Integration of Water Resource Models with Fayetteville Shale Decision Support and Information Systems

DE-FE0000804

Center for Advanced Spatial Technologies
University of Arkansas

Texas AgriLIFE Research
Texas A&M University

Argonne National Laboratory

Background

- *Water availability*, due to significant use of water for the fracturing process and the consequent disposal of wastes, is a primary concern, along with potential impairment of *water quality*.

- Science-based information and operational support systems are needed to help the *gas industry* and the *regulatory agencies* face these water resource and water management issues.

- The lack of such strategies impairs the implementation of reliable regional and basin-oriented shale gas development plans to *support regulatory streamlining and permitting.*

Objective

- Long-range objective
  - provide science-based tools to support sustainable and low-impact development of natural gas resources.

- Develop a water management decision support system
  - modify and integrate a science-proven, state-of-the art water resource simulation model with a modern enterprise geographic information system.
  - provide a reliable tool to support sustainable development of natural gas-shale plays.

Project Team (Reserachers)

- University of Arkansas, Center for Advanced Spatial Technologies
  - Dr. Jackson Cothren and Dr. Fred Limp
- University of Arkansas, Department of Chemical Engineering
  - Dr. Greg Thoma
- Texas AM AgriLife Research, Blackland Research and Extension Center
  - Dr. Mauro Di Luzio
- Argonne National Laboratory
  - Mr. John Veil

Project Team (Stakeholders)

- Producers
  - Chesapeake, LLC
  - Southwestern Energy
  - BP (?)

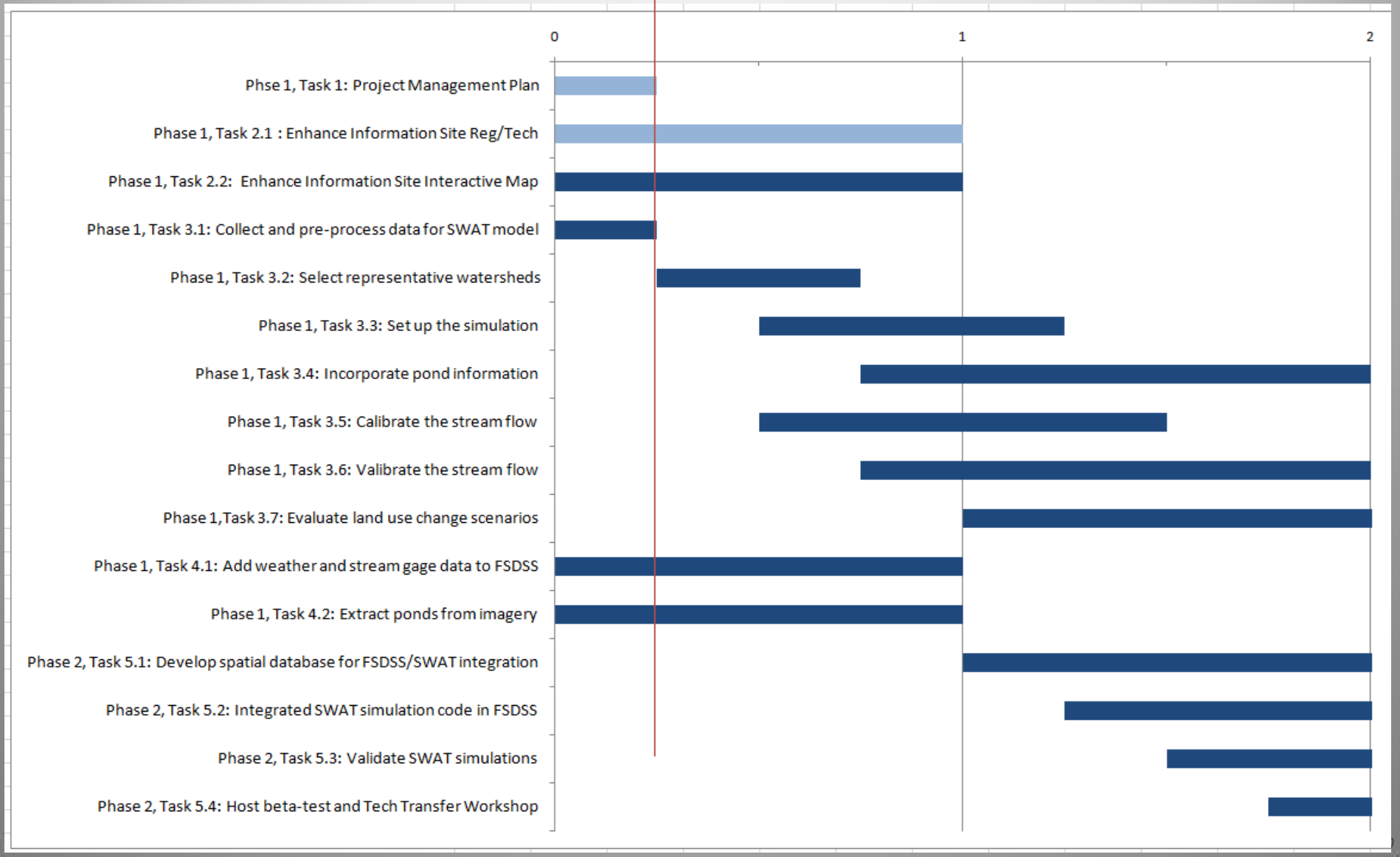
- Regulators
  - Arkansas Oil and Gas Commission
  - Arkansas Natural Resources Commission
  - Arkansas Department of Environmental Quality
  - U.S. Fish and Wildlife Service
  - U.S. Army Corps of Engineers

Project Schedule Overview

- Phase 1 (~ year 1)
  - Enhance the public-facing Fayetteville Shale Information Website to include watershed-related information
  - Develop small water body data layer and create links to USGS and NWS data
  - Develop, calibrate and validate SWAT simulations

- Phase 2 (~ year 2)
  - Integrate the newly developed SWAT simulations and data layers into the existing Fayetteville Shale Decision Support System and
  - Validate the simulations throughout the Fayetteville Shale Play.
  - Demonstrate enhanced FSDSS to stakeholders

Work Schedule



Task	Major Milestone Desc.	Project Duration 10/01/2009 – 09/31/2011								Planned Start Date	Planned End Data
		Oct 2009 – Sep 2010				Oct 2010 – Sep 2011					
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
2.0	Enhanced Fayetteville Shale Information Site									10/01/2009	09/30/2010
3.6	Develop Water Resource Models (SWAT)									10/01/2009	12/31/2010
4.0	Create/Add new data sets to FSDSS									10/01/2009	09/30/2010
5.1-2	FSDSS /SWAT Integration									04/01/2010	03/31/2011
5.3	Validate integrated FSDSS									12/31/2010	07/10/2011
5.4	Beta test and Tech Transfer workshop									07/01/2011	09/30/2011

Fayetteville Shale: Reducing the environmental impact of natural gas development - Microsoft Internet Explorer provided by Cent

http://lingo.cast.uark.edu/LINGOPUBLIC/

Fayetteville Shale Natural Gas: Reducing Environmental Impacts

Search Go

- Home
- About Fayetteville Shale
- Drilling Locations and Status
- Natural Gas Production
- Minimizing Environmental Impacts
- Regulatory Requirements

Announcements

Fayetteville Shale:

Reducing the Environmental Impact of Natural Gas Development

A public information resource on natural gas development in Arkansas' Fayetteville Shale formation.

Welcome to the Fayetteville Shale Information Web site. In this site you will learn about the **natural gas resources** available in the **Fayetteville Shale** formation in Arkansas. The site explains the steps followed by natural gas development companies, from gaining access to the land through sending the gas to the marketplace. For each step in the process, the site provides information about the **state and federal regulatory requirements** that developers must follow. The site also describes some of the technologies that can be used to minimize the **environmental impacts** of natural gas development.

Follow the links below to learn about the Fayetteville Shale, explore map data related to natural gas development activities, the natural gas development process, regulations, and environmental technologies.

About the Fayetteville Shale
What is the Fayetteville Shale?

Fayetteville Shale Play Drilling Locations and Status
Maps and data showing current natural gas development activities in the Fayetteville Shale.

Natural Gas Production
How is natural gas produced from the Fayetteville Shale?

