Response to RFI for Long-Term Agro-ecosystem Research (LTAR) Network 2012

Lower Mississippi River Basin

Abstract: The Lower Mississippi River Basin (LMRB) is a key 2-digit HUC watershed comprised of highly productive and diverse agricultural and natural ecosystems lying along the lower reaches of the largest river in North America. The alluvial plain within the LMRB is one of the most productive agricultural regions in the United States, particularly for rice, cotton, corn and soybeans. The LMRB accounts, for example, for a quarter of total U.S. cotton and two-thirds of total U.S. rice production. The 7.1 million irrigated acres of the LMRB cover a larger percentage (>10%) of the entire land area of the basin than for any other two-digit HUC in the country and the basin is second only to California in total groundwater pumped for irrigation. The LMRB is therefore one of the most intensively developed regions for irrigated agriculture in the country. This region is the hydrologic gateway to the Gulf of Mexico and thus links the agricultural practices of the LMRB and the runoff and sediment/nutrient loads from the Upper Mississippi, Missouri, and Ohio basins with the Gulf ecosystem. While the natural and agricultural ecosystems of the LMRB are each of national significance, they are also intimately inter-connected, for example, the intensive agricultural irrigation along the alluvial plain has resulted in rapidly declining water tables. Changes in stream hydrology due to declining base-flow combined with the water quality impacts of agriculture make the LMRB a tightly-coupled agro-ecosystem with national significance and thus an ideal addition to the LTAR network. To this end the USDA-ARS National Sedimentation Laboratory (NSL) in Oxford, MS is proposing a Lower Mississippi River Basin LTAR in cooperation with five other ARS research locations distributed across the basin and in collaboration with numerous government and academic research partners. NSL and its cooperating ARS partners have over 50 years of research experience across the LMRB including a variety of research efforts from short-term, plot studies to ongoing, multi-decadal, watershed-scale assessments on topics as diverse as agricultural plant genetics, nutrient transport, erosion, and aquatic ecology. The long-term presence, diversity of research, and wide spatial coverage of the ARS and its collaborators in the basin provides a natural platform for the LMRB to become a key member of the LTAR Network.

Objective: The LMRB LTAR will become a key contributor to the LTAR Network involved in long-term agro-ecosystem sustainability through development and maintenance of cropland and environmental datasets derived from long-term field and watershed research sites throughout the Lower Mississippi River Basin.

Introduction and Significance

A potential Long-Term Agro-Ecosystem Research (LTAR) location should combine an existing long-term research effort in a region of national significance with a vision and expertise for addressing the big questions of sustainable agro-ecosystems. USDA-ARS research locations within the Lower Mississippi River Basin together combine research spanning agro-ecosystem dynamics including crop development, cultivation practices, and environmental impacts with existing long-term datasets in a region of national significance making the Lower Mississippi River Basin a strong candidate for the LTAR Network.

Geography, Climate, and History

The Lower Mississippi River Basin (LMRB) (two-digit HUC 08) begins just south of Cape Girardeau, Missouri and extends southward to the Gulf of Mexico spanning 107,000 square miles over portions of

Missouri, Arkansas, Tennessee, Mississippi and Louisiana (Figure 1). The basin comprises four EPA Level II Ecoregions and five NRCS Land Resource Regions; however, over 85% of the LMRB falls into just two of these Ecoregions: the "Mississippi Alluvial Plain" consisting of the alluvial valley and floodplain of the Mississippi River and the "Southeastern Plains" made up largely of the loessal bluff hills along the margins of the alluvial valley (Figure 2) (CEC, 1997; USDA-NRCS, 2006).

Climate in the LMRB varies in detail with latitude though the entire basin lies within the Humid Subtropical climatic zone. Annual temperatures within the basin vary by 6.5 degrees Celsius from Cape Girardeau, MO (14^{o} C) to Houma, LA (20.5^{o} C). Annual precipitation is ample throughout the region with Cape Girardeau receiving 1188mm while Houma receives 1617mm. The LMRB also receives some of the most intense rainfall in the United States according to the rainfall erosivity index, a quantitative index combining rainfall intensity and energy for predicting erosion.

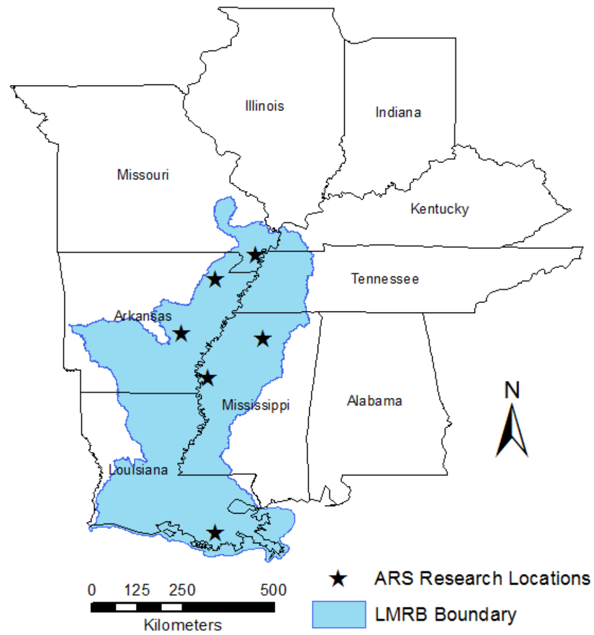

Figure 1. The proposed extent of the Lower Mississippi River Basin LTAR area.

Water has always been the key to management in the LMRB. The deep, rich soils of the alluvial valley were recognized early in European colonization for their agricultural potential despite seasonal flooding and the presence of largely unbroken expanses of lowland forests. In the mid-nineteenth century efforts to control floodwaters of the Mississippi River and subsequent clearing of greater than 75% of riparian forests allowed extensive development of the alluvial plain for agriculture on a near-unprecedented scale (Faulkner et al., 2011). As the uplands of the basin were also cleared for agriculture, however, the resulting erosion in the highly erodible loess hills clogged the sluggish streams of the alluvial valley with sediment, undermining drainage in the lowlands, and again resulting in flooding. The resulting destabilization of the uplands would require decades of reforestation and stream stabilization and a shift in focus to integrated basin management in order to balance flooding and erosion in the region.

The alluvial valley is now home to one of the most productive agricultural landscapes in the country built atop one of the three most productive agricultural aquifers in the United States (along with the California Central Valley and the Ogallala aquifer of the High Plains). And while the story of water management in the LMRB has historically been that of super-abundance, the over-development of the alluvial aquifer for irrigation has already shifted the story significantly toward one of water scarcity. As forecasted changes in climate include slight reductions in growing-season precipitation and a shift toward more intense run-off producing storms, the importance of sustainable water management in the region is expected to increase (IPCC, 2007).

