2017
Annual Report

Illinois CREP

Conservation Reserve Enhancement Program

TABLE OF CONTENTS

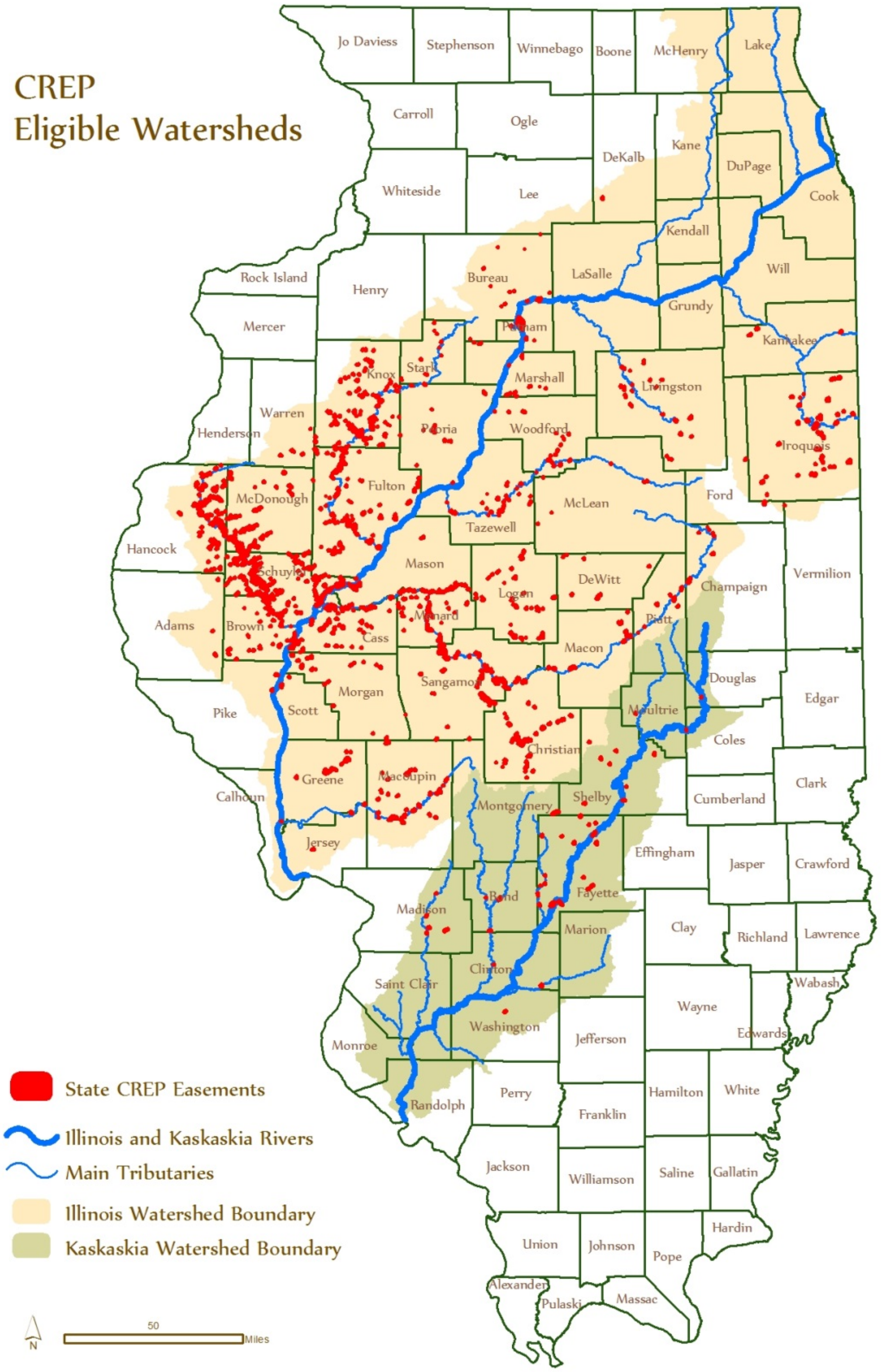
APPENDICES

Appendix A: Monitoring and Assessment of Aquatic Life in the Kaskaskia River for evaluating IDNR Private Lands Programs: Phase II
Illinois Natural History Survey

Appendix B: Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois River: Illinois River Conservation Reserve Enhancement Program (CREP)
Illinois State Water Survey

Appendix C: Sediment and Nutrient Monitoring at Selected Watersheds within the Kaskaskia River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP)
Illinois State Water Survey

CREP ELIGIBLE AREA AND EXECUTED EASEMENTS



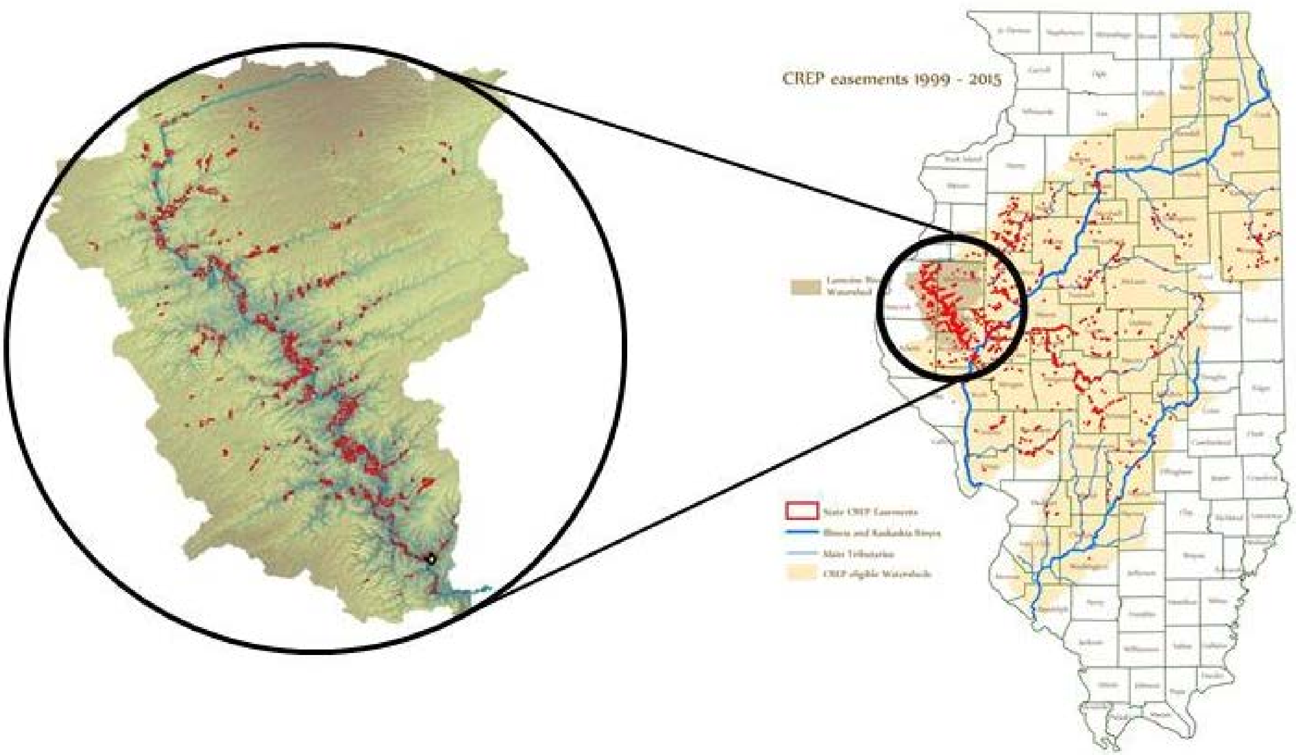
EXECUTIVE SUMMARY

The Illinois Conservation Reserve Enhancement Program (CREP) is a state incentive program tied to the Federal Conservation Reserve Program (CRP). CREP provides long term environmental benefits by allowing 232,000 acres of eligible environmentally sensitive lands within the Illinois and Kaskaskia River Watersheds to be restored, enhanced, and protected over periods ranging from 15 years to perpetuity. This program is a prime example of how partnerships between landowners, governmental entities, and non-governmental organizations can network to address watershed quality concerns.

Having worked hand-in-hand with USDA over the years, Illinois CREP has been instrumental in facilitating the ongoing restoration and management efforts within the Illinois and Kaskaskia River Watersheds. To achieve the goal of improving water quality within the targeted watersheds CREP has utilized a variety of Best Management Practices (BMP's) designed to protect and restore miles of riparian corridors. CREP is one of the many tools used by IDNR conservation partners to implement the IDNR Illinois Comprehensive Wildlife Action Plan (IWAP), which provides a framework for the restoration of critical habitats, increasing plant diversity and expanding habitat for species in greatest need of conservation on an agricultural dominated landscape.

Due to the lack of a state budget for Fiscal Years 2016, 2017 and 2018 the Illinois Department of Natural Resources is unable to offer state options under the Conservation Reserve Enhancement Program. Therefore the FSA and IDNR has temporarily suspended CREP enrollment (as of preparation of this report CREP is still suspended) Currently there are 126,805 acres enrolled in Federal CREP contracts at an average rental rate of $212.30 per acre. The State has been successful in executing 1,408 CREP easements protecting 90,990 acres.

CREP's overall success is notably highlighted by the response within the watershed of the Lamoine River, a major tributary of the Illinois River (see map below). Overall, there are 3,271 miles of streams within the watershed, spread out over five counties. 326 long-term CREP Easements, adding up to over 25,500 acres of protected land, have been established in the area and more than 50% of those acres were converted from cropland. The Lamoine River itself is approximately 131 miles long, with 92 miles flowing directly through or alongside CREP properties. In other words, 70% of the main river is under long-term protection providing a valuable riparian corridor of wildlife habitat while also significantly contributing to the overall water quality improvement in the Illinois River.



Illinois CREP Timeline

CREP is a federal-state program that was created by a Memorandum of Agreement (MOA) between the U.S. Department of Agriculture, the Commodity Credit Corporation, and the State of Illinois in March 1998. Enrollments into this program began on May 1, 1998. The MOU was amended several times during the early years to clarify terms, increase the number of practices offered, and to expand the eligible area.

In 2005 the IDNR, in cooperation with other conservation partners, initiated the implementation of The Illinois Comprehensive Wildlife Action Plan (ICWAP). The ICWAP's goals are to use consistent science-based natural resource management principles, to increase the amount and quality of habitat available to support Illinois' native plant and animal species and other game species; promote their population viability, and regulate the recreational, commercial, and scientific utilization of those species; to ensure their long-term persistence and abundance and provide for their appreciation and enjoyment by future generations of Illinoisans while also expanding the frontiers of natural resource management. CREP easements which lie within the ICWAP's priority areas will provide long term protection of quality habitats identified by the ICWAP's goals.

Due to insufficient State funds the Illinois CREP was temporarily closed to open enrollment in November 2007. However, monitoring and land stewardship continued.

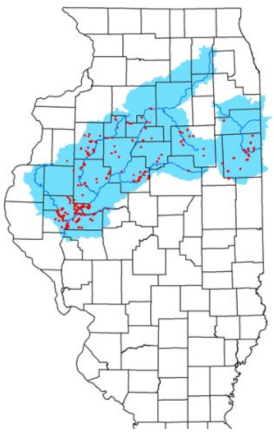
In October 2010, after overwhelming public support The Illinois General Assembly appropriated $45 million to reopen and expand CREP to include the Kaskaskia River Watershed. The USDA, Commodity Credit Corporation, and the State of Illinois subsequently amended their Memorandum of Agreement (MOA) to include the Kaskaskia River Watershed with the Illinois River Watershed.

Since 2010 a total of 159 state easements have been approved in the Kaskaskia and Illinois River Watersheds totaling 13,018 acres; the acres in the Kaskaskia River Watershed totaling 4,708 acres and those in the Illinois Watershed totaling 8,310 acres. The average acreage per enrollment is 81.87 acres.

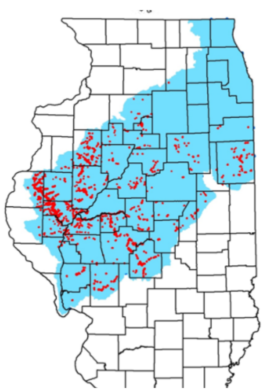
Since the program started in 1998, landowners have voluntarily enrolled 90,990 acres in CREP through 1,408 easements to help improve and restore natural habitats in the Illinois CREP eligible area.

July 1, 2015 - Due to the lack of a state budget, the Illinois Department of Natural Resources is unable to offer state options under the Conservation Reserve Enhancement Program. Therefore the FSA and IDNR temporarily suspended CREP enrollment **(as of preparation of this report CREP is still suspended).**

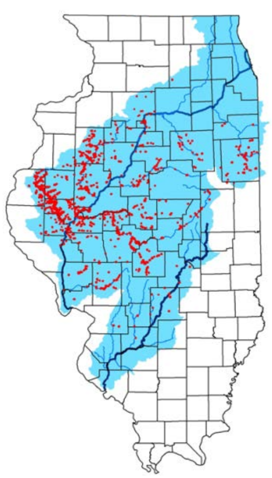
1998 - 2000



1998 - 2007



1998 - 2015



Map images depict the eligible watersheds in blue, and CREP easement locations in red

Recent Outreach, Stewardship, and Monitoring

The county Soil and Water Conservation Districts (SWCD) within the CREP area are the driving force spearheading CREP on the local level. As the Grantee of the CREP Conservation Easements (Easement) the SWCD's continue to enforce the terms of the recorded Easement by conducting compliance monitoring checks and annual land ownership reviews. Monitoring of the CREP Easements is an essential aspect of the overall future of the program. Monitoring not only protects the SWCD as the Grantee but, most importantly, it also protects the landowner from possible violations.

Prior to the suspension of CREP the Illinois Department of Natural Resources (IDNR) had partnered with the Illinois Environmental Protection Agency (IEPA) and the Association of Illinois Soil and Water Conservation Districts (AISWCD) to hire six (6) CREP Resource Specialists. These specialists were dedicated to counties primarily in the Illinois River Watershed to assist the SWCD's with landowner outreach and enrollment. IDNR also partnered with the National Great Rivers Research and Education Center (NGRREC) who were awarded a National Fish and Wildlife Fund Grant to hire four (4) Land Conservation Specialists to market CREP and assist the districts as needed in counties primarily in the Kaskaskia River Watershed. Once CREP is reopened the IDNR and the AISWCD and NGRREC will discuss details to reinstitute the CREP Resource and Land Conservation Specialists initiative.

The State continues to monitor and evaluate sediment and nutrient delivery to the Illinois River. Nutrient and sediment data have been collected since the program's inception in 1999. According to the Illinois State Water Survey's (ISWS) recent data indicates that both sediment and nutrient delivery to the Illinois River has gradually either stabilized or decreased as a result of the implementation of BMP's in the Illinois River watershed. The most significant outcome has been the slow decreasing trend of nitrate-N yield from major tributary watersheds.

The IDNR is also working with Illinois Natural History Survey to maintain a basin-wide monitoring and assessment program for wadeable streams in the Kaskaskia River. Baseline information on aquatic macroinvertebrates (EPT), freshwater mussels, and fish have been collected at selected reaches using a stratified random sampling design to characterize conditions throughout the watershed and provide for long-term trends assessments. Populations of selected species are monitored in focal reaches associated with high biological diversity Biologically Significant Streams BSS reaches) or sensitive taxa enhanced Dissolved Oxygen (DO reaches), Species in Greatest Need of Conservation (SGNC).

The IDNR has worked with the University of Illinois' Critical Trends Assessment Program (CTAP) staff to maintain a biological monitoring program for CREP to assess the conservation practices and wildlife habitat on property enrolled in CREP. CTAP samples the bird communities of forests, grasslands, and wetlands using point-count based methods. During data collection, the presence and abundance of each species seen or heard during the count period is recorded.

The Illinois Nutrient Loss Reduction Strategy (Illinois NLRS) is a framework for using science, technology, and industry experience to assess and reduce nutrient loss to Illinois waters and the Gulf of Mexico. The Illinois NLRS builds upon existing programs to optimize nutrient loss reduction while promoting increased collaboration, research, and innovation among the private sector, academia, non-profits, wastewater agencies, and state and local government. CREP contributions to nutrient loss have been included in baseline reports and will be for all future reports. IDNR has been part of the Agricultural Water Quality Partnership forum, and helping to facilitate the best way to share and aggregate Best Management Practice (BMP) implementation data across agencies, decide which BMP implementation parameters will be tracked (e.g. cover crops, wetlands, buffer strips, etc.) and how the data will be aggregated. The IDNR and CREP program will continue be involved in tracking statewide (and ag ency-wide) progress in accomplishing the INLRS.

Program Expenditures

The Memorandum of Agreement (MOA) for the Illinois CREP details the formula to determine the overall costs of the program: total land retirement costs (which will include the CRP payments made by the Commodity Credit Corporation (CCC) and the easement payments or the bonus payments made by Illinois), the total reimbursement for conservation practices paid by the CCC and Illinois, the total costs of the monitoring program, and the aggregate costs of technical assistance incurred by Illinois for implementing contracts and easements and a reasonable estimate of the cost incurred by the State to develop conservation plans.

Since the CRP contract payments are annual payments spread out over 15 years, a 2.0 percent net present value (NPV)* discount rate (per MOA) was used to compare the CRP payments to the State Easement payments.

Per the current agreement, the State of Illinois must contribute 20% of the total program costs. Based on USDA reports at https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/oct2016summary.pdf IDNR contributed 28.76% of the total program costs based on the following calculations;

$268,391,259.00 (15 years x 71,571 acres x 250.60 avg. rental rate = $268,391,250.00) given to IDNR by USDA FSA** was amended by IDNR to reflect the 2013 re-enrollment of expired CRP acres with perpetual CREP easements ($1,528,283.64),

2016 USDA Report	$268,391,250.00
2013 USDA CREP re-enrollments	($1,528,283.64)
Amended total	$ $266,862,966.36

*-- https://www.whitehouse.gov/wp-content/uploads/2017/11/Appendix-C-revised.pdf

**- – https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/oct2016summary.pdf

CREP Enrollment and Financial Figures

Illinois CREP Summary 1998 - Sept 30, 2017	
Number of Current Federal Contracts - 4,460	Current Federal Acres - 71,571
Number of State Easements - 1,408	Total State Protected Acres - 90,990

Payments 1998 - Sept 30, 2017	IDNR	USDA *	USDA (NPV 2.0) **
Acres Enrolled as of Sept, 30 2017	90,990	71,571	
Total Life of Contract Rent (15 Yrs)		$266,862,966.36	$198,283,114.89
Cost Share		$21,077,916.31	$21,077,916.31
Monitoring[a]	$8,368,975.28		
IEPA CREP Assistants IEPA 319[b]	$2,180,665.94		
Illinois State Enrollments [c]	$71,572,168.41		
IDNR In-Kind Services [d]	$6,421,305.47		

a – Illinois Natural History Survey, National Great Rivers Research and Education Center, Illinois State Water Survey and United States Fish and Wildlife Service.
b – Association of Illinois Soil and Water Conservation Districts CREP Specialists.
c – Landowner Easement Payment, Practice Cost Share, SWCD administrative costs, property survey costs, title and recording fees.
d – IDNR staff personal services associated with CREP enrollment and management.

CREP Contrubution 1998 – Sept 30, 2017	IDNR	IDNR/USDA *	IDNR/USDA **
USDA Total		$287,940,882.67	$219,361,031.20
IDNR Total	$88,543,115.10		
Program Total		$376,483,997.77	$307,904,146.30
% of IDNR Program Contribution		**23.52%**	**28.76%**
IDNR Easement Payments Total	$71,572,168.41	$359,513,051.08	$290,933,199.61
% of IDNR Easement Contribution		19.91%	24.60%

***CRP Monthly Summary – September 2017** https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/September2017Summary.pdf

****Net Present Value (NPV)** https://www.whitehouse.gov/wp-content/uploads/2017/11/Appendix-C-revised.pd

Illinois CREP Goals

The goals for the Illinois CREP were revised in 2010 to reflect the expansion into the Kaskaskia River Basin and to highlight the importance of the connection to the Mississippi River and the Gulf of Mexico. The goals of the program are:

- **Goal 1:** Help meet the Federal goals to reduce nitrogen loading to the Mississippi River and the Gulf of Mexico, thereby helping to reduce hypoxia in the Gulf of Mexico.
  - **Goal 1a**: Reduce the amount of silt and sedimentation entering the main stem of the Illinois and the Kaskaskia Rivers by 20 percent;
  - **Goal 1b**: Reduce the amount of phosphorus and nitrogen in the Illinois River and Kaskaskia River by 10 percent;
- **Goal 2:** Increase by 15 percent, the populations of waterfowl, shorebirds, nongame grassland birds, and State and Federally listed threatened and endangered species such as bald eagles, egrets, and herons;
- **Goal 3:** Increase the native fish and mussel stocks by 10 percent in the lower reaches of the Illinois River (Peoria, LaGrange, and Alton reaches) and Kaskaskia River.

Monitoring Progress toward Achieving CREP Goals

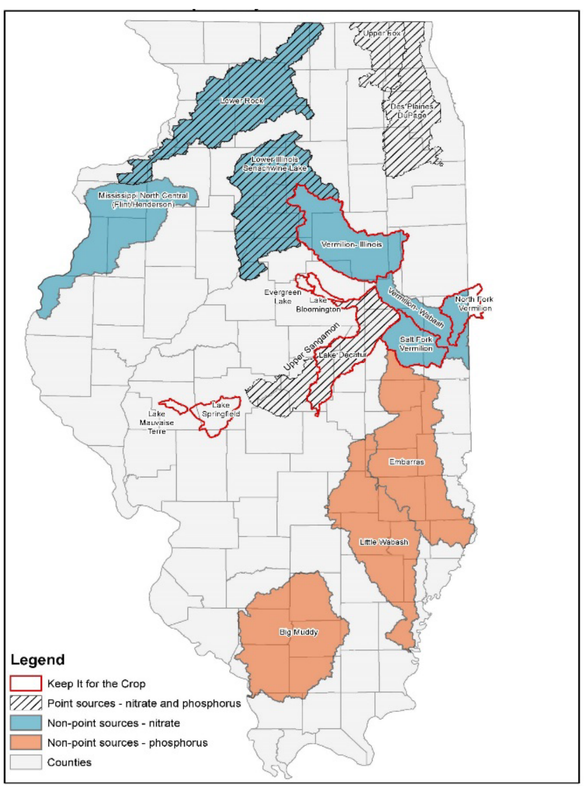
Illinois Nutrient Loss Reduction Strategy and CREP

Both point and non-point sources of nitrogen and phosphorus are added to the streams and rivers of Illinois, with these nutrients being transported to the Mississippi River and the Gulf of Mexico and contributing to the Gulf Hypoxia. These nutrients spur algae blooms that deplete oxygen levels, hinder recreation, and threaten public health. Nutrient pollution can also degrade drinking water quality and require cities to install costly treatment equipment. The Illinois Nutrient Loss Reduction Strategy (Illinois NLRS) is a framework for using science, technology, and industry experience to assess and reduce nutrient loss to Illinois waters and the Gulf of Mexico. The Strategy directs efforts to reduce nutrients from point and non-point sources in a coordinated (primarily voluntary) and cost-effective manner. The full strategy can be found through the following link: http://www.epa.illinois.gov/topics/water-quality/watershed-management/excess-nutrients/nutrient-loss-reduction-strategy/index

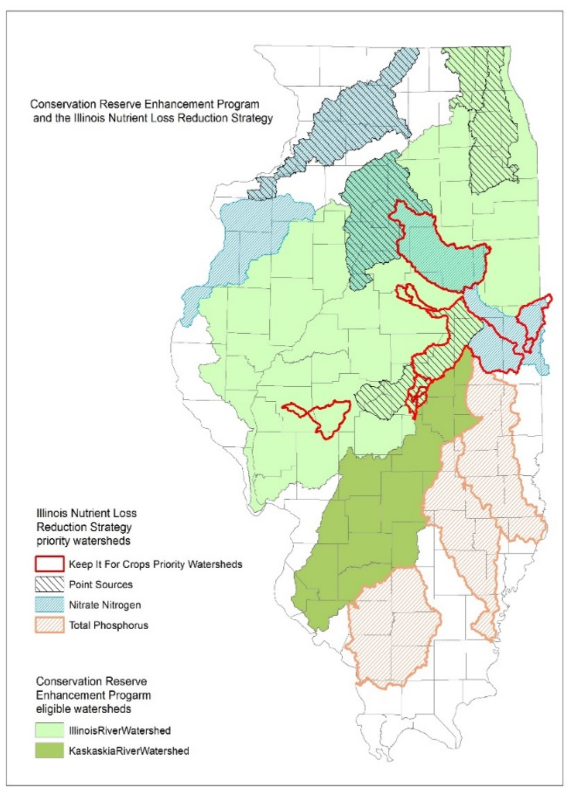
Illinois, a highly agricultural state, consists of more than 22 million acres of corn and soybeans (60 percent of the state's land area). The goal of the Illinois NLRS is for farmers to select and apply the most beneficial practices for any given field. These practices are based on the science assessment and are those deemed by the Illinois NLRS Policy Working Group to have the greatest potential impact based on available research. This does not represent all practices that could result in nutrient loss reduction. The specific suite of practices appropriate for any given field will depend on many factors including soil characteristics, landscape position and hydrology, and current cropping and management practices.

The NLRS has identified 12 "Measures" that would address nutrient reductions.

1. reduce N rate from background
2. nitrification inhibitor with fall fertilizer
3. two split applications of fall and spring
4. one spring-only application
5. three split applications
6. cover crops on tile drained
7. cover crops on non tile
8. bioreactors
9. wetlands
10. buffers on crop land
11. perennial/energy/hay crops
12. perennial/energy on tile drained



Illinois NLRS Priority Watersheds



Illinois NLRS Priority Watersheds overlayed on CREP eligible watersheds

The Conservation Reserve Enhancement Program (CREP) is driven by locally-led conservation efforts and employs a variety of Best Management Practices (BMPs) to protect and restore riparian corridors. The table to the right shows the CREP practices that were identified by the NLRS science assessment as Measures that are going to be tracked. 2011 was the baseline year chosen by the Illinois NLRS working group.

	State CREP Acres in NLRS practices - cumulative statewide totals							
	BMP	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Measure 9 CP9 and CP23	Wetland Acres	20	602	3,633	11,928	17,290	19,351	19,407
Measure 10 CP21 and CP22	Buffer Acres	526	1,324	2,787	5,534	8,835	16,636	13,831
Measure 11 CP2 and CP4D	Perennial/Energy Acres	0	7	84	1,622	2,110	4,398	4,672
	Total NLRS Acres	**546**	**1,933**	**6,504**	**19,084**	**28,235**	**40,385**	**37,910**

CREP has a number of other practices that are not identified as a contributing BMP at this time by the NLRS Science Assessment. This table below lists all CREP practices and acreages associated with CREP from the start of the program until 2017.

	NLRS CP 9 CP23	cumulative wetland acres	**NLRS CP21 CP22**	cumulative buffer acres	**NLRS CP2 CP4D**	cumulative perennial acres	**Non NLRS crop acres CP11 CP12 CP3 CP3A**	cumulative non NLRS acres	**Additional Acres**	cumulative additional acres
	Wetland acres		Buffer acres		Perennial acres		Other acres		ADD acres	
1999	0	0	0	0	0	0	9	**9**	5,031	**5,031**
2000	0	0	0	0	0	0	0	**9**	7,134	**12,165**
2001	0	0	17	17	0	0	0	**9**	7,892	**20,057**
2002	0	0	6	23	0	0	0	**9**	3,967	**24,024**
2003	0	0	0	23	0	0	0	**9**	303	**24,327**
2004	0	0	18	41	0	0	0	**9**	2,412	**26,738**
2006	0	0	0	41	0	0	0	**9**	201	**26,940**
2007	11	11	20	61	0	0	6	**15**	2,728	**29,668**
2008	0	11	46	107	0	0	0	**15**	2,382	**32,050**
2009	0	11	12	119	0	0	0	**15**	0	**32,050**
2010	0	11	83	201	0	0	0	**15**	0	**32,050**
2011	10	20	324	526	0	0	7	**22**	1,437	**33,487**
2012	582	602	799	1,324	7	7	9	**30**	2,821	**36,308**
2013	3,030	3,633	1,463	2,787	77	84	126	**156**	1,133	**37,441**
2014	8,296	11,928	2,747	5,534	1,539	1,622	978	**1,134**	1,084	**38,525**
2015	5,362	17,290	3,301	8,835	487	2,110	563	**1,697**	220	**38,746**
2016	2,061	19,351	4,800	13,636	2,288	4,398	1,718	**3,415**	51	**38,797**
2017	56	19,407	196	13,831	274	4,672	29	**3,444**	179	**38,976**
	19,407		13,831		4,672		3,444		38,976	
	Total		**Total**		**Total**		**Total**		**Total**	

***acres refer to calculations done in GIS, and may vary slightly from the other acres in the CREP Annual Report. This is due to an on-going effort to map accurate CREP boundaries and acres, which are subject to change slightly again in subsequent reports as more accurate boundaries are mapped. The date column is the federal fiscal year when that ground became part of the State CREP easement.*

easement.

PARTNER UPDATES

Illinois State Water Survey

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for evaluating IDNR Private Lands Programs: Phase II. *(Monitoring Goal 2)*

*Please reference Appendix B for the full report.*Phase II of Monitoring and Assessment of Aquatic Life in the Kaskaskia River Basin (2016-2017) has focused on continuing basin-wide assessments of stream biota, water quality and physical habitat, intensively surveying pairs of reaches with watersheds differing in conservation land density and surveying reaches with fish species sensitive to sedimentation. In 2017, 70 reaches were surveyed, bringing the 5-year total to 240 reaches. Development of a fish stock index for non-wadeable streams in the Kaskaskia River basin and GIS technical support for IDNR CREP is also included in Phase II.

Twenty basin-wide assessment reaches were surveyed in 2017. Survey reaches were selected to monitor a gradient of stream size and conservation land density in the adjacent watershed and evenly distributed across the four subbasins of the Kaskaskia River basin. Fish, benthic macroinvertebrates, water quality and habitat were assessed at each reach. Basin-wide assessment surveys will be used to track temporal trends in stream biota and physicochemical conditions.

Eight pairs of reaches were selected for intensive monitoring. One reach in each pair has a low density of conservation land in the adjacent watershed (<10%) while the other reach has a high density (≥10%). This reach selection technique may help isolate the impacts of conservation lands on stream biota and physicochemical conditions. Surveys were completed at four of the eight pairs of reaches in 2017 (all eight pairs were surveyed in 2016). Fish, benthic macroinvertebrates, mussels, water quality and habitat were assessed at each reach. Length and weight of fish species sensitive to sedimentation were measured at these paired reaches. Water quality was assessed at a subset of paired reaches during three high flow events.

Fifteen reaches with fish species sensitive to sedimentation were surveyed in 2017. Fish and habitat were assessed at each reach and length and weight of fish species sensitive to sedimentation were measured. Mussels were surveyed at two sensitive species reaches.

Work towards constructing a fish stock index for large bodied species (e.g., suckers, catfish, gar) in non-wadeable streams of the Kaskaskia River basin included acquiring length and weight information for fish collected during IDNR surveys and creating a database of relevant records. IDNR electrofishing data (survey location, date, length and weight of individual fish) from non-wadeable streams of the Kaskaskia River basin were sorted and filtered in preparation for constructing this index. This stock index will use length to weight relationships to evaluate condition of large bodied species.

One full time professional provided GIS technical support for IDNR CREP. Private land program databases were maintained and updated and used for CREP core activities. Farm Service Agency Conservation Priority Areas and Illinois Wildlife Action Plan Focal Areas were used to identify priority areas for CREP actions. Data were provided to the IEPA to facilitate analyses within the Illinois Nutrient Loss Reduction Strategy.

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for Evaluating IDNR Private Lands Programs: Phase II – Illinois Natural History Survey

(Monitoring Goal 3)
Please reference Appendix A for the full report.

Phase II of Monitoring and Assessment of Aquatic Life in the Kaskaskia River Basin (2016-2017) has focused on continuing basin-wide assessments of stream biota, water quality and physical habitat, intensively surveying pairs of reaches with watersheds differing in conservation land density and surveying reaches with fish species sensitive to sedimentation. In 2017, 70 reaches were surveyed, bringing the 5-year total to 240 reaches. Development of a fish stock index for non-wadeable streams in the Kaskaskia River basin and GIS technical support for IDNR CREP is also included in Phase II.

Twenty basin-wide assessment reaches were surveyed in 2017. Survey reaches were selected to monitor a gradient of stream size and conservation land density in the adjacent watershed and evenly distributed across the four subbasins of the Kaskaskia River basin. Fish, benthic macroinvertebrates, water quality and habitat were assessed at each reach. Basin-wide assessment surveys will be used to track temporal trends in stream biota and physicochemical conditions.

Eight pairs of reaches were selected for intensive monitoring. One reach in each pair has a low density of conservation land in the adjacent watershed (<10%) while the other reach has a high density (≥10%). This reach selection technique may help isolate the impacts of conservation lands on stream biota and physicochemical conditions. Surveys were completed at four of the eight pairs of reaches in 2017 (all eight pairs were surveyed in 2016). Fish, benthic macroinvertebrates, mussels, water quality and habitat were assessed at each reach. Length and weight of fish species sensitive to sedimentation were measured at these paired reaches. Water quality was assessed at a subset of paired reaches during three high flow events.
Fifteen reaches with fish species sensitive to sedimentation were surveyed in 2017. Fish and habitat were assessed at each reach and length and weight of fish species sensitive to sedimentation were measured. Mussels were surveyed at two sensitive species reaches.
Work towards constructing a fish stock index for large bodied species (e.g., suckers, catfish, gar) in non-wadeable streams of the Kaskaskia River basin included acquiring length and weight information for fish collected during IDNR surveys and creating a database of relevant records. IDNR electrofishing data (survey location, date, length and weight of individual fish) from non-wadeable streams of the Kaskaskia River basin were sorted and filtered in preparation for constructing this index. This stock index will use length to weight relationships to evaluate condition of large bodied species.
One full time professional provided GIS technical support for IDNR CREP. Private land program databases were maintained and updated and used for CREP core activities. Farm Service Agency Conservation Priority Areas and Illinois Wildlife Action Plan Focal Areas were used to identify priority areas for CREP actions. Data were provided to the IEPA to facilitate analyses within the Illinois Nutrient Loss Reduction Strategy.

Illinois Environmental Protection Agency

One of the key missions of Illinois EPA is to monitor and protect the water resources of Illinois; these resources are relied upon for drinking water, fishing, transportation and recreational use and other environmental and economic benefits. One of the most dramatic improvements in water quality that Illinois EPA has documented has taken place on the Illinois River.
Illinois EPA has eight Ambient Water Quality Monitoring Sites on the main channel of the Illinois River. Water chemistry is collected at these sites nine times per year. There are approximately 475 Intensive Basin Survey Sites in the Illinois and Kaskaskia River watersheds. These sites are monitored "intensively" once every five years. The monitoring includes water chemistry, macro-invertebrates, fish, habitat, sediment and at some sites fish tissue contaminants are collected. This information is cooperatively collected with the Illinois Dept. of Natural Resources, a partnership that began many years ago and continues annually.
The monitoring shows that the Illinois River mainstream water quality has improved significantly since the passage of the Federal Clean Water Act in 1972. Early improvements were due primarily to point source controls, such as additional treatment requirements and limits on discharges from wastewater treatment plants. The majority of water quality improvements over the last twenty years have been from the implementation of nonpoint source management programs that reduce urban and agricultural runoff, and programs such as CREP. Since 1999, more than $2,522,000 of Section 319 grant funds have been spent to hire and train personnel responsible for outreach and the enrollment process. The benefits derived through this financial support was not only efficiency in the sign-up process to increase CREP enrollment, but it also allowed the existing SWCD and NRCS staff to continue to implement the other conservation programs so desperately needed to improve water quality in the Illinois and Kaskaskia River watersheds.
As reported by the Illinois EPA in their 2016 Integrated Report, of the *stream miles assessed* in the Illinois River Basin for Aquatic Life Use Support attainment, 67.8% were reported as ―Good,‖ 27.6% as ―Fair,‖ and 4.6% as ―Poor.‖ This compares to statewide figures of 57.8% ―Good,‖ 37.3% ―Fair,‖ and 4.9% ―Poor.‖

Other Illinois EPA programs that complement CREP include:

Section 319: Since 1990, the Illinois EPA has implemented 303 Clean Water Act Section 319 projects within the Illinois and Kaskaskia River Watersheds. The Agency receives these federal funds from USEPA to identify and administer projects to prevent nonpoint source pollution. These projects include watershed management planning; best management practices implementation and outreach efforts. Illinois EPA has dedicated over $72 million with another $65 million of local and state funds for total project costs of over $137 million towards these projects to help improve the health of the Illinois and Kaskaskia Rivers, their tributaries and ultimately the Mississippi River and Gulf of Mexico. Hundreds of conservation practices have been installed in the Illinois and Kaskaskia River watersheds by dozens of our partners

through the Section 319 program. Traditional practices such as terraces and waterways are dotting the landscape along with porous pavement parking lots, green roofs and miles of rural and urban stabilized streambank.
Since 1990, the 319 NPS program, through on the ground implementation can show load reductions in the Illinois and Kaskaskia River watersheds of: 599,922 lbs. of nitrogen, 268,413 pounds of phosphorus, and 229,425 tons of sediment per year, each and every year since the Best Management Practices were implemented as a result of 319 grant projects between Illinois EPA and our local partners, in both the private and government sectors. The Illinois EPA invites you to visit http://water.epa.gov/polwaste/nps/success319/ for a sample of Illinois' 319 success stories.

IGIG: Since 2011, the Illinois EPA has implemented 31 Illinois Green Infrastructure Grant Program for Stormwater Management (IGIG) projects within the Illinois and Kaskaskia River watersheds. IGIG is administered by the Illinois EPA. Grants are available to local units of government and other organizations to implement green infrastructure best management practices (BMPs) to control stormwater runoff for water quality protection in Illinois. Projects must be located within a Municipal Separate Storm Sewer System (MS4) or Combined Sewer Overflow (CSO) area. Funds are limited to the implementation of projects to install BMPs. Illinois EPA has dedicated over $15 million with another $6 million of local funds for total project costs of over $21 million towards these projects to help improve water quality in the Illinois and Kaskaskia River watersheds.

Construction Site Inspection Program: Illinois EPA continues to implement a program in partnership with nineteen soil and water conservation districts covering twenty-two counties. Those partners located with the Illinois and Kaskaskia River watersheds include the Champaign, DeKalb, Jersey, Kane/DuPage, Kankakee, Kendall, Knox, Macon, Madison, McHenry/Lake, Monroe, North Cook, Peoria, St. Clair, and Will/South Cook County Soil and Water Conservation Districts. District staff complete on-site NPDES Construction Stormwater Permit inspections and provide technical assistance in implementing best management practices to minimize runoff to nearby water bodies. This program is a natural fit for properly developing acreage that does not qualify for CREP.

Total Maximum Daily Load (TMDL): TMDLs are a tool that Illinois EPA uses to restore impaired watersheds so that their waters will meet Water Quality Standards and Full Use Support for those uses that the water bodies are designated. A TMDL looks at the identified pollutants and develops, through water quality sampling and modeling, the amount or load reductions needed for the water body to meet its designated uses. USEPA has approved 308 completed TMDL evaluations and Illinois EPA is currently developing further TMDLs on impaired watersheds.

Partners for Conservation: A total of 72 lake monitoring (study) or protection/restoration projects have been conducted in the Illinois and Kaskaskia River watersheds via the Illinois EPA's Illinois Clean Lakes Program and Priority Lake and Watershed Implementation Program. Over $11.8 million of local and state funds have been allocated for these efforts.

Excess Nutrients: A High Profile Water Quality Issue
The impact of excess nitrogen and phosphorus in rivers, lakes, streams and the Gulf of Mexico has become a very high profile water quality issue. Under the right conditions, nutrients can cause excessive algal blooms, low oxygen and nuisance conditions that adversely impact aquatic life, drinking water and recreational uses of the water. The Illinois EPA has identified many waterbodies in the state with these problems.

Nitrogen and phosphorus come from municipal wastewater treatment, urban stormwater, row crop agriculture, livestock production, industrial wastewater and combustion of fossil fuels. In other words, most aspects of modern society contribute to this pollution problem. The proportion of loading to a particular waterbody from these sources varies from watershed to watershed, with point sources and urban storm water being most important in urbanized watersheds and row crop and/or livestock production being predominant contributors in agricultural watersheds.
Illinois EPA has several on-going efforts addressing nutrients. In July of 2015 Illinois EPA, Illinois Department of Agriculture and a designated Nutrient Loss Reduction Policy Workgroup submitted to U.S. EPA Illinois' Nutrient Loss Reduction Strategy (Strategy) document that provides an implementation strategy to reduce nutrient losses from Illinois. The document identifies eleven priority watersheds for the reduction of nitrogen and/or phosphorus from point and/or nonpoint sources. Five of these watersheds are in the Illinois River Basin and one is in the Kaskaskia River Basin. The Strategy also identifies eight watersheds that are considered KIC Nutrient Priority Watersheds. Six of the eight designated watersheds are in the Illinois River Basin. Each of these watersheds has a Total Maximum Daily Load developed or being developed for one or two nutrient pollutants (nitrate and total phosphorus). The agency is partnering with a program called ―KIC 2025‖ (www.kic2025.org). KIC 2025 is an agriculture industry-driven program being implemented in the watersheds listed above. This program seeks to educate the agricultural sector, dedicate significant resources toward

research to reduce nutrient losses and enhance nutrient efficiency, educate suppliers and farmers, and measure the adoption of in-field practices to enhance nutrient stewardship beginning in priority watersheds and expanding over years to a state-wide nutrient stewardship program. The Illinois EPA invites you to visit http://www.epa.illinois.gov/topics/water-quality/watershed-management/excess-nutrients/nutrient-loss-reduction-strategy/index to examine the complete Illinois Nutrient Loss Reduction Strategy.

In conclusion, the Illinois and Kaskaskia River basins are a valuable resource that we are working hard to protect and restore. Illinois EPA will continue long-term monitoring of the river basins and will continue to pursue funds to help implement water quality restoration and protection projects and to work with citizen groups, local governments, and industry to continue the progress we all have made.

Current Management Approaches and Issues

TMDL load limits are required to be implemented through National Pollutant Discharge Elimination System permits, which address point sources—municipal and industrial wastewater dischargers. Management of non-point source pollution is through voluntary implementation of best management practices (BMP) contrary to point sources which are regulated through permit limits.

Cost-share incentives to implement/install BMPs include federal Conservation Reserve Program and state Conservation Reserve Enhancement Program, state Partners for Conservation Program, various Farm Bill conservation programs and Section 319 non-point source management grants. There are various other efforts through state agricultural groups, industry and non-profit organizations to promote the use of agricultural BMPs.

Available data do indicate that Illinois producers are not over-applying fertilizers or manure and that the traditional suite of conservation practices will not be adequate to achieve such large reductions. Absent the development of an economically viable third crop such as a perennial for biofuels, the costs to significantly reduce nutrient losses from agriculture are estimated to be billions of dollars.

New and expanding major (one million gallons per day or greater design flow) municipal sewage treatment plants and some sewage treatment plants discharging to certain lake watersheds are required by Illinois Pollution Control Board regulations to limit their effluent discharge of total phosphorus to 1.0 mg/L on a monthly average basis. Plants currently achieving this level of phosphorus reduction represent 9% of the approximately 900 municipal discharges in the state. However, of the 214 major municipals discharges, whose effluent constitutes a large majority of the phosphorus loading from point sources, 25% are required to remove phosphorus. Requiring phosphorus removal from the minor facilities would be very costly for customers on a per capita basis and would represent a relatively small portion of the total point source phosphorus discharged. Therefore at this time minor facilities will not be targeted for reducing phosphorus discharge.

What U.S. EPA Expects

U.S. EPA expects states to establish numeric water quality standards for phosphorus and nitrogen and to carry out the other pieces of the Clean Water Act framework, as appropriate. U.S. EPA‘s Inspector General issued a finding in 2009 that U.S. EPA had not done enough to get state numeric nutrient water quality standards established. In response, U.S. EPA has developed a corrective action plan‖which includes a commitment to identify states where federal promulgation of nutrient water quality standards is required. U.S. EPA has been petitioned and sued by various environmental groups for failure of states to establish numeric nutrient standards, so there is mounting pressure on U.S. EPA and states to address nutrients by developing numeric nutrient water quality standards.

States have concerns on the issue of numeric nutrient water quality standards. They raise two main points:

1. There is not a straightforward relationship between nutrient concentration in the water and adverse effects, so a statewide, one size fits all, standard that meets the test of scientific defensibility is almost unachievable; and
2. The Clean Water Act programs are effective for point sources but do not assure reductions from non-point sources that are often the predominant contributors of nutrients in a particular watershed.

Through Illinois' Nutrient Loss Reduction Strategy the Illinois EPA has continued its commitment to using a science based approach to developing water quality standards. A Nutrient Science Advisory Committee has been convened to guide the development of nutrient criteria that helps protect aquatic life in Illinois' streams and rivers. It is comprised of scientific experts nominated by the stakeholder sectors represented in the Illinois Nutrient Loss Reduction Strategy Policy Working Group. Illinois EPA will propose numeric nutrient criteria to the Illinois Pollution Control Board in a rulemaking process based on the findings and determinations of the committee. The Illinois EPA will work with stakeholders to develop a plan for implementing the numeric nutrient criteria before filing the rulemaking with the Board.

Illinois Department of Agriculture

The Illinois Department of Agriculture (IDOA) administers numerous soil and water conservation programs that produce environmental benefits in the Illinois River Watershed. In FY17, the Partners for Conservation Fund Program (PFC) Agricultural Components, administered by IDOA, has allocated over
$387,500 to 22 counties that have significant agricultural acreage in the Illinois River Watershed for cost-sharing the installation of upland soil and water conservation practices. With the assistance from County Soil and Water Conservation Districts (SWCDs), the PFC provides up to 70% of the cost of constructing conservation practices that reduce soil erosion and protect water quality. Practices will be installed over the next 12 months. Conservation practices eligible for partial funding under the PFC include terraces, grassed waterways, water and sediment control basins, grade stabilization structures cover crops and nutrient management plans.

The IDOA provided grant funding to county SWCD offices in the Illinois River Watershed for operational expenses. Specifically, these funds were used to provide financial support for SWCD offices, programs, and employee' expenses. Employees, in turn, provided technical and educational assistance to both urban and rural residents in the Illinois River Watershed. Their efforts are instrumental in delivering programs that reduce soil erosion and sedimentation that ultimately protects water quality.

In an effort to stabilize and restore severely eroding streambanks that would otherwise contribute a large amount of sediment to the Illinois River and its tributaries, the IDOA, with assistance from SWCDs, administers the Streambank Stabilization and Restoration Program (SSRP). The SSRP is a component of the Partners for Conservation Fund Program that provides funds to construct low-cost techniques to stabilize eroding streambanks. A total of $40,000 has been allocated to stabilize and protect adjacent water bodies.

Illinois Department of Natural Resources

Illinois Recreational Access Program (IRAP)

One of the more challenging problems facing Illinois and the Department of Natural Resources (IDNR) is to provide more public outdoor recreational access and opportunities in Illinois. In order to carry on our outdoor traditions, it is important to connect youth and families to land and opportunities. 95 % of Illinois is privately owned and ranks 46th for public lands for recreation but hosts more than 323,000 hunters and 780,000 fishermen and millions of other recreational users.

Through the Illinois Recreational Access Program (IRAP), the IDNR is increasing public recreational opportunities for the following activities:

- Youth and Adult Spring Turkey Hunting
- Archery Deer Hunting
- Small Game and Upland bird hunting
- Waterfowl Hunting
- Fishing (Ponds and Streambanks)
- Non-Motorized Boat Access on Public Waterways
- Outdoor Naturalist (Birding, Nature Watching and Outdoor Photography)

Utilizing resources obtained from three separate grants from the US Department of Agriculture‘s Voluntary Public Access and Habitat Incentive Program, the IDNR pays an annual stipend to landowners enrolling their property into IRAP. IRAP also prepares a habitat management plan and assists with the implementation of those plans for landowners. - Emphasis is placed on developing a habitat management plan for the landowner and assisting with the implementation of the management plan. IRAP's success has led to the creation of two Habitat Strike Teams to work on private lands enrolled in IRAP.

IRAP accomplishments in the first six years:

- Leased approximately 17,690 acres in 44 counties within the Illinois River watershed.

- Provided thousands of hunting and fishing opportunities for youth and adults.
- Obtained more than 76 habitat management plans for IRAP leased properties.
- Habitat Management on IRAP leased property include,
    - Non-Native Invasive Species (NNIS) removal on 5701 acres
    - Aerial Spraying (NNIS) on 3,311 acres
    - Site Prep/Grassland management on 187 acres
    - Prescribed Burning on 3,492 acres
    - Timber stand Improvement on 467 acres
    - Prairie Plantings on 251 acres

Natural Resources Conservation Service (NRCS)

Conservation Accomplishments in the Illinois River Watershed

NRCS provides technical assistance to farmers, ranchers, and forest landowners as well as financial assistance through a number of Farm Bill conservation programs. Through the conservation title of the 2014 Farm Bill, NRCS provides cost-sharing for improved farming practices through the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP); and secures easements to protect agricultural lands and wetlands through the Agricultural Conservation Easement Program (ACEP). NRCS also has floodplain easements through the Emergency Watershed Protection Program (EWP).

For additional information on NRCS conservation programs, please visit www.nrcs.usda.gov.

US Fish and Wildlife Service

Partners for Fish and Wildlife

The US Fish and Wildlife Service Partners for Fish and Wildlife Program (PFW) has supported the Illinois River Conservation Reserve Enhancement Program (CREP) since its inception. The Midwest Region‘s PFW program assists with projects that conserve or restore native vegetation, hydrology and soils associated with imperiled ecosystems such as bottomland hardwoods, native prairies, marshes, rivers and streams. Collaborating with the Illinois and Kaskaskia River CREP has provided opportunities on a landscape scale for restoration, enhancement, and preservation of these natural habitats on private land. Benefits from this collaboration are the enhancements of privately owned land for Federal Trust Species, such as migratory birds, inter-jurisdictional fish, federally threatened or endangered species of plants and animals, as well as numerous state threatened or endangered species.

The primary contribution to the Illinois and Kaskaskia River CREP, by PFW, has been technical assistance through participation on the CREP Advisory Committee. In the field, PFW personnel coordinate with local NRCS, SWCD, and Illinois DNR staff as necessary on individual or groups of projects. Within the Illinois and Kaskaskia River Watersheds, individual Partners projects compliment CREP and other habitat programs. The PFW program provides a tool for restoration and enhancement of habitats on private lands that may not be eligible for other landowner assistance programs. PFW biologists review the full range of landowner assistance programs with each potential cooperator and refer landowners to CREP or other USDA and Illinois DNR programs that best meet their objectives. In 2017, the PFW program met with 25 landowners and completed 35 acres of wetland restoration and 117.3 acres of upland habitat restoration within the CREP area. In total, we have completed agreements with multiple landowners that will restore/enhance 173 acres of prairie and 111 acres of forest. These projects will be completed in the fall/winter of 2018. Additionally, we have helped enroll 5 acres into the Conservation Reserve Program and 67 acres into the Illinois Recreational Access Program in 2017.

For more information about the Partners for Fish and Wildlife Program please contact:
Michael_budd@fws.gov.

.

Illinois Farm Bureau

CREP is an important program in Illinois that provides cost-share incentives and technical assistance to farmers looking to address resource concerns, including nutrient loss reduction efforts and floodplain-related issues. Illinois Farm Bureau (IFB) continues to publicize and promote the Conservation Reserve Enhancement Program (CREP) through their statewide radio network, FarmWeek print publication and FarmWeekNow.com, as well as through the county Farm Bureau® system. Illinois Farm Bureau continues to voice support for CREP.

Association of Illinois Soil and Water Districts (AISWCD)

The AISWCD, in partnership with the Illinois Department of Natural Resources and the Illinois Environmental Protection Agency, participated in a grant to provide funding, hire, and administer a team of six CREP Resource Specialists. This program provided monetary income for both AISWCD and Soil & Water Conservation Districts while also helping to preserve and enhance Illinois' natural resources.

The grant began in June 2012, but due to lack of state funding, all CREP Resource Specialists were laid off on May 31, 2016. No re-hire date was specified since funding did not seem likely in the near future.

In 2017, state funds have still not been allocated for the CREP program, thus the partnership between AISWCD and the Illinois Department of Natural Resources has been minimal during calendar year 2017.

We thank the Illinois Department of Natural Resources for their support over the years of this program and we look forward to continuing our partnership when the CREP program once again becomes available.

The Nature Conservancy

The Nature Conservancy, McLean County Soil and Water Conservation District, Natural Resources Conservation Service, Farm Service Agency, and the City of Bloomington have worked with landowners and producers in McLean County to implement Farm Bill programs that reduce nutrient loss from farm fields. Since 2013, nine wetlands have been installed in watersheds of the Mackinaw River in McLean County through enrollment in the Farmable Wetlands Program, Conservation Practice-39, under the Conservation Reserve Program. These wetlands are built specifically to capture and treat tile drainage water before entering adjacent waterways through denitrification by bacteria and uptake through vegetation. Additionally, two tile-treatment wetlands were constructed on City of Bloomington property in 2013 and 2014 near Lake Bloomington and Evergreen Lake. All wetlands are monitored by The Nature Conservancy, UIUC, and the City of Bloomington to determine their nutrient loss effectiveness.

National Great Rivers Research and Education Center

Providing boots-on-the-ground, the National Great Rivers Research and Education Center's (NGRREC) *Illinois CREP* Resource and Land Conservation Specialists *Initiative* focused their efforts within the newest CREP-eligible watershed—the Kaskaskia River basin. Working in partnership with soil and water conservation districts (SWCD's) and the Illinois Department of Natural Resources (IDNR), Land Conservation Specialists (LCS) with NGRREC were dedicated to outreach with private landowners about CREP, one-on-one attention with agricultural producers about CREP options and the CREP process, and technical assistance to complete CREP projects and manage CREP conservation easement parcels. NGRREC's *Illinois CREP Initiative* has ended. Once CREP is reopened the IDNR NGRREC will discuss details to reinstitute the CREP Resource and Land Conservation Specialists initiative.

ILLINOIS NATURAL
HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for Evaluating IDNR Private Lands Programs: Phase II

Brian A. Metzke,
Leon C. Hinz, Jr.
and
Lisa Beja

INHS Technical Report 2017 (34)

Prepared for Illinois Department of Natural Resources, Office of Resource Conservation, Conservation Reserve Enhancement Program

Issue Date: 06 December 2017

Unrestricted, for immediate release

Prairie Research Institute, University of Illinois at Urbana Champaign
Mark R. Ryan, Executive Director

Illinois Natural History Survey
Leellen Solter, Interim Director
1816 South Oak Street
Champaign, IL 61820

PROJECT TITLE:

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for Evaluating IDNR Private Lands Programs: Phase II.

PROJECT OBJECTIVES:

(1) Continue established monitoring program that provides a basin-wide assessment of status and trends for aquatic life in wadeable streams of the Kaskaskia River basin; (2) expand sampling efforts in focal reaches to better characterize biological assemblages and physiochemical habitats in each of the four subbasins of the Kaskaskia River; (3) conduct additional monitoring of key populations within the Kaskaskia River; (4) provide technical support for IDNR's Private Lands Programs.

SUMMARY OF WORK COMPLETED IN PHASE I (2013-2015):

Phase I of this project (Monitoring and Assessing Aquatic Life in the Kaskaskia River) is summarized in Metzke and Hinz (2017). These efforts focused on a basin-wide assessment of wadeable stream reaches, stream segments which contain species having conservation status (i.e., focal reaches), and surveys at Illinois State Water Survey CREP study reaches. Additional survey effort was expended to support graduate student research relevant to study objectives. Both graduate students investigated the relationship between CRP density and stream assemblages; one focusing on aquatic insects and the other on fish. Both studies found a weak relationship between CRP density and species richness. In Phase I, 144 reaches were surveyed and 824 collection events (e.g., electrofishing survey, habitat evaluation, water chemistry measure) were completed (Table 1, Figure 1).

SUMMARY OF WORK COMPLETED IN PHASE II (2016-2017):

Work Completed in 2016

Phase II of monitoring continued the basin-wide assessment of wadeable streams of Phase I, but shifted remaining effort to assessing focal stream segments using more intensive sampling and assessing stream segments with fish species that may respond to CREP activities. Spring EPT macroinvertebrate surveys have been eliminated, but mussel and black light surveys for adult aquatic insect surveys were added.

Basin-wide assessment reaches were selected using a stratified random technique where reaches were distributed within size categories, CRP density categories and HUC8 subbasins. Fish, benthic macroinvertebrate, habitat and water quality were surveyed at 21 basin-wide assessment reaches (Table 1, Figure 1). Continuous temperature recorders were placed and retrieved from five basin-wide assessment reaches. Focal assessment reaches were selected using a paired design where one reach with high CRP density (>10% in the local catchment) and one with low (<10%) were selected from neighboring tributaries. This paired design was employed to control for differences in geology, land use and potential species pool to assess observed physicochemical and biotic patterns associated with level of participation in conservation programs. Fish, benthic macroinvertebrates, habitat and water quality were surveyed at sixteen paired (i.e., eight pairs) reaches. Water quality was also measured at four to five pairs of reaches during four high flow events. Two mussel and fifteen backlight surveys were conducted at paired reaches. Eleven temperature loggers were retrieved at paired reaches (loggers were placed at each reach, but five were lost). The recorded distributions of eleven species that may be intolerant of sedimentation (Table 2), and therefore may respond to CREP practices, were used to identify sensitive species reaches. Fifteen reaches with recent records of multiple sensitive species were selected and fish and habitat were surveyed at each reach. Length and weight of individuals from fish species sensitive to sedimentation were recorded at all surveyed sensitive species and paired reaches.

Work Completed During the 2017 Reporting Period

Sixty-five reaches were surveyed during summer 2017 (Table 3, Figure 2), bringing the total reaches over five survey seasons to 240 (Table 1). Several of these reaches have been surveyed in multiple years to allow for the evaluation of interannual variation or to compliment concurrent studies, and therefore the total number of monitoring events throughout the entire survey (i.e., efforts to characterize the physiochemical and biological attributes of a stream reach) is 1300.

Water quality (temperature, dissolved oxygen, specific conductivity, pH, total reactive phosphorus, ammonia nitrogen, nitrate nitrogen and turbidity) was assessed at basin-wide assessment and paired reaches during the low flow index period. Water quality (temperature, dissolved oxygen, specific conductivity, pH, nitrate nitrogen, nitrite nitrogen, total Kjeldahl nitrogen, total nitrogen, phosphorus and total suspended solids) was assessed during three high flow events at a subset of paired reaches (between four and eight reaches assessed during each event).

Forty continuous temperature recorders were deployed at basin-wide assessment and paired reaches in spring 2017 and will be retrieved in winter 2017-2018. Data from these recorders will be used to evaluate the thermal regime.

Habitat evaluations were completed at each surveyed reach using the Qualitative Habitat Evaluation Index (QHEI; OEPA 2006) and the Illinois Habitat Index (IHI; Sass, et al. 2010). The QHEI provides a qualitative index of habitat characteristics and can be viewed as a measure of biological potential. The IHI indexes landscape disturbance by qualifying relevant stream characteristics.

Benthic macroinvertebrates were surveyed at basin-wide assessment reaches twenty times, paired reaches nine times and at student research reaches seventeen times using a standard rapid assessment method (IEPA 2011). Collected organisms were preserved in ethanol for processing at a later date. Benthic samples collected during the 2015 and 2016 surveys were sorted during calendar year 2017 and 300-count subsamples were shipped to EcoAnalysts, Inc. (Moscow, IA) for identification.

Fish were surveyed using IDNR Basin Survey procedures (IDOC 1994) at all reaches. Length and weight of individuals from fish species identified as sensitive to sedimentation (Table 2) were measured at paired and sensitive species reaches.

Mussels were surveyed at fourteen paired and two sensitive species reaches. Surveys employed tactile and visual techniques to locate mussels. Eight person-hours were expended at each reach, although each hour was recorded separately to facilitate comparisons with previous IDNR and INHS surveys which use four person-hours.

Progress towards a fish stock index occurred during the reporting period. IDNR electrofishing data (survey location, date, length and weight of individual fish) from non-wadeable streams of the Kaskaskia River basin were acquired, sorted and filtered in preparation for constructing this index.

One full-time professional worked on objectives 1-3, while one part-time professional provided assistance completing field work. Four student technicians aided field work. One full-time professional staff member provided GIS support to the IDNR CREP (objective 4).

Objective 1 – Basin-Wide Status and Assessment

Twenty basin-wide assessment reaches were surveyed in 2017, five in each of the four HUC8 subbasins (Table 3, Figure 2). In each subbasin surveys were completed at one large stream (link number ≥11) with a high density (≥5%) of CRP in the local catchment, one large stream with a low density of CRP (<5%), two small streams (link number 2-10) with a high density of CRP and one small stream with a low density of CRP. These surveys will be used to evaluate physicochemical and biological status and temporal trends of wadeable stream in the Kaskaskia River basin. A total of 144 basin-wide assessment reaches have been surveyed since 2013 (Table 1).

Objective 2 – Intensive Evaluation of Physicochemical and Biotic Characteristics (Paired Streams)

Surveys were completed at eight of the paired reaches in 2017 (i.e., four pairs; Table 3, Figure 2). All paired reaches were surveyed in 2016 so those completed during this reporting period will aid evaluations of temporal variability. Mussel surveys have also been conducted at all paired reaches (two in 2016 and 14 in 2017). High flow event water quality samples were collected at least once at all pairs during Phase II.

Objective 3 – Monitoring of Focal Species (Sensitive Species and Fish Stock Index)

Length and weight of fish species sensitive to sedimentation (Table 2) were recorded at 15 reaches selected for sensitive species monitoring and at eight paired reaches in 2017 (Table 3, Figure 2). More than 1200 individuals from eleven sensitive species were measured in 2017, bringing the two-year total to 3057 individuals. Species-specific length to weight relationships will be used to provide a baseline species' condition and to evaluate condition in relation to stream characteristics or over time.

Work towards constructing a fish stock index for large bodied species (e.g., suckers, catfish, gar) in non-wadeable streams of the Kaskaskia River basin included acquiring length and weight information for fish collected during IDNR surveys and creating a database of relevant records. This stock index will use length to weight relationships to evaluate condition of large bodied species. Sufficient records (≥20 individuals) were available for seven species (Table 4) and work towards completing the index is ongoing.

Objective 4 - GIS Technical Support to IDNR CREP

Current GIS data infrastructure was updated by integrating other existing Private Lands and Watersheds (PLW) Program geospatial data and identifying overlap with CREP properties. In addition to ongoing quality control and maintenance of these PLW geodatabases, the spatial relationship of these data were examined in relationship to sources within IDNR and outside resources to produce maps showing the patterns and results required for PLW core activities and decision making.

One of the major efforts during the reporting period was to create priority areas for Private Lands work. This effort was greatly influenced by the Illinois Wildlife Action Plan (IWAP) to target priority areas for Private Lands conservation work that would maximize the benefit to the resources and to the landowner. The PLW division worked with USDA's Farm Service Agency (FSA) to map multiple scenarios influencing statewide CRP signups and worked to determine a proposal of HUC12 watersheds for their new Conservation Priority Areas (CPAs). Equitable distribution of HUC's comprising the CPA was a challenge given the guidelines provided in the 2014 Farm Bill, namely being limited to not more than 25% of the available remaining acres of state cropland. Major factors in the determination included; available state cropland identified as Highly Erodible Land, available state cropland (not already in CRP, CREP or WRP), areas with a high interest in CRP (based on CRP accepted/rejected reports), areas with low CRP contracts, areas of overlap between the IWAP and the Illinois Nutrient Loss Reduction Strategy (NLRS) Priority watersheds. Lastly, large corridors or identified areas in the IWAP received preference over small areas/sites with less connectivity.

A number of CREP practices have been identified by the NLRS as measures that would help reach the goal of reducing nutrient runoff into the Gulf of Mississippi. Over the last year, CREP has been part of discussions in the Agricultural Water Quality Technical Group working together with other members to establish baseline numbers/acreages to monitor progress towards reduction goals. All data was given a spatial component and reported by HUC12, HUC10, HUC8, County and NLRS Priority Watersheds.

Student Research/Special Questions Surveys

Nineteen reaches were surveyed in 2017 to support research relevant to understanding patterns of biotic assemblage composition or for filling data gaps (Table 3, Figure 2). Emphasis was placed on surveying reaches upstream of reservoirs to investigate the impacts of connectivity loss on fish and benthic macroinvertebrate assemblage composition. Fish, benthic macroinvertebrates, water quality and habitat were surveyed at each reach.

Reporting

One presentation at a scientific conference (Metzke 2017) was given during the reporting period. This presentation evaluated patterns of fish assemblage heterogeneity over space and time. The final project report for Phase II is in preparation.

LITERATURE CITED:

Illinois Department of Conservation. 1994. Manual of Operations. Illinois Department of Conservation, Division of Fisheries, Springfield, IL. October 1994.

Illinois Environmental Protection Agency. 2011. Standard operating procedure for method to collect aquatic macroinvertebrates from wadeable streams for biotic integrity assessments. IEPA Bureau of Water, Document Control Number 168.

Metzke, B.A. 2017. In search of the elusive community boundary: Evaluating spatial and temporal heterogeneity of stream fish assemblages. Illinois Chapter of the American Fisheries Society, Moline, IL.

Metzke, B.A. and L.C. Hinz, Jr. 2017. Establishing an aquatic monitoring program to assess the goals of the Illinois Conservation Reserve Enhancement Program in the Kaskaskia River Basin. Illinois Natural History Survey Technical Report 2017(4).

Ohio Environmental Protection Agency. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Technical Bulletin EAS/2006-06-1. State of Ohio Environmental Protection Agency, Division of Surface Water, June 2006.

Sass, L., L.C. Hinz, Jr., J. Epifanio and A.M. Holtrop. 2010. Developing a multi-metric index for wadeable streams in Illinois. Final Report to the Illinois Department of Natural Resources. Illinois Natural History Survey Technical Report 2010/21.

Table 1. Number of survey events and locations between 2013 and 2017.

	Number of Events							
Evaluated Characteristic	Basin Wide Status	Focal	ISWS	Student Research/ Special Questions	Paired	Sensitive Species	Total Events	Total Reaches
Fish Assemblage	124	0	6	50	24	30	234	197
Mussel Assemblage	0	0	0	6	16	2	24	24
Benthic Macroinvertebrate Assemblage	118	42	8	43	24	0	235	181
Spring EPT Macroinvertebrate Assemblage	68	30	3	0	0	0	101	86
Black Light Macroinvertebrate Assemblage	0	0	0	0	15	0	15	15
Water Quality	157	66	11	18	44	30	326	193
Temperature Regime	52	18	2	1	11	0	84	74
Habitat	127	42	8	50	24	30	281	240
Total Locations:	144	15	4	46	16	15		

Table 2. Focal species, or those sensitive to sedimentation, used to select reaches for sensitive species monitoring.

Common Name	Scientific Name
Horneyhead chub	*Nocomis biguttatus*
Bigmouth shiner	*Notropis dorsalis*
Central stoneroller	*Campostoma anomalum*
Creek chub	*Semotilus atromaculatus*
Orangethroat darter	*Etheostoma spectabile*
Red shiner	*Cyprinella lutensis*
Stonecat	*Noturus flavus*
Striped shiner	*Luxilus chrysocephalus*
Silverjaw minnow	*Ericymba buccata*
Sand shiner	*Notropis stramineus*
Redfin shiner	*Lythrurus umbratilis*

Table 3. Number of survey events and locations in 2017.

	Number of Events					
Evaluated Characteristic	Basin Wide Status	Paired	Sensitive Species	Student Research/ Special Questions	Total Events	Total Reaches
Fish Assemblage	20	8	15	14	57	57
Mussel Assemblage	0	14	2	0	16	16
Benthic Macroinvertebrate Assemblage	20	8	0	19	47	47
Water Quality	20	28	15	1	64	50
Habitat	20	8	15	14	57	57
Total Locations:	20	16	15	19		

Table 4. Large-bodied species from non-wadeable streams of the Kaskaskia River basin with at least 20 individuals recorded since 2000 with length and weight measures. These species will be used to complete a fish stock index.

Common Name	Scientific Name	Number of Records Since 2000
Common carp	*Cyprinus carpio*	545
Channel catfish	*Ictalurus punctatus*	789
Golden redhorse	*Moxostoma erythrurum*	144
Longnose gar	*Lepisosteus osseus*	38
Shortnose gar	*Lepisosteus platostomus*	109
Shorthead redhorse	*Moxostoma macrolepidotum*	245
Spotted gar	*Lepisosteus oculatus*	40

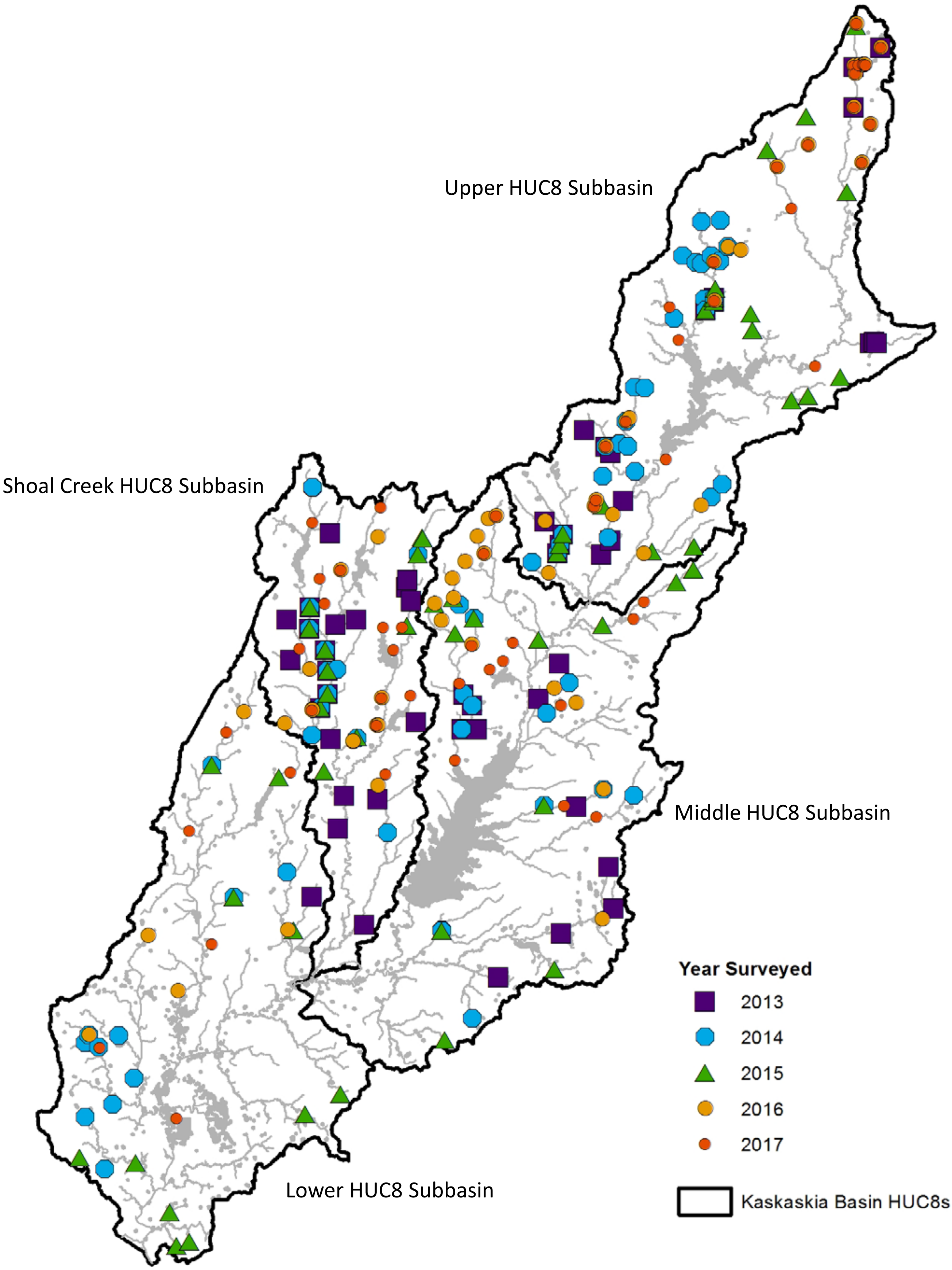


Figure 1. CREP stream bioassessment survey locations between 2013 and 2017.

