SUSTAINABILITY OF AGRICULTURAL SYSTEMS: CONCEPT TO APPLICATION.

(WATER QUALITY PROTECTION OF THE GRAND LAKE ST. MARYS)

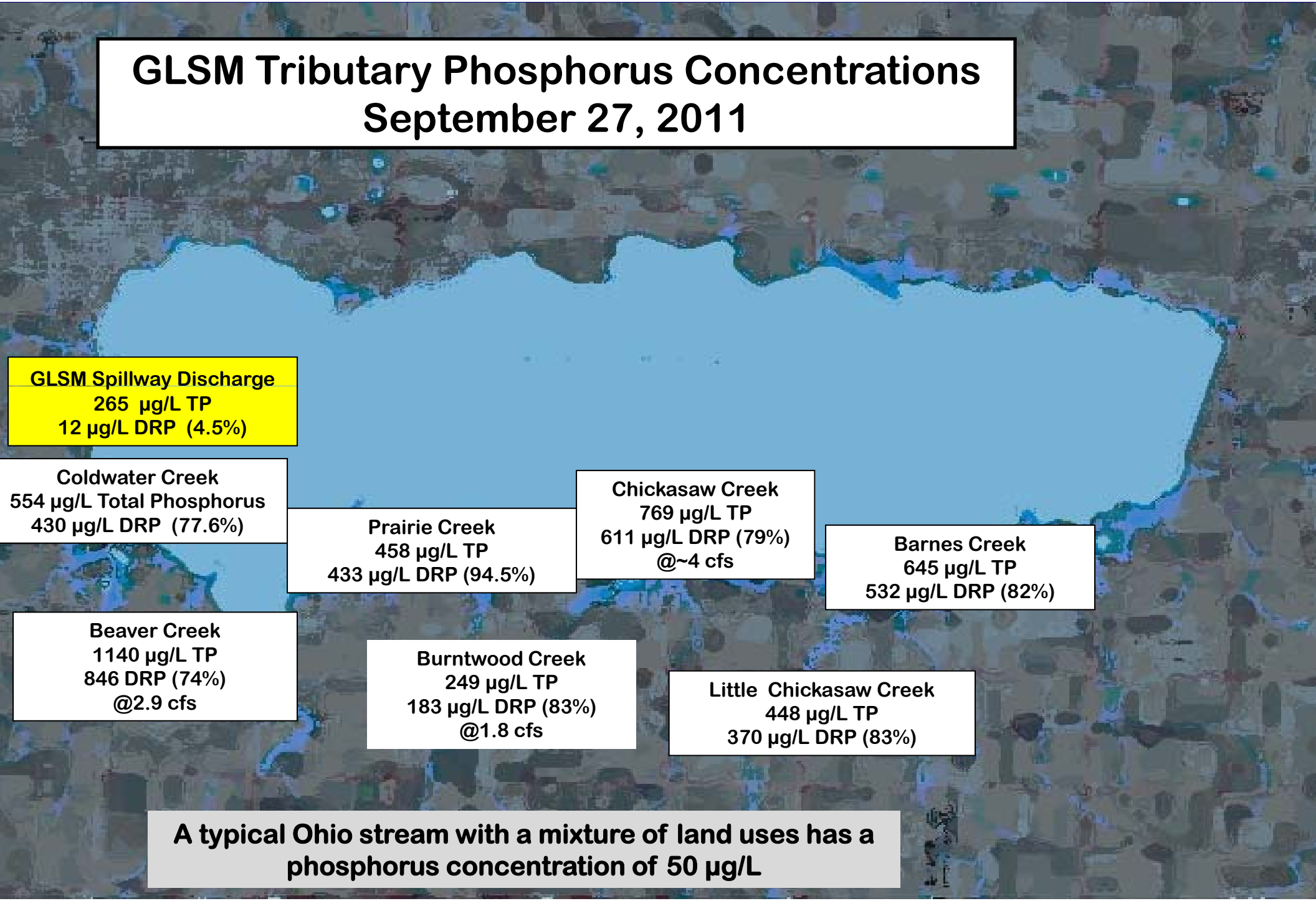
Yongping Yuan[1] and Milo Anderson[2]

1. EPA-ORD-Environmental Sciences Division, Las Vegas, NV
2. EPA-Region 5, Chicago, IL

2013 Annual International Meeting
July 24, 2013

Problem Statement

- **Grand Lake St. Marys in northwestern Ohio is experiencing toxic levels of algal blooms resulting from nutrient input from agricultural runoff.**


GLSM Tributary Phosphorus Concentrations
September 27, 2011
GLSM Spillway Discharge
265 µg/L TP
12 µg/L DRP (4.5%)
Coldwater Creek
554 µg/L Total Phosphorus
430 µg/L DRP (77.6%)
Prairie Creek
458 µg/L TP
433 µg/L DRP (94.5%)
Chickasaw Creek
769 µg/L TP
611 µg/L DRP (79%)
@~4 cfs
Barnes Creek
645 µg/L TP
532 µg/L DRP (82%)
Beaver Creek
1140 µg/L TP
846 DRP (74%)
@2.9 cfs
Burntwood Creek
249 µg/L TP
183 µg/L DRP (83%)
@1.8 cfs
Little Chickasaw Creek
448 µg/L TP
370 µg/L DRP (83%)
A typical Ohio stream with a mixture of land uses has a phosphorus concentration of 50 µg/L

Objectives

- To provide practical information to government officials and local land owners that helps to target the algae blooms in the lake.
- To achieve long term water quality protection of the GLSM.

