# Problems and prospects of the application of Soil and Water Assessment Tool (SWAT) Model for the identification of nonpoint source pollution "hotspots" in a flat coastal agricultural watershed in humid tropics

D.D. Poudel[1], R. Srinivasan[2], K.C. Abbaspour[3], and C.Y. Jeong[4]

[1] University of Louisiana at Lafayette, Lafayette, Louisiana, USA
[2] Texas A&M University, College Station, Texas, USA
[3] Eawag:Swiss Federal Institute of Aquatic Science and Technology, Switzerland
[4] Louisiana State University, Baton Rouge, Louisiana, USA

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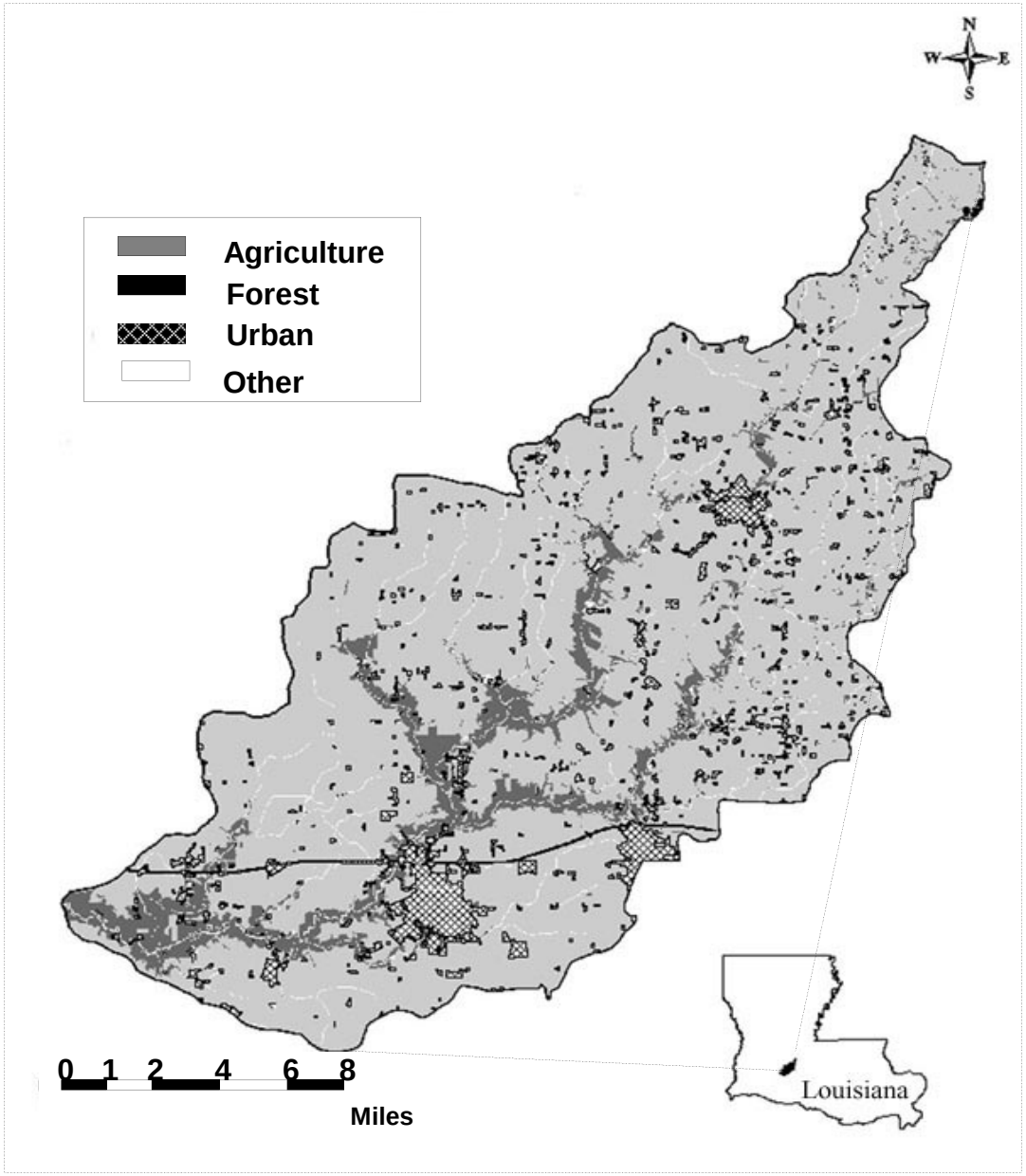
# Bayou Plaquemine Brule Watershed


LDEQ GIS Unit

Bayou Plaquemine Brule in the Mermentau Basin, Louisiana, has been included in 303(d) list since 1998.

TMDLs for DO, fecal coliform, mercury, nutrients, TSS, and TDS were developed in 1999.

Agricultural use accounts for 89% of the landuse, and remaining landuse types include urban (3.5%), forestland (3.8 %), wetland (2.9%), and others (0.8%).

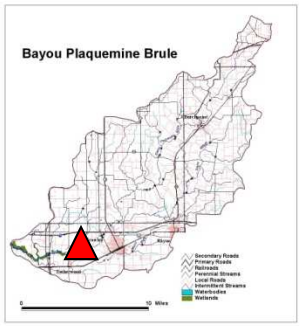
Rice, crawfish, soybean, sugarcane, pasture, corn, and other crops.

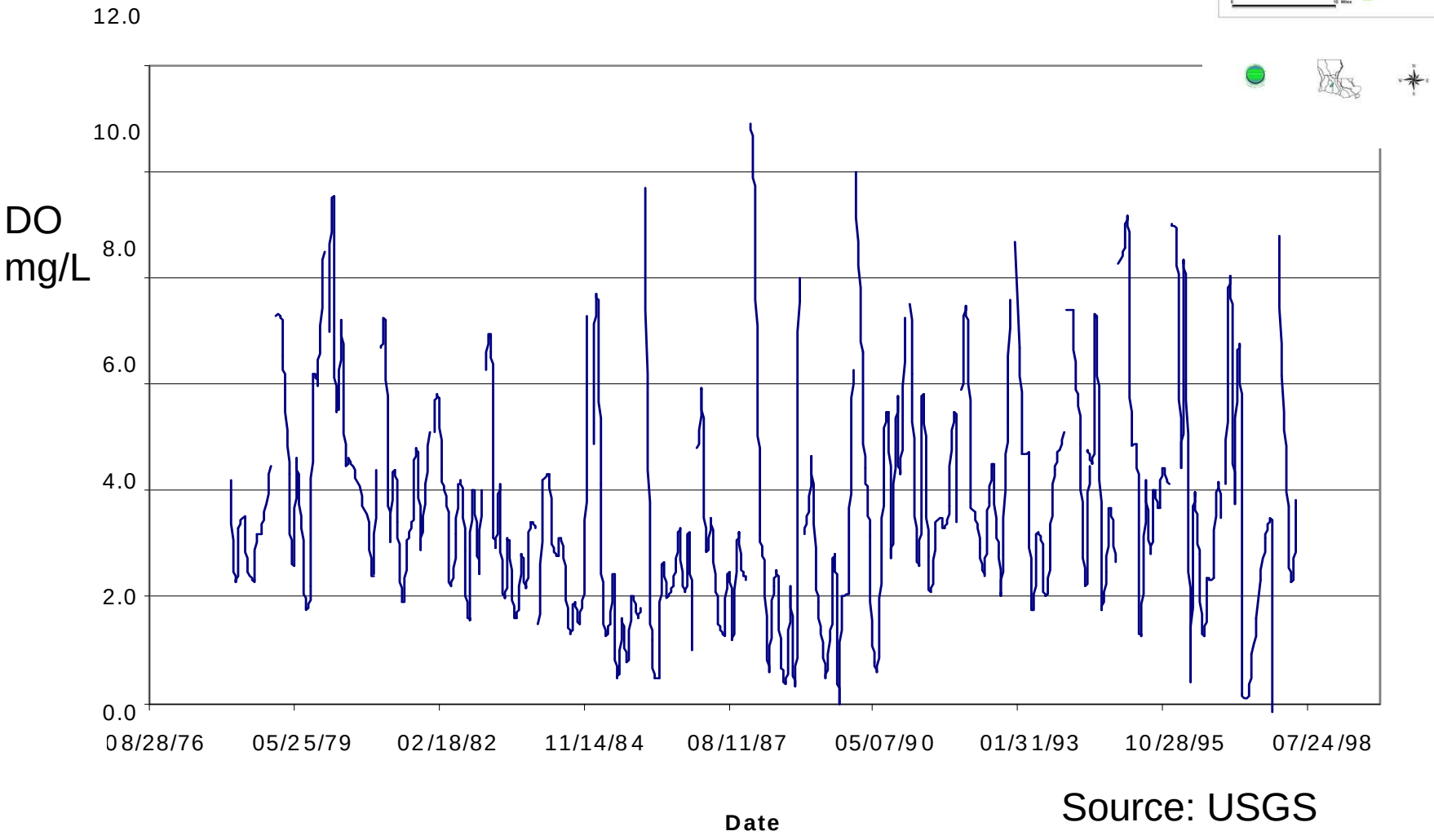
Pleistocene terrace complex – Praire complex. Deltaic deposits of Red River origin in the upper portion of the Prairie Complex (Bhattarai, 2008).

Underlain by Chicot aquifer- Pleistocene in age consisting of 1500 ft of sands interspersed with thinner irregular clays (Dues, 2006). Depth to the top of aquifer in this watershed range 50-100 ft (Jones, 1956).

Soil series: Crowley-Midland, Patoutville-Jenerette, Olivier-Loring, Acadia-Wrightsville, Memphis-Loring. Wet Alluvial Land. Nearly level to gentle sloping. Poor drainage.

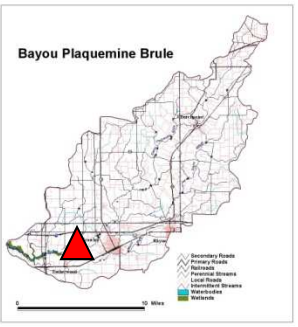
# Historical DO values at Estherwood, LA

