Date | April 22, 2010

To | Mike Kinney, PLSLWD Administrator
00758-0051 File

From | Carl K. Almer, Jason Naber, Eli Rupnow

Regarding | PLSLWD Upper Watershed Review & Assessment Technical Memo

Purpose

The purpose of this technical memorandum is to present the findings and recommendations for the Upper Watershed Review and Assessment. The sub-watersheds tributary to Spring and Upper Prior Lakes have been evaluated with respect to the practicability of volume control on a subwatershed basis. This effort was built upon previous volume management planning, the Draft Spring – Upper Prior Lake TMDL and the Scott County 2030 Comprehensive Plan. Outcomes of this effort will inform the TMDL Implementation Plan and assist Spring Lake Township in development of their LID guidelines. Page numbers of content are identified below.

Background Information

Stormwater management as it relates to controlling runoff volume to the lakes has long been an important issue for the Watershed District. Decades worth of work has been done to provide better lake water level management. More recently, with the development of a Total Maximum Daily Load study for Spring and Upper Prior Lake, District resources have been dedicated to assessing water quality and limiting in-lake phosphorus concentrations.

This technical memo utilizes past work by the District and others to target key volume and nutrient reduction strategies in the upper watershed. Following is a brief summary of each report used to inform this review and assessment.

1994 Southwest PLSLWD Wetland Basin Inventory- Scott SWCD

This hardcopy report includes maps and data sheets for wetland basins found throughout the upper watershed. Information found in the report includes: wetland size and drainage area, soils, vegetation, drainage features and potential for restoration.

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2003 Spring and Upper Prior Lakes External and Internal Phosphorus Load Modeling - Barr Engineering
This technical report analyzes external and internal loading sources to the lakes.

2004 Storage and Infiltration Study – Wenck Associates
In this report, the District inventoried potential regional infiltration opportunities (2004 Storage & Infiltration Study). Infiltration was not identified as very suitable for this drainage area however; many potential sites were identified for storage. These areas primarily included topographic low points (in some cases wetlands) and were prioritized using the following parameters.

- Upcoming annexation
- At least 10 acres in size
- Limited number of property owners
- Storage at least 2 feet deep
- Potential for wetland banking credits

2008 Spring Lake and Upper Prior TMDL – Wenck Associates
Per the Draft TMDL, the most applicable strategies to reduce runoff volume and phosphorus loading include the following:

- Rules (and Ordinances)
- Development and Redevelopment Design Standards
- Infiltration and Filtration BMPs (raingardens, soil amendments, reforestation, native plantings)
- Retrofit BMP in streets and highways
- Agricultural Conservation Practices (No Till, Buffers, CRP, Conservation Tillage)
- Educational Programs

Watershed Volume and Nutrient Reduction Considerations

Due to the generally poor infiltration potential of the soils in the watershed, priority should be given to strategies that reduce the generation of stormwater runoff at the source rather than strategies that collect, store and infiltrate stormwater. These strategies are detailed in the State Stormwater Manual's Better Site Design Chapter and include:

1. Preserving Natural Areas
    a. Natural Area Conservation
    b. Site Reforestation or Restoration
    c. Shoreline Buffers
    d. Open Space Design

2. Disconnecting and Distributing Stormwater
    a. Soil Compost Amendments and/or Soil Tilling
    b. Disconnection of Impervious Surfaces
    c. Rooftop Disconnection
    d. Grass Channels
    e. Stormwater Landscaping

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3. Reducing Impervious Cover in Site Design
    a. Narrower Streets
    b. Slimmer Sidewalks
    c. Smaller Cul-de-sacs
    d. Shorter Driveways
    e. Smaller Parking Lots

While all of these strategies apply to mitigation of future increases in runoff volume, only those strategies that are bolded will help to reduce runoff volume from existing conditions in the Upper Watershed (Spring Lake Township). To augment the applicable strategies identified above, a landuse-specific suite of BMPs were considered. Since the character of the contributory watershed varies from agriculture to urban residential, it is important to focus BMPs on specific landuse types where they provide the most benefit. Keeping in mind the primary goal of reducing volume of runoff (and therefore phosphorus loading) the following suite of BMPs were considered for application in each of the primary landuse types found in the Upper Watershed.

1. **Rural Residential** (larger than 1 ac.) – moderate scale BMPs including raingardens, rain barrels, turf management, soil amendments and tree planting
2. **Wetlands** – restoration, enhancement, drainage management, reestablishment
3. **Urban Residential** (smaller than 1 ac.) – small scale BMPs including pervious hard surfaces, raingardens, rain barrels, and roof-top disconnection
4. **Non-Residential Development** (Commercial/Institutional/Multi-Family/Parks/Etc.) – BMPs including green roofs, pervious hard surfaces, biofiltration/retention features, and turf management
5. **Agricultural Lands** – No Till, Buffers, Conservation Reserve Program (CRP), and Conservation Tillage

Assessment Process

This task involved identification of a suite of BMPs suitable to the Upper Watershed, development of applicability criteria and assessment on a subwatershed basis of those BMPs practicable to each subwatershed. The average annual runoff volume reduction realized by implementing each of the BMPs was estimated by modeling the BMP for an annual rainfall simulation derived from a 1999 rainfall distribution which yielded a total of 30.5 inches of rain. Each BMP was modeled based on the land use and soil types specific to that subwatershed. The implementation ratios (for example 1 BMP per 25 acres or a percent of land area) were consistently applied throughout, however the benefit achieved from a specific BMP was modeled reflecting the variety of underlying soils. The curve number (CN) is based on the landuse/soil combination as described in the Minnesota Hydrology Guide and are identified in Table 1 for each BMP. The BMPs were modeled as described in the following sections.

Table 1: Curve Number Summary Table

	Hydrologic Soil Group			
	A	B	C	D
Turf Management				
Existing	39	61	74	80
With BMP	30	58	71	78
Tree Planting				
Existing	39	61	74	80
With BMP	30	55	70	77
Drained Wetland Restoration				
Existing	81	81	81	81
With BMP	75	75	75	75
Roof-top Disconnection				
Existing	98	98	98	98
With BMP	58	58	58	58
No Till				
Existing	70	80	87	91
With BMP	53	69	79	84
Conservation Tillage				
Existing	70	80	87	91
With BMP	66	77	84	87
CRP				
Existing	70	80	87	91
With BMP	39	61	74	80
Buffers				
Existing	70	80	87	91
With BMP	30	58	71	78

Three subwatersheds were selected to develop BMP application rates for the types of practices where the history of actual implementation projects in the watershed was not available. Unlike agricultural BMPs where programs are active and have good records of landowner participation, practices such as tree planting, turf management, soil amendments and raingardens are more difficult to estimate in terms of application rates. In order to ensure appropriate application rates were used, three subwatersheds within the project area; Swamp Lake, Spring Lake East and Upper Prior were further evaluated. These three were selected to represent the range of land uses from primarily agriculture to rural residential to urban respectively. This evaluation included a detailed assessment of each subwatershed and a conceptual location and size of each BMP. Appendix A contains figures for each of the three subwatersheds where BMP application rates were estimated. Figure 1 illustrates the entire area identified as the Upper Watershed and the three subwatersheds selected to calibrate the BMP application rates used.

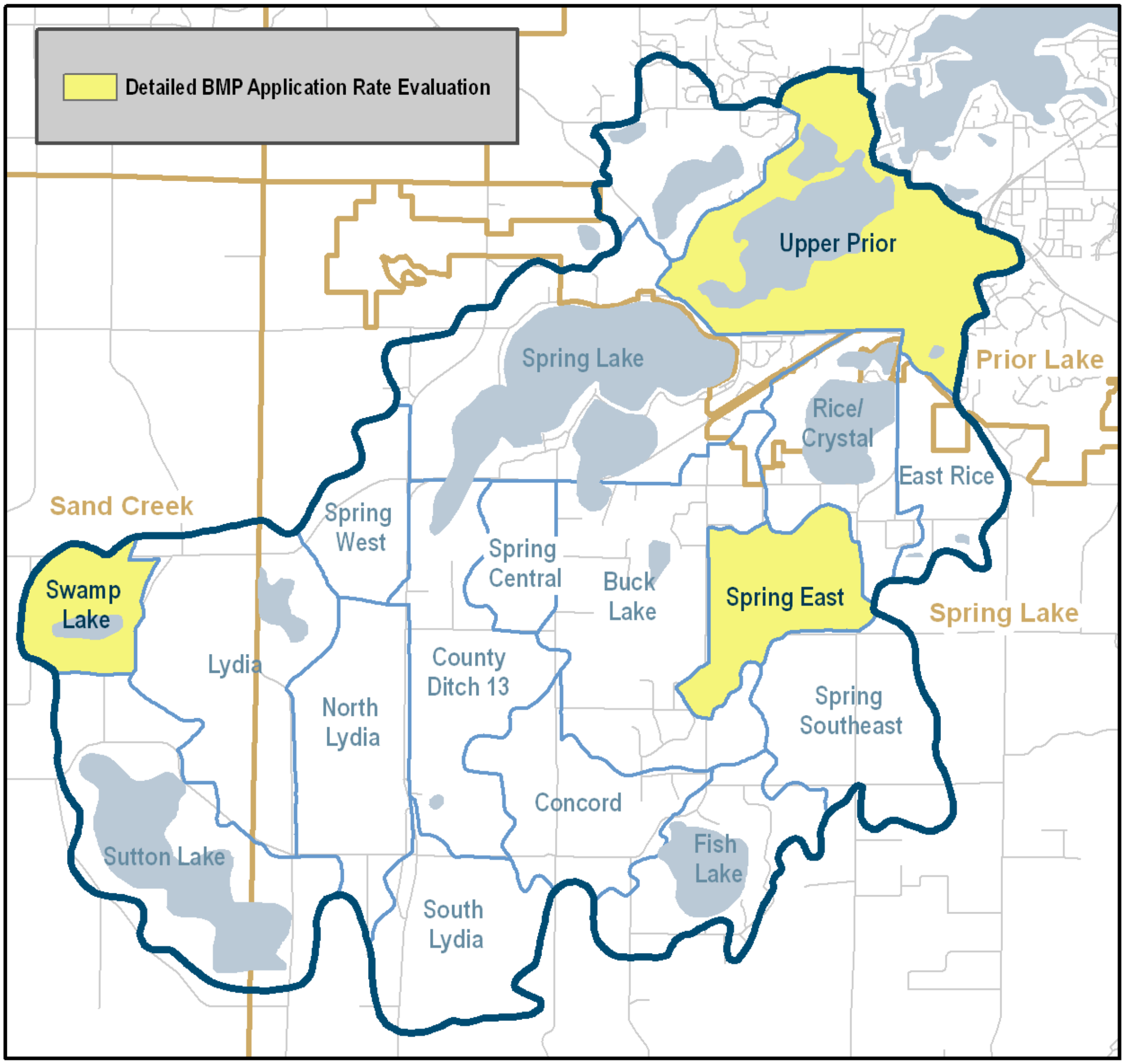

Figure 1: Upper Watershed Assessment Subwatersheds

In order to discriminate more effectively between BMPs for future implementation, a preliminary cost-benefit analysis was conducted. Estimated costs are based on capital costs to the District (excluding operation and maintenance) over a 15-year period. All BMPs are assumed to have at least a 15-year life and, for this simplified process, only a 15-year life. Annual incentives were utilized for agricultural BMPs and turf management. Benefits are based on volume reduction calculated through the assessment process.

Table 2: BMP Cost per Volume of Benefit

BMP Type	Cost per Volume of Benefit*
Rural Residential	
Raingarden (rural)	Medium
Rain Barrels	High
Turf Management	Very Low
Soil Amendments	Low
Tree Planting	High
Wetland Restoration	
Undrained	Very High
Drained	Medium
Urban Residential	
Raingarden (urban)	High
Pervious Hard Surfaces	High
Roof-top Disconnection	Low
Rain Barrels	High
Non-Residential Development	
Pervious Hard Surfaces	High
Roof-top Disconnection	Low
Raingarden (urban)	High
Turf Management	Very Low
Green Roofs+	Very High
Agricultural Lands	
No Till	Very Low
Conservation Tillage	Very Low
CRP	Very Low
Buffers	Low

* Ranges expressed in $/yr/AF volume reduction
Very Low – $0 to $149
Low – $150 to $499
Medium – $500 to $3,999
High – $4,000 to $8,999
Very High – $9,000 to $30,000
+ Assumption: extensive design

Rural Residential

Raingardens: The runoff reduction achieved from raingarden implementation was quantified using a raingarden footprint of 1800 ft^2 (30 ft by 60 ft) for the bottom contour, 5:1 side slopes, and the maximum depth allowable based on the guiding infiltration rates (“A” soils: 0.3 in/hr, “B” soils: 0.15 in/hr, “C” soils: 0.07 in/hr, and “D” soils: 0.03 in/hr) and drawdown times (48 hours). Each raingarden is assumed to have the capacity such that it will begin to discharge at events exceeding 1-inch of rainfall.

The application rate for rural residential raingardens was applied to be one per every 25 acres of rural residential landuse. The application location process targeted locations where a raingarden of the design size and shape would fit with limited tree removal, maximum distance from buildings and located at lower topographical elevations.

Rain Barrels: It is assumed that there is one rain barrel implemented per 2.5 acres of rural residential land use. The assumed rain barrel size is 55 gallons and it is assumed to be utilized twice per month for April-October. Volume removed per rain barrel equals (55 gal * 2 utilizations * 7 months / 2.5 acres) = 308 gal/year/acre = 41 CF/acre.
The application rate for rain barrels was applied at one out of every five houses.

Turf Management: Turf management is quantified by reducing the CN value from a land cover of open space (good condition) to a land cover of woods & meadow.

The application rate for turf management was applied at five percent of the rural residential area. Targeted application focused on areas located adjacent to roadways and backyards farthest from houses where large lawns currently exist and tree cover was limited.

Soil Amendments: Soil amendments are quantified by having 8-inch deep soil with 30% void space and infiltrating at the guidance rates. The soil amendments are assumed to have a 2:1 ratio of impervious area to pervious soil amendment area.

The application rate for soil amendments was applied at one acre of amended soil per 200 acres of rural residential landuse. Target areas include roadside ditches with limited tree cover.

Tree Planting: Tree planting is quantified by reducing the CN value from a land cover of open space to a forested land cover.

The tree planting application rate equaled five percent of the rural residential area. Targeted application focused on areas located adjacent to roadways and backyards farthest from houses where large lawns currently exist and tree cover was limited. Higher application would occur where agricultural fields have been developed and very limited tree cover exists currently.

Wetlands

Undrained Wetland Restoration: For undrained wetlands, vegetative enhancement is estimated to occur at a rate differentiating open water evaporation and evapotranspiration of water a semiwet wetland. The total benefit for undrained wetland restoration is estimated to be 3.3 inches per year, as determined through extensive literature search. Because these wetlands have considerable open water, which is typically too deep to afford restoration, this benefit was only applied to 20% of the wetland area. Of this 20% wetland area, 10% of that was assumed to be restored for a total of 2% of the undrained wetlands.

Drained Wetland Restoration: For drained wetlands, which are primarily drain tiled agricultural depressions, the benefit is modeled by changing the land cover from agricultural crops (average of good/poor row crops for all soil groups) to a wetland with less than 1/3 open water. Wetland restoration was assumed to occur for 10% of the drained wetlands.

Urban Residential

Raingardens: The runoff reduction achieved from raingarden implementation was quantified using a raingarden footprint of 200 ft^2 (25 ft by 8 ft) for the bottom contour, 3:1 side slopes, and the maximum depth allowable based on the guiding infiltration rates ("A" soils: 0.3 in/hr, "B" soils: 0.15 in/hr, "C" soils: 0.07 in/hr, and "D" soils: 0.03 in/hr) and drawdown times (48 hours). Each raingarden is assumed to have the capacity such that it will begin to discharge at events exceeding 1-inch of rainfall.

The application rate for urban residential raingardens was applied to be one per every five acres of urban residential landuse. The application location process targeted locations where a raingarden of the design size and shape would fit with limited tree removal, maximum distance from buildings, maintenance access and located at lower topographical elevations.

Pervious Hard Surfaces: Pervious hard surfaces are modeled to have a rock depth of 18-inches. The runoff infiltrates at the guidance rates. Pervious pavement above "D" soil has a small 4-inch outlet pipe located six-inches above the bottom of the pavement. For each square foot of porous pavement, it is assumed to have two additional square feet of impervious surface routed to the porous surface.

One acre of pervious hard surface is assumed to be implemented at a rate of one per 50 acres of urban residential landuse. Location determination prioritized cul-de-sacs and other roads/trails with low traffic volumes or parkway width roads where parking lanes could be re-constructed as pervious hard surfaces.

Roof-top Disconnection: Roof-top disconnection will be modeled by changing the curve number for the roof-tops from 98 to that of urban open space for the adjacent soil type. 20 percent of the runoff reduction will be credited to account for the limited benefit during larger storms.

Application rate of roof-top disconnection was assumed to occur for 5% of the urban residential landuse. The application focused on houses on larger lots and farthest from the wetland/lake/ditch where a longer overland flow path could occur.

Rain Barrels: It is assumed that there is one rain barrel implemented per 2.5 acres of rural residential land use. The assumed rain barrel size is 55 gallons and it is assumed to be utilized twice per month for April-October. Volume removed per rain barrel equals (55 gal * 2 utilizations * 7 months * 3.0 houses/acre) = 2310 gal/year/acre = 309 CF/acre.
The application rate for rain barrels was applied at one out of every ten houses.

