



**2013 ANNUAL REPORT:**

**ASSESSING THE IMPACT OF THE MRBI PROGRAM IN THE POINT  
REMOVE AND L'ANGUILLE WATERSHEDS**



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### **ASSESSING THE IMPACT OF THE MRBI PROGRAM IN THE POINT REMOVE AND L'ANGUILLE WATERSHEDS**

**Agreement No. 68-7103-10-393**

#### **PROJECT PURPOSE:**

The purposes of this agreement is to provide funding to the University for completion of a 3-year assessment project involving edge-of-field monitoring designed to determine the impacts of implementation of the Mississippi River Basin Initiative (MRBI) Program on representative program-enrolled farms in the Point Remove and L' Anguille watersheds.

#### **PROJECT BENEFITS:**

The MRBI program offers a new, innovative voluntary approach to addressing regional water quality issues related to agricultural nonpoint source pollution. However, previous funding has not provided for monitoring to assess the actual impact of the program. Quantifying impact is a critical component to demonstrating the effectiveness of voluntary conservation efforts in terms of justifying continued expenditures and implementing future programs.

#### **THE UNIVERSITY WILL:**

1. Establish one (1) "Discovery Farm" in the Point Remove Watershed and two (2) "Discovery Farms" in the L' Anguille watershed.
2. Install and maintain, on the Discovery Farms, all sampling equipment necessary to monitor edge-of-field water quality and water use.
3. Insure that all necessary samples are collected and monitored according to established scientific protocols.
4. Collaborate with the U.S. Geological Survey to conduct stream flow, nutrient, and sediment discharge at the 12-digit HUC scale that encompasses edge-of-field monitoring sites.
5. Utilize the previously-developed, calibrated SWAT model for the Point Remove and L' Anguille Watersheds.
6. Insure that the project will achieve the following:
  - Measured of reduction efficiencies at edge-of-field of selected MRBI-approved practices under real-world conditions,
  - Quantified cause and effect relationships between selected practices and receiving water quality parameters,
  - SWAT estimates of BMP implementation scenarios on nutrient loss reductions.

## **PROGRESS:**

### **L'Anguille Watershed**

#### **04-01-2011 to 06-30-2011:**

Installation of monitoring sites was completed at both the Woods and Clements Farms. This included installation of culvert gauges, flumes, and weirs to measure runoff water volumes, construction of stands to house the automatic water samplers, and bringing everything on-line. See photos below.

#### **07-01-2011 to 09-30-2011:**

A total of 24 water runoff samples were collected from 9 storm flow events and have been analyzed for nutrient and sediment content.

#### **10-01-2011 to 12-31-2011:**

A total of 6 water runoff samples were collected from 2 storm flow events and have been analyzed for nutrient and sediment content. Concentrations will not be reported until a sufficient number of events have been collected to ensure reliability of the results.

#### **1-1-2012 to 3-31-2012:**

- a. Work was conducted at monitoring sites to maintain all equipment in working order. This involved removing transducers to monitor flow during January, when the risk of freezing conditions destroying the transducers was too high.
- b. A total of 4 water runoff samples were collected from 1 storm flow event and have been analyzed for nutrient and sediment content.

#### **4-1-2012 to 6-30-2012:**

- a. A total of 26 water runoff samples have been collected since flume installation at the middle of last year. In 2012, a total of 5 samples have been collected and analyzed for nutrient and sediment content.
- b. To date, concentrations of all forms of phosphorus and nitrogen measured in runoff from both conventional and conservation sites monitored in the L'Anguille sites have been extremely low. Averaging <0.050 mg/L dissolved P, <0.20 mg/L total P, < 0.10 mg/L nitrate, and <2.00 mg/L total N.
- c. Water sampling will continue.

#### **7-1-2012 to 9-30-2012:**

- a. Water sampling continued.
- b. Drought during this period has limited activity at these sites to mainly maintenance.

#### **10-1-2012 to 12-31-2012:**

- a. Water sampling continued.

- b. Data for 2011 and 2012 compiled and presented in Table 1.
- c. We are working with Dharmendra Saraswat to run the SWAT model on the L'Anguille Watershed. Dr. Saraswat has completed some initial model calibration and will complete more detail simulations over the next several months to assess the relative effects of BMP implementation on nutrient and sediment runoff in the L'Anguille Watershed.

**01-01-2013 to 03-31-2013:**

- a. Water sampling continued.
- b. Dharmendra Saraswat continues to populate the SWAT model for simulation of nutrient and sediment transport in the L'Anguille Watershed, as a function of conservation management.

**04-01-2013 to 06-30-2013:**

- a. Water sampling continued.
- b. Dharmendra Saraswat continues to populate the SWAT model for simulation of nutrient and sediment transport in the Point Remove Watershed, as a function of conservation management. The plan of work for SWAT simulation of nutrient flows in the MRBI Point Remove Watershed, as developed by Dharmendra Saraswat and the BMPs available in the Watershed are given on page 8 and Table 2, respectively.

**07-01-2013 to 09-30-2013:**

- c. Water sampling continued.
- d. We contracted with Dharmendra Saraswat to hire a Graduate Student to conduct the SWAT modeling in the L'Anguille Watershed, as a function of conservation management. The budget uses grant funds and is below.

**MRBI Modeling Project (Revised Estimate, August 5, 2013)  
GRADUATE STUDENT BUDGET**

Item	Year 1 2013-2014 (Fall to summer)
Graduate student stipend @ \$18,540/year (increase by 3% each year)- 1 student	\$18,540

Undergraduate interns @\$12/hr- 400 hrs	\$4,800
Tuition fee @ \$368/credit hour/15 credit hours / year	\$5,520
Fringe benefits Graduate Students @3.4%	\$784
Fringe benefits, hourly @8%	\$384
Travel (\$1,000)	\$1,000
Indirects @31%*	
*As per the suggestion of Kris Rutherford, Pre-Award Grants Officer. He is open to discussion.	\$7,908
<b>Total Cost</b>	<b>\$38,936</b>

**Graduate Stipend:** One graduate student for year one. He shall be responsible for responsible for the entire plan of work as listed below.

**Tuition fee:** Tuition fee is included as per the rates charged by the University of Arkansas.

**Fringe benefits:** Fringe benefits are associated with graduate stipend as per the rates charged by the University of Arkansas.

**Travel:** The budgeted amount will support Dr. Dharmendra Saraswat's trip to Fayetteville for student mentoring purposes.

**10-01-2013 to 12-31-2013:**

- a. Water sampling continued.
- b. We contracted with Dharmendra Saraswat to hire a Graduate Student to conduct the SWAT modeling in the L'Anguille Watershed, as a function of conservation management. A quarterly report of progress on the L'Anguille Watershed modeling is on page 16.

## Point Remove Watershed

### **04-01-2011 to 06-30-2011:**

- a. Construction of a second cattle crossing was completed, which was then used as the point of water flow monitoring into the wetland area.
- b. Installation of monitoring sites was completed at the Willow Bend Farm. See photos below.

### **07-01-2011 to 09-30-2011:**

- a. A total of 7 water runoff samples were collected during 7 storm flow events and have been analyzed for nutrient and sediment content.
- b. A grid soil sampling protocol was established for Willow Bend Farm. This soil sampling will be conducted in October, 2011.

