Adaptive Management Plan

City of Lodi
Columbia County, Wisconsin
August 2016

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Adaptive Management Plan
City of Lodi

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EXECUTIVE SUMMARY

The City of Lodi WPDES Permit was reissued on November 1, 2011. The permit contained a requirement to comply with a water quality based effluent limit (WQBEL) of 0.075 mg/L as an annual average and 0.22 mg/L as a monthly average for total phosphorus by September 30, 2020. This is the deadline the City would have to meet if they were to construct upgrades at the wastewater treatment facility to meet the new WQBEL.

The City has evaluated compliance options and has elected to pursue Adaptive Management (AM), which has the goal of reducing the in-stream phosphorus concentration of Spring Creek from current levels to the DNR-established criterion of 0.075 mg/L. This Adaptive Management Plan (AMP) identifies load reductions needed within the AM Action Area and outlines the general approach for reducing nonpoint phosphorus loads to Spring Creek. Schedules for implementation are also proposed.

As a requirement of Adaptive Management, the City will still need to reduce phosphorus discharges from the wastewater treatment facility. Interim phosphorus discharge limits of 0.6 mg/L and 0.5 mg/L will apply for the duration of Adaptive Management. These interim limits are a reduction from the current 1.0 mg/L permit limit, and can be met without an upgrade to the existing wastewater treatment facility.

Nonpoint source phosphorus loadings from both the urban and rural landscape were quantified and potential reductions were evaluated. A variety of models were used for this purpose. Ultimately, the bulk of load reductions are anticipated to occur within the rural watershed. Improvements at specific barnyards / livestock operations are proposed, and are termed “Hard Practices”, as they require physical improvements to be constructed at these locations. Modifications to cropping and tillage practices are also proposed, and are termed “Soft Practices”, as they are implemented across the rural watershed and do not typically involve significant construction activities.

Urban practices were also evaluated for load reductions and associated cost. Urban reductions would come from the construction of new wet detention stormwater ponds, or modifications which improve the performance of existing ponds. However, additional wet detention ponds would be difficult to implement due to availability of suitable locations within the City. Furthermore, the cost per pound of these practices (~$400/lb) far exceeds the costs for rural options.

Upon request of the City Council, load reductions for urban practices were also evaluated based upon the construction of rain gardens instead of wet detention stormwater ponds. The result of this evaluation showed that rain gardens would remove less phosphorus than wet detention ponds, as expected. The cost per pound for rain gardens was in the range of $1,800/lb.

The calculated annual total phosphorous load reduction needed in Spring Creek to achieve the DNR-established 0.075 mg/L criterion is 714 pounds per year. The minimum load reduction requirement for the first AM permit term is 68 pounds of phosphorus per year. However, DNR recommendations (50% of total reduction needed) indicate a reduction of 357 pounds of phosphorus per year within the first AM permit term. This AM Plan identifies a strategy to remove approximately 1,000 pounds of phosphorus in the first permit term alone. Admittedly, this is a best case scenario, but is proposed as the recommended approach to provide greatest long-term flexibility to the City and greatest likelihood for successful implementation of Adaptive Management.

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Anticipated costs for the first 5-year permit term are anticipated to be in the range of $155,000 per year. Subsequent permit terms would have anticipated annual expenditures of $20,000 - $40,000 per year.

This Adaptive Management Plan builds upon historic efforts within the Spring Creek Watershed by the Columbia County Land and Water Conservation Department (CCLWCD), UW-Stevens-Point, The Friends of Scenic Lodi Valley, DNR, Dane County Land and Water Conservation Department, City of Lodi, and MSA.

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CHAPTER 1 – BACKGROUND

The City of Lodi owns and operates a mechanical wastewater treatment facility (WWTF) that continuously discharges treated effluent to Spring Creek in the Lake Wisconsin Watershed of the Lower Wisconsin River Basin. The City's current Wisconsin Pollutant Discharge Elimination System (WPDES) permit, which was reissued on November 1, 2011, includes a compliance schedule for meeting future water quality based effluent limits (WQBEL) of 0.075 mg/L (annual average) and 0.22 mg/L (monthly average) for phosphorus. The new WQBELs are intended to protect the water quality of Spring Creek and other downstream surface waters. The proposed WQBELs are significantly more stringent than the WWTF's current interim phosphorus limit of 1.0 mg/L (monthly average), and the existing WWTF cannot comply with the WQBELs without significant treatment process upgrades. Therefore, the City of Lodi must upgrade the existing WWTF to meet the proposed WQBELs or must consider alternative means of compliance.

As per the phosphorus compliance schedule (Section 4.1) of the City's WPDES permit, the City has submitted several reports to the Wisconsin Department of Natural Resources (DNR) to document the capabilities of the City's existing WWTF and to evaluate alternatives for achieving compliance with proposed WQBELs. Based on the findings of the *WWWT Phosphorus Optimization and Compliance Feasibility Report* (MSA Professional Services, 2012), the existing WWTF's chemical phosphorus removal process can reliably achieve an effluent phosphorus concentration of 0.5 mg/L or less with alum but cannot be optimized to meet the proposed WQBEL of 0.075 mg/L. According to this report, a tertiary phosphorus removal process upgrade (filtration or equivalent technology) would be needed to achieve the WQBEL of 0.075 mg/L. This report also identifies that the City is eligible to implement a voluntary watershed-based alternative known as Adaptive Management (AM) to comply with the proposed WQBELs. This alternative would allow the City to implement urban stormwater and/or agricultural best management practices (BMPs) in the Spring Creek Watershed in lieu of constructing costly tertiary phosphorus removal process upgrades at the WWTF.

The goal of Adaptive Management is to implement a sufficient number of BMPs upstream of the WWTF outfall in order to achieve the applicable water quality criterion for phosphorus in the receiving water. This water quality criterion was established in 2010 by the Wisconsin Department of Natural Resources (DNR) in order to better protect fish, aquatic life, and human health in Wisconsin's streams (NR 102.06(3)(b)). BMPs which may be implemented to achieve the water quality criterion include any practice which may reduce non-point source loadings of phosphorus to the receiving water. Urban BMP options include stormwater infiltration practices, detention basins, and grassed swales. Rural/agricultural BMPs can include both hard practices (e.g. barnyard improvements such as clean water diversions and heavy use protection areas) and soft practices (e.g. nutrient management, reduced tillage, and filter strips). In many cases, BMP implementation to achieve the water quality criterion of the receiving water may be less costly than upgrading a WWTF to achieve stringent WQBELs for phosphorus.

In order to be eligible for Adaptive Management, a wastewater permittee must meet the following criteria:

1. The permittee's receiving water must exceed the applicable phosphorus criteria.
2. Filtration or equivalent technology must be needed by the permittee to meet the proposed WQBEL for phosphorus.

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3. Non-point sources must contribute at least 50% of the total phosphorus load in the permittee's receiving water.

The applicable water quality criterion for Spring Creek is 0.075 mg/L. Based on past stream monitoring, the median phosphorus concentration in Spring Creek directly upstream of the WWTF outfall is 0.078 mg/L. Therefore, Spring Creek exceeds the water quality criterion. As stated above, filtration or equivalent technology is needed to meet the proposed WQBEL for phosphorus. Lastly, according to DNR's Pollutant Load Ratio Estimation Tool (PRESTO), 92% of the total phosphorus load in Spring Creek is attributable to non-point sources (http://dnr.wi.gov/topic/SurfaceWater/presto.html). Therefore, the City of Lodi meets all of the eligibility criteria for Adaptive Management.

In order to determine if a wastewater treatment facility upgrade or Adaptive Management is the preferred alternative for achieving compliance with the proposed WQBEL, the City of Lodi completed a *Preliminary Compliance Alternatives Plan* (MSA Professional Services, 2013). This report estimated that the costs associated with Adaptive Management would be significantly less than a wastewater treatment facility upgrade. As a result, the City of Lodi has selected Adaptive Management as the preferred phosphorus compliance alternative.

In 2015, the City of Lodi began the associated planning efforts needed to implement Adaptive Management. The purpose of this Adaptive Management Plan (AMP) is to outline the City's strategy for reducing phosphorus loadings within the upstream Spring Creek Watershed to reach the in-stream water quality criterion of 0.075 mg/L. The AMP follows the nine-key-element guidelines provided by the Wisconsin DNR. Specifically, the plan entails:

1. Identifying key partners for planning and implementation
2. Setting load reduction goals
3. Conducting a watershed inventory
4. Identifying Critical Source Areas (CSAs) where load reductions will occur
5. Determining possible BMPs for each CSA
6. Establishing load reductions by each permit term
7. Developing a monitoring strategy to gage water quality improvements
8. Outlining financial needs
9. Creating an implementation schedule

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CHAPTER 2 – IDENTIFY PARTNERS

Identifying local partners is important to the success of the Lodi Adaptive Management Plan (LAMP). Fortunately, the Spring Creek Watershed already has many active parties interested in water quality improvements. Tapping into local knowledge, coordinating with other governmental organizations, and reaching out to public and non-profit groups will improve relationships with local landowners and better leverage all of the available assets these groups have to offer.

Several past research studies focused on water quality within Spring Creek. The Friends of the Scenic Lodi Valley, in collaboration with the City of Lodi, Columbia County LWCD, and the DNR, began a sampling effort in 2011 (Spring Creek Watershed Survey, River Grant Project No. RP-157-09). Phosphorus concentrations, flow, and other water quality parameters were collected at five sites throughout the Spring Creek Watershed. Sampling continued through 2012 with researchers from University of Wisconsin – Stevens Point (Spring Creek Watershed Water Quality Report) collecting more base flow samples to better understand the current condition of Spring Creek. Some of this sampling data was utilized to determine the existing phosphorus loading in Spring Creek.

In 2014, Columbia County LWCD published their findings of a detailed assessment of all livestock operations within the Spring Creek Watershed. This effort entailed visiting all facilities and recommending possible Best Management Practices (BMPs) to reduce phosphorus loadings to Spring Creek. Phosphorus loadings for each site were estimated for existing and post-construction conditions using BARNY, a model which was developed by Wisconsin DNR to estimate phosphorus loads in stormwater runoff from barnyards and feedlots. Based on recommended BMPs, Columbia County developed preliminary cost estimates (low and high) for each site. This effort was critical in prioritizing possible improvements, as sites could easily be evaluated for cost-effectiveness.

Many organizations were contacted as potential partners in the Adaptive Management project. The roles and responsibilities of all partners who have agreed to participate in the project are summarized below:

Partner	Roles & Responsibilities
City of Lodi	The City of Lodi will be the lead partner in the Adaptive Management Project. All major project related decisions will be made or reviewed by the City. The City will provide a significant portion of financial assistance for the project related to technical assistance and BMP implementation costs. The City will work with other partners to best leverage external funding sources, establish timelines for proposed projects, and identify possible opportunities for phosphorus reductions in the watershed.
MSA Professional Services, Inc.	MSA Professional Services, Inc. will provide technical assistance to the City of Lodi. Technical assistance will include services related to the operation of the City's wastewater treatment facility, engineering services related to BMP implementation and the quantification of phosphorus reductions in the watershed, and funding assistance as it pertains to grant proposals and cost-share applications.

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Partner	Roles & Responsibilities
Wisconsin Department of Natural Resources (DNR)	The Wisconsin DNR will provide regulatory oversight for the Adaptive Management Project. DNR will coordinate directly with the City regarding compliance with effluent limits at the wastewater treatment facility and progress with implementing the Adaptive Management Plan.
Columbia County Land & Water Conservation Department (LWCD)	Columbia County LWCD has been supportive of the Adaptive Management planning efforts and will be an integral partner in the implementation of the Adaptive Management plan. Columbia County LWCD will provide regulatory oversight for the project as well as technical assistance for BMP implementation which occurs in Columbia County. All BMPs which are implemented within Columbia County related to Lodi's Adaptive Management Project will be reviewed by Columbia County LWCD. The Columbia County LWCD will be relied on for making determinations regarding landowner compliance with Wisconsin's agricultural performance standards and manure management prohibitions which are listed in NR 151 and for reviewing future landowner compliance with these rules. Columbia County LWCD has also agreed to provide cost-share, grant writing, stream monitoring, and public outreach/education assistance for the project.
Dane County Land & Water Resources Department (LWRD)	Dane County LWRD will provide regulatory oversight for the project as well as technical assistance for BMP implementation which occurs in Dane County. All BMPs which are implemented within Dane County related to Lodi's Adaptive Management Project will be reviewed by Dane County LWRD. The Dane County LWRD will be relied on for making determinations regarding landowner compliance with Wisconsin's agricultural performance standards and manure management prohibitions which are listed in NR 151 and for reviewing future landowner compliance with these rules.
Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP)	DATCP staff will primarily be used to provide technical assistance, public outreach, and public education for the Adaptive Management Project. Specifically, staff could be utilized to provide assistance related to nutrient management planning. DATCP staff have an in-depth knowledge of Wisconsin's nutrient management planning regulations and the SnapPlus computer model which is used to develop nutrient management plans in accordance with Wisconsin's NRCS 590 Nutrient Management Standard. Nutrient management planning will likely be implemented as part of the Adaptive Management Plan to reduce phosphorus loadings from crop fields and pastures in the Spring Creek Watershed.

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Partner	Roles & Responsibilities
Natural Resources Conservation Service (NRCS)	NRCS will provide technical assistance and financial assistance for the Adaptive Management Project. NRCS engineers and technicians may provide technical assistance for BMPs which are implemented in the rural/agricultural landscape of the Spring Creek Watershed. It is likely that NRCS programs such as the Environmental Quality Incentive Program (EQIP) and the Regional Conservation Partnership Program (RCPP) could provide cost-share/funding assistance to landowners who implement BMPs as part of the Adaptive Management Project.
Friends of Scenic Lodi Valley	Friends of Scenic Lodi Valley is a local conservation group that is interested in protecting land use, geographical features, environmental quality, and historical heritage which are important to preserving and promoting quality of life in the Spring Creek Watershed. The Friends of Scenic Lodi Valley have pledged to assist with stream monitoring, funding/grant writing, and public outreach/education. This group is also interested in promoting rain gardens to reduce non-point phosphorus loads generated in the City of Lodi.
Clean Wisconsin	Clean Wisconsin will provide technical assistance, public outreach, and public education related to the Adaptive Management Project. Clean Wisconsin is involved with several proposed Adaptive Management projects in Wisconsin. Therefore, Clean Wisconsin may be able to facilitate engagement with other Adaptive Management projects or to provide knowledge sharing between projects as Adaptive Management projects progress in the future.
Wisconsin Ducks Unlimited, Inc.	Wisconsin Ducks Unlimited, Inc. is a local conservation group which is interested in conserving, restoring, and managing wetlands and associated habitats for North America's waterfall. Wisconsin Ducks Unlimited has agreed to provide funding/grant writing assistance, technical assistance, and public outreach/education for the Adaptive Management Project.

Other potential partners who have been contacted regarding the Adaptive Management Project are listed below. Although these groups have not necessarily pledged to provide service related to the Adaptive Management Project, these groups will continue to be engaged by the City of Lodi to identify possible opportunities for phosphorus reductions in the watershed and to best leverage external funding sources for the project.

- Aldo Leopold Chapter of Trout Unlimited
- Columbia County Pheasants Forever
- Dane County Pheasants Forever
- Sand County Foundation
- Southern Chapter of Trout Unlimited

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- Town of Arlington (Columbia County)
- Town of Dane (Dane County)
- Town of Lodi (Columbia County)
- Town of Vienna (Dane County)
- University of Wisconsin – Extension
- University of Wisconsin – Stevens Point Fisheries and Water Resources Department
- Wisconsin Land and Water Conservation Association

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CHAPTER 3 – DESCRIPTION OF THE SPRING CREEK ACTION AREA AND LOAD REDUCTION GOALS

3.1 THE ACTION AREA

The Action Area for LAMP consists of the watershed upstream of Lodi's Wastewater Treatment Facility (WWTF), which discharges to Spring Creek. The Action Area is within the Spring Creek HUC 12 watershed (#070700050204) and lies within Columbia and Dane counties. The Action Area boundary was manually delineated using LiDAR derived contours, and therefore the boundary does not exactly match the HUC 12 boundary provided by the WNDR. **Figure 1** displays the proposed Action Area, the DNR's HUC 12 boundary, and the location of the Lodi WWTF. Table 1 summarizes the size and geographic location of the HUC 12 watershed and the proposed Action Area.

Table 1: Basic characteristics of the Adaptive Management Action Area.

HUC and Watershed Name		Total Area of Watershed	
		Acres	**Sq. Miles**
HUC 12: 070700050204 Spring Creek		30,000	47
County	**Size of Watershed in the County**	**Percentage of watershed within the County**	
Columbia	15,331 acres	51%	
Dane	14,675 acres	49%	
What watershed scale was used to develop the action area?		Portion of the HUC 12	

Size of the Action Area		
Acres		**Square Miles**
22,282		35
County	**Size of Action Area in the County**	**Percentage of Action Area within the County**
Columbia	8,966 acres	40%
Dane	13,316 acres	60%

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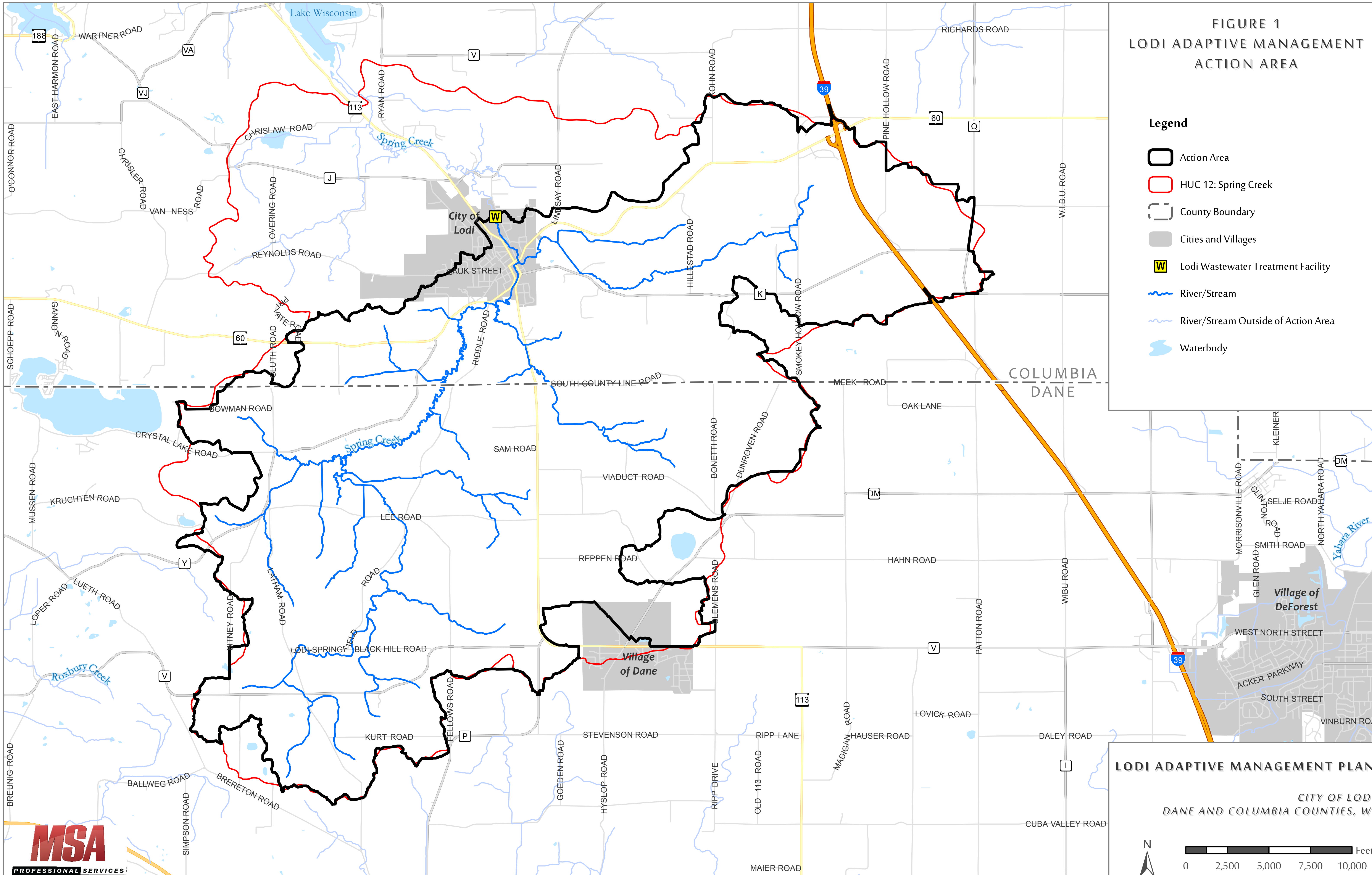
FIGURE 1
LODI ADAPTIVE MANAGEMENT
ACTION AREA
Legend
Action Area
HUC 12: Spring Creek
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0
2,500
5,000
7,500
10,000
COLUMBIA
DANE
City of Lodi
Village of Dane
Village of DeForest
Lake Wisconsin
Spring Creek
Spring Creek
Roxbury Creek
Yahara River
WARTNER ROAD
EAST HARMON ROAD
O'CONNOR ROAD
CHRISLER ROAD
VAN NESS ROAD
CHRISLAW ROAD
RYAN ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
LINDSAY ROAD
JOHN ROAD
RICHARDS ROAD
PINE HOLLOW ROAD
W.I.B.U. ROAD
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
SCHOEPP ROAD
GANNON ROAD
PRIVATE ROAD
SLUTH ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
CRYSTAL LAKE ROAD
SAM ROAD
VIADUCT ROAD
BONETTI ROAD
DUNROVEN ROAD
MUSSEN ROAD
KRUCHTEN ROAD
LEE ROAD
REPPEN ROAD
HAHN ROAD
LATHAM ROAD
LUETH ROAD
LOPER ROAD
PITNEY ROAD
LODI-SPRINGFIELD ROAD
BLACK HILL ROAD
CLEMENS ROAD
PATTON ROAD
WIBU ROAD
FELLOWS ROAD
KURT ROAD
STEVENSON ROAD
RIPP LANE
HAUSER ROAD
LOVICK ROAD
DALEY ROAD
MADIGAN ROAD
GOEDEN ROAD
HYSLOP ROAD
RIPP DRIVE
OLD 113 ROAD
BALLWEG ROAD
BRERETON ROAD
BREUNIG ROAD
SIMPSON ROAD
CUBA VALLEY ROAD
MAIER ROAD
KLEINER
MORRISONVILLE ROAD
CLINTON ROAD
SELJE ROAD
NORTH YAHARA ROAD
SMITH ROAD
GLEN ROAD
WEST NORTH STREET
ACKER PARKWAY
SOUTH STREET
VINBURN ROAD
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3.2 Characteristics of Spring Creek

The receiving water targeted for water quality improvements in the LAMP is Spring Creek (Lodi Creek, WBIC # 1261900). Spring Creek is a Class II Trout Stream, meaning that the stream has some natural reproduction of trout, but not enough to maintain a desirable sport fishery (Wisconsin DNR, Trout Stream Classification). Four miles of the Class II portion of the stream in Dane County are classified by Wisconsin DNR as an exceptional resource water (NR 102.11(1)(d)3). Exceptional resource waters include surface waters which provide valuable fisheries, hydrologically or geologically unique features, outstanding recreational opportunities, unique environmental settings, and are not significantly impacted by human activities. **Figure 2** displays the mapped floodplains, wetlands, and water resources within the Action Area. Currently, there are not any waters within the Action Area that are listed as “impaired” according to the Wisconsin DNR’s update to Section 303(d) of the Clean Water Act. However, Spring Creek is within the larger Wisconsin River Watershed, which has several reservoir lakes and tributaries that are impaired for total phosphorus and suspended solids. The Wisconsin DNR is currently developing a Total Maximum Daily Load (TMDL) for the Wisconsin River Watershed. The TMDL is expected to be completed in 2017 or 2018.

The DNR Pollutant Ratio Estimation Tool (PRESTO) indicates that approximately 8% of the phosphorus load within the Action Area is from point sources, wastewater treatment facilities or industries which discharge to phosphorus to surface waters and have a WPDES permit. The Lodi Wastewater Treatment Facility is the only WPDES permit holder within the Action Area which discharges phosphorus to Spring Creek. The remaining 92% of the phosphorus load originates from non-point sources, diffuse sources of phosphorus including contaminated runoff from urban areas, crop fields, and animal feeding operations. The PRESTO model estimates that a total of 6,744 lbs of phosphorus is exported from the Action Area annually (Presto Documentation, Validation & Analysis, Version 1.10, March 2013). Of the annual phosphorus exported, approximately 5,758 lb is estimated to be from non-point sources.

3.3 Existing Phosphorus Data for Spring Creek

Phosphorus monitoring of Spring Creek is critical to understanding the current water quality within the Action Area and for setting load reduction goals. Fortunately, efforts have been ongoing to collect water samples from the Spring Creek Watershed. An initial project designed to evaluate the water quality of Spring Creek was completed in 2011 and 2012. This effort was a partnership of the Friends of Scenic Lodi Valley, the City of Lodi, the Columbia County Land and Water Conservation Department, the Wisconsin DNR, and the University of Wisconsin-Stevens Point. The sampling efforts entailed taking bi-weekly grab samples at five locations, four of which are within the Action Area (LS01, LS02, LS03, and LS05). The water quality analysis included total phosphorus (TP) and several other parameters. A full summary of the sampling protocol is outlined in the Spring Creek Watershed Water Quality Report (Radske M. and Turyk N., 2013). **Figure 3** from this report shows the monitoring locations and summarizes the total phosphorus results of all samples collected in 2011 and 2012. This extensive sampling protocol was discontinued at the end of 2012.

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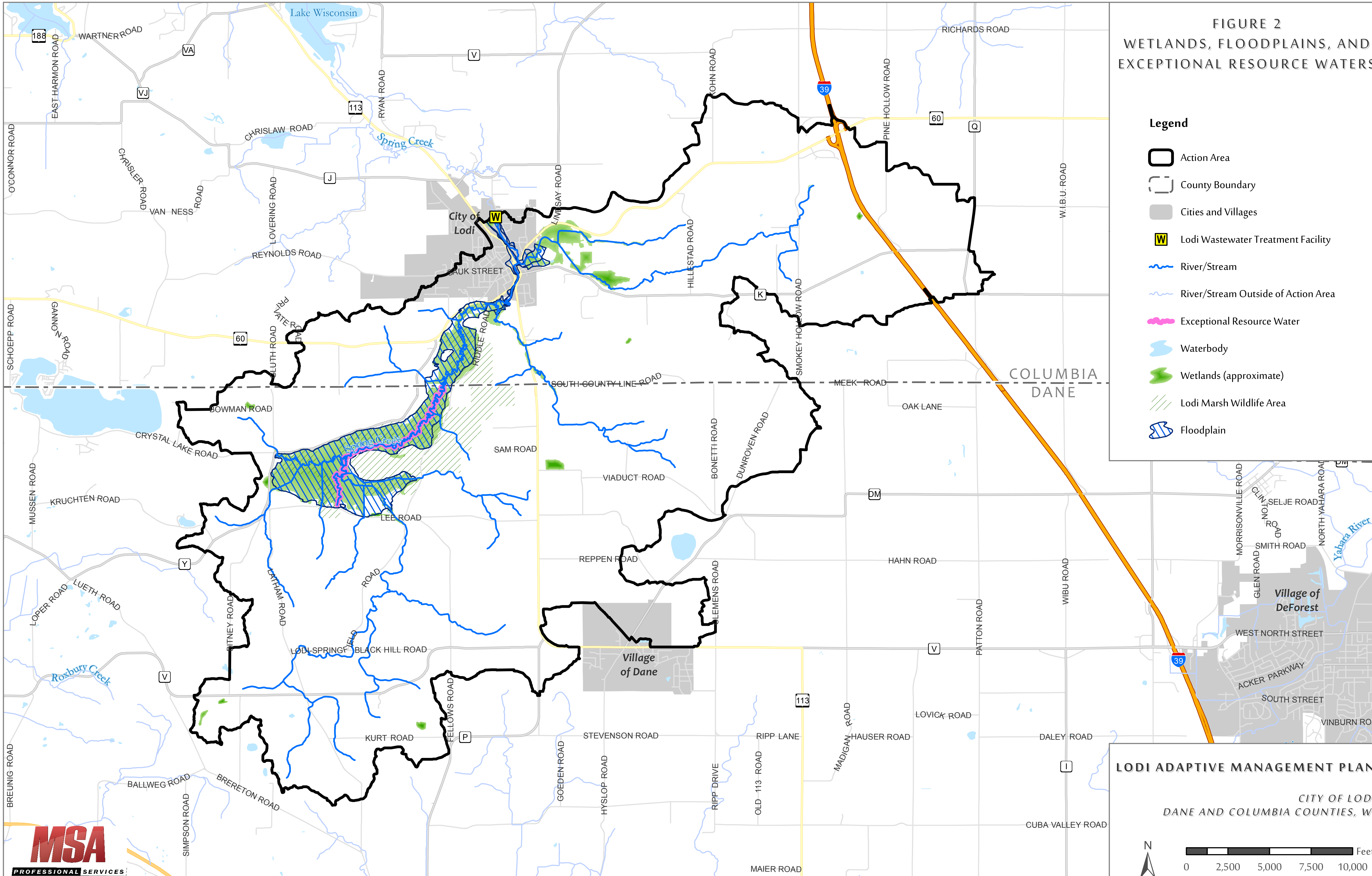
FIGURE 2
WETLANDS, FLOODPLAINS, AND EXCEPTIONAL RESOURCE WATERS
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Exceptional Resource Water
Waterbody
Wetlands (approximate)
Lodi Marsh Wildlife Area
Floodplain
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
0 2,500 5,000 7,500 10,000 Feet
COLUMBIA
DANE
City of Lodi
Village of Dane
Village of DeForest
Lake Wisconsin
Spring Creek
Roxbury Creek
Yahara River
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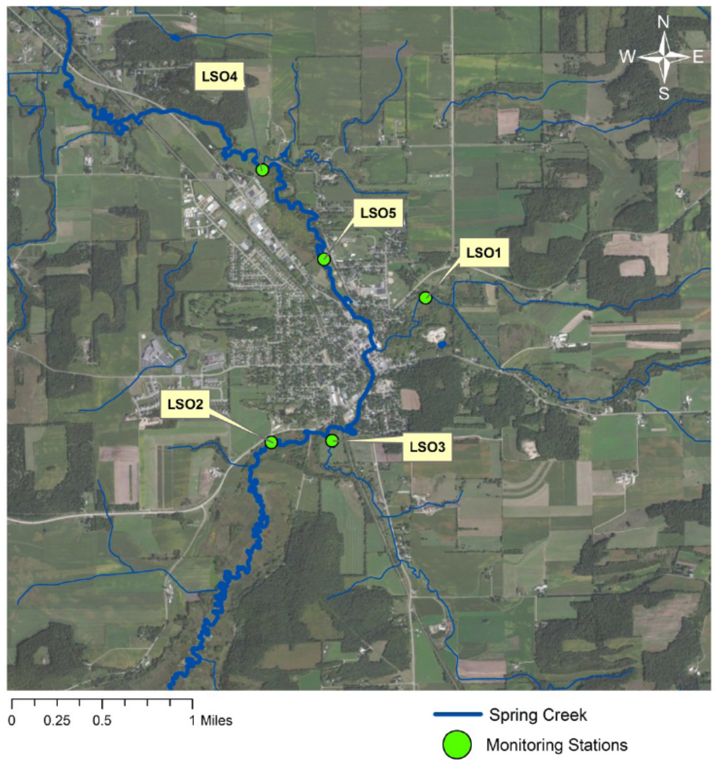
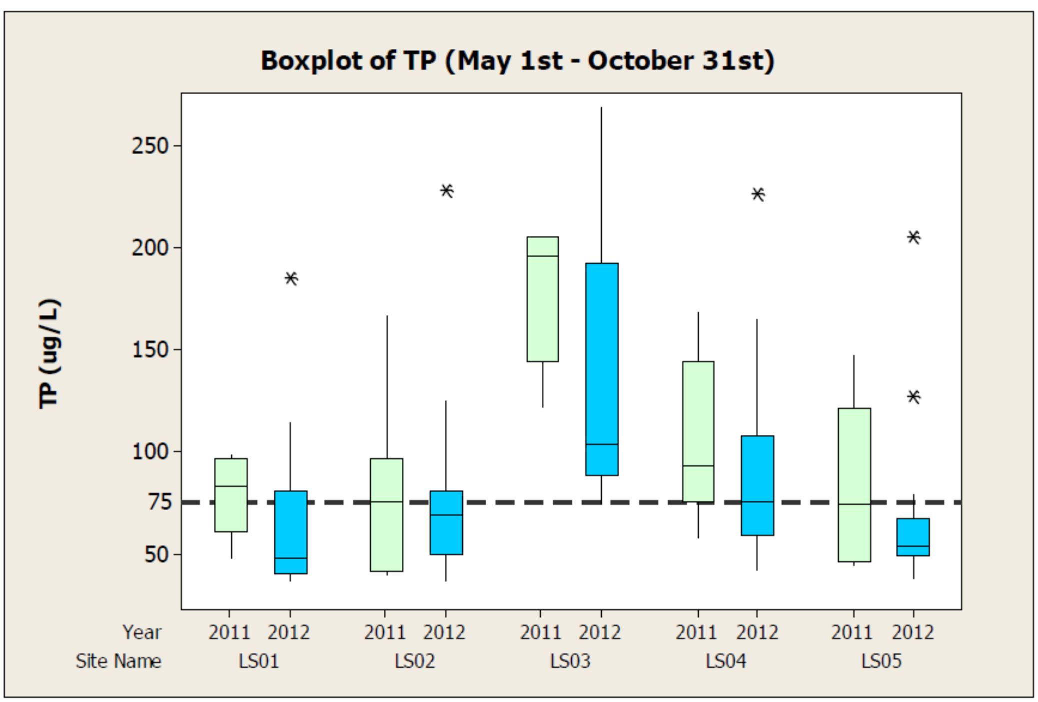
Figure 3: Map of 2012-12 sampling location for the Spring Creek monitoring sites and a boxplot of the total phosphorus (µg/L) including all samples collected each year (March – November). (Radske M. and Turyk N., 2013)





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Additional phosphorus data for Spring Creek can be found in DNR's Surface Water Integrated Monitoring System (SWIMS) database. This database stores chemical, physical, and biological sampling data that was collected by or submitted to the DNR. In the SWIMS database, there are fifteen sampling sites along Spring Creek. However, only five of these locations have sampling results available for total phosphorus. The location of each of the five sampling sites with total phosphorus data for Spring Creek are shown in **Figure 4**. As shown, three of these sites are located within the Action Area, and two are located downstream of the wastewater treatment facility. Phosphorus monitoring results from each of the five sites are shown in Table 2. It should be noted that the samples in Table 2 were collected by several groups for various projects and therefore, do not follow a uniform sampling protocol. Also note that many of the sampling efforts included additional water quality parameters (e.g. temperature, dissolved oxygen, etc.) which are not included in this report.

Table 2: Spring Creek (receiving water) characteristics and monitoring history.

Receiving Water Characteristics			
Receiving Water Name	Downstream Water	Name of Reservoirs/Impoundments on receiving water	Stream Order
Spring Creek	*Lake Wisconsin*	*None*	*3*
Impaired Segments			
Streams on the 303(d) List of Impaired Waters		Contaminants of concern	Is a TMDL scheduled or completed?
Lake Wisconsin (downstream of Spring Creek and outside of the Action Area)		*PCBs, Total Phopshorus, Mercury*	*Expected in 2017 or 2018*

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Monitoring History			
Station ID: 10031391, Spring Creek (west branch) Upstream of Riddle Rd Bridge			
Project Name	*Date Collected*	*Total Phosphorus (mg/L)*	*Data Source*
Response Monitoring	07/16/2010	0.144	SWMS, DNR STORET
NA	03/14/2012	0.066	SWMS, DNR STORET
NA	03/28/2012	0.079	SWMS, DNR STORET
NA	04/10/2012	0.027	SWMS, DNR STORET
NA	04/24/2012	0.110	SWMS, DNR STORET
NA	05/04/2012	0.124	SWMS, DNR STORET
NA	05/09/2012	0.042	SWMS, DNR STORET
NA	05/24/2012	0.053	SWMS, DNR STORET
NA	06/20/2012	0.228	SWMS, DNR STORET
NA	07/05/2012	0.070	SWMS, DNR STORET
NA	07/17/2012	0.069	SWMS, DNR STORET
NA	08/02/2012	0.075	SWMS, DNR STORET
NA	08/14/2012	0.069	SWMS, DNR STORET
NA	08/29/2012	0.075	SWMS, DNR STORET
NA	09/12/2012	0.063	SWMS, DNR STORET

Station ID: 10037079, Spring Creek (west branch) at Riddle Road Bridge			
Project Name	*Date Collected*	*Total Phosphorus (mg/L)*	*Data Source*
Wisconsin River Basin Phosphorus Assessment	05/16/2012	0.062	SWMS, DNR STORET
Wisconsin River Basin Phosphorus Assessment	06/13/2012	0.058	SWMS, DNR STORET
Wisconsin River Basin Phosphorus Assessment	07/17/2012	0.082	SWMS, DNR STORET
Wisconsin River Basin Phosphorus Assessment	08/07/2012	0.077	SWMS, DNR STORET
Wisconsin River Basin Phosphorus Assessment	09/11/2012	0.081	SWMS, DNR STORET
Wisconsin River Basin Phosphorus Assessment	10/17/2012	0.108	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	05/15/2013	0.050	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	06/19/2013	0.077	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	07/15/2013	0.074	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	08/15/2013	0.066	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	09/18/2013	0.064	SWMS, DNR STORET
Wisconsin River 2013 HUC 12 Data Gap Analysis - WCR_18_CMP13B	10/23/2013	0.034	SWMS, DNR STORET

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Station ID: 10010951, Spring Creek - Lodi-Spring Cr Sewage Treat. Plant to Fair St Bridge			
Project Name	*Date Collected*	*Total Phosphorus (mg/L)*	*Data Source*
Response Monitoring	07/16/2010	0.195	SWMS, DNR STORET
NA	03/16/2011	0.103	Columbia County
NA	04/07/2011	0.098	Columbia County
NA	04/27/2011	0.093	Columbia County
NA	05/04/2011	0.045	Columbia County
NA	05/18/2011	0.046	Columbia County
NA	05/25/2011	0.147	Columbia County
NA	06/01/2011	0.071	Columbia County
NA	06/16/2011	0.082	Columbia County
NA	07/06/2011	0.121	Columbia County
NA	07/13/2011	0.074	Columbia County
NA	08/09/2011	0.059	Columbia County
NA	08/25/2011	0.055	Columbia County
NA	09/11/2011	0.045	Columbia County
NA	09/18/2011	0.050	Columbia County
NA	09/28/2011	0.068	Columbia County
NA	10/19/2011	0.039	Columbia County
NA	11/02/2011	0.038	Columbia County
NA	11/10/2011	0.147	Columbia County
NA	03/14/2012	0.081	SWMS, DNR STORET
NA	03/28/2012	0.065	SWMS, DNR STORET
NA	04/10/2012	0.026	SWMS, DNR STORET
NA	04/24/2012	0.105	SWMS, DNR STORET
NA	05/04/2012	0.127	SWMS, DNR STORET
NA	05/09/2012	0.051	SWMS, DNR STORET
NA	05/24/2012	0.052	SWMS, DNR STORET
NA	06/07/2012	0.044	SWMS, DNR STORET
NA	06/20/2012	0.205	SWMS, DNR STORET
NA	07/05/2012	0.062	SWMS, DNR STORET
NA	07/17/2012	0.063	SWMS, DNR STORET
NA	08/02/2012	0.063	SWMS, DNR STORET
NA	08/14/2012	0.052	SWMS, DNR STORET
NA	08/29/2012	0.055	SWMS, DNR STORET
NA	09/12/2012	0.051	SWMS, DNR STORET

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Station ID: 10011031, Lodi-Spring Creek Cty J Up To Lodi Sewage Treatment Plant ***OUTSIDE OF ACTION AREA***			
Project Name	*Date Collected*	*Total Phosphorus (mg/L)*	*Data Source*
NA	03/14/2012	0.092	SWMS, DNR STORET
NA	03/28/2012	0.098	SWMS, DNR STORET
NA	04/10/2012	0.037	SWMS, DNR STORET
NA	04/24/2012	0.127	SWMS, DNR STORET
NA	05/04/2012	0.165	SWMS, DNR STORET
NA	05/09/2012	0.102	SWMS, DNR STORET
NA	05/24/2012	0.071	SWMS, DNR STORET
NA	06/07/2012	0.059	SWMS, DNR STORET
NA	06/20/2012	0.226	SWMS, DNR STORET
NA	07/05/2012	0.082	SWMS, DNR STORET
NA	07/17/2012	0.086	SWMS, DNR STORET
NA	08/02/2012	0.069	SWMS, DNR STORET
NA	08/14/2012	0.057	SWMS, DNR STORET
NA	08/29/2012	0.069	SWMS, DNR STORET
NA	09/12/2012	0.080	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	05/22/2013	0.116	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	06/21/2013	0.315	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	07/16/2013	0.095	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	08/20/2013	0.066	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	09/25/2013	0.068	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	10/17/2013	0.057	SWMS, DNR STORET

Station ID: 10039888, Spring Creek Downstream STH 113 ***OUTSIDE OF ACTION AREA***			
Project Name	*Date Collected*	*Total Phosphorus (mg/L)*	*Data Source*
Volunteers Monitoring Phosphorus	05/22/2013	0.113	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	06/21/2013	0.780	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	07/16/2013	0.081	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	08/20/2013	0.063	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	09/25/2013	0.061	SWMS, DNR STORET
Volunteers Monitoring Phosphorus	10/17/2013	0.057	SWMS, DNR STORET
Southern District Follow Up Monitoring for Impairment Decisions 2015	06/05/2015	0.084	SWMS, DNR STORET

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As part of the Adaptive Management Plan, the City began collecting additional bi-weekly water samples from Spring Creek in 2015. Bi-weekly sampling occurred during the months of May through October and included the collection of two grab samples on each sampling day: 1) one sample upstream of the wastewater treatment facility outfall and 2) one sample downstream of the outfall. This sampling protocol was started in 2015 and will continue throughout of the life of the Adaptive Management Project. A more complete description of the monitoring plan is listed in Chapter 7 of this report. The results of the first year of bi-weekly sampling are shown in Table 3.

Table 3: Bi-weekly water quality sampling results for Spring Creek, both upstream and downstream of the Lodi Wastewater Treatment Facility outfall.

Date Collected	*Upstream Total Phosphorus (mg/L)*	*Downstream Total Phosphorus (mg/L)*	*Downstream Flow (cfs)*
05/22/2015	*0.045*	*0.066*	36
06/05/2015	*0.133*	*0.120*	35
06/19/2015	*0.117*	*0.097*	30
07/02/2015	*0.074*	*0.082*	NA
07/17/2015	*0.099*	*0.118*	33
07/30/2015	*0.074*	*0.075*	27
08/14/2015	*0.084*	*0.082*	33
08/31/2015	*0.085*	*0.094*	42
09/10/2015	*0.074*	*0.082*	35
09/25/2015	*0.058*	*0.066*	34
10/09/2015	*0.055*	*0.059*	35
10/22/2015	*0.045*	*0.050*	38

Using the historical sampling data, it can be determined if Spring Creek complies with the water quality criterion of 0.075 mg/L for phosphorus. Wisconsin Administrative Code Chapter NR 217.13(2)(d) establishes the method for estimating the in-stream phosphorus concentration (Cs) which should be used for comparison with the water quality criterion. According to NR 217, the concentration that is used shall equal the median of at least four samples collected during the months of May through October. All

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samples collected during a 28-day period must be considered as a single sample and the average of the concentrations used when estimating the median concentration. Where data is available from more than one year in the last five years, all of the data may be used to estimate the in-stream phosphorus concentration. Based on the NR 217 criteria, the in-stream concentration was calculated at each of the five monitoring stations from the SWIMS database which have publically available phosphorus sampling results for Spring Creek. As per NR 217, only data which was collected in the past five years (2011 to 2015) and during the months of May through October was used for the purposes of calculating the median concentration at each site. NR 217 calculated medians for each monitoring station are shown Table 4 and **Figure 4**. As shown, four out of the five monitoring sites exceed the water quality criterion for phosphorus.

Table 4: NR 217 median concentration phosphorus concentrations for samples collected from Spring Creek (collected between May thru November in 2011-2015)

Station ID	*Samples Collected*	*NR 217 Calculated Median (mg/L)*
10031391	10	0.078
10037079	12	0.071
10010951*	36	0.078
10011031	17	0.113
10039888	7	0.084

*Note: Samples for Station 10010951 include phosphorus samples from the SWIMS database (see **Table 2**) and grab samples immediately upstream of the WWTF outfall from 2015 (see **Table 2**). All other stations only use data available from the SWIMS database (see **Table 2**).

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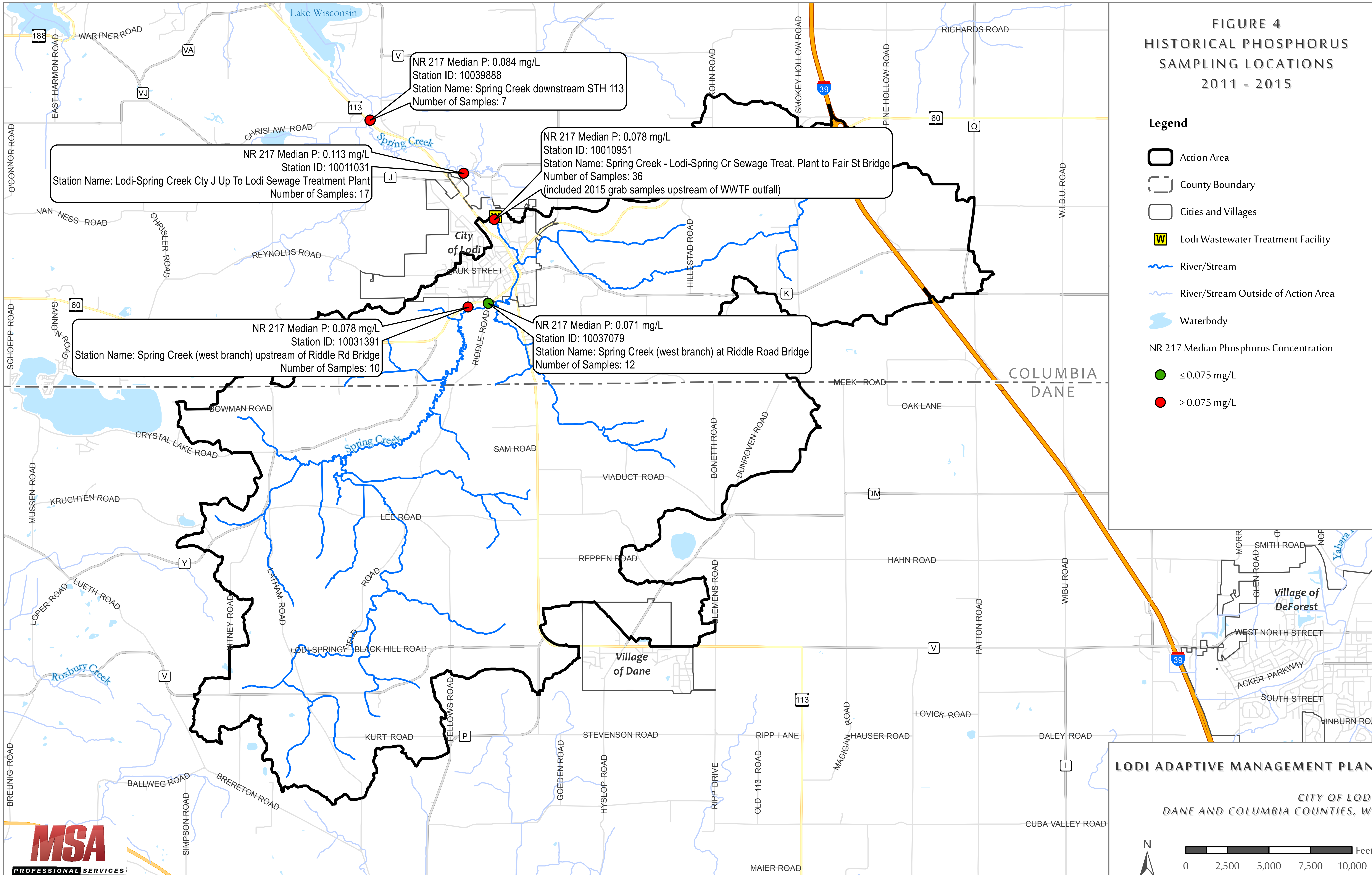
FIGURE 4
HISTORICAL PHOSPHORUS
SAMPLING LOCATIONS
2011 - 2015
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
NR 217 Median Phosphorus Concentration
≤ 0.075 mg/L
> 0.075 mg/L
NR 217 Median P: 0.084 mg/L
Station ID: 10039888
Station Name: Spring Creek downstream STH 113
Number of Samples: 7
NR 217 Median P: 0.113 mg/L
Station ID: 10011031
Station Name: Lodi-Spring Creek Cty J Up To Lodi Sewage Treatment Plant
Number of Samples: 17
NR 217 Median P: 0.078 mg/L
Station ID: 10010951
Station Name: Spring Creek - Lodi-Spring Cr Sewage Treat. Plant to Fair St Bridge
Number of Samples: 36
(included 2015 grab samples upstream of WWTF outfall)
NR 217 Median P: 0.078 mg/L
Station ID: 10031391
Station Name: Spring Creek (west branch) upstream of Riddle Rd Bridge
Number of Samples: 10
NR 217 Median P: 0.071 mg/L
Station ID: 10037079
Station Name: Spring Creek (west branch) at Riddle Road Bridge
Number of Samples: 12
Lake Wisconsin
Spring Creek
City of Lodi
Village of Dane
Village of DeForest
Roxbury Creek
COLUMBIA
DANE
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
0 2,500 5,000 7,500 10,000 Feet
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3.4 DETERMINING THE EXISTING PHOSPHORUS LOAD

In order to set a load reduction target, it is necessary to have an estimate for the current phosphorus loading at the furthest downstream point in the Action Area (i.e. immediately upstream of the Lodi Wastewater Treatment Facility). This loading will be the baseline condition and represents the current status of the watershed. This loading and observed in-stream concentration can then be compared against the water quality criterion of 0.075 mg/L to estimate the phosphorus load reduction required.
As part of the Adaptive Management Plan, bi-weekly grab samples were collected upstream of the wastewater treatment plant from May to October in 2015. Automated sampling equipment was also installed downstream of the WWTF to monitor continuous water depth (measurements at 1-minute intervals). This depth was applied to a rating curve, which was established using a HEC-RAS hydraulic model of Spring Creek, to determine stream flow (see Appendix A). Grab samples immediately upstream of the treatment plant were also collected in 2011 and 2012 (see Table 4, Station 10010951) in addition to select streamflow measurements (Radske and Turyk, 2013). Collectively this data was used to estimate the current phosphorus load in the receiving water:

$$Current\ Load\ in\ Recieving\ Water\ \left[\frac{lb}{yr}\right] = Q_S \times C_s \times 8.34\ x\ \frac{365\ days}{yr}$$

$$\begin{aligned} where: \quad & Q_S\ = annual\ average\ flow\ rate\ of\ the\ recieing\ water\ [MGD] \\ & C_s = NR\ 217\ calculated\ median\ phosphorus\ concentration\ [\frac{mg}{L}] \\ & 8.34 = converion\ factor \end{aligned}$$

Using the NR 217 calculated median phosphorus concentration of 0.078 mg/L for Station 10010951 (see Table 4) and the average stream flow of 36.93 cfs (23.87 MGD) when these samples were collected, the current phosphorus load in the receiving water is calculated using the equation above as 5,688 lb/year (23.87 MGD x 0.078 mg/L x 8.34 x 365 days/yr = 5,668 lb/yr). This estimate is very close to the most likely non-point source load which was estimated using PRESTO. PRESTO estimated the current phosphorus load in the receiving water to be 5,758 lb/yr (Presto Documentation, Validation & Analysis, Version 1.10, March 2013).

