
Water Conservation Planning: How a Systems Approach to Irrigation Promotes Sustainable Water Use

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By 2050 there will be 9 billion people on this planet, representing a need to increase food production by 70%. How can we meet that demand for food without damaging the environment? For if we meet the food need in an environmentally unsound manner, then it will not be sustainable. This is the challenge for today as we plan for tomorrow.

I (MES) lead the Natural Resources Conservation Service (NRCS) in Arkansas. A federal agency within USDA, NRCS was born during the dust bowls of the 1930s when our mission was to conserve our nation's soils. We have been very effective in this role. Between 1982 and 2007, soil erosion on US cropland decreased 43%. Water erosion (sheet and rill¹) on cropland in 2007 declined from 1.68 billion tons per year to 960 million tons per year, and erosion due to wind declined from 1.38 billion tons per year to 765 million tons per year (US Department of Agriculture, 2007). Water-erosion rates on cropland dropped from 4.0 tons per acre per year in 1982 to 2.7 tons per acre per year in 2007. Wind-erosion rates dropped from 3.3 to 2.1 tons per acre per year for the same time period. Declines in soil-erosion rates have moderated somewhat since 1997, but the general downward trend in both water and wind erosion continued through 2007.

Since the inception of the NRCS, our focus has expanded to include nine major resource concerns, which include not only soil erosion, but also soil condition, water quantity, water quality, air quality, plant condition, fish and wildlife, domestic animals,

¹Sheet erosion is the planar removal of surface soil by the action of either raindrop splash, shallow flows of surface of water, or even by wind. Rill erosion is usually linked with sheet (water driven) erosion as the shallow flows of water driving sheet erosion tend to coalesce and thus increase both in velocity and scouring capacity.

and energy. In 1994, our name was changed from the US Soil Conservation Service to better reflect our expanded conservation roles. We are a unique agency in that we work on private lands with private land owners. Our mission statement is “Helping People Help the Land,” which we accomplish by addressing the resource concerns of landowners throughout the United States.

In Arkansas, we work with a multitude of partners including the Arkansas Natural Resources Commission, University of Arkansas Extension, and the Arkansas Association of Conservation Districts. Locally we have 62 Field Service Centers that have responsibilities for all 72 counties in the state. The staff usually consists of a district conservationist and likely a soil conservationist and, in some cases, a soil-conservation technician. In addition to our Field Service Centers, we have specialists who can provide more detailed support at various levels.

WATER NEEDS IN ARKANSAS

Only 3% of the earth’s water is freshwater, upon which there are various demands. World-wide, agriculture uses approximately 70% of the freshwater (Steduto *et al.*, 2012). In the United States, Arkansas ranks in the top five for irrigation-water withdrawals (Figure 1) (United States Geologic Survey, undated). Of the water used in Arkansas, agriculture accounts for 76% (United States Geologic Survey, undated). However, Arkansas is a water-rich state; water availability and sustainability are the important issues.

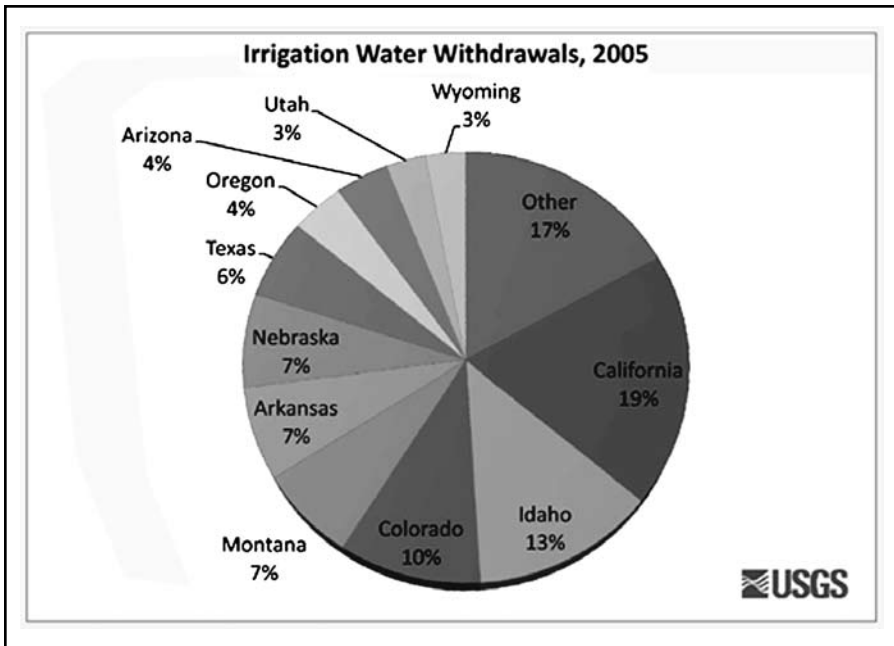


Figure 1. Irrigation-water use by state.

