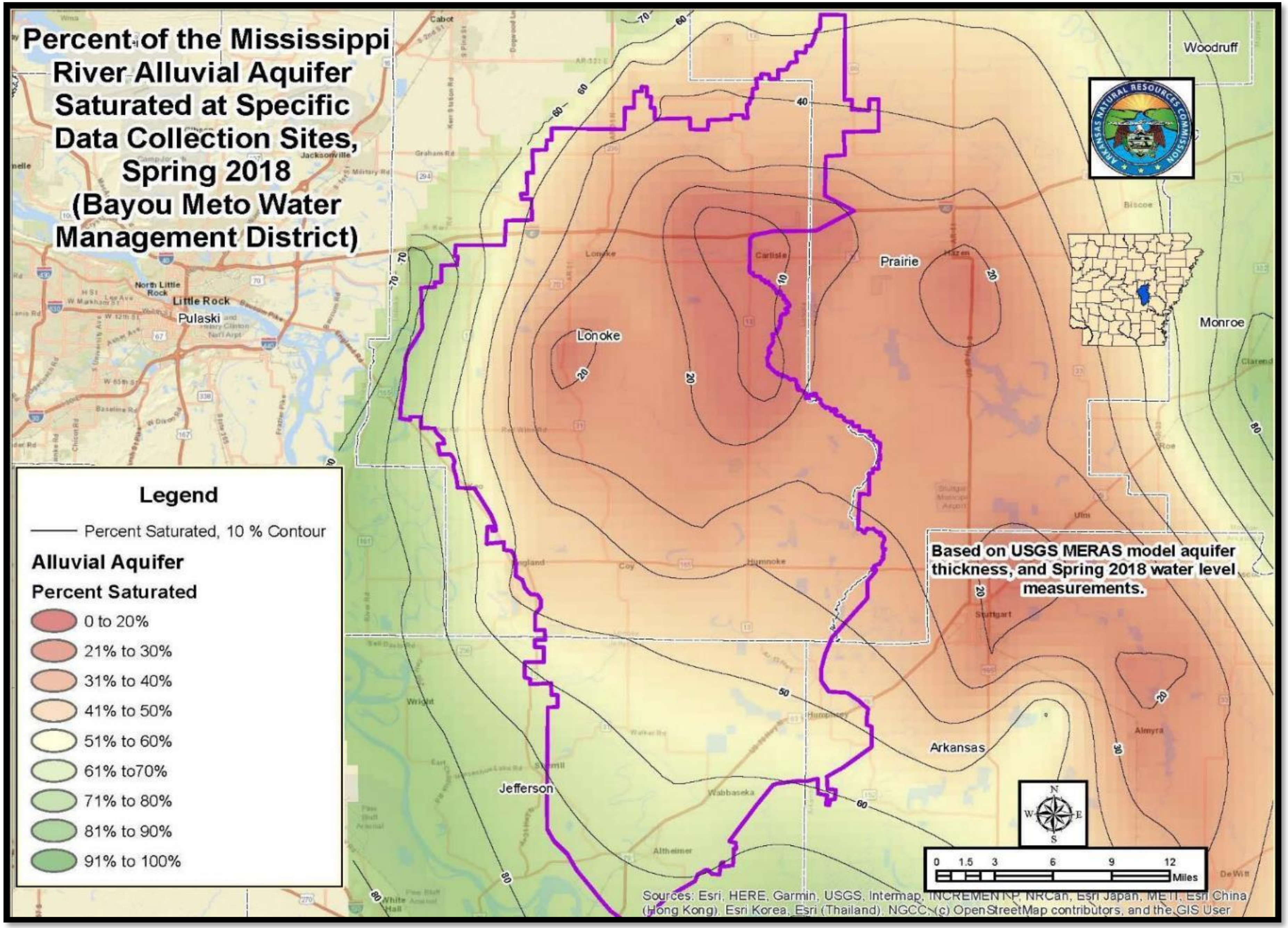
- Planning, engineering, and environmental clearances
- Land rights
- Two pump stations, several miles of canal, and one bridge
- 3.3 miles of canal are currently being built
- This “inverted siphon” on the main canal at Scott carries the canal under Ashley Bayou

Current needs

- Stay on schedule
  - Private landowners and farmers, local governments, multiple state and federal agencies
  - We have the financing in place to succeed with the first phase by working together as a team and coordinating all the moving parts
- Money to keep moving east
  - Now limited to less than one-third of project potential
  - To go beyond Indian Bayou, need American Rescue Plan money



Plum Bayou **Bayou Meto** **Grand Prairie**



Percent of the Mississippi River Alluvial Aquifer Saturated at Specific Data Collection Sites, Spring 2018 (Bayou Meto Water Management District)
Legend
Percent Saturated, 10 % Contour
Alluvial Aquifer
Percent Saturated
0 to 20%
21% to 30%
31% to 40%
41% to 50%
51% to 60%
61% to70%
71% to 80%
81% to 90%
91% to 100%
Based on USGS MERAS model aquifer thickness, and Spring 2018 water level measurements.
Woodruff
Prairie
Lonoke
Monroe
Pulaski
Little Rock
North Little Rock
Carlisle
Hazen
Stuttgart
Arkansas
Jefferson
Almyra
Humnoke
Wabbaseka
Altheimer
0 1.5 3 6 9 12
Miles
N
S
W
E
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User

To flip the switch and deliver water

Bayou Meto Water Management District

- Build Cole Deading Road Bridge
- Prepare Marion Berry Pump Station

ARDOT/Bayou Meto

- Build Highway 161 and 165 bridges

Bayou Meto/NRCS/drainage districts

- Clean out Indian Bayou and Indian Bayou Ditch

Bayou Meto/NRCS

- Install pumps on the bayous
- Build pipelines for non-riparian delivery

Corps of Engineers/Bayou Meto

- Complete Canal 1000, Phase 3.1
- Build Canal 1000, Phase 3.2 to Indian Bayou
- Clean out Wabbaseka Bayou

Two highway bridges and one county bridge

- Bayou Meto already built a Garver-designed bridge on a North Little Rock-owned road

- Highway 161 and 165 across canal
  - Corps design
  - State loan
  - ARDOT will build

- To the west, Bayou Meto will use state loan to build a Garver-designed bridge on a Lonoke County road

Three miles from here to Indian Bayou

- Corps of Engineers current construction
- Senator Boozman recently secured the money needed for the Corps to build the next three miles
- Several construction projects will be going simultaneously to deliver water in three to five years to 35,000 or more acres

Bayou cleanout

- Indian Bayou, Indian Bayou Ditch, and Wabbaseka Bayou must carry drainage and accommodate irrigation water without increasing flood risk

- Indian Bayou and Ditch
  - NRCS/State/Bayou Meto financing
  - NRCS/Garver design and const. mgt.

- Wabbaseka Bayou
  - Corps design and construction

Thank you

Edward Swaim
Bayou Meto Water Management District
501-231-3332
edwardswaim@bayou-meto.org

Chris Henry, University of Arkansas

University of Arkansas System Division of Agriculture Water Management Program Projects

Christopher G. Henry, Professor and Water Management Engineer, University of Arkansas

Rice Research and Extension Center, Stuttgart, AR

Russ Parker, Irrigation Program Associate; Travis Clark, Irrigation Program Technician; Shruti Vaman, Mobile App Program Specialist; Nathan Blankenship, Electrical Engineer Program Specialist; M. Ismanov, Program Tech Soils; Jeferson Pimental, Graduate Student

GW Summit June 21, 2022

Lonoke AR

Biological and Agricultural Engineering Department

Program Overview

- Promote Irrigation Water Management Practices (Extension)
  - Irrigation Contest
  - Irrigation Schools
  - Extension Publications
  - Mobile app Development and Delivery
- Research Field Experiments (research)
  - Development of the furrow system for rice
  - Cover crop, no-till, surge and irrigation scheduling in corn
  - Water use in soybeans (sap flow)
  - Water retention curves for irrigated soils
  - Sub-surface irrigated rice
- New technology development (research and Extension)
  - Variable flow tail water recovery system (furrow irrigated rice)
  - Portable Solar Panel Frame System
  - Poly pipe printer system for implementing Computerized Hole Selection for layflat irrigation pipe
  - Pressure compensating valve for furrow irrigation
  - Advance Surge System
  - Novel flow meter system for agriculture
  - Pump timer for southern region surface irrigation

Personnel

Nathan Blankenship
Program Specialist
Shruti Vanman
Program Specialist
Travis Clark
Irrigation Technician
Russ Parker
Irrigation Program Associate
M. Ismanov
Program Tech, Soils

Integrated Research and Extension Program

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Mobile Apps: Rice Irrigation

The University of Arkansas Multiple Inlet App can be found on Google Play and the Apple Play Store

Search for "Rice Irrigation"

Plans provide irrigators, with the size of pipe needed, number of rolls, pipe thickness, length of pipe needed, and gate settings for each levee or paddy. Additionally it provides a pumping time estimate to flood the field.

Multiple Inlet Irrigation for Rice Plan

DIVISION OF AGRICU... RESEARCH & EXTEN... University of Arkansas Syst...

Rice Irrigation Results for Field: new field

Generated Monday April 11, 2016 by chris

Levee Results for new field

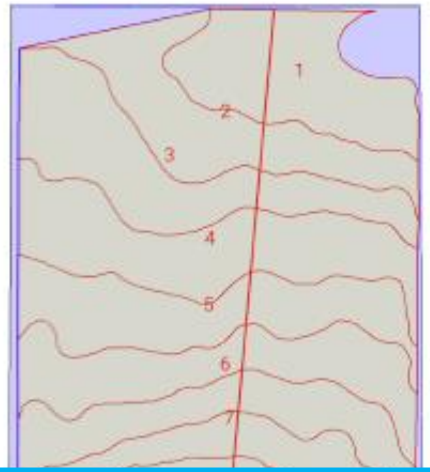
Field Area:68.64 acres
Flow Rate:1200.00 gpm
Pipe Size:15 inch (38 cm)
Measured Pipe Length:2399.86 ft
Pipe Needed*:2433.86 ft
Polytube Rolls Needed**:2
* The pipe length includes allowance for land slope and levee barrier crossing
** It is advised to use pipe thickness of 9mil, Tri-Ply 9mil, or 10 mil

Levee	Area (ac)	# of Holes	
1	4.74		1.25
2	4.59		
3	5.48		
4	5.78		
5	4.83		
6	4.61		
7	3.95		
8	4.01		
9	3.59		
10	3.88		
11	3.91		1
12	3.97		1

Multiple Inlet Irrigation for Rice Plan

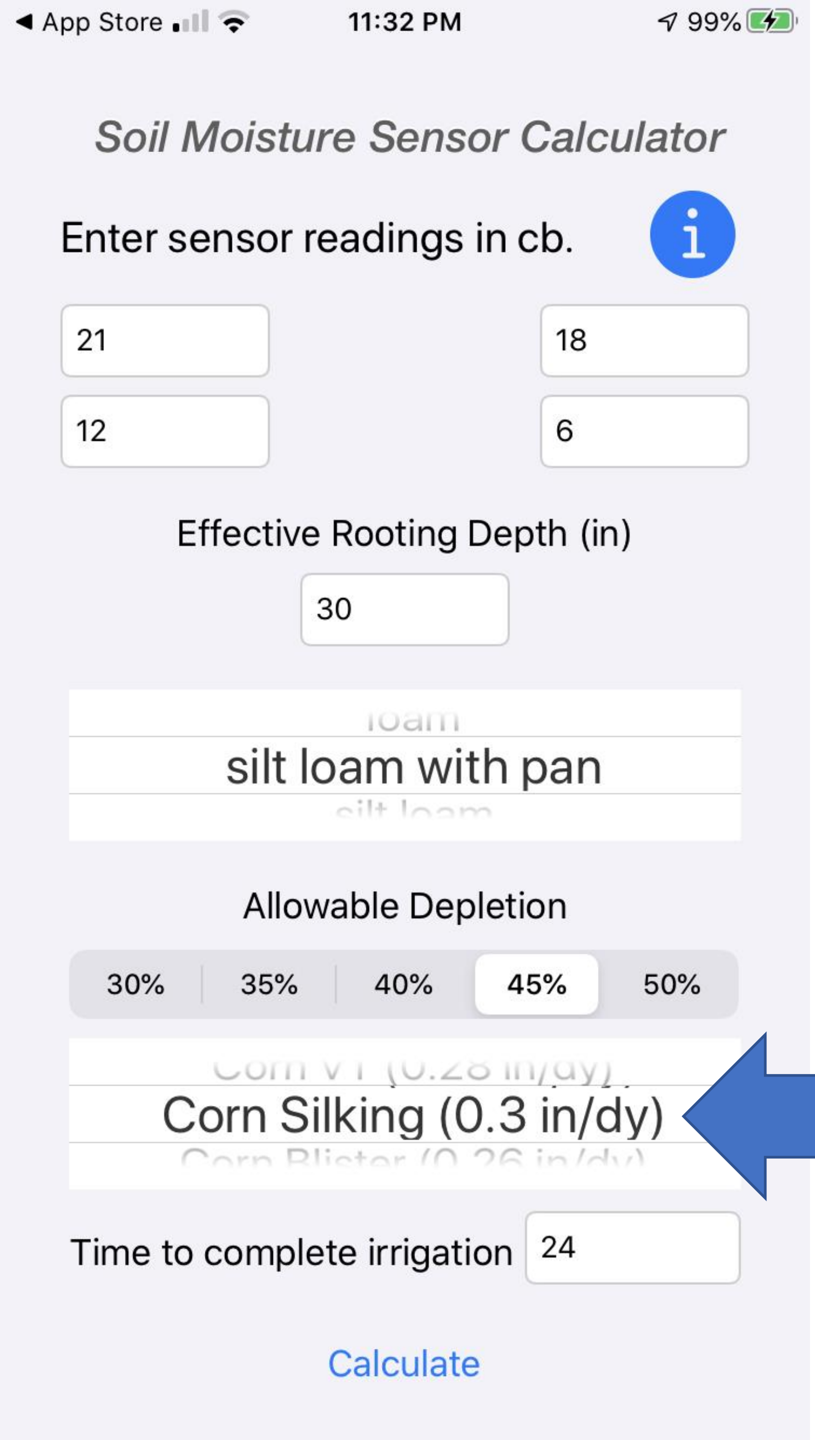
DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

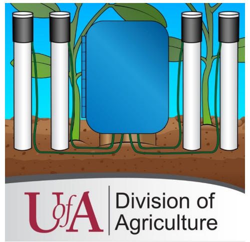
Field Drawing for new field



Impact of Rice Irrigation

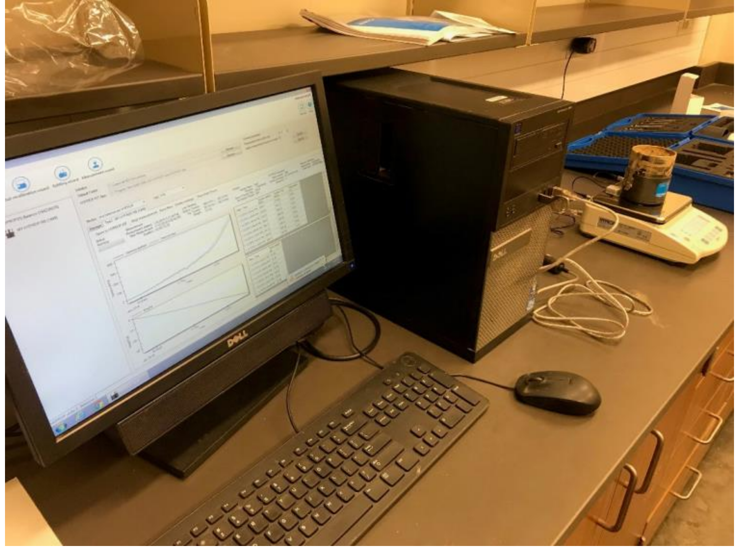
- 563 registered users
- 1814 fields planned
- 165,850 acres of MIRI rice. 12% of rice in AR
- 2.6 million feet of lay flat pipe poly pipe have been planned using the app.
- 340 Billion gallons of water saved