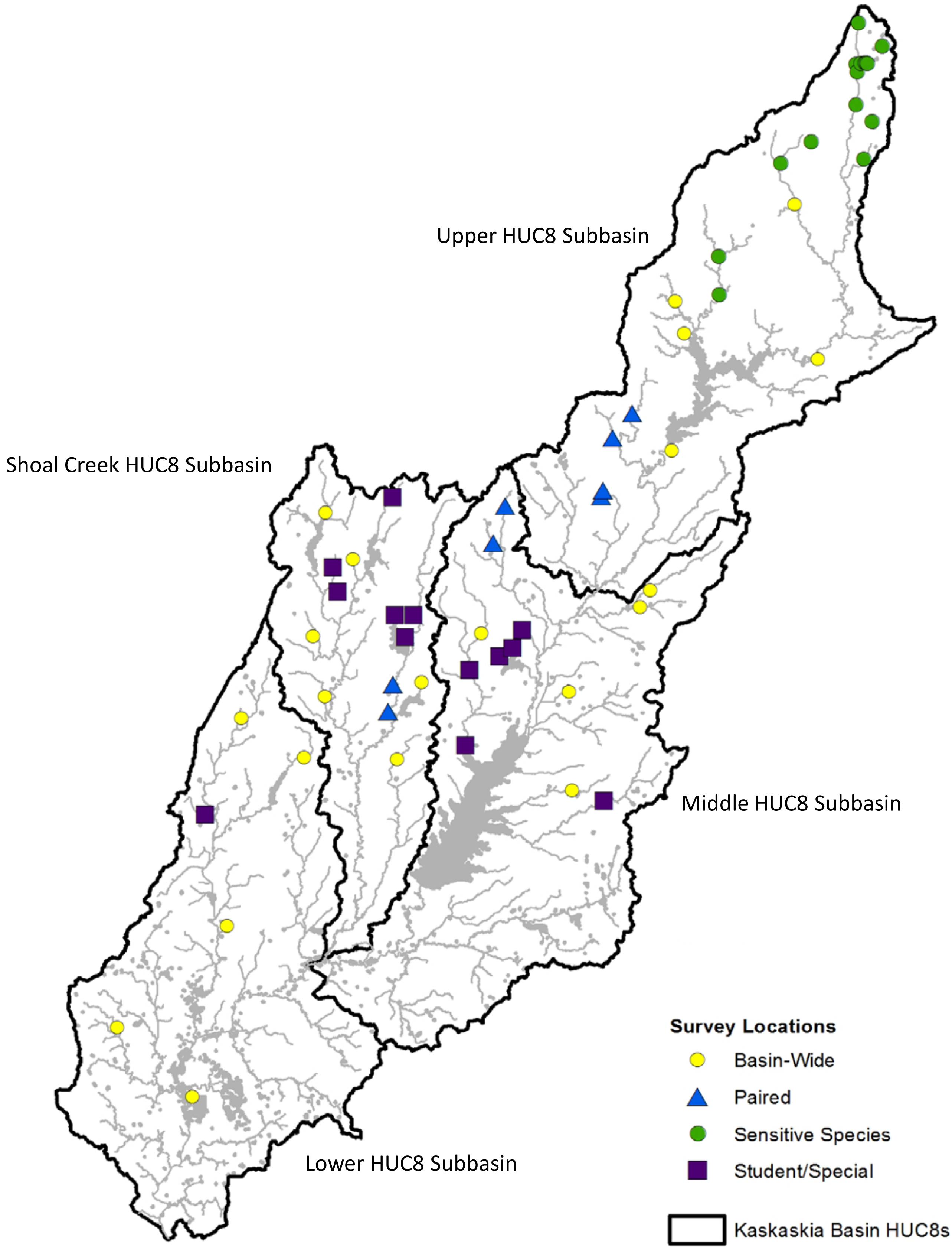


Figure 2. CREP stream bioassessment survey locations in 2017.

Sediment and Nutrient Monitoring at Selected Watersheds within the Kaskaskia River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP)

2017 Progress Report

by
Illinois State Water Survey
Prairie Research Institute, University of Illinois
Champaign, Illinois

Prepared for the
Office of Resource Conservation,
Illinois Department of Natural Resources
Springfield, Illinois

December 2017

This report was printed on recycled and recyclable papers.

Contents

List of Tables

Page

List of Figures

List of Figures (continued)

Page

Sediment and Nutrient Monitoring at Selected Watersheds within the Kaskaskia River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP)

Progress Report

by
Illinois State Water Survey
Prairie Research Institute, University of Illinois

1. Introduction

The Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois and Kaskaskia River basins. Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the rivers of Illinois were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois CREP were stated as follows:

1) Reduce the amount of silt and sediment entering the main stem of the Illinois and Kaskaskia River by 20 percent.
2) Reduce the amount of phosphorus and nitrogen loadings to the Illinois and Kaskaskia River by 10 percent.

To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation. Progress made so far in each of these efforts is presented in this report.

Acknowledgments

The work upon which this progress report is based is supported by funds provided by the Office of Resource Conservation, Illinois Department of Natural Resources, under the guidance of Mike Chandler, IDNR CREP Program Coordinator, whose support is greatly appreciated. The project is also supported as part of the authors' regular duties at the Illinois State Water Survey under the guidance of Principal Investigators Laura Keefer and Mike Demissie.

Several Illinois State Water Survey staff worked diligently to meet project objectives and their tireless dedication is much appreciated. Erin Bauer coordinated many aspects of the project including supervision the field data collection personnel and activities, as well as developed and implemented the data collection computer programming and protocols for the field instrumentation. John Beardsley and Jim Osborne designed, fabricated, and installed the instrument shelters. Erin Bauer designed, developed and managed the project databases, software programming for data processing and computations, and performs quality control. Yao Hu, University of Illinois Ph.D. candidate, wrote the MatLab code or the project data processing.

Lara Seek, John Beardsley and Erin Bauer perform the field data collection efforts that amount to many long, wet, and tiring days. Joyce Wyse performs data entry as well as track and organize project records. Erin Bauer compiled, investigated and analyzed the land cover data (Illinois and Kaskaskia Basins). Phil Graff, ISWS, and Lisa Beja, IDNR, compiled the CREP contract conservation practices database (Illinois and Kaskaskia Basins). Erin Bauer and Lara Seek produced the tables and figures. Laura Keefer is responsible for the overall investigation, implementation, management and analyses of the ISWS Kaskaskia study, as well as writing the progress report. Leon Hinz, Illinois Natural History Survey (INHS), collaborated in the ISWS/INHS co-location site selection of intensive monitoring stations and his assistance was most appreciated.

2. Watershed Characteristics

The Kaskaskia River watershed has a drainage area of 5,810 mi^2, is generally located in the southwest region of the State of Illinois, and occupies all or portions of 15 counties (Figure 2-1). The headwaters begin in Champaign and Piatt Counties in east-central Illinois and flows in a southwesterly direction to join the Mississippi River in Randolph County. Table 2-1 lists the tributary watersheds and associated drainage areas. Figure 2-1 illustrates approximately 22 tributary watersheds in the basin that range in drainage area from 53 to 917 mi^2. The two largest tributary watersheds are Shoal Creek (917 mi^2) and Silver Creek (480 mi^2) and together occupy nearly 25 percent of the Kaskaskia River watershed drainage area. In general, the Kaskaskia River watershed is divided into four sub-watersheds (Upper, Middle, Lower, and Shoal Creek) that are associated with the outlets at the two main reservoirs, Lake Shelbyville and Carlyle Reservoir, and confluence with the Mississippi River. The Shoal Creek tributary watershed is distinguished due to its large drainage area. See (Illinois Department of Natural Resources 2000) for further information.

Hydrology

Knapp and others (2012) describe the Kaskaskia River as one of the more highly managed river systems in Illinois. The streamflow on the main stem of the Kaskaskia River is controlled by two federal reservoirs (Shelbyville and Carlyle Reservoirs) and the navigation pools in the lower reaches of the river are maintained by a lock and dam. Water is withdrawn for industry and public water supplies from several reservoirs constructed on tributaries throughout the watershed. Other inflows come from effluent discharges throughout the drainage system by municipal systems and industries, as well as power plant cooling water returns. A detailed water supply assessment of the Kaskaskia River watershed can be found in (Knapp, Roadcap et al. 2012).

Geology

The surficial geology plays a role in the types of land cover in the Kaskaskia River watershed. Figure 2-2 illustrates the boundaries of the physiographic regions, loess (windblown silt) thicknesses, and shaded relief for the Kaskaskia River watershed. The watershed is predominantly in the Bloomington Ridged Plain and Springfield Plain of the Till Plains Section.

The Upper sub-watershed is entirely in the Bloomington Ridged Plain and characterized by low, broad ridges with intervening wide stretches of relatively flat or gently undulatory ground (Leighton, Ekblaw et al. (1948). These alternating ridges with flat ground are indicative of the most recent glacial period, referred to as the Wisconsinan. Therefore, the drainage system is more recent than the Springfield Plain which is older and more developed.

The Middle, Shoal Creek, and most of the Lower sub-watersheds are in the Springfield Plain which is part of the Illinoisan glacial drift period that occurred before the Wisconsinan. The Illinoisan is characteristically flat with low and broad ridges (moraines) but some areas in the Kaskaskia watershed have ridges and hills with irregular assemblages of gravel with small intervening plains. The drainage system is characterized by major rivers in low gradient and broad terraced valleys and tributaries in wide v-shaped valleys with headwaters originating from the low gradient, broad shallow valleys of the till plains. Basically, the Springfield Plain occupies the older Illinoisan glacial drift with older drainage development, whereas the

Bloomington Ridge Plain occupies the Wisconsinan, which overlies the Illinoisan, and is flat with sequences of ridges and initial stages of drainage.

Another geologic characteristic that controls drainage development and is a factor in erosion is the thickness of the windblown silt (loess) that overlies the glacial drift, similar to frosting on a layer cake (Illinoisan and Wisconsinan glacial drift), somewhat smoothing out imperfections on the surface. As seen in Figure 2-2, the loess in the Upper sub-watershed is between 0-5 feet thick and lies in the ridged and wide flat valleys of the Bloomington Ridged Plain. Most of the Middle sub-watershed and upper reaches of the Shoal Creek sub-watershed the loess is 0-5 feet thick and lies in the more developed drainage landscape of the Springfield Plain. The lower reaches of Shoal Creek and most of the Lower sub-watersheds have thicknesses that can range from 5 to greater than 20 feet proceeding from east to west toward the Mississippi River. However, many of the stream valleys in these areas do not have loess present and is considered to have been eroded. Areas with thick loess are considered prone to erosion under steep conditions which can result in unstable stream channels. A more extensive discussion on the geology and surficial materials in the Kaskaskia River watershed can be found in (Illinois Department of Natural Resources 2000).

In summary, the four sub-watersheds of the Kaskaskia River watershed are fairly distinct from each other based on geology and land cover features. These features have an influence on water quality, erosion, and aquatic habitat. Agriculture production is dominant in the Upper sub-watershed due to the consistent, relatively flat and wide valleys between gentle ridges, as well as the highly productive soil developed in the loess cap. Large areas dominated by highly productive soil and agriculture tend to have elevated nutrient levels in the stream system. The Middle and Upper-Shoal sub-watersheds have a mix of agriculture and woodlands/grasses, where the agriculture is in the flatter uplands and woodlands in the deeper valleys. Nutrients may be slightly more elevated in the drainage system but some erosion issues may play a factor in the valleys. The lower-Shoal and lower sub-watersheds are similar in land use to the Middle sub-watershed, slightly more agriculture but the loess thicknesses in combination with higher relief result in erosion being more of an issue in these areas.

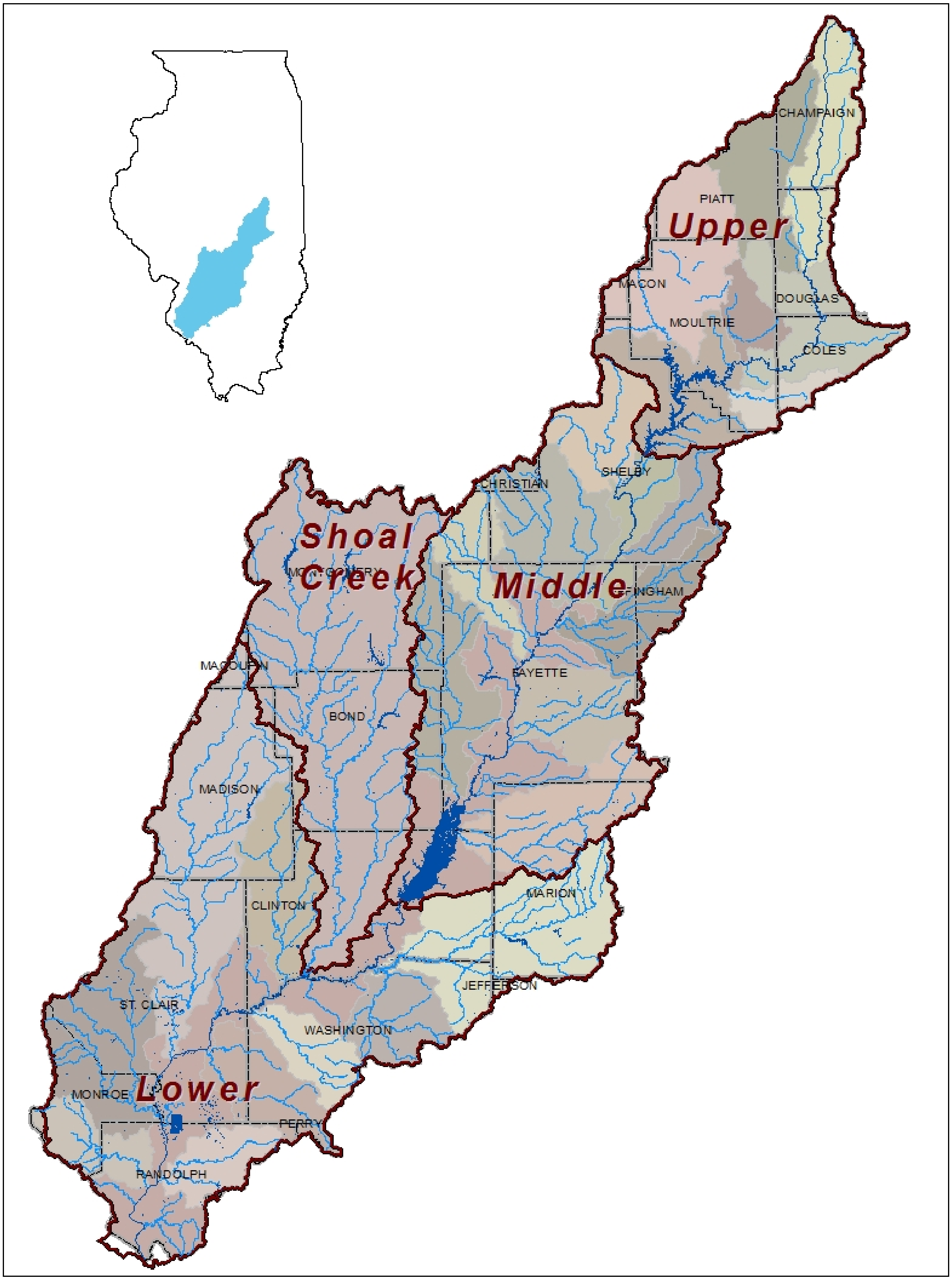


Figure 2-1. Kaskaskia River Basin, sub-basins, and major tributary watersheds

Table 2-1. Kaskaskia tributary watersheds and drainage areas

Tributary Name	*Drainage Area* *(acres)*	*(mi²)*
Ash Creek	89,610	140
Beck Creek	130,771	204
Crooked Creek	224,663	351
East Fork Kaskaskia River	132,477	207
Elkhorn Creek	56,760	89
Hickory Creek	92,224	144
Hoffman Creek	67,428	105
Horse Creek	60,175	94
Hurricane Creek	128,822	201
Johnathan Creek	36,896	58
Kaskaskia-L. Shelbyville	**122,705**	**192**
Kaskaskia Ditch	103,474	162
Kaskaskia River	**658,183**	**1,028**
Lake Fork	109,537	171
Little Crooked Creek	73,254	114
Mud Creek	87,207	136
Plum Creek	57,399	90
Richland Creek	213,431	333
Robinson Creek	79,112	124
Shoal Creek	586,584	917
Silver Creek	307,171	480
Sugar Creek	112,775	176
West Okaw River	154,219	241
Whitley Creek	33,687	53
Total	*3,718,563*	*5,810*

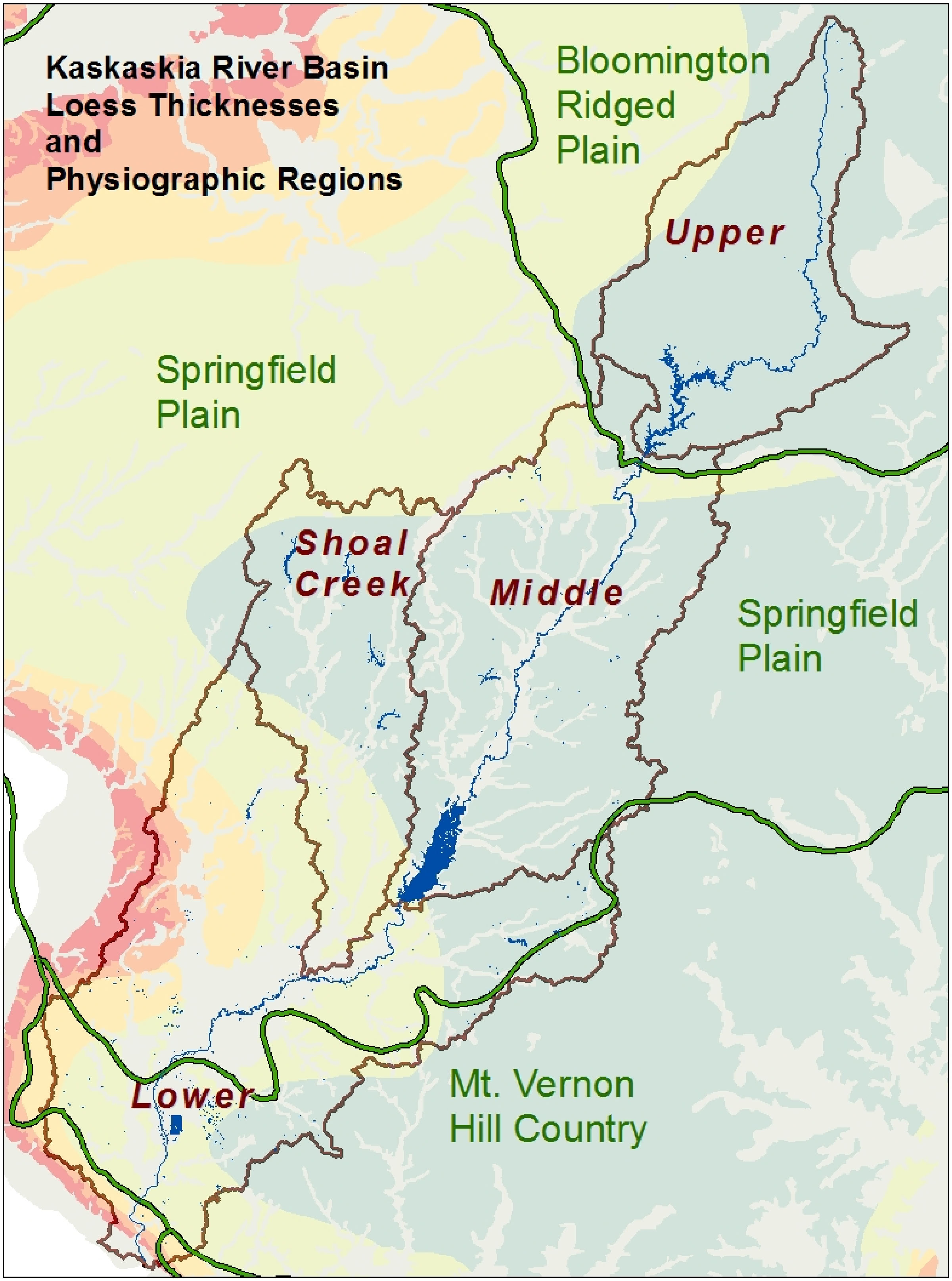


Figure 2-2.Physiographic regions and loess thicknesses in Kaskaskia Basin

3. Monitoring and Data Collection

The monitoring and data collection component consists of a watershed monitoring program to monitor sediment and nutrient for selected sub-watersheds within the Kaskaskia River basin and also to collect and analyze land use data throughout the river basin. Currently available data is insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to establish a monitoring program that will collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Kaskaskia River basin that will assist in making a more accurate assessment of sediment and nutrient delivery.

The monitoring strategy for the project was to select small Kaskaskia River tributary watersheds to establish an intensive monitoring program to detect any changes in sediment and nutrient transport characteristics that could be attributed to changes in land use or other factors. The project is designed to measure the cumulative impact within the watershed on sediment and nutrient yield and is not designed to measure the impact of specific BMPs on water quality or sediment yield. Several factors were evaluated to determine the final locations of the intensive monitoring sites, such as artificial inflow and outflow of water due to water supply, industrial, and recreation needs, geology, land use, currently available water quality data for more prescriptive monitoring plans, areas likely to have appreciable CREP sign-ups, and co-location with other physical, biological, and water quality program stations. Co-locating and/or supplementing monitoring stations with other water quality and aquatic sampling stations in the watershed is an integrated approach that contributes to understanding the mechanisms that link hydrologic, sediment, nutrient, biological, and physical information for application in other watersheds in Illinois.

Due to the highly managed nature of the Kaskaskia River watershed hydrology, this project assessed locations of water inflows and outflows that could mask monitoring results by affecting the normal balance of the sediment and nutrient loading character. For example, the streamflow in the main stem of the Kaskaskia River and several tributaries are significantly controlled by the periodic releases from reservoirs. Also, the water from those releases are more of a reflection of the water quality from lake processes rather than the transport of water and nutrients from the upper portions of the drainage system. Also assessed were locations of waste water treatment plant (WWTP) effluent, NPDES discharges, and other smaller reservoirs in the tributary watersheds. This project capitalized on a recently completed water supply assessment for the Kaskaskia River watershed, which assembled existing water availability and supply information mentioned above by Knapp, Roadcap et al. (2012).

To effectively monitor any changes in sediment and nutrient loading due to CREP, small-scale intensive monitoring in several places improves the ability to monitor changes over time. Ideally, these small-scale study watersheds should be in areas that will have the highest likelihood of CREP sign-ups. The ISWS contacted several local stakeholder groups, county Soil and Water Conservation Districts and CREP program staff to estimate areas likely to have appreciable CREP sign-ups within the Kaskaskia River watershed. This assessment period overlapped with the 2012 drought which appeared to have appreciably reduced CREP sign-ups for the first year of the monitoring project. Consequently, in collaboration with Illinois Natural History Survey (INHS) investigators, an analysis was made based on land cover, geology, hydrology, biology and conservation reserve programs (CRP) already in the watershed. This allowed for comparing and contrasting watershed land uses with physical character for selection of watersheds estimated to be likely and unlikely for CREP signups. Four watersheds were then selected to represent combinations of physical watershed character and land cover and monitoring began in late 2013.

Monitoring Stations

The four small watersheds selected for intensively monitoring sediment and nutrient within the Kaskaskia River basin are located within the Crooked Creek, North Fork Kaskaskia River, Hurricane Creek and Shoal Creek watersheds. In addition, two continuous recording raingages were established near the monitored watersheds. The general locations of the watersheds, monitoring stations and raingages are shown in figure 3-1 and more detailed station maps are shown in figures 3-2 through 3-4. Information about the stations is provided in table 3-1. Lost Creek (402) is a tributary of Crooked Creek which, in turn is a direct tributary to the Kaskaskia River with its confluence downstream of Carlyle Reservoir. The Carlyle Reservoir is a U.S. Army Corps of Engineers impoundment on the Kaskaskia River. The North Fork Kaskaskia River (403) and Hurricane Creek (404) are a direct tributaries to the Kaskaskia River at the upstream end of Carlyle Reservoir. East Fork Shoal Creek (405) is a tributary of Shoal Creek, the largest tributary of the Kaskaskia River, with its confluence downstream of Carlyle Reservoir. The type of data collected and the data collection methods have been presented in detail in the first progress report for the CREP monitoring program (Demissie et al., 2001) and in the Quality Assurance Project Plan (QAPP) which is available upon request. The data collected at each of the monitoring stations follows these protocols.

Table 3-1. Sediment and Nutrient Monitoring Stations and Raingages Established for the Kaskaskia River CREP

Station ID	*Name*	*Drainage area*	*Watershed*
402	Lost Creek	38.0 sq mi (24,320 acres)	Crooked Creek
403	North Fork Kaskaskia River	35.5 sq mi (22,701 acres)	North Fork Kaskaskia River
404	Hurricane Creek	27.7 sq mi (17,753 acres)	Hurricane Creek
405	East Fork Shoal Creek	30.9 sq mi (19,820 acres)	Shoal Creek
43	Witt, IL (raingage)	--	East Fork Shoal & Hurricane Creeks
44	Shattuc, IL (raingage)	--	Lost Creek

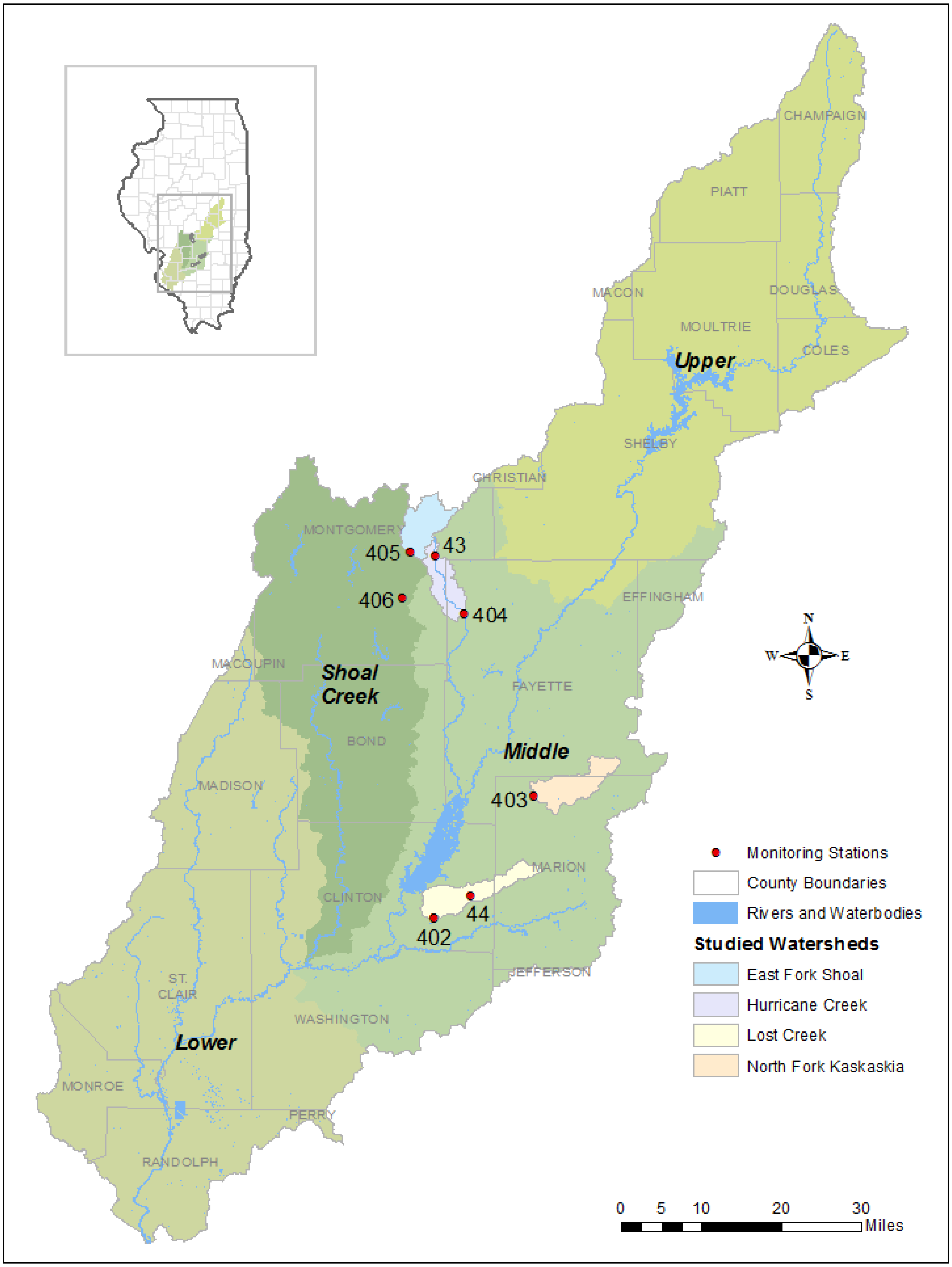


Figure 3-1. General location of monitoring stations in the Kaskaskia River watershed

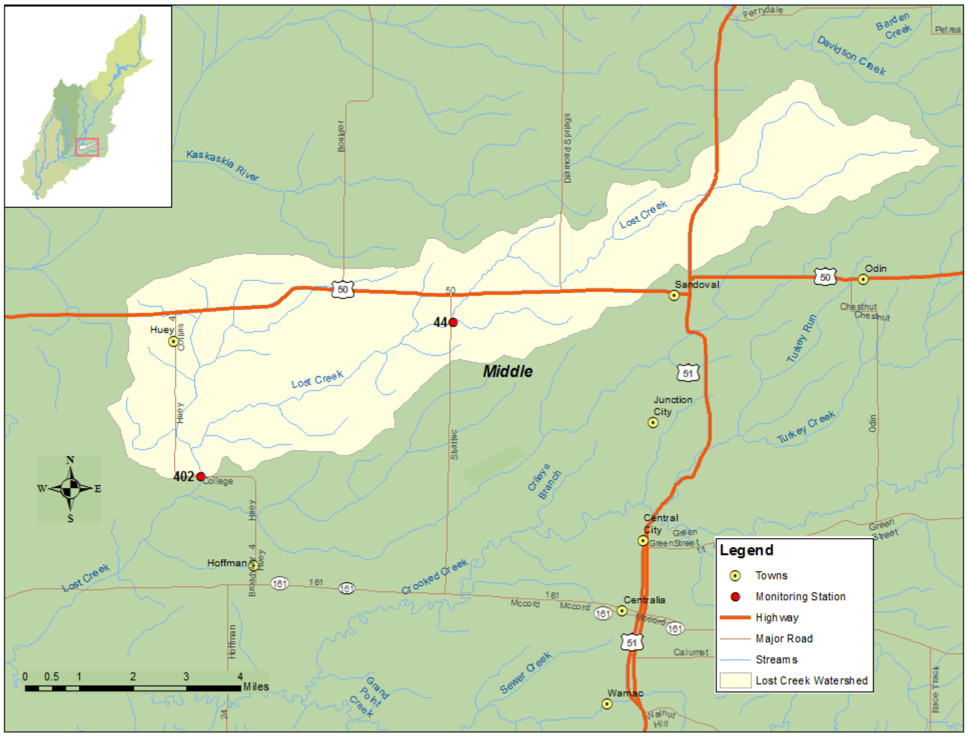


Figure 3-2. Detailed location of monitoring stations in Lost Creek (402) watershed

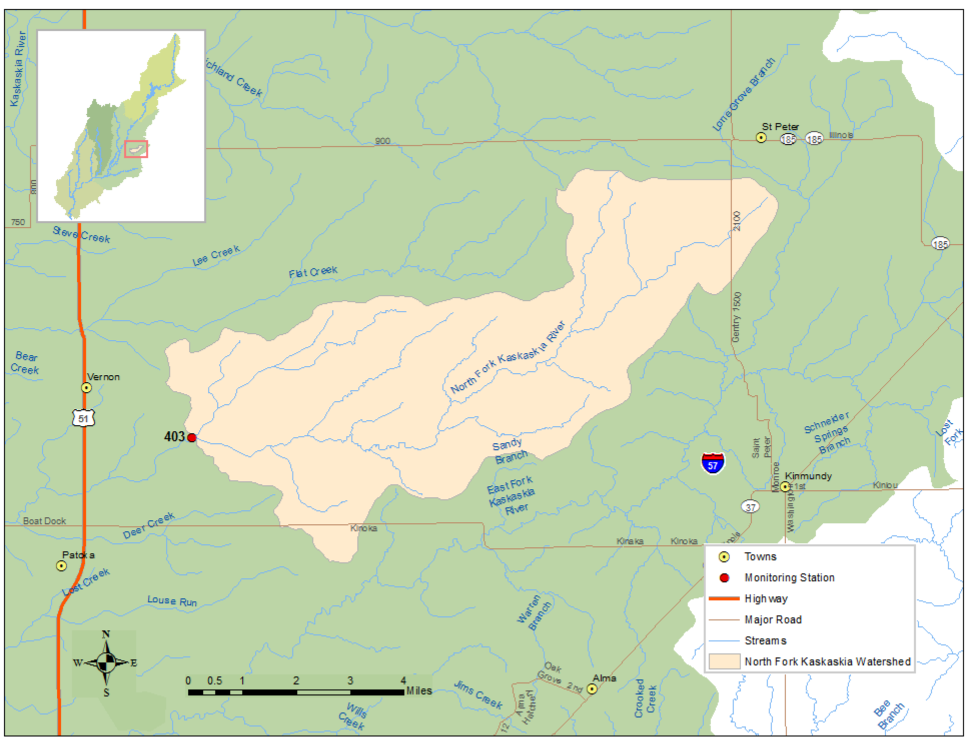


Figure 3-3. Detailed location of monitoring station in North Fork Kaskaskia River (403) watershed

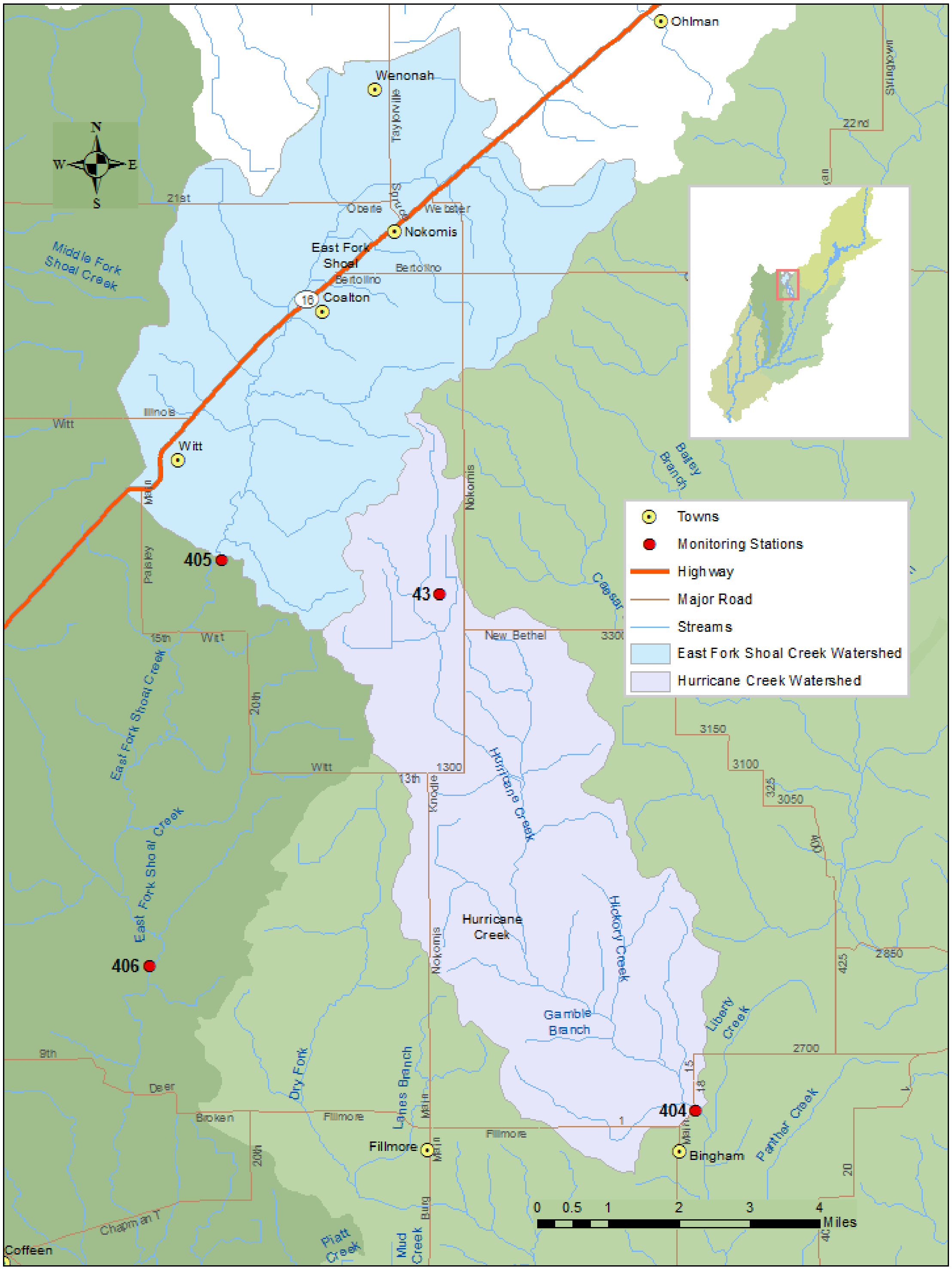


Figure 3-4. Detailed location of monitoring stations in Hurricane (404) and East Fork Shoal Creek (405) watersheds

Each of the four monitoring stations are instrumented with a Campbell Scientific CR850 datalogger, CS476 radar water level sensor, ISCO automatic water sampler, cell modem, antenna, solar panel, and batteries. All instruments, except the ISCO sampler, are housed in a stainless steel shelter to protect them from weather and vandalism. The ISCO sampler is housed in a modified 55-gallon steel drum with a hinged lid for access. The two raingages are instrumented with a modified Belfort weighing-bucket raingage, Campbell Scientific CR200 datalogger, cell modem, antenna, solar panel, and battery. The shelter and instrument configurations of the four streamgage monitoring stations are shown in Figure 3-5 and raingage stations in Figure 3-6. All data is retrieved from the station dataloggers via cell modem every hour to ISWS computer databases.

Figure 3-5. Streamgage monitoring stations in Kaskaskia River Basin: a) Lost Creek, b) North Fork Kaskaskia River, c) Hurricane Creek, and d) East Fork Shoal Creek

a) Witt, Illinois (43) **b) Shattuc, Illinois (44)**

Figure 3-6. Raingage stations in Kaskaskia River Basin: a) Witt, Illinois (43) and b) Shattuc, Illinois (44)

<u>Stream Stage and Flow</u>

The "stage" of a stream is the measurement of the water surface of a stream from an arbitrary datum. The stage record is collected continuously and makes it possible to determine the volume of water carried by a stream past a streamgaging station. Through the application of a stage-discharge rating curve, the continuous stage is converted to streamflow. Streamflow data are generated from the 15-minute stage record at a streamgaging station. The stage data are converted to discharge (streamflow) by applying a stage-discharge calibration curve. The calibration is developed by taking several detailed field measurements of the streamflow at known stages.

Methods used in this study for determining stream discharge follow established USGS procedures as outlined by Rantz (1982a, 1982b). Stream discharge is determined by measuring the mean velocity along a stream cross section. Each vertical represents the velocity of a flow area (substation), which is defined as the sum of half the distance between verticals by the water depth at the vertical. At each vertical the velocity is sampled at 20 and 80 percent of the total depth (for total depths ≥ 2.5 feet) or at 60 percent of the total depth (for total depths < 2.5 feet). The average of the 20 and 80 measurements or the single 60 percent measurement is assumed to be the mean velocity for that subsection. Each subsection discharge is calculated by multiplying the average velocity by the flow area, and then the sum of all the subsections equals the total discharge of the stream cross section. Every discharge is then plotted against the corresponding stage at which the discharge measurement occurred. After sufficient measurements have been collected, a curve is developed to express the relationship between stage and discharge. Using this stage-discharge curve, the stage data files are then converted to discharge. The discharge data can then be used to develop nutrient and sediment load data.

All data are compiled in to what is referred to as "water years", which begins on October 1st and ends September 30th of the following year. The year delineation is associated with the close of the period. For example, water year 2014 (WY2014) begins October 1, 2013 and ends September 30, 2014. The process of collecting a sufficient number of streamflow measurements to adequately develop a stage-discharge calibration takes time. This usually takes 1-2 water years into a monitoring study. Sufficient measurements have been acquired to develop the calibration and streamflow values and nutrient and sediment loads are computed for this progress report.

Sediment and Nutrient Data

Sediment Data

Suspended sediment samples are collected either manually or by ISCO automated pump sampler. The suspended sediment sampling methods used in this study followed established USGS procedures as outlined by Edwards and Glysson (1999) and FISP (1952). The manual sampling method used depth-integrating samplers for all but the shallowest conditions. The second method used to collect suspended sediment samples was the ISCO automated pump sampler. The programming of the CR850 datalogger controls the ISCO sampling schedule. This program allows automated sampling during high-flow events and is triggered by changes in stage over time. Manual suspended sediment samples were taken at all four stations during weekly station visits and during storms when possible.

The WY2017 suspended sediment concentration (SSC) data and streamflow (discharge) for all stations are shown in figures 3-7 and 3-8. Summary statistics for entire study SSC sample set can be found in table 3-2. Figures showing sediment concentration and discharge for previous water years can be found in Appendix A. As can be seen in the figures, suspended sediment concentrations are highly variable throughout a year depending on the precipitation conditions and location of the stations in the watershed. The distance between monitoring stations ranges from 10 to 45 miles and subject to rainfall and storm variability and tracking through the region. It is also evident that sediment concentrations are the highest during storm events resulting in the transport of most of the sediment during storm events. Therefore, it is extremely important that samples are collected frequently during storm events to accurately measure sediment loads at monitoring stations. Approximately 1937 SSC samples were collected at all stations. During the entire 3-year monitoring period the highest maximum SSC occurred at Lost Creek (402) at 15,704 mg/L and lowest maximum at North Fork Kaskaskia (403) with 4722 mg/L. The mean SSC for all stations ranged from 399 to 1,141 mg/L. All stations had minimum SSC below 5 mg/L.

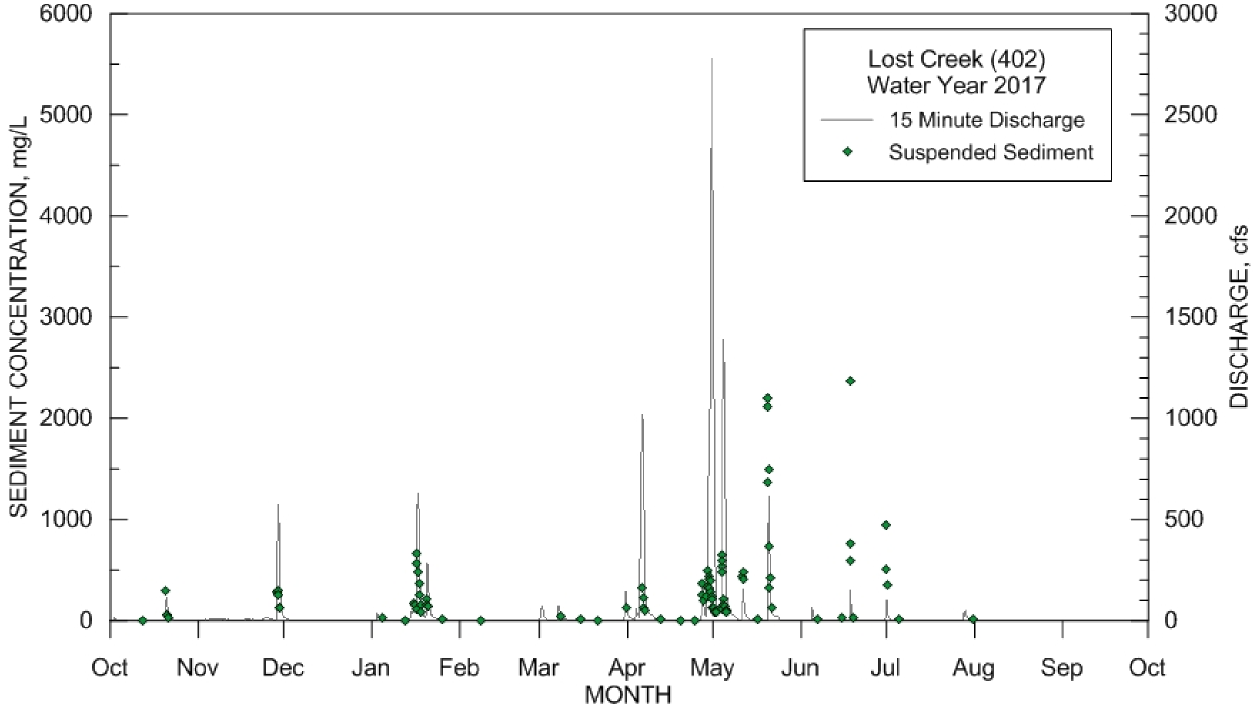
Nutrient Data

The nutrient data are organized into two groups: nitrogen species and phosphorus species. The nitrogen species include nitrate-nitrogen (NO_3-N), ammonium-nitrogen (NH_4-N), and total Kjedahl nitrogen (TKN). The phosphorus species include total phosphorus (TP), total dissolved phosphorus (TDP), and orthophosphate (P-ortho). Approximately 2189 samples have been analyzed for nitrogen and 2094 for phosphorus during the study period. Nitrogen and phosphorus sample results with discharge for WY2017 are shown in figures 3-9 to 3-10 and 3-11 to 3-12, respectively. A summary statistics for all stations showing the sample count, mean, median, minimum, maximum, 25th percentile, and 75th percentile are given in table 3-2. Figures showing nutrient concentrations and discharges for previous water years can be found in Appendix A.

Data for the nitrogen species at all four monitoring stations show that the dominant form of nitrogen transported by the streams is Total Kjeldahl Nitrogen (TKN). During storm events, the concentration of TKN rises significantly, exceeding the nitrate-N concentration (NO_3-N). TKN is highly correlated to suspended sediment concentrations. Ammonium-nitrogen (NH_4-N) maximum concentrations are low at all stations except East Fork Shoal Creek (405) with a maximum concentration over three times the other stations. TKN maximum concentration of 21.28 mg/L was at Lost Creek (402).

As can be seen in figures 3-11 and 3-12 phosphorus species at all monitoring stations show that most of the phosphorus load is transported during storm events. Total phosphorus (t-P) concentrations are the highest during storm events and relatively low most of the time. This is very similar to that shown by sediment and thus implies high correlations between sediment and phosphorus concentrations and loads. The highest maximum t-P concentration for WY2014-17 was 6.23 mg/L at Lost Creek (402). Ortho-phosphate (oPO4-P) and total dissolved phosphorus (t-P-diss) maximum and mean concentrations at all stations are similar (table 3-2).

Figures 3-13 to 3-16 illustrate the distribution of sediment, nitrogen and phosphorus concentrations for a typical storm event that occurred from April 26 through May 6, 2017. Note the two y-axes on the left of the plot showing concentrations for sediment (green diamonds) and the other for nitrogen/phosphorus. The right y-axis shows water discharge. The first observation is the variation in streamflow between the stations which is expected due to the spatial variation between the stations (see map in figure 3-1) and rainfall intensities. As seen in Figures 3-14 and 3-16 Hurricane (404) and East Fork Shoal (405) creeks share a watershed boundary but rainfall intensity, slope, and land cover can produced different stream discharge characteristics. This in turn can affect the carrying capacity of the streamflow resulting in variations in concentrations. All the figures support the concentration summary statistics which informed that TKN and t-P are the dominant nitrogen and phosphorus species at all stations and is similar in pattern with suspended sediment concentrations.



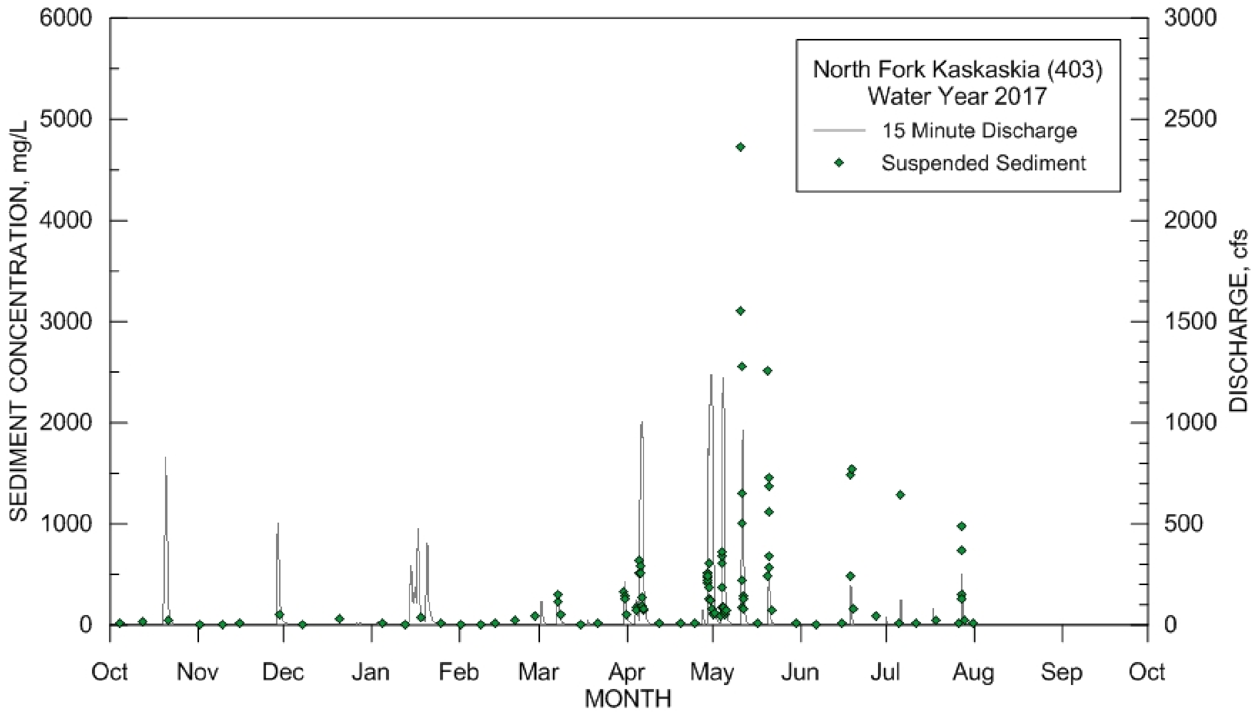


Figure 3-7. Suspended sediment concentrations and discharge for Water Year 2017: Lost Creek (402) and North Fork Kaskaskia (403)

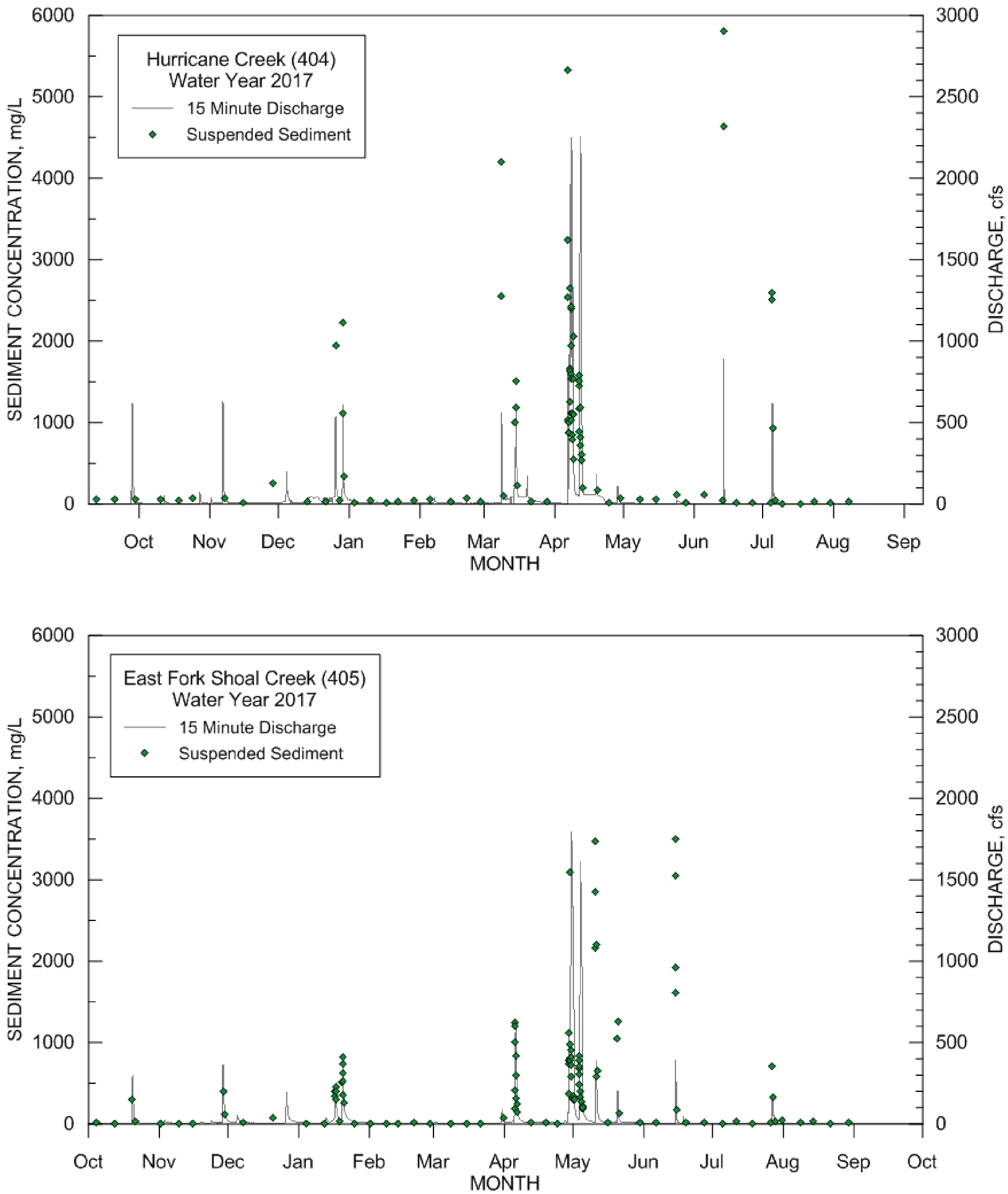


Figure 3-8. Suspended sediment concentrations and discharge for Water Year 2017: Hurricane Creek (404) and East Fork Shoal Creek (405)

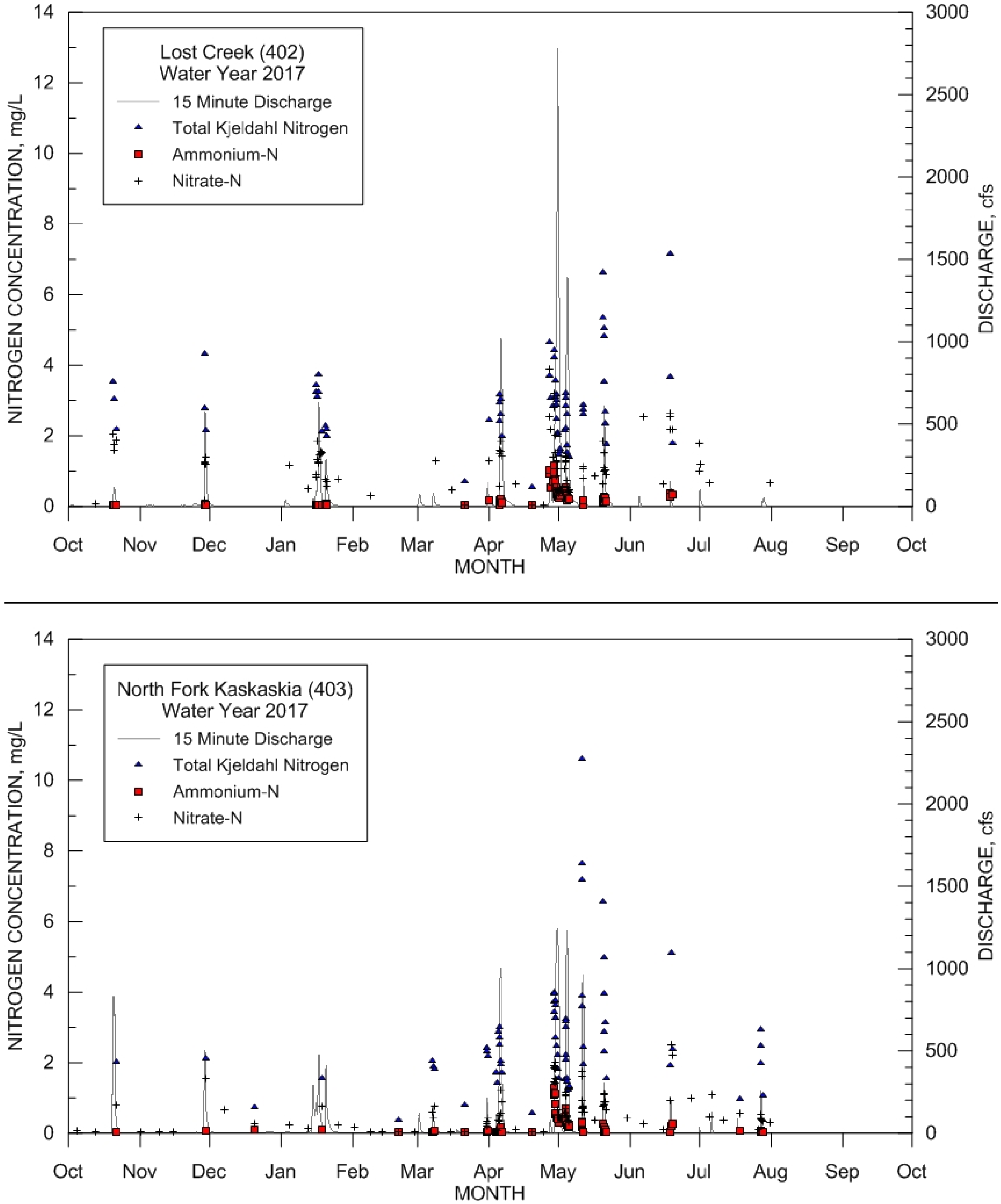


Figure 3-9. Nitrogen concentrations and discharge for Water Year 2017:
Lost Creek (402) and North Fork Kaskaskia (403)

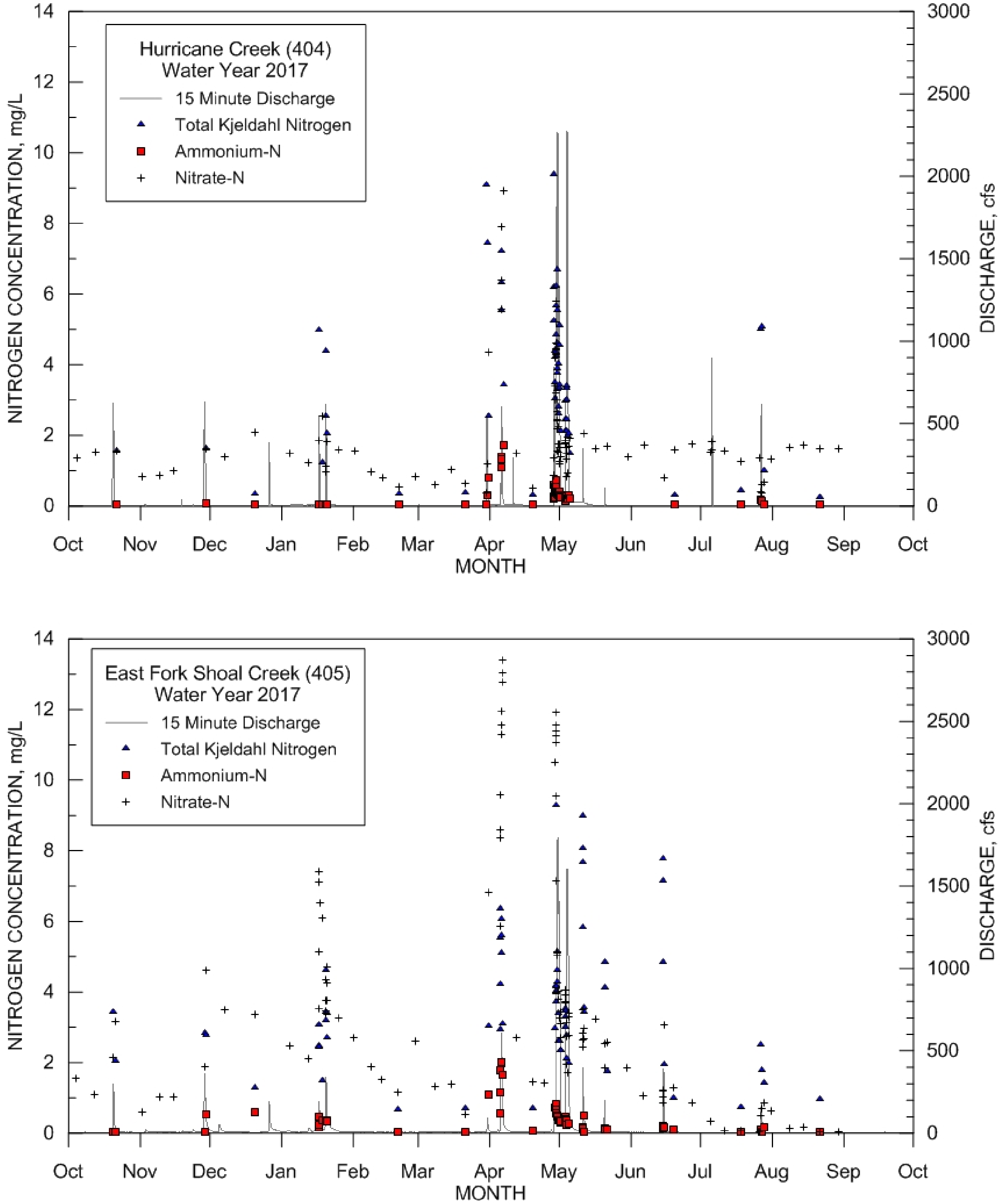
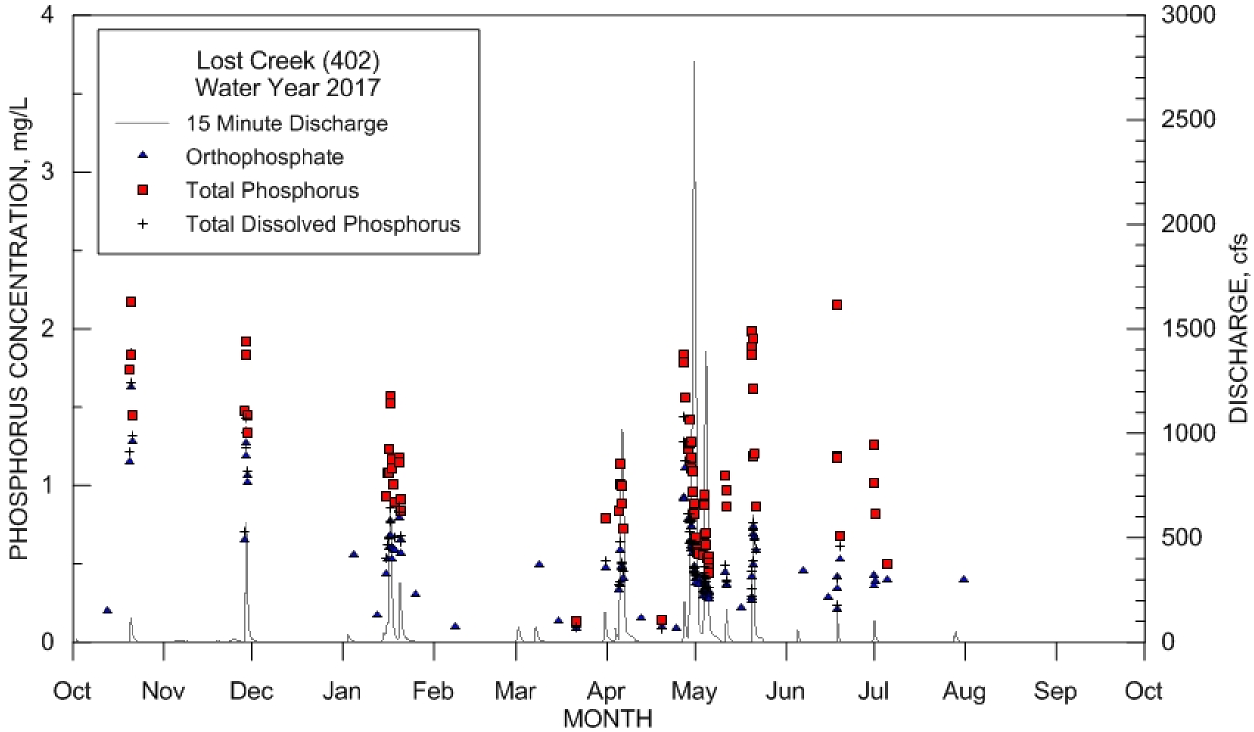


Figure 3-10. Nitrogen concentrations and discharge for Water Year 2017:
Hurricane Creek (404) and East Fork Shoal Creek (405)



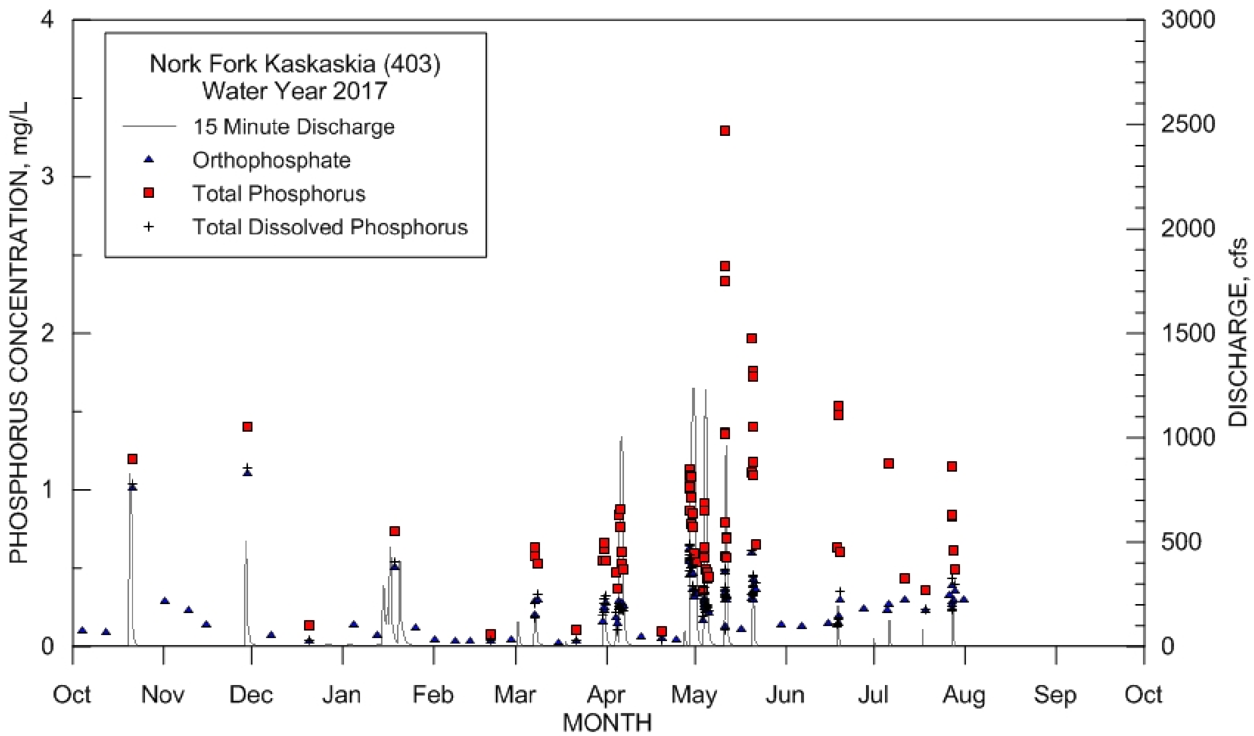
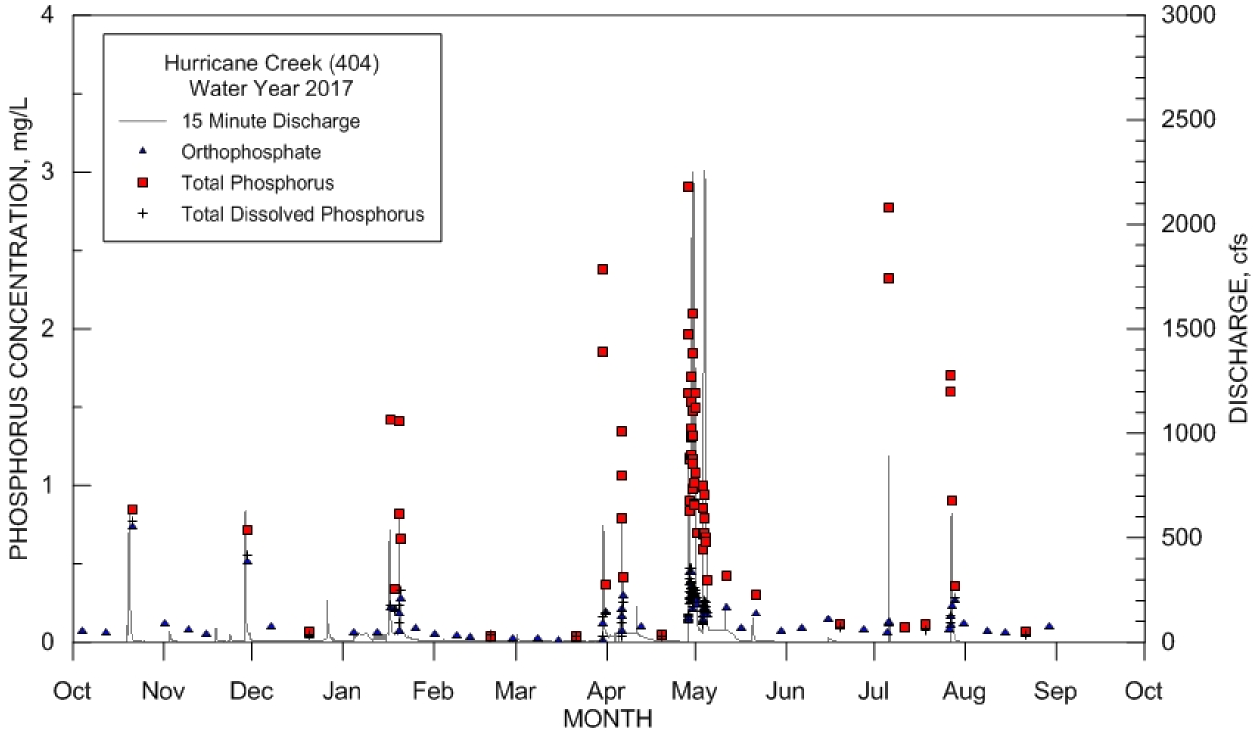


Figure 3-11. Phosphorus concentrations and discharge for Water Year 2017:
Lost Creek (402) and North Fork Kaskaskia (403)



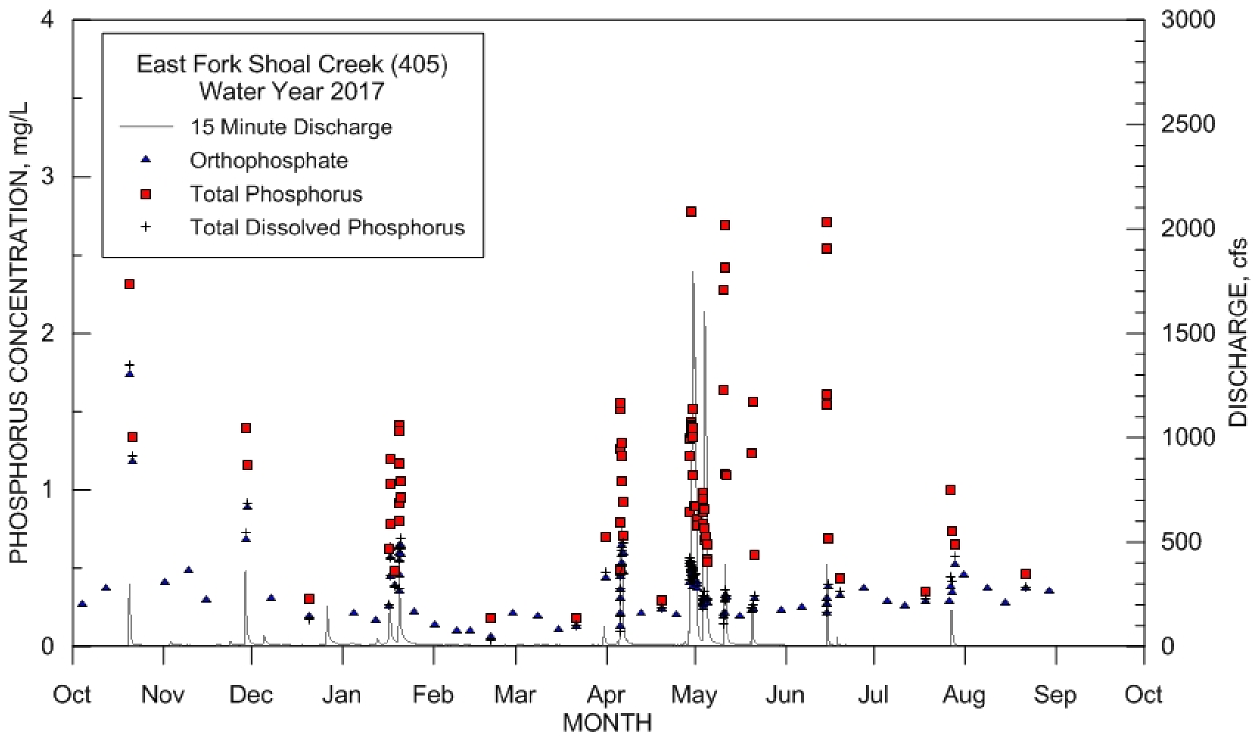
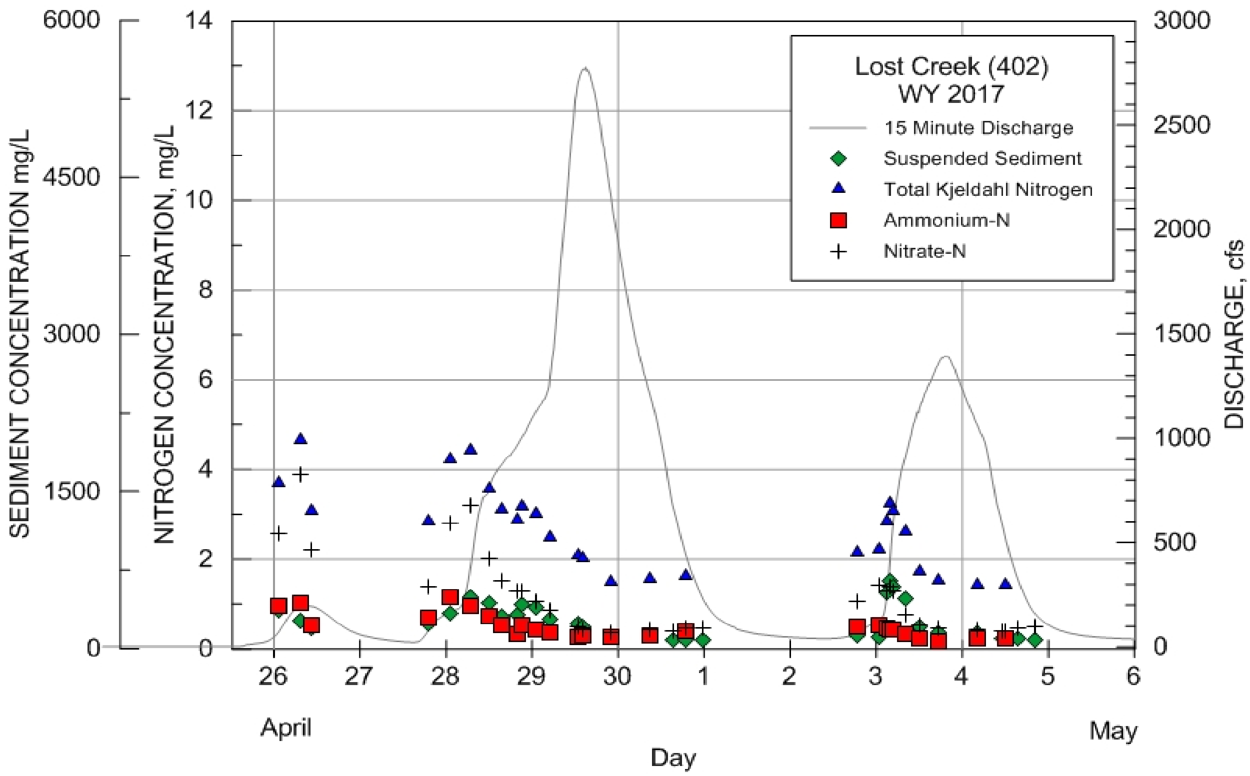


Figure 3-12. Phosphorus concentrations and discharge for Water Year 2017:
Hurricane Creek (404) and East Fork Shoal Creek (405)

Table 3-2. Summary Statistics for Water Years 2014-2017 (all concentrations in mg/L).