Minimizing Environmental Impacts
What technologies can be used to minimize environmental

Done | Internet | 100%

Fayetteville Shale Play Drilling Locations and Status - Microsoft Internet Explorer provided by Center for Advanced Spatial Tec

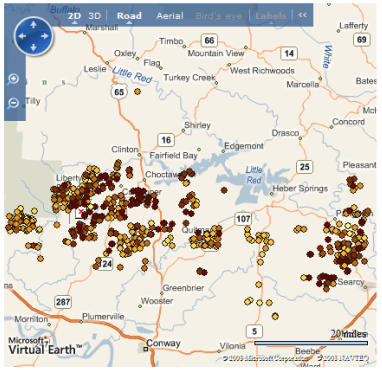
http://lingo.cast.uark.edu/LINGOPUBLIC/drilloc/index.htm

- About Fayetteville Shale
- Drilling Locations and Status
- Natural Gas Production
- Minimizing Environmental Impacts
- Regulatory Requirements

Announcements

Drilling Locations and Status

The interactive Map below shows the location of currently operating wells. By pressing the Ctrl button and dragging the mouse on the map, you can zoom to various areas of the Fayetteville Shale. You can turn information on and off using the legend on the side of the map. You can display information about a particular feature by moving your mouse over it.



Open a full screen map window

- ☐ Active Natural Gas Wells
- ☐ Drilling Permits
  - ◉ 1 week ago
  - ○ 2 weeks ago
  - ○ 3 weeks ago
- ☐ Compressor Stations
- ☐ Sections
- ☑ Monthly Production Output

Dec
2007

Production (1000 Feet³)
- 0–528
- 529–1296
- 1297–3343
- 3348–6918
- 6929–10947
- 10952–15682
- 15690–20906
- 20924–29011
- 29012–42192
- 42210–163882

Input your address or well section # to zoom to that location:
Examples:

- *Lat, Long: 35.187278, -92.304382*

Done | Internet | 100%

http://lingo.cast.uark.edu/VETest/FullScreen.aspx - Microsoft Internet Explorer provided by Center for Advanced Spatial Technol

http://lingo.cast.uark.edu/VETest/FullScreen.aspx

- ☑ Active Natural Gas Wells
- ☐ Drilling Permits
  - ◉ 1 week ago
  - ○ 2 weeks ago
  - ◉ 3 weeks ago
- ☐ Compressor Stations
- ☑ Sections
- ☐ Monthly Production Output

You can turn information on and off at the top.

Input your address or well section # to zoom to that location:

Done | Internet | 100%

Producing Natural Gas from the Fayetteville Shale - Windows Internet Explorer

http://lingo.cast.uark.edu/LINGOPUBLIC/natgas/index.htm

Favorites | Producing Natural Gas from the Fayetteville Shale

Fayetteville Shale Natural Gas: Reducing Environmental Impacts

Search Go

- Home
- About Fayetteville Shale
- Drilling Locations and Status
- Natural Gas Production
  - Gaining Access to the Resource
  - Searching for Natural Gas
  - Site Preparation
  - Drilling
  - Preparing a Well for Production
  - Well Production
  - Moving Natural Gas to Market
  - Well Closure
- Minimizing Environmental Impacts
- Regulatory Requirements

