GIS Based Pollution Load Water Quality Model

SWAMM

Jeff Boeckler
ILMA 2014

Model Overview

- SWAMM
  - Spatial Watershed Assessment and Management Model
  - GIS based pollution load model
- Purpose/use
  - Identify priority land parcels
  - Quantify upland pollutant loadings
  - Quantify load reductions from practice implementation
  - Link implementation with watershed plan targets and track plan success
- Major Model Components
  - Soils, landcover, precipitation

Common Approach to Pollution Load Estimates

- Estimates generated using existing literature and/or spreadsheets
  - IEPA Load reduction spreadsheet
  - STEPL; Spreadsheet Tool for Estimating Pollution Loading
- More detailed and comprehensive in-stream models
  - HSPF, SWAT etc

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered 1 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.

Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.

Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2; (c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.

Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.

Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6; (c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.

Step 5: Select BMPs in BMPs sheet. **Step 6**: View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input tables? Yes No ☐ **Treat all the subwatersheds as parts of a single watershed** ☐ **Groundwater load calculation**

State	County	Weather Station (for rain correction factors)
Missouri	Barry	MO PATTONSBURG 2 S

1. Input watershed land use area (ac) and precipitation (in)

Rain correction factors: 0.859 | 0.504

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Event
W1	30	0	0	0	0	0	0-24%	30	45	86	0.892

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
W1	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	0	2.43	2	0	0

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
W1	250.000	0.301	0.802	0.200	1.000	250.000	0.301	0.802	0.040	1.000	250.000	0.301	0.802	0.003	1.000

Optional Data Input:

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration

Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD conc.%
W1	○	○	●	○	C	0.080	0.031	0.160

6. Reference runoff curve number (may be modified)

SHG	A	B	C	D
Urban	77	85	90	92
Cropland	67	78	85	89
Pastureland	49	69	79	84
Forest	39	60	73	79
User Defined	50	70	80	85

6a. Detailed urban reference runoff curve number (may be modified)

Urban\SHG	A	B	C	D
Commercial	89	92	94	95
Industrial	81	88	91	93
Institutional	81	88	91	93
Transportation	98	98	98	98
Multi-Family	77	85	90	92
Single-Family	57	72	81	86
Urban-Cultivat	67	78	85	89
Vacant-Develo	77	85	90	92
Open Space	49	69	79	84
	75.11111111	83.88888889	88.77777778	91.33333333

7. Nutrient concentration in runoff (mg/l)

Land use	N	P	BOD
1. L-Cropland	**1.9**	**0.3**	**4**
1a. w/ manure	8.1	2	12.3
2. M-Cropland	**2.9**	**0.4**	**6.1**
2a. w/ manure	12.2	3	18.5
3. H-Cropland	**4.4**	**0.5**	**9.2**
3a. w/ manure	18.3	4	24.6
4. Pastureland	**4**	**0.3**	**13**
5. Forest	**0.2**	**0.1**	**0.5**
6. User Defined	0	0	0

7a. Nutrient concentration in shallow groundwater (mg/l) (may be modified)

Landuse	N	P	BOD
Urban	1.5	0.063	0
Cropland	1.44	0.063	0
Pastureland	1.44	0.063	0
Forest	0.11	0.009	0
Feedlot	6	0.07	0
User-Defined	0	0	0

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated %	Vacant (developed)	Open Space %	Total % Area
W1	30	12	0	50	20	0	1	0	2	15	100

9. Input irrigation area (ac) and irrigation amount (in)

Watershed	Total Cropland (ac)	Cropland: Acres Irrigated	Water Depth (in) per Irrigation - Before BMP	Water Depth (in) per Irrigation - After BMP	Irrigation Frequency (#/Year)
W1	0	0	0	0	0

What is Different with SWAMM

- Ability to identify pollution loading down to the field or parcel level - **ability to spatially represent loading**
  - ID loading hot spots
  - Tied to actual locations
- Ability to analyze and overlay with other GIS layers
- Ability to calculate load reductions for specific project locations
- Fully customizable based on local conditions

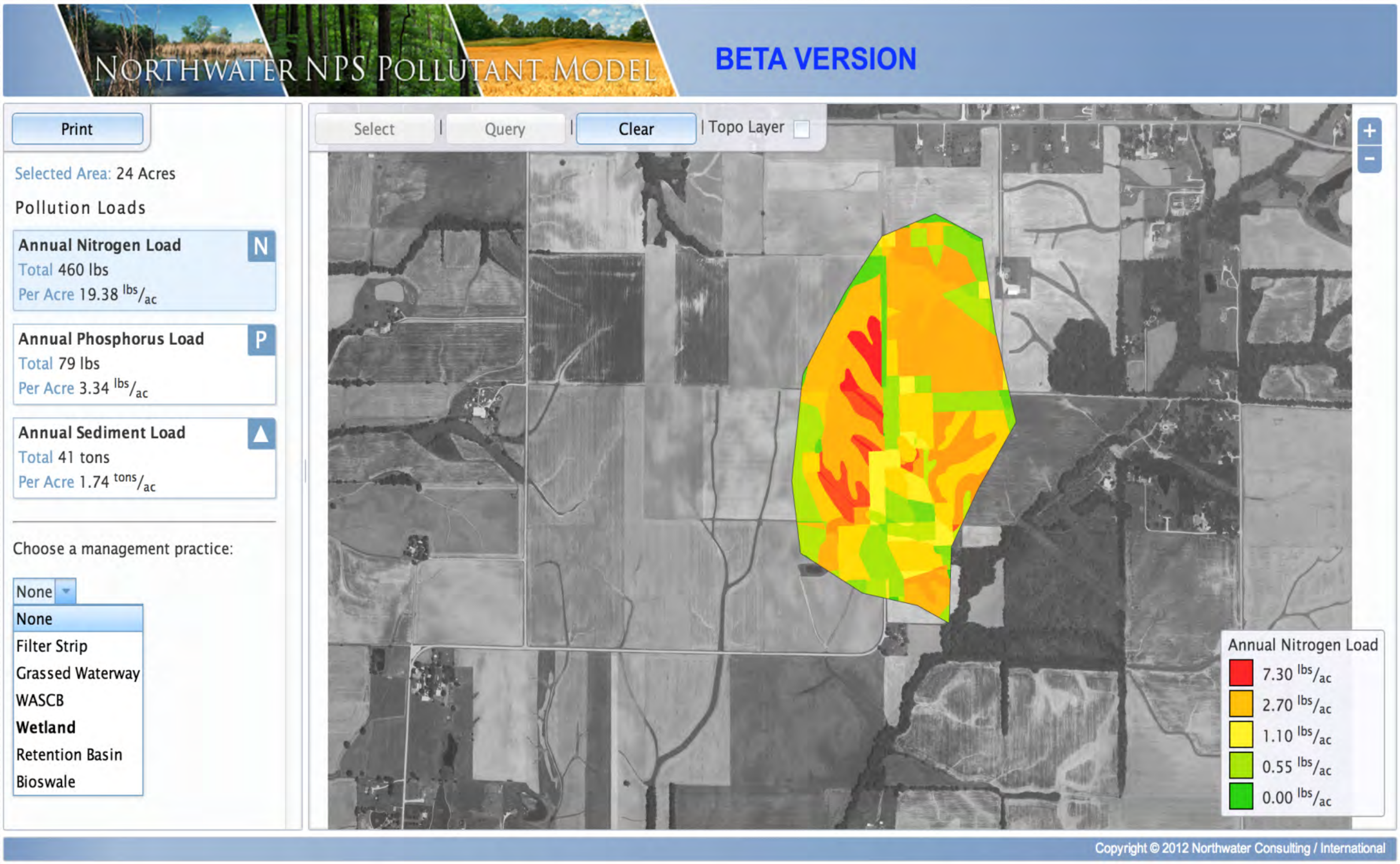
SWAMM

- Model structure includes:
  - USLE erosion component for crop ground
  - Curve Number approach for runoff
  - Event Mean Concentration (EMC) component
  - Distance/area based delivery ratio
  - Model Calibration

SWAMM

- Model outputs:
  - Pollution load concentrations, annual and storm events
    - Nitrogen, Phosphorus, Sediment, Bacteria and Chloride
  - Annual and storm event runoff (ac-ft)
    - First flush, 5-year and 25-year

SWAMM Web Application



SWAMM

- Applicable for lake management and urban stormwater planning
- Can identify critical loading and runoff land parcels
  - Evaluate changes in landuse
- Can evaluate the ACTUAL placement of BMPs to determine which will achieve the desired load reduction targets
- Can track progress in meeting goals