According to the Arkansas Legislative Policy on the State Water Plan:

15-22-201. Declaration of policy.

(a) It is in the best interest of the people of the State of Arkansas to have a water policy that recognizes the vital importance of water to the prosperity and health of both people and their natural surroundings.

(b) Preserving water of a sufficient quality and quantity will allow Arkansas to be known both as a natural state and a land of opportunity where agriculture, industry, tourism, and recreation will remain strong for future generations.

(c) It is declared to be the policy of the State of Arkansas to encourage best management practices and reliable data to provide scientific methods for managing and conserving water for future use in recognition of the facts that:

(1) Arkansas has annual rainfall providing surplus surface water for the use of persons in this state, while continuing to provide water for wildlife habitat, recreation, industry, agriculture, and commerce;

(2) In many instances much of this surplus water is now underutilized;

(3) The groundwater supplies of the state are being used at a rate that will result in valuable water aquifers being destroyed, harming both the general public and the private property rights of those owning property in this state; and

(4) Surface water and ground water supplies must be managed together for maximum effect.

(d) It is declared to be the purpose of this subchapter to permit and regulate the construction of facilities to use surplus surface water in order to, without limitation:

(1) Protect critical groundwater supplies that are a significant source of the drinking water supply for thousands of people in Arkansas;

(2) Protect the rights of all persons equitably and reasonably interested in the use and disposition of water;

(3) Maintain healthy in-stream flows for all streams and rivers;

(4) Prevent harmful overflows and flooding; and

(5) Conserve the natural resources of the State of Arkansas.

The majority of irrigation water use is, and has always been, groundwater. Wells have been used in irrigation since the early 1900s. Groundwater levels have been documented as in decline since the late 1920s. Arkansas uses 7.2 billion gallons per day, equivalent to 10,000 Olympic-sized swimming pools daily. This water comes from one primary aquifer

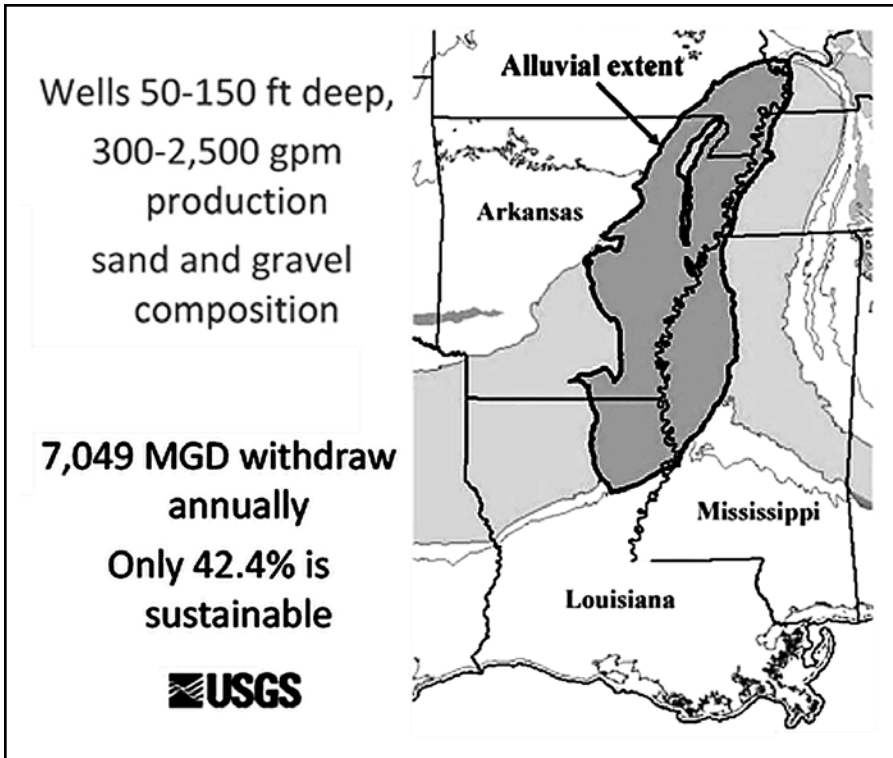


Figure 2. Mississippi River Alluvial Aquifer.