Agricultural Significance

Agriculture is the dominant land-use in the LMRB. The LMRB contains approximately three-quarters of a million farms covering a total of twenty-seven million acres, or roughly 40% of the land area in the LMRB (USDA NASS, 2008). By acreage the primary harvested crops in the watershed are soybeans, corn, cotton, and rice accounting for a full two-thirds of the total national acreage of rice and one-fourth of cotton acreage. In Arkansas in 2009 the agriculture sector accounted for a higher percentage of state gross domestic product (10.4%) than in any other state, and the majority of the state's agriculture lies

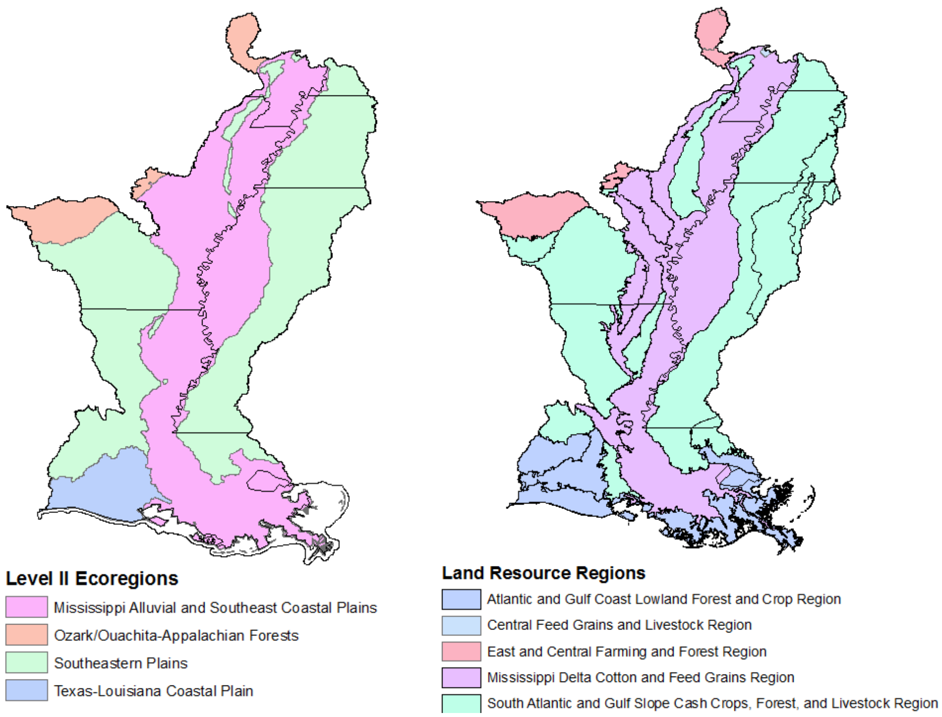

Figure 2. Level II EPA Ecoregions and NRCS Land Resource Regions (LRR) in the Lower Mississippi River Basin.

within the LMRB. Mississippi and Missouri were close behind at 8.12% and 7.1% respectively. Aquaculture is also a major component of the region's agriculture as 95% of the nation's harvested catfish is supplied by the LMRB.

While the LMRB receives plentiful rainfall, irrigated agriculture is increasingly the norm in the region. Approximately half of all harvested cropland is irrigated in the LMRB. From 2002-2007 irrigated acreage increased by 18% while total groundwater supplied by wells increased by 75% (USDA NASS, 2008). As of 2008 the LMRB was third nationally in quantity of water used for irrigation and second in acres of irrigated harvested cropland (USDA NASS, 2008). The overwhelming majority of irrigation water derives from the shallow Mississippi River Valley Alluvial Aquifer (MRVAA) underlying the alluvial plain making the MRVAA arguably the most intensively developed agricultural aquifer in the country.

In Arkansas and Mississippi the over-development of the aquifer for agricultural use is resulting in rapidly declining water levels. In Mississippi major rivers such as the Sunflower River lying entirely within the Mississippi alluvial plain have changed from net-gaining to net-losing streams and are at risk of becoming ephemeral streams incapable of maintaining environmental flows to sustain aquatic life during the summer months. In Arkansas saturated thickness of the aquifer has been reduced by as much as 100 feet in some areas requiring a regional commitment to developing alternative water resources. The sustainable conjunctive use of water from the alluvial aquifer for agricultural irrigation and the maintenance of environmental flows in the alluvial streams is a vital long-term economic and environmental concern for the region.

The LMRB has been the object of federal involvement in flood control and navigation (for the transport of agricultural commodities) virtually since the founding of the United States and will continue to be a region of national significance in agriculture as the nation faces new challenges in the sustainability of agricultural practices and the impacts of climatic change.

Ecological Significance

The LMRB is one of the most ecologically significant and vulnerable regions of the United States. The alluvial valley of the LMRB is the largest floodplain in the United States, and in its frequently-flooded, pre-developed state was a repository for sediment and nutrients while serving as habitat for a luxuriant diversity of flora and fauna (Faulkner et al., 2011). Waters of the LMRB drain into the northern Gulf of Mexico contributing sediment and nutrients to an area with one of the largest bottom-water hypoxic zones in the western Atlantic Ocean (Rabalais et al. 2001). The region has a wide diversity of riverine floodplain ecosystems encompassing the basin (Dembkowski and Miranda 2012). These aquatic ecosystems include rivers, lakes, streams, wetlands, bayous, and sloughs among the dynamic habitats within this diverse environment. The Lower Mississippi River Basin has extensive fish biodiversity and is well known for its sports fisheries (e.g. bass, crappie, catfish, etc.) (Justus 2010; Miyazono et al. 2010; Miranda 2011). The region is also a major fly-way for migratory waterfowl that feed on available fish and aquatic invertebrates while wintering (White et al. 1988). In addition, the region was once widely known for its diverse freshwater mussel communities (Haag and Warren 2007) that now exist only in isolated reaches of rivers and lakes. Due to increased anthropogenic activities such as intensive row crop agriculture, stream channelization, soil erosion, and groundwater depletion the basin is considered one the most endangered ecosystems in the U.S. (Noss et al. 1995).

Existing Long-Term Research

Goodwin Creek Experimental Watershed (GCEW) is located within the uplands of the Lower Mississippi Valley. Research was established in this north-central Mississippi watershed as part of the Streambank Erosion Control Evaluation and Demonstration Project (DEC) authorized by Section 32 of U. S. Public Law 93-251 to address excessive erosion due to deforestation and stream channelization in the uplands resulting in downstream sedimentation and flooding in the heavily agricultural alluvial plain. The U. S. Army Corps of Engineers (USACE), Vicksburg District, provided much of the construction funds when the watershed was established and the ARS-NSL has operated the data collection on the watershed since October 1981. One of the goals of the DEC project was to develop and test innovative techniques to control erosion in agricultural watersheds. GCEW has since served as a benchmark watershed for erosion research and streambank stability models.

Beasley Lake Watershed (BLW) is a small agricultural watershed located within the Mississippi River alluvial valley. Beasley Lake is an oxbow lake remnant from the adjacent Sunflower River. In 1994, the ARS-NSL co-led a consortium of federal and state organizations organized under the umbrella of the national Management Systems Evaluation Area Project (MSEA) that initiated research in BLW (Locke, 2004). The Mississippi Delta MSEA Project (MD-MSEA) implemented edge-of-field best management practices (BMPs) and began monitoring runoff from fields and lake water quality and assessing soil resources within the watershed. Since 1994, the ARS NSL has maintained a continuous presence in BLW as agriculture in the watershed has transitioned from primarily cotton monoculture to a mixture of row crops and a portion of the land enrolled in the Conservation Reserve Program (CRP) (Locke et al., 2008).