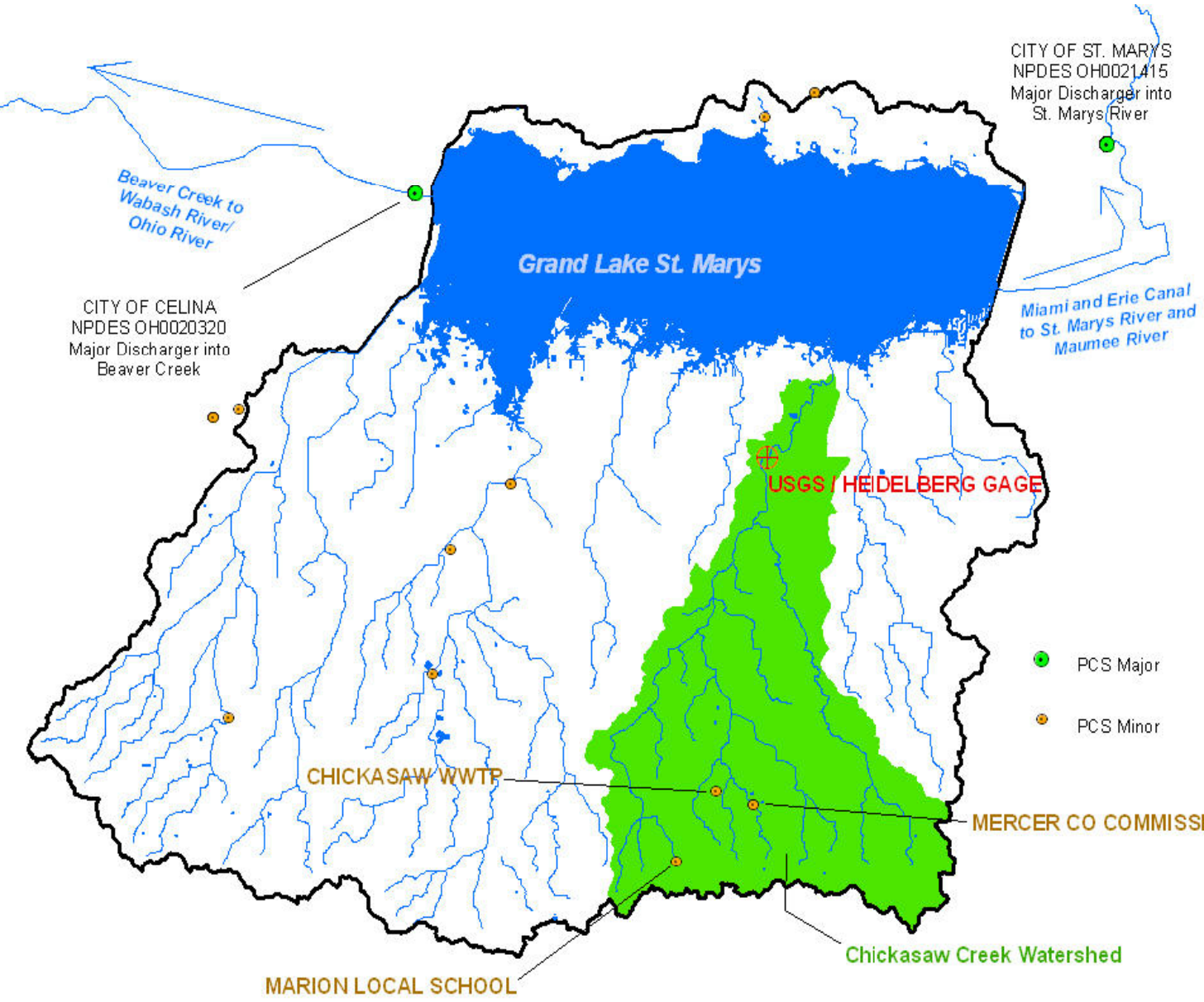
Watershed Characteristics

- The watershed is predominantly under agricultural production with corn and soybeans as major crops.
- Other crops include alfalfa, winter wheat and hay.
- Many farmers own CAFOs to sustain local economy due to the small acreage of farm land they own.

Questions to be addressed

- Whether CAFO/AFO production is sustainable in terms of the amount of animal manure produced?
- Whether point source discharges contribute to the algae bloom significantly?
- If conservation practices can be adopted to limit nutrient loadings to the lake?
- If existing drainage entering the lake from the contributing watershed can be controlled or altered to improve the lake's water quality?

