Jeff Arnold and the
SWAT Conservation Assessment Team

Current status and future directions in

watershed modeling

Presentation Overview

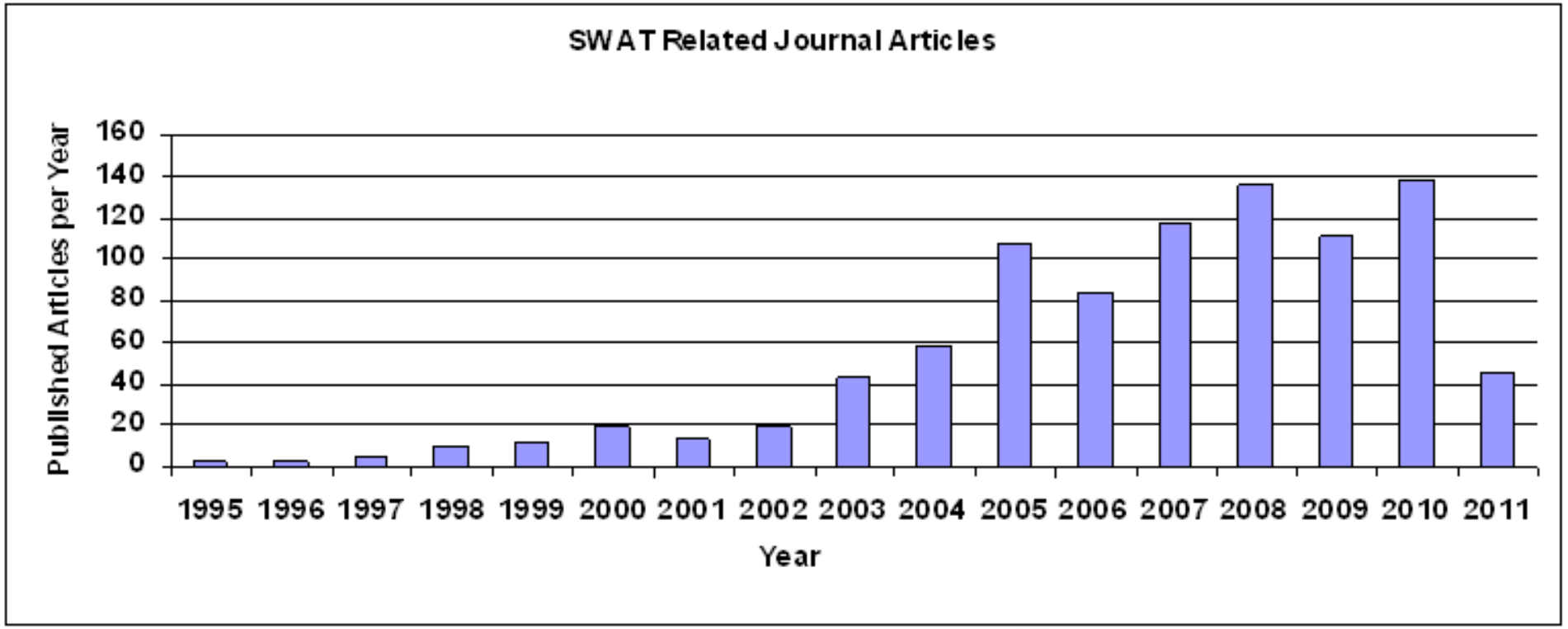
1. Current Status of SWAT and Related Projects
2. Recent Process Developments in SWAT
3. The Future - ECLIPS
4. Developer's Workshop

CURRENT STATUS

Publications

Current Status - Publications

Over 800 Journal Publications on SWAT Development and Application



SWAT2009 Status

- SWAT Version 2009 was released after the 2009 International Conference in Boulder, Colorado

- New model routines for carbon dynamics, sediment routing, irrigation, filter strips, dynamic land use and conservation structure updates

- User interfaces with ArcGIS and MapWindows and VizSWAT

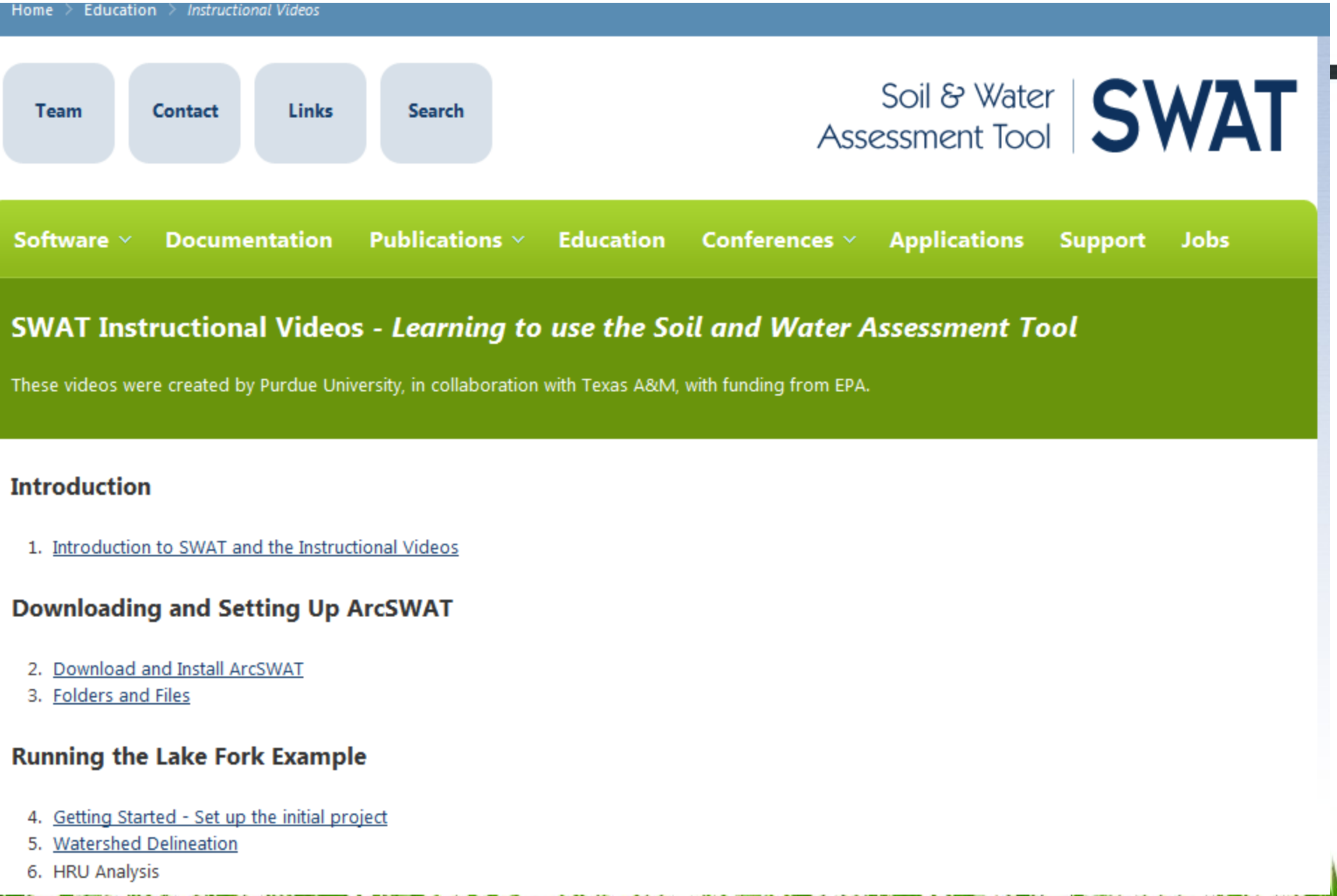
- Version control software and model developer workshops

- Instructional Videos - http://swatmodel.tamu.edu/education/instructional-videos

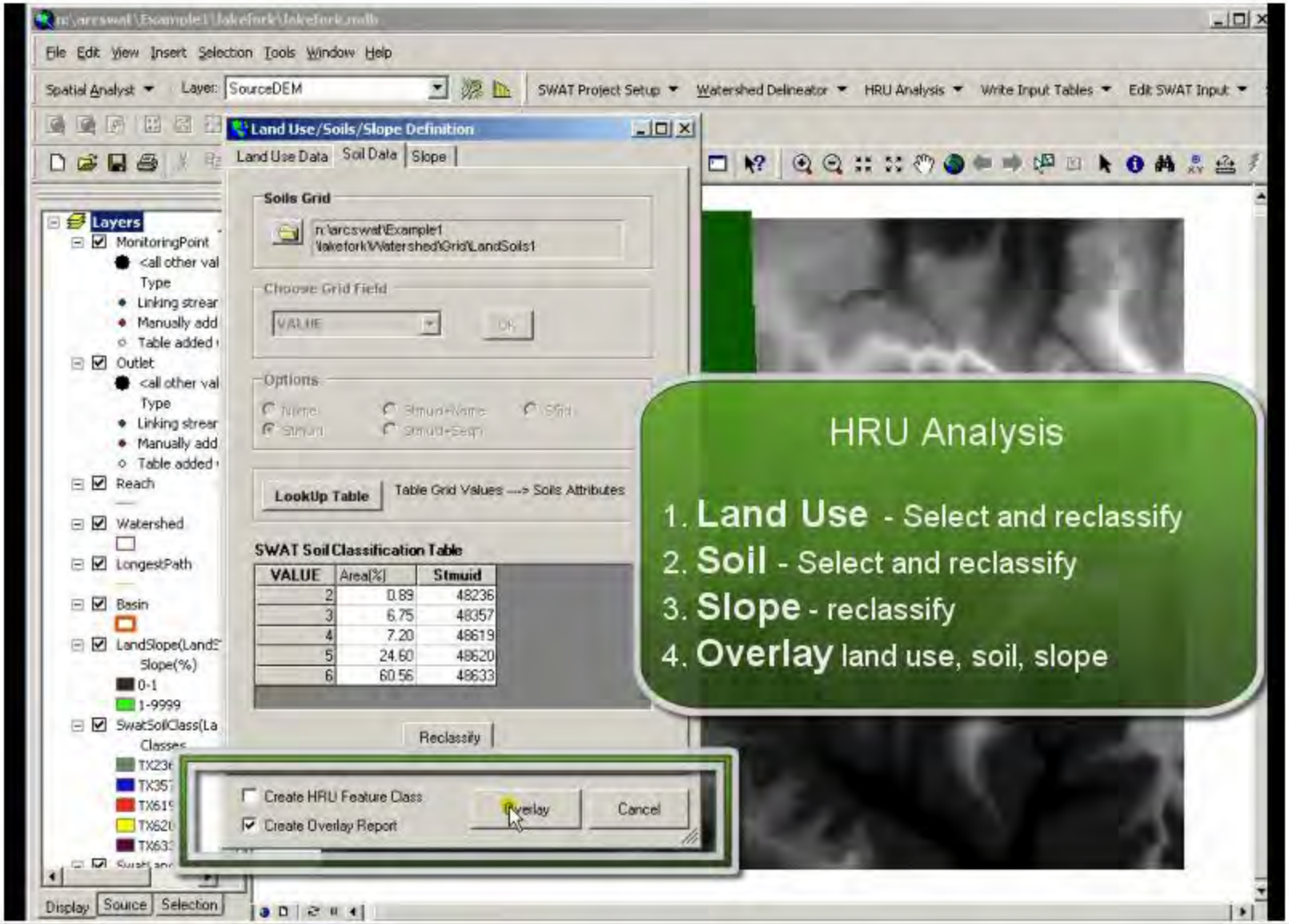
- Checker Tool – checks water, sediment, nutrient balances, plant growth