Non-Residential Development

Pervious Hard Surfaces: Pervious hard surfaces are modeled to have a rock depth of 18-inches. The runoff infiltrates at rates consistent with Watershed guidance documents based on the County identified Hydrologic Soil Groups, where "A" is 0.3in/hr, "B" is 0.15 in/hr, "C" is 0.07 in/hr, and "D" is 0.03 in/hr. The "D" soil pavement has a small 4-inch outlet pipe located six-inches above the bottom of the pavement. For each square foot of porous pavement, it is assumed to have two additional square feet of impervious surface routed to the porous surface.

One acre of pervious hard surface is assumed to be implemented at a rate of one per 25 acres of non-residential landuse. Location determination prioritized areas with large parking lots where areas farthest from the building entrance may be utilized least often.

Roof-top Disconnection: Roof-top disconnection will be modeled by changing the curve number for the roof-tops from 98 to that of urban open space for the adjacent soil type. 20 percent of the runoff reduction will be credited to account for the limited benefit during larger storms.

Application rate of roof-top disconnection was assumed to occur for 5% of the urban residential landuse. The application focused on houses on larger lots and farthest from the wetland/lake/ditch where a longer overland flow path could occur.

Green Roofs: Green roofs will be modeled using a land cover change from a curve number for impervious surface to the curve number for "B" meadow.

Green roofs are assumed to be applied at a 5% rate across the non-residential landuse. The application of green roofs focused on buildings with flat roofs where other BMPs would be more challenging.

Raingardens: The runoff reduction achieved from raingarden implementation was quantified using a raingarden footprint of 200 ft^2 (25 ft by 8 ft) for the bottom contour, 3:1 side slopes, and the maximum depth allowable based on the guiding infiltration rates ("A" soils: 0.3 in/hr, "B" soils: 0.15 in/hr, "C" soils: 0.07 in/hr, and "D" soils: 0.03 in/hr) and drawdown times (48 hours). Each raingarden is assumed to have the capacity such that it will begin to discharge at events exceeding 1-inch of rainfall.

The application rate for urban residential raingardens was applied to be one per every two acres of non-residential landuse. The application location process targeted locations where existing turfgrass exists and future parking expansion wouldn't be projected to occur.

Turf Management: Turf management is quantified by reducing the CN value from a land cover of open space (good condition) to a land cover of woods & meadow.

The application rate for turf management was applied at five percent of the non-residential area. Targeted application focused on areas located adjacent to roadways and outlots farthest from structures where under-utilized turf currently exists and tree cover was limited.

Agricultural Lands

No Till: Use average of conservation tillage and CRP values to reflect additional benefits of no tillage but the continued land use for planting and harvesting. According to the Scott SWCD's records, two landowners in the Upper Watershed are using 'No Till' practices on approximately 49 acres of land.

Conservation Tillage: The crop residue cover (CR) values for fallow, row crops, and small grain are averaged rather than the non-CR values. CR averaged values include those combined with contoured cover. Gary Feyereisen with the USDA on the St. Paul campus of the University of Minnesota published in 2008 a study that found for strip tillage a reduction of six and one points for the growing and dormant seasons, respectively, as compared to conventional tillage. Surface soils were hydrologic soil group A and subsoils were hydrologic soil group C (Feyereisen et al. 2008, *Journal of Soil and Water Conservation*). The Scott SWCD indicated that within the upper watershed, 5 fields are actively participating in a residue management program for a total of 261 acres.

CRP/CREP: Instead of using the averaged agricultural CN, the CN for the good pasture, grassland will replace those values. The Scott SWCD stated that 17 fields are currently in the CREP program totaling 50 acres and 20 fields in the CRP program totaling roughly 170 acres.

Filter Strips: Filter strips (also known as buffers) are quantified by reducing the CN value from the averaged agricultural CN to a land cover of meadow. Scott SWCD indicated 27 fields are currently in the filter strip program totaling 76.7 ac. The limiting factor for this application is typically landowner interest since there are many sites that meet the eligibility criteria and there has not been a lack of funding.

Findings

An evaluation of potential volume and phosphorus reduction associated with the implementation of selected BMPs is presented in the following section. A one-page portfolio describing landuse, applicable BMPs and volume/phosphorus removal potential for each subwatershed is provided in Appendix B. Table 3 below summarizes the results of this assessment for the entire Upper Watershed.

Table 3: Subwatershed Summary Annual Volume and Phosphorus Reduction Potential

Subwatershed	Drainage Area (AC) Not Including water surfaces	Volume Reduction Potential (AF/YR)	Phosphorus Reduction Potential (LB/YR)
Buck Lake	1,403	59	62
Concord	715	39	36
County Ditch 13	967	52	50
Crystal Bay	629	14	14
East Rice	429	17	18
Fish Lake	554	22	24
Lydia	1,253	64	57
North Lydia	831	40	36
Rice/Crystal	607	15	16
South Lydia	757	44	40
Spring Central	316	21	19
Spring East	600	19	19
Spring Lake	1,312	44	46
Spring Southeast	843	35	34
Spring West	415	35	30
Sutton Lake	1,001	52	47
Swamp Lake	343	17	15
Upper Prior	1,169	84	77
TOTAL		**673**	**640**

The TMDL for Spring and Upper Prior has identified a 2,959 pounds lb/yr reduction goal to Spring Lake. The volume reduction BMPs considered in this Upper Watershed Assessment will provide approximately 640 lbs/yr. The balance of the watershed loading reduction needed will be achieved through capital projects that target phosphorus removal.

Next Steps

The information gathered and synthesized in this project has wide ranging applicability to the District's goals and active initiatives. Most immediately obvious is the upcoming TMDL Implementation Plan where analyses completed for this effort are being used to prescribe and assess pollutant load reductions.

The Third Generation Watershed Management Plan is in its final round of revisions prior to BWSR approval. Some of the capital projects identified in the Plan such as the Highway 13 Desiltation/Improvement will help improve downstream water quality and therefore function to meet TMDL goals. The strategies laid out in this memo are programmatic-type initiatives that target source reduction of nutrients and volume and augment the capital projects found in the Plan.

Some of the progressive ideas identified in the Plan and others from the scientific community have identified other types of strategies to reduce phosphorus loading to the lakes. Recent research has indicated that projects such as conservation drainage and the use of iron filings as a filter have a potential to reduce phosphorus loading to the downstream impaired waters.

Appendix A:

Subwatersheds used for BMP application rate estimation.

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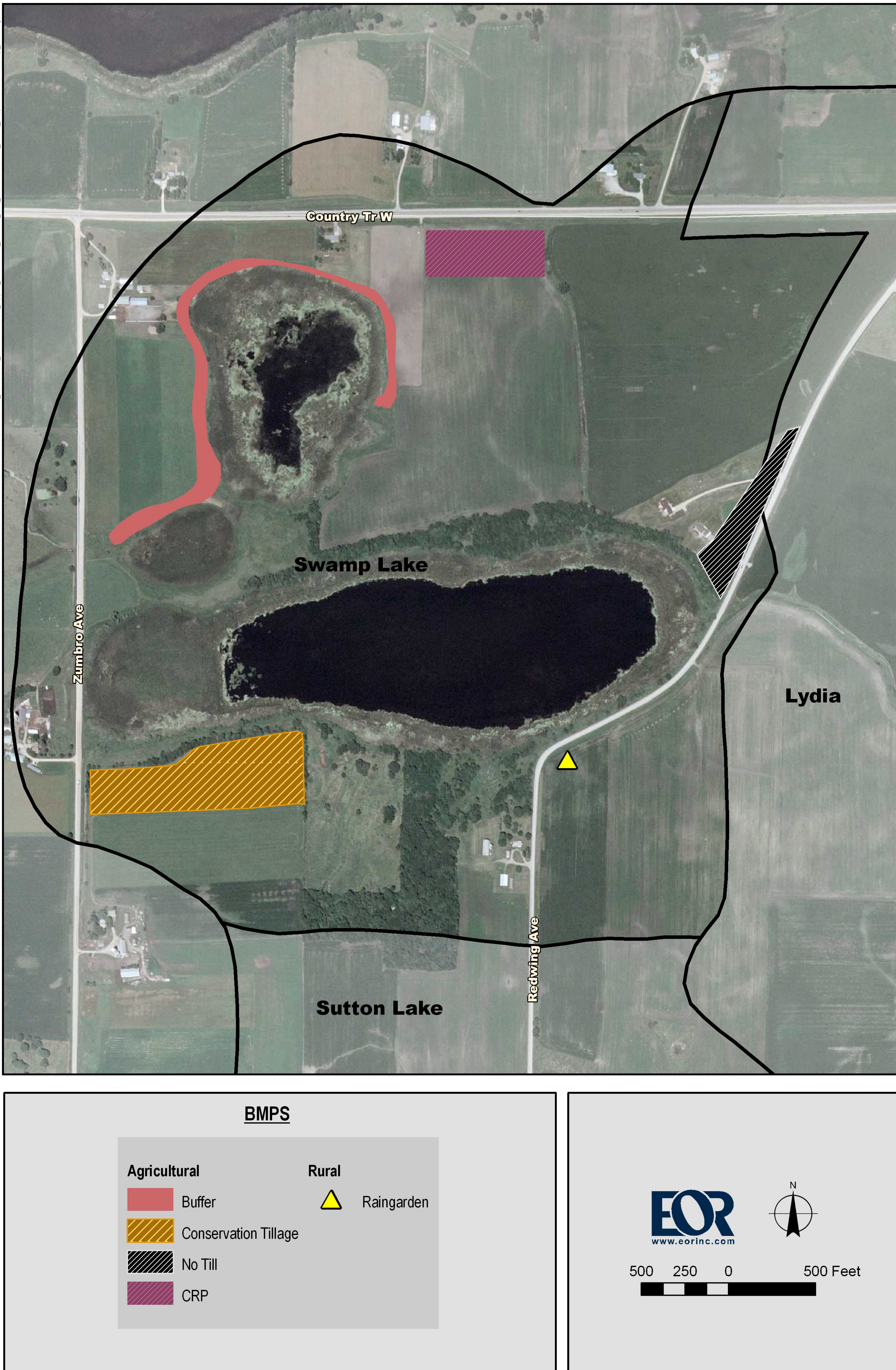
Upper Watershed Assessment: Swamp Lake



Upper Watershed Assessment: Spring East

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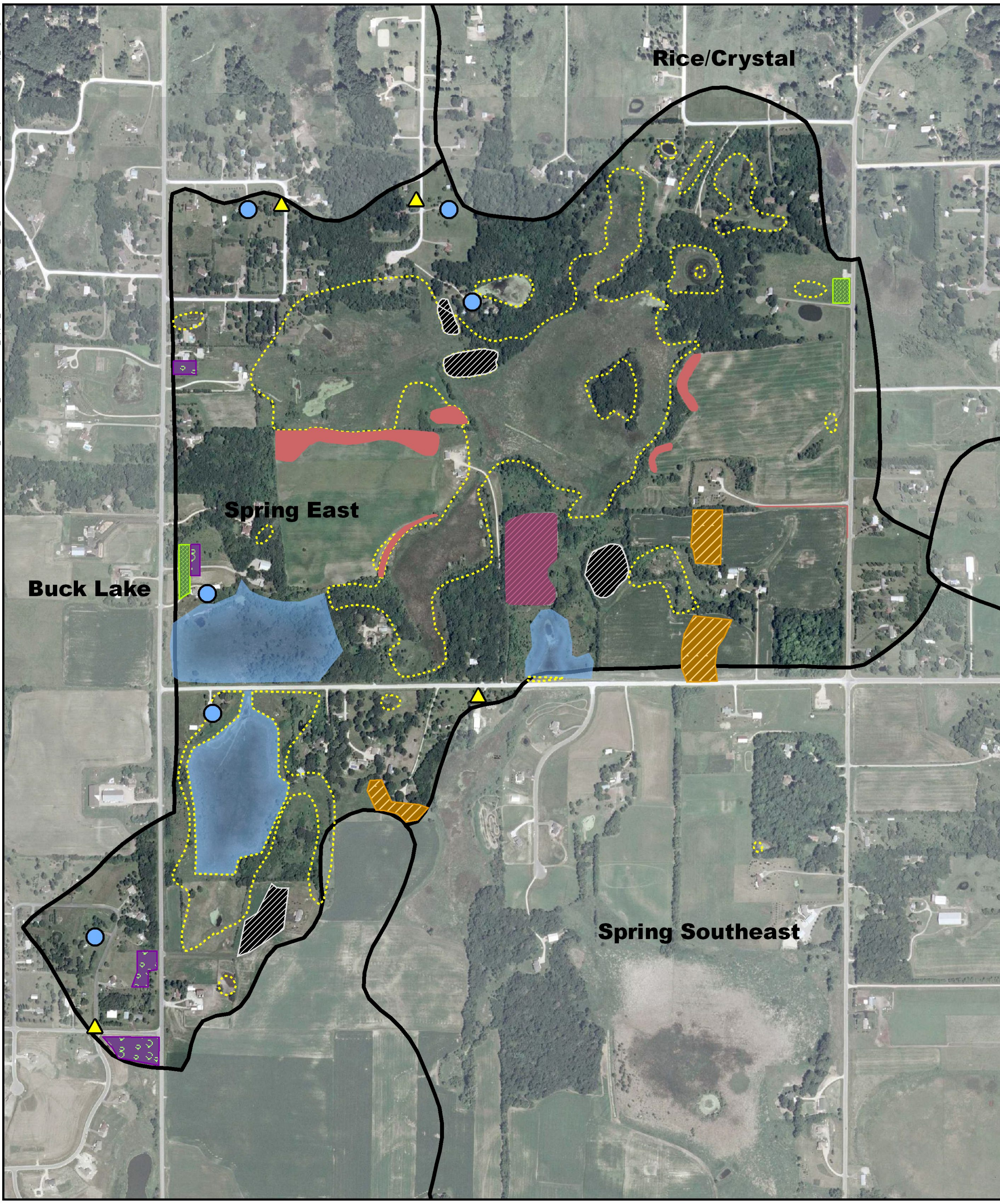
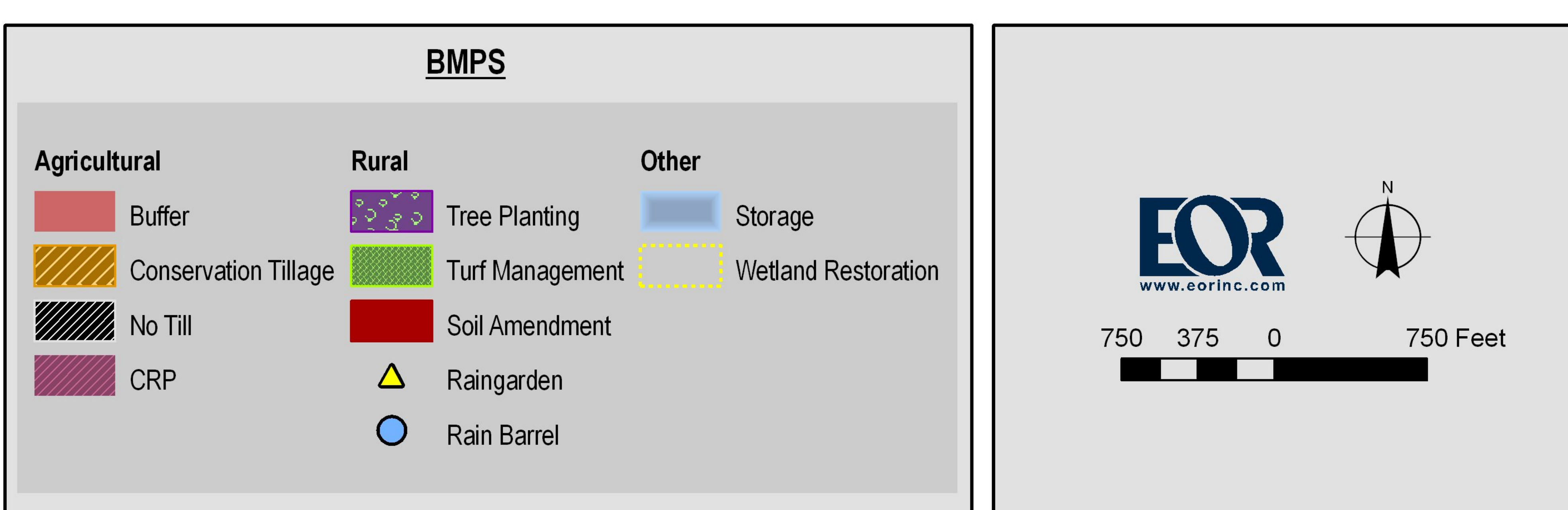
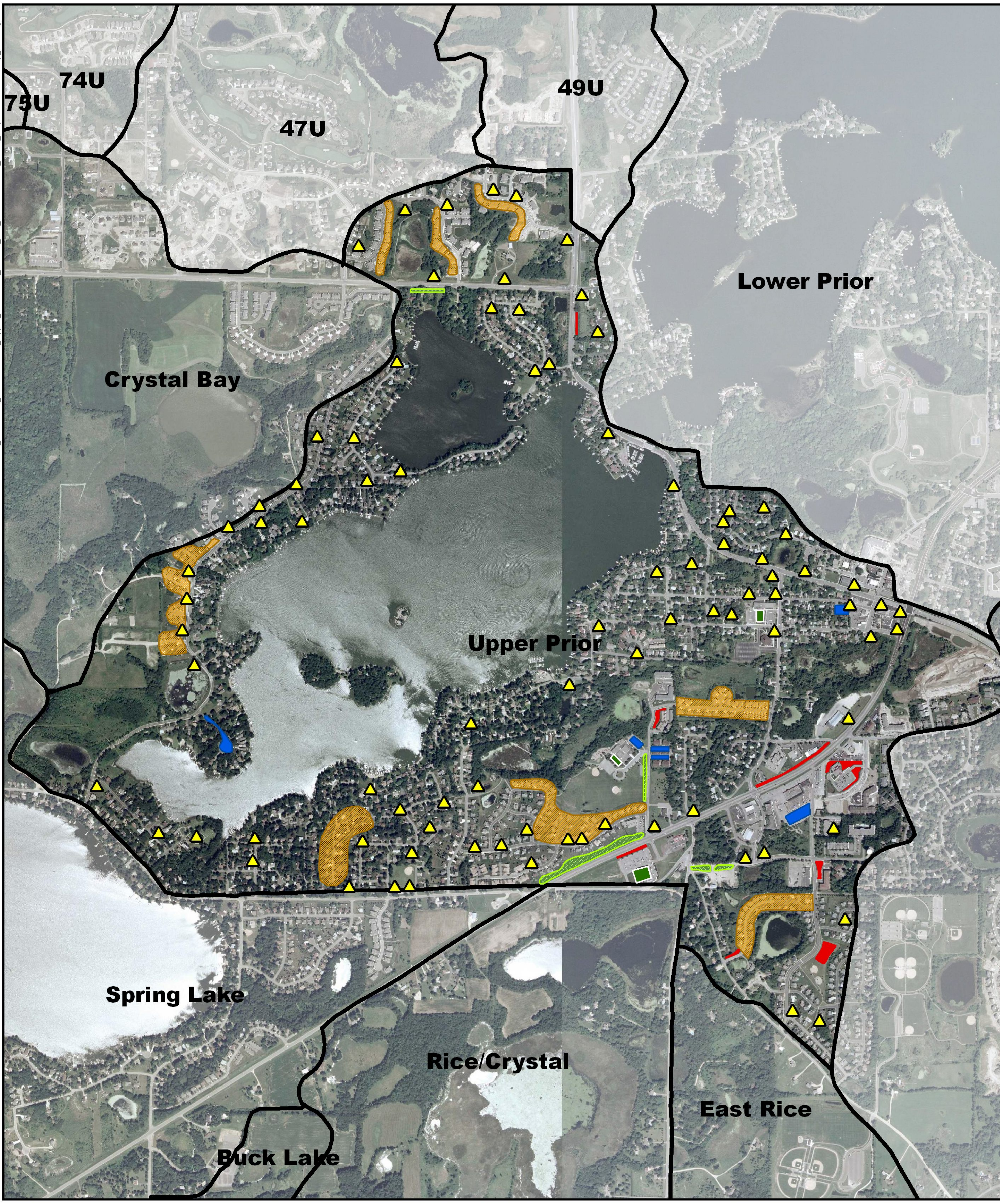