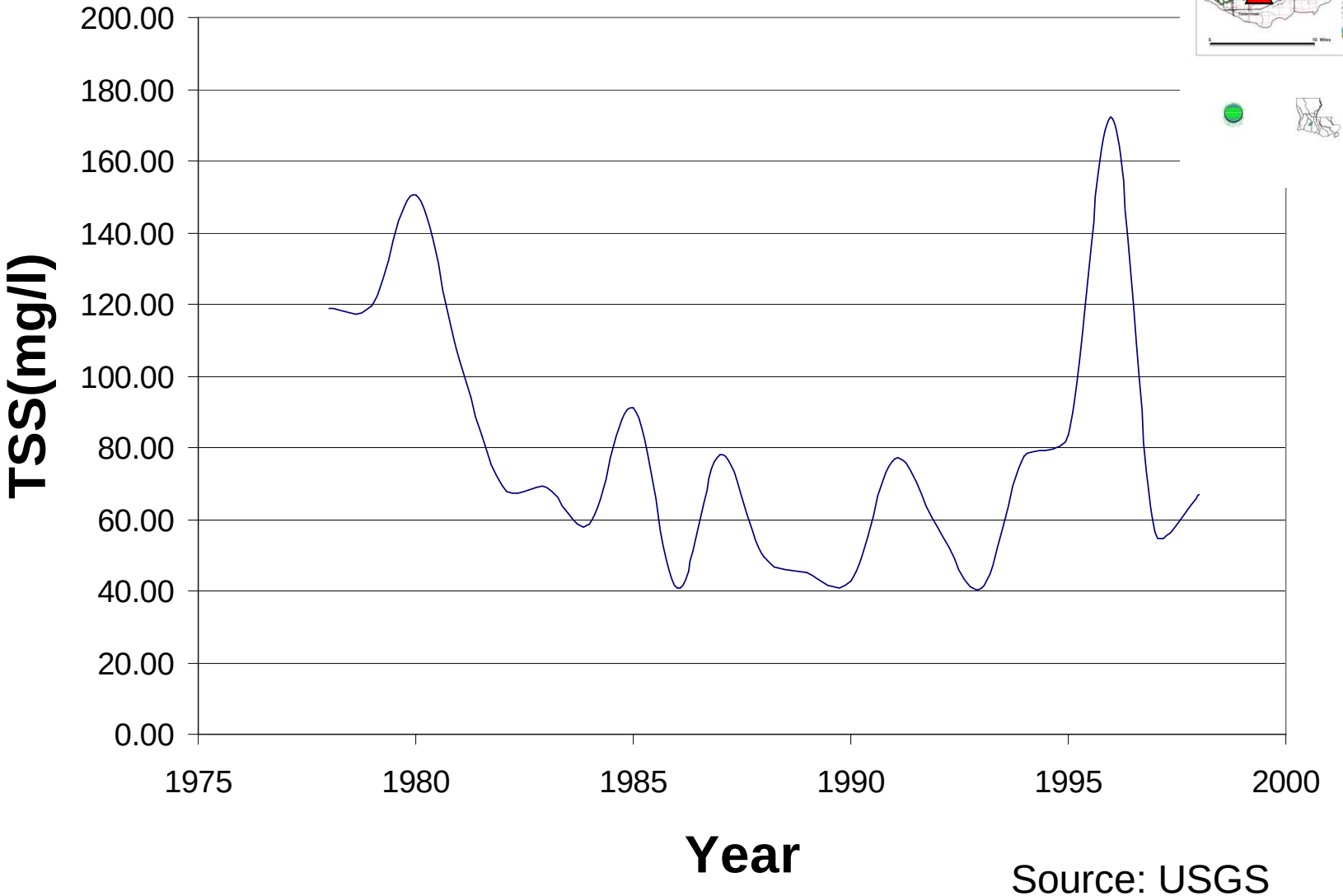



Source: USGS

# Historical TSS values at Estherwood, LA



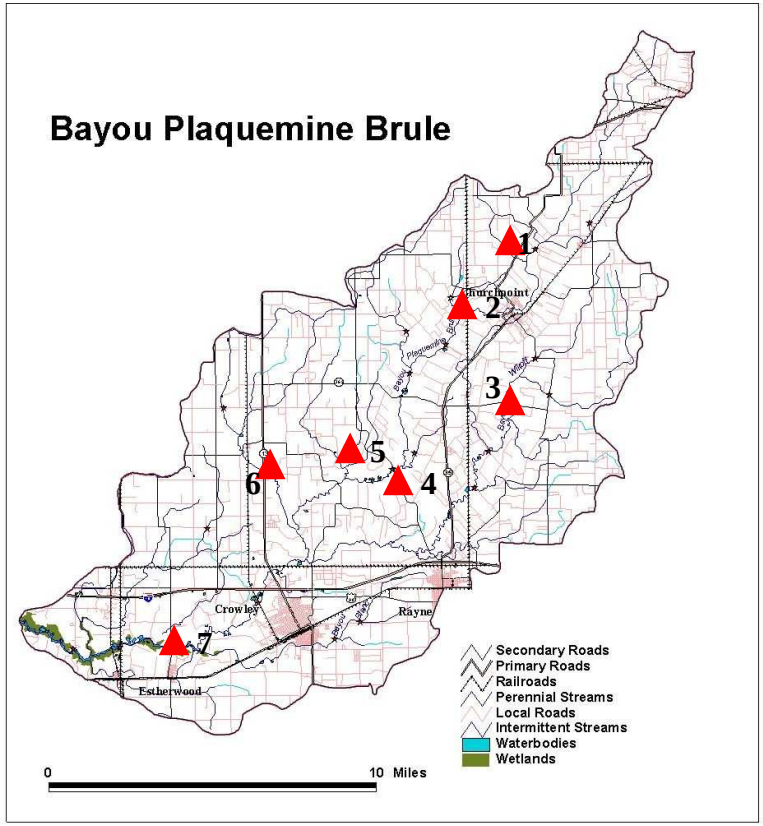

Source: USGS

# Specific objective

To examine the spatial and temporal variation of NPS pollutant sources and to identify “hotspots” for nonpoint source pollution in Bayou Plaquemine Brule watershed in Southwestern Louisiana.

# Materials and Methods

# Water Quality Monitoring




# Discharge measurement

# Water Quality Monitoring

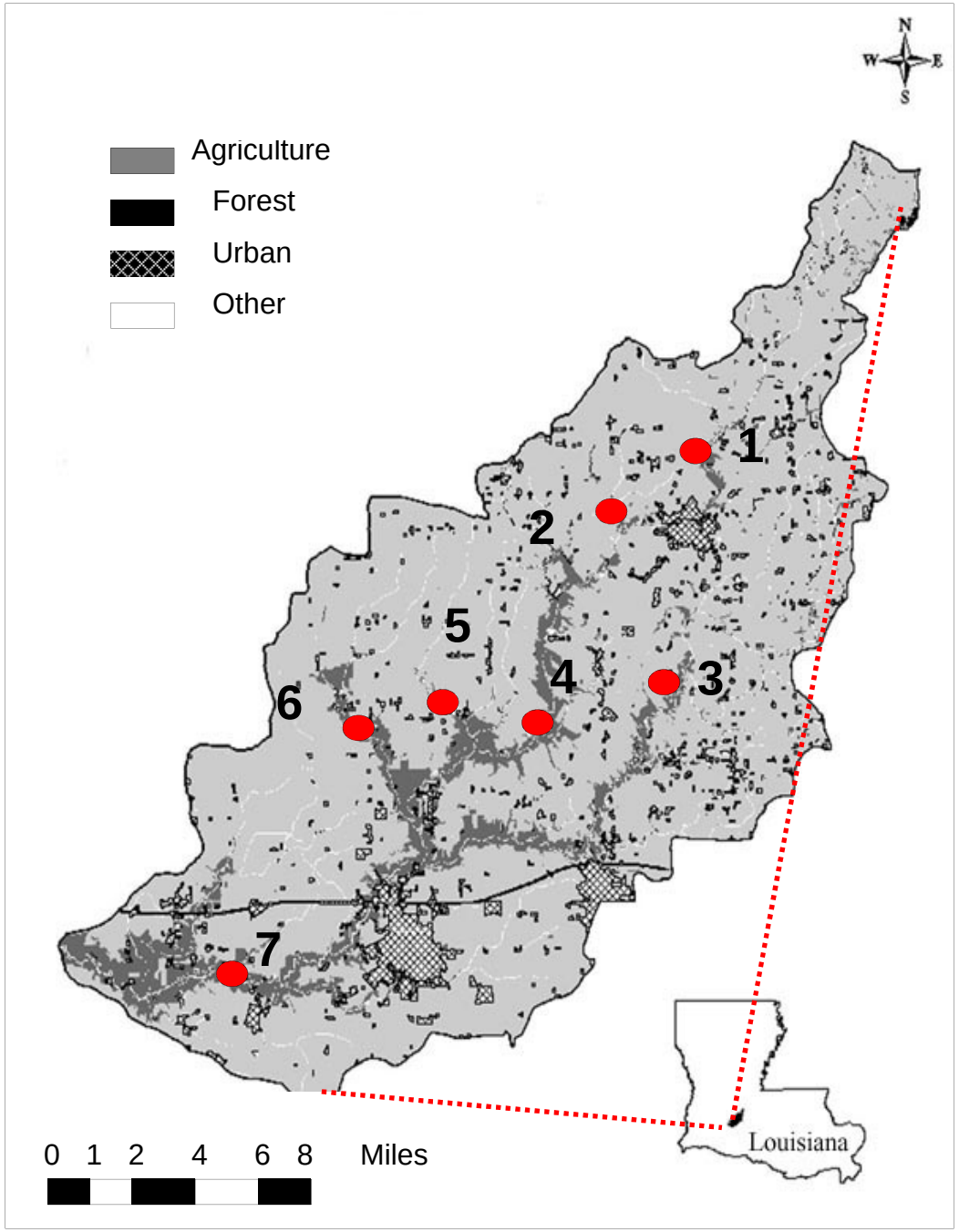
March 2002 – February 2008

DO, Turbidity, Conductivity,

pH, temperature,

TSS, BOD5, TN, NO3/NO2-N,

TP, SRP



# Water quality sampling

# The Soil and Water Assessment Tool (SWAT) Model

ArcSWAT Version 2.3.3,  ArcGIS 9.3 SP1

A process-based model.

# ArcSWAT Project – Database Setup

- Digital Elevation Model (DEM), LiDAR Data –
- 5 m DEM (http://atlas.lsu.edu/LiDAR)
- Landuse map (LDEQ – Landsat TM, 1998)
- Soils data (STATSGO 1:250,000 scale)
- Weather data (Rice Research Station, Crowley, Louisiana, 1980 to 2008)
- Daily discharge data for flow calibration and validation (http://ida.water.USGS.gov/ida/available_records.cfm?sn=08010200), June 2002 to November 2005),