and one secondary aquifer. The Alluvial Aquifer, mostly recharged from the Mississippi, White, Arkansas and other major rivers, does not provide high-quality drinking water and supplies wells that are generally 50- to 150-feet deep. The secondary aquifer, the Sparta Aquifer, is below the Alluvial Aquifer and is a source of high-quality municipal and industrial water,

In Arkansas, groundwater levels are declining in response to continued withdrawals, at rates that are not sustainable. Based on 2008 water-use data, only 43% of the current withdrawal from the Alluvial Aquifer is sustainable. Ninety-six percent of the ground-water pumped from the Alluvial Aquifer is used for agriculture. At these pumping rates, water-level declines and adverse impacts on the state's groundwater system will continue.

The Arkansas Natural Resources Commission's (ANRC) "Arkansas Ground-Water Protection and Management Report for 2010" documents areas where excessive withdrawals have led to cones of depression of the groundwater level. Without an adequate solution to the region's groundwater problems, studies predict that the Alluvial Aquifer will be commercially useless by 2015. Figure 3 (Figure 5 in the ANRC Report) shows current depths to water.

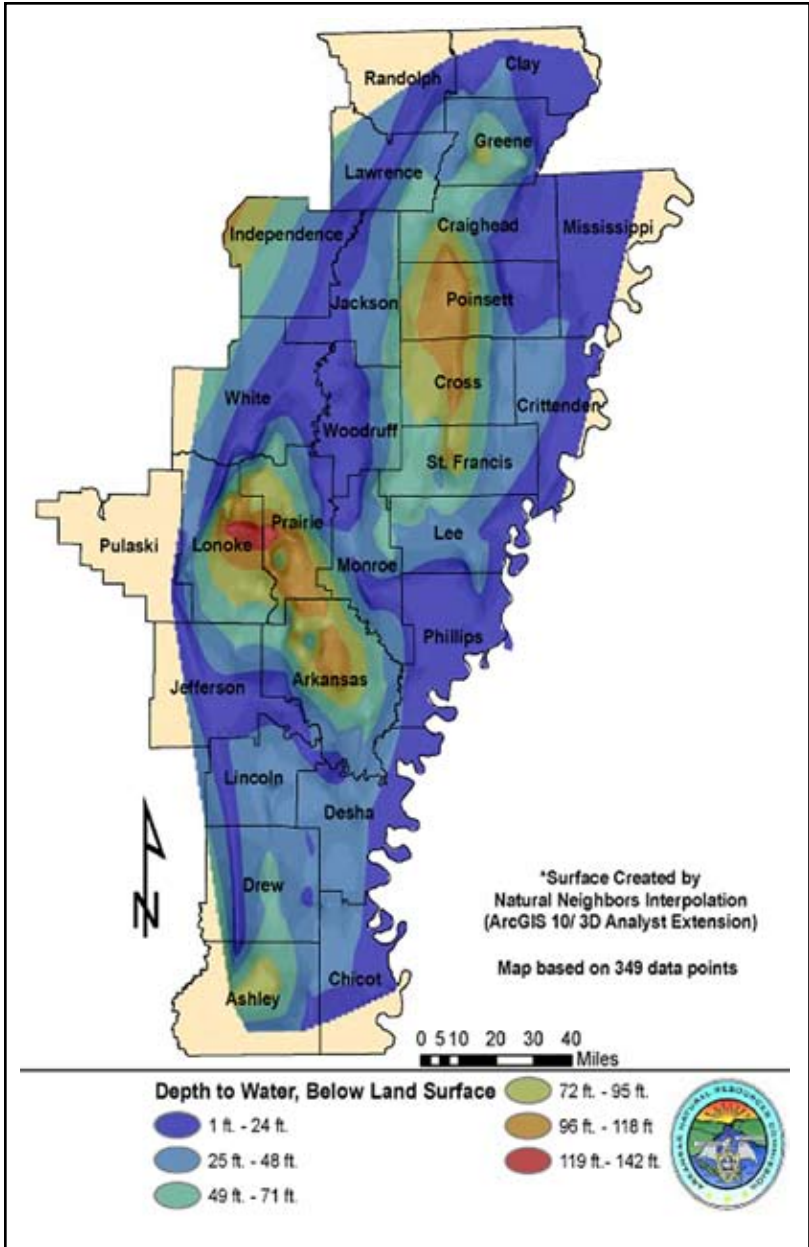


Figure 3. Alluvial Aquifer depth to water, 2010.