Upper Watershed Assessment: Upper Prior



BMPS

Rural
- Soil Amendment
- Turf Management
- Raingarden

Urban
- Green Roof
- Roof Disconnection
- Pervious Surfaces

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Appendix B:

Subwatershed BMP summaries.

BUCK LAKE

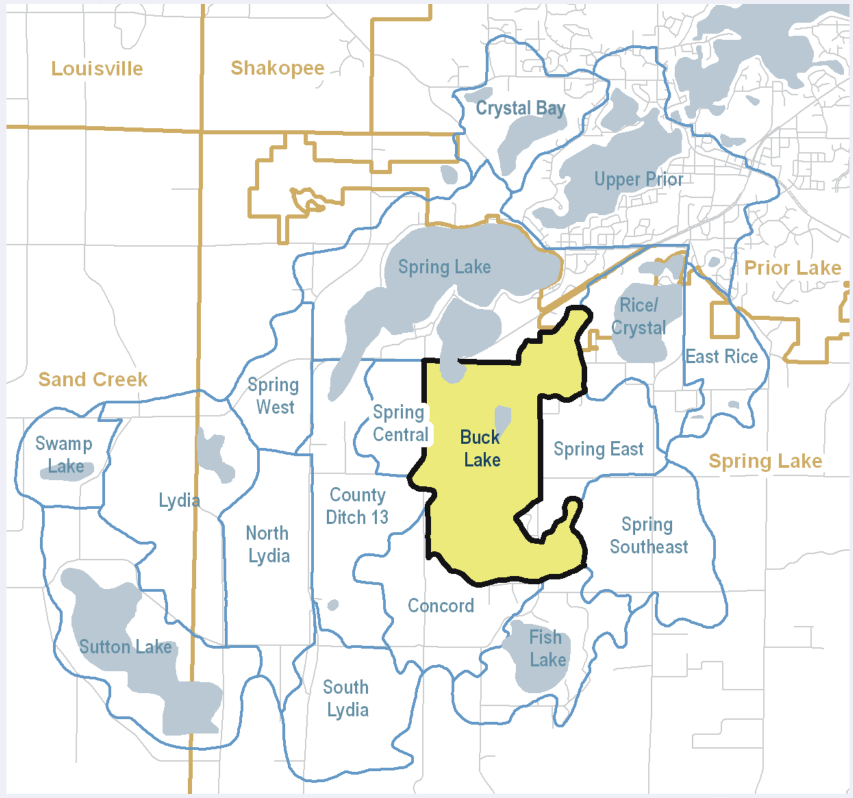
Subwatershed Description

Location:
Spring Lake

Drainage Area:
1479 Acres

Drains to:
Spring Lake

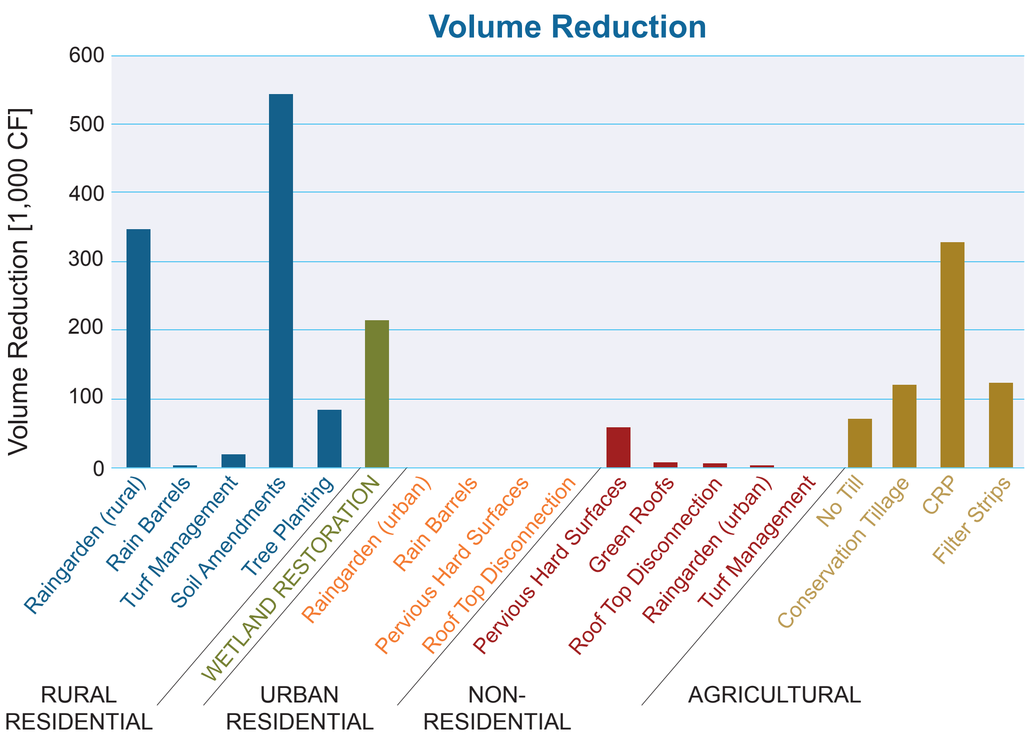
Primary Land Use:
Rural Residential & Agricultural

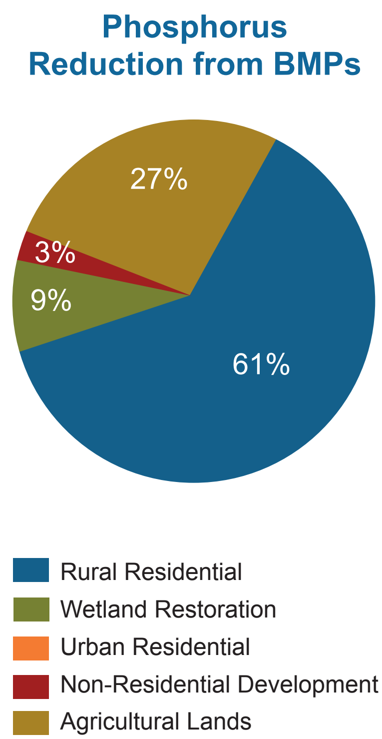


Results & Conclusions

TMDL Volume Reduction:
59 acre-feet

TMDL Phosphorus Load Reduction:
62 lb/yr (6% of total external load)





CONCORD

Subwatershed Description

Location:
Spring Lake

Drainage Area:
717 Acres

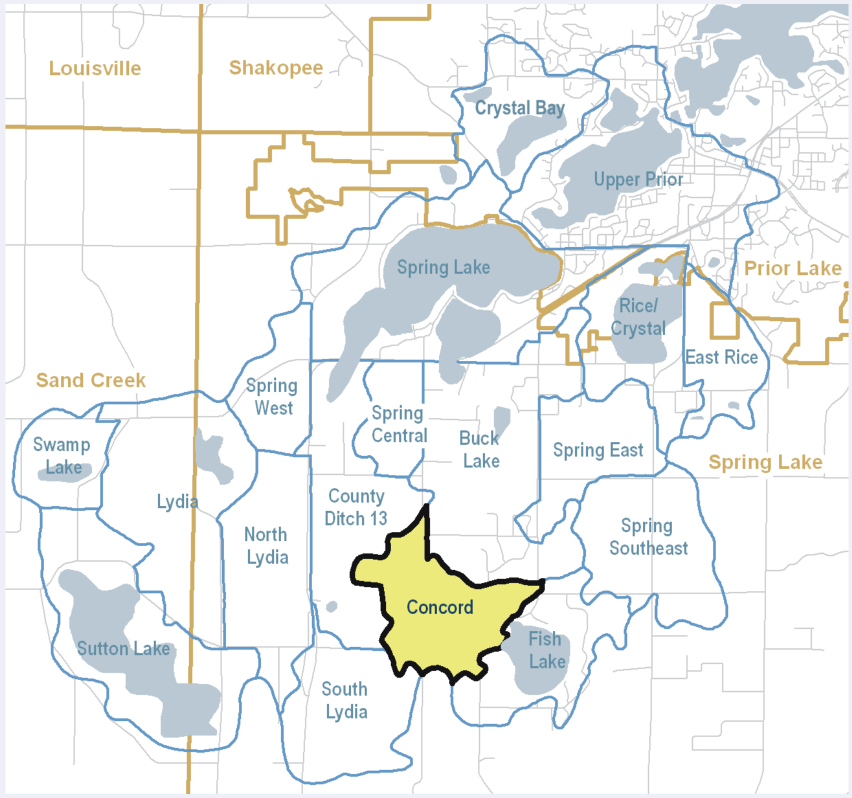
Drains to:
Spring Lake via Buck Lake

Primary Land Use:
Rural Residential & Agricultural

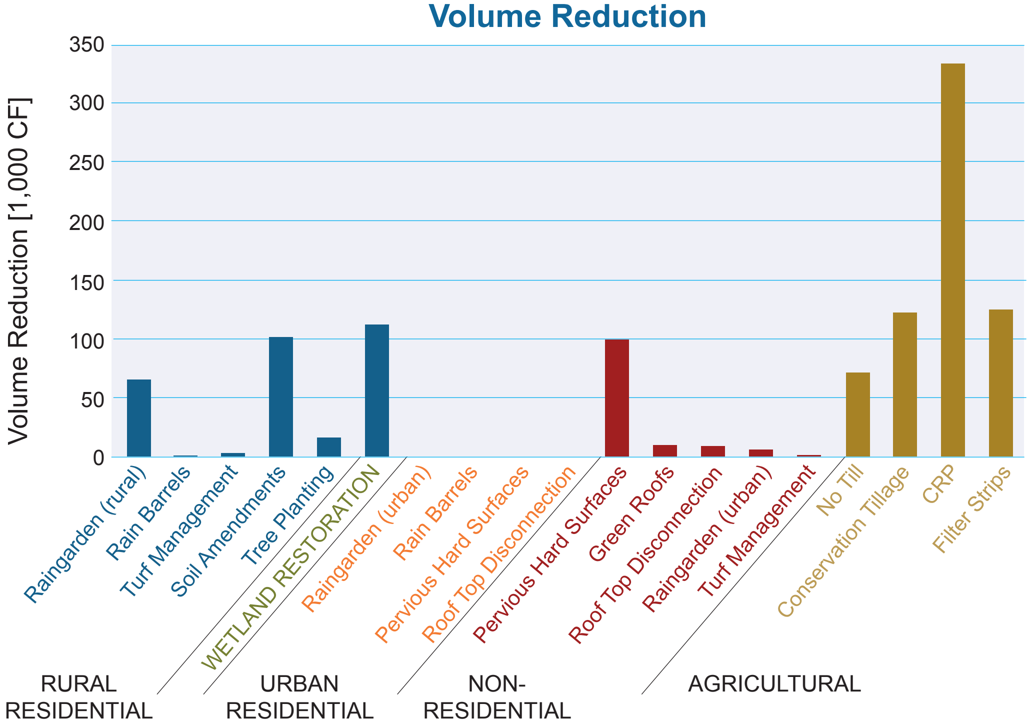
Results & Conclusions

TMDL Volume Reduction:
39 acre-feet

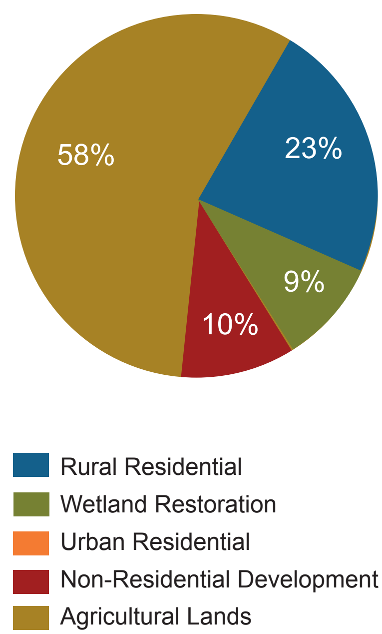
TMDL Phosphorus Load Reduction:
36 lb/yr (6% of total external load)



Volume Reduction



Phosphorus Reduction from BMPs



COUNTY DITCH 13

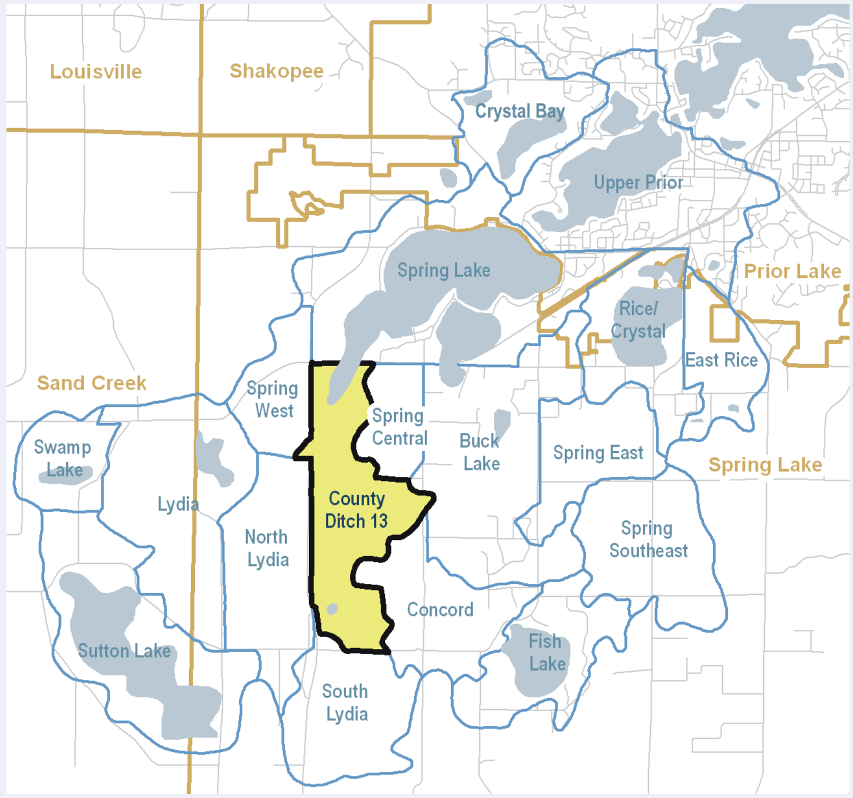
Subwatershed Description

Location:
Spring Lake

Drainage Area:
971 Acres

Drains to:
Spring Lake

Primary Land Use:
Rural Residential & Agricultural

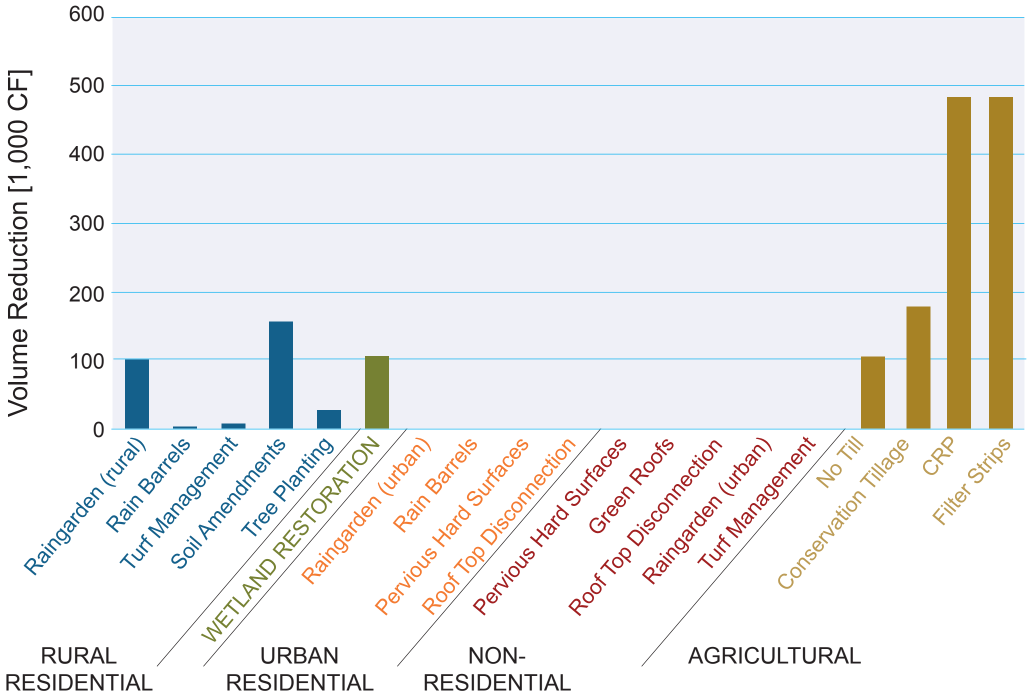


Results & Conclusions

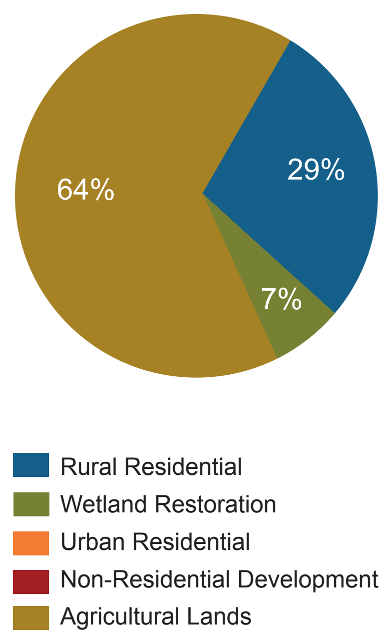
TMDL Volume Reduction:
52 acre-feet

TMDL Phosphorus Load Reduction:
50 lb/yr (8% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