	NO3-N	*NH4-N*	*TKN*	*t-P*	*t-P-dissolved*	*oPO4-P*	*SSC*
Lost Creek (402)							
Count	760	649	630	671	589	726	584
Mean	0.76	0.14	2.84	1.05	0.52	0.47	559
Median	0.51	0.08	2.38	0.95	0.50	0.45	238
Minimum	0.04	0.03	0.54	0.13	0.07	0.03	4
Maximum	4.90	1.24	21.28	6.23	1.66	1.84	15,704
25th Percentile	0.33	0.03	1.81	0.78	0.36	0.30	91
75th Percentile	1.03	0.18	3.15	1.20	0.64	0.59	525
North Fork Kaskaskia River (403)							
Count	530	431	381	412	353	507	495
Mean	0.60	0.14	2.46	0.84	0.39	0.34	399
Median	0.44	0.06	2.11	0.77	0.36	0.29	220
Minimum	0.04	0.03	0.37	0.08	0.04	0.01	4
Maximum	4.18	1.31	10.60	3.29	1.29	1.27	4,722
25th Percentile	0.21	0.03	1.59	0.54	0.25	0.18	58
75th Percentile	0.72	0.13	2.86	1.09	0.49	0.43	489
Hurricane Creek (404)							
Count	406	325	264	277	241	384	388
Mean	1.38	0.16	3.63	1.09	0.24	0.18	1,141
Median	1.22	0.05	2.99	0.91	0.20	0.12	527
Minimum	0.04	0.03	0.23	0.04	0.04	0.00	4
Maximum	8.91	1.72	19.70	5.74	0.81	0.78	10,462
25th Percentile	0.62	0.03	1.77	0.48	0.11	0.07	54
75th Percentile	1.64	0.16	4.87	1.42	0.33	0.24	1,513
East Fork Shoal Creek (405)							
Count	493	411	360	379	327	477	470
Mean	2.13	0.39	3.53	1.18	0.50	0.43	646
Median	1.59	0.17	2.92	0.99	0.41	0.37	277
Minimum	0.04	0.03	0.65	0.18	0.04	0.06	3
Maximum	13.39	6.81	16.26	4.72	1.79	1.73	11,897
25th Percentile	0.82	0.04	2.03	0.72	0.30	0.27	29
75th Percentile	2.66	0.47	4.21	1.44	0.63	0.54	673



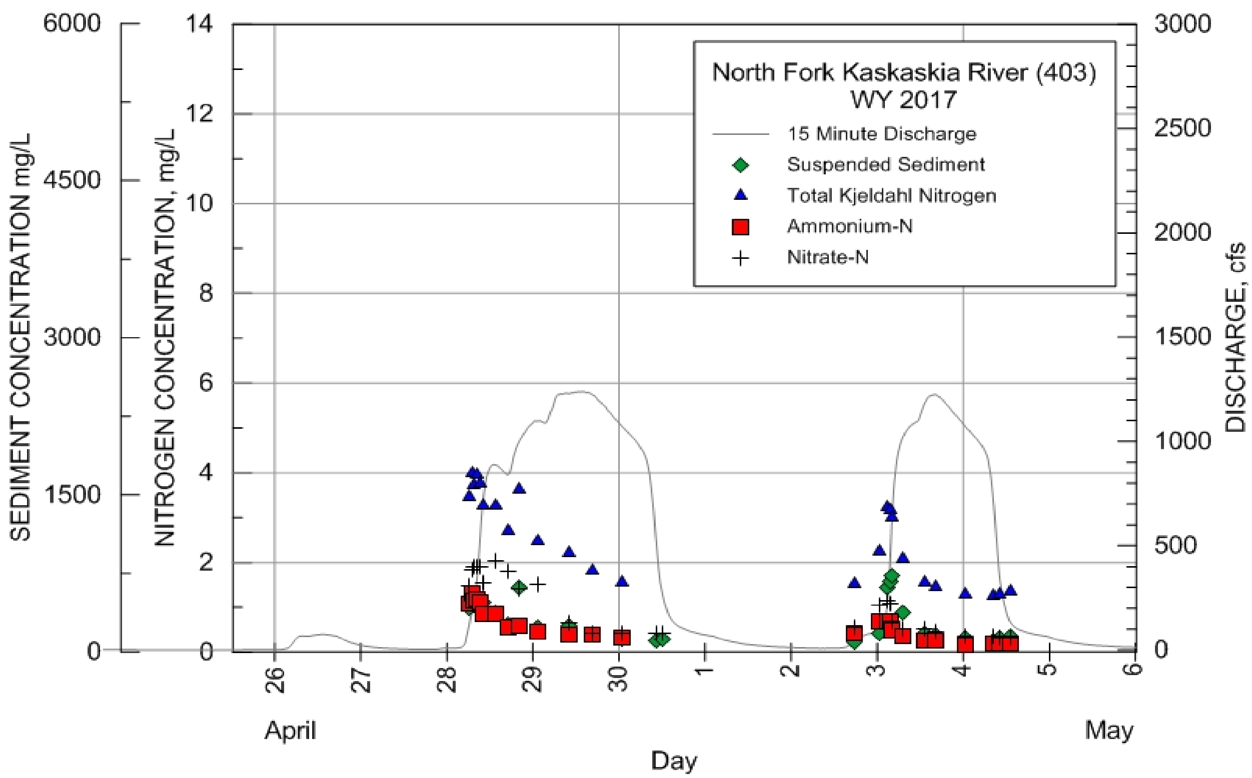
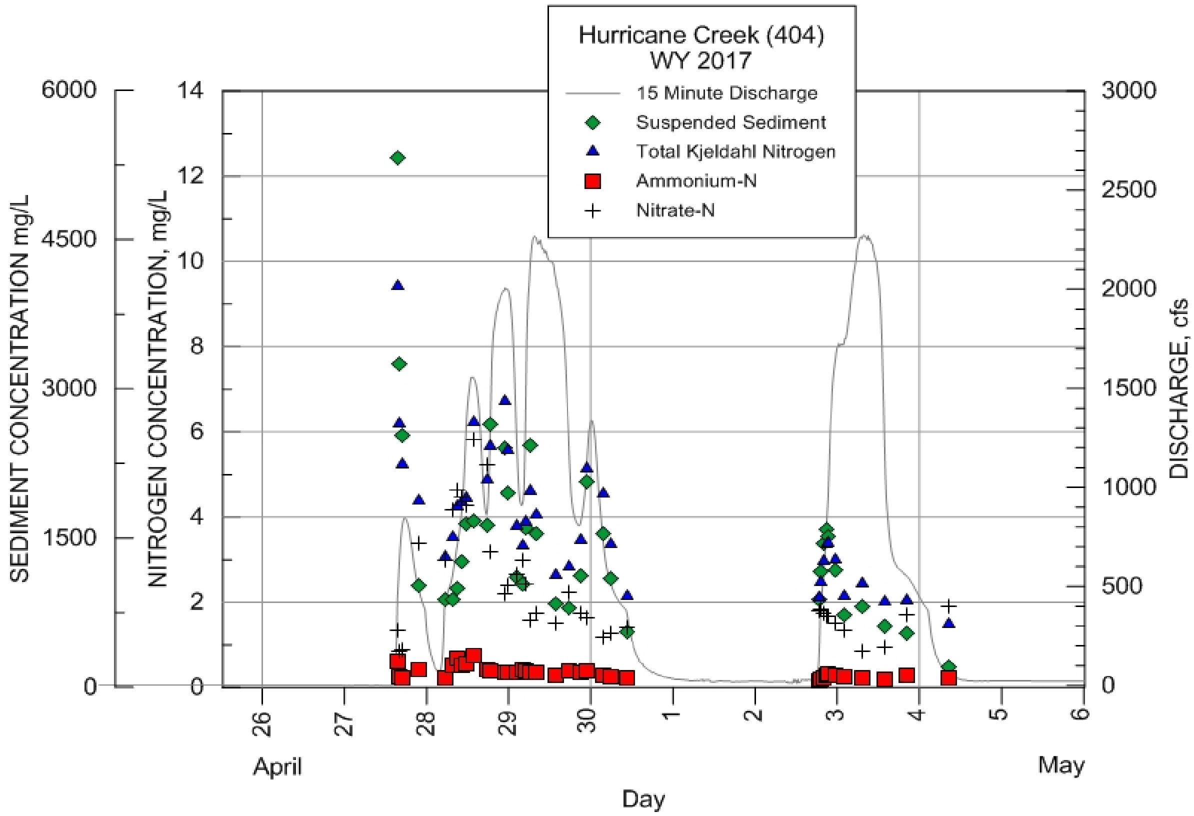


Figure 3-13. Sediment and nitrogen concentrations during April 26-May 6 2017 event at Lost Creek (402) and North Fork Kaskaskia River (403).



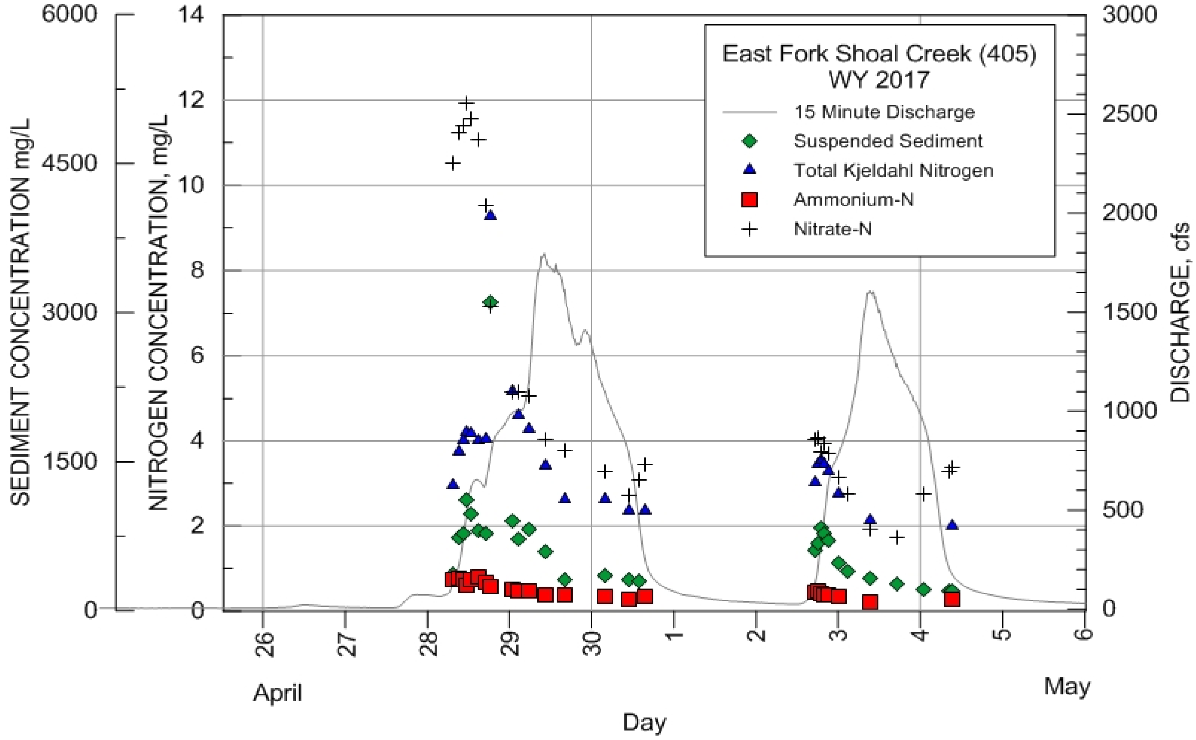
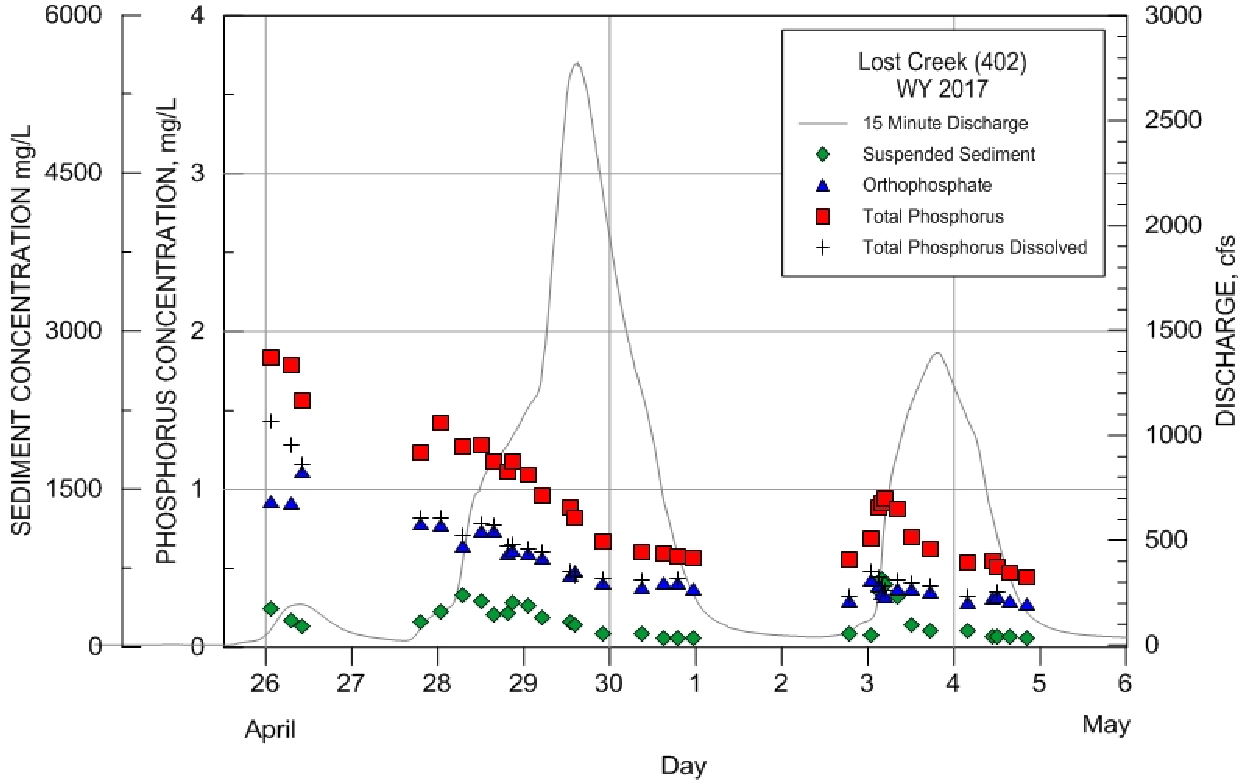


Figure 3-14. Sediment and nitrogen concentrations during April 26-May 6 2017 event at Hurricane Creek (404) and East Fork Shoal Creek (405).



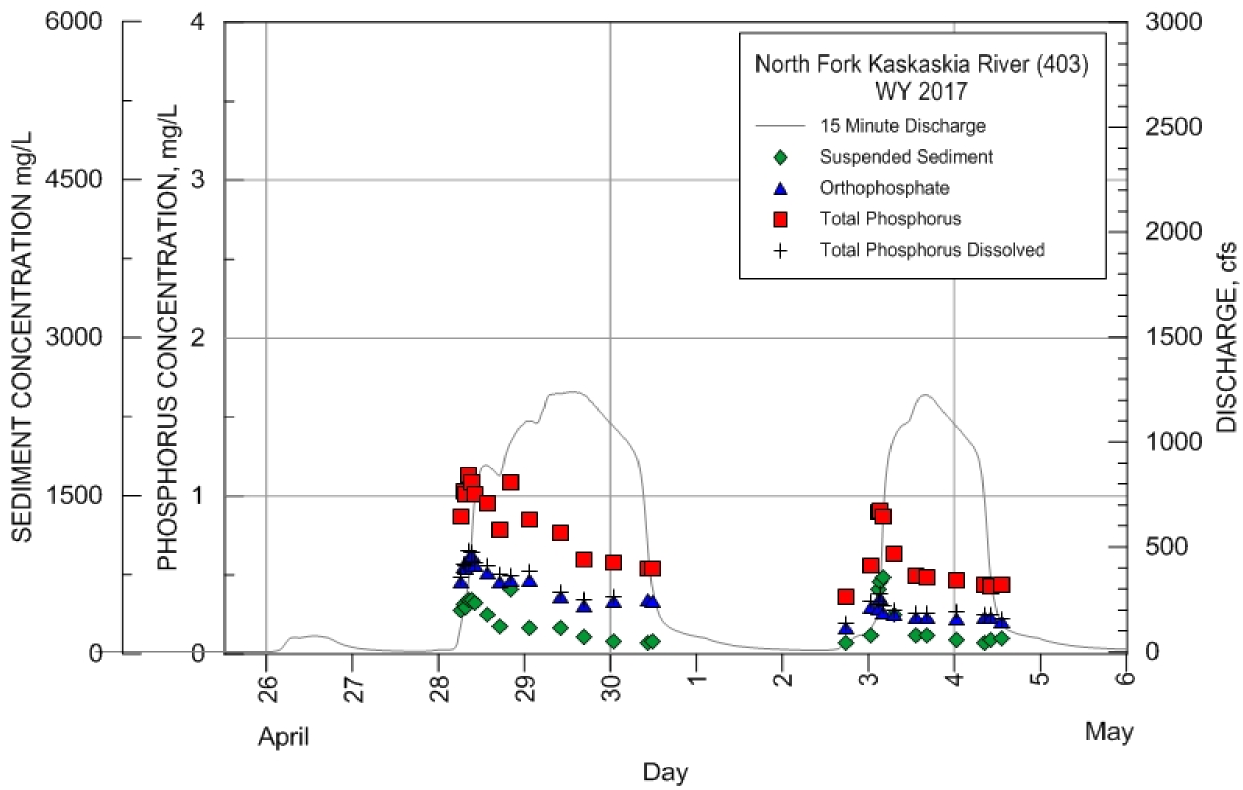
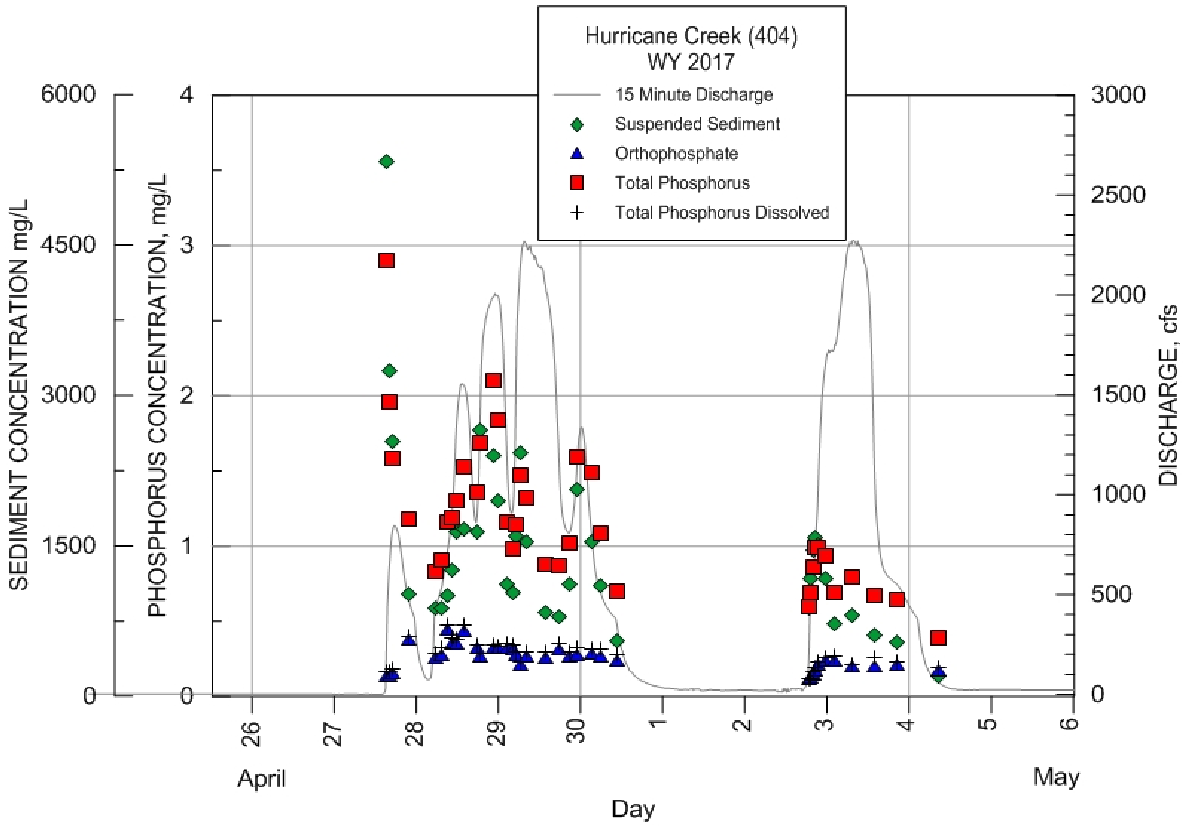


Figure 3-15. Sediment and phosphorus concentrations during April 26-May 6 2017 event at Lost Creek (402) and North Fork Kaskaskia River (403).



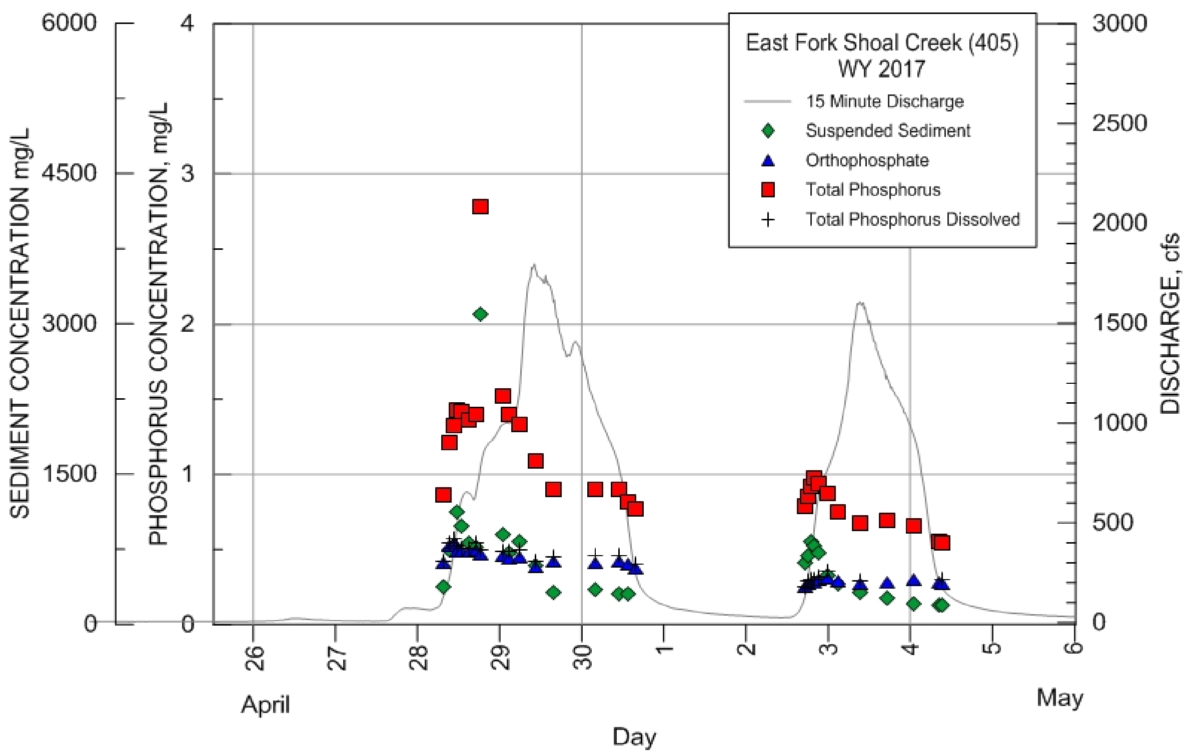


Figure 3-16. Sediment and phosphorus concentrations during April 26-May 6 2017 event at Hurricane Creek (404) and East Fork Shoal Creek (405).

Sediment and Nutrient Yields

Sediment and nutrient concentration data, as well as stream discharges, allows for computation of sediment of nutrients loads transported out of a watershed as measured at a monitoring station. Load is the mass of sediment or nutrients over a period of time. However, comparison of loads between watersheds is computed by dividing the total annual load with the drainage area in acres for each of the monitoring stations. The yield results for all stations during WY2014-2017 are provided in tables 3-3 through 3-6 for suspended sediment, nitrate-N, TKN, and total phosphorus, respectively. The monthly yield at all stations during WY2017 for sediment and total phosphorus is shown in figure 3-17 and nitrate-N and TKN in figure 3-18. It should be noted that suspended sediment yields are presented in tons per acre (tons/ac) while nitrate-N, TKN, and total phosphorus are presented in pounds per acre (lbs/ac). Figures showing monthly sediment and nutrient yields for previous water years can be found in Appendix B.

Monthly sediment yields for WY2014-17 ranged from a low of 0.0 to 1.49 tons/acre where Hurricane Creek (404) had the highest yield (table 3-3). Hurricane Creek (404) consistent had the highest annual yield for all four years, whereas the other three monitoring stations were much lower and similar in magnitude. As noted in the earlier section (table 3-2), even though, Lost Creek (402) had the highest recorded suspended sediment sample concentration, urricane Creek (404) had the highest mean and 75th quartile concentrations of all the stations. This higher mean concentration can translate into higher yields. This is why computing yields is more informative when comparing watersheds rather than concentration alone. For Water Year 2017, a drier year, Hurricane Creek (404) is transporting the equivalent of nearly 1.3 tons of suspended sediment per acre down from nearly 5 tons per acre in Water Year 2016 that was much wetter.

During WY2014-17 monthly nitrate-N yields varied from a low of 0.00 lbs/acre at several stations to a high of 8.93 lbs/acre for East Fork Shoal Creek (405) in April 2017 (table 3-4). The highest annual nitrate-N yield for WY2017 was 17.08 lbs/acre at East Fork Shoal Creek (405) with Hurricane Creek (404) next at 11.84 lb/acre. Monthly TKN yields (table 3-5) during WY2014-17 were generally higher than nitrate-N yields at all stations. Monthly total phosphorus yields varied from near zero lbs/acre to a high of 1.69 lbs/acre for Lost Creek (402) in April 2017. East Fork Shoal Creek (405) usually had the highest monthly yields for all but only a few months during WY2014-17. This station had a WY2017 annual total phosphorus yield of 4.32 lbs/acre, almost double the annual load of the other stations except for Lost Creek with 3.82 lbs/acre.

Annual sediment and total phosphorus yields are presented in figure 3-19 and nitrate-N and TKN in figure 3-20 for Water Years 2014 through 2017. Water Year 2014 is a partial year while WY2015, WY2016, and WY2017 are full monitoring years but still exhibits similar patterns between the stations all four years. Annual sediment yields were significantly higher at Hurricane Creek (404) as shown in figure 3-19a and East Fork Shoal Creek (405) had the highest total phosphorus annual yields seen in figure 3-19b. Figure 3-20a shows that Hurricane Creek (404) and East Fork Shoal Creek (405) tended to have higher annual nitrate-N yields than the other two stations. Annual TKN yields, figure 3-20b, does not appear to exhibit a pattern between stations, although East Fork Shoal Creek (405) was higher than other stations in WY2014-15, Hurricane Creek (404) had more TKN yield in WY2016-17. North Fork Kaskaskia (403) always had the lowest annual yield of all the stations in all four years, except in WY17 when Lost Creek (402) had the lowest annual TKN yield of 3.26 lbs/acre.

Table 3-3. Suspended Sediment Yield in tons/acre for Kaskaskia Monitoring Stations

	Month	*402*	*403*	*404*	*405*
WY 2014	Jan 2014	0.00			
	Feb 2014	0.01	0.00	0.00	0.05
	Mar 2014	0.01	0.00	0.00	0.00
	Apr 2014	0.00	0.12	0.69	0.24
	May 2014	0.14	0.02	0.00	0.02
	June 2014	0.00	0.00	0.10	0.07
	July 2014	0.01	0.00	0.00	0.00
	Aug 2014	0.00	0.00	0.00	0.00
	Sept 2014	0.03	0.05	0.00	0.01
WY 2015	Oct 2014	0.03	0.00	0.22	0.04
	Nov 2014	0.00	0.00	0.01	0.01
	Dec 2014	0.00	0.06	0.10	0.01
	Jan 2015	0.05	0.00	0.01	0.00
	Feb 2015	0.00	0.01	0.01	0.00
	Mar 2015	0.00	0.10	0.40	0.05
	Apr 2015	0.12	0.08	1.20	0.14
	May 2015	0.17	0.12	0.03	0.10
	2015 June	0.09	0.20	1.08	0.27
	July 2015	0.24	0.00	0.00	0.00
	Aug 2015	0.03	0.00	0.00	0.00
	Sept 2015	0.00	0.02	0.00	0.00
WY 2016	Oct 2015	0.03	0.00	0.00	0.00
	Nov 2015	0.00	0.09	0.05	0.01
	Dec 2015	0.10	0.34	1.35	0.08
	Jan 2016	0.32	0.00	0.01	0.00
	Feb 2016	0.00	0.04	0.02	0.00
	Mar 2016	0.01	0.04	0.01	0.01
	Apr 2016	0.01	0.20	1.49	0.12
	May 2016	0.04	0.03	1.04	0.03
	June 2016	0.03	0.01	0.34	0.08
	July 2016	0.01	0.01	0.49	0.04
	Aug 2016	0.00	0.12	0.20	0.01
	Sept 2016	0.06	0.07	0.00	0.00
WY 2017	Oct 2016	0.00	0.00	0.00	0.01
	Nov 2016	0.00	0.00	0.01	0.01
	Dec 2016	0.00	0.00	0.01	0.00
	Jan 2017	0.00	0.01	0.13	0.03
	Feb 2017	0.00	0.00	0.00	0.00
	Mar 2017	0.00	0.01	0.07	0.00
	Apr 2017	0.01	0.11	0.70	0.24
	May 2017	0.01	0.13	0.27	0.17
	June 2017	0.00	0.01	0.00	0.03
	July 2017	0.00	0.01	0.12	0.00
	Aug 2017	0.00	0.00	0.00	0.00
	Sept 2017	0.00	0.00	0.00	0.00
*WY 2014	(April - Sept)	0.19	0.20	0.80	0.39
WY 2015	(Oct - Sept)	0.75	0.58	3.07	0.63
WY 2016	(Oct - Sept)	0.62	0.94	5.01	0.38
WY 2017	(Oct - Sept)	0.02	0.29	1.31	0.48

[*-partial water year]

Table 3-4. Nitrate-N Yield in lbs/acre for Kaskaskia Monitoring Stations

	Month	*402*	*403*	*404*	*405*
WY 2014	Jan 2014	0.10			
	Feb 2014	0.10	0.00	0.03	0.25
	Mar 2014	0.00	0.00	0.32	0.09
	Apr 2014	0.48	0.41	2.34	1.00
	May 2014	0.08	0.27	0.40	0.40
	June 2014	0.04	0.07	0.46	0.69
	July 2014	0.00	0.00	0.01	0.00
	Aug 2014	0.10	0.02	0.02	0.00
	Sept 2014	0.06	0.06	0.01	0.01
WY 2015	Oct 2014	0.01	0.00	0.12	0.11
	Nov 2014	0.03	0.00	0.09	0.16
	Dec 2014	0.37	0.26	0.49	0.48
	Jan 2015	0.03	0.04	0.28	0.25
	Feb 2015	0.03	0.04	0.15	0.11
	Mar 2015	0.31	0.27	0.88	0.60
	Apr 2015	0.25	0.05	0.31	0.29
	May 2015	0.72	0.67	1.28	1.10
	June 2015	1.16	0.52	2.28	1.89
	July 2015	0.19	0.00	0.11	0.12
	Aug 2015	0.01	0.00	0.18	0.00
	Sept 2015	0.09	0.01	0.09	0.01
WY 2016	Oct 2015	0.00	0.00	0.03	0.00
	Nov 2015	0.00	0.54	0.41	0.30
	Dec 2015	0.59	0.39	2.00	3.05
	Jan 2016	0.38	0.03	0.22	0.72
	Feb 2016	0.03	0.36	0.17	0.29
	Mar 2016	0.19	0.08	0.17	0.94
	Apr 2016	0.08	0.54	1.88	2.18
	May 2016	0.28	0.21	0.38	0.95
	June 2016	0.31	0.04	0.27	1.10
	July 2016	0.11	0.14	0.60	1.08
	Aug 2016	0.01	0.27	0.06	0.14
	Sept 2016	0.21	0.21	0.07	0.13
WY 2017	Oct 2016	0.10	0.20	0.38	0.31
	Nov 2016	0.08	0.20	0.35	0.52
	Dec 2016	0.25	0.02	0.38	0.74
	Jan 2017	0.01	0.31	1.00	1.73
	Feb 2017	0.54	0.00	0.09	0.12
	Mar 2017	0.00	0.09	0.29	0.27
	Apr 2017	0.13	1.38	6.77	8.93
	May 2017	2.02	0.82	2.23	4.27
	June 2017	0.86	0.10	0.07	0.15
	July 2017	0.13	0.05	0.24	0.04
	Aug 2017	0.04	0.00	0.06	0.00
	Sept 2017	0.00	0.00	0.00	0.00
*WY 2014	(April - Sept)	0.98	0.81	3.59	2.43
WY 2015	(Oct - Sept)	3.21	1.85	6.25	5.13
WY 2016	(Oct - Sept)	2.19	2.81	6.27	10.89
WY 2017	(Oct - Sept)	4.16	3.17	11.84	17.08

[*-partial water year]

Table 3-5. TKN Yield in lbs/acre for Kaskaskia Monitoring Stations

	Month	*402*	*403*	*404*	*405*
WY 2014	Jan 2014	0.17			
	Feb 2014	0.34	0.00	0.00	1.44
	Mar 2014	0.00	0.00	0.07	0.29
	Apr 2014	1.72	1.67	2.06	3.77
	May 2014	0.10	0.28	0.24	0.72
	June 2014	0.10	0.08	0.46	1.32
	July 2014	0.00	0.00	0.00	0.00
	Aug 2014	0.33	0.04	0.01	0.00
	Sept 2014	0.36	0.42	0.00	0.12
WY 2015	Oct 2014	0.10	0.01	0.72	1.24
	Nov 2014	0.16	0.01	0.07	0.45
	Dec 2014	1.39	0.99	0.49	0.96
	Jan 2015	0.14	0.16	0.13	0.44
	Feb 2015	0.10	0.13	0.03	0.16
	Mar 2015	1.69	1.09	1.03	1.57
	Apr 2015	2.27	0.92	2.26	2.34
	May 2015	1.62	1.35	0.27	1.96
	June 2015	3.27	1.84	2.59	4.93
	July 2015	0.55	0.02	0.02	0.15
	Aug 2015	0.06	0.00	0.02	0.01
	Sept 2015	0.39	0.11	0.01	0.03
WY 2016	Oct 2015	0.01	0.00	0.01	0.00
	Nov 2015	2.18	0.66	0.38	0.29
	Dec 2015	4.02	1.59	3.48	7.45
	Jan 2016	0.08	0.03	0.12	0.34
	Feb 2016	0.38	0.27	0.05	0.12
	Mar 2016	0.34	0.27	0.16	0.26
	Apr 2016	0.61	1.36	7.67	3.16
	May 2016	0.59	0.26	4.62	1.28
	June 2016	0.18	0.04	1.61	2.49
	July 2016	0.01	0.07	2.31	1.47
	Aug 2016	1.26	0.63	1.03	0.48
	Sept 2016	0.79	0.46	0.02	0.12
WY 2017	Oct 2016	0.03	0.34	0.20	0.19
	Nov 2016	0.19	0.18	0.23	0.27
	Dec 2016	0.00	0.01	0.09	0.14
	Jan 2017	0.20	0.38	1.15	0.46
	Feb 2017	0.00	0.00	0.03	0.03
	Mar 2017	0.04	0.22	0.75	0.07
	Apr 2017	1.85	1.83	8.33	2.76
	May 2017	0.93	1.59	3.15	2.22
	June 2017	0.02	0.10	0.02	0.22
	July 2017	0.00	0.09	0.50	0.05
	Aug 2017	0.00	0.00	0.02	0.00
	Sept 2017	0.00	0.00	0.00	0.00
*WY 2014	(April - Sept)	3.12	2.49	2.85	7.66
WY 2015	(Oct - Sept)	11.75	6.64	7.66	14.25
WY 2016	(Oct - Sept)	10.45	5.65	21.46	17.45
WY 2017	(Oct - Sept)	3.26	4.74	14.48	6.42

[*-partial water year]

Table 3-6. Total Phosphorus Yield in lbs/acre for Kaskaskia Monitoring Stations

	Month	*402*	*403*	*404*	*405*
WY 2014	Jan 2014	0.08			
	Feb 2014	0.09	0.00	0.00	1.24
	Mar 2014	0.00	0.00	0.01	0.12
	Apr 2014	0.63	0.57	0.60	2.97
	May 2014	0.03	0.07	0.05	0.49
	June 2014	0.04	0.02	0.12	0.99
	July 2014	0.00	0.00	0.00	0.00
	Aug 2014	0.16	0.02	0.00	0.00
	Sept 2014	0.16	0.14	0.00	0.11
WY 2015	Oct 2014	0.04	0.01	0.23	1.14
	Nov 2014	0.10	0.01	0.03	0.58
	Dec 2014	0.79	0.50	0.18	1.00
	Jan 2015	0.06	0.08	0.04	0.36
	Feb 2015	0.03	0.04	0.03	0.08
	Mar 2015	0.51	0.35	0.28	1.06
	Apr 2015	0.72	0.25	0.72	1.89
	May 2015	0.56	0.40	0.08	1.50
	June 2015	1.20	0.57	0.82	3.85
	July 2015	0.18	0.01	0.01	0.15
	Aug 2015	0.02	0.00	0.01	0.01
	Sept 2015	0.18	0.04	0.00	0.05
WY 2016	Oct 2015	0.00	0.00	0.00	0.00
	Nov 2015	1.25	0.92	0.18	0.38
	Dec 2015	1.82	1.31	1.15	2.10
	Jan 2016	0.03	0.02	0.04	0.20
	Feb 2016	0.08	0.12	0.01	0.08
	Mar 2016	0.09	0.16	0.06	0.31
	Apr 2016	0.24	0.78	2.20	2.71
	May 2016	0.22	0.16	1.40	1.17
	June 2016	0.07	0.03	0.50	1.87
	July 2016	0.00	0.06	0.72	1.24
	Aug 2016	0.53	0.50	0.33	0.45
	Sept 2016	0.23	0.35	0.01	0.15
WY 2017	Oct 2016	0.09	0.17	0.00	0.26
	Nov 2016	0.37	0.09	0.00	0.31
	Dec 2016	0.01	0.00	0.00	0.11
	Jan 2017	0.51	0.09	0.13	0.36
	Feb 2017	0.00	0.00	0.00	0.03
	Mar 2017	0.04	0.05	0.09	0.03
	Apr 2017	1.69	0.52	1.16	1.66
	May 2017	1.02	0.50	0.52	1.39
	June 2017	0.06	0.02	0.00	0.13
	July 2017	0.02	0.03	0.13	0.04
	Aug 2017	0.00	0.00	0.00	0.00
	Sept 2017	0.00	0.00	0.00	0.00
*WY 2014	(April - Sept)	1.19	0.81	0.78	5.91
WY 2015	(Oct - Sept)	4.39	2.25	2.44	11.67
WY 2016	(Oct - Sept)	4.57	4.43	6.59	10.65
WY 2017	(Oct - Sept)	3.82	1.47	2.03	4.32

[*-partial water year]

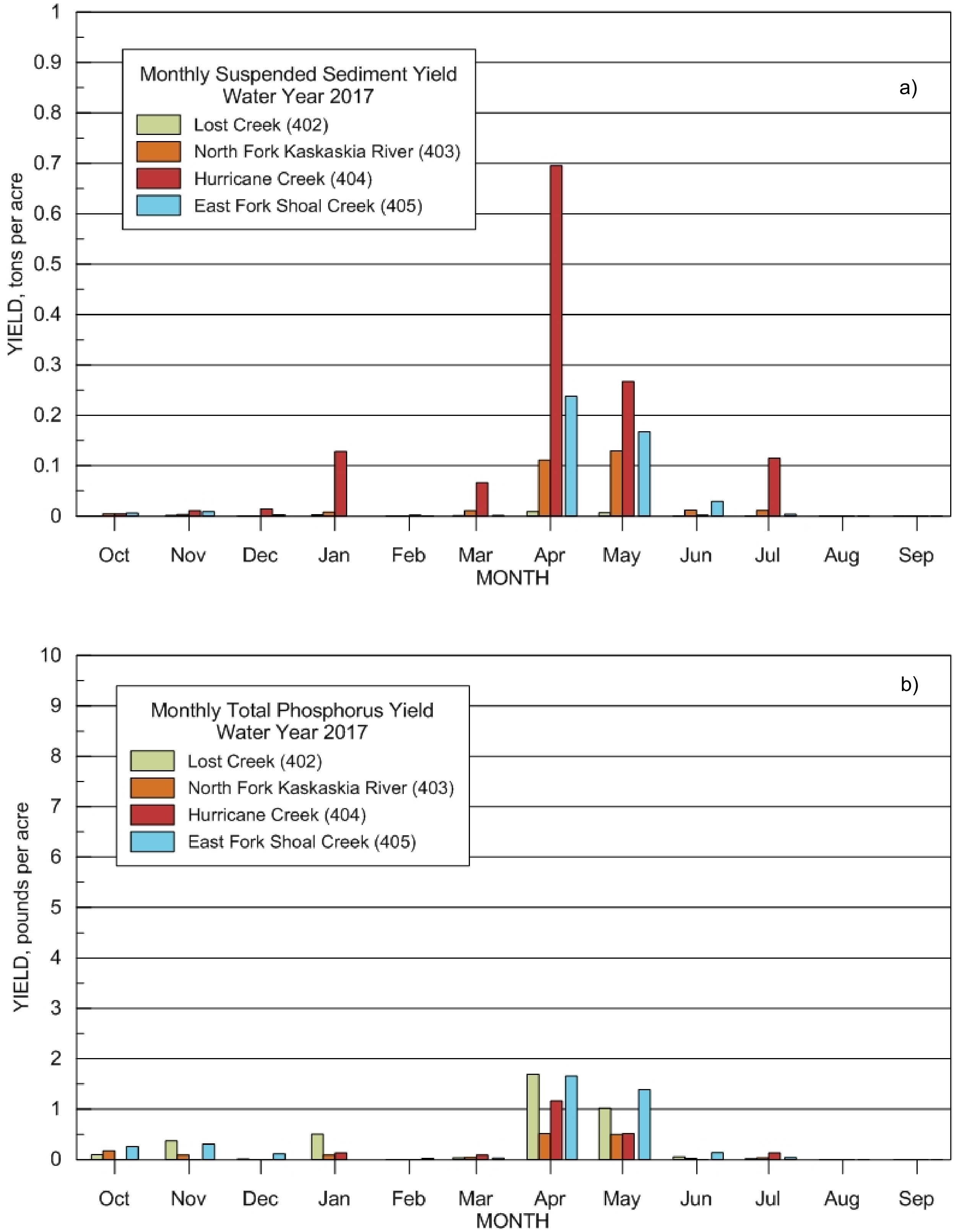


Figure 3-17. Monthly yields for all stations during Water Year 2017:
a) Suspended Sediment (tons/acre) and b) Total Phosphorus (lbs/acre)

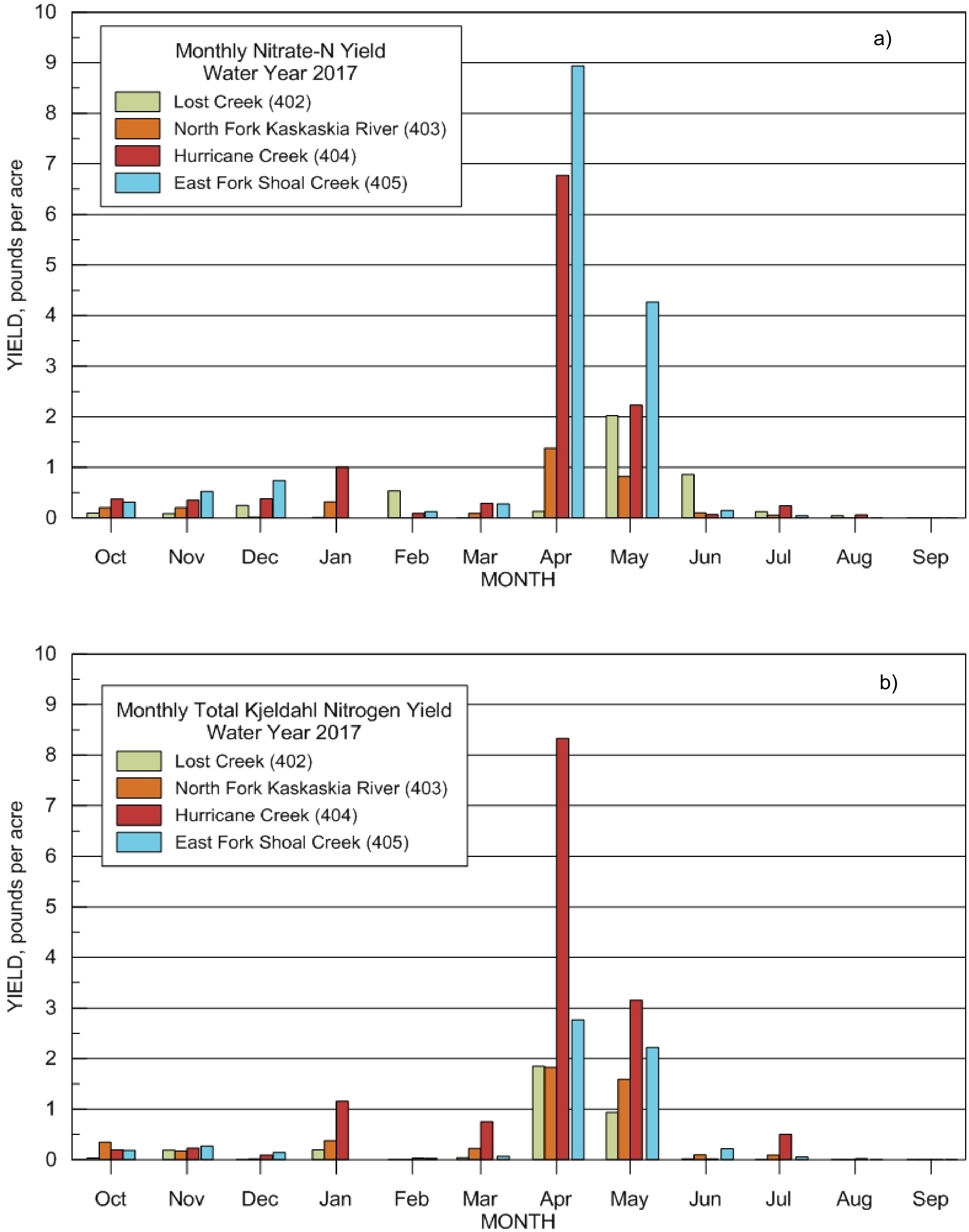


Figure 3-18. Monthly yields for all stations during Water Year 2017:
a) Nitrate-N (lbs/acre) and b) Total Kjeldahl Nitrogen (lbs/acre)

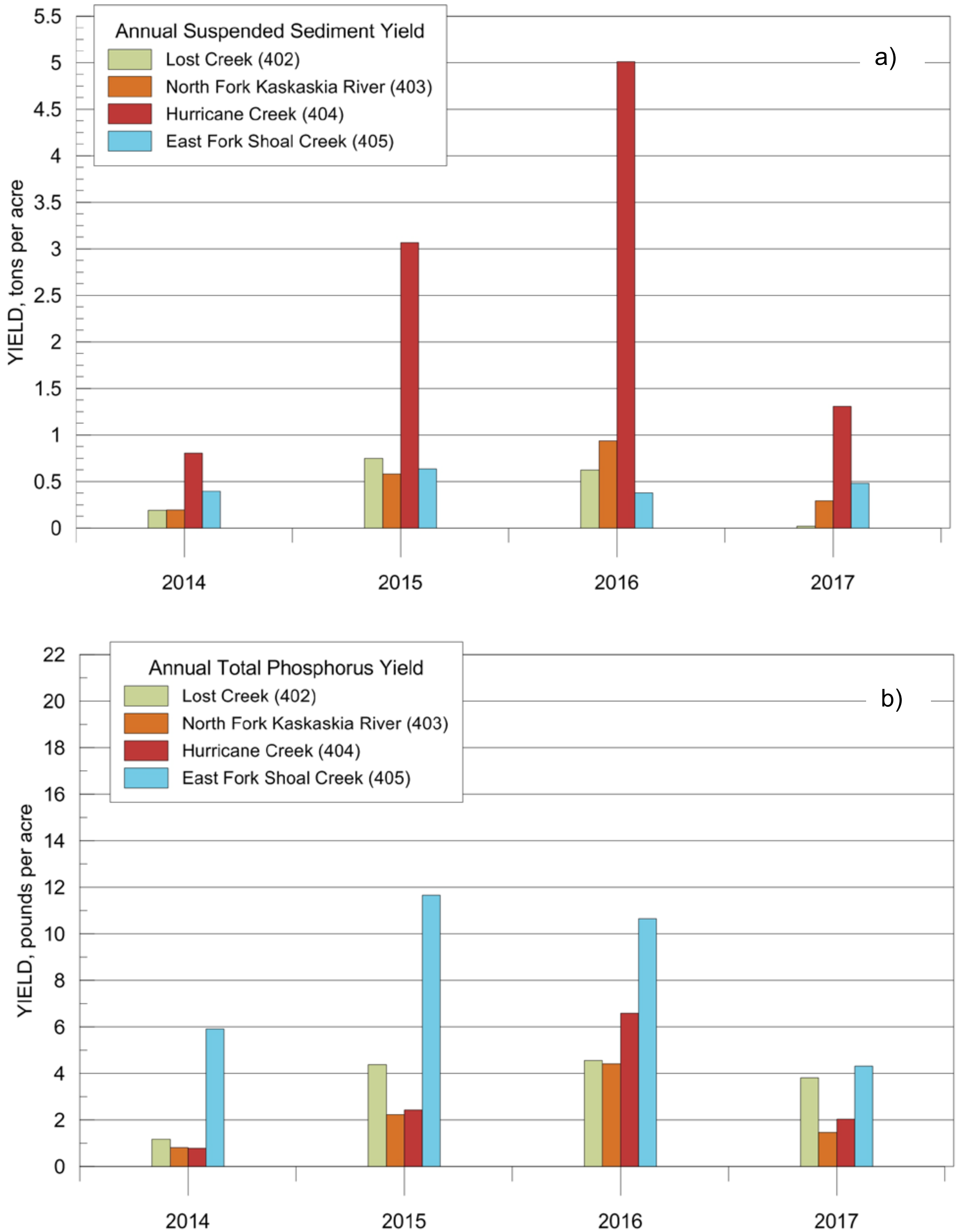


Figure 3-19. Annual yields for all stations during Water Years 2014-2017:
a) Suspended Sediment (tons/acre) and b) Total Phosphorus (lbs/acre)

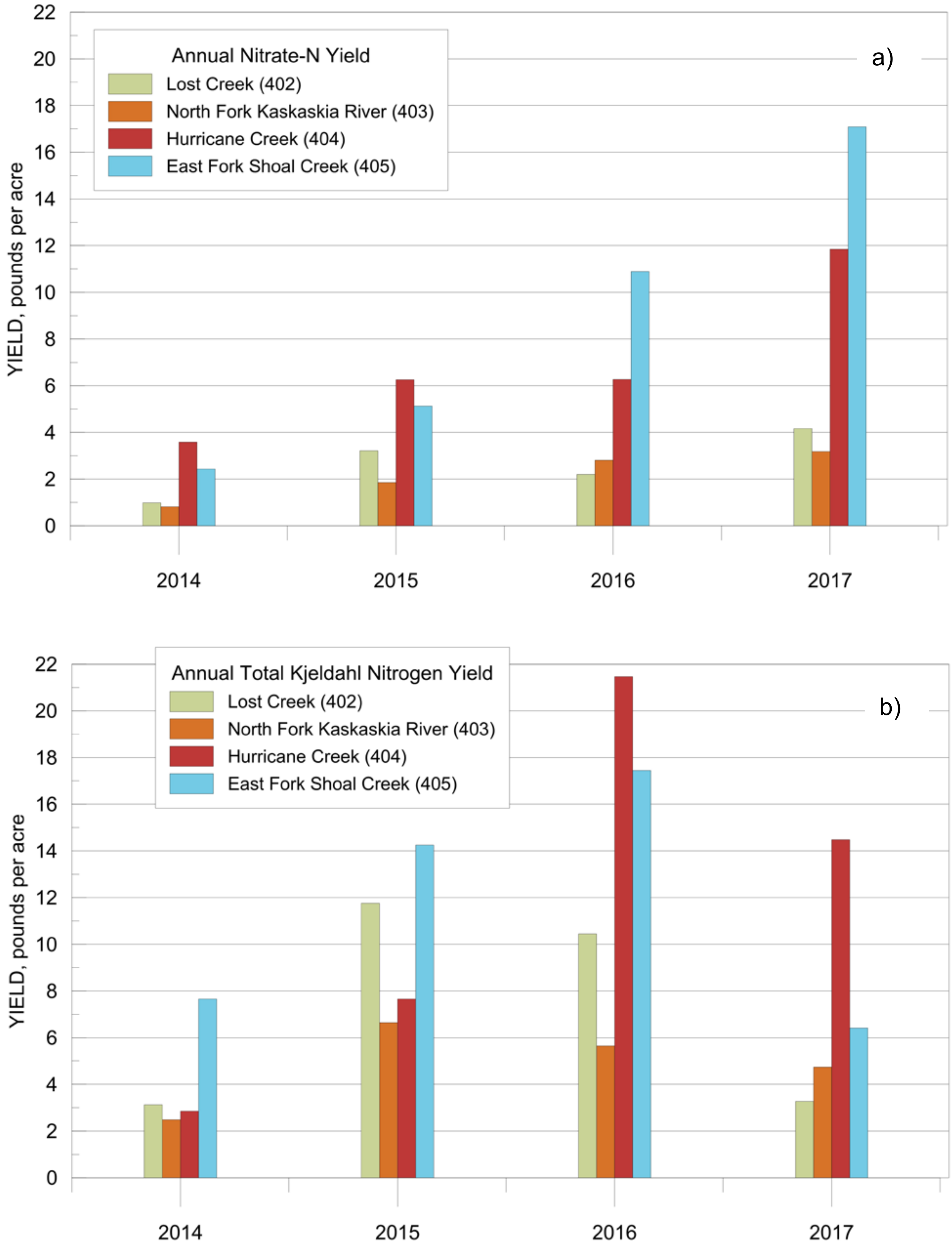


Figure 3-20. Annual yields for all stations during Water Years 2014-2017:
a) Nitrate-N (lbs/acre) and b) Total Kjeldahl Nitrogen (lbs/acre)

4. Land Cover and Conservation Practices

Land Cover

The distribution of 2014 land cover and croplands in the Kaskaskia River Basin are illustrated in Figure 4-1 and graphically summarized in Figure 4-2. The data is provided by the National Agricultural Statistics Service (NASS). In general, Figure 4-1 illustrates areas in agriculture production as represented by bright yellow and green colors, whereas woodlands, grassland, and wetlands in lighter greens and blues. Developed, urban types of areas are in gray. The Upper sub-watershed is dominated by agriculture production, the Middle sub-watershed is relatively equal between agriculture and all other land covers, and Shoal Creek and Lower sub-watersheds have agriculture in the flat upland areas and woodland, grassland, and wetlands predominantly in the stream valleys. Figure 4-2 shows land cover in decreasing order of percent area of the Illinois River Basin. Approximately 61 percent of the Kaskaskia River watershed area is in agriculture production, 16, 11 and 9 percent in woodlands, grassland, and developed areas, respectively.

As seen in Figure 4-3, these are the same dominant land covers in the four monitored watersheds with some variations. For many of these land covers the monitored watersheds appear to pair up. Lost Creek (402) and East Fork Shoal Creek (405) watersheds have agriculture production ranging from 74-78 percent while North Fork Kaskaskia (403) and Hurricane Creek (404) watersheds have lower agriculture percent areas (62-63%). This pattern is similar to developed urban-type land areas. The relationship reverses between the paired watersheds for grass/pasture/open lands and woodlands where North Fork Kaskaskia (403) and Hurricane Creek (404) watersheds have 13-14 and 17-20 percent, respectively. Lost Creek (402) and East Fork Shoal Creek (405) watersheds have 8 and 4-6 percent area in grass/pasture/open lands and woodlands, respectively.

Figure 4-4 illustrates the distribution of Conservation Reserve Program (CRP) areas throughout the Kaskaskia River watershed and counties. Based on a visual inspection, a few observations can be made. A majority of CRP areas are in close proximity to streams and waterbodies. Middle and Shoal Creek sub-watersheds appear to have higher concentrations of CRP acres than the other two sub-watersheds. The Upper sub-watershed is less dense but CRP seems to be evenly distributed. The Lower sub-watershed is similar to the Upper except Clinton and Marion Counties are denser.

The USDA National Agriculture Statistics Service (NASS) land cover data has been available since 1999. In 2006 an evaluation of the usefulness of the crop data layers for annual land cover information in Illinois was undertaken by the Illinois State Geological Survey (ISGS) and NASS. Based on inherent errors associated with satellite data, irreparable mechanical problems with older multispectral imagery satellites and land cover classification methods used to interpret that imagery, new enhanced CDL protocols were established in 2007 for Illinois. Consequently, land cover misclassifications were identified prior to the new protocol, which became more apparent when evaluating the land cover in the monitored watersheds (figure 4-5): Lost Creek (402), North Fork Kaskaskia River (403), Hurricane Creek (404), and East Fork Shoal Creek (405). Therefore, any changes in land cover will be evaluated for this report beginning in 2007 through 2013 which is the most currently available NASS CDL data.

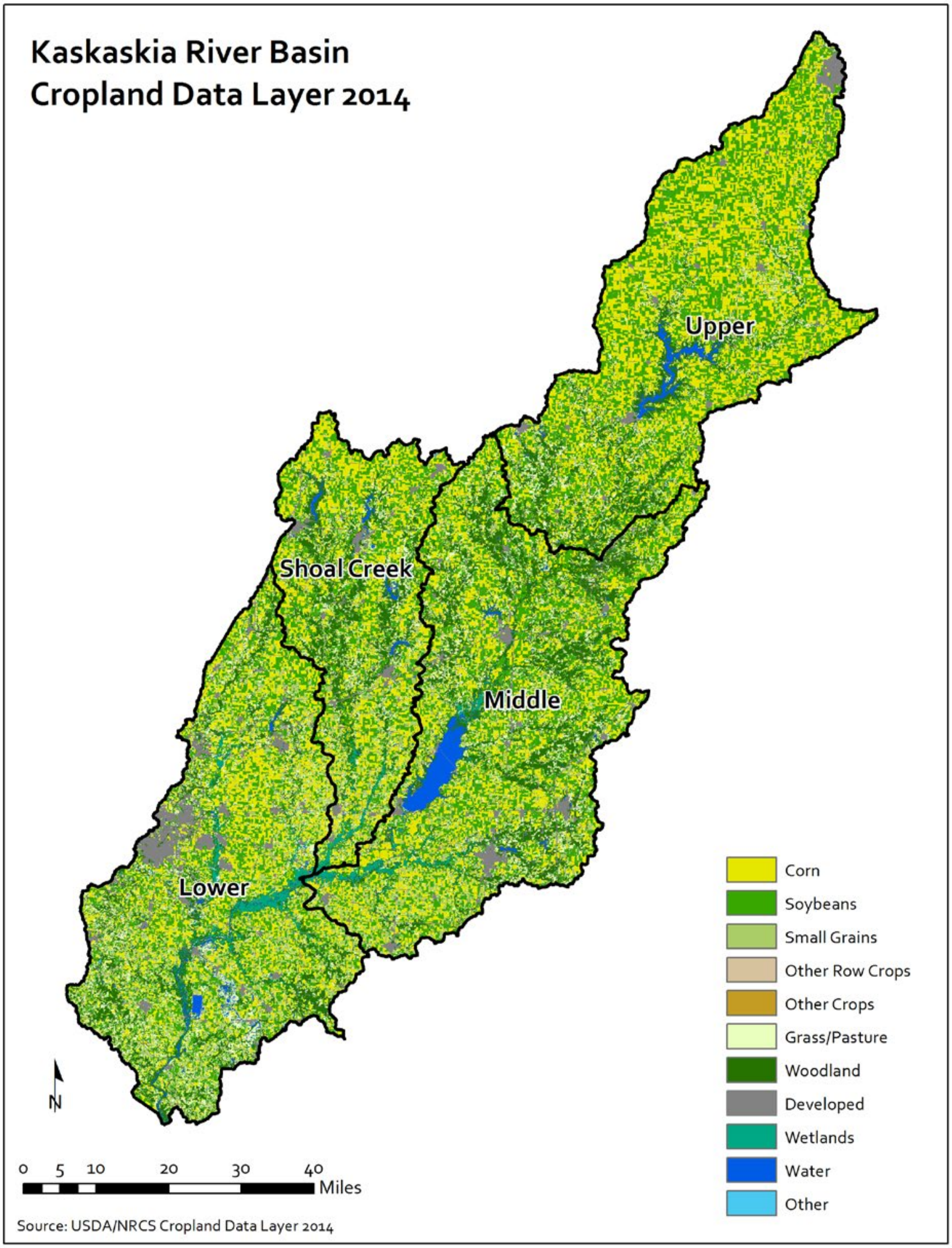


Figure 4-1. Types of land cover in Kaskaskia River Basin

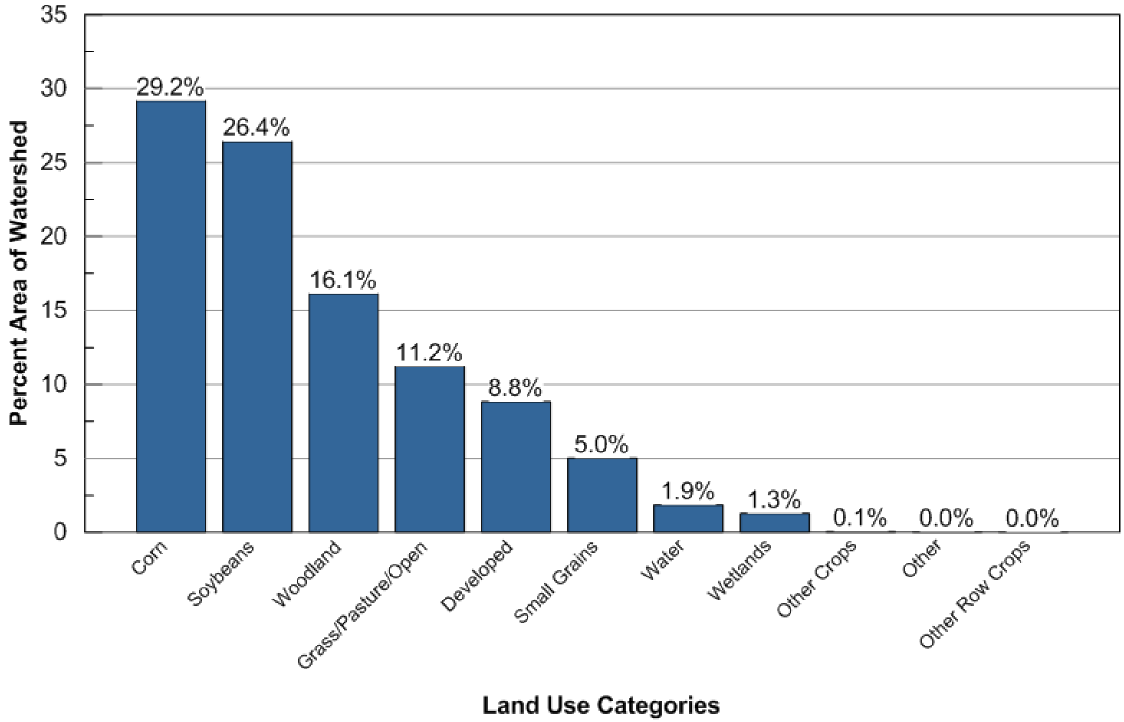


Figure 4-2. Percent watershed area of types of land cover in Kaskaskia River Basin (NASS, 2014)

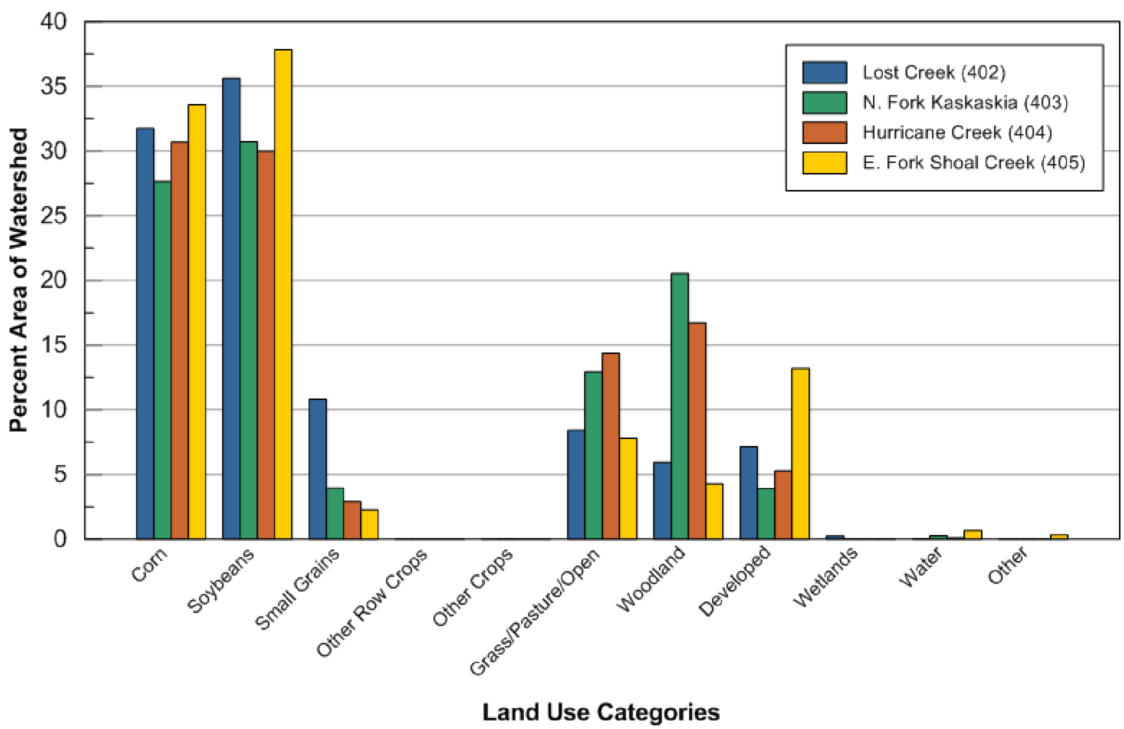


Figure 4-3. Percent watershed area of types of land cover in four monitored watersheds in Kaskaskia River Basin (NASS, 2014)

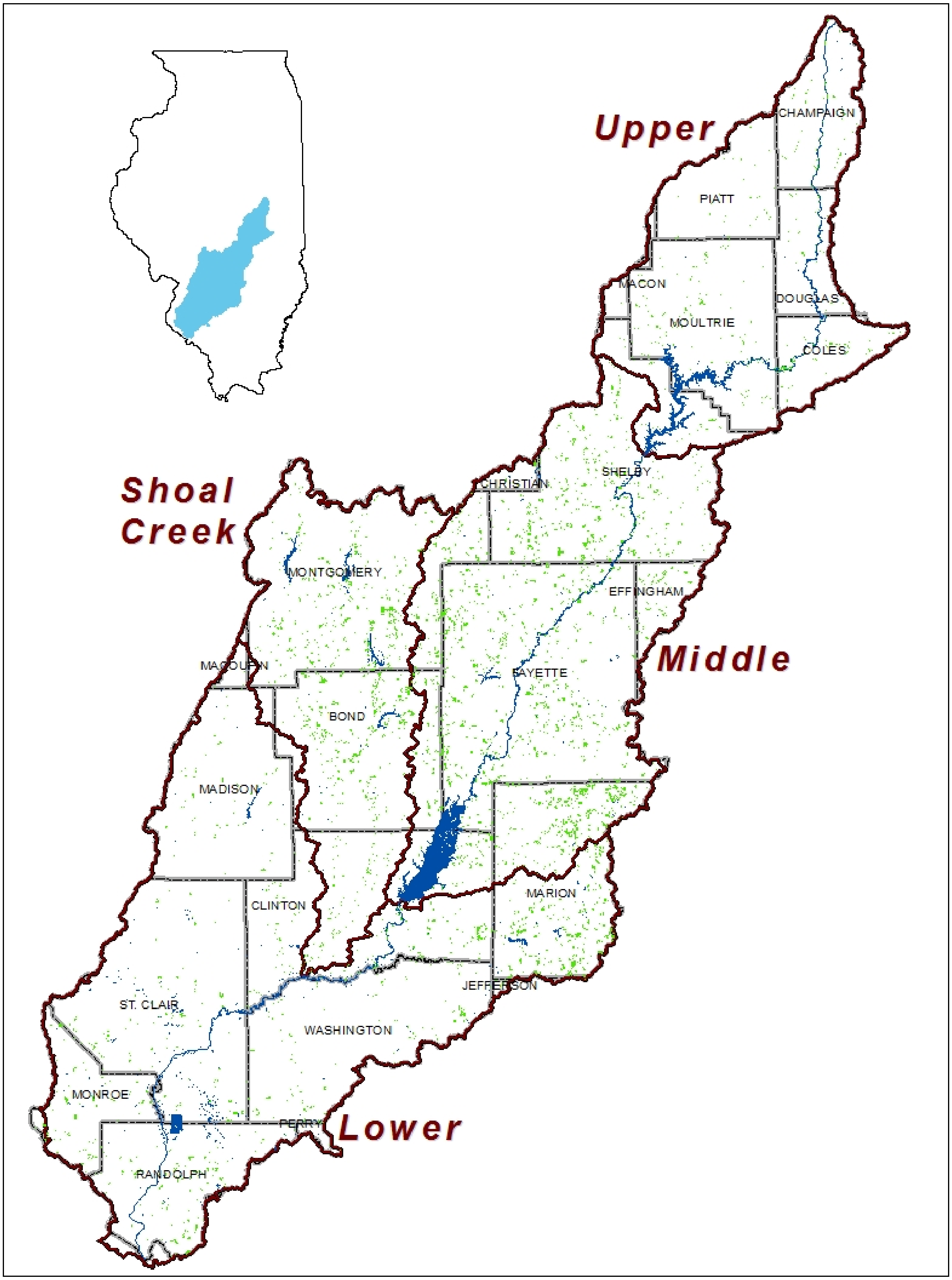


Figure 4-4.Conservation Reserve Program (CRP) in Kaskaskia Basin

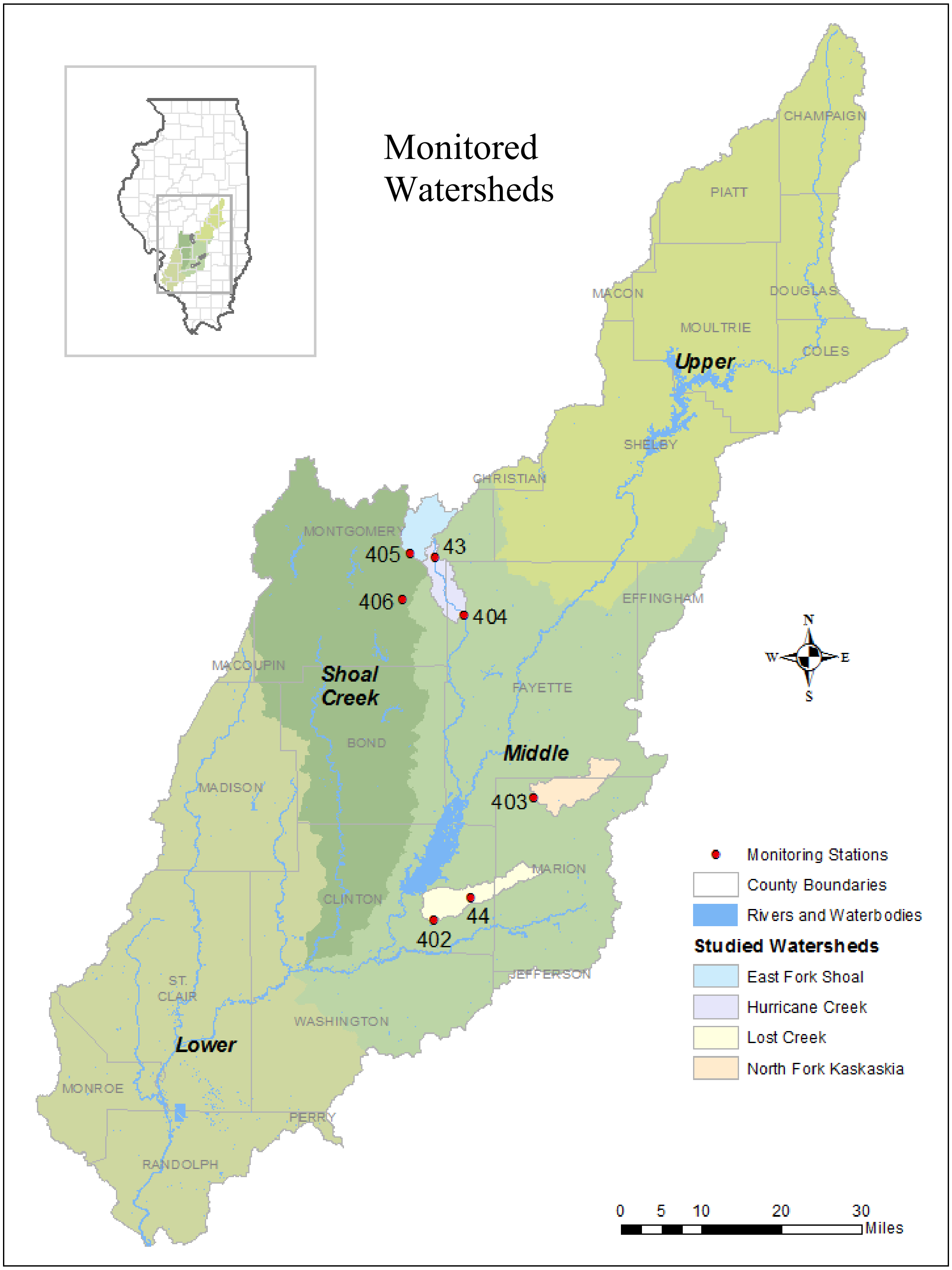


Figure 4-5. Locations of watersheds being monitored for hydrology, sediment and nutrients.

