DRAFT – 201 ACTION PLAN – 6/2/06
ARS Water Resource Management National Program (201)
Action Plan
FY 2006-2010

This draft 201 Action Plan applies to 48 Project Plans that will begin on or about October 1, 2006. An updated version of this Action Plan will be completed in June 2006, and a final version of the Action Plan will be published in October 2006. This is the official version that appears on the website, http://www.ars.usda.gov/research/programs/programs.htm.

Vision
Integrated, Effective, and Safe Water Resource Management

Mission
The mission of this National Program is twofold: (1) to conduct fundamental and applied research on the processes that control water availability and quality for the health and economic growth of the American people, and (2) to develop new and improved technologies for managing the Nation's agricultural water resources. These advances in knowledge and technologies will provide producers, action agencies, local communities, and resource advisors with the practices, tools, models, and decision support systems they need to improve water conservation and water use efficiency in agriculture, enhance water quality, protect rural and urban communities from the ravages of droughts and floods, improve agricultural and urban watersheds, and prevent the degradation of riparian areas, wetlands, and stream corridors. The rationale for this program is that water is fundamental to life and is a basic requirement for virtually all of our agricultural, industrial, urban, and recreational activities, as well as the sustained health of the natural environment.

Background
There is no substitute for fresh water nor are there replacements for its essential role in maintaining human health, agriculture, industry, and ecosystem integrity. Throughout history, a key measure of civilization’s success has been the degree to which human ingenuity has harnessed freshwater resources for the public good.

As the Nation was established and expanding, it flourished in part because of its abundant and readily available water and natural resources. With expansion to the arid west, investments in the use of limited water resources became critical to economic growth and prosperity. In the 19th century, water supplies for new cities were secured by building reservoirs and water distribution systems. The 20th century was characterized by pivotal accomplishments in U.S. water resource development and engineering. Investments in dams, water infrastructure, irrigation and water treatment provided safe, abundant, and inexpensive sources of water, aided flood management and soil conservation, and dramatically improved hygiene, health, and economic prosperity. The U.S. water resources and its water technologies were the envy of the world.

As we begin the 21st century the situation is much different for the U.S., and indeed for the world. Depleted ground water reserves, degraded water quality, and adverse climate conditions are reducing the amount of available freshwater. At the same time, allocations of our freshwater resources are shifting among different users and different needs: e.g., from agricultural use to consumption by cities, from storing water supplies in reservoirs to maintaining in-stream flows to support healthy aquatic ecosystems, from industrial and energy production to recreation. Our shared freshwater supply has been significantly reduced in the past century and is becoming more variable, unreliable, and inadequate to meet the needs and demands of an expanding population

Water-related science and technology have served our Nation very well. We have built infrastructure that provides safe drinking water to our cities, irrigation used to grow a large portion of our Nation's food supply, water for industry, and the means to keep waterways navigable. Through improved waste treatment technology, we have made great strides in improving water quality, and have protected and enhanced waterways to provide habitat for aquatic organisms and recreational opportunities for the public.

Today, the agricultural and energy sectors are the two largest users of water in the U.S. Some of the water use is consumptive; water is lost through crop water use or evaporation from cooling. When freshwater and saline water withdrawals for thermoelectric uses are combined with hydropower uses, the energy sector is the largest water use sector. When only freshwater withdrawals are considered, agriculture is clearly the largest user of water and the least understood in terms of opportunities for conserving water supplies and improving water quality for drinking, swimming, and fishing.

Agriculture faces new challenges: increasing demand for water for our cities, farms, and aquatic ecosystems; increasing reliance on irrigated agriculture for crop and animal production and farm income; changing supplies due to ground water depletion in some areas and due to climate variability and change globally. These challenges are not insurmountable. Science can provide tools needed by water planners and managers to accurately predict outcomes of their possible decisions, and new technologies can widen the range of options for future water management. The factual basis for decision-making includes an understanding of effectiveness, potential unintended consequences, and a plan for getting water users and agencies to adopt the most effective technologies. The Nation has the opportunity to use science and technology to build a strong economy and to improve human and ecological health.

Goal

The goal of the Water Resource Management National Program (201) is to effectively and safely manage water resources while protecting the environment and human and animal health. This goal will be achieved by characterizing potential hazards; developing management practices, strategies and systems to alleviate problems; and providing practices, technologies and decision support tools for the benefit of customers, stakeholders, partners, and product users. Customers, stakeholders, partners, and users of this research include producers, landowners, consultants, State agencies, Cooperative Extension Service, NRCS, FS, FSA, FAS, ORACBA, EPA, USGS, CDC, NOAA, NASA, Bureau of Land Management, Bureau of Reclamation, U.S. Army Corps of Engineers, National Park Service, and other action-oriented organizations and centers.

The 201 National Program is part of Goal 5, Protect and Enhance the Nation's Natural Resource Base and Environment, of the ARS Strategic Plan (http://www.ars.usda.gov/aboutus/docs.htm?docid=1766) and the USDA - Research, Education and Economics (REE) strategic plan (http://www.csrees.usda.gov/ree/strategic_plan.htm). It also contributes to Goal 1 (Enhance Economic Opportunities for Agricultural Producers) and Goal 3 (Enhance Protection and Safety of the Nation's Agriculture and Food Supply) of these strategic plans.

Approach

The approach for this National Program is to address the highest priorities for agricultural water management (conservation practice effectiveness, irrigation water management, drainage water management, erosion and sedimentation technologies, watershed management and water availability, and water quality protection systems). Research will be conducted to determine transport and fate of potential contaminants (sediments, nutrients, pesticides, pathogens, pharmaceutically active and other organic chemicals, and salts and trace elements) as well as assess capabilities to conserve and reuse waters in both urban and agricultural landscapes and watersheds.

Specific topics to be studied include: multiple benefits of best management or conservation practices; improved crop water use efficiency for irrigated agriculture; reuse of agricultural drainage waters; alternative treatment and uses for degraded water supplies; reducing erosion and sedimentation problems; impacts of climate variability, and forecasting and mitigating droughts and floods; aquatic and wildlife habitat improvements for degraded and restored riparian areas, wetlands, and stream corridors; new knowledge, prediction capabilities, and decision aids to reduce off-site contaminant transport; and nonpoint and point source trading for improved water quality. The overall goal is to provide solutions to problems in the utilization of the Nation's water resources**.**

This National Program is organized into six problem areas:

- Effectiveness of Conservation Practices
- Irrigation Water Management
- Drainage Water Management Systems
- Integrated Erosion and Sedimentation Technologies
- Watershed Management, Water Availability, and Ecosystem Restoration
- Water Quality Protection Systems

These problem areas were chosen after receiving input at a planning workshop designed to understand the problems and needs of our customers, stakeholders, and partners, and from other interactions with interested parties.

Cooperative research among ARS units will occur to develop the products and achieve the outcomes identified in this action plan. Cooperators from academia and other agencies will assist in the actual research and in outreach and technology transfer. Product users such as extension, USGS, EPA, and NRCS will work with us to ensure we provide the information in the most useable formats for their organization so that the expected outcomes are quickly achieved.

Planning Process and Plan Development
The 201 National Program Workshop was held in June 2005 at Denver, Colorado. More than 200 participants attended this workshop, including producers, commodity group and public interest group representatives, scientists from universities, and scientists and administrators from ARS and other Federal and State agencies. The problem areas in this action plan were formulated based on workshop inputs; inputs from other activities such as USDA and interagency programs, committees, meetings attended by our scientists and National Program Leaders; and most importantly the assessment of this National Program's impact over the previous 4 years. The workshop, recent research needs, and other activities, including the Agricultural Water Security Listening Session held in September 2004 at Park City, Utah, were used to make this National Program as relevant as possible to the concerns of our constituents.