SWAMM

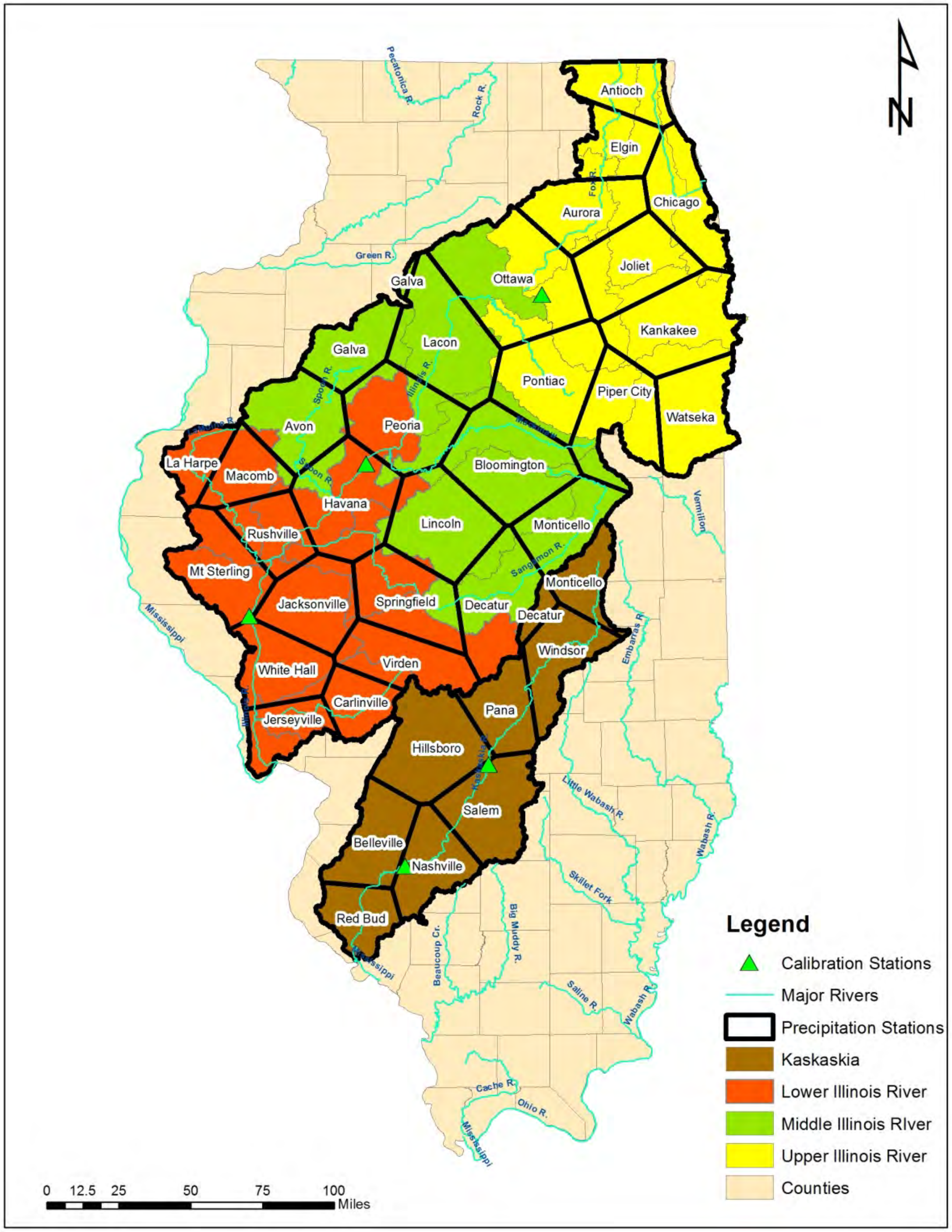
Case Studies

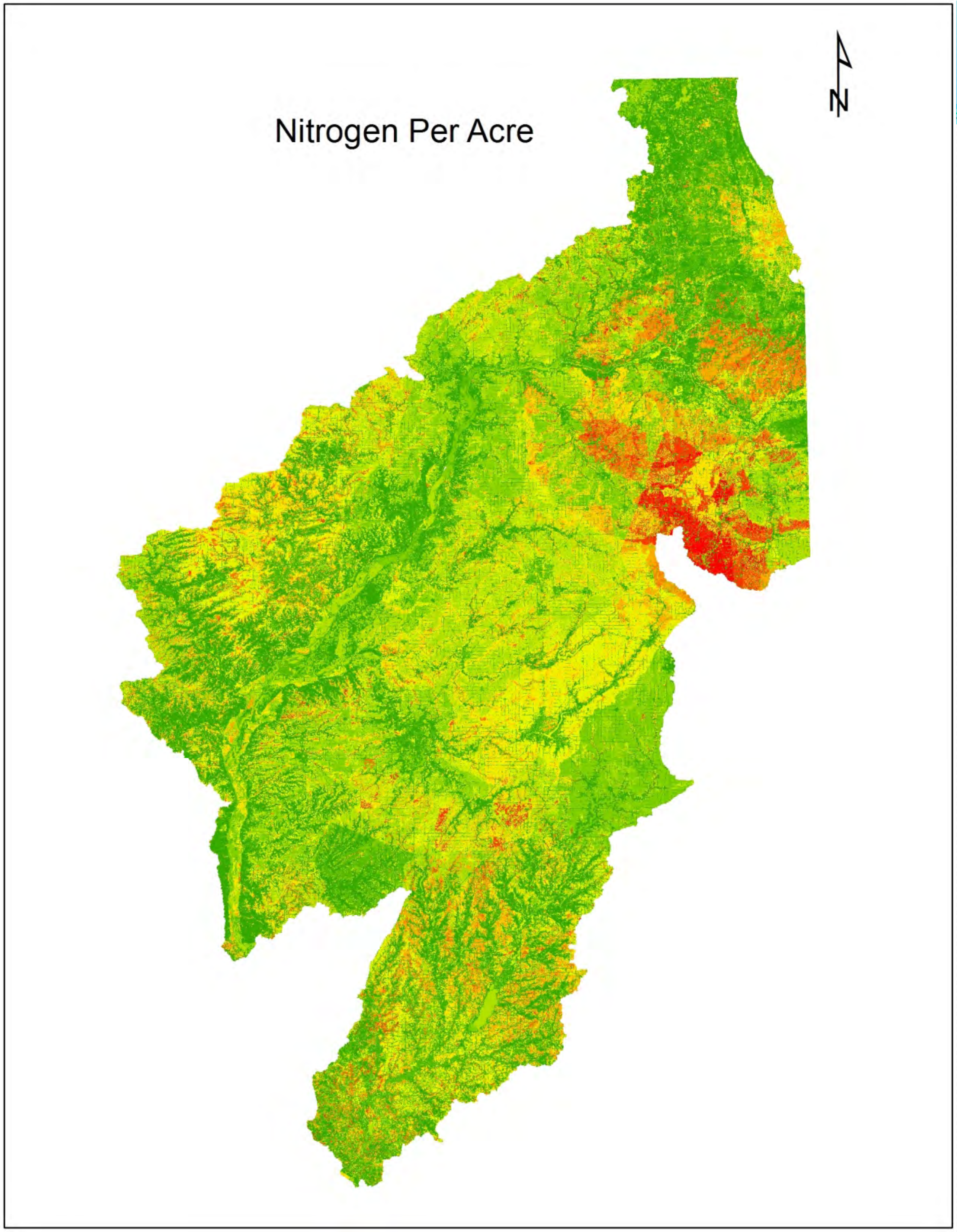
Illinois and Kaskaskia River Model

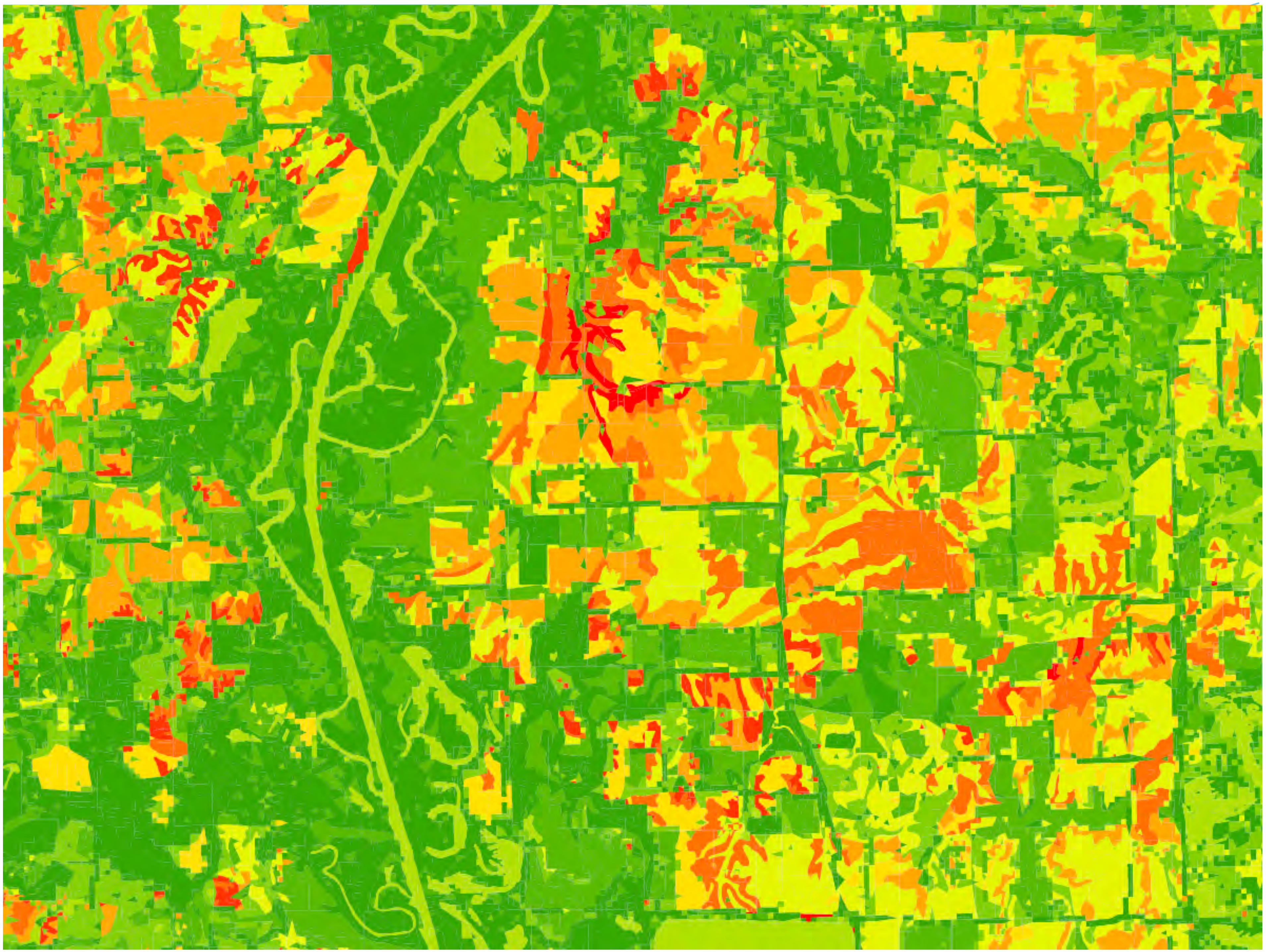
- SWAMM is being use to:
  - Identify and target conservation practices to areas of high pollution loading
  - Establish numerical water quality targets and performance measures for conservation staff
  - Quantify total pollutant load reductions
  - Assess whether or not target load reductions are being achieved