The four monitored watersheds have somewhat different ratios of land cover types. The Panther and Cox Creek watersheds in the Spoon River watershed have 53 and 73 percent area in agriculture and 47 and 27 percent in non-agriculture land covers, respectively (table 4-1). The main difference is Panther Creek has over 20 percent more land in forest/shrubland than Cox Creek, due to a large portion of the watershed lies in the Panther Creek State Conservation Area. Agriculture land cover is 44 and 56 percent in Court and Haw Creeks, respectively, while the non-agriculture area is the inverse. North Creek watershed, a tributary of Court Creek, has a larger portion of land area in forest/shrubland than Haw Creek. Figure 4-6 illustrates the percent change in total watershed acres between 2007 and 2013 for six generalized land cover categories

Table 4-1. 7-year average (2007-2013) percent acres of land cover area by watershed

	ISWS Station Number			
	402	*403*	*404*	*405*
Corn	33	26	30	31
Soybeans	38	30	28	32
Other Crops	1	1	1	1
Grasslands	16	20	22	18
Forest/Shrubland	8	22	18	14
Developed, Barren, Open Space, Water, Wetlands	4	1	2	4
AGRICULTURE	72	57	59	64
NON-AGRICULTURE	28	43	41	36

in each of the four monitored tributary watersheds in the Kaskaskia River Basin. Agriculture land covers were categorized into Corn, Soybeans, Double Crop with Soybeans and Other Cropland, as well as summed in one category identified as Agriculture. Non-agriculture land covers were categorized into Grassland and Forest/Shrubland, and summed as Non-Agriculture. All four watersheds had a 5 percent reduction in Double Crop with Soybeans and non-agricultural land cover area (Grasslands and Forest/Shrubland) between 2007 and 2013. An increase in agricultural land cover area (Corn and Soybeans) ranged from 2 to nearly 7 percent occurred on all four watersheds. Lost, Hurricane, and East Fork Shoal Creek watersheds had marked percent increases in soybean acres and North Fork Kaskaskia watershed had an increase of corn greater than soybeans. The Hurricane Creek watershed experiences the largest decrease in non-agriculture land cover mostly occurring with losses in grasslands. Grasslands decreased on the average of 3.5 percent over all four monitored watersheds.

Figures 4-7 to 4-10 show the changes in each land cover for each year between 2007 and 2013. For this report, NASS Cropland Data Layer (CDL) categories for the monitored watersheds were combined into 6 general land cover categories: 1) corn, 2) soybean, 3) other cultivated crops, 4) grassland, 5) forest/shrubland and 6) developed, barren, open space, water

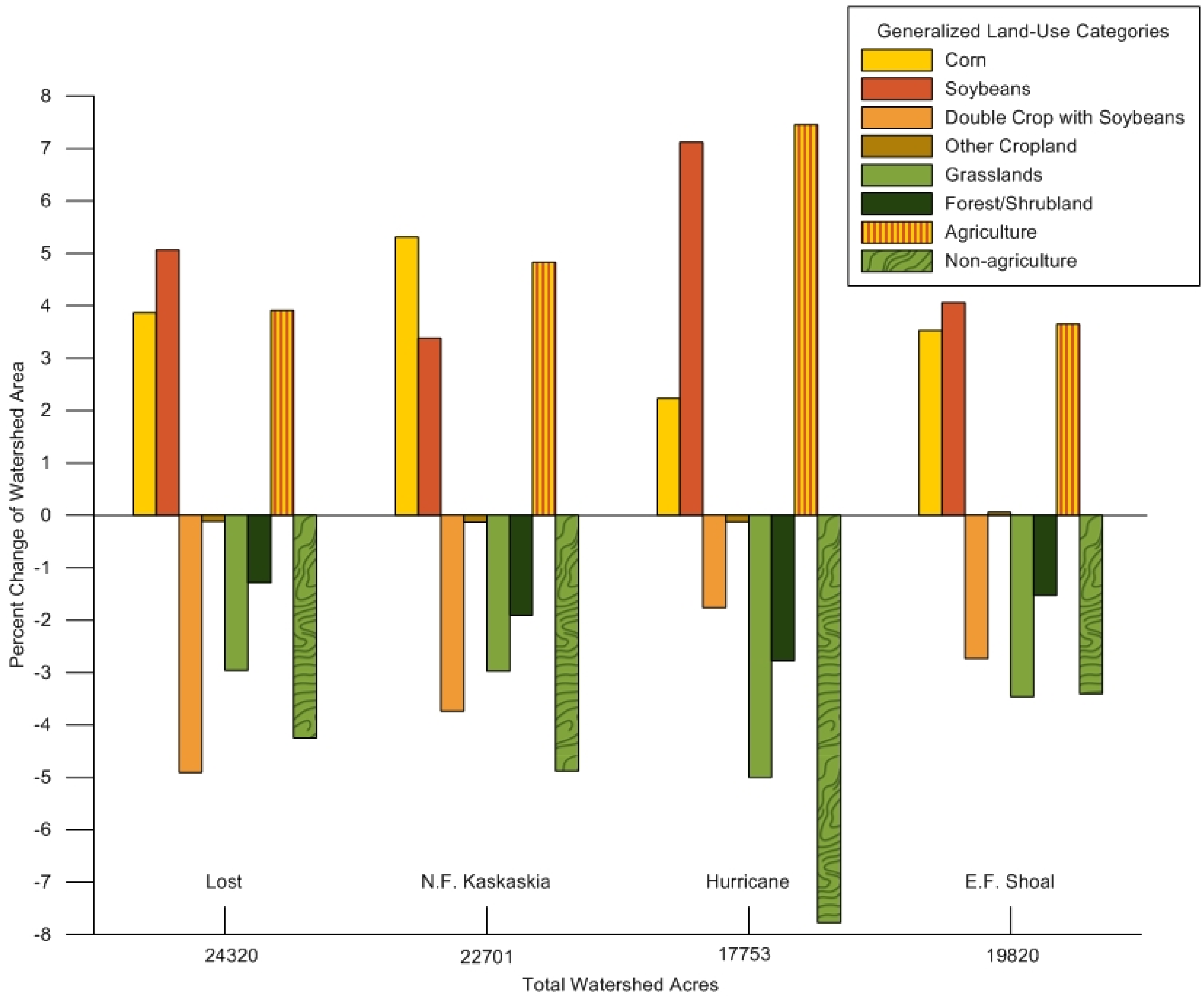


Figure 4-6. Kaskaskia River Basin Watersheds: Percent Change in Generalized NASS Land-Use from 2007-2013.

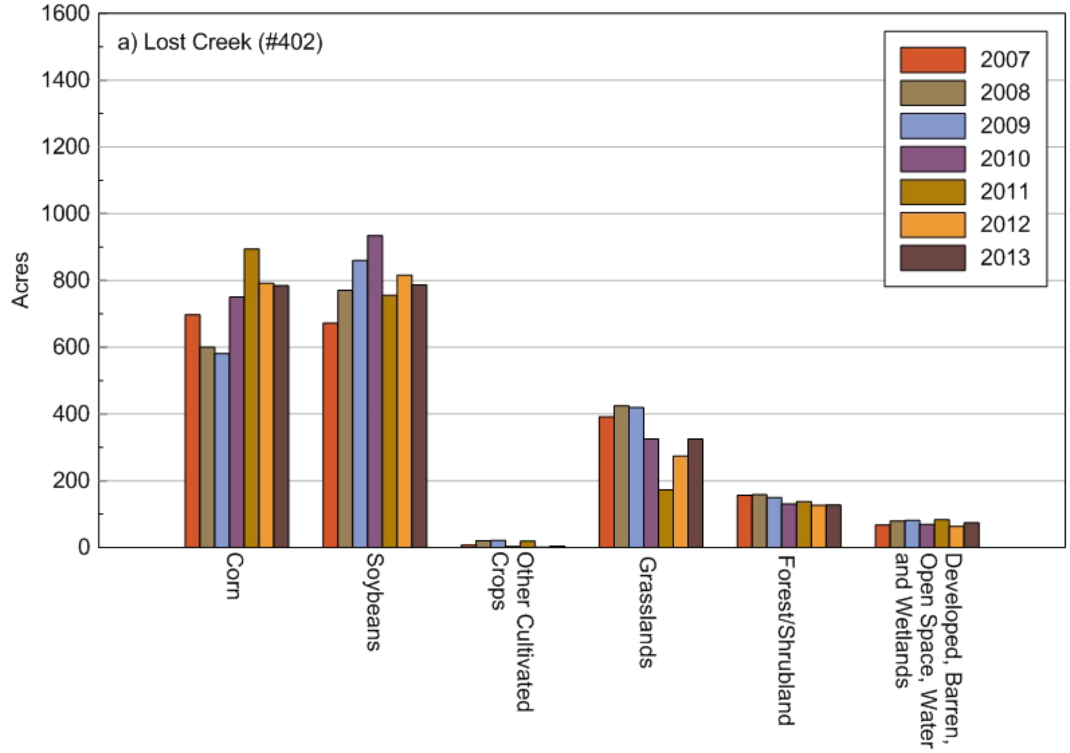


Figure 4-7. Lost Creek watershed from ISWS Station 402: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

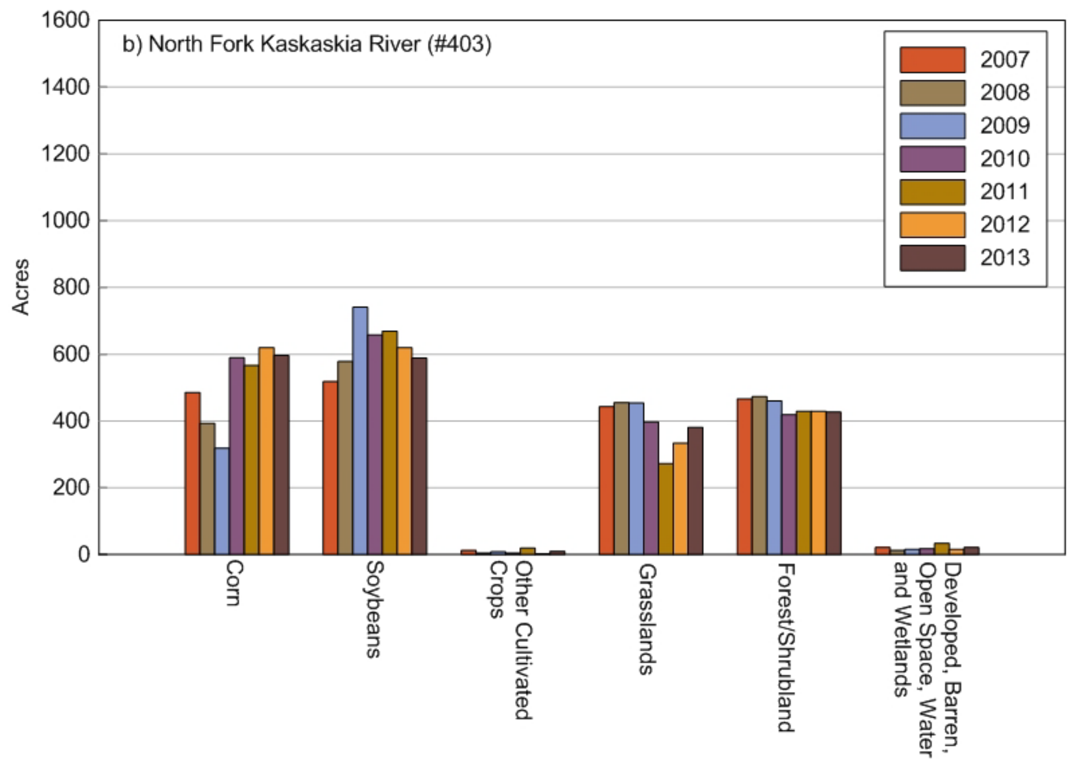


Figure 4-8. North Fork Kaskaskia River watershed from ISWS Station 403: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

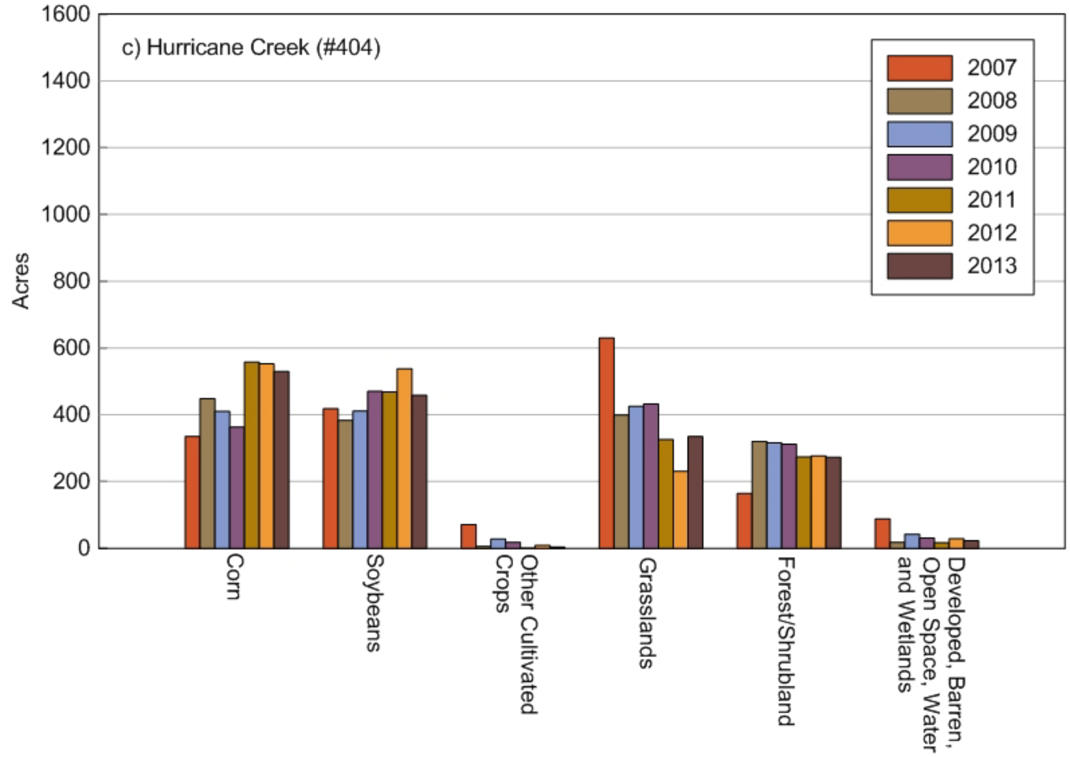


Figure 4-9. Hurricane Creek watershed from ISWS Station 404: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

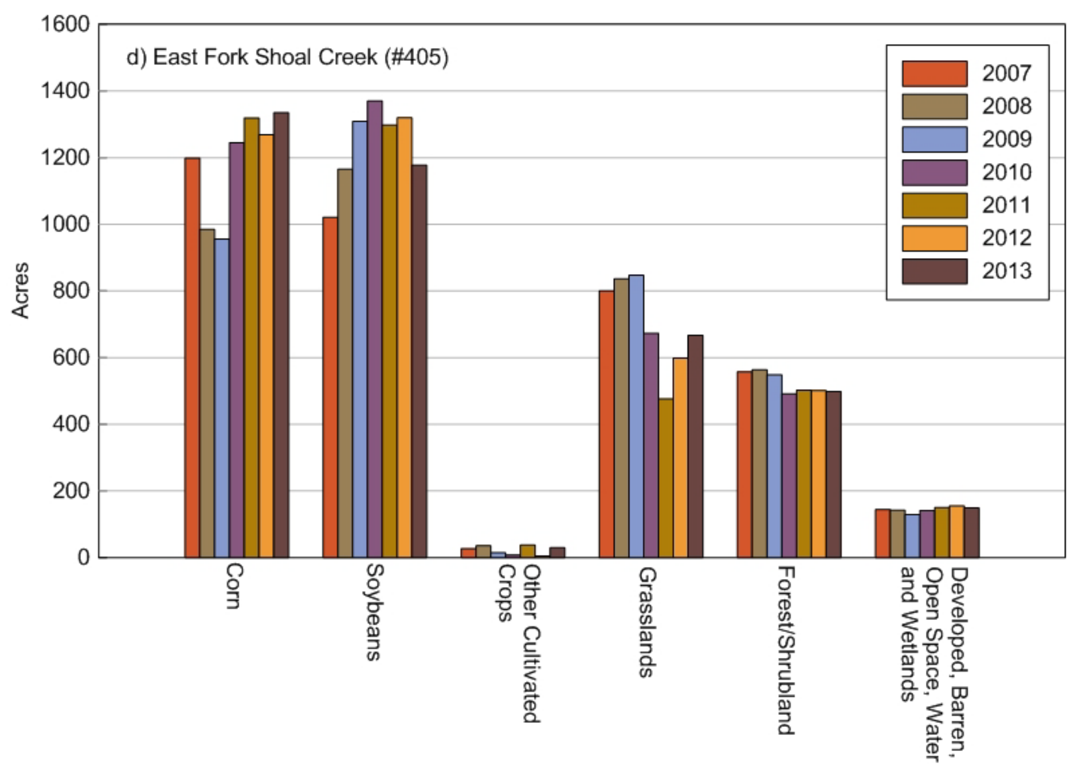


Figure 4-10. East Fork Shoal Creek watershed from ISWS Station 405: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

and wetlands. Land cover area changes between years is represented in acres. Therefore, some watersheds may appear to have greater changes in acreage from year to year but may only represent a small percentage of the watershed depending on the total watershed acres. Lost Creek watershed (figure 4-7) acres varied for corn, soybeans, and grasslands with corn and soybeans increasing in acres when comparing 2007 and 2013. All other land covers remained constant over the 7-year period. North Fork Kaskaskia watershed (figure 4-8) saw similar variability as Lost Creek watershed in most corn, soybeans, and grasslands acreage. Only minor increases in acres for forest/shrubland. North Fork Kaskaskia has equal acres in Grasslands and forest/shrubland, as well as slightly more Soybean acres than Corn. Lost Creek has the lowest acres of forest/shrubland of the four watersheds. Hurricane Creek (figure 4-9) appeared to have a significant decrease in Grasslands and Developed land covers and increase in Forest/shrubland from 2007 to 2008. . Finally, East Fork Shoal Creek (figure 4-10) exhibits the same annual variability in land cover acres between 2007 and 2013 as the other three monitored watersheds. Lost Creek and East Fork Shoal Creek watersheds have the most agriculture land covers of the four monitored watersheds, whereas North Fork Kaskaskia and Hurricane Creek watersheds are more evenly distributed of Corn, Soybean, Grassland, and forest/shrubland land covers. All four watersheds have extremely low acres devoted to other cultivated crops.

Conservation Practices

There has been a significant increase in the implementation of conservation practices in Illinois in recent years with CREP making a major contribution. Figure 4-11 shows the location of approved Illinois CREP contracts from the state of Illinois as of 2014. With this type of information it will be possible to identify areas where there has been significant participation in the CREP program and where changes in sediment and nutrient delivery should be expected. The information will provide important input data to the watershed models that are being developed to evaluate the impact of CREP practices.

There are many conservation practices implemented through the watersheds as a result of federal and state conservation reserve programs. In order to evaluate watershed monitoring efforts, knowing the when and what conservation practices are implemented in the watershed is important. Figures 4-12 to 4-15 are show the cumulative acres of conservation practices installed in the four monitored watersheds from 1999 through 2015. The order by which the practices are listed in the legend represent, from the largest to smallest, the sum of the acres by practice from 1999-2015. The most popular conservation practice is filter strips in Lost Creek and East Fork Shoal Creek watersheds, which are the two watershed with more percent agriculture land cover. Hurricane Creek and East Fork Shoal Creek favored upland bird habitat buffers. The two watersheds identified with higher percent area of woodland and grass/pasture/open lands (North Fork Kaskaskia River and Hurricane Creek) favored permanent wildlife habitat, upland bird buffers, new and existing grasses/legumes, and SAFE-wildlife enhancement conservation practices. North Fork Kaskaskia and Hurricane Creek watersheds have the most variety of practices installed.

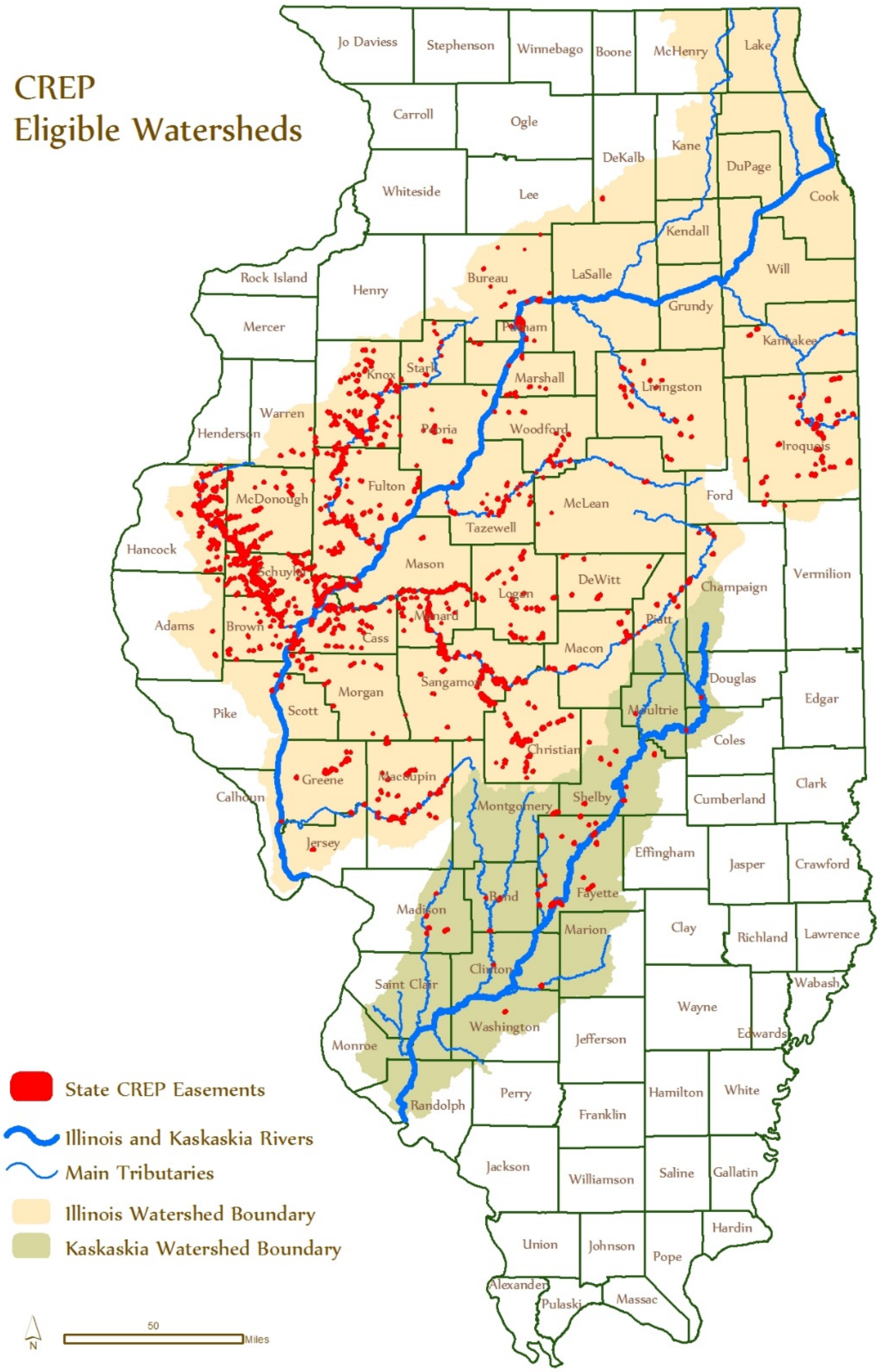


Figure 4-11. State CREP contract locations (IDNR, 2015).

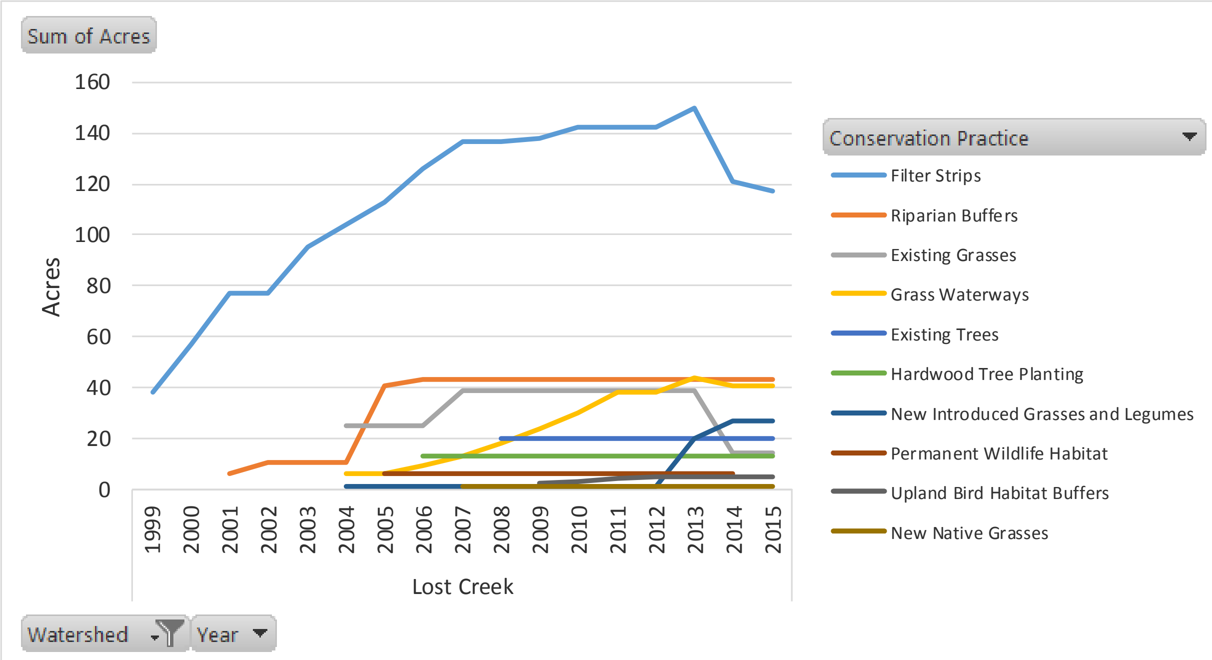


Figure 4-12. Cumulative acres of conservation practices installed in Lost Creek watershed at monitoring station ISWS #402 from 1999-2015.

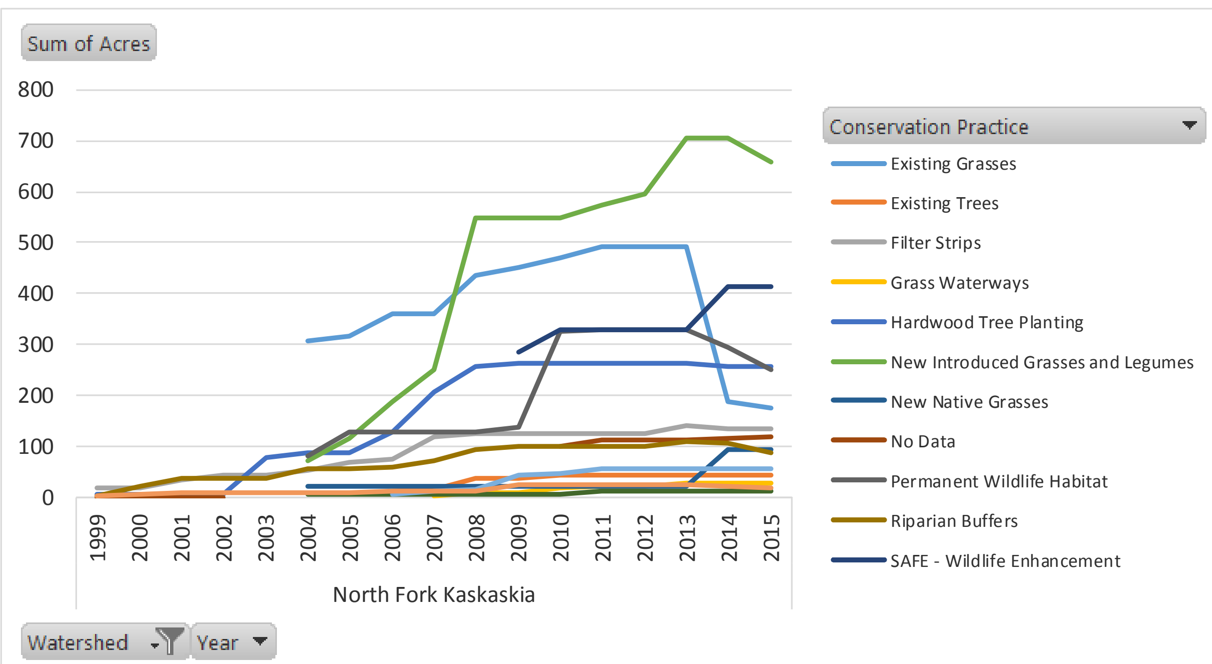


Figure 4-13. Cumulative acres of conservation practices installed in North Fork Kaskaskia River watershed at monitoring station ISWS #403 from 1999-2015.

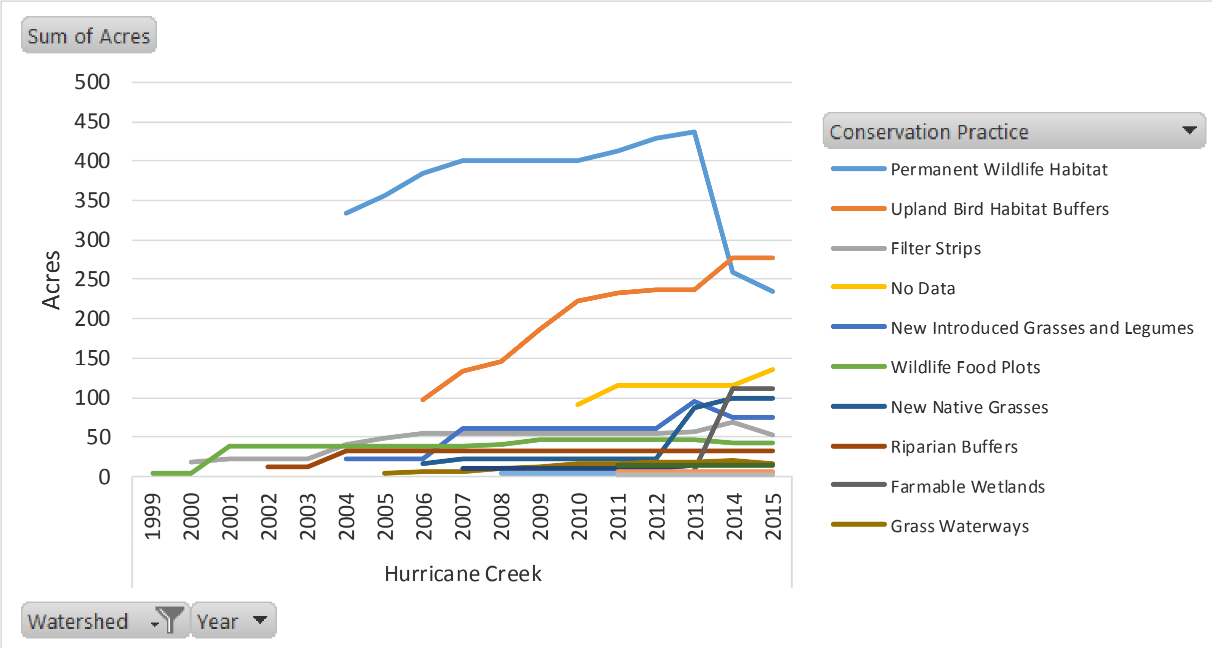


Figure 4-14. Cumulative acres of conservation practices installed in Hurricane Creek watershed at monitoring station ISWS #404 from 1999-2015.

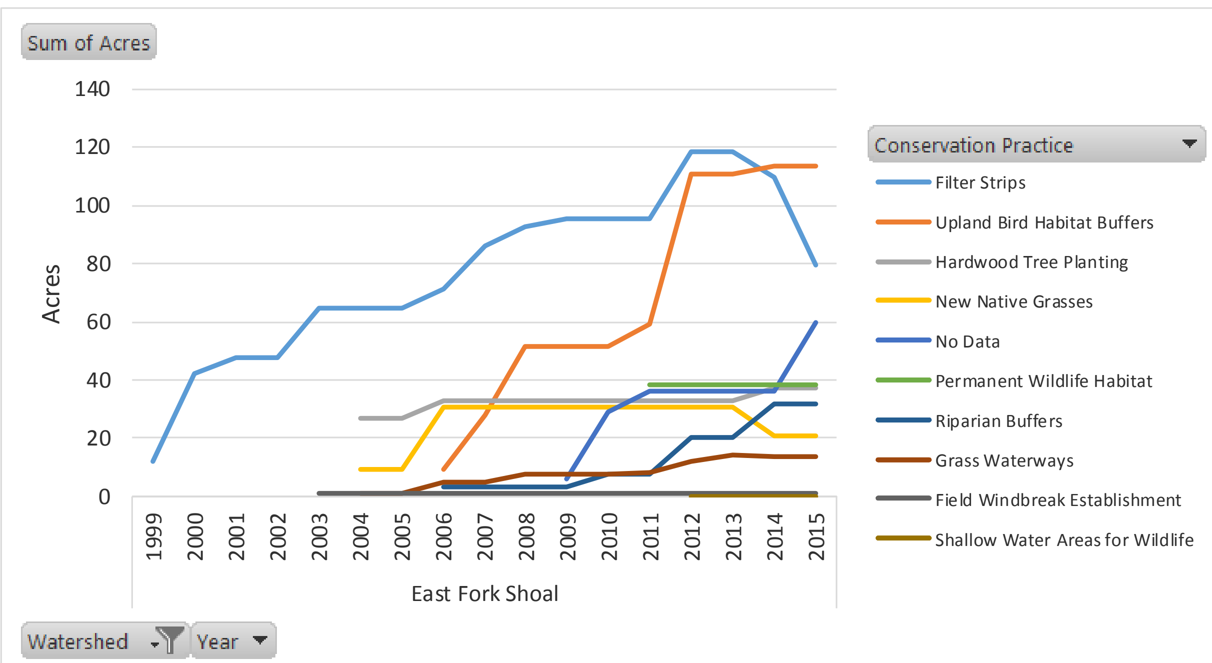


Figure 4-15. Cumulative acres of conservation practices installed in East Fork Shoal Creek watershed at monitoring station ISWS #405 from 1999-2015.

5. Summary and Conclusions

The Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois and Kaskaskia River basins. Based on numerous research and long-term data in the Illinois River basin, the two main causes of water quality and habitat degradations in major river corridors were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the CREP were to reduce the amount of silt and sediment entering the main stem of the Illinois and Kaskaskia Rivers by 20 percent; and to reduce the amount of phosphorus and nitrogen loadings to by 10 percent. To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) developed a scientific process for evaluating the effectiveness of the program.

The monitoring and data collection component consists of a sediment and nutrient watershed monitoring program for selected sub-watersheds within the Kaskaskia River basin and also to collect and analyze land use data throughout the basin. Previous available data was insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to establish a monitoring program to collect precipitation, hydrologic, sediment, nutrient and land cover data for selected small watersheds in the Kaskaskia River basin that will assist in making a more accurate assessment of sediment and nutrient delivery.

The four small watersheds selected for intensively monitoring sediment and nutrient in the Kaskaskia River basin are located within the Crooked Creek, North Fork Kaskaskia River, Hurricane Creek and Shoal Creek watersheds. In addition, two continuous recording raingages were established near the monitored watersheds. Lost Creek (402) is a tributary of Crooked Creek which, in turn is a direct tributary of the Kaskaskia River with its confluence downstream of Carlyle Reservoir. The Carlyle Reservoir is a U.S. Army Corps of Engineers impoundment on the Kaskaskia River. The North Fork Kaskaskia River (403) and Hurricane Creek (404) are direct tributaries of the Kaskaskia River and discharge directly into the upstream end of Carlyle Reservoir. East Fork Shoal Creek (405) is a tributary of Shoal Creek, the largest direct tributary of the Kaskaskia River, with its confluence downstream of Carlyle Reservoir.

After assessing and evaluating many physical, geological, biological, land cover and CRP program data and information, as well as impacts of the 2012 drought, four intensive monitoring stations were selected and the sediment and nutrient monitoring network was established for the 2014 water year (October 2013-September 2014). The WY2014 started in one of the coldest winters recorded in the region for some time. This was followed by a particularly wet spring and summer. Water Year 2015 (October 2014-September 2015) also had a particularly cold winter followed by a wet spring but did not continue very far into the summer months as happened the previous year. Water Year 2016 had several intense storms, particularly December 2015 and May 2016 which resulted in much higher annual yields than the other two monitoring years. Water Year 2017 was particularly dry with the only significant runoff events occurring between April 26, 2017 and May 6, 2017. Two stations, Lost Creek (402) and North Fork Kaskaskia, (403) experienced zero flow from late July through September.

Nitrogen and phosphorus species concentrations more associated with particulate forms (TKN, t-P) were higher than concentrations of the dissolved forms (NO_3-N and TDP). Suspended sediment concentrations were higher in watersheds with higher percent area devoted to agriculture production or higher upland slopes. However, suspended sediment yield results indicate that the highest yield of the 4 monitoring stations is from Hurricane Creek (404) which has the highest slope of the four watersheds. Nitrate-N and total phosphorus yields were highest in East Fork Shoal Creek (405) and TKN yield was generally highest in Lost Creek (402), Hurricane Creek (404) and East Fork Shoal (405).

6. References

Demissie, M., L. Keefer, and J. Slowikowski, A. Russell, T. Snider, and K. Stevenson. 2001. Sediment and Nutrient Monitoring at Selected Watersheds within the Illinois River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP). Illinois State Water Survey Contract Report 2001-12.

Edwards, T.K. and D.G. Glysson. 1999. Field Methods for Measurement of Fluvial Sediment. U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter 32, 89p.

Federal Interagency Sedimentation Project (FISP). 1952. The Design of Improved Types of Suspended Sediment Samplers. Interagency Report 6, St. Anthony Falls Hydraulics Laboratory, Minneapolis, MN.

Illinois Department of Natural Resources. 2000a. *Kaskaskia River Area Assessment, Volume 1: Geology* Springfield, IL, 127 p.

Illinois Department of Natural Resources. 2000b. *Kaskaskia River Area Assessment, Volume 2: Water Resources* Springfield, IL, 127 p.

Knapp, H. V., G. S. Roadcap, E. G. Bekele, H. A. Wehrmann, W. E. Gillespie, J. S. Hecht and F. J. Pisani. 2012. *Water Supply Assessment for Kaskaskia River Watershed Development: Phase I Technical Report*. Illinois State Water Survey Contract Report 2012-12, 29 +Appendices p.

Leighton, M. M., G. E. Ekblaw and L. Horberg. 1948. *Physiographic Divisions of Illinois*. Illinois State Geological Survey Report of Investigations 129, Urbana, ILp.

Luman, D.E., 2008, Assessment & Potential of the 2007 USDA-NASS Cropland Data Layer for Statewide Annual Land Cover Applications, unpublished report of investigations including five appendices, Illinois State Geological Survey, 17 pp. http://crystal.isgs.uiuc.edu/nsdihome/webdocs/landcover/nass07.html.

Luman, D. and T. Weicherding. *Land Cover of Illinois: 1999-2000*. 1999 January 1999 [cited 2003 November 1, 2003]; Available from: http://www.agr.state.il.us/gis/index.html.

Rantz, S. E. (1982). Measurement and Computation of Streamflow. Volume 1. Measurement of Stage and Discharge. Government Printing Office, Washington, D.C.

Rantz, S. E. (1982). Measurement and Computation of Streamflow. Volume 2. Computation of Discharge. Government Printing Office, Washington, D.C.

Appendix A

Sediment and Nutrient Concentrations and Water Discharge
WY2014-2016

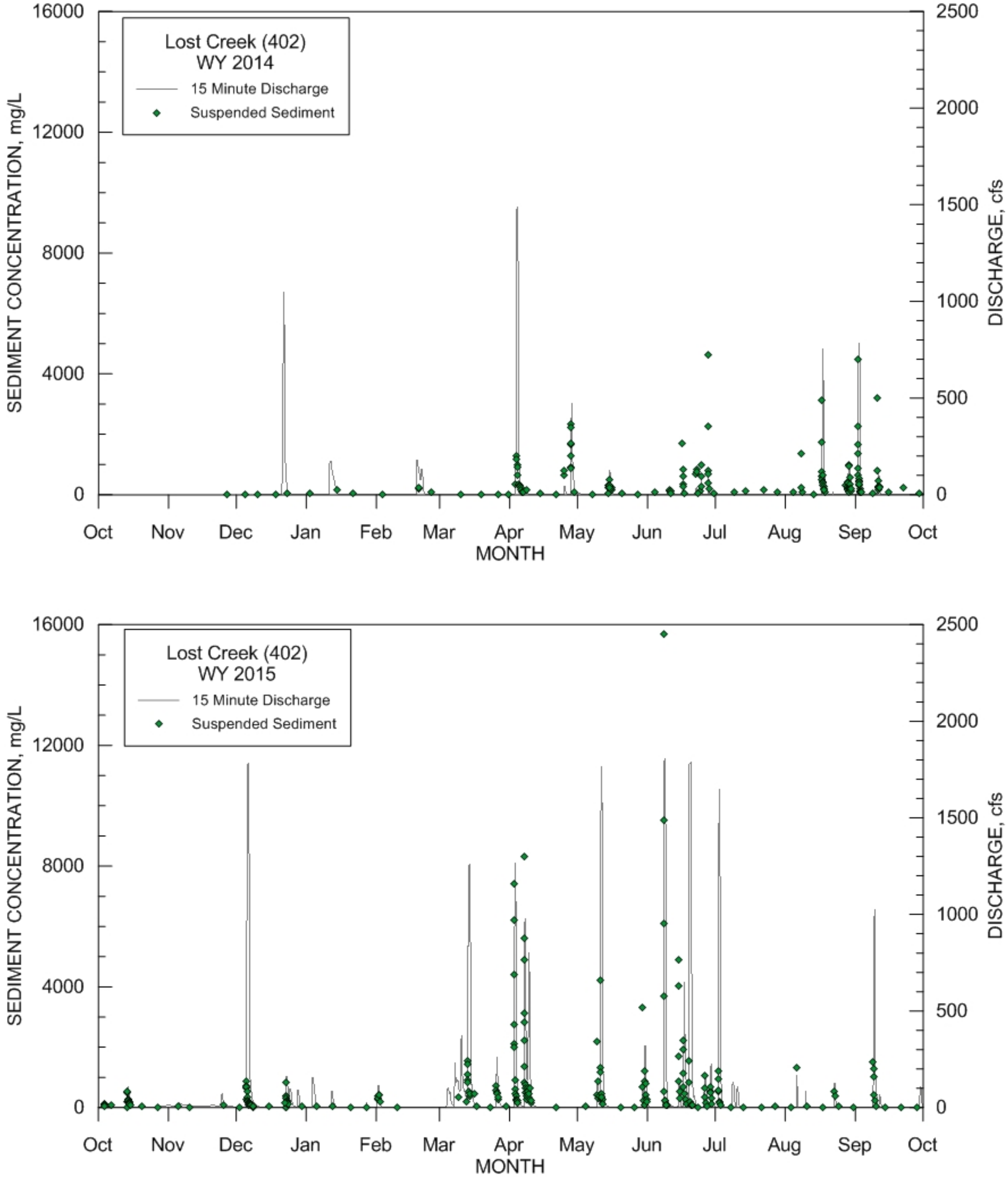
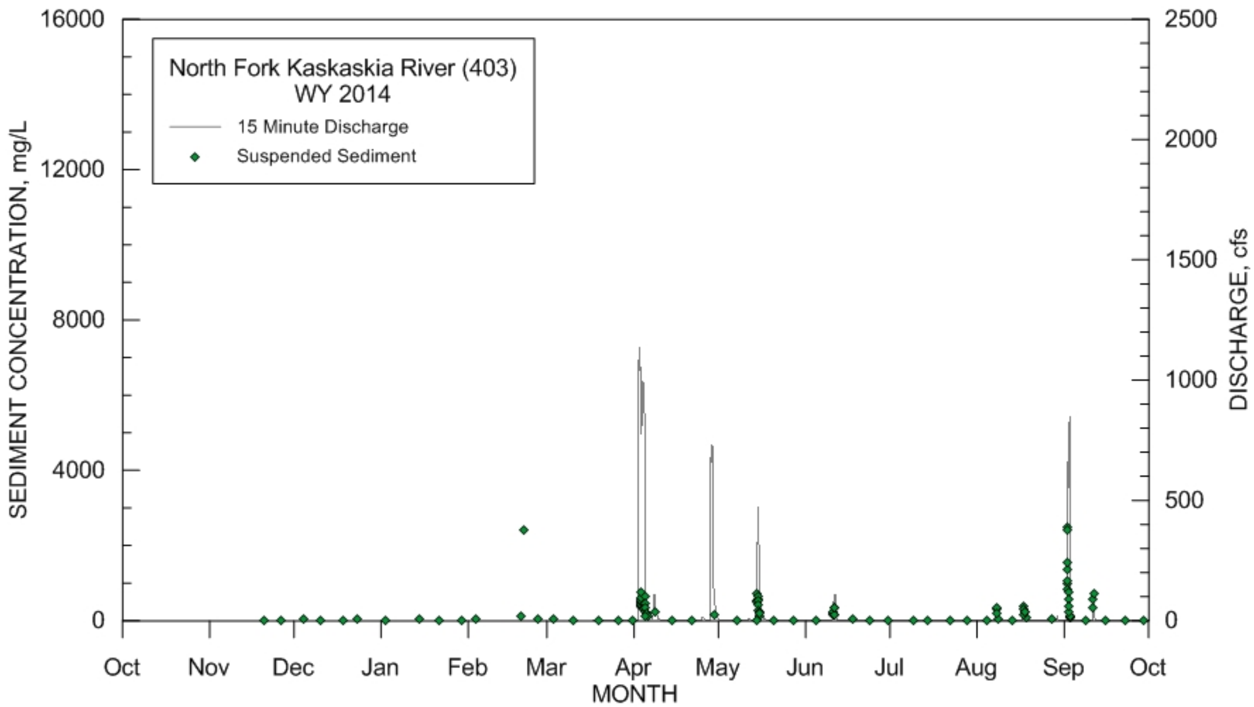


Figure A-1. Suspended sediment concentrations and discharge at Lost Creek (402):
Water Year 2014 and Water Year 2015



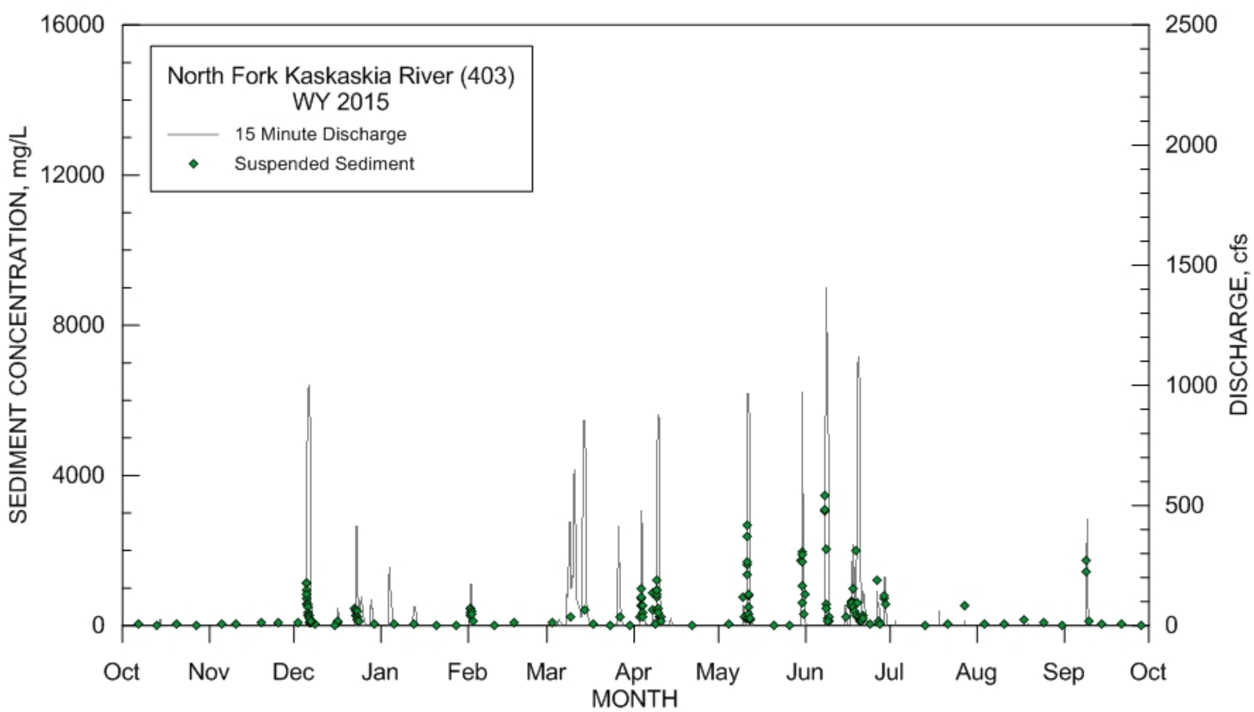


Figure A-2. Suspended sediment concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015

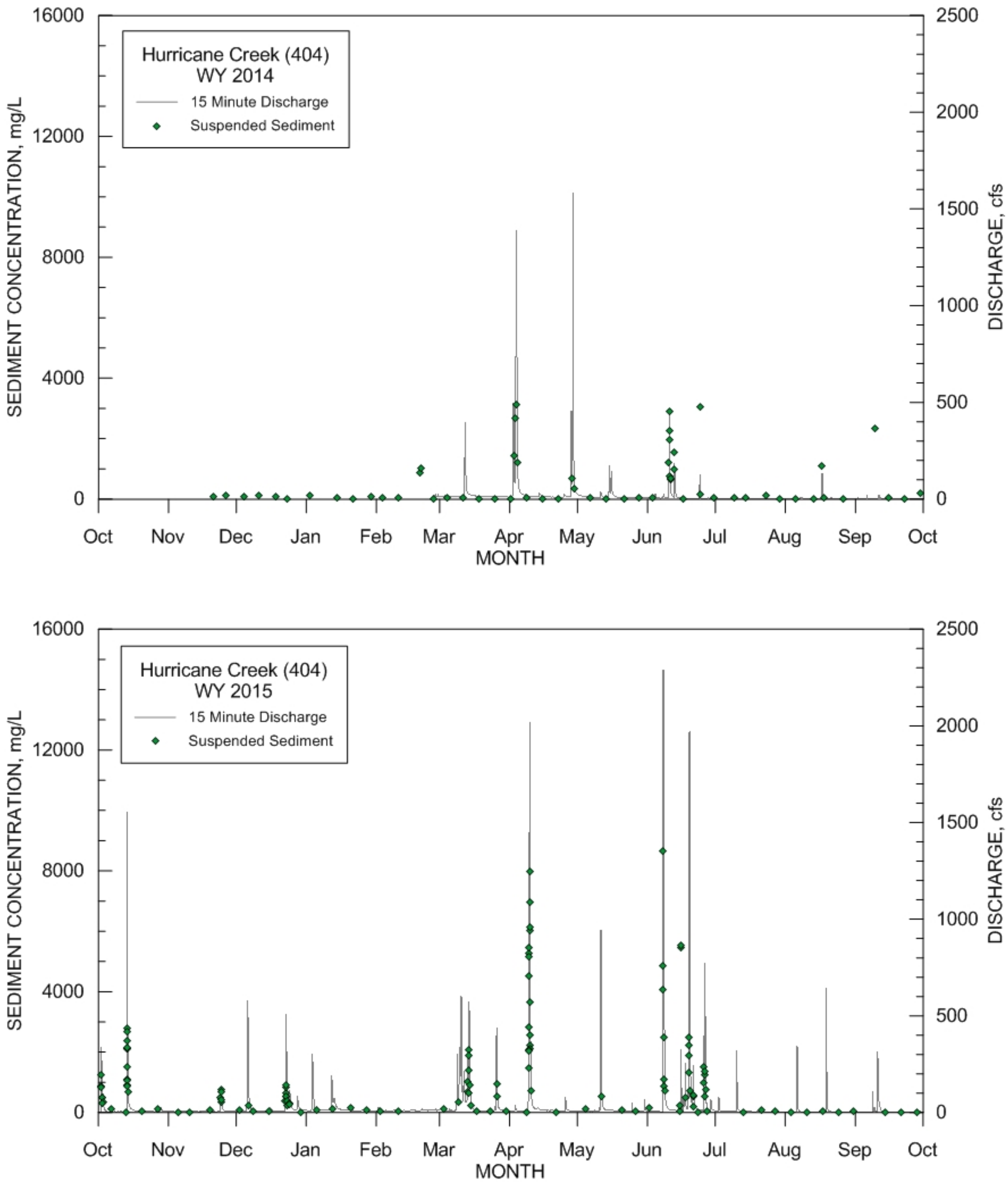
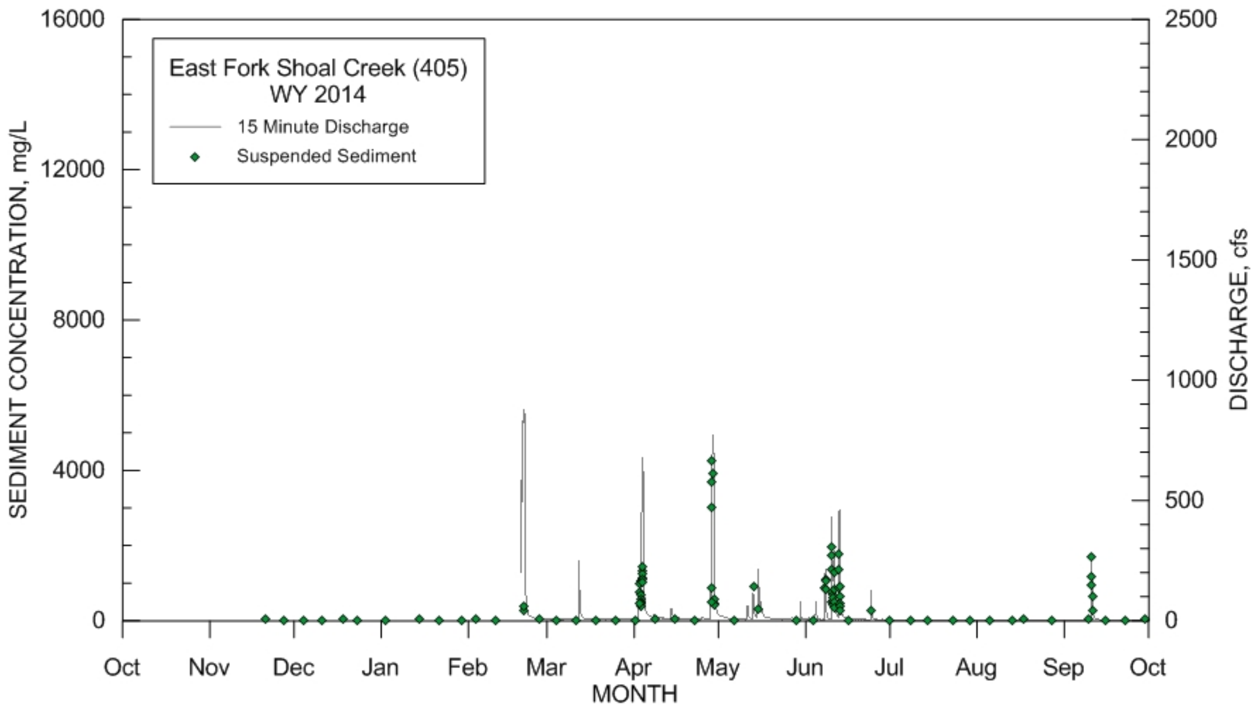


Figure A-3. Suspended sediment concentrations and discharge at Hurricane Creek (404): Water Year 2014 and Water Year 2015



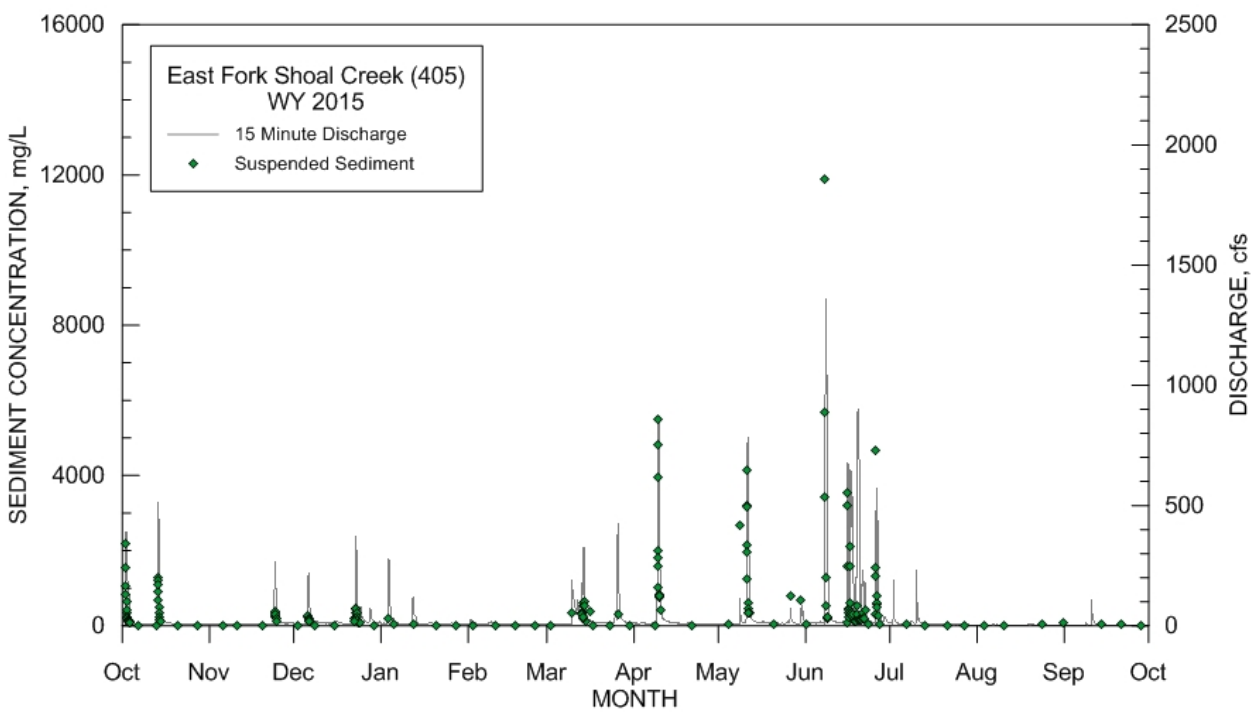


Figure A-4. Suspended sediment concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015

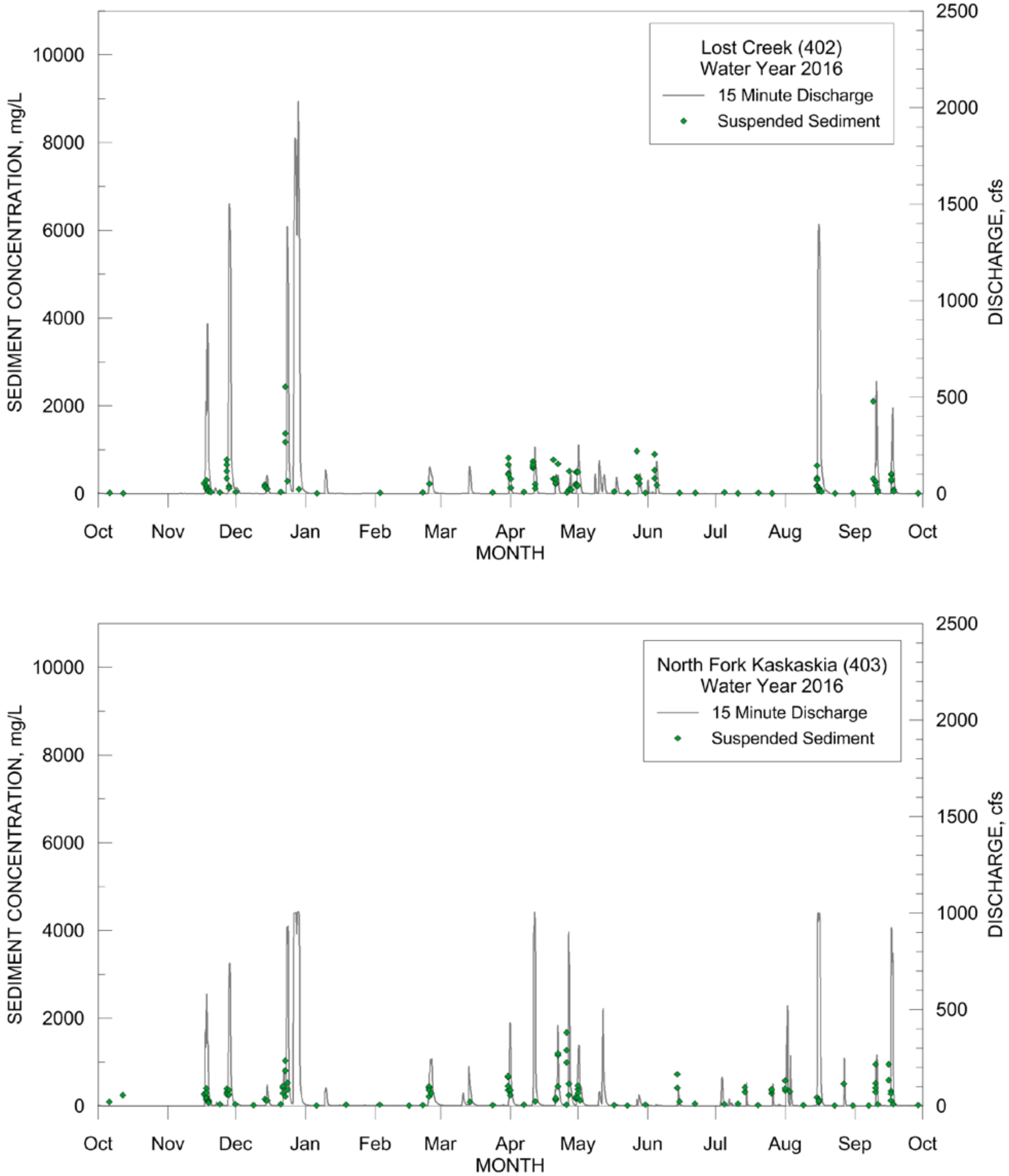


Figure A-5. Suspended sediment concentrations and discharge for Water Year 2016: Lost Creek (402) and North Fork Kaskaskia (403)

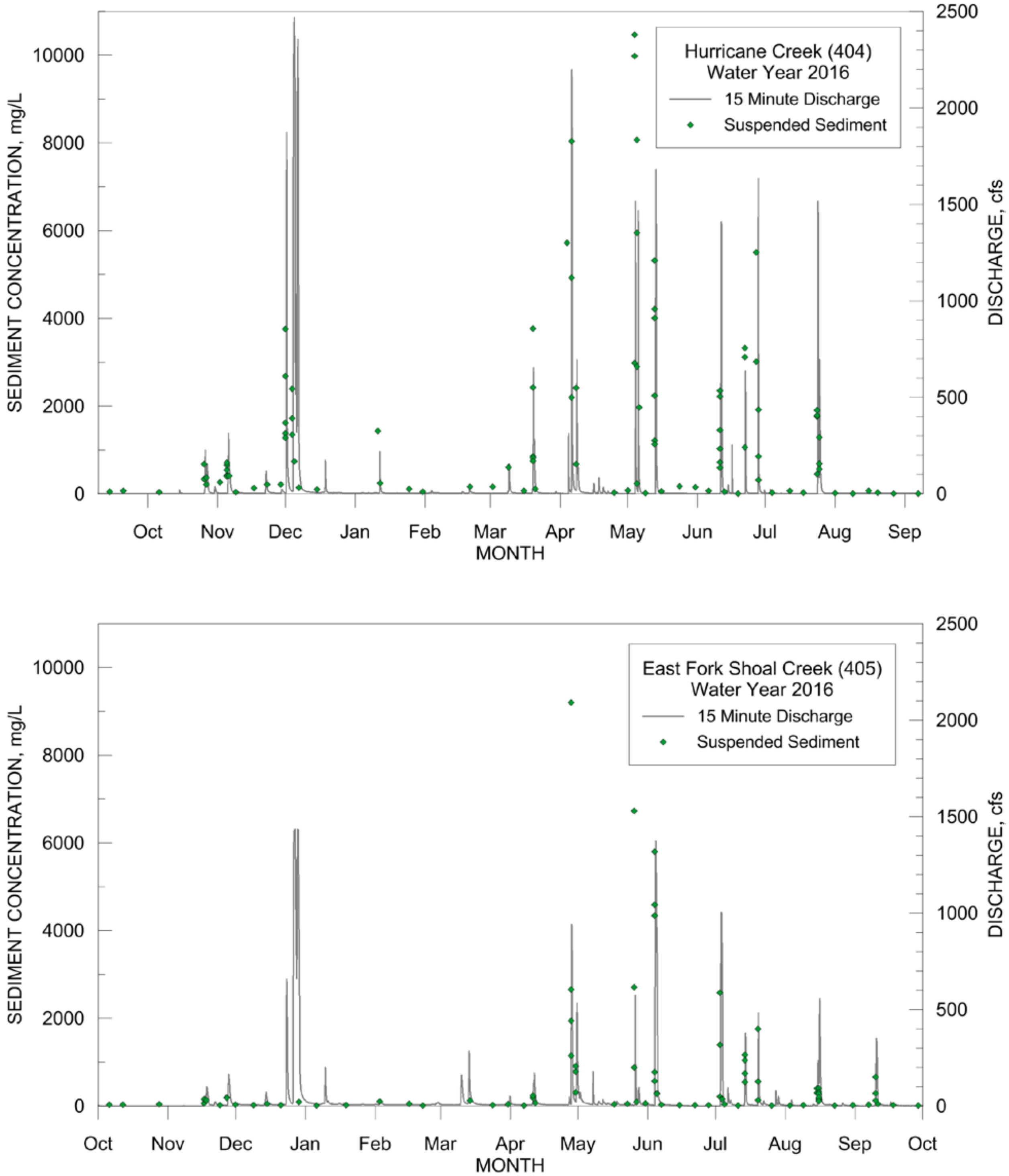
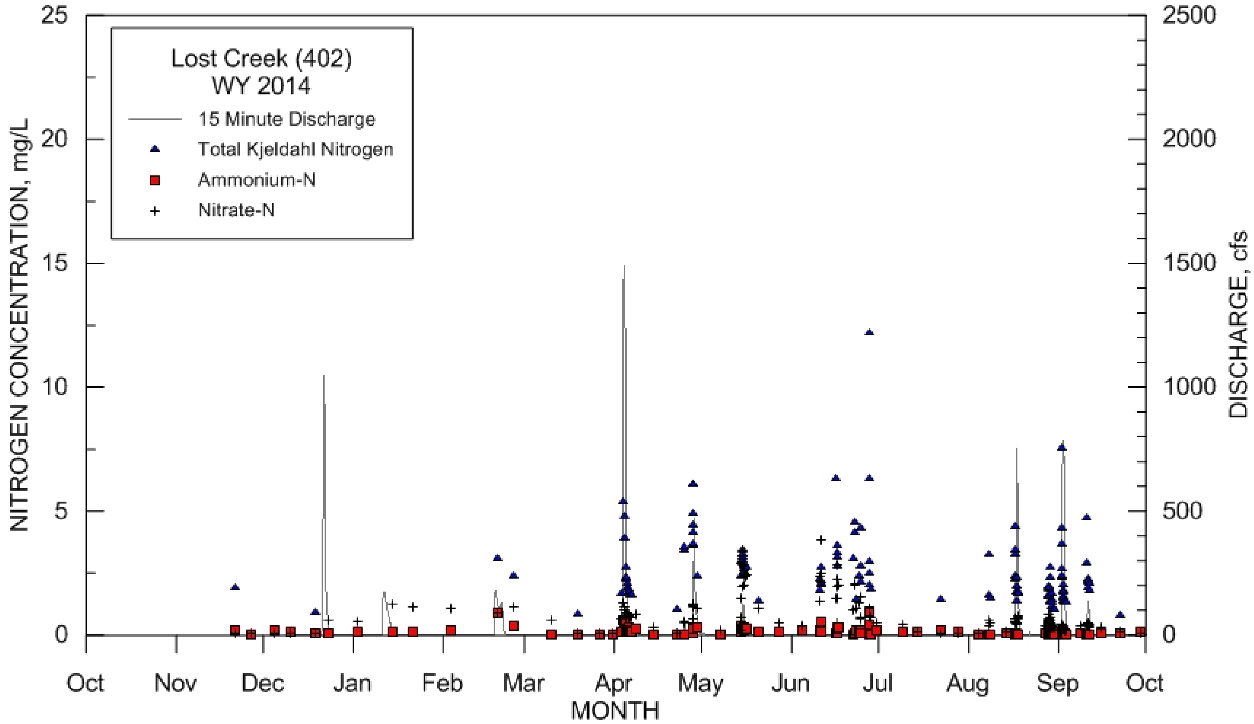