ARS scientists used the program logic model to identify general research outcomes, specific products associated with the outcomes, and the resources available to develop these products for each of the problem areas in this action plan. ARS scientists at each of the laboratories participating in NP201 and other relevant National Programs will reference this action plan when developing project plans that describe the research they will conduct. Project plans provide detailed information on objectives, anticipated products or information to be generated, the approach that will be used, roles and responsibilities of ARS scientists and their cooperators, and timelines and milestones to measure progress of the research. All project plans are reviewed for scientific quality by an independent panel of experts in the field. ARS scientists will use input from the review panel to revise and improve their planned research.

Other relevant ARS National Programs include Soil Resource Management (202); Air Quality (203); Global Change (204); Rangeland, Pasture and Forage (205); Manure and Byproduct Utilization (206); Integrated Agricultural Systems (207); Bioenergy and Energy Alternative (307); Crop Protection and Quarantine (304); Crop Production (305); Food Animal Production (101); Aquaculture (106); and Food Safety (108).

Problem Area 1 Effectiveness of Conservation Practices

Problem Statement
Rationale. The dust bowl days of the 1930s created a National awareness of the need to protect the Nation's productive land base from degradation. Public concern about the effect of agricultural activities, including the use of plant nutrients and pesticides, on the quality of the environment led to the adoption of regulations and policies to mitigate the effect of industrial and agricultural activities in the 1970s. As a result of these concerns, millions of acres of agricultural land have been treated with various types of conservation practices, or best management practices (BMPs). The cost of applying BMPs to the landscape has been offset through cost share arrangements involving both private and public funds. Numerous U.S. Department of Agriculture conservation programs were created to provide the means for applying conservation practices to the land and as a mechanism for providing cost sharing. The Natural Resources Conservation Service (NRCS), Farm Services Administration (FSA) and other USDA agencies are administering these programs.

The accountability for these conservation efforts has, in the past, been based on the number of systems installed, number of land acres treated, or some other qualitative measure. Recently the public has demanded, and Congress has requested, a quantitative assessment of the effects of conservation practices on downstream water bodies. Determining the environmental benefits of conservation practices will enable policy-makers and program managers to modify existing programs and design new programs to more effectively and efficiently meet environmental quality goals while protecting the Nation's productive capacity. NRCS and ARS are leading a project to quantify the effects of the USDA conservation programs. The project, known as the Conservation Effects Assessment Project (CEAP), has two major components: a National Assessment and a Watershed Assessment Study. The National Assessment will be conducted using NRCS data and watershed-scale models developed by ARS and will provide estimates of conservation benefits at the national scale. The ARS Watershed Assessment Study is designed to provide detailed assessment of conservation programs on selected watersheds and improve the models used by NRCS in the national assessment.

Research Needs. Previous research has evaluated the effects of conservation practices at the plot or field scale. The results are limited in that they do not capture the complexities and interactions of physical processes at the watershed and landscape scales. Research in this Problem Area will be designed to assess the benefits of USDA conservation practices at the watershed scale. The results will improve our understanding of the effects of conservation practices from beyond the edge of fields to major water bodies. Fourteen ARS research watersheds will support watershed-scale assessments of the environmental effects of USDA conservation programs. The watersheds studies will involve primarily rainfed cropland, although some of the watersheds contain irrigated cropland, grazingland, wetlands, and confined animal feeding operations. Conservation practices (or BMPs) to be emphasized will include NRCS CORE 4 practices for croplands (conservation buffers, nutrient management, pest management, and tillage management), drainage management systems, irrigation management systems, and manure management practices. Environmental effects and benefits will be estimated primarily for water and soil resources.

The goal for this Problem Area is to develop technologies for detailed assessments of conservation programs at a watershed scale, validate and improve models used to analyze relevant physical and chemical process, and support coordinated research on the effects of conservation practices across a range of resource characteristics (such as climate, terrain, land use, and soils). Numerous meetings with the Natural Resources Conservation Service (NRCS) personnel have served to identify the agencies needs regarding assessment of the effectiveness of conservation practices. Input from NRCS and other customers were received at the NP 201 planning meeting. From these customer inputs, five primary outcomes were identified that would support the need to quantify the effectiveness of conservation practices. Products were then identified that are needed to accomplish the primary outcomes. Finally, ARS research locations that will be involved in providing the products were determined. This approach is described in the following table:

Problem Area 1 Effectiveness of Conservation Practices

Inputs/Resources	Outputs/Products	Outcomes
Product 1 Leaders Columbia, MO: J. Sadler) El Reno, OK: J. Steiner **Product Locations** Ames, IA, Columbia, MO, Oxford, MS, Temple, TX, Tifton, GA, University Park, PA, and W. Lafayette, IN **Cooperators** NRCS, ARS Office of Information Officer (OICO), and USGS	1. A data system to organize, document, manipulate and compile water, soil, management, and socio-economic data for assessment of conservation practices	**Short term*** Comprehensive and consistent data sets will be developed across the 14 watersheds. The data sets will support testing and validation for models being developed under product 3 and 5 below. **Long term**** The data system will be used for cost-efficient assessments of environmental effects of conservation practices on agricultural lands.
Product 2 Leaders Ames, IA: M. Tomer Oxford, MS: Martin Locke **Product Locations** Ames, IA (202), Beltsville, MD, Columbia, MO, Columbus, OH, El Reno, OK, Kimberly, ID, Lubbock, TX, Oxford, MS, Temple, TX, and W. Lafayette, IN **Cooperators** NRCS, CSREES, FSA, Agriculture and Agri-Food Canada, USGS, and Soil and Water Conservation Districts	2. Water quality, water quantity, soil quality, and ecosystem effects of conservation practices at the field, farm, and watershed scales	**Short term** Environmental effects of conservation practices will be quantified for the 14 watersheds. **Long term** More effective conservation practices will be developed for use in future USDA conservation programs.
Product 3 Leaders Oxford, MS: R. Bingner Temple, TX: J. Arnold Tifton, GA: T. Strickland **Product Locations** Ames, IA, Columbia, MO, El Reno, OK, Oxford, MS, Temple, TX, Tifton, GA, University Park, PA, and W. Lafayette **Cooperators** NRCS, EPA, USGS, and Texas Agric. Exp. Station	3. Validate models, quantify uncertainties in model output, and conduct analyses with models at field, farm, and watershed scales	**Short term** Models will be modified, tested and validated for application to the assessment of the effects of conservation practices. **Long term** Validated models will become the primary tools used to conduct a national assessment of the environmental benefits of USDA conservation programs.

Inputs/Resources	Outputs/Products	Outcomes
		The assessments will have a major impact on the development of future USDA conservation programs.
Product 4 Leaders Corvallis, OR: G. Whittaker West Lafayette, IN: C. Huang **Product Locations** Columbus, OH, Temple, TX, and W. Lafayette, IN **Cooperators** NRCS, ERS, The Ohio State University, Pennsylvania State University, and Purdue University	4. Policy-planning tools to aid selection and placement of conservation practices to optimize profits, environmental quality, and conservation program efficiency	**Short term** The research will provide socio-economic data from selected watersheds relative to the adoption and economic value of USDA conservation practices. Tools will be provided that enable optimal choices of the selection and placement of conservation practices. **Long term** The results of this research will enable socio-economic issues to be included in the national assessment of the effects of USDA conservation programs.
Product 5 Leaders Fort Collins, CO: L. Ahuja Oxford, MS: M. Romkens **Product Locations** Ames, IA, Temple, TX, Fort Collins, CO, W. Lafayette, IN, Oxford, MS, and Tifton, GA **Cooperators** NRCS, EPA, USGS, and Colorado State University	5. Regional watershed models that can be used to quantify environmental outcomes and conservation practices in major agricultural regions **Product Users****** Producers, COE, EPA, FSA, NRCS, USGS, Cooperative Extension Agents and Specialists, State and local agencies, land improvement contractors, community planners, and consultants	**Short term** Science-based watershed models will be provided that are capable of addressing processes that are of importance to specific regions. **Long term** This work will result in a new generation of modular based models that integrate scientific components of existing models and future models into an efficient, flexible system for use by the NRCS and other agencies in future national assessments or other applications.