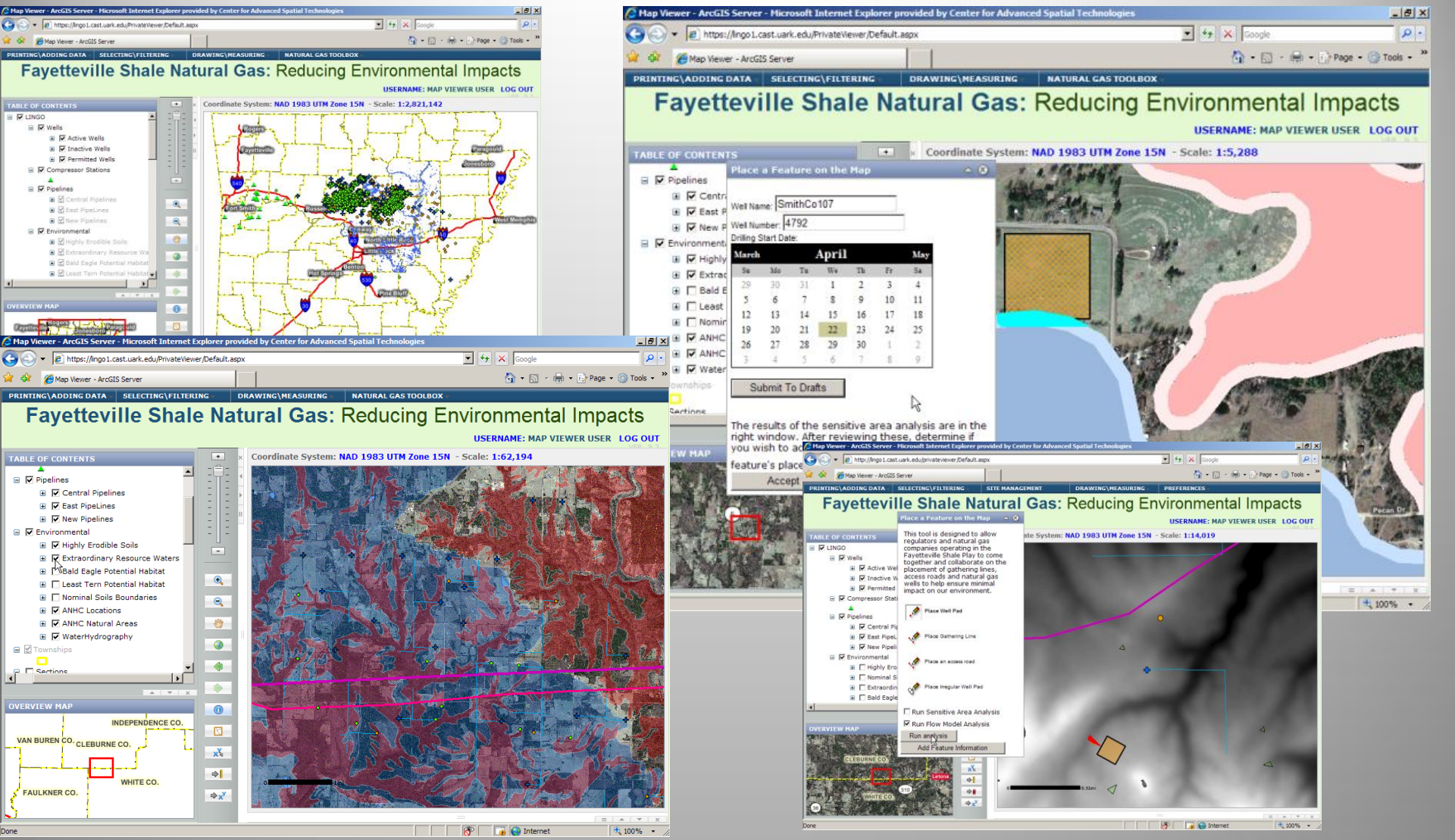
Announcements

Producing Natural Gas from the Fayetteville Shale

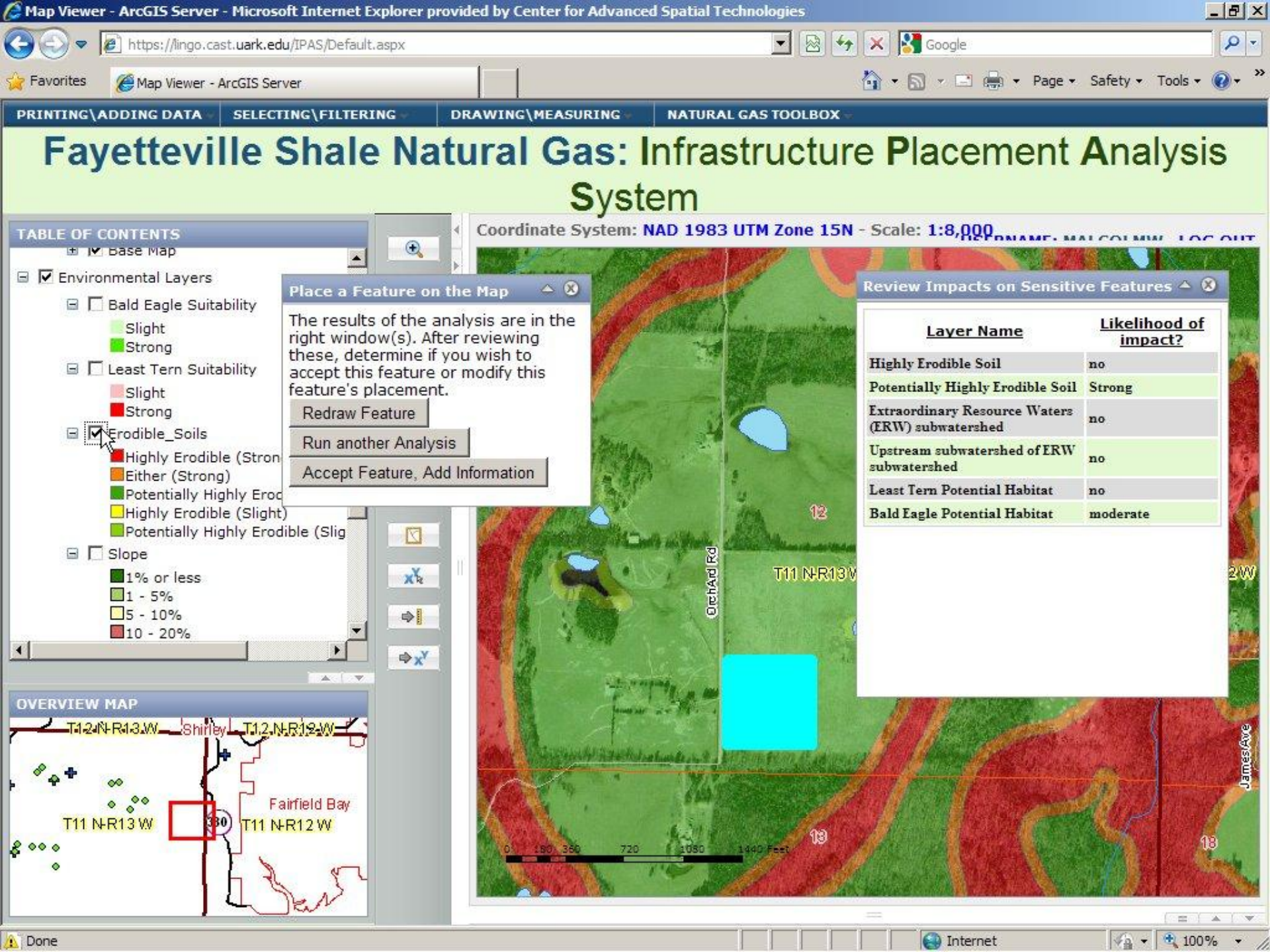
Finding and producing natural gas from the Fayetteville Shale is a multi-step process.

The process of finding and producing natural gas from the Fayetteville Shale can be described as a series of discrete steps and processes. Each major step is shown below. Click on any of the boxes for additional information about that step.

Gaining Access to the Resource
↓
Searching for Natural Gas
↓
Site Preparation
↓
Drilling
↓
Preparing a Well for Production
↓
Well Production and Water



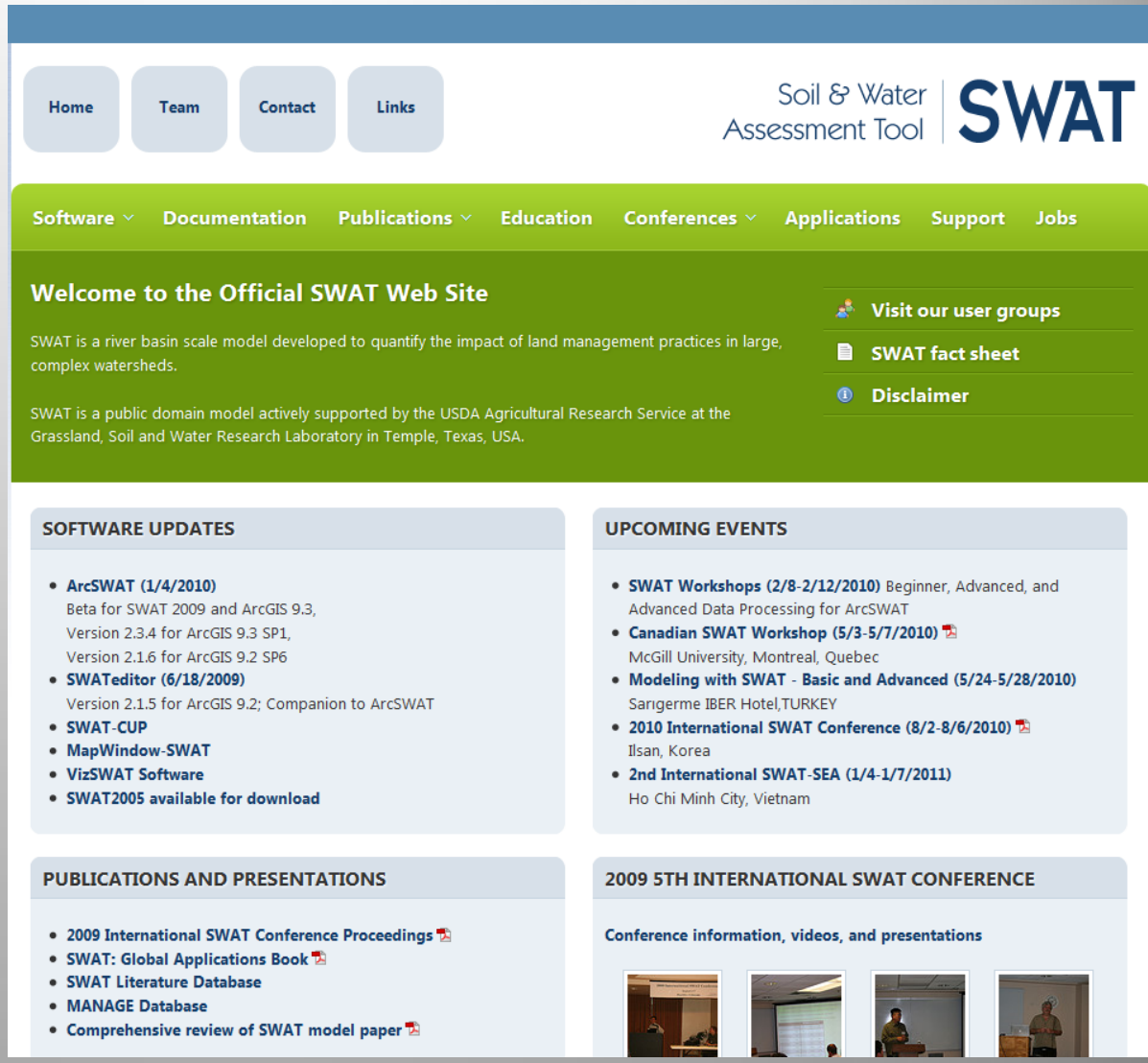
Views from the Fayetteville Decision Support System. A complete GIS using the client/server architecture of ESRI's ArcGIS Server 9.3, the system incorporates uncertainty in it's decision making using buffers around soil and habitat layers to reflect the uncertainty of their location and boundaries and "fuzzy" intersection models to report more realistic likelihood of interaction. Habitat model and down-slope water flow models are part of the system.


Map Viewer - ArcGIS Server - Microsoft Internet Explorer provided by Center for Advanced Spatial Technologies
https://lingo.cast.uark.edu/IPAS/Default.aspx
Google
Favorites
Map Viewer - ArcGIS Server
Page
Safety
Tools
PRINTING\ADDING DATA
SELECTING\FILTERING
DRAWING\MEASURING
NATURAL GAS TOOLBOX
Fayetteville Shale Natural Gas: Infrastructure Placement Analysis System
TABLE OF CONTENTS
Base Map
Environmental Layers
Bald Eagle Suitability
Slight
Strong
Least Tern Suitability
Slight
Strong
Erodible_Soils
Highly Erodible (Stron
Either (Strong)
Potentially Highly Eroc
Highly Erodible (Slight)
Potentially Highly Erodible (Slig
Slope
1% or less
1 - 5%
5 - 10%
10 - 20%
OVERVIEW MAP
T12 N-R13 W
Shirley
T12 N-R12 W
Fairfield Bay
T11 N-R13 W
T11 N-R12 W
Coordinate System: NAD 1983 UTM Zone 15N - Scale: 1:8,000
Place a Feature on the Map
The results of the analysis are in the right window(s). After reviewing these, determine if you wish to accept this feature or modify this feature's placement.
Redraw Feature
Run another Analysis
Accept Feature, Add Information
Review Impacts on Sensitive Features
Layer Name
Likelihood of impact?
Highly Erodible Soil
no
Potentially Highly Erodible Soil
Strong
Extraordinary Resource Waters (ERW) subwatershed
no
Upstream subwatershed of ERW subwatershed
no
Least Tern Potential Habitat
no
Bald Eagle Potential Habitat
moderate
Orchard Rd
T11 N-R13 W
James Ave
0 180 360 720 1080 1440 Feet
Done
Internet
100%