Figure A-6. Suspended sediment concentrations and discharge for Water Year 2016: Hurricane Creek (404) and East Fork Shoal Creek (405)



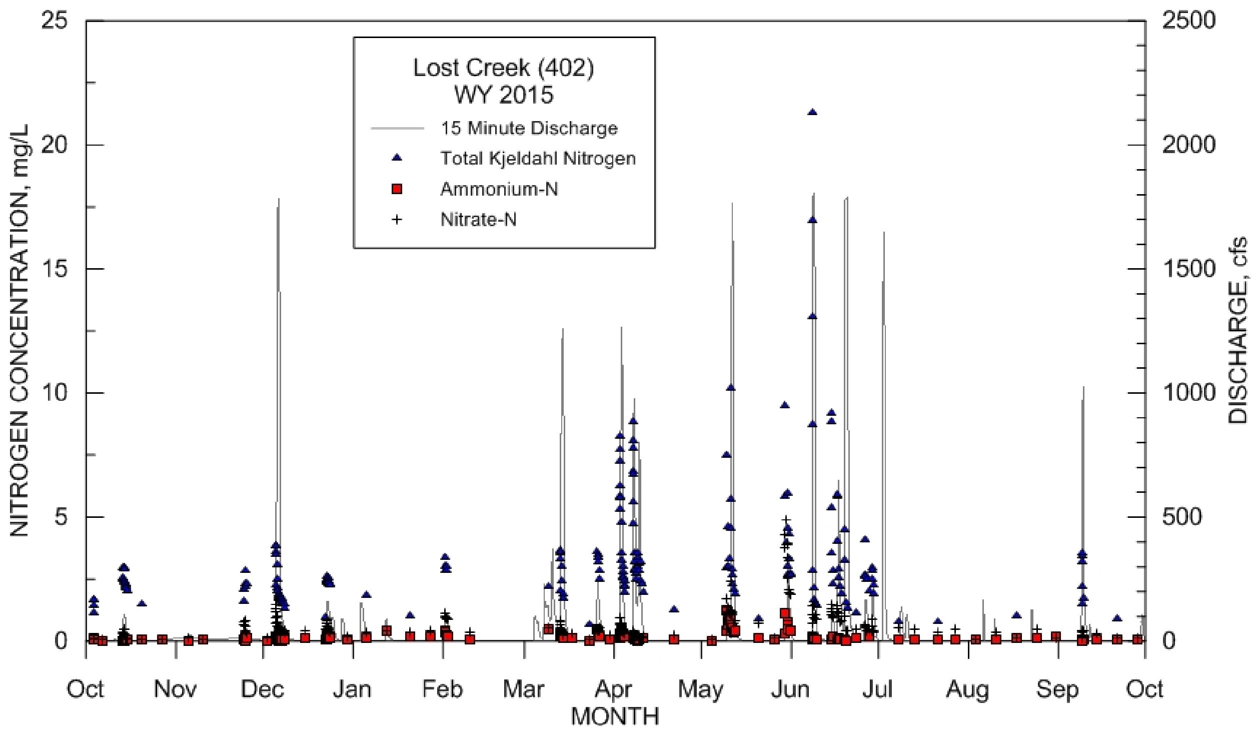
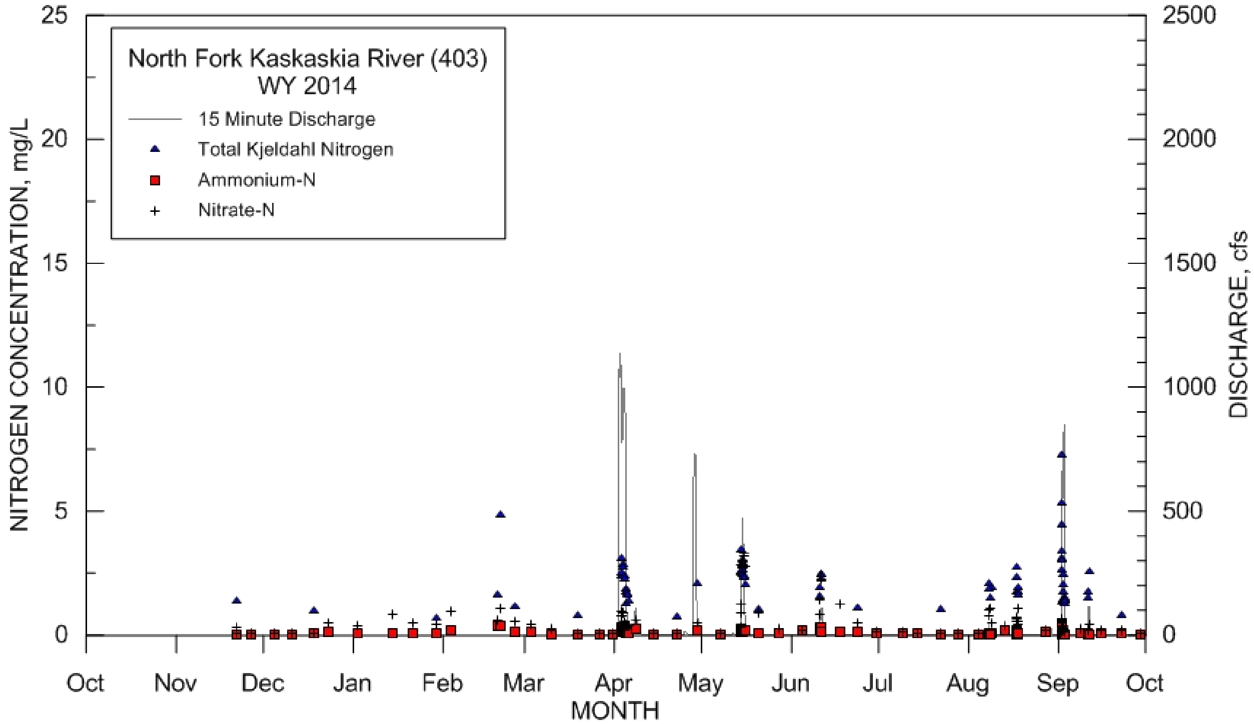


Figure A-7. Nitrogen concentrations and discharge at Lost Creek (402):
Water Year 2014 and Water Year 2015



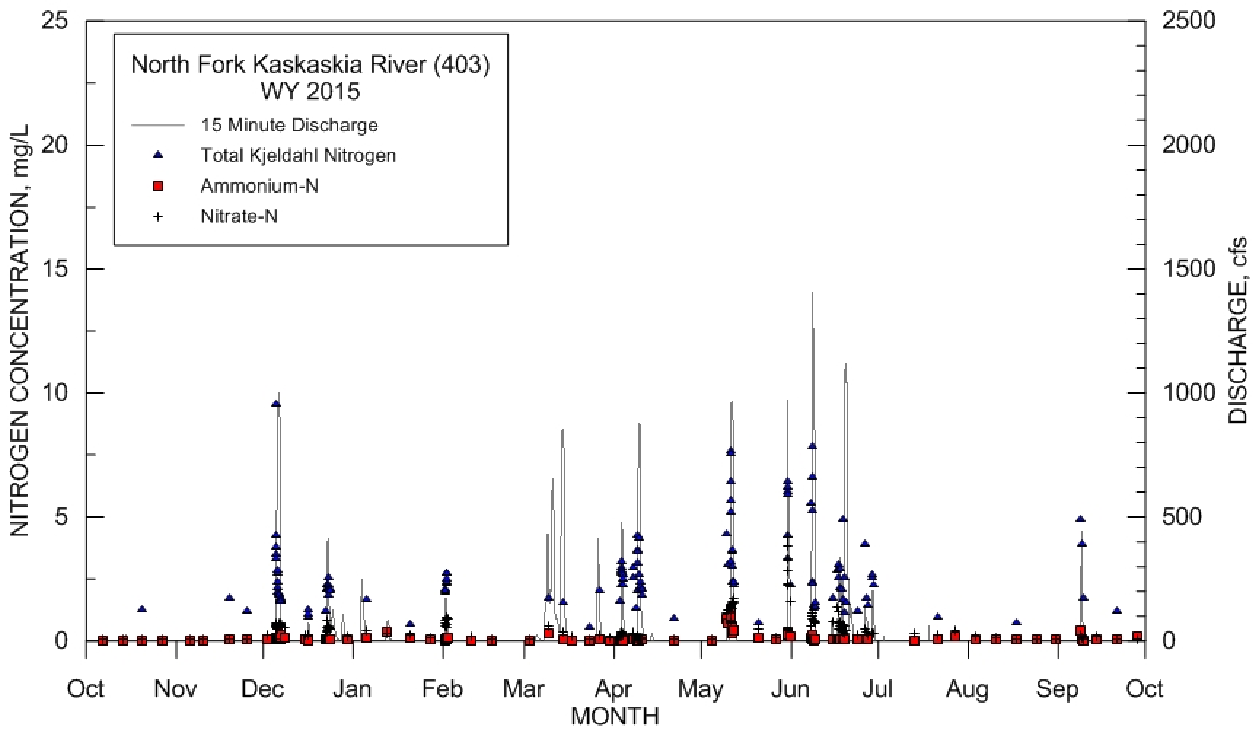


Figure A-8. Nitrogen concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015

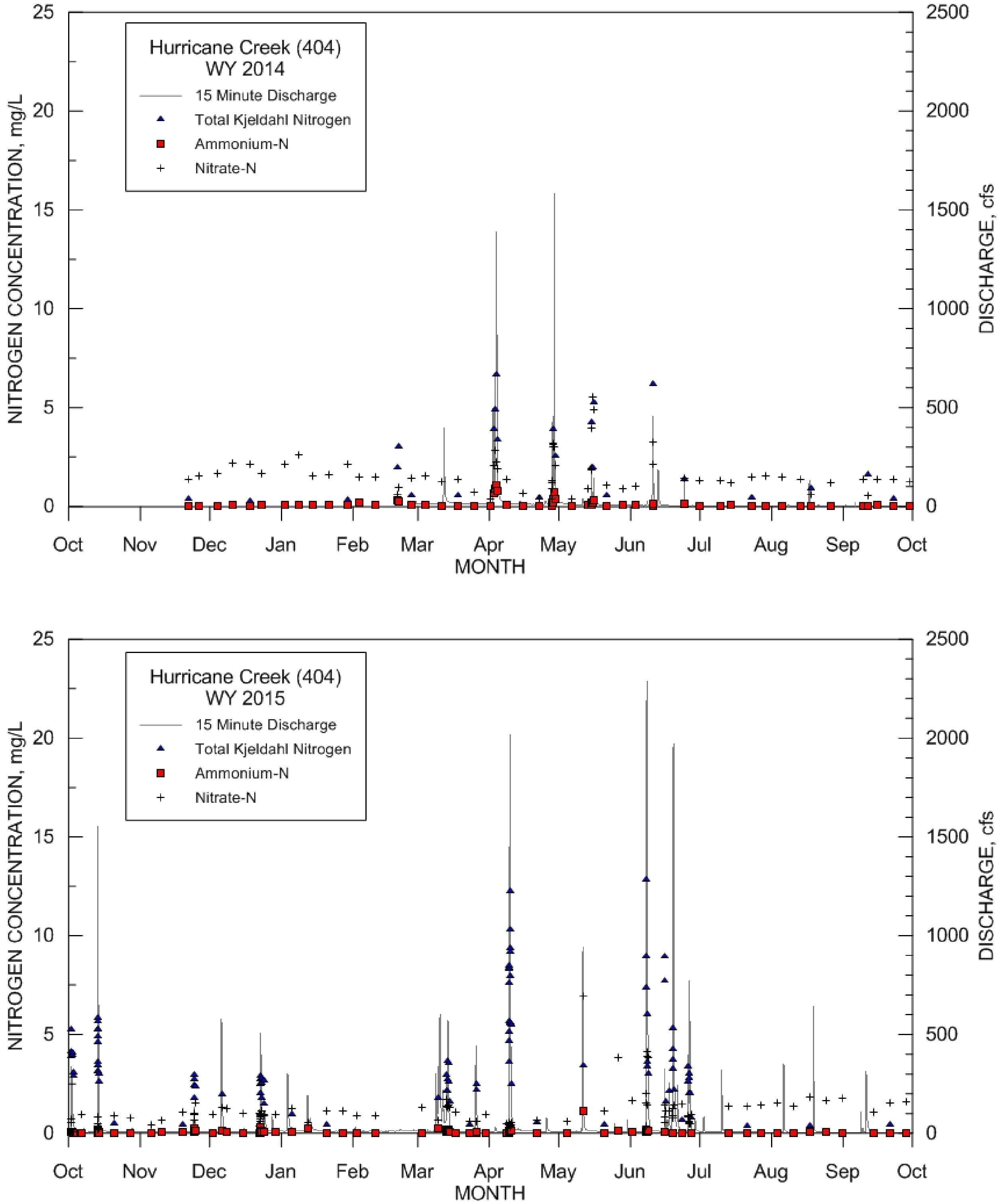


Figure A-9. Nitrogen concentrations and discharge at Hurricane Creek (404):
Water Year 2014 and Water Year 2015

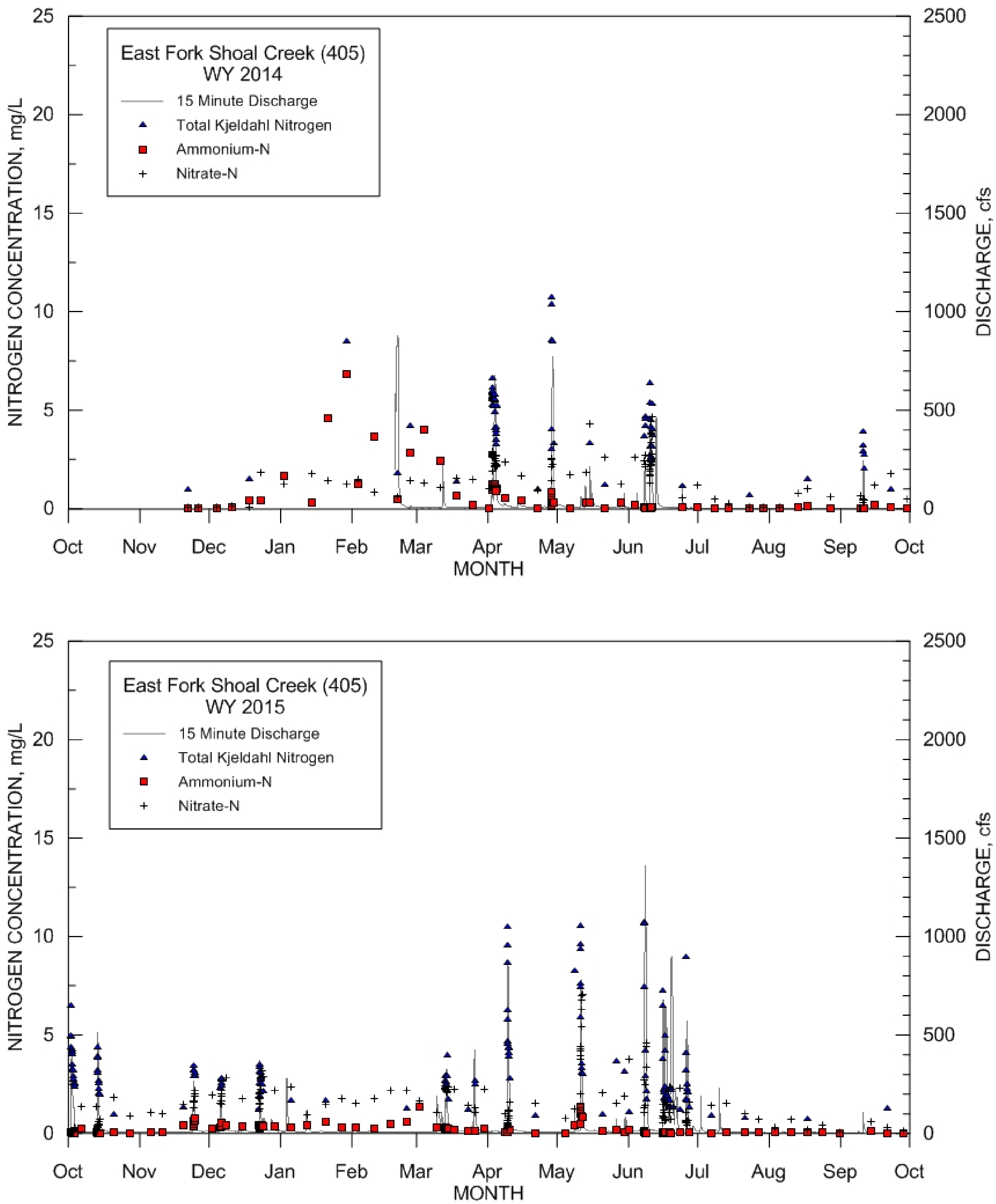
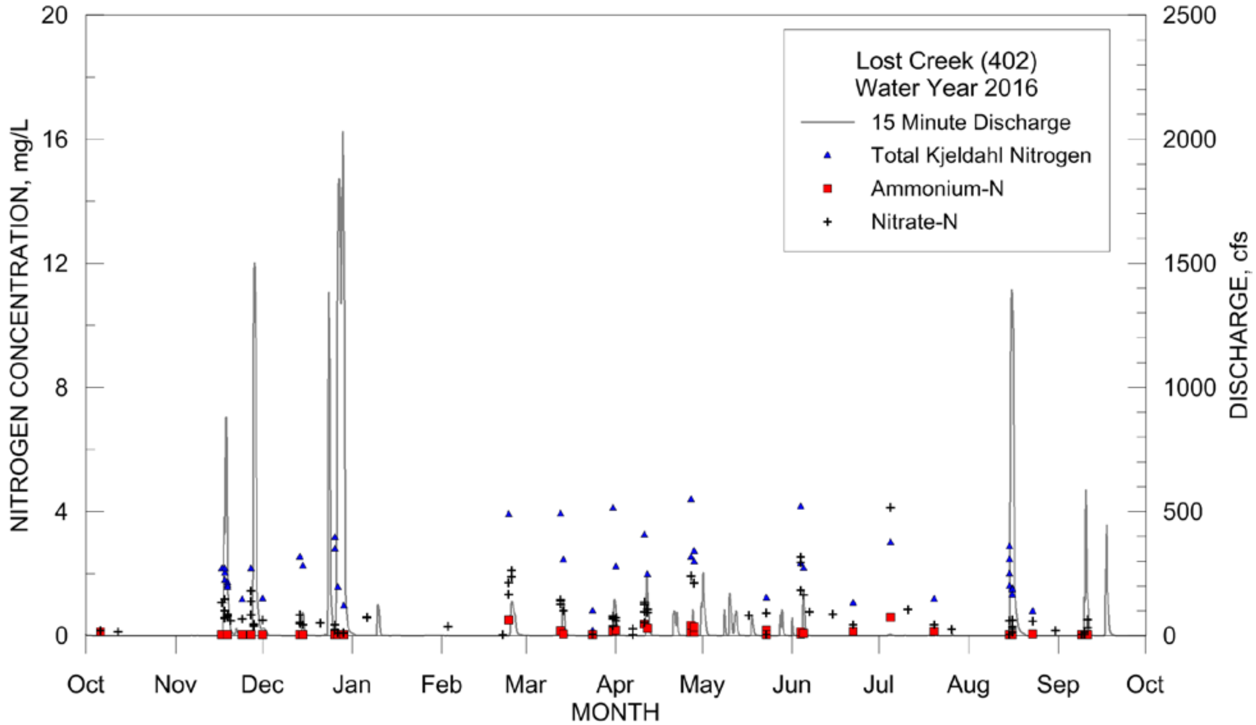


Figure A-10. Nitrogen concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015



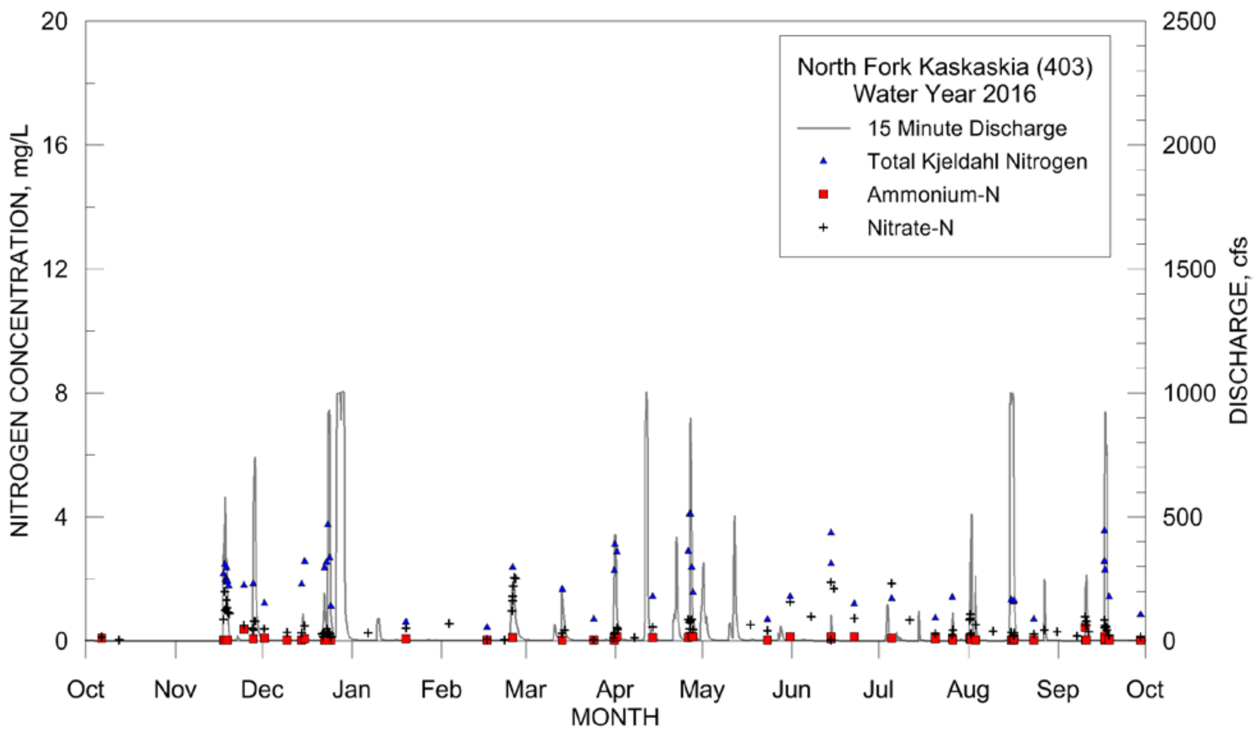
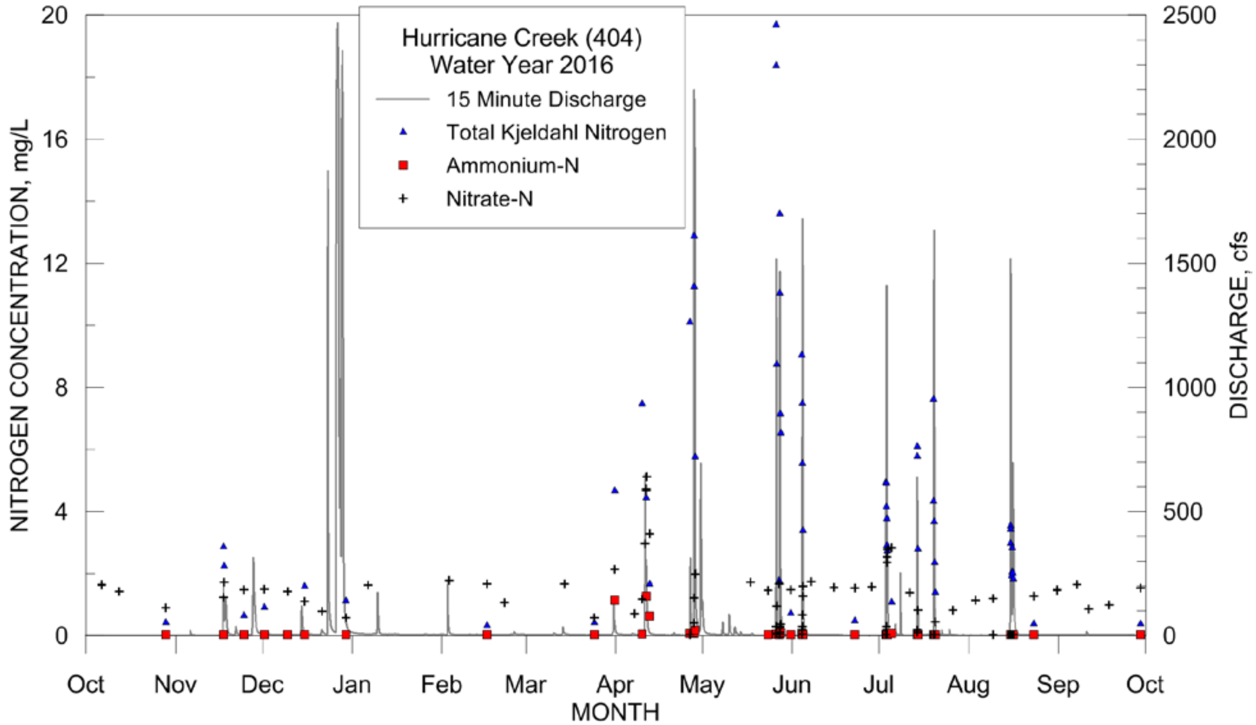


Figure A-11. Nitrogen concentrations and discharge for Water Year 2016:
Lost Creek (402) and North Fork Kaskaskia (403)



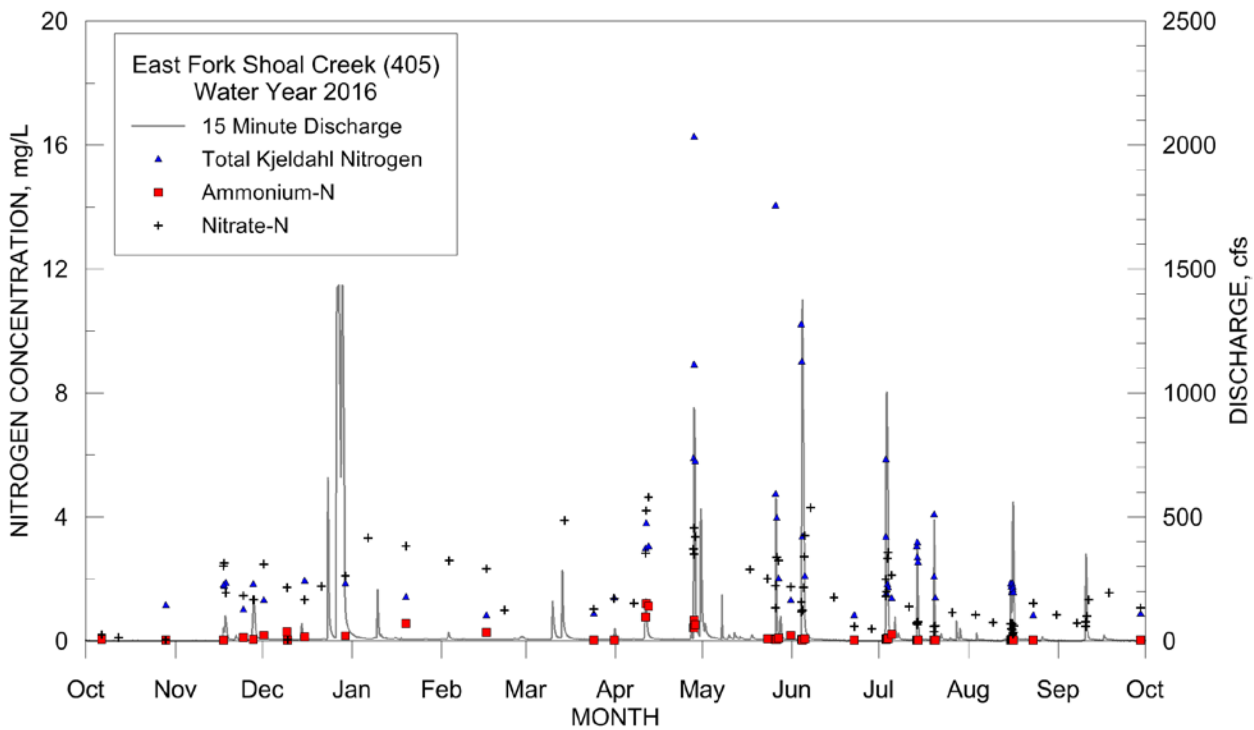


Figure A-12. Nitrogen concentrations and discharge for Water Year 2016:
Hurricane Creek (404) and East Fork Shoal Creek (405)

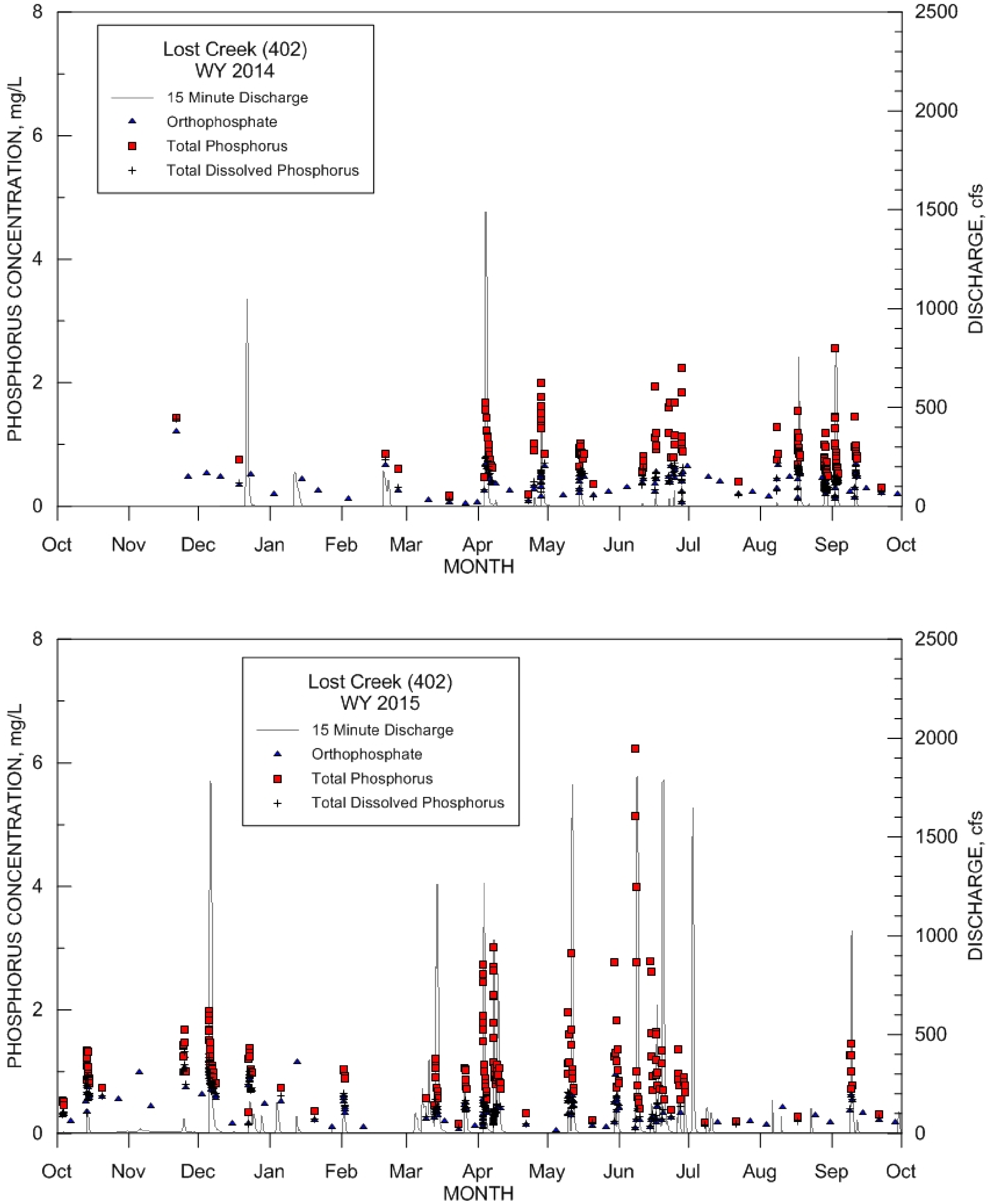
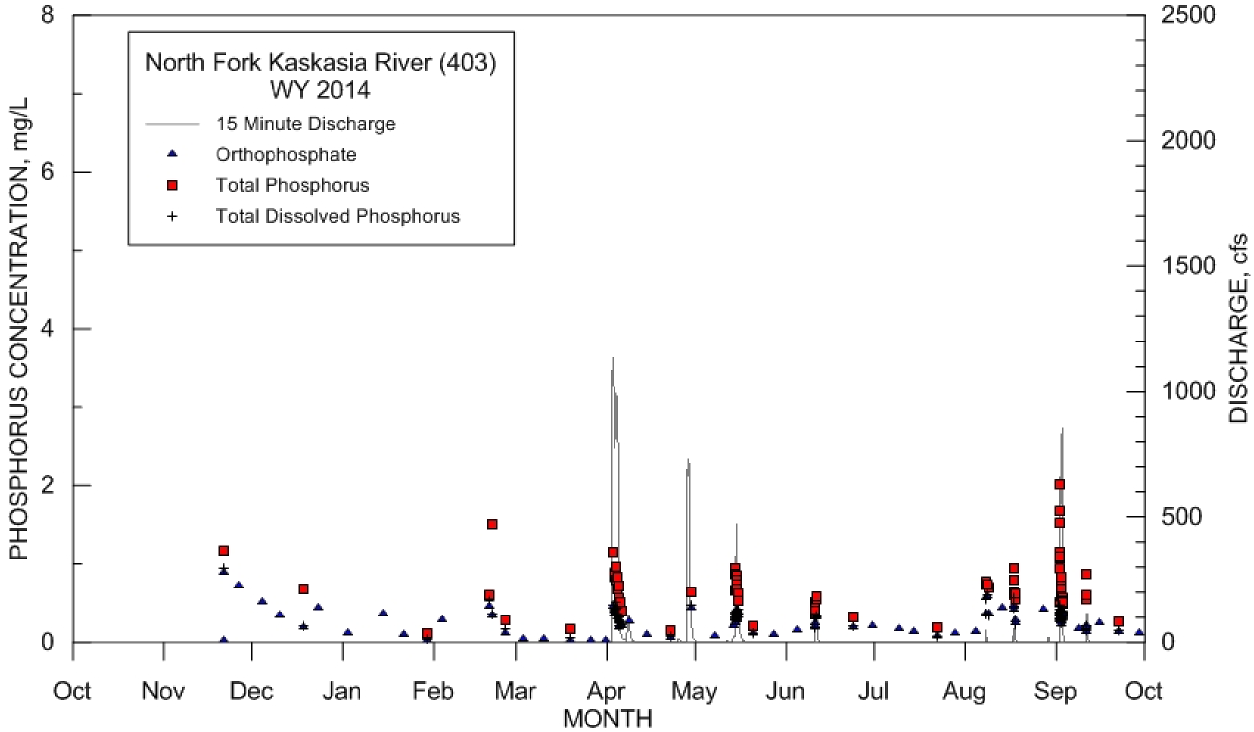


Figure A-13. Phosphorus concentrations and discharge at Lost Creek (402):
Water Year 2014 and Water Year 2015



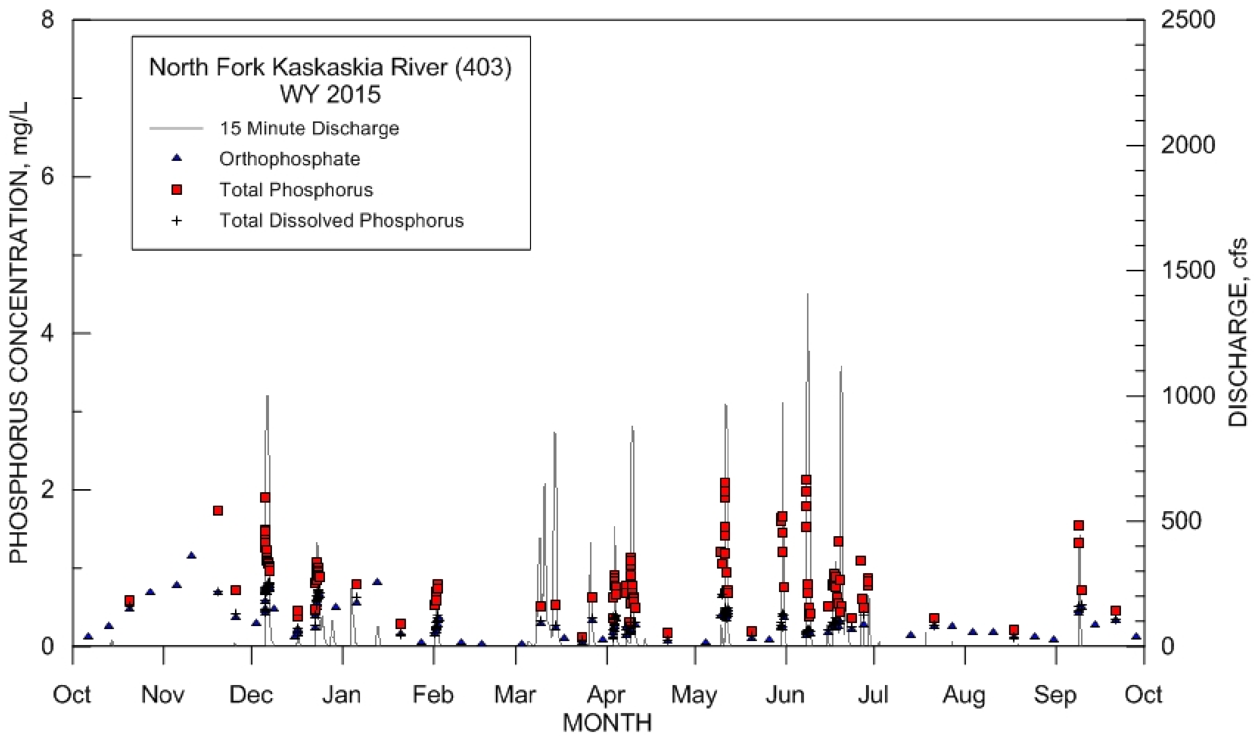


Figure A-14. Phosphorus concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015

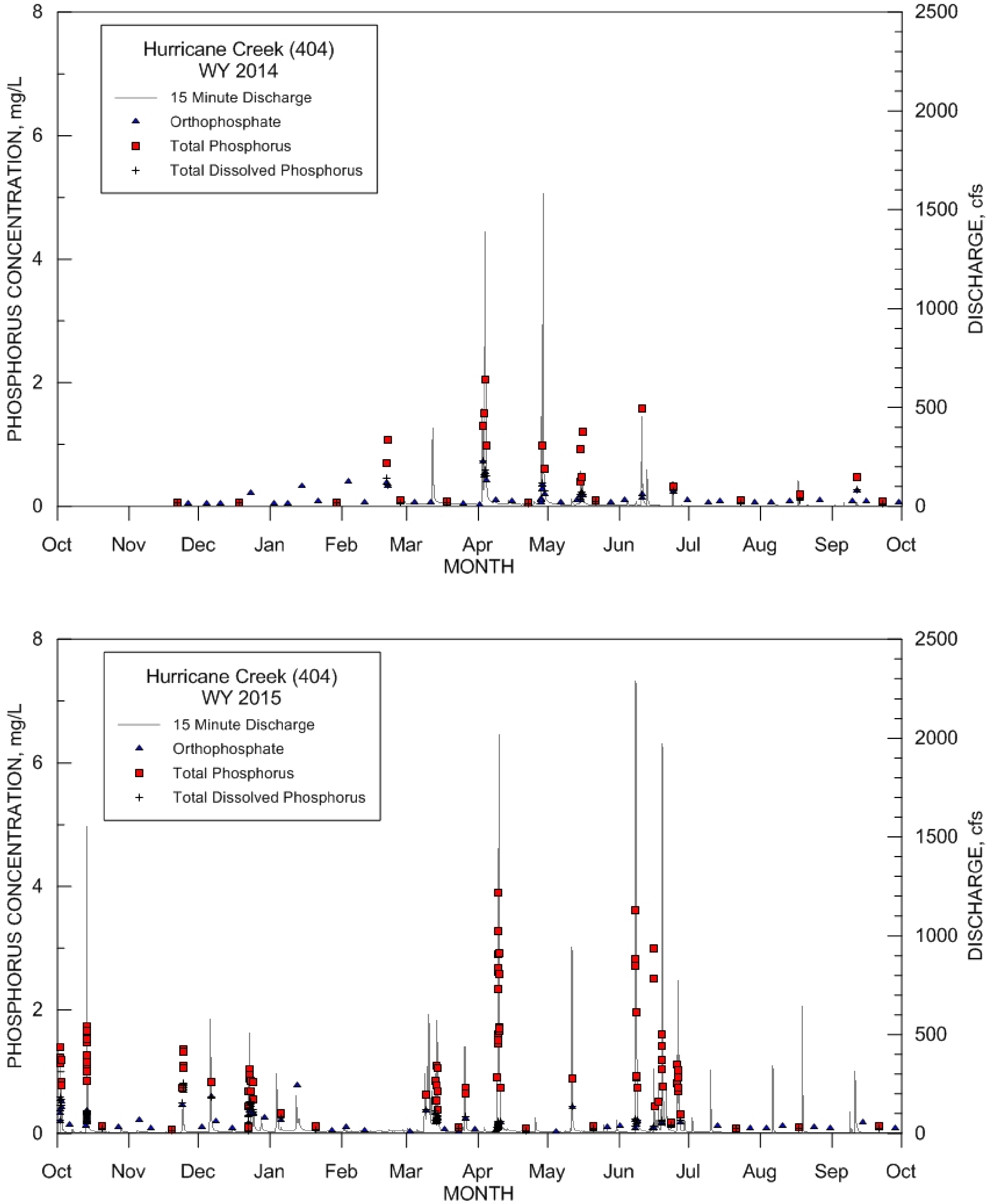
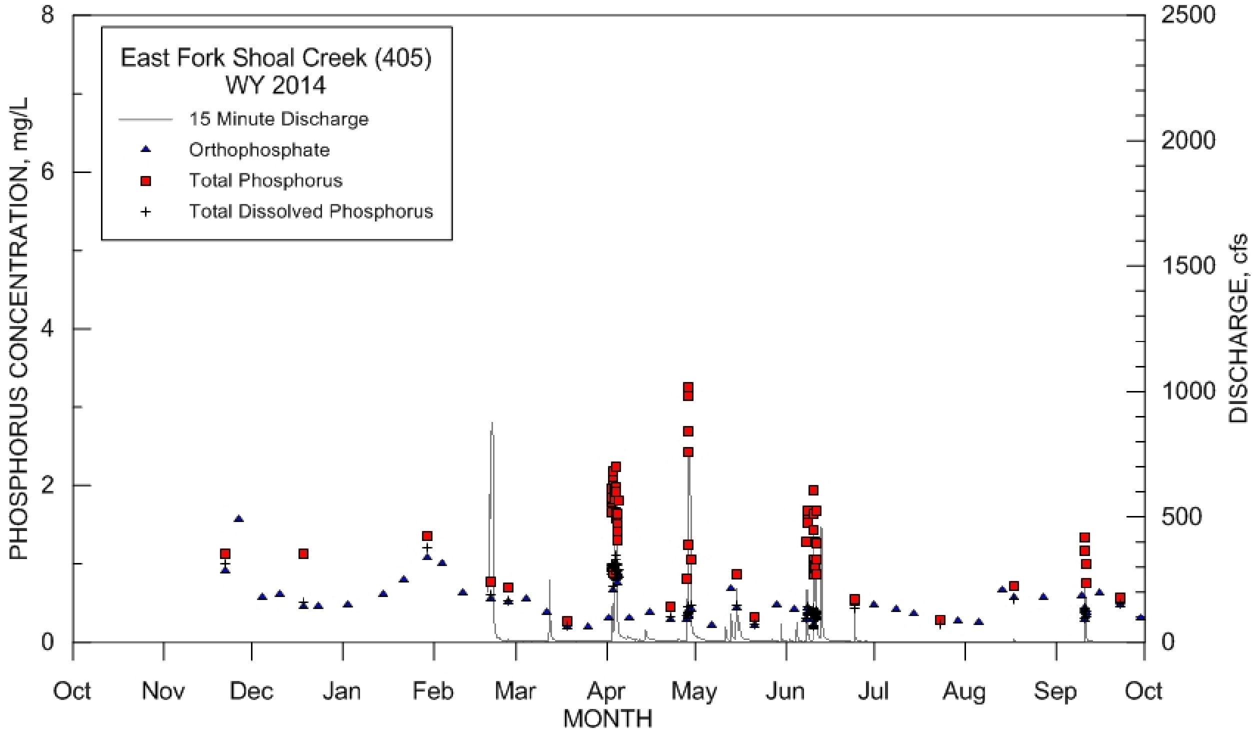


Figure A-15. Phosphorus concentrations and discharge at Hurricane Creek (404):
Water Year 2014 and Water Year 2015



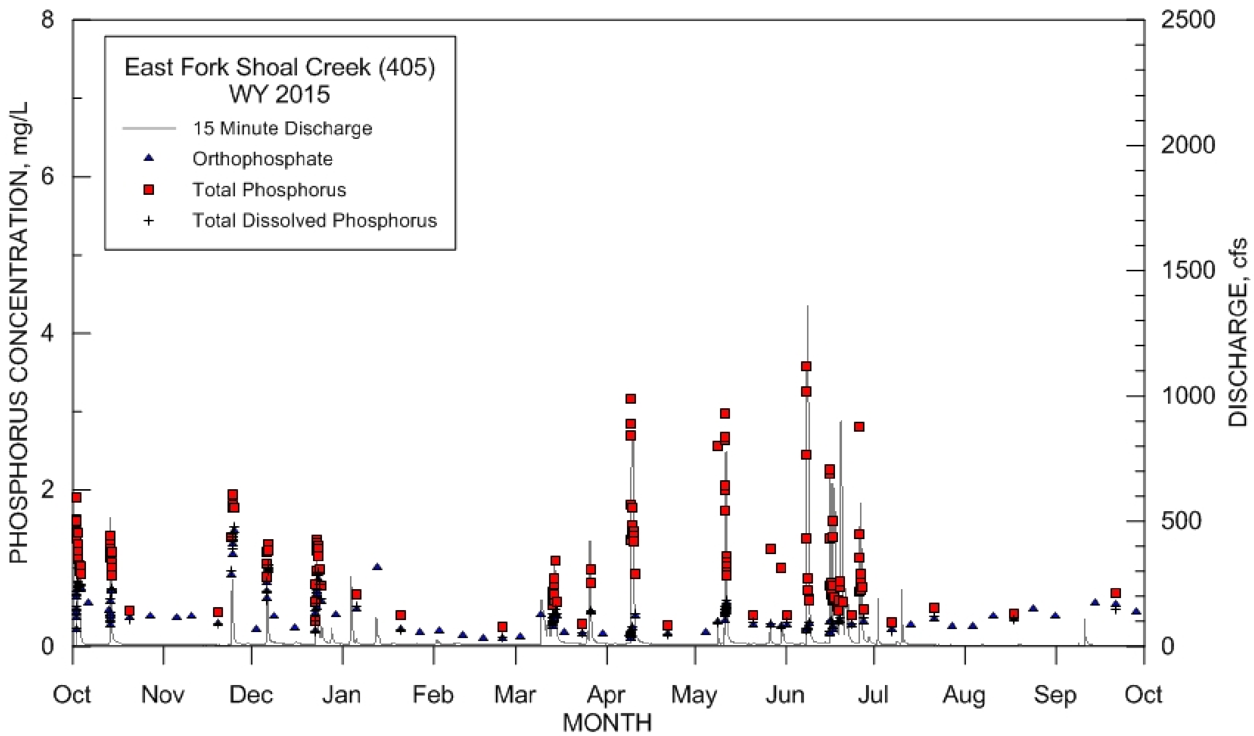
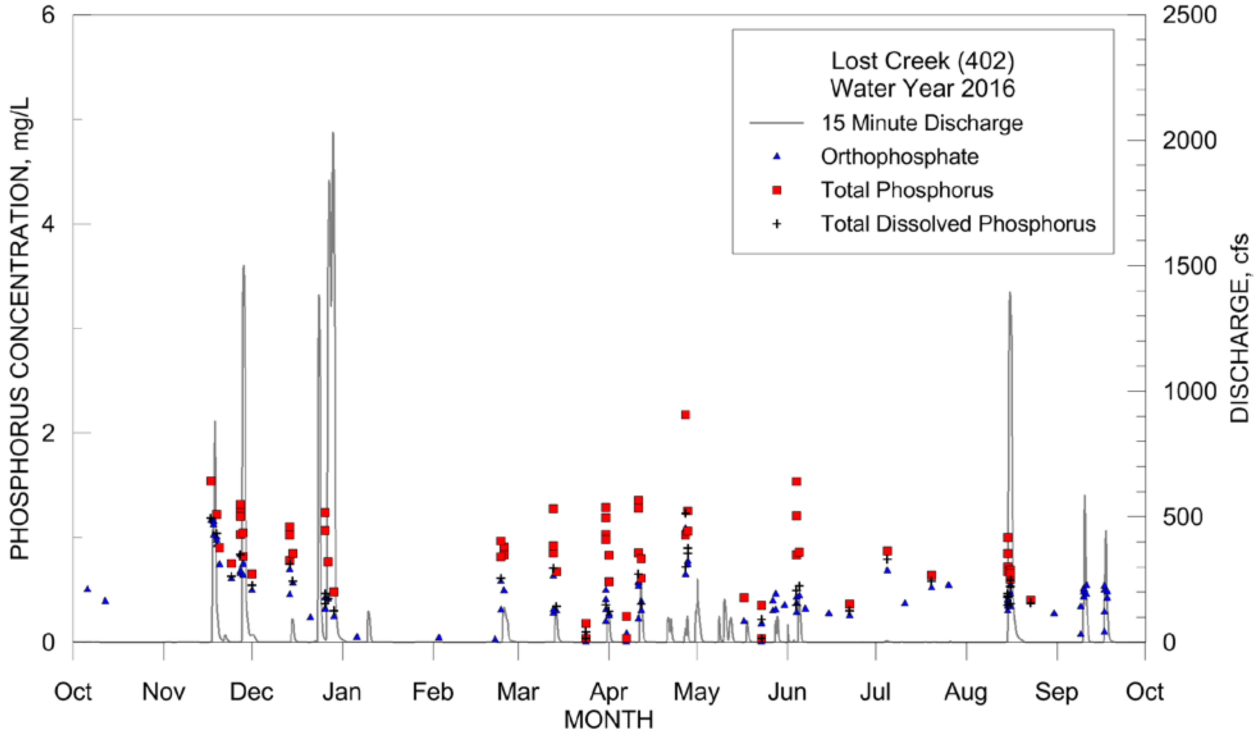


Figure A-16. Phosphorus concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015



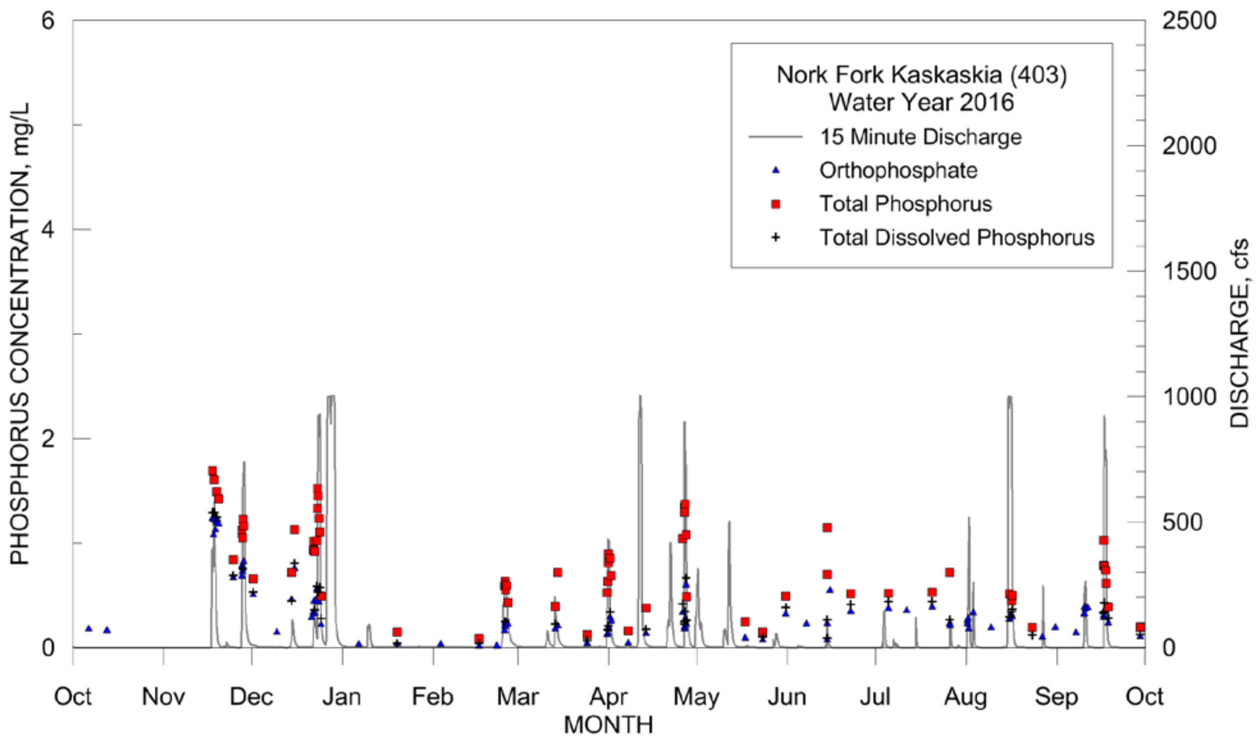


Figure A-17. Phosphorus concentrations and discharge for Water Year 2016:
Lost Creek (402) and North Fork Kaskaskia (403)

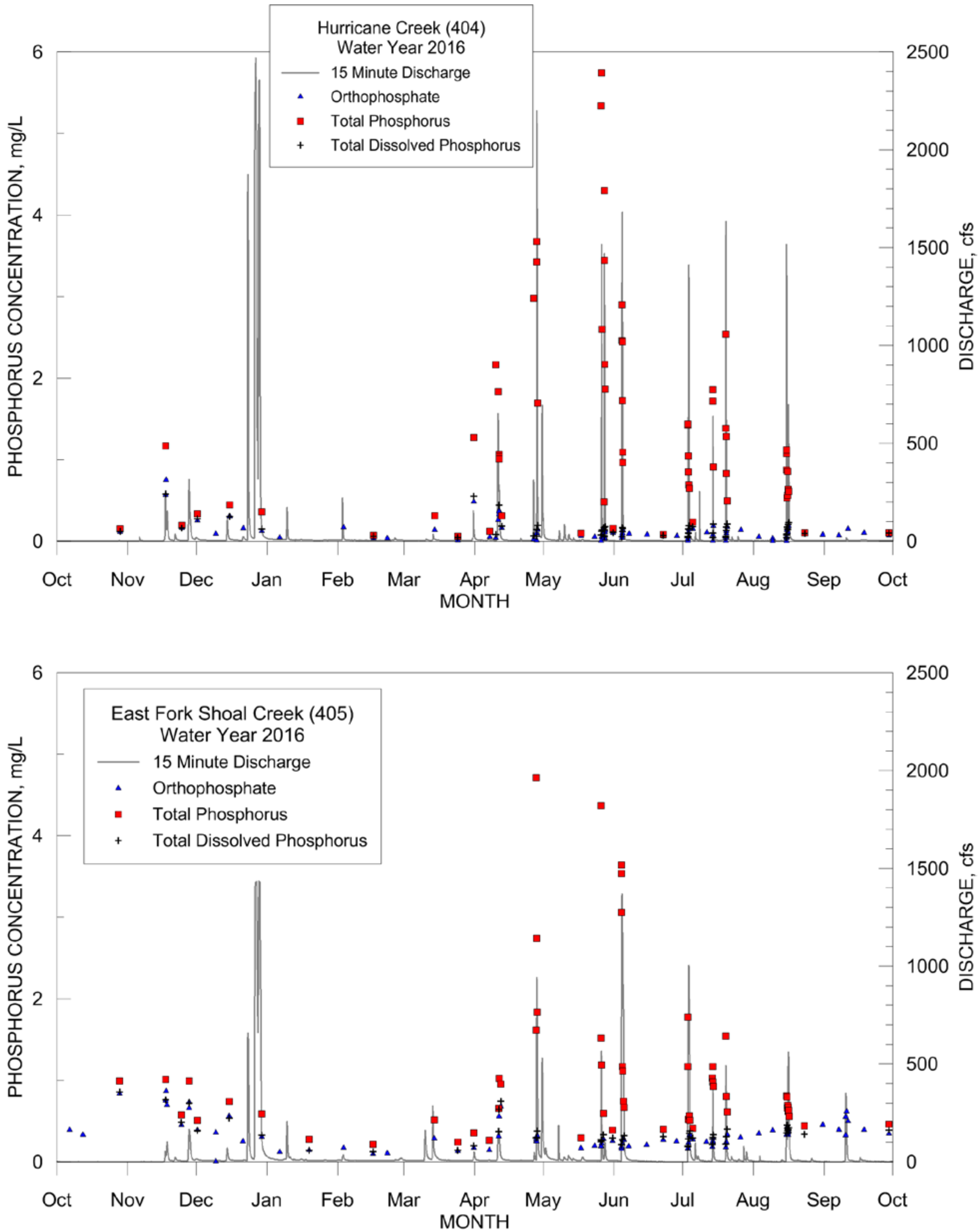
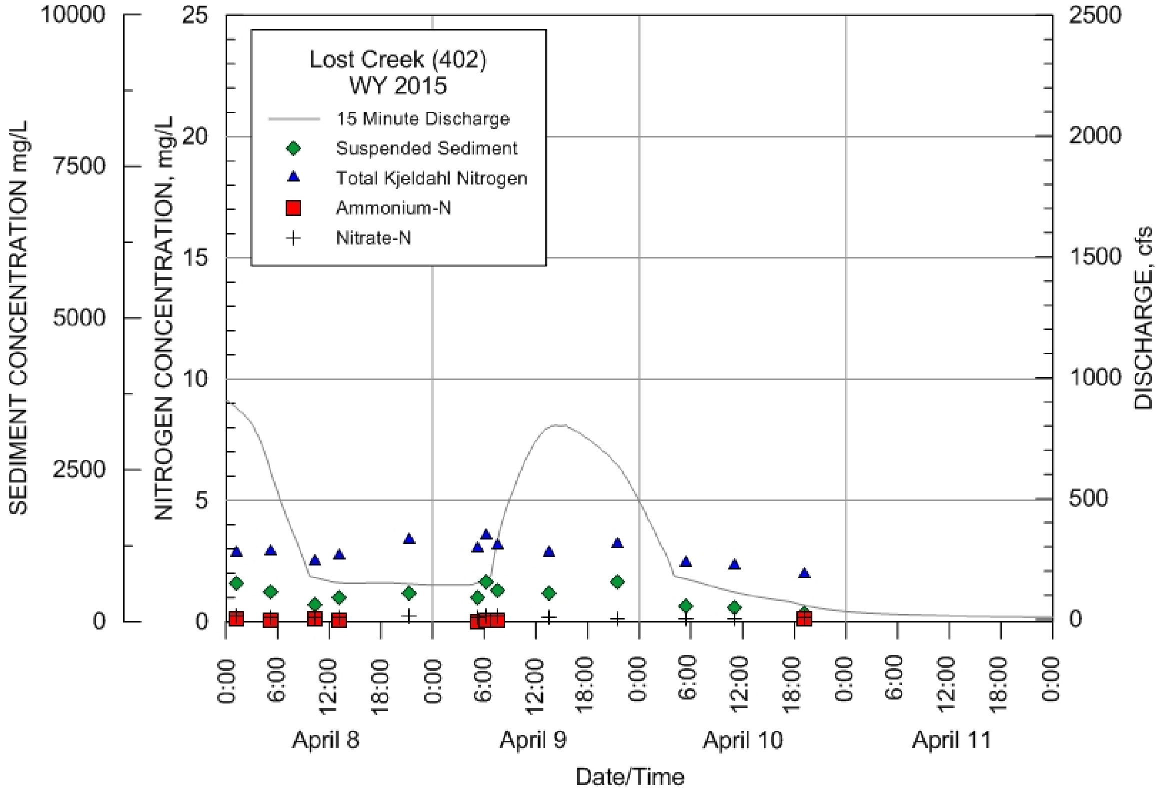


Figure A-18. Phosphorus concentrations and discharge for Water Year 2016:
Hurricane Creek (404) and East Fork Shoal Creek (405)



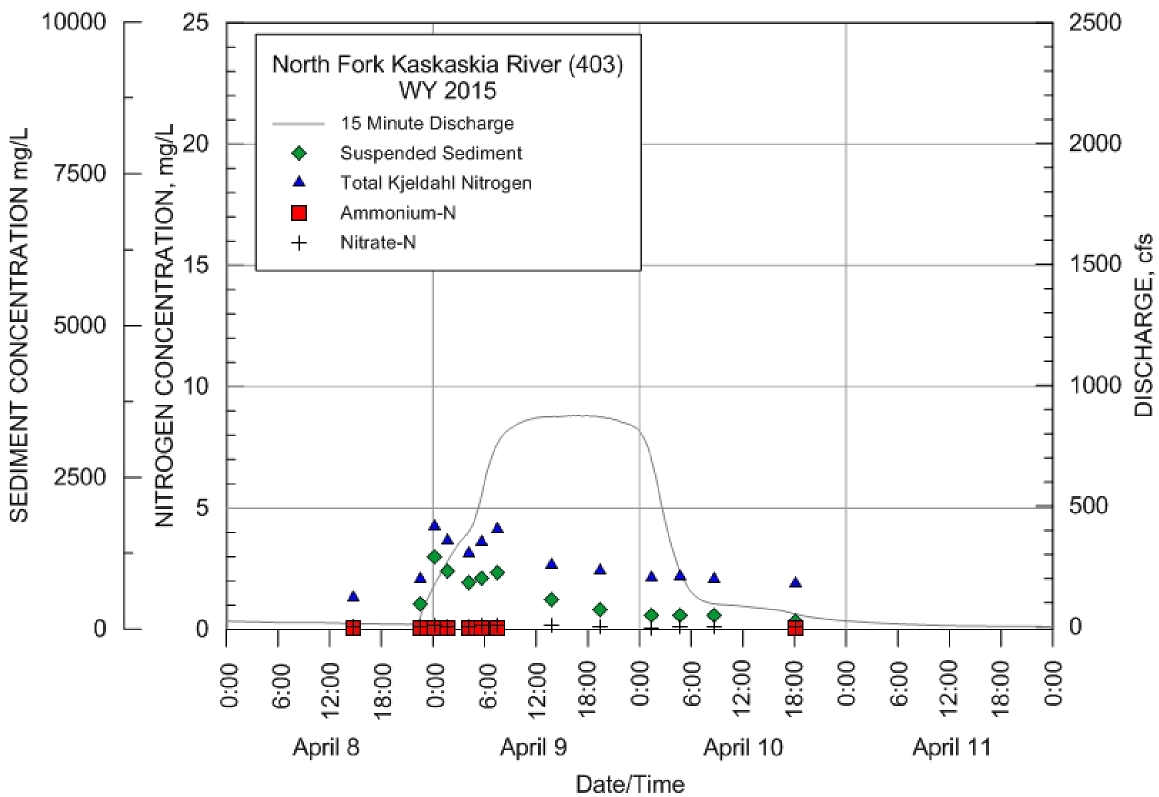
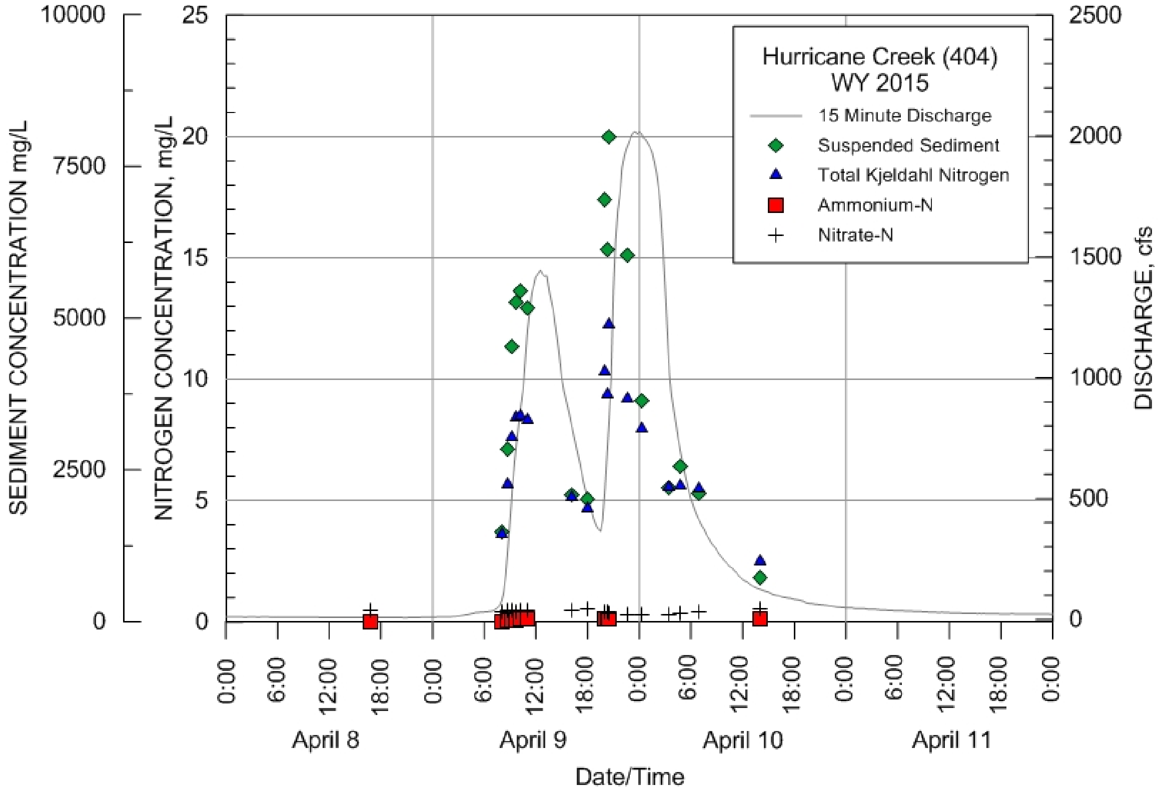


Figure A-19. Sediment and nitrogen concentrations during April 8-11, 2015 event at Lost Creek (402) and North Fork Kaskaskia River (403).



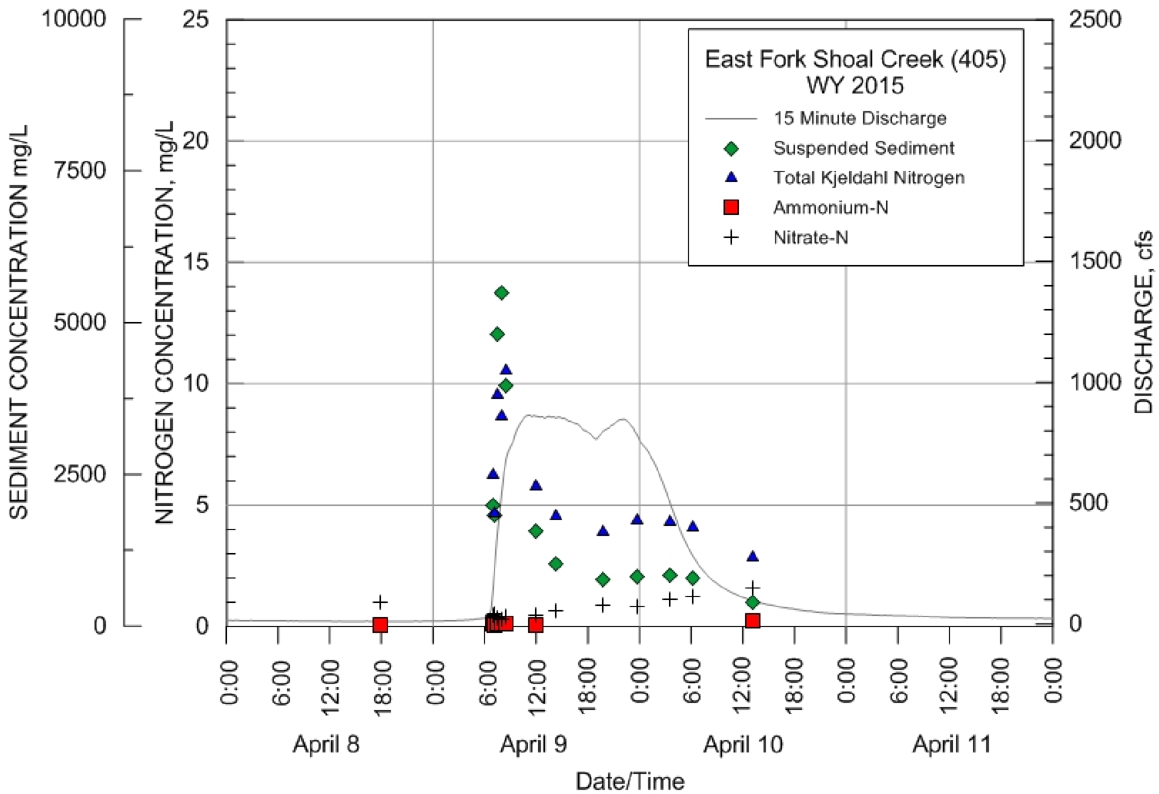


Figure A-20. Sediment and nitrogen concentrations during April 8-11, 2015 event at Hurricane Creek (404) and East Fork Shoal Creek (405).

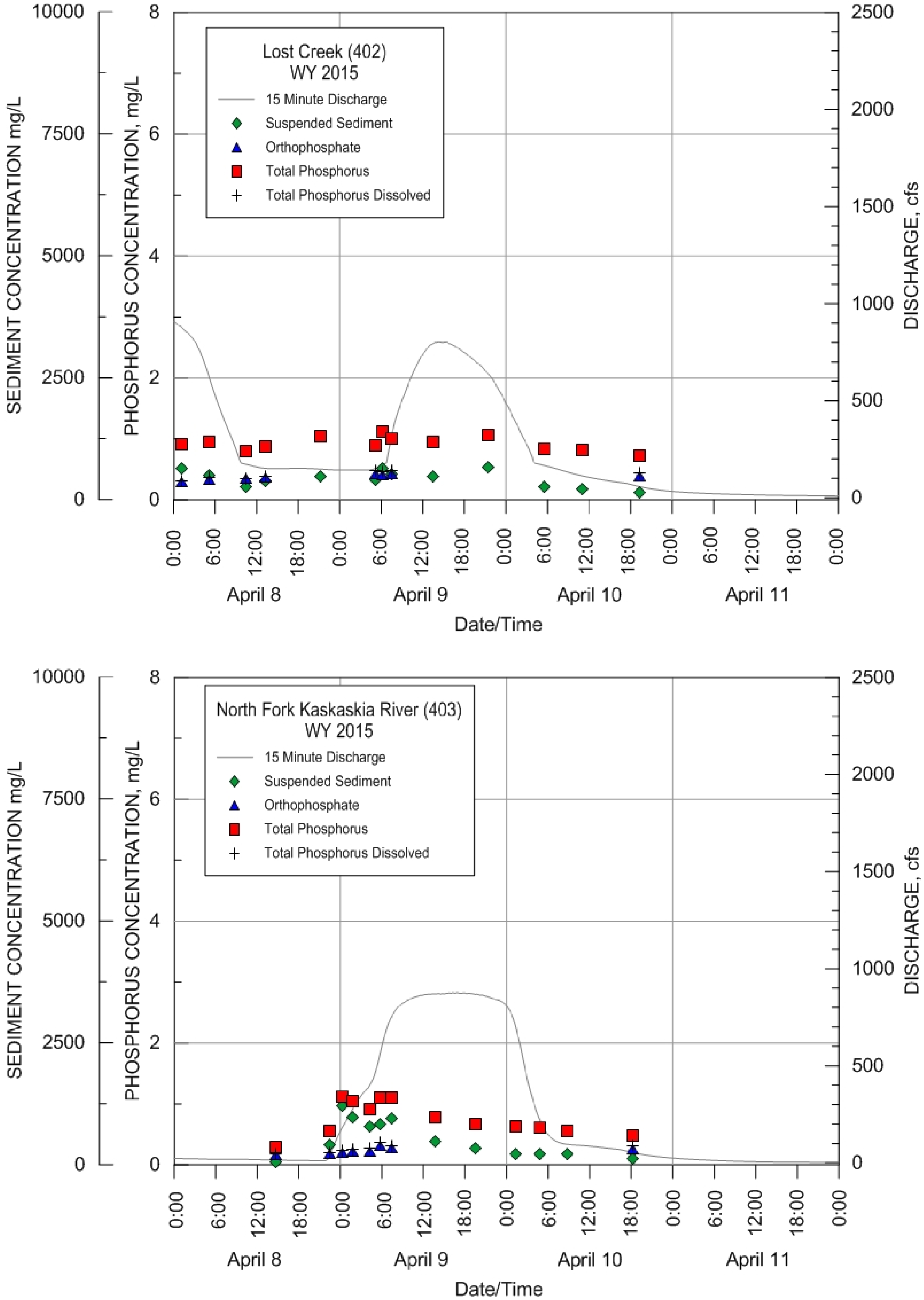


Figure A-21. Sediment and phosphorus concentrations during April 8-11, 2015 event at Lost Creek (402) and North Fork Kaskaskia River (403).