Chickasaw Tributary Selected as Pilot Watershed



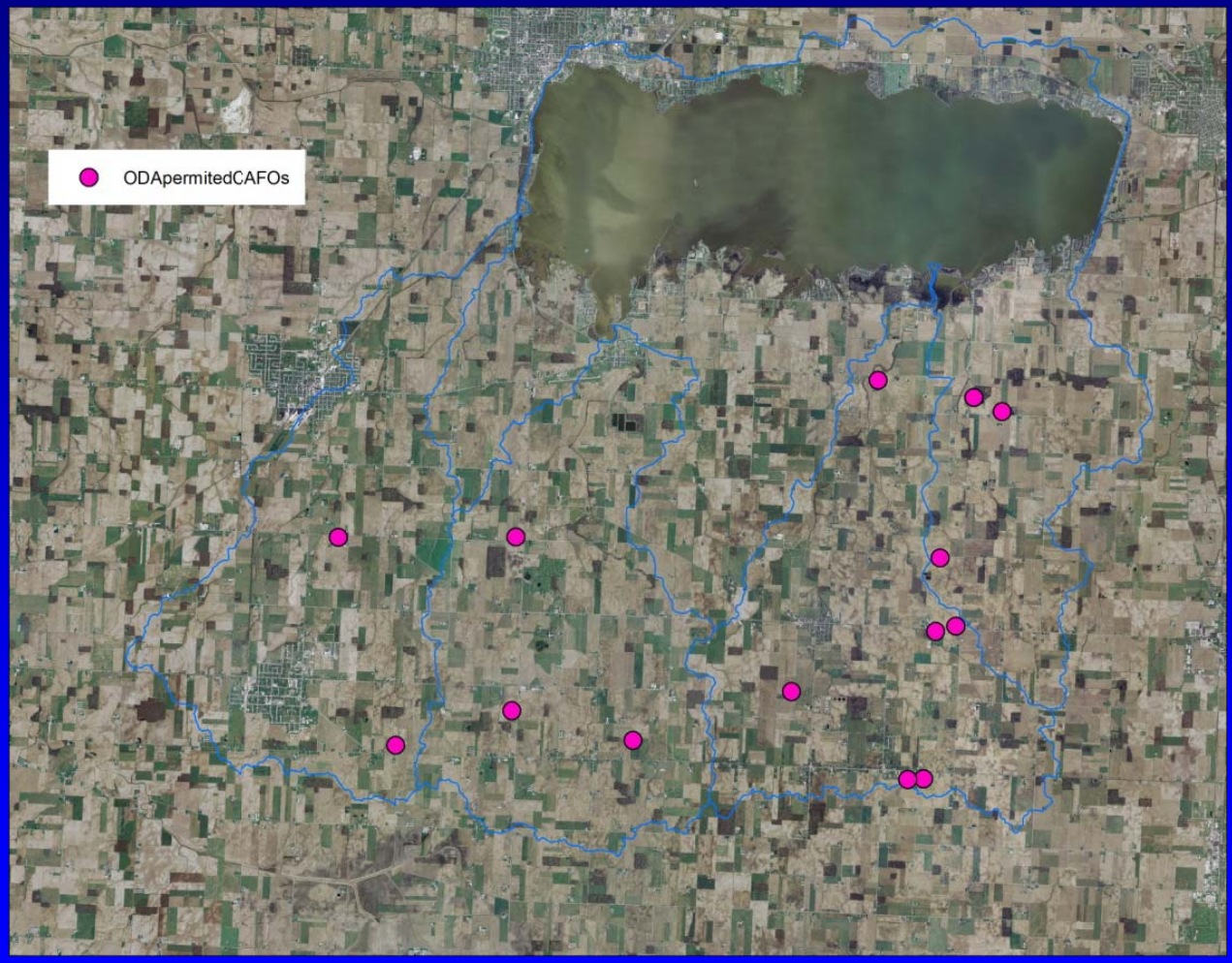
Chickasaw Creek Watershed:
12,900 Acres

85.2% Agricultural
9.5% Urban
3.2% Wooded

3 Minor Permitted Discharges in Headwaters of Chickasaw Watershed

CAFO / AFO Mapping

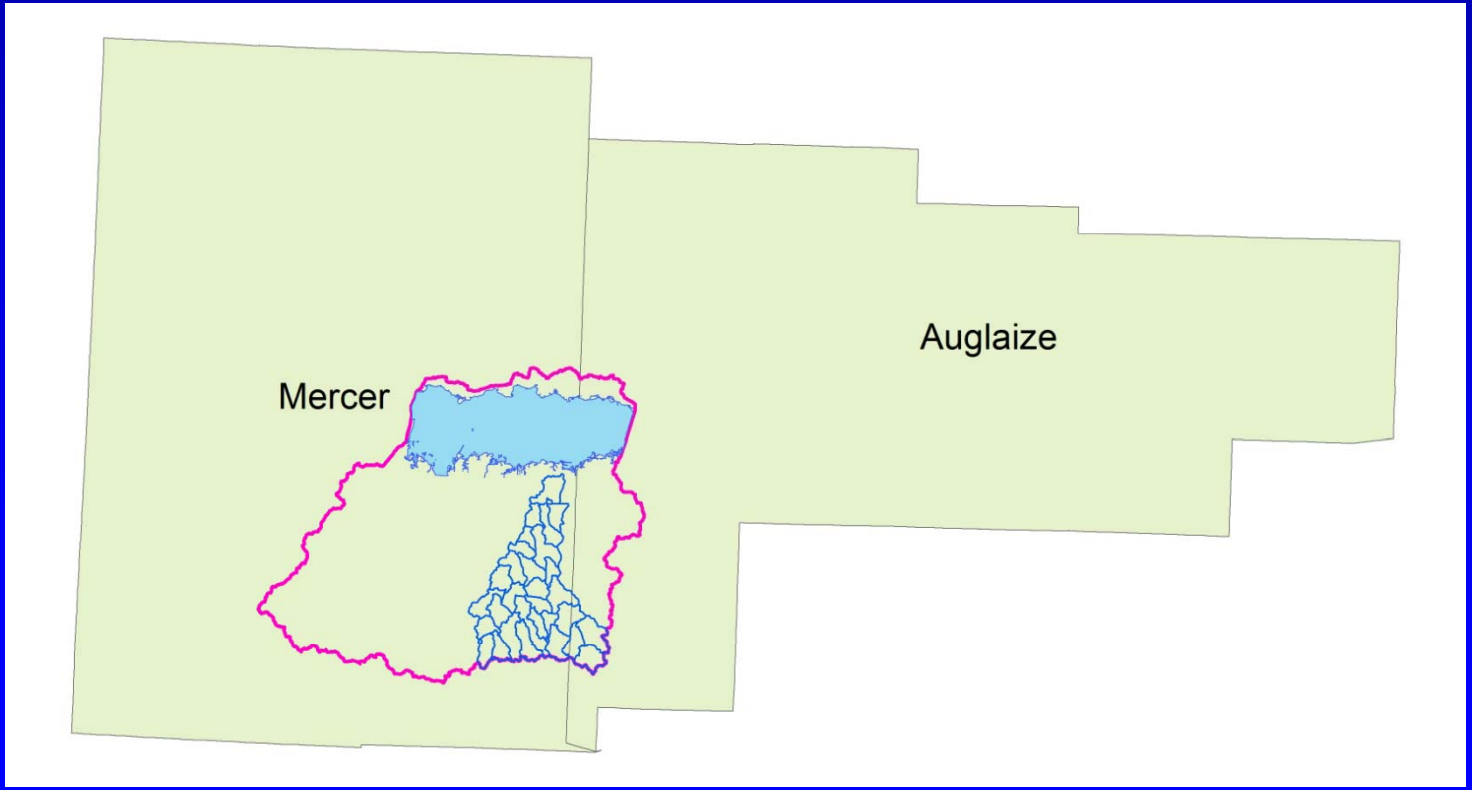
- Spatial distribution of CAFO / AFO (number and type) is poorly known.
- Ohio Department of Agriculture has 14 large permitted facilities.



County Level Data and Watershed Data

- **County level CAFO/AFO data show total number of animals and waste produced, but do not show where they applied…**

Watershed models for GLSM need more detailed information



*One animal unit = 1000 lbs; chicken information was obtained from the census data of 2007

Animal Waste and Nutrient Content Estimation

- **Animal totals were summarized per county.**
- **Manure recovery and nutrient content were obtained from literature.**
- **Example of two counties, Auglaize and Mercer.**

Table 1. Estimated total animal waste produced in Auglaize County

Species	Total head	Head/Animal Unit*	Total Animal Unit	Manure Produced (Tons/AU/Year)	Total Waste produced (Tons/Year)
Cattle	19,700	1.0	19,700	11.5	226,550
Milk cows	5,300	0.74	7,162.2	15.24	109,151
Hogs & pigs	97,000	2.67	36,329.6	6.11	221,974
Chicken*	327,377	250	1,309.5	11.45	14,994
Sheep & lamb	800	10	80	N/A	
Total					572,669

***One animal unit (AU) = 1000 lbs;**

Table 2. Estimated manure recovery and its nutrient contents