- Continued workshops and support around the world

Online Instructional Videos

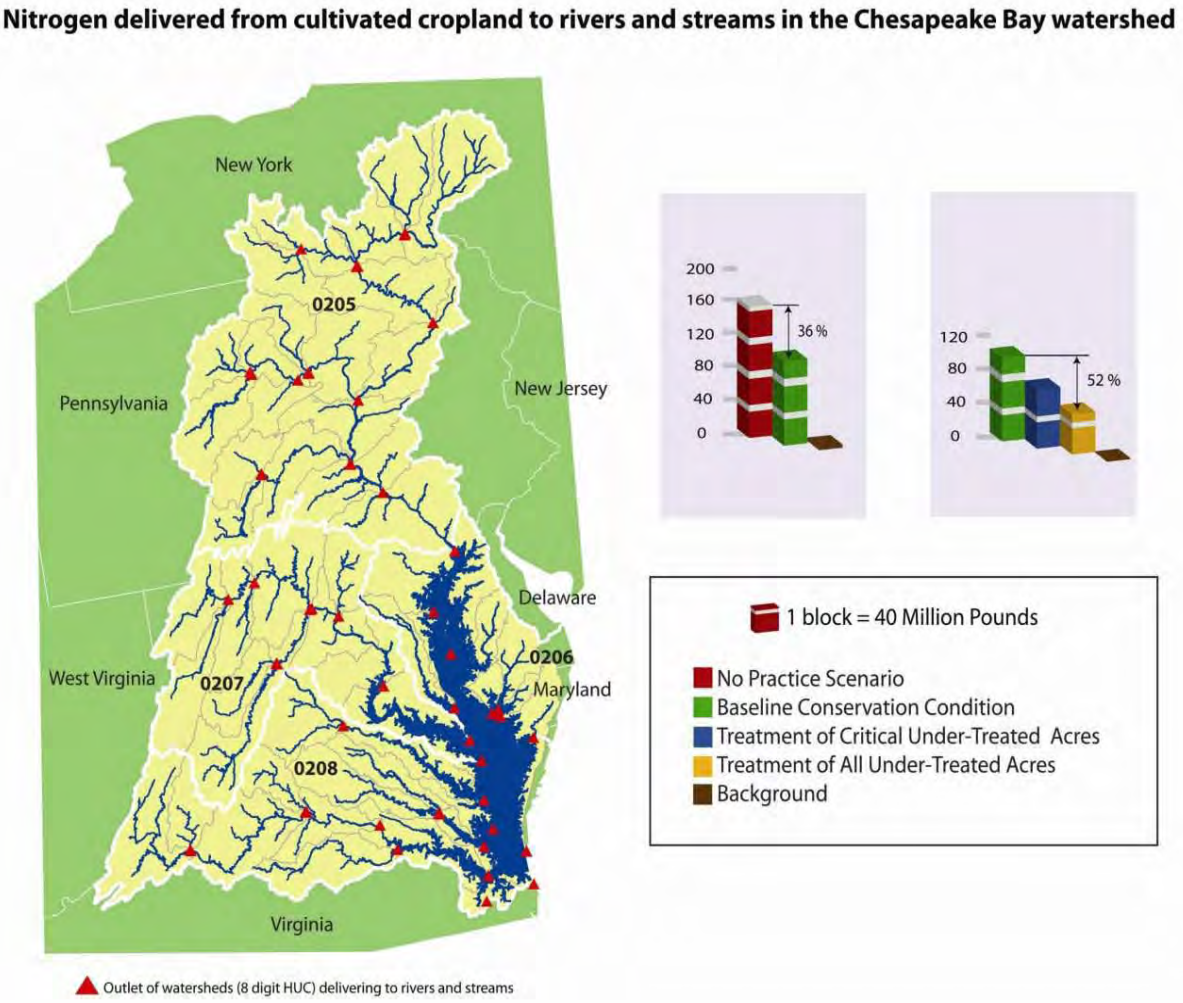


Running the Lake Fork Example - HRU Overlay



CEAP (Conservation Effects Assessment Project) Status

CEAP – Assess impact of USDA conservation practices on the environment ($2B per year)



Six reports complete

Chesapeake, Upper Mississippi, Ohio, Tennessee, Great Lakes

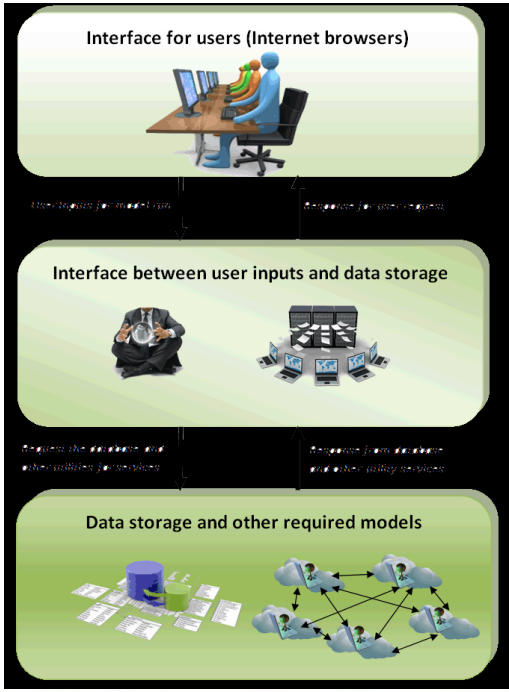
Six to go

Texas Gulf, Missouri, SE, Arkansas/Red, Lower Mississippi

HAWQS (Hydrologic and Water Quality System) Status

HAWQS is an advanced, state-of-the-art total water quantity and quality modeling system with databases, interfaces and models that is being developed for the U.S. Environmental Protection Agency's Office of Water to evaluate the impacts of management alternatives, pollution control scenarios, and climate change scenarios on the quantity and quality of water at a national scale.

- Is a server/client modeling system that uses a web-based interface to access datasets for modeling at the three spatial scales for any watershed over the contiguous lower 48 states.
- Uses latest nationally available • federal government databases at three spatial resolutions (NHD+, 10-digit and 8-digit watershed levels)
- Uses the latest SWAT model
- Uses National Hydrography Dataset (NHD+) stream network



PROCESS DEVELOPMENTS IN SWAT

SWAT Development Status

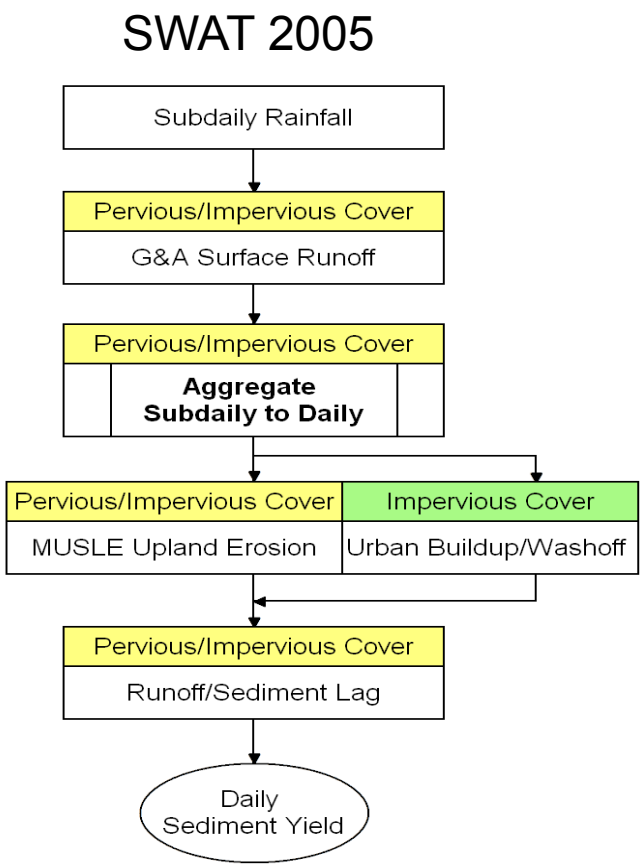
- geoCEAP
- Urban Processes and BMP's
- Septic Systems
- Emerging Contaminants
- Glaciers
- Rice Paddy Management and Pesticides
- Flood Routing
- Defining Phosphorus Pools
- Wetlands

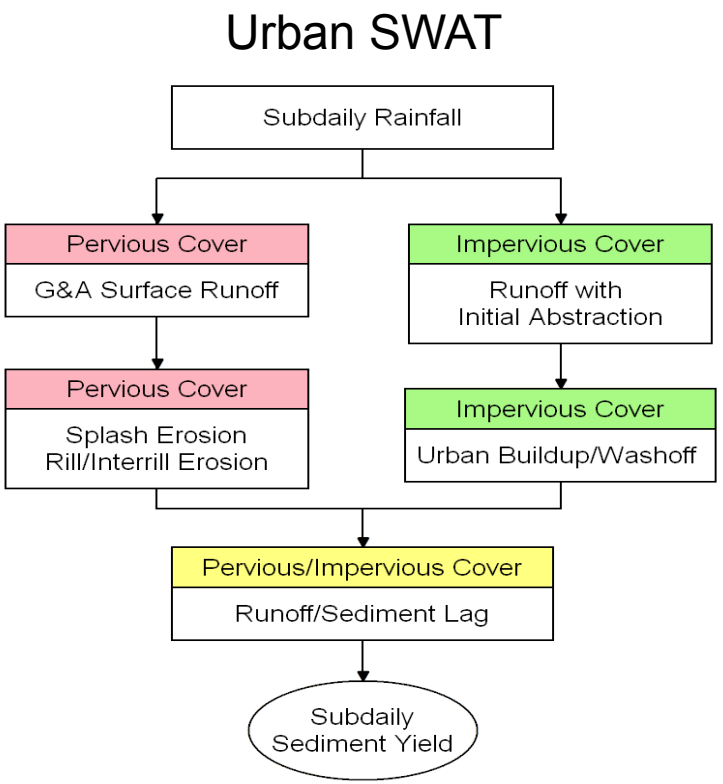
Urban Processes and BMP's

- In highly urbanized areas, impervious areas produce instantaneous runoff in response to rainfall
- This sort of quick response has to be controlled to avoid flooding, high erosion and the associated transport of pollutants to the nearby river or lake
- Structural stormwater best management practices can be helpful under these circumstances. They capture some of the instantaneous runoff, attenuate the flood peaks, and remove a portion of the pollutants before they reach the creek

Urban Processes and BMP's

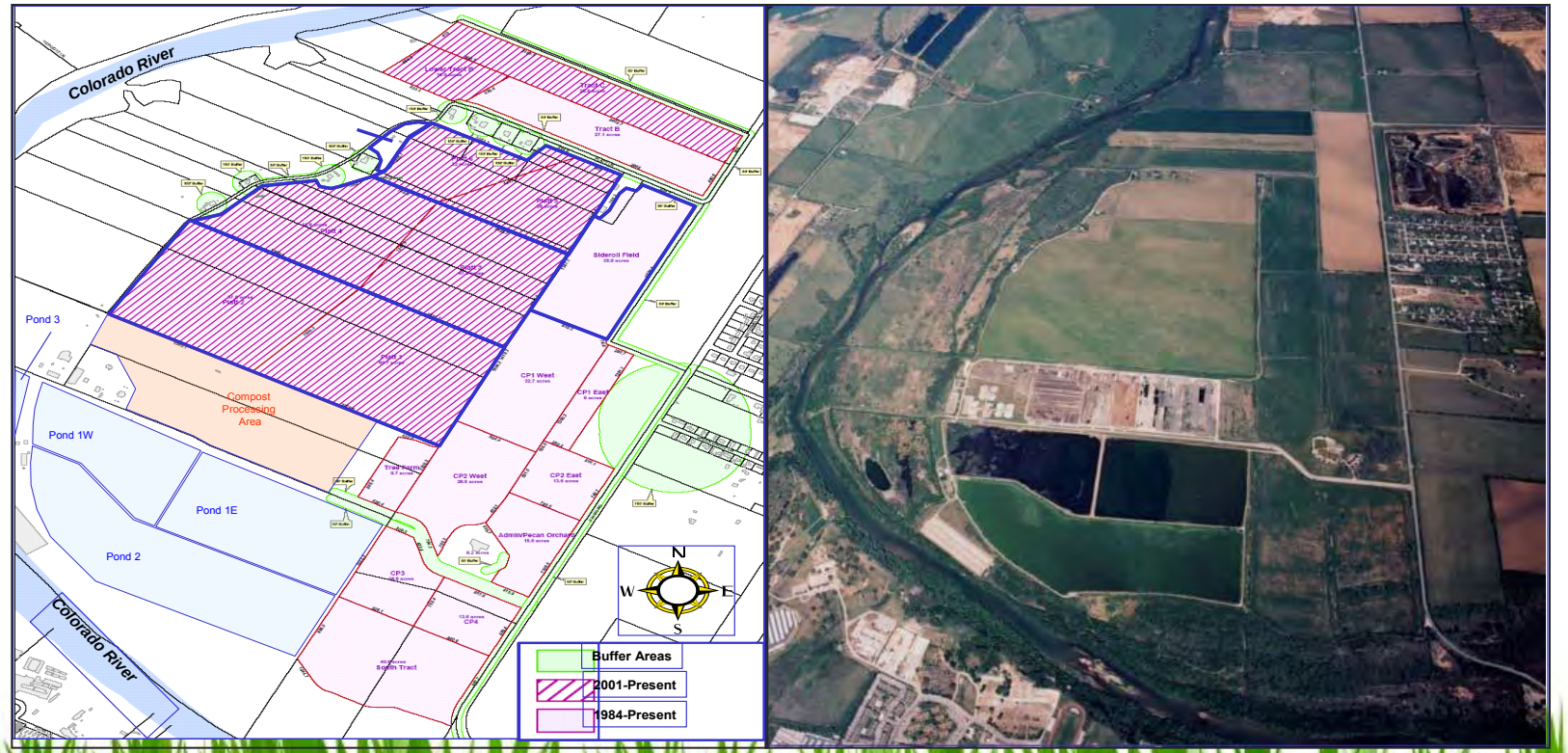
- Jaehak Jeong has developed new routines for subdaily runoff and sediment transport
- Allan Jones and Jaehak are developing urban stormwater best management practices that capture some of the instantaneous runoff, attenuate the flood peaks, and remove a portion of the pollutants before they reach the creek