  USGS 08010200 BYU PLAQUEMINE BRULE @ CHURCH POINT, LA

# Results and Discussion

# Uncertainties associated with modeling


Crawfish production


Levees


Flat landscape


Rice/crawfish system


Estherwood after Rita
27 3:56 PM

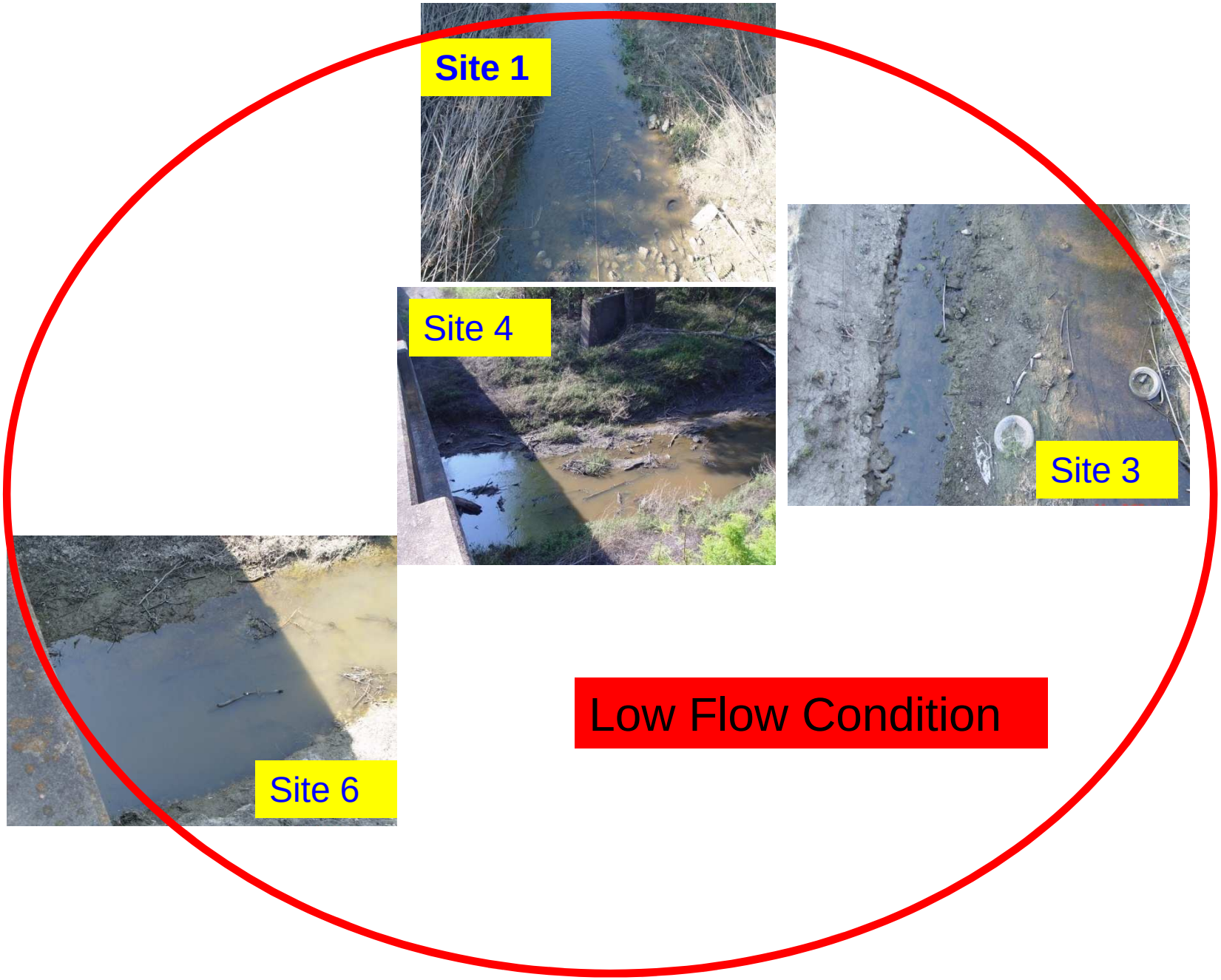
# Stream Bank Vegetation

High Flow Condition



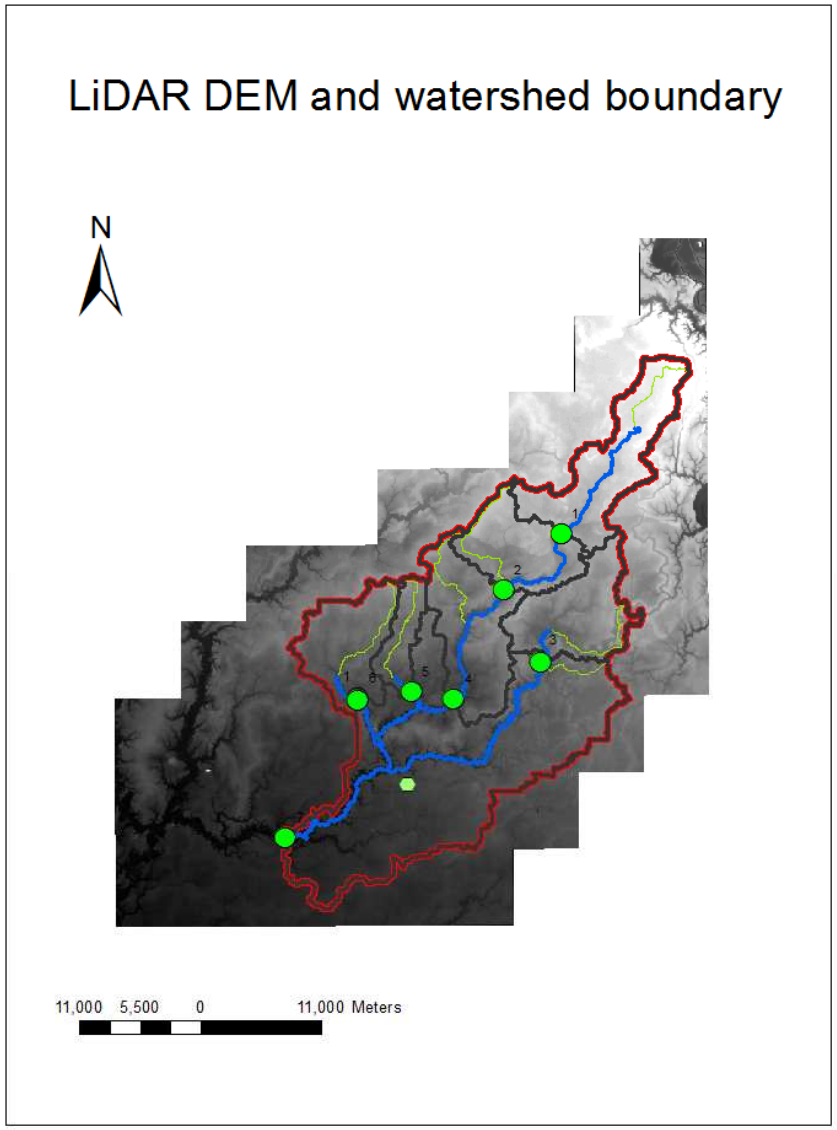




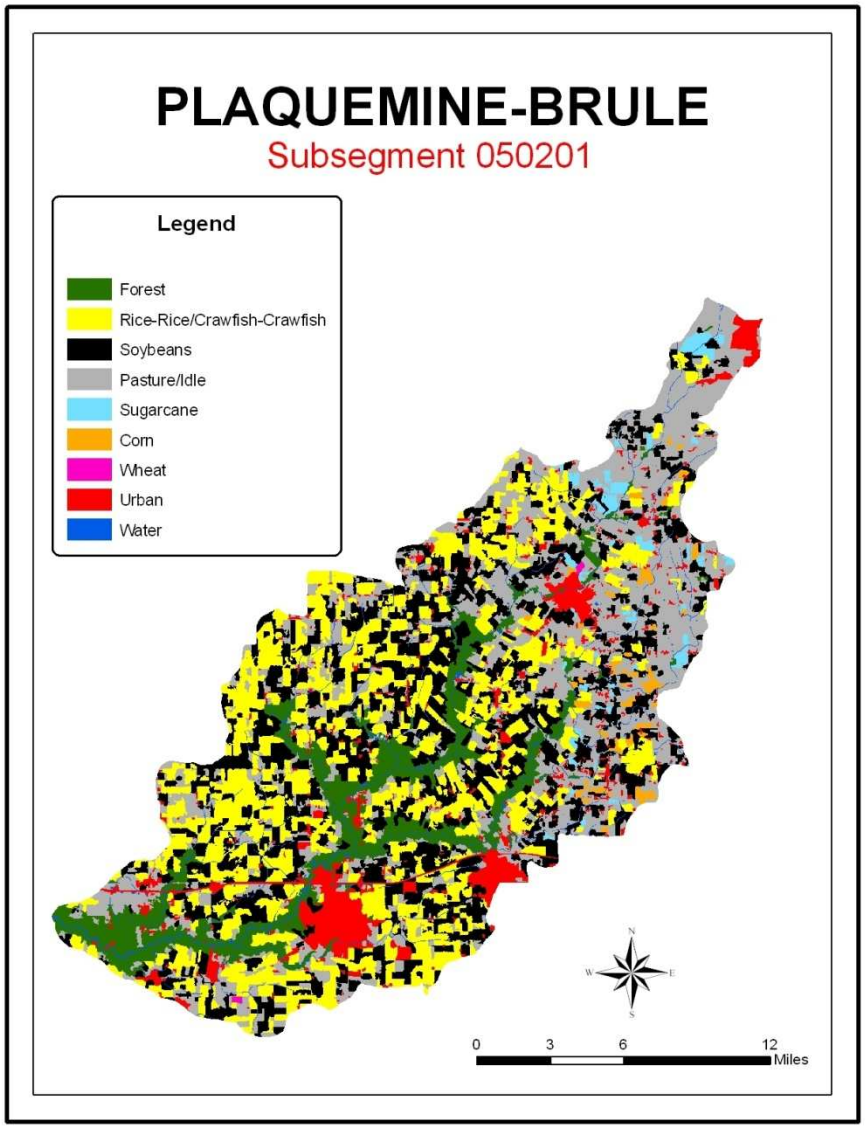

Site 1
Site 4
Site 3
Site 6
Low Flow Condition

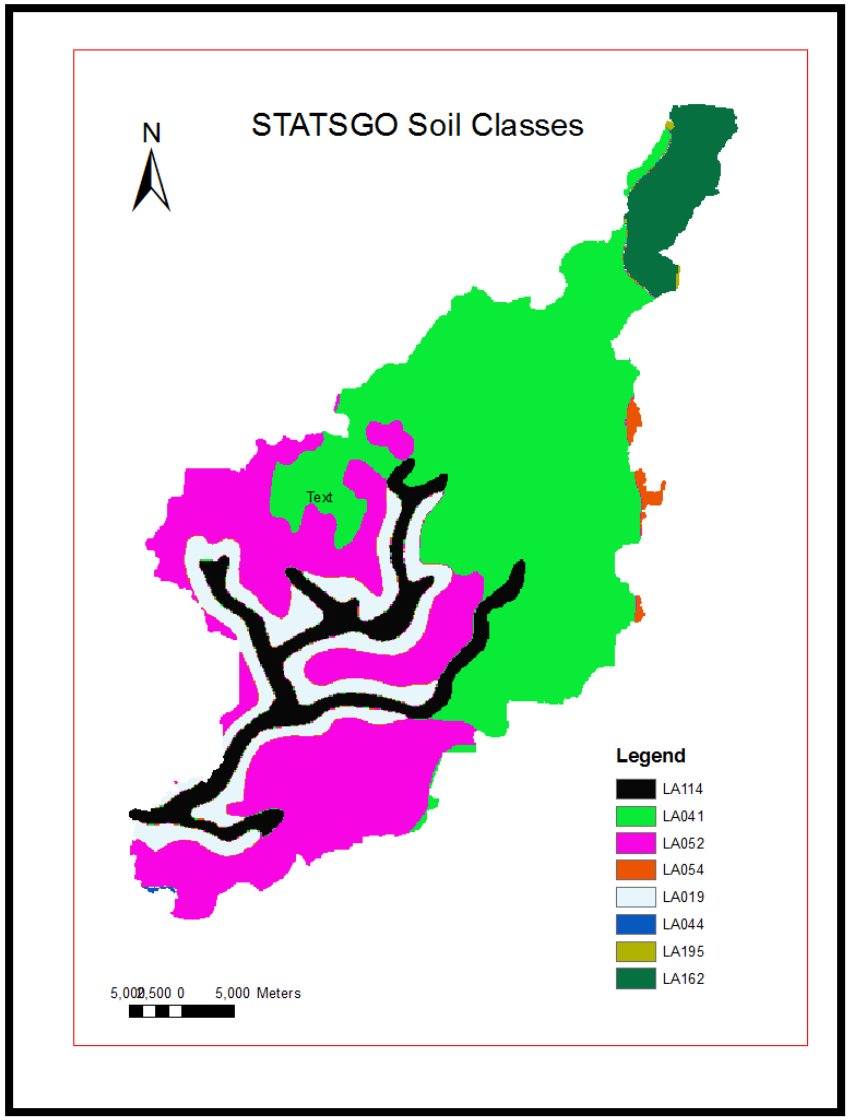
# Hydrology and hydraulics



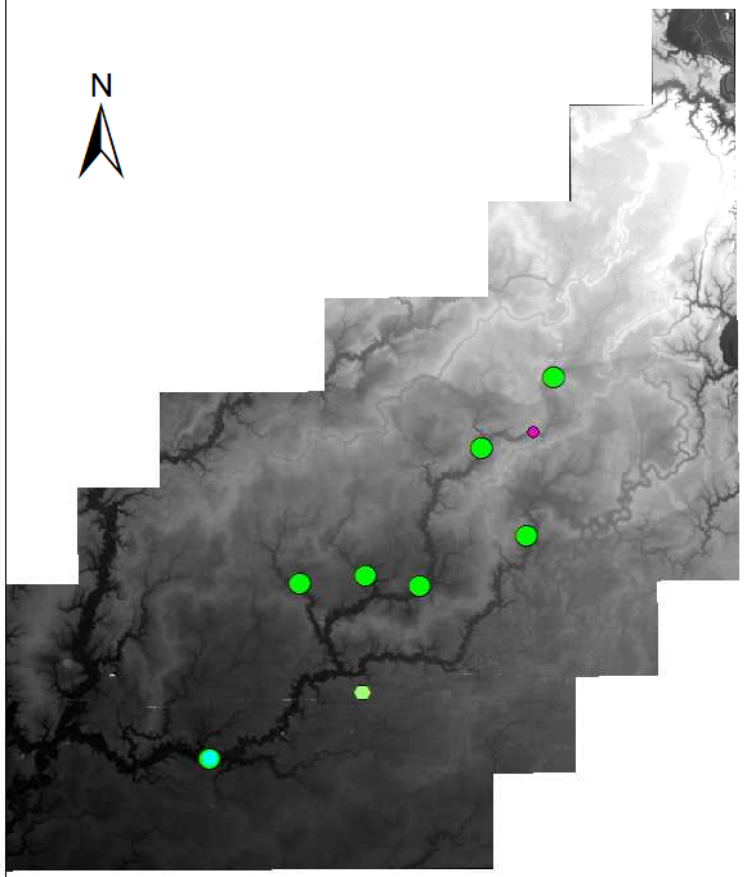



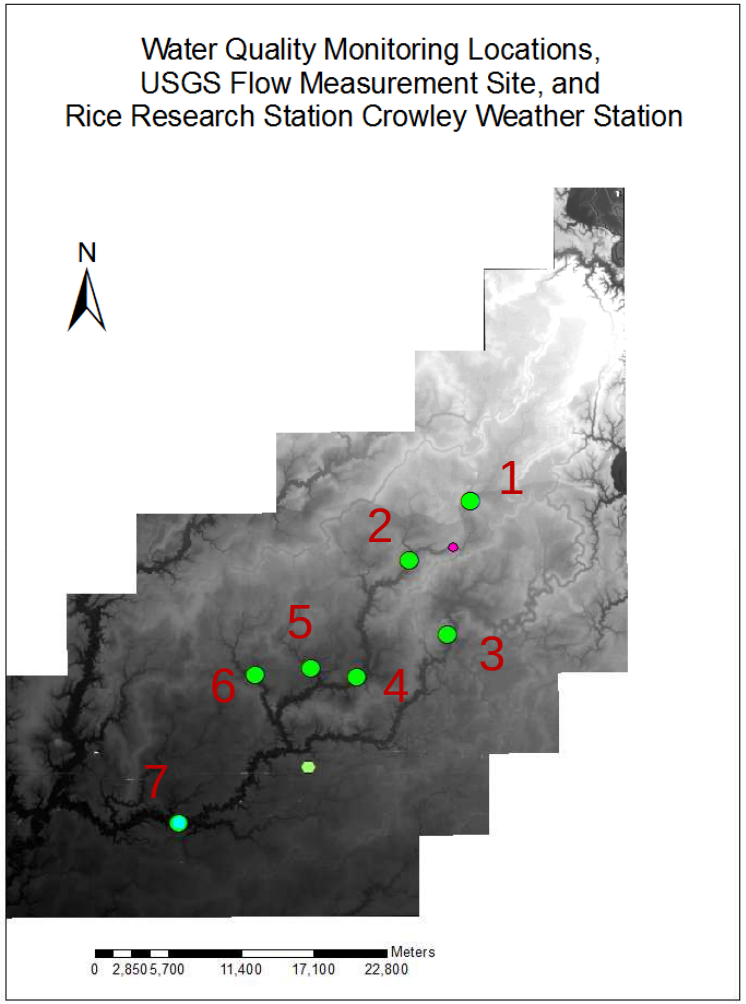

| Drainage area (ha) | |
|---|---|
| Site 1 | 9,807 |
| Site 2 | 16,610 |
| Site 3 | 7,782 |
| Site 4 | 25,760 |
| Site 5 | 2,824 |
| Site 6 | 6,993 |
| Site 7 | 78,130 |
| Total | 147,906 |
| **Distance (km)** | |
| Bndry - Site 1 | 19.3 |
| Site 1- 2 | 11.6 |
| Site 2 – 4 | 14.2 |
| Site 4 – 7 | 30.3 |


PLAQUEMINE-BRULE
Subsegment 050201