Species	Manure recovered (%)	Nitrogen (N)	Phosphorus (P)	Potassium (K)
		Lbs/Tons manure after losses		
Cattle	75	3.3	3.23	7.44
Milk cows	90	4.3	1.65	6.04
Hogs & pigs	75	3.3	3.62	7.04
Chicken	100	18.5	8.50	9.40

Source: USDA – NRCS. Nutrients Available from Livestock Manure Relative to Crop Growth Requirements. 1998
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?&cid=nrcs143_014175

Table 3. Potential nutrients available from animal waste in Auglaize County and Mercer County

Species	Auglaize County (lbs/year)			Mercer County (lbs/year)		
	N	P	K	N	P	K
Cattle	560,711	548,817	1,264,149	2,191,612	2,145,124	4,941,090
Milk cows	422,416	162,090	593,347	1,673,723	642,242	2,350,997
Hogs & pigs	552,715	602,659	1,172,022	1,652,446	1,801,763	3,503,982
Chicken	276,787	127,448	140,942	4,632,217	2,132,928	2,358,767
Total	1,812,628	1,441,014	3,170,460	10,149,998	6,722,057	13,154,836

Crop Nutrient Uptake Estimation

- **Plant nutrient content values were obtained from literature.**

Table 4. Nutrient information in harvested plants.

Crop	Nitrogen	Phosphorous	Potassium
Corn (lbs/bushels)	0.8	0.15	0.17
Soybeans (lbs/bushels)	3.55	0.36	0.84
Oats (lbs/bushels)	0.59	0.11	0.12
Wheat (lbs/bushels)	1.23	0.23	0.26
Hay (lbs/tons)	25.6	4.48	15.04

Source: USDA – NRCS. Nutrients Available from Livestock Manure Relative to Crop Growth Requirements. 1998
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/nra/rca/?&cid=nrcs143_014150

Table 5. Crop harvested in Auglaize and Mercer County in 2008.