* The short-term outcomes will be accomplished in the next five years.
** The long-term outcomes will not be fully accomplished in five years given current personnel and physical resources, but significant progress will be made.

*** These scientists are conducting research primarily in the ARS Soil Resource Management National Program (202) and ARS Global Change National Program (204).
**** Product users are for the entire problem area.

Problem Area 2 Irrigation Water Management

Problem Statement

Rationale. Irrigated agriculture produces 60% of crop market value on less than 20% of cropped lands. Irrigation is essential to the most highly productive, intensely managed, and internationally competitive sectors of our agricultural economy. Yet, irrigated agriculture is subject to growing competition for water resources, and must be improved to deal with adverse environmental effects in some areas. Also, irrigation is the largest user of freshwater resources, accounting for 80% of water use. Surface and subsurface water allocation addresses a complex system of competing and interacting claims from agricultural, energy industry, tribal, and urban groups, which increasingly leaves agriculture with less water or with lower quality water than desired. Irrigated agriculture must respond with solutions that improve water use efficiency and allow production with urban wastewaters, recycled drainage waters, and other low-quality waters. Economic forces are hastening the transfer of water from agriculture to urban areas and the subsequent decline of irrigated area in the West. At the same time, irrigated acreage east of the 100th meridian is increasing, particularly in the Southeast and Mississippi Delta regions of Arkansas, Louisiana, Mississippi, and Missouri. Competition for water has caused conflicts in areas where water was typically abundant. In these sub-humid and humid climates, irrigation problems are frequently different from those in more arid climates, requiring new solutions that are not directly transferable from the irrigated West. In all regions of the country, irrigation is now directly related to the environmental health, public health, and economic viability of the watersheds within which irrigation operates.

The quest for increased water use efficiency and water security for agricultural production requires solutions that improve irrigation scheduling and management for efficient production. Improved irrigation systems and technologies that automatically monitor crop responses to irrigation and fertilization are needed to increase irrigation efficiency and profitability. Developing new sensors to measure soil water content and plant responses is integral to developing these products. There has been recent, renewed success in providing crop water use predictions to irrigation managers using the paradigm of a reference evapotranspiration multiplied by a seasonally adjusted crop coefficient. However, this success has generated demand for new knowledge of crop coefficients for high-value horticultural and alternative crops. Demand is also growing for a crop coefficient approach that transfers well across climatic regions, especially for application in humid climates. Important new work is aimed at developing crop coefficients for high value, alternative and horticultural crops; and developing tools for irrigation scheduling in humid regions.

Beyond the scale of single irrigation systems in fields, there is a need for improved management and evaluation tools at the farm, irrigation district, and watershed scales. These include irrigation system assessment tools for managers and action agencies that encompass a range of problems from canal and pipe system operation/automation, to methods of evaluating irrigation project performance and the impact of new technologies and Best Management Practices (BMPs), to tools to assess suitability of lower quality waters and needed amendments or other management options for their use. Continued development of remote sensing applications will improve irrigation system assessment. The decreasing supply of fresh water for irrigation, coupled with the increase of wastewater from urban areas, leads to the need for irrigation strategies and new crop varieties that work well with saline and otherwise degraded waters. Safe use of these waters requires new knowledge of the fate, transport and control of emerging contaminants and pathogens, as well as the development of crops useful for phytoremediation of such waters. Finally, as irrigation water supplies decline, an important pattern of rotation between irrigated and non-irrigated crops is emerging. Efficient use of the water resource in these cropping systems requires new tillage, irrigation, and crop management tools to reduce runoff and leaching, maximize the effective use of rainfall, and minimize water losses to evaporation.

Research Needs. Customer needs were identified during the 201 Workshop in Denver, Colorado and through contacts with producer and commodity organizations, the irrigation industry, water and irrigation districts, underground water conservation districts, and action agencies at the Federal and State levels. Four overall outcomes were identified:

- More effective use of water in irrigated agriculture;
- More dependable, flexible, and efficient irrigation water delivery systems at field, farm, and watershed scales;
- Conservation of water, nutrients, and energy for economically and environmentally sustainable enterprises; and
- More effective use of precipitation and irrigation for increased water use efficiency through improved tillage and management systems and crop development for salt tolerance and phytoremediation.

Problem Area 2 Irrigation Water Management

2.1: Irrigation Scheduling for Water Use Efficiency		
Inputs/Resources	**Outputs/Products**	**Outcomes**
Product 1 Leader Bushland, TX: T. Howell **Product Locations** Bushland, TX, Fort Collins, CO, Lubbock, TX, Maricopa, AZ, Parlier, CA, and Stoneville, MS (207) **Cooperators** ASCE/EWRI ET Task Committee, CSREES Multistate Research Coordinating Committee/Information Exchange Group, WERA202, "Climatic Data Applications in Irrigation Scheduling and Water Conservation"	1. Quantification of evapotranspiration (ET) and crop coefficients under all constraints, including partitioning of ET components, regional variations, effects of tillage/irrigation methods, incomplete canopies, and deficit irrigation	**Short term*** Improved and more transportable crop coefficients and methods for adjusting those coefficients as a function of growing degree days, incomplete crop canopy and irrigation method effects will be determined. **Long term**** Irrigation scheduling will be widely adopted for more effective use of water in irrigated agriculture.

Product 2 Leader Bushland, TX: P. Colaizzi **Product Locations** Beltsville, MD, Bushland, TX, Fort Collins, CO, Lubbock, TX, Maricopa, AZ, Stoneville, MS (207), and Tifton, GA **Cooperators** Kansas State Univ., New Mexico State Univ., Texas A&M Univ., Univ. of Arizona, Univ. of Idaho, NASA, and Bur. of Rec.	2. Remote sensing tools for ET and water stress predictions for field and farm district levels	**Short term** Tools will be developed that improve prediction of crop water use and plant stress at field to irrigation project scales. **Long term** Operational tools will be used by farmers, consultants and water districts to predict crop water use and plant stress to increase irrigation water use efficiencies and improve utilization of the Nation's water resources.
Product 3 Leaders Florence, SC: K. Stone Columbia, MO: E. Vories **Product Locations** Columbia, MO, Lubbock, TX, and Stoneville, MS (207) **Cooperators** CSREES project S1018 Irrigation Management for Humid and Sub-Humid Areas	3. Irrigation scheduling tools for humid and sub-humid regions, including crop coefficients, plant stress indicators, soil water sensing, and a rice automation/feedback irrigation system **Product Users****** Producers, NRCS, water districts, State and local agencies, State planning boards, and consultants	**Short term** Irrigation scheduling will be developed for major crops grown in humid and sub-humid regions. **Long term** Planners, water districts, and farmers will use advanced irrigation scheduling tools to improve crop water use efficiencies.
2.2: Managing Irrigation for Effective Water Use		
Product 4 Leader Maricopa, AZ: B. Clemmens **Product Locations** Bushland, TX, Kimberly, ID Maricopa, AZ, and Parlier, CA **Cooperators** NRCS and Bureau of Reclamation, Water Districts	4. Management tools and practices, and new technologies to make irrigation and water delivery systems more dependable, flexible, and efficient; and methods to quantify the impacts of these practices at field, farm, project, and watershed scales, including irrigation efficiency evaluation	**Short term** A knowledge base will be developed on intake/ infiltration parameters for various application methods to be used in the design of more efficient irrigation systems. Techniques and tools will be delivered for evaluating irrigation conservation practices and their impact at the field and watershed scale. **Long term** Farmers, consultants, water districts and NRCS will be able to improve the operation and management of irrigation systems at small and large scales through the use of these water management tools.
2.3: Improved Irrigation and Cropping for Reuse of Degraded Waters		
Product 5 Leader Riverside: D. Suarez **Product Locations**	5. Guidelines for irrigating in urban and agricultural settings with degraded waters, and models and decision support systems for management of	**Short term** Guidelines will be developed for irrigating with degraded waters.