CRYSTAL BAY

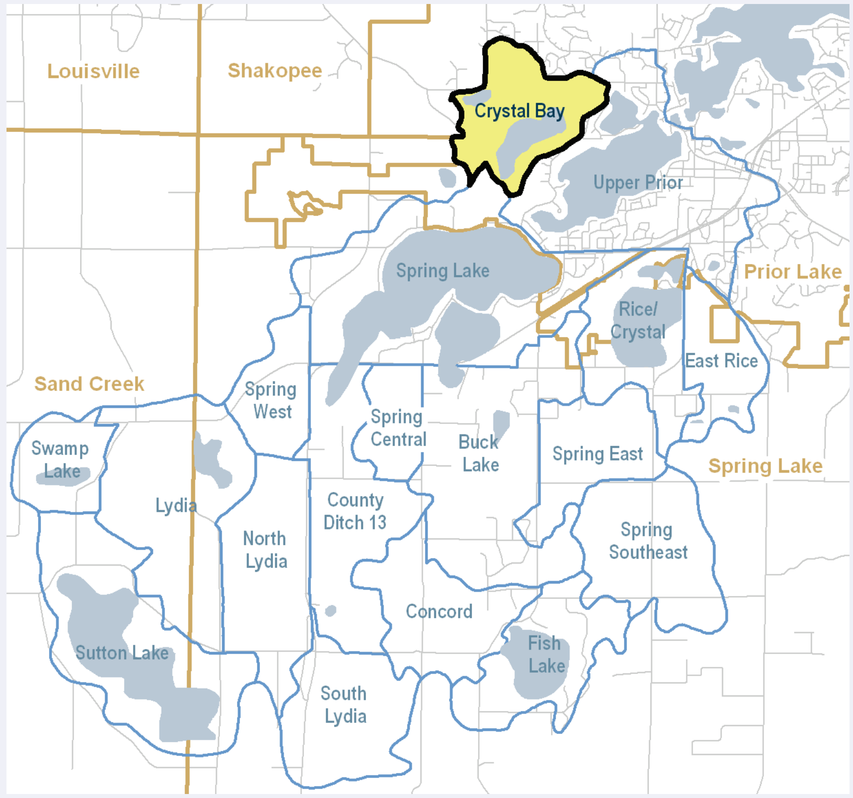
Subwatershed Description

Location:
Prior Lake

Drainage Area:
654 Acres

Drains to:
Upper Prior Lake

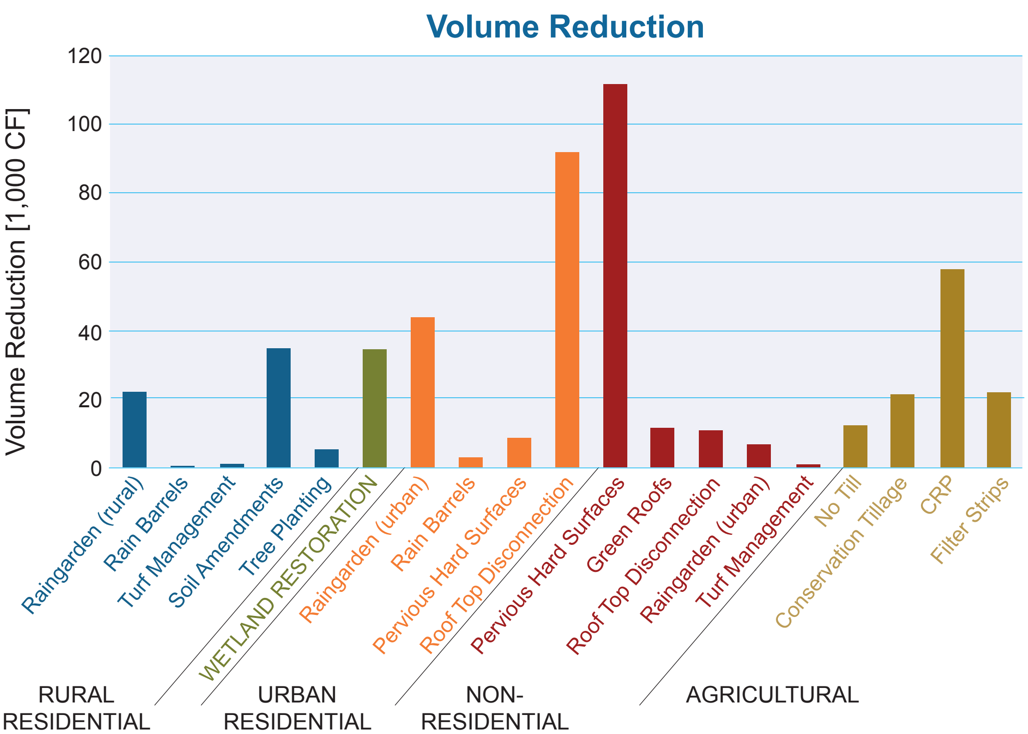
Primary Land Use:
Urban Residential, Non- Residential, & Agricultural

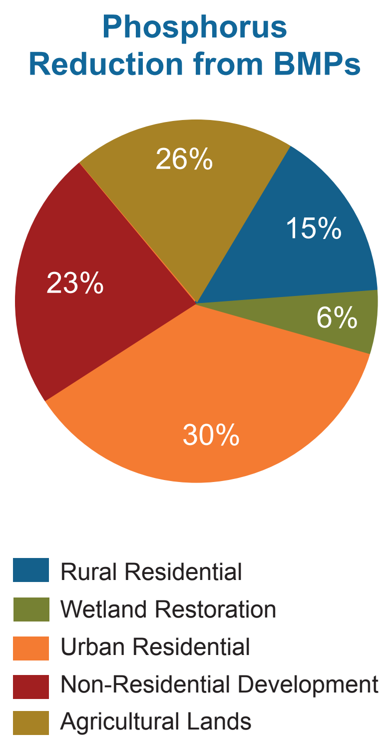


Results & Conclusions

TMDL Volume Reduction:
14 acre-feet

TMDL Phosphorus Load Reduction:
14 lb/yr





EAST RICE

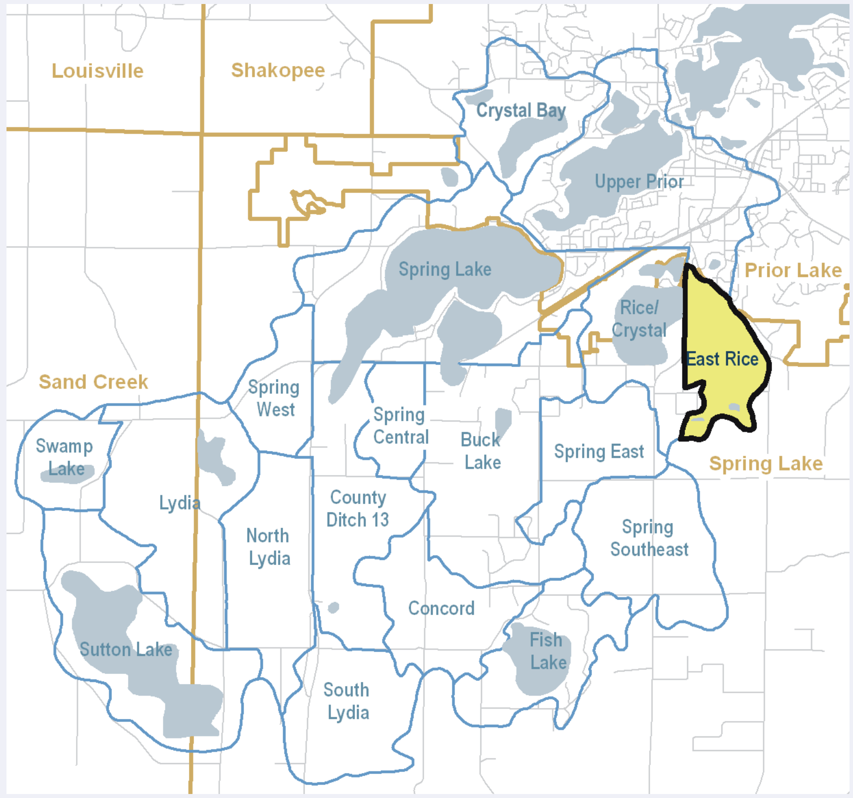
Subwatershed Description

Location:
Spring Lake

Drainage Area:
453 Acres

Drains to:
Upper Prior Lake

Primary Land Use:
Rural Residential & Agricultural

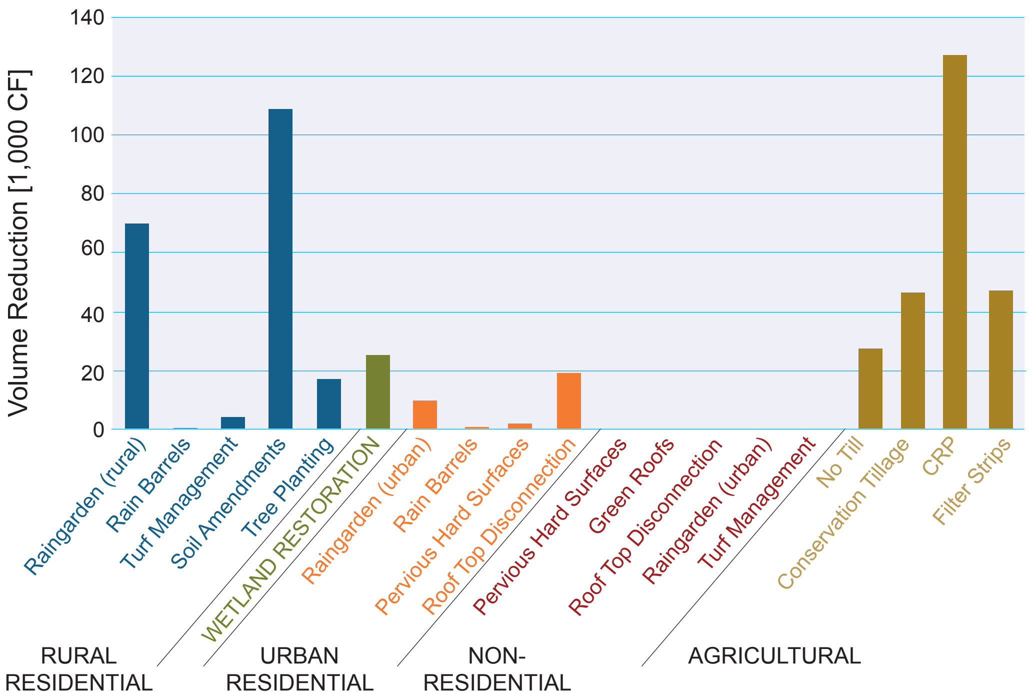


Results & Conclusions

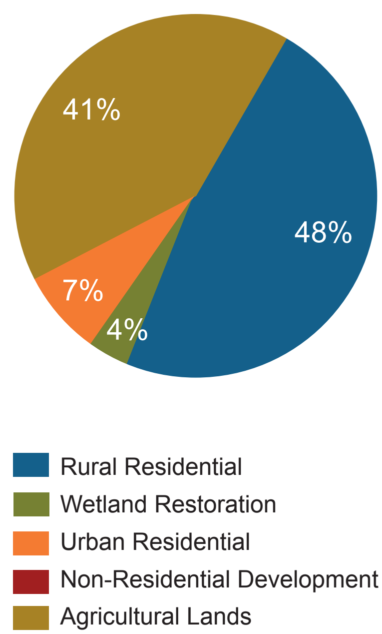
TMDL Volume Reduction:
17 acre-feet

TMDL Phosphorus Load Reduction:
18 lb/yr (9% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



FISH LAKE

Subwatershed Description

Location:
Spring Lake

Drainage Area:
721 Acres

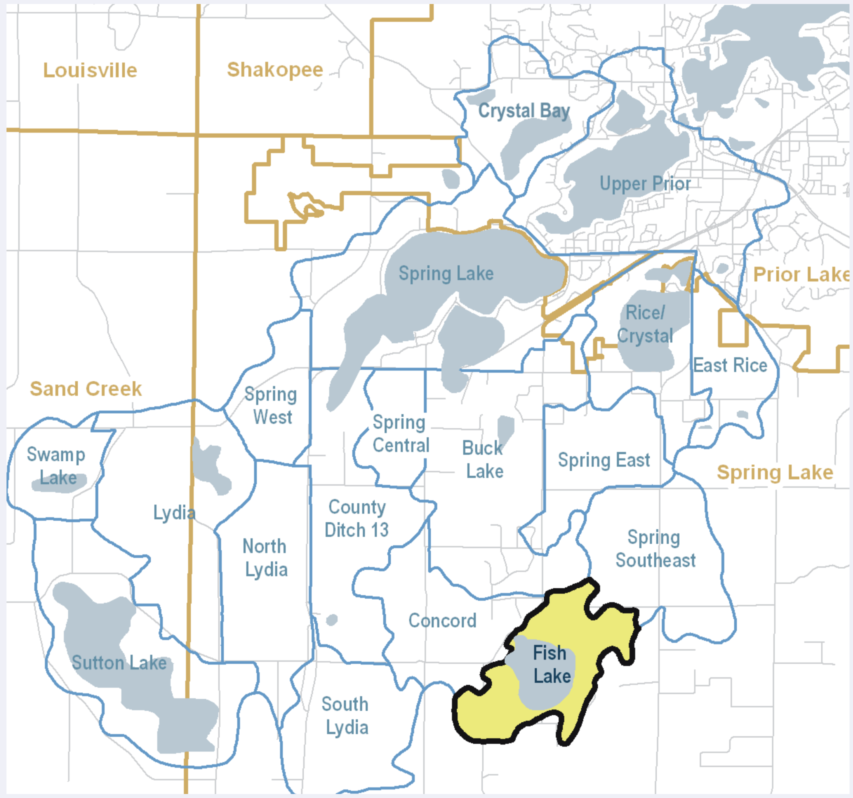
Drains to:
Spring Lake via Buck Lake

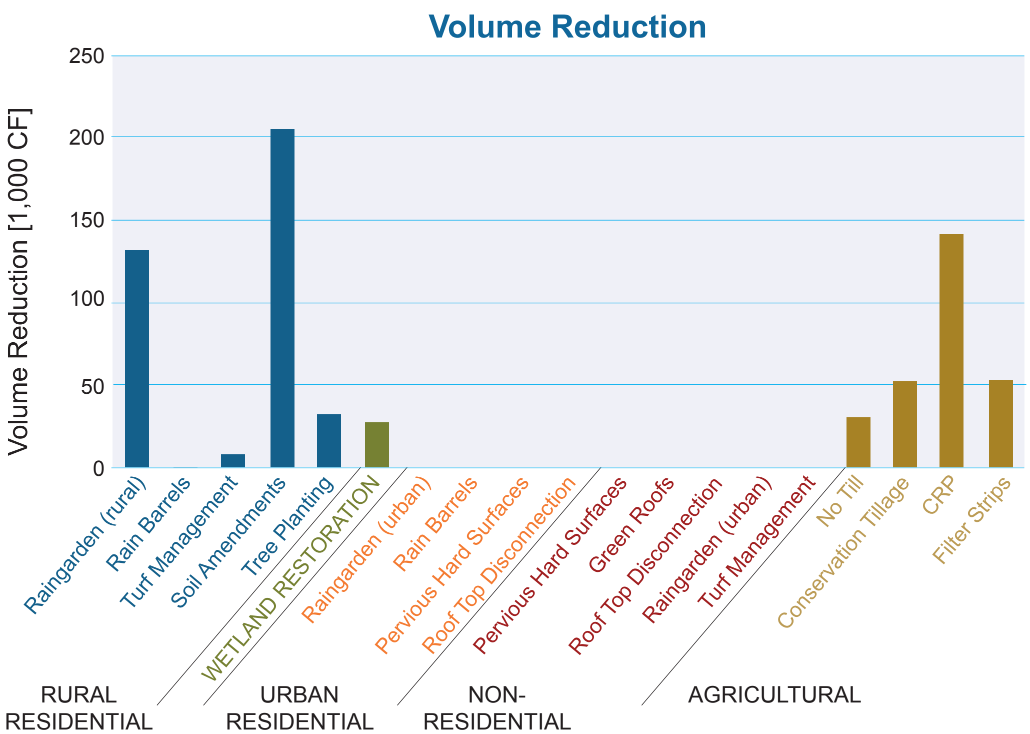
Primary Land Use:
Rural Residential & Agricultural