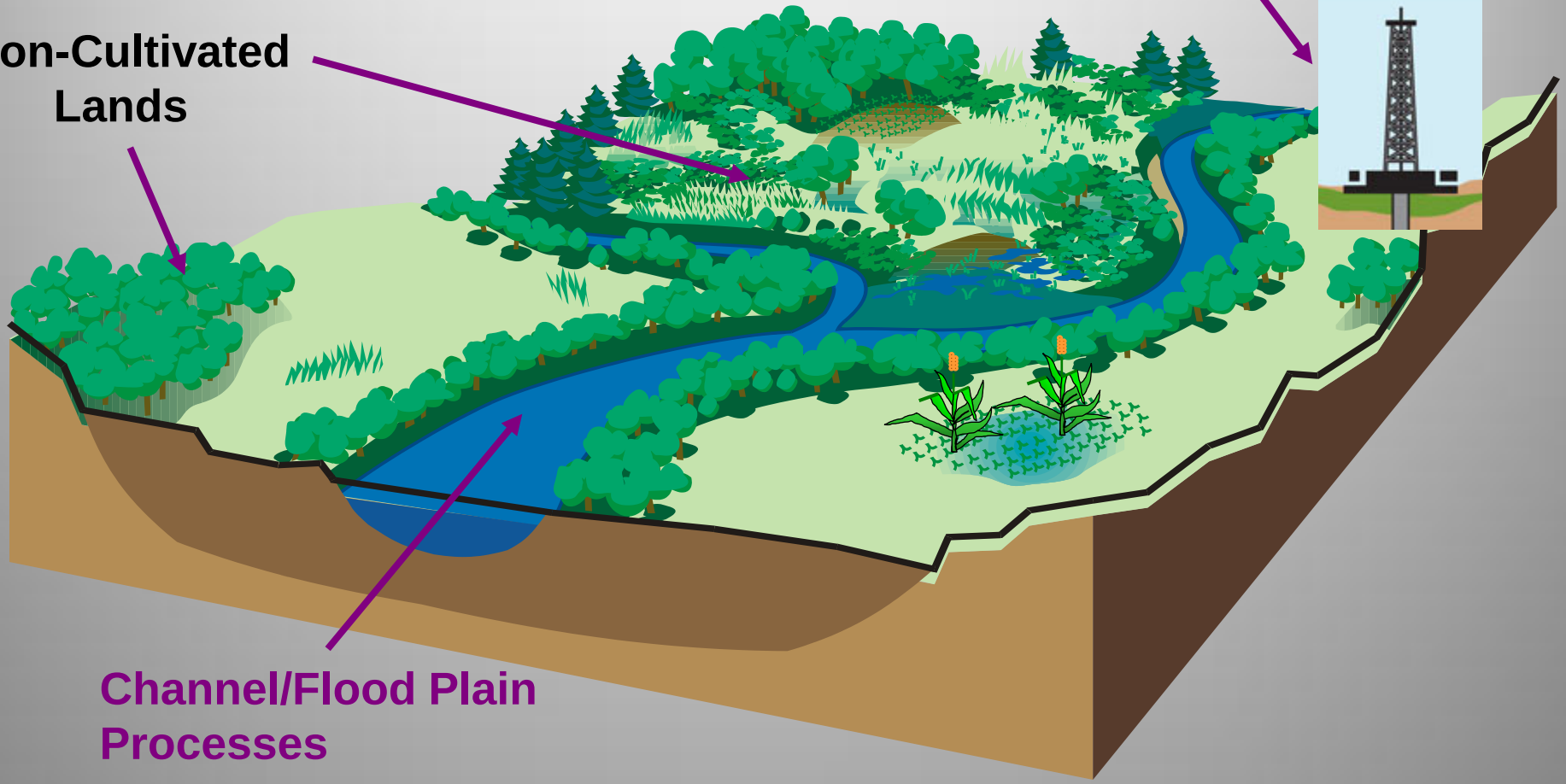
SWAT is a product of over 30 years of USDA model development

Partnership – Texas A&M, ARS, EPA, NRCS

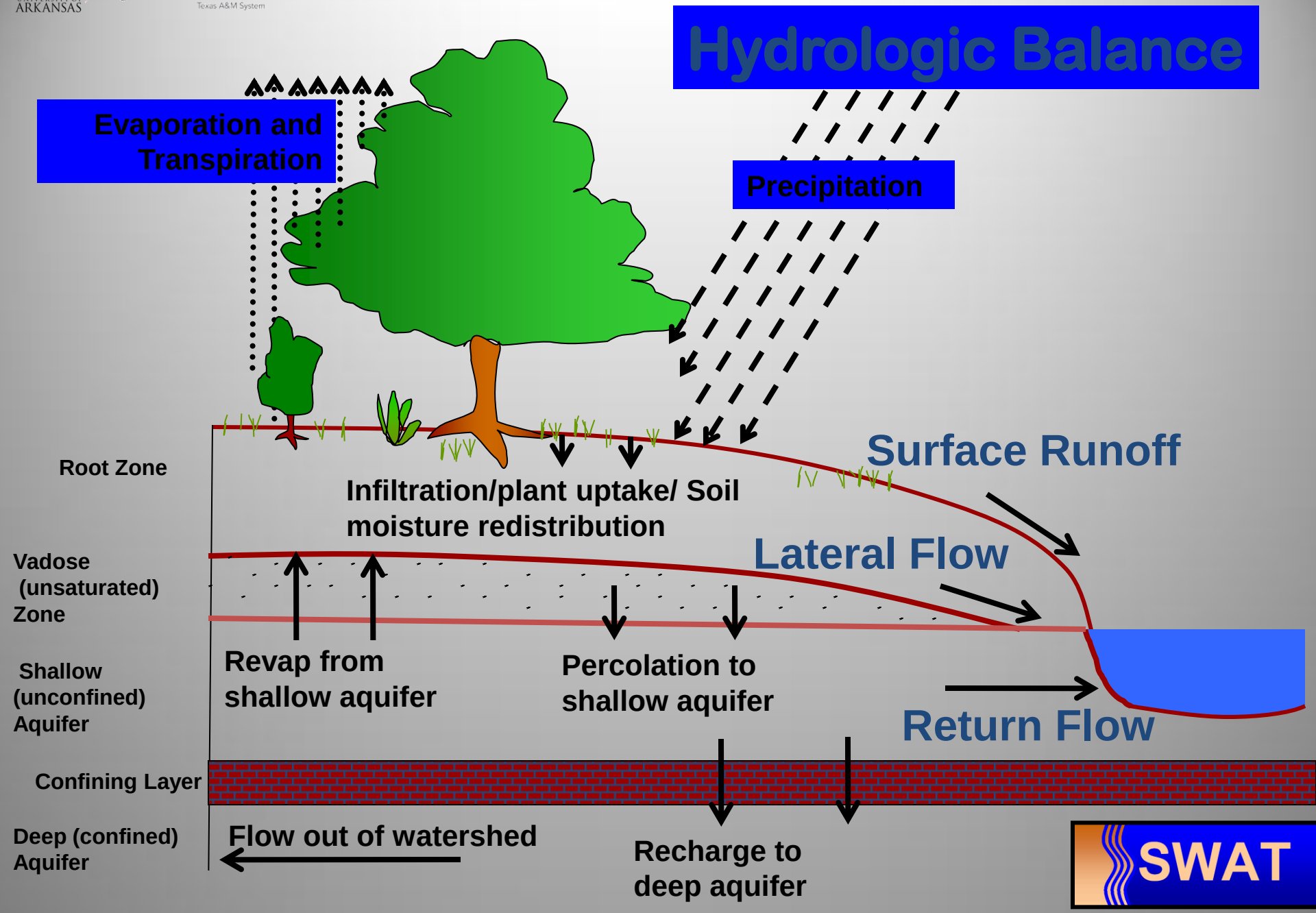
Widely used for water quality, water supply and climate change