Because of these issues, The ANRC recently designated two additional areas of the Alluvial Aquifer as critical groundwater areas (Figure 4) (Figure 3 of the ANRC Report). This designation recognizes the existence of the water-quantity problem and encourages interested local entities to develop plans of action to address the problems. Part of the designation is to encourage federal agencies to focus financial resources in the designated areas to help conserve groundwater.

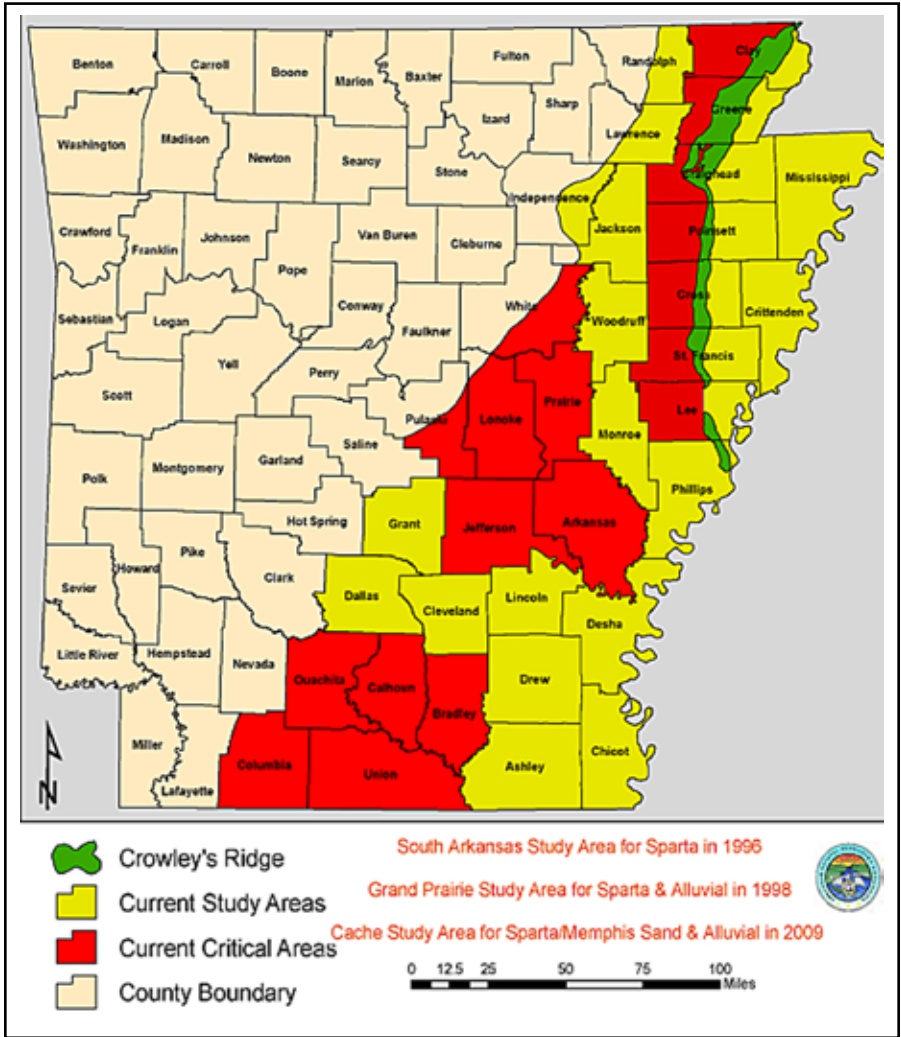


Figure 4. Critical groundwater designations.