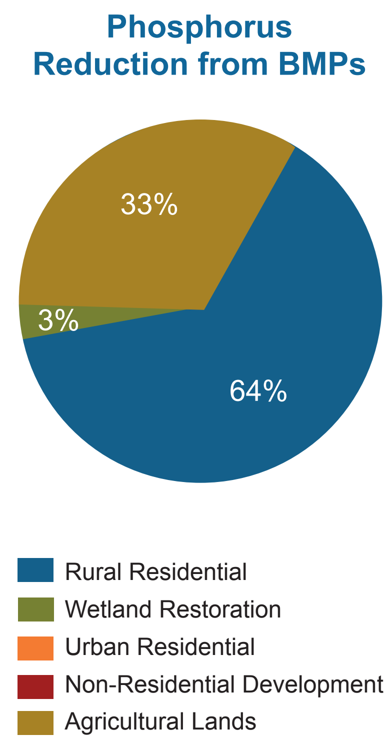
Results & Conclusions

TMDL Volume Reduction:
22 acre-feet

TMDL Phosphorus Load Reduction:
24 lb/yr (5% of total external load)







LYDIA

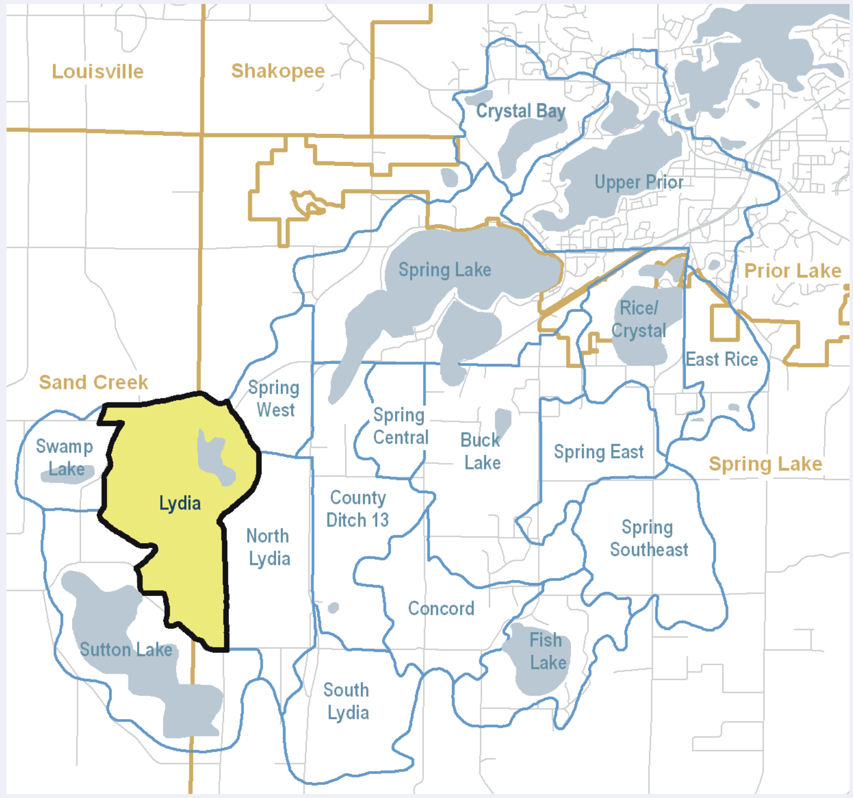
Subwatershed Description

Location:
Sand Creek / Spring Lake

Drainage Area:
1268 Acres

Drains to:
Spring Lake via County Ditch 13

Primary Land Use:
Rural Residential & Agricultural

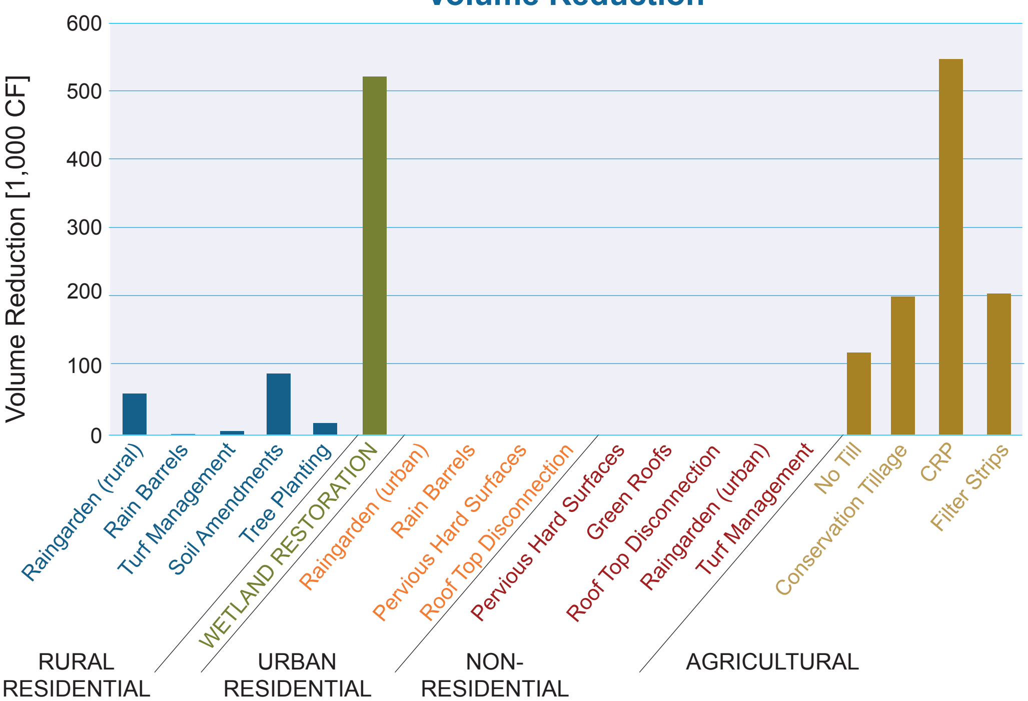


Results & Conclusions

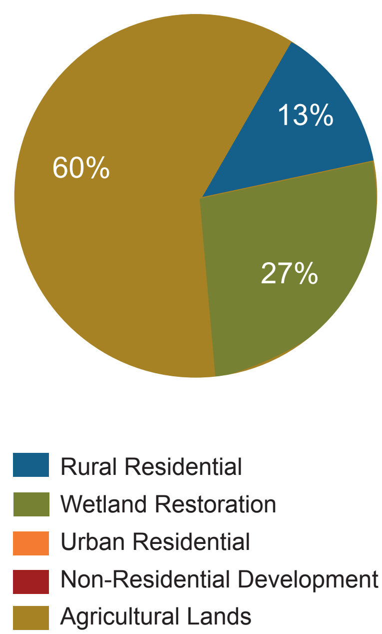
TMDL Volume Reduction:
64 acre-feet

TMDL Phosphorus Load Reduction:
57 lb/yr (7% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



NORTH LYDIA

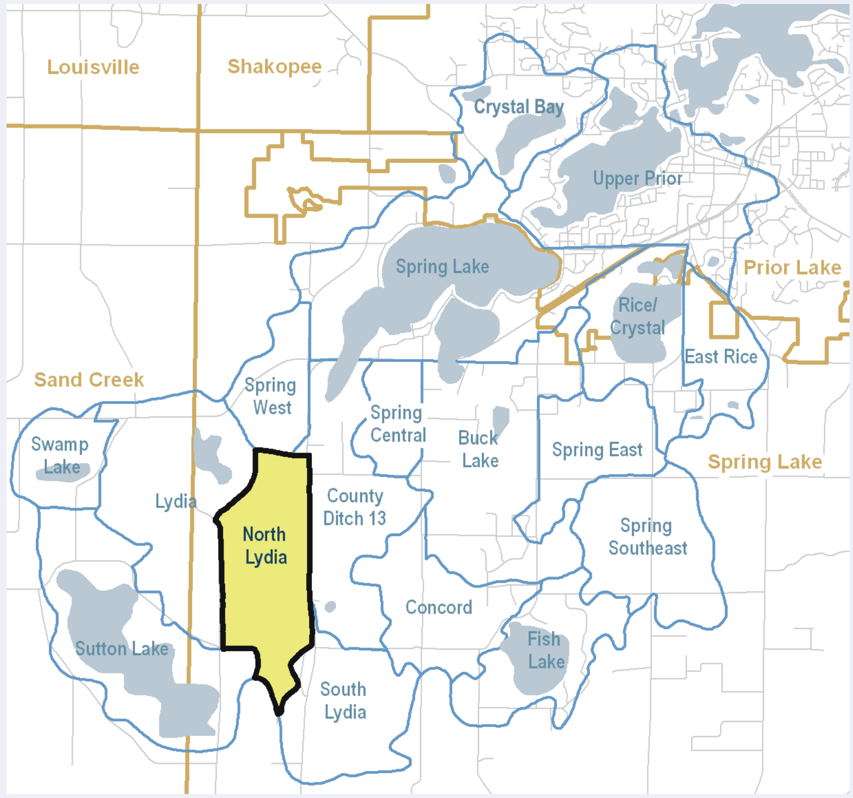
Subwatershed Description

Location:
Spring Lake

Drainage Area:
856 Acres

Drains to:
Spring Lake via County Ditch 13

Primary Land Use:
Rural Residential & Agricultural

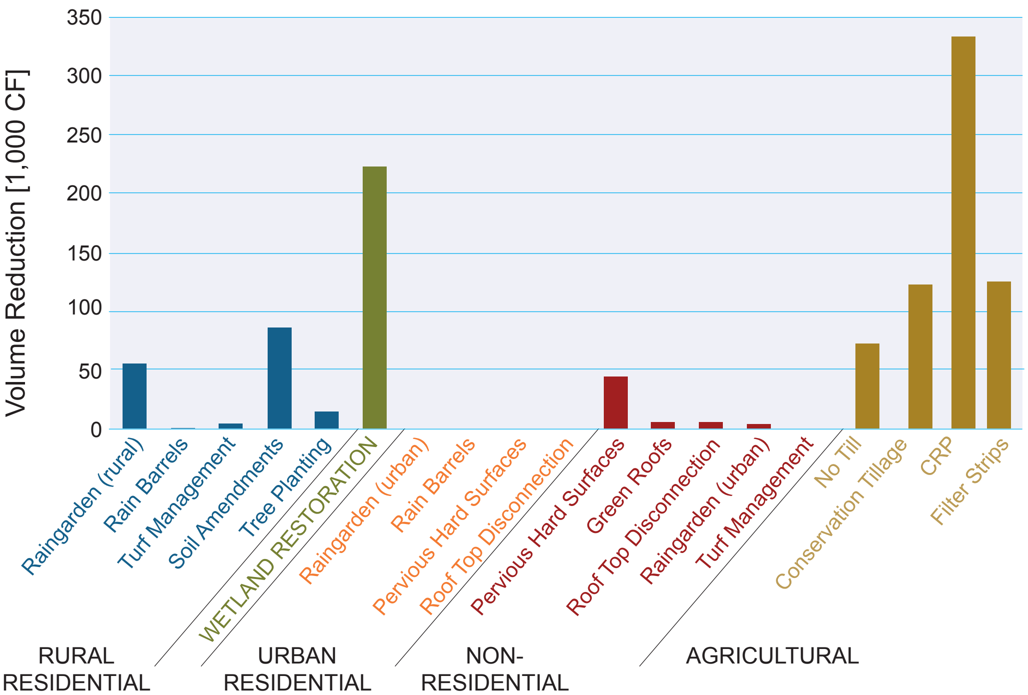


Results & Conclusions

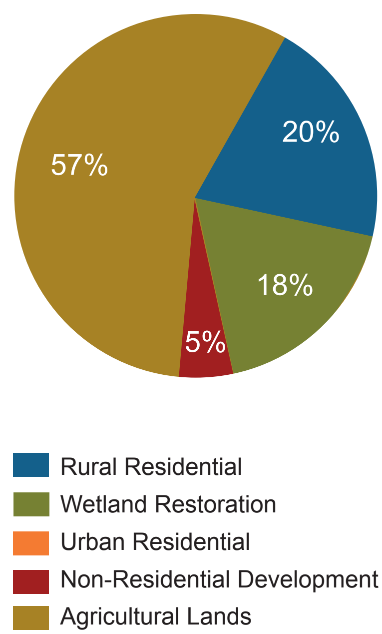
TMDL Volume Reduction:
40 acre-feet

TMDL Phosphorus Load Reduction:
36 lb/yr (7% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



RICE / CRYSTAL

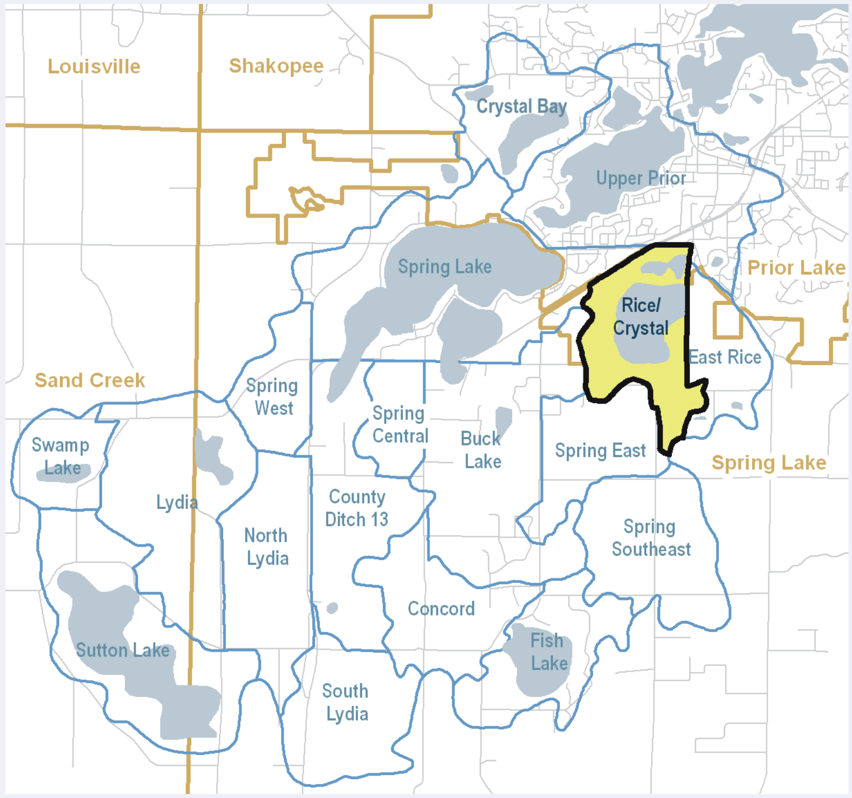
Subwatershed Description

Location:
Prior Lake / Spring Lake

Drainage Area:
748 Acres

Drains to:
Upper Prior Lake

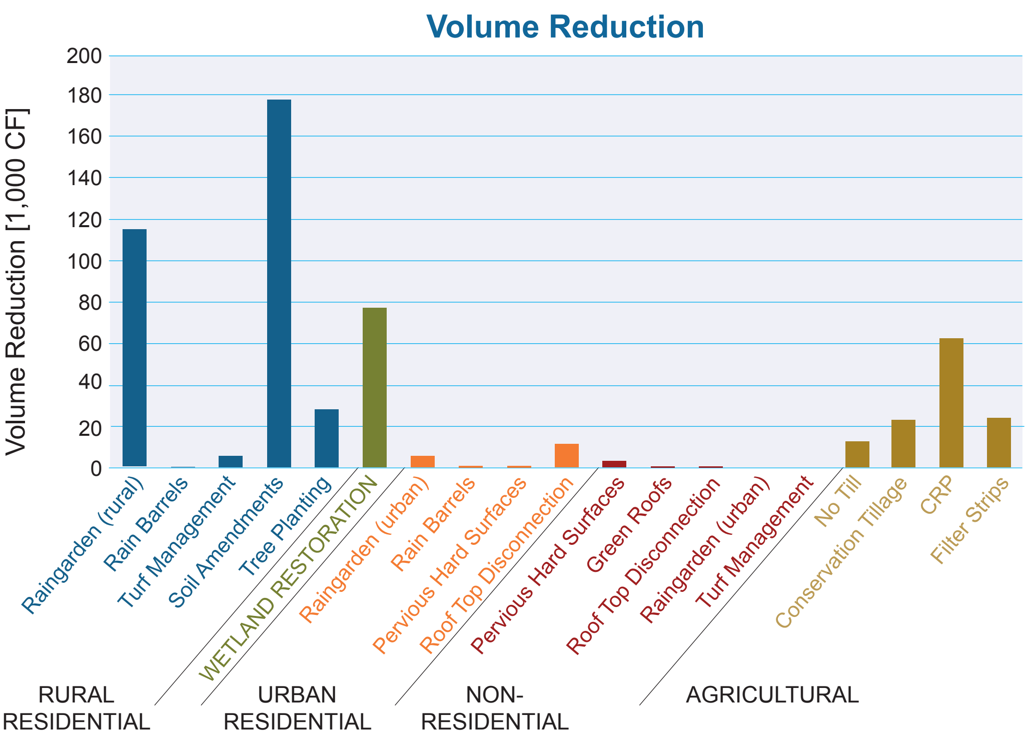
Primary Land Use:
Rural Residential & Agricultural