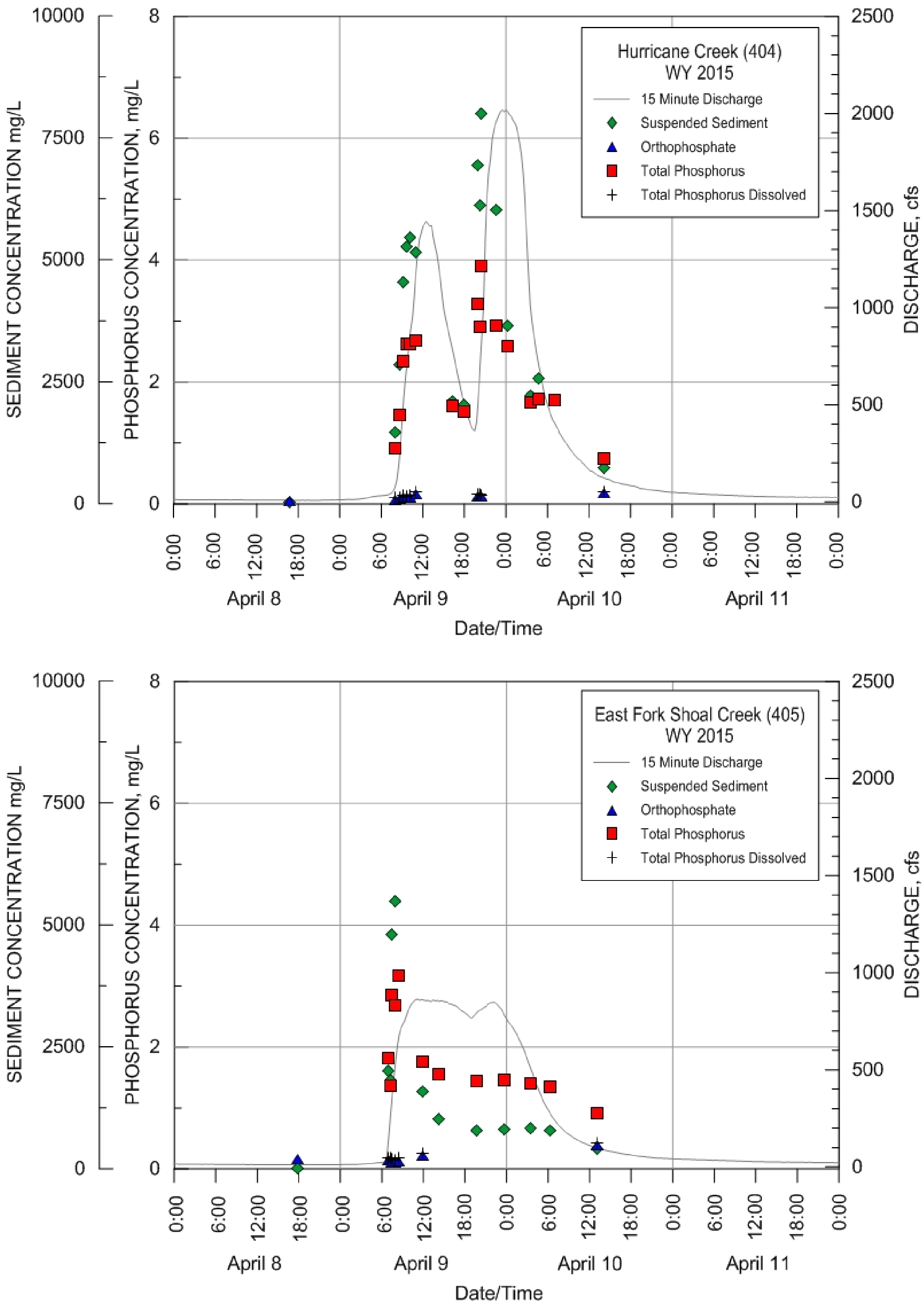


Figure A-22. Sediment and phosphorus concentrations during April 8-11, 2015 event at Hurricane Creek (404) and East Fork Shoal Creek (405).

Appendix B
Monthly Sediment and Nutrient Yields
WY2014-2016

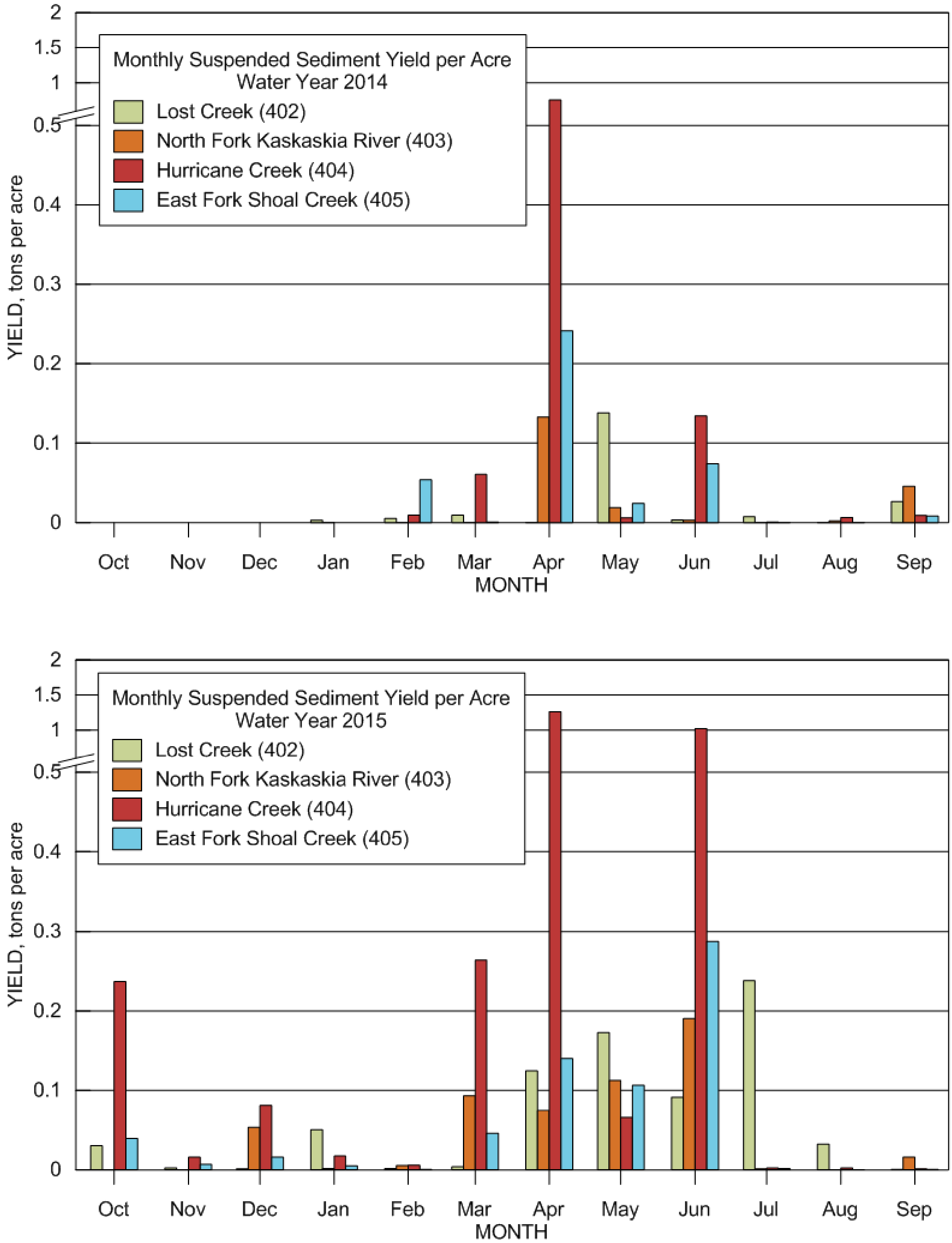
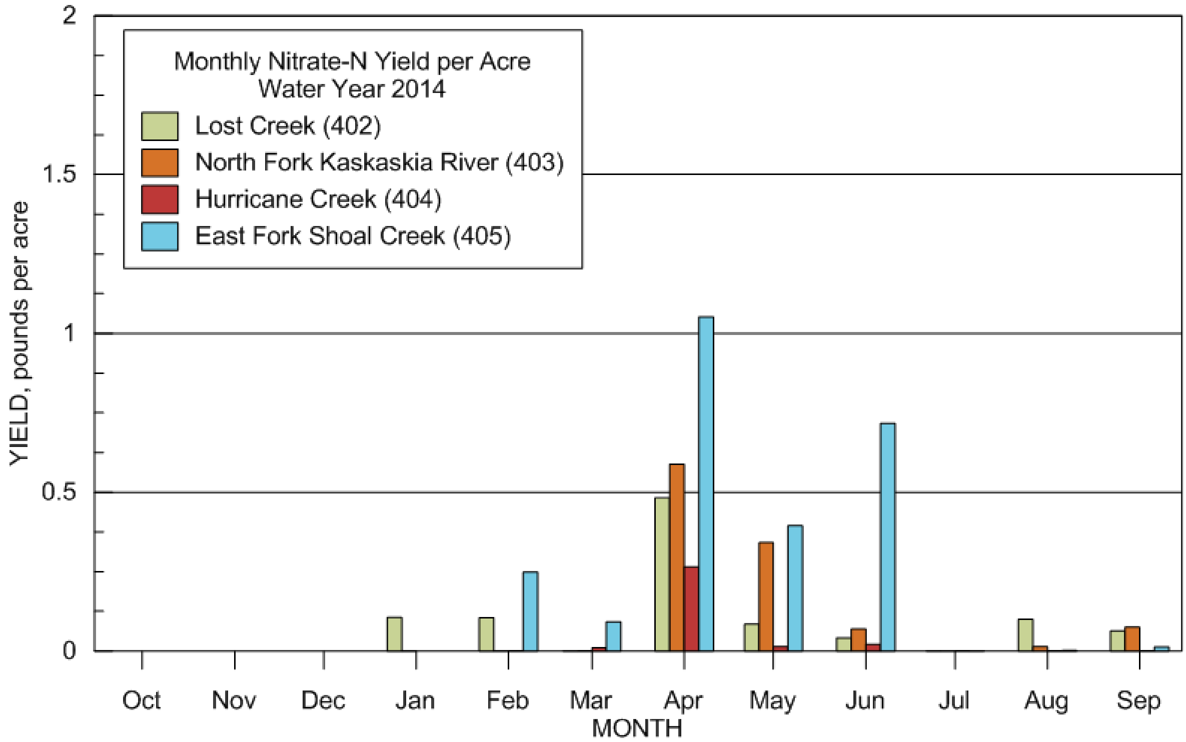


Figure B-1. Monthly sediment yield (tons/acre) for all stations during WY2014-2015



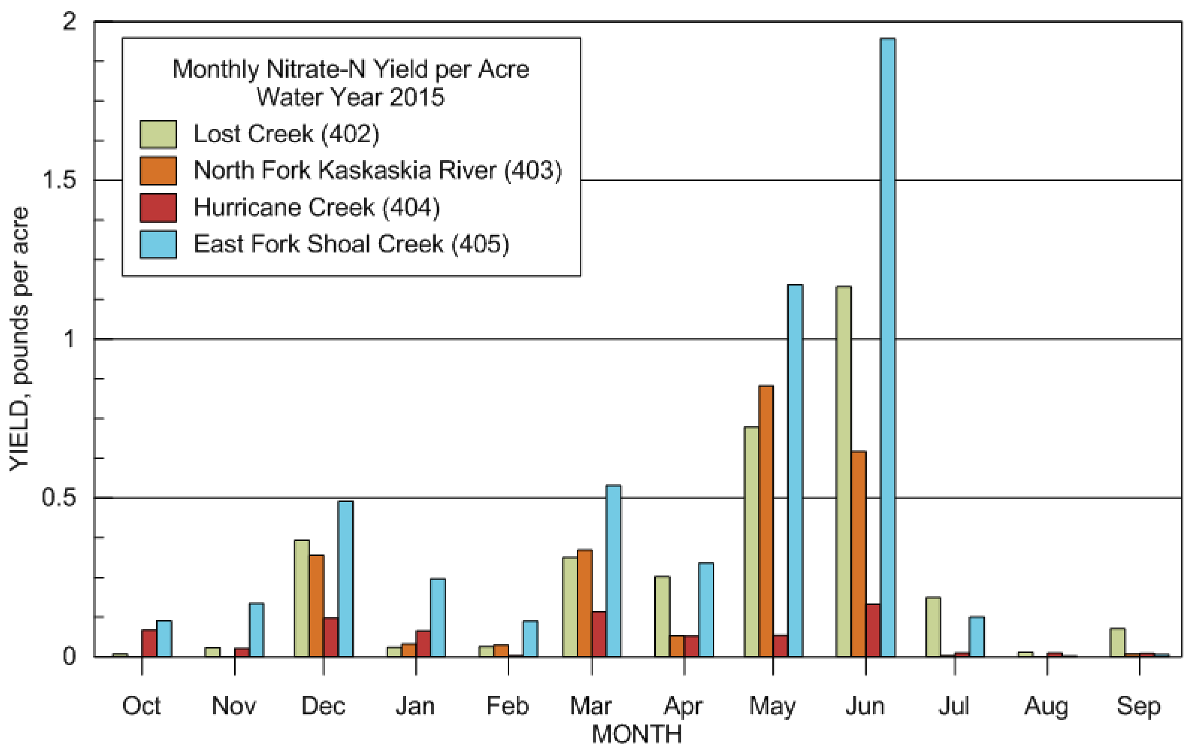


Figure B-2. Monthly nitrate-N yield (tons/acre) for all stations during WY2014-2015

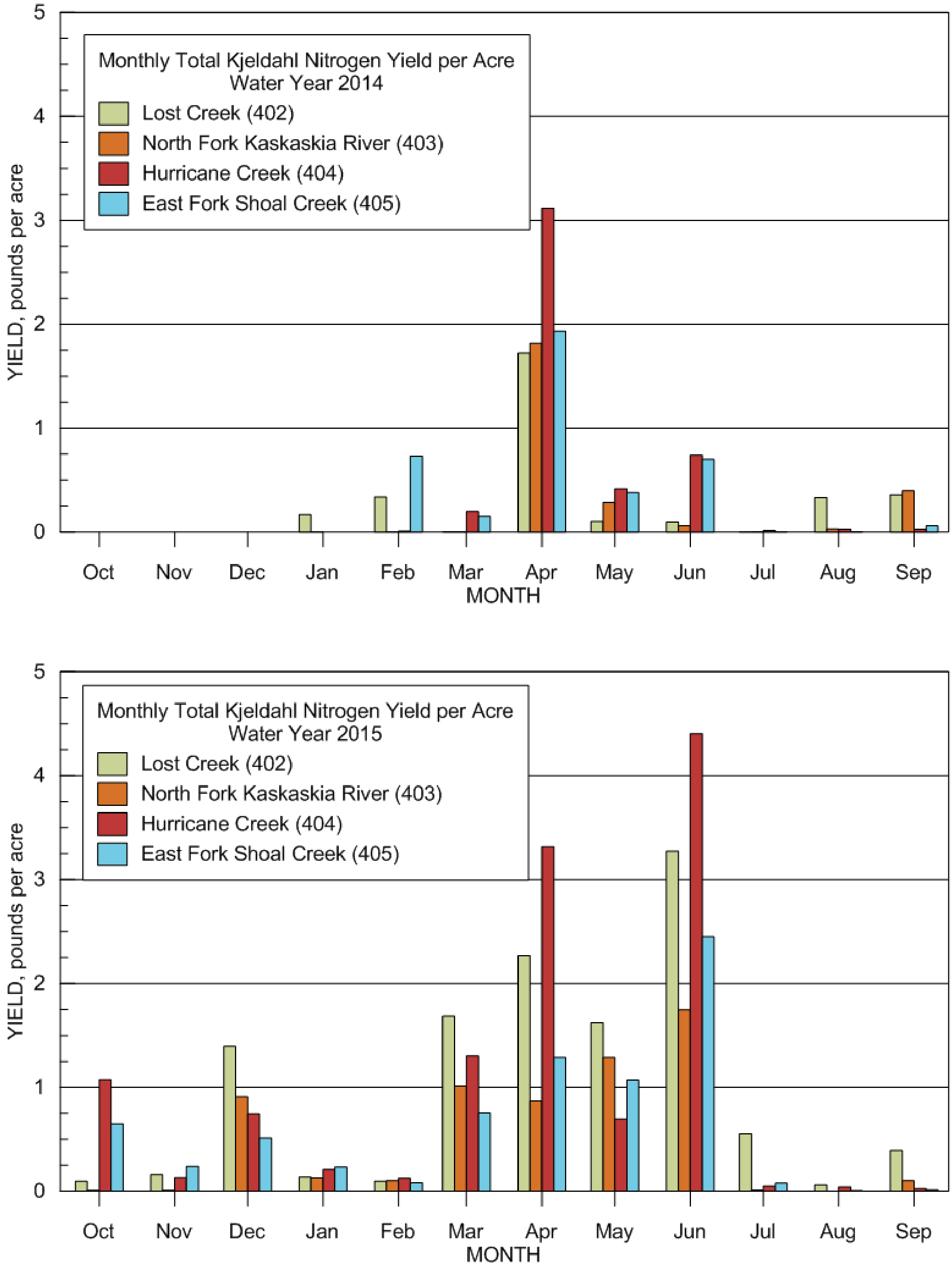
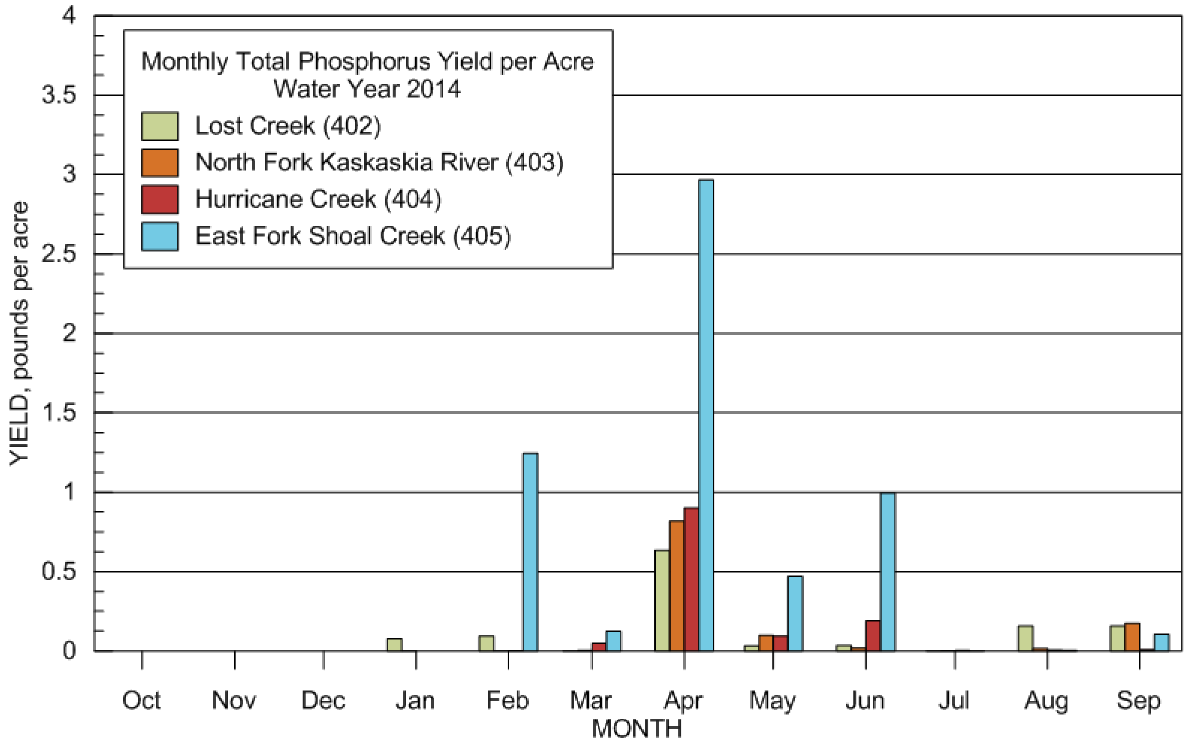


Figure B-3. Monthly TKN yield (tons/acre) for all stations during WY2014-2015



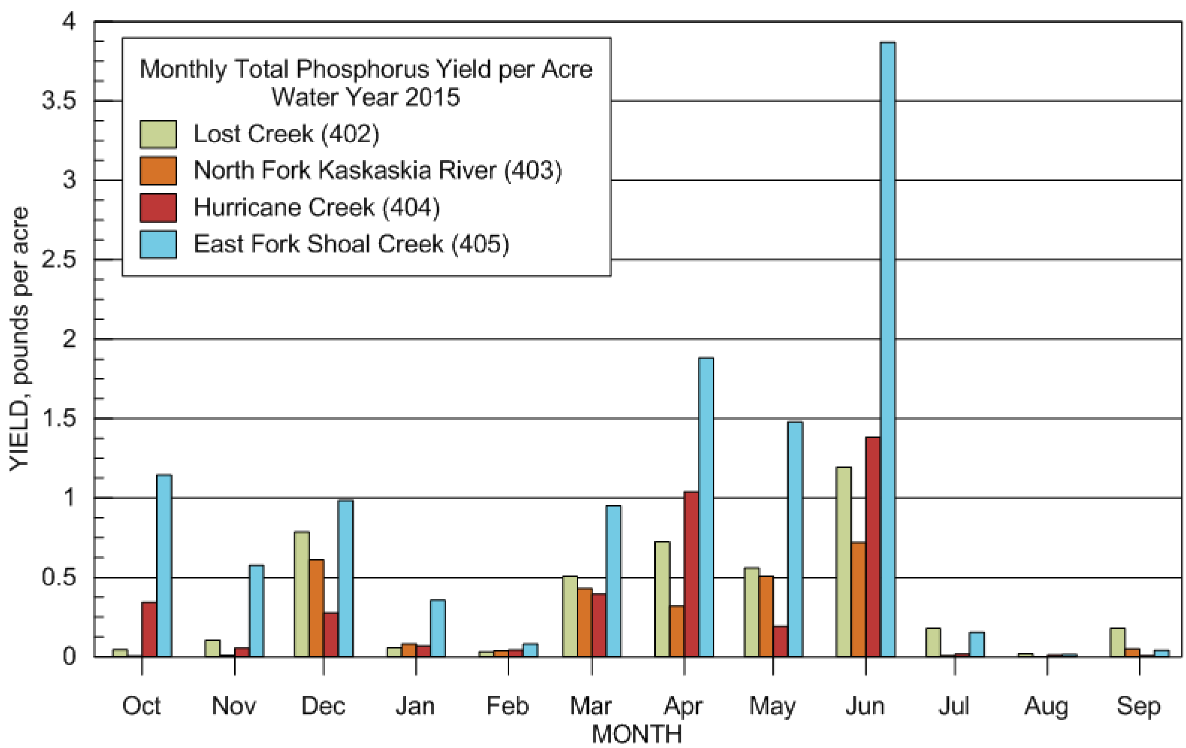


Figure B-4. Monthly total phosphorus yield (tons/acre) for all stations during WY2014-2015

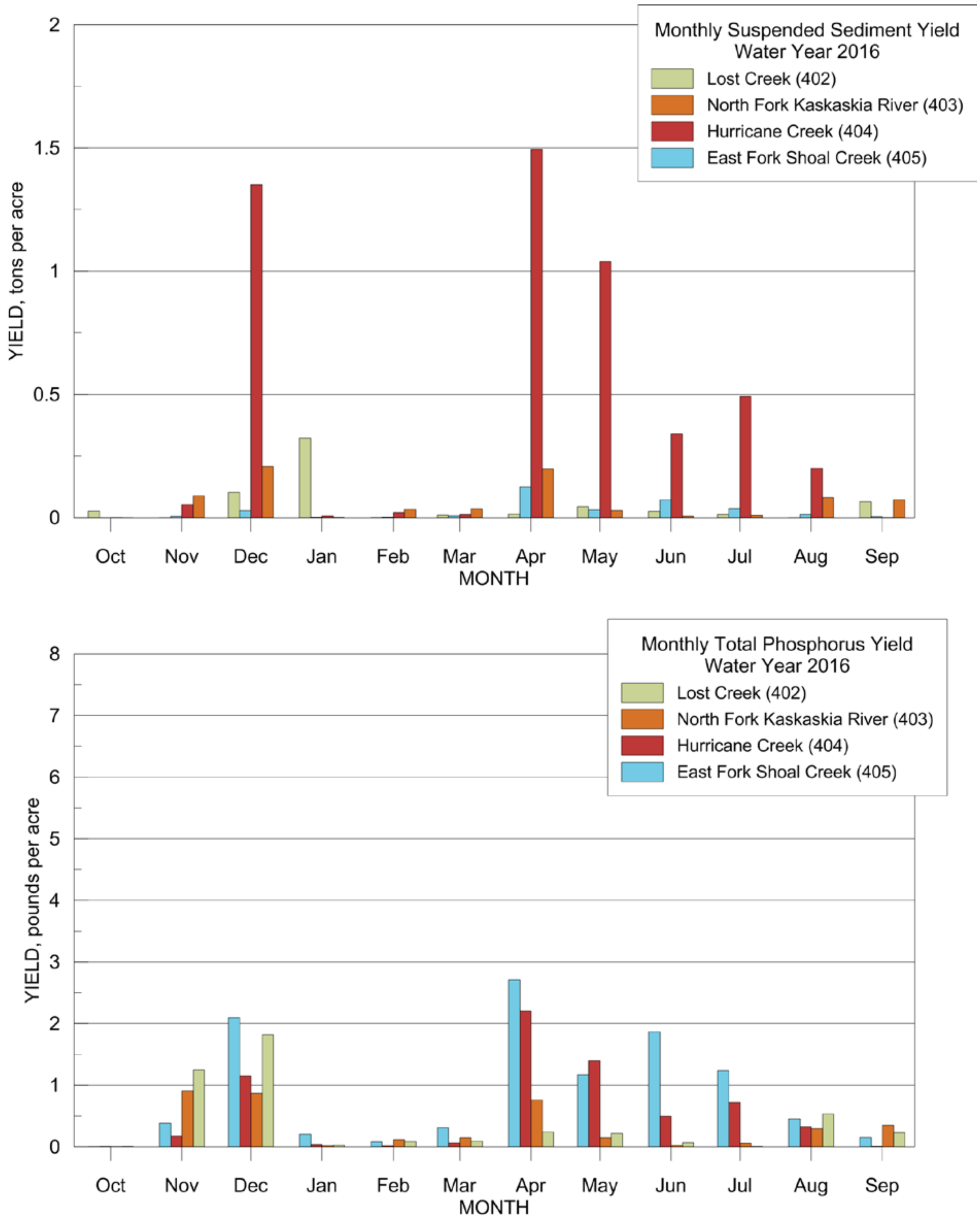
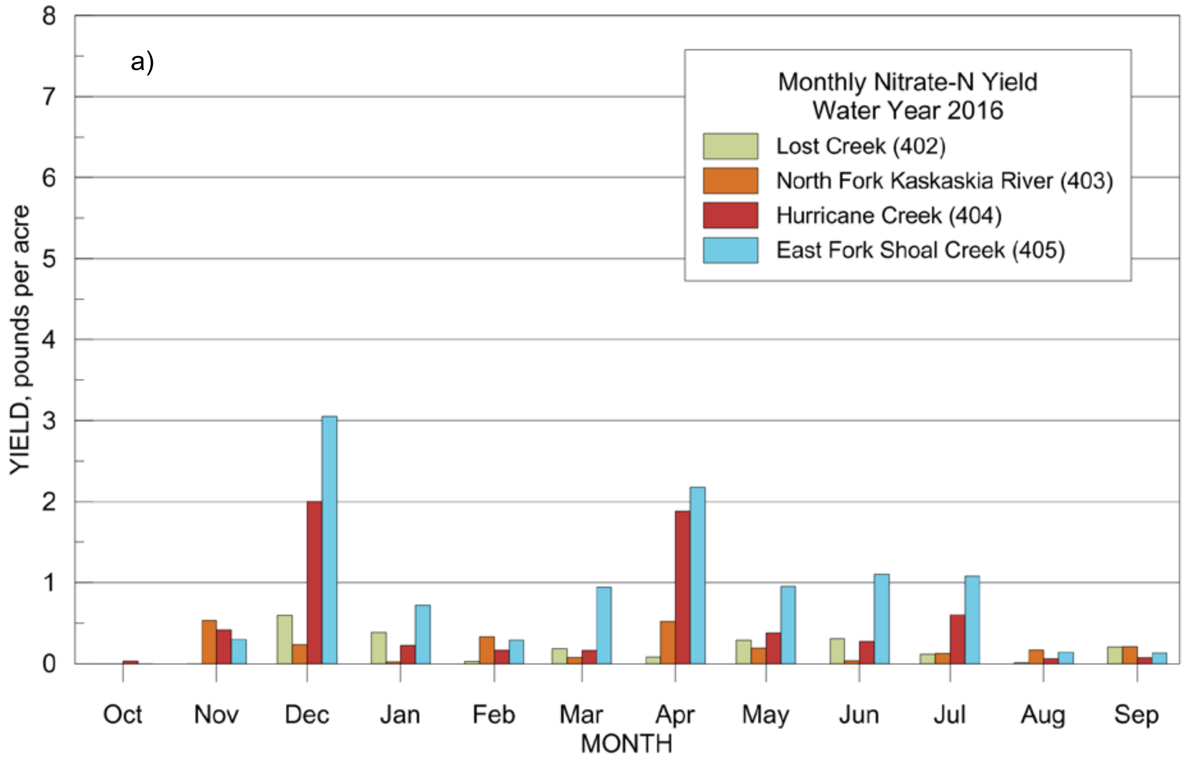


Figure B-5. Monthly yields for all stations during Water Year 2016:
a) Suspended Sediment (tons/acre) and b) Total Phosphorus (lbs/acre)



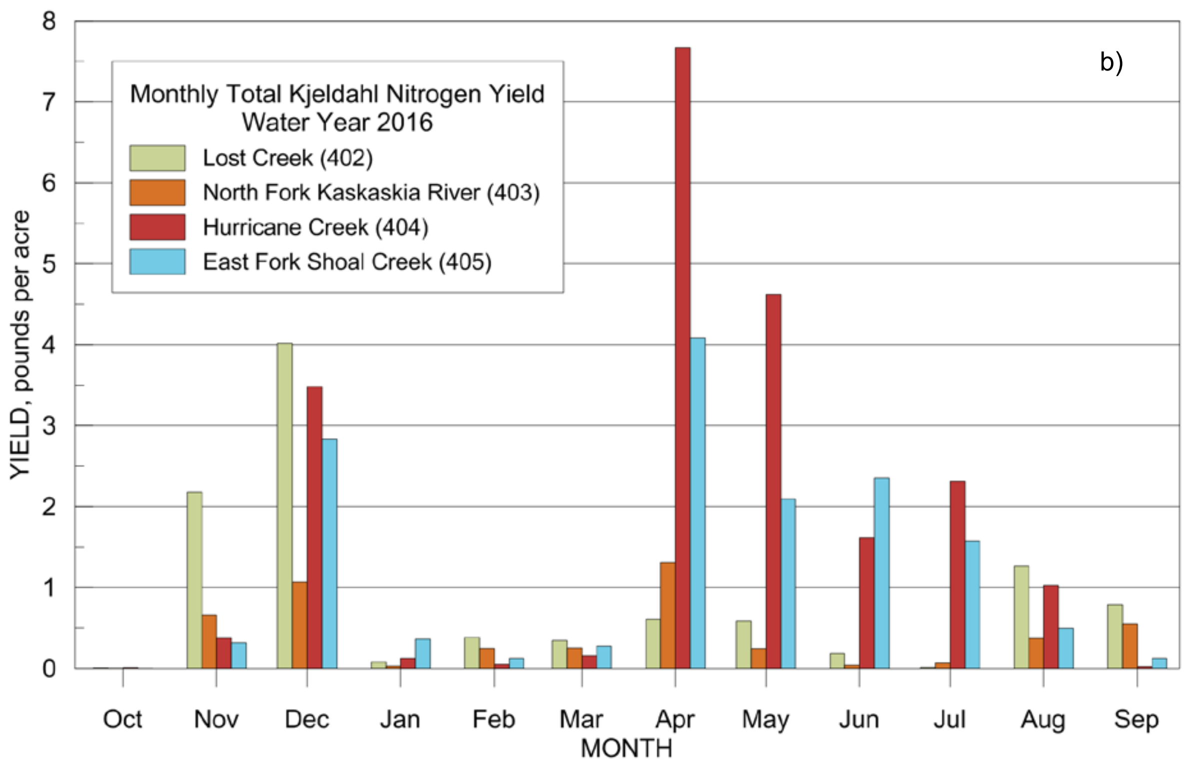


Figure B-6. Monthly yields for all stations during Water Year 2016:
a) Nitrate-N (lbs/acre) and b) Total Kjeldahl Nitrogen (lbs/acre)

Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois River: Illinois River Conservation Reserve Enhancement Program (CREP)

2017 Progress Report

by
Illinois State Water Survey
Prairie Research Institute
University of Illinois at Urbana-Champaign

Prepared for the
Office of Resource Conservation,
Illinois Department of Natural Resources

December 2017

This report was printed on recycled and recyclable papers.

Contents

List of Tables

Page

List of Figures

List of Figures (continued)

Page

List of Figures (continued)

Page

Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois River: Illinois River Conservation Reserve Enhancement Program (CREP)

by
Illinois State Water Survey
Illinois Department of Natural Resources

1. Introduction

The Illinois River Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois River basin. Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the Illinois River were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois River CREP were stated as follows:

1) Reduce the amount of silt and sediment entering the main stem of the Illinois River by 20 percent.

2) Reduce the amount of phosphorus and nitrogen loadings to the Illinois River by 10 percent.

To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) developed a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation. Progress made so far in each of these efforts is presented in this report.

Acknowledgments

The work upon which this progress report is based is supported by funds provided by the Office of Resource Conservation, Illinois Department of Natural Resources, under the guidance of Mike Chandler, IDNR CREP Program Director whose support and guidance is greatly appreciated. The project is also supported as part of the authors' regular duties at the Illinois State Water Survey under the guidance of Principal Investigators Laura Keefer and Mike Demissie, Illinois State Water Survey.

Several Illinois State Water Survey staff participated and contributed towards the successful accomplishment of project objectives. Kip Stevenson is responsible for the current data collection and compilation. Laura Keefer was responsible for analysis of the land use data

with assistance from Erin Bauer. Elias Getahun is responsible for the development of the new watershed models. Elias Getahun and Vern Knapp provided the analyses on variability and trends in precipitation and streamflow in the Illinois River basin. Momcilo Markus analyzed the Illinois Environmental Protection Agency nutrient data for analyses of long-term trends. Sangeetha Chandrasekaran and Elias Getahun analyzed the Benchmark Sediment Monitoring data for long-term trend analysis. Patti Hill prepared the report.

2. Monitoring and Data Collection

The monitoring and data collection component consist of a watershed monitoring program to monitor sediment and nutrient for selected watersheds within the Illinois River basin and also to collect and analyze land use data throughout the river basin. Historically, there are a limited number of sediment and nutrient monitoring stations within the Illinois River basin, and most of the available records are of short duration. For example, figure 2-1 shows all the active and inactive sediment monitoring stations within the Illinois River basin prior to the start of monitoring for CREP. Out of the 44 stations shown in the map, only 18 stations had records longer than 5 years and only 8 stations had more than 10 years of record. Therefore the available data and monitoring network was insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds.

To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to initiate a monitoring program that will collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Illinois River basin that will assist in making a more accurate assessment of sediment and nutrient delivery to the Illinois River.

Sediment and Nutrient Data

Five small watersheds located within the Spoon and Sangamon River watersheds were selected for intensively monitoring sediment and nutrient within the Illinois River basin. The locations of the watersheds and the monitoring stations are shown in figures 2-2 and 2-3 and information about the monitoring stations is provided in table 2-1. Court and North Creeks are located within the Spoon River watershed, while Panther and Cox Creeks are located within the Sangamon River watershed. The Spoon River watershed generates the highest sediment per unit area in the Illinois River basin, while the Sangamon River watershed is the largest tributary watershed to the Illinois River and delivers the largest total amount of sediment to the Illinois River. The type of data collected and the data collection methods have been presented in detail in the first progress report for the monitoring program (Demissie et al., 2001) and in the Quality Assurance Project Plan (QAPP) is available upon request. This report presents the data that have been collected and analyzed, when appropriate, at each of the monitoring stations.

Table 2-1. Sediment and Nutrient Monitoring Stations Established for the Illinois River CREP

Station ID	*Name*	*Drainage area*	*Watershed*
301	Court Creek	66.4 mi^2 (172 km^2)	Spoon River
302	North Creek	26.0 mi^2 (67.4 km^2)	Spoon River
303	Haw Creek	55.2 mi^2 (143 km^2)	Spoon River
201	Panther Creek	16.5 mi^2 (42.7 km^2)	Sangamon River
202	Cox Creek	12.0 mi^2 (31.1 km^2)	Sangamon River

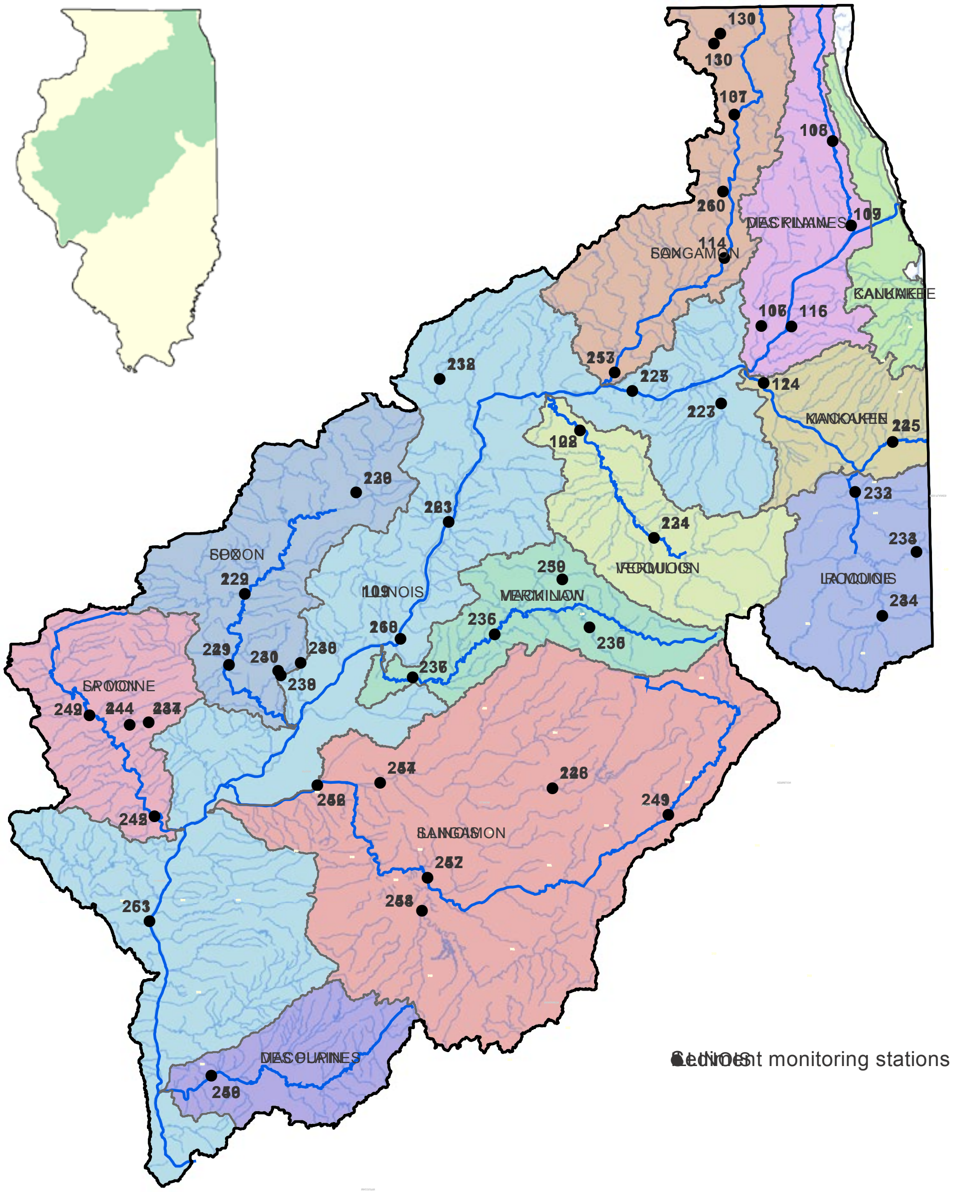


Figure 2-1. Locations of available in-stream sediment data within the Illinois River watershed, 1981-2000

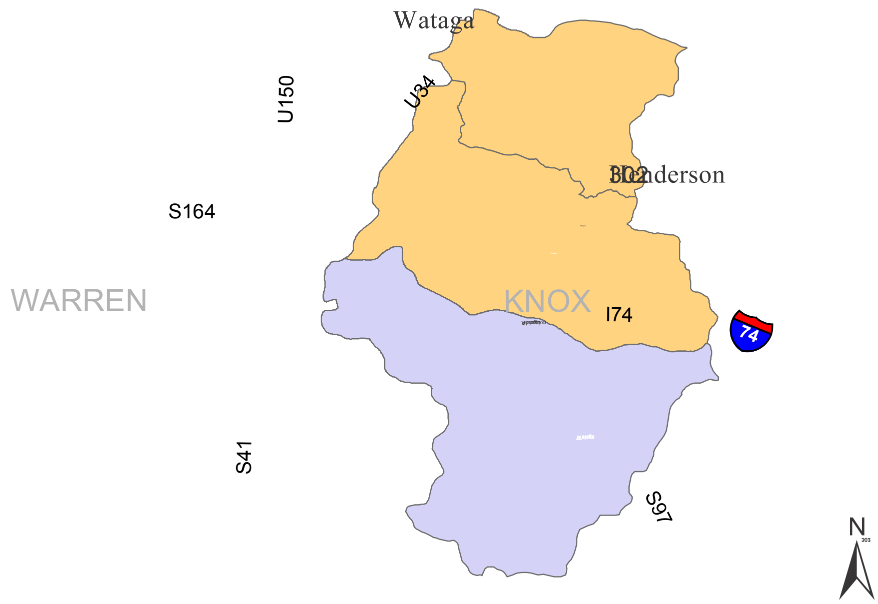


Figure 2-2. Location of monitoring stations in Court and Haw Creek watersheds

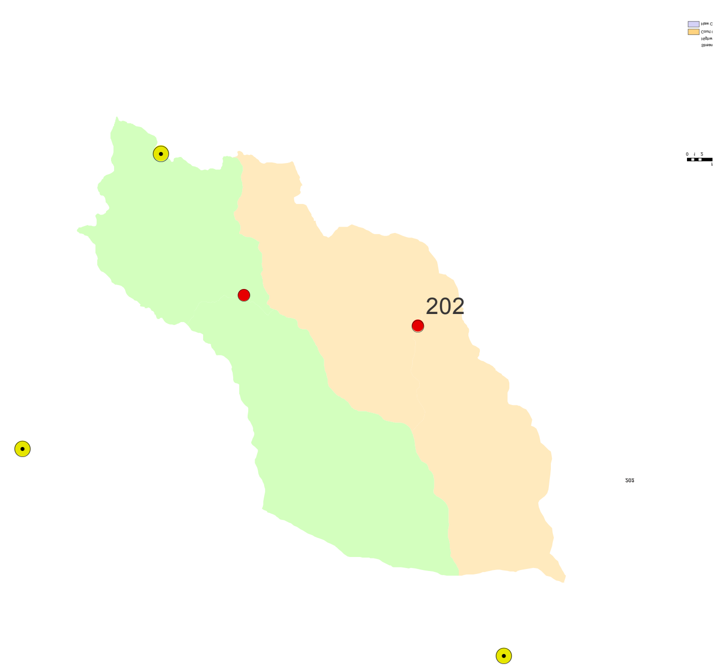


Figure 2-3. Location of monitoring stations in Panther and Cox Creek watersheds

Sediment Data

The daily streamflow and suspended sediment concentrations observed at all the five monitoring stations from Water Year 2000 to Water Year 2016 are available upon request. Examples of the frequency of data collection are shown in figure 2-4 for the Court Creek station. A summary of statistics for all stations showing the mean, medium, minimum maximum, 25th percentile, and 75th percentile are given in table 2-2. Over 34,488 samples have been collected and analyzed at the five monitoring stations since the monitoring program was initiated. As can be seen in the figures, suspended sediment concentrations are highly variable throughout a year and also from year to year depending on the climatic conditions. It is also evident that sediment concentrations are the highest during storm events resulting in the transport of most of the sediment during storm events. Therefore, it is extremely important that samples are collected frequently during storm events to accurately measure sediment loads at monitoring stations.

Nutrient Data

All the nutrient data collected and analyzed from Water Year 2000 through Water Year 2016 at the five monitoring stations are available upon request. The nutrient data are organized into two groups: nitrogen species and phosphorus species. The nitrogen species include nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonium-nitrogen (NH_4-N), and total Kjedahl nitrogen (TKN). The phosphorus species include total phosphorus (TP), total dissolved phosphorus (TDP), and orthophosphate (P-ortho). Over 6,215 samples have been collected and analyzed for nitrate (NO_3-N), ammonium (NH_4-N) and orthophosphate (P-ortho). In addition, more than 3,473 samples have been analyzed for nitrate (NO_2-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), and total dissolved phosphorus (TDP). Examples of the type of data collected for the nitrogen species are shown in figure 2-5, while those for the phosphorus species are shown in figure 2-6. A summary statistics for all stations showing the mean, median, minimum, maximum, 25th percentile, and 75th percentile are given in table 2-2.

Mean concentration data presented in table 2-2 for nitrogen species at all five monitoring stations show that nitrate-N is the dominant form of nitrogen with TKN as the next highest. During storm events, the concentration of nitrate-N and TKN both rise significantly, sometimes TKN exceeding the nitrate-N concentration. TKN is highly correlated to suspended sediment concentrations.

One significant observation that can be made from the data is the lower mean concentrations of nitrate-N at Court Creek and North Creek (Sangamon River tributaries) than at Haw Creek (Sangamon tributary), Panther Creek and Cox Creek (tributaries of the Spoon River).

Data for the phosphorus species at all five monitoring stations show that most of the phosphorus load is transported during storm events. Concentrations of total phosphorus are the highest during storm events and relatively low most of the time. This is very similar to that shown by sediment and thus implies high correlations between sediment and phosphorus concentrations and loads. In terms of phosphorus concentrations, it does not appear there is any significant difference between the different monitoring stations from the Spoon and Sangamon River watersheds.

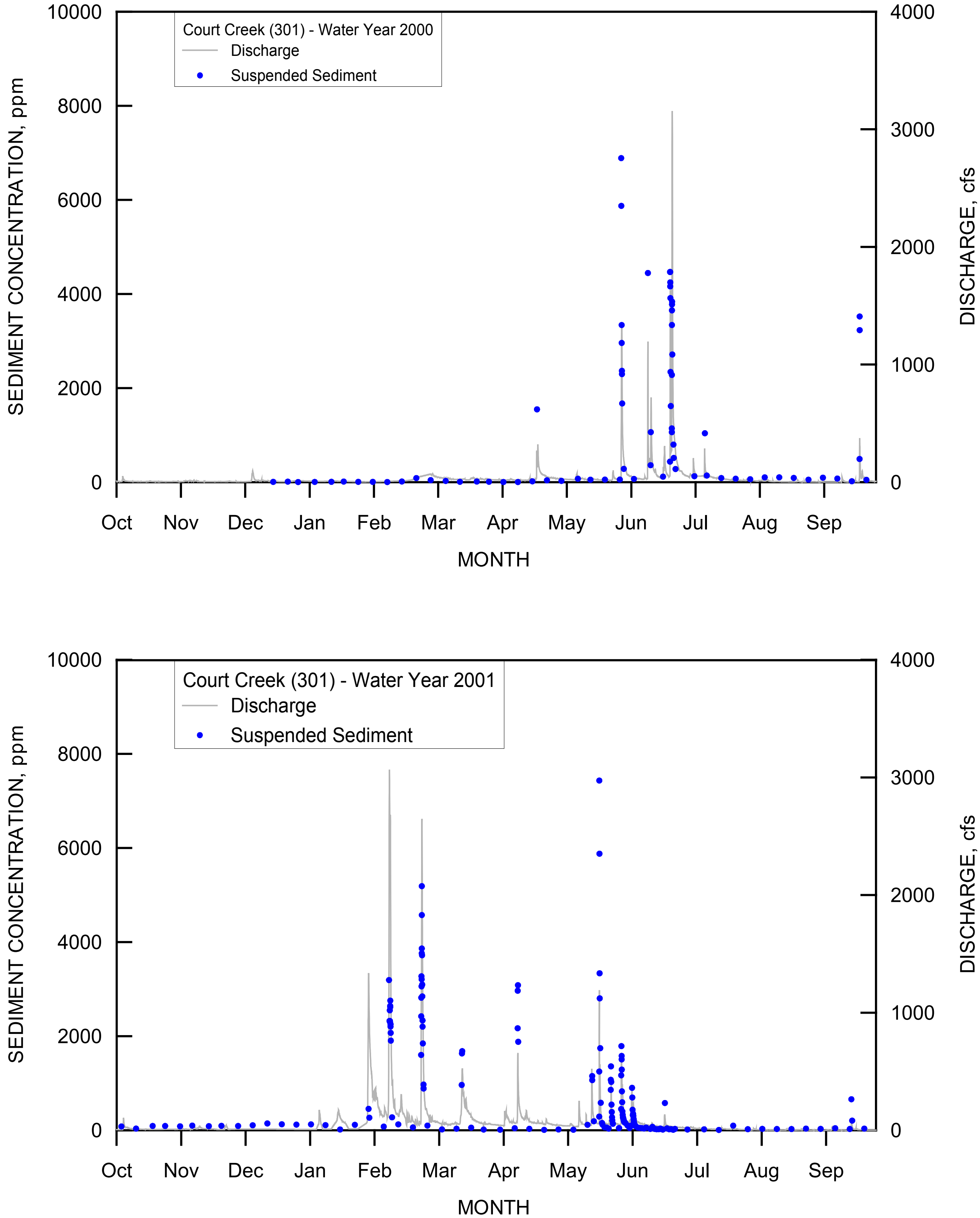
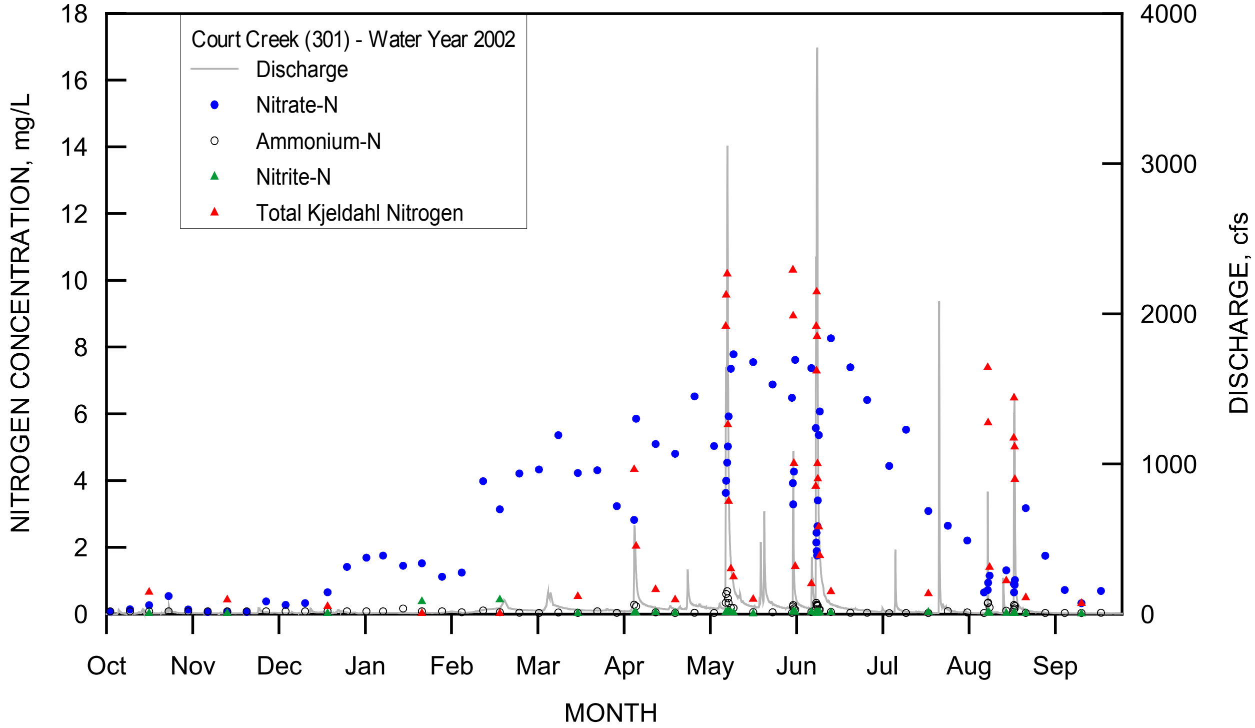


Figure 2-4. Suspended sediment concentrations and water discharge at Court Creek (301) for Water Years 2000 and 2001



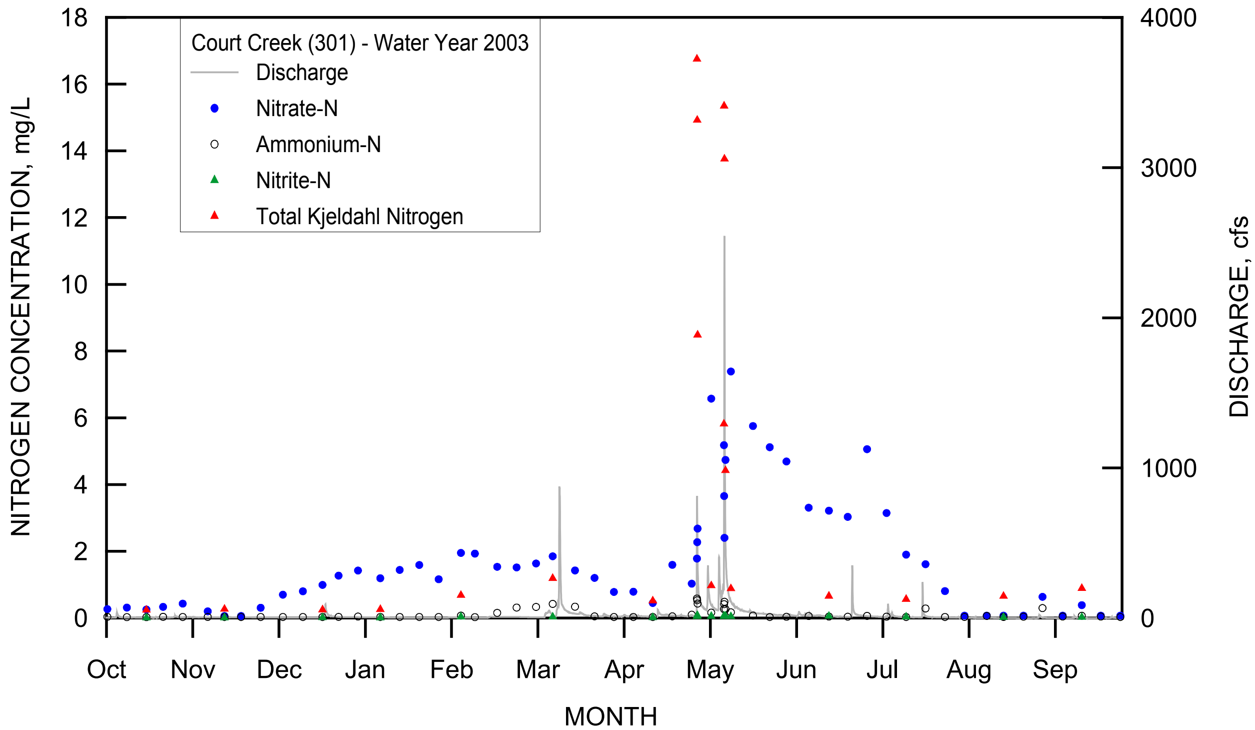


Figure 2-5. Concentrations of nitrogen species and water discharge at Court Creek (301) for Water Years 2002 and 2003

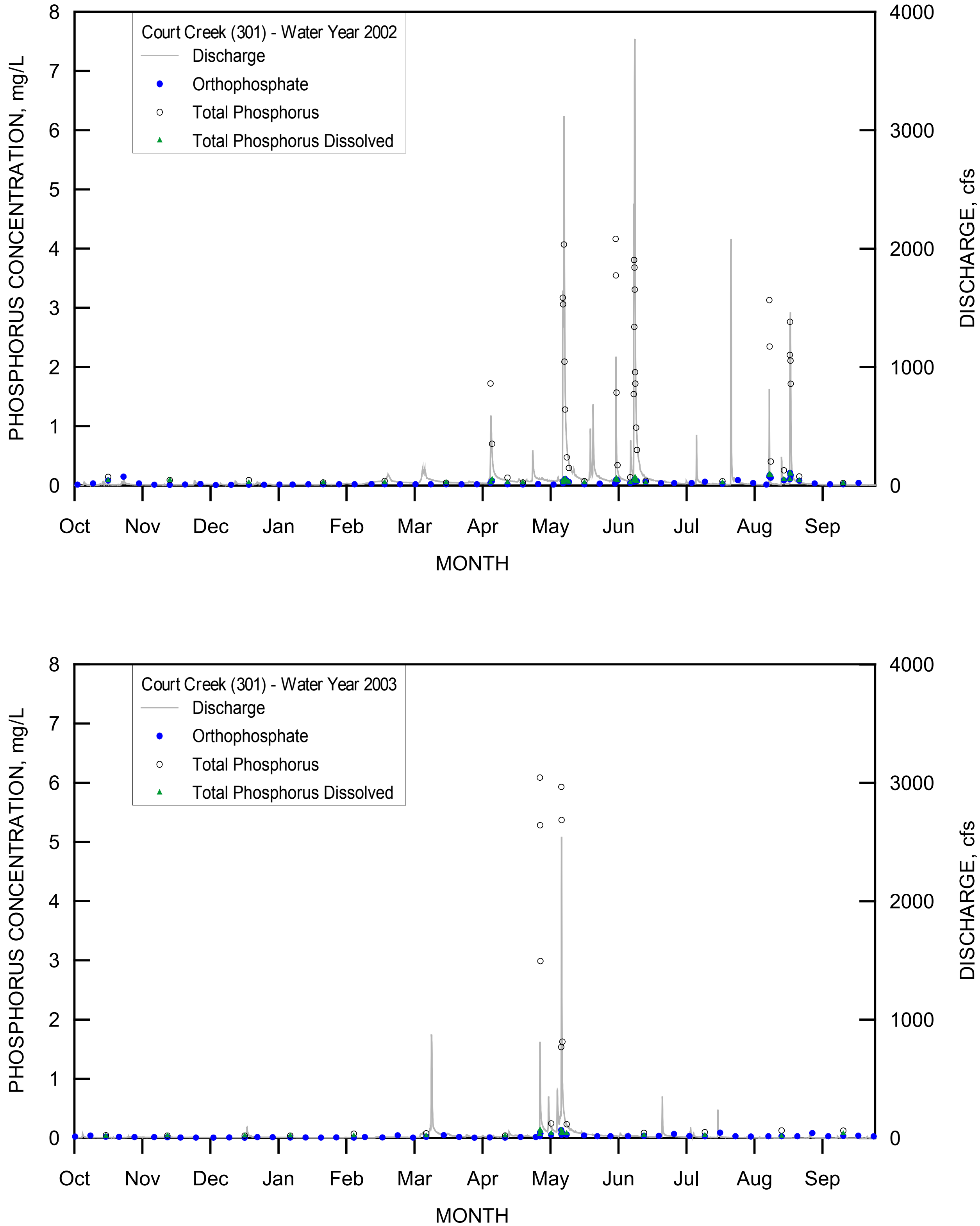


Figure 2-6. Concentrations of phosphorus species and water discharge at Court Creek (301) for Water Years 2002 and 2003

Table 2-2. Summary Statistics for Water Years 2000–2016. All concentrations in mg/L

	NO3-N	*NH4-N*	*NO2-N*	*TKN*	*t-P*	*t-P -Dissolved*	*oPO4*	*SSC*
Panther Creek (Station 201)								
Count	1119	1119	555	554	554	554	1119	6744
Mean	3.78	0.09	0.03	2.37	1.02	0.17	0.12	901.0
Median	3.09	0.06	0.02	1.02	0.35	0.13	0.08	134.5
Min	< 0.04	< 0.03	< 0.01	< 0.12	< 0.03	< 0.03	< 0.01	1.47
Max	14.76	5.99	0.21	23.99	11.21	1.38	1.31	48289.0
25th Percentile	0.28	< 0.03	0.01	0.46	0.13	0.08	0.05	62.1
75th Percentile	6.17	0.08	0.04	2.88	1.23	0.20	0.14	468.8
Cox Creek (Station 202)								
Count	1127	1127	559	559	559	559	1127	6105
Mean	5.58	0.35	0.05	2.65	1.03	0.28	0.20	673.2
Median	5.29	0.07	0.04	1.44	0.44	0.17	0.11	153.9
Min	< 0.04	< 0.03	< 0.006	< 0.14	< 0.04	< 0.03	< 0.01	0.95
Max	19.83	17.87	1.26	19.33	7.90	5.97	6.50	23010.8
25th Percentile	0.92	0.05	0.02	0.60	0.17	0.09	0.06	81.3
75th Percentile	8.96	0.19	0.06	3.37	1.23	0.34	0.22	382.7
Court Creek (Station 301)								
Count	1324	1324	789	788	788	788	1324	6697
Mean	2.94	0.14	0.04	2.49	0.85	0.12	0.08	617.3
Median	2.78	0.07	0.03	1.40	0.39	0.09	0.05	111.3
Min	< 0.04	< 0.03	< 0.01	0.23	0.03	< 0.03	< 0.003	1.93
Max	11.37	1.73	0.13	18.69	6.58	0.97	0.93	13632.0
25th Percentile	0.93	0.04	0.02	0.67	0.13	0.06	0.03	47.9
75th Percentile	4.53	0.16	0.05	3.28	1.13	0.13	0.09	489.3
North Creek (Station 302)								
Count	1307	1307	771	771	771	771	1307	7518
Mean	2.95	0.14	0.04	2.29	0.78	0.13	0.08	492.3
Median	2.73	0.07	0.03	1.20	0.32	0.09	0.05	101.7
Min	< 0.04	< 0.03	< 0.01	0.23	< 0.04	< 0.03	< 0.003	0.36
Max	12.66	2.43	0.19	19.80	7.05	1.07	1.05	15137.1
25th Percentile	0.73	0.04	< 0.02	0.64	0.11	0.06	0.02	45.4
75th Percentile	4.65	0.15	0.05	2.64	0.90	0.14	0.09	289.7
Haw Creek (Station 303)								
Count	1338	1338	799	799	799	799	1338	7424
Mean	4.32	0.13	0.05	2.39	0.81	0.13	0.09	578.8
Median	4.17	0.06	0.04	1.52	0.46	0.09	0.06	173.6
Min	< 0.04	< 0.03	< 0.006	0.23	< 0.04	< 0.03	< 0.003	2.17
Max	12.59	1.49	0.21	17.15	7.27	1.41	1.38	12586.1
25th Percentile	1.85	0.04	0.03	0.68	0.16	0.06	0.04	58.1
75th Percentile	6.47	0.14	0.06	3.20	1.12	0.13	0.10	630.2

Sediment and Nutrient Loads

The sediment and nutrient concentrations and water discharges are used to compute the amount of sediment and nutrient transported past monitoring stations. Based on the available flow and concentration data, daily loads are computed for sediment and the different species of nitrogen and phosphorus. The daily loads are then compiled to compute monthly and annual loads. Results of those calculations are summarized in tables 2-3 to 2-7 for each of the five monitoring stations. Each table presents the annual water discharge, sediment load, nitrate-N load, TKN, and the total phosphorus load for one of the stations. Similar calculations have been made for the other species of nitrogen and phosphorus, but are not included in the summary tables. The nitrate-N loads ranged from a low of 1.8 tons in 2012 at Cox Creek to a high of 585 tons in WY2010 at Haw Creek. The TKN loads ranged from a low of 0.5 tons in WY2012 at Panther Creek to a high of 322.5 tons in WY2010 at Court Creek. The total phosphorus loads ranged from a low of 0.2 tons in 2012 at Cox Creek and Panther Creek to a high of 117.6 tons in 2010 at Court Creek. For comparison purposes, annual runoff and annual sediment, nitrate-N, -N, ammonium-N, TKN-N, Total phosphorus, total dissolved phosphorus, and ortho-phosphate phosphorus loads (for the five monitoring stations) are shown in figures 2-7 to 2-14. In terms of the total annual loads, the larger watersheds, Court and Haw, consistently carry higher sediment and nutrient loads than Panther and Cox Creeks. However, as discussed in the next section, per unit area Panther and Cox generate more sediment than Court, North, and Haw Creeks.