GCEW and BLW were designated as two of fourteen USDA-ARS benchmark watersheds participating in the joint ARS and National Resources Conservation Service (NRCS) Conservation Effects and Assessment Project, Watershed Assessment Study (CEAP-WAS) in 2004 (Locke et al., 2008; Kuhnle et al., 2008). The GCEW is located in a region with highly erodible soils, plentiful rainfall (1358 mm yr^{-1}), and relatively steep slopes (0.004). Total sediment yields from the watershed have been determined to be among the highest in the nation (13.2 t ha^{-1} yr^{-1} at the watershed outlet). The BLW lies within the alluvial plain known locally as the Mississippi Delta. The landscape is relatively level, but during periods of heavy rainfall, considerable runoff occurs leading to significant sediment loads (up to 16 t ha^{-1} yr^{-1}) (Dendy, 1981; Murphree and McGregor, 1991). Taken together, GCEW and BLW have been key watersheds for the integrated assessment of conservation practices that mitigate the sediment and nutrient impacts of agriculture linking upland and lowland systems.

Research Presence in the Lower Mississippi River Basin

Overview

The Agricultural Research Service's (ARS) establishment of a Long-Term Agro-Ecosystem Research (LTAR) Network provides an opportunity for the USDA-ARS to leverage the continuity and spatial coverage of its research presence in the Lower Mississippi River Basin (LRMB) to the advantage of a nationally coordinated long-term research effort. The core of this research presence consists of two long-term research watersheds representative of the two land resource regions (LRR) (USDA-NRCS, 2006) and Level II Ecoregions (CEC, 1997) within the basin: Goodwin Creek Experimental Watershed (GCEW) in the eastern uplands and Beasley Lake Watershed (BLW) in the Mississippi alluvial plain.

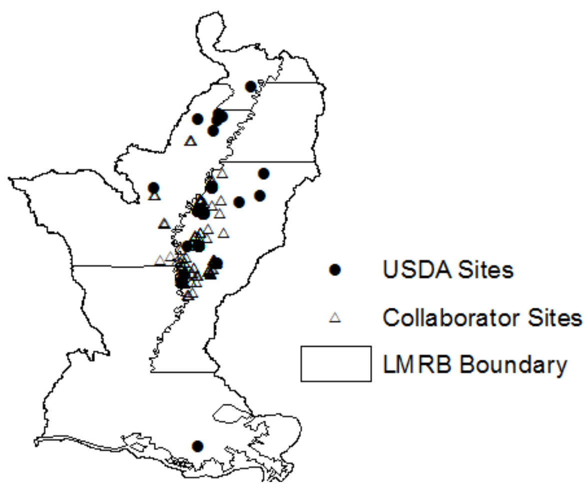

Figure 3. Research locations and field sites of USDA-ARS and its collaborators across the LMRB.

In addition to the two long-term research watersheds, six cooperating USDA-ARS research offices comprising fifteen research units are located within the LMRB and represent over five decades of research experience in the region. Research programs from these locations have led to the establishment of over fifty field sites for monitoring and experimentation across the LMRB. Activity at these sites spans a wide range of spatial and temporal scales from watershed-scale research over multiple decades, to short-term plot-scale experiment sites, to point-scale monitoring. The research conducted at these sites includes investigation of fundamental physical processes such as runoff and erosion, nutrient transport and processing, as well as plant breeding, agricultural trials, pest-control, and agricultural impacts on aquatic ecology. Research collaborations with government, academic, and stakeholder groups in the region result in a much larger field program than would be possible by ARS alone.

Long-Term Watersheds

Goodwin Creek Experimental Watershed (GCEW) – (1981-Present)

Goodwin Creek Experimental Watershed is located approximately thirty miles from NSL in the bluff hills province of the Yazoo River sub-basin of the LMRB. The GCEW has benefited from substantial investment in infrastructure from the USACE, NOAA, NRCS, and the USDA-ARS over its 30-year history. ARS-NSL maintains and operates in-channel measurement flumes, channel stabilization structures, rain gauges, onsite buildings for instrument housing and storage, and suspended walkways across the channel at select sites for additional in-stream measurements. The watershed is also home to two NRCS Soil Climate Analysis Network (SCAN) stations (pasture, forest), and one NOAA Solar Radiation Budget Network (SRBN) measuring station.

The largest infrastructure component of the watershed is composed of the original fourteen supercritical V-shaped measuring flumes constructed in the main channel and tributaries of Goodwin Creek. These flumes serve as both grade control structures and gauging sites for runoff, sediment transport, precipitation, and water quality. Thirteen of these flumes measure runoff from the sub-catchments that range in area from 0.06 km^2 to 21.39 km^2 and experience 100-yr runoff events from 3 to 176 cubic meters per second, respectively. The site of each measuring flume in the watershed is equipped with an instrument house that encloses stilling wells, water/sediment auto-samplers, data loggers, and telemetry equipment for real-time data transfer to the NSL.

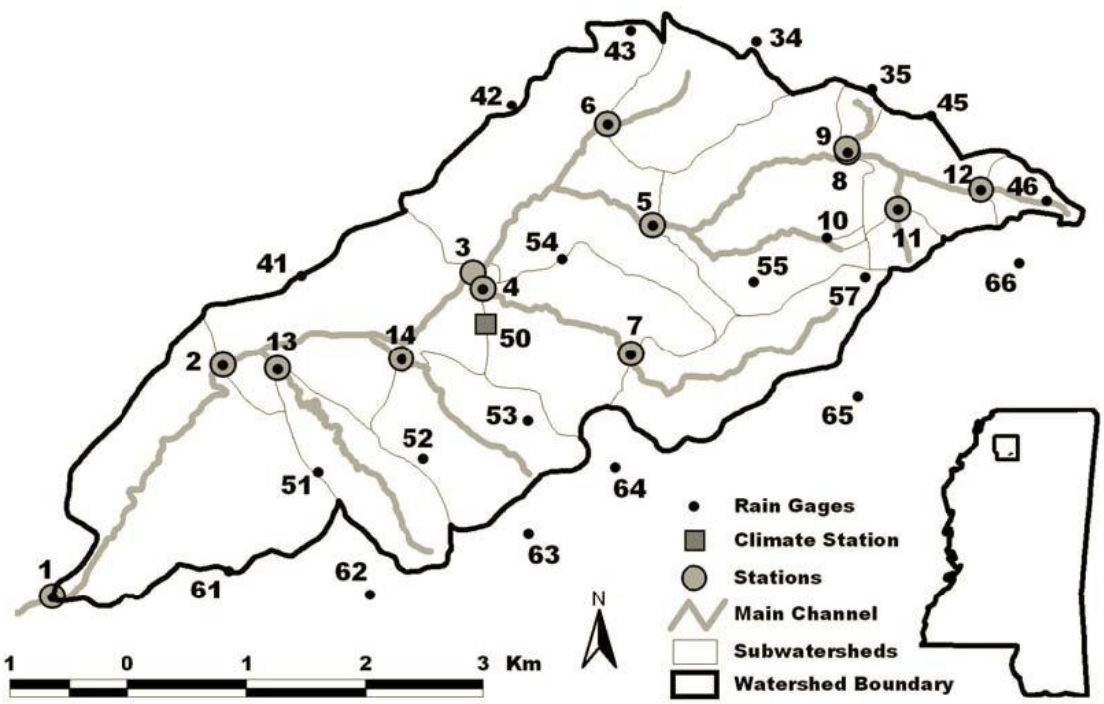

Figure 4. Goodwin Creek Experimental Watershed (1981-Present). The 21.5 sq km watershed includes 26 active rain gages and 14 concrete supercritical flumes acting as grade control structures and runoff gaging stations.