### **10-01-2011 to 12-31-2011:**

- a. A total of 2 water runoff samples were collected from 2 storm flow events and have been analyzed for nutrient and sediment content. Concentrations will not be reported until a sufficient number of events have been collected to ensure reliability of the results.
- b. Grid soil sampling of the Willow Bend Farm was completed in conjunction with Ron Day, NRCS, Conway County, the MRBI, and EQIP. Soils are being analyzed for nutrients by the U of A Soil Testing Laboratory.
- c. Flow at both sites in the Point Remove Watershed is flowing into the wetland area. Thus, the second site will be moved to a new location in the Watershed to evaluate another pasture management BMP. This will be completed in the next quarter, in order that runoff samples can be collected during the wet spring period.
- d. On October 27<sup>th</sup>, 2011 we sponsored an open meeting at the Willow Bend Farm to discuss MRBI-related progress followed by a Discovery Farm Committee meeting to discuss site selection, equipment installation and future plans. The meeting was attended by about 100 farmers, NRCS, ANRC, AACD, and Legislative Staff personnel.

### **1-1-2012 to 3-31-2012:**

- a. Completed grid soil sampling at Willow Bend Farm, collated analyses and prepared report for land owner.
- b. Work was conducted at monitoring sites to maintain all equipment in working order. This involved removing transducers to monitor flow during January, when the risk of freezing conditions destroying the transducers was too high.
- c. A total of 3 water runoff samples were collected during 3 storm flow events and have been analyzed for nutrient and sediment content.

- d. We continued to look for additional sampling edge-of-field monitoring sites at the Willow Bend Farm and other locations in the Point Remove Watershed.

**4-1-2012 to 6-30-2012:**

- a. Compiled soil nutrient maps for the farm, which will be provided as soon as available.
- b. A total of 21 water runoff samples have been collected since flume installation at the middle of last year. In 2012, a total of 8 samples have been collected and analyzed for nutrient and sediment content.
- c. Water sampling will continue.
- d. With the help of Crash Caruthers and Alice Weeks, we located another farmer in the Point Remove Watershed who was willing to have us install monitoring equipment on three fields in the Khun Bayou Watershed (HUC 11110203304 – Pope County; Figure 1). The farmer is John Maus and he has completed a Discovery Farm application and plans to complete a Memorandum of Understanding with the Division of Agriculture, University of Arkansas to proceed with monitoring. The initial plan is to monitor runoff from three fields with and without cover crops (an approved MRBI Conservation Practice in this watershed).

**7-1-2012 to 9-30-2012:**

- a. Water sampling continued.
- b. We met at the Watershed Irrigation District Office to discuss progress and to develop a new farm on the watershed.
- c. Visited with J. Maus as to the potential of using his property to conduct a Discovery Farm assessment of water quality impacts of conservation.
- d. Maus agreed to be a Discovery Farm and a MOU signed.

**10-1-2012 to 12-31-2012:**

- a. Water sampling continued.
- b. Fields located for assessment of cover crop effects on nutrient and sediment runoff.
- c. Data for 2011 and 2012 compiled and presented in Table 1.
- d. Funding obtained from EPA Region VI to monitor nutrient and sediment concentrations in Khun Bayou, adjacent to the edge-of-field monitoring sites. A Quality Management

Plan and Quality Assurance Plan of Procedures (QAPP) is being prepared for approval by EPA prior to any work being able to start.

- e. We are working with Dharmendra Saraswat to run the SWAT model on the Point Remove Watershed. Dr. Saraswat has completed some initial model calibration and will complete more detail simulations over the next several months to assess the relative effects of BMP implementation on nutrient and sediment runoff in the Point Remove Watershed.

**01-01-2013 to 03-31-2013:**

- a. Water sampling continued.
- b. Dharmendra Saraswat continues to populate the SWAT model for simulation of nutrient and sediment transport in the L'Anguille Watershed, as a function of conservation management.
- c. A QAPP was approved by EPA to allow in-stream monitoring along a reach of Lateral S to Joiner Lake. An approximate site location map is attached.
- d. The automatic flow and runoff sampling equipment was installed at the Maus Discovery Farm and is now operational and will look at the effects of cover crops on nutrient and sediment runoff. See map and photos of this site attached.

**04-01-2013 to 06-30-2013:**

- c. Water sampling continued.
- d. Dharmendra Saraswat continues to populate the SWAT model for simulation of nutrient and sediment transport in the Point Remove Watershed, as a function of conservation management. The plan of work for SWAT simulation of nutrient flows in the MRBI Point Remove Watershed, as developed by Dharmendra Saraswat and the BMPs available in the Watershed are given on page 8 and Table 2, respectively.

**07-01-2013 to 09-30-2013:**

- a. Water sampling continued.
- b. We contracted with Dr. Mansoor Leh to conduct SWAT simulations of nutrient and sediment transport in the Point Remove Watershed, as a function of conservation management. The plan of work for SWAT simulation of nutrient flows in the MRBI



Point Remove Watershed, as developed by Dr. Leh and the BMPs available in the Watershed is gen below.

## **POINT REMOVE SWAT MODELING WORK PLAN:**

### **Objective:**

Develop, calibrate and validate a SWAT model to determine the impacts of the implementation of the Mississippi River Basin Initiative (MRBI) Program on representative program-enrolled farms in the Point Remove and L'Anguille watersheds.

### **Tasks:**

1. Develop, calibrate and validate the SWAT model for Lake Conway Point Remove Watershed.
2. Run BMP implementation scenarios on sediment and nutrient (P and N) loss reductions using SWAT.

### **Task 1: Develop, calibrate and validate the SWAT model**

The Soil and Water Assessment Tool (SWAT) will be setup using the most current version of the model (SWAT2012). This version of the SWAT model includes significantly improved PET, soil moisture routing, soil P and nutrient calculations and the addition of new BMP input options.

Model setup will involve:

Lake Conway Point Remove Watershed

- Flow will be Calibrated : 2001 – 2008, validate 2009-2012
- No available water quality data

Monitored edge-of-field water quality data will be used as a validation check with the simulated subwatershed outputs. It must be noted that SWAT is not a field scale model so a direct comparison will not be possible. However, the comparison will give an indication of the general acceptable range of the simulated data.

### **Task 1 Deliverables.**

Deliverables for Task 1 will include the following:

1. Two computer models and their associated datasets provided on a DVD for simulating flow and water quality in the respective watersheds;
2. A user manual detailing the use of the model and explaining folder contents.

**Task 2. Run BMP implementation scenarios on nutrient loss reductions using SWAT.**

The calibrated SWAT model will be run with different scenarios of BMPs implementation within the watershed:

1. Scenarios of BMPs as they are currently placed infield will be compared with scenarios in the absence of BMPs.
2. The range of possible BMPs available in SWAT (Table A) will be simulated independently and in combination to identify the threshold of implementation necessary to achieve water quality standards. For example the BMP implementation will be evaluated to assess the threshold required to achieve delisting on 303d list for sediment and its effects on nutrients.
3. Based on scenarios simulated above, assess the selection and placement of BMP based on: costs, ease of implementation and appropriateness of technology given watershed characteristics.