SWAT Watershed System



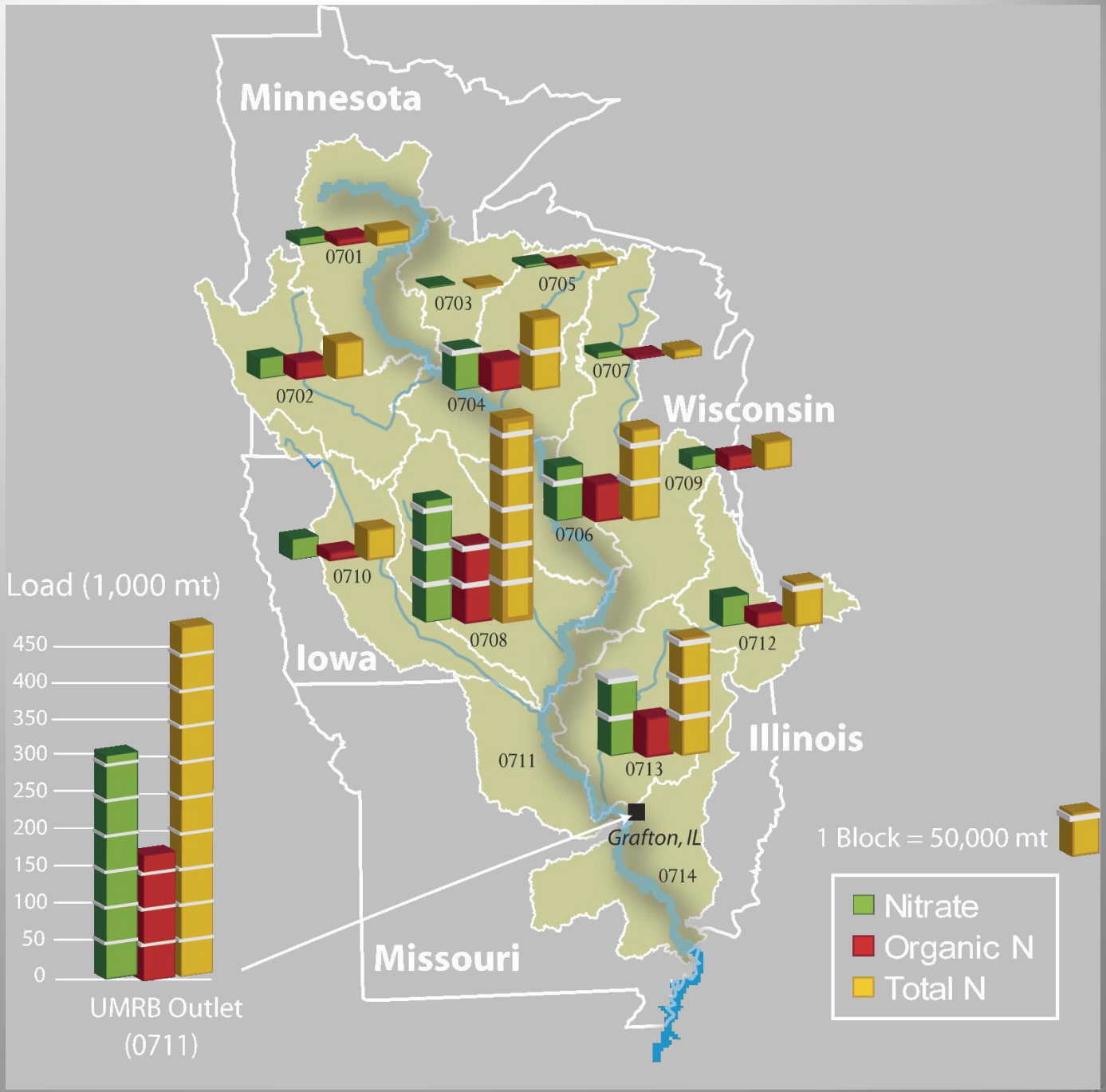
Hydrologic Balance



SWAT

Typical SWAT output :

Chemical loads at watershed level at watershed discharge points.



SWAT Strengths

Upland Processes

- Comprehensive Hydrologic Balance
- Physically-Based Inputs
- Plant Growth – Rotations, Crop Yields
- Nutrient Cycling in Soil
- Land Management - BMP

  Tillage, Irrigation, Fertilizer, Pesticides, Grazing, Rotations, Subsurface Drainage, Urban-Lawn Chemicals, Street Sweeping

SWAT Strengths

Channel Processes

- Flexible Watershed Configuration
- Water Transfer—Irrigation Diversions
- Sediment Deposition/Scour
- Nutrient/Pesticide Transport
- Pond, Wetland and Reservoir Impacts

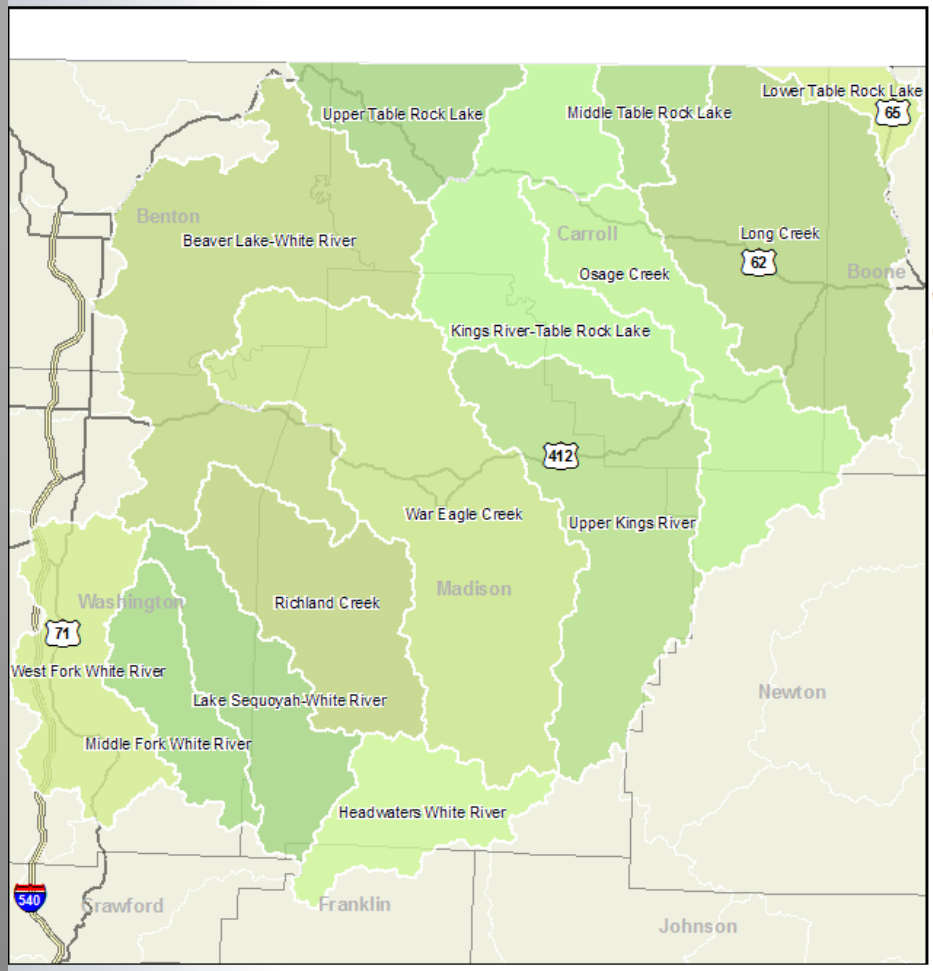
Geospatial Data Layers Required

- Existing Surface Water
  - National Hydrology Dataset (USGS)
  - Small Water Bodies (Project Task 4.2)
  - Stream Gauge Observation (USGS)
- Climate
  - Precipitation (NWS)
  - Weather Radar (provide estimates of precipitation)
  - Temperature (NWS)
- Land Cover
  - Developed from 30m and 2m imagery (CAST Project)
  - SSURGO Soils (CAST, USDA, NRCS)
- Elevation Data
  - National Elevation Dataset (USGS)
  - LiDAR Derived Elevation (CAST, ANRC, NRCS, USGS)

Arkansas Watershed Information System

a module of the Arkansas Automated Reporting and Mapping System

watersheds.cast.uark.edu



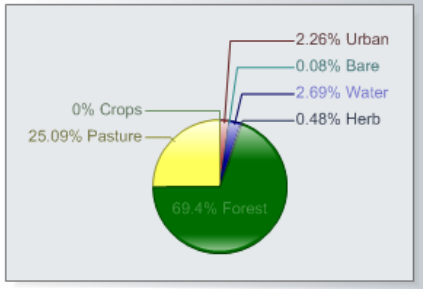
Beaver Reservoir

Huc Id	11010001
Total Area	2172.10 mi^2
Total Acres	1406444.11
Population 1990	77661
Population 2000	101859
Density 1990	35.75 persons/mi^2
Density 2000	46.89 persons/mi^2

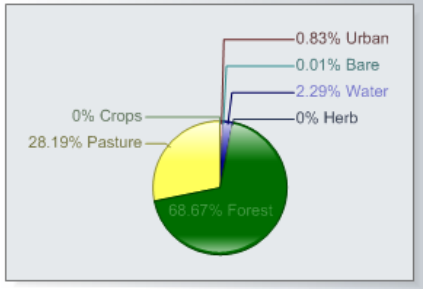
Watershed Information

(Click charts for more info.)