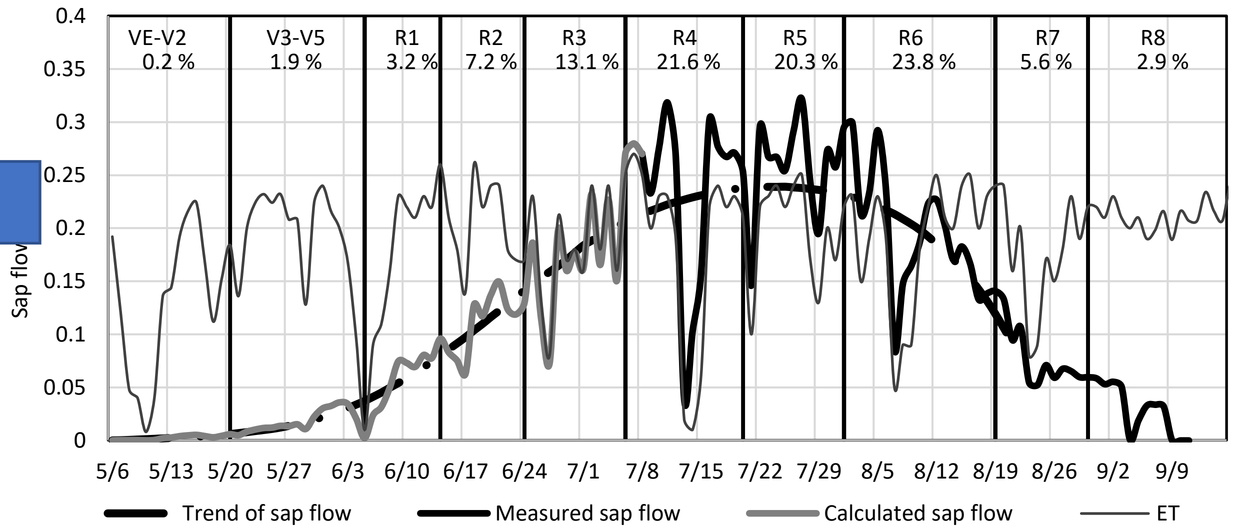


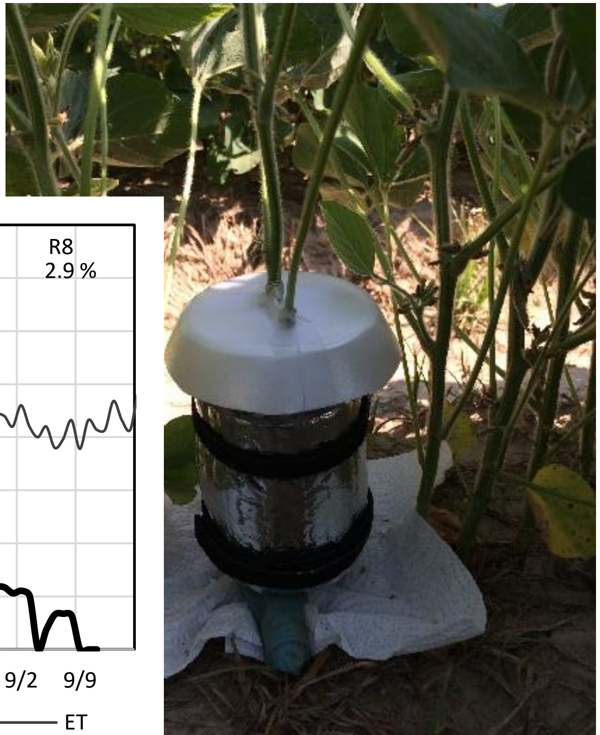


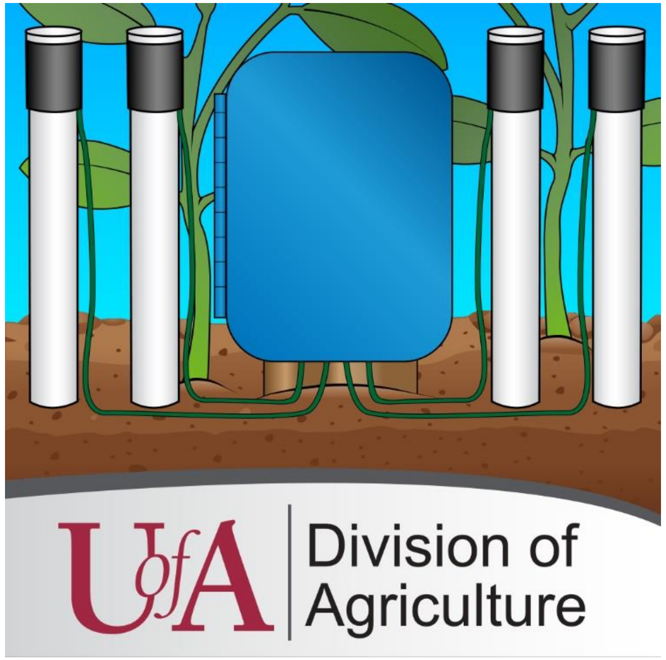
Mobile Apps: Arkansas Watermark Tool

Research results from water retention curves and 5 years of on-farm trials

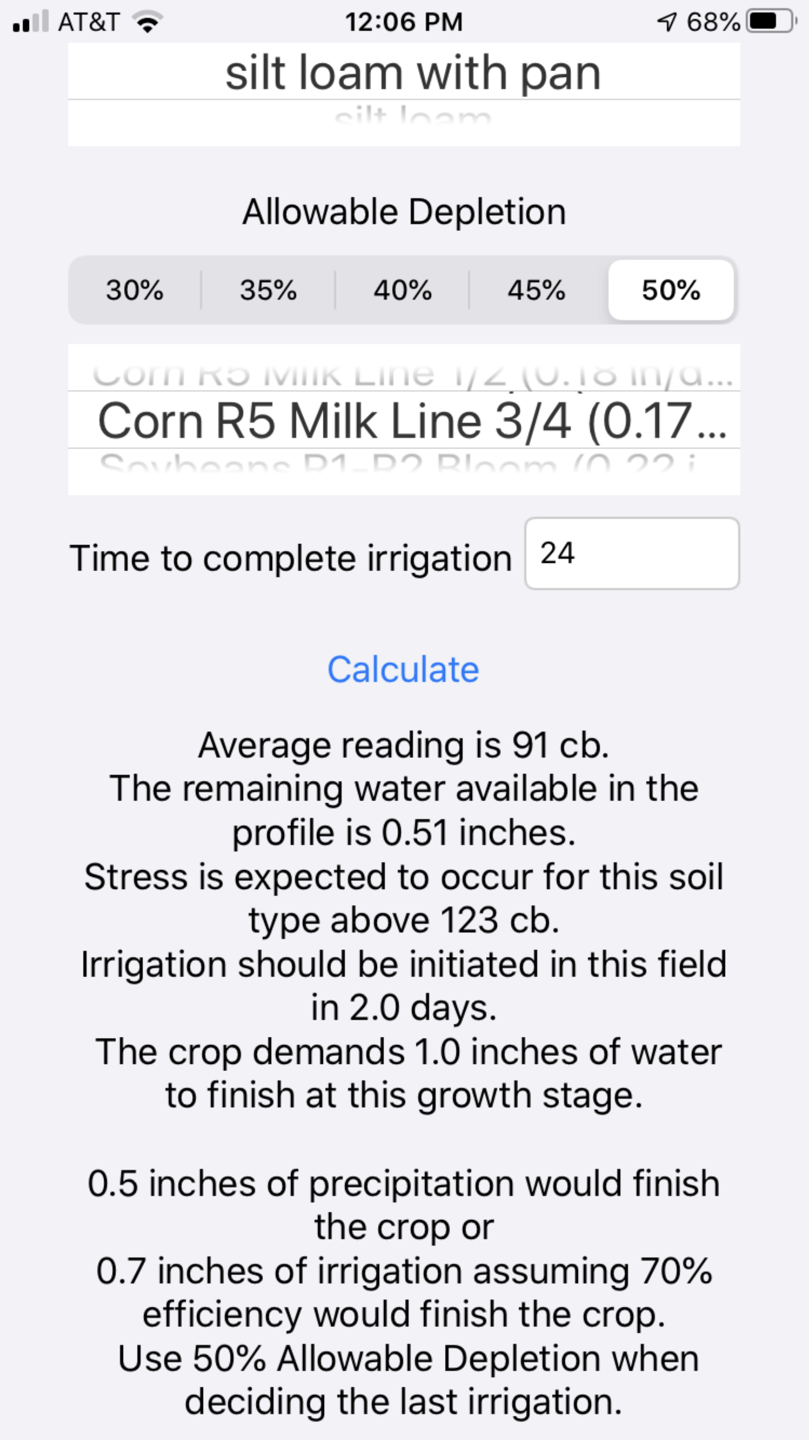








Action Plan for the irrigator



331 users

Simple Pump Timer

- Set time to 200 hrs
- Sunlight readable display
- PCB boards designed to meet the extreme conditions of an irrigation pump panel.
- Restarts when power is lost (power interruption or load management)
- Delay start (drip oil on deep wells)
- Stops when rain can set rain depth to stop
- No high voltage in control box
- No chance of rain or water intrusion.
- Tamperpoof
- Stand-alone or can be connected to cloud.
- Low cost
- Easy to bypass if needed.


Great Plains
SOLID STAND 1500


POWERCOM

240 bpa, 13.5 ac-in/ac, 9.7 bu/in

<u>Value of the Patented pitless tailwater pump system</u>

- Reduces water use by >60% (12-19 ac-in/ac)
- Irrigation efficiencies over 90%
- Allows for no-till
- Allows for cover crops
- Reduces methane emissions and N2O emissions in line with AWD
- Provides pigweed control
- Closes 16 BPA yield gap between FIR and flooded rice
- Water management is simple, maintain a shallow flood at bottom of field.
- Conserves Nitrogen (rates comparable to flood).
- Allows new fertilizer options, fertigation, time release fertilizers.
- Payback compared to Tailwater pit system is 2-3 years.
- Awaiting NRCS approval for incentive program.

USDA NRCS ARKANSAS RICE CHECK-OFF RiceTec ADAMA UPL syngenta United States Gowan FMC VALENT BAYER

What is the "Most Crop per Drop" Contest?

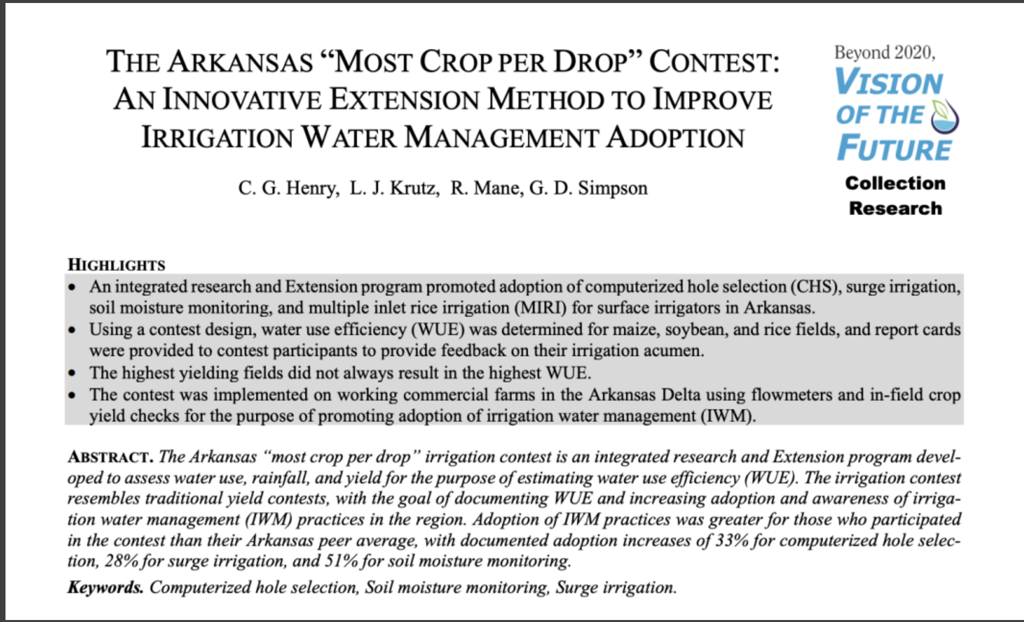
$$\text{Water Use Efficiency (Bushels/inch)} = \frac{Yield\ (BPA)}{Rain\ (in) + Irrigation\ \left(ac\text{-}\frac{in}{ac}\right)}$$

- Contest that tests the skill of achieving maximum and economically acceptable yield with the least amount of supplemental irrigation.
- Minimum yields of 60 BPA soybeans, 180 BPA rice, 200 BPA Corn
- Recognize farmers that achieve a high level of irrigation water management.
- Three contest categories: corn, soybeans and rice.
- Over $95,000 in prizes awarded annually.

MOST CROP PER DROP
Arkansas Irrigation Yield Contest

The Contest is a vehicle to showcase sustainable practices

- Sensors and sensor-based irrigation scheduling
- Lay Flat Pipe and Computerized Hole Selection
- Surge Valves
- Sensor telemetry
- MIRI and AWD rice irrigation
- Furrow irrigated rice
- 4 R nutrient management including N ST*R
- Tailwater recovery
- Unmanned Aerial Vehicles



THE ARKANSAS "MOST CROP PER DROP" CONTEST: AN INNOVATIVE EXTENSION METHOD TO IMPROVE IRRIGATION WATER MANAGEMENT ADOPTION

Beyond 2020, VISION OF THE FUTURE Collection Research

C. G. Henry, L. J. Krutz, R. Mane, G. D. Simpson

HIGHLIGHTS

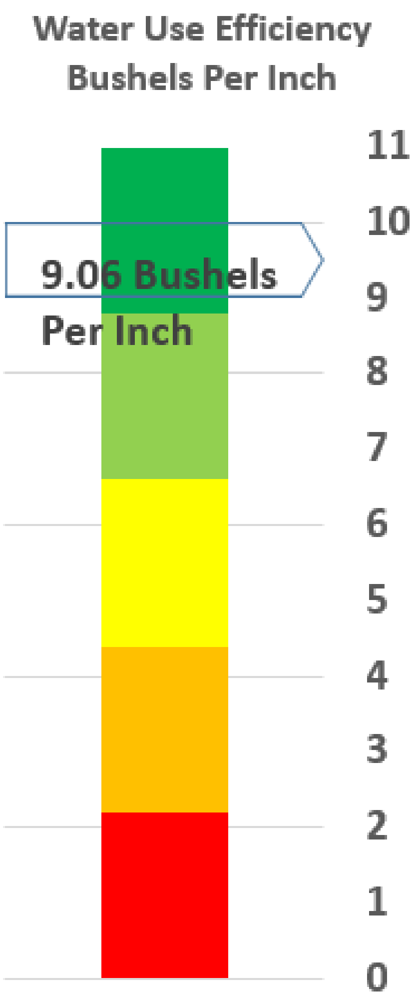
- An integrated research and Extension program promoted adoption of computerized hole selection (CHS), surge irrigation, soil moisture monitoring, and multiple inlet rice irrigation (MIRI) for surface irrigators in Arkansas.
- Using a contest design, water use efficiency (WUE) was determined for maize, soybean, and rice fields, and report cards were provided to contest participants to provide feedback on their irrigation acumen.
- The highest yielding fields did not always result in the highest WUE.
- The contest was implemented on working commercial farms in the Arkansas Delta using flowmeters and in-field crop yield checks for the purpose of promoting adoption of irrigation water management (IWM).

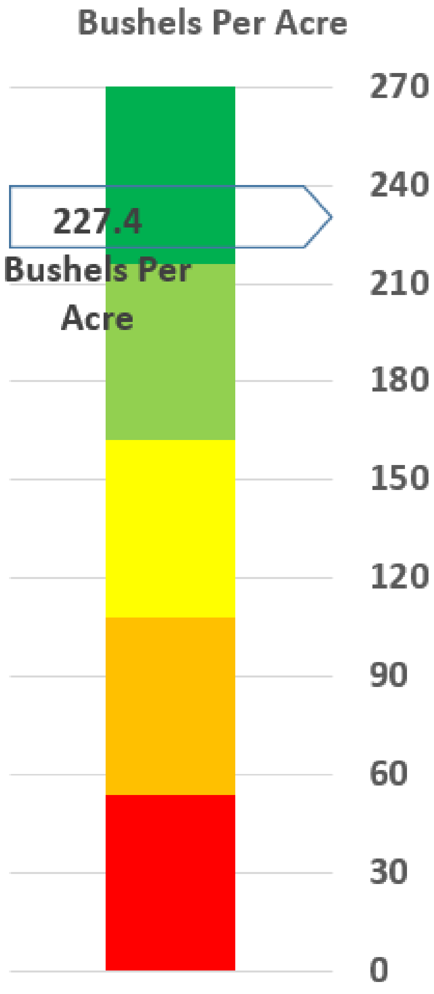
ABSTRACT. *The Arkansas "most crop per drop" irrigation contest is an integrated research and Extension program developed to assess water use, rainfall, and yield for the purpose of estimating water use efficiency (WUE). The irrigation contest resembles traditional yield contests, with the goal of documenting WUE and increasing adoption and awareness of irrigation water management (IWM) practices in the region. Adoption of IWM practices was greater for those who participated in the contest than their Arkansas peer average, with documented adoption increases of 33% for computerized hole selection, 28% for surge irrigation, and 51% for soil moisture monitoring.*

Keywords. *Computerized hole selection, Soil moisture monitoring, Surge irrigation.*