Maricopa, AZ, Parlier, CA, and Riverside, CA **Cooperators** UC Riverside, UC Davis, EPA, Bur. Rec, and NRCS	treated municipal wastewaters and other degraded waters in irrigation, including tools for determining the fate and transport of emerging contaminants and pathogens	**Long term** Tools will be made available to increase water supplies and make safer use of degraded waters in urban and agricultural settings.
Product 6 Leader Riverside, CA: C. Grieve **Product Locations** Parlier, CA, Riverside, CA, and St. Paul, MN (205) **Cooperators** Univ. of California Riverside, Univ. of California Davis, California State Univ., Fresno Tulare Lake Drainage District Imperial Valley Research Center, Brawley, CA, UC Berkeley, Panoche Drainage District, Colorado State University, and University of Zurich, Switzerland	6. New and improved crops that use degraded waters and/or phytoremediate soils, including identification of related biological components, and development of breeding lines and experimental germplasm **Product Users****** Producers, NRCS, water districts, State and local agencies, State planning boards, and consultants	**Short term** Biological processes will be identified for crop specific ion, salt or drought tolerance. **Long term** Specific crops will be available that tolerant to degraded water and soils.
2.4: Site Specific Technologies to Conserve Water, Nutrients, and Energy		
Product 7 Leaders Bushland, TX: S. Evett Sidney, MT: R. Evans **Product Locations** Ames, IA (202), Bushland, TX Columbia, MO, Florence, SC, Fort Collins, CO, Lubbock, TX, Maricopa, AZ, Riverside, CA, and Sidney, MT **Cooperators** NRCS, Universities: Colorado State Univ., Texas A&M, Univ. of Arizona, Univ. of Idaho, Utah State Univ., equipment manufacturers	7. Systems for spatially and temporally variable water, nutrient, and pesticide application based on soil-crop sensing and feedback **Product Users****** Producers, producer groups (corn, cotton, sorghum, wheat, etc.), irrigation equipment companies, NRCS, Bur. of Rec., universities	**Short term** Improved soil water and plant nutrient sensors will be developed for use in wireless mesh networked feedback control systems. **Long term** Tools will be developed for variable rate application of nutrients, pesticides, and water across fields, leading to conservation of water, nutrients, and energy for economically and environmentally sustainable enterprises; and feedback irrigation systems will be commercialized to increase water and nutrient use efficiency and reduce management time for economically and environmentally sustainable enterprises.
2.5: Cropping and Tillage Strategies to Best Use Limited Water Supplies		
Product 8 Leader Kimberly, ID: D. Bjorneberg **Product Locations** Akron, CO (202), Bushland, TX, Columbia, MO, Florence,	8. Tillage, irrigation, and crop management (including amendments and residue management) practices will be developed to improve crop water use efficiency in rainfed/irrigated cropping systems	**Short term** Cropping and tillage practices will be developed for improved crop water use efficiency in combined rainfed/ irrigated cropping systems.

SC, Fort Collins, CO, Kimberly, ID, Lubbock, TX, Riverside, CA (202), Sidney, MT, Watkinsville, GA **Cooperators** Universities, e.g. Utah State, Texas A&M, Univ. of Idaho, and many others including those associated with CSREES project S1018, "Irrigation Management for Humid and Sub-Humid Areas"	**Product Users****** Producers, producer groups (corn, cotton, sorghum, wheat, etc.), NRCS, USGS, universities, water districts, State planning boards, and consultants	**Long term** Crop and tillage systems will be adopted that optimize use of limited irrigation water supplies.

* The short-term outcomes will be accomplished in the next five years.
** The long-term outcomes will not be fully accomplished in five years given current personnel and physical resources, but significant progress will be made.
*** These scientists are conducting research primarily in the ARS Integrated Agricultural Systems National Program (207).
**** Product users are for each of subproblem areas.

Problem Area 3: Drainage Water Management Systems

Problem Statement

Rationale. Surface and subsurface drainage water management (DWM) systems are crucial for mitigating environmental impacts for both rainfed and irrigated croplands. Contaminants carried in runoff and drainage from cropland are often described as the major contributors to nonpoint source water quality problems in streams and other surface water bodies. Nitrate, phosphorus, and sediment are of primary concern in rainfed agriculture and salinity, nitrate, and toxic trace elements are the principal contaminants for irrigated agriculture. The most widely published example of nutrient contamination causing hypoxia is where nitrate and phosphorus are transported from drained agricultural lands in the Midwest through the Mississippi River system to the Gulf of Mexico. In the western U.S., toxic elements, such as selenium, are transported to wildlife habitats, where these elements can bio-accumulate to toxic levels and eventually cause wildlife deaths.

In the Midwest, drainage research has shown that traditional drainage practices can result in significant nutrient loading from subsurface drainage to streams and water bodies. At the same time, drainage water management systems are beginning to show considerable promise in reducing these nutrient loadings. Initial research has shown that controlled subsurface drainage systems can reduce annual nitrate loadings by as much as 30 to 50 percent. Surface drainage management systems have been shown to reduce phosphorus loss in runoff by controlling erosion, but research on surface drainage practices has been limited. For a variety of reasons, it may not be possible to apply surface and subsurface drainage management practices on many sites. Thus, the alternative of diverting runoff and subsurface flow through adjacent wetlands may also prove to be effective in pollutant removal.

Drainage research in the West, especially California, has demonstrated that reduced subsurface drainage flows and salinity loadings are possible for irrigated crop production. Controlled drainage or water table management systems will likely achieve short-term improvements in water use efficiency. Alternative-cropping systems that more fully utilize a combination of rainfall and shallow ground water throughout the growing season may result in further improvements in crop water use efficiency. As more irrigated land is fallowed (taken out of intensive irrigated crop production for a period of time), drainage water management systems may also provide other options for maintaining productivity and controlling specific invasive plant species through careful management. Also, reuse of saline drainage waters for supplemental irrigation can extend water supplies and increase water use efficiencies. However, various reuse technologies are not without risks associated with the accumulation of salinity in the soil and potentially increasing long-term toxic trace element problems.

Research Needs. Specific guidelines and tools should be developed for nutrient and pesticide management for both surface and subsurface drainage water management systems. Design specifications and recommendation in terms of proper installation of these controlled drainage systems will be required. Automation of these systems, including the integration of weather forecasts, could enhance water conservation benefits during short-term drought periods in humid areas. Long-term soil quality effects also need to be evaluated. Increased water quantity, quality, and wildlife benefits are all possible either with or without improvements in wetland management practices. In terms of irrigated agricultural, improved drainage water management practices need to be evaluated in terms of increased water use efficiency along with long-term effects on salinity and trace elements under different cropping systems. Research studies also need to be conducted on combined effects of improved subsurface drainage water management practices and alternative cropping systems for irrigated agriculture. Lastly, improved drainage water management systems need to be incorporated into an environmental and economic decision support system that fully evaluates the cost-effectiveness of these systems.