NRCS APPROACH TO CONSERVE WATER

The State Water Management Plan and NRCS planning encourage the use of surface water. Preventing further declines will require converting groundwater systems to excess surface-water systems for 50% of their water sources. Pieces of conservation may target a small aspect of the issues, but complete systems work toward solving the issue instead of band-aiding the problem. Irrigation water conservation practices are a major component in the process of reducing groundwater use when applied as a complete system.

Figure 5 illustrates a systems approach to irrigation-water management, showing where water is being used and where improvements can be made. A complete inventory, evaluation, and scheduling of water delivery allows producers to make the best use of their water resources and minimize inefficient use of ground or surface water. Typically, NRCS plans to have 50% of the water needs stored in large reservoirs, 25% of the crop needs supplied through surface runoff during the growing season, and a supplementary 25% of the water supplied through wells.

The solid line in Figure 5 separates irrigation water supply and irrigation water recovery. A complete system always includes practices on both sides of the line. Starting anywhere on the wheel eventually returns you to where you start. The goal of sustainable irrigation water use is to reuse every drop of water multiple times.

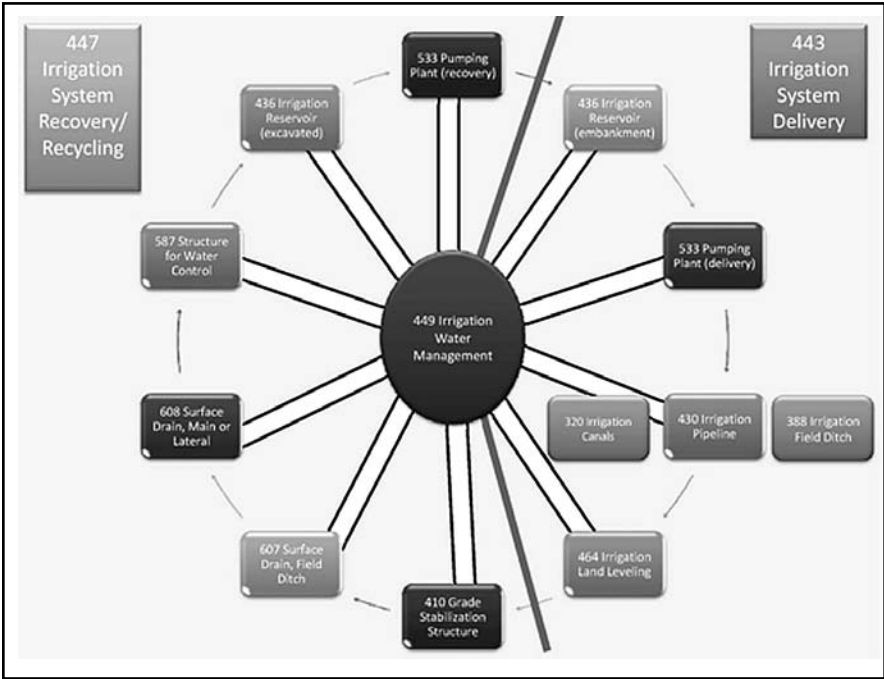


Figure 5. Irrigation water management.

The first practice and the lynchpin of the system is the irrigation reservoir, the purpose of which is to store large quantities of water (Figure 6). Ideally the reservoir is full during the non-growing season and replenished during the growing season from runoff from inefficient upstream systems and rainwater runoff.

Pumping plants pull water from reservoirs and send it to desired locations (Figure 7). They are used on both the supply and recovery sides of the solid line in Figure 5. Irrigation pipelines supply the water to fields (Figure 8).



Figure 6. Irrigation storage reservoir.



Figure 7. Electric pumping plant.



Figure 8. Robin Frazier (NRCS) checks out a pipeline.

Land leveling improves the flow of irrigation water by grading to either a very gentle slope or no slope at all. The goal is to minimize runoff and provide uniform distribution of water across the field. Leveling plays a major role in improving water-use efficiency and reducing soil erosion. At the end of the field, any extra water crosses the solid line (Figure 5) from irrigation water supply to irrigation tailwater recovery. A grade-stabilization structure at the end of the field drops water from the field to the tailwater-recovery system. This controls the water flow from the field and avoids erosion (Figure 9).

The water-control structure directs flow into or out of the excavated irrigation reservoir. The excavated irrigation reservoir is a basin to regulate water supply to the pump before sending it to a larger storage reservoir or to the field. These basins are usually pre-existing ditches that have been enlarged to allow long pump periods. A second pumping plant is used to pull water from the excavated reservoir for storage in the above-ground reservoir; many times it doubles as the delivery pump and reduces the system to a single pump.