A network of 26 recording rain gauges (6 at gauging stations, 20 at remote sites) is currently maintained within and around the watershed and has been continuously recording rainfall since 1981 providing an average spatial density of 1.3 gauges per square kilometer.

Two NRCS Soil Climate Analysis Networks (SCAN) stations are located within the watershed. The two stations provide hourly soil moisture measurements at five depths (2cm, 4cm, 8cm, 20cm, 40cm) for one pasture and one forest location in GCEW. Additional hourly measurements include air temperature, barometric pressure, humidity, dew point, relative humidity, soil temperature, vapor pressure, wind direction, and wind speed. These stations have been in continuous operation in GCEW since January of 1999 and data are available online from the SCAN website.

In addition, GCEW houses one of six NOAA Surface Radiation Budget (SURFRAD) stations in the United States. This station, established in 1994, is located at the same pasture site that houses one of the two NRCS-SCAN stations. The SURFRAD instruments collect continuous observations of long-wave and short-wave radiation, direct and diffuse solar radiation, photosynthetically active radiation, UV-B, and meteorological variables such as wind speed, temperature, and humidity. This data is available online from the SURFRAD website.

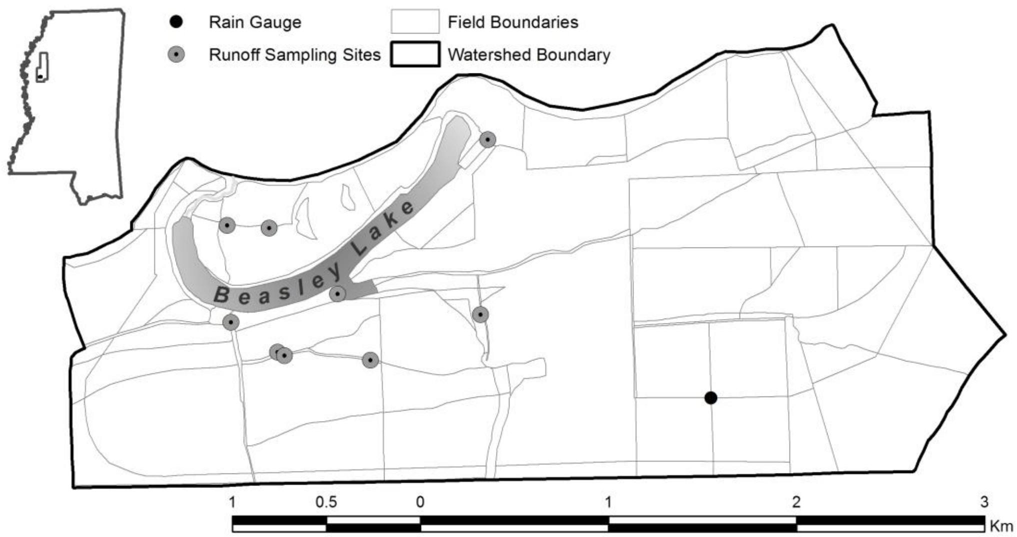

Figure 5. Beasley Lake Watershed (1994-Present) located in the Mississippi River alluvial plain, showing current gauging locations and field boundaries.

Beasley Lake Watershed – (1994-Present)

Beasley Lake Watershed (Fig. 5) is located in Sunflower County, Mississippi, approximately 125 miles southeast of the ARS-NSL in the Mississippi River Alluvial Plain. During the MD-MSEA project period (1994-2004), USGS maintained and operated automated sampling systems at key sub-drainage sites associated with vegetative filter strips; pipes with slotted board risers for water impoundment during the fallow season; or pipes with slotted inlets to control water flow positioned at outlets of sub-drainage areas. The ARS-NSL focused on lake sampling at three geo-referenced sites within the lake and has a continuous record of lake water quality from 1995 to present. The USGS discontinued sampling at runoff sites in BLW in 2004.

From 2003-2004, 12.4% (114 ha) of the arable land was removed from row-crop production and planted in trees under the Conservation Reserve Program (CRP). In 2006, 4-5 ha of arable land along the southern lake shoreline was removed from row-crop production and converted to vegetative buffer habitat to attract northern bobwhite quail (*Colinus virginianus*) (Locke et al., 2008). In 2006, ARS-NSL focused research on runoff from sub-drainage areas involving these new practices established in the watershed. The ARS-NSL currently operates and maintains instrumented samplers at three sites within each management regime to compare runoff and changes in soil resources (CRP, buffer, and row crop) (Fig. 5). In 2003, a constructed wetland was established on the northeast side of the lake, and a sediment retention basin was constructed in 2009 on the south part of the lake intercepting the convergence of two major drainage ditches entering the lake (Fig. 5). ARS-NSL installed automated samplers to collect water entering the sediment retention pond on the south side of the lake.

The first of two tipping bucket rain gauges installed in the BLW was by the USGS in 1996 in support of the MD-MSEA project. The period of record for this gauge was 1996-1999. A second rain gauge was installed in 1999 as part of the NRCS SCAN site within the watershed that collects soil moisture and soil temperature data along with precipitation, wind, and solar radiation data. BLW data are available on the SCAN website.

At each of the eleven BLW runoffs site, storm event or runoff samples are collected using automated pumping samplers activated by acoustic-Doppler water level and area velocity water flow sensors.

Selected USDA-ARS Research and Key Partnerships in the LMRB

USDA-ARS

The USDA-ARS research effort in the LMRB consists of numerous research units addressing all facets of agro-ecosystems including crops, cultivation, and ecology. The diversity of this research effort is one of the great assets of the proposed inclusion of the LMRB in the LTAR Network. While many of the USDA research entities in the LMRB, including the USDA-ARS National Sedimentation Laboratory, have a research focus on soil and water resources, the crop-specific research groups are key contributors to the proposed LTAR as agro-ecosystems are evolving landscapes of innovation in both crop characteristics and agricultural practice. In this section we highlight contributions from both the soil/water conservation emphasis of NSL as well as the broader contributions envisioned through the cooperative effort of USDA-ARS locations. Table 1 lists a number of sites past and present and their associated data. Letters of support from cooperating USDA-ARS locations are included below after the appendices.

National Sedimentation Laboratory (Oxford, MS)

The National Sedimentation Laboratory is home to two research units addressing water quality/ecology and watershed physical processes. Consistent with its mission and location in the highly erodible loess bluffs of Mississippi, NSL is the preeminent research location for soil erosion, sediment transport, and bank stability in the nation. NSL is the research home for a suite of models representing the state of the art in physical understanding of erosion and sediment transport in agricultural watersheds including the Revised Universal Soil Loss Equation (RUSLE) model which is the most widely used field-scale planning tool employed in agricultural soil conservation, the Annualized Agricultural Non-Point Source Pollution (AnnAGNPS) watershed model, the Bank Stability Model (BSTEM), and the Conservation Channel Evolution and Pollutant Transport Model (CONCEPTS). The laboratory has also been a leader in understanding the impacts of agricultural practices on water quality and aquatic ecology resulting in development of new best-management practices for nutrient retention and water quality improvement in agricultural watersheds. NSL scientists also led a consortium of agencies and organizations in the Mississippi Delta Management Systems Evaluation Area (MD-MSEA) project in watershed assessments of the effects of conservation practices on water quality and ecology. NSL scientists conduct research at numerous field sites nearly all of which are located within the LMRB. Listed below are three specific research projects of regional significance.