**Task 2 Deliverables.**

Deliverables for Task 2 (Table B) will be a comprehensive report detailing SWAT model development results, BMP scenario results and overall analysis.

**Plan of Work:**

During one year life of the project the following will be accomplished:

- i. Input data will be obtained from various agencies; individuals etc. and processed to cover the period of 1990-2012 for the Point Remove Watershed.
- ii. Latest version of SWAT model will be setup for PRW
- iii. NRCS provided information on BMP practices shall be obtained and processed to represent in the model
- iv. Subwatershed level outputs related to flow, sediment, and nutrients (TP and TN) shall be analyzed.
- v. Those BMPs that are part of the SWAT database and are currently implemented in PRW shall be simulated independently and in combinations (to be determined in advance by NRCS, Arkansas office) for 25 years beyond validation time frame using statistical weather calculator available in SWAT. An analysis shall be performed.

**Table A. Approved BMP practices for Lake Convey Point Remove Watershed to be considered in the SWAT model.**

<b>Watershed</b>	<b>Conservation Practice</b>
<b>Lake Conway Point Remove</b>	324 Deep Tillage
Lake Conway-Point Remove Wetlands Reclamation	328 Conservation Crop Rotation
& Irrigation District MRBI/CCPI Project	329 Residue Management, No-Till

<p><b>Target Reduction:</b> Not Available</p> <p><b>Participants:</b> Not Available</p> <p><b>Ranking of Practices Based on Area under Each:</b> Not Available</p>	<p>340 Cover Crop</p> <p>367 Roofs and Covers</p> <p>378 Pond</p> <p>391 Riparian Forest Buffer</p> <p>393 Filter Strip</p> <p>410 Grade Stabilization Structure</p> <p>412 Grassed Waterway</p> <p>443 Irrigation System, Surface and Subsurface</p> <p>449 Irrigation Water Management</p> <p>484 Mulching</p> <p>511 Forage Harvest Management</p> <p>512 Forage and Biomass Planting</p> <p>528 Prescribed Grazing</p> <p>554 Drainage Water Management</p> <p>587 Structure for Water Control</p> <p>590 Nutrient Management</p> <p>614 Watering Facility</p> <p>658 Wetland Creation</p>
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**Table B. Schedule of tasks and expected outputs to be completed for project.**

<b>Task</b>	<b>Description</b>	<b>Start</b>	<b>Completion</b>
1.1	Data collection	07/13	08/13
1.2	Data preprocessing and SWAT development	07/13	09/13
1.3	SWAT model Sensitivity & Calibration (for 2 watersheds)	09/13	06/14
1.4	SWAT model Validation (for 2 watersheds)	09/13	06/14
2.1	BMP Scenario development	03/14	06/14
2.2	BMP Scenario Runs	03/14	06/14
2.3	Analysis and write-up	05/14	07/14

**Table 1. Concentrations of phosphorus, nitrogen, and sediment in runoff from edge-of-field monitoring sites in the L'Anguille and Point Remove Watersheds.**

Site	Date	Management	Dissolved P	Total P	Nitrate-N	Total N	Sediment
			----- mg L <sup>-1</sup> -----				g L <sup>-1</sup>
<b>Cherry Valley</b>							
CVC1	2011	Rice	0.076	0.115	0.03	3.18	406
	2012	Soybeans	0.089	0.496	0.16	1.56	976
CVC2	2011	Rice	0.068	0.24	0.11	2.64	686
	2012	Soybeans	0.030	0.108	0.23	1.07	501
CVC Well	2011		0.017	0.137	0.58	0.78	405
	2012		0.011	0.164	0.28	0.58	419
CVW1	2012	Soybeans	0.064	0.745	0.66	1.65	729
CVW2	2012	Soybeans	ND	ND	ND	ND	ND
CVW3	2012	Soybeans	0.081	0.344	0.34	1.21	532
CVW4	2012	Soybeans	0.183	0.554	0.75	1.85	640
CVW Well	2011		0.041	0.167	0.17	0.84	501
<b>Morrilton</b>							
Mor 1	2011	Pasture	3.030	3.119	0.42	1.66	229
	2012	Pasture	2.597	3.803	0.20	2.47	177
Mor 2	2011	Pasture	2.416	2.683	0.176	1.23	185
Wetland	2012		1.799	2.036	0.08	1.36	177





Projects	Approved Conservation Practices	Available in SWAT
	608 Surface Drain, Main or Lateral	No
	612 Tree & Shrub Establishment	No
	614 Watering Facility	Yes
	629 Waste Treatment	No
	633 Waste Utilization	No
	634 Waste Transfer	No
	643 Restoration & Management of Declining Habitats	No
	645 Upland Wildlife Habitat Management	No
	657 Wetland Restoration	No
	658 Wetland Creation	Yes
	659 Wetland Enhancement	No

Points for information and further review in order to assess requirement for resources needed:

- a. Modeling time period used for already completed studies for two MRBI watersheds is as given below:

**Lake Conway Point Remove Watershed:**

Only Flow was calibrated and validated for the following time period. No calibration/validation conducted for water quality constituents

Calibration: 2001 – 2005, Validation: 2006-2008

**L'Anguille River Watershed:**

Monitoring Station	Drainage Area in the LRW (sq. km)	Data Providing Agency	Time Period	Calibrated/Validated Variables
Colt	552	USGS*  ( <a href="http://www.usgs.gov/">http://www.usgs.gov/</a> )	Calibration – 1990 to 2005  Validation – 2006 to 2008	Total flow  Surface flow  Base flow  Sediment

				Total Phosphorus Nitrate-nitrogen
Palestine	728	USGS <a href="http://www.usgs.gov/">(http://www.usgs.gov/)</a>	Calibration – 1998 to 2005  Validation – 2006 to 2008	Total flow Surface flow Base flow
Vannadale	751	ECO** <a href="http://www.ecoconservation.org/">(http://www.ecoconservation.org/)</a>	Validation – 2006 to 2008	Total flow Sediment Total Phosphorus Nitrate-nitrogen

\*United States Geological Survey    \*\*Ecological Conservation Organization

- b. It is proposed to repeat setting up SWAT model for the same time period using the latest version of SWAT (SWAT2012)
- c. The first year of work will involve setting up SWAT Model for the L'Anguille River Watershed for only those subwatersheds that are part of the MRBI proposal using the protocol developed for ANRC studies. Subwatershed level outputs related to flow, sediment, and nutrients (TP and TN) shall be analyzed.
- d. Those BMPs that are part of the SWAT database shall be simulated independently and in combinations (to be determined in advance by NRCS, Arkansas office) for 25 years beyond validation time frame using statistical weather calculator available in SWAT
- e. Spatial optimization of BMPs using genetic algorithm shall be performed to perform BMP efficiency analysis for 5, 10, 15, 20, and 25 years of time period beyond validation time frame
- f. By end of September, 2013- Long term impact of BMPs efficiency analysis for selected BMPs for L'Anguille River Watershed shall be provided.
- g. Future efforts beyond September, 2013 would involve completing the BMP studies for rest of the conservation practices for L'Anguille River Watershed, applying SWAT model and BMP analysis approach for Lake Conway Point Remove Watershed, developing Targeted land use change and automated BMP efficiency analysis tool, both driven by Graphical User Interface (GUI) for automating the BMP analysis.