Crop	Auglaize	Mercer
Corn (Bushels)	774,2100	12,884,300
Soybeans (Bushels)	3,063,650	3,655,600
Oats (Bushels)	0	90,090
Wheat (bushels)	1,944,800	2,059,000
Hay (Tons)	24,400	51,090

- **Crop yields were summarized per county.**
- **Plant nutrient content values were obtained from literature.**

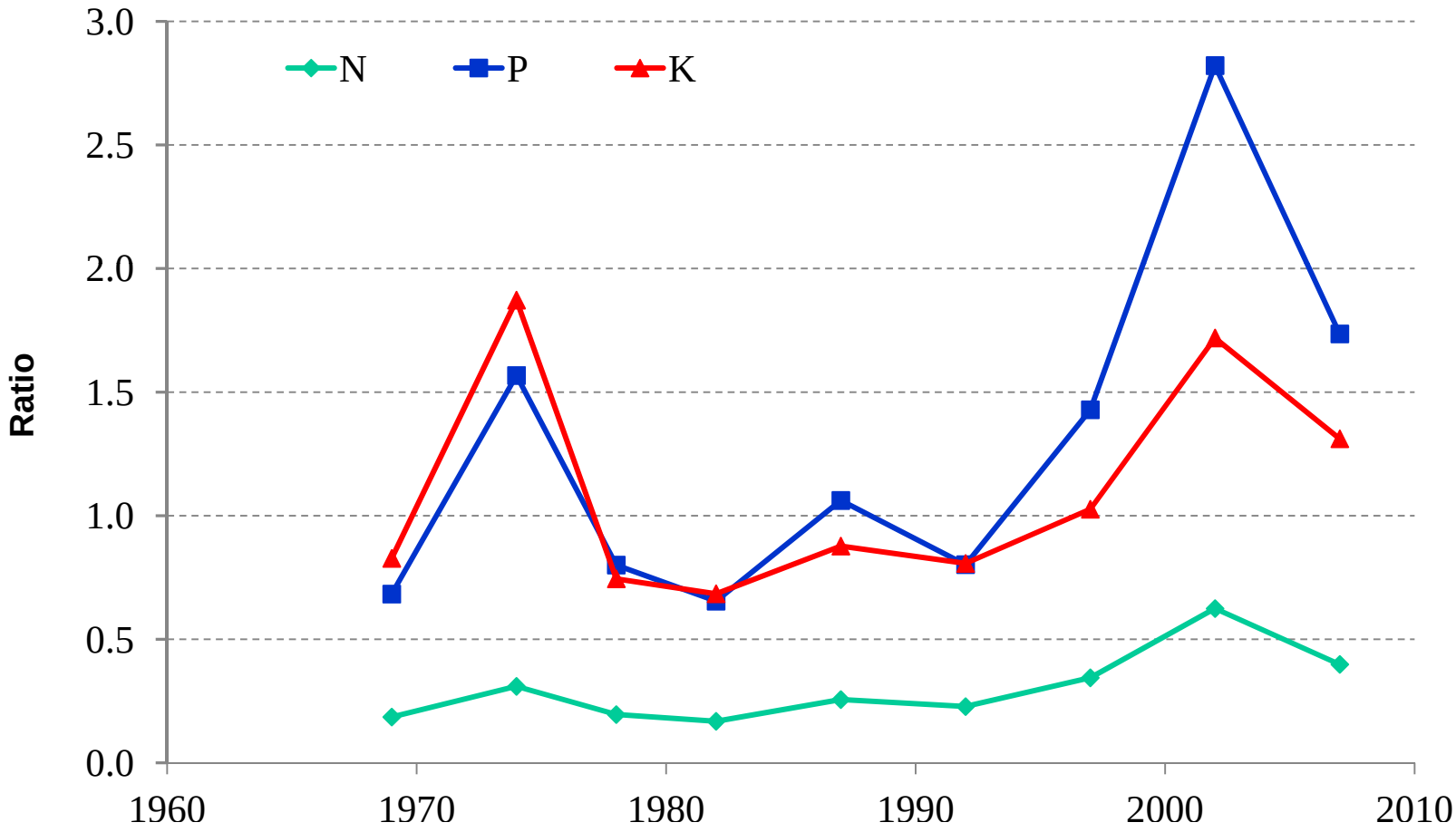
Table 8. total available nutrients and total removed in 2008 (ratio greater than 1 means an excess of nutrients)

Table 6. Estimated total nutrients available from animal manure and total by crop use (ratio >1 means available nutrient from animal manure is more than crop use).