- *Delta Bayou Watershed Study (MS):* Three representative watersheds in the Mississippi River alluvial plain feeding oxbow lakes (Roundaway Lake, Cow Oak Lake, and Howden Lake) are instrumented to evaluate the interaction of nutrients, pesticides, and sediments with watershed hydrology in regulating water quality and aquatic ecosystem structure and function in agricultural watersheds.

- *Irrigation Tail-Water Recovery and Storage (MS, AR):* More than fifty farms in the Mississippi and Arkansas portions of the alluvial plain are being studied to assess the potential long-term impact of irrigation tail-water recovery and storage on regional water availability and water quality. These data will assist in determination of contaminant trapping efficiency of the reservoir and quantify the reduction in contaminant loads from agricultural watersheds.

- *Sunflower Surface-Groundwater Connectivity (MS):* The heterogeneity of sedimentary deposits in the Mississippi River alluvial plain makes direct estimation of aquifer recharge extremely difficult. Scientists from USDA-ARS and the USGS are collaborating at sites on the Sunflower River to determine the pathways and degree of connection between surface water and groundwater. This work will help quantify recharge from surface streams and improve understanding of nutrient exchange between agricultural fields and groundwater.

- *Irrigation water use (AR):* A number of farms in northeastern Arkansas are being studied to better understand water use under current producer practices. These sites include rice, soybean and cotton production-sized fields. Much of this work is being done in collaboration between USDA-ARS-Jonesboro and the White River Irrigation District and University of Arkansas.

Jamie Whitten Delta States Research Center (Stoneville, MS)

The Delta States Research Center is located on a 17-acre research farm in the Mississippi River alluvial plain and is home to seven research units with expertise including genetics, insect management, and crop production systems. The Center also serves as the headquarters of the USDA-ARS Mid-South Area. Some sixty-five doctoral scientists conduct research at the Center addressing all phases of production agriculture. Accomplishments include a new yield-increasing cotton production system, development of new water management tools for farmers, tools for insect management, and development of disease resistant crop varieties. Research in crop irrigation systems and water management tools complements the work at NSL and serves as a bridge between the two research locations for integrating expertise in the proposed LTAR.

Dale Bumpers National Rice Research Center (Stuttgart, AR)

The National Rice Research center conducts extensive research to understand rice responses to pests, pathogens, and weather stress (e.g., water availability) in order to enhance efficiency and sustainability for U.S. rice production. As more than two-thirds of U.S. rice is produced in the LMRB, the work at the Rice Research Center is a vital contributor to the region’s agriculture. Within a LMRB LTAR the Rice Research Center will contribute expertise in crop development and field trials to form a substantially richer LTAR dataset.

USDA-ARS Sugarcane Research Unit (Houma, LA)

Sugarcane is one of the nation’s oldest cash crops and is now grown primarily in Florida, Louisiana and Texas. In 2011, 40% of U.S. sugarcane was produced within the LMRB in southern Louisiana. The USDA-ARS Sugarcane Research Unit in southern Louisiana conducts field studies of best management practices for the sustainable production of sugarcane including determination of nutrient budgets, assessment of sugarcane’s effect on soil health and water availability, and enhancement of the use of sugarcane for providing ecosystem services. Such enhancement of production agriculture’s contribution to ecosystem services is an important link in the development of sustainable agro-ecosystems.

Missouri Agricultural Experiment Station Delta Research Center (Portageville, MO)

The 1,024 acre Delta Research Center consists of four separate farms. Research conducted at the Delta Center is focused on crop production and management and is home to the University of Missouri's cotton and rice production research program. Scientists at the Delta Center also conduct research on soybean cropping systems, weed, insect and disease control in all crops and variety evaluations. The USDA-ARS lead scientist at the Delta Center conducts research focused on improving irrigation water management and water quality as an extension of the Cropping Systems and Water Quality Research Unit in Columbia, MO. These units work together on a series of sites within the Little River Ditches watershed in close proximity to multiple Mississippi River Basin Initiative Focus Area Watersheds. These sites are continuously monitored for water quality impacts.

Selected Collaborators

Yazoo-Mississippi Water Management District (YMD) and Arkansas Natural Resources Commission (ANRC) - The YMD in Mississippi and the ANRC in Arkansas are key partners with ARS on issues of water resources in their respective states. Each conducts a manual census of water levels from a total of approximately 1,300 irrigation wells across the Mississippi and Arkansas portions of the alluvial plain annually. In Mississippi the census is conducted twice annually in April and October to show annual fluctuations of the aquifer before and after irrigation pumping. This record exists from 1996-present in Mississippi and 2004-present in Arkansas and provides an invaluable dataset for monitoring agricultural impacts on groundwater resources and working towards sustainable irrigation practice in the region.

Arkansas Edge-of-Field Monitoring Network - A statewide monitoring network consisting of thirty monitoring sites on twelve farms was established in 2010 to monitor and assess agricultural impacts on water quality and quantity in Arkansas (Reba et al., 2013). The network is a collaborative effort of USDA-ARS, Arkansas State University, the University of Arkansas, the USDA-NRCS, Arkansas Commission on Natural Resources, Arkansas Association of Conservation Districts, and agricultural producers representing major commodities produced in the state. The monitoring effort includes instrumentation to monitor flow and collect physical samples for sediment and nutrient analysis. In 2012 the primary network partners received a Conservation Innovation Grant to utilize existing monitoring stations to evaluate the performance of low-cost sampling equipment developed at the University of Wisconsin. Support for the network is expected to continue through universities, stakeholder organizations, and government entities as monitoring water quality and quantity remains a state-wide priority.

Natural Resources Conservation Service (NRCS) - The NRCS works closely with ARS scientists throughout the region on issues of soil and water conservation including groundwater conservation, tail-water recovery systems, and investigations of agricultural runoff. Each of NSL’s long-term watersheds was selected as benchmark watersheds for the NRCS Conservation Effects Assessment Program (CEAP). In addition, fourteen of the forty-one national Focus Area watersheds recognized by the NRCS Mississippi River Basin Initiative (MRBI) fall within the proposed Lower Mississippi River Basin LTAR.

U.S. Army Corps of Engineers (USACE) - The USACE has constructed several flow control structures in LMRB watersheds including the supercritical flumes of GCEW. The Vicksburg District of the USACE also maintains five water quality monitoring stations throughout the Mississippi Delta and has also partnered with other government entities to establish the Delta Monitoring Fixed Station Network. Data collected from this network will contribute data on sediment and nutrient loadings at selected sites within the alluvial plain in Mississippi.

U.S. Geological Survey (USGS) - The USGS Groundwater Resources Program initiated the Mississippi Embayment Regional Aquifer Study (MERAS). A major product of this study is the MERAS regional groundwater model covering approximately 78,000 square miles of the Mississippi Embayment, comprising hydrogeologic information from a compilation of 2,600 bore-hole logs, and representing USGS collaboration over seven states. Since the completion of the initial model USGS Water Science Centers in Mississippi and Arkansas have been working on refining the simulation for sub-regions of the MERAS model, e.g., limiting the simulated area to the alluvial plain to better understand the water balance of the alluvial aquifer. ARS scientists are working closely with the USGS in both states to better constrain these models with a set of processed-based investigations of stream-aquifer connections in the alluvial plain.