Problem Area 3 Drainage Water Management Systems

Inputs/Resources	Outputs/Products	Outcomes
Product 1 Leaders Columbus, OH: N. Fausey St. Paul, MN: J. Baker **Product Locations** Ames, IA, Baton Rouge, LA, Columbus, OH, Fort Collins, CO, and St. Paul, MN **Cooperators:** Iowa State Univ. Louisiana State Univ., Univ. of IL, NRCS, Univ. of MO, North Carolina State Univ., Univ. of MN and Purdue Univ.	1.Guidelines for management practices that optimize soil, water, and economic benefits associated with surface and subsurface drainage water management (DWM) systems and wetland resources in humid rainfed areas With adoption of surface and subsurface drainage water management (DWM) systems in humid rainfed areas, tentative guidelines developed for improved agronomic, nutrient and pesticide management practices, and benefits or impacts assessed regarding water conservation, water quality, soil quality, economic factors, and management of combined areas of DWM systems and wetland resources	**Short term*** Tentative Guidelines for agronomic, nutrient, and pesticide management practices will be made available to users of DWM systems. **Long term**** Expanded guidelines will be developed in short-term project to include other conservation practices, such as cover crops, buffer strips, tillage management, wetland diversions, etc., to enhance water quality benefits in surface waters and in coastal waters.

Inputs/Resources	Outputs/Products	Outcomes
Product 2 Leaders Baton Rouge, LA: J. Fouss Parlier, CA: J. Ayars **Product Locations** Baton Rouge, LA Columbus, OH **Cooperators:** NRCS, Univ. of IL, The Ohio State Univ., North Carolina State Univ., and Univ. of MN	2. Design specifications of DWM systems for environmental benefits in the Midwest and West	**Short term** Design specifications for DWM systems will be developed for optimizing water quality benefits. **Long term** Design specifications for DWM systems will be developed for multiple environmental benefits.
Product 3 Leader Parlier, CA: J. Ayars **Product Locations** Parlier CA **Cooperators:** Bureau of Reclamation, U.C.-Davis, CA Dept. of Water Resources, NRCS, Water/Drainage Districts	3. Evaluation of the advantages and limitations associated with operation of DWM systems for irrigated areas	**Short term** Recommendations for operation of DWM systems will be developed for California. **Long term** Assessment and recommendations for use of DWM systems will be developed for the West.
Product 4 Leaders Ames, IA: R. Malone Fort Collins, CO: L. Ahuja **Product Locations** Ames, IA, Baton Rouge, LA, Fort Collins, CO and University Park, PA **Cooperators** NRCS, North Carolina State Univ., and University of Minnesota **Other Problem Area #4** **Cooperators:** Drainage industry; producers; commodity organizations; and international organizations	4. Decision support systems that include environmental and economic effects associated with DWM systems **Product Users****** Producers, NRCS, Cooperative Extension Agents and Specialists, EPA, land improvement contractors, community planners, and consultants	**Short term** A DWM decision support system will be developed for benefit analysis in the Midwest. **Long term** A DWM decision support system will be developed for cost benefit analysis throughout the Nation. DWM guidelines will be developed to estimate the length of time required to obtain measurable water quality improvements at the watershed scale.

* The short-term outcomes will be accomplished in the next five years.
** The long-term outcomes will not be fully accomplished in five years given current personnel and physical resources, but significant progress will be made.
*** These cooperative scientists are employed by Land-Grant Universities.
**** Product users are for the entire problem area.

Problem Area 4 Integrated Soil Erosion and Sedimentation Technologies

Problem Statement

Rationale. Soil erosion, sediment movement, and deposition processes involve the interactions of land resource management practices with climate, soil, and landscape properties. Soil erosion control is essential for sustainable agricultural production systems because erosion affects soil properties progressively over time and generally results in decreased soil quality and reduced resistance of agricultural systems to stresses. Sediment generated by soil erosion has costly, negative off-site impacts on downstream channel evolution, flooding, water quality, and air quality. Customers have identified two basic areas for new and improved soil erosion and sedimentation technologies: (1) better erosion control technologies and (2) improved decision support systems for planning and assessment. In both cases, the interest is in addressing both local effects on a field, farm, or channel and off-site impacts at the larger watershed scale.

Development is needed of an integrated conservation-planning tool that uses a common interface, common databases, and sound science to allow comprehensive assessment of the impact of alternative management scenarios on resource conservation and environmental quality. There is also a need for improved technologies for conserving soil, improving its functionality, and reducing its off-site impacts. Complementary, but not duplicative, products are expected from scientists working in this National Program in cooperation with other ARS National Programs.

Research Needs. Improved decision support systems need to be developed that integrate water erosion, wind erosion, irrigation erosion, tillage erosion, channel erosion, sediment transport, and sedimentation predictions. Design tools for erosion prevention, water infrastructure improvements, and riparian corridor management will be developed that reduce sediment losses from fields, streams**,** lakes, and rivers. The long-term need for this research is to develop improved, site-specific conservation practices for maintaining our natural resources and reducing sediment losses from the Nation's fields, streams, lakes, and rivers.
Customers have been clear in expressing the need for a unified erosion assessment tool for soil erosion by wind, water, and tillage. Processes associated with soil erosion by wind and rain has received the attention of previous ARS and university research. However, experience and understanding of processes driving specialized forms of erosion have a much smaller scientific knowledge base: winter erosion processes, irrigation-induced erosion, ephemeral gully and head-cut erosion, rangeland erosion, tillage erosion, and channel erosion and evolution. Better tools are also needed to design and quantify the effect of erosion control structures and other methodologies across most of the western U.S. Methods and data are needed for sediment source identification and tracking for validation of computer model predictions. Guidelines are needed for reducing the risk of dam breaching and subsequent failure triggered by concentrated flow action. The long-term effects of soil loss and sediment redistribution on future landscape topography, soil profiles, soil productivity, and hydrologic and erosion processes within fields and channels, as well as the reduction in storage capacity of impounded waters must be considered in a comprehensive conservation planning tool.

Problem Area 4 Integrated Soil Erosion and Sedimentation Technologies

Inputs/Resources	Outputs/Products	Outcomes
Product 1 Leader Oxford, MS: S. Dabney **Product Locations** W. Lafayette, IN, Oxford, MS, and Pendleton, OR **Cooperators** Oklahoma State Univ	1. Database and predictive relationships for erosion and sediment transport caused by concentrated flow in irrigation furrows, ephemeral gullies, and edge-of-field gullies	**Short term*** Predictive ability and databases will allow improved estimation of concentrated flow erosion from selected sites. **Long term**** Robust predictive ability and comprehensive database will provide reliable estimation of erosion and sediment transport caused by concentrated flow
Product 2 Leader Oxford, MS: R. Kuhnle **Product Locations** Oxford, MS and Tucson, AZ **Cooperators** Univ. of Mississippi, USBR, USGS, NRCS, USFS	2. Decision support tools and databases for sediment loads, yields, and off-site impacts considering fractional sediment transport and deposition, geomorphic aspects of stream evolution, and reservoir/pond sedimentation for purposes of quantifying landscape scale erosion rates	**Short term** Intermediate gains will increase ability to quantify landscape scale erosion. Science-based and cost-effective techniques will be developed to monitor changes in storage of aging reservoirs. **Long term** Ability to quantify landscape scale erosion and off-site impacts will be enhanced. Improvements to CONCEPTS will be developed for more accurate assessments of dam decommissioning/rehabilitation impact at watershed and larger scales that will be used by Federal and State agencies.
Product 3 Leader Stillwater, OK: D. Temple **Product Locations** Stillwater, OK and Oxford, MS **Cooperators** NRCS, USACE (ERDC), USBR (WRRL), CEATI (DSIG), KSU (CIS), NRCS, and Univ. of Mississippi	3. Improved tools for evaluating the potential for earthen embankment breach due to erosion and deterioration due to wave action **Product Users** Producers, COE, EPA, NRCS, USBR, Cooperative Extension Agents and Specialists, State and local agencies, land improvement contractors, community planners, and consultants	**Short term** Improved predictive and preventive capabilities with regard to earthen embankment dam breach will be achieved. Science-based and cost - effective techniques will be developed to control erosion from streams and levees. **Long term** Ability to predict performance of existing structures and ability to improve designs based on simulation will be demonstrated.