Social Media and Recognition

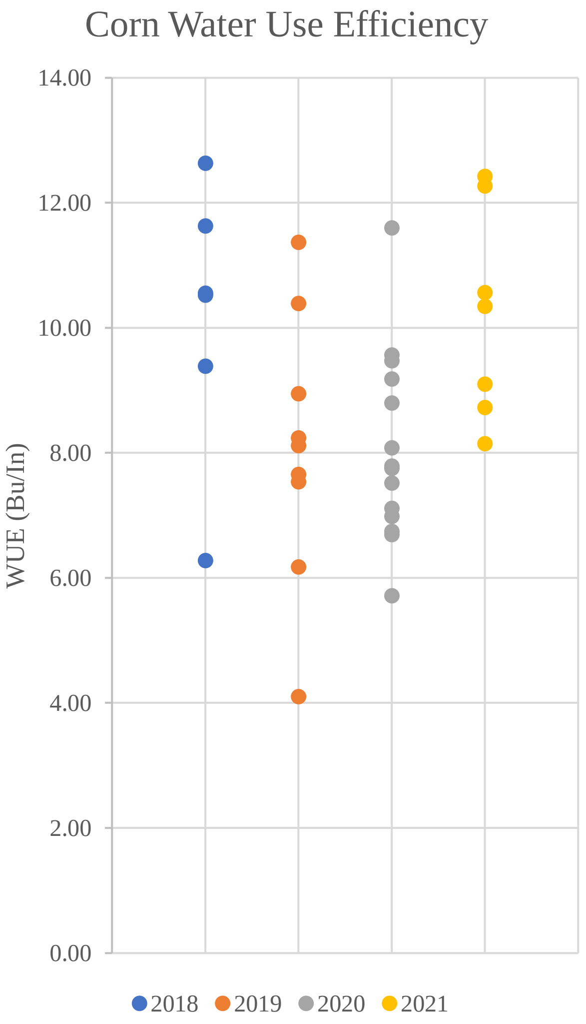
All contestants receive a report card

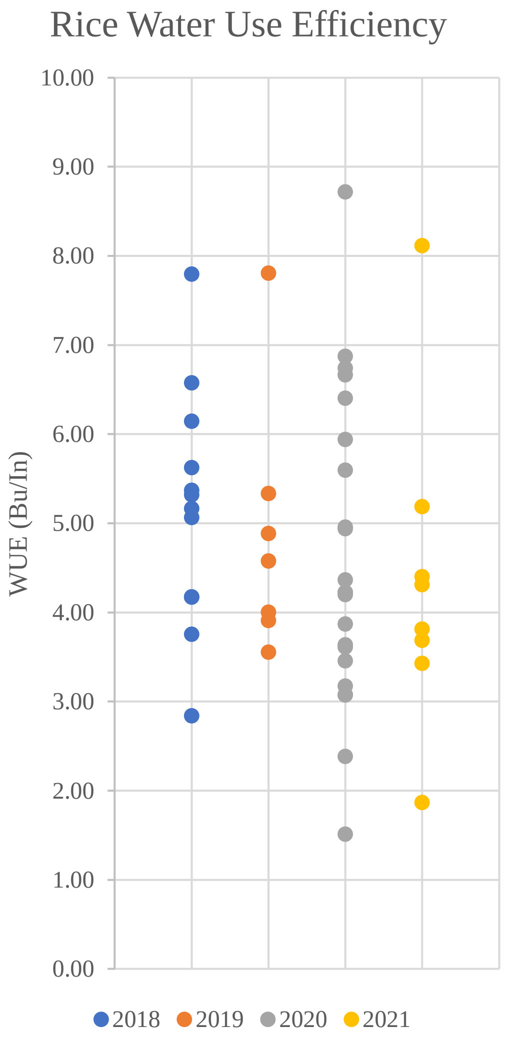


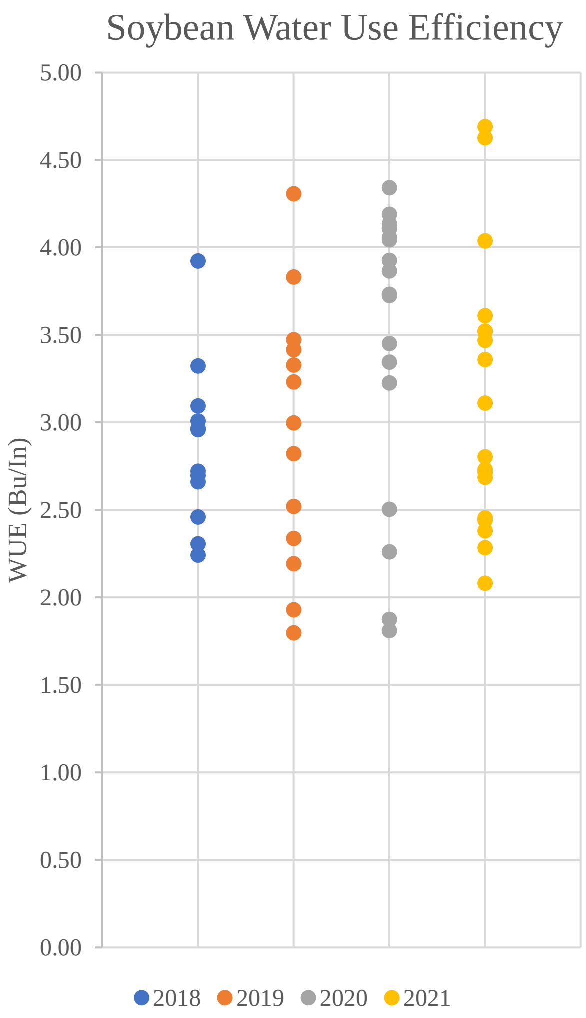


WUE in Most Crop per Drop for 4 Years

MOST CROP PER DROP
Arkansas Irrigation Yield Contest







Adoption of IWM technology is increasing in the contest

MOST CROP PER DROP

Arkansas Irrigation Yield Contest

	Soil Moisture Sensors	Computerized Hole Selection	Surge Irrigation
2021	87%	97%	35%
2020	42%	100%	16%
2019	40%	43%	28%
2018	50%	73%	44%

- QQ Huang is leading a 2022 irrigation survey that will help us assess impact of irrigation contest and irrigation schools and why farmers adopt IWM practices and barriers to adoption.

Irrigation

Water

Management

Water use savings from WUDB versus Irrigation Contest

MOST CROP PER DROP
Arkansas Irrigation Yield Contest

		2012 Water User Database Ac-in/ac	Irrigation Contest (2018-2021)	Difference (%)
Rice	Min	13.5	13.4	
	Average	**37**	**28.7**	**22%**
	Max	47.6	92.1	
Soybeans	Min	1.0	2	
	Average	**16.3**	**8.9**	**45%**
	Max	32.3	20.8	
Corn	Min	2.6	1.5	
	Average	**18.1**	**9.1**	**50%**
	Max	30.6	19.3	

Use of soil moisture monitoring has increased 51% in Arkansas and 114% in Mississippi (USDA NASS 2013, 2017)

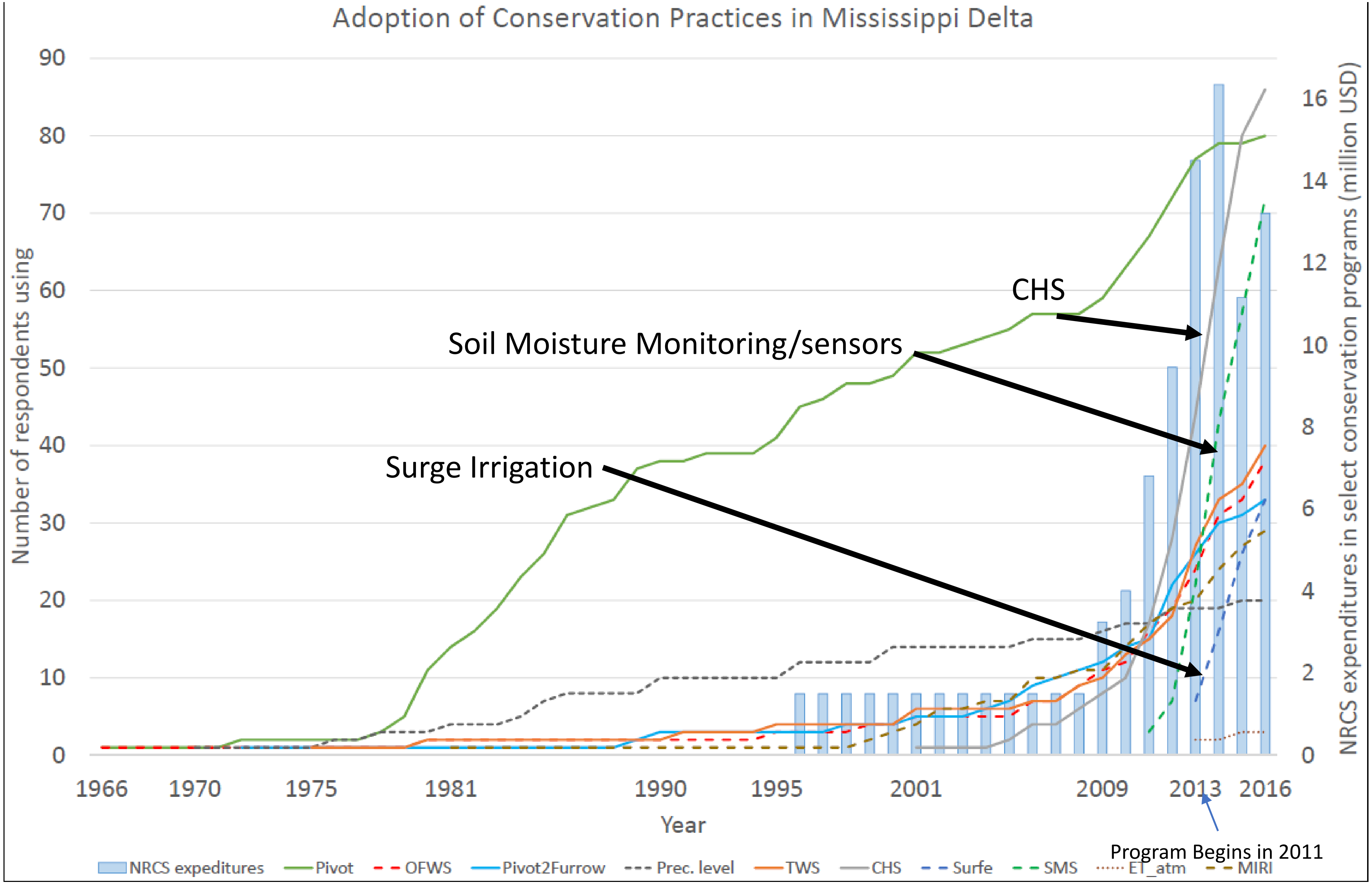


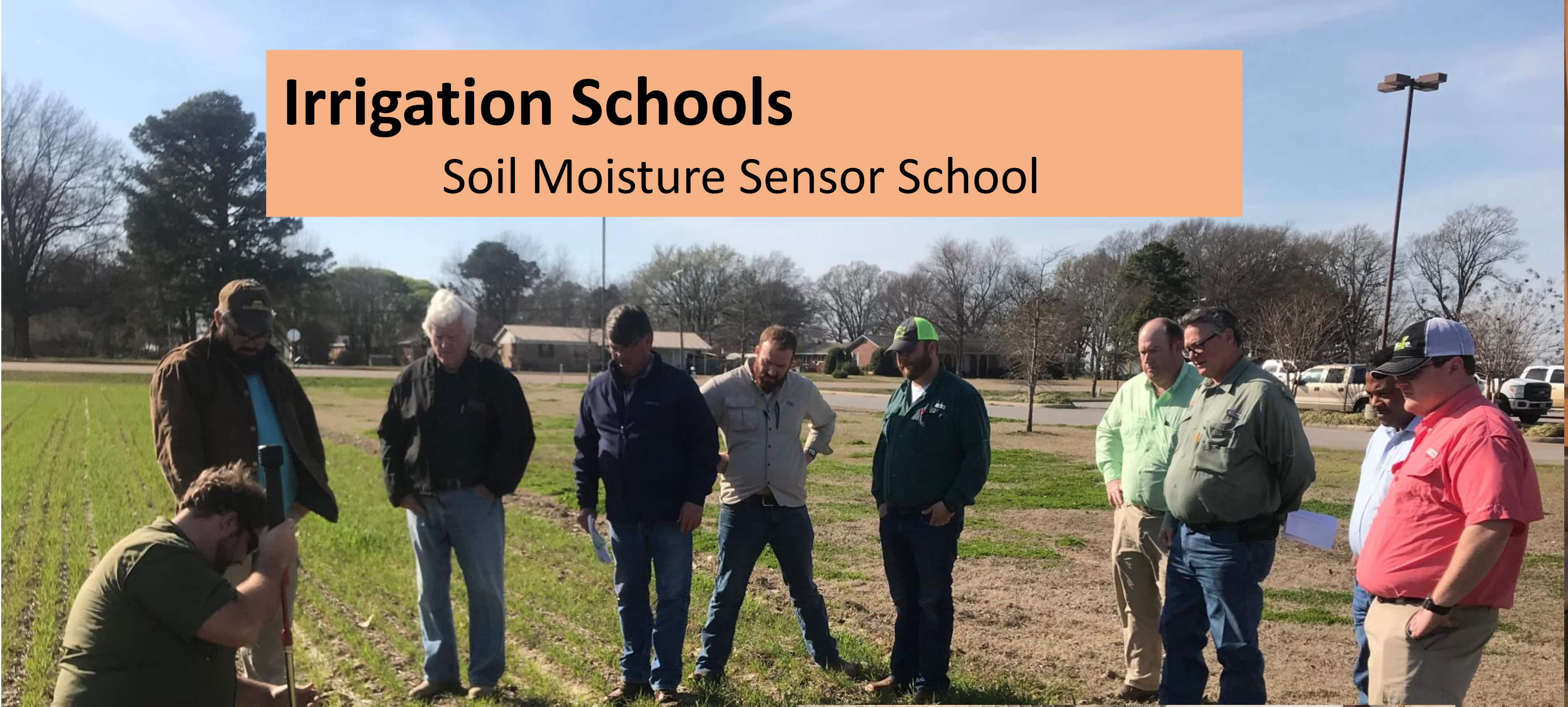
Figure 3. Timeline of adoption of conservation practices and USDA-NRCS EQIP expenditures in the Mississippi portion of the Lower Mississippi River Basin Delta area. Source: Quintana-Ashwell *et al.*

Source: Quintana-Ashwell, N.E.; Gholson, D.M.; Krutz, L.J.; Henry, C.G.; Cooke, T. Adoption of Water-Conserving Irrigation Practices among Row-Crop Growers in Mississippi, USA. Agronomy **2020**, 10. doi:10.3390/agronomy10081083.

Data Source: Henry, C.G., L. J. Krutz, J. Henggeler, R. Levy, Q.Q. Huang and K. Kovacs. 2020. A Survey of 2015 Mid-South Irrigation Practices: Report to the Mid-South Soybean Board and dataset. Mid-South Soybean Board. University of Arkansas Division of Agriculture.

Irrigation Schools

Soil Moisture Sensor School



Irrigation Schools

Gain skills on how to use UA soil moisture sensor app and Rice Irrigation app

Program surge valves under different scenarios

Build Watermark Sensor, install, learn to interpret

230 participants
1025 contact hours
87% report substantial learning

National Master Irrigator Initiative

- Certification program based on 24 workshop hours and practical application component
- Uniform national recognition for Irrigation acumen
- Committee (Henry (AR) and Kremen (CO) co-chairs) is seeking resources for curriculum development and regional coordination

2020 CO Master Irrigator Graduates

Arkansas Corn & Grain Sorghum Board

USDA United States Department of Agriculture
Natural Resources Conservation Service

Arkansas Soybean Promotion Board

RiceTec

IRROMETER

McCROMETER

AGSENSE A valmont COMPANY

cropx

Seametrics

TRELLIS

Delta Plastics
Preserving Our Farmland

UofA DIVISION OF AGRICULTURE
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University of Arkansas System

MOST CROP PER DROP
Arkansas Irrigation Yield Contest

Twitter: UA_cghenry
cghenry@uada.edu
785-741-0393

http://www.uaex.uada.edu/irrigation

"I believe the overdraft problem is solvable, once water management is on the mind of every Arkansas Irrigator"

Chris Henry 2022

"It is not the quantity of water applied to a crop, it is the quantity of intelligence applied which determines the result – there is more due to intelligence than water in every case."

Alfred Deakin 1890

Much of the work presented would not have been possible without support from Arkansas NRCS, field offices, Conservation District staff and UADA Extension agents.

Dennis Carmen, White River Irrigation District

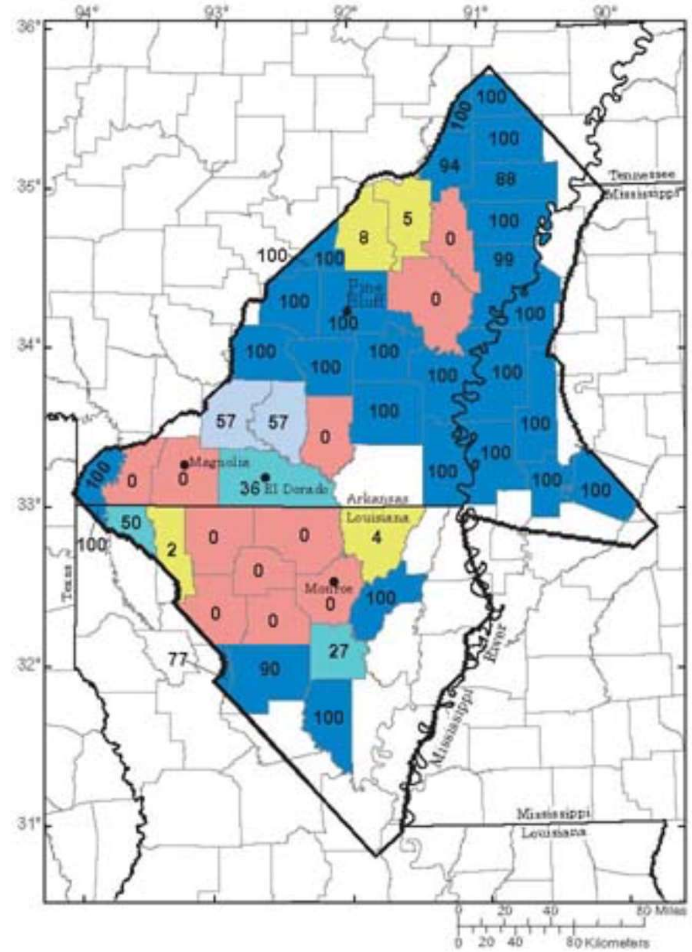
Grand Prairie Irrigation

Affordable Water for the Regions Farmers
Protecting The Regions Drinking Water
Building Our Economy

June 21, 2022

●●○○○ AT&T LTE 8:58 AM 37%

pubs.usgs.gov



Percentage of 1990-97 withdrawal from Sparta aquifer that is sustainable by county (Sparta model).