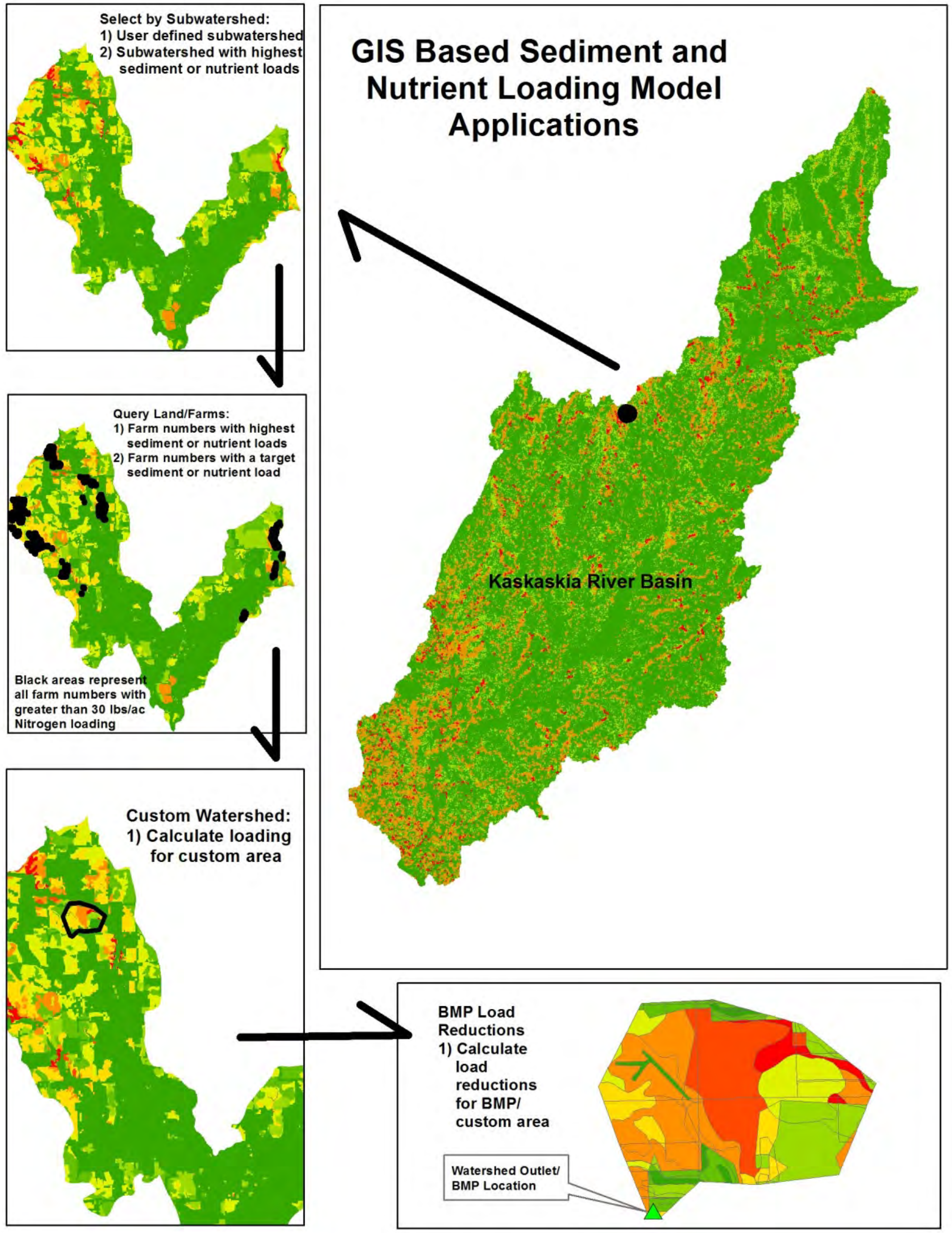
Illinois/ Kaskaskia River Basin

- Constructed 4 separate models
  - Kaskaskia
  - Lower Illinois River
  - Middle Illinois River
  - Upper Illinois River