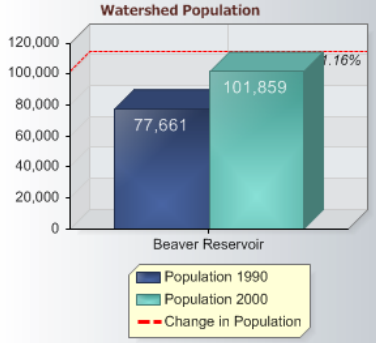
2004 Land Cover



1999 Land Cover



Watershed Population

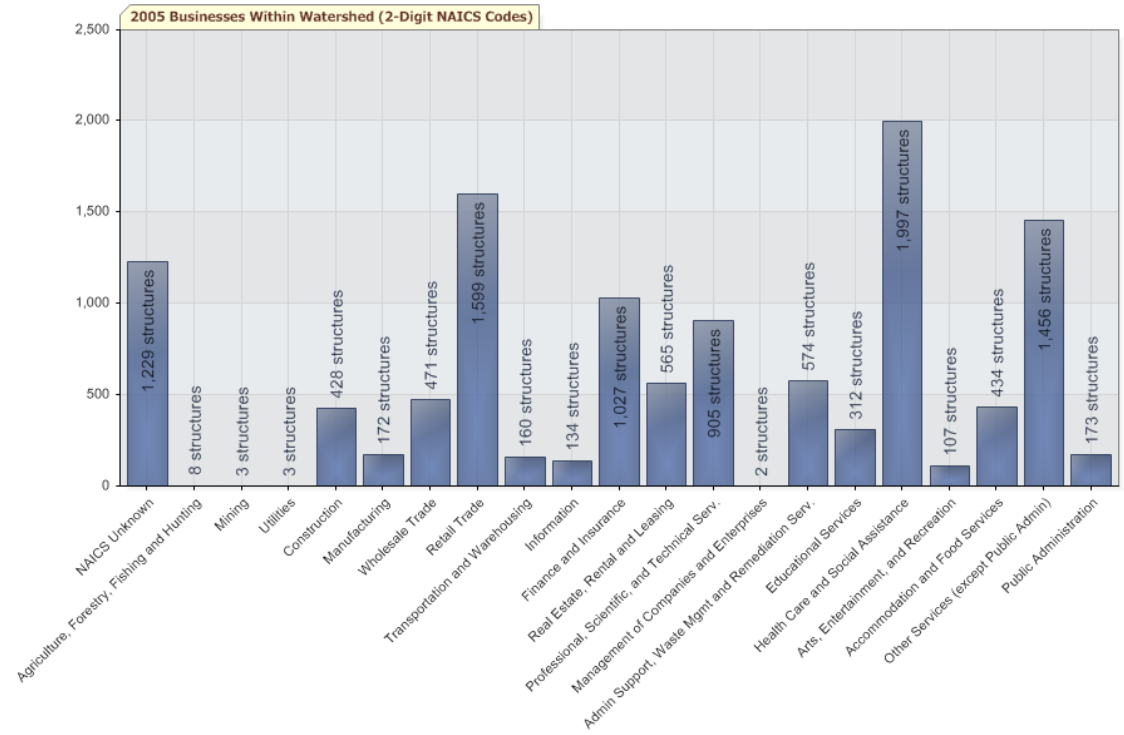


digit HUC names and codes.

digit HUC names and codes.

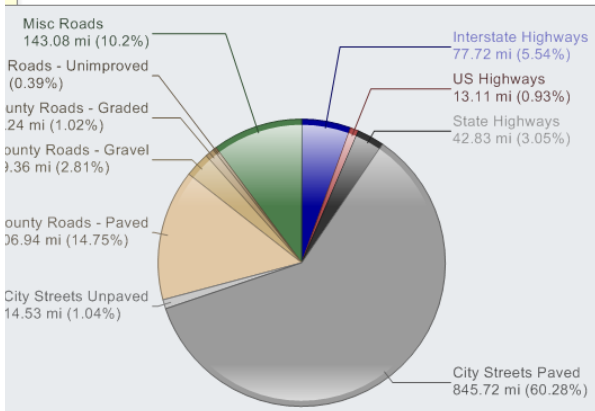
Arkansas Natural Resources Commission

Aggregated business data derived from the InfoBase® List data product provided by Acxiom® Corporation (snapshot date 2006).



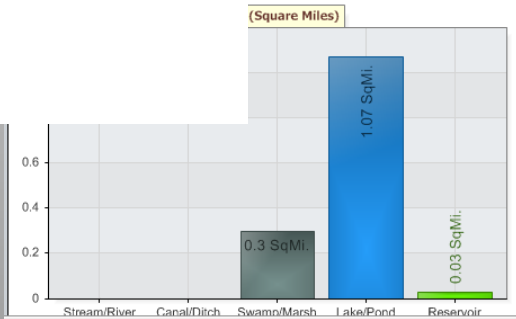
NAICS 2 Digit	NAICS 4 Digit	Description	Records
62	6211	Offices of Physicians	1313
00	0000	NAICS Code Unknown	1229
52	5241	Insurance Carriers	440
81	8131	Religious Organizations	380
81	8121	Personal Care Services	367
56	5614	Business Support Services	299
54	5411	Legal Services	293
72	7221	Full-Service Restaurants	291
53	5311	Lessors of Real Estate	280
62	6213	Offices of Other Health Practitioners	180

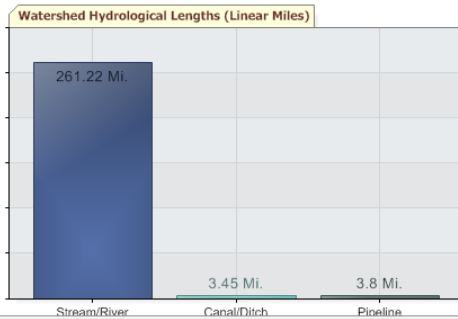
derived from data provided by the Arkansas State Highway and Transportation Department (publication date August 2006).



l Lengths in Miles

ed from data provided by the United States Geological Survey, National Hydrography Dataset (publication date 1999).

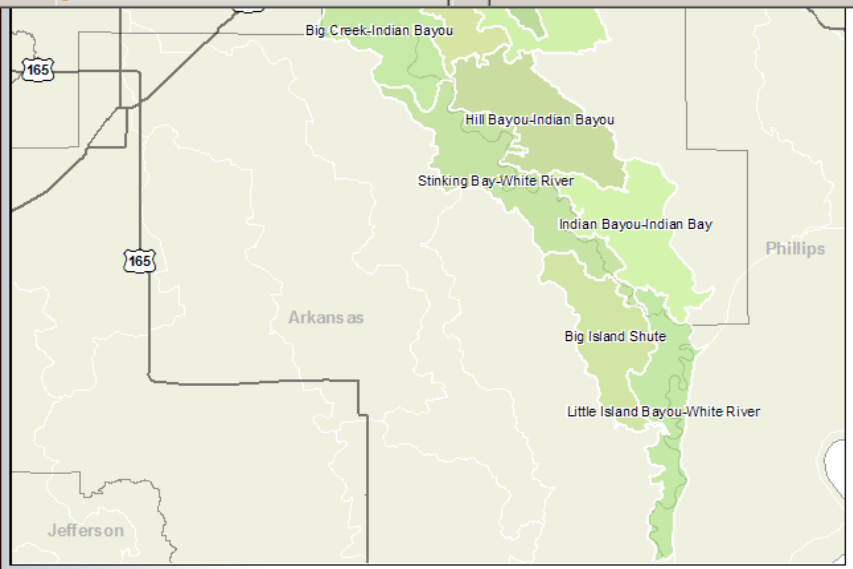




Arkansas Watershed Information System - 10-Digit: 0802030305 - Windows Internet Explorer

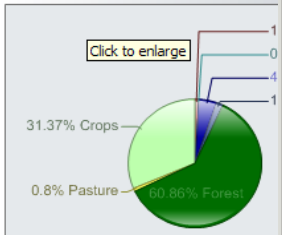
http://watersheds.cast.uark.edu/viewhuc.php?hucid=0802030305

Arkansas Watershed Information System - 10-Digit: 0...