Grand Prairie Project

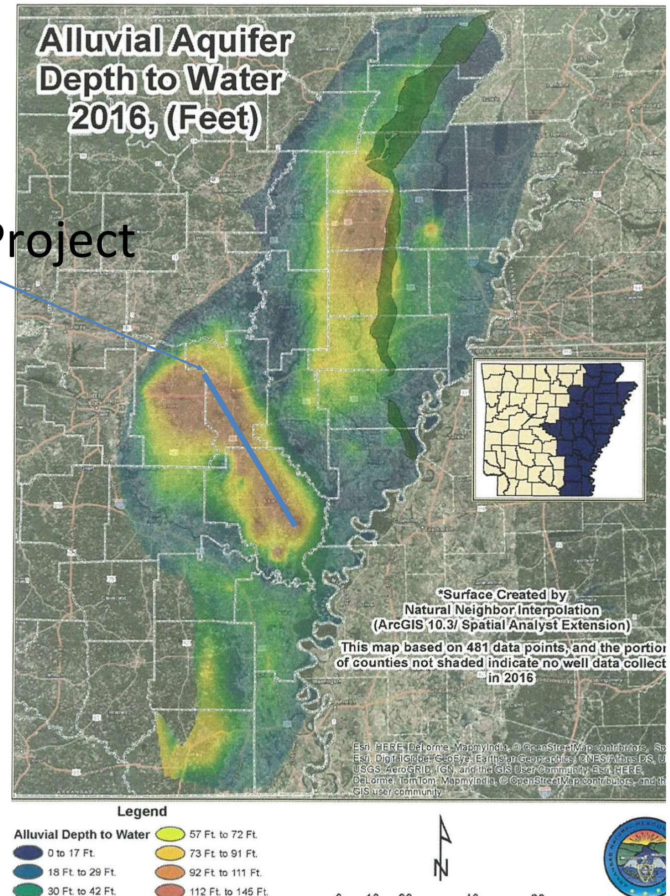
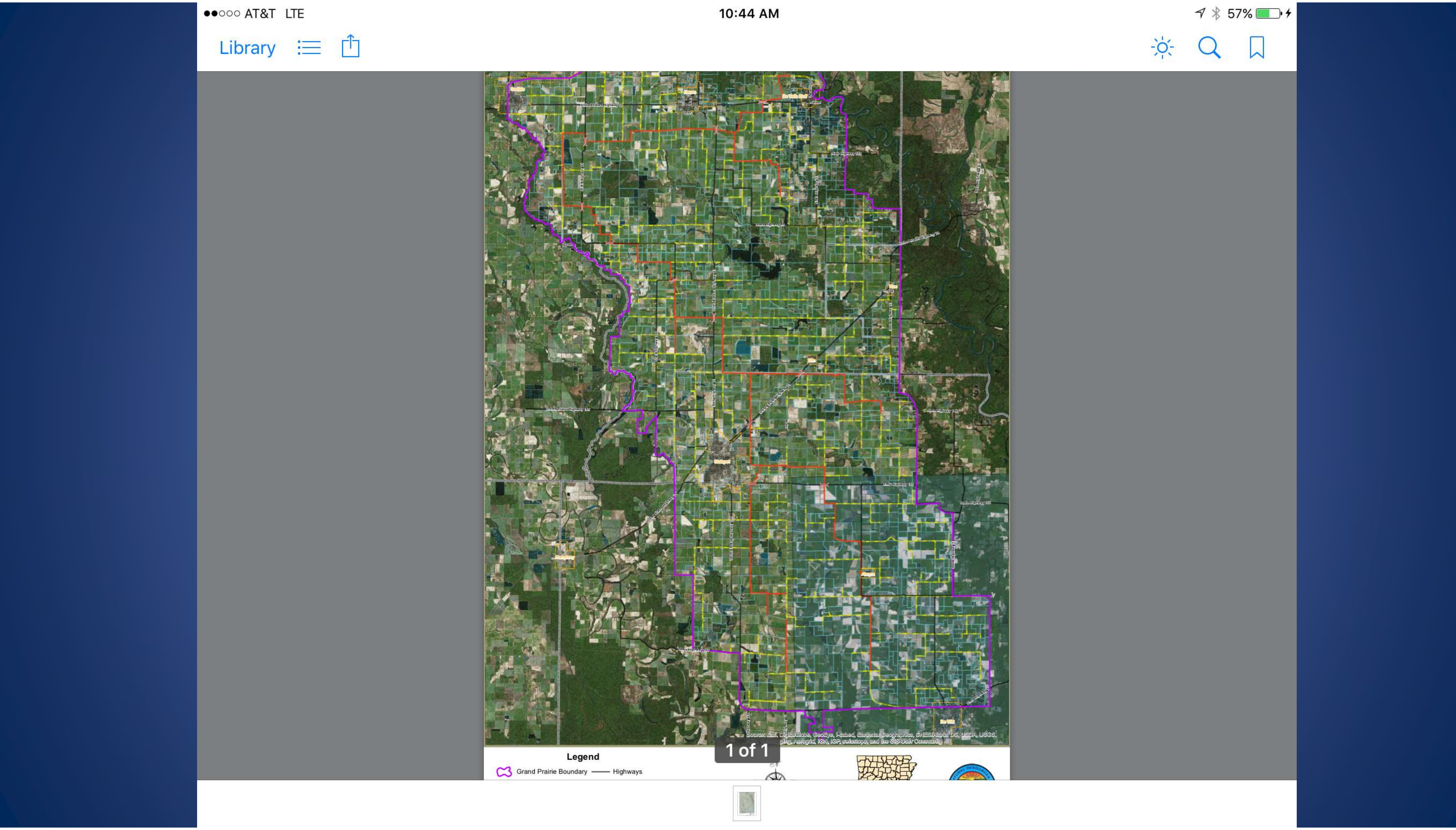


Fig. 3

Who Are We?

- White River Irrigation District
  - Legally formed Water District
  - 15 Farmer Elected board members
  - District has been in operation since 1984
  - We do not have taxing authority
  - We do not want that authority
  - Our goal is to become sustainable by delivering affordable water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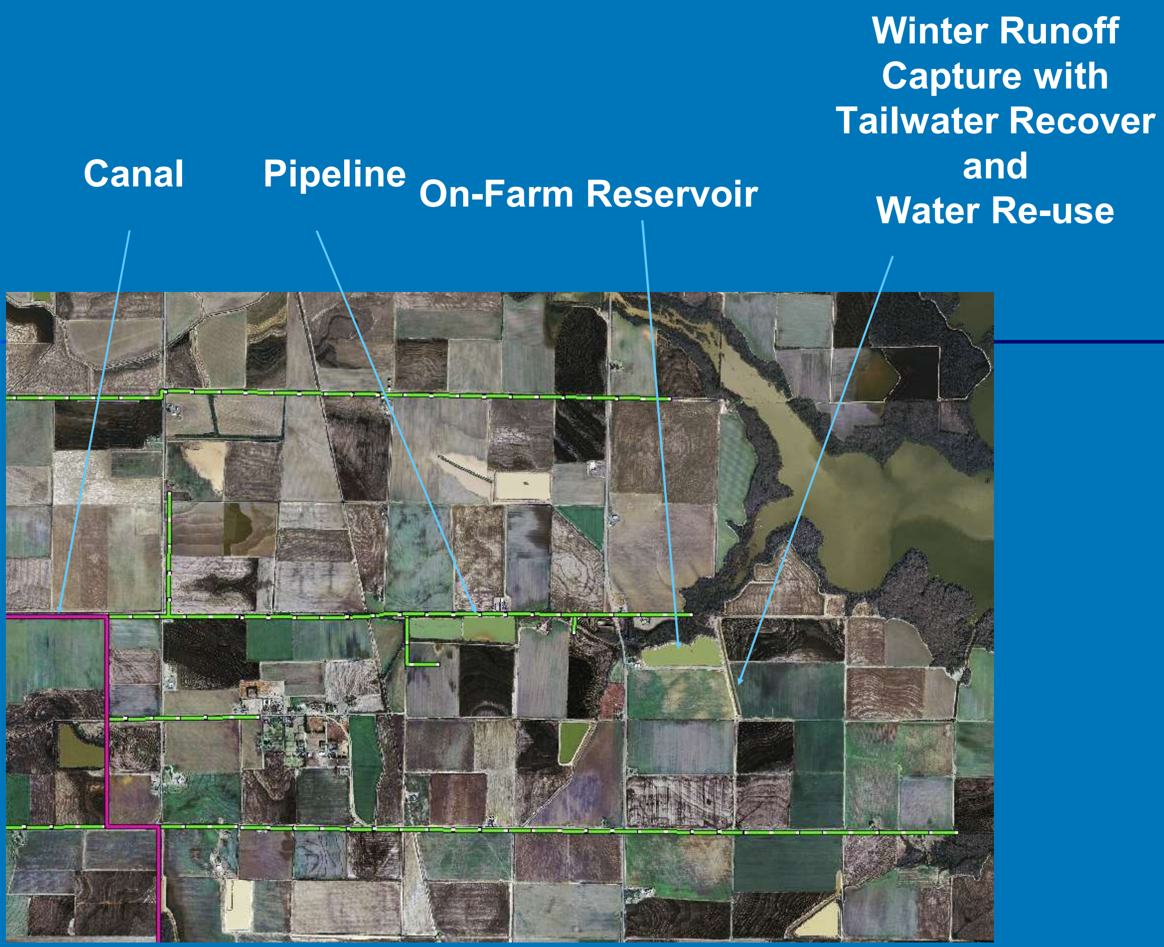
Library
1 of 1
Legend
Grand Prairie Boundary
Highways


Canal
Pipeline
On-Farm Reservoir
Winter Runoff
Capture with
Tailwater Recover
and
Water Re-use

How many farms are there?

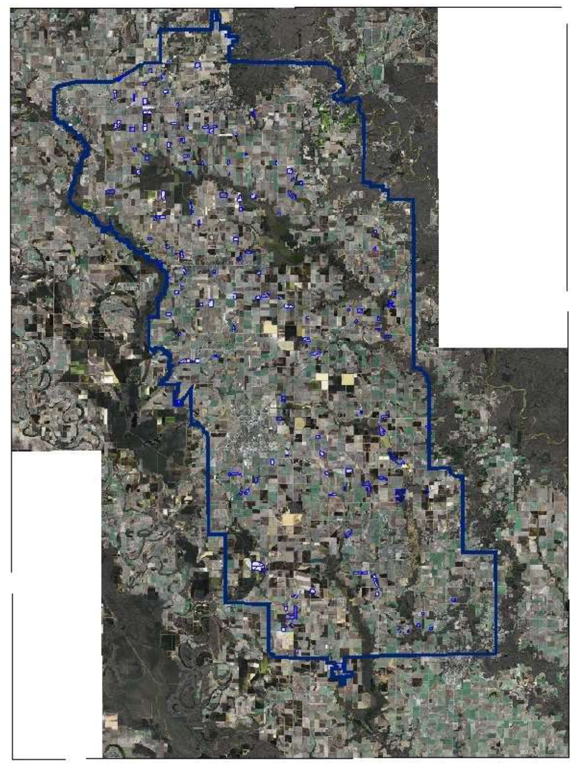
- **867 farms**
- **1363 tracts**
- **Measuring and metering points**
  - **1000 to 1200 depending on final design**

PROJECT AREA LANDS

- **300,000 ACRES**
  - **250,000 IRRIGATED CROPLAND**
    - **90,000 ACRES RICE**
    - **140,000 ACRES SOYBEANS**
    - **10,000 ACRES OF CORN**
    - **10,000 ACRES OF OTHER**

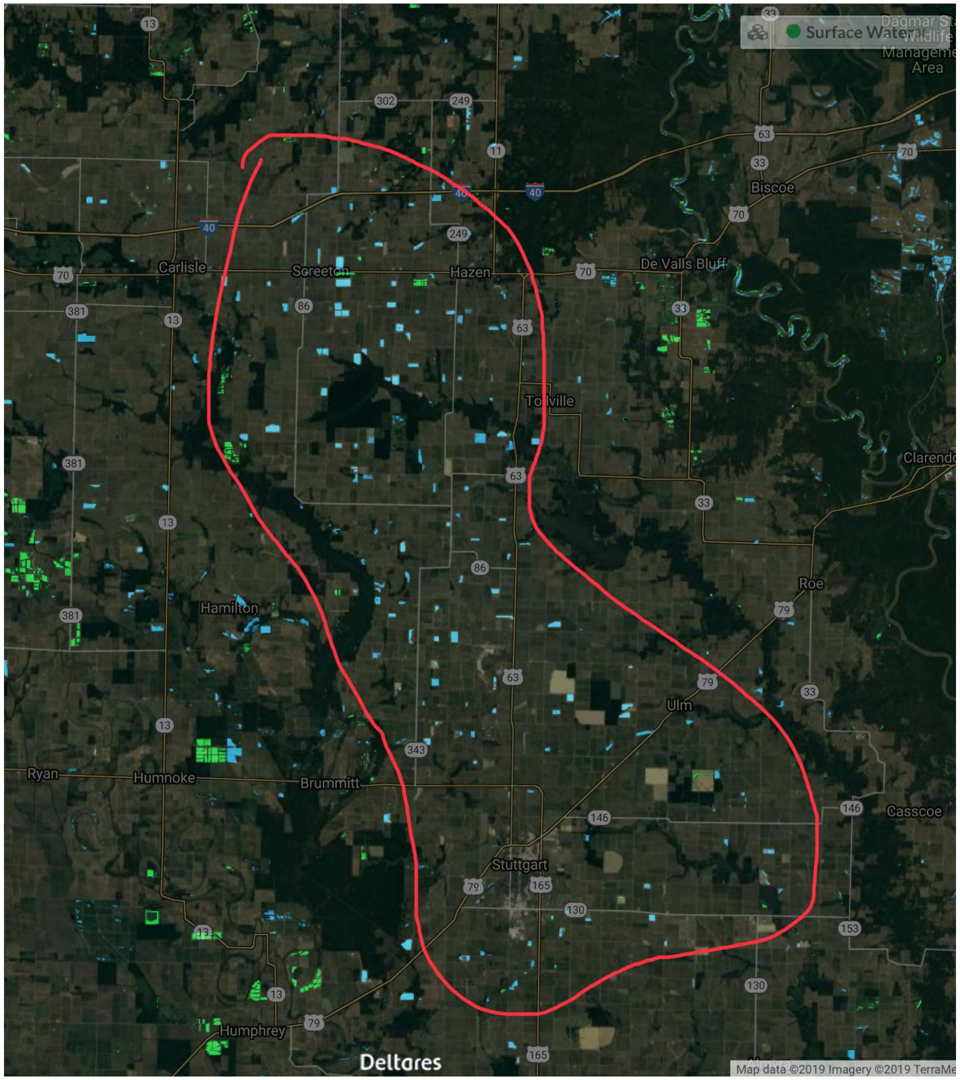
About 350 on farm reservoirs have been built with tailwater systems, pumps, and pipelines