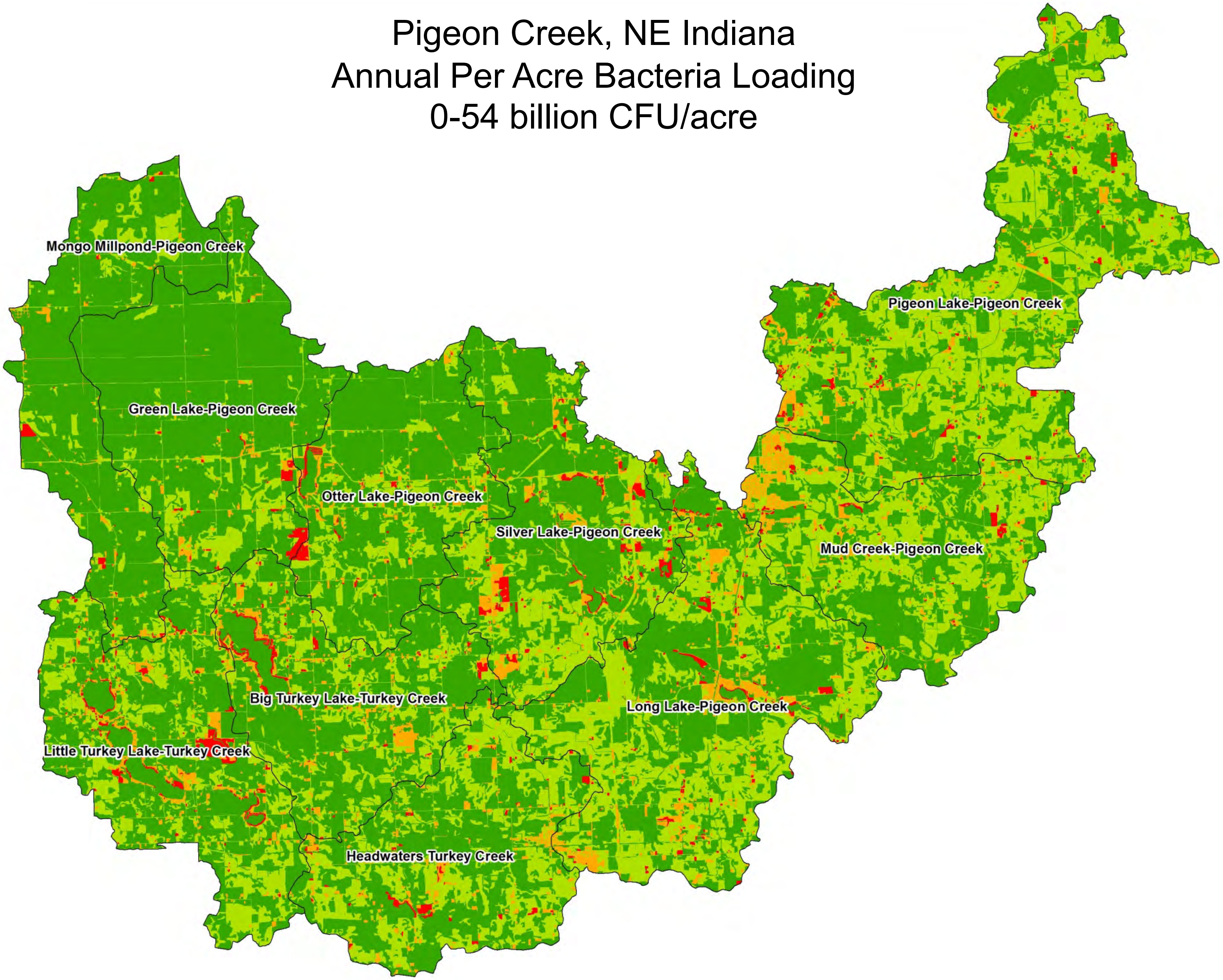


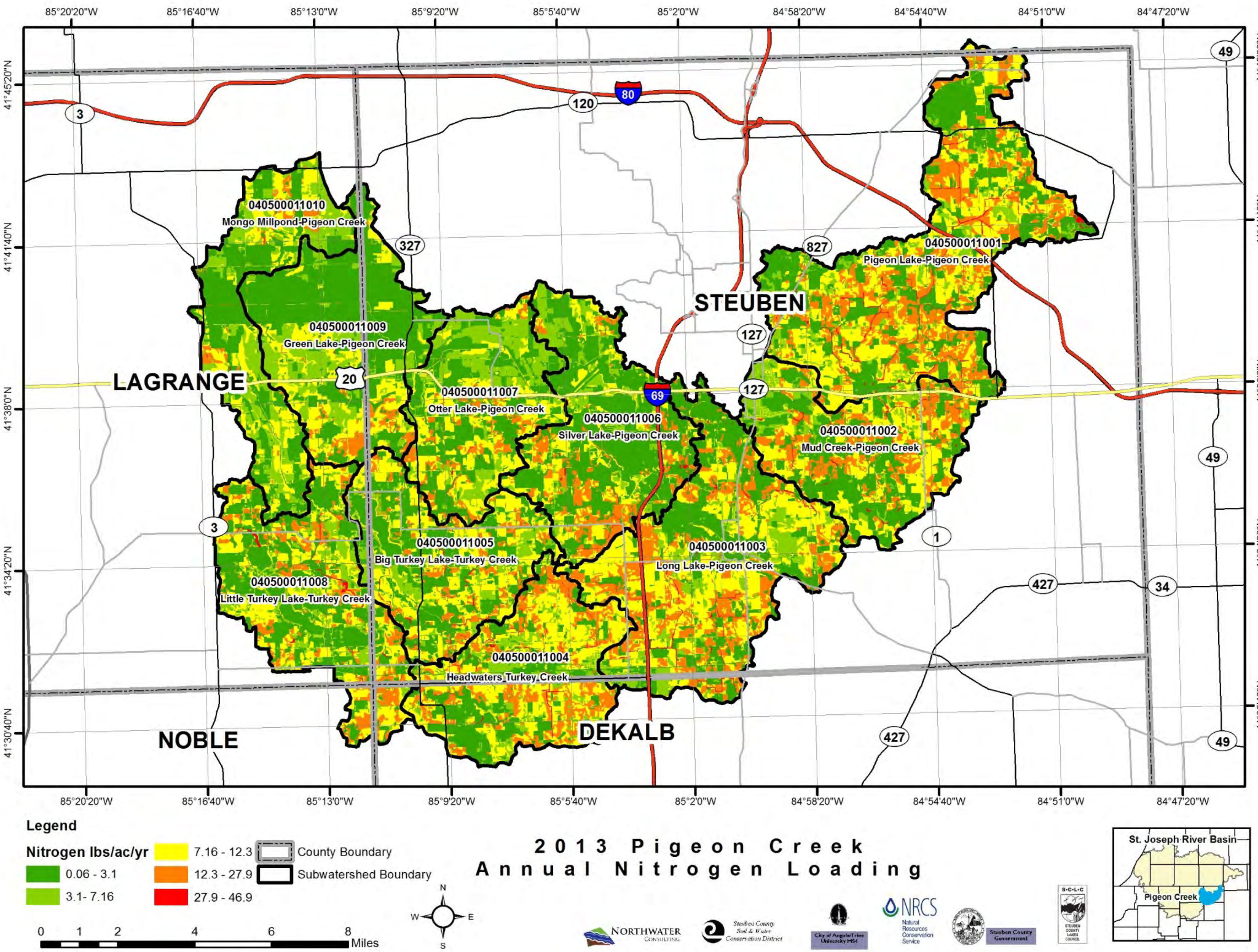

Nitrogen Per Acre
N



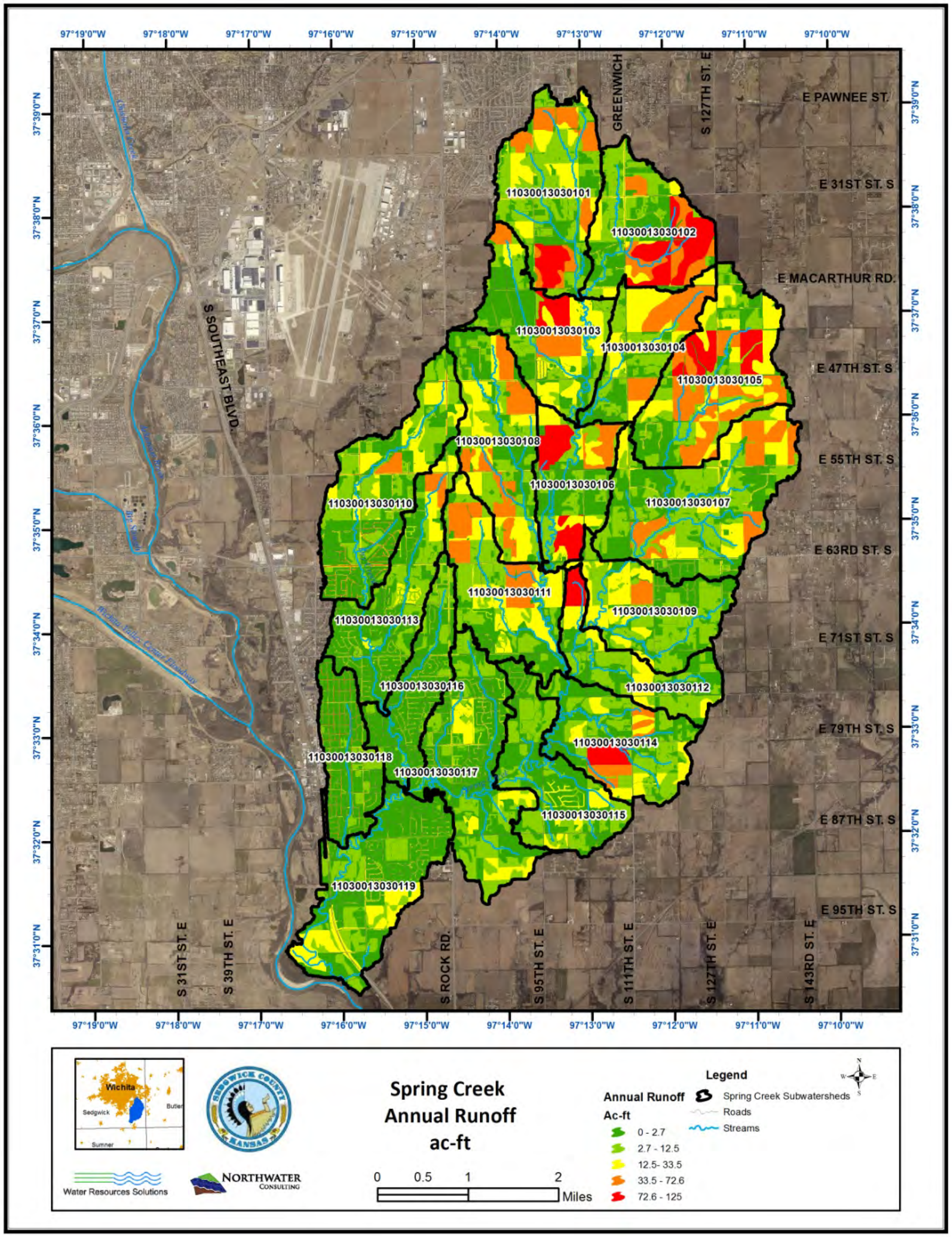

GIS Based Sediment and Nutrient Loading Model Applications
Select by Subwatershed:
1) User defined subwatershed
2) Subwatershed with highest sediment or nutrient loads
Query Land/Farms:
1) Farm numbers with highest sediment or nutrient loads
2) Farm numbers with a target sediment or nutrient load
Black areas represent all farm numbers with greater than 30 lbs/ac Nitrogen loading
Custom Watershed:
1) Calculate loading for custom area
Kaskaskia River Basin
BMP Load Reductions
1) Calculate load reductions for BMP/ custom area
Watershed Outlet/ BMP Location