## L'Anguille River Watershed

**Report Period: August 15 to October 31, 2013**

### (a) Hydrology:

The streamflow data was acquired from the United States Geological Survey (USGS) website (<http://waterdata.usgs.gov/nwis>) at a daily time scale. Long-term streamflow data was available for the two USGS stations: Colt and Palestine. Locations of both stations along with their drainage areas and monitoring periods are shown in Table (1) and Figure (1). Daily streamflow data was separated into the surface and base flow using the baseflow filter program developed by Arnold and Allen (1999) available on the Soil and Water Assessment Tool (SWAT) website (<http://swat.tamu.edu/software/baseflow-filter-program/>). This digital filter includes two equations for calculating filtered surface runoff and baseflow, based on  $q_t$ , the filtered surface runoff at the time step  $t$  (one day),  $\beta$  the filter parameter (0.925),  $Q_t$  the original streamflow (total flow) at the time step  $t$  (one day), and  $b_t$  the filtered baseflow at the time step  $t$  (one day).

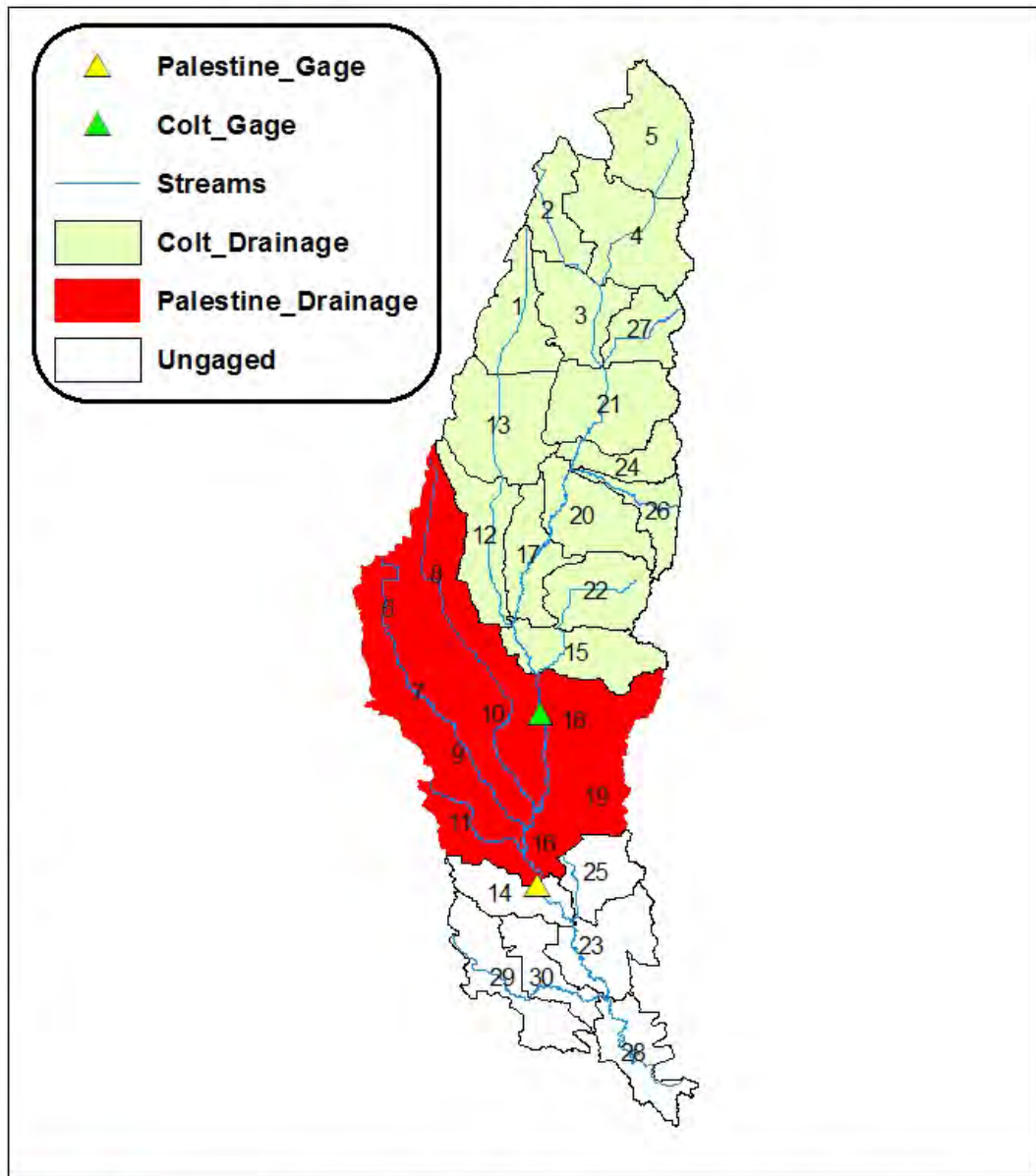
Variables NDMIN (minimum number of days used to calculate the value for alpha in the groundwater recession constant equation) and NDMAX (maximum number of days used to calculate the value for alpha in the groundwater recession constant equation) were assigned a value of 10. Variable IPRINT (daily print option) was set to 1 for printing daily filtered results. Using the baseflow filter program, three passes can be made over the streamflow data with each pass resulting in less baseflow as a percentage of total flow. In general, the fraction of streamflow contributed by baseflow should be between the first and second baseflow pass. Suitable baseflow pass can be selected to better match the simulated values from the model.

Table 1. Location of USGS streamflow stations along with their drainage areas and monitoring periods

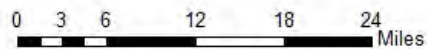
Gage No.	Location	Drainage Area (sq. mi)	Flow	
			Start	End
07047942	Colt	213	1992	2012
07047950	Palestine	281	1998	2012

# Monitoring Stations

## L'Anguille River Watershed



Department of Biological and Agricultural Engineering



Data Source:  
 USDA-NRCS ([www.nrcs.usda.gov](http://www.nrcs.usda.gov))  
 NHD-USGS ([nhd.usgs.gov](http://nhd.usgs.gov))  
 USGS ([waterdata.usgs.gov](http://waterdata.usgs.gov))  
 Map Created: October, 2013



Figure 1. Location of gage stations within the L'Anguille River watershed and the draining subwatersheds

**(b) Weather Data:**

Regarding weather data, studies have reported that the model performance in simulating streamflow was improved by using the Next-Generation Radar (NEXRAD) derived rainfall data compared to the rain gauge data (Tobin and Bennett, 2009; Tuppad et al., 2010a). Beeson et al. (2011) reported that superior results for the streamflow simulation can be obtained by combining the rain gauge and NEXRAD data. As a result, in addition to the weather stations, NEXRAD data was also used in this study.

L'Anquille River watershed (LRW) lies within the Lower Mississippi River Forecasting Center (LMRFC) region. As a result, the NEXRAD data was obtained from the National Weather Service (NWS) website (<http://amazon.nws.noaa.gov/hdsb/data/nexrad/nexrad.html>) for the LMRFC – Stage III. The NexRad data (precipitation) was available from 1996 to 2012 at an hourly scale. NEXRAD data was processed in a tool named NEXRAD-VC developed by Zhang and Srinivasan (2010). Subbasin center option was used for grid discretization and bias adjustment was used as an interpolation method.