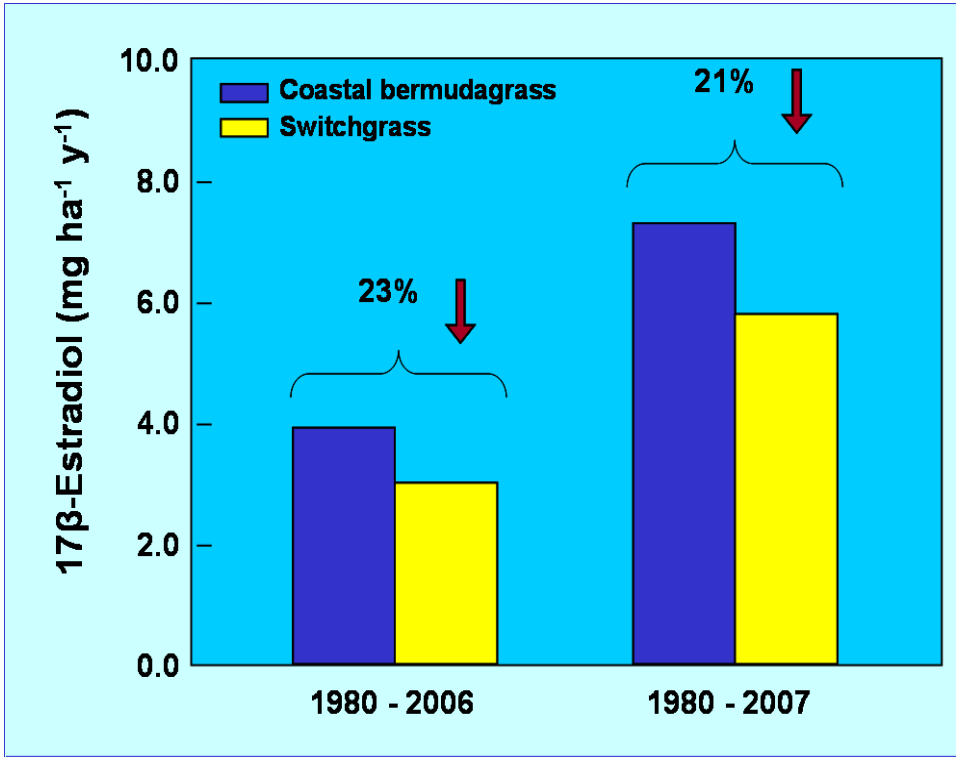
Municipal Biosolids Applications
Fate of Hormones and Antibiotics

- City of Austin, Texas biosolids facility
- Applied to pasture over the last 25 years at differing rates
- Monitoring nutrients, metals, hormones and antibiotics in pasture soils, Colorado River, wetlands, and biota (earthworms)
- Virginia Jin (ARS-Lincoln, NE) and Mari-Vaughn Johnson



Municipal Biosolids Applications Fate of Hormones and Antibiotics

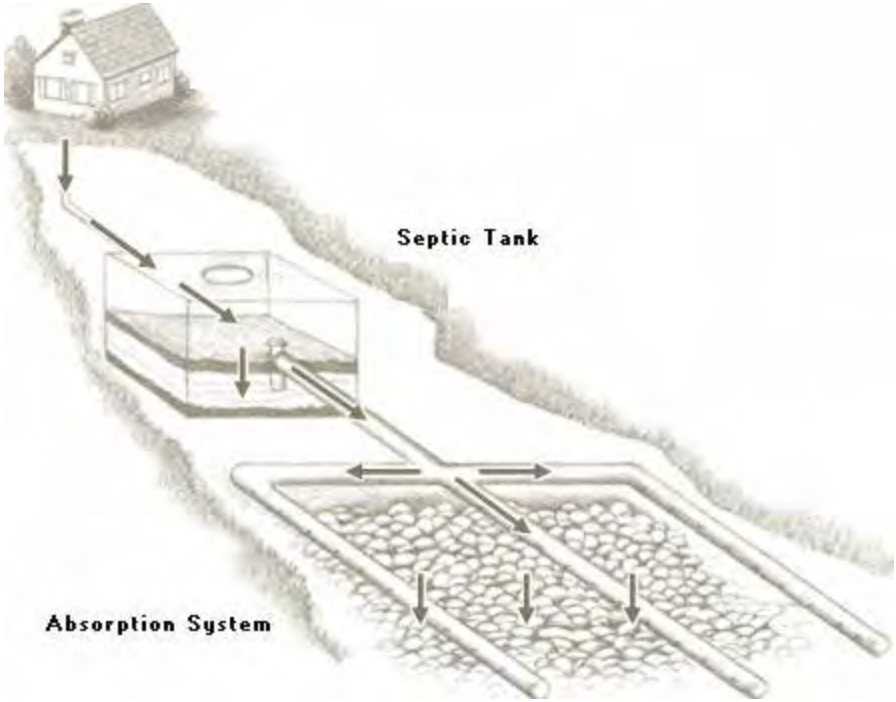
- SWAT used to simulate the amount of estradiol that leaches into the groundwater under different management and climate
- Fate emerging contaminants in rivers at the watershed scale at the Shell River in Nebraska from animal manure applications



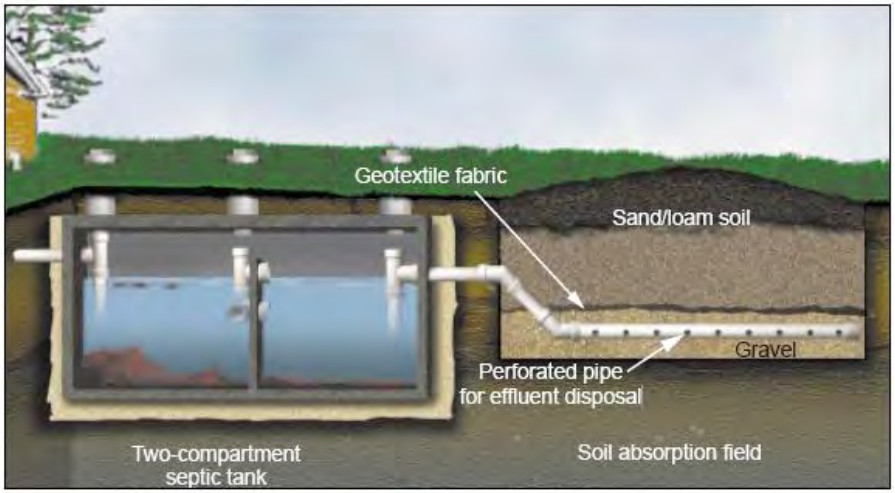
SWAT simulation of 17β-Estradiol leached from the A horizon in Bergstrom silt loam (0-23 cm depth). Note less hormone leaches from deeper rooted switchgrass than from currently cultivated coastal bermudagrass. Also, note the inclusion of the high-rainfall year, 2007, increased soil leaching by almost 90% under current forage-production management.

Onsite Wastewater Systems

❖ Conventional septic systems



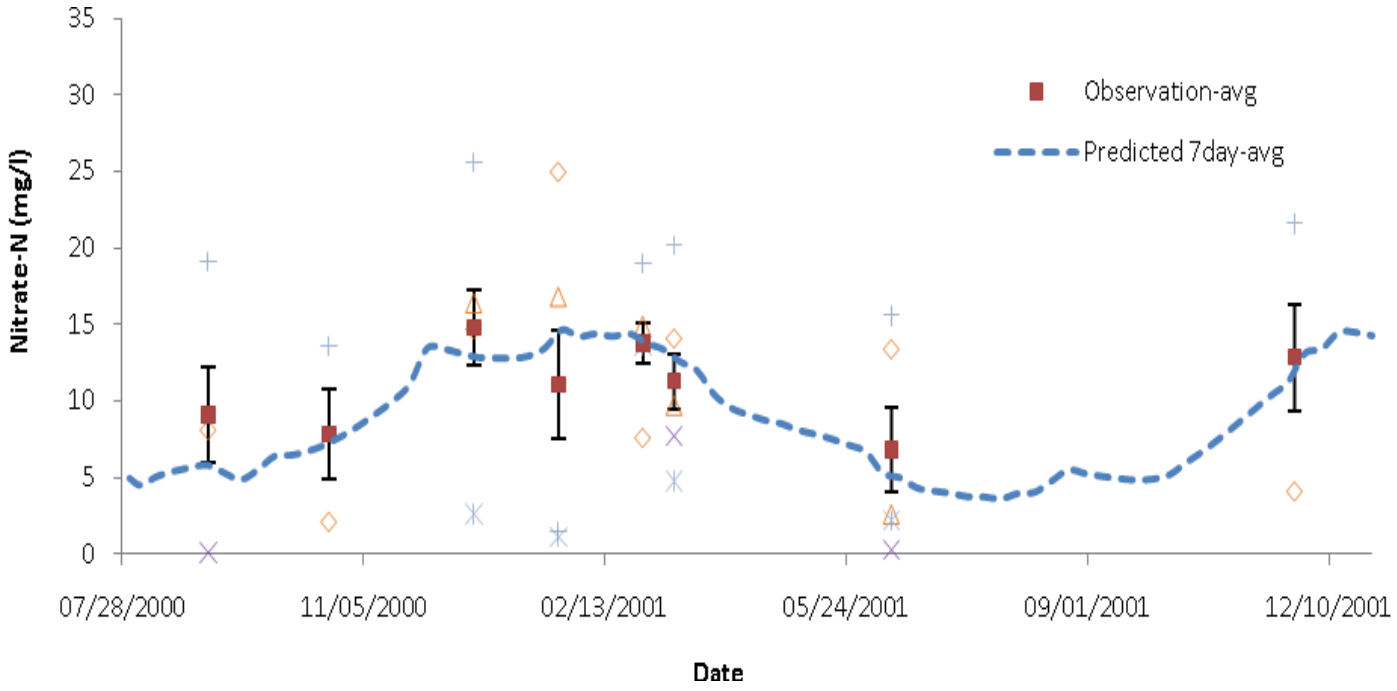
Conventional septic system, (Swann, 2001)



Septic tank
- Pass partially treated wastewater
- Anaerobic digestion of nutrients

Soil absorption system
- Drainfield
- Dispose/treat wastewater by filtering through soil profile below drainfield