The load contributed by the WWTF can be determined several ways, such as using the current loading, the loading at the facility's design flow, or the predicted loading in 20-years. The Adaptive Management guidelines dictate that phosphorus load reduction goals should be based on the facility's design flow. However, the Lodi WWTF design flow is considerably higher than the predicted flow in 20-years. This is because the WWTF was designed when Lodi's population was rising quickly, and therefore the facility was designed to accommodate this growth. Since that time, the City's growth rate has slowed, and therefore the projected population is significantly less. The most recent Population Projections from the Wisconsin Department of Administration indicate the 2035 population projection for the City of Lodi is 3,790. Application of the 2013 per capita daily flow rate of 101 gallons per capita per day to the projected 2035 population yields a future average daily flow of 0.383 MGD (3,790 capita x 101 gal/capita/day x (1 Mgal/1,000,000 gal) = 0.383 MGD). The Adaptive Management permit requires an interim phosphorus limit of 0.5 mg/L in the 2nd and 3rd permit term of phosphorus compliance. Using these values of flow and concentration, the projected load from the Lodi Wastewater Treatment Facility can be calculated using the equation below:

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$$Projected\ Point\ Source\ Load\ \left[\frac{lb}{yr}\right] = Q_e \times C_e \times 8.34\ x\ \frac{365\ days}{yr}$$

$$\begin{aligned} where: \quad & Q_e\ = projected\ average\ annual\ flow\ rate\ of\ WWTF\ [MGD] \\ & C_e = projected\ average\ effluent\ phosphorus\ concentration\ [\frac{mg}{L}] \\ & 8.34 = converion\ factor \end{aligned}$$

Based on the projected 2035 average annual flow of the WWTF of 0.383 MGD and the anticipated average phosphorus concentration of 0.5 mg/L, the projected phosphorus load from the Lodi Wastewater Treatment Facility is calculated as 583 lb/yr (0.383 MGD x 0.5 mg/L x 8.34 x 365 days/yr = 583 lb/yr).

3.5 LOAD REDUCTION TARGET

The phosphorus load reduction target is determined by adding the current upstream load within the receiving stream to the projected load from the WWTF and then subtracting the receiving water's allowable load based on the water quality criterion. The allowable load in Spring Creek can be calculated with the equation below:

$$Allowable\ Load\ in\ Receiving\ Water\left[\frac{lb}{yr}\right] = (Q_S + Q_e) \times WQC \times 8.34\ x\ \frac{365\ days}{yr}$$

$$\begin{aligned} where: \quad & Q_S\ = annual\ average\ flow\ rate\ of\ the\ recieving\ water\ [MGD] \\ & Q_e\ = projected\ average\ annual\ flow\ rate\ of\ WWTF\ [MGD] \\ & WQC = water\ quality\ criterion\ for\ phosphorus\ [\frac{mg}{L}] \\ & 8.34 = Converion\ Factor \end{aligned}$$

Using the previous values of 23.87 MGD for Q_S, 0.383 MGD for Q_e, and the water quality criterion (WQC) of 0.075 mg/L for Spring Creek, the allowable phosphorus load in Spring Creek is calculated as 5,537 lb/yr ([23.87 MGD + 0.383 MGD] x 0.075 mg/L x 8.34 x 365 days/yr = 5,537 lb/yr).

Using the current receiving water load, projected point source load, and allowable load in the receiving water, the future phosphorus load reduction goal for the watershed can be determined using the equation below:

$$\begin{aligned} & Phosphorus\ Reduction\ Needed\ \left[\frac{lb}{yr}\right] \\ & \quad = Current\ Load\ in\ Receiving\ Water\left[\frac{lb}{yr}\right] + Projected\ Point\ Source\ Load\left[\frac{lb}{yr}\right] \\ & \quad - Allowable\ Load\ in\ Receiving\ Water\left[\frac{lb}{yr}\right] \end{aligned}$$

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Based on this equation, the phosphorus reduction needed to bring Spring Creek into compliance with the water quality criterion is 714 lb/yr (5,668 lb/year + 583 lb/year – 5,537 lb/year = 714 lb/year).

Using the methodology presented above, phosphorus load reductions were estimated for each future permit term of Adaptive Management compliance as shown in Table 5. As shown, the phosphorus reduction needed to reach the water quality criterion in Spring Creek is variable for each permit term. This is due to an increase in average flows at the wastewater treatment facility over time and different interim phosphorus limits in each permit term. Since permittees have up to three permit terms (15 years) to achieve the water quality criterion in the receiving water, the phosphorus load reduction which is calculated for Permit Terms #2 and #3 is the most reasonable goal for the City to pursue. Therefore, 714 lb/yr was selected as the long term phosphorus reduction goal for the Spring Creek Action Area. It should be noted that load reduction goals will be recalculated at the end of each permit term in order to account for actual changes in wastewater loadings and non-point source loadings to Spring Creek.

Within the first permit term of Adaptive Management compliance, permittees are required to offset, at a minimum, the fraction of the total phosphorus load reduction which is attributable to the WWTF. This fraction is calculated by first estimating the permittee's percent contribution of the total downstream phosphorus load during Permit Term #1. As shown in Table 5, the estimated effluent phosphorus load from the WWTF during the first permit term is 584 lb/yr, and the total downstream load is estimated as 6,252 lb/yr. Therefore, the WWTF's percent contribution of the total downstream load is:

$$WWTF's\ Percent\ Contribution = \frac{584\frac{lb}{yr}}{6{,}252\frac{lb}{yr}} = 9.3\%$$

Next, the minimum phosphorus load reduction needed in Permit #1 can be estimated by multiplying the WWTF's percent contribution to the downstream load by total load reduction needed to meet the water quality criterion. As shown in Table 5, the total phosphorus load reduction needed to meet the water quality criterion in Permit Term #1 is 729 lb/yr. Therefore, the minimum amount of phosphorus which must be removed from the watershed by the City of Lodi in Permit Term #1 is:

$$Minimimum\ Load\ Reduction\ Required\ =\ (9.3\ \%)\left(729\frac{lb}{yr}\right) = 68\frac{lb}{yr}$$

Although the minimum load reduction required in Permit Term #1 is 68 lb/yr, the City of Lodi will attempt to remove at least 50% of the long term phosphorus reduction goal of 714 lb/yr within Permit Term #1. Therefore, the goal of the City is to remove at least 357 lb of phosphorus per year from the Spring Creek Action Area prior to the end of the first permit term.

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Table 5: Estimated phosphorus loading and total load reduction requirements.

	Permit Term #1 (2017-2021)	*Permit Terms #2 & #3 (2022-2031)*	*WWTF @ Design Flow (2032+)*
Stream Flow (MGD)	23.87	23.87	23.87
Upstream Phosphorus Concentration (mg/L)	0.078	0.078	0.078
Upstream Phosphorus Load (lb/yr)	5,668	5,668	5,668
WWTF Flow (MGD)	0.320	0.383	0.542
WWTF Phosphorus Concentration (mg/L)	0.60	0.50	0.50
WWTF Phosphorus Load (lb/yr)	584	583	825
Total Downstream Load (lb/yr)	6,252	6,251	6,493
Allowable Downstream Load (lb/yr)	5,523	5,537	5,573
Total Load Reduction Needed (lb/yr)	729	**714**	920
WWTF % Contribution	9.3%	9.3%	12.7%
Minimum Load Reduction Required (lb/yr)	**68**	N/A	N/A

In addition to the phosphorus load reductions presented above, a more conservative load reduction goal that incorporates phosphorus loadings from storm events is outlined in Appendix B. Phosphorus reduction goals are much higher if phosphorus loadings from storm events are considered. Due to the complexities of phosphorus fate and transport at the watershed scale it is possible that the phosphorus load reductions estimated in Table 5 may not be sufficient to achieve the water quality criterion in Spring Creek by the end of the 3rd permit term of Adaptive Management compliance. If BMP implementation doesn't appear to significantly affect the phosphorus concentration by the end of Permit Term #2, it is recommend that the City consider adjusting phosphorus removal goals to more closely match the goals which are presented in Appendix B.

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CHAPTER 4 – WATERSHED INVENTORY

The proposed Adaptive Management Action Area covers 34.8 square miles, and is the headwaters for the Spring Creek watershed lying within Dane and Columbia counties. The only named stream within the Action Area is Spring Creek, and there are not any large open bodies of water. The Lodi Marsh covers a relatively large region of the Action Area, stretching from Dane County across into Columbia County. The marsh is a large wetland complex with natural springs. The march contains the segment of Spring Creek which is classified as an exceptional resource water. The surrounding landscape is primarily agricultural, and includes portions of two urbanized areas: the City of Lodi and the Village of Dane.

The topography of the Action Area generally slopes from higher elevations in the northeast (~1200 feet max. elev.) and the southwest (~1160 feet max. elev.), and drains towards the City of Lodi where the elevation is ~800 ft. The outlet of the Action Area is immediately downstream of the WWTF outfall within the Lodi corporate limits. **Figure 5** displays the topography for the region.

There are 150 different soil types within the Action Area. Of these, the majority are classified as silt loam (78.3%) followed by loam (11.5%) and sandy loam (4.6%). Table 6 shows all of the soils within the Action area with more than 1% coverage and some of the basic soil properties. Of particular interest is the Soil Erodibility Factor (K). This is a numerical value which represents the susceptibility of a given soil to erosion. The greater the value of K for a given soil, the more likely the soil is to erode. Clay soils typically (fine texture) have low K values since they resist detachment from other soil particles. Sandy soils (coarse texture) also have low K values. Sandy soils are easily detached from other soil particles, but sandy soils typically have lower runoff rates than other soils and therefore have a lower potential to be transported during storm events. Soils with high silt content typically have the highest K values, as they are the most erodible soils. Within the Action Area, K values range from 0.02 to 0.55. **Figure 6** summarizes the distribution of K values by land area within the Action Area. **Figure 7** displays geographical distribution of soil K Factors, and **Figure 8** shows the different erodibility for soils within the Action Area.

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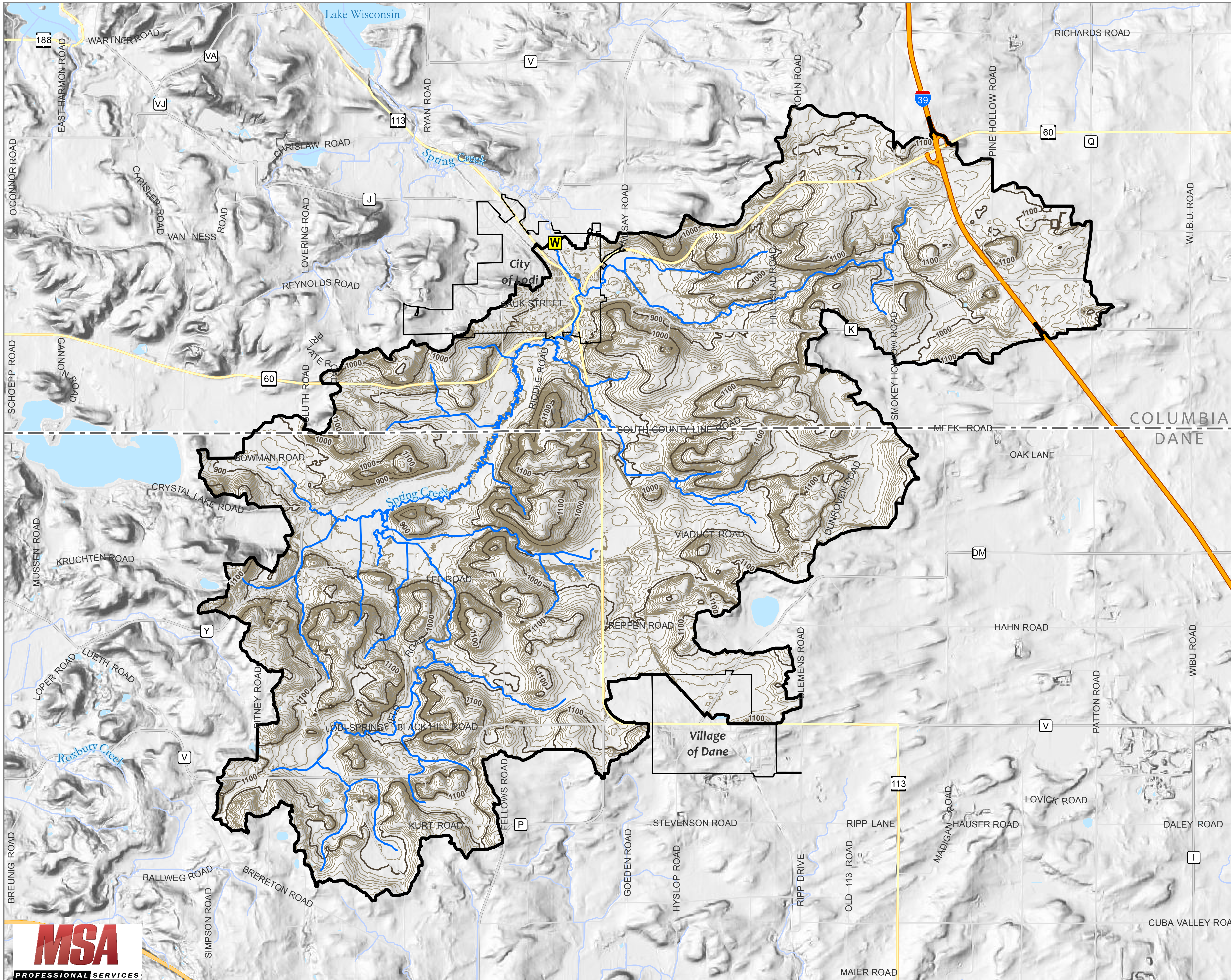
FIGURE 5
TOPOGRAPHY



Legend

- Action Area
- County Boundary
- Cities and Villages
- Lodi Wastewater Treatment Facility
- River/Stream
- River/Stream Outside of Action Area
- Waterbody
- Major Contours (100 ft)
- Minor Contours (10 ft)

LODI ADAPTIVE MANAGEMENT PLAN

CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI

N

0 | 2,500 | 5,000 | 7,500 | 10,000 Feet

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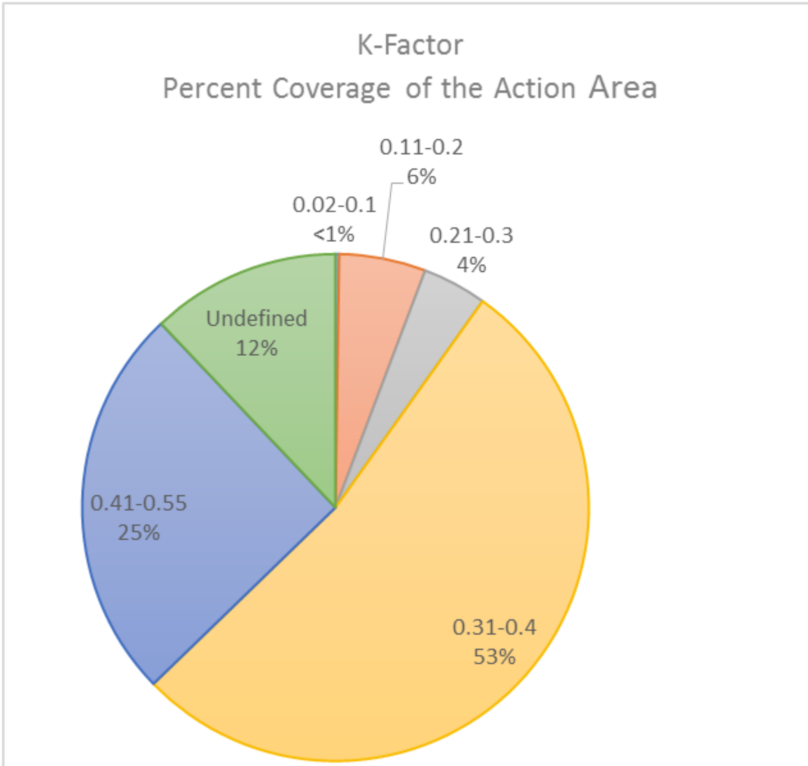
Figure 6 Soil erodibility Factor (K) distribution within the Action Area.



It is also notable that approximately 51% of the Action Area is comprised of soils which are listed as having a Land Capability Classification of Class 2. The Land Capability Classification of soil is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Soils defined as Land Capability Class 2 have moderate limitations that reduce the choice of plants and/or require moderate conservation practices.

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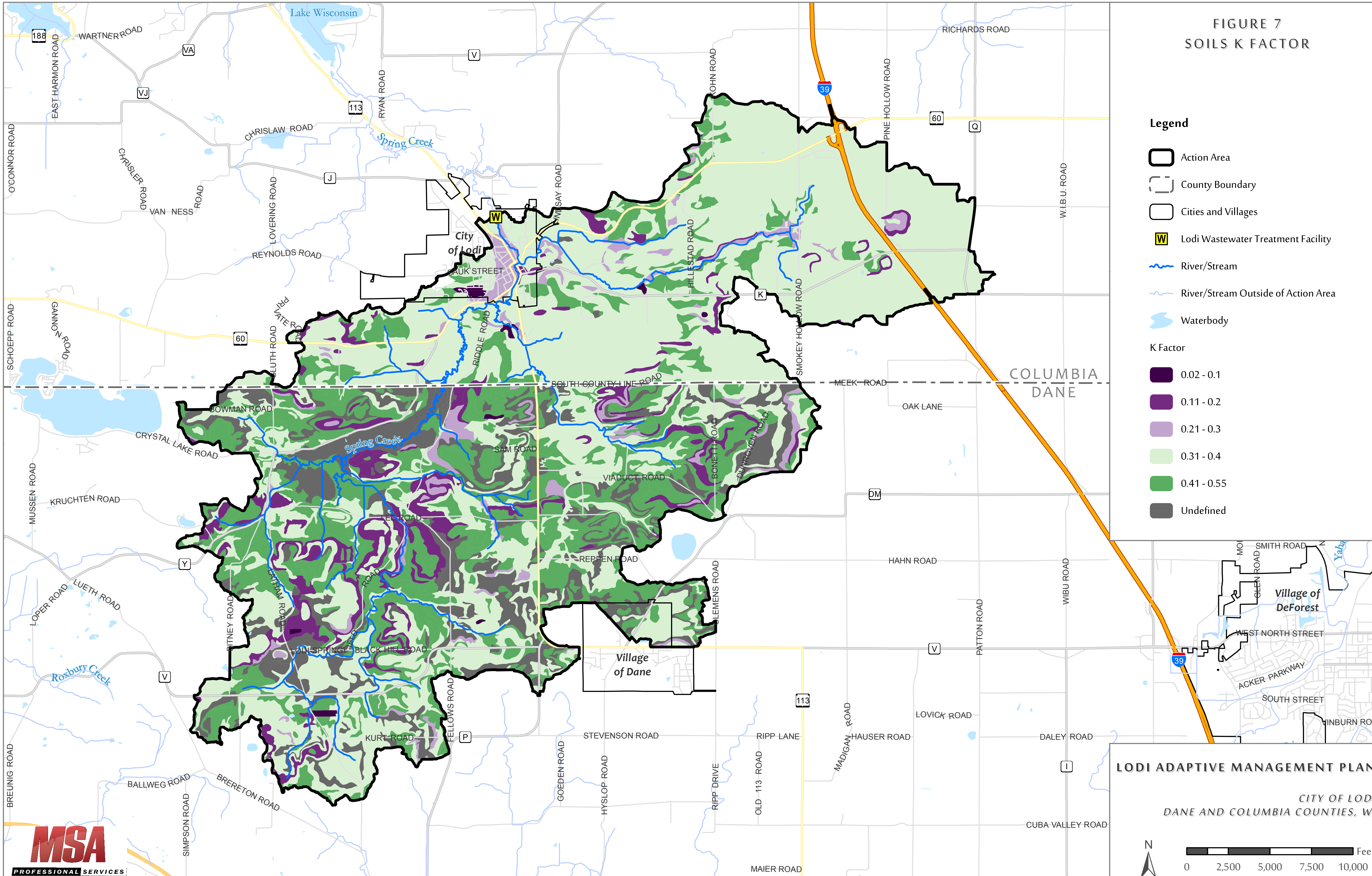
FIGURE 7
SOILS K FACTOR
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
K Factor
0.02 - 0.1
0.11 - 0.2
0.21 - 0.3
0.31 - 0.4
0.41 - 0.55
Undefined
COLUMBIA
DANE
City of Lodi
Village of Dane
Village of DeForest
Lake Wisconsin
Spring Creek
Roxbury Creek
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0 2,500 5,000 7,500 10,000
MSA
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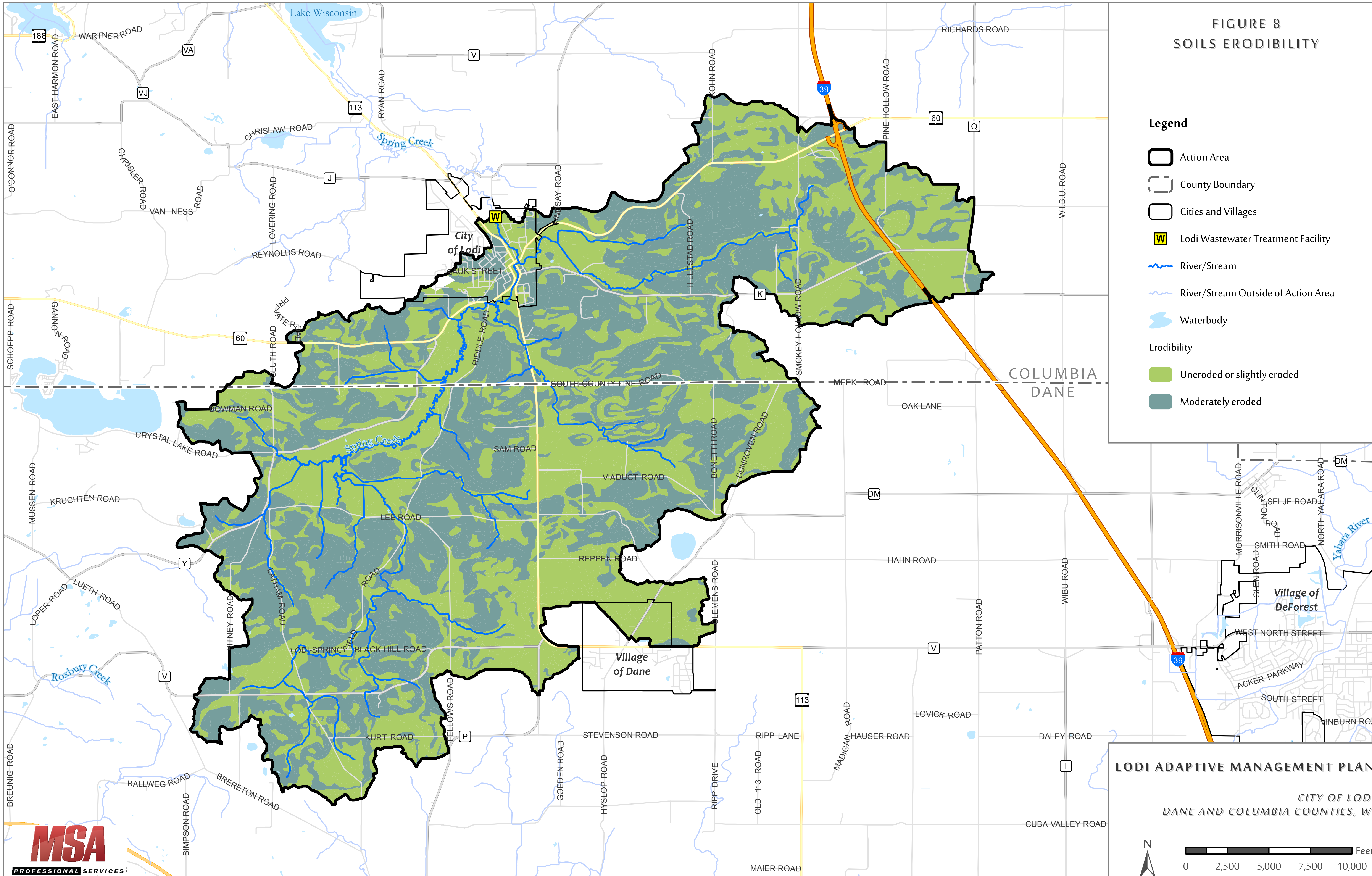
FIGURE 8
SOILS ERODIBILITY
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
Erodibility
Uneroded or slightly eroded
Moderately eroded
COLUMBIA
DANE
City of Lodi
Village of Dane
Village of DeForest
Lake Wisconsin
Spring Creek
Roxbury Creek
Yahara River
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0 2,500 5,000 7,500 10,000
MSA
PROFESSIONAL SERVICES

Table 6: Soils within the Action Area, with more than 1% coverage by area.

Soil Symbol	Soil Name	Area (ac)	% Cover	Frequency of Flooding	Erodibility	Erodibility Factor (K)	Hydrologic Soil Group	County	Soil Type	Class
PnB	Plano silt loam, 2 to 6 percent slopes	2204.2	9.9	None	Uneroded or slightly eroded	0.32	B	Columbia	Silt Loam	Undefined
PnB	Plano silt loam, till substratum, 2 to 6 percent slopes	1135.4	5.1	None	Uneroded or slightly eroded	Undefined	B	Dane	Silt Loam	Undefined
TrB	Troxel silt loam, 1 to 3 percent slopes	1030.4	4.6	None	Uneroded or slightly eroded	0.37	B	Dane	Silt Loam	Undefined
KdD2	Kidder loam, 12 to 20 percent slopes, eroded	915.3	4.1	None	Moderately eroded	0.15	B	Dane	Loam	2
MdC2	McHenry silt loam, 6 to 12 percent slopes, eroded	876.5	3.9	None	Moderately eroded	0.43	B	Dane	Silt Loam	2
RnB	Ringwood silt loam, 2 to 6 percent slopes	666.5	3.0	None	Uneroded or slightly eroded	0.43	B	Dane	Silt Loam	Undefined
DnC2	Dodge silt loam, 6 to 12 percent slopes, eroded	631.6	2.8	None	Moderately eroded	0.32	B	Dane	Silt Loam	2
RdC2	Ringwood silt loam, 6 to 12 percent slopes, eroded	594.5	2.7	None	Moderately eroded	0.32	B	Columbia	Silt Loam	2
GwC	Griswold loam, 6 to 12 percent slopes	538.9	2.4	None	Uneroded or slightly eroded	0.32	B	Dane	Loam	Undefined
PnC2	Plano silt loam, 6 to 12 percent slopes, eroded	470.6	2.1	None	Moderately eroded	0.32	B	Columbia	Silt Loam	2
DnB	Dodge silt loam, 2 to 6 percent slopes	446.7	2.0	None	Uneroded or slightly eroded	0.49	B	Dane	Silt Loam	Undefined
RnC2	Ringwood silt loam, 6 to 12 percent slopes, eroded	442.4	2.0	None	Moderately eroded	0.32	B	Dane	Silt Loam	2
TsA	Troxel silt loam, 0 to 3 percent slopes	421.2	1.9	None	Uneroded or slightly eroded	0.32	B	Columbia	Silt Loam	Undefined
LaD2	Lapeer fine sandy loam, 12 to 20 percent slopes, eroded	407.6	1.8	None	Moderately eroded	0.32	B	Columbia	;andy Loan	2
SmC2	Seaton silt loam, 6 to 12 percent slopes, eroded	404.9	1.8	None	Moderately eroded	0.49	B	Dane	Silt Loam	2
MdD2	McHenry silt loam, 12 to 20 percent slopes, eroded	395.0	1.8	None	Moderately eroded	0.43	B	Dane	Silt Loam	2
WxD2	Whalan silt loam, 12 to 20 percent slopes, eroded	373.6	1.7	None	Moderately eroded	Undefined	C	Dane	Silt Loam	2
KdC2	Kidder loam, 6 to 12 percent slopes, eroded	352.6	1.6	None	Moderately eroded	0.37	B	Dane	Loam	2
Ho	Houghton muck	330.9	1.5	None	Uneroded or slightly eroded	Undefined	A/D	Dane	Muck	2
ScB	St. Charles silt loam, 2 to 6 percent slopes	322.7	1.4	None	Uneroded or slightly eroded	Undefined	B	Dane	Silt Loam	Undefined
PnA	Plano silt loam, 0 to 2 percent slopes	319.5	1.4	None	Uneroded or slightly eroded	0.32	B	Columbia	Silt Loam	Undefined
RdB2	Ringwood silt loam, 1 to 6 percent slopes, eroded	306.9	1.4	None	Moderately eroded	0.32	B	Columbia	Silt Loam	2
MeC2	McHenry silt loam, 6 to 12 percent slopes, eroded	277.7	1.2	None	Moderately eroded	0.43	B	Columbia	Silt Loam	2
DuE2	Dunbarton silt loam, 20 to 30 percent slopes, eroded	256.5	1.2	None	Moderately eroded	0.43	D	Dane	Silt Loam	2
PoB	Plano silt loam, gravelly substratum, 2 to 6 percent slopes	251.5	1.1	None	Uneroded or slightly eroded	Undefined	B	Dane	Silt Loam	Undefined
GrC2	Griswold silt loam, 6 to 12 percent slopes, eroded	247.2	1.1	None	Moderately eroded	0.32	B	Columbia	Silt Loam	2
PnA	Plano silt loam, till substratum, 0 to 2 percent slopes	241.3	1.1	None	Uneroded or slightly eroded	0.37	B	Dane	Silt Loam	Undefined
OsA	Ossian silt loam, 0 to 3 percent slopes	239.2	1.1	Occasional	Uneroded or slightly eroded	0.32	B/D	Columbia	Silt Loam	Undefined
WxC2	Whalan silt loam, 6 to 12 percent slopes, eroded	234.7	1.1	None	Moderately eroded	0.43	C	Dane	Silt Loam	2
CaE2	Channahon silt loam, 12 to 30 percent slopes, eroded	221.2	1.0	None	Moderately eroded	0.37	D	Columbia	Silt Loam	2

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The land within the Action Area is dominated by agriculture (crops and pasture), encompassing approximately 70% of the total area. Other land cover consists of woods/forest, grassland, urban development, and wetlands. The Lodi Marsh State Wildlife Area falls within Action Area covering 1,209 acres, accounting for approximately 5.4% of the total land area. **Figure 9** displays the current land use as derived from the 2014 Cropland Data Layer, collected by the USDA-NRCS using satellite imagery. All agricultural crops (e.g. corn, soybean, wheat, etc.) were grouped into a single category (Cropland) for simplicity.

By looking at multiple years of the Cropland Data Layers, it is possible to infer crop rotations in agricultural areas. The Wisconsin DNR's Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) tool was used to develop a Crop Rotation dataset for the Action Area (**Figure 10**) based on the USDA-NRCS Cropland Data Layers from 2009 through 2013. An abbreviated summary of how the crop rotations are classified during this 5-year period is outlined below, but a comprehensive description is provided within the "EVAAL Methods" documentation.

- The 'continuous corn' classification was assigned to land with at least 3 years of corn and no other crops.
- The 'cash grain' rotation was assigned to land with at least 2 years of corn and soy/grain but no other crops.
- The 'dairy rotation' was assumed for land that had at least one year of alfalfa and one year of corn/soy/grain. It was also assigned to land with 1 year of potatoes and 1 year of alfalfa and no other vegetables.
- The 'potato/vegetable' classification was assigned to land with at least 1 year of potatoes or other vegetables.
- The 'pasture or hay or grassland' classification was assigned to land that had at least 2 years of pasture/alfalfa but no other crops.
- All other land was assumed to be 'no agriculture'.

A broad overview of the existing land use is provided in Table 7. It outlines the approximate land area associated with different land use types, crop rotations, and estimated livestock density. Different tillage practices are best assessed via a windshield survey in the spring, before new crops cover the soil.

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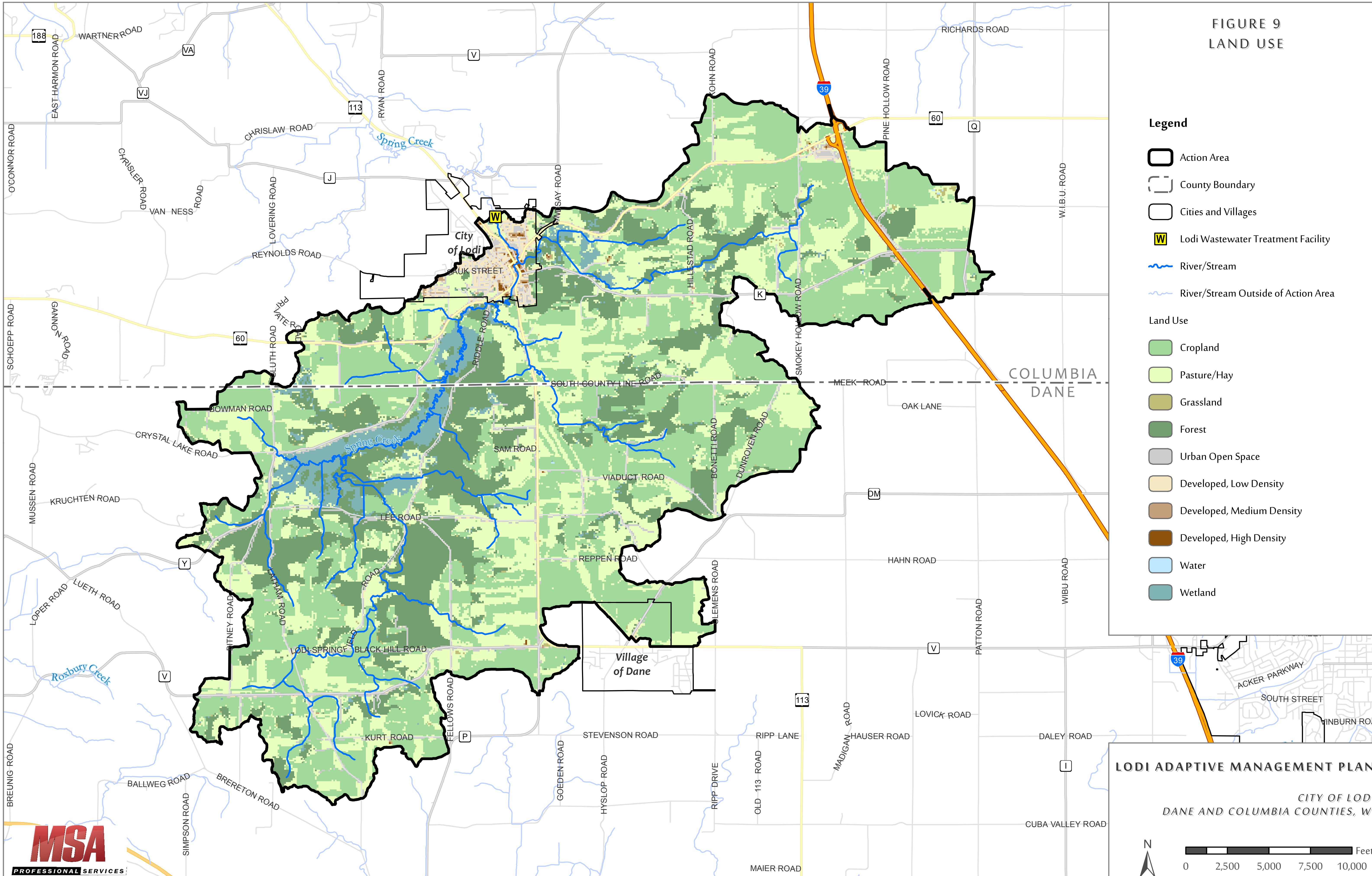
FIGURE 9
LAND USE
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Land Use
Cropland
Pasture/Hay
Grassland
Forest
Urban Open Space
Developed, Low Density
Developed, Medium Density
Developed, High Density
Water
Wetland
City of Lodi
Village of Dane
COLUMBIA
DANE
Spring Creek
Roxbury Creek
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
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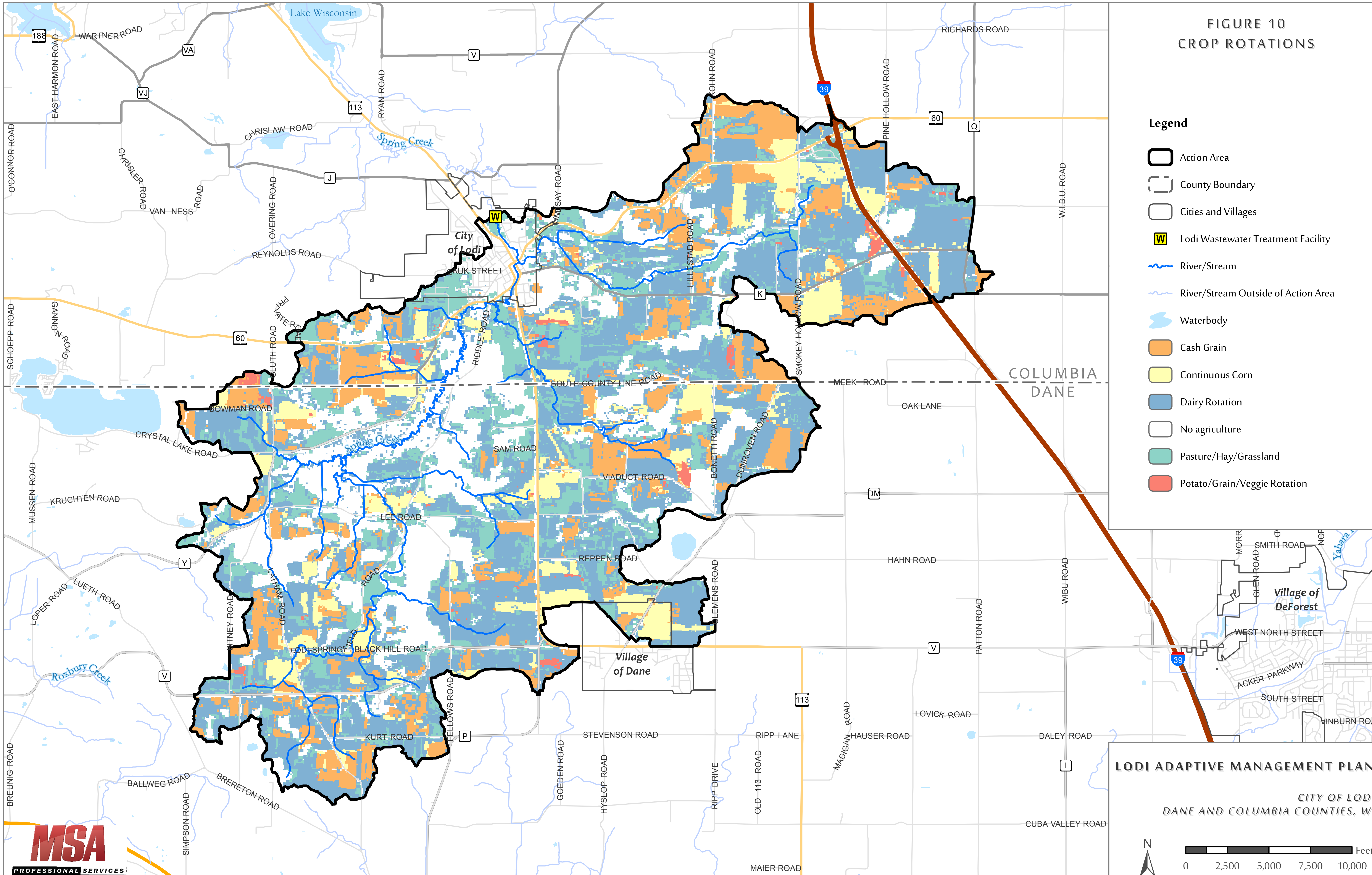
FIGURE 10
CROP ROTATIONS
Legend
Action Area
County Boundary
Cities and Villages
W Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
Cash Grain
Continuous Corn
Dairy Rotation
No agriculture
Pasture/Hay/Grassland
Potato/Grain/Veggie Rotation
COLUMBIA
DANE
City of Lodi
Village of Dane
Village of DeForest
Lake Wisconsin
Spring Creek
Roxbury Creek
WARTNER ROAD
EAST HARMON ROAD
CHRISLAW ROAD
RYAN ROAD
O'CONNOR ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
RICHARDS ROAD
KOHN ROAD
PINE HOLLOW ROAD
LINDSAY ROAD
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
W.I.B.U. ROAD
SCHOEPP ROAD
GANNON ROAD
PRIVATE ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
CRYSTAL LAKE ROAD
SAM ROAD
BONETTI ROAD
DUNROVEN ROAD
VIADUCT ROAD
MUSSEN ROAD
KRUCHTEN ROAD
LEE ROAD
REPPEN ROAD
HAHN ROAD
SMITH ROAD
GLEN ROAD
LOPER ROAD
LUETH ROAD
LATHAM ROAD
CLEMENS ROAD
WIBU ROAD
PATTON ROAD
WEST NORTH STREET
LODI SPRINGFIELD
BLACK HILL ROAD
ACKER PARKWAY
SOUTH STREET
FELLOWS ROAD
KURT ROAD
STEVENSON ROAD
RIPP LANE
HAUSER ROAD
LOVICK ROAD
DALEY ROAD
BREUNIG ROAD
BALLWEG ROAD
BRERETON ROAD
SIMPSON ROAD
GOEDEN ROAD
HYSLOP ROAD
RIPP DRIVE
OLD 113 ROAD
MADIGAN ROAD
CUBA VALLEY ROAD
MAIER ROAD
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
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Table 7: Land use within the Action Area.

Current Land Use				*Source: 2014 USDA-NRCS Cropland Data Layer*
Land Use	*Approximate Land Cover (ac)*	*Approximate Land Cover (%)*	*Typical Impervious Fraction/Runoff Coefficient*	*Approximate Impervious Area in Watershed*
Developed, low density	478	2.1%	0.30	0.6%
Developed, medium density	134	0.6%	0.50	0.3%
Developed, high density	23	0.1%	0.70	0.0%
Urban open areas	887	4.0%	0.05	0.2%
Wetland	887	4.0%	0.08	0.3%
Forest	4,507	14.7%	0.10	1.5%
Grassland	58	0.2%	0.10	0.0%
Cropland/Pasture/Hay	15,305	60.6%	0.10	6.1%
Animal Feedlots	unknown	unknown	0.75	unknown
Water	4	0.02%	0.00	0.0%
Total	*22,281*	*100%*		*9.0%*
Description of Cropping Practices			*Source: 2009 to 2013 USDA-NRCS Cropland Data Layers; crop rotations derived through EVAAL modeling.*	
Common Rotations	*Approximate Land Cover (ac)*		*Approximate Land Cover (%)*	
Dairy Rotation	8,399		50.2%	
Pasture or Hay or Grassland	3,230		19.3%	
Cash Grain	2,989		17.9%	
Continuous Corn	1,936		11.6%	
Other crop	176		1.0%	
Total	*16,731*		*100% (75% of the total watershed)*	
Tillage Practices				
*To be determined in Spring 2016**				
Livestock Density	*Source: STEPL Input Data Server, using data from USDA Census of Agriculture 2007. Scaled down from HUC 12 Spring Creek to Action Area by land area.*			
Animal Type	*Approximate number of animals in watershed*			
Beef	318			
Dairy	1,420			
Pork	1,032			
Poultry	8,856			
Other	439			
Comments				
**A review of current tillage practices will be completed in the Spring of 2016 via a wind shield survey.*				

It is important to know if regions of the Action Area might transition from one land use to another. For example, a property that is currently agricultural might be subdivided into residential lots. This will impact how Critical Source Areas are selected, since many BMPs that target phosphorus load reductions are highly dependent on the existing land use and management practices. To estimate potential areas where development occurs, future land use plans were reviewed for both Columbia and Dane County. In Columbia County, the future land use for 2030 (updated in 2014) was supplied by the County in GIS format. In Dane County, a printed map for the Town of Dane (adopted in 2002) was reviewed and converted into a GIS dataset. A combination of both datasets are show in **Figure 11**, and calls out potential areas where

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future development might occur within the Action Area. It should be noted that both of these datasets are approximate, and should not be referenced as definitive sources. They are included here simply as an additional planning tool for the Adaptive Management Project, and specific questions regarding projected land uses should be directed to the appropriate county officials.

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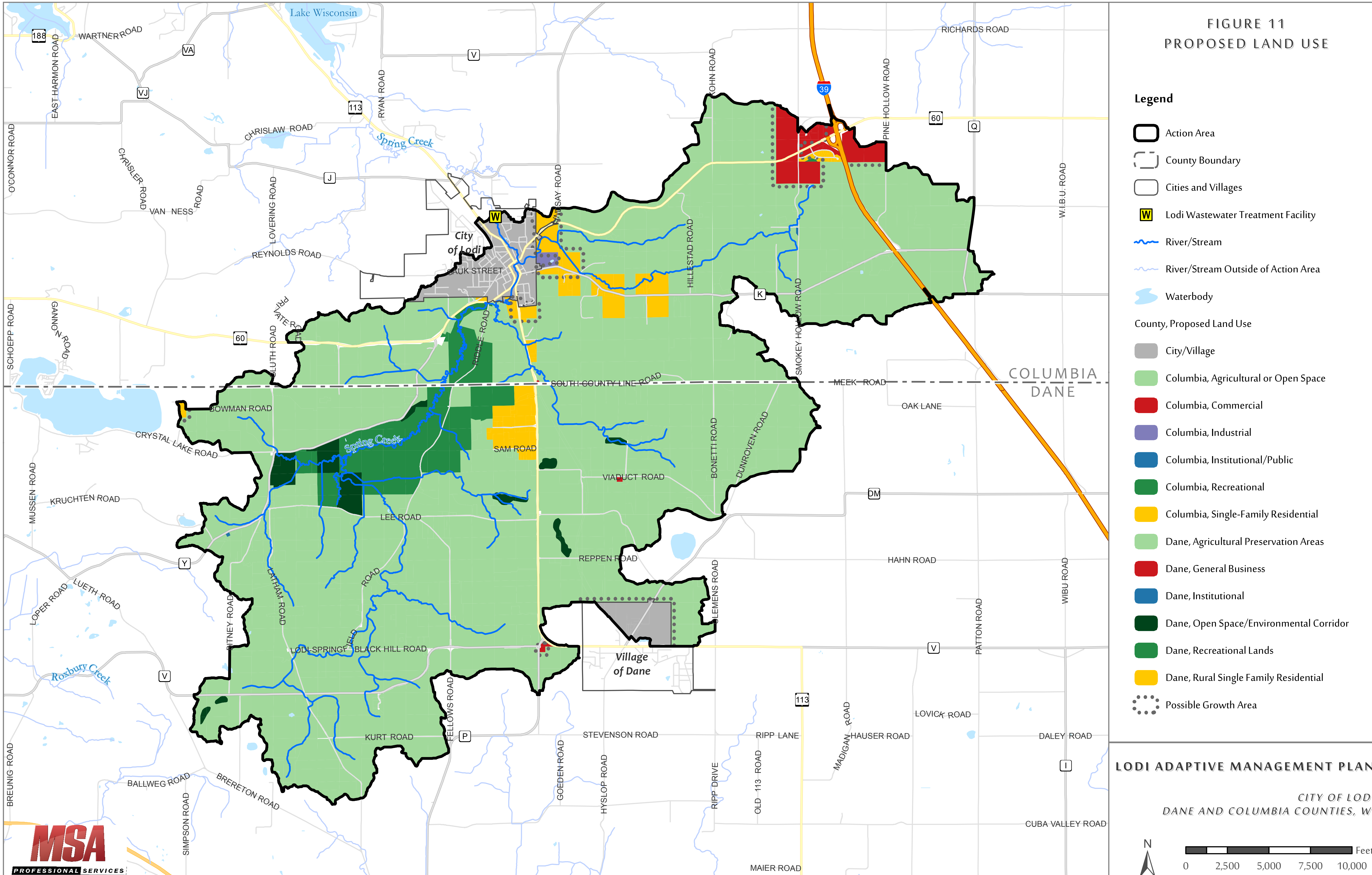
FIGURE 11
PROPOSED LAND USE
Legend
Action Area
County Boundary
Cities and Villages
Lodi Wastewater Treatment Facility
River/Stream
River/Stream Outside of Action Area
Waterbody
County, Proposed Land Use
City/Village
Columbia, Agricultural or Open Space
Columbia, Commercial
Columbia, Industrial
Columbia, Institutional/Public
Columbia, Recreational
Columbia, Single-Family Residential
Dane, Agricultural Preservation Areas
Dane, General Business
Dane, Institutional
Dane, Open Space/Environmental Corridor
Dane, Recreational Lands
Dane, Rural Single Family Residential
Possible Growth Area
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COLUMBIA
DANE
City of Lodi
Village of Dane
Lake Wisconsin
Spring Creek
Roxbury Creek
WARTNER ROAD
EAST HARMON ROAD
O'CONNOR ROAD
CHRISLER ROAD
VAN NESS ROAD
CHRISLAW ROAD
RYAN ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
RICHARDS ROAD
JOHN ROAD
PINE HOLLOW ROAD
LINDSAY ROAD
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
W.I.B.U. ROAD
SCHOEPP ROAD
GANNON ROAD
SLUTH ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
CRYSTAL LAKE ROAD
SAM ROAD
VIADUCT ROAD
BONETTI ROAD
DUNROVEN ROAD
MUSSEN ROAD
KRUCHTEN ROAD
LEE ROAD
REPPEN ROAD
HAHN ROAD
LUETH ROAD
LOPER ROAD
LATHAM ROAD
CLEMENS ROAD
WIBU ROAD
PATTON ROAD
LODI SPRINGFIELD ROAD
BLACK HILL ROAD
FELLOWS ROAD
KURT ROAD
STEVENSON ROAD
RIPP LANE
LOVICK ROAD
HAUSER ROAD
MADIGAN ROAD
DALEY ROAD
BREUNIG ROAD
BALLWEG ROAD
BRERETON ROAD
SIMPSON ROAD
GOEDEN ROAD
HYSLOP ROAD
RIPP DRIVE
OLD 113 ROAD
CUBA VALLEY ROAD
MAIER ROAD
188
VA
VJ
113
V
J
W
60
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CHAPTER 5 – IDENTIFY WHERE REDUCTIONS WILL OCCUR (CRITICAL SOURCE AREAS)

Phosphorous load reductions can occur anywhere within the proposed Action Area. However, in the interest of efficiency, it is beneficial to identify locations where phosphorus reductions are likely to be the most cost effective. In other words, identification of those locations that might be contributing higher phosphorus loads relative to other locations within the Action Area is desirable. These locations are called 'Critical Source Areas' (CSAs); they are both a likely source of phosphorus and also likely to readily transport phosphorus to receiving waters. Since the Action Area only contains one permitted point-source contributor to Spring Creek (the Lodi Wastewater Treatment Facility), the CSAs within the Action Area are all non-point source contributors.