Grand Prairie Project
State Tax Credits
EQIP
MRBI

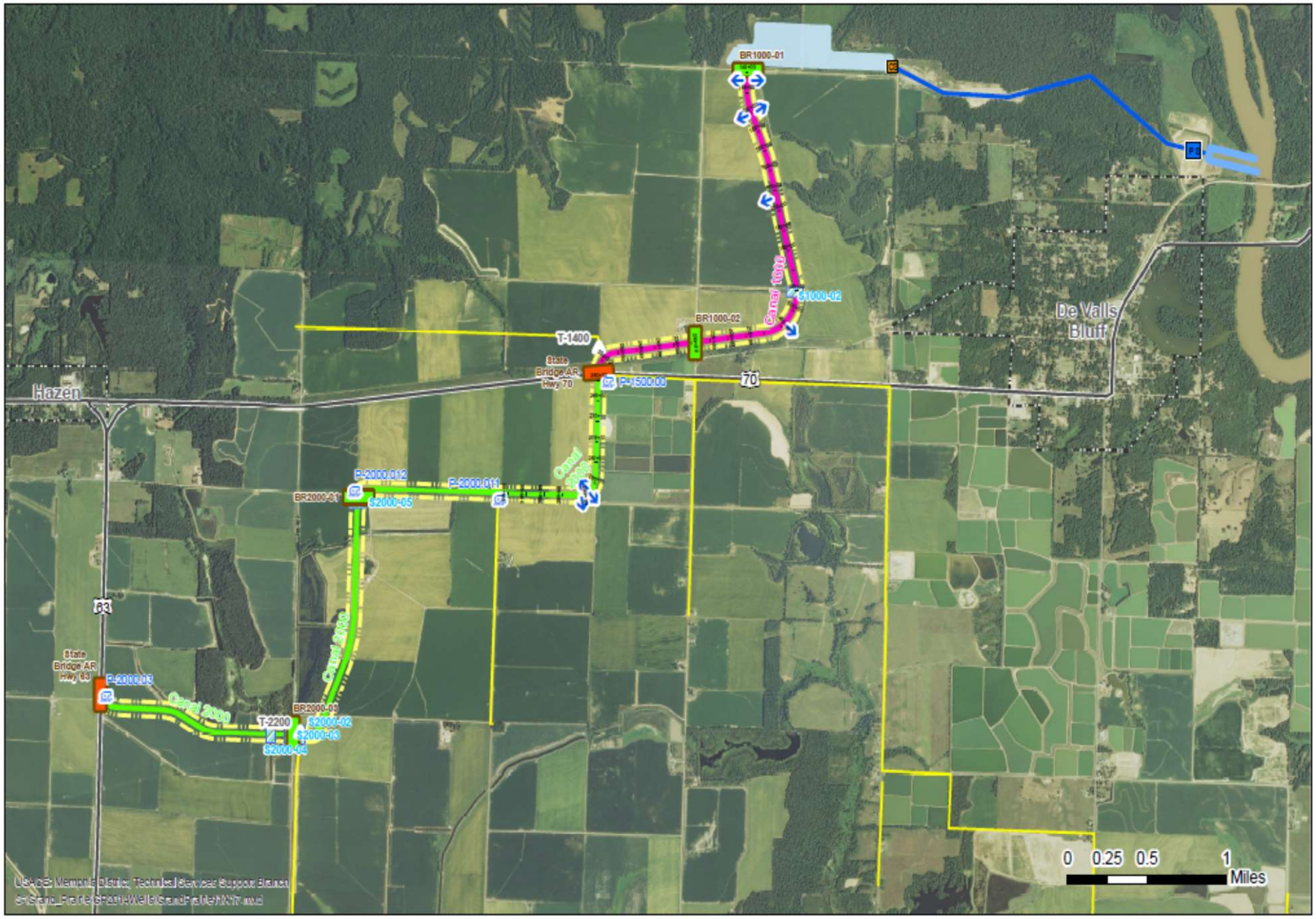


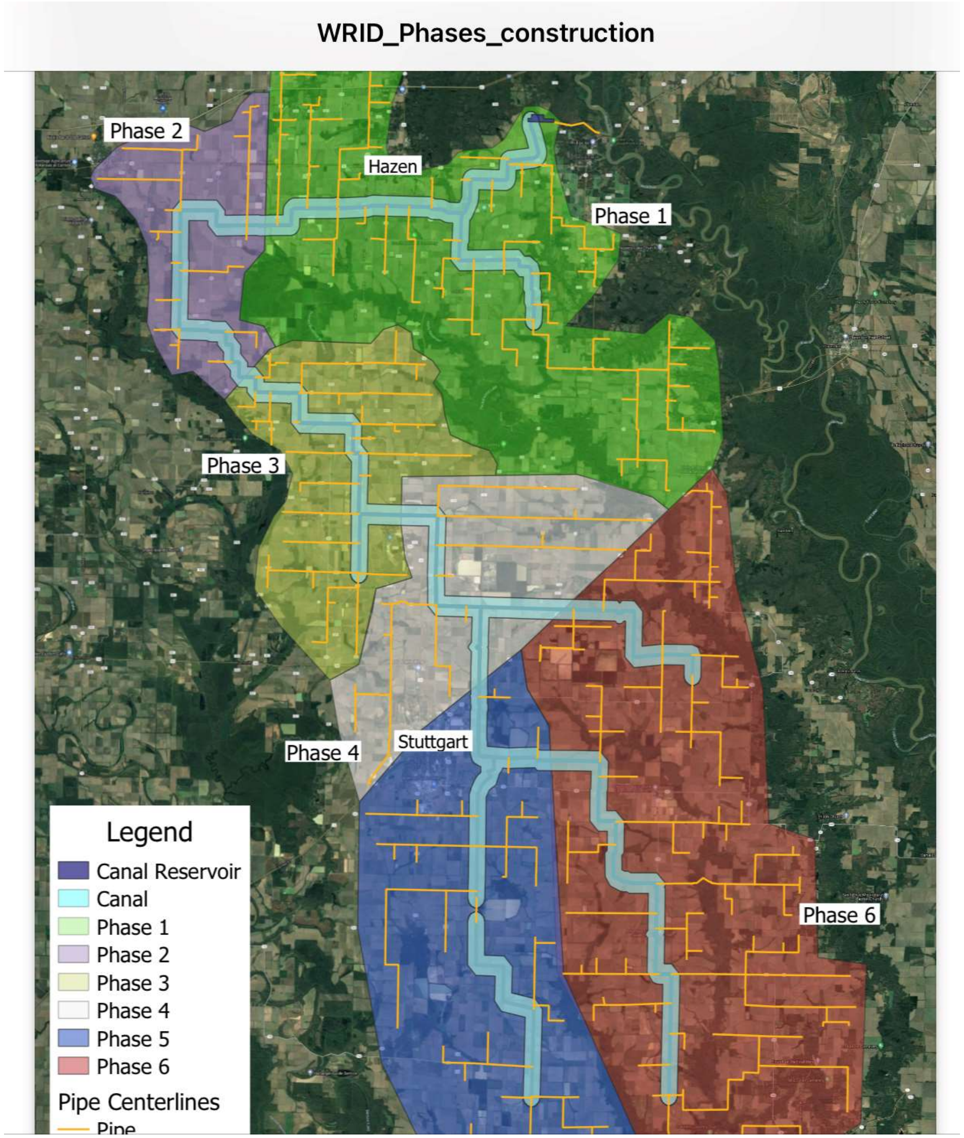
Surface Water Storage Added since 1986

From Satelite imagery



Grand Prairie to Hwy 63





Break Into Phases

Build Canal
Install pipelines

Start Water Delivery
Generate Income

Repeat

Funding

- NRCS has approved $48 million
- WRID has borrowed $40 million from AR AG NRD
- COE has $13 million for ENTERGY to deliver power
- Phase 1 Cost Estimate was $82 million

Cost - Canal 1000 Done Our Way

- 2 mile
- Estimate $3.5 to $4 million
- Bid was $3.7 million
- Completed cost was $3.6 million
- Main Canal length remaining?
- About 10 mile

Cost control
70 and 63 Crossings

- State bridges
- Our Original estimate was $6 million
- Final Bridge Design was $9.5 million
- Stop! Re-Design to Culverts by Michael Baker Intl.
- New cost estimate $6 million

Pipe stockpiled at lower cost
15,000 feet of 4 foot steel

Downs Road Crossing

Downs Road Crossing

Looking Upstream

Looking Downstream

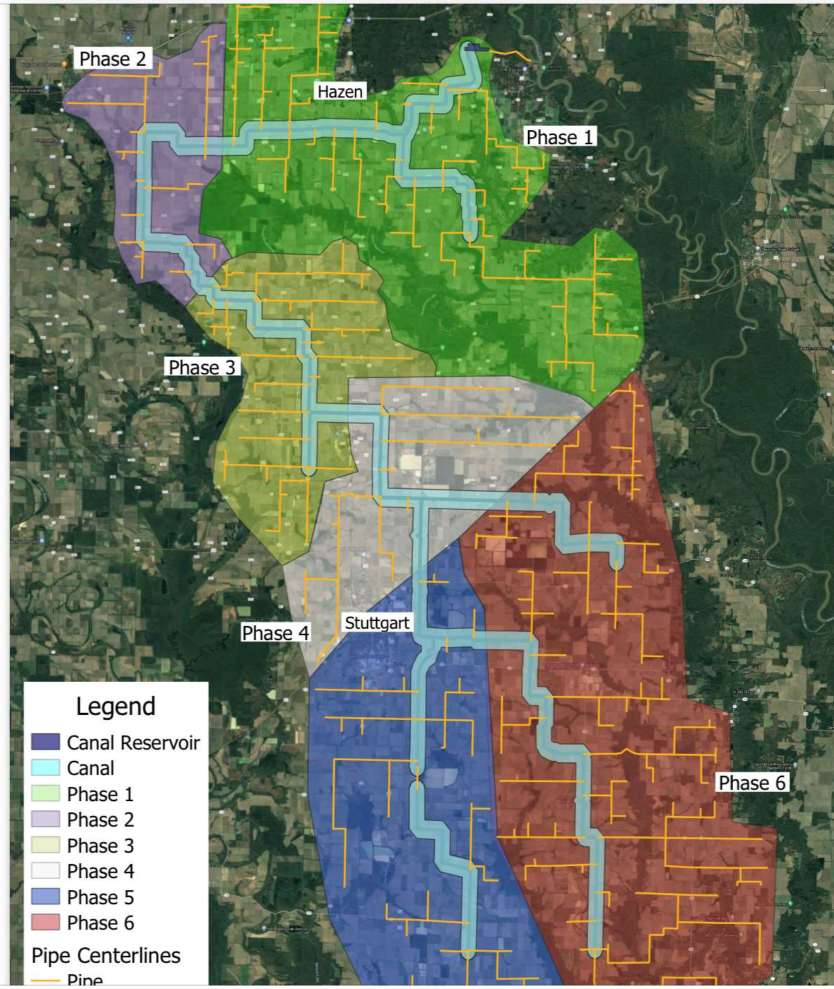
Production and Performance

1 full construction season Per Canal Segment

Followed by second year for pipelines

Per Phase

WRID_Phases_construction



Phase 1 2022 Has Started

Water Cost

- $26 per acre foot of water for Operation and Maintenance
- $27 per acre foot for debt financing
- $53 per acre foot per acre for the first foot
- $26 per acre foot for additional water
- We hope to reduce the financing cost by lower construction cost

Partners

NRCS
Natural Resources Conservation Service

WHITE RIVER IRRIGATION DISTRICT

Arkansas Game & Fish Commission

Grand Prairie Partners

ARKANSAS HERITAGE

ARKANSAS DEPARTMENT OF AGRICULTURE

AR


Thank You
from your friends at the
White River Irrigation District
White River Irrigation District
Bringing Water For Agriculture to the Grand Prairie
870-255-2202
WHITE RIVER IRRIGATION DISTRICT
USDA United States Department of Agriculture
Natural Resources Conservation Service
US Army Corps of Engineers
ARKANSAS DEPARTMENT OF AGRICULTURE
AR

Mike Hamilton, University of Arkansas – Extension

Discovery Farms Irrigation

Mike Hamilton
Irrigation Instructor

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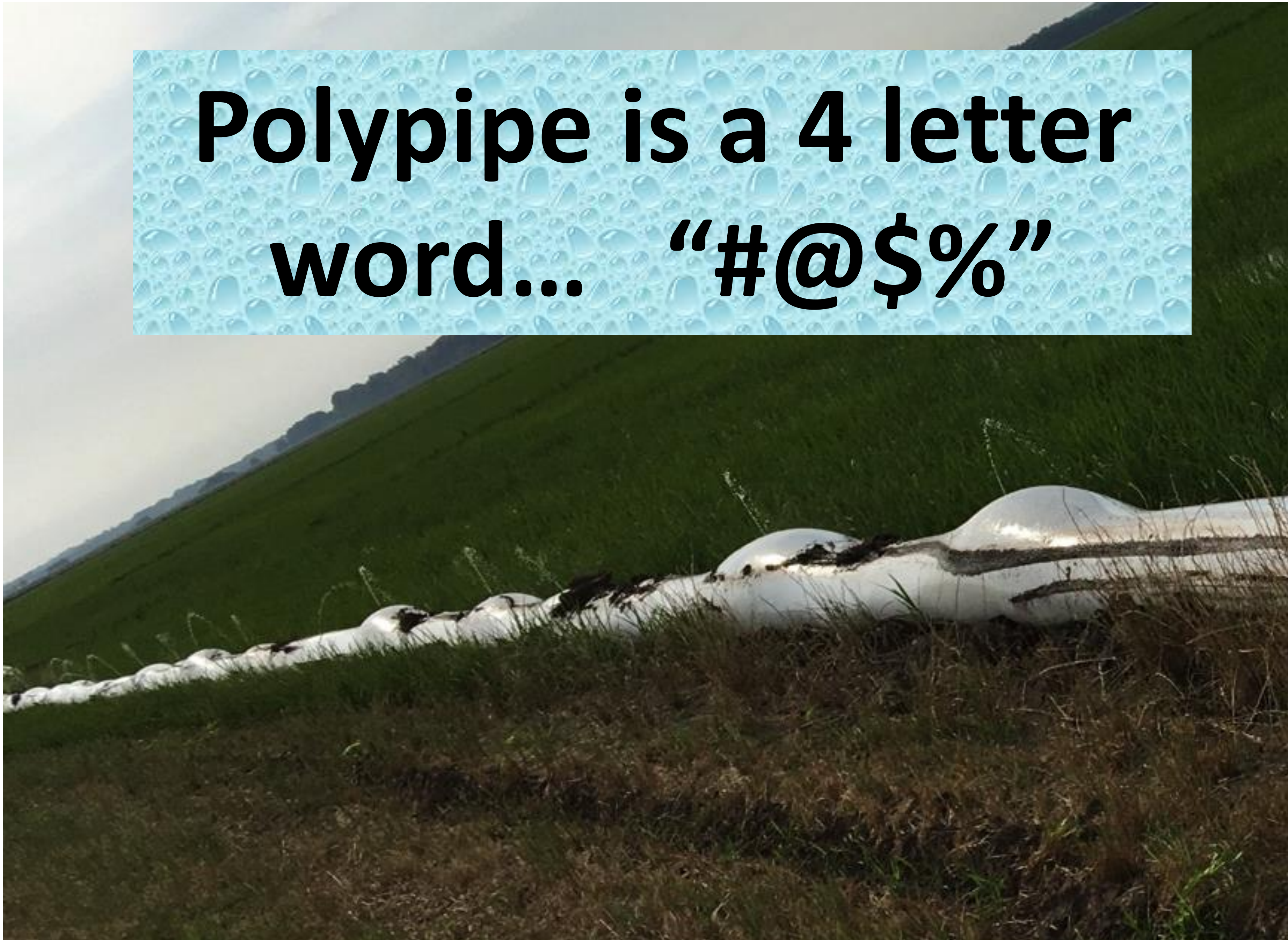
The Nature Conservancy


Polypipe is a 4 letter
word… “#@$%”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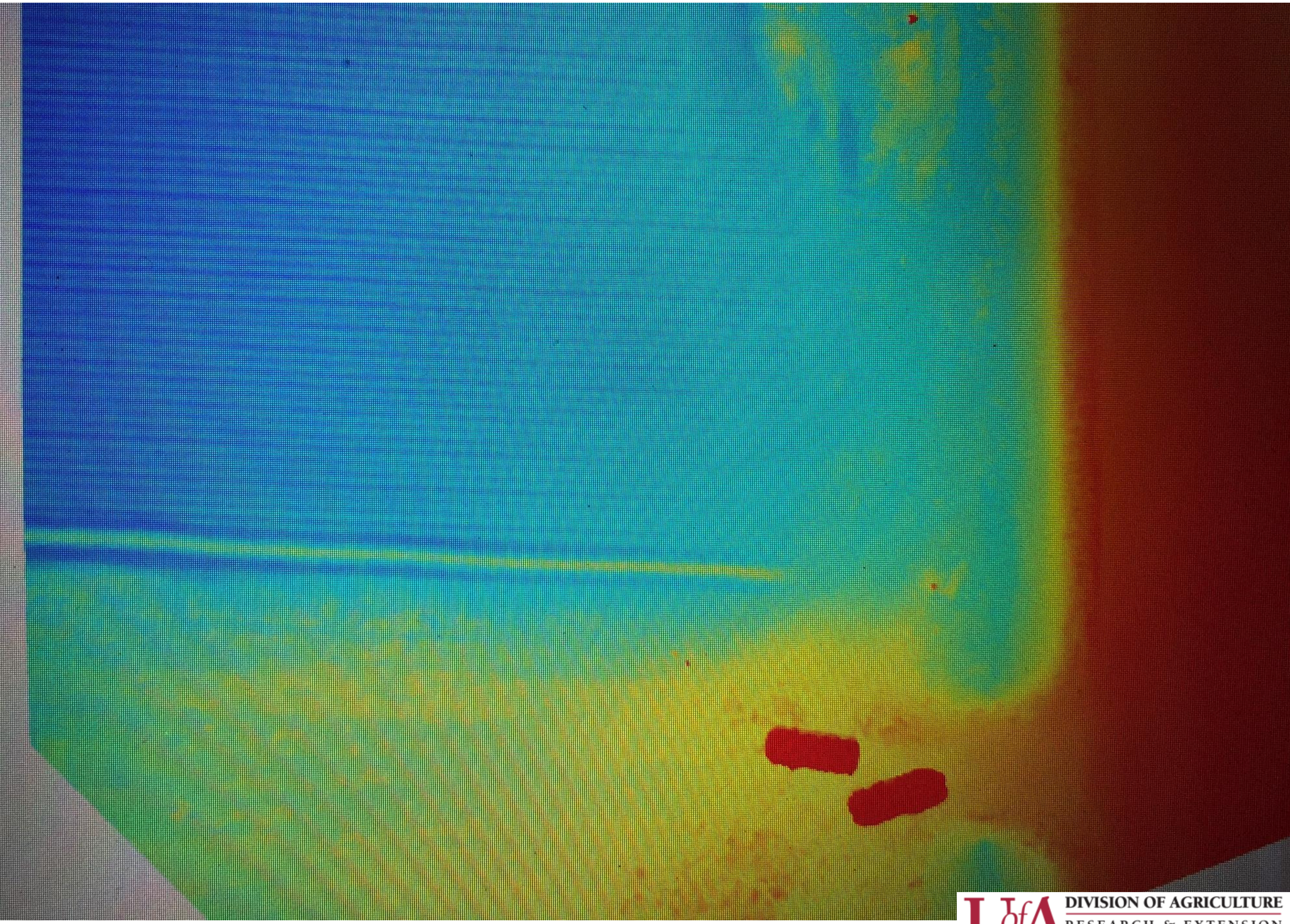
Leveling Fields

- Drone Mapping software is using 11.44 reference points per square foot to build a topography map of the field.