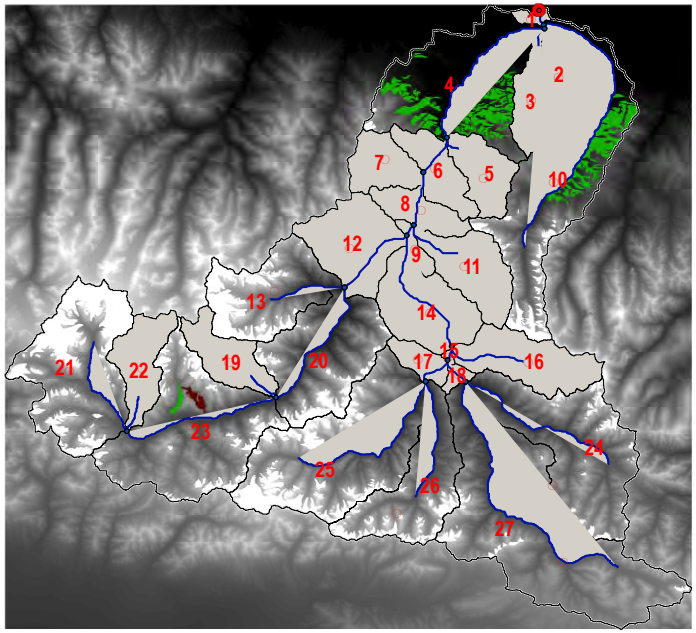
Application in Hoods Creek, NC:Results

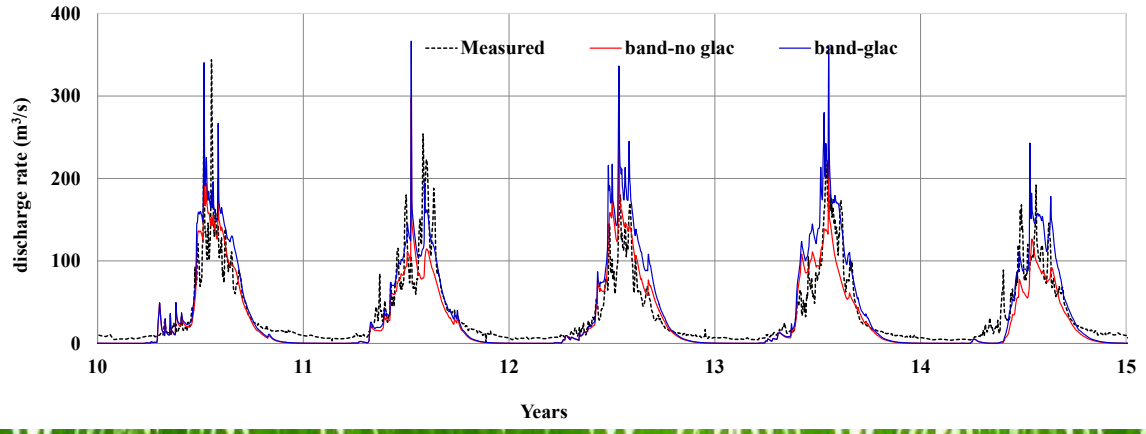


Calibrated Profile of nitrate concentration in the groundwater at Site 1. The red squares show the average of observed values – blue line is predicted 7-day average

Glacier Dynamics

Dr Yi Luo – Chinese Academy of Sciences

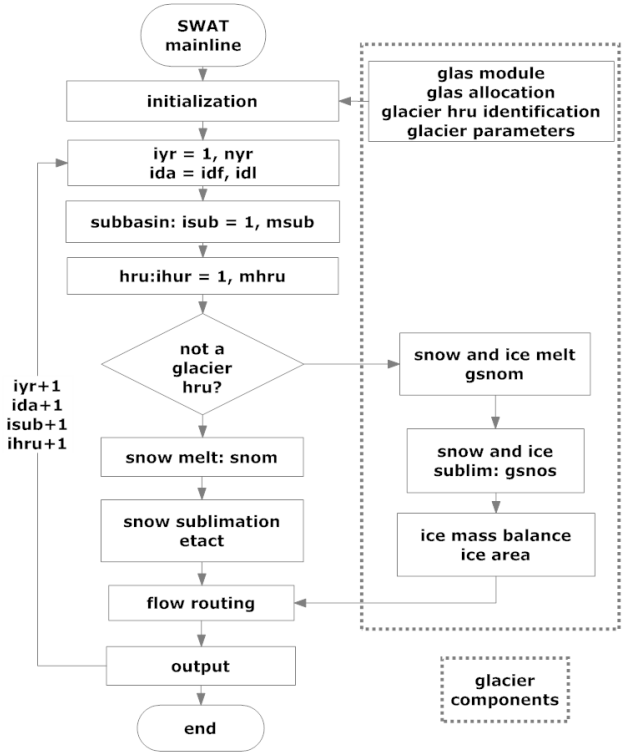




Modified SWAT to simulate glacier melt and dynamic growth and retreat

Found excellent agreement with daily streamflow given minimum input data

Also reasonably simulated glacier retreat



Rice Paddy Simulation

- Hiro Somura is developing new routines for rice paddy water balance, sediment and nutrient release
- Management includes irrigation and ponded water depth, puddling impacts on sediment concentrations and conductivity of the soil, planting and harvest, nutrient and pesticide applications, and wildlife nutrient inputs
- Validation on monitored rice paddies near Matsue, Japan

THE FUTURE - ECLIPS

Environmental Conservation on Landscapes for Integrated Policy Scenarios

ECLIPS

Environmental
Conservation on
Landscapes for
Integrated
Policy
Scenarios

Goal

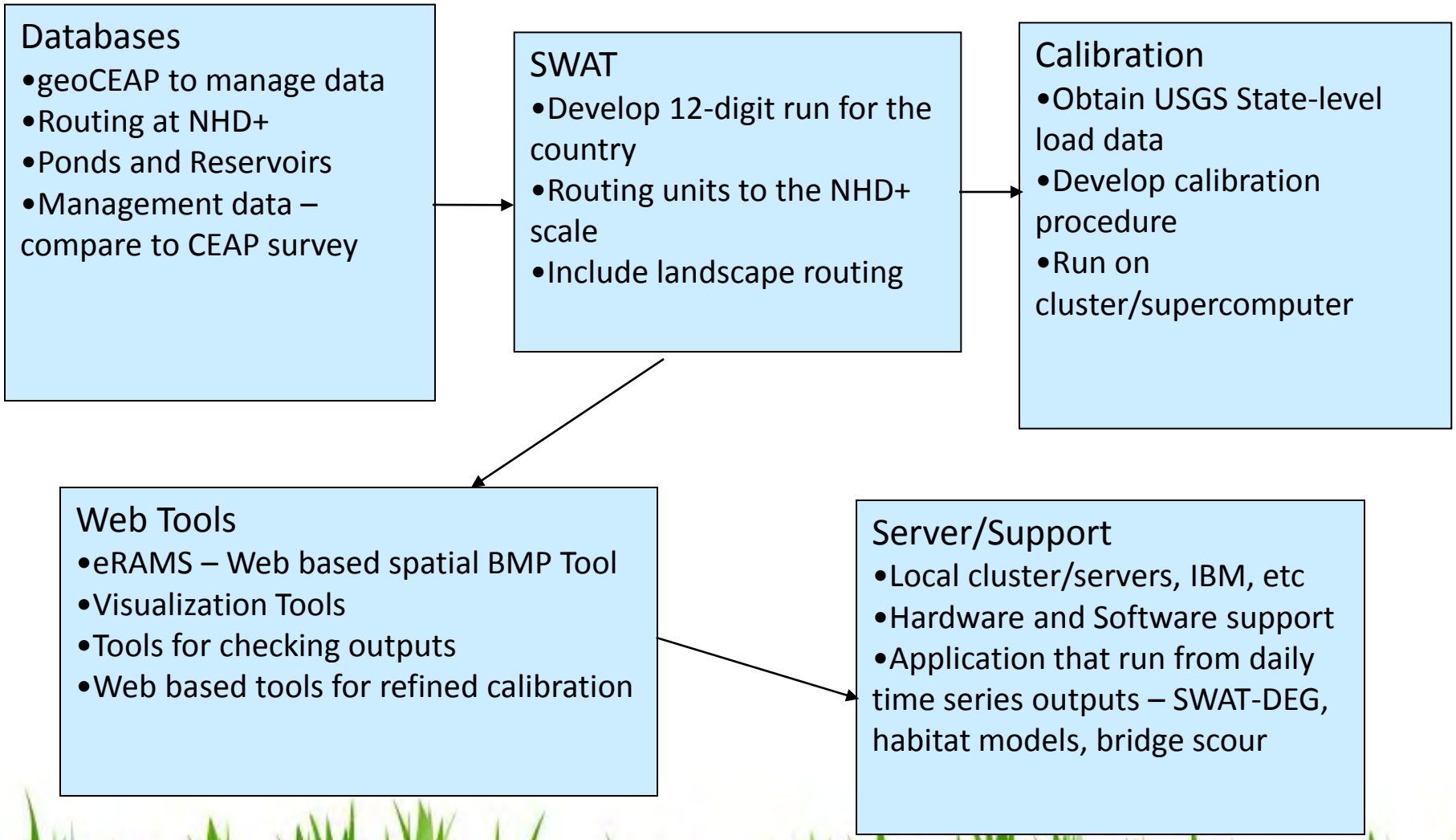
Develop Regional/National "Pre-Calibrated" SWAT/APEX Simulations with a Web/Google Interface and Spatial BMP Tool for Scenario Analysis and Policy Planning

Pulls together CEAP, GeoCEAP, HAWQS, Calibration tools, Visualization and analysis tools, Optimization/Cost

Outcome

Web-Based Decision Support System for Direct Use by Decision and Policy Makers

ECLIPS Structure



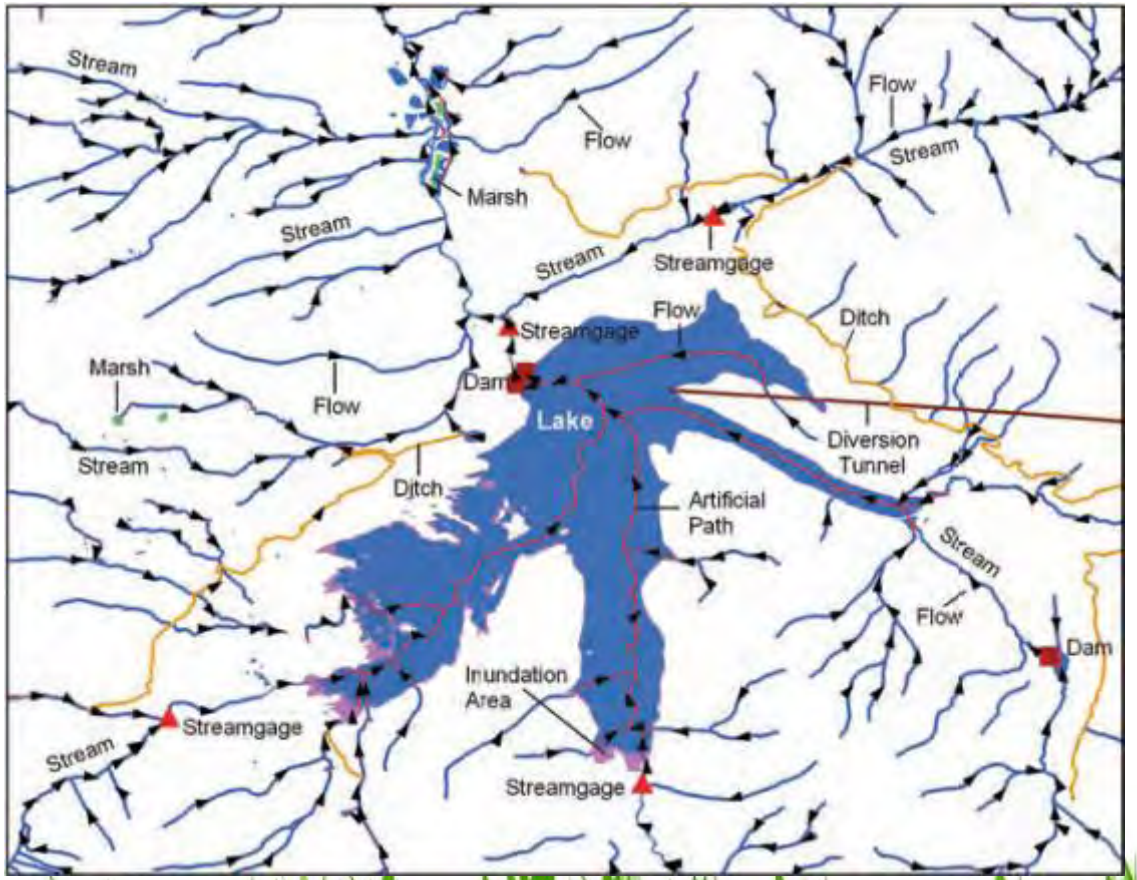
National Hydrography Dataset (NHD)