Field ditches collect excess irrigation water (Figure 10).

CONSERVATION BENEFITS

On-farm water conservation practices have saved roughly 200,000 acre feet of water over the past 5 years in the critical groundwater area of Arkansas. On-farm conservation systems in Arkansas typically replace 25% to 50% of valuable groundwater with excess

surface water. In one local project, 243 conservation systems are saving 36,600 acre-feet of ground water on 89,600 irrigated acres of farmland yearly. An aerial photo from this project illustrates how they fit on the landscape (Figure 11, Charolette Bowie, NRCS Arkansas data, personal communication).



Figure 9. Grade-stabilization structure, water-control structure, and excavated storage reservoir.



Figure 10. A surface drain.

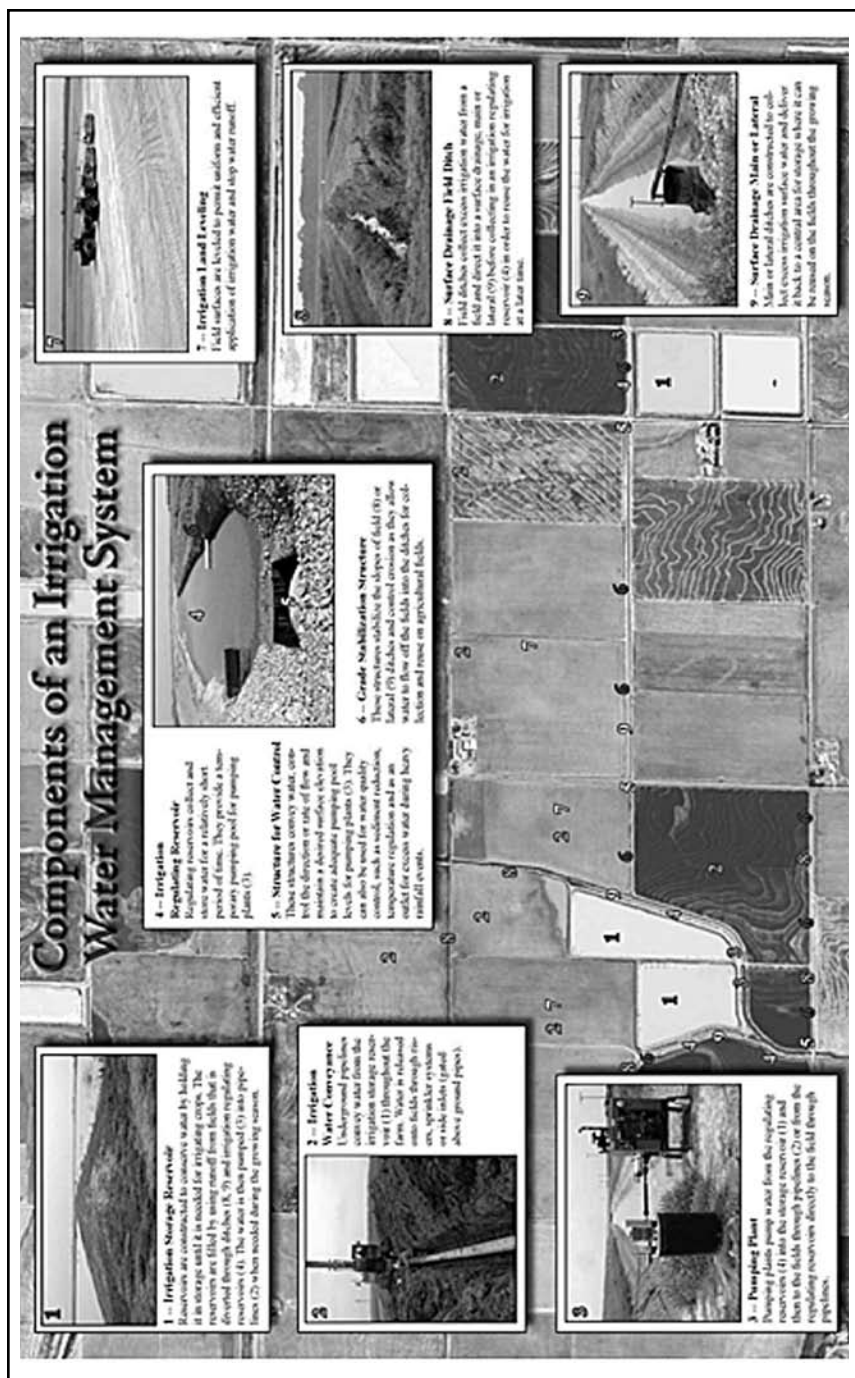


Figure 11. Aerial photograph of an irrigation system.