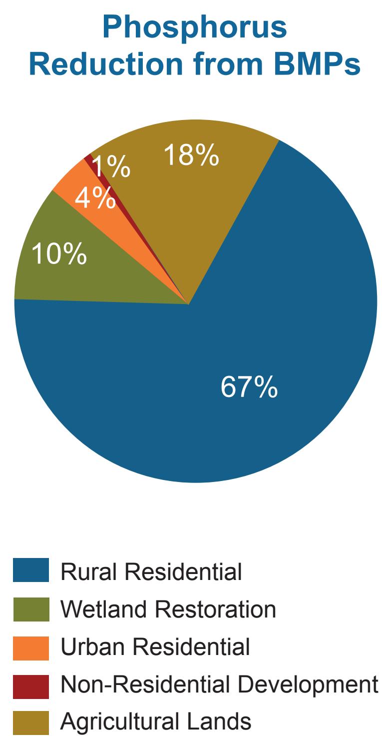


Results & Conclusions

TMDL Volume Reduction:
15 acre-feet

TMDL Phosphorus Load Reduction:
16 lb/yr (6% of total external load)





SOUTH LYDIA

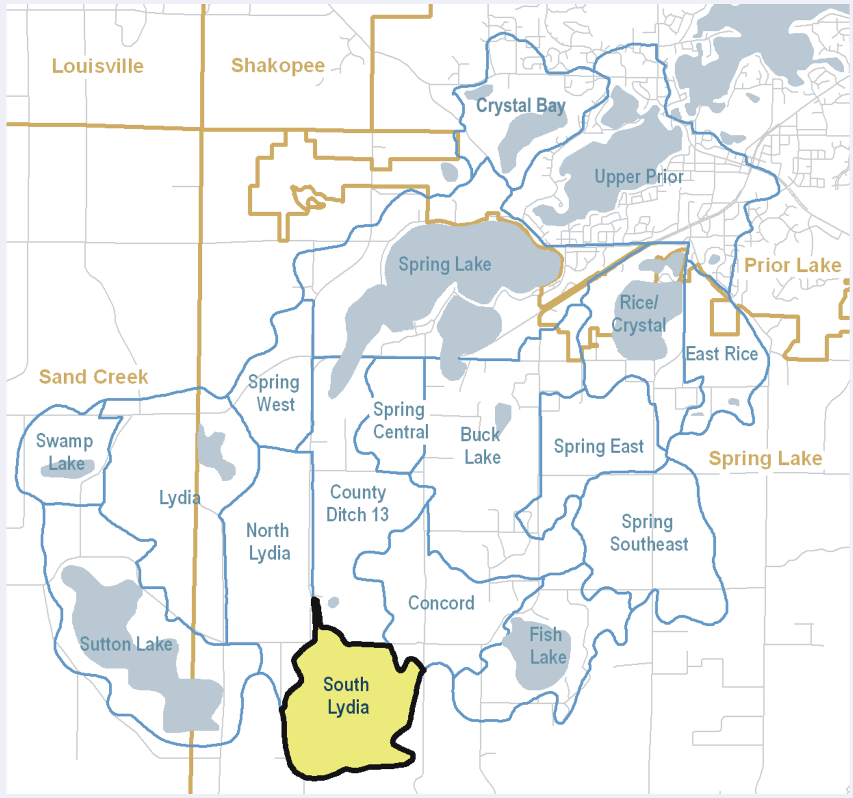
Subwatershed Description

Location:
Spring Lake

Drainage Area:
759 Acres

Drains to:
Spring Lake via County Ditch 13

Primary Land Use:
Rural Residential & Agricultural

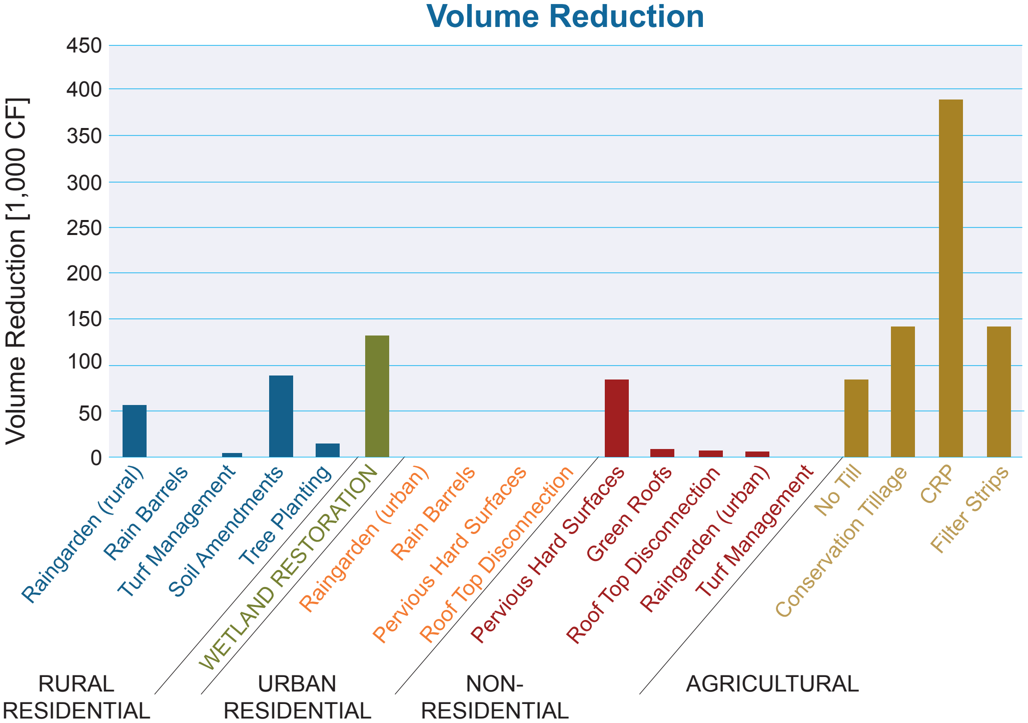


Results & Conclusions

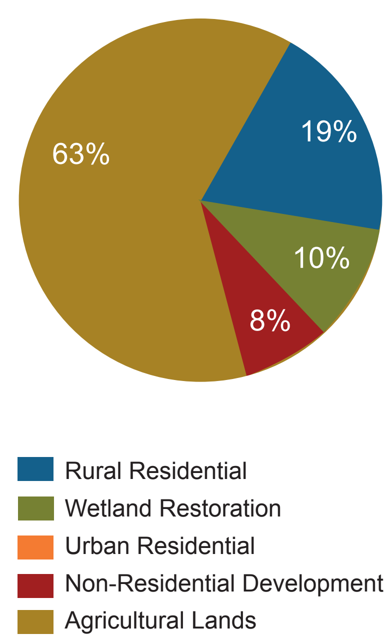
TMDL Volume Reduction:
44 acre-feet

TMDL Phosphorus Load Reduction:
40 lb/yr (9% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



SPRING CENTRAL

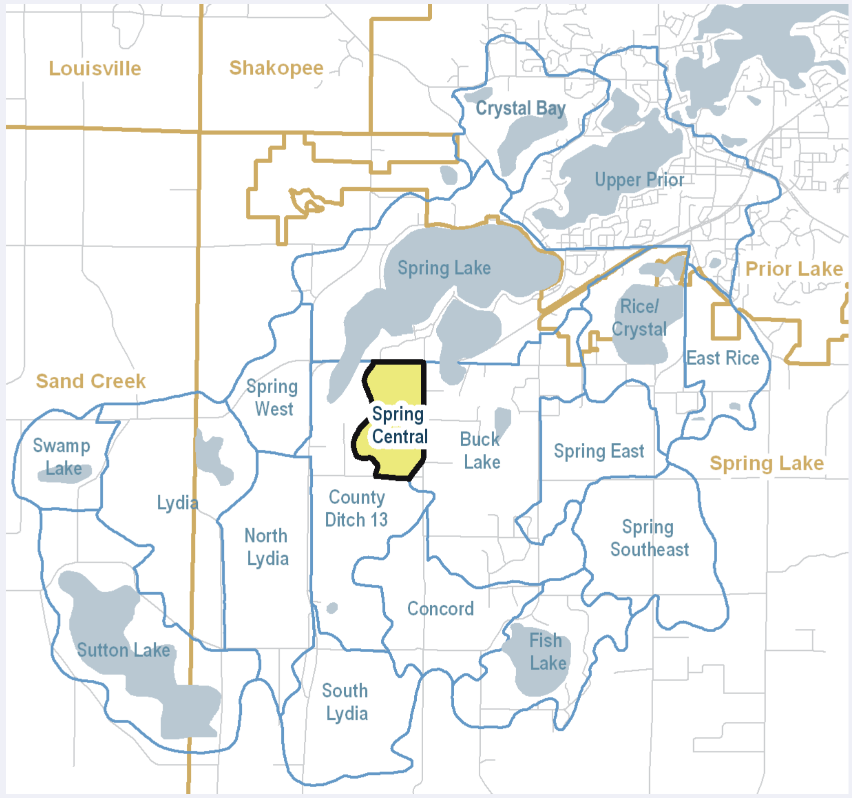
Subwatershed Description

Location:
Spring Lake

Drainage Area:
316 Acres

Drains to:
Spring Lake

Primary Land Use:
Rural Residential & Agricultural

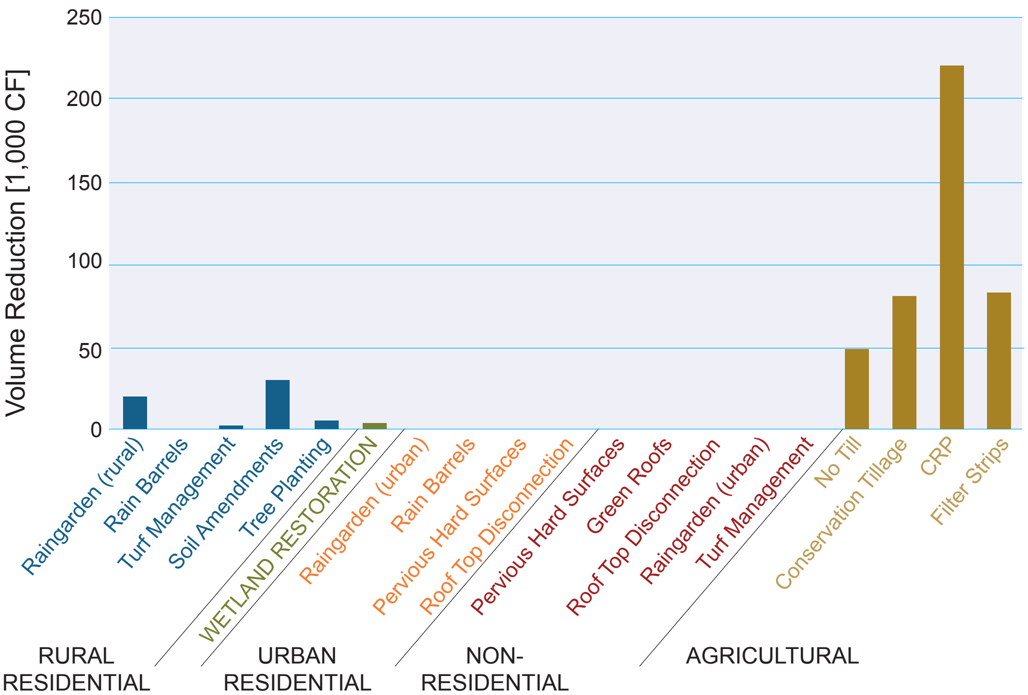


Results & Conclusions

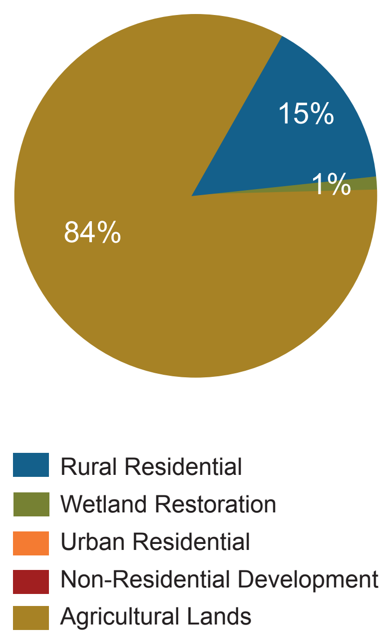
TMDL Volume Reduction:
21 acre-feet

TMDL Phosphorus Load Reduction:
19 lb/yr (3% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs



SPRING EAST

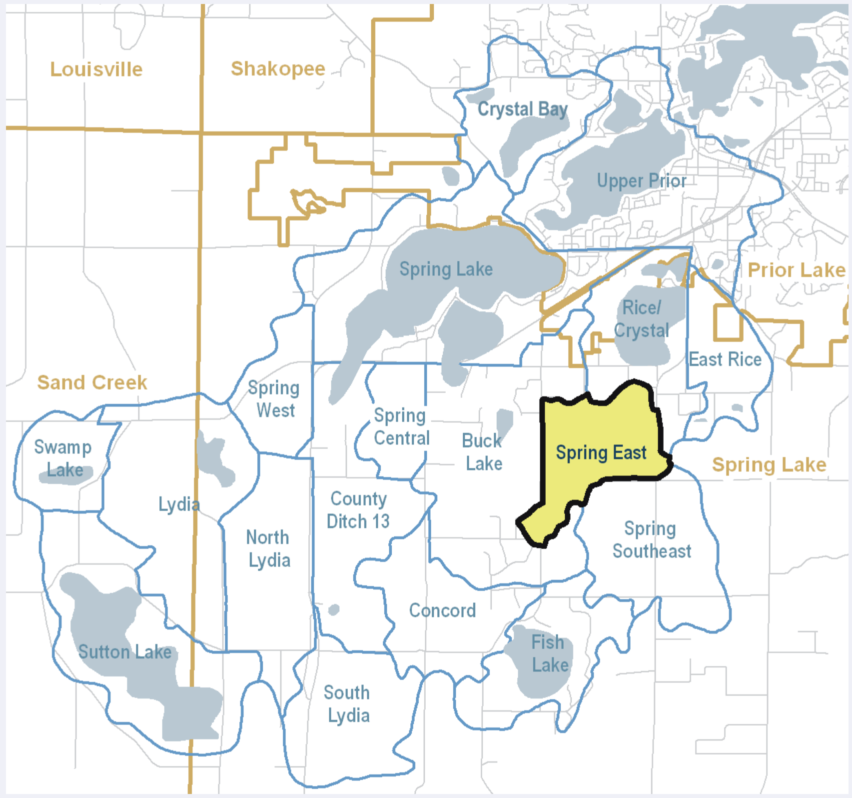
Subwatershed Description

Location:
Spring Lake Township

Drainage Area:
602 Acres

Drains to:
Spring Lake via Buck Lake

Primary Land Use:
Agricultural & Rural Residential

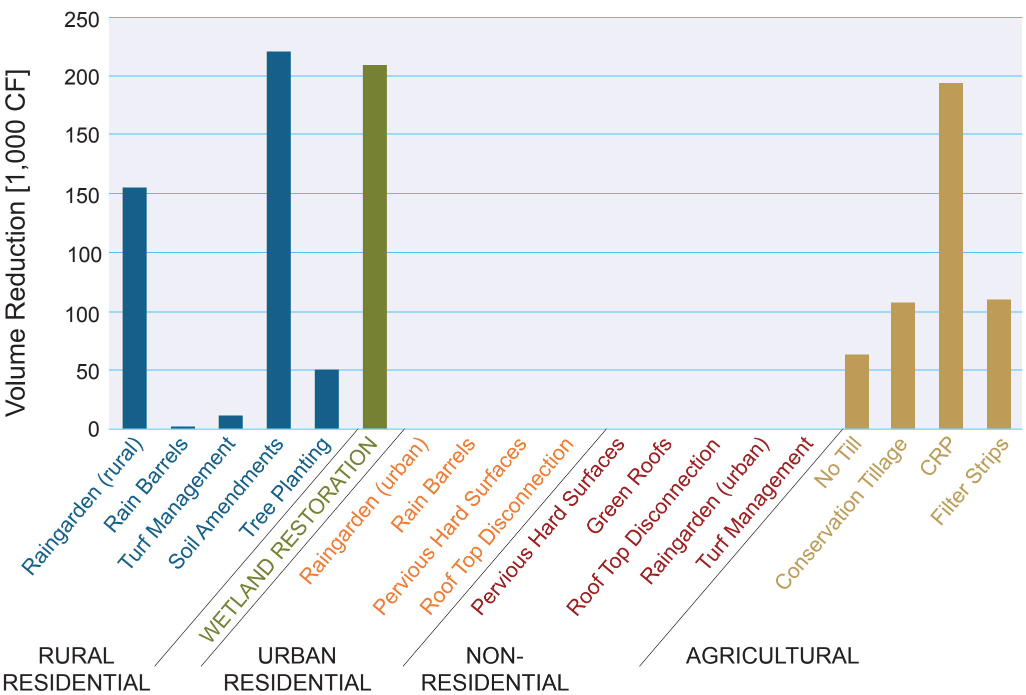


Results & Conclusions

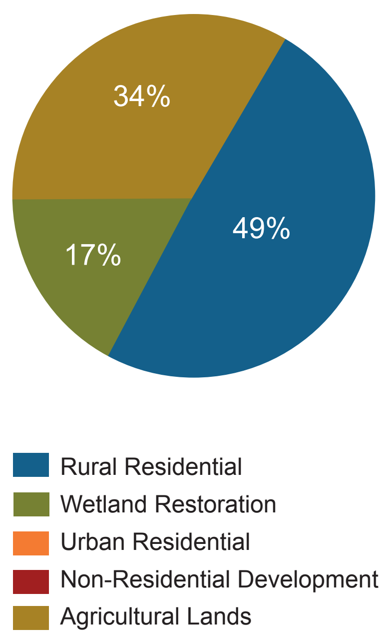
TMDL Volume Reduction:
19 acre-feet

TMDL Phosphorus Load Reduction:
19 lb/yr (4% of total watershed load)