Set of digital spatial maps of lakes, ponds, streams, rivers, canals, stream gages, and dams

Network – trace movement in upstream and downstream directions

Watershed Boundary Dataset

Defines the perimeter of drainage areas formed by the terrain and other landscape characteristics

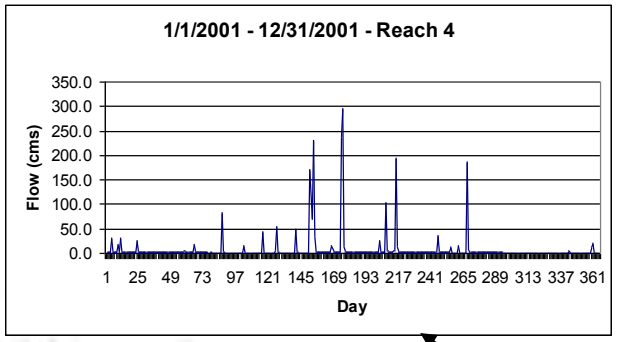


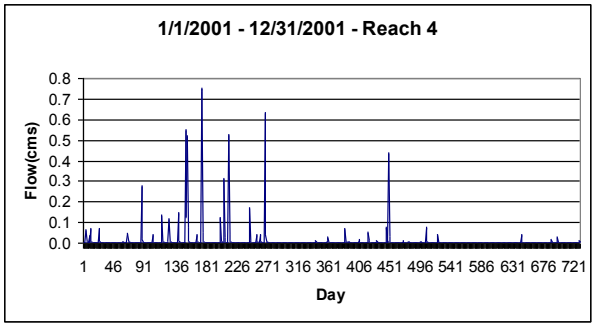
Texas Gulf River Basin
(USGS #12)

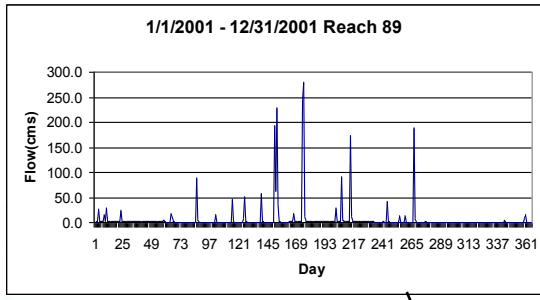
Middle Bosque River
USGS 12060203 – 1092 km^3)

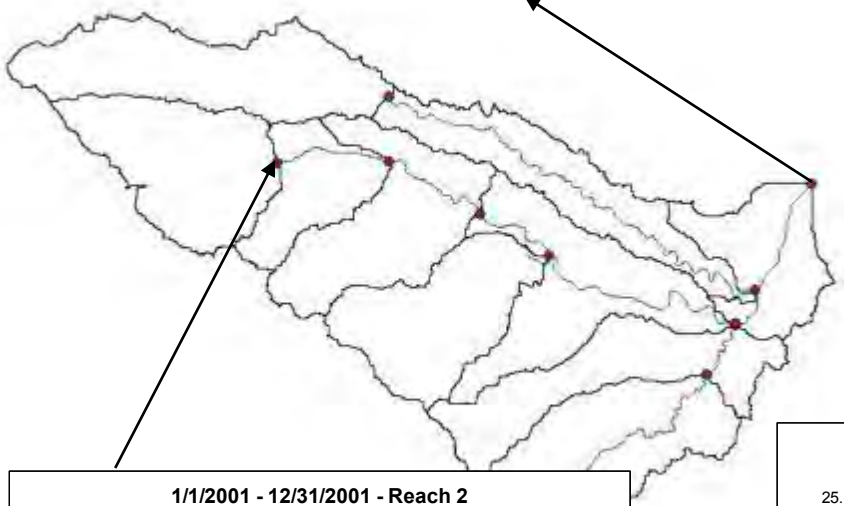
Willow Creek Subbasin
(USGS 120602030301 134 km^2)

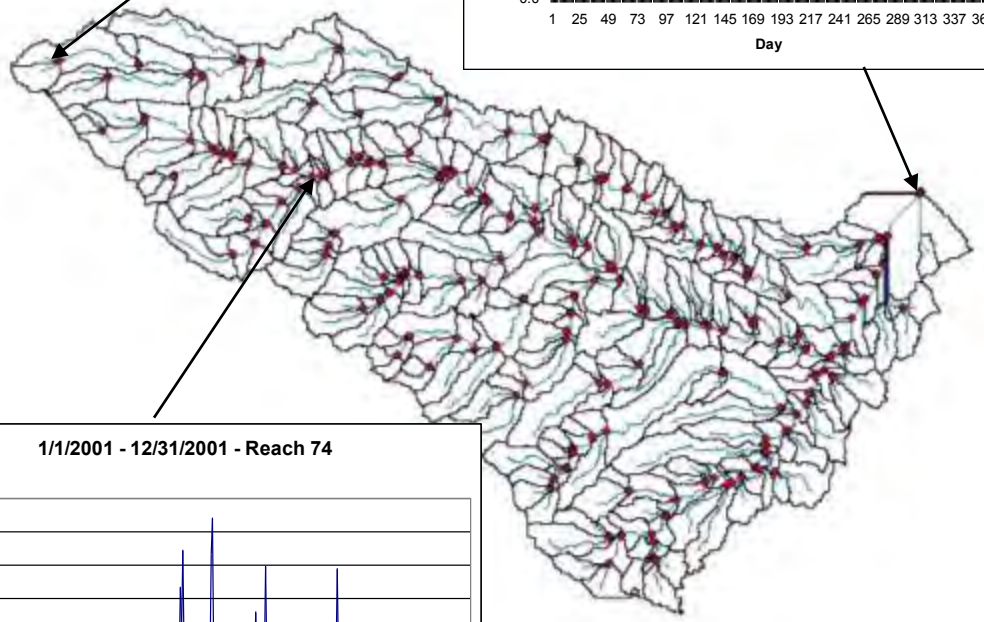
NHD+ Routing Units (43)
Average area = 3.1 km^2

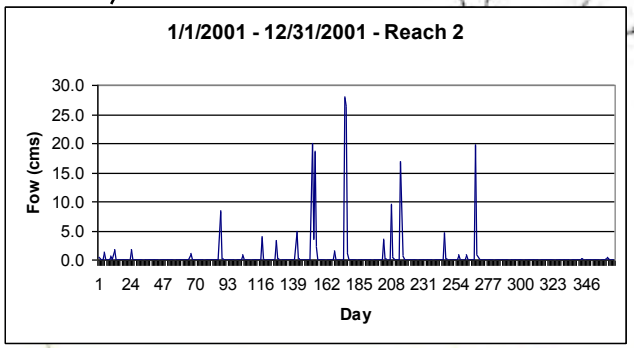

1/1/2001 - 12/31/2001 - Reach 4
Flow (cms)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1 25 49 73 97 121 145 169 193 217 241 265 289 313 337 361
Day

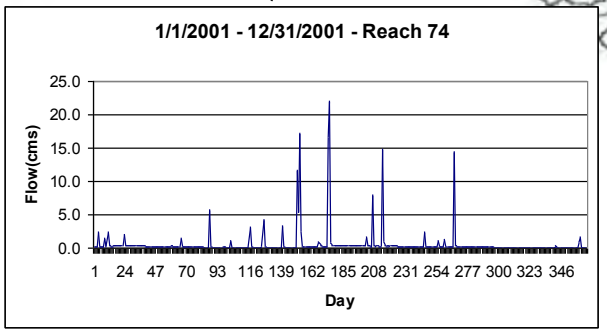

1/1/2001 - 12/31/2001 - Reach 4
Flow(cms)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 46 91 136 181 226 271 316 361 406 451 496 541 586 631 676 721
Day


1/1/2001 - 12/31/2001 Reach 89
Flow(cms)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1 25 49 73 97 121 145 169 193 217 241 265 289 313 337 361
Day






1/1/2001 - 12/31/2001 - Reach 2
Fow (cms)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 24 47 70 93 116 139 162 185 208 231 254 277 300 323 346
Day


1/1/2001 - 12/31/2001 - Reach 74
Flow(cms)
25.0
20.0
15.0
10.0
5.0
0.0
1 24 47 70 93 116 139 162 185 208 231 254 277 300 323 346
Day

eRAMS
A Web-Technology for Conservation Assessment and Planning

Mazdak Arabi
Assistant Professor
Department of Civil & Environmental Engineering
December 16, 2009