This system approach fosters sustainable use of Arkansas' surface water and groundwater. Groundwater usage becomes more sustainable. Every gallon of what is recovered is a gallon that does not have to be pumped from the declining groundwater.

SECONDARY BENEFIT: IMPROVED WATER QUALITY

The system approach not only sustains the groundwater, but it also provides water-quality and energy benefits.

Runoff water moves sediment and adsorbed phosphorus as well as dissolved nitrogen and phosphorus to the receiving waters. The irrigation-conservation practices minimize or eliminate runoff from irrigated fields. Every drop of water that does not run off to a receiving stream reduces loss of nutrients and transfer of sediment.

Tailwater recovery systems that include irrigation-storage reservoirs capture 100% of nutrient-laden water and sediment. In storage reservoirs, excess nitrogen is volatilized and adsorbed phosphorus sinks with the sediment.

Land leveling has been shown to significantly decrease erosion while grade-stabilization structures drop the water from the field into the reservoir and prevent gully erosion. Irrigation pipelines ensure efficient delivery, allowing water to reach all locations within the field at the same time, thereby reducing runoff and erosion.

In addition to water-quality benefits, conversion to surface water from groundwater reduces the use of energy. The energy needed to pump water from a 150-foot well is 6 times as much as from a 25-foot deep canal and reservoir system.

NEW TECHNOLOGIES

NRCS encourages adoption of new technologies to improve water conservation, some of which are:

- Phaucet software, which allows irrigators to determine the hole size in polyethylene pipe translating into more even water distribution and less runoff.
- Automatic controls allow remote control and:
 - Monitoring of water levels in reservoirs and tailwater recovery ditches
 - Turning pumps on and off
 - Monitoring of pumping-plant efficiencies
 - Control by computer or smart phone.
- Pumping plant evaluations to:
 - Determine peak efficiencies of pump and power units
 - Reduce fuel costs.

PROGRAMS THAT HAVE IMPACTED WATER QUANTITY AND WATER QUALITY

In a perfect world everyone would install these practices for the good of the country. However, we do not live in a perfect world, so many producers need a financial incentive