- Half a million reference points with a drone image per acre

- Traditional surveying equipment uses One point to reference the area that could represent 120 square feet to possibly as high as a 1000 square feet area.

- a 43 to 363 reference points per acre



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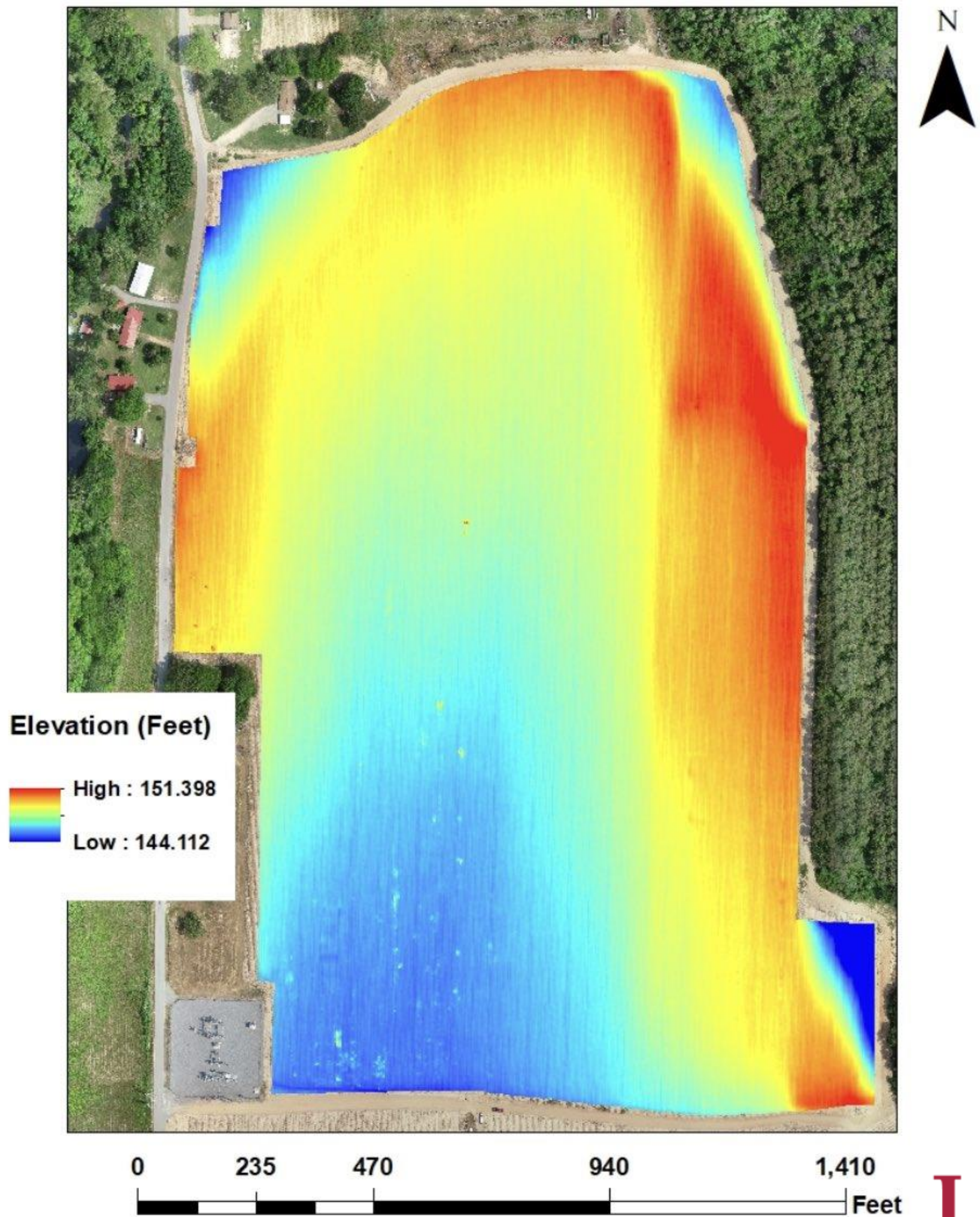
Desha Discovery Farm



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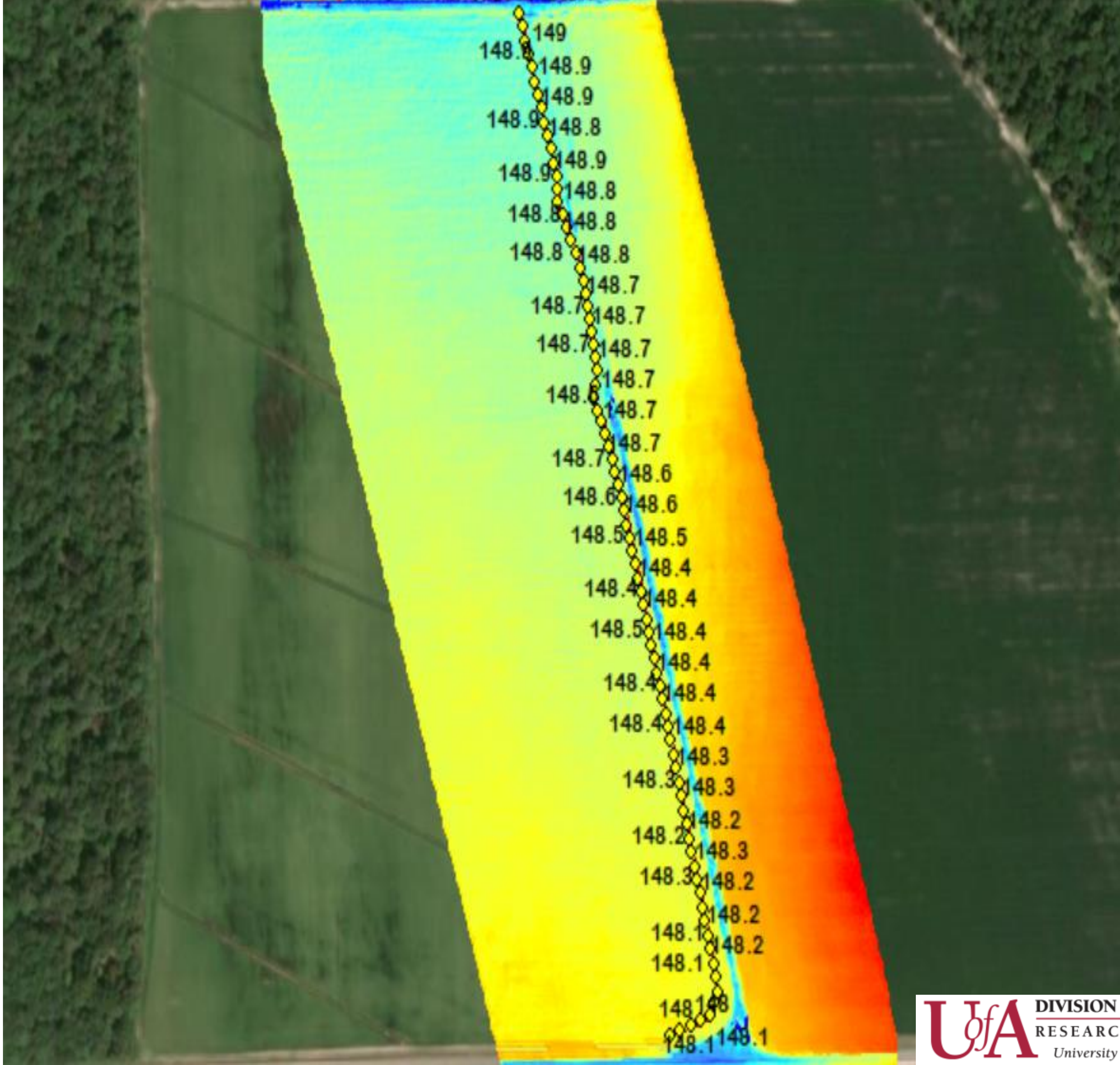

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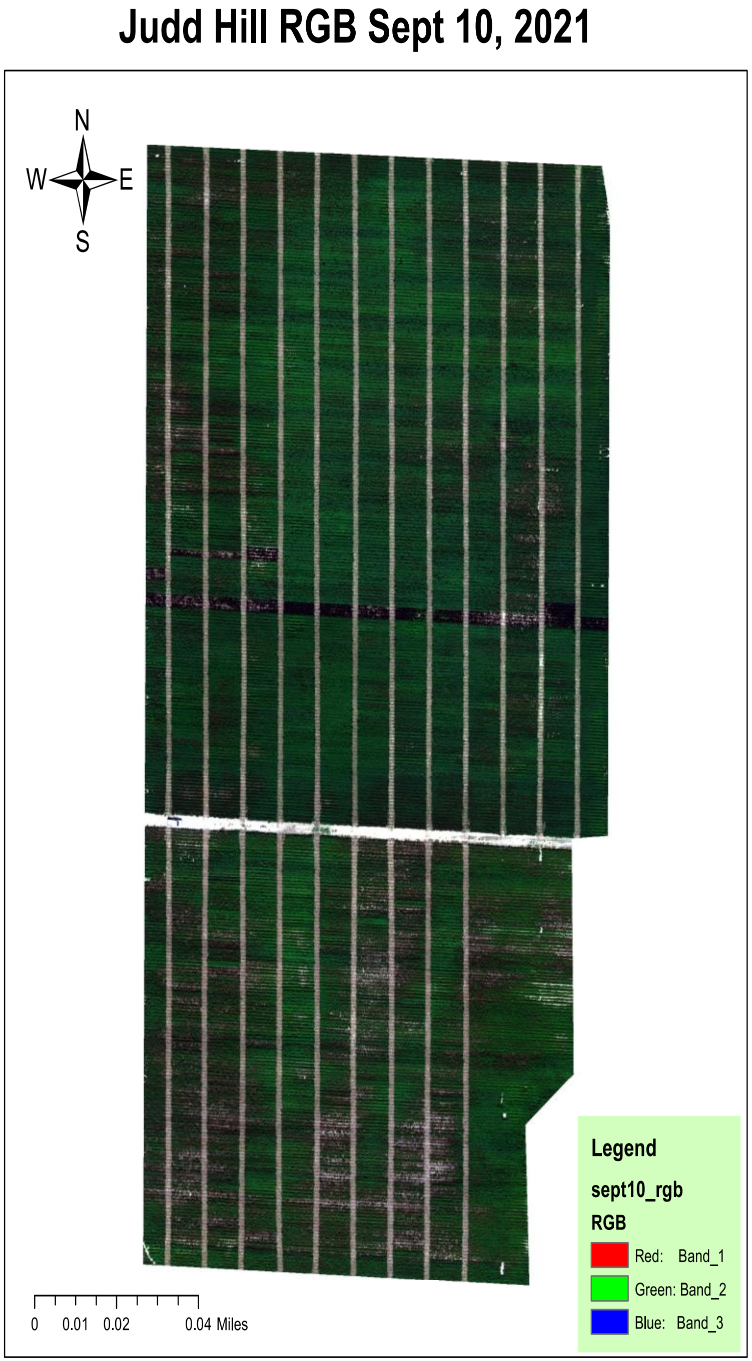