5.1 RURAL CRITICAL SOURCE AREAS

In order to more readily identify the CSAs in rural areas, a two-fold approach was utilized.

I. First, the Wisconsin DNR offers a GIS-based model called 'Erosion Vulnerability Assessment for Agricultural Lands' or EVAAL. This model uses publically available geospatial data to identify regions that are vulnerable to erosion, and therefore are more likely to export phosphorus into receiving waters. It uses two methods to estimate erosion: (1) sheet and rill erosion using the Universal Soil Loss Equation and (2) gully erosion using the Stream Power Index. The output of the model is a geospatial grid (an image) where each pixel of the output 'ranks' its relative erosion vulnerability. The rank can only be compared to other locations within the Study Area, and is therefore project specific. The results can be aggregated to the parcel level, providing a graphical method to select those parcels with the highest average 'rank' for potential erosion. These locations are best suited for implementing "soft" Best Management Practices, such as grassed waterways, reduced tillage, buffer strips, etc. For the purposes of this evaluation, "Hard" Best Management Practices consist of physical, engineered improvements, such as manure storage, covered feed lots, and clean water diversions to direct rainwater away from animal staging areas, etc. Hard Practices can also be thought of as "Bricks and Mortar" type approaches.

   It should be noted that the model was run without knowing where soft BMPs have already been implemented. For example, the model might suggest that a particular field is vulnerable to gully erosion due to the existing topography. However, the landowner might be proactive in their management methods and may have already established a grassed waterway, protecting the soil from concentrated flows and significantly reducing gully erosion. This location would be initially identified by EVVAL as a CSA, but after accounting for the existing management practices, it would no longer be considered a CSA. Therefore, the outputs from EVAAL were carefully reviewed, using aerial imagery and a windshield survey. A more complete description of the EVAAL modeling effort is included in Appendix D.

II. The second approach for identifying CSAs entailed collaboration with the Columbia County Land and Water Conservation Department. The County conducted an NR 151 Livestock Inventory for all of the existing Livestock Operations within the Spring Creek Watershed (HUC 12), and each operation was analyzed using the BARNY model. This model can estimate the phosphorus loading from the edge of the lot before and after a series of BMPs are implemented. Those sites that had

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low edge-of-lot phosphorus discharge (<15 lbs of phosphorus per year) were not modeled for BMP installation. A cost estimate (low and high) was also determined to evaluate the cost-effectiveness of upgrading each barnyard to reduce phosphorus loadings. These CSAs target "hard" Best Management Practices at livestock facilities, as described previously, such as modifying gutters, installing sediment basins, or updating manure storage facilities. A copy of the County's Report is located in Appendix E.

Finally, it was necessary to develop a cut-off criteria to prioritize the CSAs. Adaptive Management hinges on seeing measurable reductions in phosphorus concentrations immediately downstream of the Lodi Wastewater Treatment Facility. Although implementing a specific practice upstream in the watershed will reduce phosphorus loading from that particular parcel of land, it is challenging to accurately predict the fate and transport component of how the rest of the watershed will respond and how it may manifest at the WWTF. For example, if 1,000 lbs of phosphorus per year are removed by a specific BMP at an upstream location, will the results of that reduction be visible at the Wastewater Treatment Plant in the form of reduced in-stream phosphorus concentrations?

Of particular concern is how the Lodi Marsh will effect fate and transport. Wetlands are notoriously difficult to model, and (depending on environmental factors) have been known to be both a source and a sink for phosphorus. Unfortunately, the scope of the Adaptive Management project does not allow for full-scale modeling of the Lodi Marsh, and therefore its impact on fate and transport of phosphorus is unknown at this time. Therefore, CSAs located upstream of the Lodi Marsh were considered to be a lower priority, since effects of reductions upstream of the Marsh may or may not be evident at the WWTF. Additional sampling was completed in 2015 near the outlet of the Marsh (upstream of the Riddle Road bridge) to get a better estimate of phosphorus loading passing through the Marsh. The goal of this investigation was to gain an understanding of whether the rest of the Action Area contributes a large enough fraction of the total phosphorus present within the Action Area to make Adaptive Management feasible without placing a large number of BMPs in the Marsh subwatershed. This effort estimated that approximately 60% of the total phosphorus load at the WWTF drains through the Marsh (Appendix C).

Cropland CSAs were selected based on EVAAL modeling at the parcel level using the following criteria:

- **High EVAAL score:** The selected parcels had an average EVAAL rank of 1.25 or greater. These areas have a higher relative potential for erosion and associated phosphorus loading than other sites in the watershed.
- **Larger Parcel Size:** Larger parcels are often better suited for soft management practices. For example, it might be challenging to operate large machinery around BMPs if the parcel is too small. The parcel cut off size was set at 10 acres.
- **Location within the Action Area:** Parcels that were not upstream of the Lodi Marsh were considered to be a higher priority since the fate and transport impact of the Marsh is unknown at this time.
- **Common Adjacent Landowner:** Often groups of parcels are owned or managed by the same landowner. If a specific parcel was identified by EVAAL using the above criteria, all of the adjacent parcels were reviewed to determine if there was a common landowner. If yes, these parcels were added to the CSA. Future planning efforts for BMPs will likely include all of the properties owned by an individual, to determine the best site for BMP installation.

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- **Outside of Possible Future Development Areas:** Many of the BMPs will be located on agricultural lands. For the longevity of the Adaptive Management Project, it is important to consider how possible future development will impact the lifespan of any partnership with a specific landowner.

Barnyard CSAs were selected based on Columbia County's BARNY modeling of livestock sites and expanded to the parcel level using the following criteria:

- **Possible Phosphorus Load Reductions:** The phosphorus load reductions associated with BMP installation at each livestock operation were obtained from Columbia County.
- **Estimated BMP Cost:** Sites were ranked in order of magnitude with respect to cost per pound of phosphorus removed. Initially, a cut-off for the Top 20 sites was established. The Top 20 sites had phosphorus reductions ranging from 7 lbs/site to 277 lbs/site. Costs per pound ranged from roughly $7/lb to $52/lb (construction cost), or roughly $9/lb to $65/lb (construction cost + engineering and administrative cost).
- **Location within the Action Area:** Sites located far upstream and particularly those within the Marsh Watershed were removed from the list due to the unknowns of fate and transport. Ultimately, 7 priority sites were identified as being critical sources where reductions were most likely to have measureable impacts on the water quality immediately downstream of the City of Lodi WWTF.
- **Common Adjacent Landowner:** Often groups of parcels are owned by the same landowner. If a specific parcel was identified by BARNY using the above criteria, all of the adjacent parcels were reviewed to determine if there was a common landowner. If yes, these parcels were added to the CSA. Future planning efforts for BMPs will likely include all of the properties owned by an individual.

This initial set of criteria can be easily modified as the Adaptive Management Project progresses. More CSAs can be identified by loosening the criteria set above, and provide the next 'tier' of possible locations for implementing BMPs. **Figure 12** and **Figures 13A-D** identify the 16 CSAs determined through the above selection process. Note that some of the CSAs extend beyond the Action Area boundary. This is typically due to common adjacent landownership; BMPs implemented for the LAMP should be carefully reviewed to ensure that any improvements would results in phosphorus reductions within the Action Area.

A windshield survey of all sixteen of the CSAs was completed in the fall of 2015. Although such surveys are often completed in the spring (after snow melt and before substantial plant growth on agricultural fields) the timeline for the submittal of the LAMP did not allow for this effort to be completed in the spring. Even in the fall of 2015, the windshield survey clearly identified areas where BMPs would be needed. Additional site surveys would be carried out prior to implementing new BMPs as needed. These future windshield surveys will further identify existing and potential BMPs within the CSAs. Table 8 identifies the CSAs and the potential BMPs that could be implemented on each property, as determined by the windshield survey (for soft management practices) and from Columbia County's 2013 report reviewing existing barnyard practices.

It should be noted that all BMPs which are implemented to reduce non-point phosphorus loadings from rural critical source areas will be designed, installed, and maintained according to applicable NRCS technical standards. In addition, all practices will be reviewed by the Columbia County Land & Water

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Conservation Department or Dane County Land and Water Resources Department prior to implementation.

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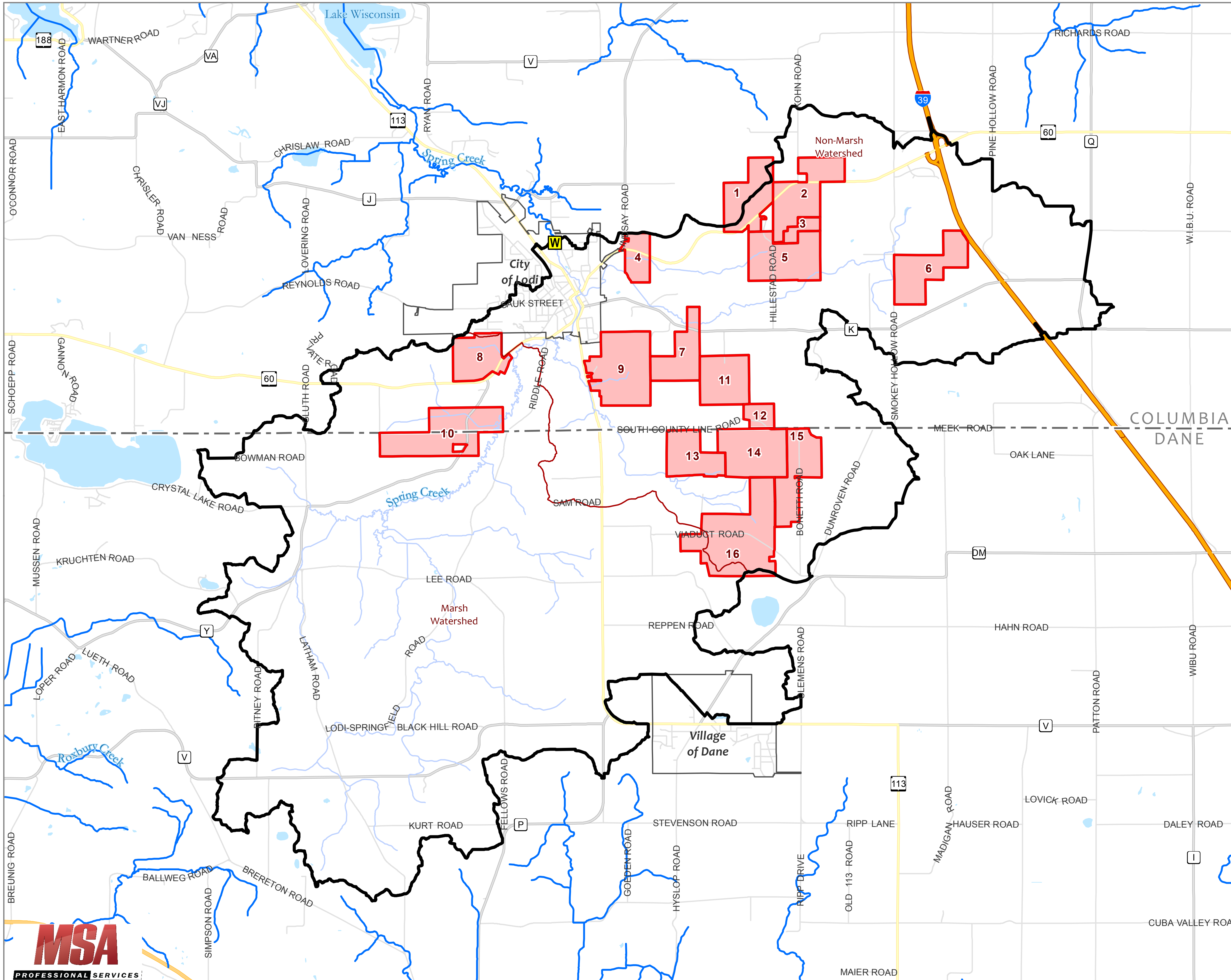
FIGURE 12
CRITICAL SOURCE AREAS



Legend

- Action Area
- County Boundary
- Cities and Villages
- Watershed Divide (Marsh and Non-Marsh)
- Critical Source Area
- W Lodi Wastewater Treatment Facility
- River/Stream
- River/Stream Outside of Action Area
- Waterbody

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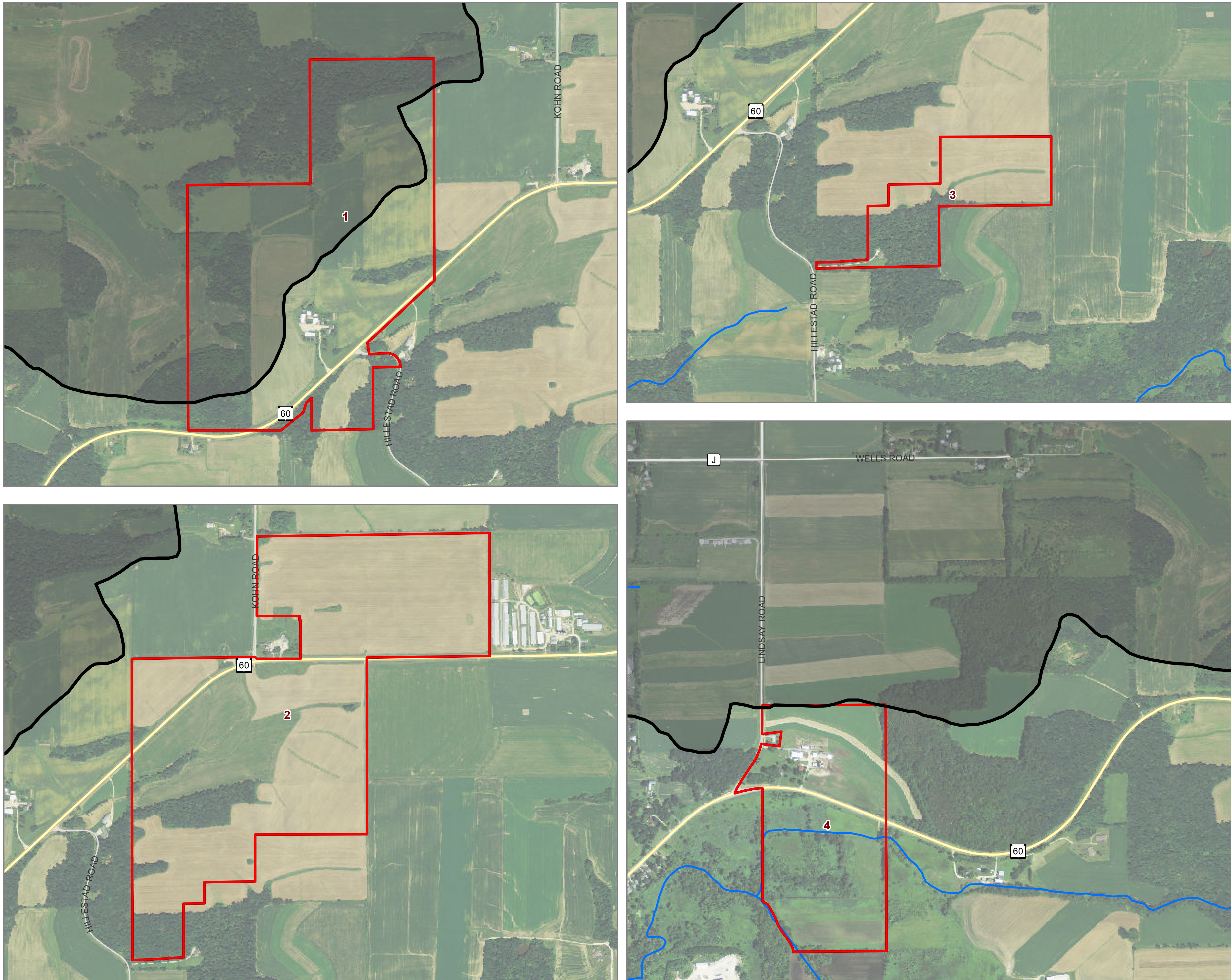
FIGURE 13A
CRITICAL SOURCE AREAS 1-4



Legend

- Action Area
- Outside of Action Area
- Critical Source Area
- River/Stream

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LODI ADAPTIVE MANAGEMENT PLAN

CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI

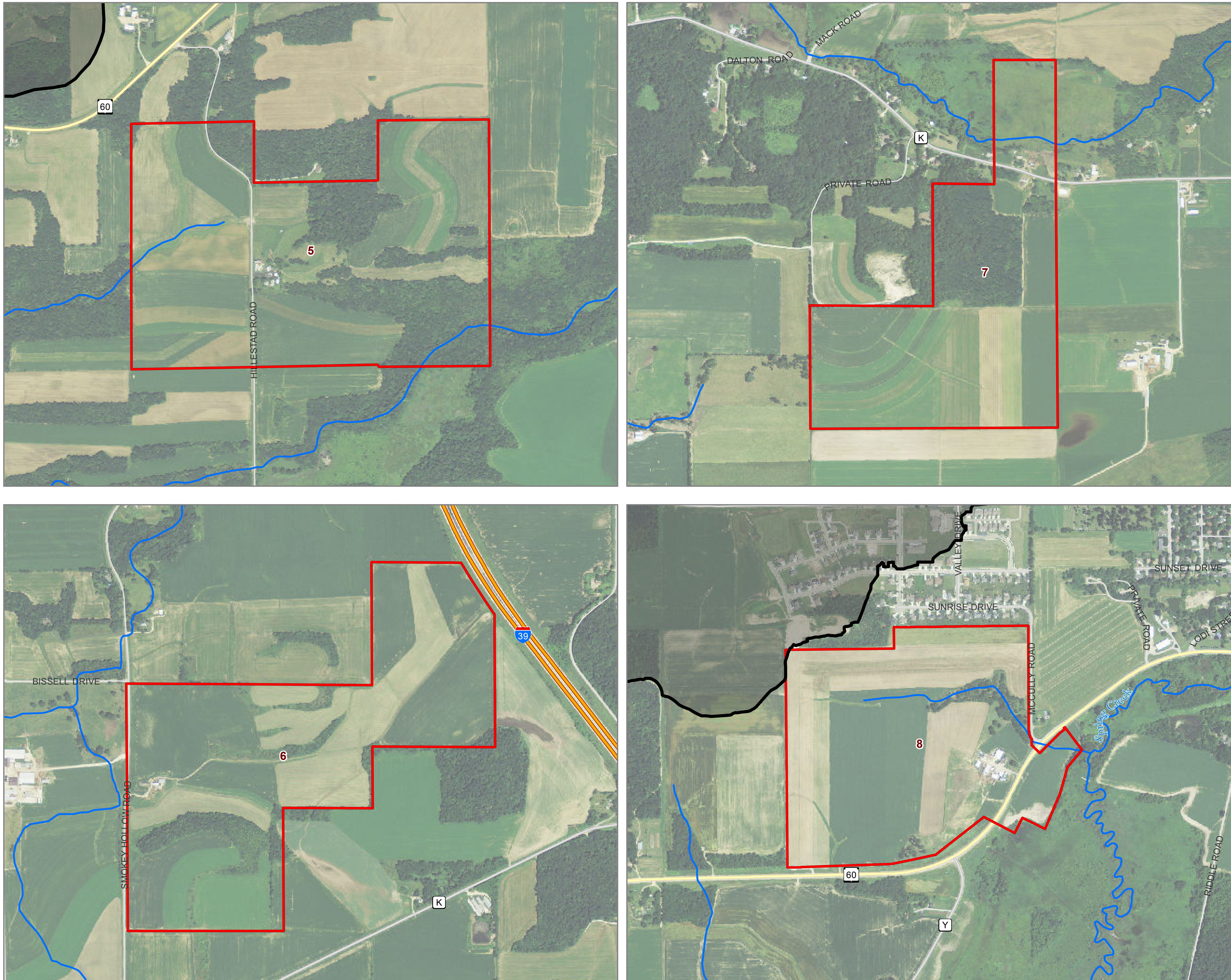

FIGURE 13B
CRITICAL SOURCE AREAS 5-8

Legend

- Action Area
- Outside of Action Area
- Critical Source Area
- River/Stream

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CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI

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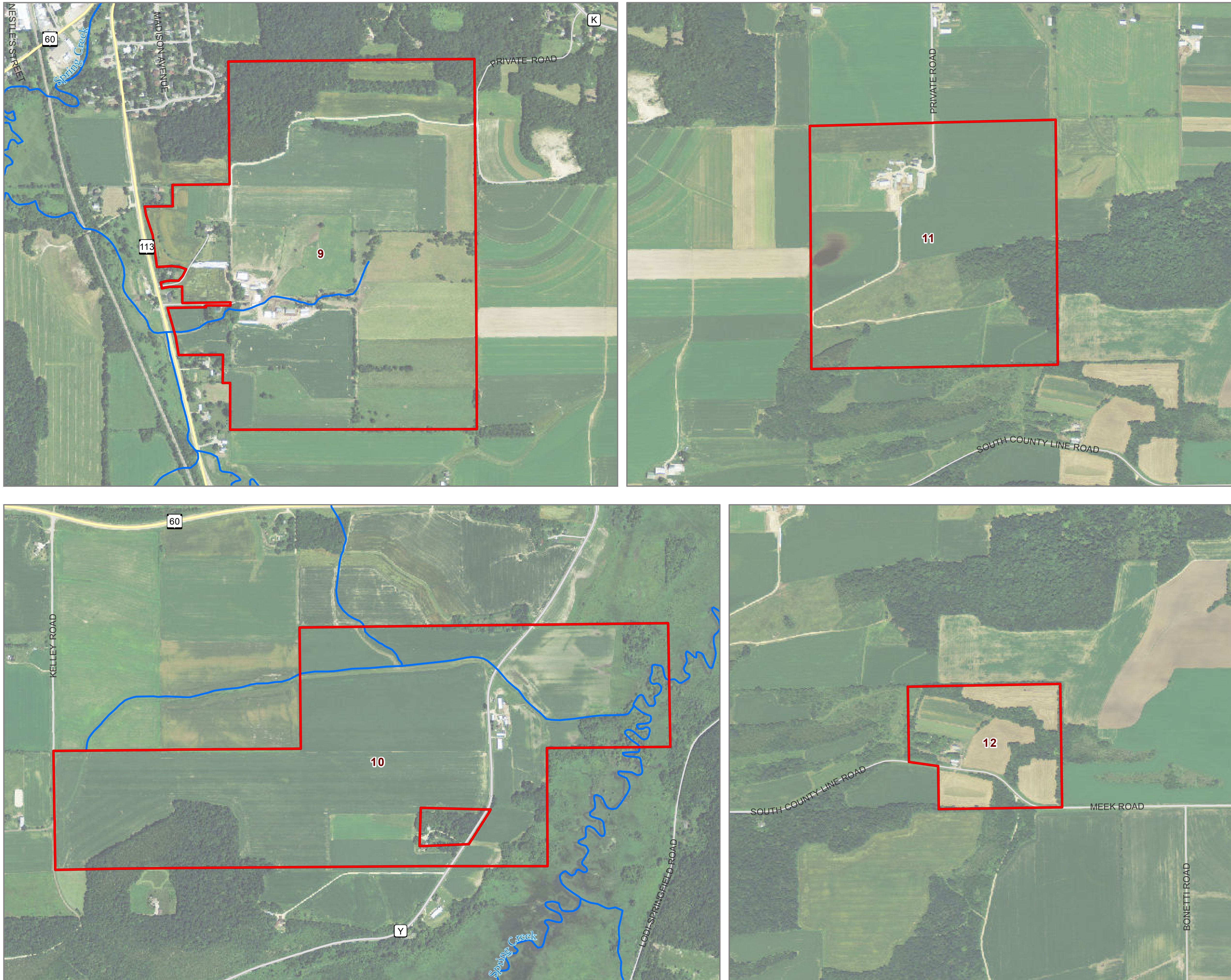
FIGURE 13C
CRITICAL SOURCE AREAS 9-12



Legend

- Action Area
- Outside of Action Area
- Critical Source Area
- River/Stream

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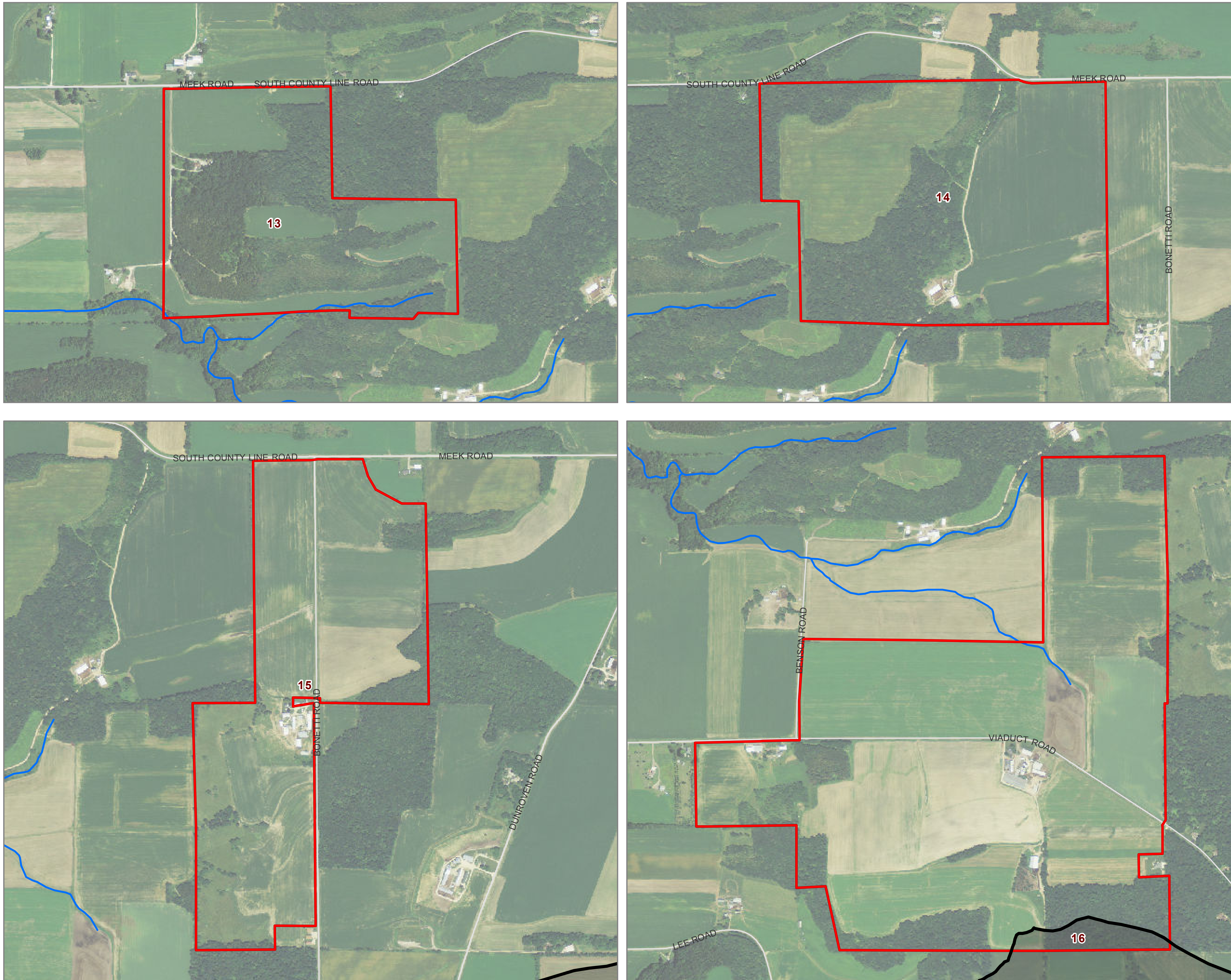
FIGURE 13D
CRITICAL SOURCE AREAS 13-16



Legend

- Action Area
- Outside of Action Area
- Critical Source Area
- River/Stream

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LODI ADAPTIVE MANAGEMENT PLAN

CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI

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Table 8: Rural Critical Source Areas and potential best management practice s (BMPS).

Critical Source Area	*Selection Criteria*	*Parcel Area (ac)*	*Land within Action Area (ac)*	*Cropland in Action Area (ac)*	*Pasture in Action Area (ac)*	*Potential Soft Practices*	*Potential Hard Practices*
1	EVAAL	181.8	76.0	52.8	4.0	Nutrient Management (if needed), Contour Farming, Contour Buffer Strips, Filter Strips, Continued Use of Cover Crops	
2	EVAAL	207.5	207.5	176.8	1.9	Nutrient Management (if needed), Grassed Waterways, Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops	
3	EVAAL	35.7	35.7	25.9	2.2	Nutrient Management (if needed), Grassed Waterways, Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops, Grade Stabilization Structure	
4	Barnyard Analysis	79.5	79.4	23.5	36.3		Heavy Use Area Protection, Buffer, Natural Buffer
5	EVAAL and Barnyard Analysis	213.1	213.1	153.9	4.4	Nutrient Management (if needed), Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	Diversions, Roof Gutters
6	EVAAL	189.3	189.3	168.1	5.2	Nutrient Management (if needed), Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	

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Critical Source Area	Selection Criteria	Parcel Area (ac)	Land within Action Area (ac)	Cropland in Action Area (ac)	Pasture in Action Area (ac)	Potential Soft Practices	Potential Hard Practices
7	Barnyard Analysis	140.7	140.7	76.9	20.0		Roof Gutters, Livestock Exclusion, Heavy Use Area Protection, Sediment Basin, Buffers
8	Barnyard Analysis	143.0	142.9	93.8	23.9	Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	Diversions, Roof Gutters, Livestock Exclusion, Heavy Use Area Protection, Waterways, Sediment Basin, Buffers
9	EVAAL and Barnyard Analysis	269.7	269.7	142.8	28.3	Nutrient Management, Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops, Grade Stabilization Structure	Diversions, Roof Gutters, Livestock Exclusion, Lanes, Heavy Use Area Protection, Sediment Basin, Waste Storage
10	Barnyard Analysis	265.6	265.6	212.7	2.5	Nutrient Management (if needed), Reduced Tillage, Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops	Diversions, Roof Gutters, Buffer
11	EVAAL	159.5	159.5	116.2	12.4	TBD	
12	EVAAL	46.3	46.3	32.5	12.2	Nutrient Management (if needed), Reduced Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	

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Critical Source Area	Selection Criteria	Parcel Area (ac)	Land within Action Area (ac)	Cropland in Action Area (ac)	Pasture in Action Area (ac)	Potential Soft Practices	Potential Hard Practices
13	EVAAL	139.9	139.9	65.3	2.7	Nutrient Management (if needed), Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops	
14	EVAAL and Barnyard Analysis	209.7	209.7	139.9	4.1	Nutrient Management (if needed), Grassed Waterways, Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Buffer Strips, Filter Strips, Cover Crops	Roof Gutters, Heavy Use Area Protection, Sediment Basin, Buffers
15	EVAAL	177.2	177.2	123.7	16.3	Nutrient Management (if needed), Grassed Waterways, Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	
16	EVAAL	378.7	369.3	292.1	3.3	Nutrient Management (if needed), Grassed Waterways, Reduced Tillage/Reduced Fall Tillage, Contour Farming, Contour Strips, Contour Buffer Strips, Filter Strips, Cover Crops	

*Note: Parcel area based on GIS parcel data obtained from Dane and Columbia Counties. Cropland and pasture areas determined from Crop Rotations dataset generated through EVAAL modeling (USDA-NRCS Cropland Data Layers from 2009 through 2013)

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5.2 URBAN CRITICAL SOURCE AREAS

The City completed the Spring Creek Watershed Study & Urban Stormwater Plan in 2009. This plan included a review all of the existing stormwater BMPs within the then urbanized areas of the City. For the Adaptive Management project, the 2009 study was revisited with specific attention given to that portion of the City draining to Spring Creek upstream from the WWTF. This portion of the City includes four existing stormwater quality ponds (one recently constructed as a recommendation of the 2009 study). In addition to these structural practices, the City also seasonally operates a street sweeper which, while not specifically operated for water quality treatment purposes, does result in a reduction of pollutants discharged to Spring Creek. Note that while this study included an evaluation of existing sweeping practices, it was never intended that modifications to sweeping practices would be evaluated as a method for TP reductions for the Adaptive Management Project because street sweeping is on the low end of cost effectiveness for achieving phosphorus reductions. Rather, street sweeping practices were evaluated because reductions achieved by sweeping needed to be separately tracked to determine the net benefit of new and retrofit structural stormwater practices.

The effectiveness of existing stormwater management practices was determined through development of a WinSLAMM (Source Loading and Management Model [for Windows]) Version 10.0 computer model. This model estimated the annual loads of TP generated by watersheds tributary to, and removed by, existing BMPs. Once baseline conditions were established, the urban area was reviewed for possible retrofits to existing storm sewers as well as for installation of new management practices. Locations for five (5) alternative future ponds were determined though examination of lands within 300 feet of existing storm sewers, taking into account the upstream drainage area (i.e. larger drainage areas typically have higher TP loads and are served by larger diameter sewers). Properties with comparatively lower assessed values within the 300 foot buffer were identified as potential sites for stormwater quality ponds. Drainage areas, land use, and runoff and pollutant generation data were developed for each of these BMPs and conceptual BMPs were evaluated to determine potential additional phosphorus reductions that may be achieved through their construction. Additionally, review of the individual performance of the existing BMPs within the study area showed that ponds EX1, EX2, and EX3 all achieved relatively low levels of TP reduction. Since pond EX3 receives runoff from ponds EX1 and EX2, pond EX3 was identified as a potential site as a water quality treatment optimization project; a simple modification to the pond's outlet control structure was found to achieve a marked improvement in TP capture rates.

Table 9 highlights the existing BMP structures, and possible new BMP locations that could be implemented for Adaptive Management. Table 9 also shows the relative costs per pound of TP captured using the proposed BMPs on a 20-year present value basis. As shown, the cost per pound of phosphorus removed is significantly higher than costs previously discussed for hard practices and soft practices on the rural landscape.

As another method of comparison, if the total cost of proposed BMPs ($521,525) is divided by the total mass of phosphorus reduced (64.6 lb/year) over a 20-year lifespan for the BMPs, the resultant cost per pound may be calculated as $521,525 / (64.6 lb/yr * 20 years) = $404. Costs for BMPs on the rural landscape are projected to be in the range of $50 - $60 per pound.

After presentation of a draft version of this report, City Council members requested that urban BMPs be re-evaluated assuming that they would be implemented in the form of rain gardens, similar to the recently installed Lodi Community Rain Garden. Table 10, below, presents TP reduction efficiency and present

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worth TP reduction costs for each proposed BMP if installed as a rain garden as opposed to the previously discussed wet detention ponds. The rain gardens were evaluated assuming that they would occupy the same footprint as the wet ponds, and were modeled following standard protocols as identified in WNDR Conservation Practice Standard 1004. The use of rain gardens in place of ponds produced less overall TP reductions in addition to having larger construction costs.

To provide a final point of comparison between the wet detention ponds and the rain gardens, the resultant cost per pound of TP reduction is calculated to be $1,795/yr. This is substantially higher than the efficiency of the proposed wet detention ponds, let alone proposed agricultural practices.

Figure 14 shows the location of each proposed improvement within the City, as well as the associated subwatershed. A full description of the urban WinSLAMM modeling is provided in Appendix F.

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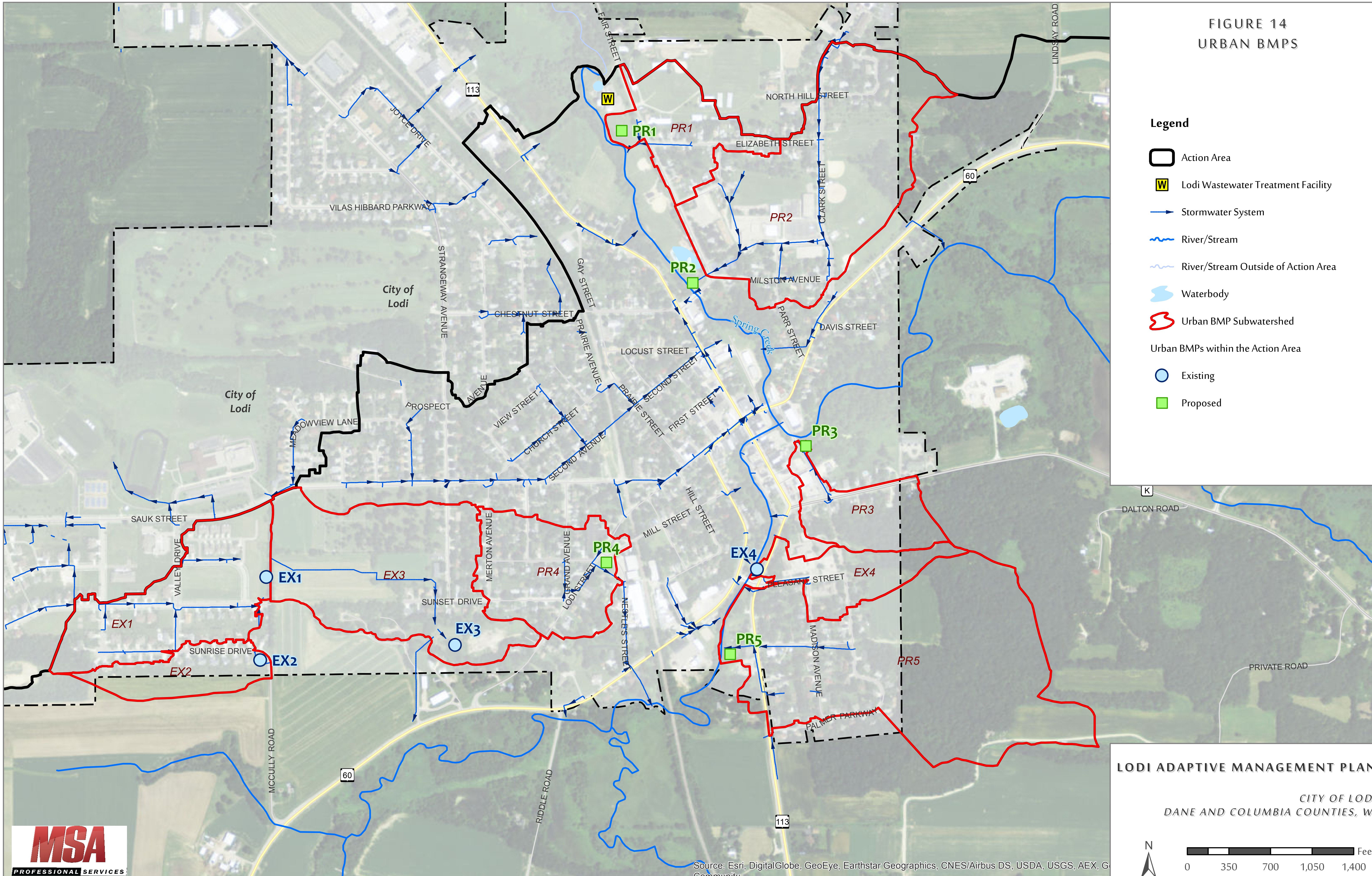
FIGURE 14
URBAN BMPS



LODI ADAPTIVE MANAGEMENT PLAN

CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI

Table 9: Alternative Stormwater BMP Cost-Effectiveness.

BMP	*Drainage Area*	*TP Load*	*BMP Efficiency*	*TP Trapped*	*Total Construction Cost*	*TP Capture Present Worth*[2]
	(ac)	(lbs/yr)	(%)	(lbs/yr)		($/lb/yr)
EX3	47.3			4.9[1]	$20,000	$311
PR1	17.5	14.4	54.6	7.9	$84,700	$549
PR2	61.1	54.8	45.5	25.0	$89,300	$185
PR3	14.6	10.5	34.6	3.6	$92,725	$754
PR4	24.1	22.2	50.3	11.2	$132,200	$358
PR5	78.9	48.6	24.7	12.0	$102,600	$258
Totals				64.6	$521,525	

1. *Net additional TP trapped following modifications to the existing pond outlet structure.*
2. *Assumes that annual maintenance represents 2% of initial construction cost (maintenance costs for pond EX3 assumed to be equal to the average of all other proposed ponds); that the maintenance life span is 20 years, and that the applied inflation rate is 4.625%.*

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Table 10: Alternative Stormwater BMP Cost-Effectiveness – Rain Gardens.

BMP	*Drainage Area*	*TP Load*	*BMP Efficiency*	*TP Trapped*	*Total Construction Cost*	*TP Capture Present Worth*[1]
	(ac)	(lbs/yr)	(%)	(lbs/yr)		($/lb/yr)
PR1 – Rain Garden	17.5	14.4	16.0	2.3	$120,830	$2,856
PR2– Rain Garden	61.1	54.8	12.4	6.8	$139,320	$1,140
PR3– Rain Garden	14.6	10.5	10.5	1.1	$81,740	$1,816
PR4– Rain Garden	24.1	22.2	14.4	3.2	$164,710	$1,877
PR5– Rain Garden	78.9	48.6	9.3	4.5	$136,030	$1,160
Totals				17.9	$642,630	

1. *Assumes that annual maintenance represents 2% of initial construction cost; that the maintenance life span is 20 years, and that the applied inflation rate is 4.625%.*

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CHAPTER 6 – ESTIMATE LOAD REDUCTIONS EXPECTED BY PERMIT TERM

The Adaptive Management Compliance option allows permittees up to three permit terms, each 5-years in length, to achieve the water quality criterion in the receiving water. During the first Adaptive Management permit term, the WWTF will be required to meet an interim effluent phosphorus limit of 0.6 mg/L. In the second and third permit terms, the interim effluent phosphorous limit will be 0.5 mg/L. If the in-stream water quality criterion of 0.075 mg/L is not attained within the first permit term, the AM Plan may require modification. Additional measures would be required during the second and third AM permit terms until the in-stream phosphorus criterion is achieved. Once the phosphorus criterion is attained, the WWTF would continue discharging at the 0.5 mg/L effluent limit as long as the phosphorus concentration in the stream remains below 0.075 mg/L.

The total phosphorus load reduction of 714 lb/yr would be required in the second and third permit terms. It is possible that additional load reductions may be needed in these permit terms in order to achieve the in-stream water quality criterion, and the AM Plan would be reviewed and adjusted accordingly. Within the first permit term, a minimum of 68 lb/yr need to be reduced. However, the Lodi AM Plan has a goal to reduce at least 357 lbs/yr (50% of the calculated total load reduction required for AM) prior to the end of the first permit term under Adaptive Management.

The load reductions from each CSA at this time are estimates. Certain BMPs will be more feasible with existing management activities, and more accurate load reduction estimates will be completed after detailed knowledge of the existing conditions is obtained from cooperating landowners on a site-specific basis. As a result, the load reductions resulting from AM measures will be updated prior to implementation.

Finally, CSA's were broadly categorized into two categories: those to be considered within the first permit term, and those to be considered within the second or third permit term. Prioritization was based on several different factors including feedback from local landowners, discussions with Columbia County LWCD, and the windshield survey. Although initial efforts will follow this prioritization, the order of implementation will likely change over time. Additional CSAs were purposefully included within the planning process to account for unknown factors including: the participation rate by local landowners, the types of practices implemented and the associated reduction efficiencies, and the fate and transport component.

6.1 LOAD REDUCTIONS IN RURAL AREAS

Load reductions in rural areas will come from both hard and soft practices. The estimated load reductions and cost estimates from hard practices were derived from the County's 2014 Livestock Assessments. These reductions are listed in Table 11, and can be cross referenced to the County's original report (Appendix E). Cost estimates and load reductions will be refined upon discussions with landowners and implementation of BMPs.

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Table 11: Timeline and cost estimates for implementation of rural hard practices.

Critical Source Area	Recommended BMPs	Load Reduction (lb/yr)	Estimated Cost ($)	Implementation Timeframe
4	Heavy Use Area Protection, Buffer, Natural Buffer	83	$31,250 - $62,500	Permit Term 2/3
5	Diversions, Roof Gutters	27	$6,250 - $12,500	Permit Term 2/3
7	Roof Gutters, Livestock Exclusion, Heavy Use Area Protection, Sediment Basin, Buffers	154	$50,000 - $62,500	Permit Term 1
8	Diversions, Roof Gutters, Livestock Exclusion, Heavy Use Area Protection, Waterways, Sediment Basin, Buffers	277	$156,250 - $187,500	Permit Term 1
9	Diversions, Roof Gutters, Livestock Exclusion, Lanes, Heavy Use Area Protection, Sediment Basin, Waste Storage	241	$281,250 - $312,500	Permit Term 1
10	Diversions, Roof Gutters, Buffer	30	$18,750 - $31,250	Permit Term 2/3
14	Roof Gutters, Heavy Use Area Protection, Sediment Basin, Buffers	48	$31,250 - $43,750	Permit Term 2/3

Estimating the load reductions resulting from soft management practices is less definitive, since practices will vary significantly in their reduction efficiency based on topography, current management practices, and proximity to the stream. Also, individual landowners may adopt different subsets of the soft practices based on their own preferences. Therefore, two methodologies were used to estimate the possible load reduction efficiencies of soft practices.

One method incorporates SnapPlus modeling to estimate field scale phosphorus load reductions. SnapPlus is a publically available computer software program which is used in Wisconsin to develop nutrient management plans and to estimate sediment and phosphorus loadings from crop fields and pastures. For the purposes this report, SnapPlus modeling was performed on one farm in the Action Area. The farm which was chosen for SnapPlus modeling included three different tracts which were located in three topographically different areas of the Action Area. One of the three tracts which were analyzed was identified as a CSA using the EVAAL model. The farm included crop fields and pastures which were believed to be representative of other crop fields and pastures in the watershed. In addition, the

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landowner kept sufficient records of soil test results, nutrient applications, etc. which were needed to estimate phosphorus load reductions for various BMPs.

Using the P Trade Report in SnapPlus, a series of realistic BMP combinations were modeled for the site to determine the phosphorus reduction potential. Based on this modeling effort, it was estimated that on average approximately 0.3 lb/ac/yr of phosphorus can be removed by implementing soft practices on crop fields within the watershed. It should be noted that the selected farm already utilized many best management practices such as no-till and cover crops to reduce non-point pollution. Therefore, it is likely that phosphorus reductions of greater than 0.3 lb/ac/yr can likely be quantified for CSAs in the action area which do not incorporate these BMPs. For the purposes of estimating phosphorus load reductions at other CSAs within the watershed, this site-specific phosphorus reduction of 0.3 lb/ac/yr was applied to all of the other rural CSAs within the Action Area. While it is understood that SnapPlus modeling is highly site specific, this estimate is likely conservative and should provide a realistic estimate for the potential load reductions achievable within the CSAs. A more detailed description of the SnapPlus modeling process is included in Appendix G.

The second method used to estimate phosphorus reductions from soft practices incorporates the estimated BMP efficiencies taken from the EPA's STEPL model (Spreadsheet Tool for Estimating Pollutant Loads). The STEPL model is relatively coarse resolution, designed for use at the HUC 12 watershed scale, and is intended for use as a planning tool. This model was selected to be paired with the SnapPlus model to provide a less site-specific estimate for potential phosphorus load reductions.

Based on the windshield survey of the rural CSAs, a complete list of possible soft practices was generated, and this was further reduced to those practices that were available in the STEPL model: Contour Farming, Cover Crop, Filter Strip, and Reduced Tillage Systems. The reduction efficiencies of each individual practice was taken from STEPL. Then, the practices were combined in series using the BMP Calculator Tool, ranging from combining only two practices to combining all four practices. Table 12 lists the efficiency from each soft practice combination. Since it is unknown which practices will be implemented at this time, the average reduction efficiency of all the potential BMP combinations, 74% phosphorus reduction, was used to estimate the reduction potential for soft practices in the cropland areas of the CSAs.

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Table 12: Reductions efficiencies for soft practice BMP combinations derived from STEPL modeling.

BMP(s)	*Number of Practices*	*Phosphorous Reduction Efficiency*	*Sediment Reduction Efficiency*
Contour Farming	*1*	0.55	0.41
Cover Crop	*1*	0.25	0.35
Filter Strip	*1*	0.75	0.65
Reduced Tillage Systems	*1*	0.45	0.75
Contour Farming, Cover Crop	*2*	0.66	0.61
Contour Farming, Filter Strip	*2*	0.89	0.79
Contour Farming, Reduced Tillage Systems	*2*	0.75	0.85
Cover Crop, Filter Strip	*2*	0.81	0.77
Cover Crop, Reduced Tillage Systems	*2*	0.59	0.84
Filter Strip, Reduced Tillage System	*2*	0.86	0.91
Contour Farming, Cover Crop, Filter Strip	*3*	0.92	0.87
Contour Farming, Cover Crop, Reduced Tillage Systems	*3*	0.81	0.90
Contour Farming, Filter Strip, Reduced Tillage Systems	*3*	0.94	0.95
Cover Crop, Filter Strip, Reduced Tillage System	*3*	0.90	0.94
Contour Farming, Cover Crop, Filter Strip, Reduced Tillage System	*4*	0.95	0.97
Average		***0.74***	***0.77***

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The average phosphorus load reduction (lb/acre cropland) was then modeled for the entire HUC 12 Spring Creek Watershed, applying the averaged BMP reduction efficiency as calculated in Table 12 (0.74 for phosphorus and 0.77 for sediment). The combined BMP was applied 100% of the cropland within the modeled area. The remaining input data was provided by the EPA's STEPL Input Data Server. Table 13 outlines the data inputs used within STEPL for the Spring Creek watershed; note that the water and 'other' land use categories were not used within the modeling (accounting for ~6% of the total land area). All other values were left as defaults.

The STEPL model predicts that 40,730 lbs of phosphorus are exported form the Spring Creek Watershed each year, with 32,980 lb/yr from cropland (81%). Applying the average BMP efficiency to *all* cropland results in a reduction of 24,694 lb/yr. This translates to a reduction of 1.7 lbs/acre of cropland. This value was applied to all cropland areas within the Rural CSAs as the high-end-estimate for potential phosphorus reductions resulting from soft BMP implementation.