Academic Partners – USDA-ARS maintains research collaborations with universities throughout the region. At the University of Mississippi, NSL scientists have worked closely with the National Center for Computational Hydroscience and Engineering (NCCHE) in developing world-leading flow and sediment transport models and with the Jamie Whitten National Center for Physical Acoustics (NCPA) in developing acoustic instrumentation for watershed research. The University of Arkansas's Discovery Farms and Mississippi State University's REACH program have each created networks of research farms for assessing farm practices for resource conservation and habitat enhancement in collaboration with USDA-ARS. A strong collaboration with the Arkansas State University Biosciences Institute and Ecotoxicology Facility has been key to water quality studies with USDA-ARS in the Mississippi alluvial plain.

Stakeholder Partners – USDA-ARS research is conducted with the support and involvement of stakeholder groups such as Delta Farmers for Resource Conservation (FARM) and the local irrigation districts of Arkansas and Mississippi, especially the Yazoo-Mississippi Water Management District and the White River Irrigation District. These collaborators are key to translating research into practice in the region and provide a vital link between producers and scientists in the LMRB.

Table 1. Summary of additional NSL research sites within the LMRB, past and present, complementing the long-term datasets at GCEW and BLW.

Site Name	Data	Project	Time Period
Pigeon Roost	Runoff/Sediment	-	1958-1971
Holly Springs	Runoff/Sediment	-	1956-Present
Nelson Farm	Runoff/Sediment	-	1989-2000
Deep Hollow	Runoff/Sediment/Nutrients/Water Quality/Soil Characteristics	MD-MSEA	1995-2003
Thighman	Runoff/Sediment/Nutrients/ Water Quality	MD-MSEA	1995-2002
Stoneville	Runoff/Sediment/Nutrients/Soil Characteristics	-	2005-Present
Little Topashaw	Runoff/Sediment	CEAP	1999-2009
Coldwater	Water Quality/Aquatic Ecology/ Water Quality	-	2004-2010
Roundaway	Water Quality/Aquatic Ecology/ Water Quality/Sediment Cores	-	2011-Present
Howden	Water Quality/Aquatic Ecology/ Water Quality	-	2011-Present
Cow Oak	Water Quality/Aquatic Ecology/	-	2011-Present

	Water Quality		
UMFS/CWWR	Water Quality/Aquatic Ecology	-	1985-Present
Sky Lake	Sediment Cores	-	2006
Washington Lake	Sediment Cores	-	2009
Wolf Lake	Sediment Cores	-	2009
Moon Lake	Sediment Cores	-	2009
Hampton	Sediment Cores	-	2008

Data Richness at Long-Term Watersheds

The ARS-NSL maintains several datasets from GCEW and BLW that include both static, background data concerning the watershed and active, continuously updated, long-term records of variables such as stream stage, sediment and nutrient concentrations. Static data sets include those providing either background information for the watershed (e.g., soils and stratigraphy) or the results of particular studies conducted in the watershed. These static datasets provide a wealth of information for researchers on the physical, biological, and geologic characteristics of GCEW and BLW and can be referenced either in summarized documentation (e.g., Blackmarr, 1995; Nett et al., 2004) or in the peer-reviewed literature (Appendices I and II). In addition to GCEW and BLW research, research at other sites within the Yazoo River Basin contributes to the overall record. Some of these sites are shown in Table 1.

Precipitation
Precipitation has been collected in GCEW since 1981 and from BLW since 1994. In GCEW data is currently collected through a network of 26 recording rain gauges in and around the watershed. Of these, 8 are located at supercritical measurement flume sites while the other 20 are distributed across the watershed. Precipitation has also been collected in BLW at a single rain gauge near the center of the watershed.

Runoff
Stage has been recorded continuously at multiple stations within the watershed since 1981. Initially stage was recorded at 15-min intervals for baseflow and 1 minute intervals for storm-flow at each of the 14 measuring flumes in GCEW. As of 2007 stage measurements are being recorded from 9 of the flumes. These stage records are converted to volumetric discharge by means of rating curves established for each structure.

Fine Sediment Concentration
Since 1981 water samples have been collected in GCEW during runoff events and processed for sand and fine sediment concentrations. Using pump auto-samplers, sediment samples are collected for every 0.07 m rise in stage and every 0.14 m on fall in stage. Samples taken during flow events are dried, sand is separated, and weights of sand and fine fractions recorded. The fine sediment concentrations are used to produce stage-sediment rating curves for each of the flumes in the watershed. These rating curves are then used to determine annual average sediment yield from the basin based on the continuous runoff record.

Water Quality
Bi-weekly grab samples were collected upstream of Station 1 in GCEW near the watershed outlet for the period 1985-2007 and also upstream of Station 2 for the period 2004-2007. As of July 2010 monthly water quality sampling has been restarted at both previous sites as well as three additional sites. In

addition composite samples are collected over the course of storm events using auto-samplers at Stations 1 through 5. All samples are analyzed for total phosphorus, filterable phosphorus, NO_2, NO_3, NH_3, TKN, turbidity, total solids, dissolved solids and dissolved organic carbon.

Runoff monitoring sites were established in BLW from 1995 to 1996 and monitored by USGS for the MD-MSEA project from 1995 to 2003 (Rebich, 2004). Additional sites with various edge-of-field management practices (e.g., slotted board risers, tile drainage, stiff grass hedges) were instrumented by NSL scientists to sample runoff (1999-2001). Nutrient and pesticide analyses were conducted, and preliminary results are reported in Smith et al. (2002).

Soil assessments

Soils research in BLW included assessments of the spatial distribution of soil characteristics (Gaston et al., 2001) and their effects on herbicide dissipation (Locke et al., 2003) under conventional tillage cotton production. Other research demonstrated the effects of vegetative buffers on soil characteristics and potential implications for herbicide dissipation (Staddon et. al, 2001). Current research is focused on assessing various physical and chemical parameters such as aggregate stability, soil organic carbon, and nutrient content following conversion of land from row crop to CRP and buffers.

Channel Cross-Section Surveys

Cross-sectional channel geometry has been surveyed at a number of sites within the watershed beginning in 1977 and as recently as 2007. The core of this data set consists of approximately 30 independent surveys conducted between 1982 and 1995 each detailing the cross-section at selected sites within the watershed. A detailed listing of surveys through 1995 is available in Blackmarr (1995).

Land Use Surveys

A land use survey has been conducted annually for GCEW from 1980 through the present. These surveys divided the watershed into 1,136 distinct areas and designated each area into one of twelve distinct land uses (including 6 different crop types for agricultural fields). Beginning in 2013 details of farming practices and yields will be collected for the watershed.

Agricultural management activity is collected and recorded from 30 field units within BLW. The data are collected annually and are based on observations of ARS scientists and technicians in collaboration with farmers, landowners, consultants, and custom pesticide applicators. The data includes crops grown, tillage activities, pesticide applications, and fertilizer applications.

Remotely Sensed Data

- **LiDAR**: In 2009 the USACE provided one-meter resolution LiDAR dataset for the entire Yazoo River basin encompassing both GCEW and BLW.
- **Multi-Spectral**: Eight bands of data were collected for BLW in 2011 from satellite imagery suitable for classification of land characteristics, soil moisture, vegetation type, stress, and health.
- **Satellite Elevation Data**: A combined image elevation model was developed from satellite topographic data obtained in 2007 resulting in a 5 meter by 5 meter grid of elevation points describing the topography of BLW.
- **Aerial Photography:** A set of digitized aerial photographs exists for the entire GCEW for the period 1937-2011 at an average interval of five years between photographs. The imagery is available annually since 2006 with the exception of 2008.