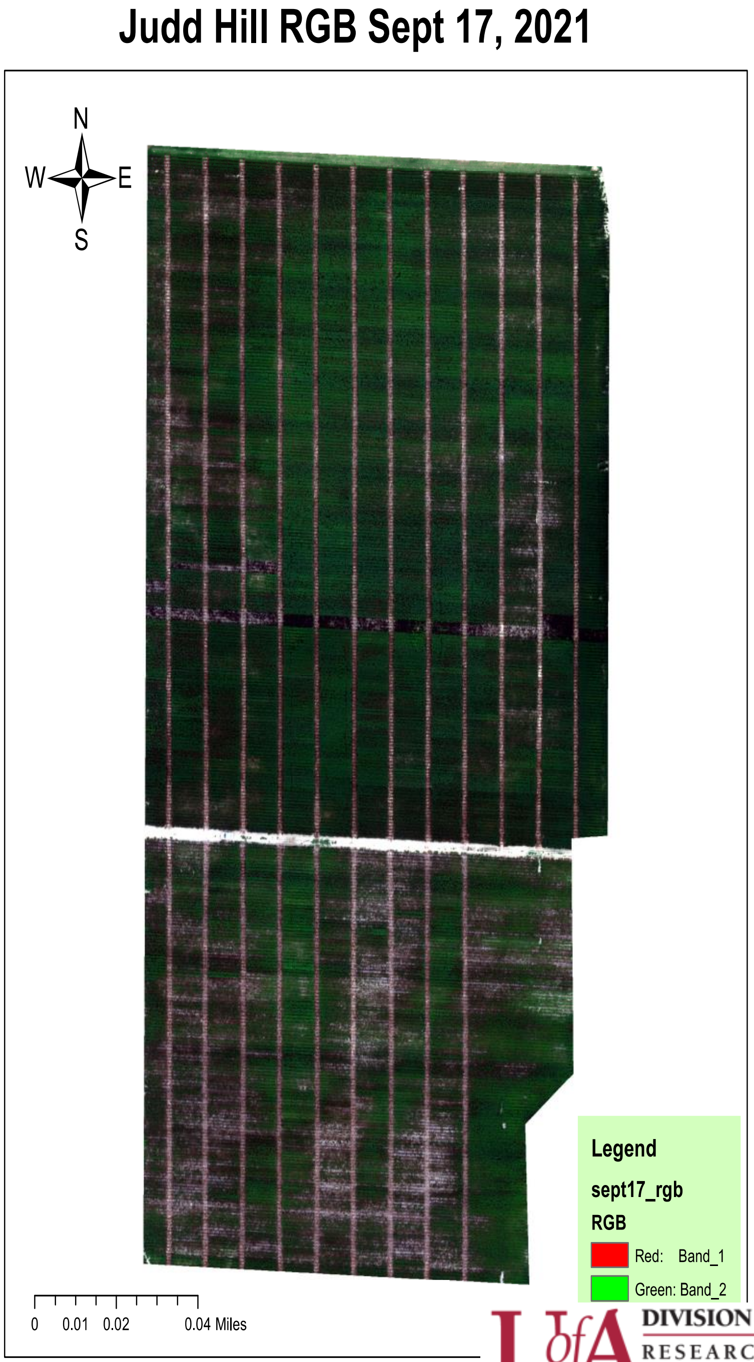

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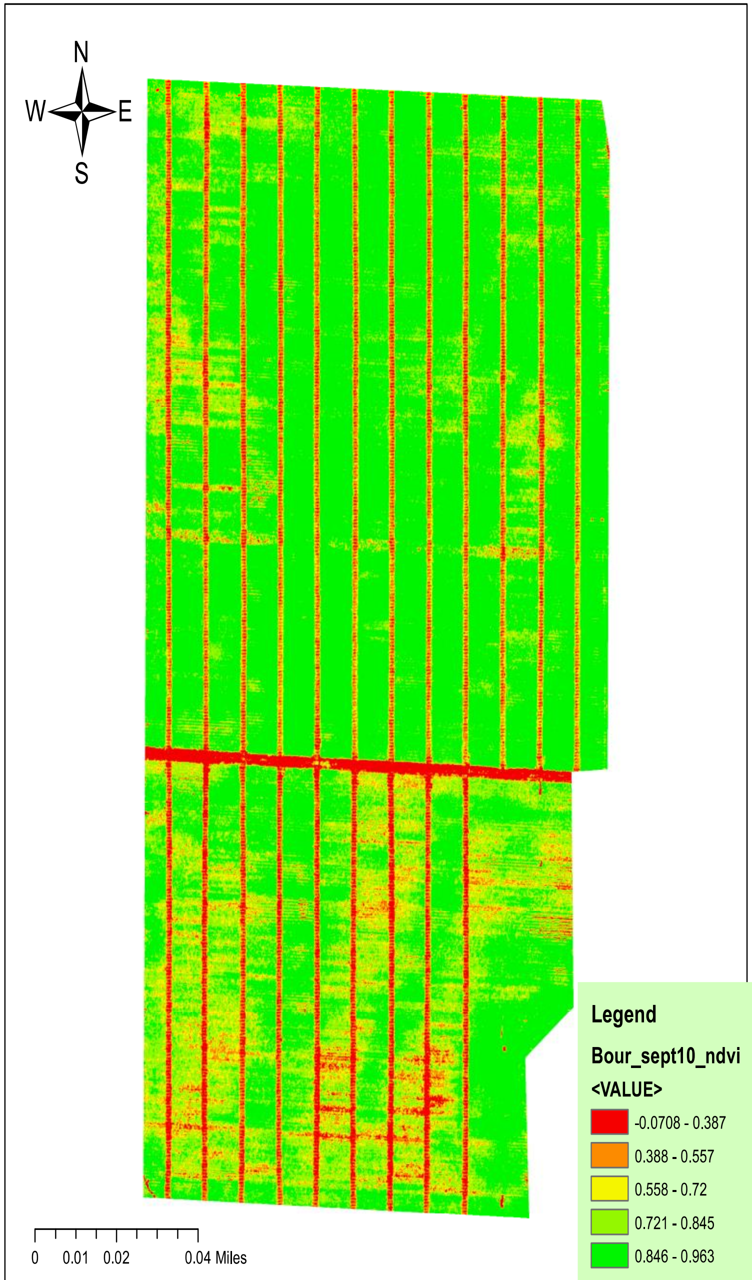
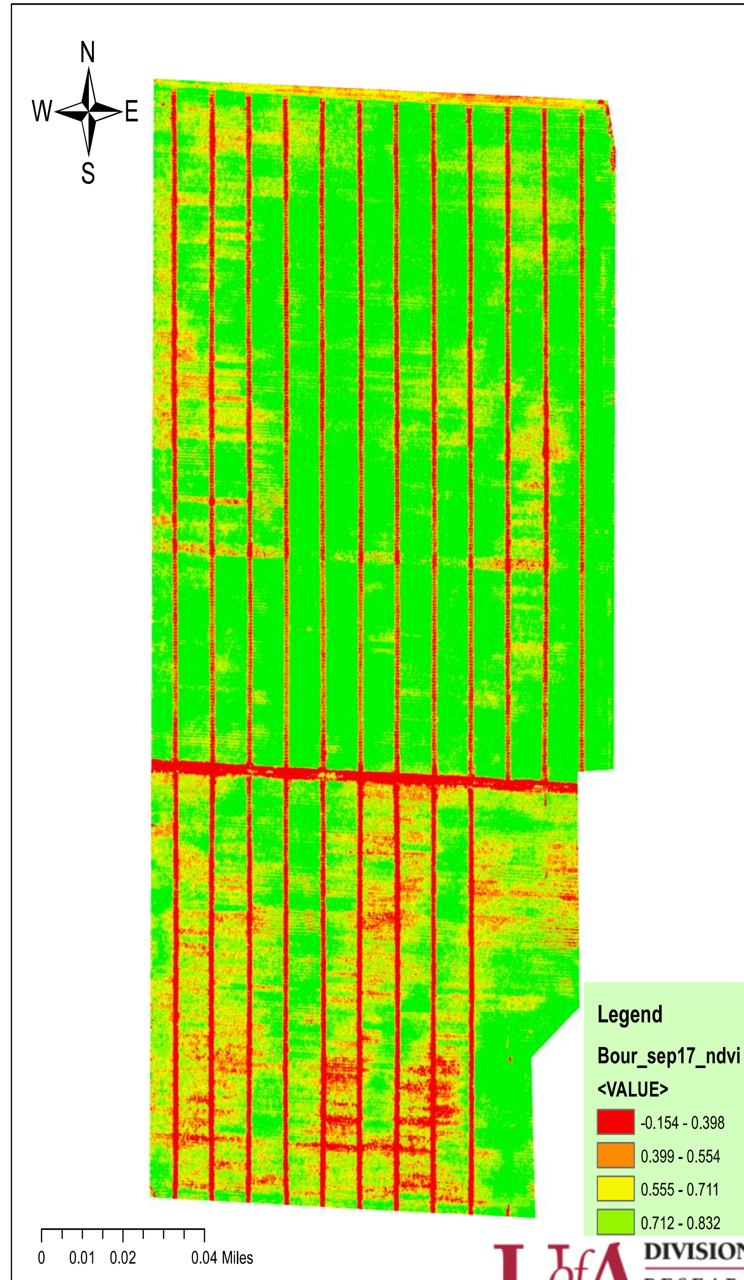
Judd Hill NDVI Sept 10, 2021



Judd Hill NDVI Sept 17, 2021



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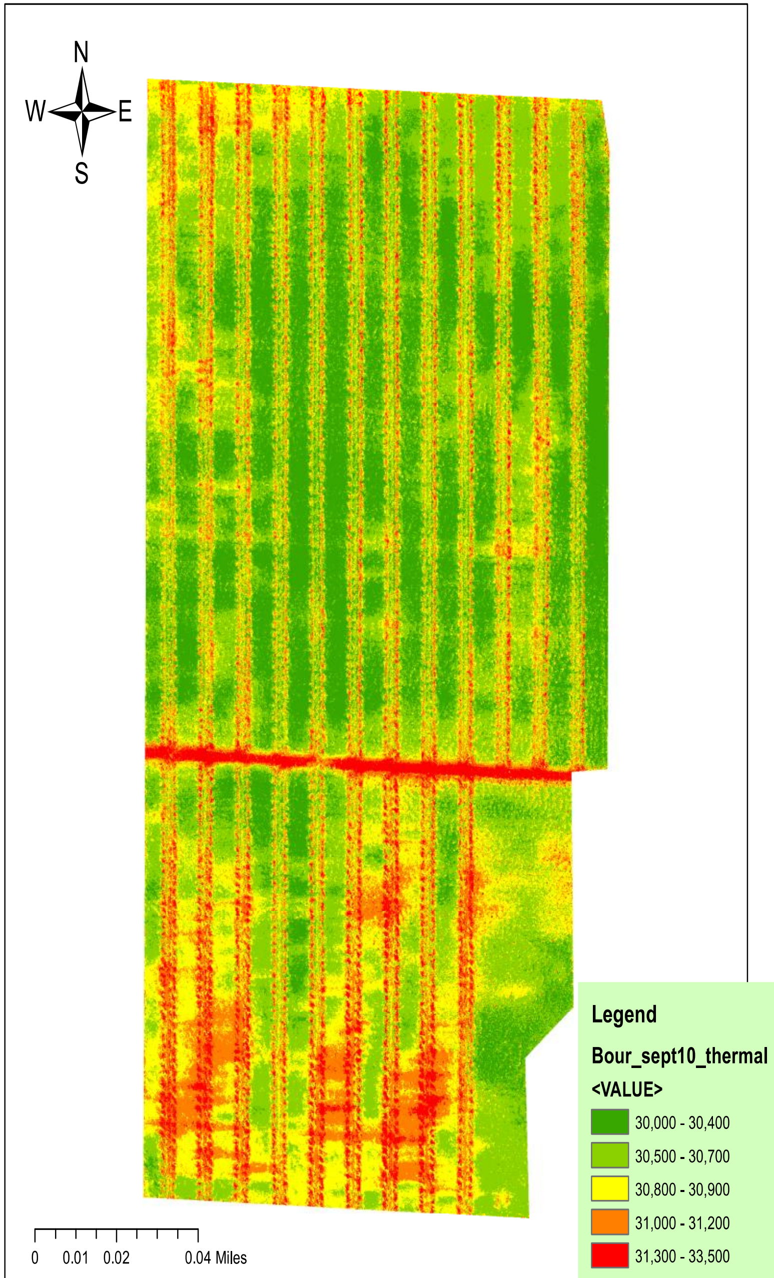
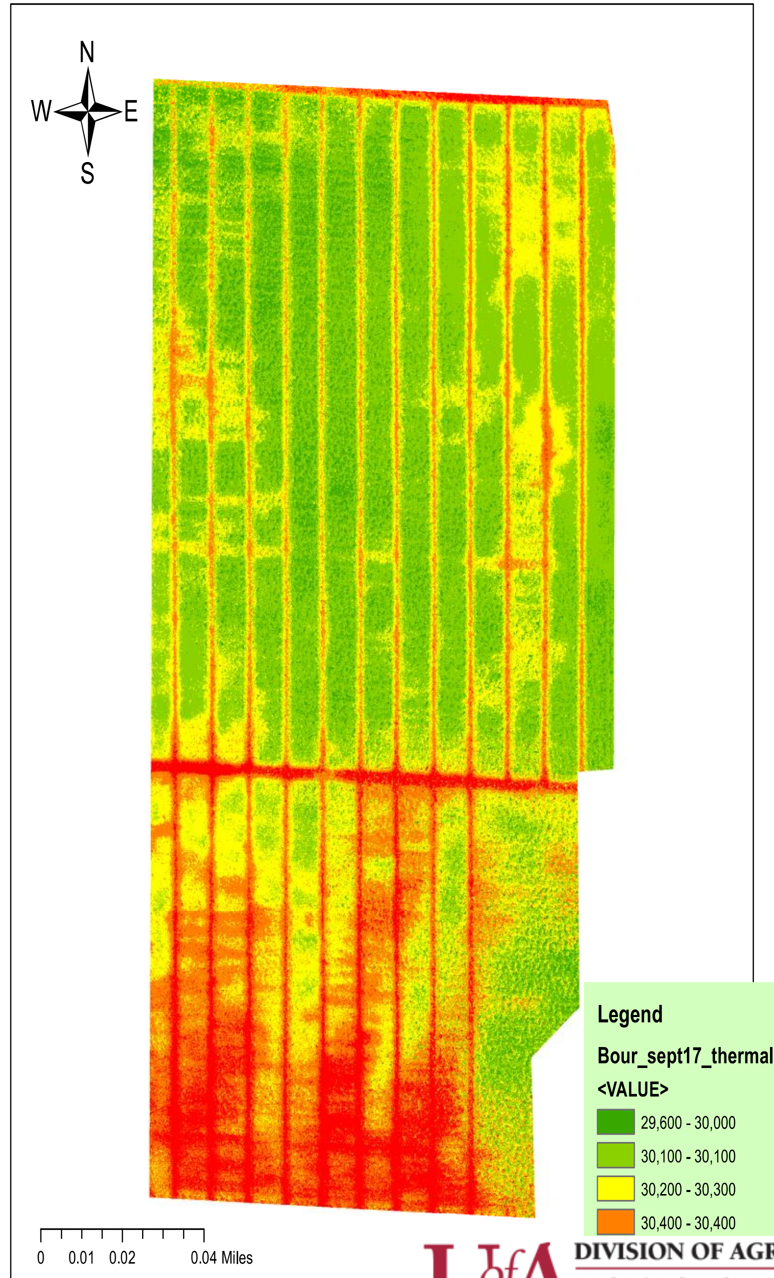
Judd Hill Thermal Sept 10, 2021



Judd Hill Thermal Sept 17, 2021



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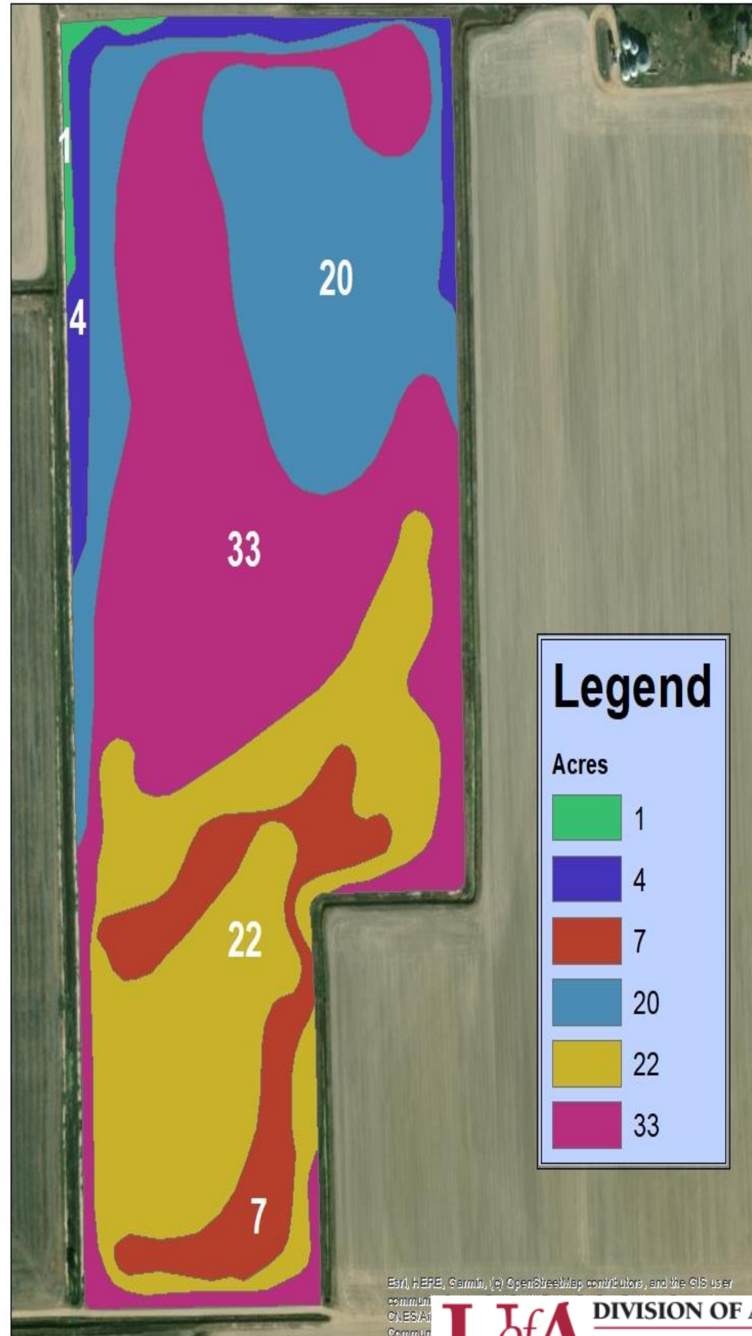

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NRCS

Mike Hamilton

mhamilton@uada.edu

870-919-5061

Twitter @themikehamilton

APPENDIX D

Printouts of Slides for Current Projects Panel 2

Adam Shea, Riceland Foods


RICELAND®

Riceland Foods, Inc.

- Farmer-owned cooperative, est. 1921
- 5,500 members (farmers & landowners)
- Handle rice and soybeans
- Largest rice milling and marketing cooperative in the world
    - 22 drier locations (procurement facilities)
    - 7 rice mills throughout Arkansas & Missouri
    - 1 soybean crush plant

Supply Chain Positioning

Our cooperative structure gives us unique position, in that we fit multiple sectors of the agriculture supply chain. This really gives us the ability to provide transparency from "farm to table"

UNITED USA WE GROW®

Ingrain Good

Riceland Sustainability Initiative

Est. June 2020

The Ingrain Good logo stands for more than just rice, ducks, and water. It represents the larger picture of sustainability and depicts an ecosystem that depends on the stewardship of rice farmers across the country

Cycle of Life

Water is needed to grow rice

↓

Rice is needed to feed ducks and other migratory waterfowl

↓

Ducks depend on flooded rice fields to provide habitat and other things essential to their migration journey each year

Our Mission

"Our mission is to create value for Riceland's members, employees, customers and consumers. By prioritizing the education and adoption of sustainable practices, we will continue to improve across all sectors by reducing our carbon footprint, maximizing efficiencies, reducing consumption of natural resources and optimizing the safety and wellbeing for all people associated with our cooperative."

Data Validation

Data is key to success

- Allows us to highlight the good that's being done today
- Sheds light on opportunities to create a better tomorrow
- Provides transparency & proof of sustainability that is needed to tell our story from "farm to table"
- Allows us to narrow our focus as an organization & set sustainability goals

Water Goal: 250 Billion Gallons by 2025

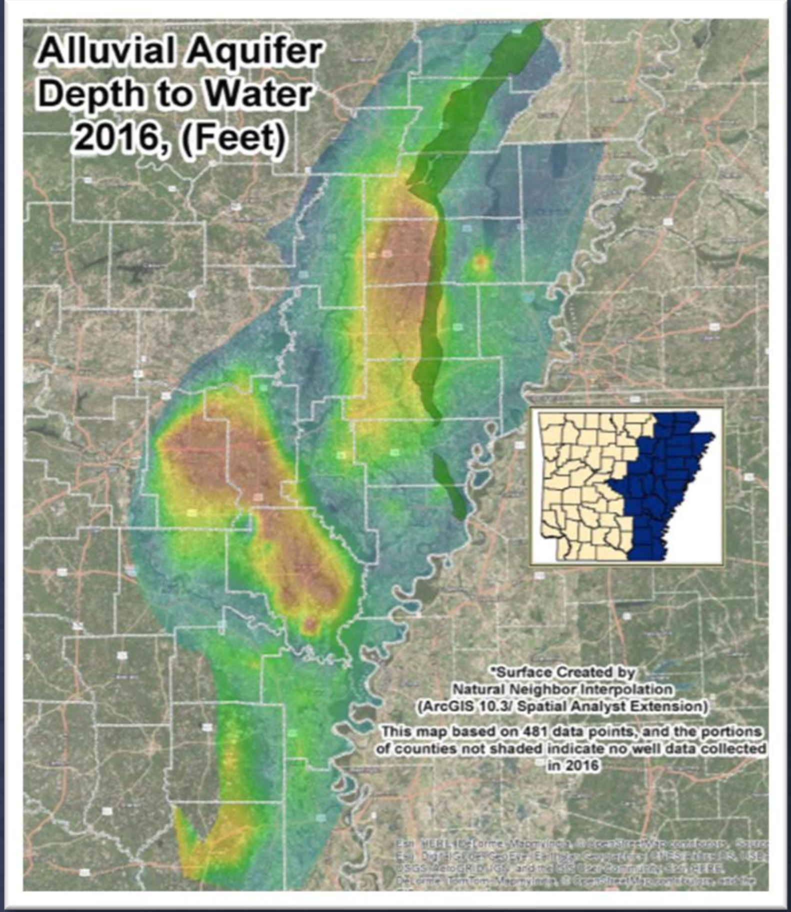
Through the promotion and implementation of sustainable irrigation practices, Riceland and its farmer-members aim to reduce the water usage in rice production by more than

250 billion gallons by 2025

Why Water

Water = Greatest Opportunity

- Critical to rice production
- Groundwater levels declining
- Offers diversity across multiple sustainability indicators



Our Role as Riceland

Our role is to promote sustainable practices that can be beneficial to our farmer members

- 100% voluntary
- Not a “one size fits all”

We realize that we are not the expert, so we aim to bring value to our members by collaborating with organizations who can help provide resources and information on how our members can increase efficiency on their farm

Alternative Wetting and Drying (AWD)

- We continue to see the adoption of AWD increase. While the number of people hasn’t increased as much over the past couple of years, the total acres have increased – leading us to believe many farmers are starting small and increasing acres as they become more comfortable.