Inputs/Resources	Outputs/Products	Outcomes
Product 4 Leader West Lafayette, IN: C. Huang , D. Smith **Product Locations** Lubbock, TX (NP 202), Oxford, MS, and Pullman, WA	4. Improved tool for assessment of soil susceptibility to erosion including spatial, temporal, topographical, vegetative, and management effects	**Short term** Improved assessment of how climate, topography, and management affect erodibility and threshold velocities will lead to improved management systems and more reliable modeling of conservation effects at select locations. **Long term** Improved assessment of how climate, topography, and management affect erodibility and threshold velocities will lead to improved management systems and more reliable modeling of conservation effects nationally.
Product 5 Leader Tucson, AZ: M. Nearing **Product Locations** Beltsville, MD (202), Kimberly, ID (201 and 202), W. Lafayette, IN, Lubbock, TX (202), Mandan, ND (202), Manhatten, KS (203), Oxford, MS, Pendleton, OR (202), Stillwater, OK, and Tucson, AZ **Cooperators** Oklahoma State University (BAE), NRCS, Engineering Division, Univ. Az. Ext. Service, and Malpai Borderlands Group	5. Best Management Practices and design tools for in-field erosion control, gully and ephemeral channel erosion prevention, riparian corridor stabilization, and sediment retention structures	**Short term** Design tools and practices for erosion prevention, water infrastructure improvements, and riparian corridor management will be developed to reduce sediment losses from fields and streams. Improved technology for design and rehabilitation of water resource structures will be developed. **Long term** Improved conservation practices will be developed for reducing sediment losses from fields, streams to lakes, and rivers. Engineering tools for design and rehabilitation of water resource structures will be completed.
Product 6 Leader Kimberly, ID: D. Bjorneberg **Product Locations** Fort Collins, CO, Kimberly, ID, and Maricopa, AZ **Cooperators** Producers, Industry,	6. Model to predict irrigation-induced erosion using a common interface with shared databases: development, parameterization, and validation (surface, center pivot and set/move sprinklers). **Product Users****** Producers, NRCS, USGS, EPA,	**Short term** Field-scale single event models will be developed for improved predictions of irrigation-induced erosion. **Long term** Integration of irrigation-induced erosion model into a

Inputs/Resources	Outputs/Products	Outcomes
Consultants, University Extension, NRCS, Federal Agencies (COE, BLM, EPA, USGS,), State Agencies (DEQs), University of Mississippi	universities, soil and water conservation districts, State planning boards, farmers, ranchers, engineers, and consultants	comprehensive decision support system for water erosion, wind erosion, tillage erosion, and sedimentation predictions will improve long-term conservation planning and impact assessments.
Product 7 Leader West Lafayette, IN: D. Flanagan **Product Locations** Boise, ID (205), Canal Point, FL (202), Lubbock, TX (202), Manhattan, KS (203), Morris, MN (202), Oxford, MS, Pendleton, OR, Pullman, WA (201 and 203) , Temple, TX (202), Tifton, GA(202), Tucson, AZ, and W. Lafayette, IN **Cooperators** Producers, Industry, Consultants, University Extension, Amendment Industry, Construction Industry NRCS-The Central National Technology Support Center, Ft. Worth, TX, NRCS-National Water and Climate Center, Portland, OR, USFS, BLM, Other federal agencies (COE, EPA, USGS), State Agencies (DEQs), University of Mississippi, U of Arizona, Arizona State University, Purdue University, University at Buffalo, NY, Michigan Technological University, University of Nottingham, UK INTA, Argentina, and Mexico (INIFAP)	7. Multi-scale modeling system to predict wind, water, and tillage erosion, and downstream impact of sediment movement on agricultural landscapes using a common interface with shared databases: development, parameterization, and validation **Product Users********** Producers, NRCS, USFS, USGS, EPA, universities, soil and water conservation districts, State planning boards, farmers, ranchers, engineers, and consultants	**Short term** Integration of existing field-scale water, wind, and tillage erosion models will facilitate conservation planning on agricultural lands. Improved predictions of winter erosion processes, rangeland hydrology and erosion, tillage erosion, and wind erosion threshold velocities and dust emissions will improve resource protection. **Long term** Comprehensive decision support system that integrates water erosion, wind erosion, tillage erosion, and sedimentation predictions will improve long-term conservation planning and impact assessments.

* The short-term outcomes will be accomplished in the next five years.
** The long-term outcomes will not be fully accomplished in five years given current personnel and physical resources, but significant progress will be made.
*** These scientists are conducting research primarily in the ARS Soil Resource Management National Program (202), etc.
**** Product users are for the entire problem area.

Problem Area 5 Watershed Management, Water Availability, and Ecosystem Restoration

Problem Statement

Rationale. Society relies on adequate freshwater resources to support populations, agriculture, industry, wildlife habitat, aquatic ecosystems and a healthy environment. Agricultural watersheds, including crop, pasture, and range lands, constitute over 70% of the continental U.S. and thereby play a dominant role in the management of the Nation's watersheds and water resources. The confluence of unprecedented demands for freshwater, rapidly changing land use, recurring droughts, and regional climatic variations means that the Nation’s freshwater resources, agricultural production and ecosystems are at risk more than ever before. A primary concern of ARS customers, stakeholders, and partners is to accurately quantify and manage our water resources to support people, agriculture, and the environment. Increasingly, this is done across heterogeneous agricultural and urban landscapes. Watershed management based on multiple objectives that include water supply, water pollution, urban development, climate variability, recreation, ecosystem protection and habitat restoration is a complex task necessary not only to support the goals of the Clean Water Act and the Endangered Species Act, but also to address concerns of watershed coalitions, policy makers and the public.

The primary challenge remains the development and application of an integrated research approach based on hydrological, geomorphic and ecological principles to provide a better, watershed-scale understanding of water availability, allocation potential, and impacts on wetlands, riparian ecosystems and associated fluvial systems. ARS, which operates a national network of experimental watersheds, is uniquely situated to address these questions. Long-term and continuous observations from these watersheds enable development of an integrated approach to watershed management, flood/drought risk evaluation, flood protection, water supply management, ecosystem restoration, habitat maintenance, and assessment of other water-related issues.

Research Needs. Fundamental research and development of tools and methodologies are required to address and resolve issues related to watershed management, water availability, and ecosystem restoration at the watershed scale. Tools are needed to assess and improve aquatic habitats, riparian buffers, wetlands and streams, and to evaluate Best Management Practices (BMPs) for ecosystem restoration and establish threshold values for ecological integrity. Remotely sensed and geospatial information are needed to support BMP assessment and management of watershed landscapes impacted by agricultural and urban development. Decision support tools and information are needed to assist land managers in the selection of BMP to facilitate water resources management and improve environmental quality in mixed agricultural and urban areas. NRCS and action agencies have requested technologies and decision support systems that enhance our understanding of impacts associated with dam decommissioning, rehabilitation and construction on fluvial and ecological systems. Investigations are needed to identify the existence and impact of regional climate variations on water resources availability and management, including the identification of risk of drought and occurrence of climate extremes. Also, the utility and applicability of NOAA's seasonal climate forecasts for strategic and tactical planning in agricultural production and water resources management must to be explored to take advantage of recent advances in climate/atmospheric sciences. Further research and development is needed to improve comprehensive simulation models for watershed processes, plant productivity, and environmental response assessment under variable climate, changing land use, increasing urban activity, and ecosystem restoration efforts. These scientific research activities, tool developments, simulation model investigations, BMP evaluations, and environmental enhancement efforts must be supported by new remote sensing tools and enhanced instrumentation for watershed-scale evapotranspiration, soil moisture, snow accumulation and melt, water budgets, and water stress estimation, mapping and interpretation. These needs will be built on existing ARS expertise and offer an integrated research and development approach that enhance the beneficial utilization of land and water resources in agricultural watersheds, and meet today's competitive and multi-objective management of land and water resources.