Volume Reduction



Phosphorus Reduction from BMPs



SPRING LAKE

Subwatershed Description

Location:
Spring Lake

Drainage Area:
1922 Acres

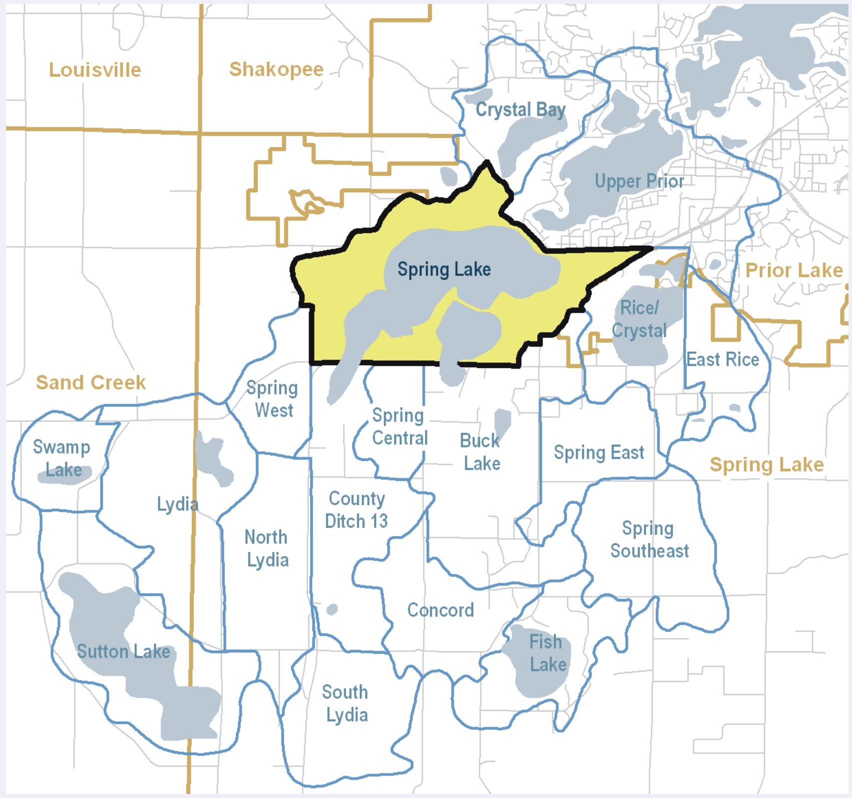
Drains to:
Direct

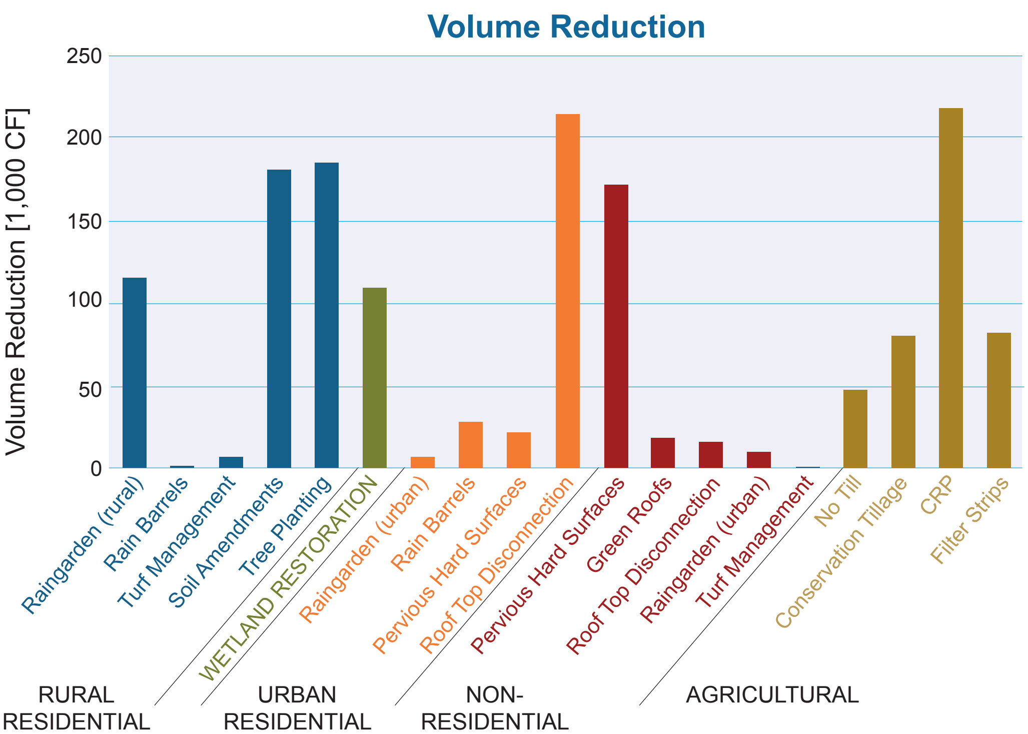
Primary Land Use:
Urban Residential, Rural Residential, & Agricultural

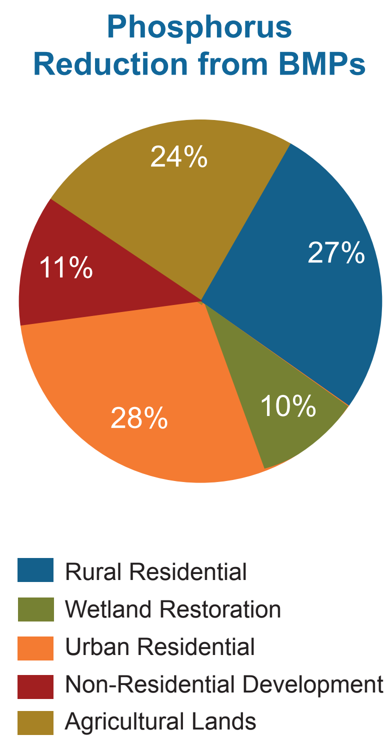
Results & Conclusions

TMDL Volume Reduction:
44 acre-feet

TMDL Phosphorus Load Reduction:
46 lb/yr (8% of total external load)







SPRING SOUTHEAST

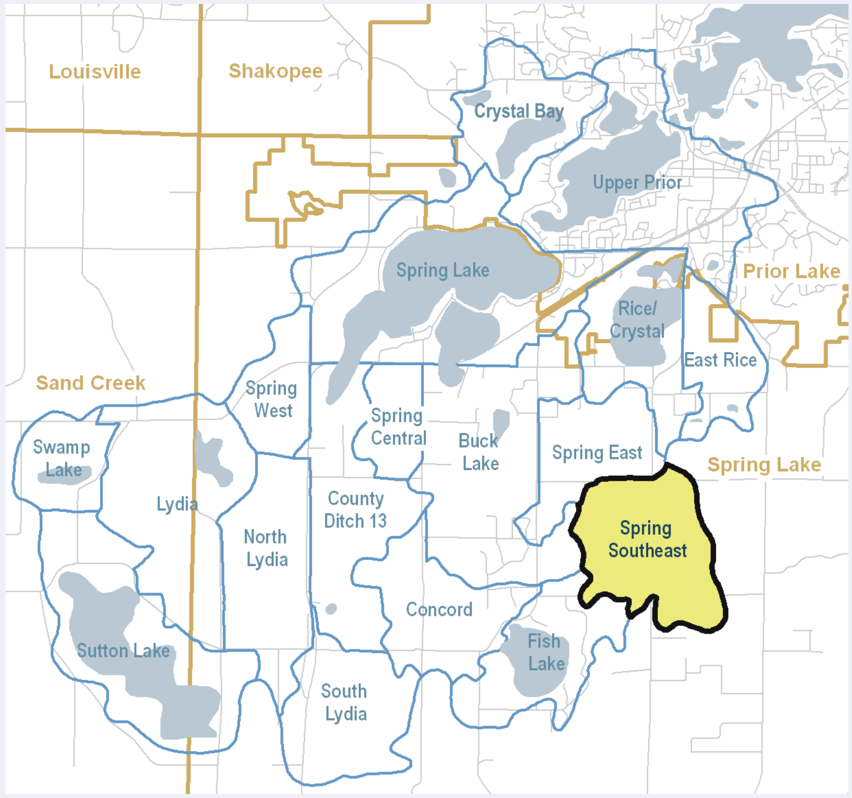
Subwatershed Description

Location:
Spring Lake

Drainage Area:
862 Acres

Drains to:
Spring Lake via Buck Lake

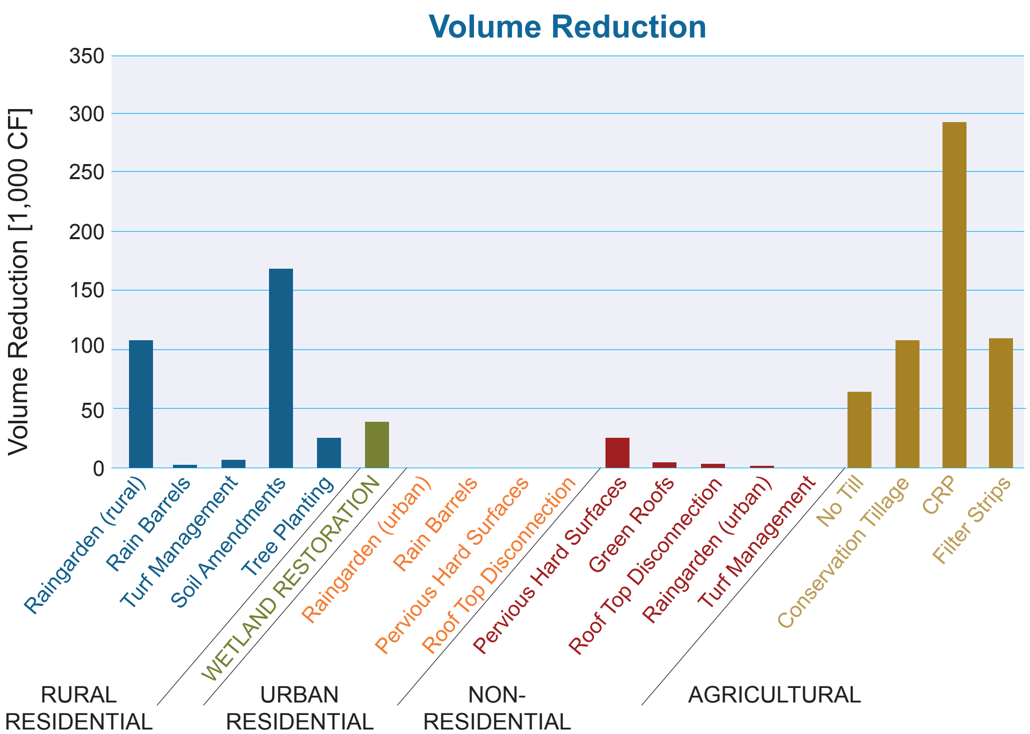
Primary Land Use:
Rural Residential & Agricultural

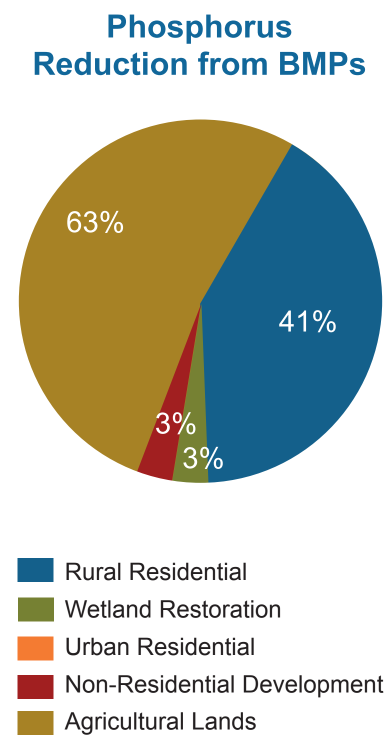


Results & Conclusions

TMDL Volume Reduction:
35 acre-feet

TMDL Phosphorus Load Reduction:
34 lb/yr (5% of total external load)





SPRING WEST

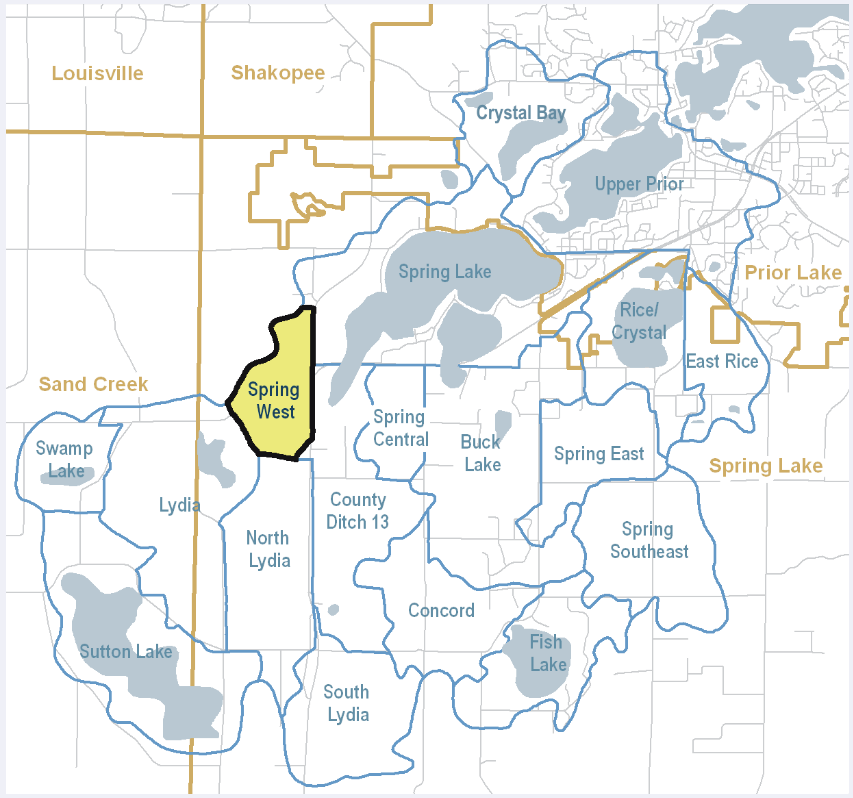
Subwatershed Description

Location:
Spring Lake

Drainage Area:
415 Acres

Drains to:
Spring Lake

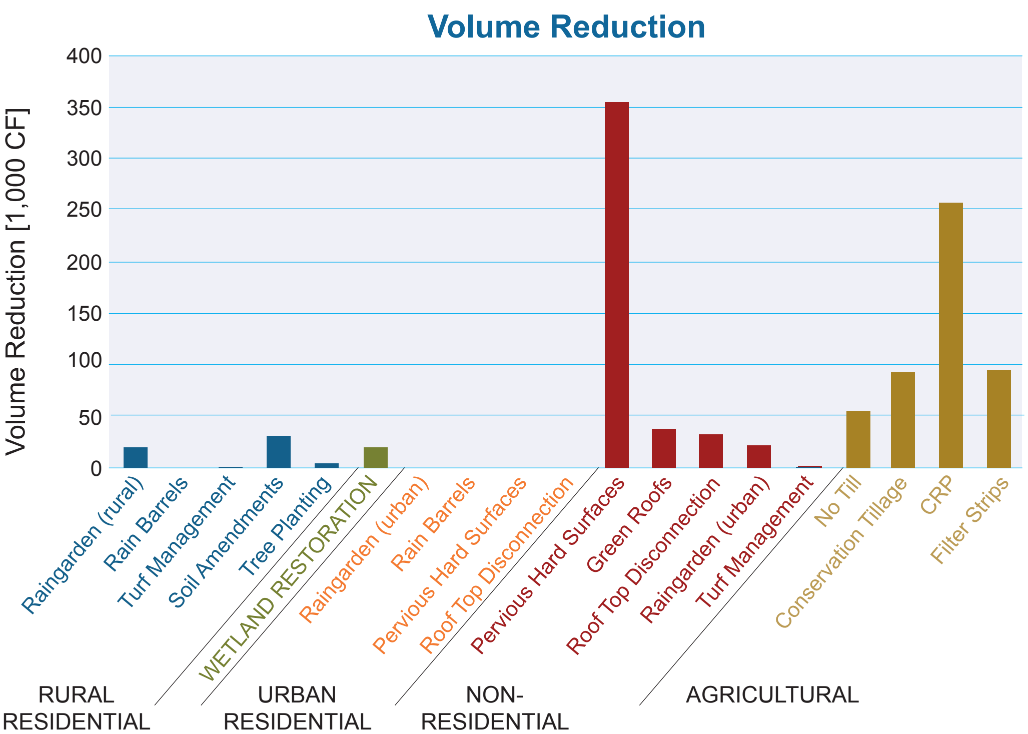
Primary Land Use:
Non-Residential & Agricultural