Pigeon Creek, NE Indiana
Annual Per Acre Bacteria Loading
0-54 billion CFU/acre

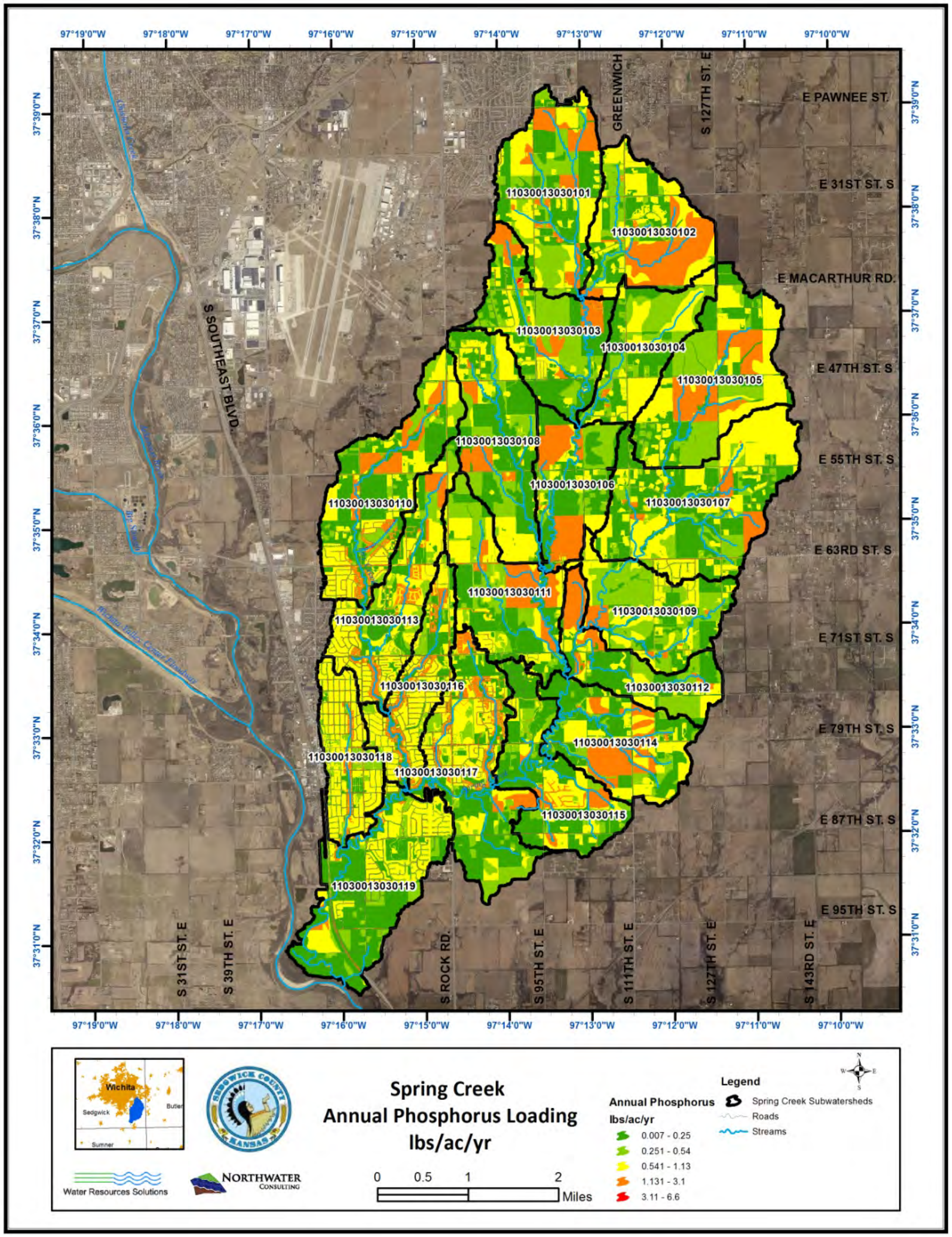


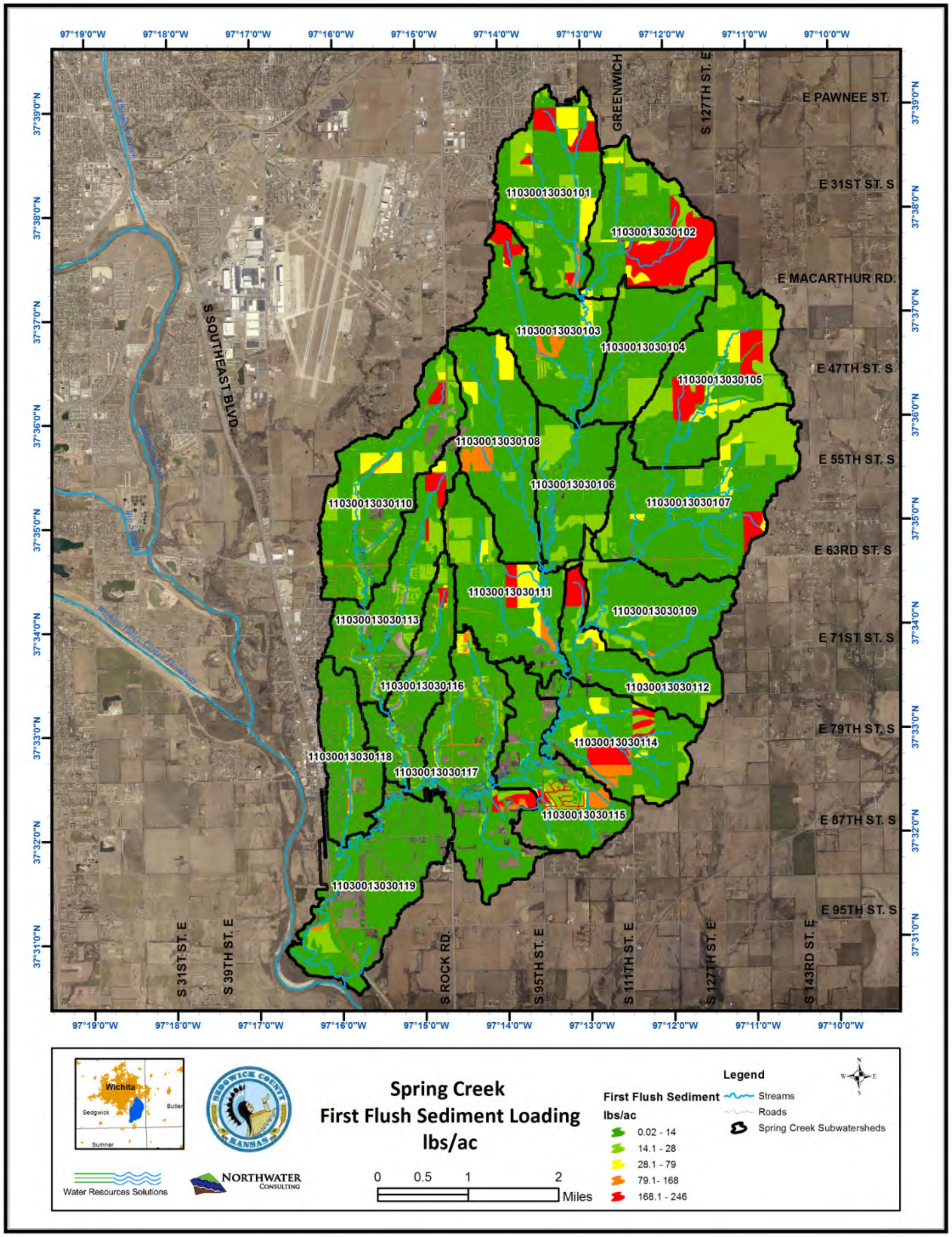


2013 Pigeon Creek Annual Nitrogen Loading



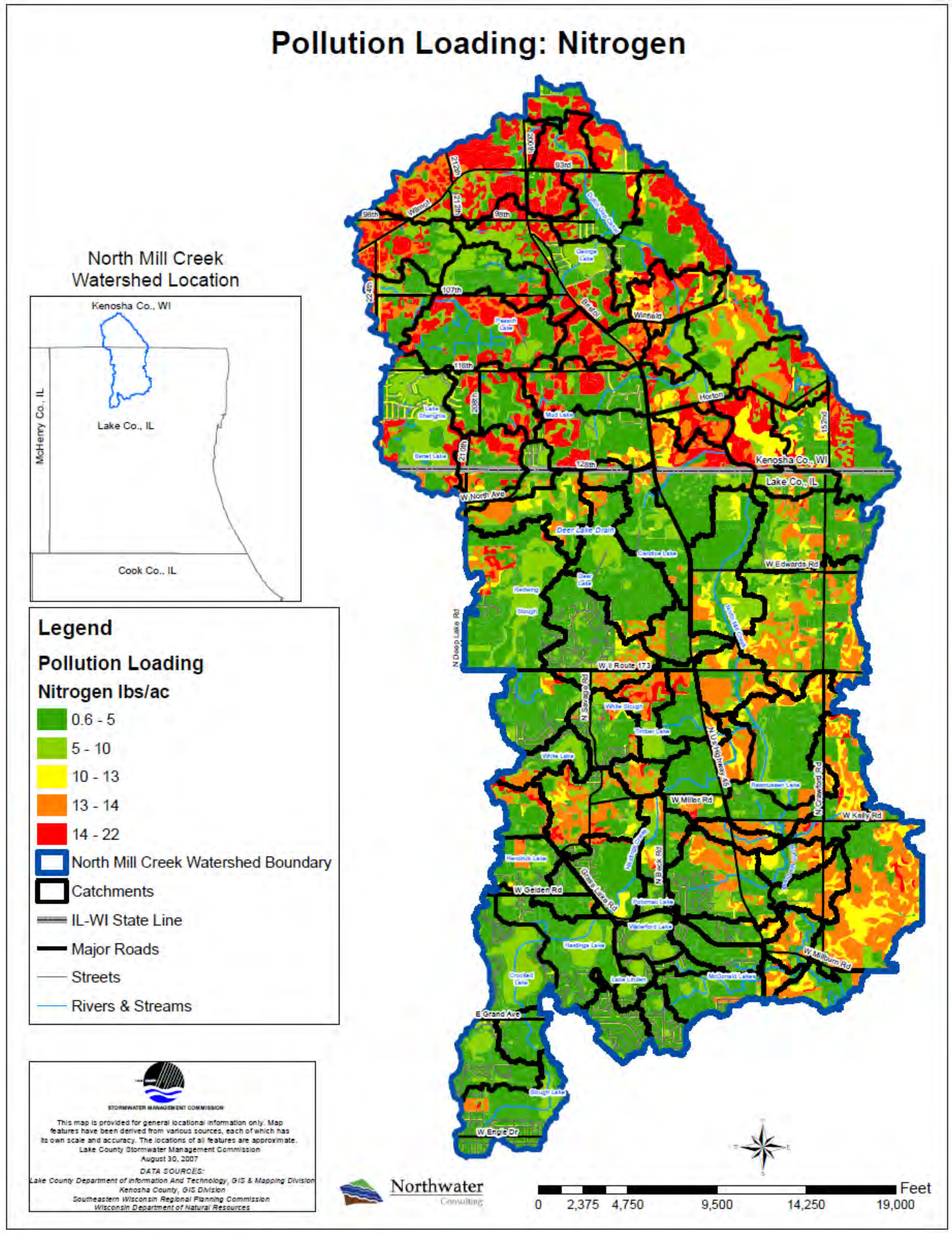
Spring Creek
Annual Runoff
ac-ft
Legend
Annual Runoff
Ac-ft
0 - 2.7
2.7 - 12.5
12.5- 33.5
33.5 - 72.6
72.6 - 125
Spring Creek Subwatersheds
Roads
Streams
0
0.5
1
2
Miles
Wichita
Sedgwick
Butler
Sumner
Water Resources Solutions
NORTHWATER CONSULTING
SEDGWICK COUNTY KANSAS
E PAWNEE ST.
E 31ST ST. S
E MACARTHUR RD.
E 47TH ST. S
E 55TH ST. S
E 63RD ST. S
E 71ST ST. S
E 79TH ST. S
E 87TH ST. S
E 95TH ST. S
GREENWICH
S 127TH ST. E
S SOUTHEAST BLVD.
S 31ST ST. E
S 39TH ST. E
S ROCK RD.
S 95TH ST. E
S 111TH ST. E
S 127TH ST. E
S 143RD ST. E
11030013030101
11030013030102
11030013030103
11030013030104
11030013030105
11030013030106
11030013030107
11030013030108
11030013030109
11030013030110
11030013030111
11030013030112
11030013030113
11030013030114
11030013030115
11030013030116
11030013030117
11030013030118
11030013030119
97°19'0"W
97°18'0"W
97°17'0"W
97°16'0"W
97°15'0"W
97°14'0"W
97°13'0"W
97°12'0"W
97°11'0"W
97°10'0"W
37°39'0"N
37°38'0"N
37°37'0"N
37°36'0"N
37°35'0"N
37°34'0"N
37°33'0"N
37°32'0"N
37°31'0"N