Rain gage data was downloaded from the National Oceanic and Atmospheric Administration (NOAA) for precipitation, maximum and minimum temperature for the years 1992 to 2012 (<http://gis.ncdc.noaa.gov/map/viewer/#app=cdo>). The PCP\_SWAT tool was used to interpolate precipitation data using the inverse distance weighted (IDW) method for each subwatershed with subbasin centers used for grid discretization. The IDW method uses the rain gauge data from selected weather stations and creates pseudo weather stations at the centroid of each subwatershed, along with estimated precipitation data for the subwatersheds.

SWAT's weather generator was used to generate other weather related data viz. relative humidity, solar radiation, and wind velocity. The data was aggregated along with the rain gage data at the subwatershed level on a daily basis.

**(c) Water Quality:**

The water quality samples were acquired from the USGS website ([waterdata.usgs.gov](http://waterdata.usgs.gov)). The water quality data was available few times a year for only one USGS station: Colt (Table 2). As a result, the available data was converted to continuous monthly dataset with the help of Load Estimator (LOADEST; <http://water.usgs.gov/software/loadest/>). The continuous monthly dataset is generally required for the calibration and validation of the model. LOADEST provide three methods for the calculation of load estimates: maximum likelihood estimation (MLE), adjusted maximum likelihood estimation (AMLE), and least absolute deviation (LAD). AMLE assumes that the samples are normally distributed with a constant variance, and is the primary load estimation method used within LOADEST for generating a nearly unbiased estimates of instantaneous load even when the data is censored (data censoring occurs when one or more observations have constituent concentrations less than the laboratory detection limit) (Runkel et al., 2004). The Adjusted Maximum Likelihood Estimation (AMLE) method incorporated in LOADEST was used to estimate monthly loadings for sediment, total phosphorus, and nitrate-

nitrogen by building a regression model with the daily flow data available at Colt. LOADEST also uses the daily flow data for generating continuous monthly loads.

One of the files required for the LOADEST is the Header file. This file gives some general settings for the program to follow. The PRTOPT (Estimated Values Print Option) was set to 1 which means individual load estimates are included in a separate output file. The SEOPT (Standard Error Option) was set to 3 which means the exact standard error will be calculated for AMLE along with stand error calculation for MLE and LAD. The LDOPT (Load Option) was set to 2 indicating load calculations for each month of data in the estimation file are included when LDOPT equals 2. The MODNO (Model Number) was set to 0 so that LOADEST will automatically select the best model for regression. The NCONST (Number of Constituents) was set to 1 for a specific constituent (such as sediment, total phosphorus, or nitrate-nitrogen). Under the constituent specific variables: CNAME (Constituent Name) was set to the specific constituent in consideration (such as sediment total phosphorus, or nitrate-nitrogen), UCFLAG (Concentration Unit Flag) was set to 1 so that the user supplied constituents are in milligrams per liter, an ULFLAG (Load Unit Flag) was set to 4 to request load estimates in tons per day.

**Table 2. Location of USGS streamflow stations along with their drainage areas and monitoring periods**

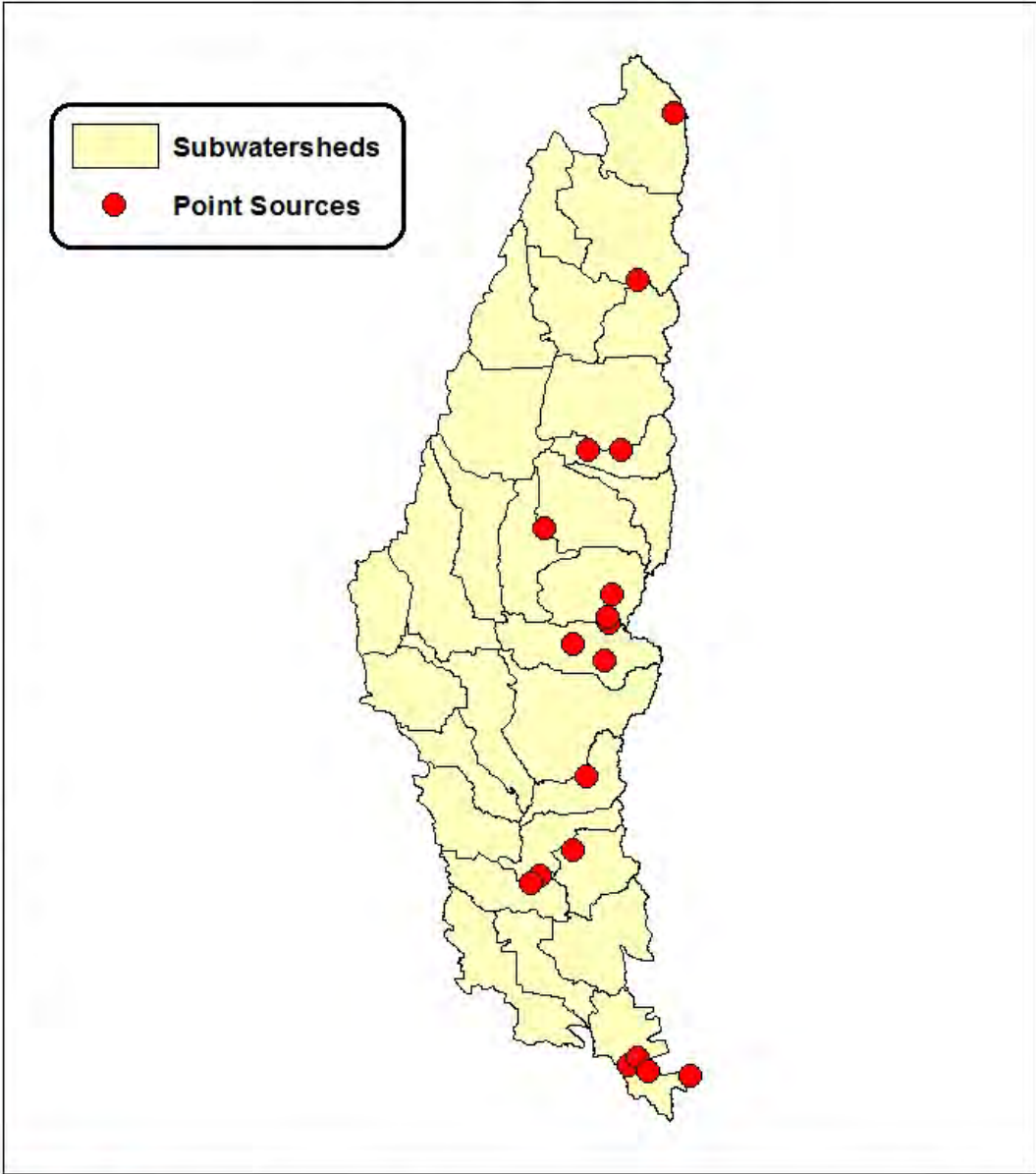
Gage No.	Location	Sediment		Total Phosphorus		Nitrate-Nitrogen	
		Start	End	Start	End	Start	End
07047942	Colt	1992	2012	1992	2012	1992	2012

**(d) Point Source:**

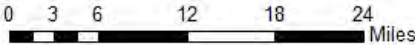
The point source data was acquired from the Arkansas Department of Environmental Quality and the Environmental Protection Agency (<http://www.adeq.state.ar.us/>; [www.epa-echo.gov](http://www.epa-echo.gov); <http://www.epa.gov/enviro/facts/pes-icis/search.html>). The point source data was collected from 18 major point source locations in the form of daily loadings (Figure 2). The point sources falling within the subwatersheds were combined to get the aggregated loads for each subwatershed. As a result, one point source file was prepared for each subwatershed. These subwatershed level point source files can then be input into the SWAT model.