For planning purposes, an average of the SnapPlus and STEPL reductions (lb/acre) may be most appropriate. This average load reduction is 1.0 lb/acre. Furthermore, since not all soft practices will be implemented across all acreage and with all potential landowners, a 50% participation rate is assumed for soft practices.

Table 13: STEPL data inputs for the HUC 12 Spring Creek Watershed (#070700050204)

Land Use (acres)				
Urban	Cropland	Pasture	Forest	Feedlot
2188	14555	6232	5297	3

Agricultural Animals	
Dairy Cattle	# of Months Manure Applied
1914	4

Septic Systems		
# of Septic Systems	Population per Septic System	Septic Failure Rate, %
413	2	0.96

Average soil hydrologic group (SHG)
B

The estimated load reductions for the rural CSAs are listed in Table 14. Cost estimates for soft practices were assumed to be $60/lb. This value will change, but is considered to be an acceptable cost estimate for soft practice implementation, including potential technical assistance costs.

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Table 14: Estimated load reductions and costs from soft practices on rural CSAs.

Critical Source Area	*Cropland in Action Area (ac)*	*Load Reductions using SnapPlus Estimate (lb/yr)*	*Load Reductions using STEPL Estimate (lb/yr)*	*Average Anticipated Load Reduction (lb/yr)*	*Estimated Cost ($60/lb)*	*Implementation Timeframe*
1	52.8	16	90	53	$960 - $5400	Permit Term 2/3
2	176.8	53	301	177	$3180 - $18060	Permit Term 2/3
3	25.9	8	44	26	$480 - $2640	Permit Term 2/3
4	23.5	7	40	24	$420 - $2400	Permit Term 2/3
5	153.9	46	262	154	$2760 - $15720	Permit Term 2/3
6	168.1	50	286	168	$3000 - $17160	Permit Term 2/3
7	76.9	23	131	77	$1380 - $7860	Permit Term 2/3
8	93.8	28	160	94	$1680 - $9600	Permit Term 1
9	142.8	43	243	143	$2580 - $14580	Permit Term 2/3
10	212.7	64	362	213	$3840 - $21720	Permit Term 2/3
11	116.2	35	198	116	$2100 - $11880	Permit Term 2/3
12	32.5	10	55	33	$600 - $3300	Permit Term 1
13	65.3	20	111	65	$1200 - $6660	Permit Term 2/3
14	139.9	42	238	140	$2520 - $14280	Permit Term 1
15	123.7	37	210	124	$2220 - $12600	Permit Term 1
16	292.1	88	497	292	$5280 - $29820	Permit Term 1
TOTAL	***1,897.0***	***569***	***3,225***	***1,897***	***$34140 - $193500***	

Of the soft practices discussed above, one practice that has gained recent popularity is the concept of a harvestable buffer strip. A harvestable buffer consists of a buffer strip that is used to grow a perennial grass cover which can be harvested and utilized while maintaining the functionality and phosphorus reductions of grass buffer strips. Dane County Land and Water Conservation has implemented this program in the Yahara River and the Badfish Creek Watersheds within Dane County. Preliminary findings from Dane County indicate costs in the range of $22 per pound of phosphorus reduced. This is based

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upon 44 acres of buffer strip along roughly 8 miles of streambank, and an annual phosphorus reduction of roughly 1,000 pounds. Payments are roughly $500 / acre / year for landowners who sign 10 year agreements.

If a Buffer Program similar to this were implemented, the City would pay a rental fee, on a per-acre basis, for farmers to implement buffer strips in along critical areas adjacent to Spring Creek or tributaries thereof for a period of perhaps 5 or 10 years. Higher rental rates could be offered for 10 year agreements compared to 5-year agreements. The City could administer this program on their own, or perhaps in partnership with Dane and Columbia Counties. County technicians could recommend participation in the program when meeting with landowners and provide information pertaining to the program at the time of the visit. The goal for the program would be that critical areas could be easily identified, modeled for phosphorus reductions, Agreements signed, and buffers installed in a relatively straightforward manner. The buffers could be implemented throughout the CSAs, with multiple landowners and not just CSAs targeted for hard and/or soft practices.

While the development and implementation of a Harvestable Buffer Program is outside the scope of this Adaptive Management Plan, it is recommended that a buffer program be investigated and implemented (if feasible) during the early stages of Adaptive Management. **Figure 15** displays the results of a preliminary assessment for possible buffer locations. Existing elevation data (LiDAR) was used to generate a set of concentrated flow paths that drain 10 acres or greater. Concentrated flow paths within the non-marsh watershed were reviewed against the USDA-NRCS cropland data layer and against aerial imagery to determine if the flow path was cropped (or adjacent to cropland). These locations might be good candidates for a Harvestable Buffer Program.

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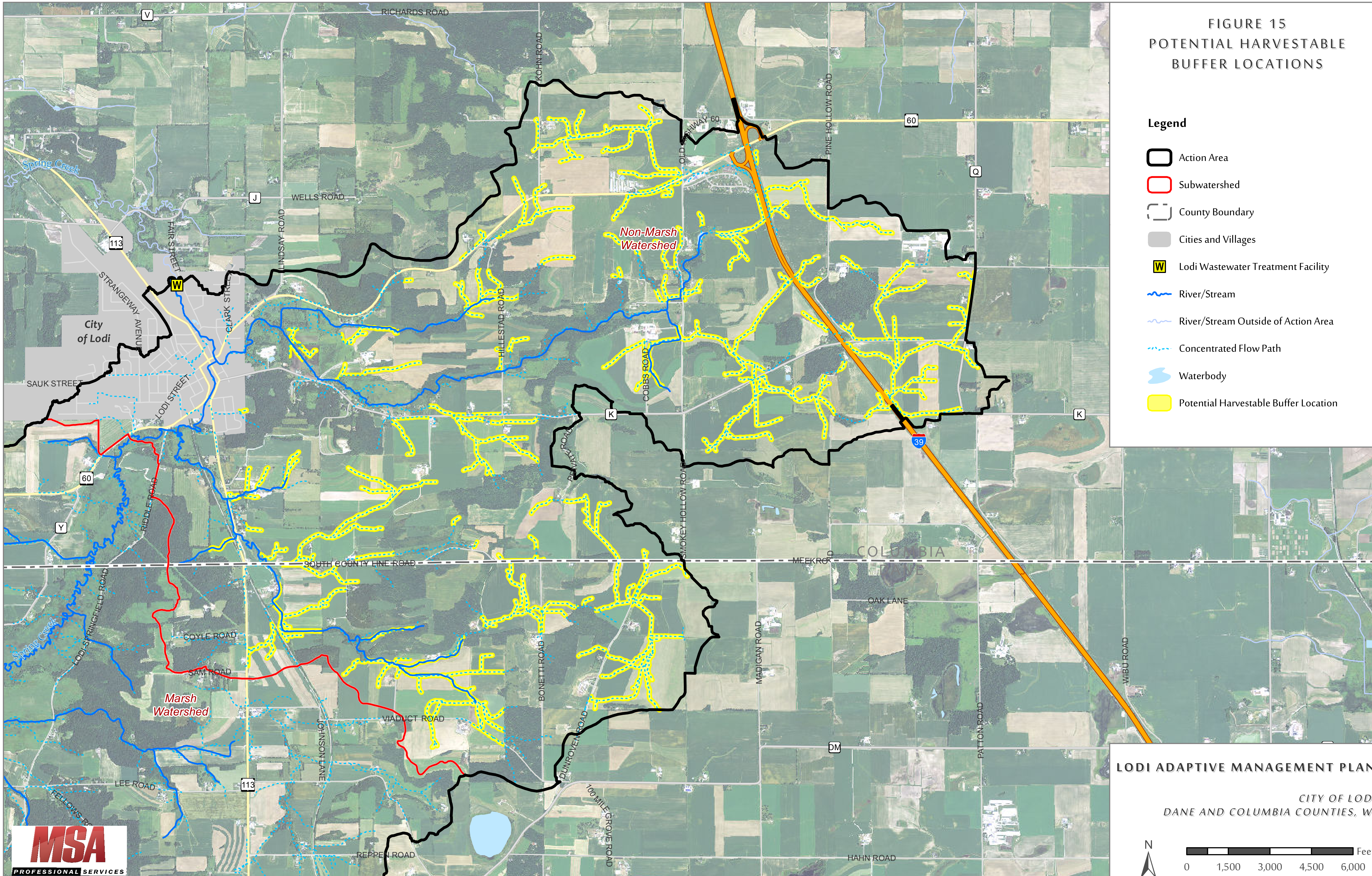

FIGURE 15
POTENTIAL HARVESTABLE
BUFFER LOCATIONS

6.2 LOAD REDUCTIONS IN URBAN AREAS

Based upon comparative cost effectiveness, urban CSAs are not anticipated to be implemented as part of this project. The average urban structural practices achieves phosphorus reductions at a cost of approximately $400/lb/yr as opposed to agricultural practices which cost approximately $50/lb/yr. Additionally, some of the low cost alternatives require conversion of existing park land to stormwater management practices, which are anticipated to be unacceptable to the public. Factoring in these social concerns make it even less likely that structural urban BMPs will be implemented.

However, the 2009 Spring Creek Watershed Study & Urban Stormwater Plan identified several soft practices that the City chose to undertake to improve the water quality of stormwater discharges. These included a modified street sweeping regime, leaf collection program, retrofits to road side swale drainage systems, and additional maintenance of existing storm sewer systems, including routine cleaning of storm sewer catch basins. These activities are in addition to the construction of EX4, a new urban rain garden that was constructed as a result of the 2009 Study. All of these efforts are a testament to the City's commitment to improving water quality within urbanized areas.

Although urban BMPs are not anticipated at this time, urban BMPs should be still be considered in the future. Due to uncertainties related to phosphorus fate and transport and legacy phosphorus in the Spring Creek Watershed, it is possible that the implementation of BMPs in rural CSAs will not result in significant water quality improvements for some time. It is recommended that urban BMPs be reevaluated in the future if the City has difficulty achieving the phosphorus water quality criterion of 0.075 mg/L in Spring Creek.

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CHAPTER 7 – MONITORING

It is necessary to monitor the water quality of Spring Creek in order to assess trends and monitor the effectiveness of the Adaptive Management Project. The City has developed a standard phosphorus monitoring program for collecting bi-weekly grab samples upstream and downstream of the WWTF outfall. Sampling began in May of 2015 and occurs every other Friday during the months of May through October. City staff collect grab samples from the portion of the stream with the greatest flow, 3-6 inches from below the water surface, using triple-rinsed sample bottles. Care is taken to not disturb the site or underlying sediment when collecting the samples. Stream samples are analyzed for total phosphorus, typically immediately after collection. Samples that need to be analyzed at a later date are adjusted to a pH of 2 or less with concentrated sulfuric acid and kept refrigerated at 43˚F or below prior to analysis. Laboratory analysis of the samples is completed at the Lodi WWTF, a Wisconsin DNR non-commercial certified laboratory. The stream sampling protocol and laboratory analysis methodology are summarized in Table 15. This monitoring strategy will be followed throughout the life of the Adaptive Management Project.

Table 15: Monitoring locations and phosphorus sampling methodology.

Monitoring Location					
Sample Point	Sample Point Description	Latitude	Longitude	Parameters to be collected	Sampling Frequency
1	Spring Creek, Upstream of the Lodi WWTF Outfall	43.320911	-89.531218	Total Phosphorus	Bi-weekly
2	Spring Creek, Downstream of the Lodi WWTF Outfall	43.321820	-89.531164	Total Phosphorus	Bi-weekly
Sampling methodology					
Who will collect the samples?	City of Lodi Wastewater Treatment Plant Staff				
Lab Information	Name:	Lodi Wastewater Treatment Plant			
	Lab ID:	111001770			
	Address:	130 South Main Street Lodi WI 53555			
Phosphorus Analysis	Methodology Used:	SM 4500 (5) and E 1999			
	LOD:	0.008 mg/L			
	LOQ:	0.028 mg/L			

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In addition to the proposed bi-weekly sampling, a short term storm event sampling protocol was developed in 2015 to gage the water quality impact of storm loads on Spring Creek. A complete description of this effort is outlined in Appendix B and C. Storm event sampling in 2015 took place downstream of the WWTF and at the outlet of Lodi Marsh. Additional storm event monitoring will occur in 2016 and potentially in future years, if deemed necessary.

In the future, it is also recommended that the City of Lodi consider the installation of a permanent and automated monitoring station upstream of the wastewater treatment facility to measure streamflow in Spring Creek. To date, only limited streamflow information is available for Spring Creek. A permanent and automated monitoring station would allow the City to obtain accurate real-time stage and streamflow data. This information could be useful for developing phosphorus load reduction goals in the future and may be a helpful for determining the overall success of BMP implementation in the watershed. The preferred location of a future gaging station would be somewhere upstream of the wastewater treatment facility outfall and the Fair Street Bridge, which is located approximately 2,000 ft upstream of the outfall. There are no major inputs of runoff or streamflow between the wastewater treatment facility outfall and the Fair Street Bridge, making this an ideal location for a permanent monitoring station. The Fair Street Bridge or the pedestrian bridge, located approximately 1,500 ft upstream of the wastewater treatment outfall, would be potential advantageous locations to install a future permanent monitoring station. Often monitoring stations are installed near bridges to provide easy access to equipment. It is recommended that the Village consider the installation of a permanent streamflow monitoring station during the first permit term of the Adaptive Management Project.

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CHAPTER 8 – FINANCIAL SECURITY

The City of Lodi has evaluated the potential costs of Adaptive Management over the last three years. Specifically, both the Operations and Needs Review (MSA, November 2012) and the Preliminary Compliance Alternatives Plan (MSA, October 2014) contained evaluations and assessments of the potential cost for Adaptive Management.

Cost estimates to date were based solely upon the completion of Hard Practices at Livestock Sites and implementation of nutrient management planning for the majority of the action area. The costs of hard practices were obtained through the efforts of Columbia County Land and Water Conservation Department's 2014 Livestock Inventory. This AM Plan has taken the evaluation one step further, in that the Hard Practices have been further prioritized to include seven (7) livestock operation CSAs and also includes the costs and associated reductions resulting from soft practice implementation throughout the 16 CSAs within the AM Action Area.

Specific costs for implementing the AM Plan during the first two permit terms of AM are presented in Table 17 and Table 18 in Chapter 9. Based on these tables, the maximum estimated cost of implementing the AM Plan is approximately $777,000 in the first permit term and $100,000 in the second permit term. This assumes that all proposed improvements will be implemented on CSAs 7, 8, 9, 12, 14, 15, and 16 during the *first permit term*. These costs assume that barnyard improvements which are implemented in the first permit term will still be generating phosphorus reductions in the second permit term and that annual costs for implementing soft practices on crop fields will continue throughout both permit terms. Assuming the costs in each permit term can be spread equally over each year of the permit, the annual cost of implementing the AM Plan is approximately $155,000/year in the first permit term and $20,000/year in the second permit term.

The City of Lodi has the capacity to budget for the full costs of the AM Plan through the first two permit terms of AM. However, in order to reduce the financial risk of the proposed project, the City plans to leverage outside funding sources which could provide cost-share or matching funds for the project. Specifically, the City will be considering the use of funds from the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) and the Regional Conservation Partnership Program (RCPP). Additionally, the City may utilize funding from DNR's Targeted Runoff Management (TRM) Grant Program. Based on DNR's draft *Agricultural Nonpoint Source Implementation Handbook for Adaptive Management and Water Quality Trading WPDES Permit Compliance Options*, EQIP and RCPP funds can be used to fund improvements for AM projects with no restrictions. Conversely, funds from the TRM program can only be used for improvements above and beyond the WWTF's contributing load to the receiving water. Therefore, the City of Lodi cannot use TRM funds to meet the minimum phosphorus load reduction of 68 lb/yr during the first permit term of AM. Because of this requirement, TRM funds are only anticipated to be used for barnyard improvements during the first permit which are above and beyond the City's minimum reduction requirement of 68 lb/year. In order to mitigate the risk of using funds for ineligible AM projects, the City will keep record of which funding sources are used to fund each BMP that is implemented as part of the AM project.

Another factor which will improve the City's financial security throughout the AM project is that the City will be retiring debt service on a low interest Clean Water Fund loan in May 2016. Due to the retirement of this debt, the City should be able to provide funding for the AM project without having to increase

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existing sewer rates. However, BMP implementation will need to be thoughtfully staged so that, in any given year, funds are not exhausted.

The last item pertaining to financial security to the City is related to how BMPs will be implemented and how agreements will be created with landowners. In order to improve the probability that BMPs will reduce phosphorus loads to Spring Creek, the City will require that all agricultural conservation practices which are implemented as part of the AM project be designed, installed, and maintained according to applicable NRCS technical standards and specifications. In addition, all practices will be reviewed by the Columbia County Land & Water Conservation Department or Dane County Land and Water Resources Department prior to implementation. This will mitigate the risk of funding projects that do not meet current standards and will facilitate each County's ability to track landowner compliance with NR 151 agricultural performance standards and manure management prohibitions. The City or an agent of the City will also annually inspect BMPs to determine if the BMPs are present and appear to be performing as intended. Annual inspections will allow the City to identify deficient BMPs and determine if repairs may be needed. The results of annual inspections will be sent to Columbia County Land & Water Conservation Department or Dane County Land and Water Resources Department for review and concurrence with findings. Lastly, when the City creates legal agreements with landowners to provide funding for the implementation of BMPs, it is recommended that these agreements include language which would make the BMPs eligible for phosphorus credit generation under Water Quality Trading. Although the City currently has no plans to pursue Water Quality Trading in the short term, making agreements which could be transferrable to Water Quality Trading would allow the City to pursue trading in the event that the AM project is not successful in improving the water quality of Spring Creek.

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CHAPTER 9 – TIMING

The LAMP project is required to reduce at least 68 lb/yr within the first permit term. However, the preliminary target within the first permit term is 50% of the total required phosphorus reductions, 357 lb/yr. CSAs have been prioritized for both hard and soft practices during the first, second, and third permit terms, and discussions are underway to develop project-specific timelines. It is anticipated that conversations/collaboration with partners and landowners will be the primary focus of the first 1-2 years of the Adaptive Management project, and implementation of specific projects will begin in the second or third year. Table 16 outlines the minimum phosphorus load reduction goals throughout the first two permit terms of AM. This table assumes that 17% of the long term phosphorus reduction goal will be achieved in each year from Year 3 through Year 8. If the City follows the minimum goals of this timeline, the City will be able to achieve the 50% reduction goal of 357 lb/yr by the end of the first permit term and will be able to achieve the long term reduction goal of 714 lb/yr by the end of the second permit term.

Note, the best case scenario has a goal of completing improvements on CSAs 7, 8, 9, 12, 14, 15, and 16 during the *first permit term*. If this were to occur, using City, County, State, and Federal funds where applicable and available, the load reduction in the first permit term would be in the range of approximately 1000 lb/yr. For this scenario, hard practices would generate a reduction of 672 lb/yr, and soft practices would generate a reduction of 341 lb/yr. Again, this is a best case scenario and exceeds the long term reduction goal of 714 lb/yr, and well exceeds the recommended 50% load reduction of 357 lb/yr for the first permit term.

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Table 16: Estimated timing and load reductions within the first three permit terms.

		Total Load Reduction (lb/yr)	Fraction of Target Goal
Permit Term 1	Year 1	0	0%
	Year 2	0	0%
	Year 3	121	17%
	Year 4	243	34%
	Year 5	364	51%
Permit Term 2	Year 6	486	68%
	Year 7	607	85%
	Year 8	728	102%
	Year 9	*WQC achieved/water quality monitoring and/or additional improvements*	--
	Year 10	*WQC achieved/water quality monitoring and/or additional improvements*	--
Permit Term 3	Year 15	*WQC achieved/water quality monitoring and/or additional improvements*	--
	Year 16	*WQC achieved/water quality monitoring and/or additional improvements*	--
	Year 17	*WQC achieved/water quality monitoring and/or additional improvements*	--
	Year 18	*WQC achieved/water quality monitoring and/or additional improvements*	--
	Year 19	*WQC achieved/water quality monitoring and/or additional improvements*	--

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Tables 17 and 18, below, contain a summary of potential reductions and associated costs for the near term (Permit Term 1 under Adaptive Management), and could be used for budgetary planning. Note for hard practices, the costs are assumed to be spread out over the 5-year term of each permit. Once completed, hard practices are assumed to be "complete", and therefore would not require continued capital investment. Soft practices, however, are different. Soft practices are assumed to require annual expenditures for the life of Adaptive Management.

Table 17: Potential Hard Practice Implementation and Costs

Critical Source Area	*Implementation Window*	*Estimated Load Reduction (lb/yr)*	*Estimated Cost (high range + 20% Contingency)*	*Cost/year*
7,8,9	Permit Term 1 (2017 thru 2021)	672	$675,000	$135,000
Total Cost of Hard Practice CSA's planned			**$675,000**	

Table 18: Potential Soft Practice Implementation and Costs

Critical Source Area	*Implementation Window*	*Estimated Load Reduction (lb/yr)*	*Cost/year*
8,12,14,15,16	Permit Term 1 (2017 thru 2021)	682	$40,927
Total Cost of Soft Practice CSA's Planned			**$40,927**
Total Cost of Soft Practice CSA's, Assuming 50% Participation (341 lb/yr reduction)			**$20,463**

If the annual expenditures in Tables 17 and 18 for both hard practices and soft practices are summed, the total annual cost for the first 5-years of Adaptive Management would be approximately $155,000/year, for a total investment of $777,000 over the permit period. Moving forward into Permit Term two, the annual costs from hard practices completed during Permit Term 1 would no longer be present, but the soft practice annual cost of $20,463 would remain. If needed, additional hard practices as previously discussed (CSAs 4, 5, 10, and 14) could be considered for implementation, as could additional soft practices.

It is important note that portions of the costs outlined above would be eligible for some degree of cost-sharing through County, State, and Federal grant programs. Furthermore, front-loading the Adaptive Management efforts to achieve as much load reduction as possible during the first permit term provides the most flexibility to the City moving forward. Specifically, this provides the most time for the ecosystem to respond to the reduced phosphorus loading, and would increase the likelihood of success by the end of the Third Permit Term.

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ACROYMNS

AM: Adaptive Management

BARNY: Wisconsin Barnyard Runoff Model

BMP: Best Management Practice

CSA: Critical Source Areas

DNR: Department of Natural Resources

EVAAL: Erosion Vulnerability Assessment for Agricultural Lands

HUC: Hydrologic Unit Code

LAMP: Lodi Adaptive Management Plan

LWCD: Land and Water Conservation Department

PRESTO: Pollutant Ratio Estimation Tool

SWIMS: Surface Water Integrated Monitoring System

TP: Total Phosphorus

TMDL: Total Maximum Daily Load

USDA-NRCS: United States Department of Agriculture – Natural Resources Conservation Service

WBIC: Water Body Identification Code

WinSLAMM: Windows Source Loading and Management Model

WQBEL: Water Quality-Based Effluent Limitation

WQT: Water Quality Trading

WWTF: Wastewater Treatment Facility

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MAP DATA SOURCES

City and Village Boundaries: Dane and Columbia Counties

County Boundaries: Dane and Columbia Counties

Crop Rotations: Created via DNR's EVAAL model, using USDA-NRCS Cropland Data Layers from 2009-13

Elevation: Dane and Columbia Counties

Exception Resource Waters: Wisconsin DNR

Floodplain: FEMA

HUC 12 Watershed Boundaries: Wisconsin DNR

Land Use: USDA-NRCS Cropland Data Layer 2014

Lodi Marsh Wildlife Area: Wisconsin DNR

Median Phosphorus Concentrations: Wisconsin DNR

Proposed Land Use: Dane and Columbia Counties. Considered approximate.

Rivers/Streams: USGS, National Hydrography Dataset

Roads: Dane and Columbia Counties

Soils (K Factor, Erodibility): USDA-NRCS, SSURGO Soils

Waterbodies: USGS, National Hydrography Dataset

Wetlands: Wisconsin DNR, derived from the Surface Water Data Viewer

Aerial Imagery: USDA- National Agriculture Imagery Program (NAIP) 2013

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Appendix A

Stream Rating Curve Development

APPENDIX A

Stream Rating Curve Development

1.1 INTRODUCTION

Monitoring of water levels in Spring Creek occurred at two locations – at the Lodi wastewater treatment facility (WWTF) and in the marsh just upstream of the City – as described elsewhere in this report. A mathematical function relating water depth to flow rate, known as a "rating curve" needed to be developed so that total flow quantities in the creek could be determined. The resulting flow rates were used to evaluate total phosphorous loading in the creek with LOADEST modeling. This modeling is further discussed in Appendix B.

1.2 METHODS

For both monitoring locations, a hydraulic model of the stream using the Army Corps of Engineers' software tool HEC-RAS was constructed, using available floodplain model data previously developed by WDNR/FEMA and augmented with additional channel survey data completed by MSA for the Adaptive Management Plan and with terrain data available from the County. Actual stream flow was measured at each monitoring site at several representative water depths using a velocity meter. Results from the field measurements were compared with results from the hydraulic model; initial model runs produced higher stream flow rates for a given depth than were observed in the field. To rectify differences between modeled flow rates and measured flow rates, the channel roughness coefficient (Manning's 'n') was iteratively adjusted until a reasonable match between measurements and model results was achieved. For the WWTF location, the channel Manning's n was set to 0.120; for the marsh, the channel Manning's n was set to 0.090.

At the monitored locations, a transducer recorded flow depths on a continuous basis. Based on the surveyed elevation of the transducer and of the stream bottom at the monitoring site, flow elevations from the model were converted to flow depths. Thus, a relationship between modeled water elevation, measured flow depth, and modeled stream flow was established.

1.3 RESULTS

Water elevations, water depths, and stream flow as discussed above were tabulated, and a best-fit line based on a log-log relationship between depth and flow rate was determined. Because stream flow characteristics for high (out-of-bank) flows are markedly different than low (in-bank) flows, a piecewise function was chosen to represent the relationship between flow and depth. The data used to develop the rating curves are presented in the tables and figures below, and the resulting functions are published at the end of this Appendix.

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Table A-1: Summary of modeled flow-to-depth tabular data used to develop rating curve function for WWTF location.

Flow (CFS)	Water Elevation (NAVD 88 Datum)	Transducer Reading (feet)	Water Depth (feet)
0	797.21	-1.33	0
15	799.75	1.21	2.54
30	800.44	1.9	3.23
60	801.49	2.95	4.28
90	801.89	3.35	4.68
150	803.06	4.52	5.85
240	803.8	5.26	6.59
360	804.32	5.78	7.11
480	804.63	6.09	7.42
600	804.79	6.25	7.58
750	805.03	6.49	7.82

Figure A-1: Best-fit line representation of rating curve function for WWTF location.

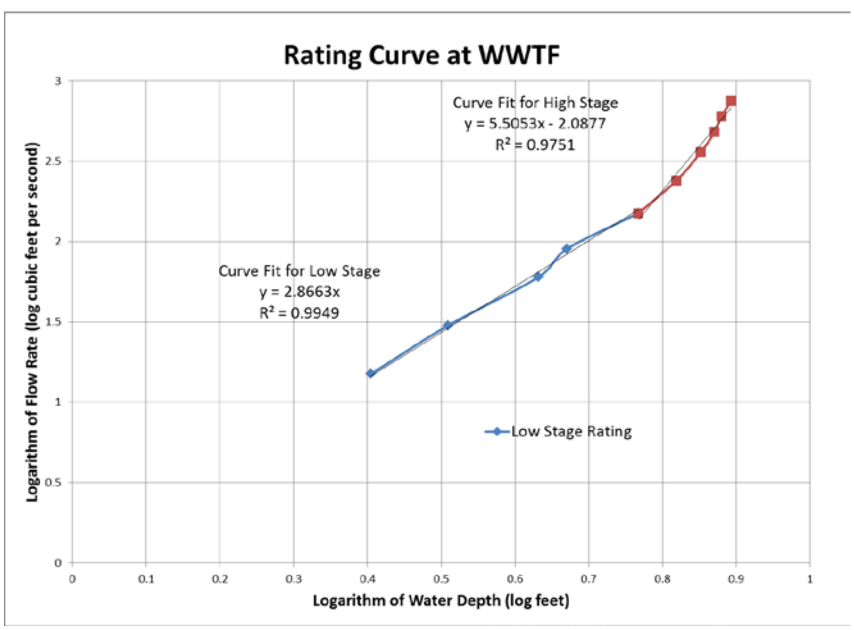

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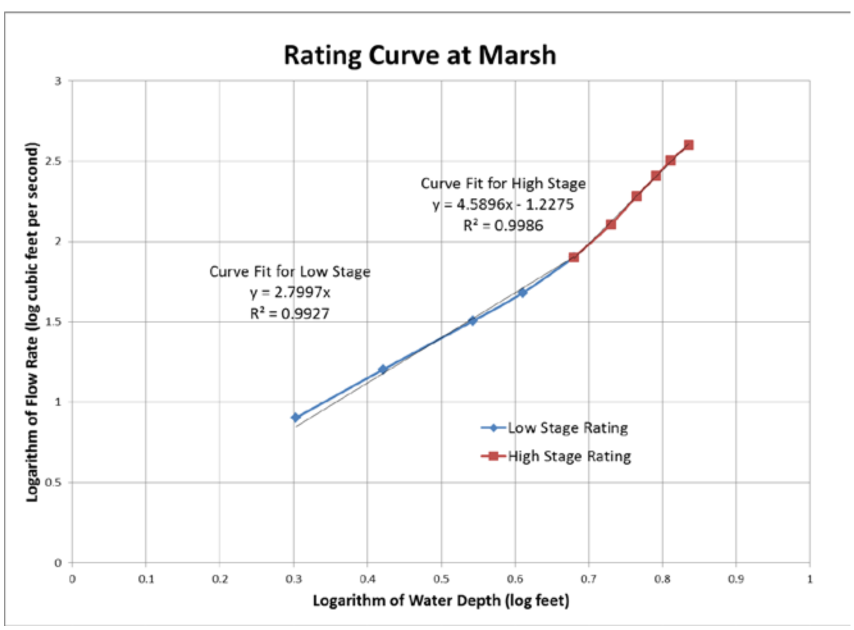
Table A-2: Summary of modeled flow-to-depth tabular data used to develop rating curve function for marsh location.

Flow (CFS)	Water Elevation (NAVD 88 Datum)	Transducer Reading (feet)	Water Depth (feet)
0	823.99	-0.56	0
8	826	1.45	2.01
16	826.63	2.08	2.64
32	827.48	2.93	3.49
48	828.07	3.52	4.08
80	828.78	4.23	4.79
128	829.36	4.81	5.37
192	829.81	5.26	5.82
256	830.18	5.63	6.19
320	830.46	5.91	6.47
400	830.84	6.29	6.85

Figure A-2: Best-fit line representation of rating curve function for marsh location.



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Resulting functions are as follows:

- T = transducer reading (feet)
- Q = stream flow rate (CFS)

Flow rate at WWTF:

- High flow (T>4.85): $Q = 0.00817 * (T+1.33)^{5.505}$
- Low flow (T<4.85): $Q = (T+1.33)^{2.866}$

Flow rate at Marsh:

- High flow (T>4.29): $Q = 0.0589 * (T+0.56)^{4.590}$
- Low flow (T<4.29): $Q = (T+0.56)^{2.800}$

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Appendix B

Storm Event Sampling Protocol Downstream of the WWTF outfall and LOADEST Modeling

APPENDIX B

Storm Event Sampling Protocol Downstream of the WWTF outfall and LOADEST Modeling

1.1 INTRODUCTION

As part of the Lodi Adaptive Management Project, it was necessary to develop a water quality sampling routine to develop a phosphorus load estimate under existing conditions. Adaptive Management guidelines require that samples are collected at the furthest downstream point of the Action Area. This sampling protocol is description in Chapter 7 of the Lodi Adaptive Management Plan. The rolling 28-day median of the grab samples taken upstream of the WWTF was used to determine the current phosphorous loading in Spring Creek and to set the load reduction goal of 714 lbs of phosphorus per year (Chapter 3.5).

However, it is likely that most of the bi-weekly grab samples will be taken during low-flow conditions. In watersheds with a flashy hydrology from high surface run-off, there is the potential that short duration storm events can account for a significant portion of the total phosphorus load (Cassidy and Jordan, 2011). Local knowledge from the treatment plant operators suggest that stream levels adjacent to the Wastewater Treatment Plant rise quickly during storm events, indicating that it might be a flashy system. Therefore, short term water quality monitoring efforts were developed to incorporate storm event sampling. These samples were not used in in developing the official load reduction goal. Instead, the storm event samples were used to set a higher, more conservative target for planning purposed only.

A regression model can be used to determine the relationship between measured phosphorus concentrations and flow rates. If the continuous flow is known for the location, the model would then predict the phosphorus concentrations for the duration of that time period. The relationship could be linear, or it could be non-linear. A series of other mathematical relationships are commonly used to correlate flow and nutrient concentrations. A regression model should be developed using both regular baseflow sampling (low flow) and storm event sampling (high flow) so as to capture a wide range of conditions.

The USGS developed a model called LOAD ESTimator (LOADEST) to estimate constituent loads in streams. The model incorporates a time series dataset for flow and constituent concentrations (e.g. phosphorus concentrations), and can use three different statistical estimation methods. A previous study (Haggard et al. 2003) used the LOADEST regression model to determine phosphorus loading on the Illinois River in Arkansas. The study had collected intensive phosphorus data over a two year period which would be used in LOADEST to determine phosphorus loads. The researchers then selected only a subset of their sampling data to run in LOADEST, simulating some more common sampling protocols, where intensive data collection was not feasible. The study recommended using a water quality sampling routine that incorporated a **15-day fixed interval grab sample, and nine storm samples taken from the top 25% of the storm hydrograph**. For their system, this resulted in the lowest root-mean-square-error (RMSE) of only 8%. Although the river system is not perfectly analogous to Spring Creek, this recommendation provided a good basis for developing a water quality sampling strategy for Spring Creek that could result in a more accurate phosphorus load prediction for the May-October sampling period.

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The purpose of this effort was to collect enough base flow and storm event samples to use within the LOADEST model to gain a better understanding of true phosphorus loads within the stream. This load would then be used to develop a more conservation phosphorus reduction goal for planning purposes only.

1.2 METHODS

The Lodi Wastewater Treatment Facilities are located adjacent to Spring Creek, and have the manpower and technical capabilities to collect grab samples from the stream, and analyze the samples in-house for total phosphorus. Bi-weekly samples were collected every 14 days (every other Friday at 8am) and immediately brought into the laboratory for analysis. Samples were collected both upstream and downstream of the Wastewater Treatment Plant outfall, following the protocol outlined in the Wisconsin DNR Adaptive Management Technical Handbook. Note that only the downstream samples were used in determining the total phosphorus loading for the Action Area using LOADEST.

An automated sampler (ISCO 6712, Full-Size Portable Sampler) was installed adjacent to the Wastewater Treatment Plant, downstream of the treatment plant outfall. The sampler was fitted with 24-1000 mL polypropylene sample bottles, and configured to take sequential 500-mL samples (not composite). It also recorded water-level depth (ISCO 720 Submerged Probe Module) and rainfall (ISCO 674 0.1 mm Tipping Bucket Rain Gauge) at one minute intervals. The continuous measurements of water level depth was used in a rating curve (developed with a hydrologic model) to determine stream flow (cfs). A description of rating curve development is outlined in Appendix A.

The sampler was installed in a shed inside of the Treatment Facility fence with power supplied by the Treatment Facility. The tipping bucket rain gage was installed on top of the Treatment Facility fence, away from trees or other overhead cover as required for proper installation (i.e. the height of the surrounding objects did not exceed twice their distance from the rain gauge). The submerged probe was placed in the center of the stream, resting on the stream bottom anchored to a stake. Small amounts of sediment accumulation on the probe does not affect the output readings for water level depth. However, any large debris was removed during site visits. The sample intake tube was anchored to the same stake in the center of the stream, several inches above the stream bottom. Any debris accumulating on the intake was removed during site visits. The sampler was programed the flush out the intake tube prior to each sample to remove any sediment that might have accumulated over time.

The automated sampler was set to trigger and collect a sample when the water level rose above 2.3 feet, indicating a storm event. This water level depth was originally set lower, but modified upon realizing that the stream exhibited a diurnal pattern in water level depth, cresting in the evenings and dropping during the day. The sampler was inadvertently triggered by the higher water levels at night, and therefore the trigger depth was increased. Since previous water level depth information for this site was not previously available, the trigger height was purposefully set low in order to collect as many storm event samples as possible during the initial data collection year. In the future, the sampling routine could be modified to only collect samples during larger rain events if desired.

Storms might have a higher phosphorus concentration during the rising limb of the hydrograph, but it could be lower on the falling limb. Therefore, a storm sampling regime was developed to capture samples along the course of the hydrograph to account for these differences. Once the sampler was triggered, a

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total of eight samples were collected: (1) upon the trigger, (2) at 15 minutes, (3) at 30 minutes, (4) at 1.5 hours, (5) at 2.5 hours, (6) at 3.5 hours, (7) at 5.5 hours, and (8) at 7.5 hours. Although each storm is different, it was clear that the hydrograph often peaked quickly, and the initial samples were collected at shorter intervals in an attempt to catch the rising limb. The timing intervals increased to capture the falling limb of the hydrograph or in case of a more prolonged storm event. This timing routine was developed after the 3rd storm event, once the team had adequate data to revise the protocol to match the characteristics exhibited during the initial sampling events.

All of the data was collected and stored on the ISCO sampler which is capable of saving 100 days of monitoring data. Regular site visits were necessary to download the data onto a laptop computer, and were analyzed using ISCO FlowLink Software.

1.3 SAMPLING RESULTS

The sampling equipment was installed on May 14th, 2015. The samplers were accidentally turned off for periods after the initial installation, and therefore only the data collected from May 19th –October 31st were used for estimating the phosphorus loading.

A power outage at the Treatment Facility occurred on June 24th due to a squirrel chewing through wiring. The sampler reset and was not noticed until July 7th resulting in a thirteen day gap in the water level depth record. No rain events occurred during this period, and therefore it was assumed that water levels remained relatively constant, and similar to the period immediately after the power outage. Since the LOADEST program requires a strictly complete dataset, without missing records, the day following the power outage was used as a proxy for this period. The water level depth appeared to have a slightly downward trend during this period, which is logical since the outage occurred during the warm summer months without a rain event. Therefore, this data replacement will be a slight underestimate the average streamflow during this period. Any other small gaps in the water level depth (totaling 23 minutes, with the longest break of 20 minutes) were filled with time period immediately following.

The water level depth measurements were converted to flow using a rating curve that was developed with a hydrologic model. A complete description of this effort is provided in Appendix A. The 1-minute flow measurements were then aggregated to an average daily flow, since the LOADEST model can only have up to 24 flow inputs per day (est file). However, the *actual flow associated with each water quality sample* was used in the LOADEST model for calibration (calib file).

For the May-October 2015 sampling period, a total of twelve (12) bi-weekly grab samples were collected and the sampler was triggered for eleven (11) storm events collecting a total of 90 samples. In additional, the sampler was purposefully triggered on a non-rain event period as a preliminary investigation to see if the diurnal pattern visible in the water level was associated with a change in phosphorus concentrations. More sampling and a detailed study is required to further investigate if phosphorus levels are tied to any diurnal cycling.

To determine those storm event samples that were collected within the top 25% of the hydrograph, each storm event was individually reviewed to determine the baseflow before the storm and flow at the hydrograph peak. Any sample collected within the top 25% of this range was flagged (21 of the 90 samples, from 9 of the 11 storm events). The remaining samples were in the lower 75% of the hydrograph.

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Therefore, two storm events did not have any representative samples within the top 25% of the hydrograph.

Finally, a large storm event occurred at the very beginning of the sampling period (May 26th), with water level depth recorded, but no phosphorus samples collected. On May 31st, the flow returned to baseflow conditions. It is important to gage the impact of this event, as it might not be representative of the average year. Unfortunately, no phosphorus samples were collected during the large event, and therefore any relationship developed between flow and phosphorus-concentration might not be appropriate. Because it occurred near the beginning of the sampling period, it was relatively easy to determine the average phosphorus load with and without this storm event for comparison purposes.

1.4 LOADEST MODELING RESULTS

Four different runs of LOADEST were completed to gage the impact of including/excluding data from the analysis:

May 19th - October 31st

a) Using the bi-weekly grab sampling (12) and **no** storm event sampling
b) Using the bi-weekly grab sampling (12) and all storm event sampling (90 samples, 11 storms)
c) Using the bi-weekly grab sampling (12) and storm event sampling from the top 25% of the hydrograph (21 samples, 9 storms)

May 31st - October 31st

d) Using the bi-weekly grab sampling (12), and storm event sampling from the top 25% of the hydrograph (21 samples, 9 storms), excluding a large storm event (May 26th – May30th) at the beginning of the sampling period.

Table 1 displays the outputs from the four different LOADEST outputs. The associated statistics (R^2, B_p, PLR, and E) describe how well the sampling data matches the statistical model. Another 'review tool' is to determine if the streamflow values used for estimation *exceed* the maximum streamflow used in calibration. If yes, the load estimates require extrapolation beyond the calibration dataset. Additional data collection during high flow events and modeling might be necessary.

While the model fit appears to be the best using just the bi-weekly grab samples (Routine a), all of the grab samples were collected at relatively low-flow and therefore the load estimate would require extrapolation to account for the higher-flow events. The model fit decreased when incorporating the storm events (Routine b). This was anticipated, since there is often more variability in concentrations within the storm samples. The model fit improved when only using the storm samples from the 25% of the hydrograph (Routine c). Finally, the model did not require extrapolation when the first large storm event was excluded (Routine d). Therefore, Routine d was selected as the best model fit for Spring Creek, and the initial storm sampling effort.

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Table 1: LOADEST model outputs for phosphorus sampling take downstream of the Lodi WWTF outfall.

LOADEST Routine		Time Period	Days in Time Period	Number of Grab Samples	Number of Storm Samples	Number of Storms Captured	Mean Flow (cfs)	Mean Phosphorus Load (kg/day)	Mean Phosphorus Concentration (mg/L)	R^2	B_p	PLR	E	Model Required Extrapolation
a	Bi-weekly grab sampling and no storm event sampling	May 19th - Oct 31st	166	12	0	0	37	6.49	0.072	0.94	-0.11	1.00	0.94	Yes
b	Using the bi-weekly grab sampling and all storm event sampling	May 19th - Oct 31st	166	12	90	11	37	12.84	0.142	0.65	-5.11	0.95	0.50	Yes
c	Bi-weekly grab sampling and storm event sampling from the top 25% of the hydrograph	May 19th - Oct 31st	166	12	21	9	37	13.83	0.153	0.85	-5.57	0.94	0.89	Yes
d	Bi-weekly grab sampling, storm event sampling from the top 25% of the hydrograph, beginning after a large storm event (May 26th-30th)	May 31th - Oct 31st	154	12	21	9	35	8.69	0.101	0.85	-5.57	0.94	0.89	No

R^2: Coefficient of determination. A value of 1 indicates a perfect model fit.

B_p: Load Bias in Percent. A positive (negative) value indicates over (under) estimation. Do not use model if exceeds 25%.

PLR: Partial Load Ratio. Summation of estimated loads divided by sum of observed load. Values > 1 indicate overestimation; values < 1 indicate underestimation. PLR = (Bp + 100) / 100

E: Nash Sutcliffe Efficiency Index: E ranges from -infinity to 1.0. E = 1; a perfect fit to observed data. E = 0; model estimates are as accurate as the mean of observed data. E < 0; the observed mean is a better estimate than the model estimates

Model Required Extrapolation: The maximum estimation data set streamflow exceeds the maximum calibration data set streamflow. Load estimates require extrapolation.

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The mean flow from Routine d was 35 cfs and the mean estimated phosphorus concentration was 0.101 mg/L. These values correspond to the sampling location *downstream* of the treatment plant outfall. While the WWTF contributions (both flow and phosphorus) varies over time, determining the exact loading for each day within the sampling period is outside of the scope of this project. Therefore, the current mean contributions from the treatment plant (0.46 cfs and 0.74 mg/L) can be subtracted from this model result to estimate the current loading *upstream* of the treatment plant. This results in an in-stream estimated concentration of 0.092 mg/L and flow of 34.5 cfs.

Using this revised stream loading, and the estimated WWTF loading in 2035, the reduction goal target becomes 1,646 lbs/yr. This value is not the official targeted reduction goal, but can be used as a more conservative goal for Adaptive Management planning. Table 2 outlines how this value was determined.

Table 2: Summary of conservative phosphorus load reduction needed based on bi-weekly grab sampling, 2015 storm event sampling, and estimated WWTF loading in 2035 under Adaptive Management.

	LOADEST Modeled Stream Flow and Concentration; WWTF at Predicted Flow in 2035
Stream Flow (MGD)	22.30
Stream Phosphorus Concentration (mg/L)	0.092
Stream Phosphorus Load (lb/yr)	6,245
WWTF Flow (MGD)	0.383
WWTF Phosphorus Concentration (mg/L)	0.5
WWTF Phosphorus Load (lb/yr)	583
Total Load (lb/yr)	6,827
Allowable Load (lb/yr)	5,178
Total Load reduction Needed (lb/yr)	1,649
WWTF % Contribution (%)	8.5%
Conservative Reduction Estimate (lb/yr)	**1,649**

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Appendix C

Storm Event Sampling Protocol near the outlet of Lodi Marsh and LOADEST Modeling

APPENDIX C

Storm Event Sampling Protocol near the outlet of Lodi Marsh and LOADEST Modeling

1.1 INTRODUCTION

The purposed of the Lodi Adaptive Management Project is to reduce phosphorus loadings in the watershed upstream of the Lodi Wastewater Treatment Facility (WWTF) in order to reach water quality goals. However in the process of developing the plan, it was recognized that the Lodi Marsh could be a large unknown variable in predicting the fate and transport component of any phosphorus reduction measurements that are installed upstream of the marsh. Wetland/marsh sites can be unpredictable to changes in water quality. If the water entering the marsh has reduced phosphorus levels, how will the marsh react? Will those water quality improvements be seen downstream of the marsh? Or will the marsh *release* phosphorous it was previously storing, effectively eliminating any water quality improvements further downstream at the WWTF? Understanding the nuances of the Lodi Marsh is beyond the scope of this project. Therefore, it was recommended that the majority of the water quality improvements take place with other regions of the Action Area watershed.

However, it is necessary to gage the relative contribution of phosphorus loading coming from the fraction of the watershed draining through the marsh (marsh subwatershed). If this region is contributing very large fraction of the total phosphorus load seen at the WWTF, there might not be enough phosphorus loading coming from other regions to make Adaptive Management feasible. If that was the case, the Lodi WWTF might want to consider more carefully studying the marsh site, or pursue a different phosphorus compliance option. Therefore, a sampling protocol was developed to determine the relative phosphorus load coming out of the marsh subwatershed.

Storm sampling in tandem with regular grab sampling is a common method used to determine the total phosphorus load for a watershed. A storm-event sampling routine was developed downstream of the WWTF site in 2015 (Appendix B) and a total phosphorus load estimate was developed using the USGS model LOAD ESTimator (LOADEST). A similar sampling protocol was developed at a sample site near the outlet of the Lodi Marsh subwatershed in order to develop a comparable phosphorus load estimate from the Marsh. More detailed information about the selection of the LOADEST model is provided in Appendix B.

1.2 METHODS

An automated sampler (ISCO 6712, Full-Size Portable Sampler) was installed adjacent to Spring Creek, upstream of the Riddle Road bridge. This site was chosen because previous sampling efforts (2010-2012, site LS02) used this location, and therefore any data collected previously could be used to augment the 2015 sampling data. Permission was obtained from the Wisconsin DNR to install a temporary job size storage box to house the equipment, and to have the sample intake staked into the streambed for the duration of the sampling efforts. The sampler was fitted with 24-1000 mL polypropylene sample bottles, and configured to take sequential 500-mL samples (not composite). It also recorded water-level depth

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(ISCO 720 Submerged Probe Module) at one minute intervals. The continuous measurements of water level depth was used in a rating curve (developed with a hydrologic model) to determine stream flow (cfs). A description of rating curve development is outlined in Appendix A.

The sampler was locked (for security) inside of a metal job site storage box with power supplied by a 12-V battery. The submerged probe was placed in the center of the stream, resting on the stream bottom anchored to a stake. Small amounts of sediment accumulation on the probe does not affect the output readings for water level depth. However, any large debris was removed during site visits. The sample intake tube was anchored to the same stake in the center of the stream, several inches above the stream bottom. Any debris accumulating on the intake was removed during site visits. The sampler was programed the flush out the intake tube prior to each sample to remove any sediment that might have accumulated over time.

The automated sampler was set to trigger and collect a sample when the water level rose above 2.5 feet, indicating a storm event. This water level depth was originally set lower, but modified upon realizing that the stream exhibited a diurnal pattern in water level depth, cresting in the evenings and dropping during the day. The sampler was inadvertently triggered by the higher water levels at night, and therefore the trigger depth was increased. Since previous water level depth information for this site was not previously available, the trigger height was purposefully set low in order to collect as many storm event samples as possible during the initial data collection year. In the future, the sampling routine could be modified to only collect samples during larger rain events if desired.

Storms might have a higher phosphorus concentration during the rising limb of the hydrograph, but it could be lower on the falling limb. Therefore, a storm sampling regime was developed to capture samples along the course of the hydrograph to account for these differences. Once the sampler was triggered, a total of eight samples were collected: (1) upon the trigger, (2) at 15 minutes, (3) at 30 minutes, (4) at 1.5 hours, (5) at 2.5 hours, (6) at 3.5 hours, (7) at 5.5 hours, and (8) at 7.5 hours. Although each storm is different, it was clear that the hydrograph often peaked quickly, and the initial samples were collected at shorter intervals in an attempt to catch the rising limb. The timing intervals increased to capture the falling limb of the hydrograph or in case of a more prolonged storm event. This timing routine was developed after the 3rd storm event, once the team had adequate data to revise the protocol to match the characteristics exhibited during the initial sampling events.

All of the data was collected and stored on the ISCO sampler which is capable of saving 100 days of monitoring data. Regular site visits were necessary to download the data onto a laptop computer, and were analyzed using ISCO FlowLink Software.

1.3 SAMPLING RESULTS

The sampling equipment was installed on May 14th, 2015. The samplers were accidentally turned off for periods after the initial installation, and therefore only the data collected from May 19th –October 31st were used for estimating the phosphorus loading. The LOADEST program requires a strictly complete dataset, without missing records. Therefore, any small gaps in the water level depth were filled with time period immediately following.

The water level depth measurements were converted to flow using a rating curve that was developed with a hydrologic model. A complete description of this effort is provided in Appendix A. The 1-minute

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flow measurements were then aggregated to an average daily flow, since the LOADEST model can only have up to 24 flow inputs per day (est file). However, the *actual flow associated with each water quality sample* was used in the LOADEST model for calibration (calib file).