Legend
Forest
Rice-Rice/Crawfish-Crawfish
Soybeans
Pasture/Idle
Sugarcane
Corn
Wheat
Urban
Water
0 3 6 12
Miles


STATSGO Soil Classes
N
Text
Legend
LA114
LA041
LA052
LA054
LA019
LA044
LA195
LA162
5,000 2,500 0 5,000 Meters

Water Quality Monitoring Locations,
USGS Flow Measurement Site, and
Rice Research Station Crowley Weather Station






SWAT Project I

Pilot Basin, USGS Site as an outlet, calibration and validation for flow.

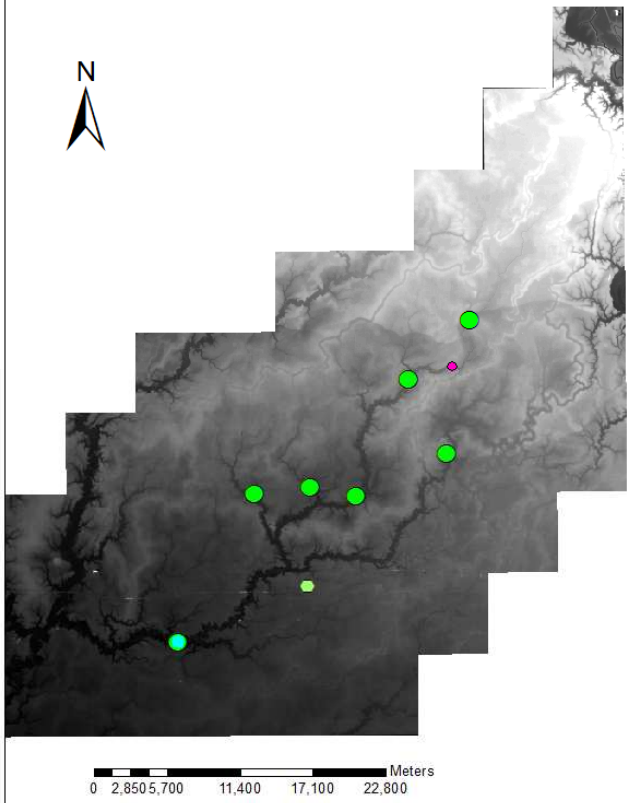
SWAT Project II

Site 2 as an outlet, use optimized parameters for flow from SWAT Project I, calibrate sediment, mineral-P and nitrate using monitoring data from Site 4, and validate the model with monitoring data from Site 2.

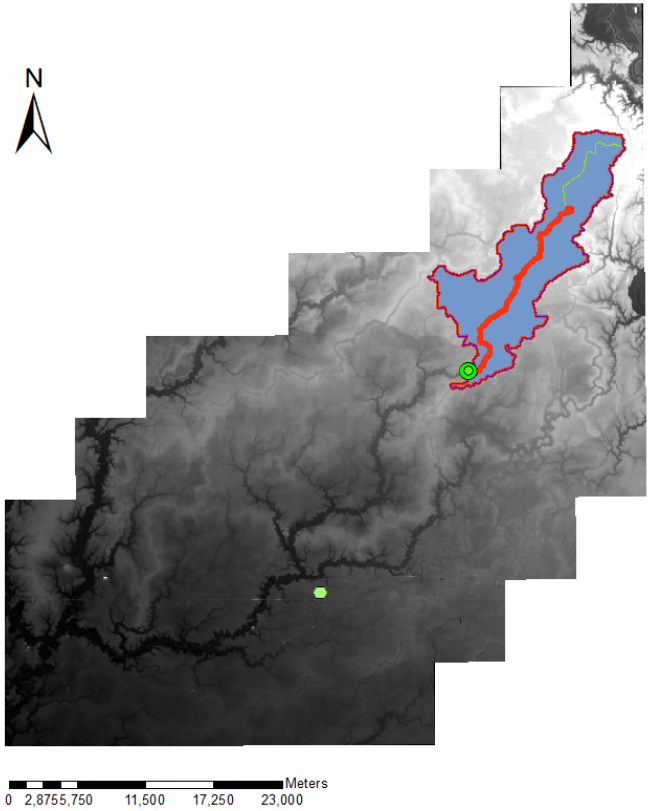
SWAT Project III

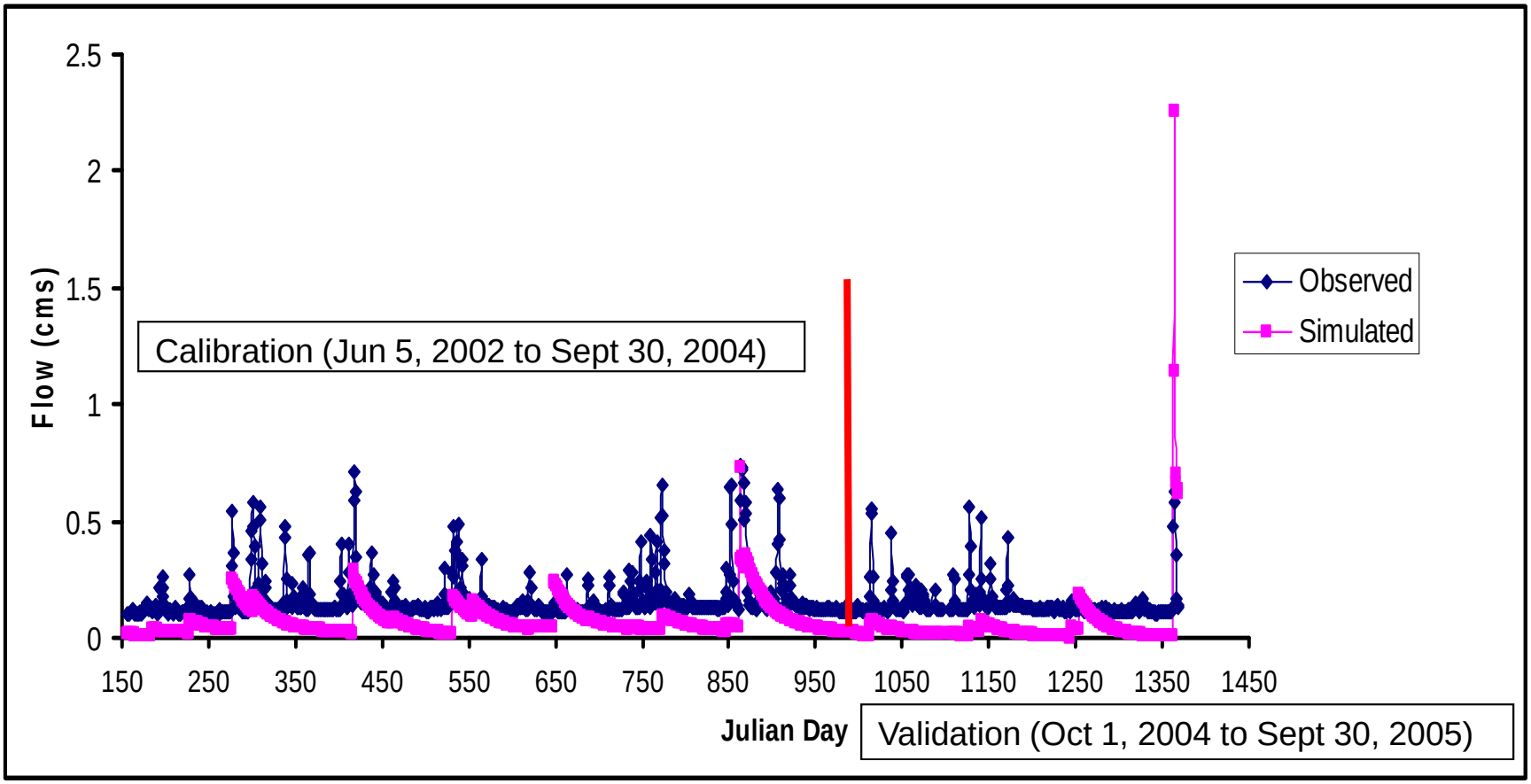
Site 7 as outlet, calibrate the whole watershed model using optimized flow, sediment, mineral-P and nitrate parameters from SWAT Project I and II.