Lake Limnology and Pesticides

Since 1995, lake water has been sampled biweekly at three locations in BLW, and water samples processed and evaluated for sediment, TOC, chlorophyll, Secchi visibility and nutrients (Knight and Welch, 2004, Locke et al., 2008). Lake ecology was assessed by evaluating fisheries (1998, 2004, 2006, 2009, 2011), enzymes (e.g., [FDA] fluorescein diacetate hydrolysis 2000-2003), planktonic activity (total algae), bacteria, and chlorophyll *a*. Several physical and chemical characteristics such as total organic carbon (TOC), total solids, electrical conductivity, and pH were measured. For lake pesticide evaluations (1998 to 2011), 4-L water samples were collected monthly in triplicate. Additionally, bottom sediments were cored at multiple sites within the lake in 2009 and 2011 for use in determining long-term sedimentation rates and contaminant accumulation.

COSMOS Soil Moisture

In addition to the current active data sets GCEW has recently been added as a contributor to the Cosmic-ray Soil Moisture Observing System (COSMOS), a National Science Foundation supported project to use ambient fast neutron activity generated by cosmic rays as a passive measure of field-scale average soil moisture. The COSMOS probe was installed in GCEW in 2012 near the pasture SCAN site allowing comparison of point soil moisture measurements from SCAN at multiple depths with the field-scale average delivered by COSMOS.

Ameriflux

GCEW was a member of the **AMERIFLUX** network from 2002-2007. The tower was maintained and eventually decommissioned by NOAA. Communication from NOAA technicians early in 2011 indicated that plans were in place to re-establish the eddy covariance tower in GCEW within the next five years.

Data Availability

The Lower Mississippi River Basin LTAR will be led by an **oversight committee** composed of representatives from the six ARS research locations and collaborators with NSL providing the administrative leadership. The long-term research watersheds will continue to be administered by the National Sedimentation Laboratory. Individual field sites will be administered by the contributing partner (e.g., ARS-Stoneville, University of Arkansas, etc.).

Data from long-term watersheds (Beasley Lake and Goodwin Creek) are currently being made available through the STEWARDS online database (http://www.nrrig.mwa.ars.usda.gov/stewards/stewards.html). Additional Goodwin Creek data products are available from the NSL website (http://ars.usda.gov/Business/docs.htm?docid=5120). Core date sets from both locations will be contributed to STEWARDS on an ongoing basis as part of the LTAR effort. In addition, data from selected field sites associated with the LTAR will also be made available through STEWARDS.

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Anna McClung, Ph.D., Center Director, Dale Bumpers National Rice Research Center

Sugarcane Research Unit - Houma, LA

Michael Grisham, Research Leader, Sugarcane Unit

Paul White, Ph.D., Soil science

Collaborators

ARS scientists have maintained many vital research partnerships with federal agencies, state institutions, private organizations, and universities across the Lower Mississippi River Basin including:

Government
- U.S. Army Corps of Engineers, Environmental Laboratory, ERDC
- National Oceanic and Atmospheric Administration (NOAA)
- USDA Natural Resources Conservation Service (NRCS)
- Federal Interagency Sedimentation Project (FISP)
- Mississippi Department of Environmental Quality (MDEQ)
- Mississippi Water Resources Research Institute (MWRRI)
- USGS Arkansas Water Science Center
- USGS Mississippi Water Science Center
- Arkansas Natural Resources Commission
- Mississippi Soil and Water Commission

Academic
- Arkansas State University
- University of Arkansas
- University of Arkansas – Pine Bluff
- Mississippi State University
- University of Mississippi

Stakeholder
- Delta FARM
- Delta Council
- Yazoo Mississippi Water Management District
- Arkansas Association of Conservation Districts
- White River Irrigation District

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Appendix I: Selected Scientific Publications From GCEW Research

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Appendix II: Selected Scientific Publications From BLW Research

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March 29, 2013

SUBJECT: Support for Lower Mississippi River Basin Nomination for LTAR Membership

TO: Colette Wood

FROM: Edgar G. King, Mid-South Area Director

The Lower Mississippi River Basin (LMRB) is a heavily agricultural watershed in which a quarter of the nation's cotton and over two-thirds of its rice is produced. The basin is of national significance for the scale of production of agricultural commodities and its natural ecosystems. Additionally, the interplay of agriculture and the environment within the basin is nationally representative at both the local and continental scales. At the local scale, issues of agricultural practices and the conservation of soil and water resources are of acute interest as the region is home to some of the most erodible land and over-taxed aquifers in the country. At the continental scale the Lower Mississippi is the gateway to the Gulf of Mexico and the integrator of water quality impacts of agricultural land across almost half of the continental U.S.

The USDA-ARS has been active across the Lower Mississippi River Basin and has numerous collaborations with federal, state, and local government organizations as well as local producers and stakeholders. This research addresses the full spectrum of agriculture-ecosystem interactions including the development of new crops, tracking the fate of pesticides, evaluating and conserving the biodiversity of aquatic communities, and developing practices to conserve soil resources and improve nutrient retention. Among the USDA-ARS research locations the National Sedimentation Laboratory (NSL) has been the key ARS research organization addressing water and soil conservation issues in the Mississippi River alluvial plain and eastern uplands for the past fifty years. Scientists at NSL are ideally suited to address the agro-ecosystem emphasis as the laboratory houses two research units covering both water quality-ecology and watershed physical processes. NSL currently operates two long-term research watersheds in the Lower Mississippi River Basin, Beasley Lake (BLW) in the alluvial valley and Goodwin Creek (GCEW) in the uplands, that combined represent the physiography of approximately 85% of the basin. Both sites were selected as benchmark watersheds in the USDA Conservation Effects and Assessment Project, Watershed Assessment Study (CEAP-WAS). The long-term data sets at these two locations provide a strong foundation on which to build an LTAR program for the LMRB.

In addition to these long-term research watersheds, the ARS and its collaborators have operated over fifty research sites in Mississippi, Missouri, Arkansas, and Louisiana contributing to the understanding of the physical and biological processes at work in and around agricultural watersheds in the LMRB. When combined with the other ARS locations, a coherent research effort across the LMRB emerges which addresses long-term sustainable agriculture amidst immense ecological diversity. The Mid-South Area recognizes the rarity and value of such long-term research efforts and is committed to continued support of research and data acquisition at the existing long-term watershed sites as well the numerous field sites across the region operated by ARS and its collaborators. The USDA Mid-South Area is pleased to support the proposal for the Lower Mississippi River Basin as a member of the LTAR Network. We further believe that the Lower Mississippi River Basin has the potential to be one of the key watersheds in the LTAR Network.

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April 1, 2013

SUBJECT: Support for Lower Mississippi River Basin Nomination for LTAR Membership

TO: Colette Wood
Program Analyst, Natural Resources and Sustainable Agricultural Systems

FROM: M. J. M. Römkens
Laboratory Director/Location Coordinator, USDA ARS Oxford Location

The inclusion of the Lower Mississippi River Basin (LMRB) in ARS's Long Term Agro-Ecosystem Research Network (LTAR) with Goodwin Creek Experimental Watershed (GCEW) and Beasley Lake Watershed (BLW) as key anchors would be an appropriate and opportune selection at this point in time. GCEW has a 30-year history of hydrologic and erosion/sedimentation research, while BLW has a 17-year history of water quality and ecology research. Both watersheds have excellent infrastructure for carrying out long-term research.