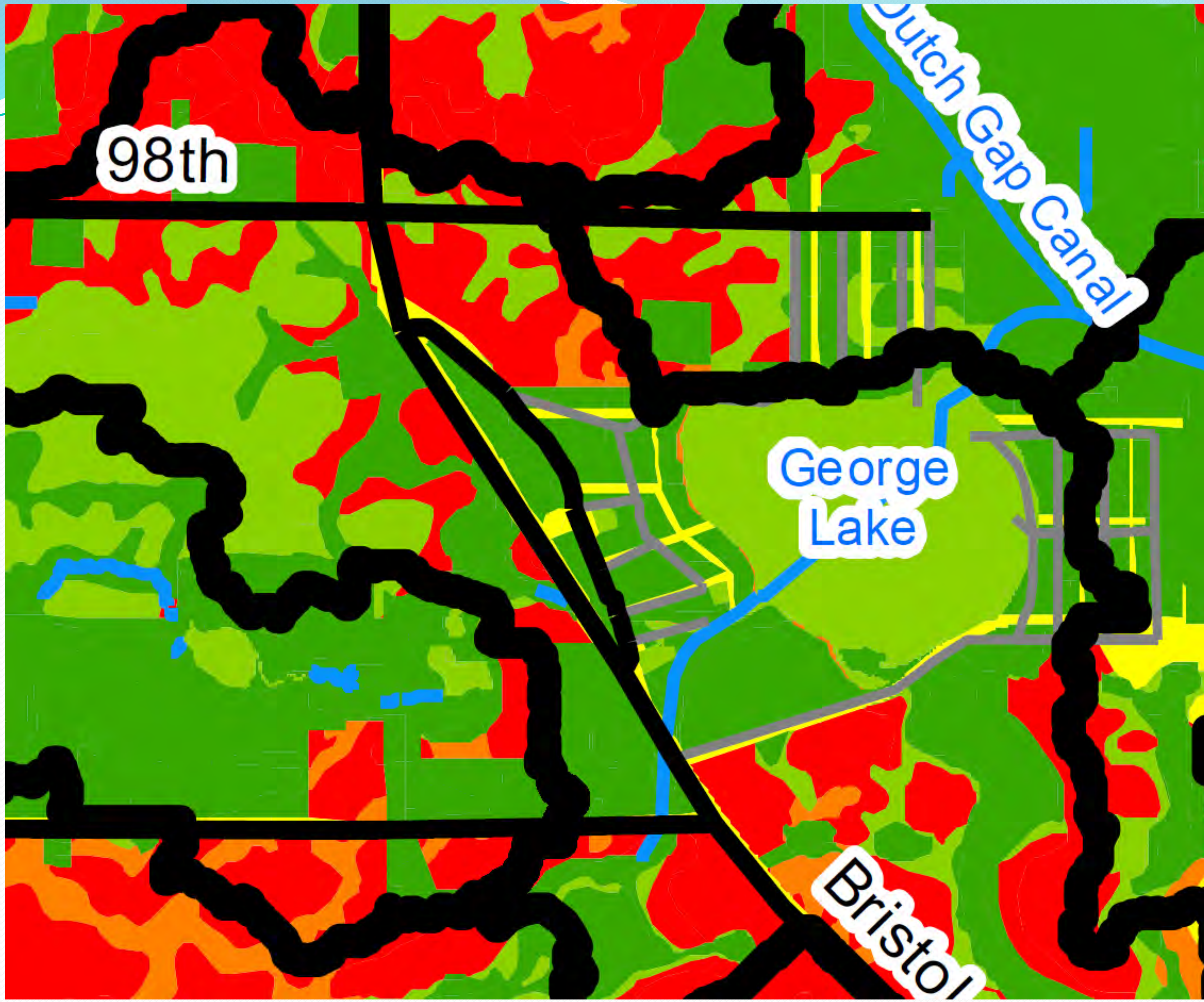

Spring Creek
Annual Phosphorus Loading
lbs/ac/yr
Legend
Spring Creek Subwatersheds
Roads
Streams
Annual Phosphorus
lbs/ac/yr
0.007 - 0.25
0.251 - 0.54
0.541 - 1.13
1.131 - 3.1
3.11 - 6.6
0 0.5 1 2 Miles
Wichita
Sedgwick
Butler
Sumner
Water Resources Solutions
NORTHWATER CONSULTING
E PAWNEE ST.
E 31ST ST. S
E MACARTHUR RD.
E 47TH ST. S
E 55TH ST. S
E 63RD ST. S
E 71ST ST. S
E 79TH ST. S
E 87TH ST. S
E 95TH ST. S
GREENWICH
S 127TH ST. E
S SOUTHEAST BLVD.
S 31ST ST. E
S 39TH ST. E
S ROCK RD.
S 95TH ST. E
S 111TH ST. E
S 127TH ST. E
S 143RD ST. E
11030013030101
11030013030102
11030013030103
11030013030104
11030013030105
11030013030106
11030013030107
11030013030108
11030013030109
11030013030110
11030013030111
11030013030112
11030013030113
11030013030114
11030013030115
11030013030116
11030013030117
11030013030118
11030013030119
97°19'0"W
97°18'0"W
97°17'0"W
97°16'0"W
97°15'0"W
97°14'0"W
97°13'0"W
97°12'0"W
97°11'0"W
97°10'0"W
37°39'0"N
37°38'0"N
37°37'0"N
37°36'0"N
37°35'0"N
37°34'0"N
37°33'0"N
37°32'0"N
37°31'0"N