Problem Areas 5 Watershed Management, Water Availability, and Ecosystem Restoration

Inputs/Resources	Outputs/Products	Outcomes
Product 1 Leader Coshocton, OH: J. Bonta **Product Locations** Corvallis, OR (207), West Lafayette, IN, Tucson, AZ Columbus, OH, St. Paul, MN, and Weslaco, TX **Cooperators** APHIS, BLM, EPA, NASA, State and local agencies, and USGS, NRCS, and other Federal and Local agencies	1. Best management practices (BMPs), assessment tools, and decision support systems for managing water quantity and quality within agricultural and urban landscapes	**Short term*** Science-based tools and improved watershed BMPs will be developed for specific applications at the agricultural/urban interface. **Long term**** Science-based management tools and BMPs will be developed for cost-effective watershed management practices for application at the agricultural/urban interface.
Product 2 Leader Oxford, MS: A. Simon **Product Locations** Beltsville, MD, Florence, SC, Oxford, MS, and Tifton, GA **Cooperators** EPA, COE, NRCS, USGS State and local agencies, U.S. Forest Service, U.S. Fish and Wildlife Service, and State Departments of Environmental Quality	2. Management tools and decision support information for restoration of riparian buffers, wetlands, and streams, and improvement of aquatic ecology	**Short term** Science-based management tools and decision support systems will be developed for stream, wetland, and riparian restoration. Documentation will be provided on the effects of ecosystem erosion control practices on off-site water quality. Science-based tools will be developed for assessing and designing improvements in aquatic ecology for use in TMDL development. **Long term** Management tools and decision support systems will be delivered to Federal and State agencies to meet multiple goals of environmental restoration.

Inputs/Resources	Outputs/Products	Outcomes
		Use of integrated BMPs and assessment technologies will provide improvements in watershed management and water quality.
Product 3 Leader Ft. Pierce, FL: J. Albano **Product Locations** Ft. Pierce, FL, Miami, FL, and Brooksville, FL **Cooperators** University of Florida, South Florida Water Management District, USACE, Comprehensive Everglades Restoration Project Leaders, and other Federal and Local agencies	3. BMPs and assessment tools for determining economically and environmentally sustainable agricultural enterprises in South Florida	**Short term** BMPs will be developed for improving agricultural production systems and improve water quality in South Florida. Improved practices and technologies will be provided that quantify effects of agriculture/riparian/wetland interactions as a means of enhancing water quality in South Florida. Science-based decision support systems will be developed to enhance agricultural production, facilitate water management, and improve water and environmental quality in South Florida. **Long term** The use of assessment technologies and tools will improve watershed management at the urban/agricultural interface in South Florida. Agricultural production will be sustained during and beyond the South Florida Ecosystem Restoration by securing water and environmental resources for future generations.
Product 4 Leaders Boise, ID: G. Flerchinger Tucson, AZ: D. Goodrich Beltsville, MD: W. Crow **Product Locations** Beltsville, MD, Boise, ID, Bushland, TX, Coshocton, OH, El Reno, OK (204), Lubbock, TX, Temple, TX,	4. Improved watershed simulation, plant growth, and weather generation model components and data assimilation tools for water budget, water quality assessment, and flood and drought risk and impact assessment **Product Users****** Producers, universities, CEAP project scientists, Crop and Watershed	**Short term** Improved methods will be developed to predict watershed response, water supply, and crop production over large areas in selected hydroclimatic regions. Decision support tools will be completed that account for

Inputs/Resources	Outputs/Products	Outcomes
Tifton, GA, and Tucson, AZ **Cooperators** NRCS-NWCC - Guidance in identifying research needs and actively participating in technology development Texas Tech, U of Idaho, CRREL, Penn St, Reading U, U of Wales, and NASA	Management Modelers, consultants, State, Local, and Federal Agencies, NRCS, Water Managers through improved hydrologic modeling capability integrated with web-based tools	climate variations and seasonal forecasts for water supplies and that illustrate yield and profit outcomes associated with user-specified management strategies. **Long term** Predictions of watershed response and crop production over larger areas based on current climate and land conditions and future scenarios will be improved. More reliable and sustainable agricultural production, land management, and water supply will result from improved water supply predictions and local weather modeling Agricultural management strategies will be developed that are economically optimal to climatological or forecast growing season conditions
Product 5 Leader: Beltsville, MD: B. Kustas **Product Locations** Beltsville, MD, Boise, ID, Bushland, TX, Lubbock, TX, Maricopa, AZ, Oxford, MS, and W. Lafayette, IN **Cooperators** NRCS – guidance in identifying research needs and actively participating in technology development. NASA – use of ARS watershed data for remote sensing validation Universities and US Forest Service – collaboration on Lidar processing methods. MIT, NAS	5. New remote sensing tools for terrain, ET, soil moisture, and water stress characterization and data interpretation methods for agricultural and rangeland environments **Product Users****** NRCS, USGS, Water Districts, State Planning Boards, FAS, and Farmers	**Short term** Improved observational technology, estimation of components of the basin water budget will result in greater certainty, and more certain linkage between water, energy and bio-geochemical cycles. **Long term** Improved remote sensing and spatial information technologies will be developed for more accurate water resources assessment at watershed and larger scales and near-real time operational remote sensing techniques to aid in crop production.
Product 6 Leaders: Beltsville, MD: M. Cosh Tucson, AZ: S. Moran **Product Locations**	6. More accurate quantitative components of basin water budgets that consider ecosystem feedbacks affecting watershed states and fluxes and enhanced instrumentation (in-situ soil	**Short term*** Improved observational technology, estimation of components of the basin water budget will result in greater

Inputs/Resources	Outputs/Products	Outcomes
Boise, ID, Bushland, TX, Tifton, GA, Tucson, AZ and Watkinsville, GA **Cooperators** NRCS – Guidance in identifying research needs and actively participating in technology development NASA, NOAA – Integration of ARS efforts into GEWEX & GAPP. University Scientists – Collaboration for teaching and research use of models and databases USGS – Cooperation with collection of flow data	moisture, eddy-covariance, etc.) applications coordinated with ecosystem and biogeochemical observations **Product Users****** Watershed research scientists, NRCS, universities, watershed managers, county and regional planners, federal/state agencies, consultants, farmers and ranchers, and regulatory entities	certainty, and more certain linkage between water, energy and bio-geochemical cycles. **Long term**** Water budgets and measurements will be developed for improved watershed management system planning and decision-making.

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** The long-term outcomes will not be fully accomplished in five years given current personnel and physical resources, but significant progress will be made.
*** These scientists are conducting research primarily in the ARS Integrated Farming Systems National Program (207), Soil Resource Management National Program (202), ARS Global Change National Program (204), etc.
**** Product users are shown for the entire problem area.

Problem Area 6 Water Quality Protection Systems

Problem Statement

Rationale. Many crop production systems rely on chemical inputs (nutrients and pesticides) to be economically viable. Nutrients, especially nitrogen and phosphorus, are needed for efficient and predictable agricultural production systems. Nutrients are also essential for aquatic ecosystems; however, excess nutrients can cause eutrophication of both fresh and marine coastal waters. Eutrophication can lead to problems such as shifts in species composition, noxious algae blooms, and, in extreme cases, hypoxia, i.e., oxygen depletion. Besides the effects of excess nutrients on freshwater and marine coastal ecosystems, high nitrate levels in drinking water are a human health concern in many parts of the U.S and the world.