For the May-October 2015 sampling period, the sampler was triggered for five (5) storm events collecting a total of 39 samples. In additional, the sampler was triggered three times for a on a non-rain event period (one time purposefully) because of the diurnal pattern in water level depth. More sampling and a detailed study is required to further investigate if phosphorus levels are tied to any diurnal cycling.

At the WWTF site, only those samples collected within the top 25% of the storm hydrograph were included in the LOADEST modeling; see Appendix B for the rationale behind this decision. The same rational was applied to the Marsh site. To determine those storm event samples that were collected within the top 25% of the hydrograph, each storm event was individually reviewed to determine the baseflow before the storm and flow at the hydrograph peak. Any sample collected within the top 25% of this range was flagged (15 of the 39 samples, from 4 of the 5 storm events). The remaining samples were in the lower 75% of the hydrograph. Therefore, one storm event did not have any representative samples within the top 25% of the hydrograph.

Finally, a large storm event occurred at the very beginning of the sampling period (May 26th), with water level depth recorded, but no phosphorus samples collected. On May 31st, the flow returned to baseflow conditions. At the WWTF site, this large event was excluded from the LOADEST modeling; see Appendix B for the rationale behind this decision. The same rational was applied to the Marsh site, and therefore the LOADEST modeling only included the flow data collected between May 31st and October 31st.

No grab sampling at the Marsh site was collected in 2015. However, grab sampling was conducted in in 2010, 2011, and 2012 by other organizations (Columbia County LWD, UW Stevens Point, and Friends of Scenic Lodi Valley). These groups graciously shared their data with the Lodi Adaptive Management project, and measurements of both flow and phosphorus concentration could be used within the LOADEST model to provide a more realistic phosphorus load estimate. Of the data provided by these groups, there were 9 total grab samples taken within the May-October sampling period that also had an associated flow measurement (seven from 2011 and two from 2012). Additional grab sampling efforts can be included in the future to provide a more robust load estimate if needed.

1.4 LOADEST MODELING RESULTS

LOADEST was run several different ways, but ultimately the chosen method for the Marsh site followed the methodology selected at the WWTF site (Appendix B):

> *May 31st - October 31st*
> Using the historic grab sampling (9), and storm event sampling from the top 25% of the hydrograph (15 samples, 4 storms), excluding a large storm event (May 26th – May30th) at the beginning of the sampling period.

Table 1 displays the output from the LOADEST model. The associated statistics (R^2, B_p, PLR, and E) describe how well the sampling data matches the statistical model. Another 'review tool' is to determine if the

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streamflow values used for estimation *exceed* the maximum streamflow used in calibration. If yes, the load estimates require extrapolation beyond the calibration dataset. Additional data collection during high flow events and modeling might be necessary.

The mean flow during the sample period was 19 cfs and the mean estimated phosphorus concentration was 0.104 mg/L. It should be noted that the loading estimates required extrapolation, since the maximum daily flow exceeded the maximum streamflow within the calibration dataset. Therefore, more sampling data during high flow events might be required.

Assuming the flow and phosphorus concentrations are appropriate for the entire year, this translates to a load of 3,879 lb/yr coming from the Lodi Marsh watershed. This accounts for ~60% of the total phosphorus load estimated from the Action Area using the LOADEST model based on samples collected the WWTF (6,245 lbs/ year, Appendix B).

An alternative method for determining the relative phosphorus load from the Marsh would be to use grab samples. Upstream of the WWTF outfall, the rolling median (2011-2015) grab sample concentration was 0.078 mg/L with an average flow of 36.93 cfs; this equates to a total load of 5,668 lb/yr. At the Marsh site, the rolling median (2011-2012) grab samples phosphorus concentration 0.0585 mg/L and the average streamflow was 20.7 cfs; this equates to a load of 2,384 lb/year from the Marsh site. Based on this methodology, the marsh site contributes ~40% of the total load estimated from the Action Area. However, storm events can be a significant driver in phosphorous loading. Because of this, more confidence is given to the LOADEST modeling, which incorporated the storm event sampling.

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Table 1: LOADEST model outputs for phosphorus sampling taken at the Marsh Site, upstream of the Riddle Road bridge.

LOADEST Routine	Time Period	Days in Time Period	Number of Historic Grab Samples	Number of Storm Samples	Number of Storms Captured	Mean Flow (cfs)	Mean Phosphorus Load (kg/day)	Mean Phosphorus Concentration (mg/L)	R^2	B_p	PLR	E	Model Required Extrapolation
Historic grab sampling, storm event sampling from the top 25% of the hydrograph, beginning after a large storm event (May 26th-30th)	May 31st - Oct 31st	154	9	15	4	19	4.82	0.104	0.74	-2.02	0.98	0.53	Yes

R^2: Coefficient of determination. A value of 1 indicates a perfect model fit.

B_p: Load Bias in Percent. A positive (negative) value indicates over (under) estimation. Do not use model if exceeds 25%.

PLR: Partial Load Ratio. Summation of estimated loads divided by sum of observed load. Values > 1 indicate overestimation; values < 1 indicate underestimation. PLR = (Bp + 100) / 100

E: Nash Sutcliffe Efficiency Index: E ranges from -infinity to 1.0. E = 1; a perfect fit to observed data. E = 0; model estimates are as accurate as the mean of observed data. E < 0; the observed mean is a better estimate than the model estimates

Model Required Extrapolation: The maximum estimation data set streamflow exceeds the maximum calibration data set streamflow. Load estimates require extrapolation.

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Appendix D

EVAAL for the Lodi Adaptive Management Action Area

APPENDIX D

EVAAL for the Lodi Adaptive Management Action Area

1.1 INTRODUCTION

The Wisconsin DNR reissued the City's wastewater discharge permit in 2012. The new permit identified a future phosphorus limit of 0.075 mg/L on an annual average basis. As required by the DNR, the City began a process of evaluating how to comply with this new limit. The City could choose to: (a) Upgrade the physical treatment facilities to reduce the amount of phosphorus in the treated wastewater (point source reduction) or (b) Use a watershed approach to reduce the phosphorus inputs upstream of the treatment facilities (non-point source reduction). After evaluating both options, a watershed based approach was deemed more cost effective than upgrading the treatment facility, and therefore the City began a planning process looking at Adaptive Management. This method allows for cooperation between the City's Wastewater Treatment Plant (a point source) and non-point sources (e.g. urban stormwater, agricultural producers, developers, etc.) to meet water quality standards.

Adaptive Management allows point-sources to comply with permit requirements by working with nonpoint sources to reduce phosphorus loading to the stream. Nonpoint sources are "indirect, non-permitted sources of pollution, including excess phosphorus, to Wisconsin's waters. These can include agricultural runoff from barnyards, cropland, and feedlots. Runoff from non-permitted municipal separate storm sewer systems and construction sites disturbing less than one acre of land are examples of urban nonpoint sources." (WDNR, Adaptive Management Handbook). Adaptive Management has the end goal the stream (or river or lake) achieving the applicable water quality criterion. As a result, the DNR requires regular in-stream monitoring to show that upstream reductions in phosphorus loadings result in lower downstream phosphorus concentrations.

The City is considering both hard and soft practices for the Adaptive Management project. This entails working with the Columbia and Dane County Land and Water Conservation Departments, local landowners, and other partners to enact physical/structural improvements on barnyards (hard practices) as well as implementing alternate cropping and tillage practices in key locations where erosion is more likely to occur (soft practices). As part of the planning process, it is helpful to determine Critical Source Areas (CSAs), those areas that contribute a relatively higher proportion of phosphorus to the stream than other areas within the watershed. CSAs are both a source of phosphorus and also transport phosphorus into the receiving water (Spring Creek). Once identified, these locations can be prioritized for both hard and soft Best Management Practices (BMPs).

CSAs for hard practices were prioritized based on previous field investigations conducted by Columbia County. The Columbia County Land and Water Conservation Department Staff performed a comprehensive review of barnyards within the Spring Creek watershed, and identified areas where structural improvements could help reduce erosion and phosphorus loadings to nearby streams. More details on the prioritization of sites is documented within Chapter 5.1 of the Adaptive Management Plan. CSAs for soft practices were prioritized Wisconsin DNR's elevation-based model called Erosion Vulnerability Assessment for Agricultural Lands (EVAAL). The model highlights locations where soft practices, such as grassed waterways, might be most beneficial at reducing erosion and phosphorus

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loading. EVAAL uses LiDAR elevation data, soils information, land use, and other variables to help identify priority areas that are vulnerable to water erosion.

The following is a description of the methodology and results from the EVAAL modeling for the Lodi Adaptive Management Action Area. Soft practice CSAs were prioritized based on the outputs from the modeling exercise, a windshield survey, and local knowledge of the area. A complete description of the CSA prioritization is outlined in Chapter 5.1 of the Adaptive Management Plan

1.2 METHODS

The Wisconsin DNR publishes the EVAAL model as a series of Python computer scripts that are used within ESRI's ArcGIS Desktop software. The model estimates soil erosion vulnerability for sheet and rill erosion using the Universal Soil Loss Equation (USLE) and gully erosion using the Stream Power Index (SPI). Those regions that are not hydrologically connected to surface waters (internally drained areas) are identified and deprioritized within the model. The final output is a soil erosion vulnerability index that can be used to see regions within the Action Area that could be more prone to soil loss. As phosphorus typically binds to soil particles, it is assumed that loss of soil will likely coincide with a loss of phosphorus.

The model requires several basic input GIS datasets. Each input is described in Table 1 with the associated data source.

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Table 1: Description of EVAAL inputs and data source.

Dataset	**Description**	**Source**
LiDAR DEM	Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM): 3D representation of the terrain's surface collected using an aerial survey	Wisconsin View (Columbia and Dane Counties), 3-meter grid
Action Area/Watershed Boundary	Predefined area where erosion vulnerability is assessed	Delineated by MSA based on 2' contours, aerial imagery, and stormwater infrastructure.
gSSURGO Data	Gridded Soil Survey Geographic Database (gSSURGO): Soils data for the Action Area	USDA-NRCS
Culverts	Locations where concentrated flow/streams pass through culverts, typically perpendicular to roads	Located by MSA using aerial imagery and street view
Frequency-Duration Precipitation Data	Precipitation amounts for a given frequency and duration of storm event	Downloaded within the EVAAL model from the National Weather Service
National Cropland Data Layer (CDL)	Crop-specific land cover data, collected using satellite imagery and ground truthing	Downloaded within the EVAAL model from the National Agricultural Statistics Service (NASS)
Parcel (Zone) Boundaries	Parcel boundaries within the Action Area	Columbia and Dane Counties
Best Management Practices (BMPs)	*Existing Best Management Practices (BMPs) within the Action Area*	*Dataset not used within EVAAL modeling*

The EVAAL modeling followed the basic guidance given within the WDN's EVAAL Tutorial (v 1.0). The following is a brief description of the individual steps; for more a detailed, please review the WDNR's EVAAL documentation.

The LiDAR DEM was conditioned using the culvert dataset. Frequency-duration precipitation data was downloaded for a 10-year, 24-hour event. A curve number raster dataset was developed using 5-years of cropland data (2009-2013) and the gSSURGO (soils) database. The high-estimate for Curve Number was selected, assuming management practices that increase runoff. Combined, the conditioned DEM, precipitation data and curve number was used to determine the internally draining areas within the Action Area. The DEM was then re-conditioned using these internally draining areas. Next, the Stream Power Index (SPI) was generated using a flow accumulation threshold of 50,000 and the conditioned DEM. For use in the USLE, a K-factor

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dataset was determined based on the gSSURGO (soils). Also for use in the USLE, the C-factor was determined using 5-years of cropland data (2009-2013); the high-C-factor was selected assuming management practices that would enhance runoff. A USLE dataset was generated using the conditioned DEM, K-Factor and C-factor, and a flow accumulation threshold of 1000. A rainfall erosivity factor was not used. Finally, the Erosion Vulnerability Index was developed using the USLE dataset and SPI dataset, deprioritizing the internally draining areas. Parcel boundaries were used as the Zonal statistic field, as field boundaries for the entire Action Area were not available.

All of the existing BMPs within the Action Area were not known at the time of running the EVAAL model. Therefore, any regions that indicated a high level of erosion vulnerability needed to be individually reviewed using aerial imagery and a windshield survey. Many landowners have already established best management practices to field reduce soil loss. Therefore, all CSA locations selected for soft management BMPs were individually reviewed.

1.3 RESULTS

The EVAAL model produced an Erosion Vulnerability Index (EVI) for the Action Area ranging from -2.6 to 9.4. These values are relative, and therefore only appropriate for internal comparison between locations inside of the modeled Action Area. The average EVI was computed for all of the parcels in the Action Area, with values ranging from -2.6 to 3.8. Ideally, EVI values would be aggregated at the field-scale; however, field boundaries were not available at this time. EVAAL outputs were then used to prioritize locations for soft management practices, as outlined in Chapter 5.1 of the Adaptive Management Plan.

EVAAL outputs are best displayed graphically, and can be used for future planning purposes. Figures (1-7) contain the major inputs/outputs of the model. These include the Digital Elevation model with identified culverts, assumed crop rotations based on 2009-2013 cropland data layers, the identified internally draining areas, the stream power index grid, the Universal Soil Loss Equation (USLE) grid, the Erosion Vulnerability Index (EVI) and the average Erosion Vulnerability Index by parcel.

A series of cutoff criteria were developed to focus planning efforts within Action Area to CSAs. A full description of the selection process is provided in Chapter 5.1 of the Adaptive Management Plan. The major selection criteria for soft practices was as follows:

- **High EVAAL score**: The selected parcels had an average EVAAL rank of 1.25 or greater. These areas have a higher relative potential for erosion and associated phosphorus loading.
- **Larger Parcel Size**: Larger parcels are often better suited for soft management practices. For example, it might be challenging to operate large machinery around BMPs if the parcel is too small. The parcel cut off size was set at 10 acres.
- **Location within the Action Area**: Parcels that were not upstream of the Lodi Marsh were considered to be a higher priority since the fate and transport impact of the Marsh is unknown at this time.
- **Common Adjacent Landowner**: Often groups of parcels are owned or managed by the same landowner. If a specific parcel was identified by EVAAL using the above criteria, all of the adjacent parcels were reviewed to determine if there was a common landowner. If yes, these

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parcels were added to the CSA. Future planning efforts for BMPs will likely include all of the properties owned by an individual, to determine the best site for BMP installation.

- **Outside of Possible Future Development Areas**: Many of the BMPs will be located on agricultural lands. For the longevity of the Adaptive Management Project, it is important to consider how possible future development will impact the lifespan of any partnership with a specific landowner.

After the selection criteria was applied, all of the identified CSAs were individually reviewed using aerial imagery and a windshield survey to confirm that each location would be appropriate for soft practice implementation (Chapter 5.1 of the Adaptive Management Plan). Each location will be more carefully reviewed as he Adaptive Management Project progresses overall. The results of the EVAAL modeling can also be re-used in the future, if additional CSA locations need to be identified.

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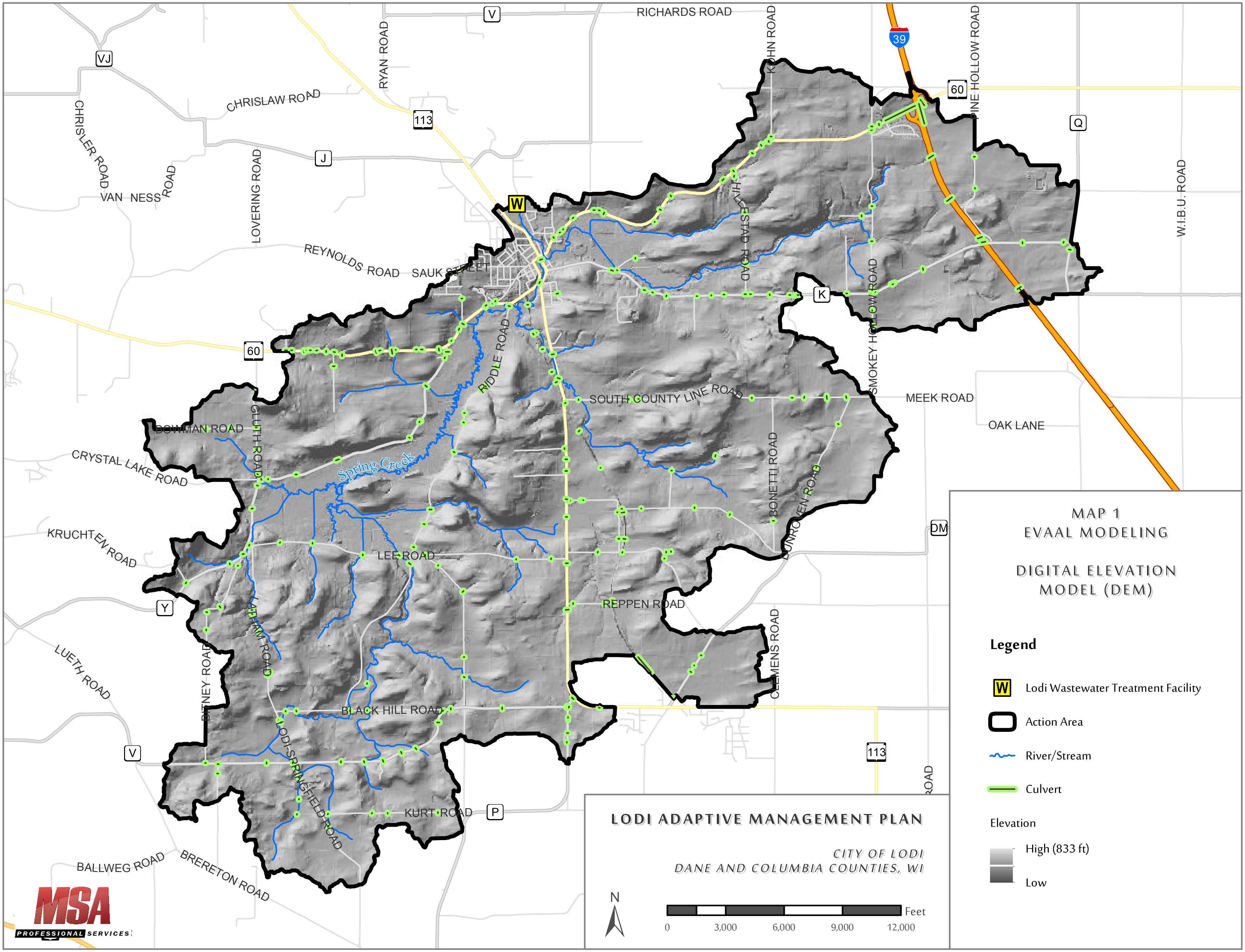
MAP 1
EVAAL MODELING
DIGITAL ELEVATION MODEL (DEM)
Legend
Lodi Wastewater Treatment Facility
Action Area
River/Stream
Culvert
Elevation
High (833 ft)
Low
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
0
3,000
6,000
9,000
12,000
Feet
RICHARDS ROAD
CHRISLAW ROAD
RYAN ROAD
KOHN ROAD
PINE HOLLOW ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
W.I.B.U. ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
GLUTH ROAD
CRYSTAL LAKE ROAD
Spring Creek
BONETTI ROAD
DUNROVEN ROAD
KRUCHTEN ROAD
LEE ROAD
REPPEN ROAD
LATHAM ROAD
LUETH ROAD
CLEMENS ROAD
BLACK HILL ROAD
LODI-SPRINGFIELD ROAD
KURT ROAD
BALLWEG ROAD
BRERETON ROAD
V
VJ
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113
60
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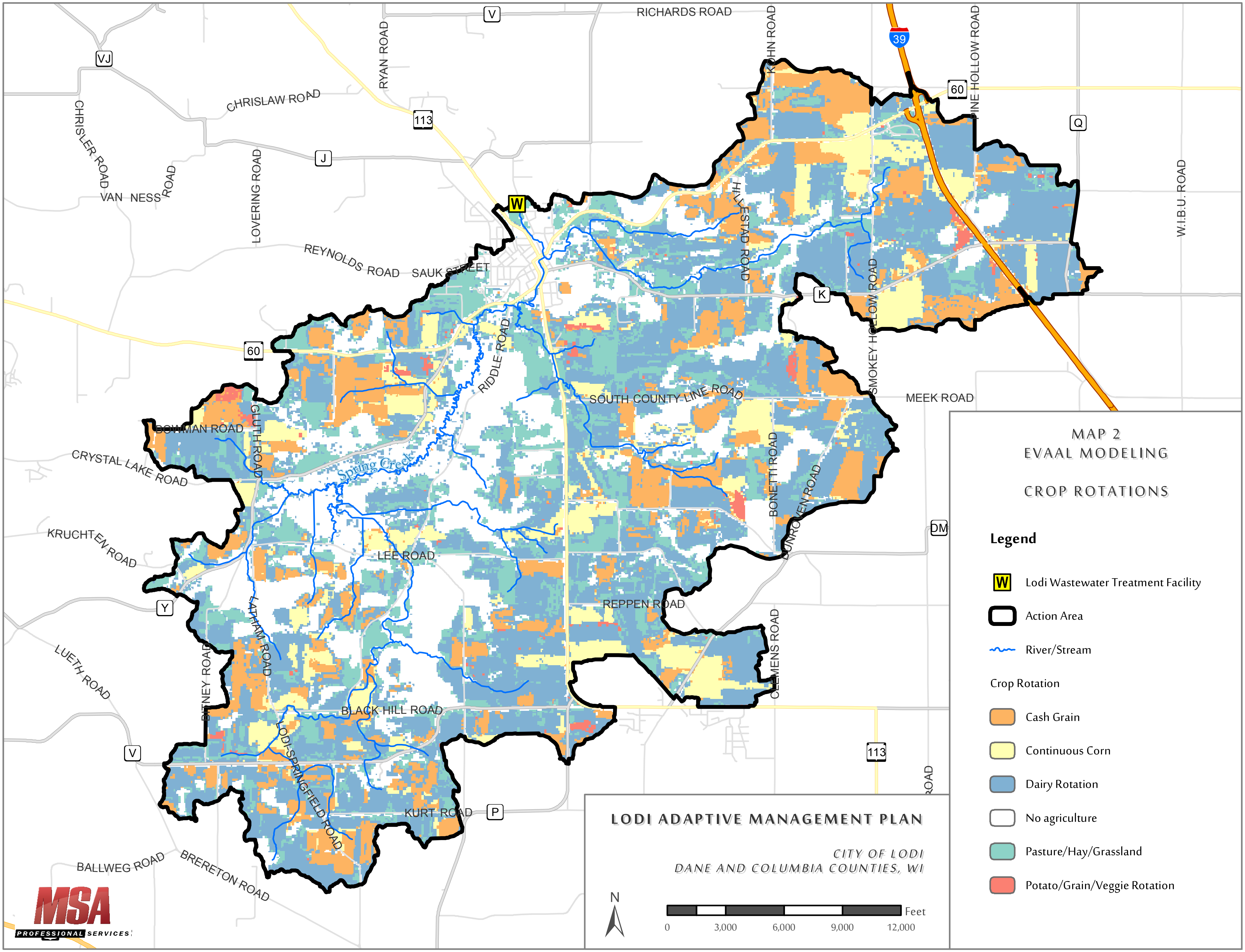
MAP 2
EVAAL MODELING
CROP ROTATIONS
Legend
Lodi Wastewater Treatment Facility
Action Area
River/Stream
Crop Rotation
Cash Grain
Continuous Corn
Dairy Rotation
No agriculture
Pasture/Hay/Grassland
Potato/Grain/Veggie Rotation
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0
3,000
6,000
9,000
12,000
RICHARDS ROAD
CHRISLAW ROAD
RYAN ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
BOWMAN ROAD
GLUTH ROAD
CRYSTAL LAKE ROAD
Spring Creek
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REPPEN ROAD
BONETTI ROAD
DUNROVEN ROAD
CLEMENS ROAD
SMOKEY HOLLOW ROAD
HILLESTAD ROAD
PINE HOLLOW ROAD
W.I.B.U. ROAD
LUETH ROAD
BLACK HILL ROAD
LODI-SPRINGFIELD ROAD
KURT ROAD
BALLWEG ROAD
BRERETON ROAD
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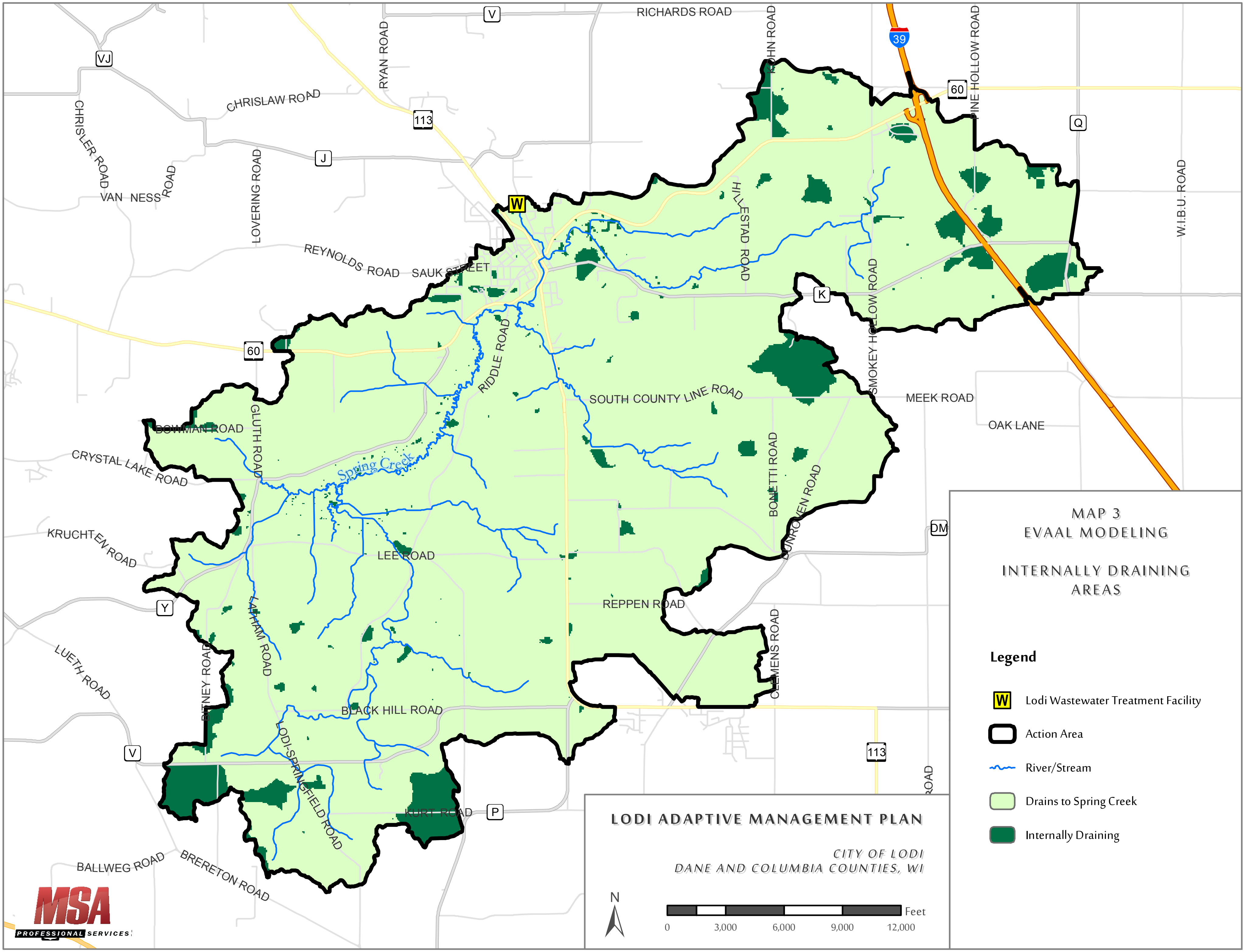

MAP 3
EVAAL MODELING
INTERNALLY DRAINING AREAS
Legend
Lodi Wastewater Treatment Facility
Action Area
River/Stream
Drains to Spring Creek
Internally Draining
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0
3,000
6,000
9,000
12,000
Spring Creek
RICHARDS ROAD
CHRISLAW ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
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GLUTH ROAD
CRYSTAL LAKE ROAD
KRUCHTEN ROAD
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LATHAM ROAD
LUETH ROAD
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KURT ROAD
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SMOKEY HOLLOW ROAD
PINE HOLLOW ROAD
W.I.B.U. ROAD
BONETTI ROAD
DUNROVEN ROAD
CLEMENS ROAD
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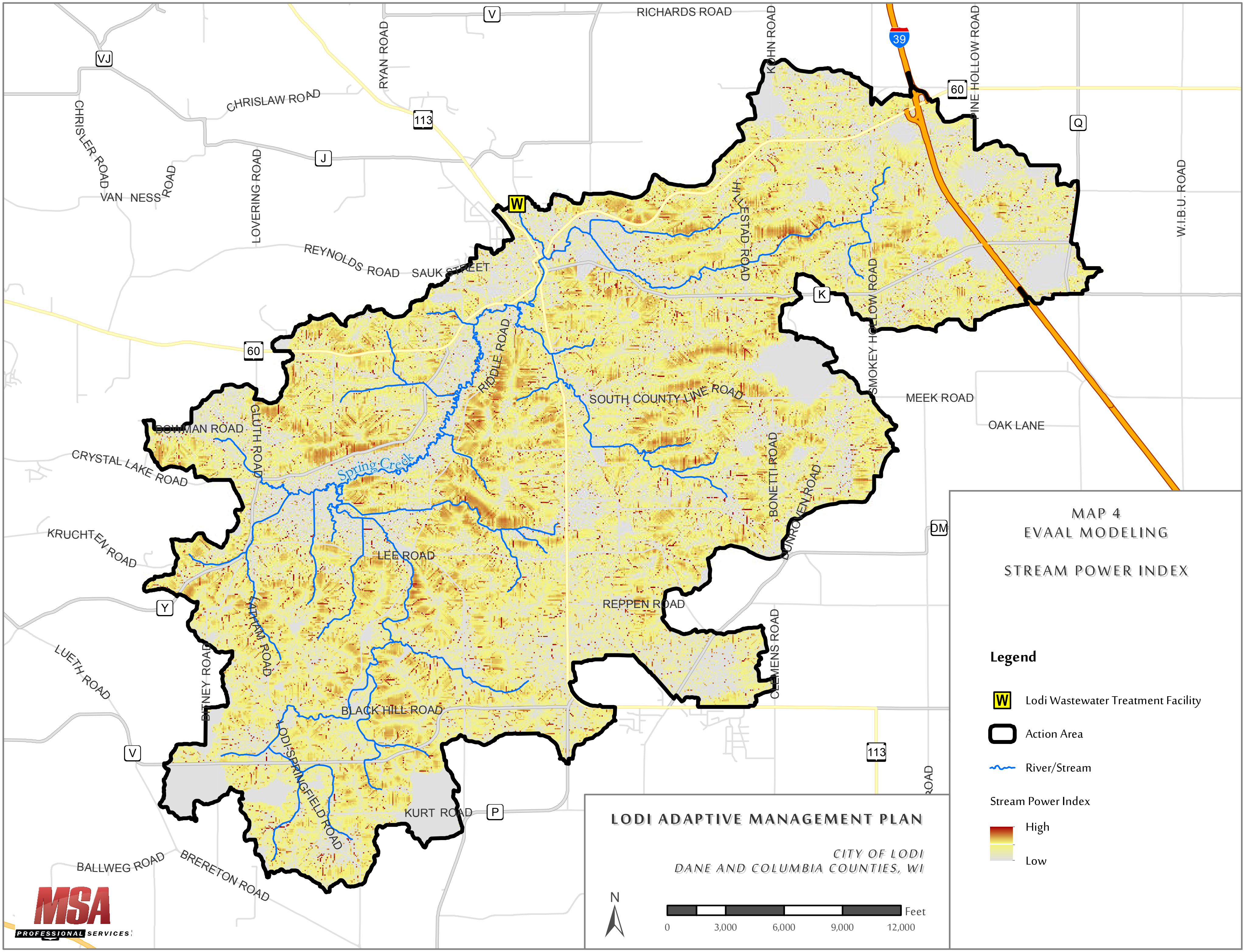
MAP 4
EVAAL MODELING
STREAM POWER INDEX
Legend
W Lodi Wastewater Treatment Facility
Action Area
River/Stream
Stream Power Index
High
Low
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
0
3,000
6,000
9,000
12,000
MSA
PROFESSIONAL SERVICES
RICHARDS ROAD
RYAN ROAD
KOHN ROAD
PINE HOLLOW ROAD
CHRISLAW ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
W.I.B.U. ROAD
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SOUTH COUNTY LINE ROAD
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CRYSTAL LAKE ROAD
Spring Creek
KRUCHTEN ROAD
LEE ROAD
BONETTI ROAD
DUNROVEN ROAD
REPPEN ROAD
CLEMENS ROAD
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BITNEY ROAD
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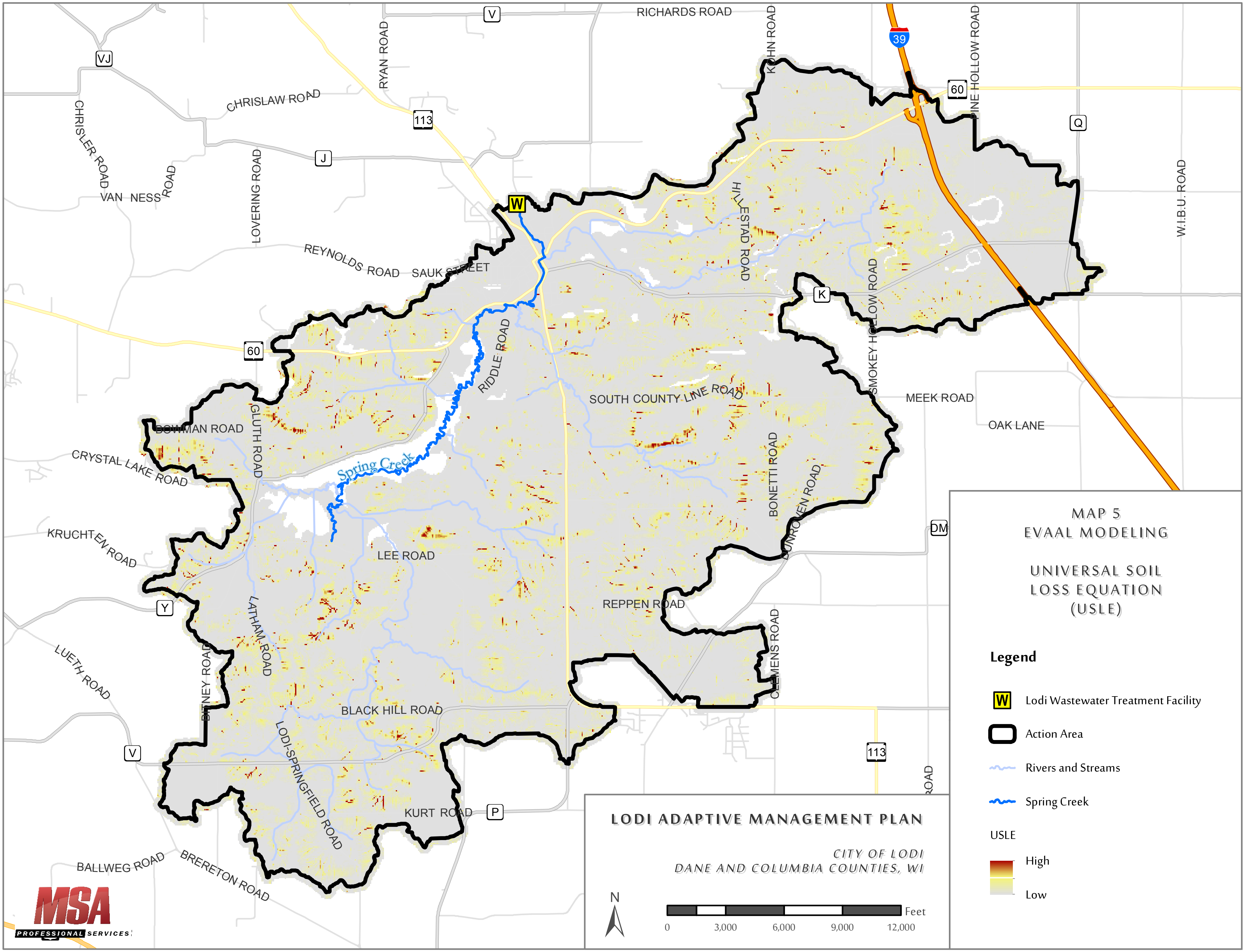
MAP 5
EVAAL MODELING
UNIVERSAL SOIL LOSS EQUATION (USLE)
Legend
Lodi Wastewater Treatment Facility
Action Area
Rivers and Streams
Spring Creek
USLE
High
Low
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
N
Feet
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3,000
6,000
9,000
12,000
MSA
PROFESSIONAL SERVICES
Spring Creek
RICHARDS ROAD
KOHN ROAD
PINE HOLLOW ROAD
RYAN ROAD
CHRISLAW ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
HILLESTAD ROAD
SMOKEY HOLLOW ROAD
W.I.B.U. ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
GLUTH ROAD
CRYSTAL LAKE ROAD
KRUCHTEN ROAD
LEE ROAD
BONETTI ROAD
DUNROVEN ROAD
REPPEN ROAD
LATHAM ROAD
LUETH ROAD
PITNEY ROAD
CLEMENS ROAD
BLACK HILL ROAD
LODI-SPRINGFIELD ROAD
KURT ROAD
BALLWEG ROAD
BRERETON ROAD
V
VJ
113
J
W
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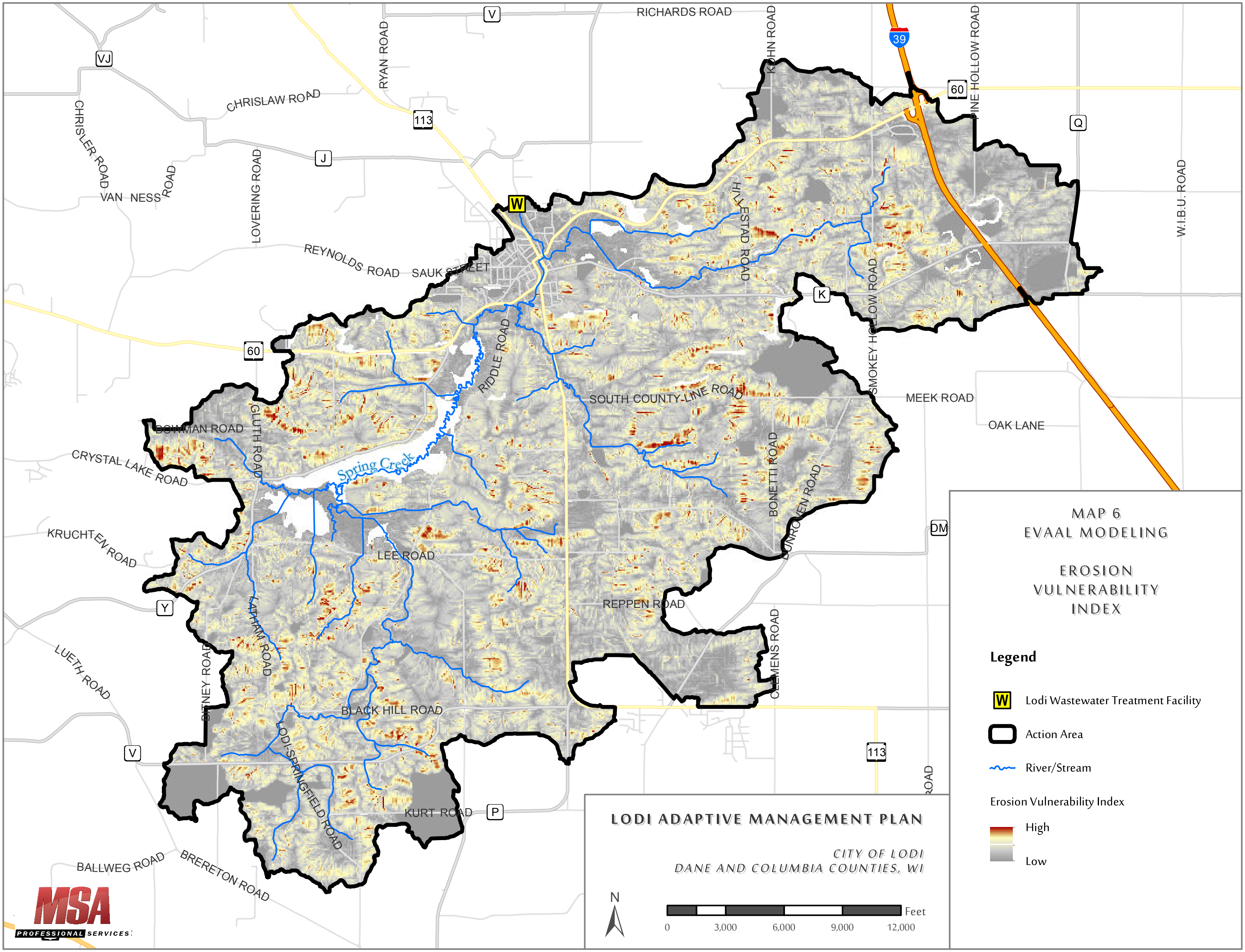
39
Q
K
DM
Y
P



MAP 6
EVAAL MODELING

EROSION VULNERABILITY INDEX

Legend

W Lodi Wastewater Treatment Facility

Action Area

River/Stream

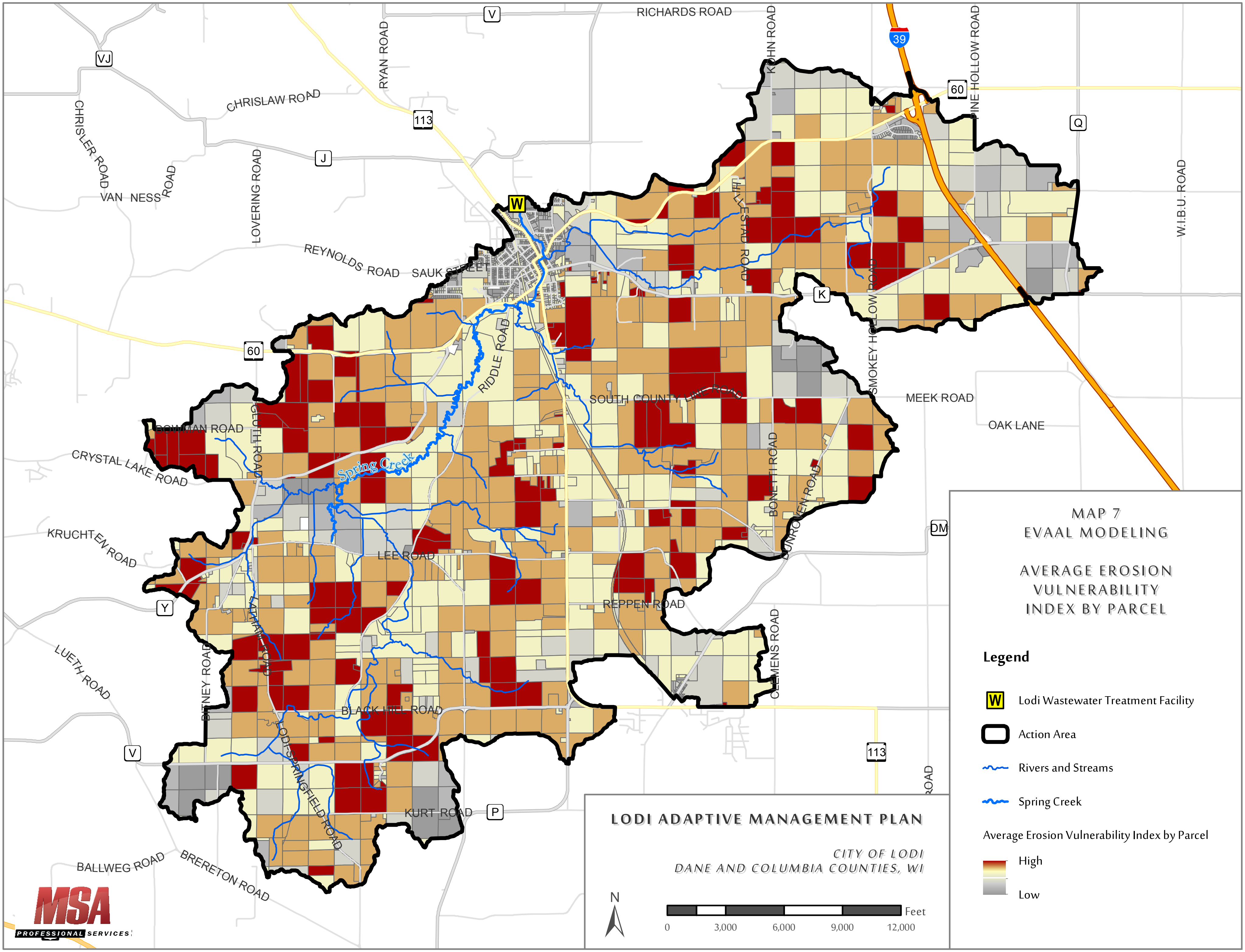
Erosion Vulnerability Index

High

Low

LODI ADAPTIVE MANAGEMENT PLAN

CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI


MAP 7
EVAAL MODELING
AVERAGE EROSION VULNERABILITY INDEX BY PARCEL
Legend
Lodi Wastewater Treatment Facility
Action Area
Rivers and Streams
Spring Creek
Average Erosion Vulnerability Index by Parcel
High
Low
LODI ADAPTIVE MANAGEMENT PLAN
CITY OF LODI
DANE AND COLUMBIA COUNTIES, WI
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3,000
6,000
9,000
12,000
MSA
PROFESSIONAL SERVICES
RICHARDS ROAD
RYAN ROAD
KOHN ROAD
PINE HOLLOW ROAD
CHRISLAW ROAD
CHRISLER ROAD
VAN NESS ROAD
LOVERING ROAD
REYNOLDS ROAD
SAUK STREET
W.I.B.U. ROAD
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SMOKEY HOLLOW ROAD
RIDDLE ROAD
SOUTH COUNTY LINE ROAD
MEEK ROAD
OAK LANE
BOWMAN ROAD
GLUTH ROAD
CRYSTAL LAKE ROAD
Spring Creek
BONETTI ROAD
DUNROVEN ROAD
KRUCHTEN ROAD
LEE ROAD
REPPEN ROAD
CLEMENS ROAD
LATHAM ROAD
PITNEY ROAD
LUETH ROAD
BLACK HILL ROAD
LODI-SPRINGFIELD ROAD
KURT ROAD
BALLWEG ROAD
BRERETON ROAD
V
VJ
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113
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Q
K
DM
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Appendix E

Spring Creek Watershed Pre & Post BARNY Livestock Assessments

2012 Results

Spring Creek Watershed Water Quality Report

February 2013

Prepared by M. Radske and N. Turyk

Center for Watershed Science and Education
College of Natural Resources
University of Wisconsin-Stevens Point

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Watershed Description

Spring Creek is located in south central Wisconsin on the border of Columbia County and Dane County. It flows northwest through the Lodi Marsh State Wildlife Area, into the City of Lodi, and empties into Lake Wisconsin (Figure 1). Spring Creek's headwaters and tributaries lie in an area with mixed land uses including forests, wetlands, and agriculture. Just below the confluence of the south and west branches of Spring Creek, Spring Creek flows through the City of Lodi and received the effluent from its wastewater treatment plant before in drains into Lake Wisconsin (Figure 3). The watershed draining to Spring Creek is approximately 28,813 acres.

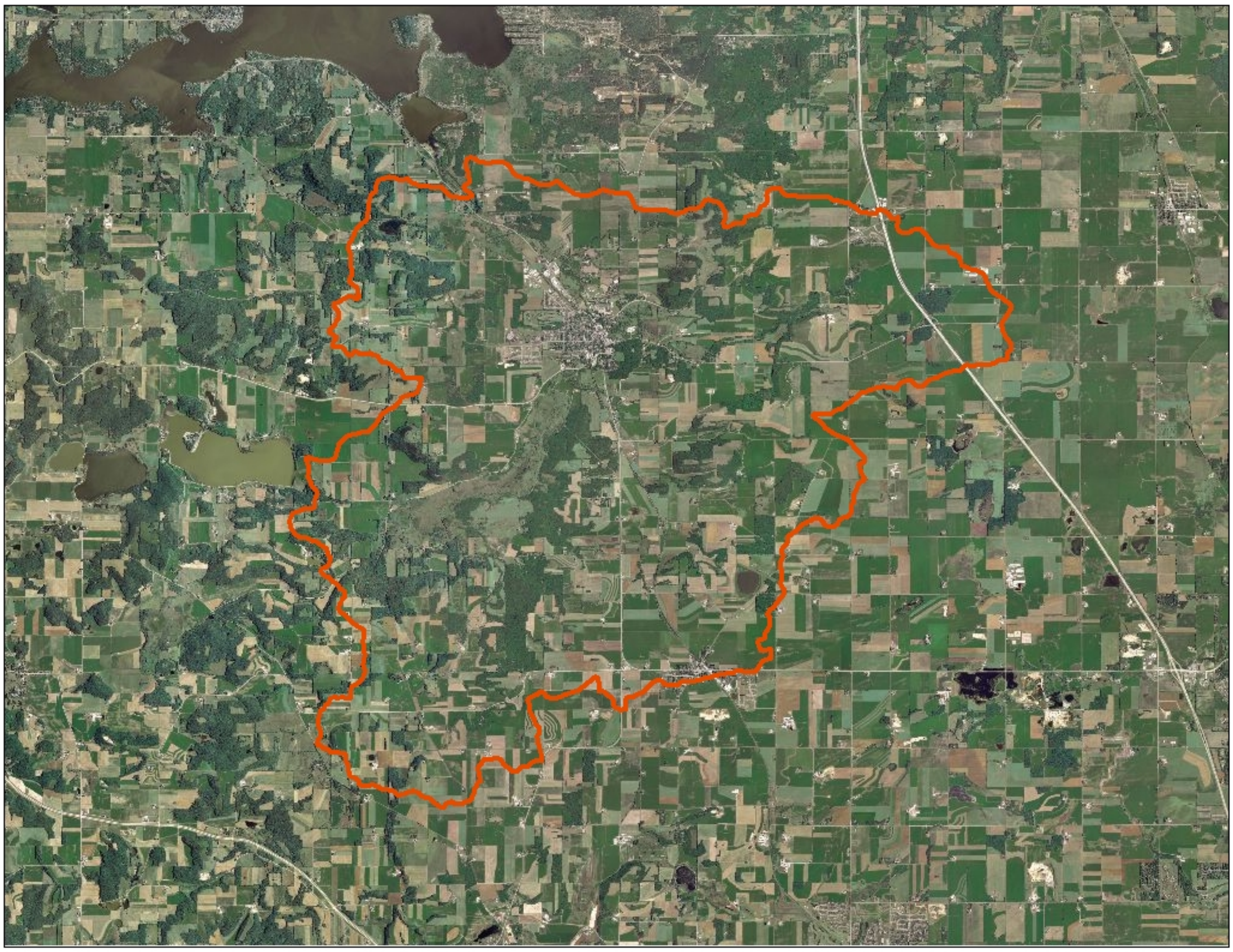

Figure 1. Ortho photo showing the watershed boundary for Spring Creek and its tributaries.