Water Quality Monitoring Locations,
USGS Flow Measurement Site, and
Rice Research Station Crowley Weather Station

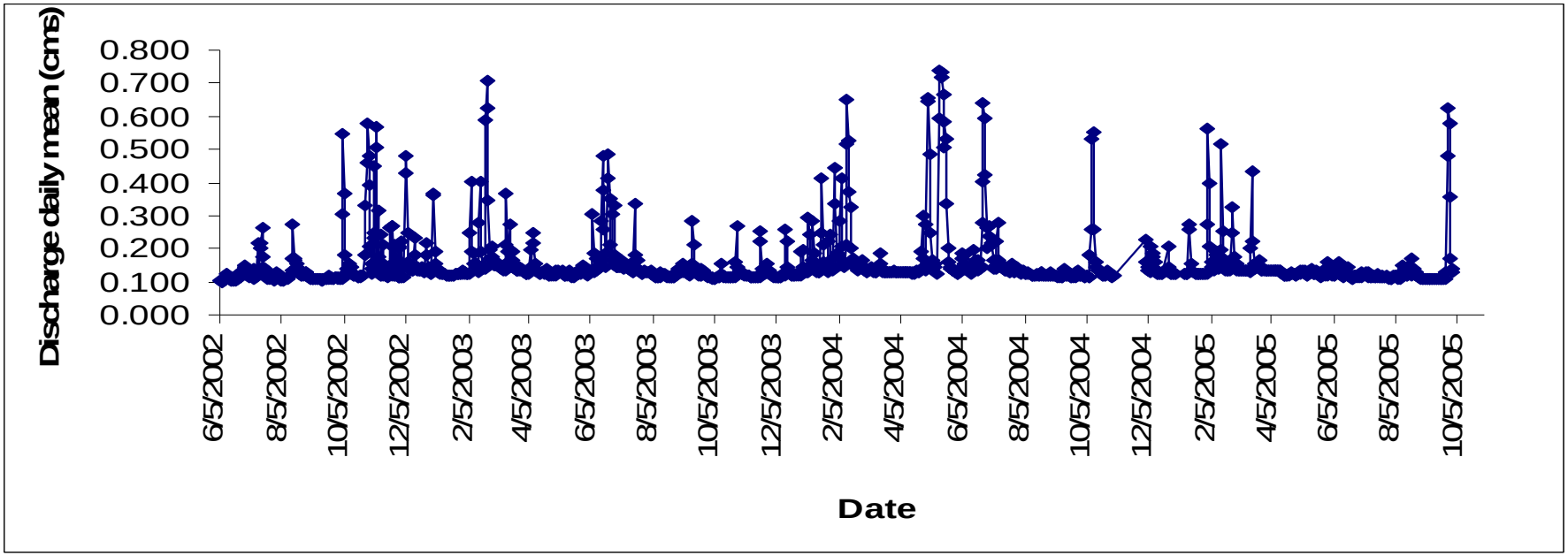



Pilot basin for flow calibration and validation






USGS Site in BPB near Churchpoint, LA.