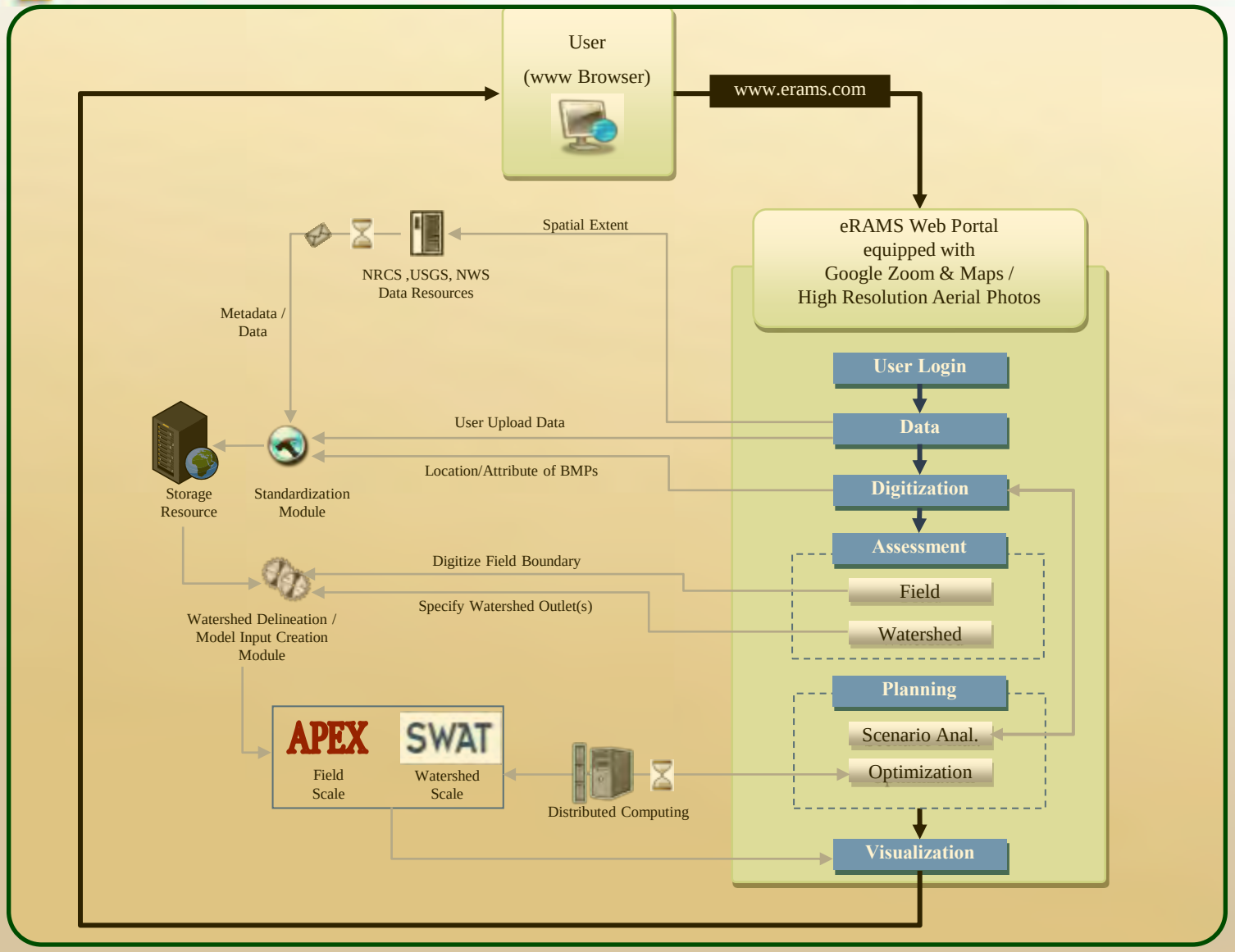
Colorado State University

Technology Drivers

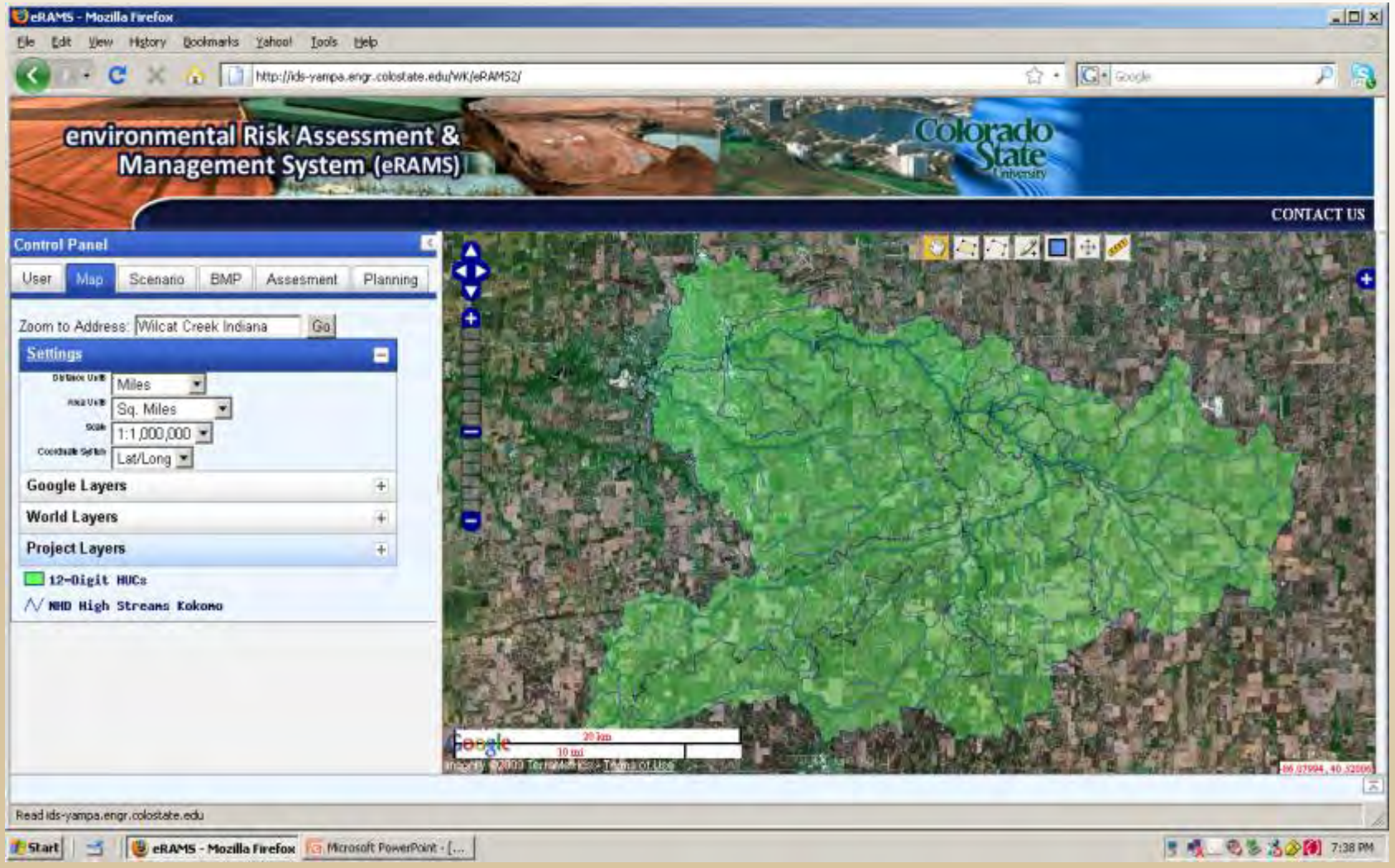
- No specific hardware or software requirements
  - Reduce training requirements
  - Eliminating the collection of duplicate data across agencies
  - Reduce long-term development and maintenance costs
  - Mobile system accessible, end-to-end, on the web
- Compatibility with existing databases/GIS technologies
  - Take advantage of readily available data

Technology Drivers

- Benefit from Google products and other commonly-used internet technologies
  - Common “look and feel” interface
  - High resolution aerial photos, etc.
- Compatibility with long-term vision of NRCS, EPA, and other instructions involved with management of natural resources
- Working across scales: field to watershed



eRAMS Architecture for Conservation Planning and Assessment


eRAMS - Mozilla Firefox
File Edit View History Bookmarks Yahoo! Tools Help
http://ids-yampa.engr.colostate.edu/WK/eRAMS2/
environmental Risk Assessment & Management System (eRAMS)
Colorado State University
CONTACT US
Control Panel
User
Map
Scenario
BMP
Assesment
Planning
Zoom to Address:
Wilcat Creek Indiana
Go
Settings
Miles
Sq. Miles
1:1,000,000
Lat/Long
Google Layers
World Layers
Project Layers
12-Digit HUCs
NHD High Streams Kokomo
Google
20 km
10 mi
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Start
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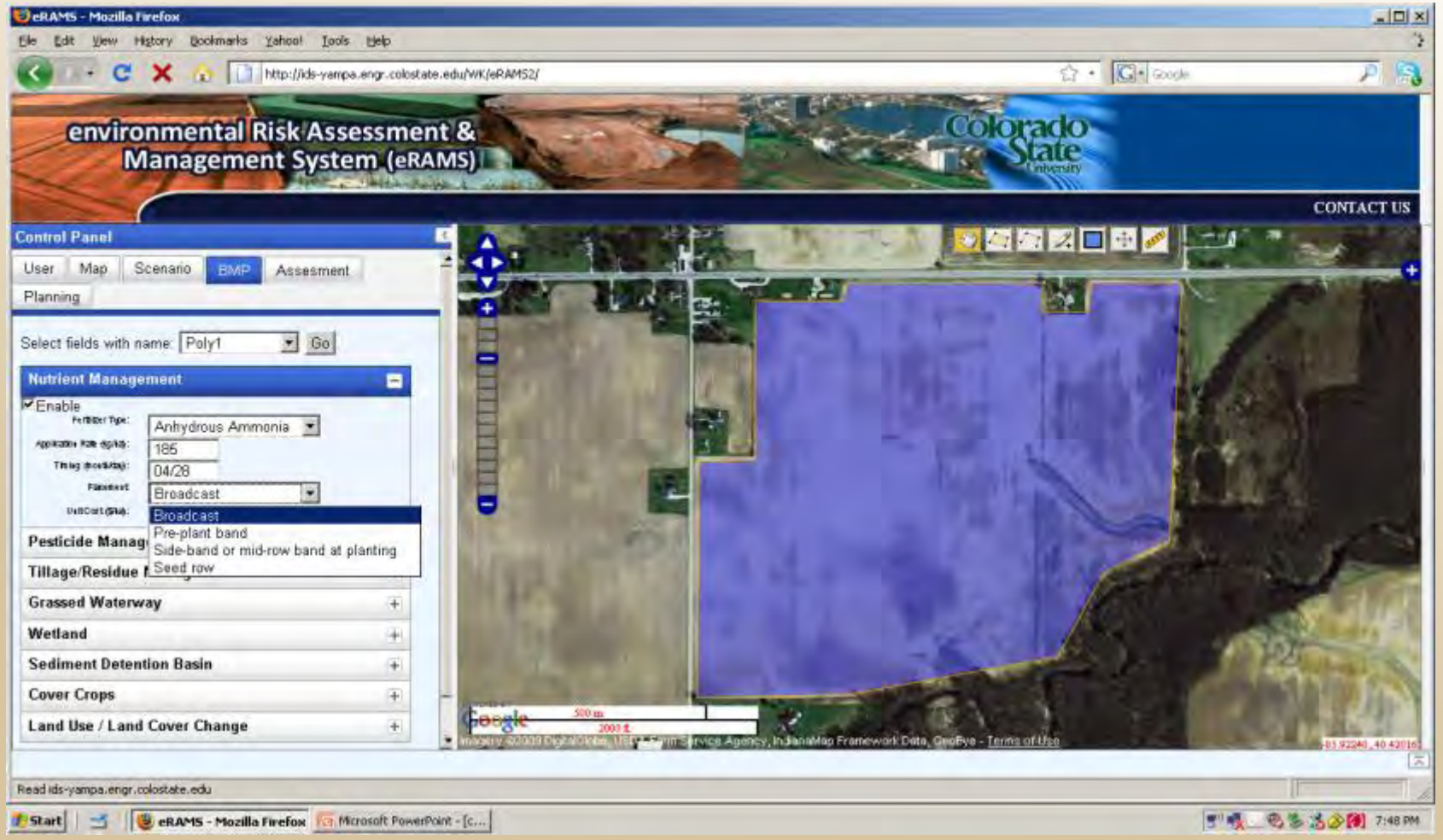
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environmental Risk Assessment & Management System (eRAMS)
Colorado State University
CONTACT US
Control Panel
User Map Scenario BMP Assesment
Planning
Select fields with name: Poly1 Go
Nutrient Management
Enable
Fertilizer Type: Anhydrous Ammonia
Application Rate (kg/ha): 185
Timing (month/day): 04/28
Placement: Broadcast
Broadcast
Pre-plant band
Side-band or mid-row band at planting
Seed row
Pesticide Manag
Tillage/Residue M
Grassed Waterway
Wetland
Sediment Detention Basin
Cover Crops
Land Use / Land Cover Change
Google
500 m
2000 ft
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Start
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Microsoft PowerPoint - [c...
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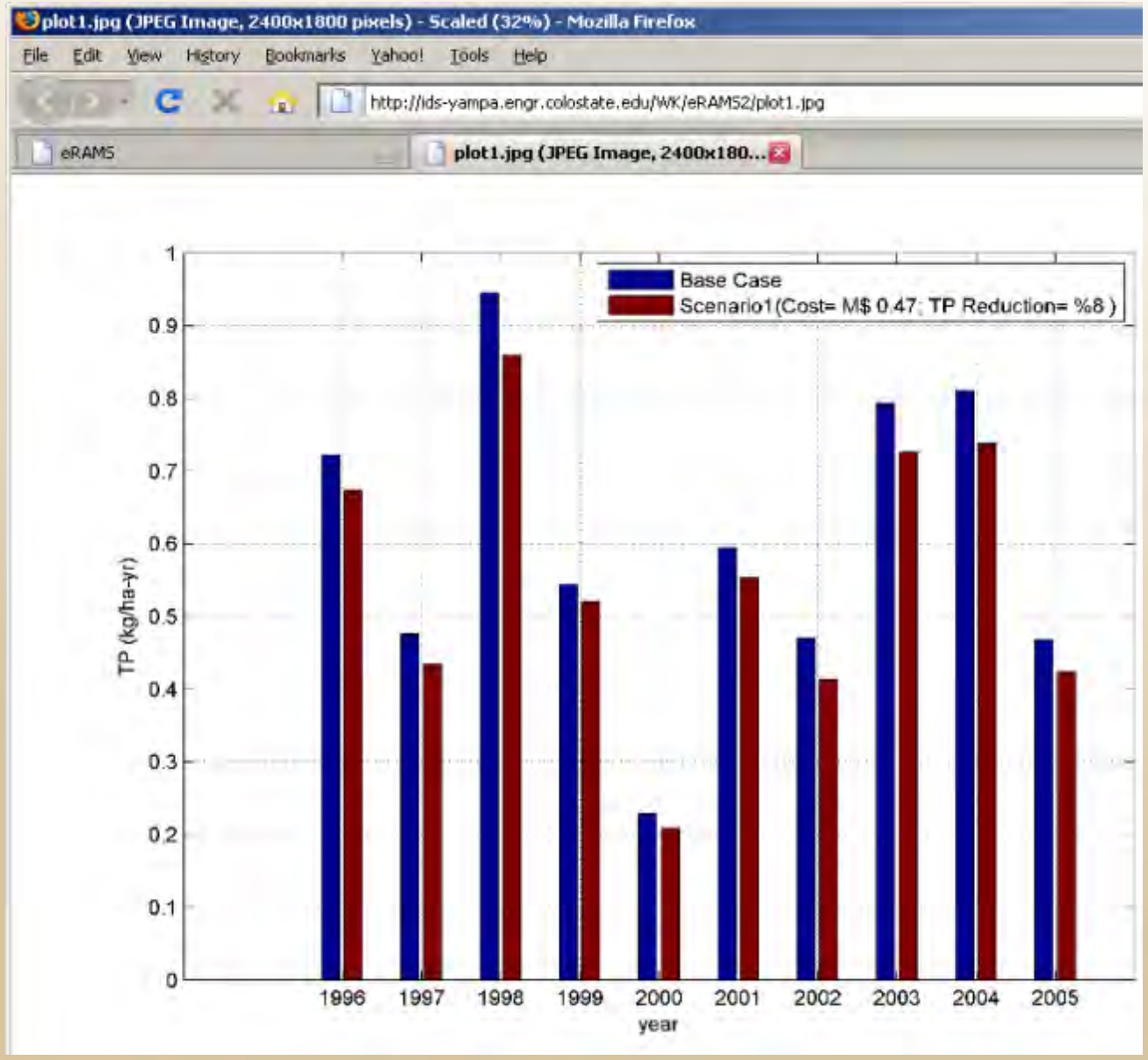
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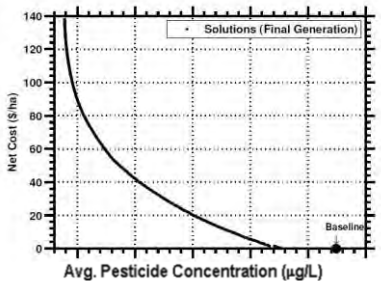
File Edit View History Bookmarks Yahoo! Tools Help
http://ids-yampa.engr.colostate.edu/WK/eRAMS2/plot1.jpg
eRAMS
plot1.jpg (JPEG Image, 2400x180...
Base Case
Scenario1(Cost= M$ 0.47, TP Reduction= %8)
TP (kg/ha-yr)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
year