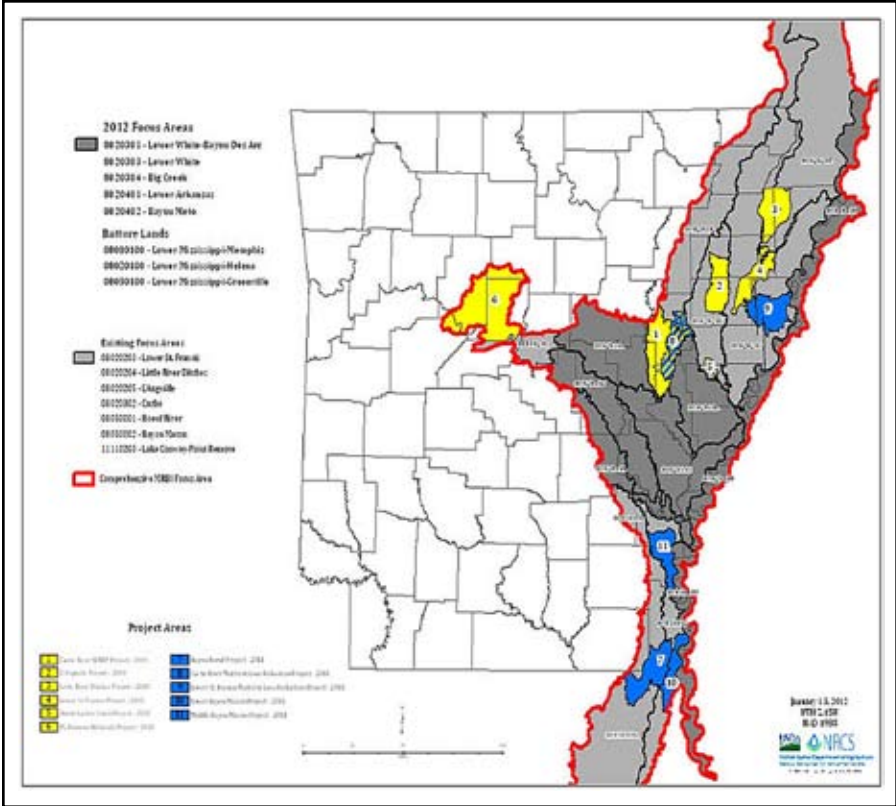


Figure 12. Mississippi River Basin Initiative, focus areas, 2012, Arkansas.

to adopt these practices. NRCS operates the Environmental Quality Incentives Program (EQIP) for a host of practices promoting environmental quality and enhancing agricultural production for local producers.

In 2011, NRCS provided \$26.7 million for these practices, scattered across the state. We have recognized that targeting money to a specific watershed is much more effective than “random acts of conservation.” One of the ways we have done this is through special initiatives within EQIP. The Mississippi River Basin Initiative targets specific watersheds for specific water-quality practices (Figure 12, Figure 13).

CONCLUSION

NRCS’s focus is to help individual landowners implement conservation practices across the landscape and in targeted locations. By providing technical and financial assistance, NRCS in Arkansas is helping people help the land and move toward water sustainability in agriculture.

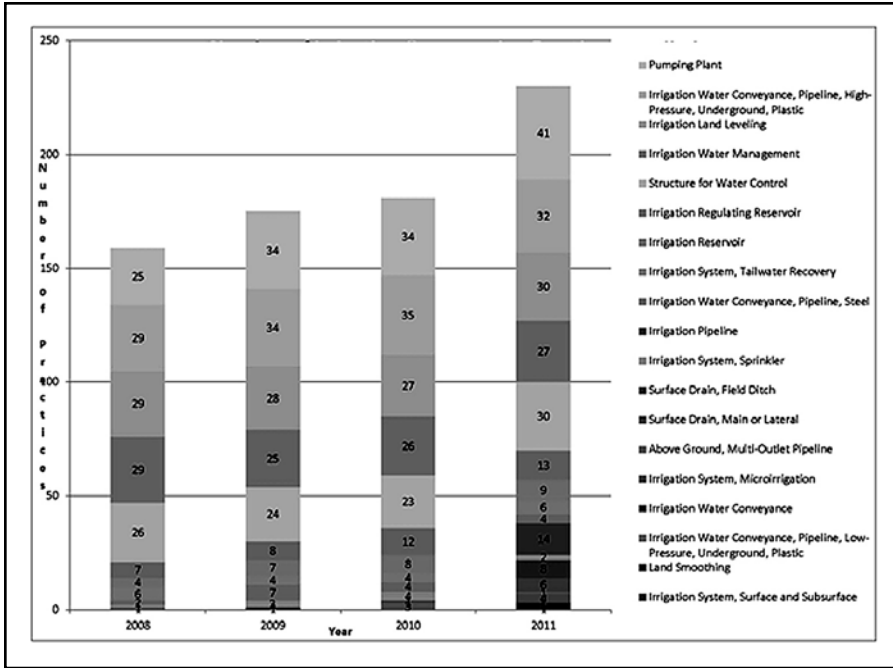


Figure 13. Number of irrigation conservation practices installed.

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MICHAEL SULLIVAN began his career with the Natural Resources Conservation Service (NRCS) as a student trainee in Lincoln, Nebraska, and then served in Arkansas, Mississippi and Arizona. As state conservationist, he leads NRCS activities throughout Arkansas. From 2004 to 2009, he served as leader of the Mississippi River Basin Healthy Watersheds Initiative, an \$80 million per year effort to improve water quality, enhance wildlife habitat, and maintain agricultural productivity. He provided national leadership for partnering with the US Army Corps of Engineers and served as lead staff support to the USDA Deputy Undersecretary providing input for the Mississippi River/Gulf Hypoxia Task Force. Sullivan spent two years (2002–2004) as the NRCS National Science and Technology Coordinator. Prior to that, he worked in Little Rock, establishing and leading the NRCS National Water Management Center. He has a Bachelor's degree in civil engineering from the University of Arkansas and a Master's in business administration from Arizona State University.