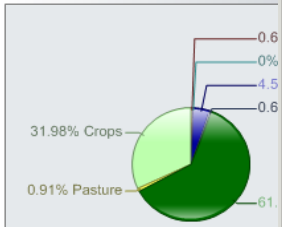


(Click charts for more info.)

2004 Land Cover

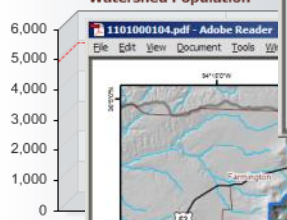


1999 Land Cover

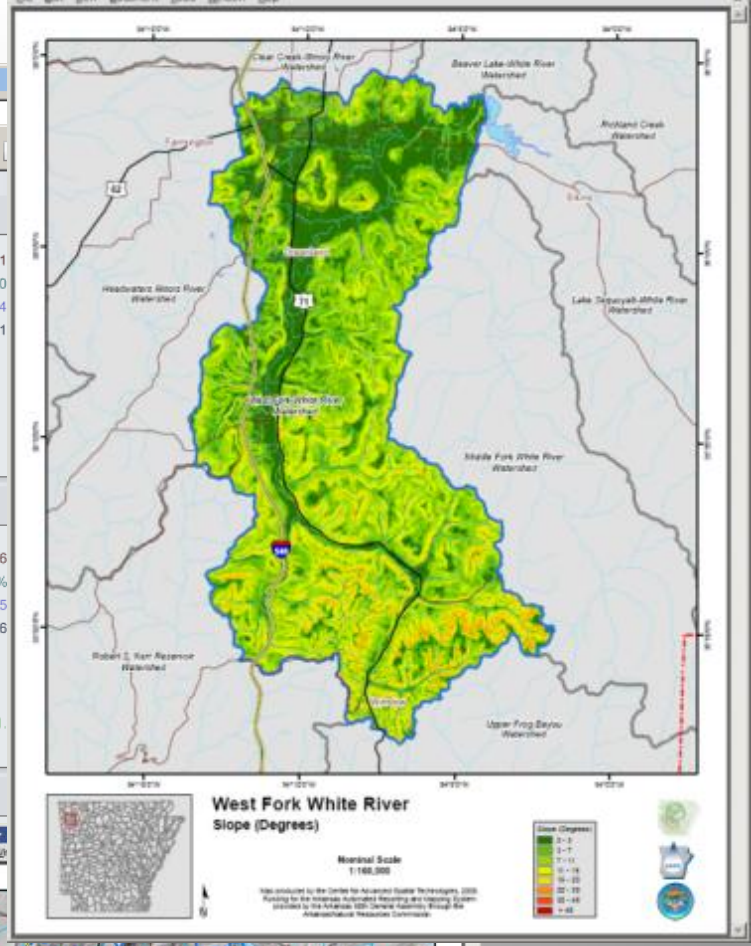


Category	Maps		Watershed Reports		Sub-Watershed Reports	
Hydrography	8.5x11	17x22	HTML	PDF	HTML	PDF
Hydrography with Shaded Relief	8.5x11	17x22	HTML	PDF	HTML	PDF
Land Use / Land Cover, 1999	8.5x11	17x22	HTML	PDF	HTML	PDF
Land Use / Land Cover, 2004	8.5x11	17x22	HTML	PDF	HTML	PDF
Land Use Change, 1999-2004	8.5x11	17x22	HTML	PDF	HTML	PDF
Population Change, 1990-2000	8.5x11	17x22	HTML	PDF	HTML	PDF
Population Density, 2000	8.5x11	17x22	HTML	PDF	HTML	PDF
Roads	8.5x11	17x22	HTML	PDF	HTML	PDF
Slope	8.5x11	17x22				
Soils - Hydric Soils	8.5x11	17x22	HTML	PDF	HTML	PDF
Soils - Productivity	8.5x11	17x22	HTML	PDF	HTML	PDF
Soils - Septic Suitability	8.5x11	17x22	HTML	PDF	HTML	PDF
Sub-Watersheds	8.5x11	17x22				

Watershed Population



1101000104.pdf - Adobe Reader



Click here for a cross-reference list of the 8-digit HUC names and codes.

Click here for a cross-reference list of the 10-digit HUC names and codes.

Funded by the Arkansas 85th General Assembly through the Arkansas Natural Resources Comm

http://watersheds.cast.uark.edu/viewchart.php?hucid=0802030305&hucname=Indian Bayou-White River

National Weather Service
Precipitation Analysis

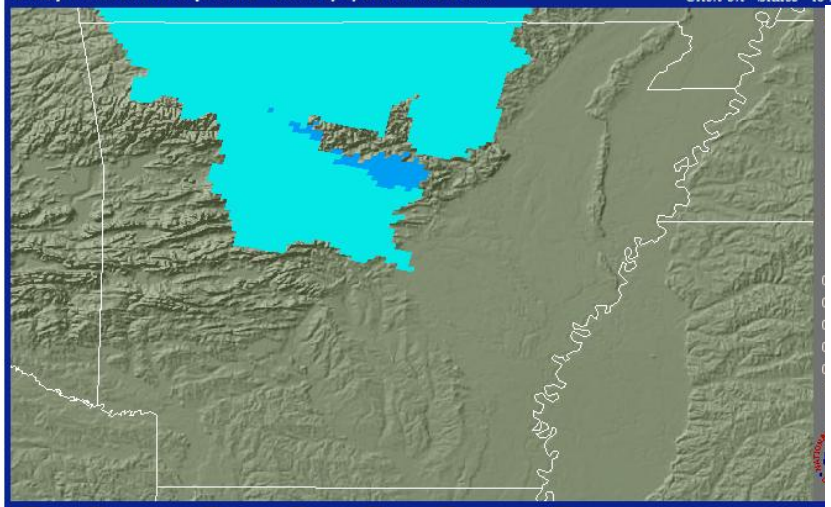
weather.gov

Local weather forecast by "City, St" or zip code City, St Go

Images | Download | About NWS Precip Analysis | Other Useful Information | Survey & Feedback | Hourly Precip Analysis

Arkansas
1-Day Observed Precipitation - Valid 1/4/2010 1200 UTC

Click on the image to zoom in
Click on "States" to zoom out



Topo | Pcpn Amount | Counties | Rivers | States | Highway/City | RFC Boundary | Last Update: 1/5/2010

1. Timeframe
- Current Data
- Archive: Month/Year
- Archive: Daily

Year: 2010
Month: January
Day: 4

2. Product: Observed

3. Location
- States
- NWS RFC/Regions

Continental United States
Alaska
Alabama
Arizona
Arkansas

NOTE TO USERS: The precipitation analysis website is moving! Please update your links to http://water.weather.gov.

USGS science for a changing world

USGS Home | Contact USGS | Search USGS

National Water Information System: Web Interface

USGS Water Resources

Data Category: Real-time | Geographic Area: Arkansas | GO

News - updated November 2009

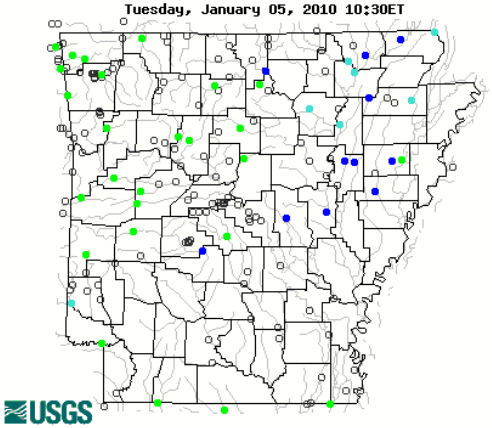
USGS Real-Time Water Data for Arkansas

--- Predefined displays --- : Introduction
Group table by: -- no grouping --
Select sites by number or name: go

Daily Streamflow Conditions

Select a site to retrieve data and station information.