After Lily, October 25-26, 2002

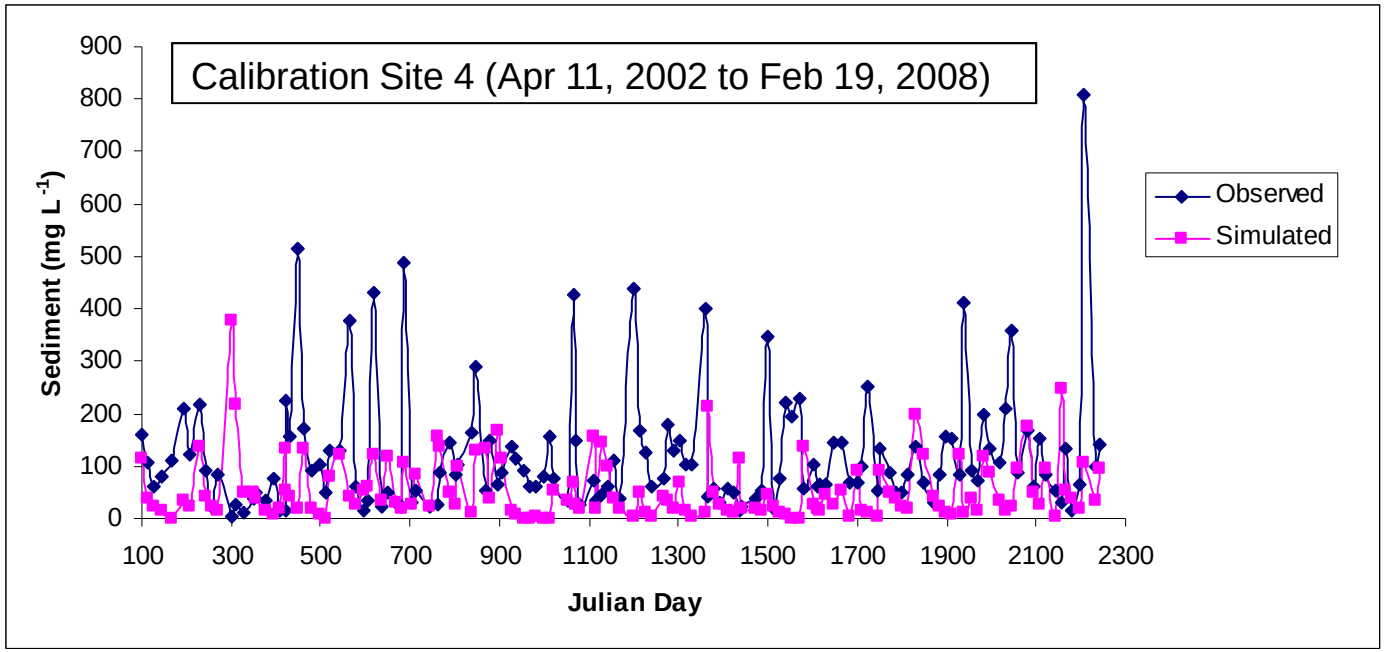

USGS Site in BPB near Churchpoint, LA

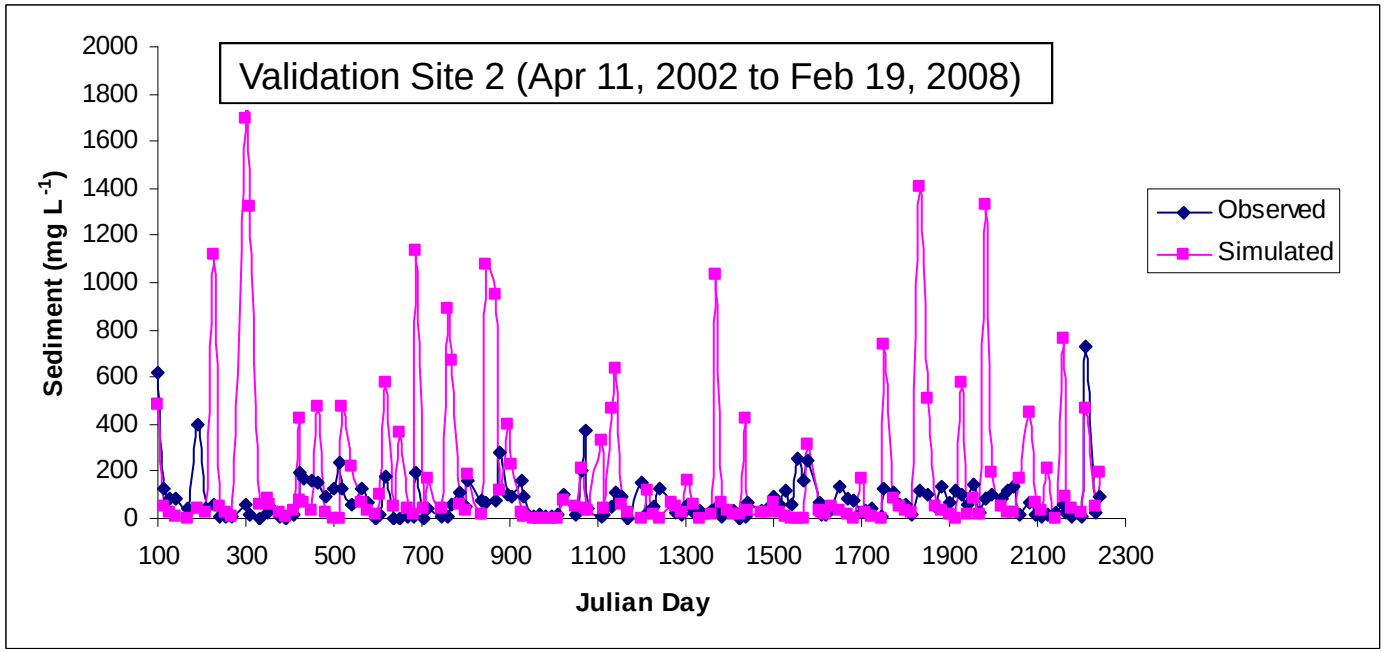


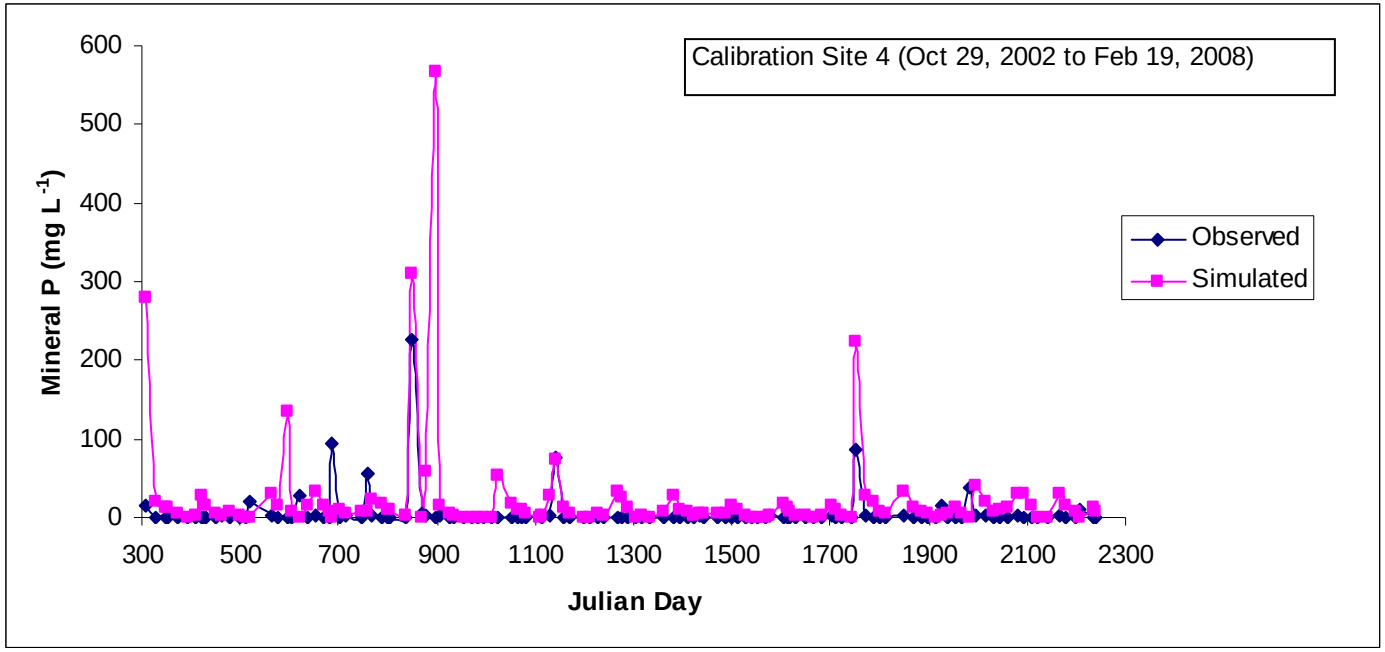


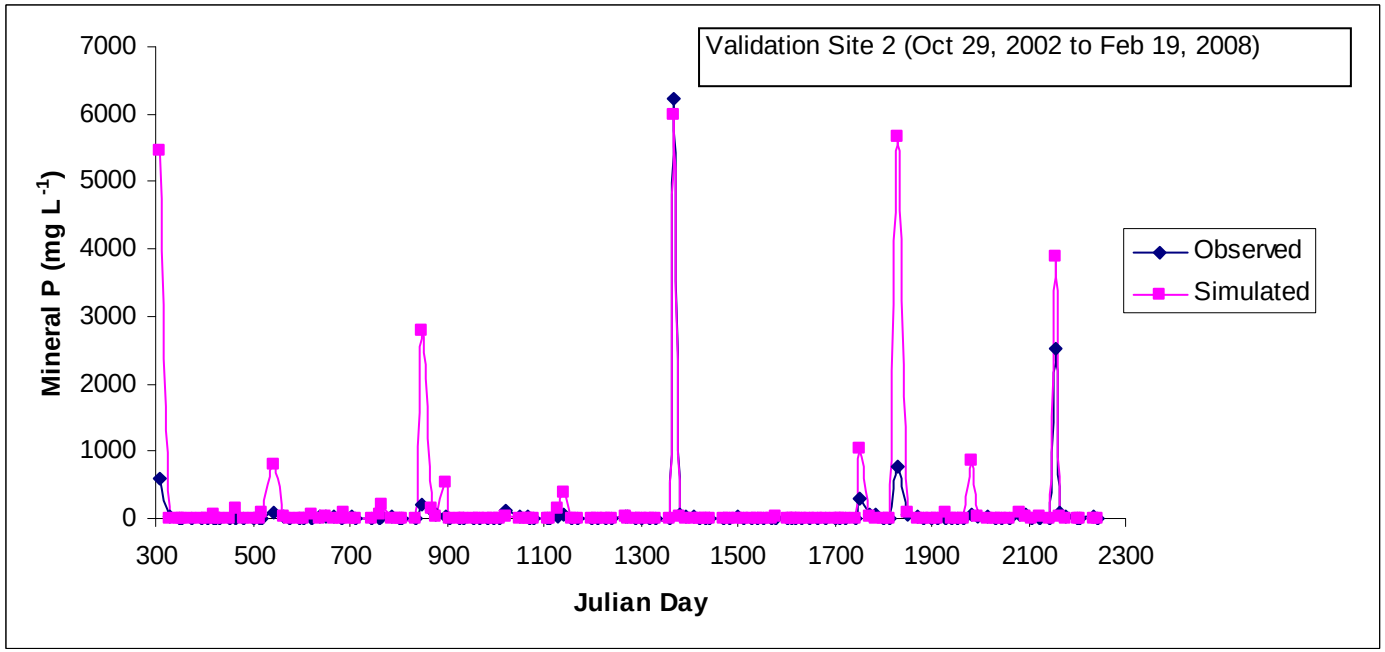

“Based on the USGS annual discharge data representing 22 years from 1940 to 1982, average annual discharge rate for Bayou Plaquemine Brule near Crowley was 15.68 cubic feet per second, with the maximum and the minimum discharge values of 25.51 and 9.85 cubic feet/second, respectively. Based on 30 years annual discharge rates between 1948 and 1978, the average annual discharge rate of Bayou Plaquemine Brule near Estherwood, which is located downstream from Crowley, was 9.4 cubic feet/second, with the maximum and the minimum discharge rates values of 15.6 and 4.4 cubic feet/second, respectively”.

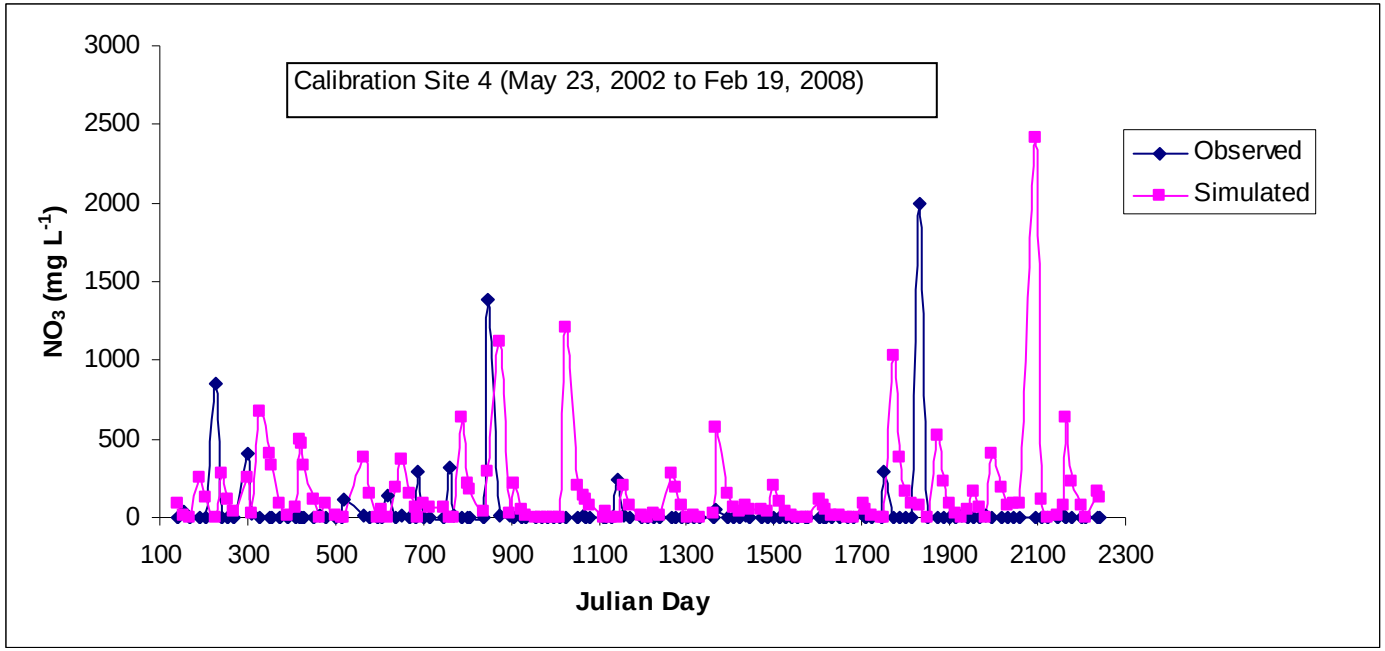
Bayou Plaquemine Brule, Final Report, 2005

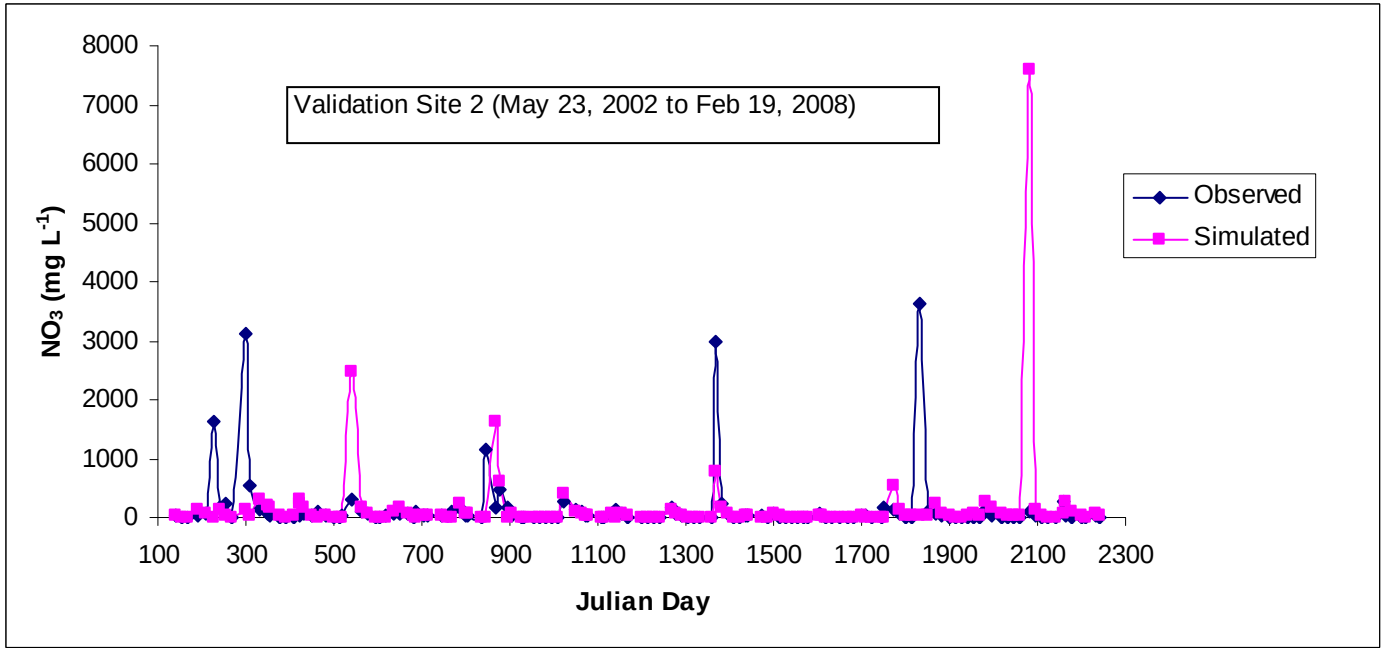

Calibration Site 4 (Apr 11, 2002 to Feb 19, 2008)
Sediment (mg L-1)
900
800
700
600
500
400
300
200
100
0
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day
Observed
Simulated


Validation Site 2 (Apr 11, 2002 to Feb 19, 2008)
Sediment (mg L-1)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day
Observed
Simulated


Calibration Site 4 (Oct 29, 2002 to Feb 19, 2008)
Mineral P (mg L-1)
600
500
400
300
200
100
0
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day
Observed
Simulated


Validation Site 2 (Oct 29, 2002 to Feb 19, 2008)
Mineral P (mg L-1)
7000
6000
5000
4000
3000
2000
1000
0
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day
Observed
Simulated