Some of the newer livestock production systems being implemented can result in large quantities of manure being generated. The storage and disposal of the manure is a concern because the manure may contain excess nutrients, pathogens, and/or pharmaceutical compounds, which may harm the environment if not properly treated and utilized. Pathogen transmission to humans can occur via contaminated drinking or recreational waters. Water-borne transmission is of particular concern for parasites such as *Cryptosporidium parvum*, which remain viable for months in natural waters and are resistant to many disinfectants. Water-borne transmission of bacterial pathogens such as certain strains of *E. coli* may occur when sources (e.g., wastewaters, feces/manures) are located in close proximity to potable or recreational waters.

Pesticides (insecticides, herbicides, fungicides) applied to agricultural fields and pharmaceuticals (antibiotics and hormones) used in livestock production can move from their point of use into surface and ground waters. Their presence in surface and ground water raises concerns about their impact on aquatic and terrestrial ecosystems and human health. To evaluate fully the risks of using these chemicals and compounds in agriculture, we need to know the sources, transport behavior, fate, and biological impact at different concentrations and in different combinations in the environments.

Agricultural producers are under increasing pressure to reduce the off-site movement of nutrients, pathogens, pesticides, and pharmaceuticals. NRCS and States are under pressure to provide reliable and accurate information and technical assistance to help agriculture reduce its impact on water quality. ARS has been asked to help provide information in this area under three broad themes; (1) better understanding and prediction of source, fate, and transport of constituent loads; (2) fate, transport, and environmental effects of emerging contaminants; and (3) information on best management practices effectiveness and socio-economic feasibility, across a range of climates, soils, and agricultural and urban settings. While a wide range of practices is available for reducing off-site movement of contaminants, they are often not applicable to specific farming situations.

Agricultural management practices that decrease runoff and sediment loss such as conservation or reduced tillage, buffers, riparian areas, and wetlands have been proposed as ways to reduce nutrient, pesticide, and pathogen transport to waters. However, better scientific understanding is required to optimize the design, combination, and placement in watersheds of these technologies and practices and to allow accurate estimates of their efficacy and costs over a wide range of soils and climates. Existing practices and technologies are often limited in their effectiveness, their mechanisms for controlling off-site contaminant movement poorly understood, or their efficacy and economics are uncertain. To better design and refine existing practices, new scientific information needs to be developed that clearly delineates how agricultural contaminants move and are transformed within the environment.

Research Needs. Effective and reliable control strategies and technologies can be developed through the development, collection, and application of scientific knowledge of the fate and transport of nutrients, pesticides, pharmaceuticals, and pathogens. Research needs to quantify the role of climate, soils, crops, and farm management on the generation, persistence, movement, and cycling of these water contaminants. New and existing scientific knowledge needs to be synthesized and made available to scientists, producers, and action agency personnel so they can better understand the linkages between soil, climate, and farming practices on water contamination. This knowledge needs to be formulated into fact sheets, guidelines, and mathematical algorithms incorporated into existing computer models to improve the management of our natural resources and reduce the impact of agriculture on water quality degradation.

Problem Area 6 Water Quality Protection Systems

Inputs/Resources	Outputs/Products	Outcomes
Product 1 Leader St Paul, MN: J. Baker **Product Locations** Ames, IA, Columbia, MO, Coshocton, OH, Lincoln, NE, Oxford, MS, St. Paul, MN, Sidney, MT, Temple, TX, University Park, PA, Watkinsville, GA and West Lafayette, IN **Cooperators** Ohio State University and Small Farm Institute	1. Scientific information regarding nutrient retention, transformation and transport processes, and field management techniques that reduce off-site nutrient movement	**Short term*** The ability to predict the impact of management practices on N losses in different farming systems will be improved. **Long term**** Nutrient levels in ground and surface waters will be significantly reduced.
Product 2 Leader University Park, PA: A. Sharpley **Product Locations** Ames, IA, Temple, TX and University Park **Cooperators** NRCS, EPA, CSREES, Land Grant Universities, ARS Fayetteville, AR (206), ARS Tifton, GA (202), Univ. Arkansas, Univ. New Mexico Mullins, and Iowa State Univ.	2. Refinement and evaluation of P-based risk assessment tools at field, farm, and watershed scales	**Short term** Next generation P Index will result in development of effective CNMPs. The integrated P & N management will overcome limitations of surface and ground water quality tradeoffs. **Long term** Nutrient levels in ground and surface waters will be significantly reduced.
Product 3 Leader Lincoln, NE: J. Shanahan **Product Locations** Beltsville, MD (206), Bushland, TX, Fort Collins, CO, Lincoln, NE, Sidney, MT, and University Park, PA **Cooperators** Colorado State Univ., Iowa State Univ., Kansas State Univ., North Dakota State Univ., Ohio State Univ., Oklahoma State Univ., Texas A&M Univ., Virginia Tech Univ., Univ. of Idaho, Univ. of Illinois, Univ. of Kentucky, Univ. of Minnesota, and Univ. of Nebraska	3. Develop and refine sensors that detect variation in canopy nitrogen and water status and develop methods using these sensors for improved crop management and water quality	**Short term** A network of researchers will gain experience in using active sensors on various crops. **Long term** Producers will use in-season nitrogen and water management to reduce nutrient levels in ground and surface waters.

Inputs/Resources	Outputs/Products	Outcomes
Industry AGCO, Holland Scientific, John Deere, Inc. and NTECH Ind. **International Research Organizations** Ag Canada, N. Tremblay CIMMYT, Mexico, I. Ortiz-Monasterio EMBRAPA, Brazil, R. Inamasu Instituto Nacional de Tecnología Agropecuaria, Argentina, R. Melchiori		
Product 4 Leader Columbus, OH: B. Allred **Product Locations** Ames, IA, Coshocton, OH, Oxford, MS, University Park, PA and West Lafayette, IN **Cooperators** Arkansas State, Ohio State Univ., USDA/NRCS, University of Maryland - Eastern Shore, University of Maryland - College Park, University of Missouri, Rolla Fraunhofer Center for Energy and Environment, University of Florida, Clemson University, NCSU	4. New and improved technologies that remove nutrients from surface or subsurface water	**Short term** New management practices will be developed for reducing nutrient loading to surface and shallow ground water. **Long term** Nutrient levels in ground and surface waters will be significantly reduced
Product 5 Leader: Lincoln, NE: J. Schepers **Product Locations:** Beltsville, MD (206), Fort Collins, CO (202), St. Paul, MN (206), Sidney, MT, Tifton, GA and University Park	5. A Nitrogen Index (N Index) relative risk assessment tool that provides field guidance for potential movement of nitrogen via runoff, leachate, or gas emission from various landscapes and cropping systems	**Short term** The N Index tool will be developed for use by NRCS state and field office staffs, conservation partners, private Technical Service Providers (TSPs), and other natural resource personnel. **Long term** Nitrate-nitrogen levels in ground and surface waters will be reduced.

Inputs/Resources	Outputs/Products	Outcomes
Product 6 Leader Ames, IA: T. Moorman **Product Locations** Beltsville, MD, Oxford MS, Riverside, CA, St. Paul, MN, Tifton, GA, Watkinsville, GA, West Lafayette, IN, Columbus, OH, Coshocton, OH, and Temple, TX **Cooperators:** Univ. of Georgia, Arkansas State Univ., Univ. Memphis, Univ. of MO, and Ohio State Univ.	6. New knowledge and prediction capabilities of the physical, chemical, and biological processes affecting the retention, transformation, and transport of pesticides, pathogens, and pharmaceuticals and other contaminants and new management practices and tools for reducing their offsite movement	**Short term** The ability to predict the impact of management practices on movement of agricultural chemicals and pathogens in different systems will be improved. Identification and quantification of effective strategies and practices to limit or reduce contamination of water will be developed for pesticides, pharmaceuticals and pathogens. **Long term** Offsite movement of pesticides, pharmaceuticals and pathogens will be reduced in ground and surface waters

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*** These scientists are conducting research primarily in the ARS Soil Resource Management National Program (202), etc.
**** Product users are for the entire problem area.