# Point Sources

## L'Anguille River Watershed



Department of Biological and Agricultural Engineering



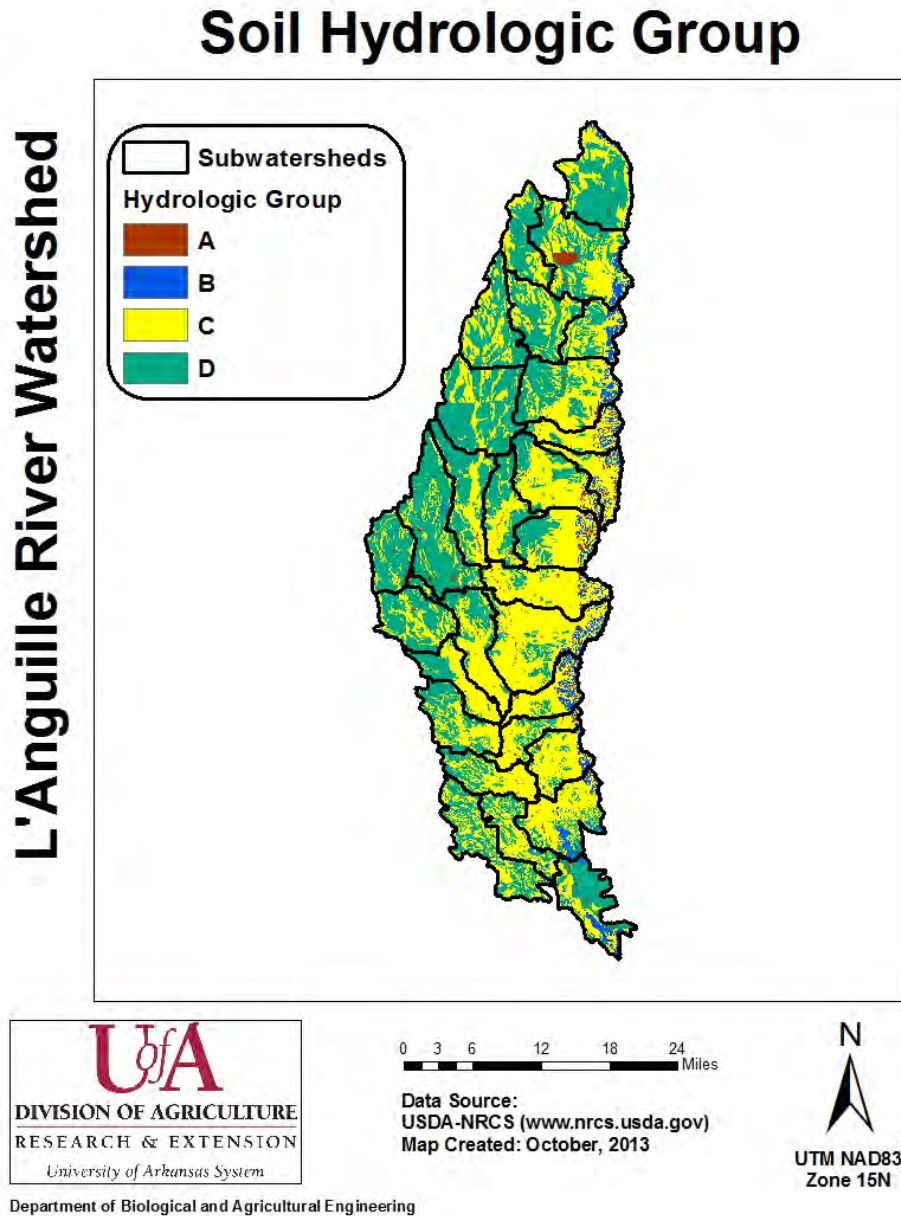
Data Source:  
ADEQ ([www.adeg.state.ar.us](http://www.adeg.state.ar.us))  
Map Created: October, 2013



Figure 2. Location of point sources within the L'Anguille River watershed.

(e) **Soil:**

The Soil Survey Geographic (SSURGO) soil layers for each county comprising LRW were downloaded from the United States Department of Agriculture – National Resources Conservation Service (USDA-NRCS). The downloaded soil county layers were merged followed by clipping of the merged layer with the LRW boundary layer. A map of various hydrological soil groups in the L’Anguille River watershed is shown in Figure (3).



**Figure 3. Various hydrological soil groups in the L’Anguille River watershed**

**(f) Elevation:**

The digital elevation model (DEM) (5m resolution) was downloaded from the GeoStor website (<http://www.geostor.arkansas.gov/G6/Home.html>). The DEM layer was extracted with the LRW boundary layer. An elevation map for the L'Anguille River watershed is shown in Figure (4). The elevation in the LRW ranges from 46 to 140 meters with an average elevation of 72.1 meter and standard elevation of 12.2 meter. The eastern edge of the L'Anguille River watershed has higher elevations even exceeding 100 meters. These higher elevation are because of the presence of the Crowley's ridge. The elevations on the west of Crowley's ridge are relatively lower (less than 76 meters). As far as the slope is concerned, 90% of the slopes in LRW are in the range of 0-3% except the Crowley's Ridge which has slopes ranging 8-38%.

**(g) Hydrography:**

The high resolution stream geodatabase for Arkansas (1:24000) was downloaded from the National Hydrography Dataset (NHD) website (<ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/>). From this geodatabase, NHD flowline layer was exported as a shapefile and clipped using the LRW boundary layer. The clipped layer contains all the streams in the watershed and was named as burn-in layer. This burn-in stream layer forced the SWAT subwatershed reaches to follow known stream locations, thereby improving the hydrographic segmentation. A separate copy of the burn-in stream layer was processed further in ArcMap to generate the user stream layer. Only the major stream in various subwatersheds was retained by deleting all other streams. This resulted in one stream per subwatershed and the layer was named as user-stream layer. The aggregated constituent load in a subwatershed is routed from the top to the bottom of user streams in respective subwatersheds.