Tuesday, January 05, 2010 10:30ET



USGS

Explanation
- High
- ≥ 90th percentile
- 75th - 89th percentile

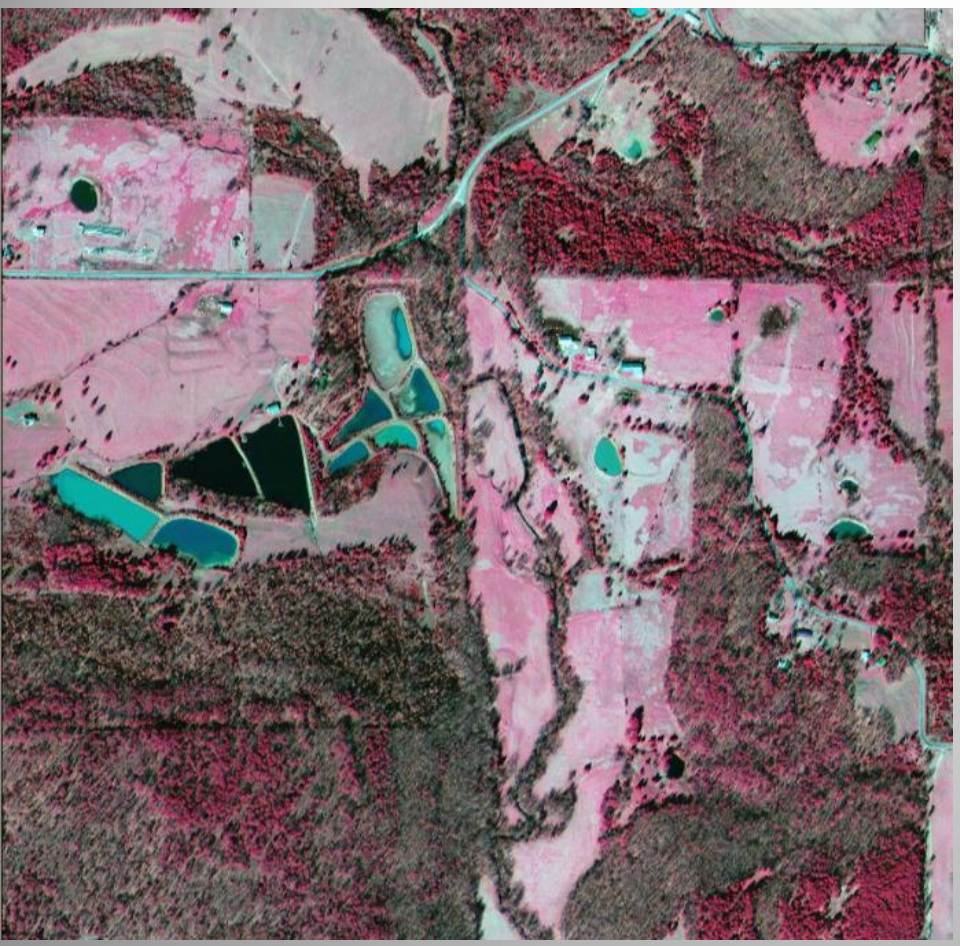
The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years

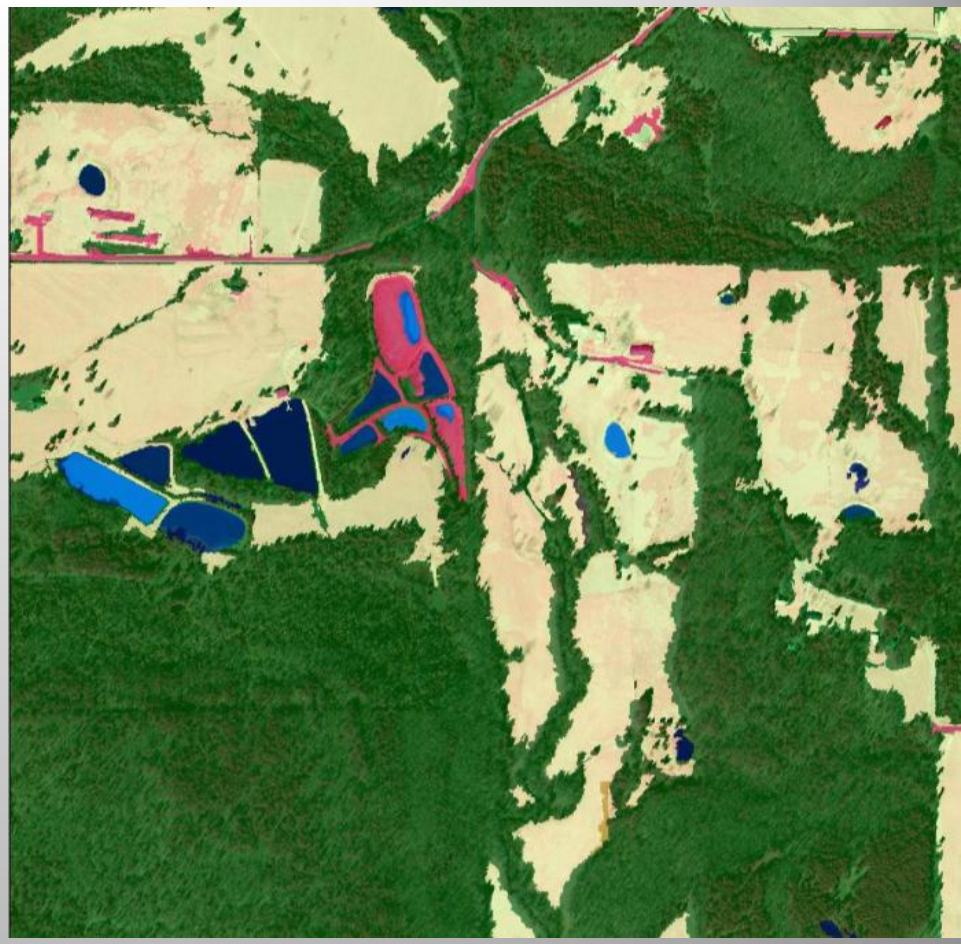
Statewide Streamflow Table

Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.

All real-time data are provisional and subject to revision.

Build Table	Build a custom summary table for one or more stations.
Build Sequence	Build a custom sequence of graphical or tabular data for one or more stations.





Retention ponds in this North Central area of Arkansas in the White River Basin as seen in 1-meter resolution color infrared imagery. NONE of these water bodies appear in the NHD.

Object oriented classification of the color-infrared imagery. Surface water objects appear in shades of blue and range in size from 250m² to 12,000m².

SWAT Model Development

- Develop and modify SWAT models
  - Make appropriate for water use in oil and gas operations
- Calibrate chosen models
  - Three (3) watersheds
- Validate chosen models
  - In additional watersheds
- Integrate Models in FSDSS
  - Develop user interface (UI)
  - Build data feeds for external layers

Deliverables

- Fayetteville Shale Information Website
  - water-related regulatory requirements and information on technologies related to obtaining, transporting and disposing of water.
  - updated interactive map containing watershed specific information.
- Reports and publications documenting the SWAT model application in the Fayetteville Shale area.
- Fayetteville Shale Decision Support System
  - enhanced with data layers from the National Weather Service (Doppler radar, humidity, precipitation and temperature).
  - enhanced with spatial data layer of small retention ponds and their associated drainage areas.
  - enhanced with SWAT models.

Impacts (1/2)

- Provide information to the public, regulators and industry regarding water issues in the Fayetteville Shale Play
- Develop and implement quantitative tools for visualization and water management
- Provide an open and transparent accounting of the water supplies

Impacts (2/2)

- Advance knowledge of how ground and surface water withdrawal affects water availability and water quality in a watershed – particularly in the Fayetteville Shale Play.
- An accurate map of retention ponds and small water bodies will be available for a very large area, and the effect of this usually unaccounted for water can be estimated.
- Provides well-organized information at the intersection of gas-shale development and water use
  - producers and regulators who will be able to immediately share extensive, model-driven information about the effects of the development decisions they make.

Project Costs

Total Project	Phase 1 (~Year 1)	Phase 2 (~Year 2)	Total
DOE	$270,287	$246,189	$516,475
Cost Share	$90,722	$88,795	$179,517
Total	$361,009	$334,984	$695,992