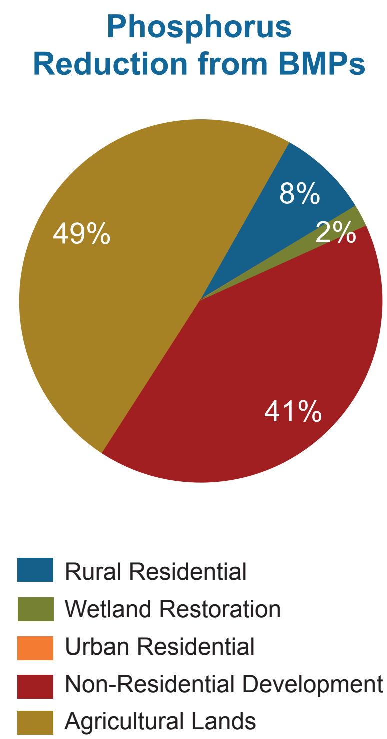


Results & Conclusions

TMDL Volume Reduction:
35 acre-feet

TMDL Phosphorus Load Reduction:
30 lb/yr (5% of total external load)





SUTTON LAKE

Subwatershed Description

Location:
Sand Creek / Spring Lake

Drainage Area:
1386 Acres

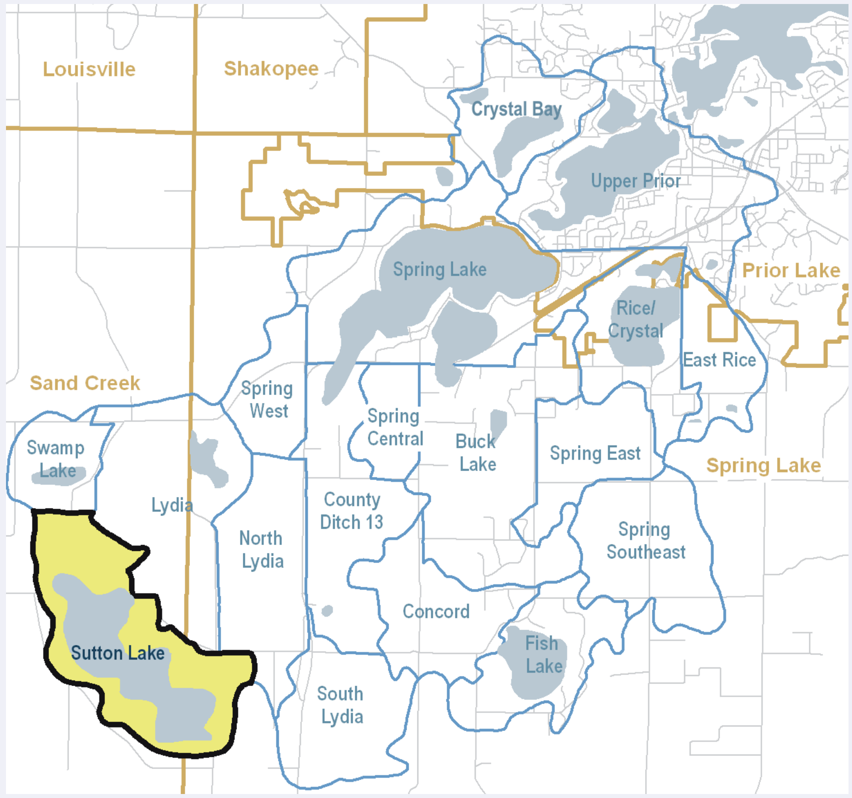
Drains to:
Spring Lake via County Ditch 13

Primary Land Use:
Rural-Residential & Agricultural

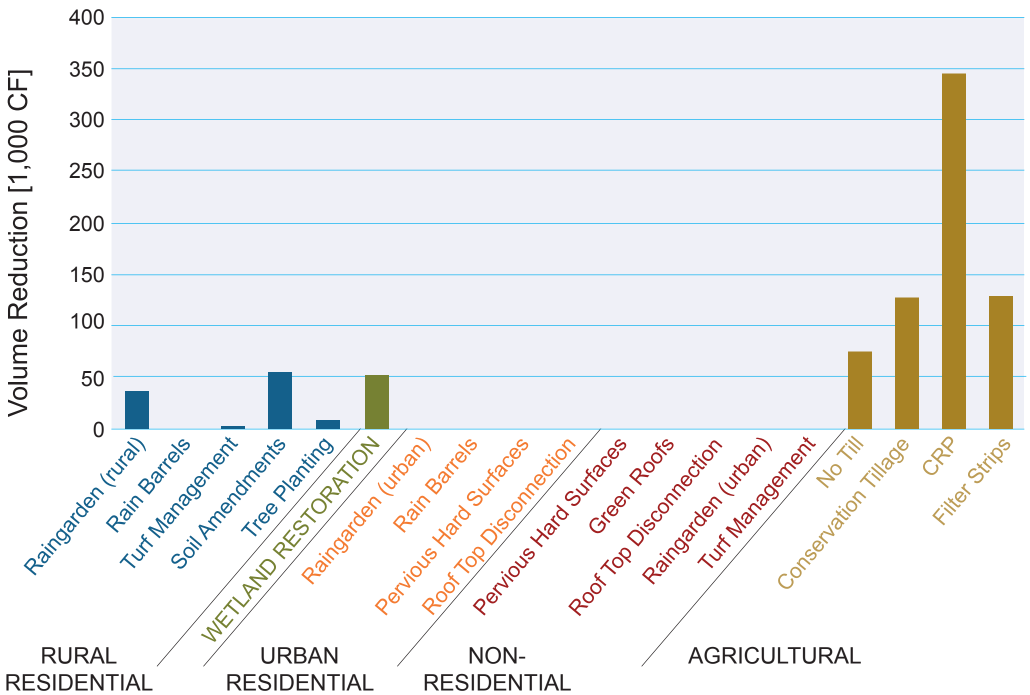
Results & Conclusions

TMDL Volume Reduction:
52 acre-feet

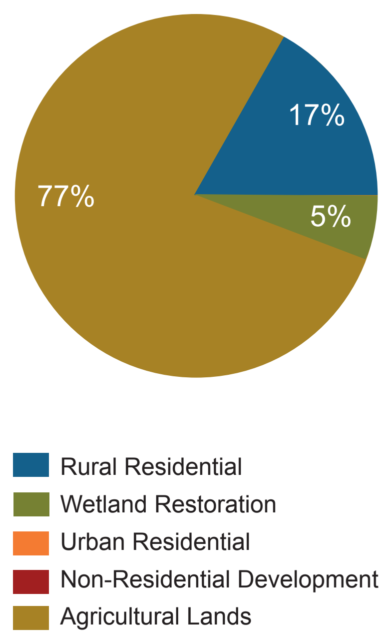
TMDL Phosphorus Load Reduction:
47 lb/yr (8% of total external load)



Volume Reduction



Phosphorus Reduction from BMPs



SWAMP LAKE

Subwatershed Description

Location:
Sand Creek Township

Drainage Area:
396 Acres

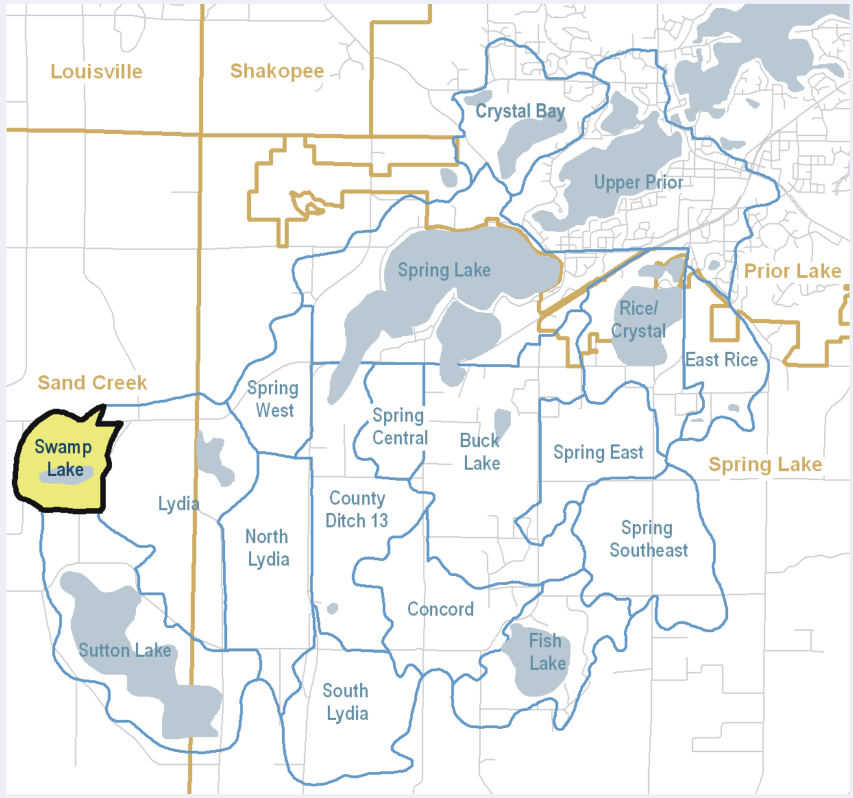
Drains to:
Spring Lake via County Ditch #13

Primary Land Use:
Agricultural

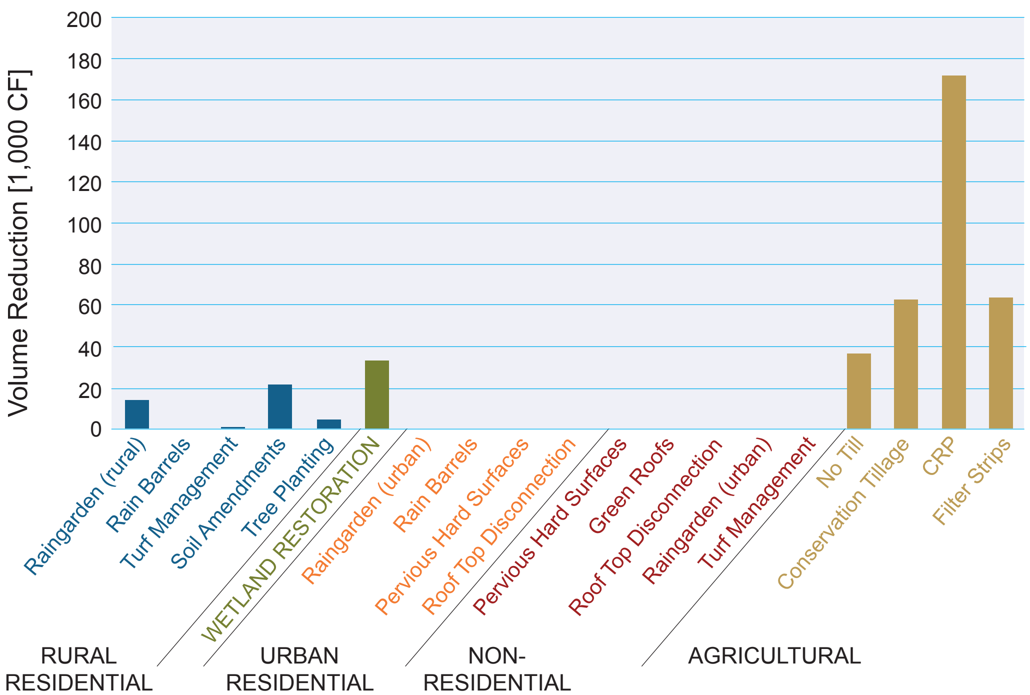
Results & Conclusions

TMDL Volume Reduction:
17 acre-feet

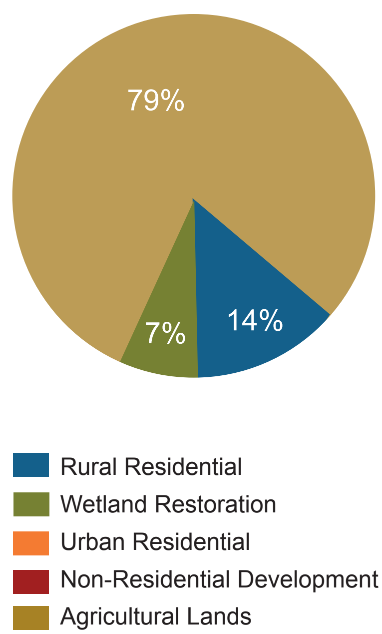
TMDL Phosphorus Load Reduction:
15 lb/yr (7% of total watershed load)



Volume Reduction



Phosphorus Reduction from BMPs



UPPER PRIOR LAKE

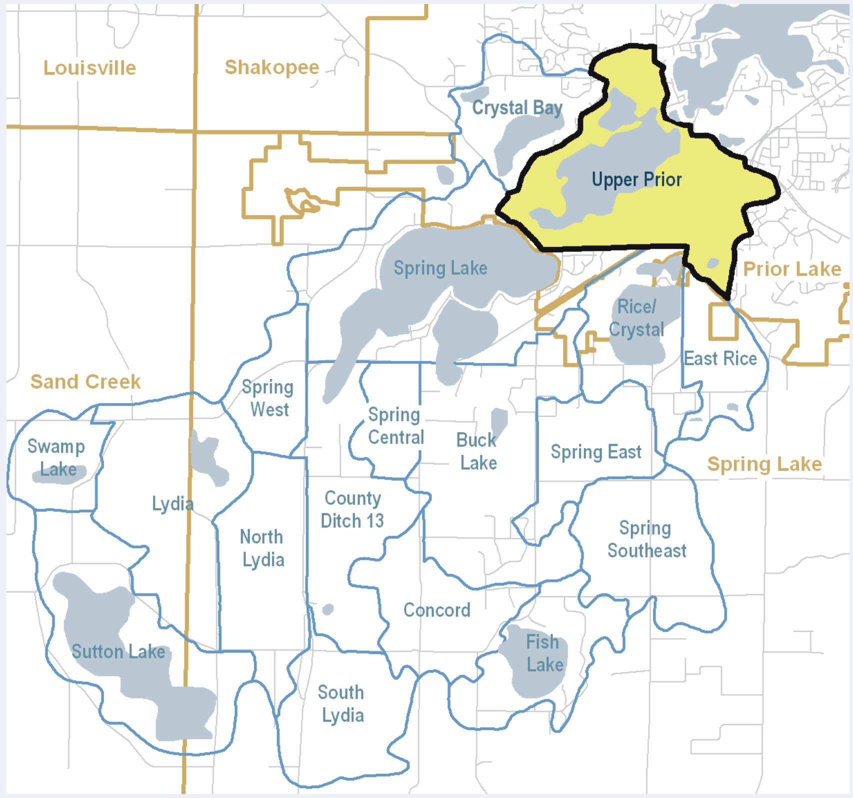
Subwatershed Description

Location:
Prior Lake

Drainage Area:
1589 Acres

Drains to:
Direct

Primary Land Use:
Urban Residential
& Non-Residential

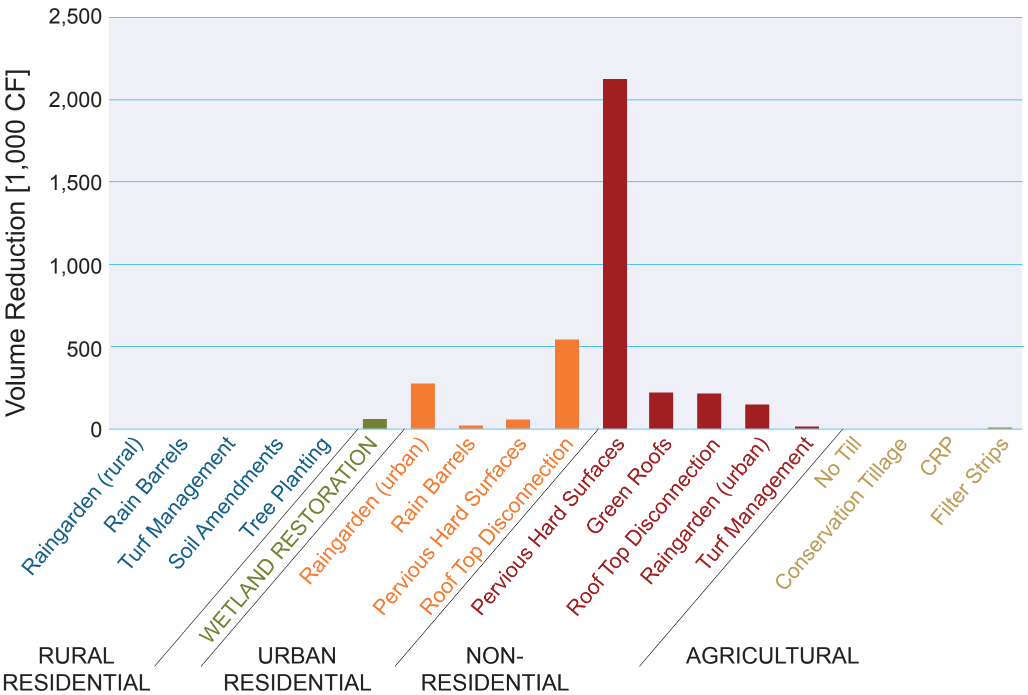


Results & Conclusions

TMDL Volume Reduction:
84 acre-feet

TMDL Phosphorus Load Reduction:
77 lb/yr (15% of total external load)

Volume Reduction



Phosphorus Reduction from BMPs