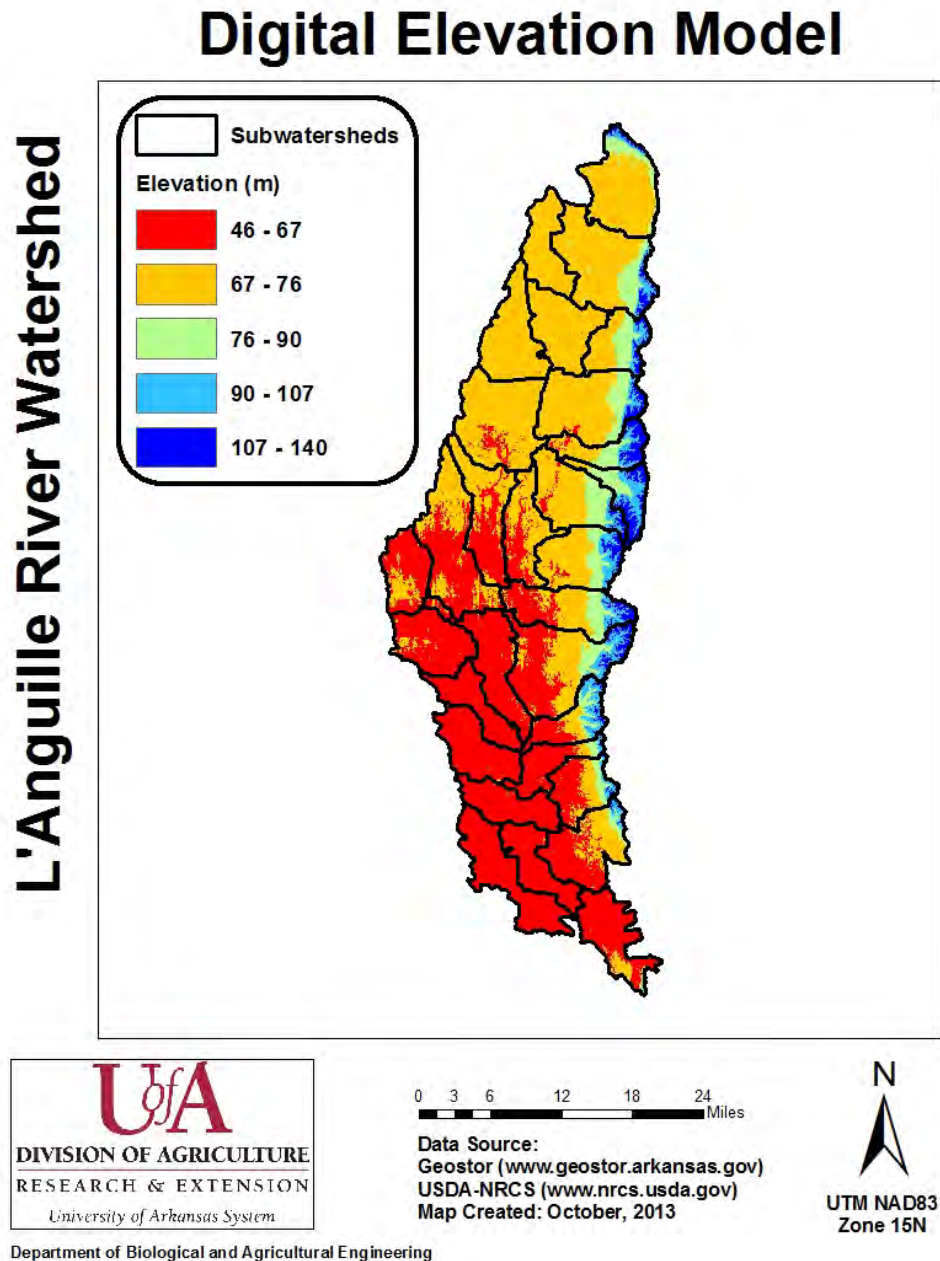
**(h) Land Use and Land Cover:**

Land use and land cover layers were downloaded from the Center for Advanced Spatial Technologies (CAST) website ([www.cast.uark.edu](http://www.cast.uark.edu)) for the year 1999, 2004, and 2006 (28.5m resolution), and from the National Land Cover Dataset (NLCD) website ([www.mlrc.gov](http://www.mlrc.gov)) for the year 1992 and 2001 (30m resolution). CAST and NLCD uses a different classification schemes for land use maps. As a result, each map was post-processed for obtaining a common land use classification. Similar categories were merged into a single category. A lookup table for land uses is also required in the SWAT model. The lookup table links the numerical values of land uses in the attribute of land use raster with their respective land use names.

**(i) Determining land management activities, creating crop, tillage, and other appropriate databases/look up tables, formatting, and processing this data for input files to the model.**

The management practices for the crops grown in the LRW were obtained for each county from the research verification reports published by the University of Arkansas' Cooperative Extension Service (UACES). The management practices should be inputted into the model via

the management operations table in the ArcSWAT interface for the SWAT model. As per the UACES, the recommended management practices for corn, cotton, rice, and soybean are shown in Tables (3-6).



**Figure 4. Elevation map for the L'Anguille River watershed.**



**Table 3. Management practices for corn.**

General Timing	Mo/Day	Operation	Implement	Material Used
Pre-plant	4/5	Fertilizer		63-50-78-12-5
Sidedress	5/2	Fertilizer		130-0-0-3-0
Pre-tassel	6/1	Fertilizer		46-0-0-0-0
	4/26	Herbicide	Weed control	1.5 qts atrazine and 22 oz Roundup
	5/30	Irrigation	Furrow	8 irrigations

**Table 4. Management practices for Soybean**

General Timing	Mo/Day	Operation	Implement	Fertilizer	Pesticide	Herbicide	Rainfall (in)
Burndown		Herbicide				22 oz/a Roundup PowerMaxx + 2 oz/a Valor	
Post-emerge		Herbicide				32 oz/a Glyphosate	
		Pesticide	Frogeye		6 oz/a Headline		
		Pesticide	Bollworm/ Defoliators		1.8 oz/a Karate Z		
		Pesticide	Stinkbug		5 oz/a Brigade		
		Irrigation	Flood Center pivot Dry				4.4
Pre-plant		Fertilizer		0-48-82			