Project Description

This project was funded through a grant from the Wisconsin Department of Natural Resources (WI DNR) to conduct a water quality study of Spring Creek. It is a partnership between the Friends of the Scenic Lodi Valley (FSLV) the City of Lodi, Columbia County Land and Water Conservation Department (LWCD), the WI DNR, and University of Wisconsin-Stevens Point (UWSP). Five monitoring stations were chosen along Spring Creek and its tributaries to evaluate the water quality in Spring Creek (Figure 2). Descriptions of the locations for each sampling site can be found in Table 1.

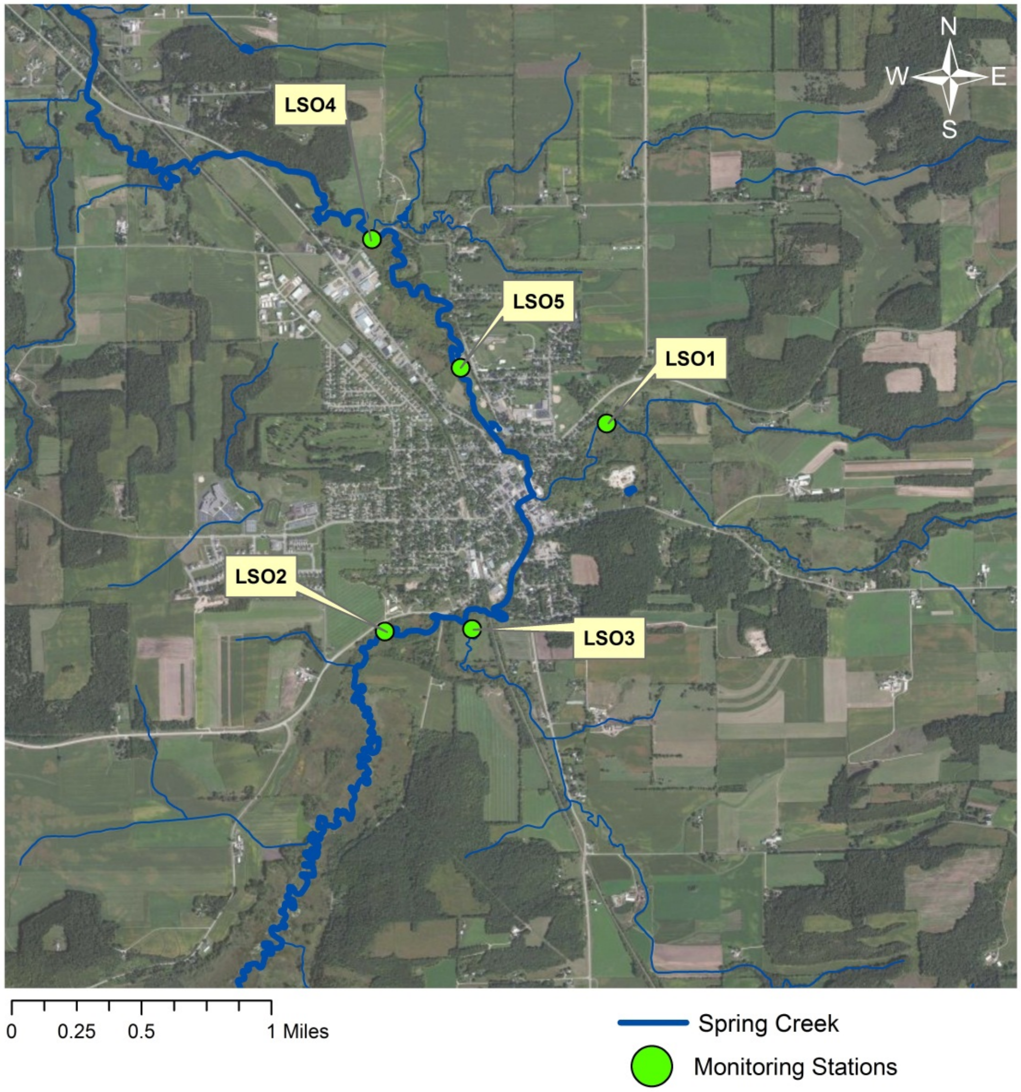

Figure 2. Map displaying the location of the Spring Creek project monitoring sites LS01-LS05.

Table 1. Site ID and description for monitoring sites in the Spring Creek watershed.

Monitoring Site ID	***Site Name***	***Site Description***
LS01	***Bohlman (East) Branch of Spring Creek***	Located south of STH 60 east of the city of Lodi.
LS02	***West Branch of Spring Creek***	Located in the Lodi Marsh State Wildlife Area, several hundred yards upstream of the bridge on Riddle Rd above the city of Lodi.
LS03	***South Branch of Spring Creek***	Located between Riddle Road and the railroad trestle just upstream of the confluence with the West Branch.
LS04	***Spring Creek at County Hwy J Bridge***	Located north of the city of Lodi and downstream of City of Lodi wastewater treatment plant.
LS05	***Spring Creek at Elizabeth Street***	Located upstream of the discharge from the City of Lodi wastewater treatment plant and downstream of all of the city's stormwater outfalls

Results and Discussion

Water Quality

During 2012, water quality samples were collected by grab method on a bi-weekly schedule at each of five monitoring sites beginning in March and ending in November. Samples were collected by staff from Columbia County LWCD and brought to UWSP's state certified Water and Environmental Analysis Lab (WEAL). Each water sample was analyzed for total suspended solids (TSS), total phosphorus (TP), soluble reactive phosphorus (SRP), total Kjeldahl nitrogen (TKN), nitrate (NO_2+NO_3-N), ammonium (NH_4), and chloride (Cl). Field parameters were also measured by Columbia County LWCD professionals at the time of sample collection including pH, specific conductance, dissolved oxygen, and temperature using an YSI multi-meter. Stream discharge was measured at each site with a Swoffer current velocity meter and corresponding staff gauge readings were recorded on the same date. During the sampling period, continuous flow and temperature were recorded with Solinst Level loggers at each site.

Total phosphorus (TP) is a primary focus of this study because of its role in the eutrophication in Spring Creek and Lake Wisconsin. Wisconsin's TP criteria for a wadable stream or river is a median concentration of 75 µg/L, in samples collected between May 1 and October 31 of each year (WI Administrative Code NR102.06). Median concentrations greater than 75 µg/L can contribute to changes in the aquatic ecosystem related to increases in algae and aquatic plant growth. In 2012, median TP concentrations at sites LS01, LS02, and LS05 were below 75 µg/L, LS04 was exactly 75 µg/L, and LS03 had a median TP concentration of 103 µg/L (Figure 3).

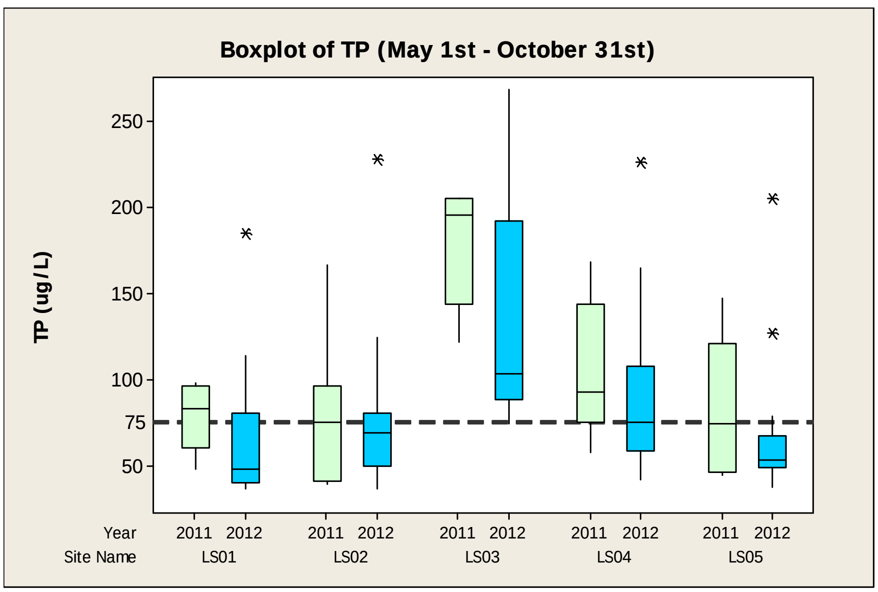

Figure 3: Boxplots showing total phosphorus (TP) concentrations in stream samples collected between May 1 and October 31 2011 and 2012.

Nitrate (NO_2+NO_3-N) comprised the greatest form of nitrogen in the stream samples. Inorganic forms of nitrogen exceeding 0.3 mg/L can result in increases in algae in lakes; however criteria does not exist for flowing water. During 2012, median nitrate concentrations ranged from 2.6 mg/L to 7.9 mg/L. LS03 had the greatest nitrate concentrations, ranging from 6.8 mg/L to 7.9 mg/L. Concentrations at LS02 demonstrate expected background concentrations for this part of the state.

During low flow (baseflow) conditions, stream water generally represents an average concentration of the groundwater in the sub-watershed discharging to that site. With this in mind, there is concern that some of the private drinking water wells may have concentrations that exceed state and federal drinking water standard of 10mg/L. Therefore, we encourage landowners in the LS01 and LS03 sub-watersheds to have their drinking water tested for NO_2+NO_3-N.

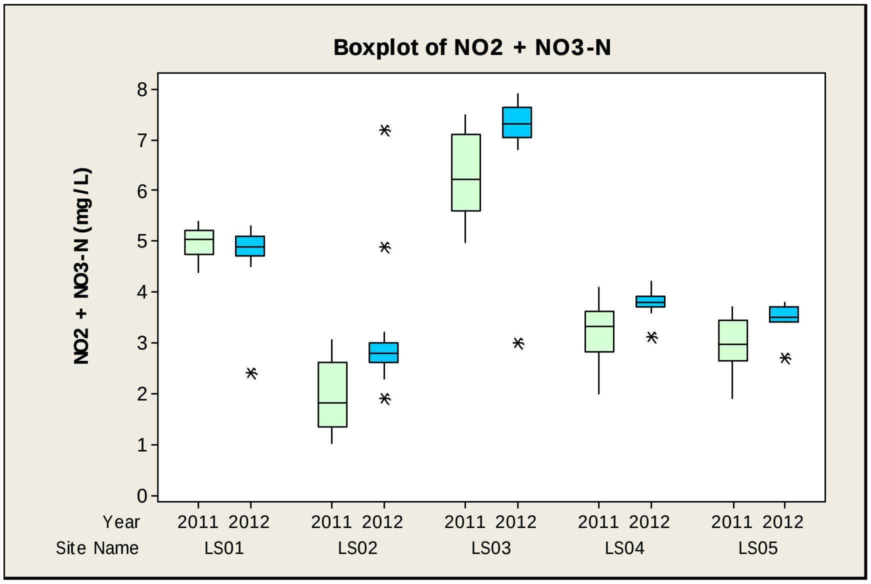

Figure 4: Boxplots of nitrate (NO2+NO3-N) concentrations in stream samples collected between May 1 and October31 2011 and 2012..

Total suspended solids (TSS) is a measure of sediment in suspension in water. Soil erosion and other particles moving to the stream from the landscape or re- suspension of in-stream sediment can result in elevated TSS within Spring Creek, especially following snowmelt or storms. Samples collected from sites LS02 and LS05 exhibited increased median TSS concentrations during 2012 compared to those measured during 2011. Samples collected from site LS03 consistently had higher concentrations of TSS than the other sites.

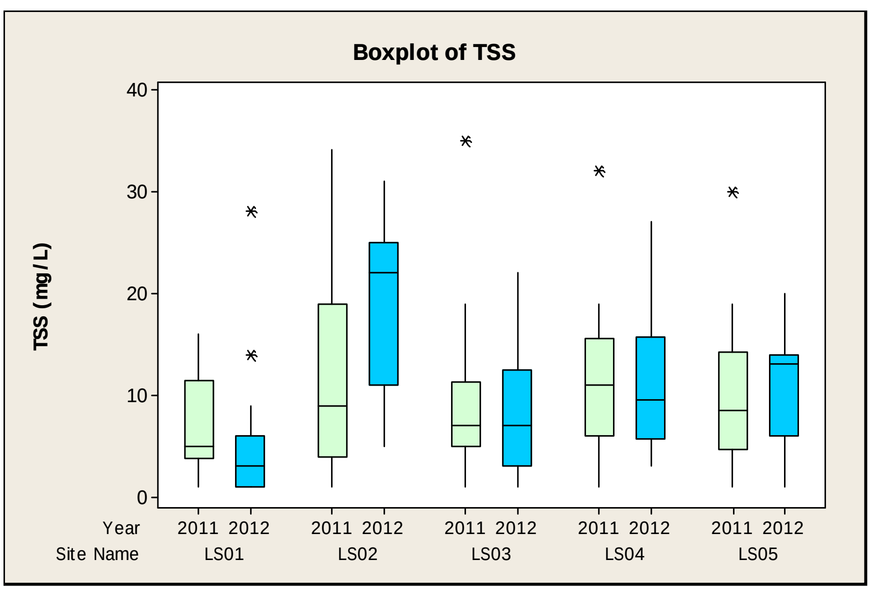

Figure 5: Boxplots showing total suspended solids (TSS) concentrations in stream samples collected between May 1 and October31 2011 and 2012.

In surface water, chloride (Cl) can be an indicator for human influence from land use practices in the watershed. In Wisconsin, background Cl concentrations are approximately 2mg/L. At sites LS01 and LS05, concentrations of Cl were greater during baseflow, suggesting that Cl is entering the streams via groundwater.

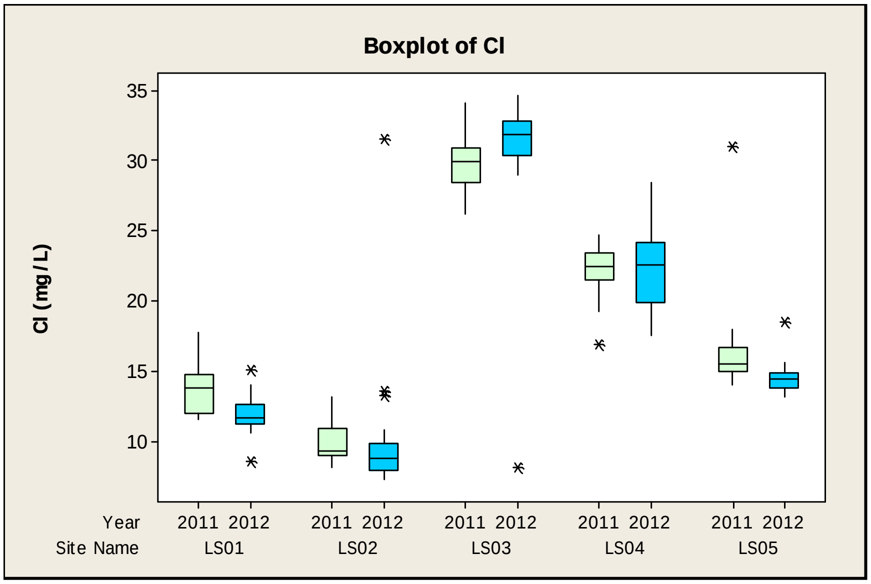

Figure 6: Boxplots showing chloride (Cl) concentrations in stream samples collected between May 1 and October31 2011 and 2012.

Discharge Measurements

At each monitoring location, staff gauges were installed along the river bank to measure water height throughout the sampling season. During this project, rating curves were developed by measuring discharge and recording staff gauge readings when sample sites were visited. In 2012, discharge was only measured when data was lacking for a particular water level. Discharge measurements began in 2010 by the WI DNR and citizen monitors. Professionals from Columbia County LWCD began measuring discharge in 2011. Different flow meters were used by the partners, do their data was displayed independently in the rating curves. Discharge measurements and rating curves are display in Figure 7, Figure 8, Figure 9, Figure 10, and Figure 11.

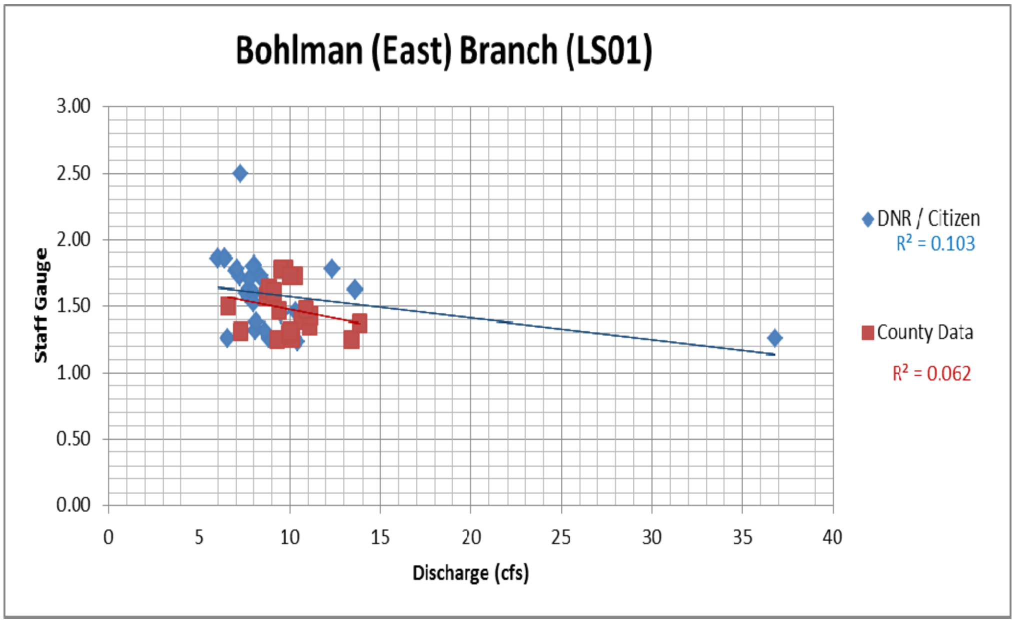

Figure 7. Rating curve for Spring Creek monitoring station LS01. (2010-2012)

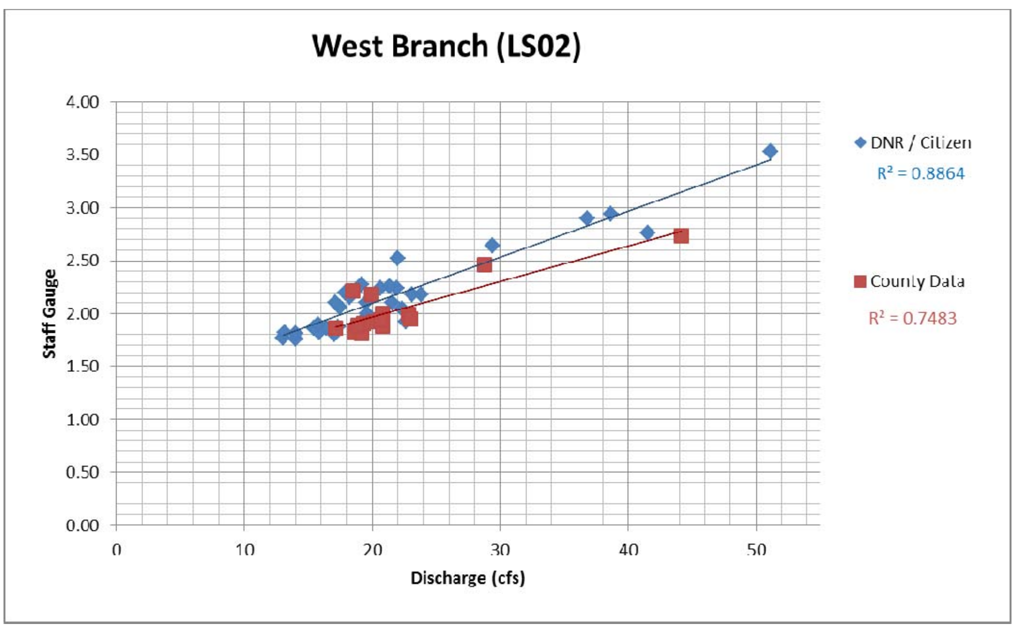

Figure 8. Rating curve for Spring Creek monitoring station LS02. (2010-2012)

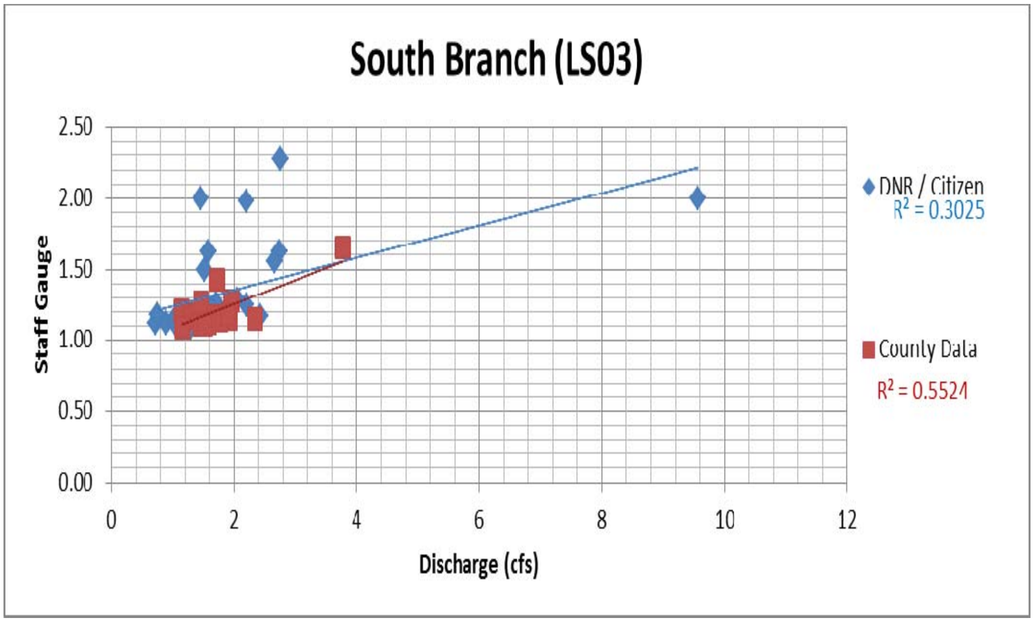

Figure 9: Rating curve for Spring Creek monitoring station LS03. (2010-2012)

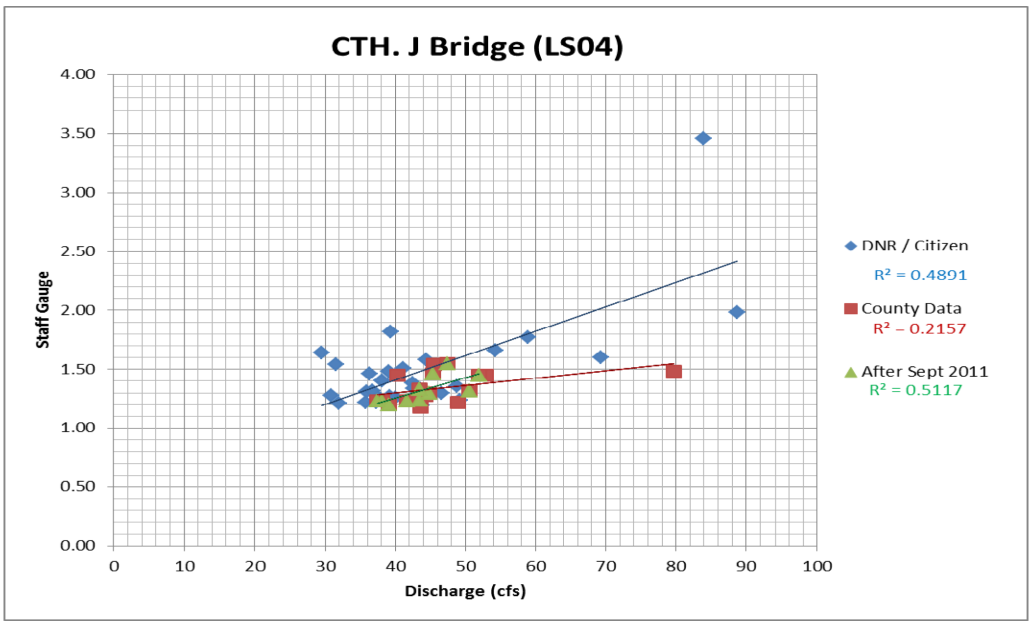

Figure 10: Rating curve for Spring Creek monitoring station LS04. (2010-2012) Columbia County's monitoring location was moved in to a different location in September 2011.

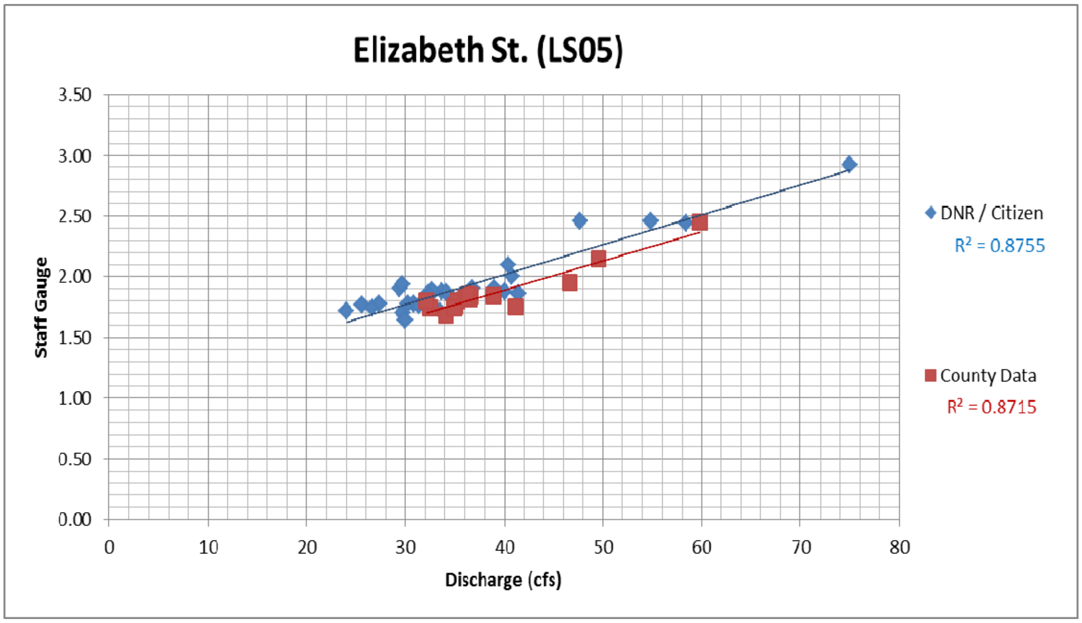

Figure 11. Rating curve for Spring Creek monitoring location LS05. (2010-2012)

Appendix

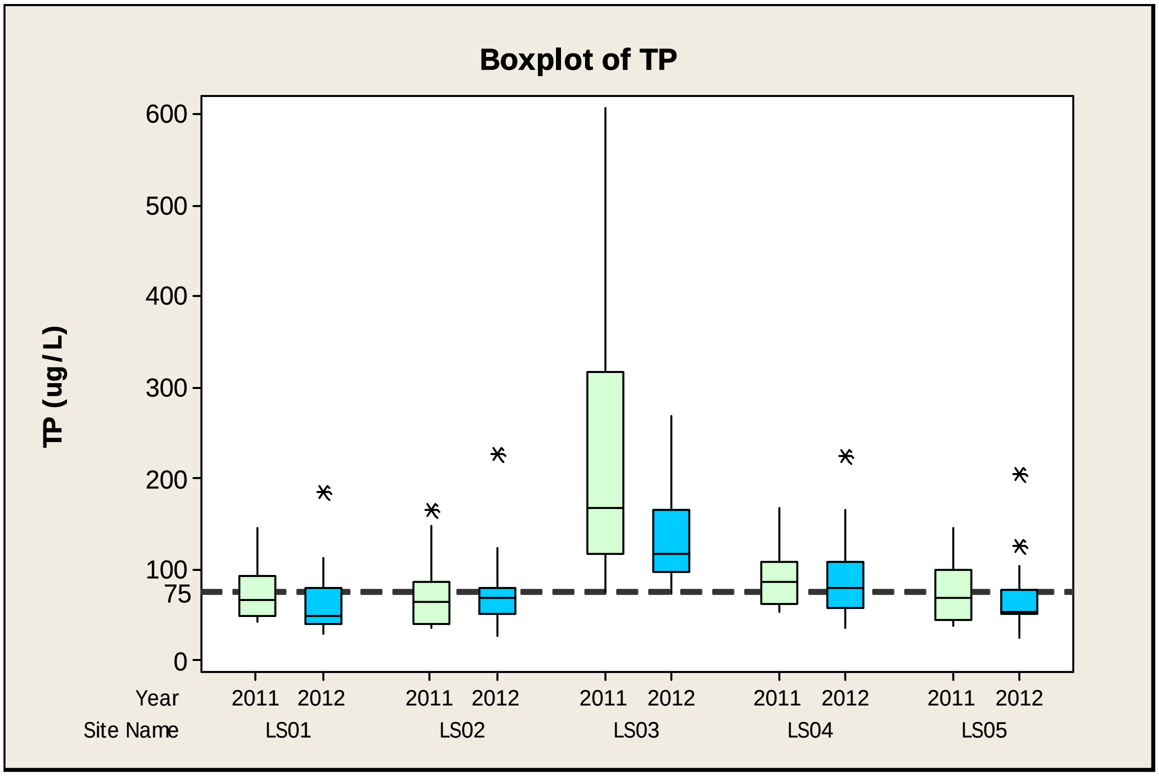

Figure 12: Boxplot of total phosphorus (µg/L) including all samples collected each year (March - November).

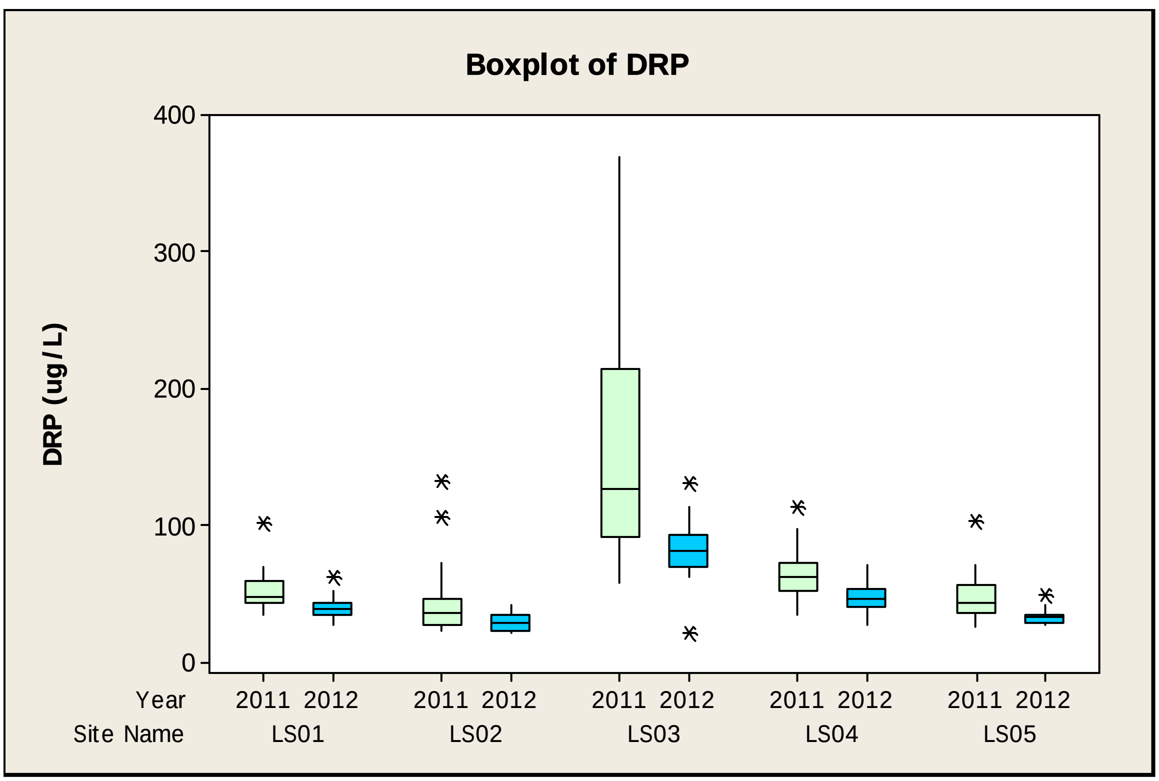

Figure 13. Boxplot of dissolved reactive phosphorus (µg/L) at sampling sites on Spring Creek (2011-2012).

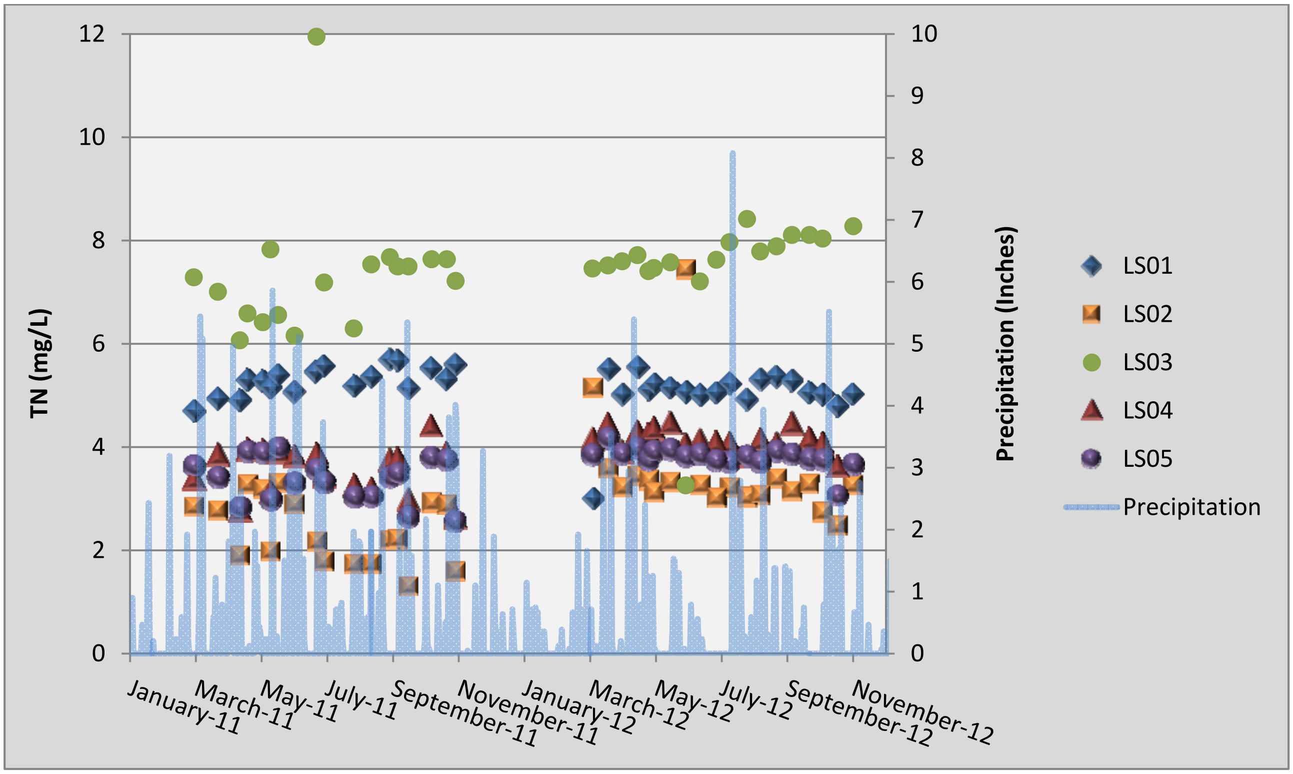

Figure 14. Scatterplot of total nitrogen concentrations (mg/L) in all samples collected at sites on Spring Creek (2011-2012). NOAA precipitation data (inches) plotted in background.

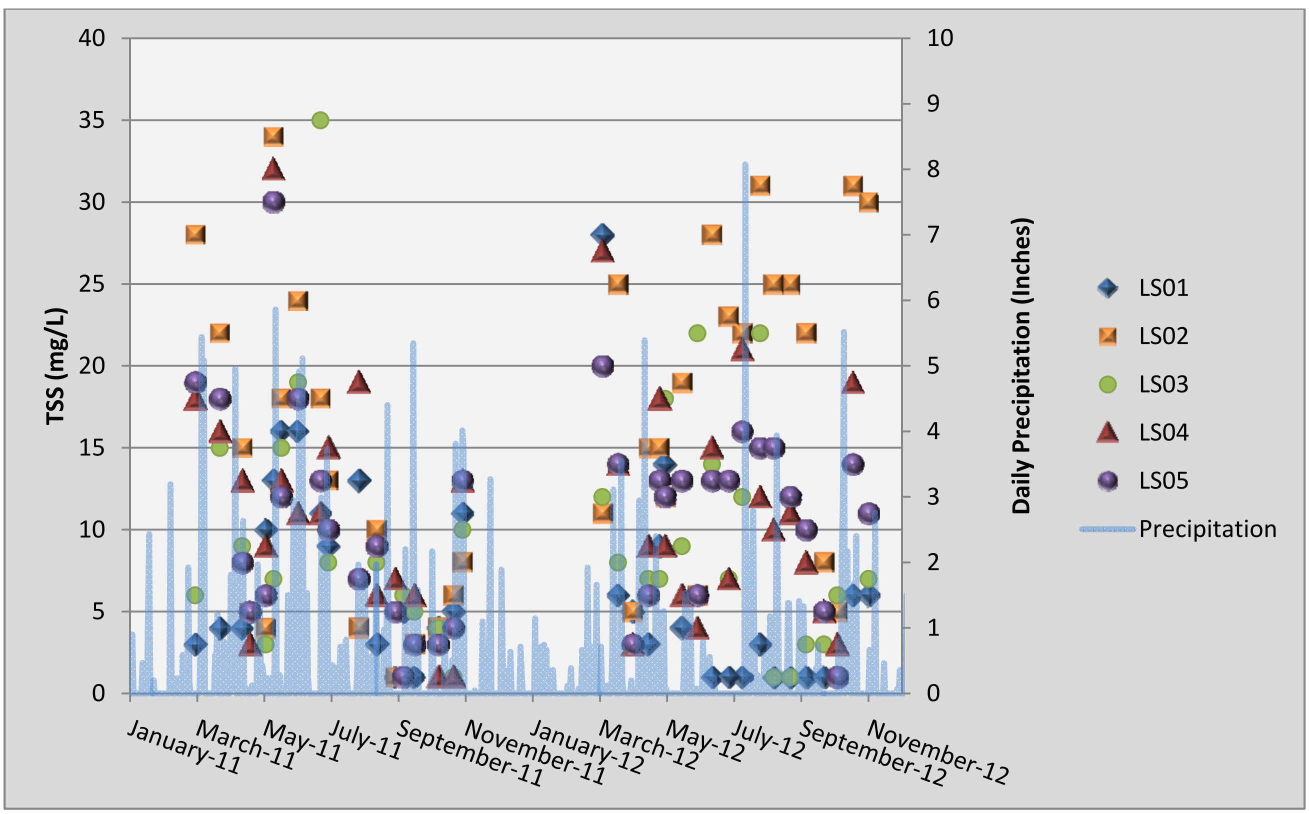

Figure 15. Scatterplot of total suspended solids (mg/L)in all samples collected at sampling sites on Spring Creek (2011-2012). NOAA precipitation data plotted in the background.

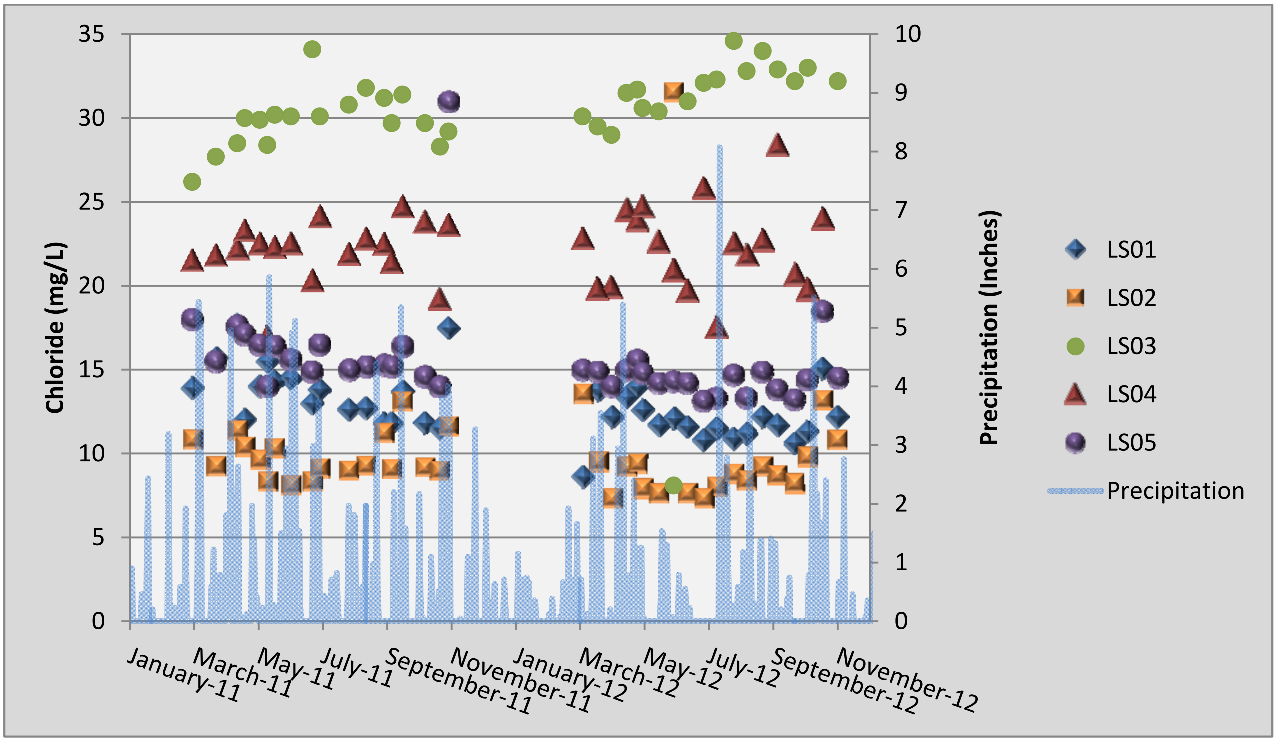

Figure 16. Scatterplot of chloride concentrations (mg/L) in samples collected at all sites on Spring Creek (2011-2012). NOAA precipitation data (inches) plotted in background.

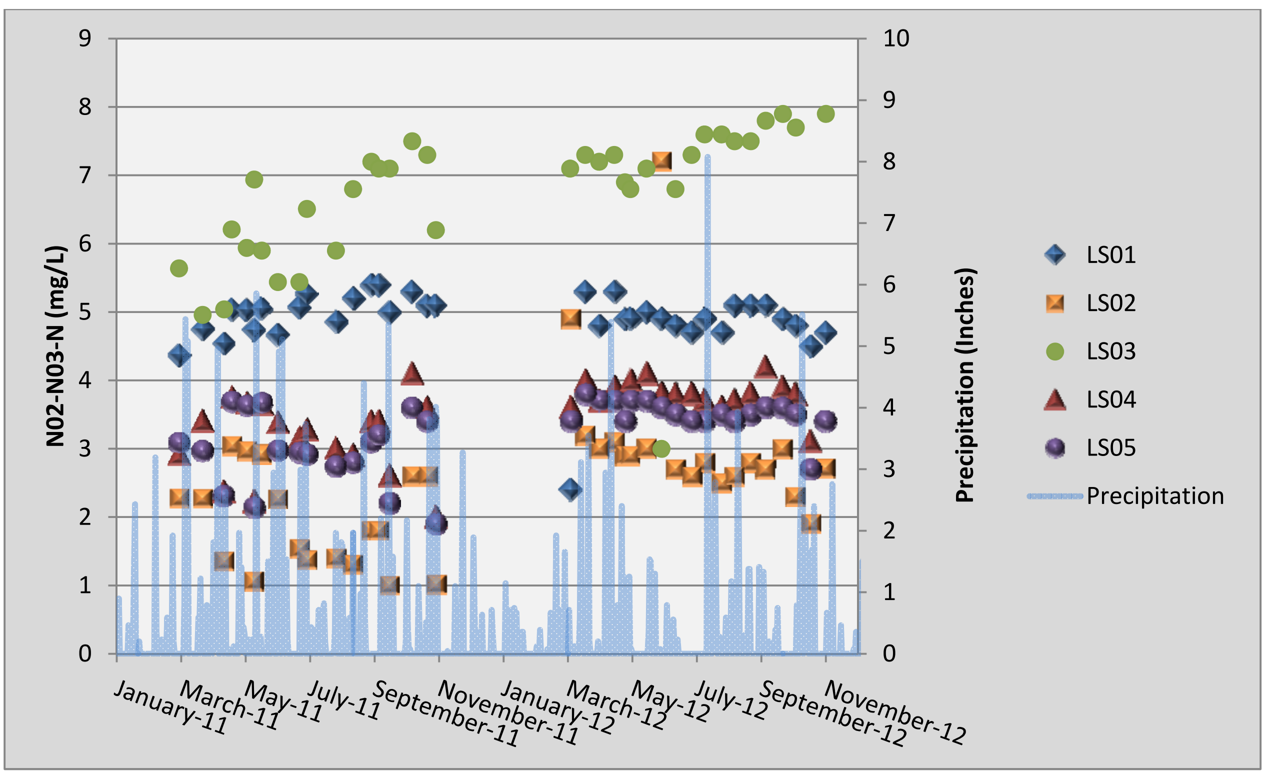

Figure 17. Scatterplot of NO_2+NO_3-N concentrations (mg/L) in all samples collected from Spring Creek (2011-2012). NOAA precipitation data are plotted in the background.

2014 Results

Spring Creek Watershed
Pre & Post BARNY Livestock Assessments

August 2014

Prepared by
Columbia County Land & Water Conservation
C. Arnold and T. Rietmann

COLUMBIA COUNTY

Land & Water Conservation

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Project Description

This project was funded by the Columbia County Land and Water Department (CCLWCD) to conduct a NR 151 Livestock Inventory Study in the Spring Creek Watershed as an assessment tool to determine benefit of Phosphorus (P) reductions and the types of and the cost of best management practices (BMP's) needed to obtain the suggested P reductions.

Methods

The CCLWCD conducted a satellite image analysis of the Spring Creek Watershed for the purposes of locating the existing livestock operations. Using this as the starting point, CCLWCD staff visited these locations and any other livestock operations that were witnessed while in the Spring Creek Watershed during the Spring and Summer of 2014. Each livestock operation was reviewed using the criteria established in NR 151 Runoff Management, Subchapter II – Agricultural Performance Standards and Prohibitions and calculated the pre and post BMP edge of lot P discharge using BARNY. The BMP's used to provide the P reductions in BARNY were listed with a low and high cost range. It should be noted not all operations were calculated in BARNY: Operations currently retired are listed as No Livestock (NL), Operations with no open lots, existing under a roof with no discharge are listed as (NOL), Pastures are listed as such, and one large dog kennel lists as (DK). After calculating pre BMP P discharge, sites with low edge of lot P discharge (< 15 lbs. of P) were not considered for BMP installation.

Watershed Description

Spring Creek is located in south central Wisconsin on the border of Columbia County and Dane County. The watershed draining to Spring Creek is approximately 28,813 acres. It flows northwest through the Lodi Marsh State Wildlife Area, into the City of Lodi, and empties into Lake Wisconsin (Figure 1). Spring Creek's headwaters and tributaries lie in an area with mixed land uses including forests, wetlands, and agriculture. Just below the confluence of the south and west branches of Spring Creek, Spring Creek flows through the City of Lodi and received the effluent from its wastewater treatment plant before in drains into Lake Wisconsin.

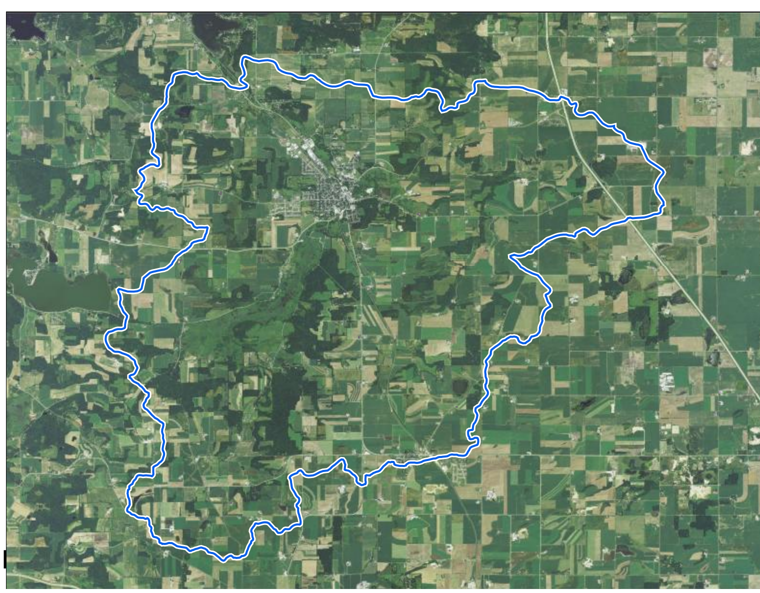

Figure 1. Spring Creek Watershed -2013 NAIP Ortho Photo showing the Watershed Boundary Dataset HUC12 for Spring Creek.