GCEW and BLW provide a backbone of long-term research in two important areas within the Lower Mississippi River Basin. GCEW is located on the Bluff Line Area, while BLW lies within the Mississippi Delta. In addition to these two locations, scientists from NSL maintain collaborations with other ARS locations as well as academic institutions at several field sites across the region. Data from these many sites augment the long-term presence in the research watersheds. As director of the laboratory I believe that the LMRB will be central to any national program working toward long-term agro-ecosystem sustainability and am pleased to support a proposal for its inclusion in the LTAR Network.

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March 28, 2013

SUBJECT: Support for Lower Mississippi River Basin Nomination for Long-Term Agro-ecosystem Research (LTAR) Membership

TO: Colette Wood

FROM: Krishna Reddy
Research Leader, Crop Production Systems Research Unit

This is to confirm that I am willing and interested to collaborate and support the Lower Mississippi River Basin to become LTAR watershed. The Lower Mississippi River Basin is one of the most important agricultural watersheds in the United States and serves as the strongest link between agricultural practices and large-scale ecological impacts in the Gulf of Mexico. The Crop Production Systems Research Unit in Stoneville, MS supports the proposal submitted by the USDA-ARS National Sedimentation Laboratory (NSL) for the Lower Mississippi River Basin to become an LTAR contributing watershed. Our research unit has collaborated with the NSL on past projects and would be eager to cooperate in research and data sharing as a part of the LTAR Network.

I look forward to participate in LTAR Network. If you have any questions, please feel free to contact me at 662 686 5272 or Krishna.reddy@ars.usda.gov.

ars
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March 28, 2013

SUBJECT: Support for Lower Mississippi River Basin LTAR Proposal

TO: Colette Wood

FROM: Anna Myers McClung
Research Leader

Anna Myers McClung

The Dale Bumpers National Rice Research Center in Stuttgart, Arkansas strongly supports the National Sedimentation Laboratory's proposal for the Lower Mississippi River Basin as a contributing LTAR watershed. More than two-thirds of U.S. rice production is located within the LMRB, and water availability is the most important issue determining the sustainability of rice production in the U.S. For the state of Arkansas, which produces 50% of the nation's crop, most of the counties with significant acreage in rice production have been designated as critical groundwater areas by the Arkansas Soil and Water Conservation Commission. In these counties, groundwater resources have been so depleted that rice production cannot be sustained into the future. As a result, significant resources are being expended for infrastructure development for greater use of surface water and for on-farm impoundment. In areas along the Gulf Coast, there have been thousands of acres of rice taken out of production because of salt water intrusion, some of which is related to loss of protective marshlands and to hurricane tidal surges. Thus, managing water resources along the LMRB is critical for long term viability of the rice industry in the southern US.

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March 28, 2013

SUBJECT: Support for Lower Mississippi River Basin Nomination for Long-Term Agro-ecosystem Research (LTAR) Network Membership

TO: Colette Wood, Program Analyst

FROM: Earl Vories, Research Agricultural Engineer Earl D. Vories
Cropping Systems and Water Quality Research Unit

CC: John Sadler, Research Leader
Cropping Systems and Water Quality Research Unit

Robert Matteri, Area Director
USDA-ARS Midwest Area

The Lower Mississippi River Basin (LMRB) is one of the most productive agricultural regions in the United States, accounting for a quarter of the total U.S. cotton and two-thirds of the total U.S. rice production along with large areas of corn and soybean. Over 80% of farms receive irrigation, and the 7.1 million irrigated acres, approximately the same amount as in California, represent over 10% of the entire land area of the basin. The LMRB is one of the most intensively developed regions for irrigated agriculture in the U.S. and is ecologically one of the most productive and diverse ecosystems. Furthermore, the ecology and agriculture of the LMRB are intimately connected with one another, with the intensive agricultural irrigation along the alluvial plain resulting in rapidly declining water tables in some regions. Changes in stream hydrology resulting from declining base-flow, together with the water quality impacts of agricultural runoff, make the LMRB an important and appropriate addition to the LTAR network.

The USDA-ARS Cropping Systems and Water Quality Research Unit (CSWQRU) is based in Columbia, Missouri, and maintains a work site at Portageville in southeastern Missouri. The project “Improving Irrigation Management for Humid and Sub-humid Climates” (3622-13610-003-00D) is based in Portageville and includes an objective to “Evaluate the quality of runoff from irrigated cropland to determine current and potential environmental risks and develop guidelines and BMPs to reduce impact of irrigated agriculture on water quality degradation.” One of the subobjectives, “Determine nutrient content of runoff from surface drained land in the lower Mississippi River basin,” is a joint effort with another CSWQRU project “Development of Alternative Practices for Improved Watershed Management” (3622-12130-004-00D). CSWQRU is also the leader for the Central Mississippi River Basin LTAR site.

Cropping Systems and Water Quality Research Unit
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A 2006 preliminary study observed nutrient concentration in runoff from four drainage ditches in the Little River Ditches watershed in southeastern Missouri. The lower-than-expected levels detected demonstrated the need to expand the monitoring program and include runoff volume to calculate nutrient loads. Therefore, a new study was designed and two of those earlier sites plus another site have been continuously monitored since May, 2011. The three sites reside in different sub-watersheds of the Little River Ditches watershed, have quite different drainage areas, and were selected for close proximity to locations participating in the NRCS Mississippi River Basin Initiative. Rating curves have been developed and refined for the sites and data defining the precise sizes and locations of the drainage areas as well as the crops and practices in those areas are being obtained. Routine analyses include total and dissolved N and P and total suspended sediment. Sampling protocols at all sites include collection of baseflow and runoff samples. Monthly grab samples are currently collected and flow-proportional runoff samples will be collected with automated samplers. A single composite runoff sample will be collected for each runoff event. This sampling scheme will allow for assessment of contaminant concentrations under baseflow and runoff conditions and, when combined with discharge data, will facilitate computation of contaminant loads.

Although this effort began more recently than some in the LMRB, it is recognized as essential at the CSWQRU, Midwest Area, and National Programs levels and all possible effort will be exercised to maintain the program. We believe this work will complement the other sites and serve as an important component of the proposed LMRB LTAR. We look forward to cooperating with the USDA-ARS National Sedimentation Laboratory in Oxford, MS, and other ARS research locations and in collaboration with numerous government and academic research partners in this endeavor.

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March 28, 2013

Ms. Colette M Wood, Program Analyst
GWCC-BLTSVL
5601 Sunnyside Avenue - Room 4-2294
Beltsville, Maryland 20705-5140

Dear Ms. Wood:

SUBJECT: Lower Mississippi River Basin LTAR

On behalf of the USDA, ARS, Sugarcane Research Unit in Houma, LA, I want to convey our intent that Dr. Paul White will cooperate in the proposed Lower Mississippi River Basin Long-Term Agro-ecosystem Research Network headed by the National Sedimentation Laboratory in Oxford, MS.

Paul has been and continues to monitor runoff volume and sediment loads from sugarcane fields in Schriever, LA, at our research farm. He is also planning rainfall
l simulations to determine the impacts of crop residue and soil type on runoff in sugarcane fields.

We believe that these research activities will be beneficial to the proposed LTAR by improving our understanding of the benefits of conservation practices on sugarcane fields and water quality in Louisiana.

Sincerely,

Michael P. Grisham

Michael P. Grisham, Ph.D.
Research Leader/Location Coordinator

Sugarcane Research Unit
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