Efficient Communication / Outputs

Economic Conservation Practice Placement to Reduce Atrazine Concentration Levels in the Wildcat Creek Watershed

Wildcat Creek Watershed Objective: reduction of atrazine loads into the Kokomo reservoir by 10% (Concentration reduction target from average 3.31 µg/L to 3.0 µg/L, EPA MCL).

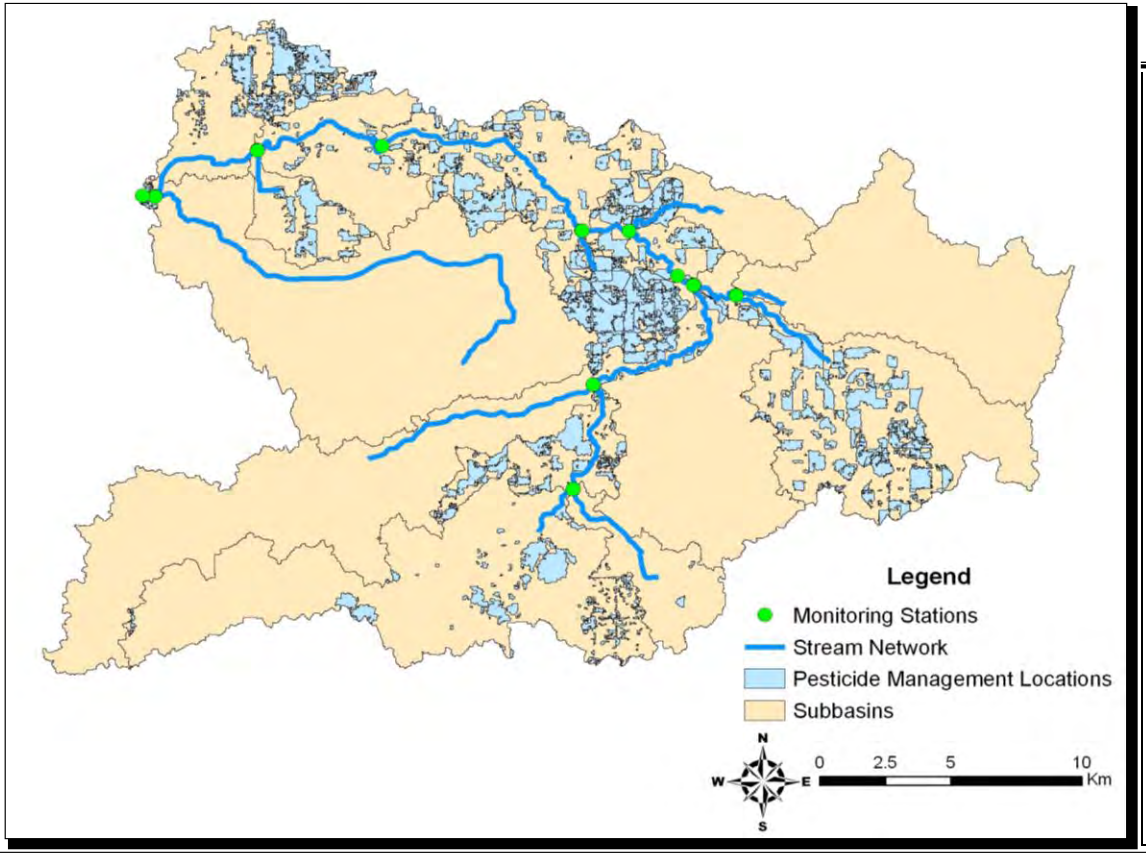


Finding a balance between cost and environmental improvements.

This recommendation on where to target conservation implementation (provided in the map to the right) is based on the above cost / benefit placement. As demonstrated by the curve, reducing pesticide concentration generally requires the increased cost of conservation practices installation. Choosing how to address water quality concerns is a unique decision for each community, and can be affected by a water quality improvement goal, or the budgetary resources available.

Cost Breakdown of Recommendation

Practice	Cost ($)
Pesticide Management	
Filter Strips	
Residue Management	
Tillage– No Till	
TOTAL COST ($)	**$ xxxx.xx**

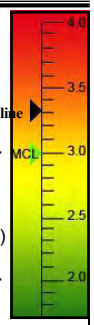


Atrazine Concentrations and Targets

Source of Pollutant in Drinking Water
Runoff from herbicide used on row crops

Maximum Contaminant Level (MCL)
0.003 milligrams per Liter (mg/L) or 3 parts per billion (ppb)

Maximum Contaminant Level Goal (MCLG)
0.003 mg/L or 3 ppb

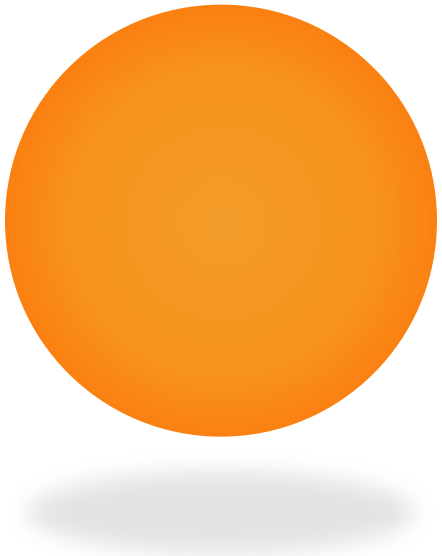


Health Effects
Some people who drink water containing atrazine in excess of the MCL over many years could experience problems with their cardiovascular system or reproductive difficulties.

More information
http://epa.gov/ogwdw/contaminants/basicinformation/atrazine.html#one

Targeted Conservation Practice Influences on Water Quality

Practice	Influence	Estimated Benefit(s) Across Watershed
Pesticide Management	Reduces application rates, etc.	xxx ug/L
Filter Strips	Filters surface	xxx ug/L
Residue Management/No Till	Reduces erosion	xxx ug/L



Developer's Conference

Potsdam October 2006

PIK – Valentina Krysanova

Fred Hatterman

Potsdam Developer's Conference

- **Special Issue – Hydrological Processes 53(5) Oct 2008**
- **Landscape routing – published still under development**
- **Plant growth – parameterized forest and energy plants**
- **Improved channel sediment routing**
- **Carbon dynamics, Improved phosphorus, tile nitrates**
- **Version Control**
- **Web-based spatial BMP tools**

Time for another developer's conference?
How many would be interested (40)?
On line forum and web site?
Discuss at wrap up on Friday

Trends in Worldwide Use

Worldwide Use

- **Use is expanding in China, India, SE Asia and South America**

- **Brazil – 70 papers/reports/dissertations in Portuguese**

- **Regional (CEAP type) assessments in Europe, Black Sea, Ganges River Basin, Nile**

- **Manuals and interfaces in Chinese, Spanish and Portuguese**

Summary

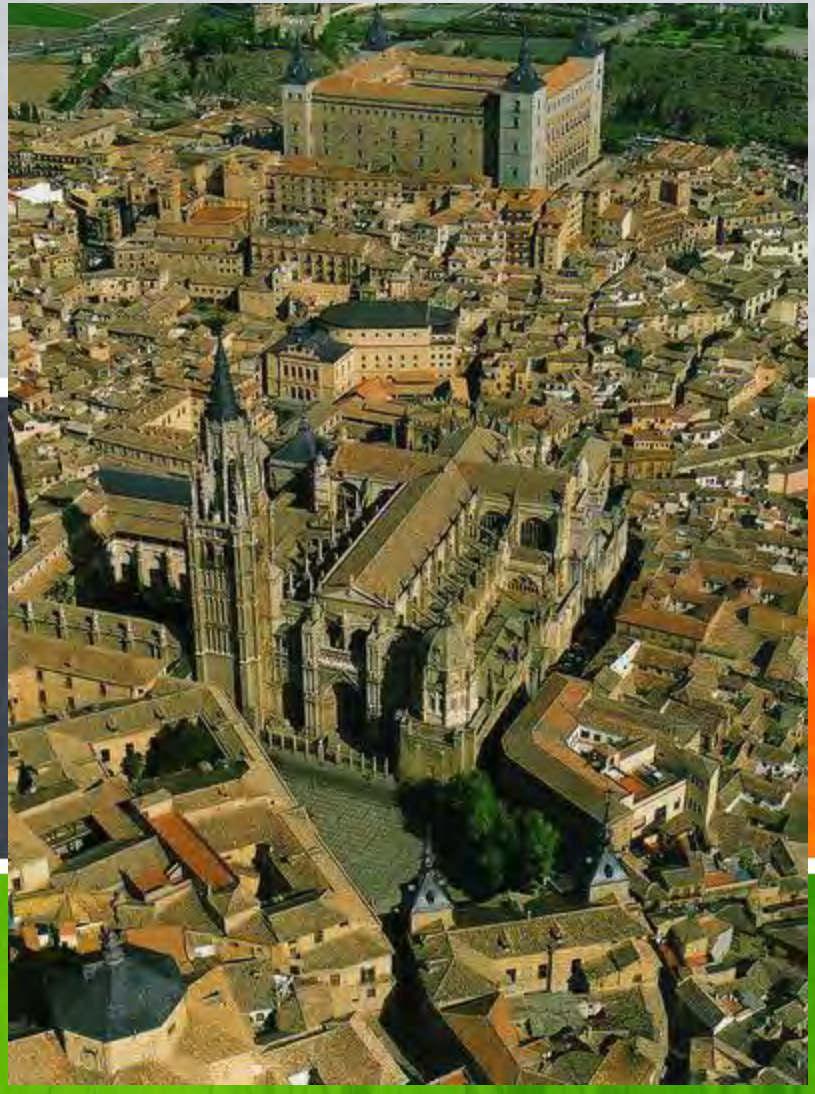
- **Water – Most important resource on earth**
- **We are developing tools being used around the world to manage water and landscapes that are directly impacting policy**

Next Generation

- **Integrate our models, databases and tools into web based DSS for watersheds from 1 mi^2 to the Mississippi River Basin**

- **Real Time – soil moisture, reservoir and aquifer levels, river flooding and recession (NEXRAD precip input)**