Calibration Site 4 (May 23, 2002 to Feb 19, 2008)
Observed
Simulated
NO3 (mg L-1)
3000
2500
2000
1500
1000
500
0
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day


Validation Site 2 (May 23, 2002 to Feb 19, 2008)
Observed
Simulated
NO3 (mg L-1)
8000
7000
6000
5000
4000
3000
2000
1000
0
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Julian Day

# Summary statistics of model calibration and validation using Sequential Uncertainty Fitting (SUFI2) parameter optimization algorithm that uses Latin Hypercule Sampling approach

| | P-factor | R-factor | $R^2$ | NS |
|---|---|---|---|---|
| Flow cal(val) | 0.06(0.04) | 0.10(0.25) | 0.17(0.21) | -0.70 (-4.25) |
| TSS cal(val) | 0.25(0.50) | 0.42(1.69) | 0.00(0.02) | -0.58(-11.31) |
| Nitrate cal(val) | 0.01(0.14) | 0.07(0.07) | 0.00 (0.00) | -1.90 (-1.75) |
| Mineral P cal(val) | 0.10(0.22) | 5.70(0.32) | 0.18(0.53) | -5.31(-0.30) |

*P-factor is the percentage of measured data bracketed by the 95% prediction uncertainty. R-factor is the average thickness of the 95PPU band divided by the standard deviation of the measured data. A P-factor of 1 and R-factor of zero is a simulation that exactly corresponds to measured data. The goodness of fit is determined by the $R^2$ and NS between the observed values and the simulated values.*

# Flow calibration-parameter optimization

Goal_type= br2 (type 6) Best_sim_no= 47 Best_goal = 4.895435e-002

| | Parameter_Name | Fitted_Value | Min_value | Max_value |
|---|---|---|---|---|
| 1 | r__CN2.mgt | -0.539674 | -0.584302 | -0.539450 |
| 2 | v__ALPHA_BF.gw | 0.043688 | 0.031557 | 0.043999 |
| 3 | v__GW_DELAY.gw | 82.338600 | 78.761780 | 82.430313 |
| 4 | v__GWQMN.gw | 106.747116 | 102.820999 | 109.204926 |
| 5 | v__CH_N2.rte | 0.160806 | 0.157862 | 0.167208 |
| 6 | v__CH_K2.rte | 7.686971 | 7.602056 | 7.948648 |
| 7 | r__ALPHA_BNK.rte | -0.119561 | -0.136256 | -0.086420 |
| 8 | r__SOL_AWC(1).sol | 0.185191 | 0.179369 | 0.188685 |
| 9 | r__SOL_K(1).sol | 0.364869 | 0.351342 | 0.394286 |
| 10 | r__SOL_BD(1).sol | 0.165437 | 0.159384 | 0.165722 |
| 11 | v__GW_REVAP.gw | 0.061345 | 0.060926 | 0.065335 |
| 12 | v__SURLAG.bsn | 89.655388 | 80.678001 | 200.376495 |
| 13 | v__REVAPMN.gw | 2.201996 | 1.140712 | 3.423043 |
| 14 | v__EPCO.hru | 0.617585 | 0.174402 | 0.724940 |
| 15 | v__CH_S2.rte | -0.000003 | -0.000020 | 0.000010 |
| 16 | v__OV_N.hru | 0.163729 | 0.162350 | 0.175480 |
| 17 | v__RCHRG_DP.gw | 0.174746 | 0.113545 | 0.200355 |
| 18 | v__SFTMP.bsn | 1.320887 | 0.719513 | 1.548995 |
| 19 | v__ESCO.hru | 0.019492 | 0.018174 | 0.106040 |
| 20 | v__EVLAI.bsn | 6.911025 | 6.256000 | 9.999000 |
| 21 | v__LAT_TTIME.hru | 86.063652 | 84.699898 | 88.652802 |

# Sediment calibration-parameter optimization

Goal_type= br2 (type 6) Best_sim_no= 3 Best_goal = 5.773653e-006

| | Parameter_Name | Fitted_Value | Min_value | Max_value |
|---|---|---|---|---|
| 1 | v__USLE_P.mgt | 0.332123 | 0.301656 | 0.373344 |
| 2 | r__SLSUBBSN.hru | 0.021389 | 0.012535 | 0.044732 |
| 3 | v__SPCON.bsn | 0.025757 | 0.001677 | 0.065890 |
| 4 | v__SPEXP.bsn | 0.742985 | 0.007041 | 1.969558 |
| 5 | r__CH_COV.rte | 0.014451 | 0.002832 | 0.054470 |
| 6 | r__CH_EROD.rte | 0.011720 | 0.004135 | 0.011915 |
| 7 | v__PRF.bsn | 0.346427 | 0.022831 | 0.354724 |

# Mineral P calibration-parameter optimization

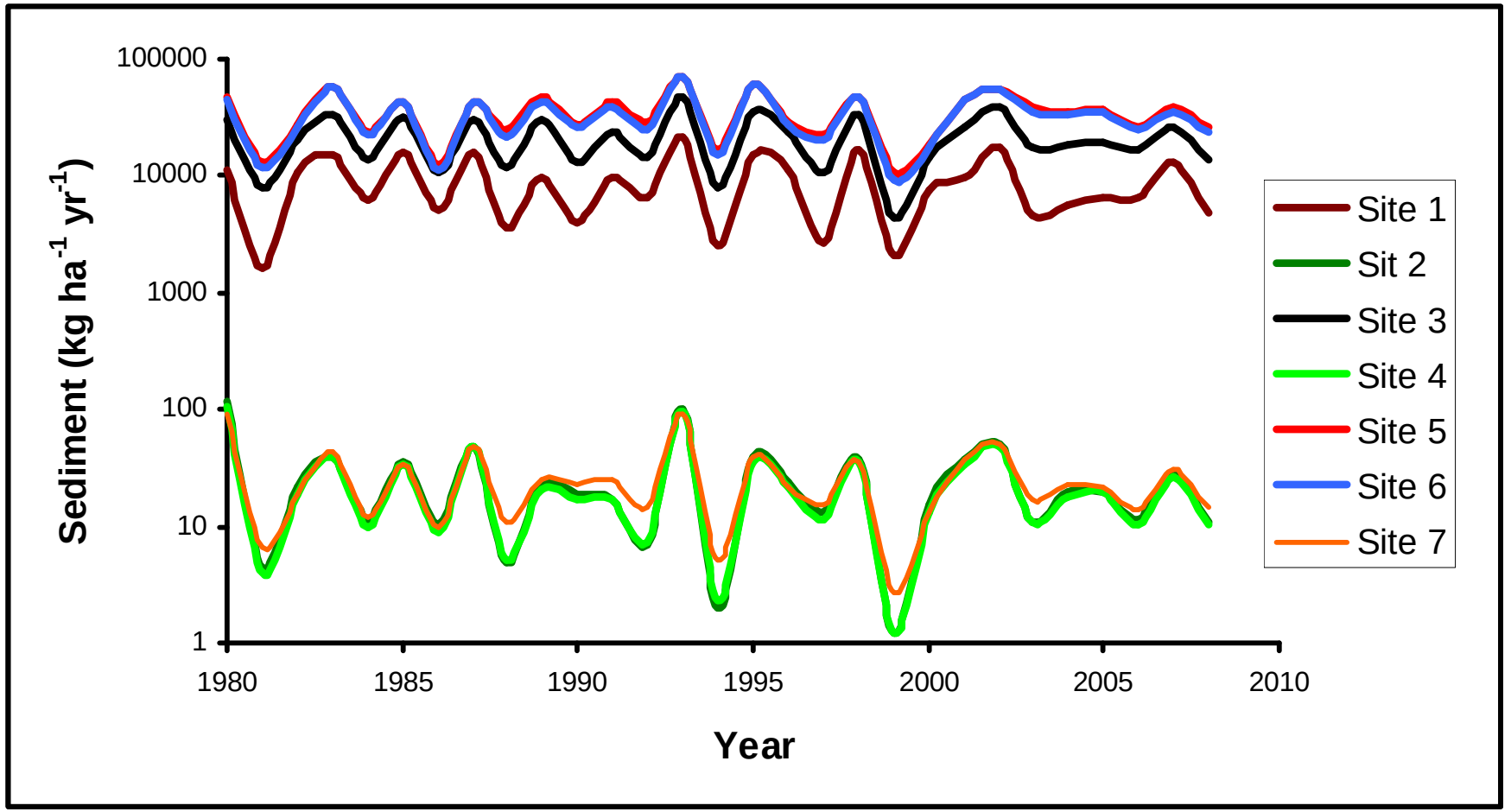
Goal_type= br2 (type 6) Best_sim_no= 7 Best_goal = 1.586811e-001

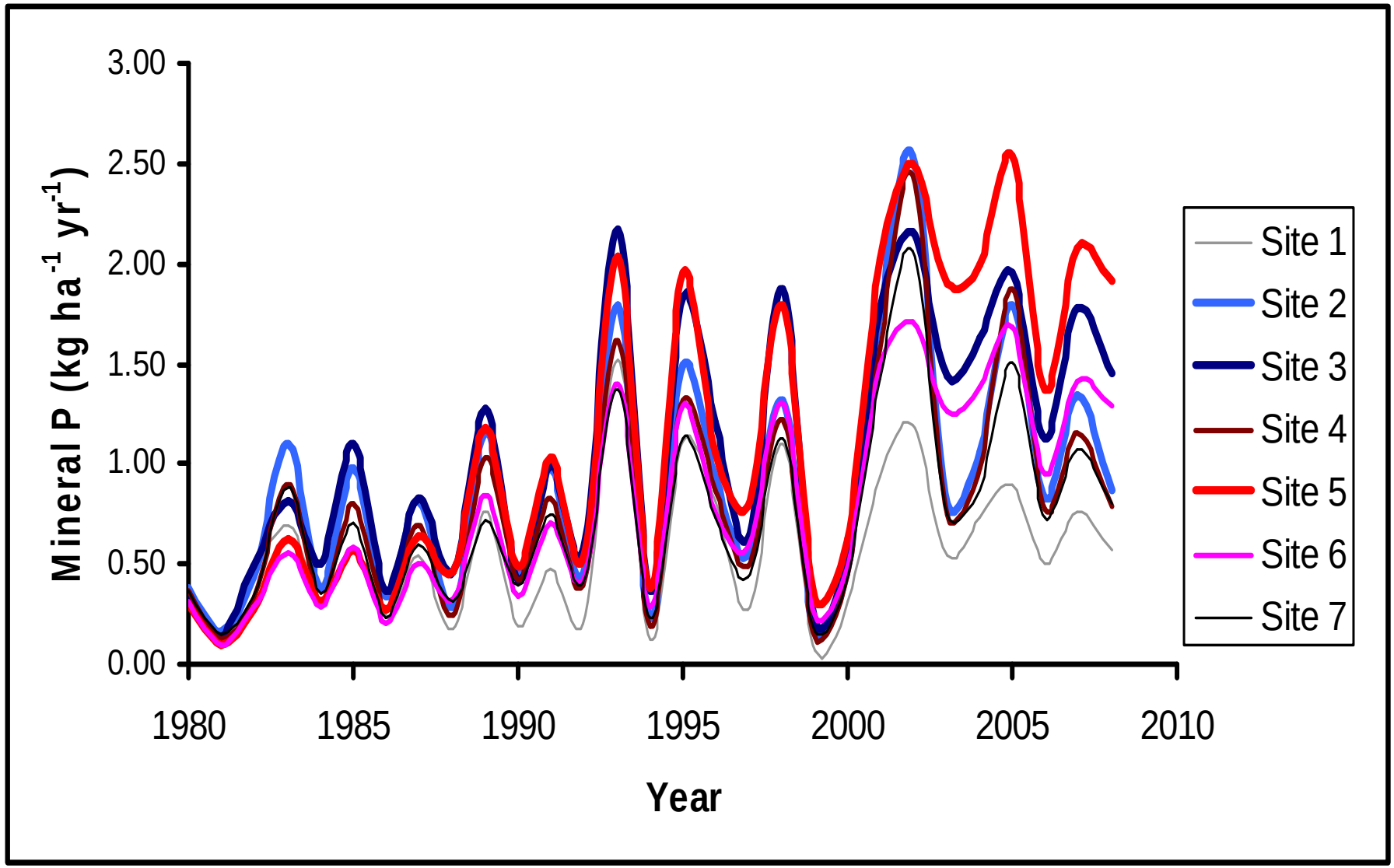
| | Parameter_Name | Fitted_Value | Min_value | Max_value |
|---|---|---|---|---|
| 1 | v__sol_orgp(1).chm | 0.010095 | -0.000258 | 0.030416 |
| 2 | v__sol_solp(1).chm | 0.062027 | 0.003279 | 0.064957 |
| 3 | v__PHOSKD.bsn | 7.086204 | 6.361831 | 8.476788 |
| 4 | v__PPERCO.bsn | 11.920528 | 10.326839 | 15.509569 |
| 5 | v__RSDCO.bsn | 0.065228 | 0.064400 | 0.067137 |
| 6 | v__BIOMIX.mgt | 0.103358 | 0.006680 | 0.103600 |
| 7 | v__P_UPDIS.bsn | 21.306997 | 20.096554 | 23.346066 |
| 8 | v__PSP.bsn | 1.370028 | 1.236422 | 1.406080 |