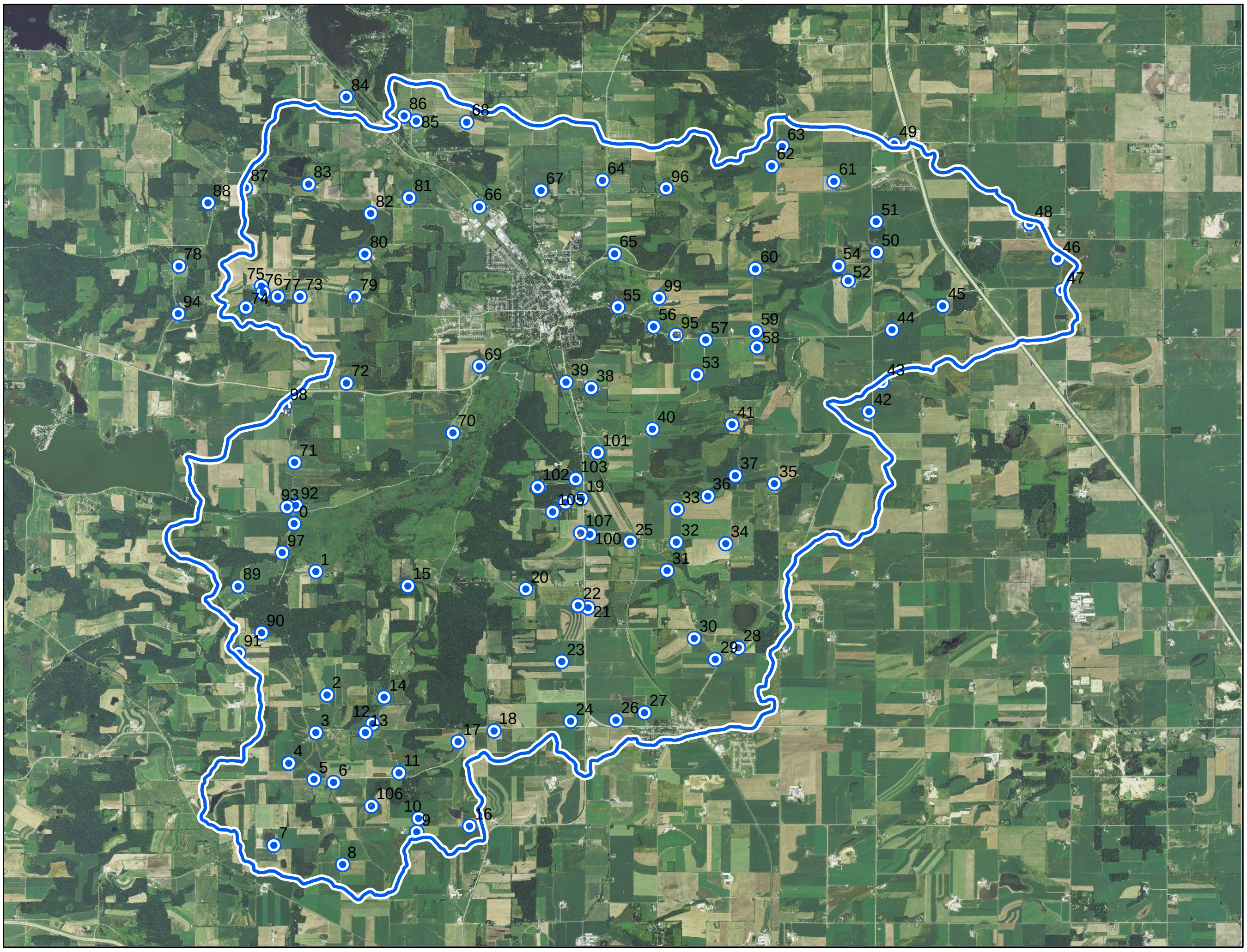

Figure 2 2013 Spring Creek Watershed-NAIP Ortho Photo with BARNY Assessed Livestock SItes

Summary Results

110 Livestock Locations Visited

- 54 Livestock Locations in Columbia County
- 54 Livestock Locations in Dane County
- 2 Miscellaneous Locations

24 Locations have No Livestock Currently

85 Locations have Livestock Present

- 74 Locations have Livestock Lots
- 7 Locations have active pastures
- 5 Locations are completely confined with No Open Lots (NOL)

1 Miscellaneous Location is a Dog Kennel

40 Locations have potential to remove greater than 5lbs through BMP implementation

- 17 Dane County
- 23 Columbia County

2817 lbs of P calculated with BARNY at edge of lot before BMP

- 1,587 lbs P at edge of lot in Columbia County
- 1,230 lbs P at edge of lot in Dane County

876 lbs of P calculated with BARNY at edge of lot after BMP

- 407 lbs P at edge of lot in Columbia County
- 469 lbs P at edge of lot in Dane County

1941 lbs of P reduced with BMP implementation calculated, at edge of lot

- 1180 lbs P at edge of lot in Columbia County
- 760 lbs P at edge of lot in Dane County

$1,684,200 Low range for BMP installation

$2,194,500 High range for BMP installation

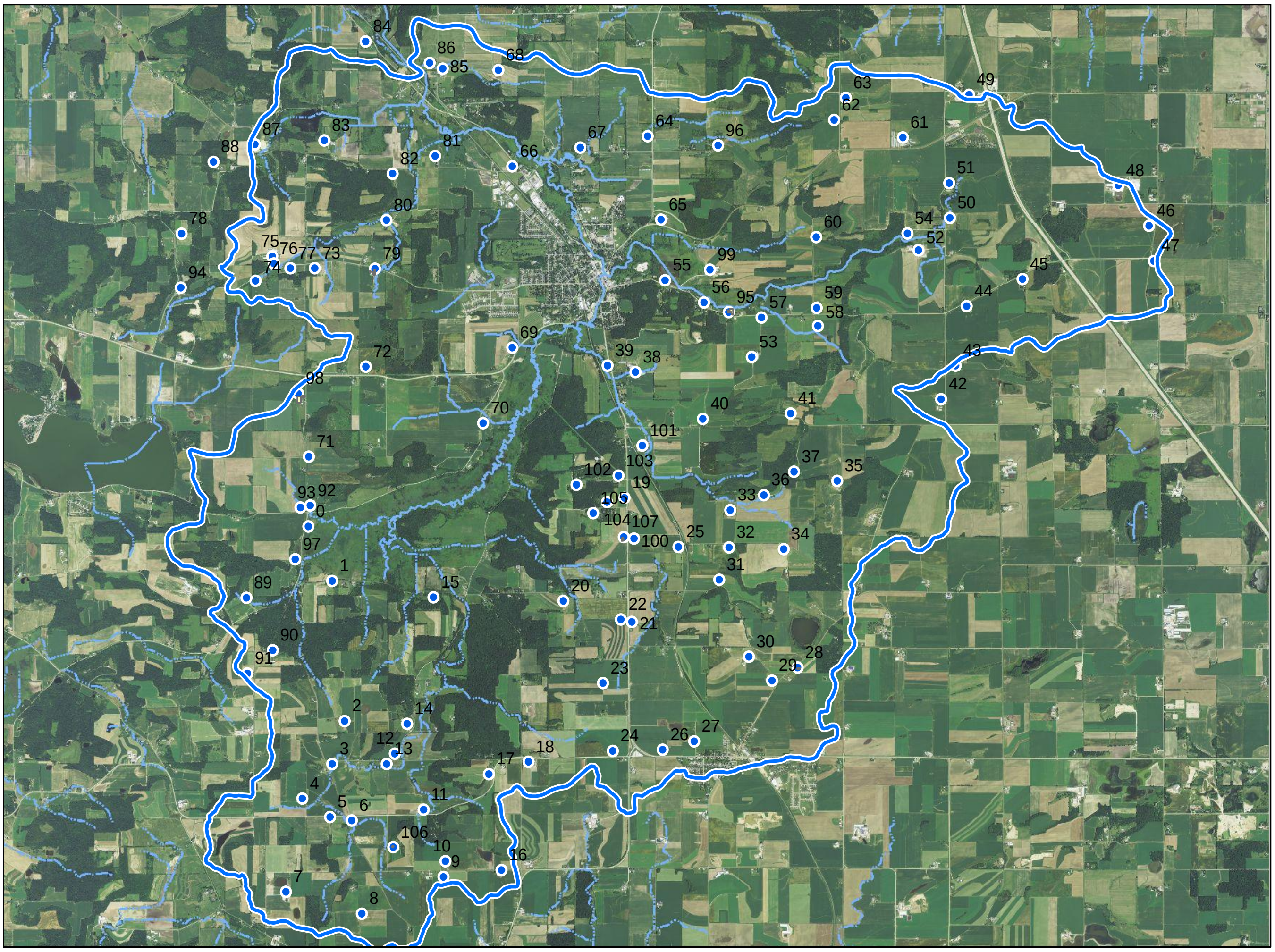

Figure 4 Spring Creek Watershed-2013 NAIP Ortho Photo with Hydrology and BARNY Assessed Livestock Sites

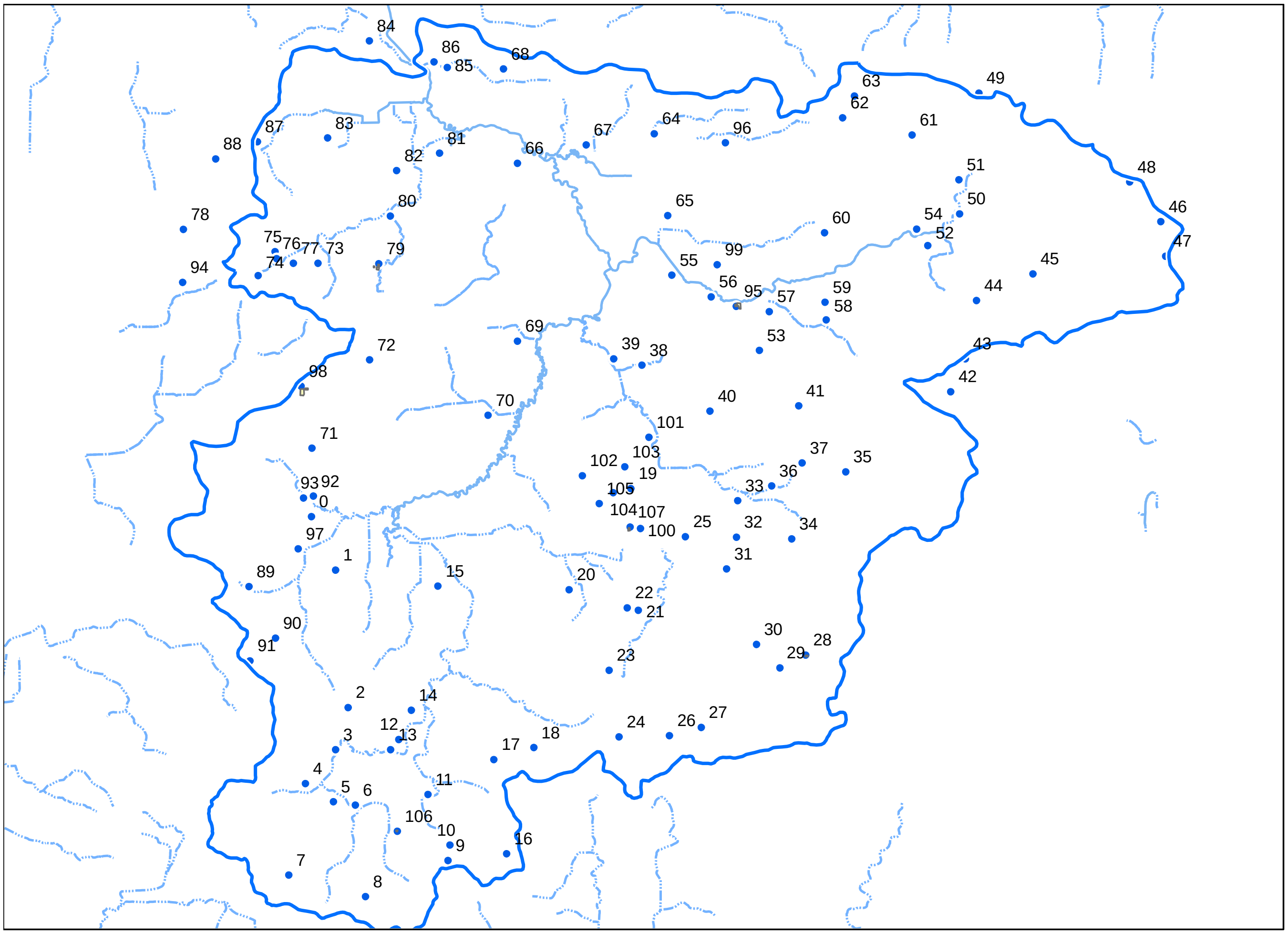

Figure 5 Spring Creek Watershed- Hydrology and BARNY Assessed Livestock Sites

Appendix F

Urban Critical Source Area WinSLAMM Modeling

APPENDIX F

Urban Critical Source Area WinSLAMM Modeling

1.1 INTRODUCTION

This report documents the findings of a study conducted for purposes of determining whether the City of Lodi's stormwater management system could be modified to cost-effectively capture additional amounts of Total Phosphorus (TP) from annual stormwater runoff. Potential modifications to the stormwater system evaluated in this report which have the potential for reduction of TP from runoff within the City have been evaluated and conceptual cost-estimates prepared for purposes of comparison to other TP-reducing alternatives focused on agricultural practices outside the City. The most effective options of all those evaluated, in terms of total cost per pound of phosphorus captured, will be implemented as part of the City of Lodi's Adaptive Management Program for phosphorus compliance for their wastewater treatment plant.

The findings of this study are taken from water quality model of the approximately 300 acre portion of the City (including some surrounding areas draining through the City) draining to Spring Creek upstream from the WWTF. The model was used to evaluate Total Phosphorus loads generated by land uses within the watershed, as well as reductions to loads achieved by four existing stormwater management ponds and the City's current street sweeping program. The modeling was used to evaluate potential retrofits to existing ponds as well as the potential benefits to construction of five other stormwater ponds.

1.2 METHODS

This study is based upon a detailed WinSLAMM Version 10.0 model of the City's stormwater management system. WinSLAMM is a Wisconsin Department of Natural Resources (WDNR) approved model recommended for use in determining TP loads and removal rates from stormwater management practices for development of Adaptive Management Plans (see notation within "Adaptive Management Technical Handbook – A guidance Document for Stakeholders," January 07, 2013) 'WinSLAMM' abbreviates "Source Loading and Management Model [for Windows]."

SLAMM was originally developed to better understand the relationships between sources of urban runoff pollutants and runoff quality. It has been continually expanded since the late 1970s and has been revised to include a wide variety of source area (runoff and pollutant generators) and outfall control practices (runoff and pollutant management practices). SLAMM is based on actual field observations and has minimal reliance on theoretical processes.

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Input data required by WinSLAMM for each model application includes a number of data files that describe local meteorological and hydrological conditions and pollutant loading characteristics. These files are prescribed for use in the WinSLAMM model by the USGS Wisconsin Water Science Center and include parameter files for rainfall, pollutant distribution, runoff coefficients, particulate solids concentrations, and pollutant delivery data.

1.2.1 RAINFALL DATA

The USGS has evaluated rainfall data collected across the state of Wisconsin for many years and has identified annual rainfall records for five locations in the state that are felt to be representative of typical rainfall precipitation conditions. For Lodi, the closest rainfall record recommended for use in water quality modeling is the Madison rainfall record of 1981. Modeling protocols established by WDNR require elimination of the winter season (where precipitation principally falls as snow or ice) from the model simulation as WinSLAMM cannot accommodate snowfall and runoff from snowmelt events. The range of winter dates applicable to the Minneapolis rainfall data run from December 2 to March 12. Thus, any single-year simulation runs from March 13 to December 1.

It is noted that a five-year model run is specified by WDNR for evaluations which include street sweeping. While this study included an evaluation of existing sweeping practices, it was never intended that modifications to sweeping practices would be evaluated as a method for TP reductions for the adaptive management program. Since modeling of the five-year rainfall record resulted in much longer modeling solutions, the one year rainfall record was applied for expendiency.

1.2.2 WINSLAMM POLLUTANT LOADING FILES

Pollutant loading files required by the WinSLAMM model include a *Pollutant Probability Distribution File, Runoff Coefficient File, Particulate Solids Concentration File, a Street Delivery Parameter File, and a Source Area Particle Distribution File.*

The *Pollutant Probability Distribution File* describes the pollutant loading from different source areas (land use types). This data is based upon actual pollutant loading collected from the study area or region.

The *Runoff Coefficient File* describes parameters specific to different source areas (land use types) that determine the runoff volumes resulting from rainfall events of different depth.

The *Particulate Solids Concentration File* contains parameters allowing the WinSLAMM model to determine the weight of particulate solids loadings resulting from runoff

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events of different volumes. The particulate solids concentration file includes data measured by the USGS from source areas including residential, commercial, and industrial rooftops; residential lawns; residential driveways; residential, commercial and industrial streets; commercial and industrial parking lots; freeways; and undeveloped areas.

The *Street Delivery Parameter File* contains data describing the fraction of total particulates that do not reach the outfall during a rain event, for different rain depths and street textures.

The *Source Area Particle Distribution File* provides the default particle size distribution files for each source area within each land use type.

1.2.3 MODEL PARAMETER FILES

The following model parameter files were entered into the WinSLAMM model(s) for evaluation of the City of Lodi's stormwater management system.

Rainfall Files -	WisReg - Madison WI 1981.RAN
Pollutant Probability Distribution File -	WI_GEO03.ppdx
Runoff Coefficient File -	WI_SL06 Dec06.rsv
Particulate Solids Concentration File -	v10.1 WI_avg01.pscx
Street Delivery File:	
Residential/Other -	WI_Res and Other Urban Dec06.std
Institutional/Commercial/Industrial -	WI_Com Inst Indust Dec06.std
Freeway -	Freeway Dec06.std

1.2.4 WATERSHEDS, LAND USES, SOURCE AREAS, AND SOIL TYPES

Watersheds are the sources of runoff and pollutants simulated by the program. WinSLAMM Version 10 is capable of modeling complex systems of interconnected *watersheds* each of which can contain up to six discrete *land uses*; residential, institutional, commercial, industrial, freeway, and other urban areas. Each land use contains specific runoff and pollutant *source areas* including roofs, paved parking/storage areas, unpaved parking/storage areas, playground, driveways, sidewalks/walks, street areas, landscaped areas (small and large), undeveloped areas, isolated/water body area, other pervious areas and impervious areas (directly connected and indirectly connected). Each source area is further categorized by *soil texture*, including sand, silt, and clay soil types.

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1.2.4.1 Determination of Watershed Boundaries

For this study, watershed areas draining to existing or proposed water quality management practices were delineated using the GIS program ArcMap 10.3. Delineation of watersheds was completed using two-foot contour interval topographic maps overlaid with storm sewer and surface drainage system maps as well as watersheds that were previous used in the 2009 Spring Creek Watershed Study and Urban Stormwater Plan developed for the City of Lodi.

The water quality modeling study area is identified in Map-1, 'Study Area Limits'.

1.2.4.2 Development of WinSLAMM Land Use Data

Land Use was assigned by MSA, based on several data sources. The County provided a GIS parcel dataset, and each parcel within the Study Area was assigned a unique land use, based on a combination of aerial imagery, parcel ownership information, and Google Street View. Land uses were assigned to match built-in WinSLAMM standard land use classifications. Land uses included in the model are shown in Table 1.

Table 1
Land Use classifications for WinSLAMM

Agricultural
Cemetery
Commercial, Downtown
Commercial, Shopping Center
Commercial, Strip
Industrial, Light
Institutional, Misc.
Institutional, School
Open Space
Park
Residential, Duplex
Residential, Low Density

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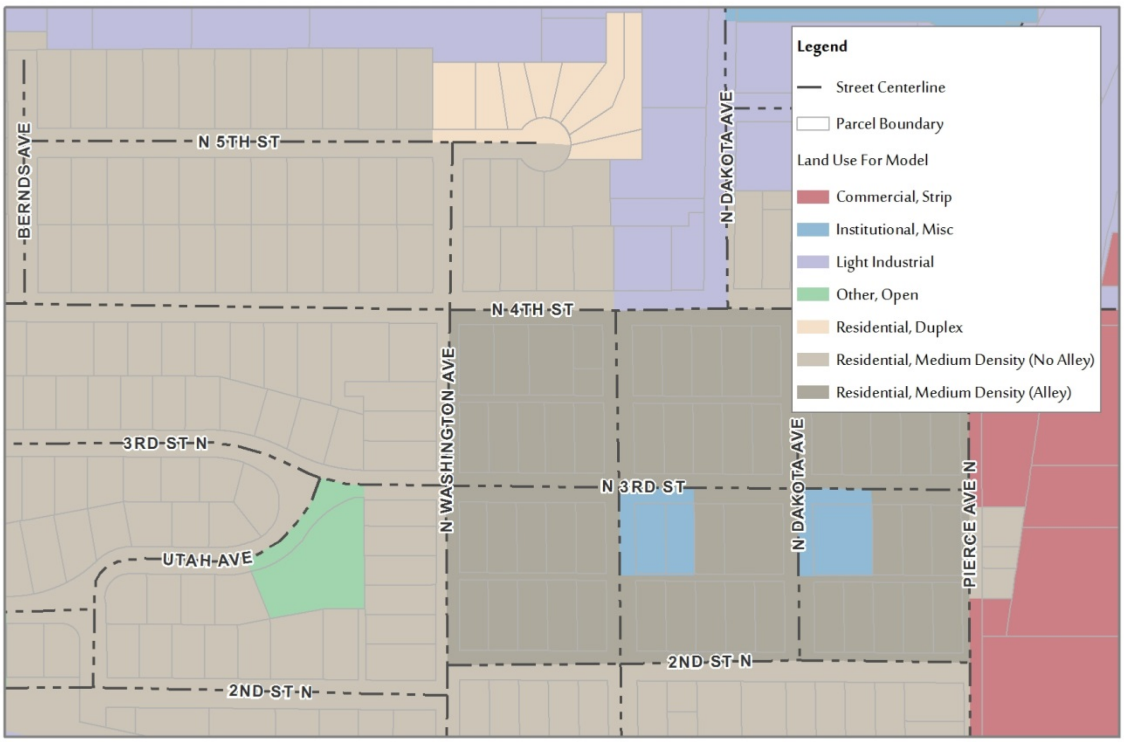
Residential, Medium Density (No Alley)
Residential, Multi-Family

For the non-highway street right-of-way (ROW) areas, MSA created a generalized 'ROW' polygon (covering all regions not classified within the original land use dataset – i.e. areas not defined as parcels). This new polygon was then divided along the street centerlines with the resulting pieces assigned land use according to the classification of the adjacent parcel. Figure 1, below, provides an example of how this was accomplished.

Figure 1



Land Use Classifications were assigned to ROW areas.

Map-2 identifies WinSLAMM land uses within the study area.

1.2.4.3 Development of WinSLAMM Soil Texture Data

WinSLAMM requires that the soil underlying all source areas be classified by texture as *sand, silt, or clay*. The WinSLAMM 'Frequently Asked Questions (FAQ)' document on the WinSLAMM web site (http://winslamm.com/faq.html) states that soil textures are to be assigned according to the hydrologic soil group (HSG) assigned

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each soil type by to the USDA county soil atlas; 'When we set up the soil classifications clayey, silty and sandy, we assumed that they would correspond to the SCS classification A, B, C, and D soils, with: A – Sandy, B – Silty, C and D - Clayey.'

Table 2 identifies the soil types within the project study area identified in the Columbia County Soil Atlas and identifies the soil texture class assigned to each soil for entry into WinSLAMM according to the relationship described above. Soils with a dual classification such as B/D indicate the HSG of the soil in a drained and undrained condition, respectively. Soils were assumed to be drained as this is a common condition in urban areas.

Map 3 identifies the locations within the study area where sandy, silty, and clayey soils were applied in this study.

Table 2
Study Area Soil Textures

Soil Map Unit	Soil Name	Hydrologic Soil Group (HSG)	WinSLAMM Soil Texture
Ah	Alluvial land	B	Silty
AtB	Atterberry silt loam	B	Silty
CaE2	Channahon silt loam	D	Clayey
DoB2	Dodge silt loam	B	Silty
DoC2	Dodge silt loam	B	Silty
DoD2	Dodge silt loam	B	Silty
DrC2	Dresden loam	B	Silty
DrD2	Dresden loam	B	Silty
GP	Gravel pit	A	Sandy
JoA	Joy silt loam	B	Silty
LaC2	Lapeer fine sandy loam	B	Silty
LaD2	Lapeer fine sandy loam	B	Silty
MeB2	McHenry silt loam	B	Silty
MeC2	McHenry silt loam	B	Silty
MnC2	Military fine sandy loam	B	Silty
MnD2	Military fine sandy loam	B	Silty
MtB	Mt. Carroll silt loam	B	Silty
MtC2	Mt. Carroll silt loam	B	Silty
NoE	Northfield sandy loam	D	Clayey
OsA	Ossian silt loam	B	Silty

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Ot	Otter silt loam	D	Clayey
PnA	Plano silt loam	B	Silty
PnC2	Plano silt loam	B	Silty
RdC2	Ringwood silt loam	B	Silty
Rk	Rock land	D	Clayey
SaB2	St. Charles silt loam	B	Silty
SaC2	St. Charles silt loam	B	Silty
SbC2	Salter fine sandy loam	B	Silty
Sd	Sandy land	B	Silty
SeC2	Saybrook silt loam	B	Silty
W	Water	D	Clayey
PnB	Plano silt loam	B	Silty
PnB	Plano silt loam	B	Silty
PnB	Plano silt loam	B	Silty
PnB	Plano silt loam	B	Silty
QUA	Quarry1		
W	Water1		

1. Quarry and Water areas were manually reclassified according to the HSG of neighboring soils.

1.2.5 WATER QUALITY MANAGEMENT PRACTICES

WinSLAMM allows for assignation of water quality management practices for individual *source areas* within a land use type, within the *drainage system* serving the watershed, or at the '*outfall*' (point of discharge of the watershed). The portion of the City of Lodi evaluated in this study contains water quality management practices including street sweeping which was applied at the (street) source level and stormwater quality ponds which were applied at the outfall level. There were no management practices applied at the drainage system level (i.e. no vegetated swales or catch basins).

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1.2.5.1 Application of Street Sweeping in WinSLAMM

Street sweeping is a management practice applied at the *street source area* level within the WinSLAMM model and was the only management practice evaluated in this manner.

WinSLAMM is capable of modeling both mechanical and high-efficiency (vacuum) street sweeping. Sweeping intervals may be altered and sweeping may be evaluated with and without parking restrictions. Parking restrictions assume that cars are not allowed to park on streets on days when sweeping is to occur. Within the model, the sweeping frequency is assigned as part of the land use classification.

Street sweeping frequency data was provided by the City of Lodi Engineering Department. Sweeping is done at different intervals: (a) once per week, (b) one time every two weeks, and (c) no sweeping. There are no street sweeping parking controls enforced by the City, however after discussion it was determined that the parking density while sweeping occurs is low and so a classification of 'light' was entered into the model.

To assign the appropriate sweeping classification within the WinSLAMM model, each parcel was assigned a sweeping classification based on its location relative to a swept road. If the parcel boundary was within 70 feet of a swept road centerline, it was assigned the associated sweeping classification. For those parcels adjacent to two or more streets with different sweeping frequencies, the sweeping interval was assigned based on the classification of the longest road segment adjacent to the property. Large parcels were individually reviewed and adjusted to confirm the sweeping classification was appropriate. For example, agricultural fields that were adjacent to a small road segment with sweeping where changed to 'no sweeping'.

Map 4 shows the different street sweeping routines identified by City staff, the land areas classification determined by the above methodology, and the region that was modelled within WinSLAMM for sweeping.

Note that because street sweeping occurs throughout the City, the TP load delivered to existing and proposed BMPs is affected by sweeping operations.

1.2.5.2 Application of Stormwater Detention Ponds in WinSLAMM

The WinSLAMM model is capable of modeling several configurations of ponds including wet detention ponds, dry detention ponds, and infiltration ponds.

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Each of these pond subtypes are included in the assessment of the City's stormwater management system.

WinSLAMM requires several input parameters in order to define stormwater detention ponds so as to evaluate their effectiveness at reducing pollutants in stormwater runoff. These parameters include; drainage area, storage volume (expresses as surface area at different elevations), and the configuration of outlet control structures (orifices, culverts, weirs, etc.). All ponds that were configured as dry or infiltration ponds were also assigned an infiltration rate.

1.2.5.2.1 Determining Pond Drainage Areas

Watershed areas draining to existing stormwater detention ponds were determined using GIS. The City provided a GIS map identifying the locations of known stormwater management facilities which MSA supplemented through review of aerial topographic maps and photos as well as field inspections. MSA digitized the boundaries of drainage areas tributary to each detention pond according to storm sewer mapping provided by the City and aerial topographic maps.

Locations for the five alternative future ponds were determined by looking for areas within 300 feet of existing storm sewers, taking into account the upstream drainage area (i.e. larger drainage areas typically have higher TP loads and are served by larger diameter sewers). Properties with comparatively lower assessed values within the 300 foot buffer were identified as potential sites for stormwater quality ponds. As with existing detention ponds, MSA digitized the boundaries of drainage areas tributary to each alternative future pond according to storm sewer mapping provided by the City and aerial topographic maps.

Map-5 identifies the location of existing and proposed stormwater detention ponds and areas served by ponds within the study area.

1.2.5.2.2 Sources of Stormwater Pond Geometry Input Data

As indicated previously, WinSLAMM modeling included four existing stormwater management ponds and five alternative future ponds. MSA used pond geometry from the 2009 Spring Creek Watershed Study and Urban Stormwater Plan prepared for the City of Lodi.

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1.3 FINDINGS

Table 3, below, summarizes results of the WinSLAMM modeling. These results reflect TP reductions achieved by existing structural water quality practices as well as operational practices including street sweeping.

TABLE 3
City of Lodi Current Total Phosphorus Loads

Area within Study Limits	Annual TP Load		TP Removed by Existing BMPs	
acres	lbs/yr	lbs/ac/yr	lbs/yr	%
299.7	229.5	0.77	37.7	16.4%

Review of the individual performance of existing BMPs showed that ponds EX1, EX2, and EX3 all achieved relatively low levels of TP reduction. Since pond EX3 receives runoff from ponds EX1 and EX2, pond EX3 was identified as a potential site as a water quality treatment optimization project; a simple modification to the pond's outlet control structure was found to achieve a marked improvement in TP capture rates.

Table 4 presents the anticipated additional TP reduction achieved by retrofits to one of the existing stormwater management ponds (EX3) as well as by construction of five new water quality ponds. Cumulatively, these modifications could achieve an estimated additional 59.7 pounds of TP reduction per year, or another 26.0% of the study area estimated annual load.

TABLE 4
Alternative Stormwater BMP Cost-Effectiveness

BMP	Drainage Area	TP Load	BMP Efficiency	TP Trapped	Total Construction Cost	TP Capture Present Worth[2]
	(ac)	(lbs/yr)	(%)	(lbs/yr)		($/lb/yr)
EX3	47.3			4.9[1]	$20,000	$311
PR1	17.5	14.4	54.6	7.9	$84,700	$549
PR2	61.1	54.8	45.5	25.0	$89,300	$185
PR3	14.6	10.5	34.6	3.6	$92,725	$754
PR4	24.1	22.2	50.3	11.2	$132,200	$358
PR5	78.9	48.6	24.7	12.0	$102,600	$258

1. *Net additional TP trapped following modifications to the existing pond outlet structure.*
2. *Assumes that annual maintenance represents 2% of initial construction cost (maintenance costs for pond EX3 assumed to be equal to the average of all other proposed ponds); that the maintenance life span is 20 years, and that the applied inflation rate is 4.625%.*

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The estimated costs to achieve these reductions range from $185/lb/yr to $754/lb/yr expressed as a present worth value. Setting aside potential social issues such as conversion of existing open spaces (some within park areas) to stormwater management practices, the magnitude of potential TP reductions achievable by urban practices is small relative to practices which may be applied in surrounding agricultural areas. Agricultural management practices also typically cost much less, typically only around $50/lb/yr. With higher unit costs for urban applications it seems unlikely that application of urban stormwater quality retrofits will be applied as part of the Lodi Adaptive Management Program.

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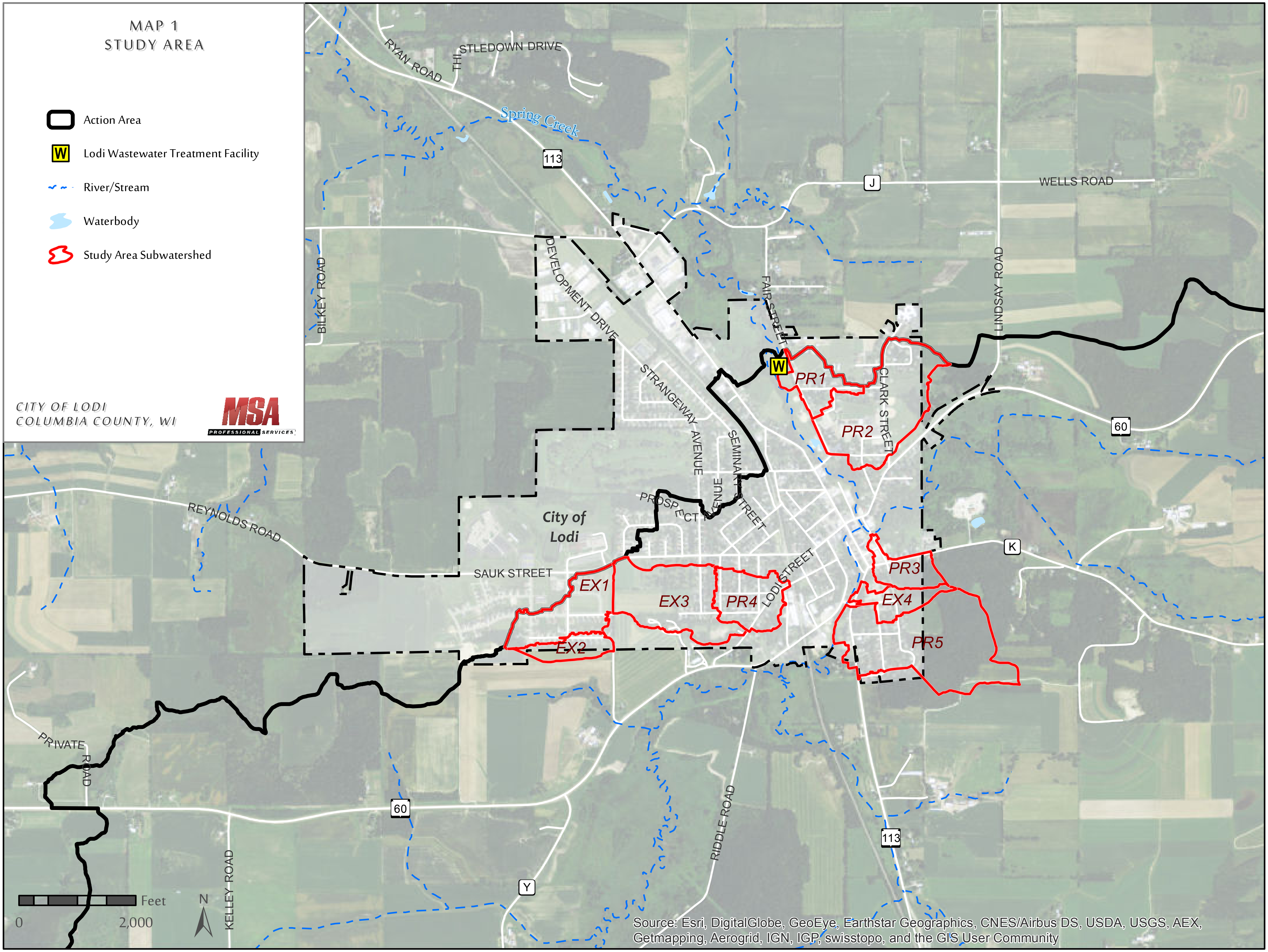
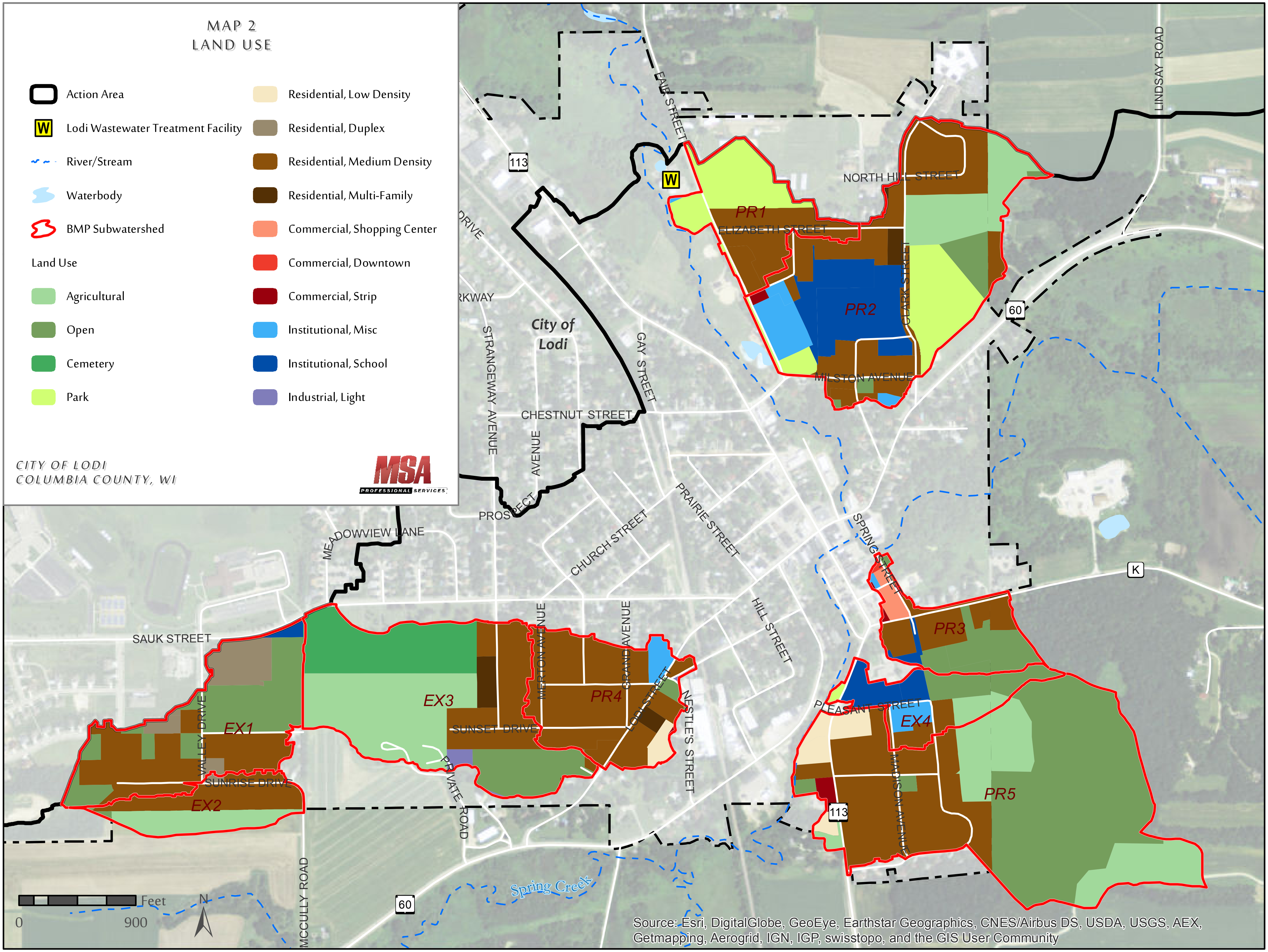
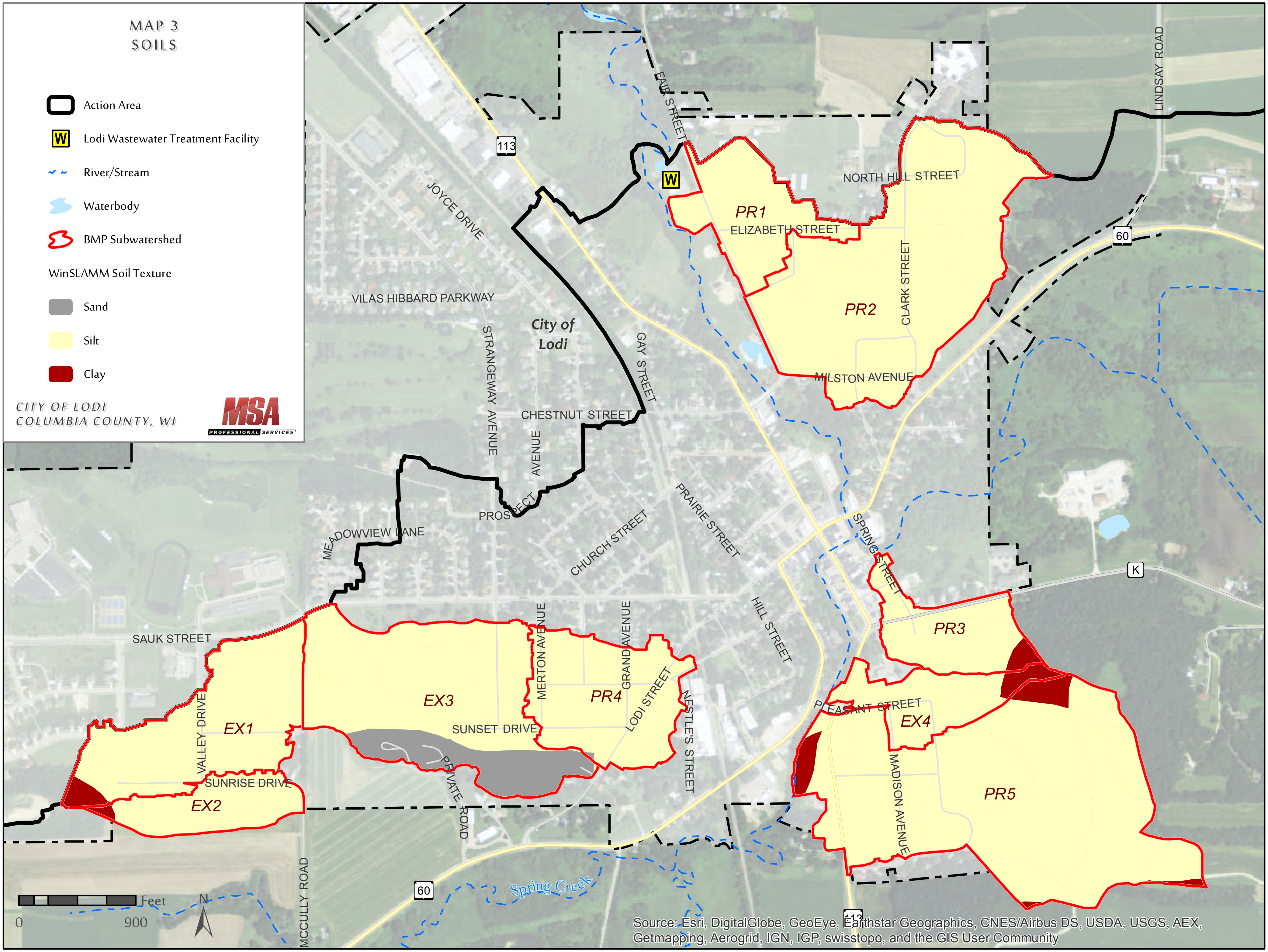
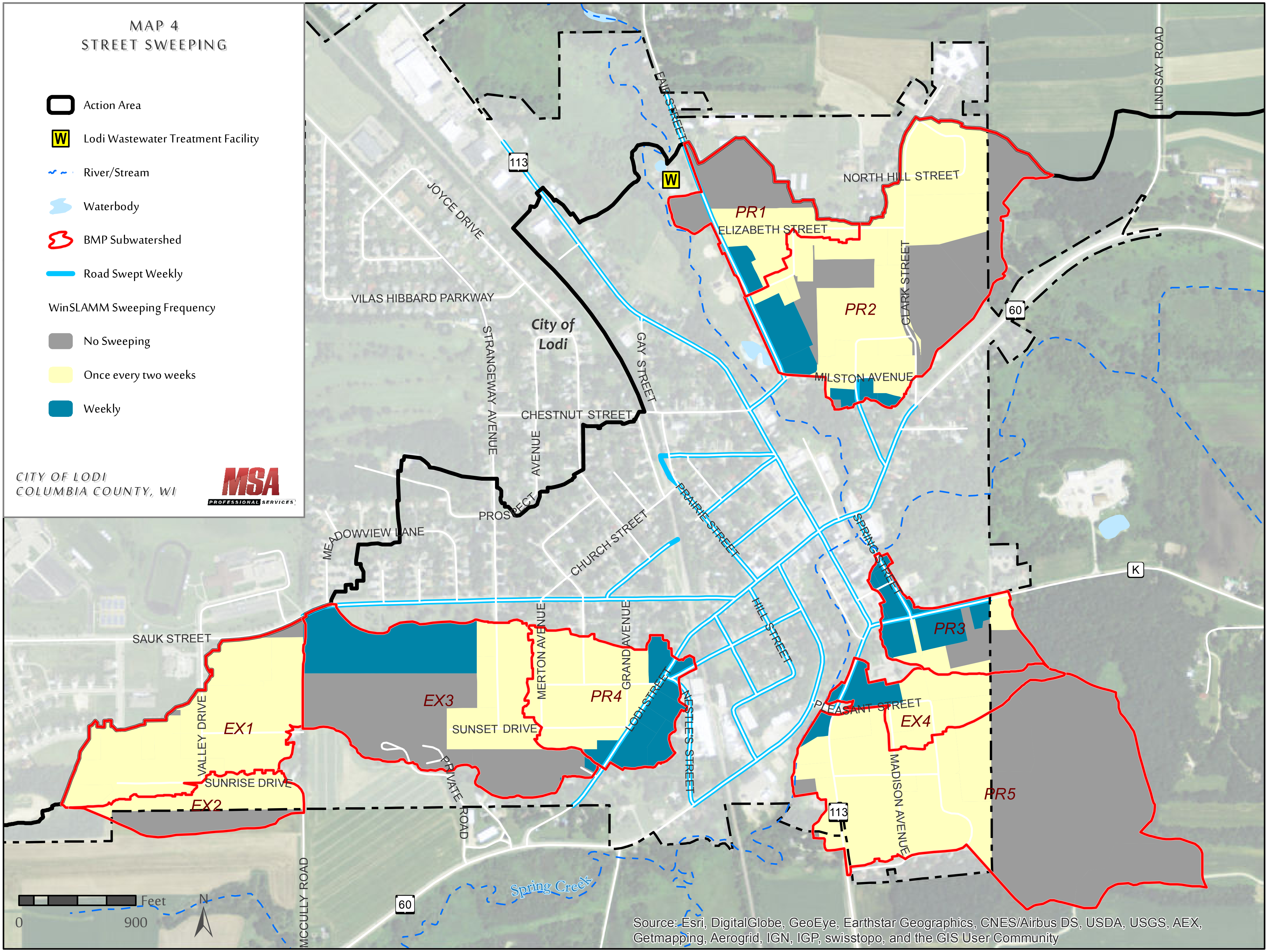
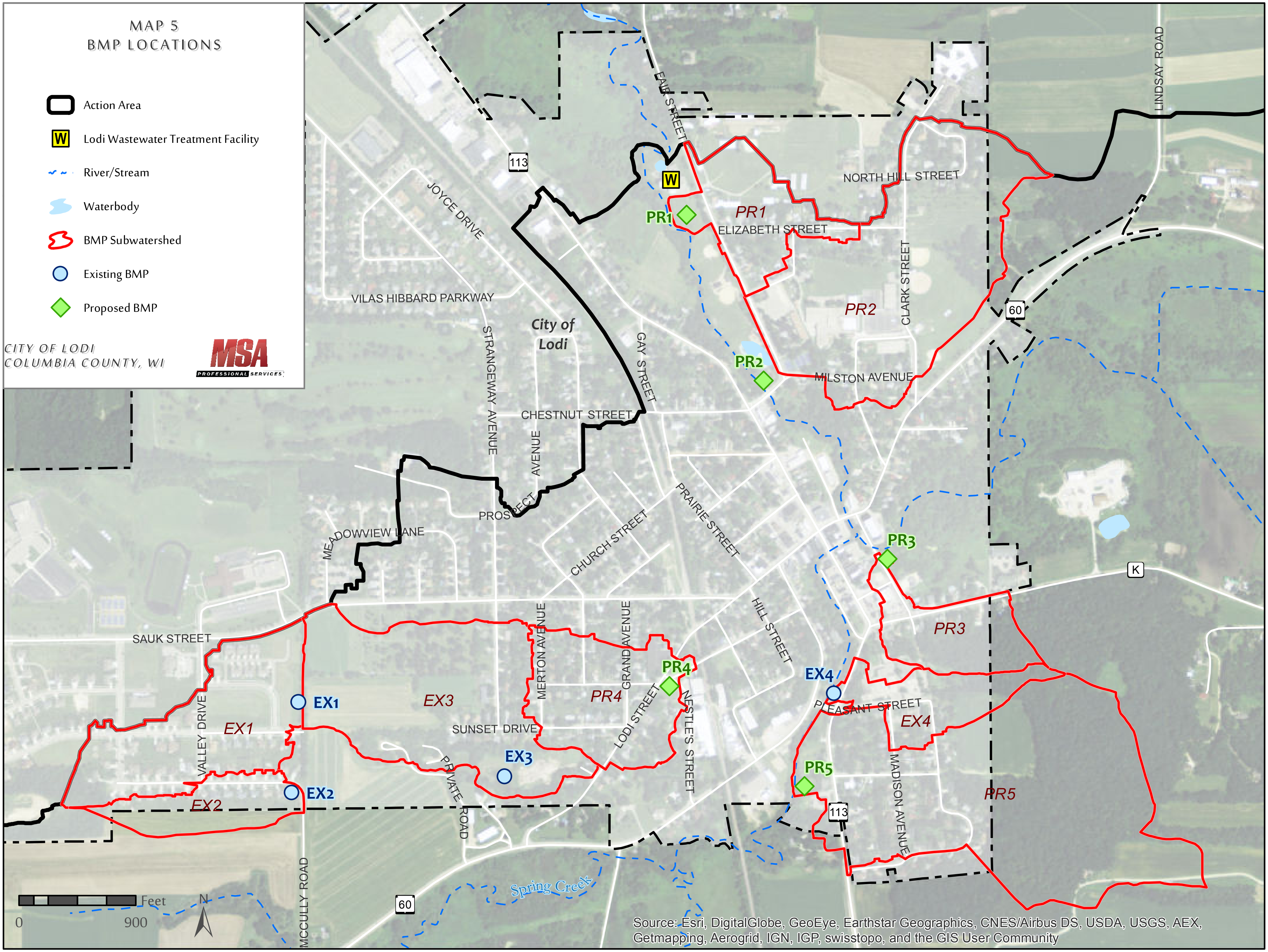

MAP 1
STUDY AREA
Action Area
Lodi Wastewater Treatment Facility
River/Stream
Waterbody
Study Area Subwatershed
CITY OF LODI
COLUMBIA COUNTY, WI
MSA PROFESSIONAL SERVICES
Feet
0
2,000
N
RYAN ROAD
STLEDOWN DRIVE
Spring Creek
113
J
WELLS ROAD
BILKEY ROAD
DEVELOPMENT DRIVE
FAIR STREET
LINDSAY ROAD
STRANGEWAY AVENUE
SEMINARY STREET
CLARK STREET
PR1
PR2
60
PROSPECT
City of Lodi
REYNOLDS ROAD
SAUK STREET
LODI STREET
K
PR3
EX1
EX3
PR4
EX4
PR5
EX2
PRIVATE ROAD
RIDDLE ROAD
KELLEY ROAD
Y
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