RICELAND®

Water Conservation

Almost 50% of our members have invested in a Tail Water Recovery system, enabling them to capture excess water and reuse it in future irrigation cycles.

RICELAND®

Water
Use Efficiency

Almost 40% increase in adoption of more efficient irrigation methods since 2019 including:

- Furrow Irrigated Rice (Row Rice)
- Multiple Inlet Rice Irrigation (MIRI)
- Zero Grade

RICELAND®

Value Proposition

Ultimately, we're looking to identify sustainable practices that will make a positive impact on the environment while also generating value for Riceland and our farmer-members

By tracking and reporting our collective progress, we will be able to provide transparency to customers and consumers and tell our cooperative story from "farm to table"

RICELAND®

+

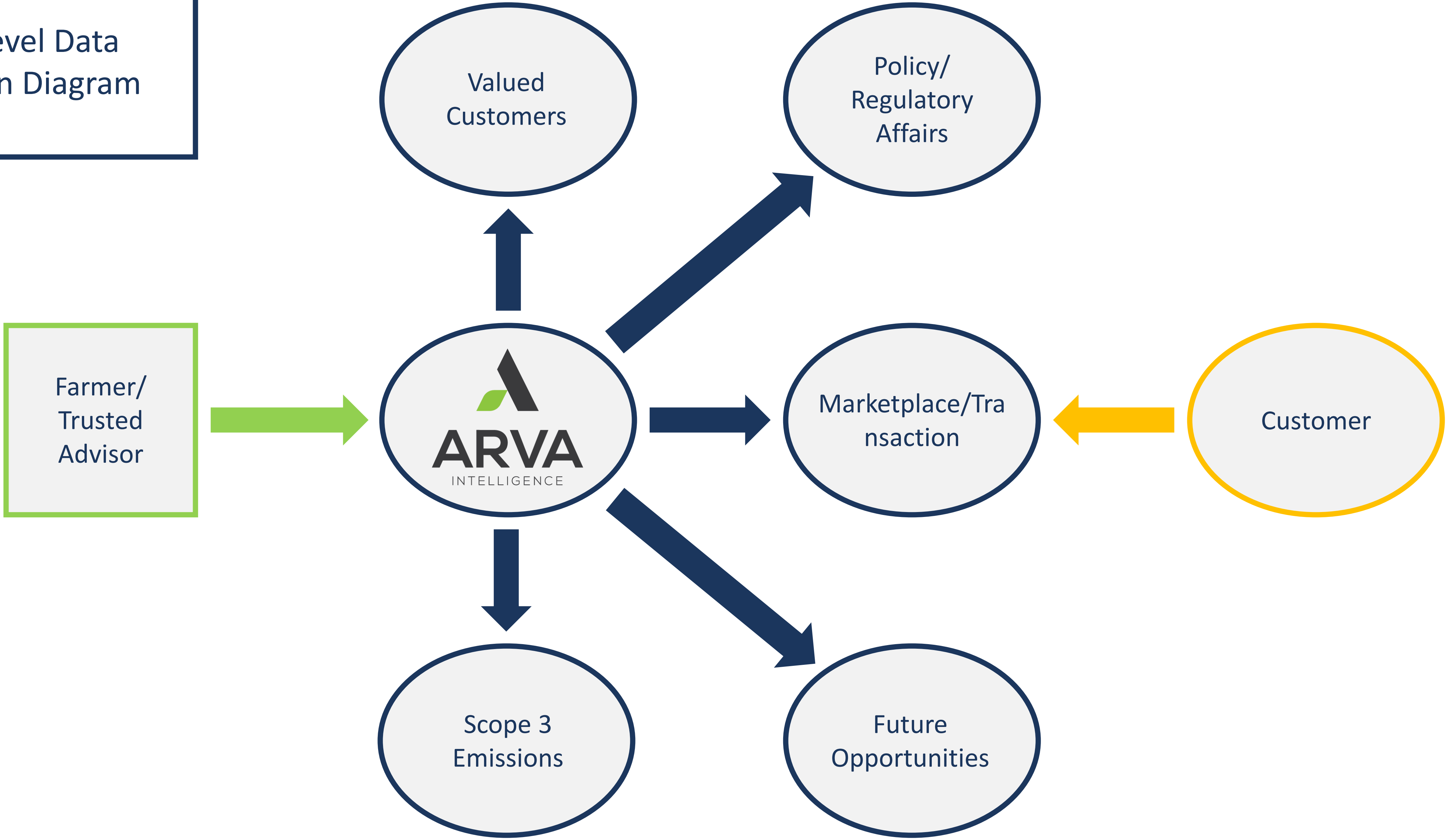
ARVA
INTELLIGENCE

Closing “The Gap”

- Problem
  - “The Gap” - This is referring to the farm level information that we need and don’t have

- Solution
  - ARVA Intelligence - The software/data repository that Arva provides will allow us to aggregate and access farm level data across the entire cooperative

Farm Level Data Ascension Diagram



“Riceland Carbon Ready Program”

- How Riceland Carbon Ready Works
  - Onboarding Process
    - Identify interested Riceland members
    - Set up accounts
    - Map field boundaries & customize
  - Begin Capturing Data
    - Interactive Carbon Ready Assessment
  - Individual Results
    - Know where you stand – “What are you playing for?”

- Carbon Ready Prepares…
  - Riceland Carbon Ready will position participating members to capitalize on the evolving environmental asset markets of the future
  - Riceland Carbon Ready will also close “the gap”, by providing the data necessary to finally leverage our unique farm-to-table position

ingrain good

ingrain good

Adam Shea
awshea@riceland.com
(870) 659-8921

Blake Forrest, Arkansas NRD Tax Credit Program

NATURAL RESOURCES
DIVISION

Groundwater Conservation Tax Credit Program

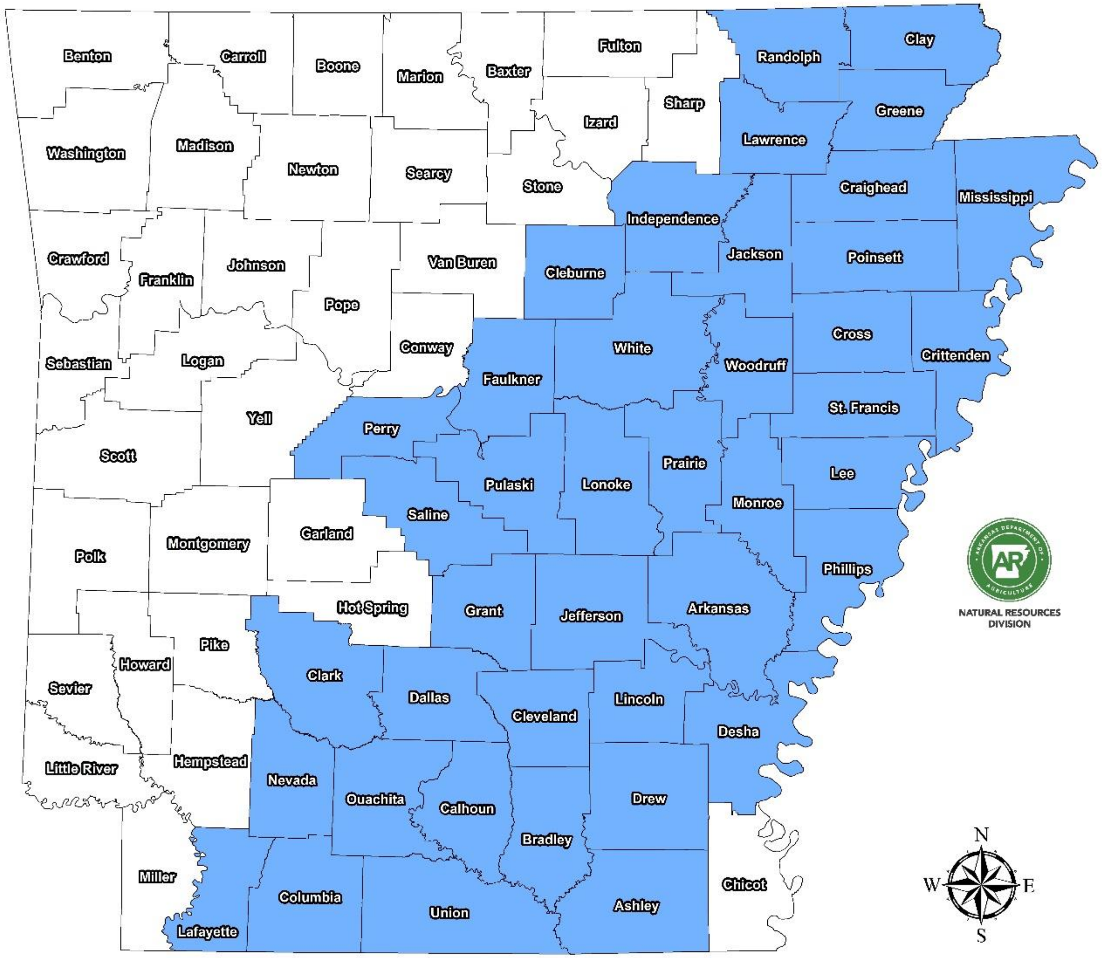
Program Overview

- Title 14 Water Resource Conservation and Incentives Act.
    - Purpose: to encourage water users to invest in practices that reduce groundwater use by utlitizing surface water resources and improving irrigation efficiency.
    - Currently applies to reservoir/impoundment construction, installation or restoration, land leveling, and surface water conversion projects, and water meters

Program Overview

- **<u>Reservoirs</u>**:
  - Minimum 20 acre feet capacity required
  - 50% of project cost
  - Maximum credit amount: $120,000
- **<u>Land Leveling</u>:**
  - 25% of project cost
  - Maximum credit amount: $35,000
- **<u>Conversion to Surface Water</u>:**
  - 50% of project cost in a Critical Groundwater Area county
  - 25% outside a Critical Groundwater Area
  - Max credit amount: $35,000
- **<u>Water Meters</u>:**
  - 10% of project cost outside of a critical area
  - 50% within a critical area
  - Does not require pre-approval

Critical Groundwater Area for Groundwater Conservation Tax Credits



Legend

Critical Groundwater Water Area for Groundwater Conservation Tax Credits

County Boundaries

0 10 20 40 60 80 Miles

Application

- **<u>Must have</u>**:
  - Name of entity and Tax ID (farm, business, trust, corporation, partnership, etc.)
  - Farm #, Tract #, legal description of project site
  - Names and Tax IDs of persons/entities receiving tax credit and % issued to each
  - Application Fee (3% of estimated tax credit. Min $100, Max $1,500)
  - Plans, location map
    - Plans must be developed by an Arkansas registered P.E. or an agent of the USDA-NRCS
  - Estimation of groundwater use before and after project completion
  - Certified by a Conservation District Board Member
  - Signatures of all persons receiving a % of the credit
  - Notarization

Approval

- **Approval Certificate issued when:**
  - All required information on application is received
  - Dept. of Finance and Administration verifies tax info
  - NRD Director approval

- **Approval must be granted before work on the project begins**

- 5 years to complete an approved project

- Income tax credit can be claimed as soon as approval is received
  - $18,000 is the max amount that can be used in a taxable year
  - Unused credit can be carried over for a maximum of 15 years

Completion

- **<u>Project must be completed within 5 years of approval date</u>**

- **<u>Must have</u>**:
  - Break down of expenditures with receipts
  - Additional application fee (if required)
  - Inspection by P.E. or NRCS staff – signature

- If applicant has used the tax credit in the amount that exceeds the final tax credit amount, then DFA is owed the difference

- All projects must be maintained for a minimum of 10 years following issuance of completion

Example

Approval	
Estimated Project Cost:	$304,000
Cost Share Received	$160,000
Cost excluding Cost Share	$144,000
Approved Tax Credit (50%):	$72,000
Application Fee:	$1,500

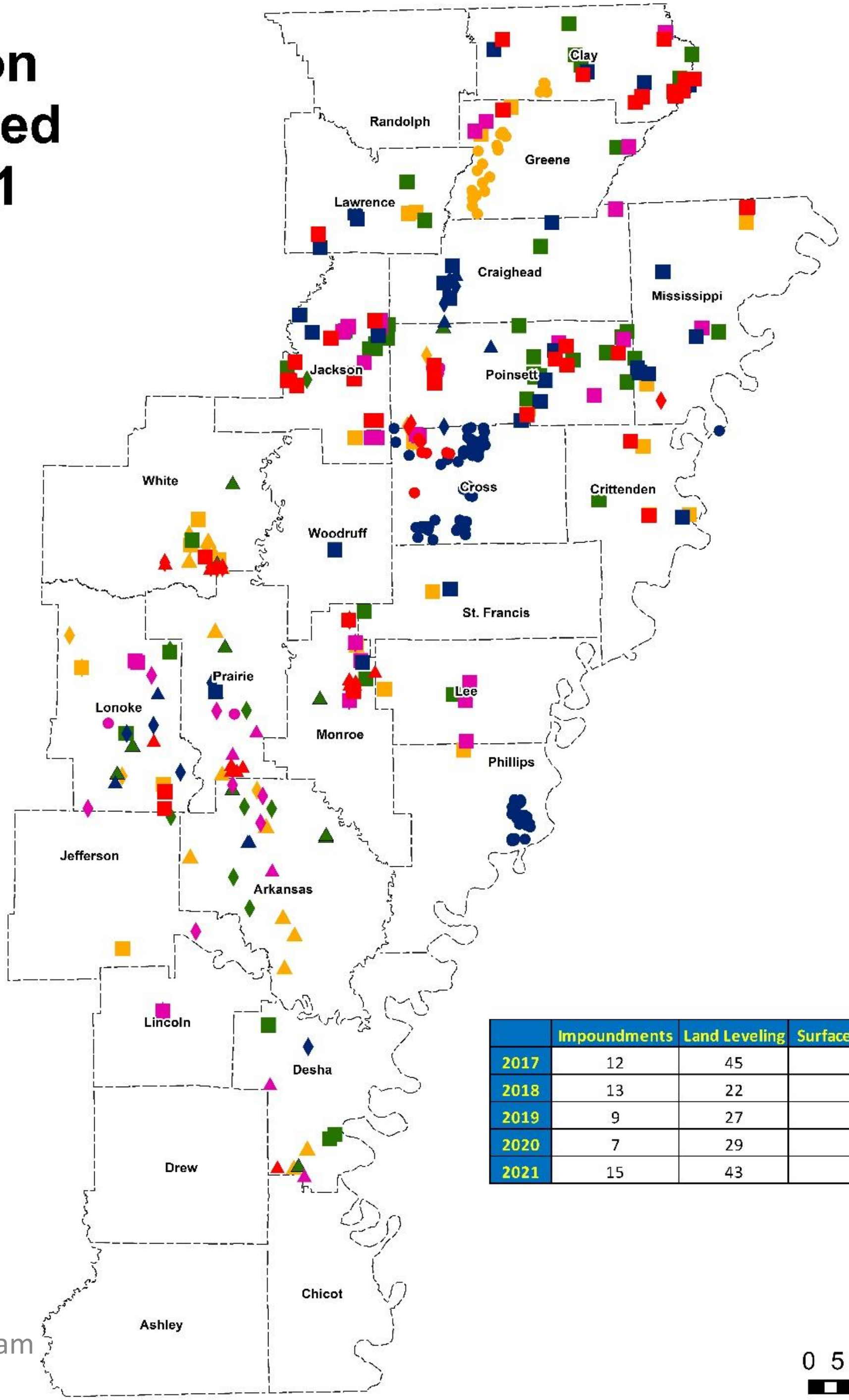
Project takes 5 years. Total approval credit is used in first 4 years, $18,000 per year.

Completion	
Total Project Cost:	$120,000
Final Tax Credit Amount:	$60,000
Difference from Approval:	$12,000
Amount owed to DFA:	$12,000

Transferability

- "An approved applicant may freely transfer ownership of a tax credit to a transferee who shall be entitled to an income tax credit only to the extent the income tax credit has not been previously used by the approved applicant" 1405.1 A

Water Conservation Tax Credits Approved from 2017 to 2021



	Impoundments	Land Leveling	Surface Water Conversions	Water Meter Installations	Total
2017	12	45	8	0	**65**
2018	13	22	15	23	**73**
2019	9	27	12	9	**57**
2020	7	29	10	80	**126**
2021	15	43	10	7	**75**

Project Type:

- ● Water Meters
- ▲ Impoundments
- ■ Land Leveling
- ♦ Surface Water Conversions

Year:

Red - 2021
Blue - 2020
Pink - 2019
Yellow - 2018
Green - 2017