Thank you

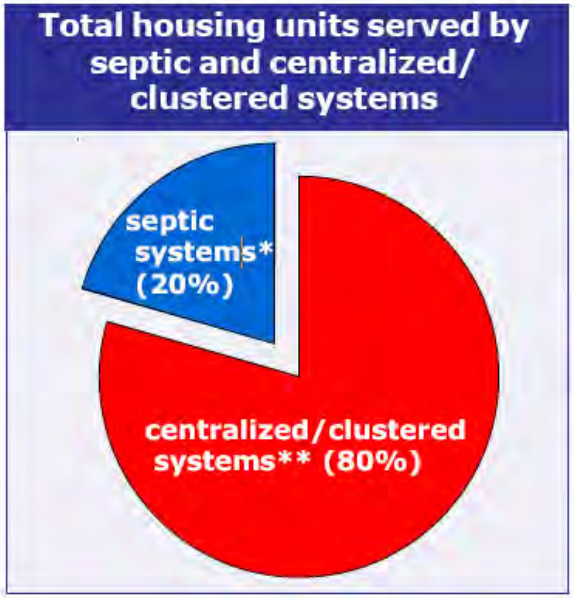


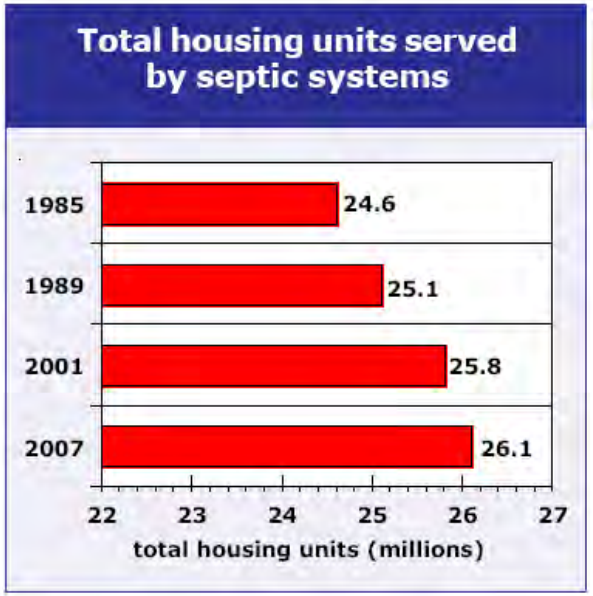
Recent Accomplishments - Publications

- Acta Ecologica Sinica
- Advances in Engineering Software
- Advances in Geosciences
- Advances in Water Resources
- Agricultural Water Management
- Biogeochemistry
- Bioresource Technology
- Boreal Environment Research
- Catena
- Chemosphere
- Climatic Change
- Desalination
- Ecological Economics
- Ecological Modelling
- Environ. Geol.
- Environmental Management
- Environmental Modelling and Software
- Environmental Pollution
- Environmental Science & Policy
- Global and Planetary Change
- Hydrological Processes
- Hydrological Sciences Journal
- Hydrology and Earth System Sciences
- Journal of Archaeol. Sci.
- Journal of Environmental Management
- Journal of Environmental Quality
- Journal of Hydrologic Engineering
- Journal of Hydrology
- Journal of Soil and Water Conservation
- Journal of the American Water Resources Association
- Land Use Policy
- Nile Water Science and Engineering Magazine
- Physics and Chemistry of the Earth
- Quaternary International
- Review of Agricultural Economics
- Science in China Series D: Earth Sciences
- Science of the Total Environment
- The Open Hydrology Journal
- Transactions of the ASABE
- Vadose Zone Journal
- Water Research
- Water Resources Management
- Water Resources Research
- Water SA
- Water Science and Technology
- Water, Air, and Soil Pollution

Simulation of Septic Systems in SWAT - Overview

- Development of algorithms to simulate the effects of different types of septic systems on watershed water quality in SWAT



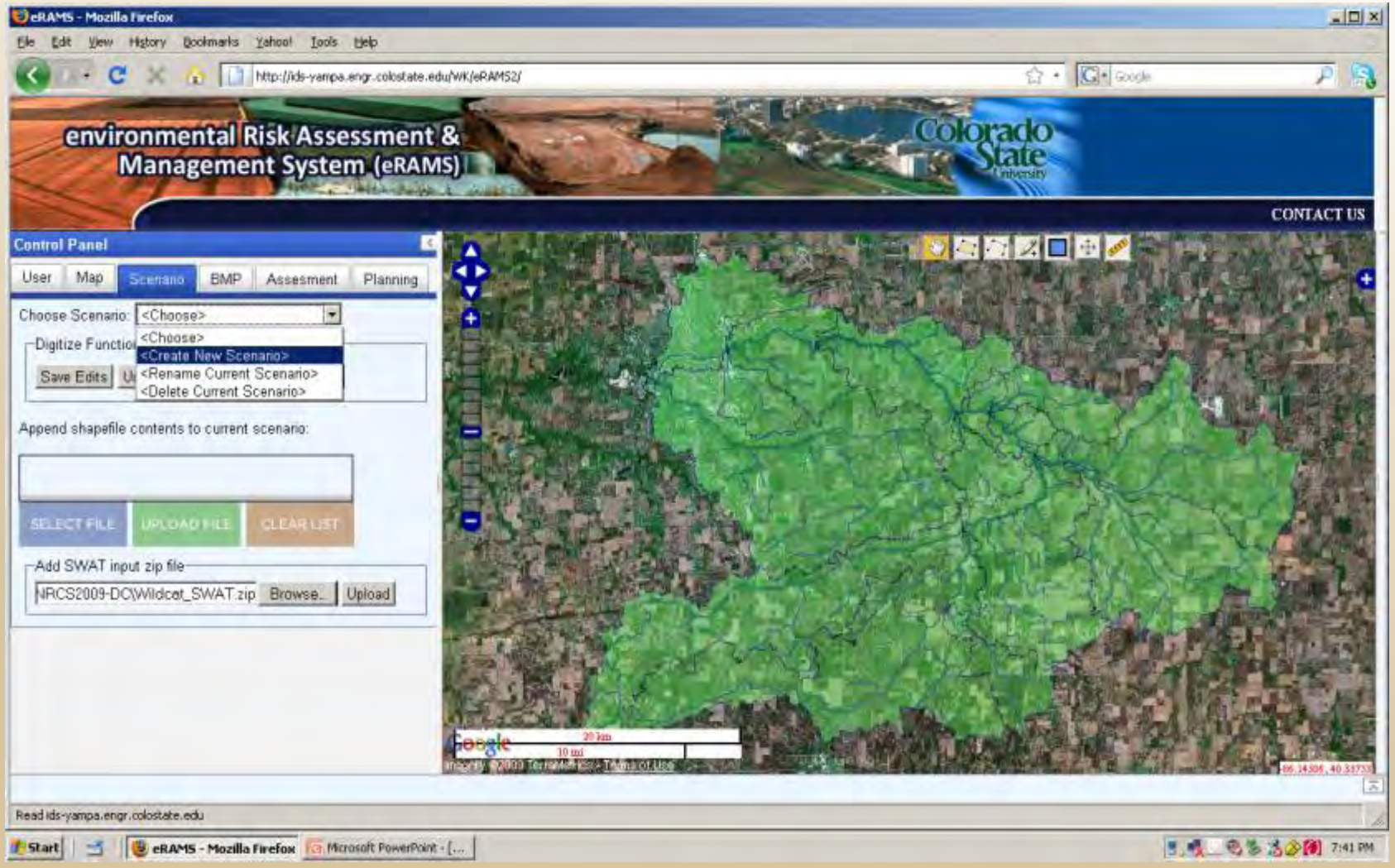


In 2007, an estimated 20 percent (26.1 million) of total U.S. housing units were served by septic systems. This is an increase of 1.54 million septic systems since 1985.

In 2007, 22 percent (1.6 million) of all housing units less than 4 years old used septic systems.

Overall Goal

- Develop a decision support system to
  - Establish **baseline conditions** for a field/watershed
  - **Assessment**: costs and environmental benefits of a given set of practices or a watershed management plan
  - **Planning**: scenario analysis and system optimization for developing sound resource management alternatives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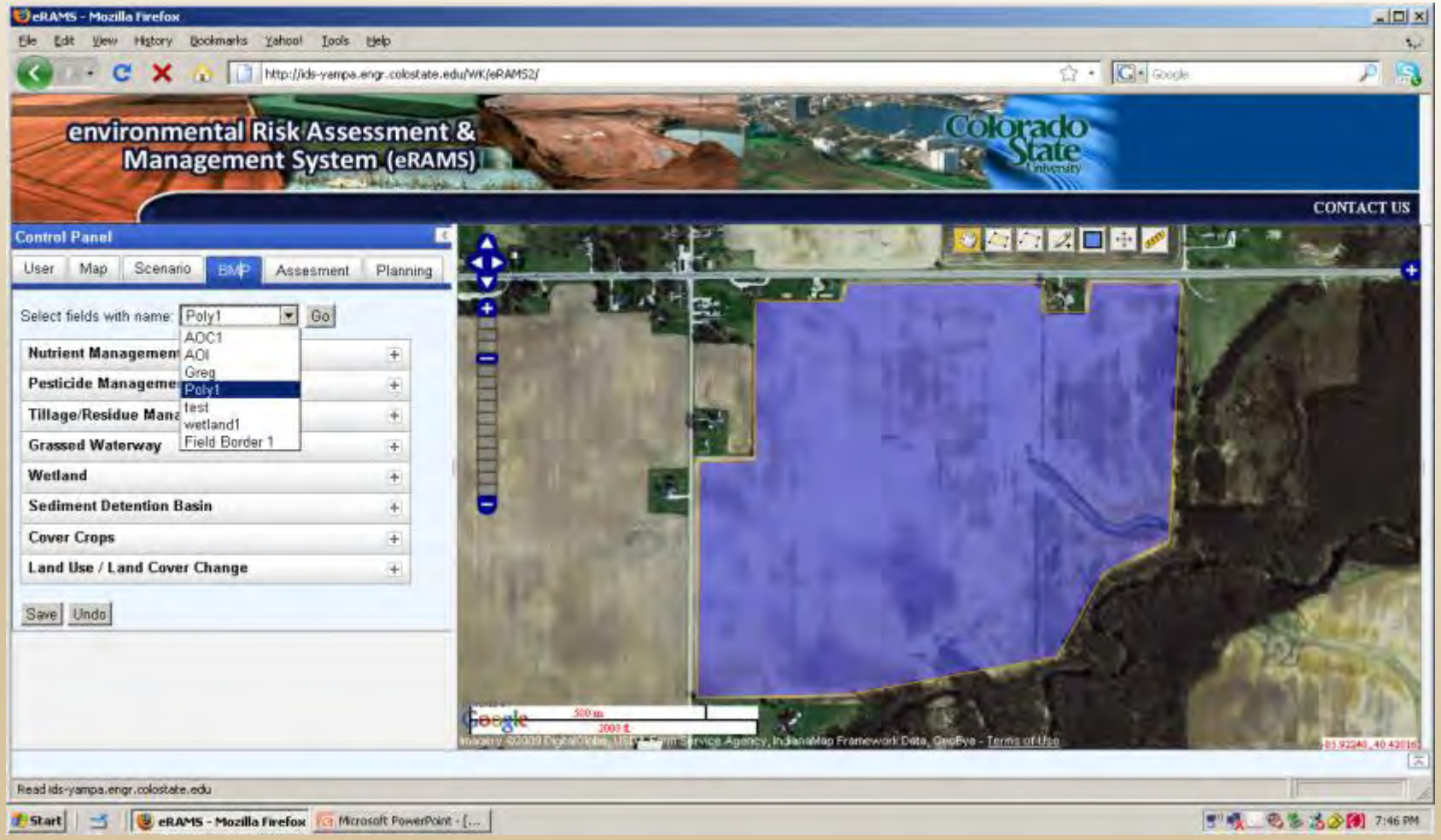
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Poly1
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Nutrient Management
Pesticide Management
Tillage/Residue Management
Grassed Waterway
Wetland
Sediment Detention Basin
Cover Crops
Land Use / Land Cover Change
Save Undo
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