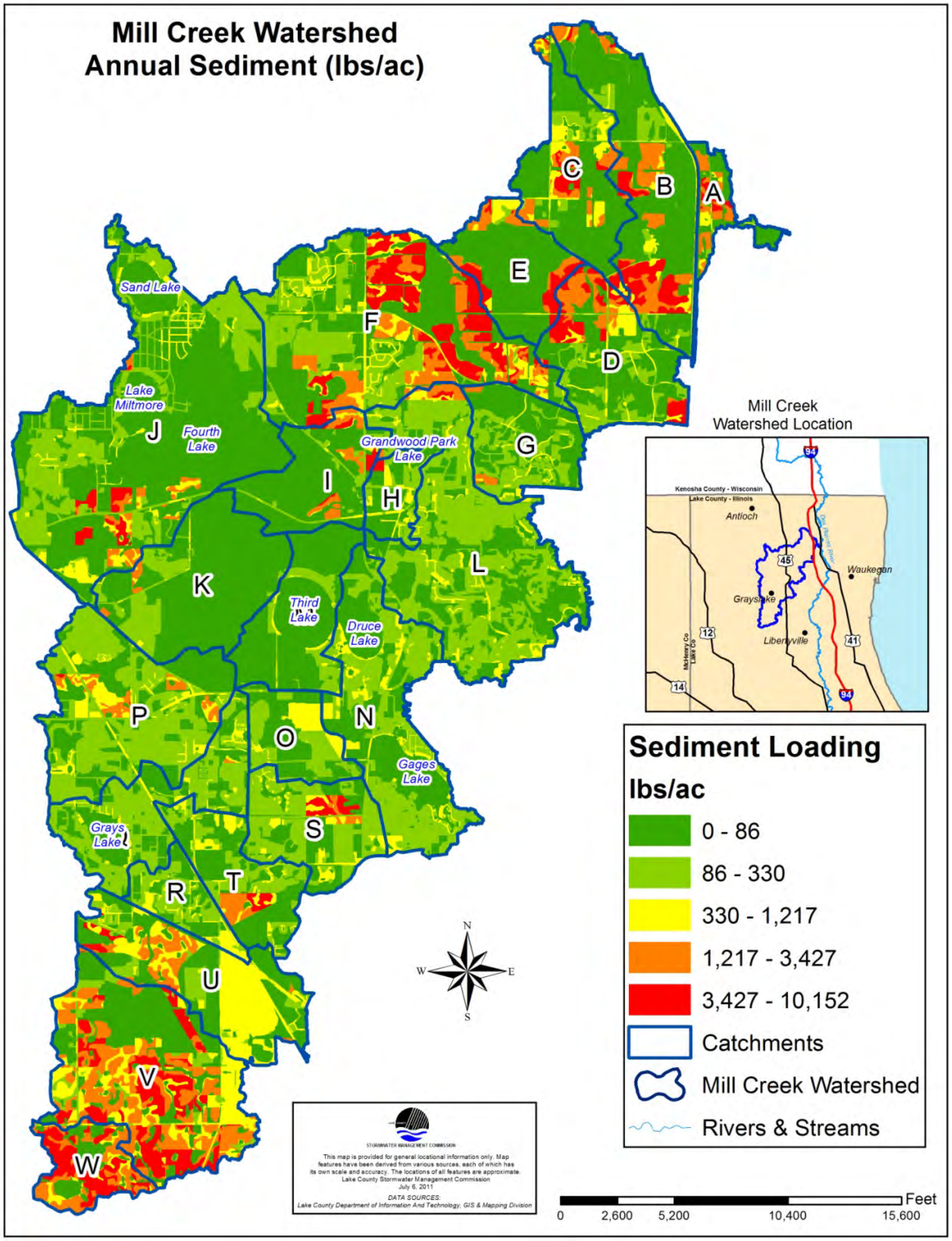


Spring Creek
First Flush Sediment Loading
lbs/ac
Legend
First Flush Sediment
lbs/ac
0.02 - 14
14.1 - 28
28.1 - 79
79.1 - 168
168.1 - 246
Streams
Roads
Spring Creek Subwatersheds
0
0.5
1
2
Miles
Wichita
Sedgwick
Butler
Sumner
Water Resources Solutions
NORTHWATER
CONSULTING
E PAWNEE ST.
E 31ST ST. S
E MACARTHUR RD.
E 47TH ST. S
E 55TH ST. S
E 63RD ST. S
E 71ST ST. S
E 79TH ST. S
E 87TH ST. S
E 95TH ST. S
GREENWICH
S 127TH ST. E
S SOUTHEAST BLVD.
S 31ST ST. E
S 39TH ST. E
S ROCK RD.
S 95TH ST. E
S 111TH ST. E
S 127TH ST. E
S 143RD ST. E
11030013030101
11030013030102
11030013030103
11030013030104
11030013030105
11030013030106
11030013030107
11030013030108
11030013030109
11030013030110
11030013030111
11030013030112
11030013030113
11030013030114
11030013030115
11030013030116
11030013030117
11030013030118
11030013030119
97°19'0"W
97°18'0"W
97°17'0"W
97°16'0"W
97°15'0"W
97°14'0"W
97°13'0"W
97°12'0"W
97°11'0"W
97°10'0"W
37°39'0"N
37°38'0"N
37°37'0"N
37°36'0"N
37°35'0"N
37°34'0"N
37°33'0"N
37°32'0"N
37°31'0"N

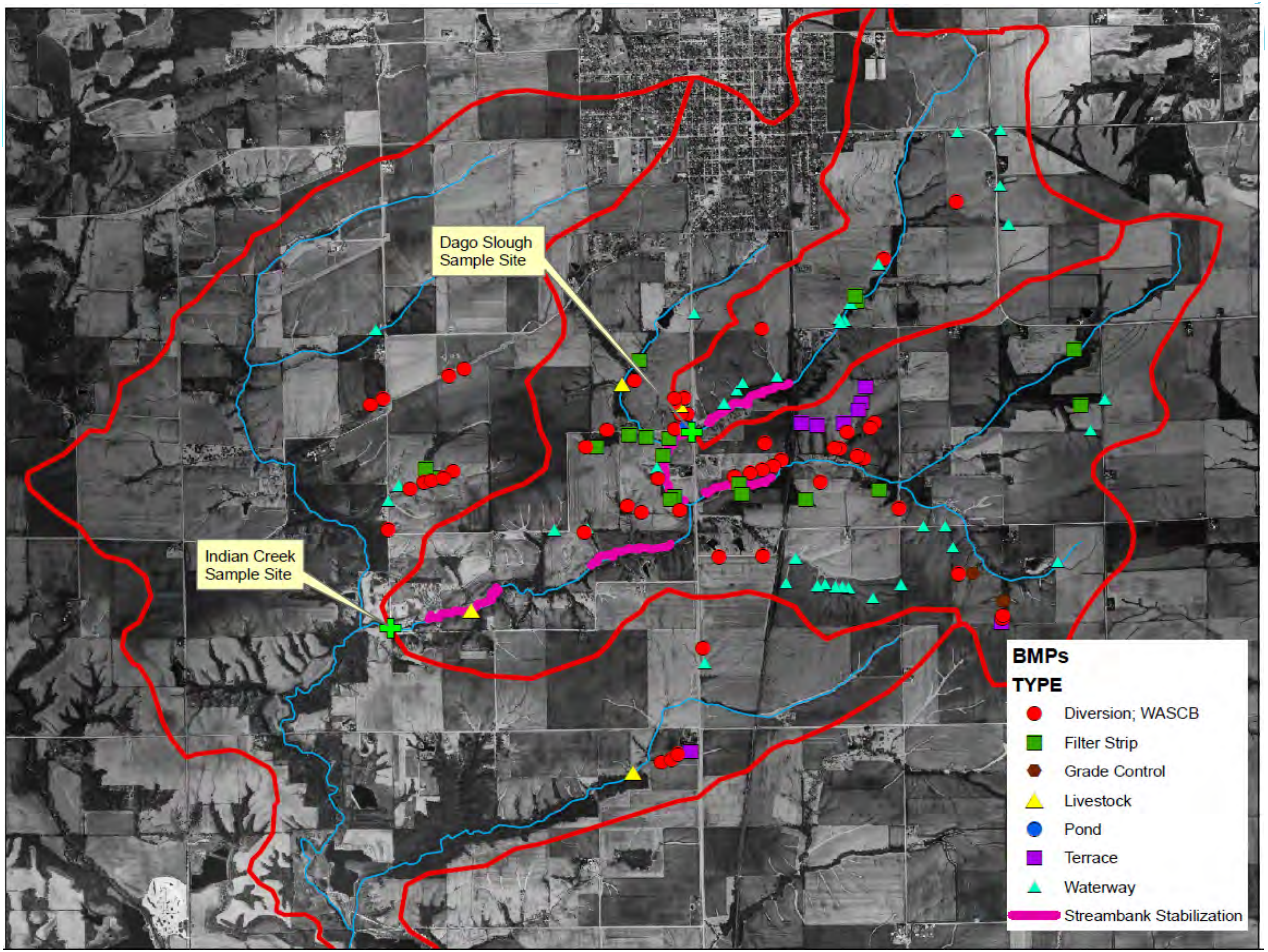
North Mill Creek / Dutch Gap Watershed Northern Illinois and South Wisconsin