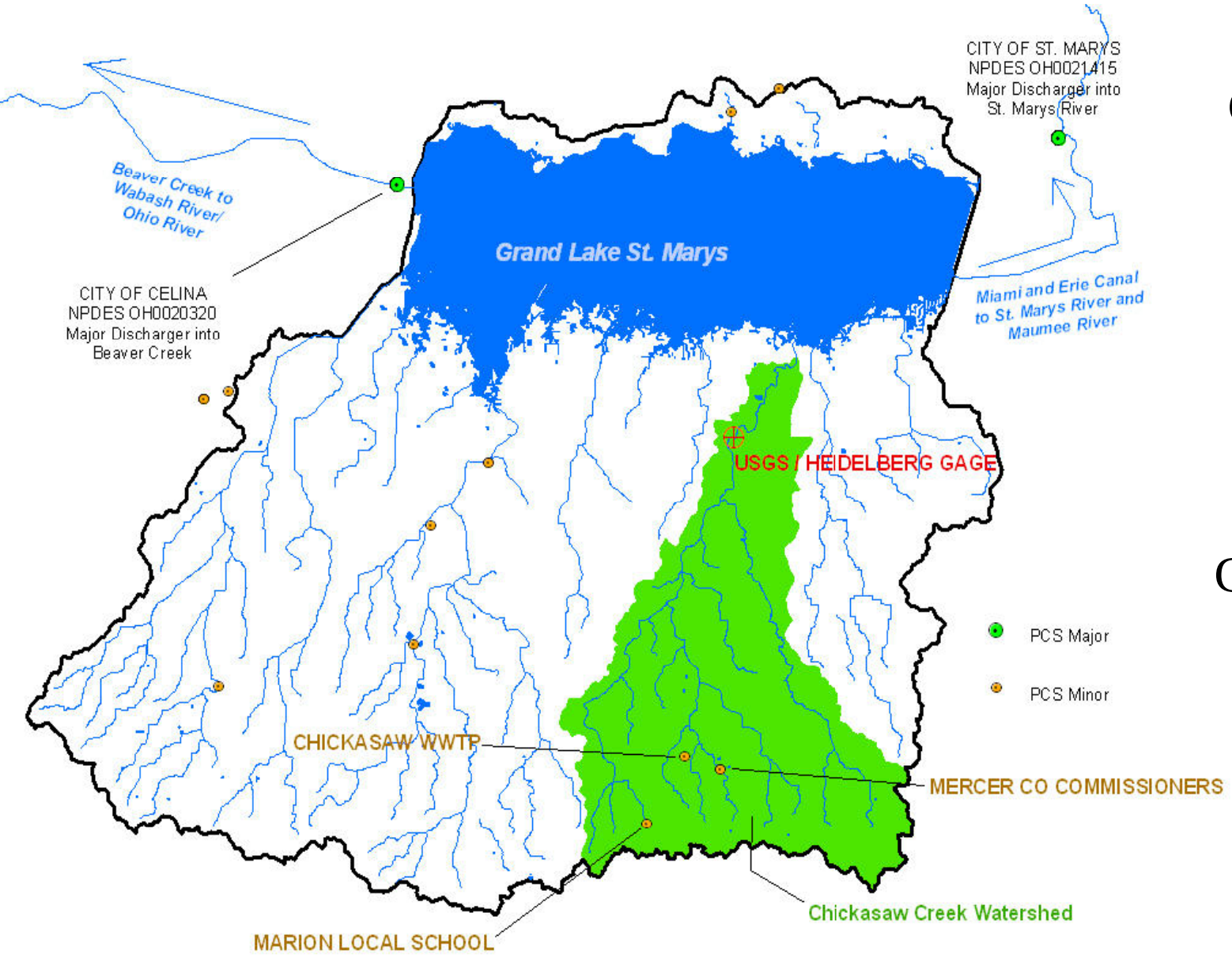
County	Auglaize (lbs/year)			Mercer County (lbs/year)		
Nutrients	N	P	K	N	P	K
Total from manure	1,812,629	1,441,014	3,170,460	10,149,998	6,722,057	13,154,836
Total harvested by crop	20,086,382	2,820,845	4,762,247	27,178,447	3,961,024	6,575,579
Ratio	0.09	0.51	0.67	0.37	1.70	2.00

Commercial fertilizer application is not counted.

Ratios of nutrients from animal manure to crop production (N, P and K) in Mercer County