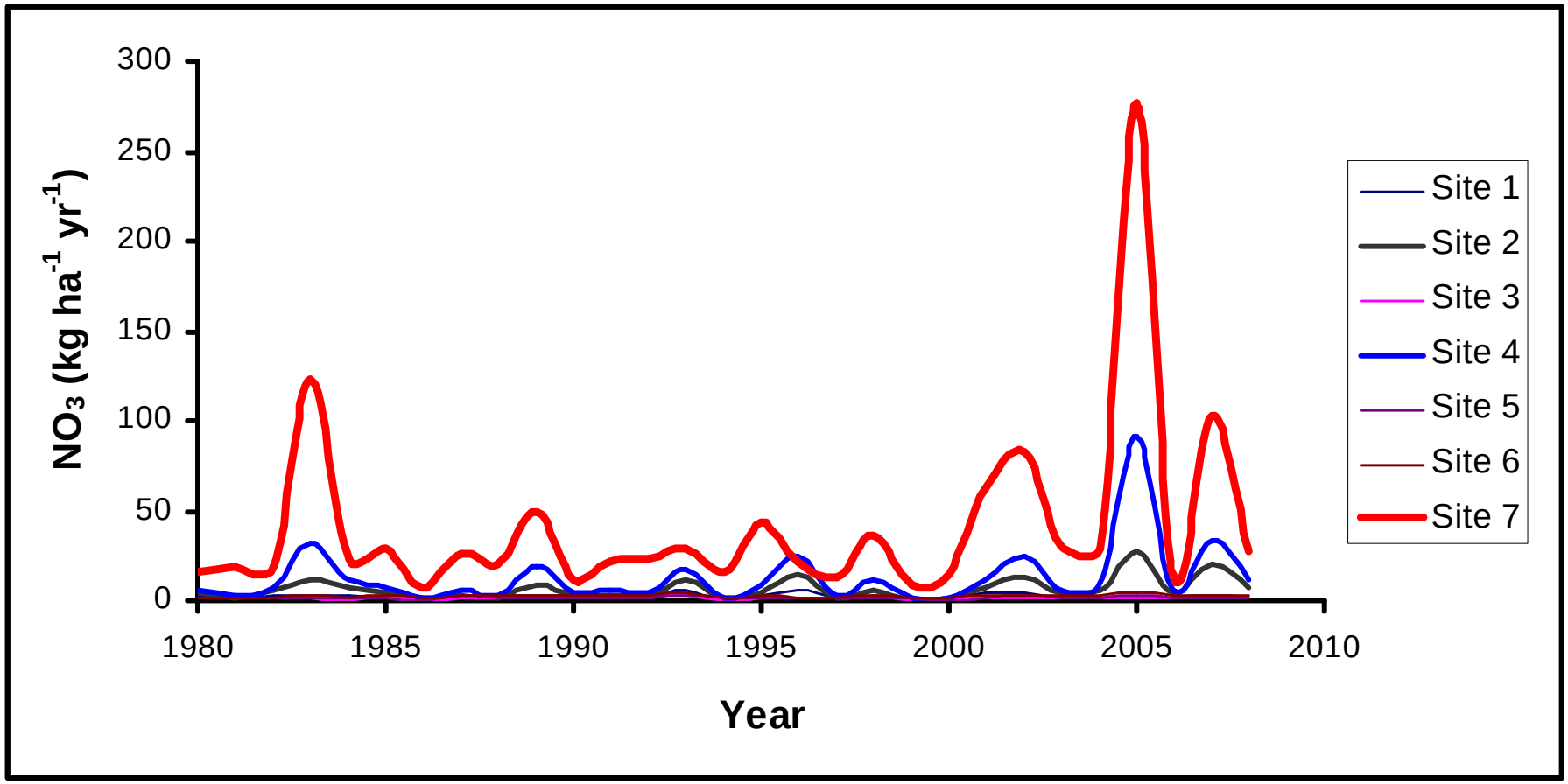
# Nitrate calibration-parameter optimization

Goal_type= br2 (type 6) Best_sim_no= 114 Best_goal = 1.935223e-005

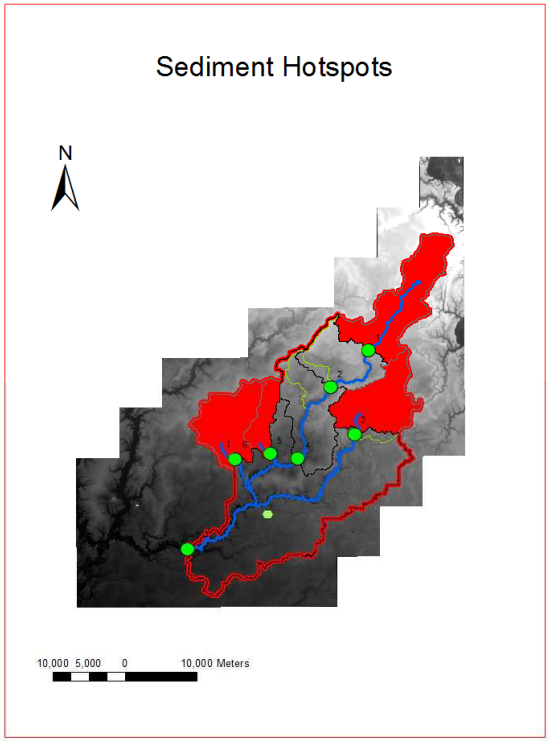
| | Parameter_Name | Fitted_Value | Min_value | Max_value |
|---|---|---|---|---|
| 1 | v__Sol_NO3(1).chm | 0.000003 | 0.000001 | 0.000010 |
| 2 | v__NPERCO.bsn | 0.000076 | 0.000001 | 0.000100 |
| 3 | v__CMN.bsn | 0.001963 | 0.001000 | 0.002000 |
| 4 | v__SOL_ORGN(1).chm | 0.218887 | 0.121400 | 0.523410 |
| 5 | v__RSDCO.bsn | 0.066103 | 0.064270 | 0.066184 |
| 6 | v__BIOMIX.mgt | 0.067307 | 0.054968 | 0.151748 |


100000
10000
1000
100
10
1
Sediment (kg ha-1 yr-1)
1980
1985
1990
1995
2000
2005
2010
Year
Site 1
Sit 2
Site 3
Site 4
Site 5
Site 6
Site 7

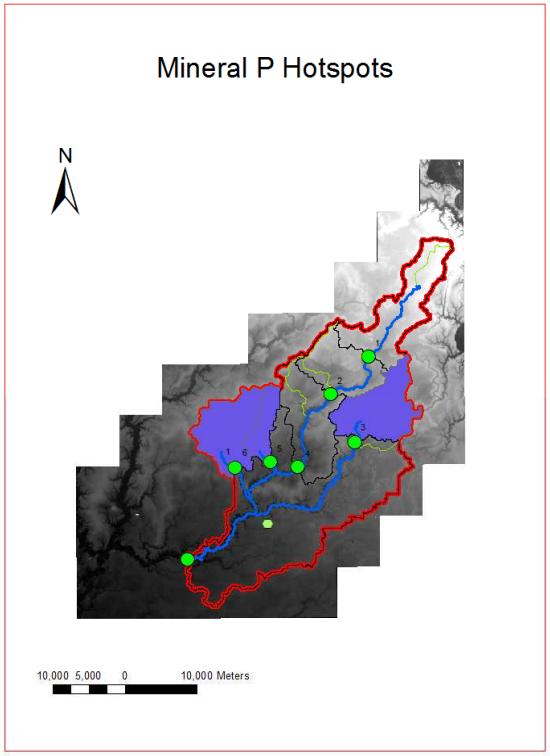

3.00
2.50
2.00
1.50
1.00
0.50
0.00
Mineral P (kg ha-1 yr-1)
1980
1985
1990
1995
2000
2005
2010
Year
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7


300
250
200
150
100
50
0
NO3 (kg ha-1 yr-1)
1980
1985
1990
1995
2000
2005
2010
Year
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7

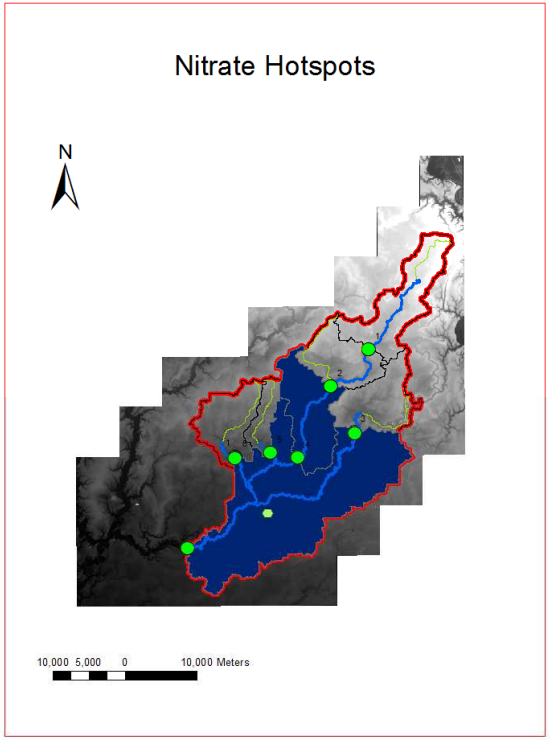
# Sediment, Mineral P, and Nitrate Hotspots in Bayou Plaquemine Brule Watershed




Site 5, 6, 3, 1




Site 5, 3, 6




Site 7, 4

## Conclusions

- **Extreme conditions for SWAT application. Sensible simulation results for targeting watershed.**
- **Daily flow data and multiple weather stations in the watershed for better water quality modeling.**
- **Hydraulics and hydrology are challenging factors in water quality modeling especially in the flat landscape of Louisiana.**
- **Grab samples and less frequent samplings add to the model uncertainty.**
- **Development of the Louisiana version of ArcSWAT is suggested.**

# Thank You

## Questions?