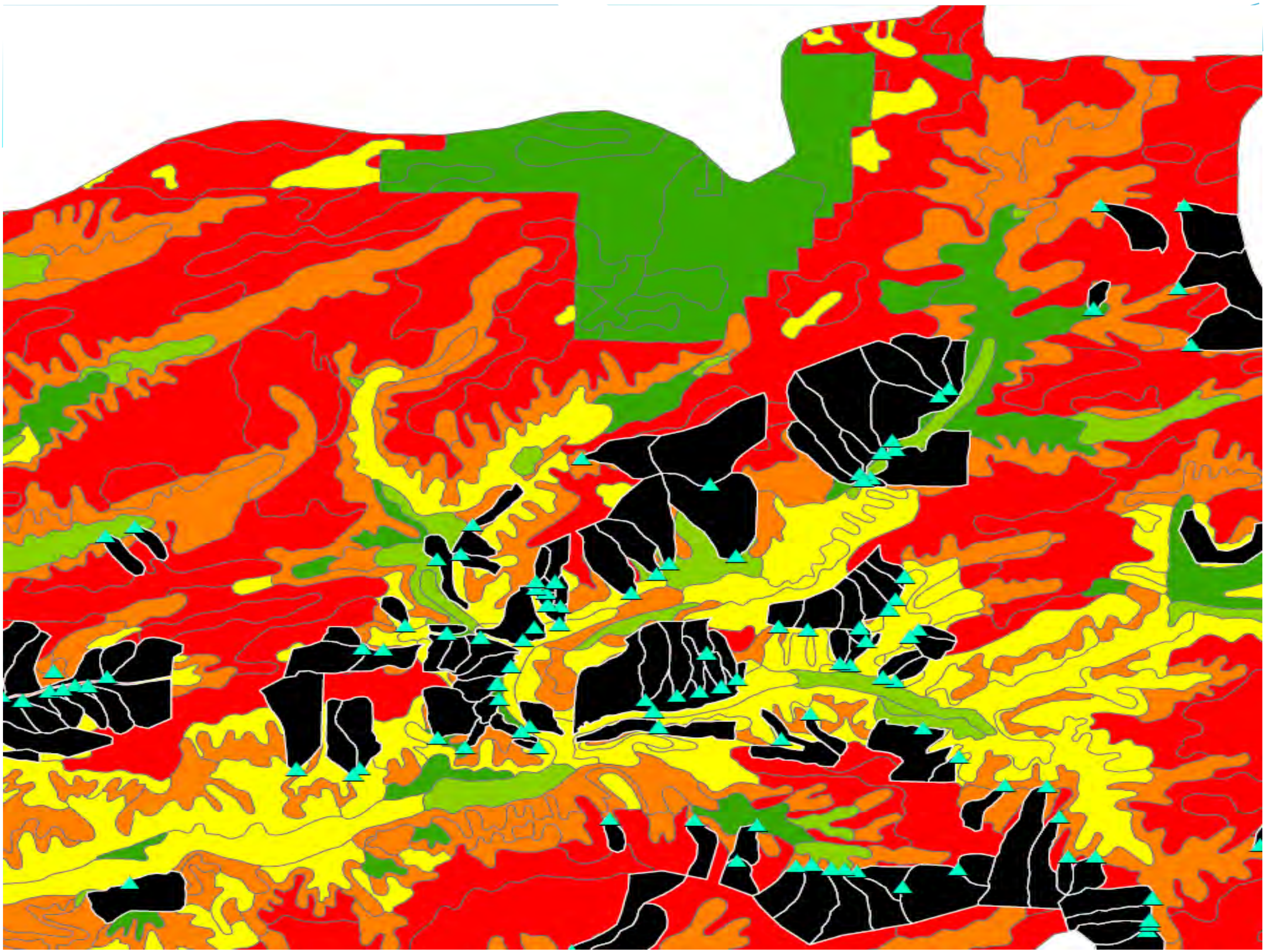

98th
Dutch Gap Canal
George
Lake
Bristol



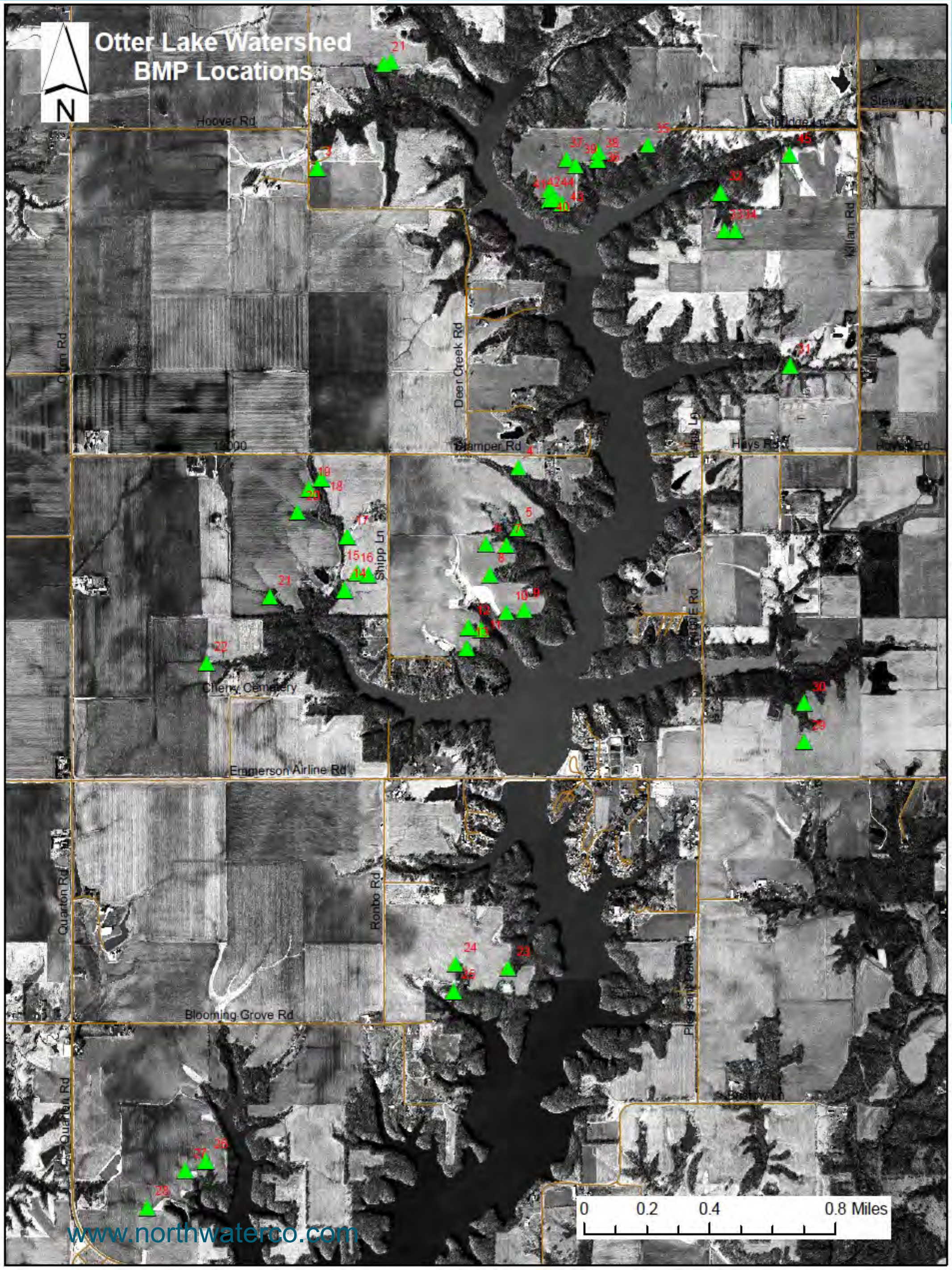
Mill Creek Watershed
Annual Sediment (lbs/ac)
A
B
C
D
E
F
G
H
I
J
K
L
N
O
P
R
S
T
U
V
W
Sand Lake
Lake Miltmore
Fourth Lake
Grandwood Park Lake
Third Lake
Druce Lake
Gages Lake
Grays Lake
Mill Creek Watershed Location
Antioch
Waukegan
Grayslake
Libertyville
Sediment Loading
lbs/ac
0 - 86
86 - 330
330 - 1,217
1,217 - 3,427
3,427 - 10,152
Catchments
Mill Creek Watershed
Rivers & Streams
N
S
E
W
Feet
0
2,600
5,200
10,400
15,600

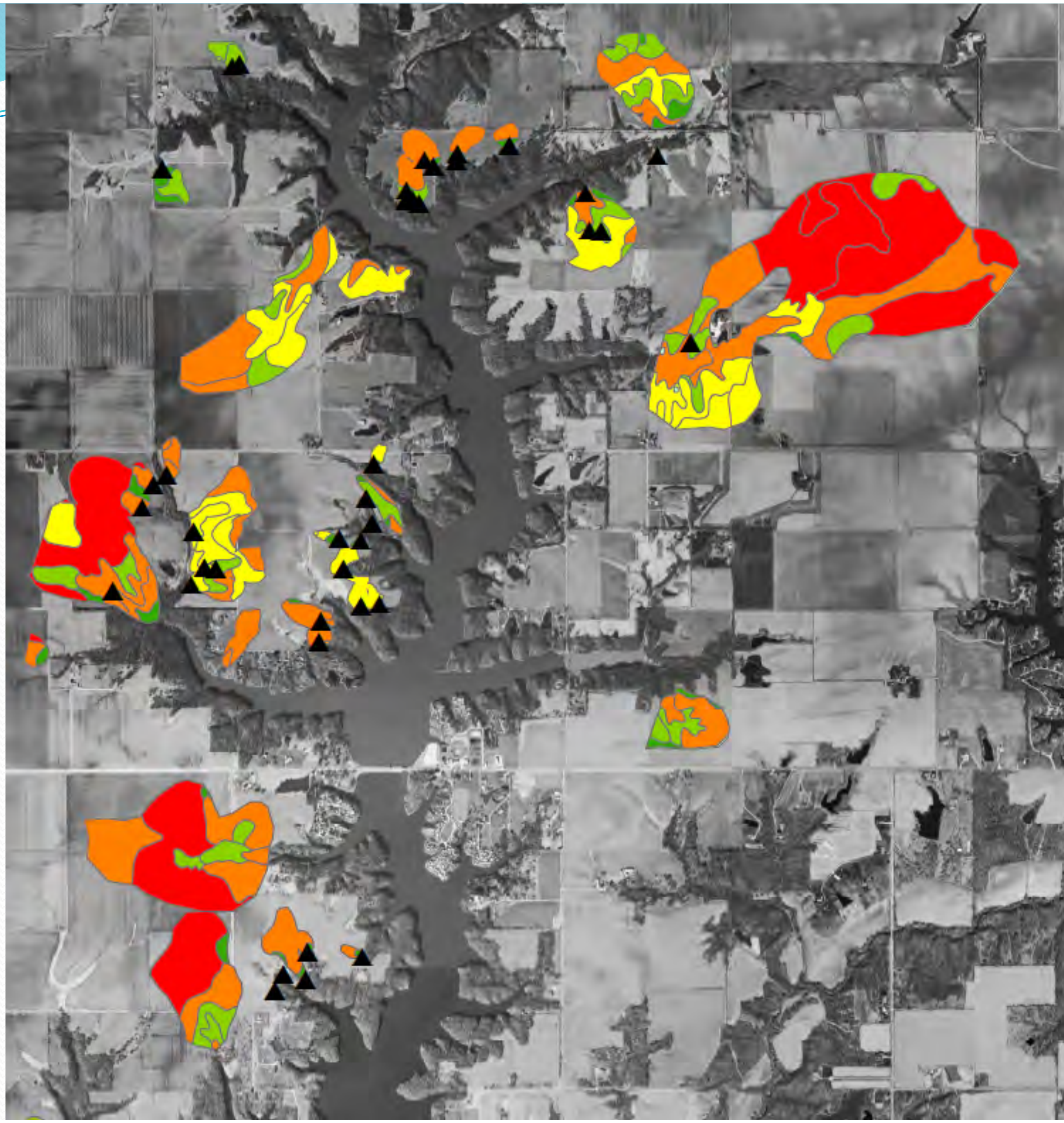


Dago Slough
Sample Site
Indian Creek
Sample Site
BMPs
TYPE
Diversion; WASCB
Filter Strip
Grade Control
Livestock
Pond
Terrace
Waterway
Streambank Stabilization



Otter Lake
Public Water
Supply












Any Questions?