MAP 2
LAND USE
Action Area
Lodi Wastewater Treatment Facility
River/Stream
Waterbody
BMP Subwatershed
Land Use
Agricultural
Open
Cemetery
Park
Residential, Low Density
Residential, Duplex
Residential, Medium Density
Residential, Multi-Family
Commercial, Shopping Center
Commercial, Downtown
Commercial, Strip
Institutional, Misc
Institutional, School
Industrial, Light
CITY OF LODI
COLUMBIA COUNTY, WI
MSA PROFESSIONAL SERVICES
City of Lodi
PR1
PR2
PR3
PR4
PR5
EX1
EX2
EX3
EX4
W
113
60
K
NORTH HILL STREET
ELIZABETH STREET
MILSTON AVENUE
LINDSAY ROAD
FAIR STREET
GAY STREET
CHESTNUT STREET
STRANGEWAY AVENUE
PROSPECT AVENUE
MEADOWVIEW LANE
CHURCH STREET
PRAIRIE STREET
HILL STREET
SPRING STREET
PLEASANT STREET
MADISON AVENUE
SAUK STREET
VALLEY DRIVE
SUNRISE DRIVE
SUNSET DRIVE
MERTON AVENUE
GRAND AVENUE
LODI STREET
NESTLE'S STREET
PRIVATE ROAD
MCCULLY ROAD
Spring Creek
Feet
0
900
N
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


MAP 3
SOILS
Action Area
Lodi Wastewater Treatment Facility
River/Stream
Waterbody
BMP Subwatershed
WinSLAMM Soil Texture
Sand
Silt
Clay
CITY OF LODI
COLUMBIA COUNTY, WI
MSA PROFESSIONAL SERVICES
City of Lodi
PR1
PR2
PR3
PR4
PR5
EX1
EX2
EX3
EX4
NORTH HILL STREET
ELIZABETH STREET
CLARK STREET
MILSTON AVENUE
LINDSAY ROAD
JOYCE DRIVE
VILAS HIBBARD PARKWAY
STRANGEWAY AVENUE
AVENUE
CHESTNUT STREET
GAY STREET
PROSPECT
MEADOWVIEW LANE
CHURCH STREET
PRAIRIE STREET
SPRING STREET
HILL STREET
SAUK STREET
VALLEY DRIVE
MERTON AVENUE
GRAND AVENUE
LODI STREET
NESTLE'S STREET
SUNSET DRIVE
SUNRISE DRIVE
PRIVATE ROAD
PLEASANT STREET
MADISON AVENUE
MCCULLY ROAD
Spring Creek
113
60
K
Feet
0
900
N
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


MAP 4
STREET SWEEPING
Action Area
Lodi Wastewater Treatment Facility
River/Stream
Waterbody
BMP Subwatershed
Road Swept Weekly
WinSLAMM Sweeping Frequency
No Sweeping
Once every two weeks
Weekly
CITY OF LODI
COLUMBIA COUNTY, WI
MSA PROFESSIONAL SERVICES
City of Lodi
JOYCE DRIVE
VILAS HIBBARD PARKWAY
STRANGEWAY AVENUE
AVENUE
GAY STREET
CHESTNUT STREET
PROSPECT
MEADOWVIEW LANE
CHURCH STREET
PRAIRIE STREET
HILL STREET
SPRING STREET
NORTH HILL STREET
ELIZABETH STREET
CLARK STREET
MILSTON AVENUE
LINDSAY ROAD
SAUK STREET
VALLEY DRIVE
SUNRISE DRIVE
MERTON AVENUE
GRAND AVENUE
LODI STREET
NESTLE'S STREET
SUNSET DRIVE
PRIVATE ROAD
MCCULLY ROAD
PLEASANT STREET
MADISON AVENUE
Spring Creek
PR1
PR2
PR3
PR4
PR5
EX1
EX2
EX3
EX4
113
60
K
W
Feet
0
900
N
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


MAP 5
BMP LOCATIONS
Action Area
Lodi Wastewater Treatment Facility
River/Stream
Waterbody
BMP Subwatershed
Existing BMP
Proposed BMP
CITY OF LODI
COLUMBIA COUNTY, WI
MSA
PROFESSIONAL SERVICES
City of Lodi
JOYCE DRIVE
VILAS HIBBARD PARKWAY
STRANGEWAY AVENUE
AVENUE
CHESTNUT STREET
PROSPECT
MEADOWVIEW LANE
GAY STREET
FAIR STREET
NORTH HILL STREET
ELIZABETH STREET
CLARK STREET
MILSTON AVENUE
LINDSAY ROAD
CHURCH STREET
PRAIRIE STREET
HILL STREET
SAUK STREET
VALLEY DRIVE
MERTON AVENUE
GRAND AVENUE
LODI STREET
NESTLE'S STREET
SUNSET DRIVE
PRIVATE ROAD
PLEASANT STREET
MADISON AVENUE
MCCULLY ROAD
Spring Creek
113
60
K
W
PR1
PR2
PR3
PR4
PR5
EX1
EX2
EX3
EX4
Feet
0
900
N
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

More ideas. Better solutions.®

Memo

To: Reader

From: MSA Project Team

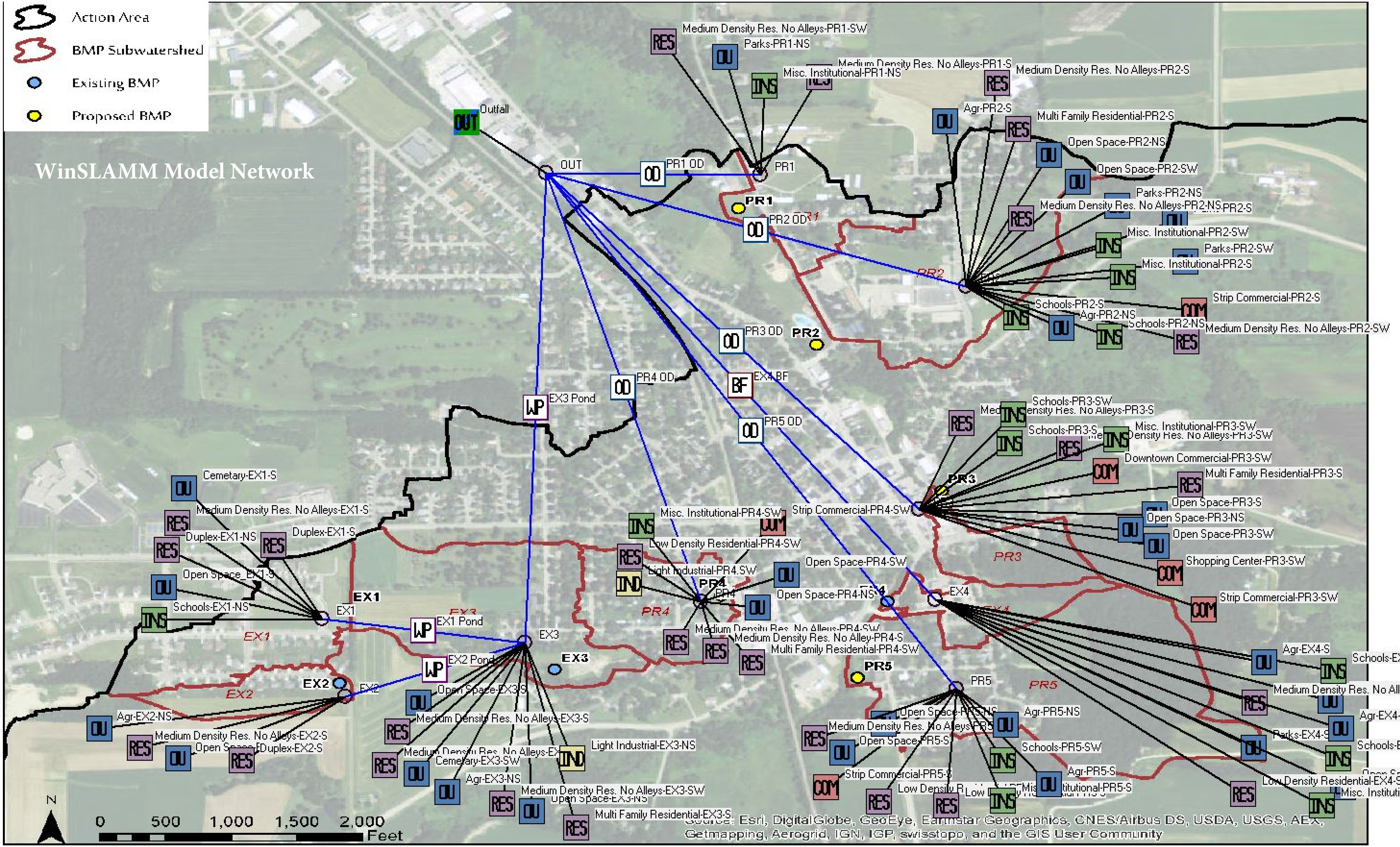
Subject: Interpreting Urban Modeling Input/Output Data

Date: March 7, 2016

The following pages are taken from the WinSLAMM models referred to in the Urban Modeling study described in Appendix F. Below is a list of what's included in the following pages:

- Model network
- Pond input screen for each existing pond, and EX3 proposed
- Summary output for existing conditions
- Summary output for proposed ponds
- Input text file for existing condition

Due to idiosyncrasies associated with WinSLAMM reports for TP reductions as well as limitations to the scope of this study, the performance of alternative future BMPs estimated through application of WDNR Conservation Practice Standard 1001 and other guidance documents. Specifically, the ratio of watershed area to BMP area was determined so as to estimate potential Total Suspended Solids (TSS) Reductions achievable by future pond. Estimated TSS reductions were converted to estimated TP reductions through application of pollutant portioning ratios developed by WDNR as part of TMDL implementation guidance documents. The total load attributable to a proposed BMP was determine by calculating the net TP reduction achieved by a hypothetical BMP with 100% capture efficiency relative to existing conditions baseline loads. The actual estimated capture rate for the BMP was determined by multiplying the estimated TP capture rate to the calculated load.


Action Area
BMP Subwatershed
Existing BMP
Proposed BMP
WinSLAMM Model Network
OUT
Outfall
OUT
PR1 OD
PR1
PR2 OD
PR3 OD
PR2
PR4 OD
EX4 BF
EX3 Pond
PR5 OD
PR3
PR4
EX4
PR5
EX1
EX1 Pond
EX3
EX2 Pond
EX2
PR2
PR3
PR4
PR5
EX1
EX2
Medium Density Res. No Alleys-PR1-SW
Parks-PR1-NS
Medium Density Res. No Alleys-PR1-S
Misc. Institutional-PR1-NS
Medium Density Res. No Alleys-PR2-S
Agr-PR2-S
Multi Family Residential-PR2-S
Open Space-PR2-NS
Open Space-PR2-SW
Parks-PR2-NS
Medium Density Res. No Alleys-PR2-NS
Misc. Institutional-PR2-SW
Parks-PR2-SW
Misc. Institutional-PR2-S
Strip Commercial-PR2-S
Schools-PR2-S
Agr-PR2-NS
Schools-PR2-NS
Medium Density Res. No Alleys-PR2-SW
Schools-PR3-SW
Schools-PR3-S
Misc. Institutional-PR3-SW
Downtown Commercial-PR3-SW
Multi Family Residential-PR3-S
Open Space-PR3-S
Open Space-PR3-NS
Open Space-PR3-SW
Shopping Center-PR3-SW
Strip Commercial-PR3-SW
Misc. Institutional-PR4-SW
Strip Commercial-PR4-SW
Low Density Residential-PR4-SW
Light Industrial-PR4-SW
Open Space-PR4-SW
Open Space-PR4-NS
Medium Density Res. No Alley-PR4-S
Multi Family Residential-PR4-SW
Agr-EX4-S
Agr-PR5-NS
Schools-PR5-SW
Agr-PR5-S
Strip Commercial-PR5-S
Low Density Residential-EX4-S
Cemetary-EX1-S
Medium Density Res. No Alleys-EX1-S
Duplex-EX1-NS
Duplex-EX1-S
Open Space_EX1-S
Schools-EX1-NS
Agr-EX2-NS
Medium Density Res. No Alleys-EX2-S
Duplex-EX2-S
Open Space-EX3-S
Medium Density Res. No Alleys-EX3-S
Light Industrial-EX3-NS
Cemetary-EX3-SW
Agr-EX3-NS
Medium Density Res. No Alleys-EX3-SW
Multi Family Residential-EX3-S
N
0 500 1,000 1,500 2,000
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Wet Detention Control Device

Pond Number 1

Drainage System Control Practice

Pond EX1

Select Particle Size Distribution File

Not needed - calculated by program

Initial Stage Elevation (ft):

Peak to Average Flow Ratio: 3.80

Maximum Inflow into Pond (cfs) Enter 0 or leave blank for no limit:

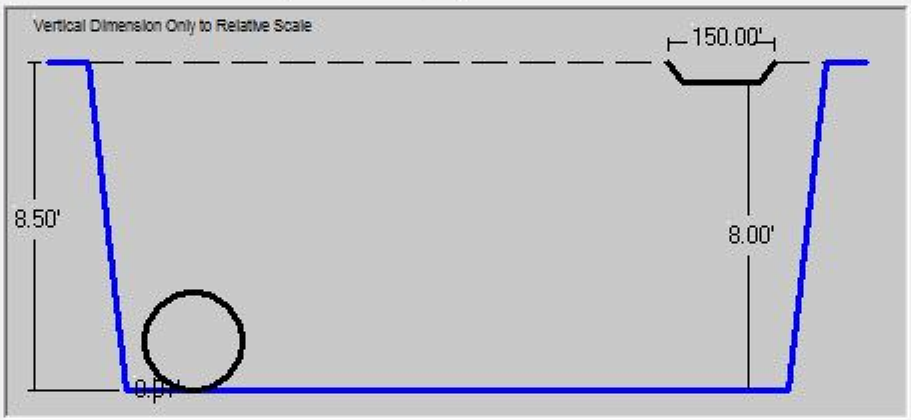
Copy Pond Data | Paste Pond Data

Enter fraction (greater than 0) that you want to modify all pond areas by and then select 'Modify Pond Areas' button: 0.00

Modify Pond Areas

	Stage (ft)	Area (acres)	Cumulative Volume (ac-ft)
0	0.00	0.0000	0.000
1	0.01	0.0010	0.000
2	0.50	0.0250	0.006
3	1.50	0.1140	0.076
4	3.50	0.2360	0.426
5	5.50	0.3650	1.027
6	6.50	0.4320	1.425
7	7.50	0.5000	1.891
8	8.50	0.5710	2.427
9			
10			
11			
12			
13			
14			
15			
16			
17			

Recalculate Cumulative Volume



Delete Pond | Cancel | Continue

Add — Sharp Crested Weir

Weir Length (ft)	
Height from datum to bottom of weir opening (ft)	

Add — V-Notch Weir

Weir Angle (<180 degrees)	
Height from datum to bottom of weir opening (ft)	
Number of V-Notch weirs	

Remove — Orifice Set 1

Orifice Diameter (ft)	2.50
Invert elevation above datum (ft)	0.01
Number of orifices in set	1

Add — Orifice Set 2

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add — Orifice Set 3

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add — Stone Weeper

Width at bottom of weeper (ft)	
Weeper side slope (_H:1V)	
Upstream side slope (_H:1V)	
Downstream side slope (_H:1V)	
Horizontal flow path length at top of weeper (ft)	
Average rock diameter (ft)	
Distance from bottom to top of weeper (ft)	
Height from datum to bottom of weeper (ft)	

Add — Vertical Stand Pipe

Pipe diameter (ft)	
Height above datum (ft)	

Add | Add

Month	Evaporation (in/day)	Water Withdraw Rate (ac-ft/day)
Jan	0.00	0.000
Feb	0.00	0.000
Mar	0.00	0.000
Apr	0.00	0.000
May	0.00	0.000
Jun	0.00	0.000
Jul	0.00	0.000
Aug	0.00	0.000
Sep	0.00	0.000
Oct	0.00	0.000
Nov	0.00	0.000
Dec	0.00	0.000

Add | Add

Stage (ft)	Natural Seepage Rate (in/hr)	Other Outflow Rate (cfs)
0.00	0.00	0.000
0.01	0.00	0.000
0.50	0.00	0.000
1.50	0.00	0.000
3.50	0.00	0.000
5.50	0.00	0.000
6.50	0.00	0.000

Remove — Broad Crested Weir (Required)

Weir crest length (ft)	150.00
Weir crest width (ft)	6.00
Height from datum to bottom of weir opening (ft)	8.00

Add — Seepage Basin

Infiltration rate (in/hr)	
Width of device (ft)	
Length of device (ft)	
Invert elevation of seepage basin inlet above datum (ft)	

Control Practice # : 9 | CP Index # : 1

Wet Detention Control Device

Pond Number 3

Drainage System Control Practice

Pond EX2

Select Particle Size Distribution File

Not needed - calculated by program

Initial Stage Elevation (ft):

Peak to Average Flow Ratio: 3.80

Maximum Inflow into Pond (cfs) Enter 0 or leave blank for no limit:

Copy Pond Data | Paste Pond Data

Enter fraction (greater than 0) that you want to modify all pond areas by and then select 'Modify Pond Areas' button: 0.00

Modify Pond Areas

	Stage (ft)	Area (acres)	Cumulative Volume (ac-ft)
0	0.00	0.0000	0.000
1	0.01	0.1360	0.001
2	0.02	0.1360	0.002
3	1.00	0.2110	0.172
4	2.00	0.2860	0.421
5	2.01	0.2860	0.423
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Recalculate Cumulative Volume

Delete Pond | **Cancel** | **Continue**

Add **Sharp Crested Weir**

Weir Length (ft)	
Height from datum to bottom of weir opening (ft)	

Add **V-Notch Weir**

Weir Angle (<180 degrees)	
Height from datum to bottom of weir opening (ft)	
Number of V-Notch weirs	

Remove **Orifice Set 1**

Orifice Diameter (ft)	2.00
Invert elevation above datum (ft)	0.01
Number of orifices in set	1

Add **Orifice Set 2**

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add **Orifice Set 3**

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add **Stone Weeper**

Width at bottom of weeper (ft)	
Weeper side slope (_H:1V)	
Upstream side slope (_H:1V)	
Downstream side slope (_H:1V)	
Horizontal flow path length at top of weeper (ft)	
Average rock diameter (ft)	
Distance from bottom to top of weeper (ft)	
Height from datum to bottom of weeper (ft)	

Add **Vertical Stand Pipe**

Pipe diameter (ft)	
Height above datum (ft)	

Add | Add

Month	Evaporation (in/day)	Water Withdraw Rate (ac-ft/day)
Jan	0.00	0.000
Feb	0.00	0.000
Mar	0.00	0.000
Apr	0.00	0.000
May	0.00	0.000
Jun	0.00	0.000
Jul	0.00	0.000
Aug	0.00	0.000
Sep	0.00	0.000
Oct	0.00	0.000
Nov	0.00	0.000
Dec	0.00	0.000

Add | Add

Stage (ft)	Natural Seepage Rate (in/hr)	Other Outflow Rate (cfs)
0.00	0.00	0.000
0.01	0.00	0.000
0.02	0.00	0.000
1.00	0.00	0.000
2.00	0.00	0.000
2.01	0.00	0.000
0.00	0.00	0.000

Remove **Broad Crested Weir (Required)**

Weir crest length (ft)	10.00
Weir crest width (ft)	10.00
Height from datum to bottom of weir opening (ft)	1.99

Add **Seepage Basin**

Infiltration rate (in/hr)	
Width of device (ft)	
Length of device (ft)	
Invert elevation of seepage basin inlet above datum (ft)	

Control Practice # : 135 | CP Index # : 3

Wet Detention Control Device

Pond Number 2

Drainage System Control Practice

Pond EX3

Select Particle Size Distribution File

Not needed - calculated by program

Initial Stage Elevation (ft): 8.00

Peak to Average Flow Ratio: 3.80

Maximum Inflow into Pond (cfs) Enter 0 or leave blank for no limit:

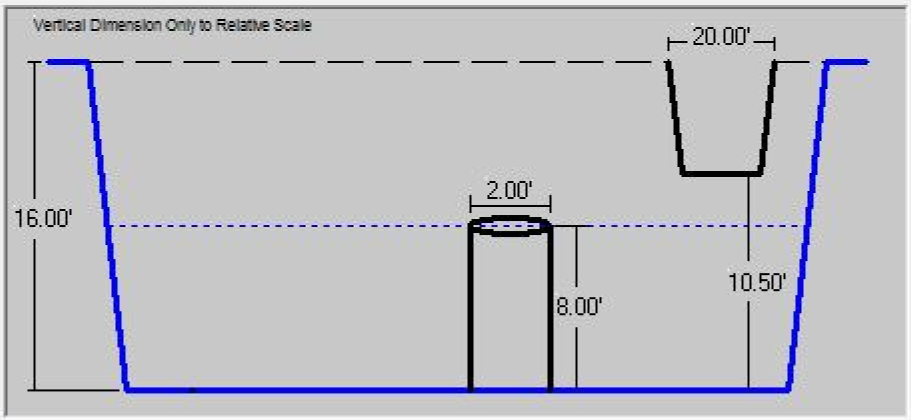
Copy Pond Data | Paste Pond Data

Enter fraction (greater than 0) that you want to modify all pond areas by and then select 'Modify Pond Areas' button: 0.00

Modify Pond Areas

	Stage (ft)	Area (acres)	Cumulative Volume (ac-ft)
0	0.00	0.0000	0.000
1	0.01	0.1500	0.001
2	3.00	0.3450	0.741
3	5.00	0.6420	1.728
4	7.00	0.9380	3.308
5	9.00	1.2550	5.501
6	11.00	1.5710	8.327
7	13.00	1.7630	11.661
8	15.00	1.9540	15.378
9	16.00	2.0000	17.355
10			
11			
12			
13			
14			
15			
16			
17			

Recalculate Cumulative Volume



Delete Pond | Cancel | Continue

Add **Sharp Crested Weir**

Weir Length (ft)	
Height from datum to bottom of weir opening (ft)	

Add **V-Notch Weir**

Weir Angle (<180 degrees)	
Height from datum to bottom of weir opening (ft)	
Number of V-Notch weirs	

Add **Orifice Set 1**

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add **Orifice Set 2**

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add **Orifice Set 3**

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add **Stone Weeper**

Width at bottom of weeper (ft)	
Weeper side slope (_H:1V)	
Upstream side slope (_H:1V)	
Downstream side slope (_H:1V)	
Horizontal flow path length at top of weeper (ft)	
Average rock diameter (ft)	
Distance from bottom to top of weeper (ft)	
Height from datum to bottom of weeper (ft)	

Remove **Vertical Stand Pipe**

Pipe diameter (ft)	2.00
Height above datum (ft)	8.00

Add | Add

Month	Evaporation (in/day)	Water Withdraw Rate (ac-ft/day)
Jan	0.00	0.000
Feb	0.00	0.000
Mar	0.00	0.000
Apr	0.00	0.000
May	0.00	0.000
Jun	0.00	0.000
Jul	0.00	0.000
Aug	0.00	0.000
Sep	0.00	0.000
Oct	0.00	0.000
Nov	0.00	0.000
Dec	0.00	0.000

Add | Add

Stage (ft)	Natural Seepage Rate (in/hr)	Other Outflow Rate (cfs)
0.00	0.00	0.000
0.01	0.00	0.000
3.00	0.00	0.000
5.00	0.00	0.000
7.00	0.00	0.000
9.00	0.00	0.000
11.00	0.00	0.000

Remove **Broad Crested Weir (Required)**

Weir crest length (ft)	20.00
Weir crest width (ft)	20.00
Height from datum to bottom of weir opening (ft)	10.50

Add **Seepage Basin**

Infiltration rate (in/hr)	
Width of device (ft)	
Length of device (ft)	
Invert elevation of seepage basin inlet above datum (ft)	

Control Practice #: 26 | CP Index #: 2

Wet Detention Control Device

Pond Number 2

Drainage System Control Practice

Pond EX3 - Proposed Retrofit

Select Particle Size Distribution File

Not needed - calculated by program

Initial Stage Elevation (ft): 8.00

Peak to Average Flow Ratio: 3.80

Maximum Inflow into Pond (cfs) Enter 0 or leave blank for no limit:

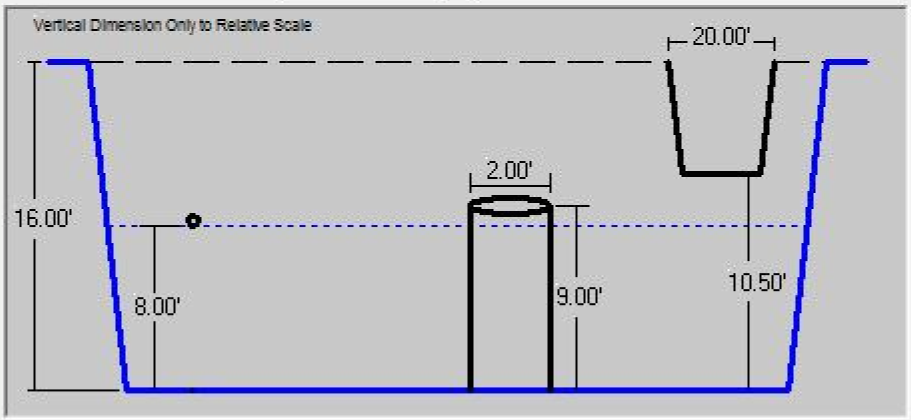
Copy Pond Data | Paste Pond Data

Enter fraction (greater than 0) that you want to modify all pond areas by and then select 'Modify Pond Areas' button: 0.00

Modify Pond Areas

	Stage (ft)	Area (acres)	Cumulative Volume (ac-ft)
0	0.00	0.0000	0.000
1	0.01	0.1500	0.001
2	3.00	0.3450	0.741
3	5.00	0.6420	1.728
4	7.00	0.9380	3.308
5	9.00	1.2550	5.501
6	11.00	1.5710	8.327
7	13.00	1.7630	11.661
8	15.00	1.9540	15.378
9	16.00	2.0000	17.355
10			
11			
12			
13			
14			
15			
16			
17			

Recalculate Cumulative Volume



Delete Pond | Cancel | Continue

Add — Sharp Crested Weir

Weir Length (ft)	
Height from datum to bottom of weir opening (ft)	

Add — V-Notch Weir

Weir Angle (<180 degrees)	
Height from datum to bottom of weir opening (ft)	
Number of V-Notch weirs	

Remove — Orifice Set 1

Orifice Diameter (ft)	0.50
Invert elevation above datum (ft)	8.00
Number of orifices in set	1

Add — Orifice Set 2

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add — Orifice Set 3

Orifice Diameter (ft)	
Invert elevation above datum (ft)	
Number of orifices in set	

Add — Stone Weeper

Width at bottom of weeper (ft)	
Weeper side slope (_H:1V)	
Upstream side slope (_H:1V)	
Downstream side slope (_H:1V)	
Horizontal flow path length at top of weeper (ft)	
Average rock diameter (ft)	
Distance from bottom to top of weeper (ft)	
Height from datum to bottom of weeper (ft)	

Remove — Vertical Stand Pipe

Pipe diameter (ft)	2.00
Height above datum (ft)	9.00

Add | Add

Month	Evaporation (in/day)	Water Withdraw Rate (ac-ft/day)
Jan	0.00	0.000
Feb	0.00	0.000
Mar	0.00	0.000
Apr	0.00	0.000
May	0.00	0.000
Jun	0.00	0.000
Jul	0.00	0.000
Aug	0.00	0.000
Sep	0.00	0.000
Oct	0.00	0.000
Nov	0.00	0.000
Dec	0.00	0.000

Add | Add

Stage (ft)	Natural Seepage Rate (in/hr)	Other Outflow Rate (cfs)
0.00	0.00	0.000
0.01	0.00	0.000
3.00	0.00	0.000
5.00	0.00	0.000
7.00	0.00	0.000
9.00	0.00	0.000
11.00	0.00	0.000

Remove — Broad Crested Weir (Required)

Weir crest length (ft)	20.00
Weir crest width (ft)	20.00
Height from datum to bottom of weir opening (ft)	10.50

Add — Seepage Basin

Infiltration rate (in/hr)	
Width of device (ft)	
Length of device (ft)	
Invert elevation of seepage basin inlet above datum (ft)	

Control Practice # : 26 | CP Index # : 2

Biofiltration Control Device **EX4 Rain Garden**

Drainage System Control Practice

Device Properties — Biofilter Number 1

Top Area (sf)	14080
Bottom Area (sf)	3905
Total Depth (ft)	4.10
Typical Width (ft) (Cost est. only)	10.00
Native Soil Infiltration Rate (in/hr)	0.500
Native Soil Infiltration Rate COV	N/A
Infil. Rate Fraction-Bottom (0.001-1)	1.000
Infil. Rate Fraction-Sides (0.001-1)	1.000
Rock Filled Depth (ft)	2.00
Rock Fill Porosity (0-1)	0.33
Engineered Media Type	Media Data
Engineered Media Infiltration Rate	3.60
Engineered Media Infiltration Rate COV	N/A
Engineered Media Depth (ft)	1.00
Engineered Media Porosity (0-1)	0.27
Percent solids reduction due to Engineered Media (0 -100)	N/A
Inflow Hydrograph Peak to Average Flow Ratio	3.80
Number of Devices in Source Area or Upstream Drainage System	1

Activate Pipe or Box Storage ( ) Pipe ( ) Box

Diameter (ft)	
Length (ft)	
Within Biofilter (check if Yes)	
Perforated (check if Yes)	
Bottom Elevation (ft above datum)	
Discharge Orifice Diameter (ft)	

Select Native Soil Infiltration Rate

- Sand - 8 in/hr
- Loamy sand - 2.5 in/hr
- Sandy loam - 1.0 in/hr
- Loam - 0.5 in/hr
- Silt loam - 0.3 in/hr
- Sandy silt loam - 0.2 in/hr
- Clay loam - 0.1 in/hr
- Silty clay loam - 0.05 in/hr
- Sandy clay - 0.05 in/hr
- Silty clay - 0.04 in/hr
- Clay - 0.02 in/hr
- Rain Barrel/Cistern - 0.00 in/hr

Select Particle Size File — Not needed - calculated by program

Remove — Sharp Crested Weir

Weir Length (ft)	100.00
Height from datum to bottom of weir opening (ft)	3.50

Remove — Broad Crested Weir-Reqrd

Weir crest length (ft)	10.00
Weir crest width (ft)	10.00
Height from datum to bottom of weir opening (ft)	3.00

Add — Vertical Stand Pipe

Pipe diameter (ft)	
Height above datum (ft)	

Add — Surface Discharge Pipe

Pipe Diameter (ft)	
Invert elevation above datum (ft)	
Number of pipes at invert elev.	

Remove — Drain Tile/Underdrain

Pipe Diameter (ft)	0.33
Invert elevation above datum (ft)	1.33
Number of pipes at invert elev.	1

Use Random Number Generation to Account for Infiltration Rate Uncertainty

0.00 Initial Water Surface Elevation (ft)

Est. Surface Drain Time = 12.2 hrs.

Copy Biofilter Data

Paste Biofilter Data

Add — Other Outlet

Stage Number	Stage (ft)	Other Outflow Rate (cfs)
1		
2		
3		
4		
5		

Add — Evapotranspiration

Soil porosity (saturation moisture content, 0-1)	
Soil field moisture capacity (0-1)	
Permanent wilting point (0-1)	
Supplemental irrigation used?	
Fraction of available capacity when irrigation starts (0-1)	
Fraction of available capacity when irrigation stops (0-1)	

Evaporation — Add

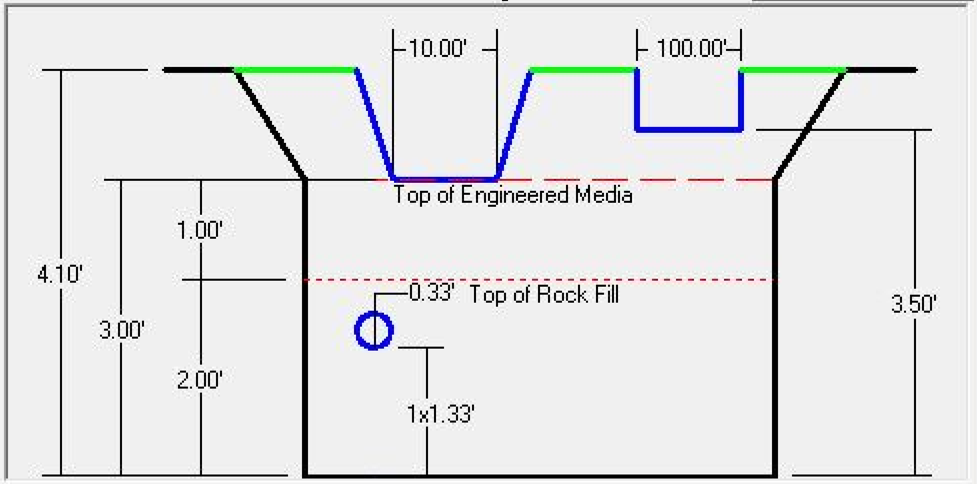
Month	Evapotranspiration (in/day)	Evaporation (in/day)
Jan		
Feb		
Mar		
Apr		
May		
Jun		
Jul		
Aug		
Sep		
Oct		
Nov		
Dec		

Plant Types

	1	2	3	4
Fraction of biofilter that is vegetated				
Plant type				
Root depth (ft)				
ET Crop Adjustment Factor				

Biofilter Geometry Schematic

Refresh Schematic



Delete Cancel Continue

Control Practice # : 141 CP Index # : 4

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Existing Conditions\00080036 Lodi WinSLAMM Existing with pond data 030416.mdb

Existing Conditions Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	5.806E+06	2.44 %	0.17	112.2	40651	24.47 %
Current File Output: Annualized Total After Outfall Controls	5.821E+06	Years in Model Run:	1.00		40763	

Pollutant	Concentration - No Controls	Concentration - With Controls	Concentration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	112.2	mg/L	53823	40651	lbs	24.47 %
Total Phosphorus	0.6178	0.5293	mg/L	229.5	191.8	lbs	16.41 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac)

299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.17	Fair

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Proposed\PR1.mdb

PR1 Model Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	5.469E+06	8.10 %	0.16	109.4	37362	30.58 %
Current File Output: Annualized Total After Outfall Controls	5.484E+06	Years in Model Run:	1.00		37465	

Pollutant	Concen-tration - No Controls	Concen-tration - With Controls	Concen-tration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	109.4	mg/L	53823	37362	lbs	30.58 %
Total Phosphorus	0.6178	0.5197	mg/L	229.5	177.4	lbs	22.70 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac): 299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.16	Fair

Land Uses | Junctions | Control Practices

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Proposed\PR2.mdb

PR2 Model Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	4.200E+06	29.42 %	0.12	101.0	26484	50.79 %
Current File Output: Annualized Total After Outfall Controls	4.212E+06	Years in Model Run:	1.00		26557	

Pollutant	Concentration - No Controls	Concentration - With Controls	Concentration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	101.0	mg/L	53823	26484	lbs	50.79 %
Total Phosphorus	0.6178	0.5224	mg/L	229.5	137.0	lbs	40.32 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac): 299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.12	Good

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Proposed\PR3.mdb

PR3 Model Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	5.431E+06	8.74 %	0.16	111.9	37928	29.53 %
Current File Output: Annualized Total After Outfall Controls	5.446E+06	Years in Model Run:	1.00		38032	

Pollutant	Concen-tration - No Controls	Concen-tration - With Controls	Concen-tration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	111.9	mg/L	53823	37928	lbs	29.53 %
Total Phosphorus	0.6178	0.5347	mg/L	229.5	181.3	lbs	21.02 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac)

299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.16	Fair

Land Uses | Junctions | Control Practices

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Proposed\PR4.mdb

PR4 Model Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	5.166E+06	13.19 %	0.15	108.9	35107	34.77 %
Current File Output: Annualized Total After Outfall Controls	5.180E+06	Years in Model Run:	1.00		35203	

Pollutant	Concen-tration - No Controls	Concen-tration - With Controls	Concen-tration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	108.9	mg/L	53823	35107	lbs	34.77 %
Total Phosphorus	0.6178	0.5258	mg/L	229.5	169.6	lbs	26.12 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac): 299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.15	Fair

Land Uses | Junctions | Control Practices

File Name:

P:\80s\80\00080036\Calculations\WinSLAMM\Proposed\PR5.mdb

PR5 Model Output Summary

Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of All Land Uses without Controls	5.951E+06		0.17	144.9	53823	
Outfall Total with Controls	4.639E+06	22.05 %	0.13	107.8	31225	41.99 %
Current File Output: Annualized Total After Outfall Controls	4.652E+06	Years in Model Run:	1.00		31310	

Pollutant	Concen-tration - No Controls	Concen-tration - With Controls	Concen-tration Units	Pollutant Yield - No Controls	Pollutant Yield - With Controls	Pollutant Yield Units	Percent Yield Reduction
Particulate Solids	144.9	107.8	mg/L	53823	31225	lbs	41.99 %
Total Phosphorus	0.6178	0.4945	mg/L	229.5	143.2	lbs	37.61 %

Print Output Summary to Text File

Print Output Summary to .csv File

Total Area Modeled (ac)

299.678

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Outfall Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.17	Fair
With Controls	0.13	Fair

Appendix G

Rural Critical Source Area SnapPlus Modeling

APPENDIX G

Rural Critical Source Area SnapPlus Modeling

1.1 INTRODUCTION

In order for the City of Lodi to successfully implement Adaptive Management, the City will likely need to implement a combination of phosphorus reduction strategies throughout the Spring Creek Action Area. This includes the implementation of agricultural conservation practices on local crop fields and pastures. Currently, one of the best models for quantifying phosphorus load reductions from the rural landscape is SnapPlus. SnapPlus (Soil Nutrient Application Planner) is a publically available computer software program that was developed by researchers at the University of Wisconsin - Madison Department of Soil Science. The model was specifically created to help agricultural producers, crop consultants, and regulators develop Nutrient Management Plans in accordance with Wisconsin's NRCS 590 Nutrient Management Standard. The purpose of a Nutrient Management Plan is to aid an agricultural producer in selecting the proper amount, source, placement, form, and timing of nutrient applications on their farm. The primary goals of Nutrient Management Planning are to optimize the economic return from fertilizer applications, promote soil conservation, and to protect water quality of nearby water resources.

Nutrient recommendations in SnapPlus are made on a field-by-field basis for N, P_2O_5, and K_2O using recommendations from the University of Wisconsin – Extension Publication A2809. Inputs to SnapPlus include field slope, soil type, soil sampling results, crop rotations, tillage practices, and manure and fertilizer applications. SnapPlus uses these inputs and incorporates several models, including the Revised Soil Loss Equation Version 2 (RUSLE2) and the Wisconsin Phosphorus Index (PI), to estimate average annual sediment and phosphorus loadings from crop fields and pastures. Specifically, SnapPlus can be used to model phosphorus reductions from reduced tillage practices, contour farming, contour strip cropping, contour buffer strips, edge-of-field filter strips, manure incorporation, cover crops, etc. Phosphorus reductions for BMPs are estimated using SnapPlus's "*P Trade Report*." The P Trade Report estimates the annual mass of phosphorus [lb] which is likely to be transferred from the field to nearby surface waters. SnapPlus estimates phosphorus losses based a field's predominant soil type, soil test phosphorus concentration, crop rotation, tillage, and other nutrient management practices. The model only estimates losses from sheet and rill erosion. Losses from concentrated flow areas or gully erosion are not included in the calculations.

1.2 METHODS

For the purposes this report, SnapPlus modeling was performed on only one farm in the Spring Creek Action Area. This was due to limitations to the project scope and budget. SnapPlus modeling requires a significant amount of data inputs and is time consuming compared to models which estimate phosphorus losses at the watershed scale (e.g. STEPL). Since the budget for SnapPlus modeling was limited at this stage of the project, it was important to select a landowner who owned and operated land which was representative of other farms in the action area. The farm which was chosen for SnapPlus modeling included three different tracts which were located in three topographically different areas of the Action Area. One of the three tracts which was analyzed with SnapPlus was identified as a critical source area (CSA) of phosphorus using the EVAAL model. The farm included crop fields and pastures which were believed to be representative of other crop fields and pastures in the watershed. In addition, the

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landowner kept sufficient records of soil test results, nutrient applications, etc. which were needed to estimate phosphorus load reductions for various BMPs.

Using the P Trade Report in SnapPlus, a series of realistic BMP combinations were modeled for the site to determine the phosphorus reduction potential for the farm. In order to use the P trade report, it was first necessary to create a baseline condition to which other BMP scenarios could be compared. To create this baseline condition, the modeler and farm operator re-created 5 years of past cropping practices and nutrient applications in SnapPlus. Historical management was then projected five years into the future to estimate the average annual phosphorus losses which would occur without implementing additional BMPs on the farm's cropland. Once the baseline condition was established using the P Trade Report, five separate BMP scenarios were modeled in SnapPlus:

- Scenario #1 – Cover Crops
- Scenario #2 – Contour Farming
- Scenario #3 – Edge-of-Field Filter Strips
- Scenario #4 – Contour Farming & Edge-of-Field Filter Strips
- Scenario #5 – Rotational Grazing

BMPs which were chosen for this analysis were selected and modeled based on the modeler's perceived benefit of the BMP for a given field and the landowner's interest in certain practices. BMPs were not applied to fields where there was no apparent benefit to the environment or if the landowner was not interested in the practice. It should be noted that the landowner who operates the farm already implements several BMPs on the farm, including extensive no-till and occasional cover crops. For this reason, certain conservation practices (e.g. reduced tillage) were not practical for this site.

1.3 RESULTS

The results of the SnapPlus modeling are shown in **Table 1** and **Table 2** below. **Table 1** summarizes the farm's predicted baseline phosphorus loss for the next 5 years (2016-2017). As shown, the farm is predicted to export a total of 518 lb/yr of phosphorus to nearby surface waters, if no additional improvements are made to the farm. Approximately 457 lb/yr (0.9 lb/ac/yr) are expected to come from the landowner's crop fields, and approximately 61 lb/yr (0.6 lb/ac/yr) are expected from pastures.

Table 1: Average Annual Baseline Phosphorus Losses for 2016 - 2020 (assumes no additional BMPs)

Land Use	*Avg. Phosphorus Loss (lb/yr)*	*Avg. Phosphorus Loss (lb/ac/yr)*
Crop Field	457	0.9
Pasture	61	0.6
All Fields	518	0.8

Table 2 summarizes the amount of phosphorus which could be prevented from entering nearby waters if additional BMPs were implemented. The management strategies which would result in the most phosphorus reduction for the farm are Scenario #4 (contour farming & edge-of-field filter strips) and Scenario #5 (rotational grazing). If both of these strategies were implemented, approximately 64 lb/yr (53 lb/yr + 11 lb/yr = 64 lb/yr) of phosphorus production could be achieved.

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It is interesting to note that additional implementation of cover crops on the farm actually results in more phosphorus loss. This result was likely due to an increase in modeled soil loss which was caused by the soil disturbance from the no-till drill which was used to seed the cover crop. This situation was likely site-specific and attributable to the landowner's extensive use of no-till management. Therefore, phosphorus load reductions may still be achievable in other areas of the watershed by implementing cover crops, especially if the farm does not incorporate no-till.

Table 2: Average Phosphorus Load Reductions for Each BMP Management Scenario

Management Scenario	*Avg. Phosphorus Load Reduction (lb/yr)*	*Avg. Phosphorus Load Reduction (lb/ac/yr)*
#1 - Cover Crops	-15	-0.1
#2 - Contour Farming	35	0.2
#3 - Edge-of-Field Filter Strip	27	0.2
#4 - Contour Farming & Edge-of-Field Filter Strips	53	0.3
#5 - Rotational Grazing (Pastures)	11	0.1

As shown in **Table 2**, the projected phosphorus load reductions for all BMP management scenarios are ≤ 0.3 lb/ac/yr. This result was somewhat unexpected. It was expected that much larger phosphorus reductions could be achieved since the landowner incorporates continuous row crops (corn and soybeans) on the majority of the farm's crop fields. The results suggest that the landowner's implementation of no-till and appropriate use of cover crops have done a substantial job in preventing phosphorus losses from the farm. The important take home message is that implementing additional BMPs on lands which are already operated properly may not result in large phosphorus reductions. Moving forward, it would be in the City of Lodi's best interest to specifically target lands in the Spring Creek Action area which do not implement no-till or cover crops. It is likely that phosphorus reductions of greater than 0.3 lb/ac/yr can be realized for CSAs in the Action Area that do not already incorporate these BMPs. For these areas, load reductions on the order of 1.0 lb/ac/yr or more may be realized.

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Appendix H

Form 3200-139 (1/12) – Watershed Adaptive Management Request

State of Wisconsin
Department of Natural Resources
Bureau of Watershed Management
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Watershed Adaptive Management Request

Form 3200-139 (1/12)

Notice: Pursuant to s. NR 217.18, Wis. Adm. Code, this form must be completed and submitted to the Department at the time of the reissuance of an existing WPDES (Wisconsin pollutant discharge elimination system) permit to request adaptive management for phosphorus water quality based effluent limits (WQBEL).Failure to provide all requested information may result in denial of your request. Personal information collected will be used for administrative purposes and may be provided to requestors to the extent required by Wisconsin Open Records law [ss. 19.31-19.39, Wis. Stats.].

Type of Request:

☒ This is the formal adaptive management request as required in s. NR 217.18(2)

☐ This is a preliminary adaptive management request (to be submitted as part of facility planning.)

Facility and Permit Information

Facility Name	WPDES Permit No.
CITY OF LODI WASTEWATER TREATMENT FACILITY	WI-0022918-08-0

Facility Address	City	State	ZIP Code
707 FAIR ST.	LODI	WI	53555

Receiving Water: SPRING CREEK - LW19 - LOWER WISCONSIN RIVER BASIN

Owner Contact Information

Last Name	First Name	MI	Phone No. (incl. area code)
BUHR	KENNAN		608-592-3247

Street Address	FAX Number
130 SOUTH MAIN ST.	608-592-3271

City	State	ZIP Code	Email address
LODI	WI	53555	Kbuhr@wppienergy.org

Facility Information

Provide listed information for each lagoon or pond basin

Required for AM Request	Wis. Administrative Code Reference	Conclusion	Evidence/Source of information (attach as needed)
1. NPS contribute at least 50% of total P contribution	s. NR 217.18(2)(b)	☒ NPS contributes at least 50% ☐ NPS DOES NOT contribute at least 50%	HISTORIC SAMPLING DATA, PRESTO OUTPUT, SEE AM PLAN
2. WQBEL Requires Filtration	s. NR 217.18(2)(c)	☒ Filtration required ☐ Filtration NOT required	STRINGENT LIMIT OF 0.075 mg/L
3. AM Plan	s. NR 217.18(2)(d)	☒ Plan is Included – Page 3 ☐ Plan is NOT Included *For a preliminary adaptive management request, AM plan not required*	

Facility Operation and Performance

1. **Current P removal capability** – If the facility is currently required by a WPDES permit to monitor effluent phosphorus (P) provide a summary of the influent and effluent annual average P concentrations for each of the past three (3) years. If permit required P data is not available, the applicant should provide any other P data that may be applicable and available. If no data is available, the Department may estimate the P effluent concentration by based on data from other similar facilities.

SEE "CITY OF LODI PRELIMINARY COMPLIANCE ALTERNATIVES PLAN," OCTOBER 2014

2. **Facility Operation** – Provide a summary description of overall facility operation. If not a continuously discharging facility, describe storage procedures and the time periods when effluent discharge occurs.

- SEE "CITY OF LODI PRELIMINARY COMPLIANCE ALTERNATIVES PLAN," OCTOBER 2014

3. **Previous Studies** – Reference or attach any facility planning or evaluation study that evaluated facility performance capabilities (Note – Only include studies that are recent, within 5 years, or otherwise applicable for the evaluation of the existing facility and current conditions).

- SEE "CITY OF LODI PRELIMINARY COMPLIANCE ALTERNATIVES PLAN," (APPENDICES), OCTOBER 2014

Adaptive Management Plan (s. NR 217.18(d))

This section should summarize the Adaptive Management Plan for internal and external review. A complete Adaptive Management Plan should be attached. Note: If this is a preliminary adaptive management request, this section is not required.

Watershed	Percent Contribution of Applicant Discharge
HUC 12: 070700050204 SPRING CREEK - 30,000 ACRES / 47 mi²	9.3% - SEE TABLE 5, SECTION 3.5 OF AM PLAN

Action Area (Include map) - PORTION OF HUC 12 - UPSTREAM OF WWTF OUTFALL
22,282 ACRES, 35 mi² SEE FIGURE 1 OF AM PLAN

Watershed Characteristics and Timeline Justification
PRIMARILY AGRICULTURAL AND MARSH, FOREST, URBAN. SEE TABLE 7 OF AM PLAN

Key Proposed Actions
HARD PRACTICES (BARNYARD IMPROVEMENTS) FOR 7 CSAs (LONG TERM)
SOFT PRACTICES (BUFFERS, NMP, TILLAGE MODIFICATIONS, ETC) FOR 16 CSAs (LONG TERM)

Key Goals and Measures for Determining Effectiveness

- STREAM MONITORING UPSTREAM & DOWNSTREAM OF WWTF
- POTENTIAL CONTINUATION OF AUTOMATED STORM EVENT MONITORING
- GOAL: HARD PRACTICE REDUCTION OF 672 LB/YEAR, SOFT PRACTICE REDUCTION OF 341 LB/YEAR BY END OF FIRST PERMIT TERM
- GOAL: IMPLEMENT HARVESTABLE BUFFER PROGRAM W/ DANE & COLUMBIA COUNTIES.
- SEE AM PLAN FOR ADDITIONAL DETAIL.

Partner(s) SEE CHAPTER 2 OF AM PLAN

Funding Sources
CITY OF CODI, COLUMBIA/DANE COUNTY, TRM, EQIP, NRCS, USDA RCPP, PRIVATE SOURCES

Adaptive Management Request and Certification

Based on the information provided, I am requesting the Watershed Adaptive Management option to achieve compliance with phosphorus water quality standards in accordance with s. NR 217.19, Wis. Adm. Code.
I certify that the information provided with this request is true, accurate and complete to the best of my knowledge.

Print or type name of person submitting request*	Title
PATRICK S. MORROW, P.E.	SENIOR PROJECT ENGINEER MSA PROFESSIONAL SERVICES
Signature of Official	Date Signed
Kenman Bethr	3-28-16

*Must be an Authorized Representative for the treatment facility