Table 2-3. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Court Creek Monitoring Station (301)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	11880	26527	131.2	89.1	35.0
2001	22100	43633	274.8	121.4	39.2
2002	17320	62898	203.7	131.9	47.9
2003	6805	21749	59.9	56.9	18.3
2004	7459	7359	76.0	26.1	7.5
2005	14400	18831	207.5	58.1	20.4
2006	5650	7897	84.3	23.2	6.5
2007	19376	48974	240.8	140.1	46.8
2008	22442	41077	265.4	131.4	45.6
2009	41207	174742	429.6	318.9	116.9
2010	44836	146202	425.9	322.5	117.6
2011	23311	55337	270.9	125.2	43.3
2012	6129	4145	36.7	18.0	4.8
2013	26158	116616	270.8	250.4	94.9
2014	14338	25407	59.9	88.9	30.4
2015	14834	24740	112.3	76.9	26.3
2016	23683	59831	248.3	102.2	33.3

Table 2-4. Summary of Annual Water Discharges, Sediment and Nutrient Loads at North Creek Monitoring Station (302)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	4009	6969	42.8	28.2	10.4
2001	8091	16747	102.9	39.4	12.7
2002	7372	29269	97.8	66.4	24.2
2003	3039	11422	32.9	26.0	9.1
2004	3224	2038	37.7	10.0	2.4
2005	5266	6061	76.3	22.8	7.7
2006	2151	4179	36.2	11.3	3.4
2007	7524	16702	99.3	43.6	14.3
2008	9416	19762	119.0	58.7	21.0
2009	16544	62806	167.9	126.4	45.2
2010	18577	66501	167.4	143.6	52.7
2011	9491	25979	105.4	69.7	25.2
2012	2506	2207	14.9	7.6	2.0
2013	12624	60934	121.1	117.2	44.9
2014	5374	9176	19.4	36.1	12.1
2015	5525	8399	41.9	25.2	8.2
2016	9751	22512	103.9	36.6	10.9

Table 2-5. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Haw Creek Monitoring Station (303)

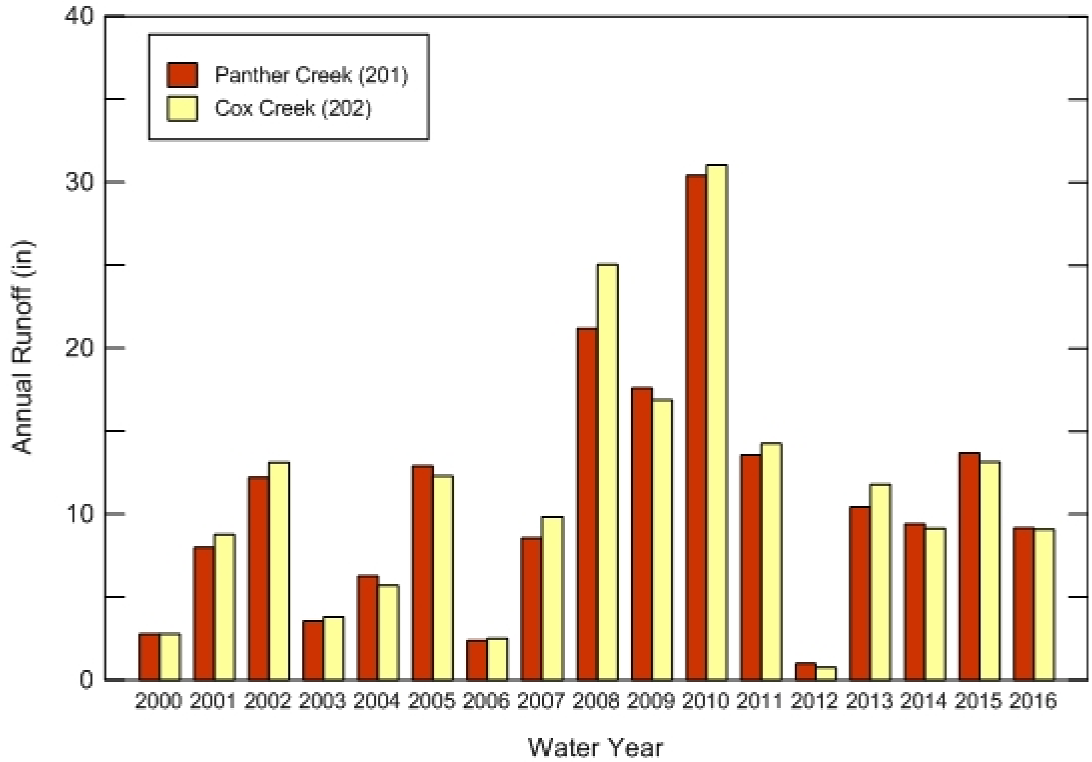
		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	11433	21283	162.2	85.2	32.0
2001	19878	49580	322.0	146.9	58.0
2002	15603	44221	256.5	119.5	42.8
2003	4337	5908	41.7	27.0	8.3
2004	8676	10914	143.4	38.8	12.6
2005	14661	18047	281.4	51.1	18.5
2006	5341	5770	113.7	20.1	6.0
2007	15032	20127	262.5	76.1	23.9
2008	14054	16396	227.0	69.5	25.5
2009	34003	104081	506.4	260.4	85.9
2010	40230	92974	585.2	236.2	85.4
2011	20788	37379	372.5	103.9	34.3
2012	5326	2185	55.1	13.5	3.3
2013	23581	75175	357.8	205.0	74.1
2014	14640	24149	115.3	86.9	29.8
2015	21718	49921	229.0	135.2	50.0
2016	17564	26363	249.9	63.6	19.0

Table 2-6. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Panther Creek Monitoring Station (201)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	1236	4342	13.8	10.0	4.4
2001	3550	9839	84.9	11.0	5.1
2002	5440	34596	101.8	43.8	16.4
2003	1578	2955	26.4	5.0	1.8
2004	2787	7820	52.5	13.0	5.8
2005	5743	13793	112.2	21.6	10.2
2006	1053	2694	22.5	6.2	2.5
2007	3809	13410	75.4	22.1	10.6
2008	9437	83924	123.1	100.6	46.7
2009	7833	30921	117.7	31.5	13.9
2010	13539	56979	124.8	57.0	25.7
2011	6033	16786	72.8	26.7	9.9
2012	437	105	2.5	0.5	0.2
2013	4637	12309	123.9	16.8	6.0
2014	4184	21806	26.2	25.5	11.0
2015	6086	29908	78.1	27.8	12.3
2016	4078	19142	50.8	16.8	6.3

Table 2-7. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Cox Creek Monitoring Station (202)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	894	4153	10.3	12.4	5.7
2001	2833	9626	77.9	13.0	5.5
2002	4242	23207	100.6	44.6	16.1
2003	1226	1827	29.6	4.9	1.7
2004	1844	4597	45.3	8.7	3.7
2005	3976	8132	109.0	19.0	8.8
2006	806	3662	19.3	3.9	1.6
2007	3181	10105	81.5	17.5	7.2
2008	8097	73678	154.7	79.3	31.4
2009	5459	16331	135.9	21.9	8.6
2010	10040	27283	155.9	41.0	17.5
2011	4607	14021	91.5	29.7	9.6
2012	246	149	1.8	0.7	0.2
2013	3810	9906	149.7	13.9	5.2
2014	2955	13759	25.3	19.1	8.7
2015	4253	15156	97.7	16.8	6.9
2016	2935	9908	61.8	9.4	3.3



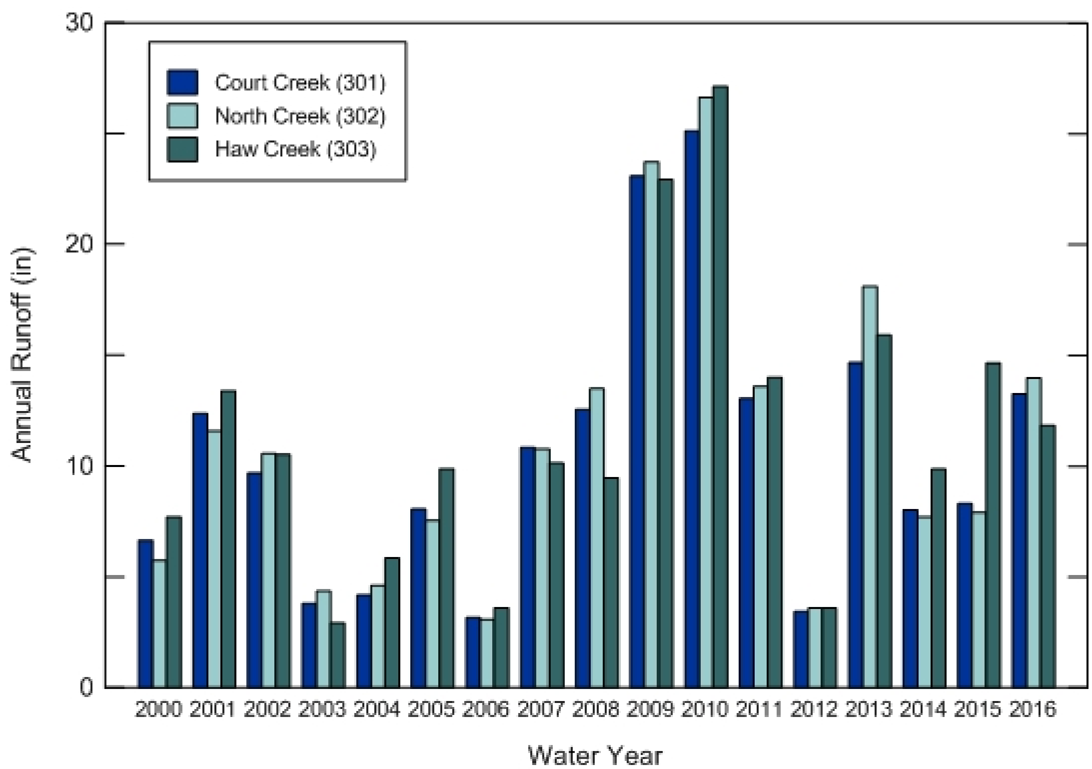


Figure 2-7. Annual runoff at the five CREP monitoring stations

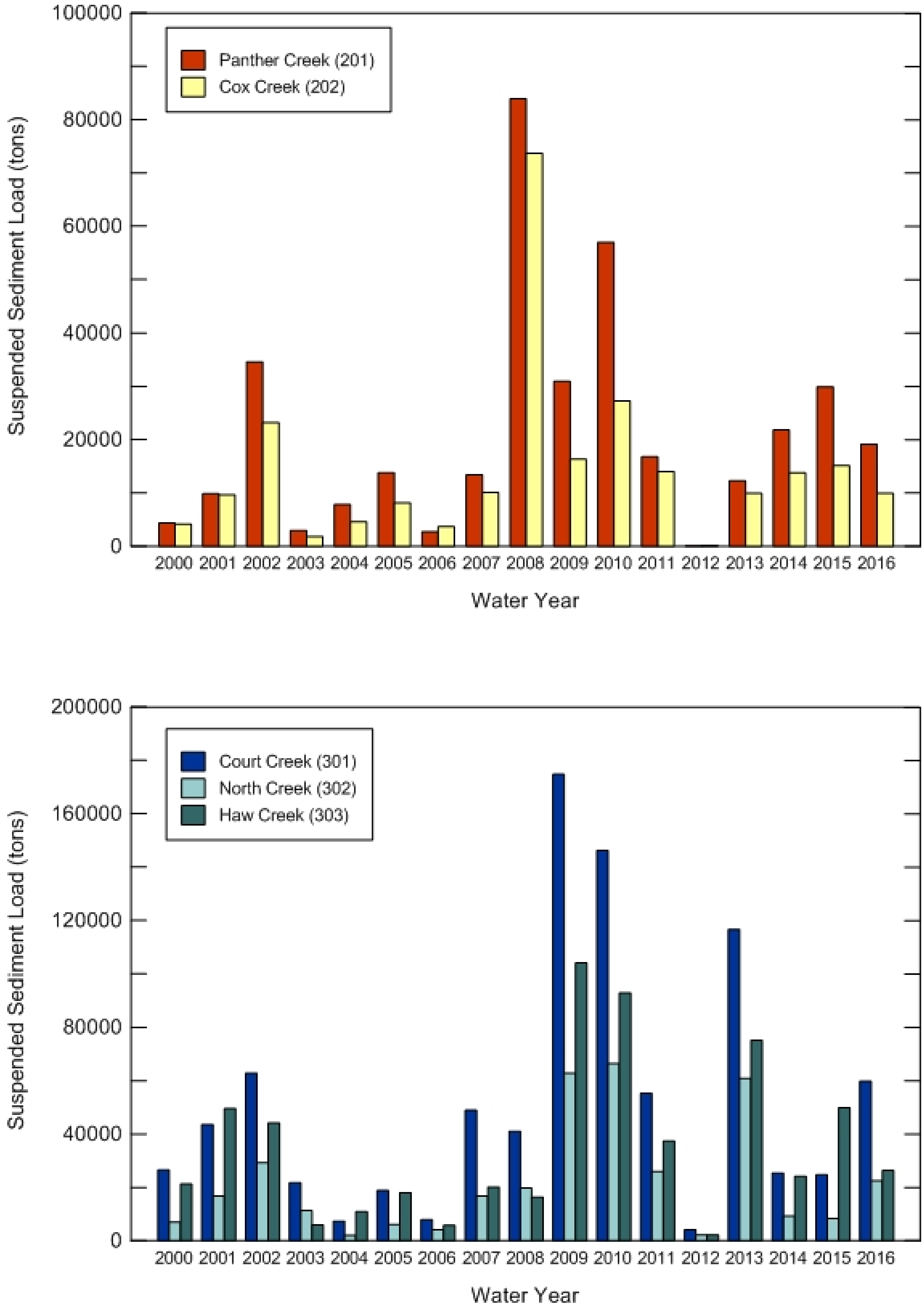
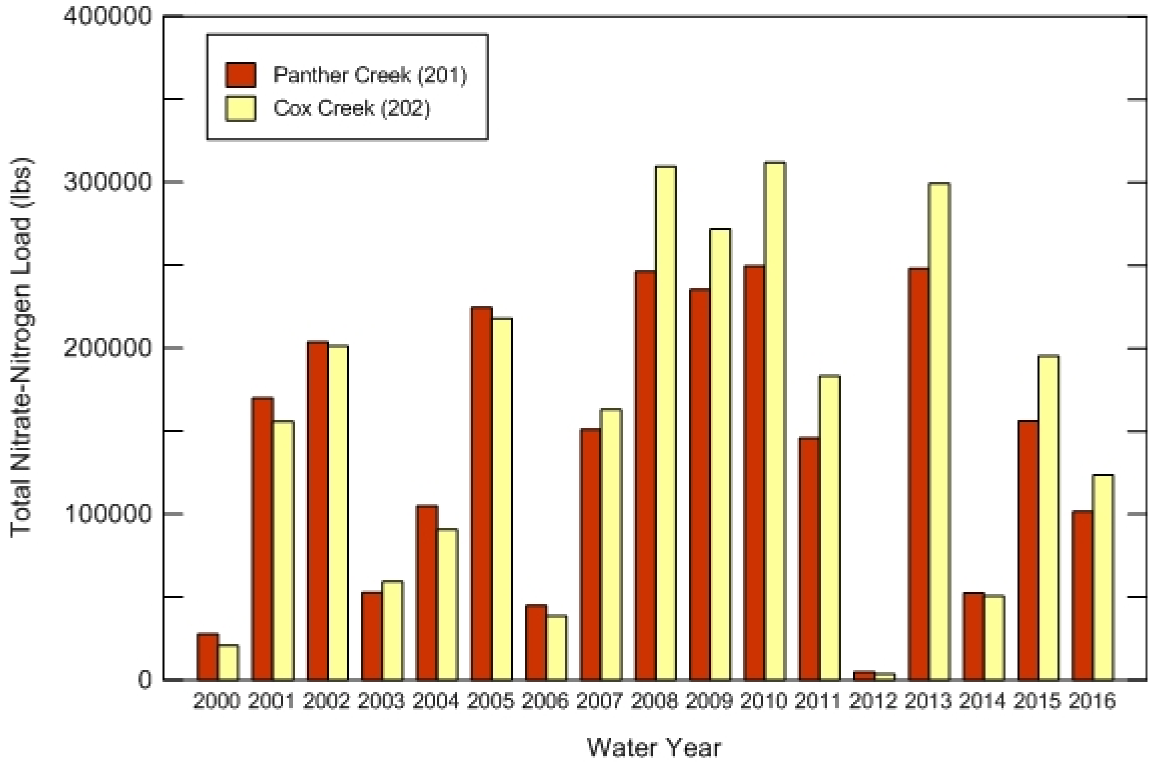


Figure 2-8. Annual suspended sediment loads at the five CREP monitoring stations



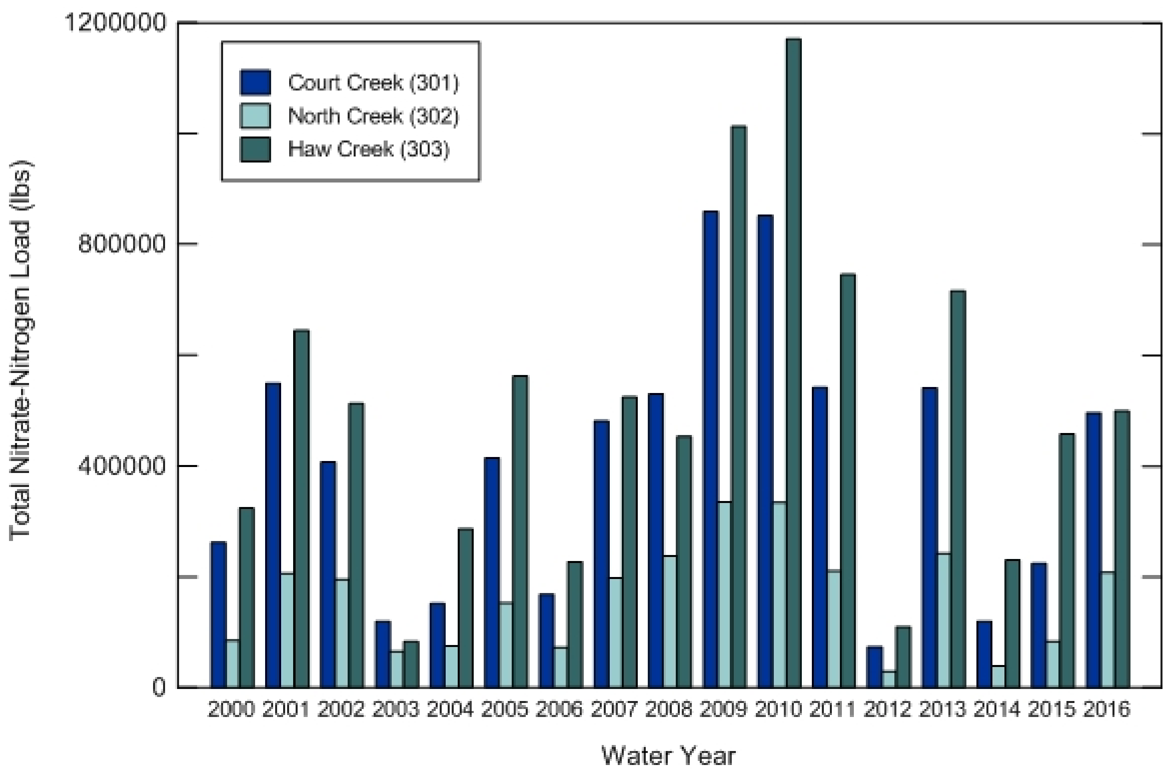


Figure 2-9. Annual nitrate-N loads at the five CREP monitoring stations

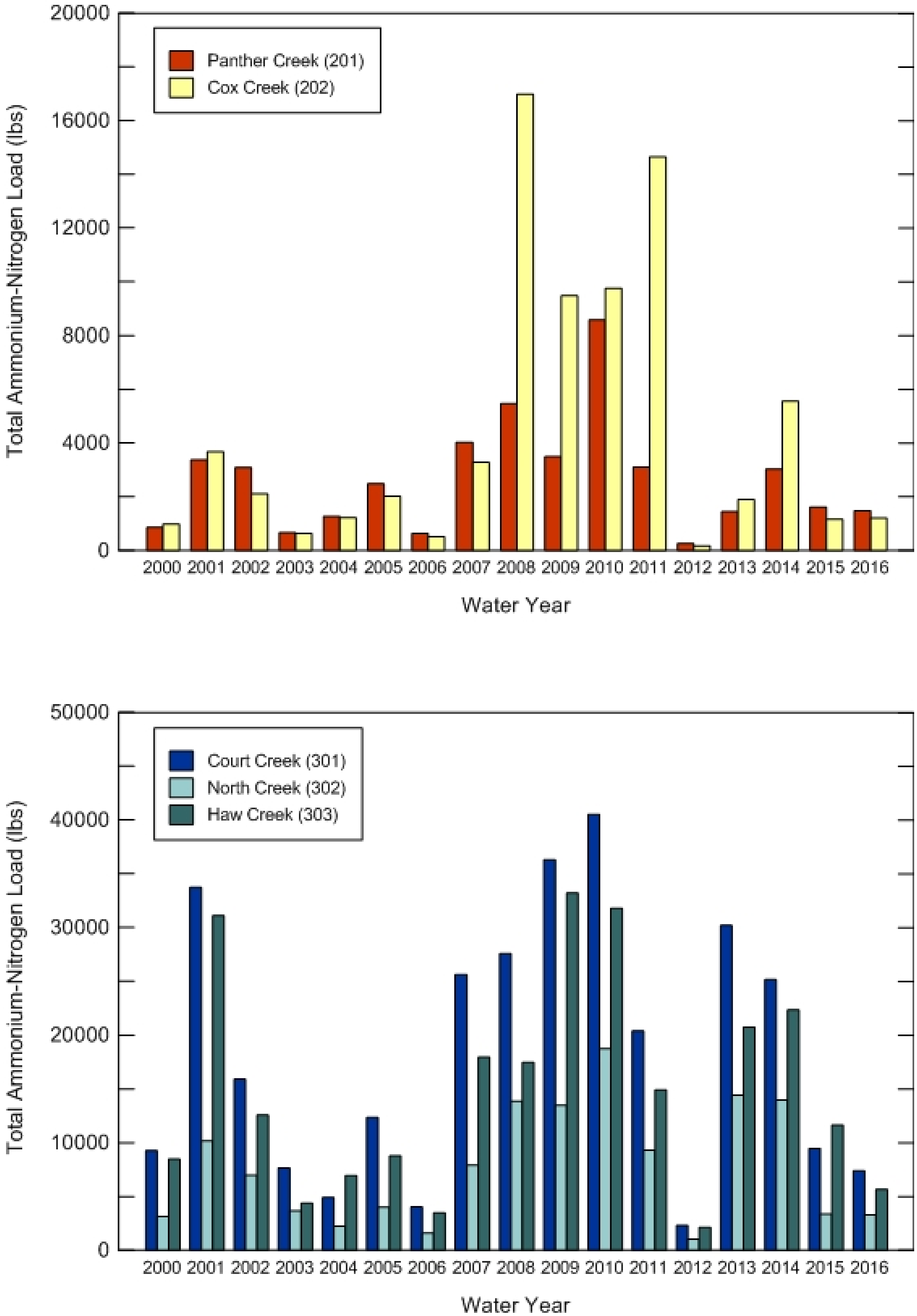
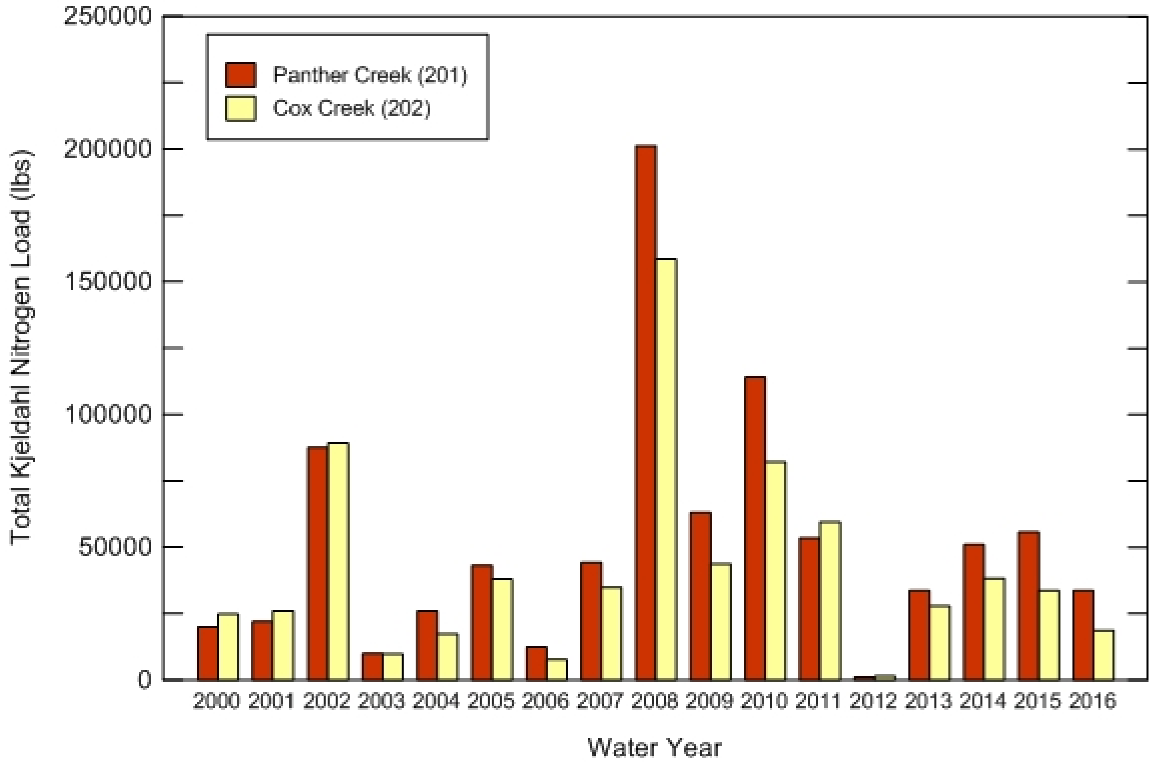


Figure 2-10. Annual ammonium-N loads at the five CREP monitoring stations



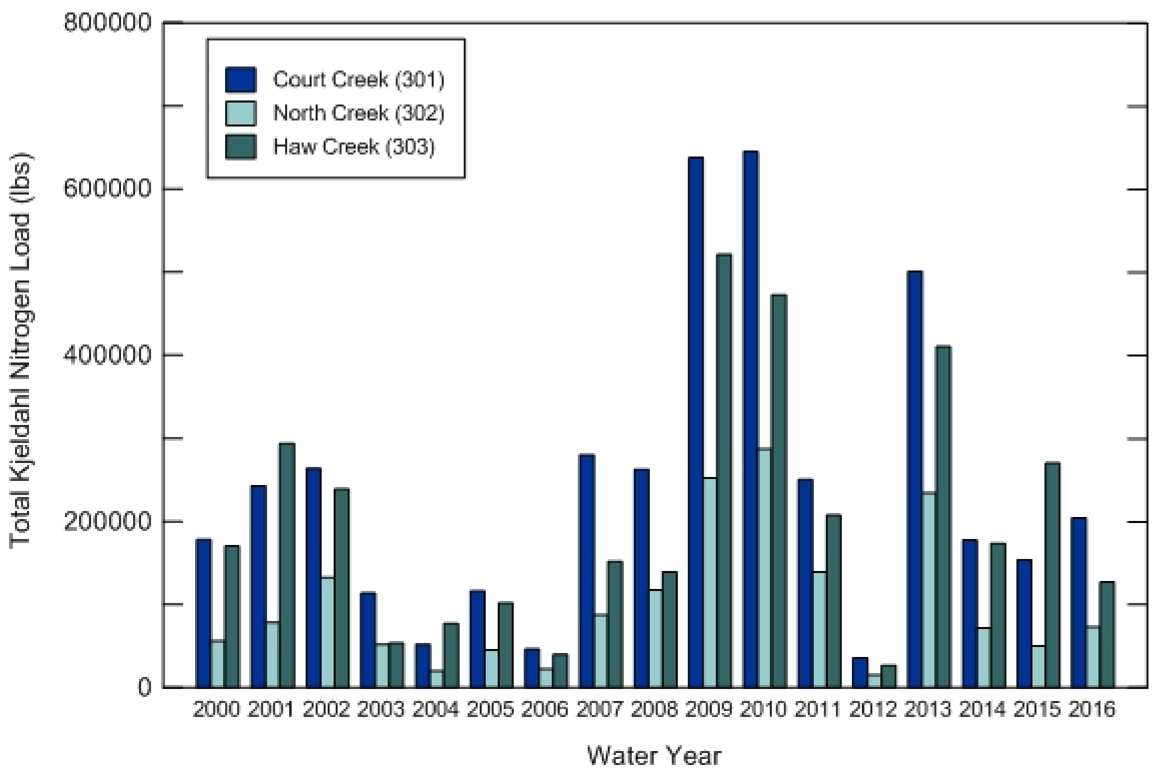


Figure 2-11. Annual Kjeldahl nitrogen loads at the five CREP monitoring stations

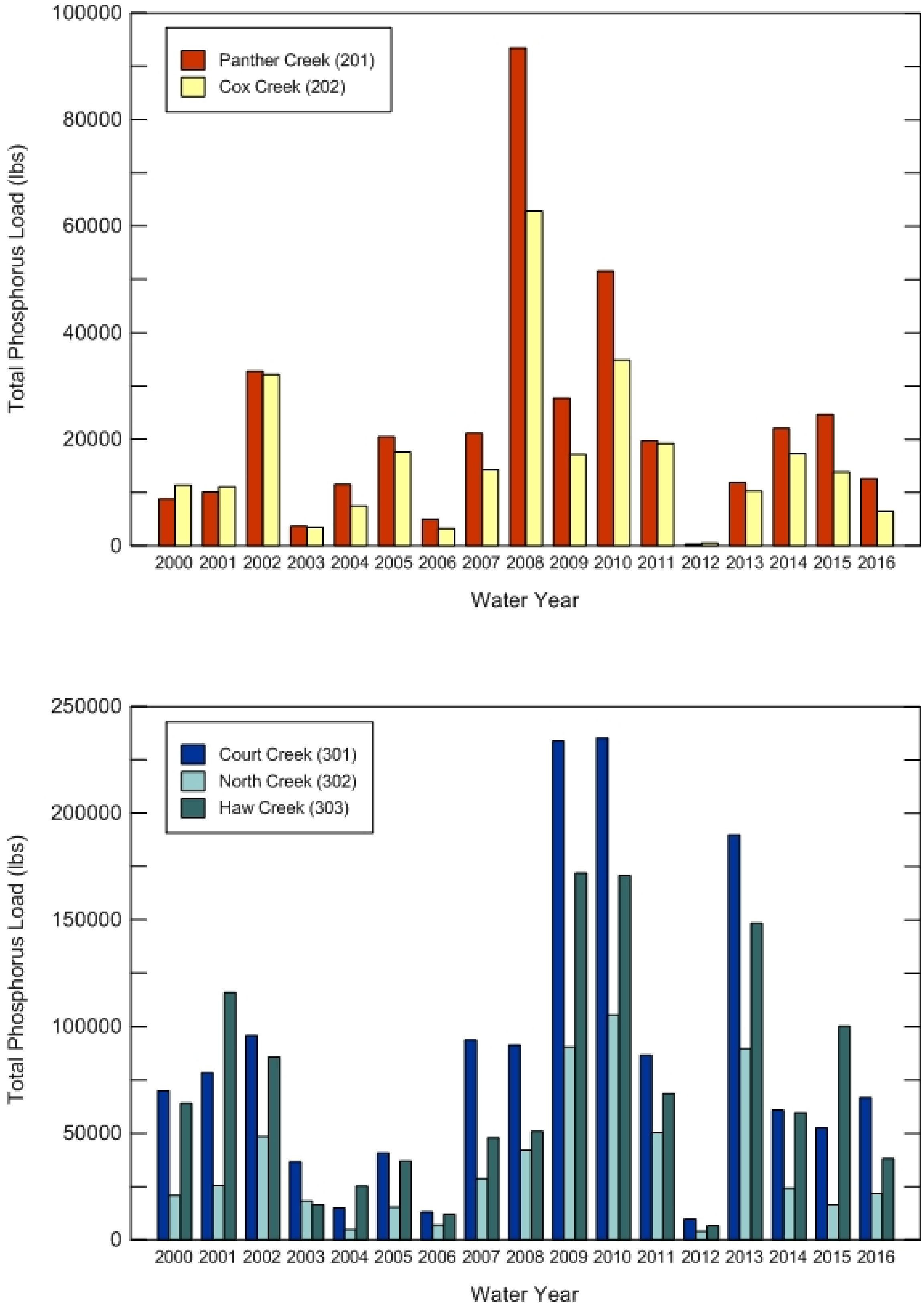
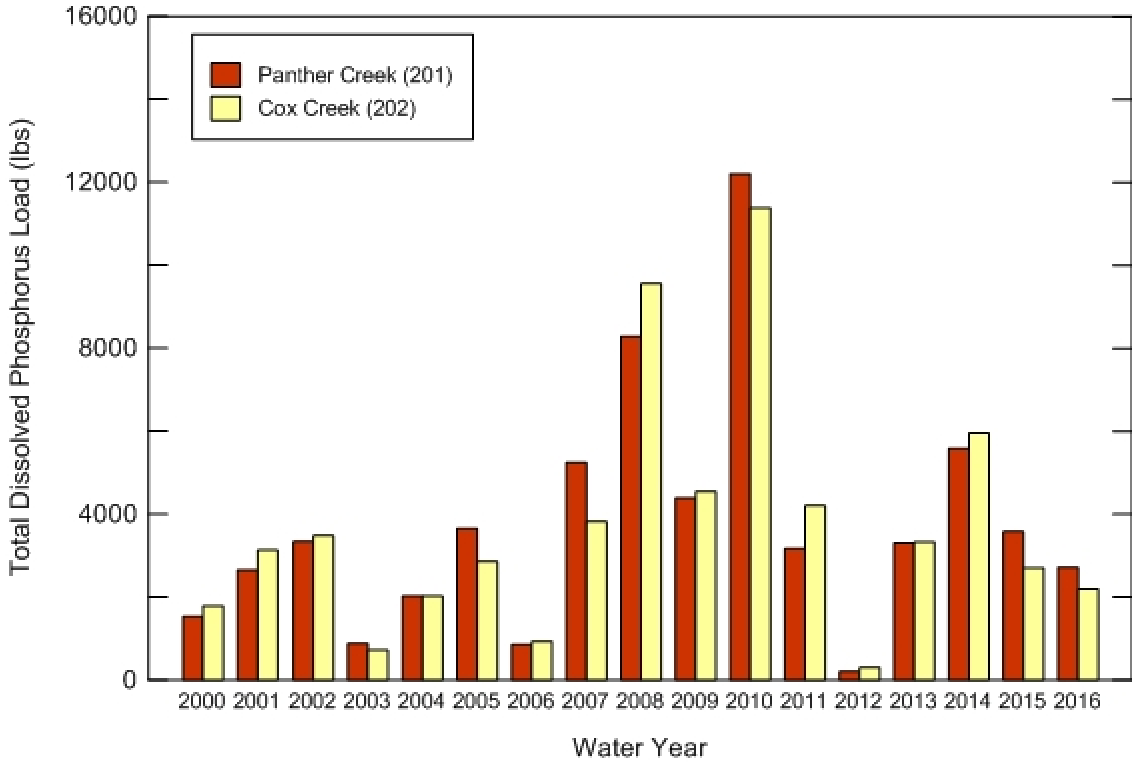


Figure 2-12. Annual phosphorus loads at the five CREP monitoring stations



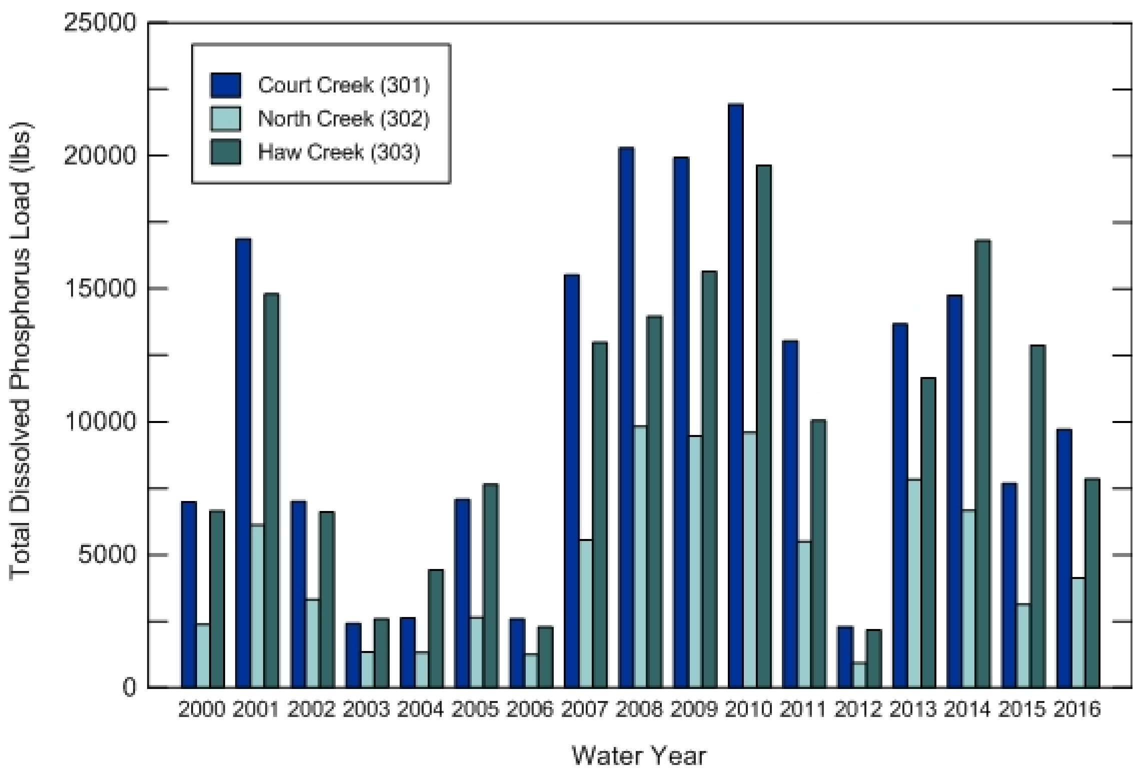
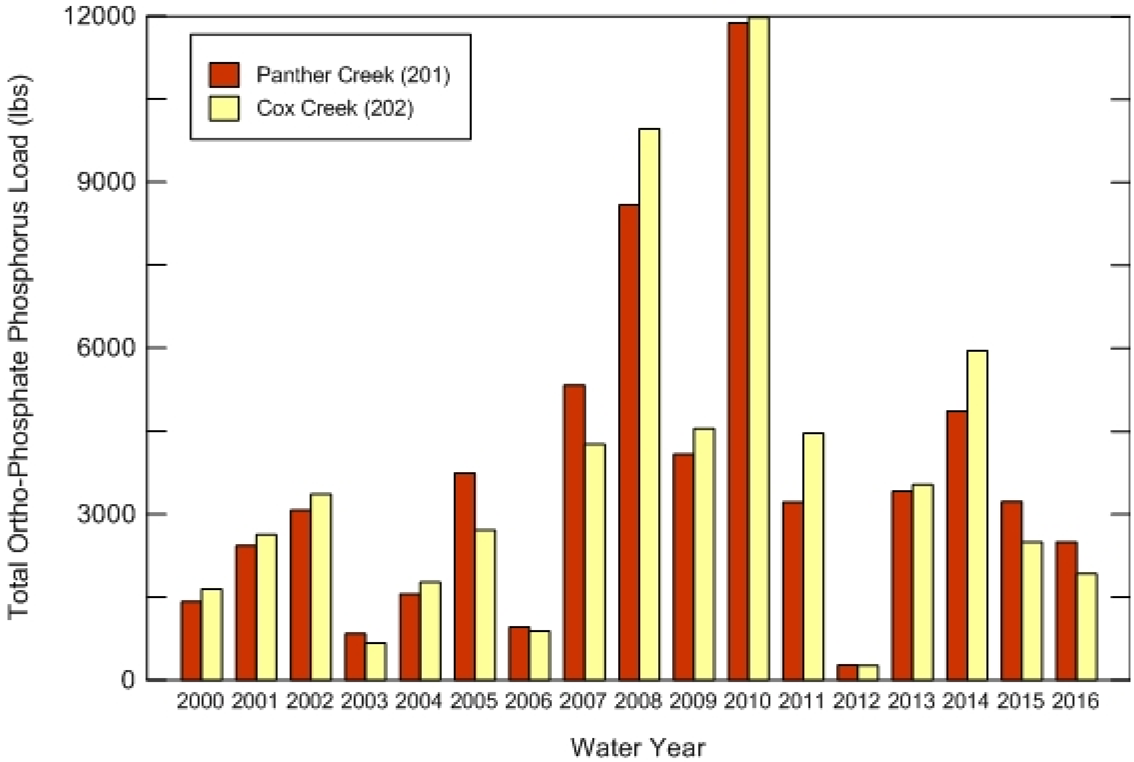


Figure 2-13. Annual dissolved phosphorus loads at the five CREP monitoring stations



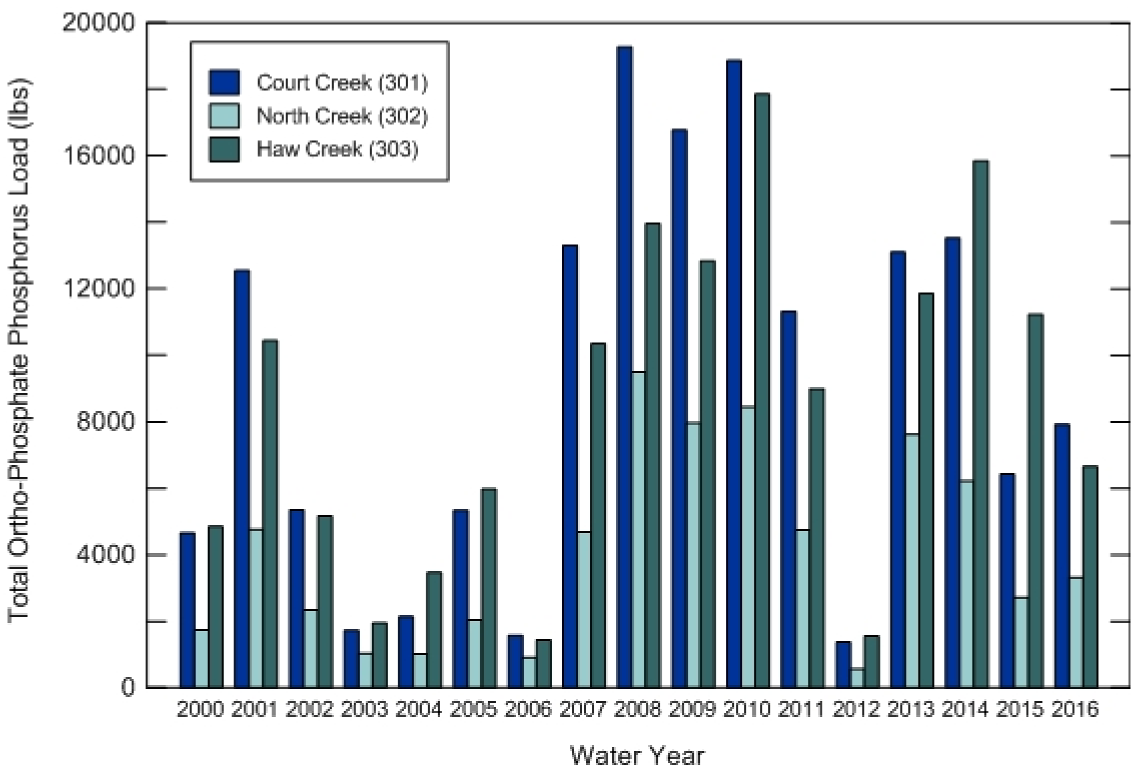


Figure 2-14. Annual ortho-phosphate phosphorus loads at the five CREP monitoring stations

Sediment and Nutrient Yields

To compare the different watersheds in terms of the amount of sediment and nutrient generated per unit area from each of the watersheds, the annual sediment and nutrient yields were computed by dividing the total annual load with the drainage area in acres for each of the monitoring stations. Yield results are provided in tables 2-8 through 2-11 for sediment, nitrate-N, total phosphorus and TKN, respectively. Sediment yields range from a low of 0.01 tons/acre for station 201 (Panther) in WY2012 to a high of 9.57 tons/acre for station 202 (Cox) in WY2008. Because of the high level of variability from year to year the average sediment yield for the 17 years of data collection are compared in figure 2-15. The stations are arranged in order of their drainage area, with the station with the smallest drainage area (202) on the left and the station with the largest area (301) on the right. As can be seen in the figure, on the average the stations with the smaller drainage areas (202 and 201) yield higher sediment (about 2.0 ton/acre) than the stations with the larger areas (302, 303, 301) that yield less than 1.5 tons/acre.

Nitrate-N yields vary from a low of 0.5 lbs/acre for stations 201 and 202 in WY2012 to a high of 40.2 lbs/acre for station 202 in WY2010. For comparison purposes the average annual nitrate-N yield for the five stations is shown in figure 2-16. In general four of the stations have similar average annual yields with the smallest watershed generating more nitrate per unit area

Total phosphorus yields vary from a low of 0.03 lbs/acre for station 201 in WY2012 to a high of 8.81 lbs/acre for station 201 in WY2008. For comparison purposes, the average annual total phosphorus yield for the five stations is shown in figure 2-17. There appears to be little differene between the stations.

Total Kjedahl Nitrogen (TKN) yields vary from a low of 0.1 lbs/acre for station 201 in WY2012 to a high of 20.6 lbs/acre for station 202 in WY2008. For comparison purposes, the average annual TKN yield for the five stations is shown in figure 2-18. Yields for the stations with small drainage areas are only slightly less than those for the larger.

It is apparent that the 2012 drought had a significant impact on the lowest loads and yields at all stations.

Table 2-8. Sediment Yield in tons/acre for the CREP Monitoring Stations

	CREP sediment yield (tons/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	0.41	0.54	0.62	0.42	0.60
2001	0.93	1.25	1.03	1.01	1.40
2002	3.26	3.01	1.48	1.76	1.25
2003	0.28	0.24	0.51	0.69	0.17
2004	0.74	0.60	0.17	0.12	0.31
2005	1.30	1.06	0.44	0.37	0.51
2006	0.25	0.48	0.19	0.25	0.16
2007	1.27	1.31	1.15	1.01	0.57
2008	7.92	9.57	0.97	1.19	0.46
2009	2.92	2.12	4.11	3.78	2.95
2010	5.38	3.54	3.44	4.01	2.63
2011	1.58	1.82	1.3	1.57	1.06
2012	0.01	0.02	0.10	0.13	0.06
2013	1.16	1.29	2.74	3.67	2.13
2014	2.06	1.79	0.60	0.55	0.68
2015	2.82	1.97	0.58	0.51	1.41
2016	1.81	1.29	1.41	1.36	0.75

Table 2-9. Nitrate-N Yield in lbs/acre for the CREP Monitoring Stations

	CREP nitrate-nitrogen yield (lbs/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	2.6	2.7	6.2	5.2	9.2
2001	16.0	20.2	12.9	12.4	18.2
2002	19.2	26.1	9.6	11.8	14.5
2003	5.0	7.7	2.8	4.0	2.4
2004	9.9	11.8	3.6	4.5	8.1
2005	21.2	28.3	9.8	9.2	15.9
2006	4.2	5.0	4.0	4.4	6.4
2007	14.2	21.2	11.3	12.0	14.9
2008	23.2	40.2	12.5	14.3	12.9
2009	22.2	35.3	20.2	20.2	28.7
2010	23.6	40.5	20.0	20.2	33.2
2011	13.7	23.8	12.8	12.7	21.1
2012	0.5	0.5	1.7	1.8	3.1
2013	23.4	38.9	12.7	14.6	20.3
2014	5.0	6.6	2.8	2.3	6.5
2015	14.7	25.4	5.3	5.1	13.0
2016	9.6	16.0	11.7	12.5	14.2

Table 2-10. Total Phosphorus Yield in lbs/acre for the CREP Monitoring Stations

CREP total phosphorus yield (lbs/ac)					
Water Year	*201*	*202*	*301*	*302*	*303*
2000	0.83	1.48	1.65	1.25	1.81
2001	0.95	1.44	1.84	1.53	3.28
2002	3.09	4.17	2.25	2.92	2.43
2003	0.34	0.45	0.86	1.10	0.47
2004	1.09	0.97	0.35	0.29	0.72
2005	1.93	2.28	0.96	0.92	1.05
2006	0.47	0.42	0.31	0.41	0.34
2007	2.00	1.86	2.20	1.72	1.35
2008	8.81	8.16	2.15	2.53	1.44
2009	2.62	2.23	5.50	5.45	4.87
2010	4.86	4.53	5.54	6.35	4.84
2011	1.86	2.50	2.04	3.03	1.94
2012	0.03	0.06	0.23	0.24	0.19
2013	1.13	1.34	4.46	5.40	4.20
2014	2.08	2.25	1.43	1.45	1.69
2015	2.32	1.80	1.24	0.99	2.83
2016	1.19	0.84	1.57	1.31	1.08

Table 2-11. Total Kjeldahl Nitrogen Yield in lbs/acre for the CREP Monitoring Stations

CREP total Kjeldahl Nitrogen yield (lbs/ac)					
Water Year	*201*	*202*	*301*	*302*	*303*
2000	1.9	3.2	4.2	3.4	4.8
2001	2.1	3.4	5.7	4.7	8.3
2002	8.3	11.6	6.2	8.0	6.8
2003	0.9	1.3	2.7	3.1	1.5
2004	2.4	2.3	1.2	1.2	2.2
2005	4.1	4.9	2.7	2.7	2.9
2006	1.2	1.0	1.1	1.4	1.1
2007	4.2	4.5	6.6	5.3	4.3
2008	19.0	20.6	6.2	7.1	3.9
2009	5.9	5.7	15.0	15.2	14.8
2010	10.8	10.7	15.2	17.3	13.4
2011	5.0	7.7	5.9	8.4	5.9
2012	0.1	0.2	0.8	0.9	0.8
2013	3.2	3.6	11.8	14.1	11.6
2014	4.8	5.0	4.2	4.3	4.9
2015	5.2	4.4	3.6	3.0	7.7
2016	3.2	2.4	4.8	4.4	3.6

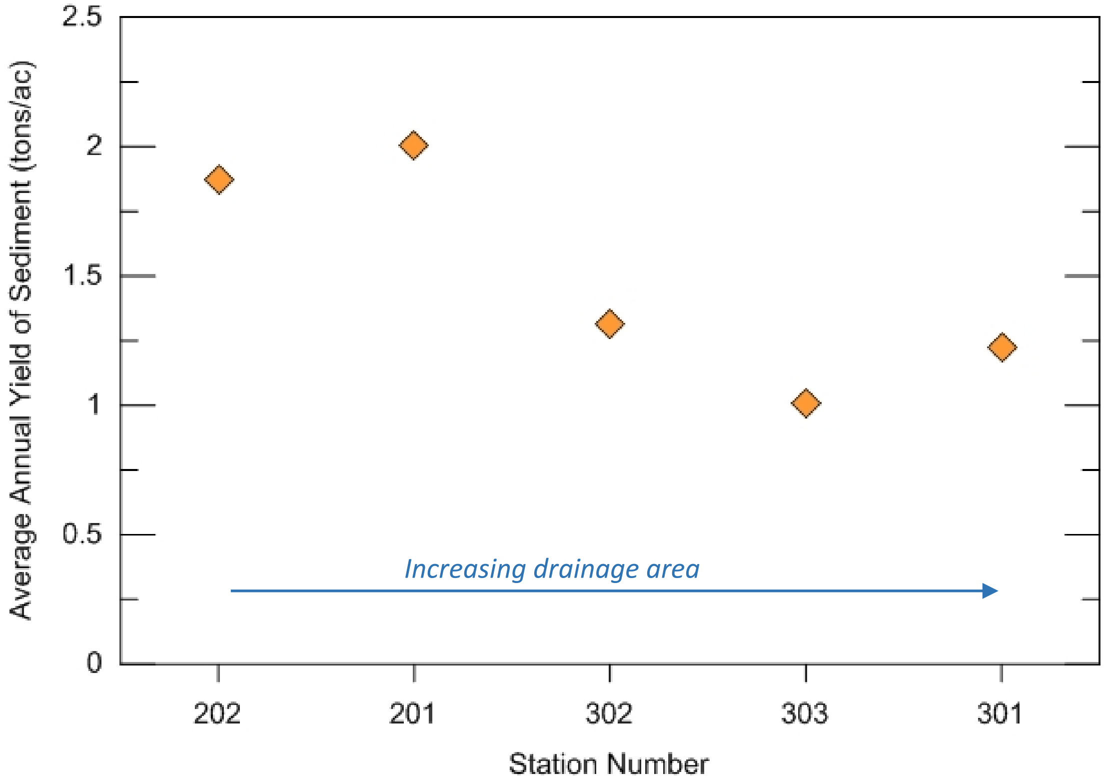


Figure 2-15. Average annual sediment yield in tons/acre for the CREP monitoring stations

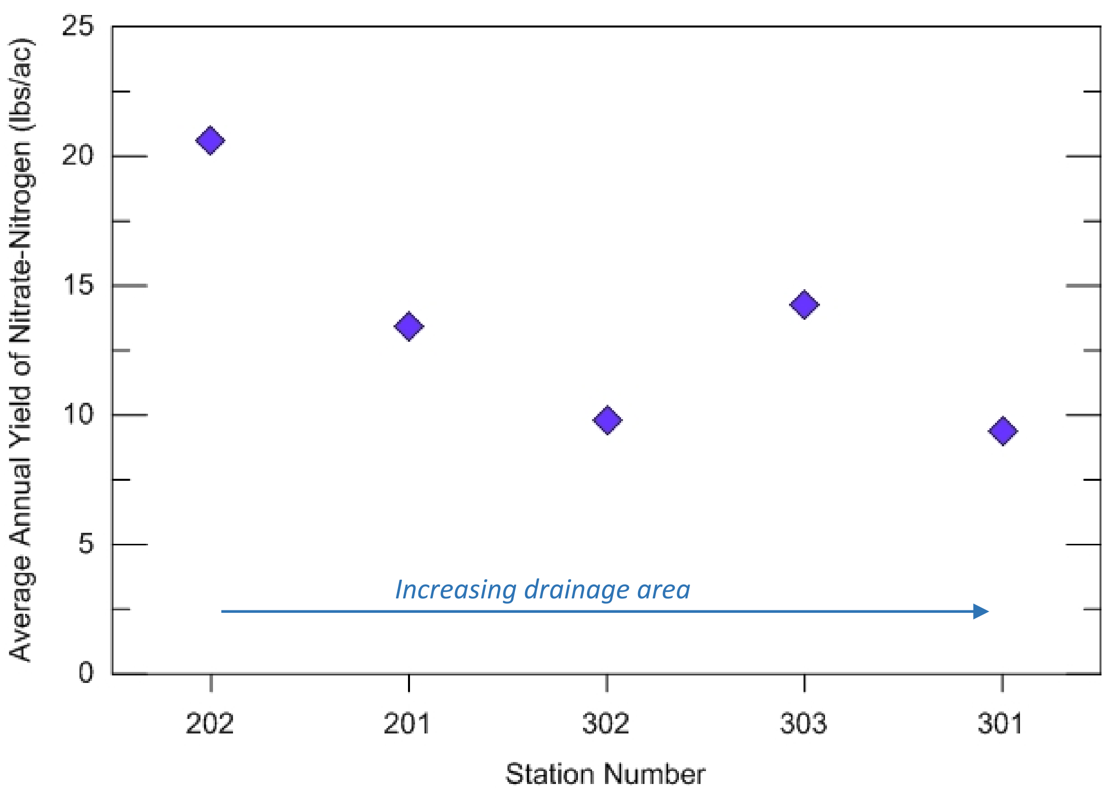


Figure 2-16. Average annual nitrate-N yield in lbs/acre for the CREP monitoring stations

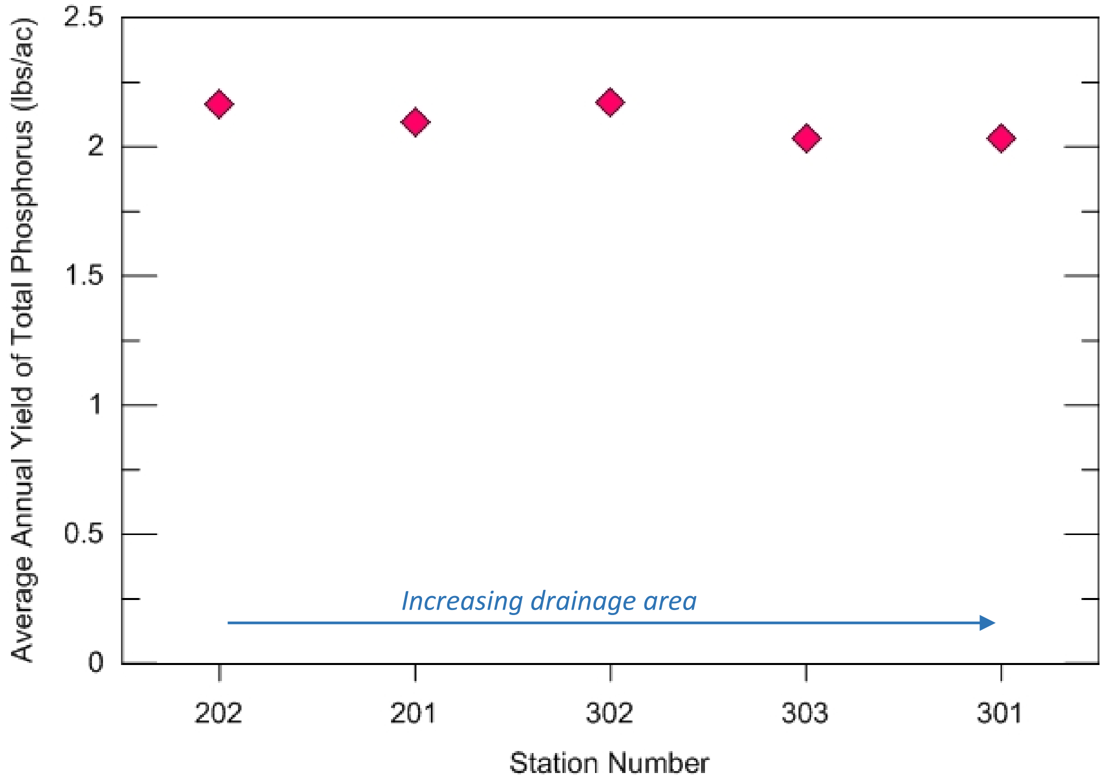


Figure 2-17. Average annual total phosphorus yield in lbs/acre for the CREP monitoring stations

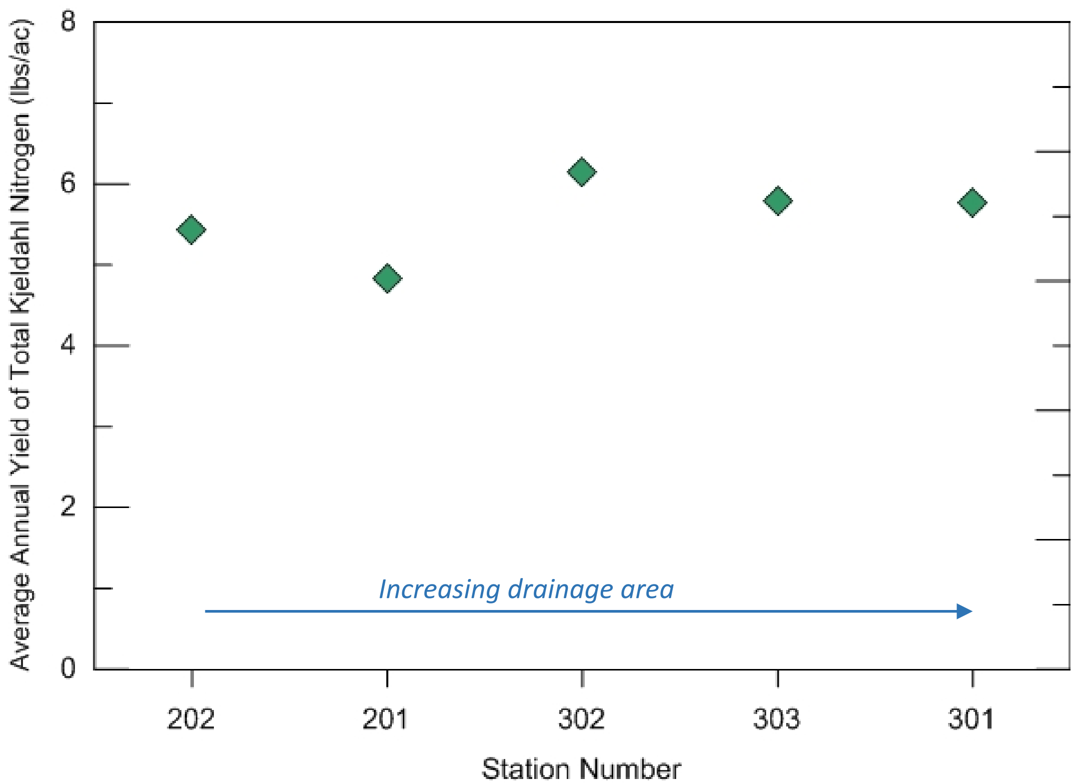


Figure 2-18. Average annual TKN yield in lbs/acre for the CREP monitoring stations

Additional CREP Data Collection Efforts

In addition to the CREP monitoring in the Court/Haw and Panther/Cox watersheds, that was initiated in 1999, several additional monitoring efforts have been initiated by the ISWS through the CREP project in order to provide additional information on the role BMPs in reducing sediment and nutrient yields and to better define the context of existing CREP data on a larger watershed scale.

During September of 2006 in response to significant CREP enrollments and an intensive restoration effort by the Natural Resources Conservation Service (NRCS), two additional monitoring stations (table 2-12) were installed in the Cedar Creek watershed, located in the Spoon River basin (figure 2-19). Station 306 is located on the right descending bank of the mainstem of Cedar Creek where it intersects CR 000 E in Fulton County (border with Warren Co). The second gage, station 305, is located near the left descending bank of Swan Creek, a major tributary of Cedar, where it flows beneath CR 000 E Fulton County, approximately 2.1 miles south of the Cedar Creek (306) gage.

Table 2-12. Additional CREP Monitoring Stations in the Spoon River Watershed

Station ID	*Name*	*Drainage area*	*Location*	*Watershed*
305	Swan Creek	98.1 sq mi (254 sq km)	N 40.67700 W 090.44391	Spoon River
306	Cedar Creek	146.2 sq mi (379 sq km)	N 40.70847 W 090.44540	Spoon River
RG39	Rain Gage 39	NA	N40.79145 W090.49999	Spoon River

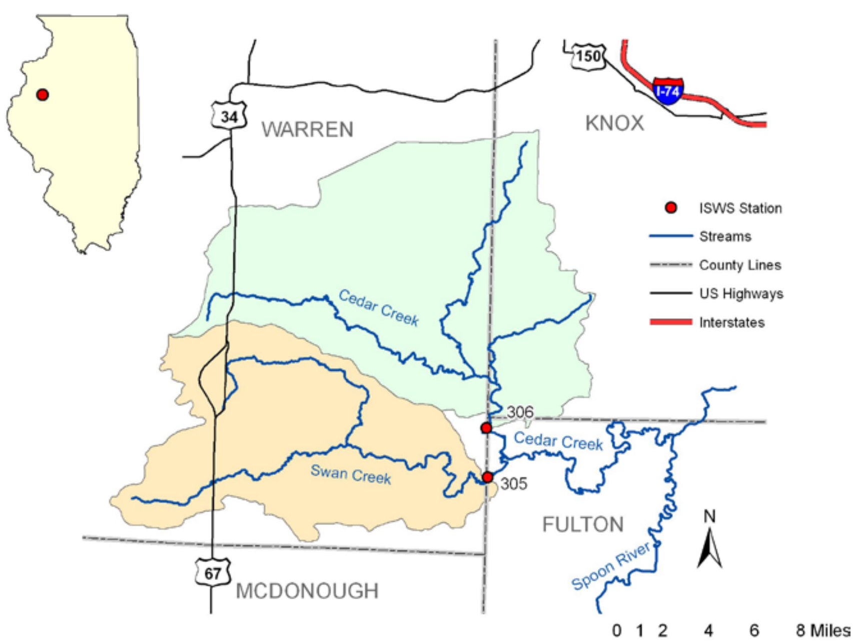


Figure 2-19. Locations of monitoring stations in the Cedar and Swan watersheds

Both watersheds are located in the Galesburg Plain physiographic region. The topography is flat to gently rolling and the soils are primarily loess. Stream channels and associated floodplains are heavily dissected with stream channels commonly being incised into the floodplain. Both watersheds are mostly rural with agriculture the predominant land use. Pasture and woodlands are also common due to the topography introduced by the dissected stream channels.

Both gages became operational near the end of WY2006 (9/15/2006) and are instrumented and operated as are all CREP gages, in accordance to the CREP QAPP (Appendix A). Both stations utilize a pressure transducer to determine stage, log data on a 15 minute time step and are equipped with an ISCO automated pump sampler slaved to the stage sensor in order to augment manual discrete sampling efforts. Thirty-eight and thirty-three discharge measurements have been collected at stations 305 and 306 respectively in an effort to establish a reliable rating in as short a time as possible. Based on provisional data, summary statistics for suspended sediment concentration data is provided in table 2-13.

In addition to the two streamgages the ISWS has installed a recording raingage immediately east of CR1500E and approximately 0.5 mi north of CR1100N in Warren Co. The raingage is a modified Belfort equipped with a linear potentiometer, in order to provide a digital output, and can be operated throughout the year. Raingage deployment and maintenance as well as the download and reduction of precipitation data can be found in the CREP QAPP (Appendix A).

ISWS field staff began suspended sediment sampling at two U.S. Geological Survey (USGS) gages located on the mainstem of the Spoon River on 3/29/2004. Samples are collected weekly at both sites with additional samples collected during runoff events. Sampling at London Mills (05569500) is done from the Route 116 bridge where the USGS gaging station is located. Sediment sampling at Seville (05570000) is done approximately 1 mile downstream of the current USGS gage location on State Route 95. Current USGS sediment data are also collected at this location. As of 9/30/12, 568 samples have been collected at London Mills while 521 samples have been collected at Seville. Summary statistics for suspended sediment concentration data collected through WY2012 are presented for each station in Table 2-14.

Table 2-13. Suspended Sediment Concentration Data (mg/L) for Swan and Cedar Creeks

	Swan (305)	*Cedar (306)*
Count (samples)	3515	3623
Mean	380.1	471.3
Max	7872.6	8101.8
Min	1.99	1.59
Median	137.1	132.6
25th Percentile	49.3	51.0
75th Percentile	416.3	462.7

Table 2-14. Suspended Sediment Concentration Data (mg/L) for Spoon River at London Mills and Seville

	London Mills (05569500)	*Seville (05570000)*
Count (samples)	568	521
Mean	296.1	293.1
Max	4952.7	4730.7
Min	1.91	3.93
Median	116.0	122.2
25th Percentile	49.9	58.8
75th Percentile	285.7	266.7

3. Land Use Cover and Conservation Practices

Land Cover

The Illinois River Basin (IRB) is nearly 16 million acres with a diverse range of land covers. The extent of these land covers is illustrated in figure 3-1 using the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) 2014 land cover data. The database contains almost 150 land cover category types. For the purpose of this study those types have been grouped into 11 categories: corn, soybeans, small grains, other row crops, other crops, grass/pasture, developed, woodland, wetlands, water, and other. Figure 3-2 show in 2014 the Illinois River Basin was dominated by agricultural land, comprising of 63% of the basin. Corn and soybean acreage accounts for most of the agricultural land cover. Developed urban-type lands, woodlands, and grass/pasture lands are the next highest with 14%, 12%, and 8%, respectively. The Illinois River Basin is unique in that a large portion of the watershed contains the six-county developed areas surrounding the City of Chicago.

As seen in Figure 3-3, these are the same dominant land covers in the five monitored watersheds with some variations. The Panther (201) and Cox Creek (202) watersheds are located next to one another (Figure 2-3) but show marked differences in land cover between agriculture production and woodland. Cox Creek watershed has 78% land cover in corn/soybean acreage whereas Panther Creek watershed has 55%. Woodland acreage in Panther Creek watershed is 3 times more than Cox Creek due to the IDNR Jim Edgar Panther Creek State Fish and Wildlife Area. Both watersheds have similar acreages in grassland/pasture/open lands and developed urban areas. Court Creek (301) and Haw Creek (303) watersheds are also located next to each other. North Creek (302) is a subwatershed within the Court Creek (301) watershed. Percent area of agriculture is 47% and 59% in Court and Haw Creek watersheds, respectively, where difference is offset by the woodland and developed areas of 39% and 29%. The higher woodland land cover area in Court Creek watershed is due to the North Creek (302) subwatershed.

Outside of natural factors such as the physical settings and climate variability, land use is the main driving factors that affect a watershed's hydrology, erosion, sedimentation, and water quality. It is therefore important to document and analyze changes in land use for a given watershed to properly understand and explain changes in its hydrology, water quality, and the erosion and sedimentation process. The Illinois River basin has undergone significant changes in land use practices during the last century. These changes have been used to explain degradation in water quality and aquatic habitat along the Illinois River. In recent years, there have been significant efforts at the local, state, and federal level to improve land use practices by implementing conservation practices throughout the watershed. The Illinois River CREP is a course of major state and federal initiatives to significantly increase conservation and restoration practices in the Illinois River basin.

The USDA National Agriculture Statistics Service (NASS) land cover data has been available since 1999. In 2006 an evaluation of the usefulness of the crop data layers for annual land cover information in Illinois was undertaken by the Illinois State Geological Survey (ISGS) and NASS. Based on inherent errors associated with satellite data, irreparable mechanical problems with older multispectral imagery satellites and land cover classification methods used

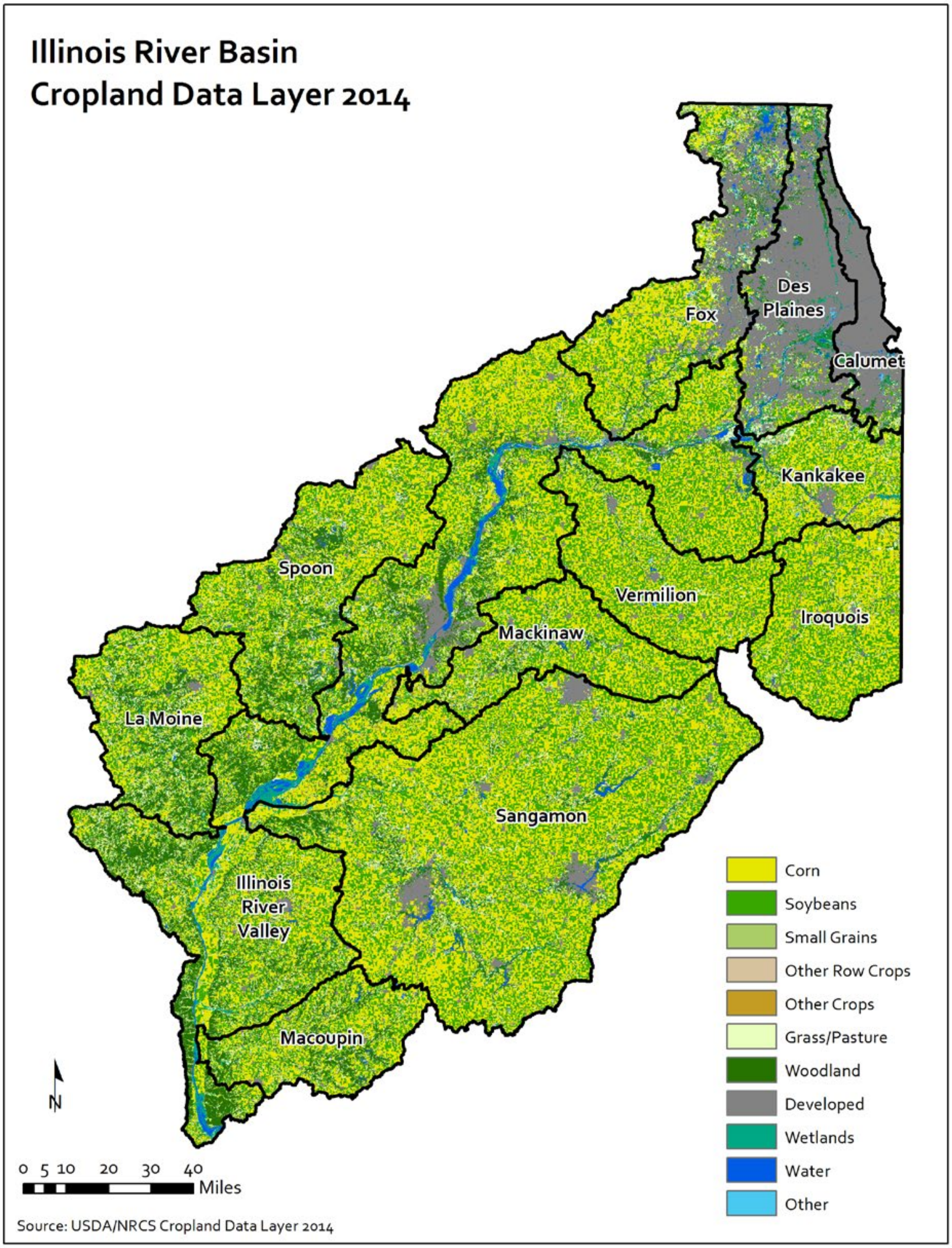


Figure 3-1. Land cover of the Illinois River Basin (NASS, 2010)

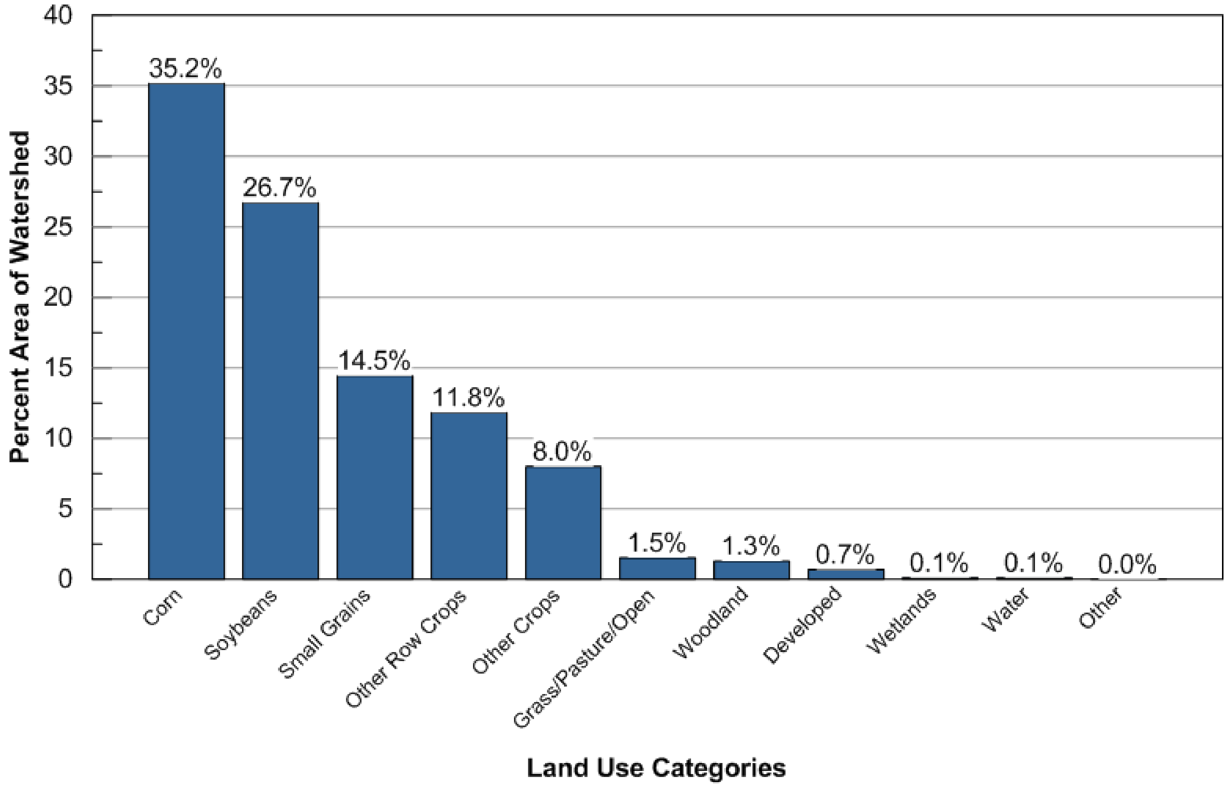


Figure 3-2. Percent watershed area of types of land cover in Illinois River Basin (NASS, 2014)

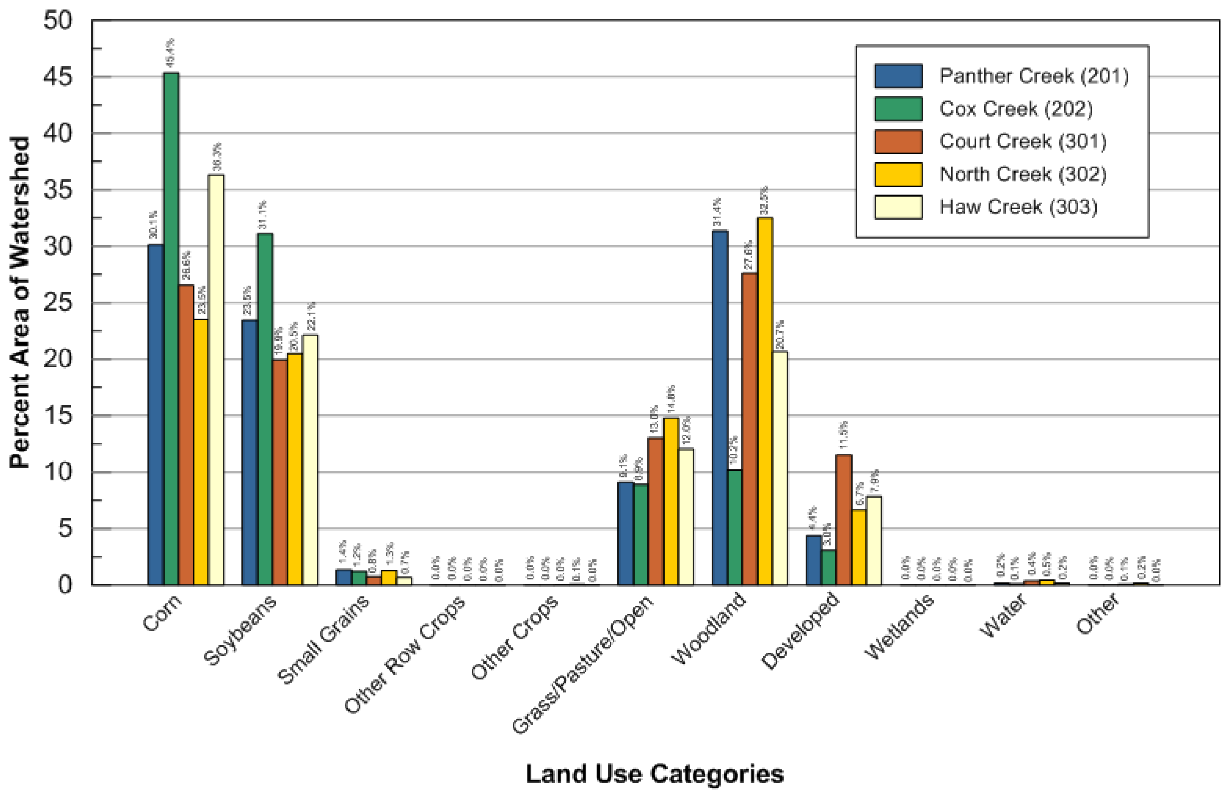


Figure 3-3. Percent watershed area of types of land cover in five monitored watersheds in the Illinois River Basin (NASS, 2014)

to interpret that imagery, new enhanced CDL protocols were established in 2007 for Illinois. Consequently, land cover misclassifications were identified prior to the new protocol, which became more apparent when evaluating the land cover in the monitored watersheds (figure 3-4): Panther Creek (201), Cox Creek (202), Court Creek (301), North Creek (302), and Haw Creek (303). Therefore, any changes in land cover will be evaluated for this study beginning in 2007 through 2013 which is the most currently available NASS CDL data.