**Table 5. Management practices for Cotton**

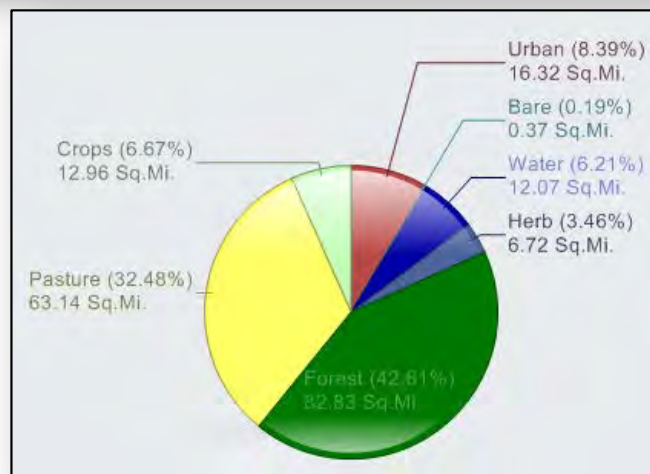
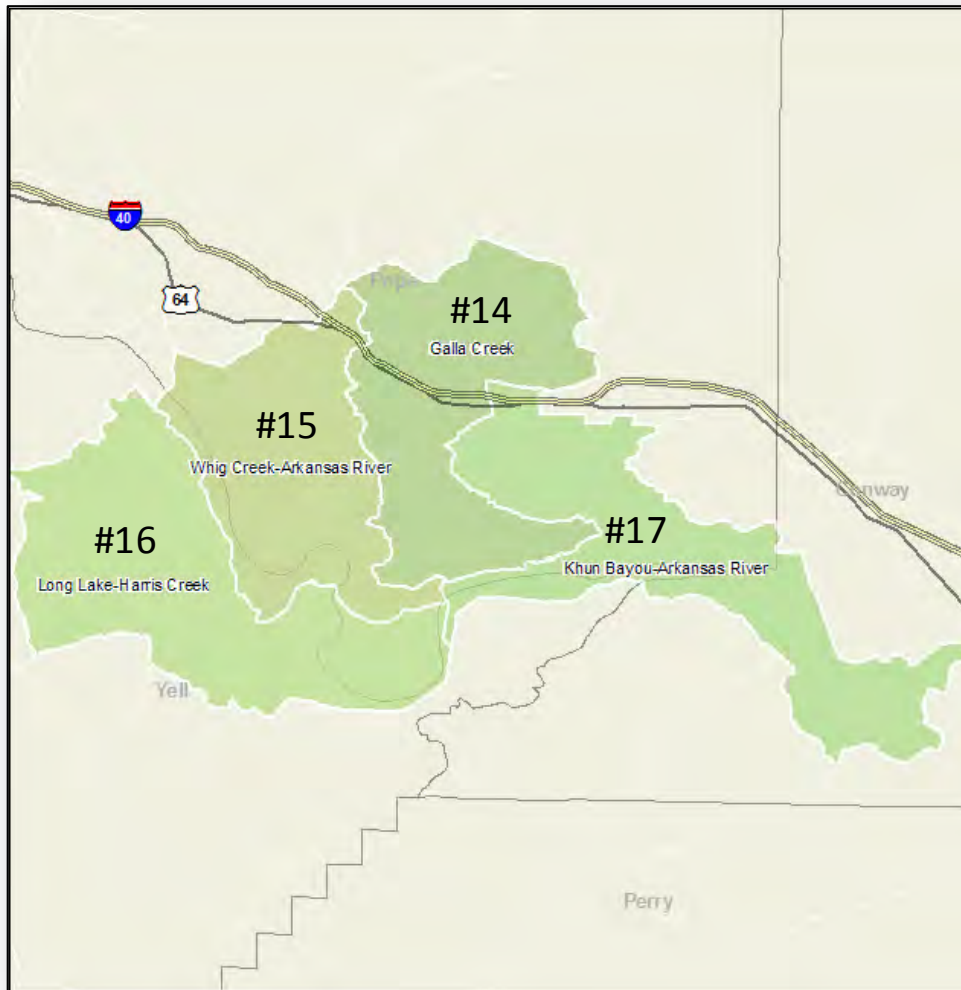
General Timing	Mo/Day	Operation	Implement	Material Used
Early/Burn-down		Herbicide		Dicamba
Pre-emerge		Fertilizer		45-20-60 (units)
Pre-emerge		Herbicide	Weed control	Diuron
Post-emerge		Insecticide		4 applications
Post-emerge		Fertilizer		51-0-0 (units)
Post-emerge		Herbicide	Morningglory treatment	Roundup

**Table 6. Management practices for Rice**

General Timing	Month/Day	Operation	Implement	Fertilizer	Pesticide	Herbicide	Total Irrigation (inches)
	4/8	Planting					
	9/12	Harvesting					
Pre-emergence		Herbicide				Command 12 oz + glyphosate (32 oz)	
Post-emergence		Herbicide				Newpath .5 lbs Clearpath (.5 lbs) Facet (.5 lbs)	
Pre-plant		Pesticide	Seed Treatment			CruiserMax x (7 fl oz)	
		Pesticide	Sheath Blight/Kerne l Smut/False Smut			Quilt Xcel (16 oz)	
		Irrigation	Flood				40.77
Pre-flood		Fertilizer	Urea	239 lbs/ac			
Post-flood		Fertilizer	Urea	100 lbs/ac			

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- Beeson, P., P. Doraiswamy, A. Sadeghi, M. Di Luzio, M. Tomer, J. Arnold, and C. Daughtry. 2011. Treatments of precipitation inputs to hydrologic models. *Trans. ASABE* 54(6): 2011-2020.
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- Tobin, K. J. and M. E. Bennett. 2009. Using SWAT to model streamflow in two river basins with ground and satellite precipitation data. *J. American Water Res. Assoc.* 45(1): 253-271.
- Zhang, X., and R. Srinivasan. 2010. GIS-based spatial precipitation estimation using next generation radar and rain gauge data. *Environ. Modeling and Software*. doi:10.1016/j.envsoft.2010.05.012.



**Figure 1. Khun Bayou– Arkansas River and 2006 land use (12-digit HUC level; from Arkansas Watershed Information System, CAST & ANRC - <http://watersheds.cast.uark.edu/viewhuc.php?hucid=1111020303>).**

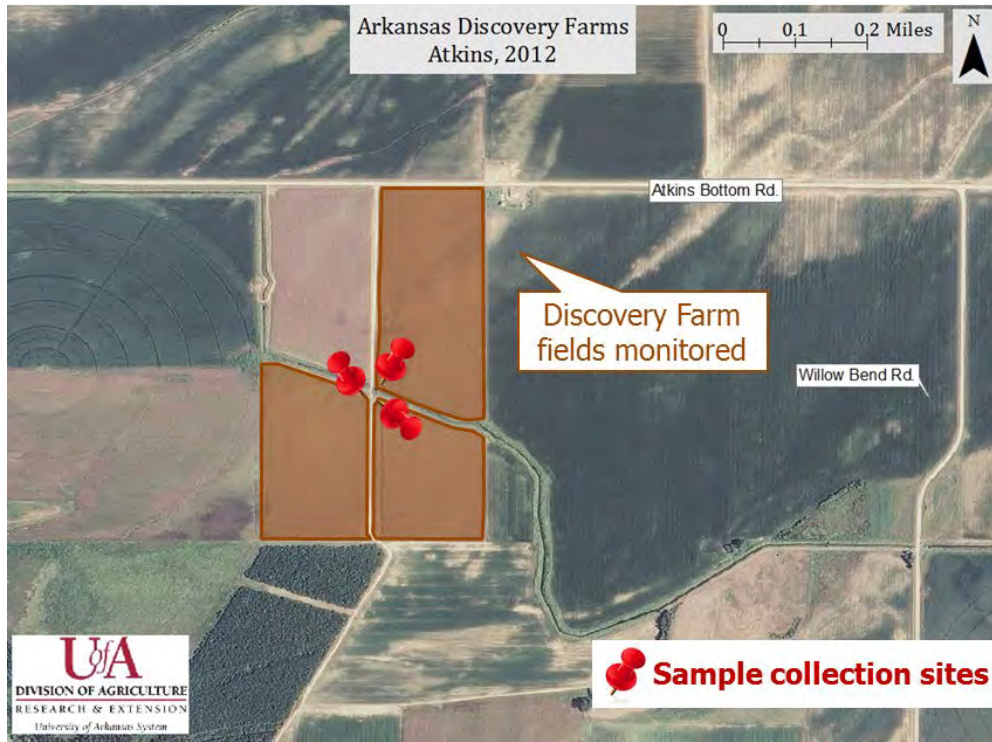
## The L'Anguille Site, Cherry Valley



The Point Remove Site, Morrilton



Location of Maus Discovery Farm, Atkins, AR.



Approximate location of in-stream sampling near Lateral S to Joiner Lake, AR.