Chickasaw Tributary Selected as Pilot Watershed

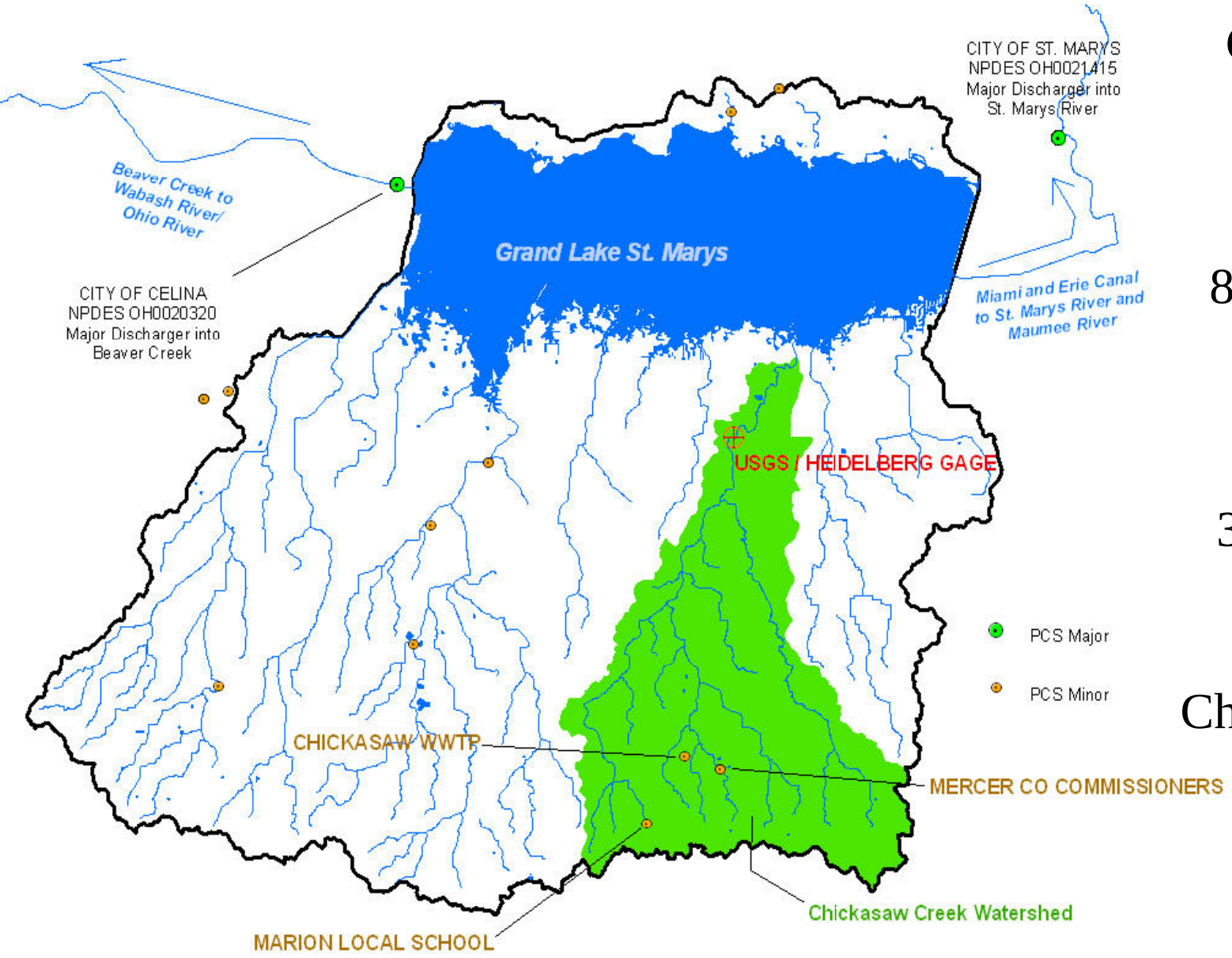


GLSM Watershed:
72,900 Acres

Grand Lake:
13,500 Acres

Chickasaw Creek
Watershed:
12,900 Acres

Chickasaw Tributary Selected as Pilot Watershed



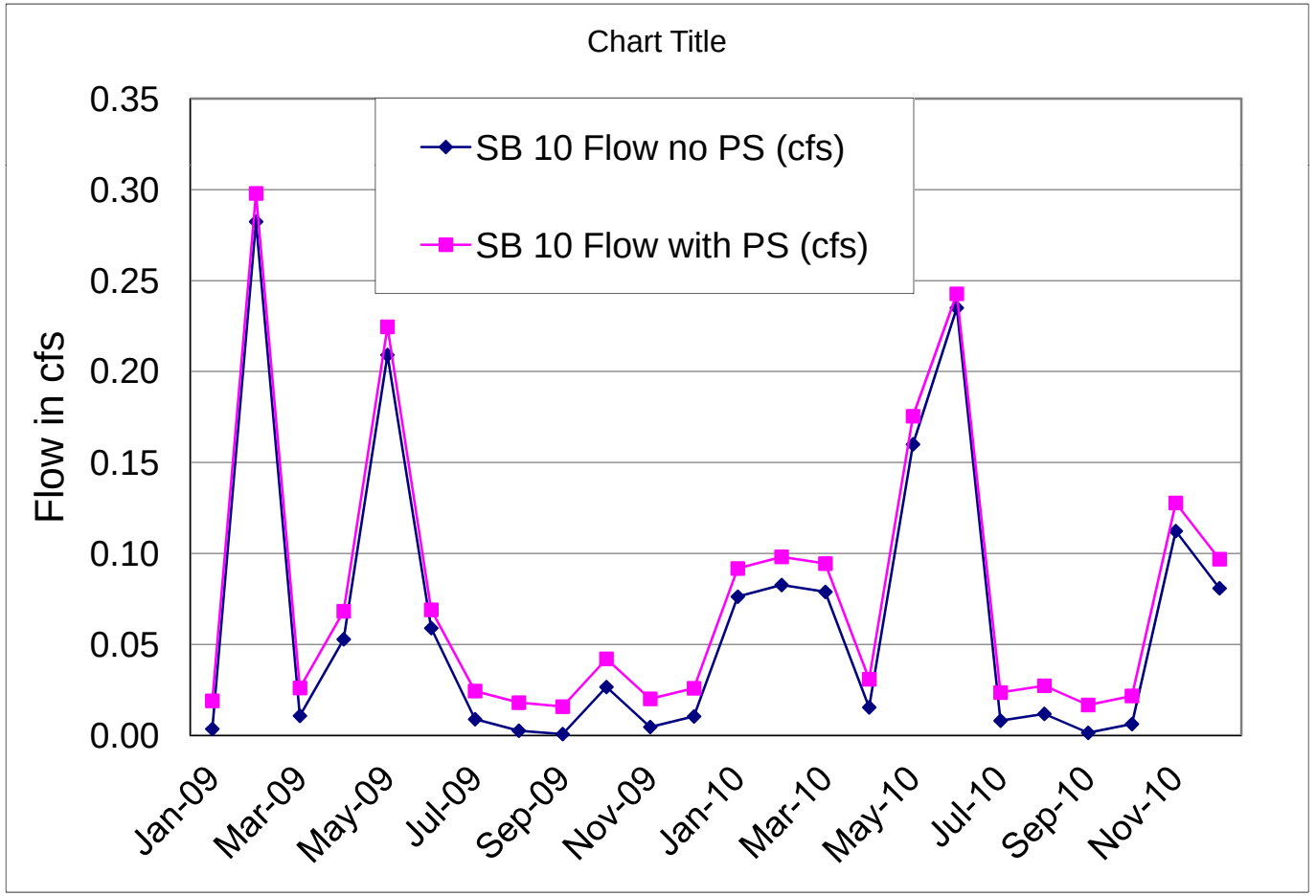
Chickasaw Creek Watershed:
12,900 Acres

85.2% Agricultural
9.5% Urban
3.2% Wooded

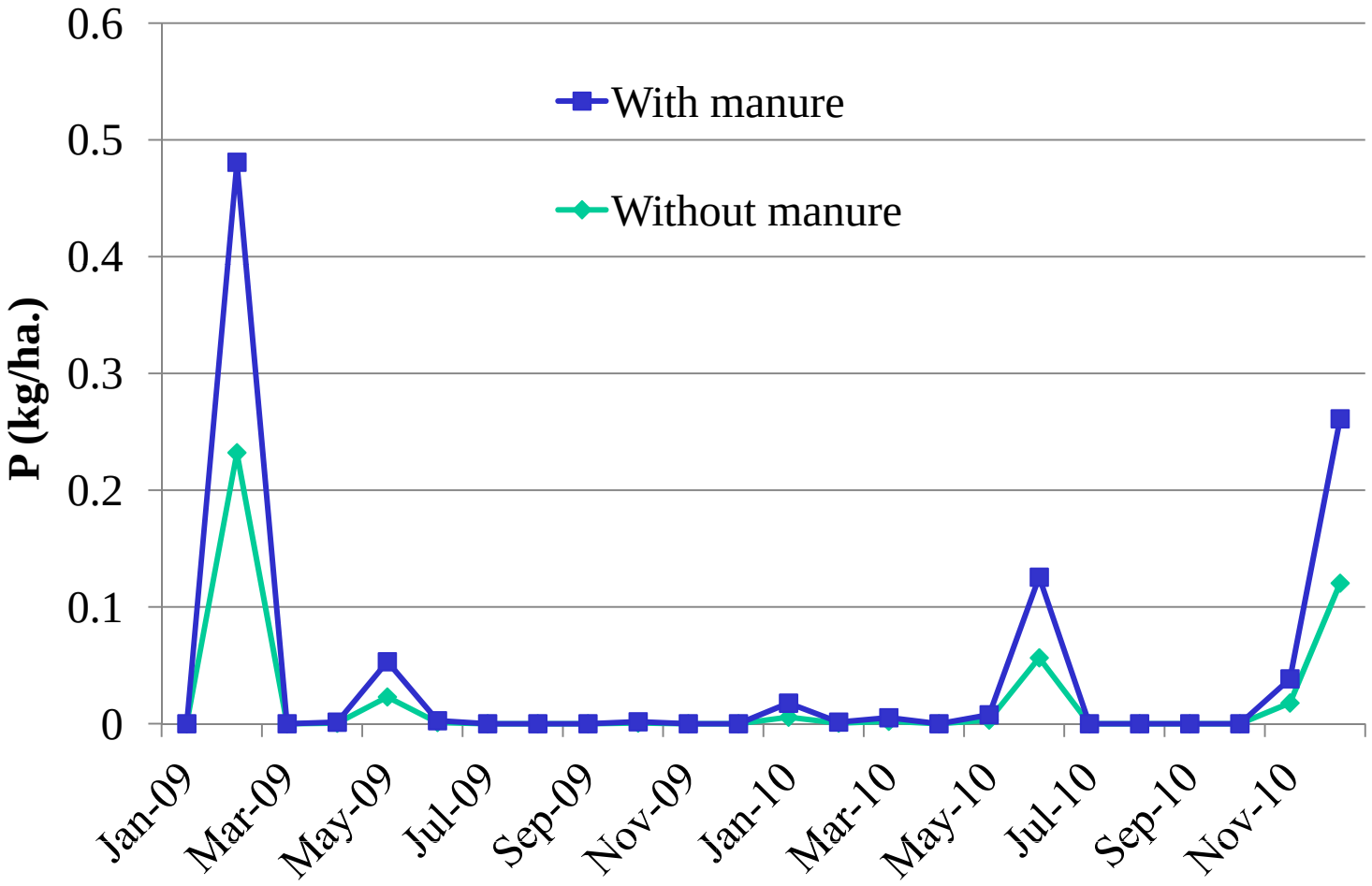
3 Minor Permitted Discharges in Headwaters of Chickasaw Watershed

SWAT Model Results

Point source contribution is not significant



Soluble P Increases 50% by Adding In Manure Application



Future Work for Modeling

- **Nutrient removal by agricultural conservation practices such as cover crops and buffers.**

Future Work: Manure Treatment Technologies

- Anaerobic digestion.
- Nutrient removal.
- Composting.
- Converting animal manure to biofuel .

Thank you!

Yongping Yuan, Ph.D
EPA-Office of Research and Development
(702)-798-2112
Yuan.yongping@epa.gov