The five monitored watersheds have somewhat different ratios of land cover types. The Panther and Cox Creek watersheds in the Spoon River watershed have 53 and 73 percent area in agriculture and 47 and 27 percent in non-agriculture land covers, respectively (table 3-1). The main difference is Panther Creek has over 20 percent more land in forest/shrubland than Cox Creek, due to a large portion of the watershed lies in the Panther Creek State Conservation Area. Agriculture land cover is 44 and 56 percent in Court and Haw Creeks, respectively, while the non-agriculture area is the inverse. North Creek watershed, a tributary of Court Creek, has a larger portion of land area in forest/shrubland than Haw Creek. Figure 3-5 illustrates the percent change in total watershed acres between 2007 and 2013 for six generalized land cover categories in each of the five monitored tributary watersheds in the Illinois River Basin. Agriculture land covers were categorized into Corn, Soybeans, Double Crop with Soybeans and Other Cropland, as well as summed in one category identified as Agriculture. Non-agriculture land covers were categorized into Grassland and Forest/Shrubland, and summed as Non-Agriculture. All five watersheds had a 5 percent reduction in non-agricultural land cover area (Grasslands and Forest/Shrubland) between 2007 and 2013. An increase in agricultural land cover area (Corn, Soybeans, Double Crop with Soybeans and Other Cropland) ranged from 2 to nearly 11 percent occurred on all five watersheds. The three Spoon River tributary watersheds (Court, North, and Haw Creeks) had marked percent increases in soybean acres and decreased percent of corn acres. The two Sangamon River watersheds (Panther and Cox Creeks) had an increase percent of corn acres, with Panther having an increase percentage of soybean acres and Cox with an increase in other cropland acres.

Figures 3-6 to 3-10 show the changes in each land cover for each year between 2007 and 2013. For this report, NASS Cropland Data Layer (CDL) categories for the monitored watersheds were combined into 6 general land cover categories: 1) corn, 2) soybean, 3) other cultivated crops, 4) grassland, 5) forest/shrubland and 6) developed, barren, open space, water and wetlands. Land cover area changes between years is represented in acres. Therefore, some watersheds may appear to have greater changes in acreage from year to year but may only represent a small percentage of the watershed depending on the total watershed acres. Panther Creek watershed (figure 3-6) acres remained constant for move land covers when comparing 2007 and 2013. Corn and soybean acres shifted between years and inversely as reflected by normal corn and soybean rotation practices. Forest/shrubland saw a minor shift in 2010. Cox Creek watershed (figure 3-7) saw similar variability as Panther Creek watershed in most land cover acreage. Only minor increases in acres for cultivated crops and developed, barren, open space, water and wetlands. Court Creek (figure 3-8) appeared to have corn and Grasslands trade acres each year, with Corn increasing to a high in 2011 and then returning to near 2007 acreage. Soybean acres increased every other year for a seven year increase. Forest/Scrubland acres decreased slightly with little variability. North Creek watershed (figure 3-9) is a subwatershed within Court Creek watershed explaining the significant reduction in total watershed acres. The same patterns and variability as Court Creek watershed appear here. Finally, Haw Creek watershed (Figure 3-10) land cover patterns and variability in acreages were similar to Court/North Creek watersheds.

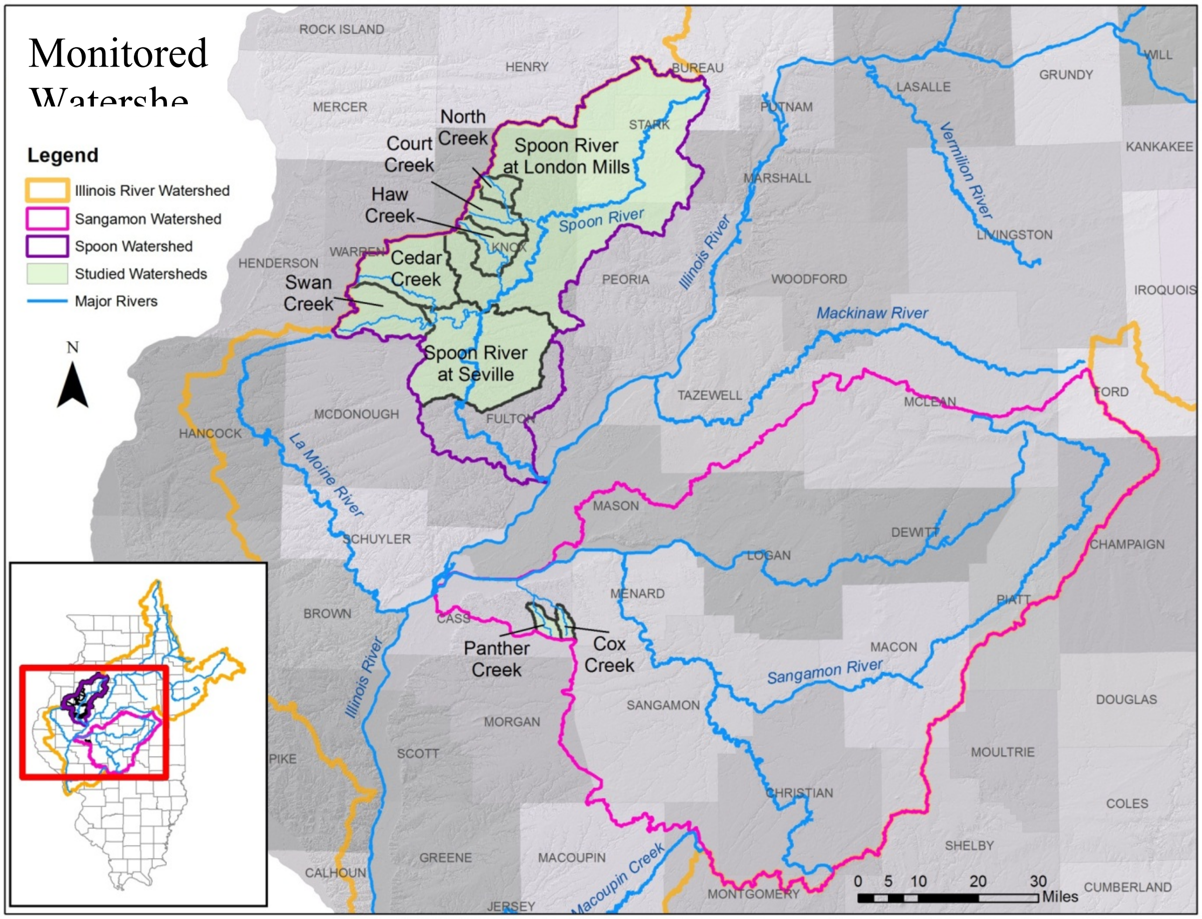


Figure 3-4. Watersheds being monitored for hydrology, sediment and nutrients.

Table 3-1. 7-year average (2007-2013) percent acres of land cover area by watershed

	ISWS Station Number				
	201	*202*	*301*	*302*	*303*
Corn	31	46	28	26	36
Soybeans	21	26	16	16	20
Other Crops	1	2	0	0	0
Grasslands	11	13	20	20	17
Forest/Shrubland	32	11	29	34	21
Developed, Barren, Open Space, Water, Wetlands	4	3	7	4	6
AGRICULTURE	53	73	44	42	56
NON-AGRICULTURE	47	27	56	58	44

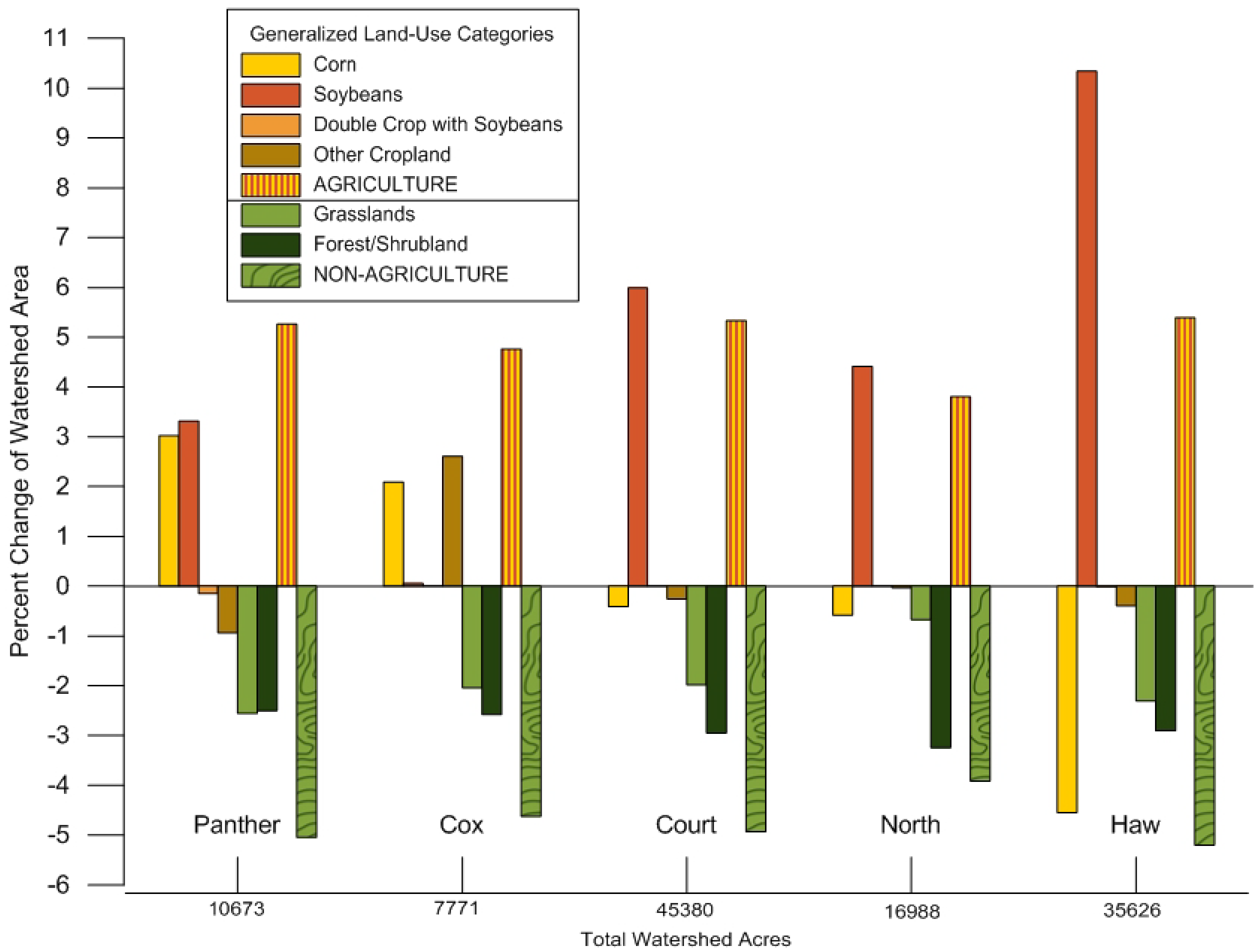


Figure 3-5. Illinois River Basin Watersheds: Percent Change in Generalized NASS Land-Use from 2007-2013.

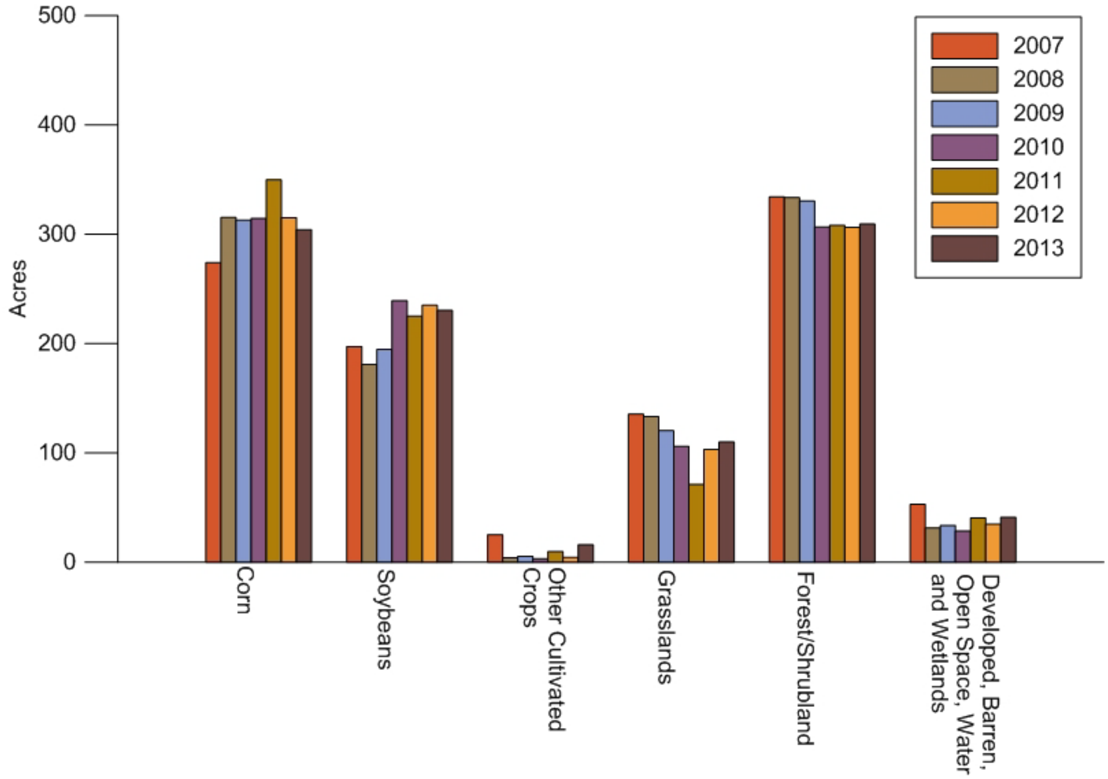


Figure 3-6. Panther Creek Watershed from ISWS Station 201: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

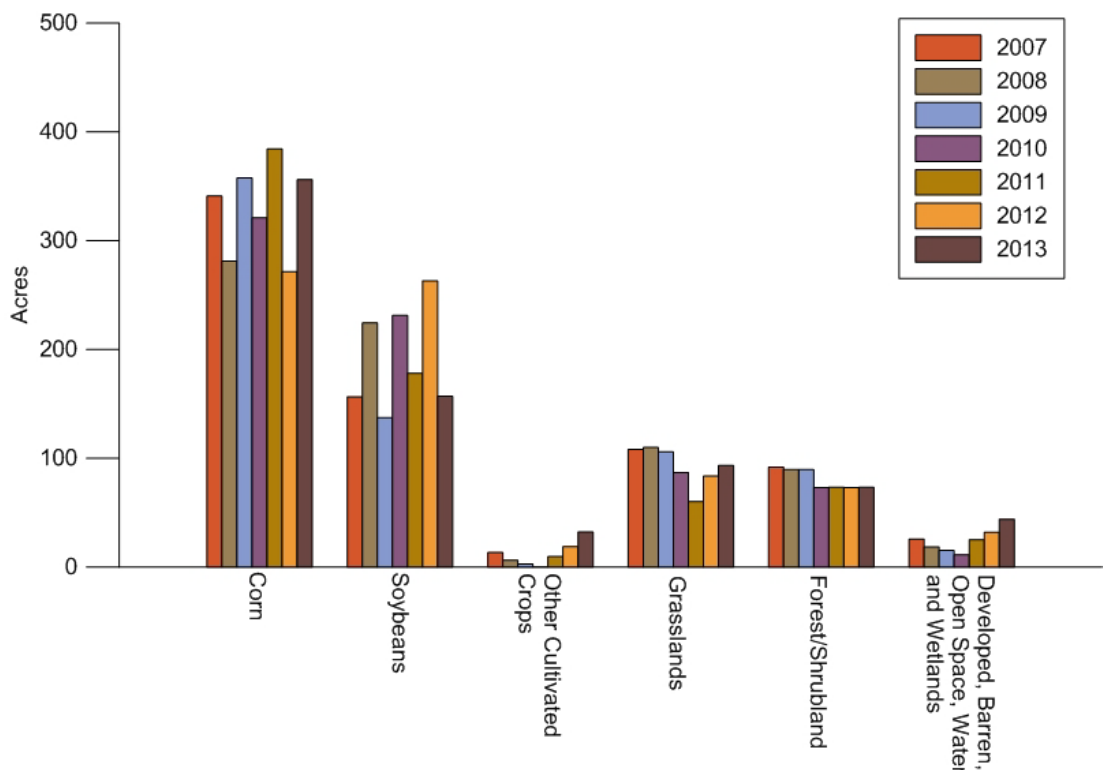


Figure 3-7. Cox Creek Watershed from ISWS Station 202: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

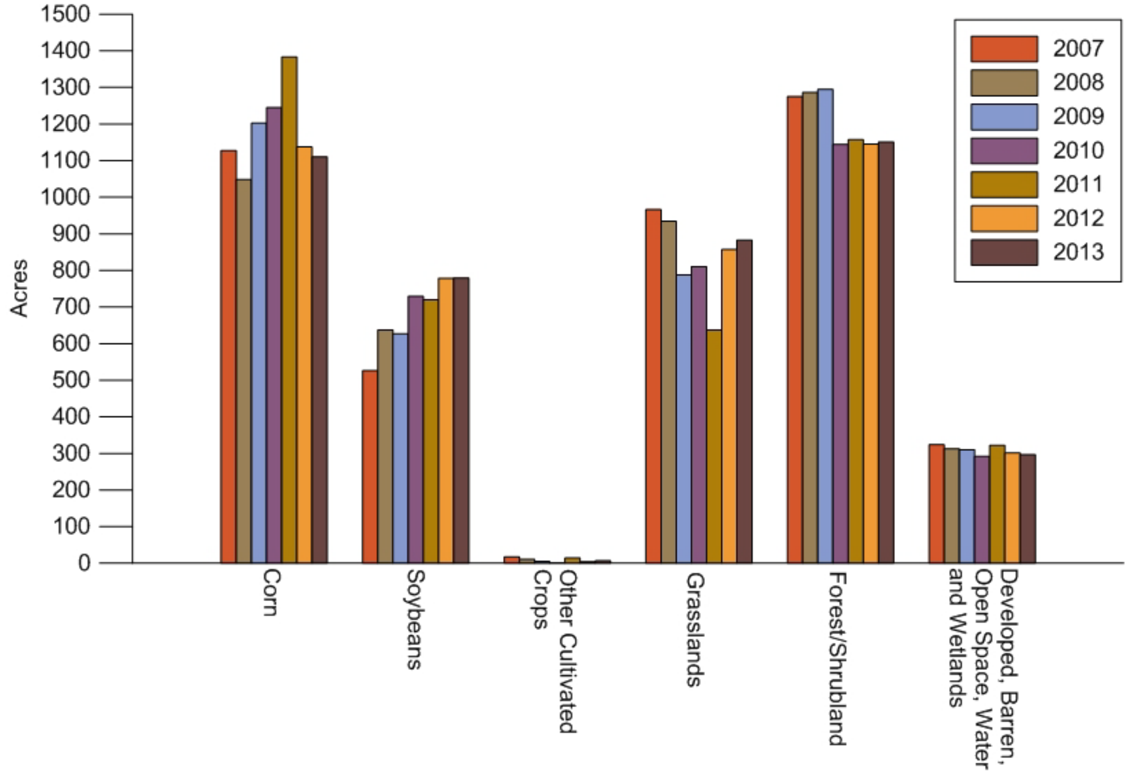


Figure 3-8. Court Creek Watershed from ISWS Station 301: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

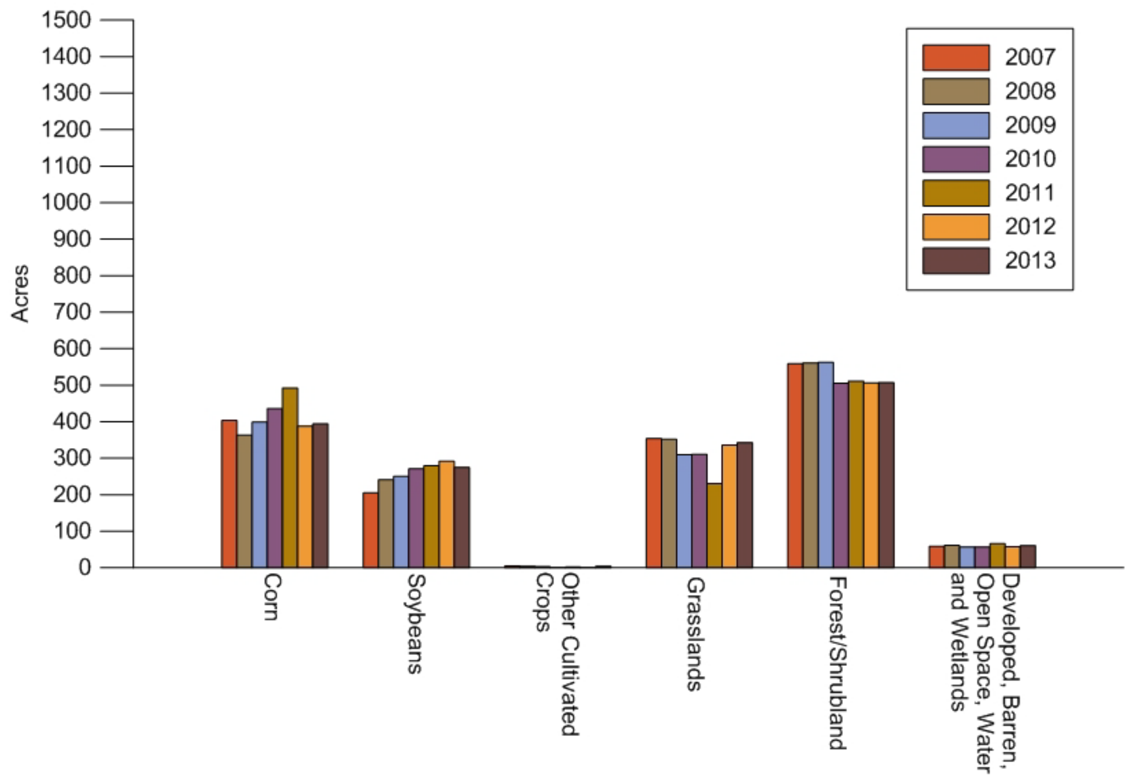


Figure 3-9. North Creek Watershed from ISWS Station 302: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

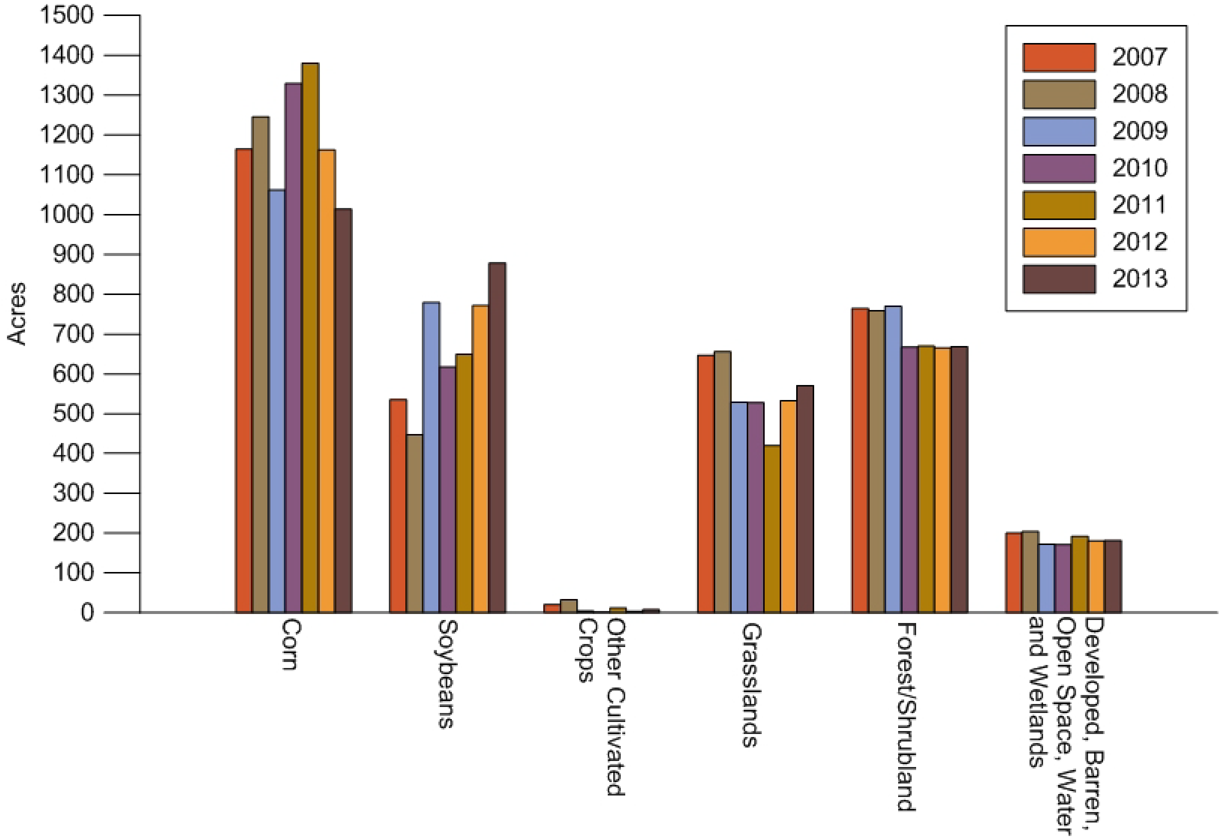


Figure 3-10. Haw Creek Watershed from ISWS Station 303: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

Conservation Practices

There has been a significant increase in the implementation of conservation practices in Illinois in recent years with CREP making a major contribution. Figure 3-11 shows the location of approved Illinois CREP contracts from the State of Illinois as of 2014. With this type of information it will be possible to identify areas where there has been significant participation in the CREP program and where changes in sediment and nutrient delivery should be expected. The information will provide important input data to the watershed models that are being developed to evaluate the impact of CREP practices.

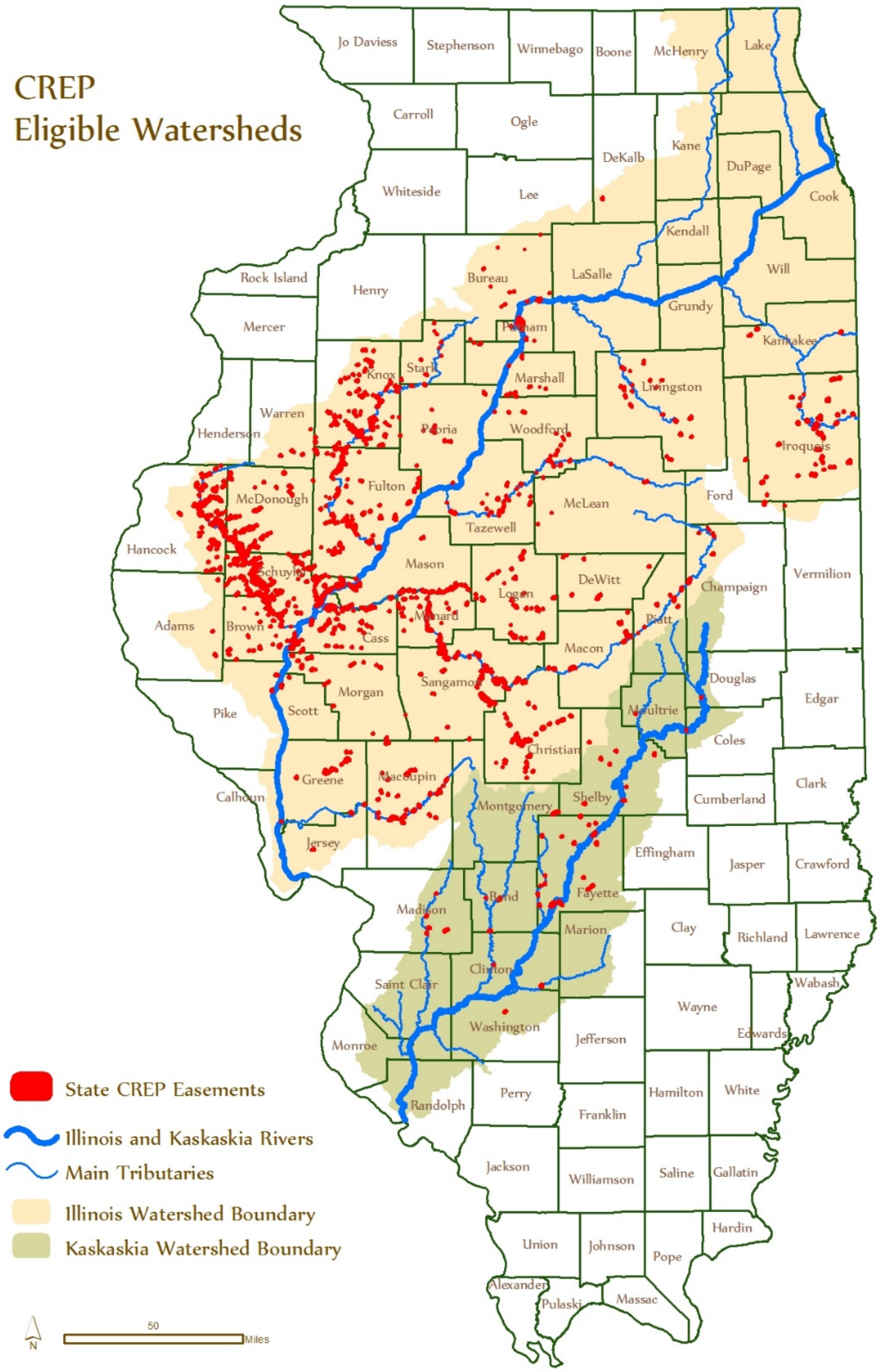


Figure 3-11. State of Illinois CREP contract locations (IDNR, 2015).

There are many conservation practices implemented through the watersheds as a result of federal and state conservation reserve programs. In order to evaluate watershed monitoring efforts, knowing when and what conservation practices are implemented in the watershed is important. Figures 3-12 to 3-13 are examples of cumulative acres of conservation practices installed in a couple of the monitored watersheds from 1999 through 2015. There were no contract signups in 2016, therefore the figures are not updated. The order by which the practices are listed in the legend represent, from the largest to smallest, the sum of the acres by practice from 1999-2015. Riparian buffers, wetland restoration, filter strips and SAFE habitat are the most installed conservation practice in Court Creek (301) watershed with most of the acres occurring prior to 2009. Whereas, permanent wildlife habitat (Additional Acres) was the most installed practice installed prior to 2005 in the Haw Creek (303) watershed. Existing grasses and trees, filter strips and grass waterways are the next most installed.

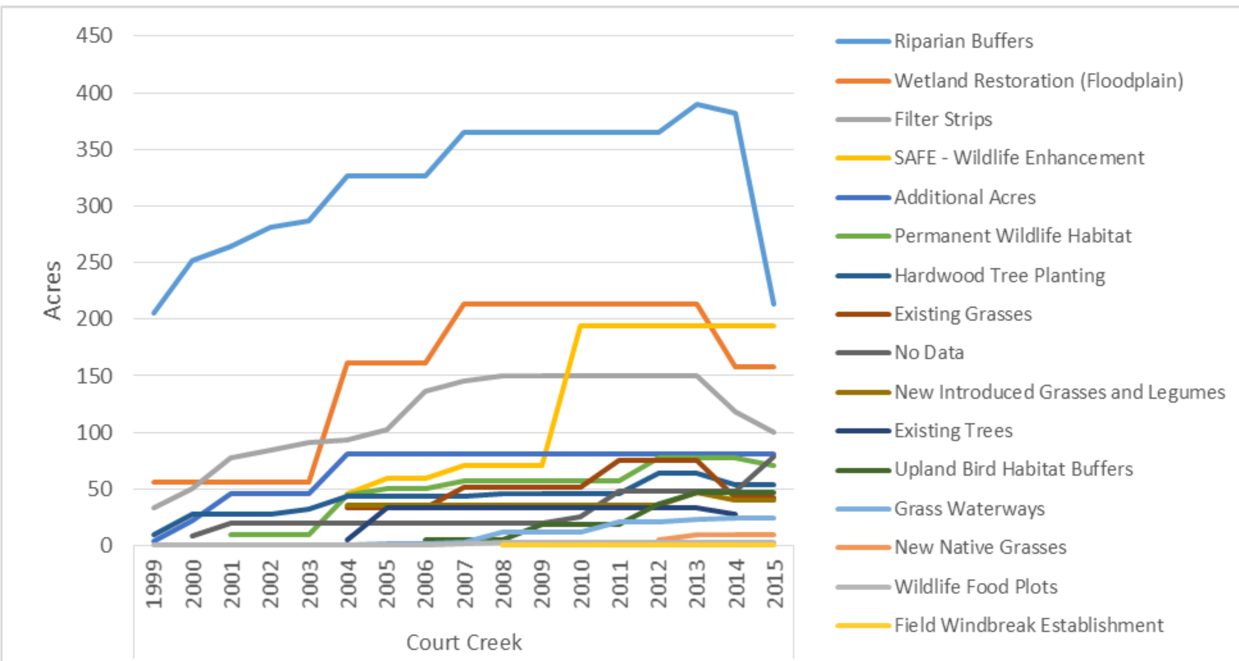


Figure 3-12. Cumulative acres of conservation practices installed in Court Creek watershed at monitoring station ISWS #301 from 1999-2015.

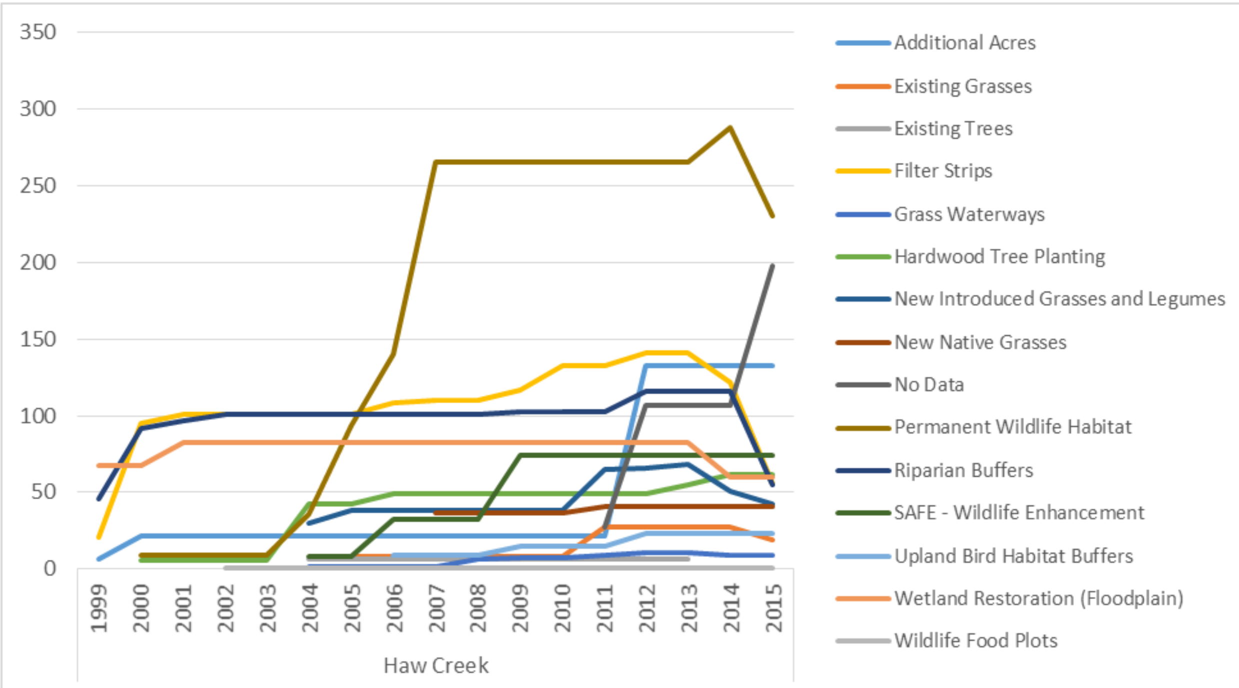


Figure 3-13. Cumulative acres of conservation practices installed in Haw Creek watershed at monitoring station ISWS #303 from 1999-2015.

4. Variability and Trends in Precipitation and Streamflow

Results of a short-term monitoring program have to be viewed with respect to the climatic and hydrologic conditions under which the data was collected. Under ideal conditions, which rarely happen, the monitoring period would include a combination of wet, dry, and normal climatic conditions that represent the range of variability in climatic and hydrologic conditions in the watershed. The influence of climatic and hydrologic conditions on the data collected has been taken into consideration, especially when different datasets collected at different times and conditions are combined or compared. The Illinois River basin, as any major watershed, has experienced significant variability in precipitation and streamflow over the last century and recent periods. Data collection for the CREP program started in 1999 to provide a perspective as to how the current monitoring period compares to the long-term variability of precipitation and streamflows within the Illinois River basin. Historical precipitation and streamflow data from 1900-2005 are analyzed and presented in this segment of the report. An additional 10 years will be added on to this analyses for the next annual report.

Climate and hydrologic records from the past 100 years in Illinois show considerable long-term variability. These variabilities and trends were analyzed for two stations on the Illinois River and six tributary stations in the Illinois River basin (figure 4-1). Figure 4-2 compares average precipitation and streamflow for the Upper Illinois River watershed since the 1880s, as expressed in moving 10-year average values. Similar comparisons are shown in figures 4-3 to 4-8 for the Fox, Kankakee, Spoon, Sangamon, LaMoine, and Macoupin subwatersheds, respectively, but for shorter time periods as limited by the available gaging records. Figure 4-9 for the entire Illinois River Basin (at the Valley City streamgage) is nearly identical to figure 1 except for the period of record. The 10-year average precipitation and streamflow values plotted in figures 4-2 to 4-9 represent the approximate midpoint of the 10 years; for example, the value for 1995 represents the average for 10 years from 1990-1999, the value for 1996 represents the average for the 10 years 1991-2000, and so forth. Streamflow values are expressed in inches of water spread uniformly over the entire watershed such that average streamflow can be compared directly with precipitation for the concurrent period. Streamflow values in figure 4-2 are computed from flow and stage records at Peoria prior to 1940 and at Kingston Mines since 1940.

Figure 4-2 shows that precipitation and streamflow in the Upper Illinois River watershed from 1970 to 1995 were considerably higher than at any other time in the 20th Century. Prior to 1895, precipitation for the Illinois River watershed is estimated from a small set of gaging records dating back to 1870. These precipitation records show that there was a decade of high precipitation in the late 1870s and early 1880s similar in magnitude to high precipitation amounts during 1970-1995. A comparison of 10-year average precipitation and streamflow amounts clearly shows that streamflow has been very closely related to concurrent precipitation throughout the past 125 years, with a correlation coefficient (r) of 0.958.

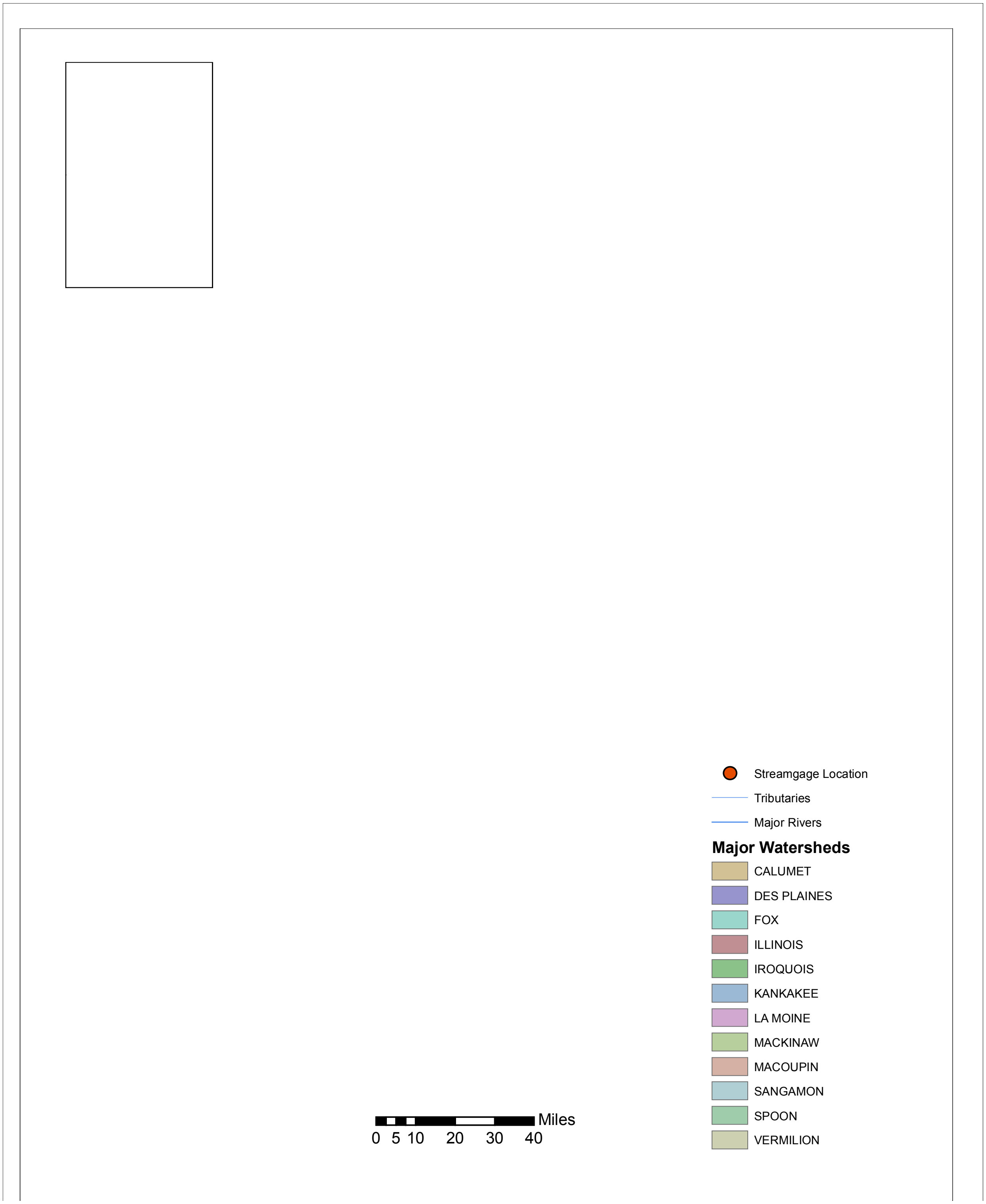


Figure 4-1. Location of streamgaging stations with long-term data used in the analysis of variability and trends

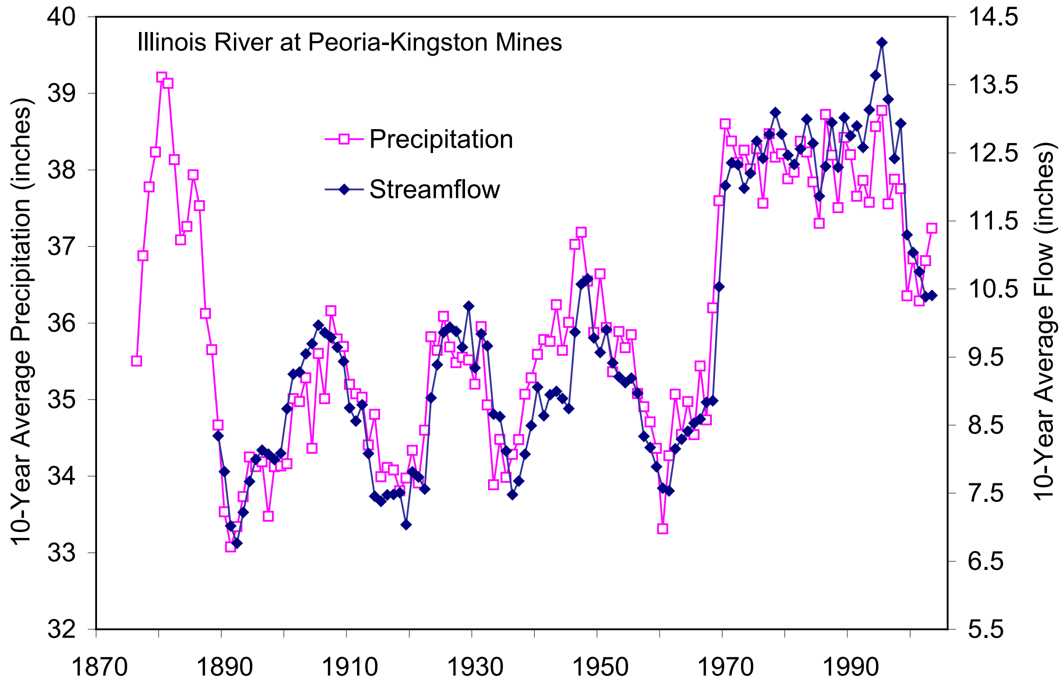


Figure 4-2. Ten-year average precipitation and streamflow, Illinois River at Peoria-Kingston Mines

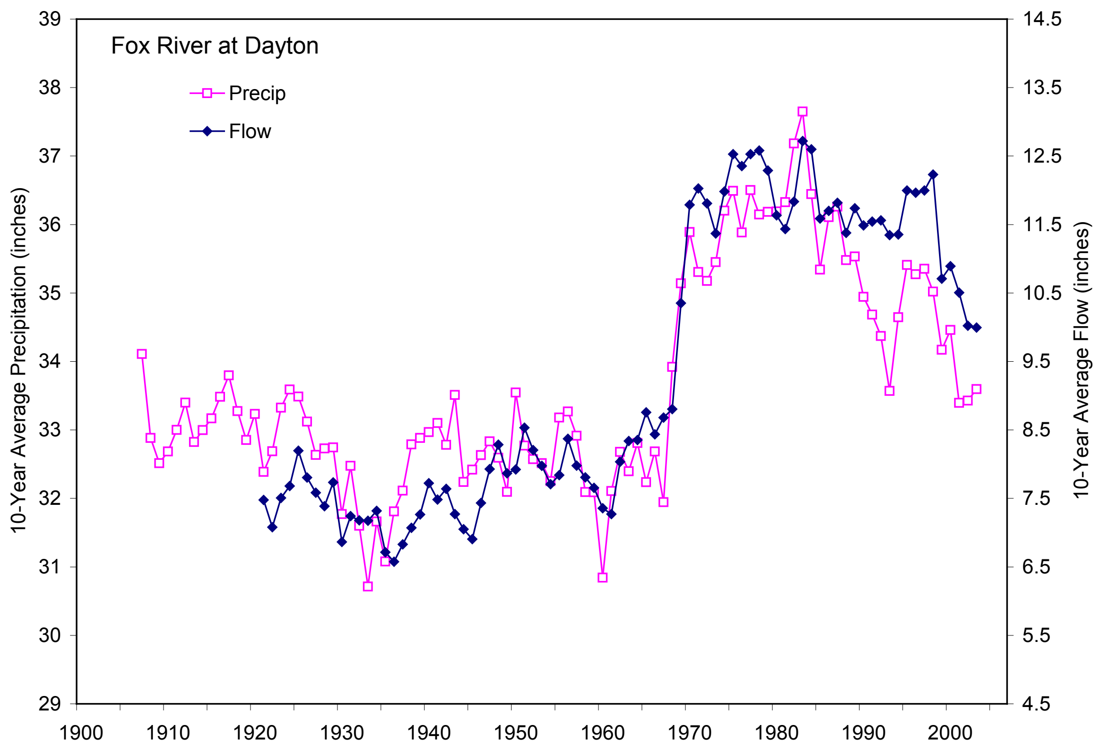


Figure 4-3. Ten-year average precipitation and streamflow, Fox River at Dayton

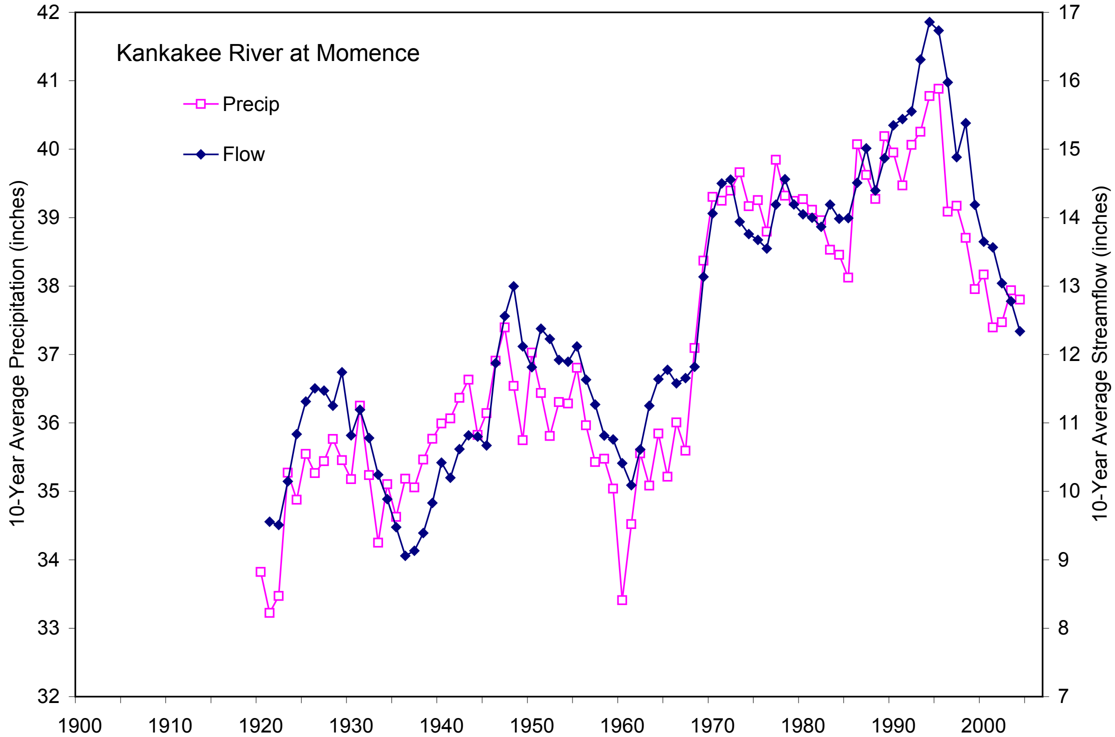


Figure 4-4. Ten-year average precipitation and streamflow, Kankakee River at Momence

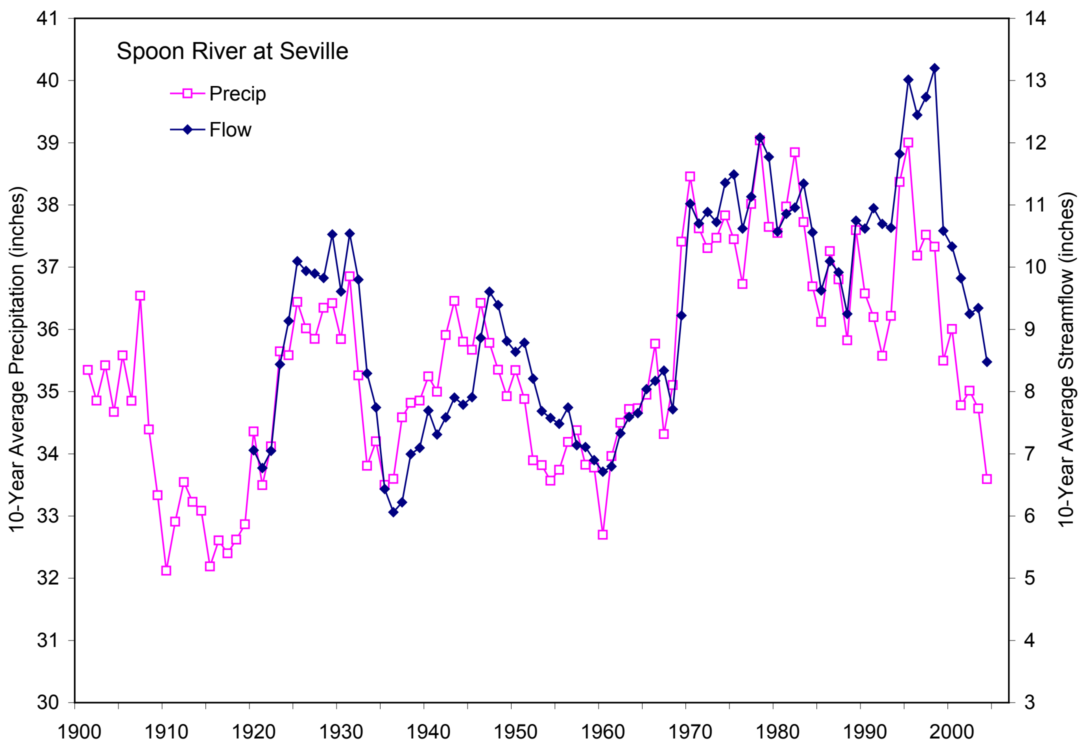


Figure 4-5. Ten-year average precipitation and streamflow, Spoon River at Seville

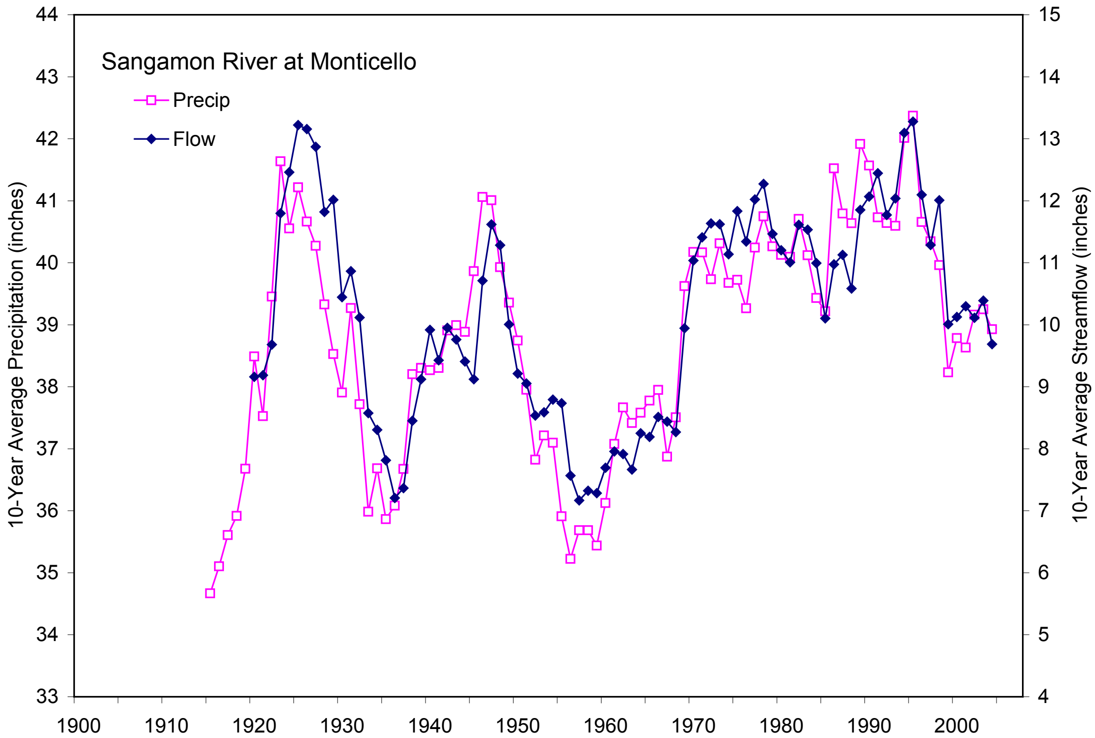


Figure 4-6. Ten-year average precipitation and streamflow, Sangamon River at Monticello

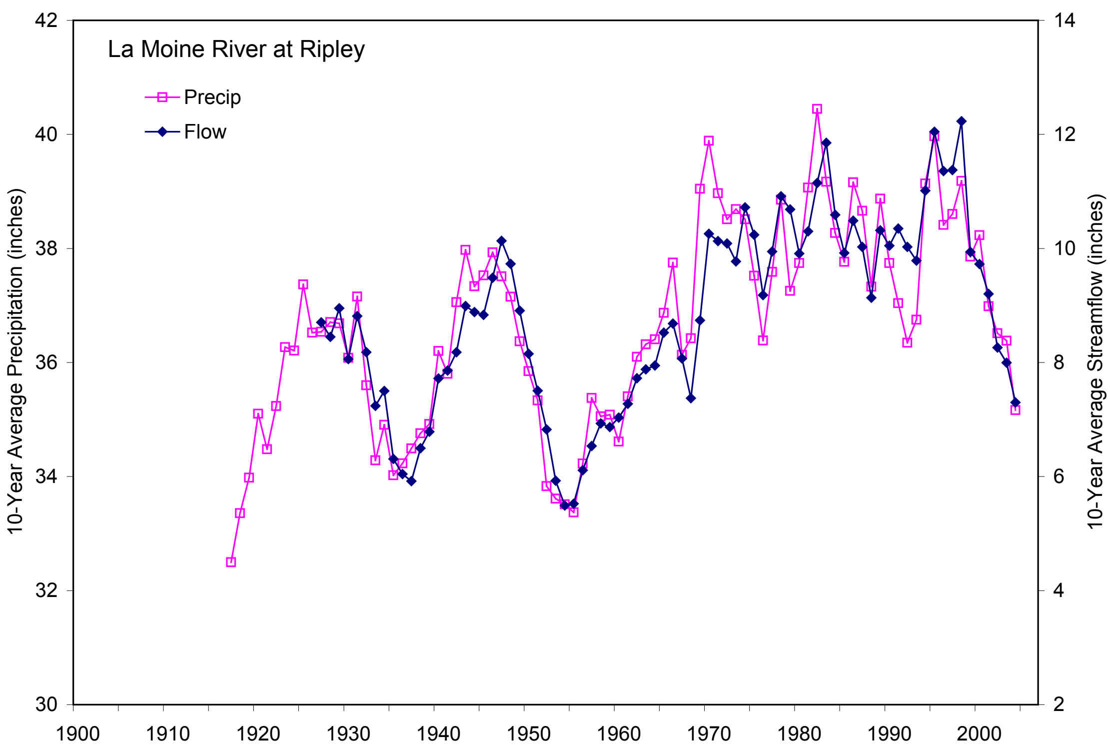


Figure 4-7. Ten-year average precipitation and streamflow, LaMoine River at Ripley

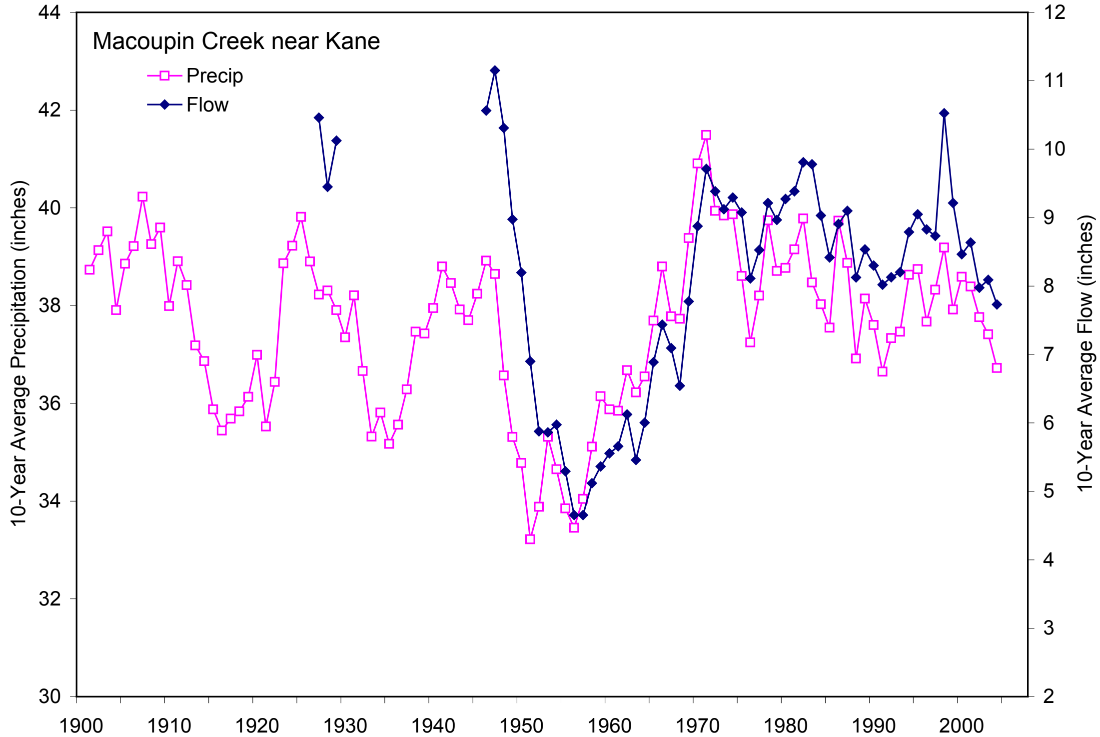


Figure 4-8. Ten-year average precipitation and streamflow, Macoupin Creek near Kane

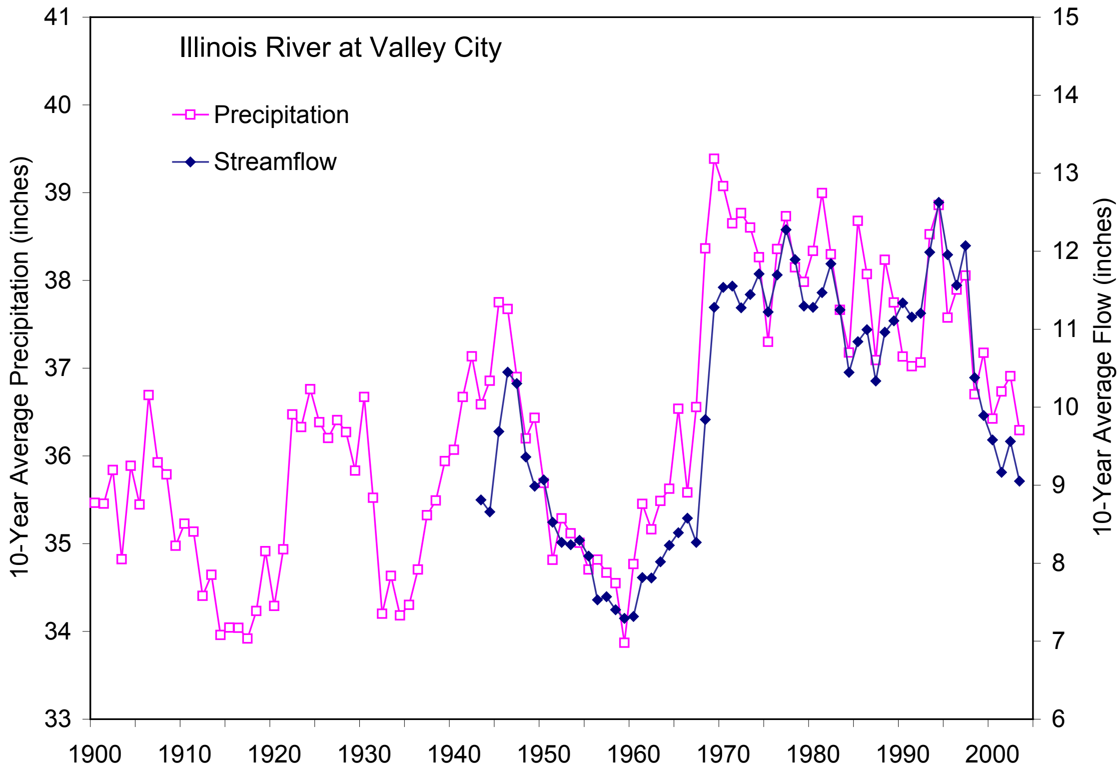


Figure 4-9. Ten-year average precipitation and streamflow, Illinois River at Valley City

Precipitation and streamflow trends shown in figure 4-2 are consistent with regional trends that have affected northern Illinois and much of the upper Midwest (Knapp, 2005). Statistical analyses of long-term streamflow records by Knapp (2005) using the Kendall tau-b trend statistic indicate that streamgage records in northern Illinois, eastern Iowa, and Minnesota all exhibit increasing trends in average streamflow (figure 4-10). Conversely, long-term flow records in the southern two-thirds of Illinois generally do not show significant increases in streamflow.

Figures 4-2 to 4-9 illustrate that trends in precipitation and streamflow vary across the Illinois River watershed. Increasing trends are particularly evident in the Upper Illinois River watershed and its two primary tributaries, the Fox and Kankakee River (figures 4-3 and 4-4). In contrast, the Macoupin, LaMoine, and Sangamon River subwatersheds, in the southern portion of the Illinois River basin, show much less or no overall trend in precipitation or streamflow — even though these records show considerable variation in precipitation and streamflow from decade to decade. The Spoon River watershed, having an intermediate location, shows an increasing trend in flow amount, but to a lesser degree than the Fox and Kankakee River watersheds located farther to the north. In all cases, there is a strong correlation between average precipitation and streamflow.

The significance of the trends is identified using the Kendall tau-b statistic. The Kendall tau-b statistical test provides a quantitative measure of trend, with a coefficient value of 0 indicating no trend and a value of 1 indicating an absolute increasing trend. For the 93-year flow records dating back to 1915, a coefficient value greater than or equal to 0.115 indicates an increasing trend at a 90 percent confidence level, and a value greater than or equal to 0.162 indicates an increasing trend at a 98 percent confidence level. Table 3-2 shows the Kendall Tau-b trend coefficients computed for two time periods, 1915-2007 and 1970-2007. The 1915-2007 trend analyses for the Fox, Kankakee, and Upper Illinois (Peoria-Kingston Mines) flow records show increasing trends with very high levels of confidence. The 1915-2007 trend analysis for the Spoon River record shows an increasing trend, with roughly a 94 percent level of confidence. The flow records for the tributaries located farther south in the watershed do not show a significant trend (having less than an 80 percent level of confidence). The 1915-2007 trend coefficient for the Illinois River at Valley City is not shown because the flow record does not date back to 1915.

Although flow records from the northern half of the Illinois River watershed display an general increasing trend over their full period of record, a closer look indicates: 1) there was a geographically widespread and sizable jump in average flow amount between the 1960s and 1970s (this jump also occurred in the southern part of the basin to a lesser extent); and 2) for most locations there has been little or no additional increase since the 1970s. In fact, for most locations, the average flows since 1995 have declined from the high flow levels that occurred from 1970 to 1995. Table 3-3 presents the average annual precipitation and streamflow amounts for the Illinois River and its major tributaries over the past 12 years (1996-2007) and compares these amounts to those for earlier periods (1915-1969 and 1970-1995) and to the overall long-term record. Except for the Kankakee River, the average flow from 1996-2007 for these rivers is much closer to the long-term average than it is to the higher flow amounts that were experienced

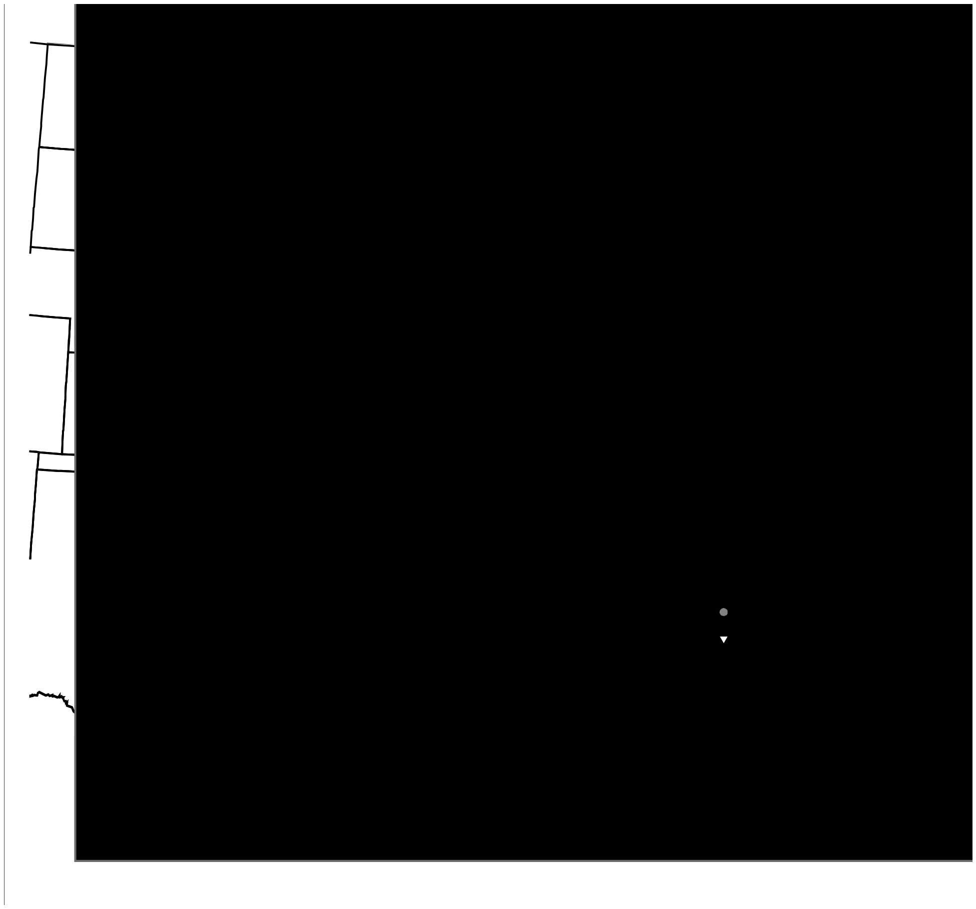


Figure 4-10. Locations of long-term streamflow gages (at least 89 years of record) showing statistically significant trends in mean annual flow in the eastern United States (from Knapp, 2005)

from 1970 to 1995. Thus, with the exception of the Kankakee River watershed, it is reasonable to conclude that other flow records collected throughout the Illinois River watershed over the 1996-2007 timeframe may represent conditions similar to their expected long-term average condition.

Although it is not possible to predict how these trends will progress in the future, concerns expressed in previous decades regarding the potential for continued increases in flows throughout the Illinois River watershed (for example by Ramamurthy et al., 1989) for the time being may no longer be an issue. If anything, there may be growing concerns that the occurrence of drought periods such as existed prior to 1970 may become more frequent. This analysis does not specifically look at trends of flooding or low flows. However, for long-term gaging records in the Illinois River watershed, Knapp (2005) found that trends in high flows and low flows tended to be coincident and proportional to trends in average flow.

Table 4-1. Kendall Tau-b Trend Statistics for Flow Records on the Illinois River and Major Tributaries

	Kendall Tau-b coefficient value period-of-record used in the analysis	
Streamgage record	*1915-2007*	*1970-2007*
Fox River at Dayton	0.294	-0.135
Kankakee River at Momence	0.316	-0.007
Illinois River at Peoria-Kingston Mines	0.315	-0.144
Spoon River at Seville	0.127	-0.127
Sangamon River at Monticello	0.087	-0.081
LaMoine River at Ripley	0.075	-0.166
Macoupin Creek near Kane*	-0.009	-0.081
Illinois River at Valley City**	------	-0.112

Notes:
* The periods of record for the Macoupin Creek gage near Kane are 1921-1933 and 1941-2007.
** The flow record at Valley City only extends back to 1939. The trend coefficient for the 1939-2007 period at Valley City, 0.162, is somewhat less than the trend coefficient for Peoria-Kingston Mines for the same time period (0.192).

Table 4-2. Average Annual Precipitation and Streamflow (inches) for Different Periods of Record

Precipitation

Watershed	*1915-2007*	*1915-1969*	*1970-1995*	*1996-2007*
Fox	33.7	32.6	35.9	34.4
Kankakee	37.0	35.5	39.5	38.4
Upper Illinois (Peoria)	36.3	35.2	38.3	37.1
Spoon	35.7	34.9	37.7	34.8
Sangamon	38.9	38.1	40.7	38.9
LaMoine	36.6	35.8	38.6	35.9
Macoupin	37.4	37.0	38.6	36.9
Entire Illinois (Valley City)	36.5	35.6	38.3	36.6

Streamflow

Watershed	*1915-2007*	*1915-1969*	*1970-1995*	*1996-2007*
Fox	9.3	7.7	12.1	10.0
Kankakee	12.3	10.9	14.7	13.5
Upper Illinois (Peoria)	10.2	8.8	12.9	10.8
Spoon	9.1	8.0	11.3	9.2
Sangamon	10.4	9.5	12.4	10.1
LaMoine	8.7	7.7	10.7	8.2
Macoupin	8.4	8.1	9.1	7.8
Entire Illinois (Valley City)	9.8	8.4	11.7	9.5

5. Hydrologic and Water Quality Modeling and Trends

The Illinois State Water Survey has been developing hydrologic and water quality models for the major watersheds of the Illinois River Basin to assess the impacts of conservation measures on reduction of nonpoint source pollution in streams and rivers. Figure 5-1 shows the location of the Illinois River basin and its major watersheds. Because of its large size, a watershed model configuration that is based on both the delineation of the major watersheds of the Illinois River (e.g., Spoon, Sangamon, etc.) and their subwatersheds (e.g., Upper, Lower, Salt Creek and South Fork subwatersheds of Sangamon) is adopted, rather than developing a single coarse model for the entire Illinois River Basin. This watershed model configuration allows more accurate representation of the inherent variability in topography, land use, soils, management practices and weather conditions throughout the basin. Consequently, all upland watersheds will have a standalone model, whose hydrologic and water quality responses will be required as inputs by downstream receiving watersheds. For example, all subwatersheds of Sangamon River but Lower Sangamon will have standalone simulation models independent of one another, increasing their practical utility. In addition, this watershed model configuration facilitates distributed calibration and validation of the watershed models that will make up the Illinois River basin model. The Soil and Assessment Tool (SWAT) is selected for this modeling effort because of the model's suitability for simulating agricultural watersheds, which make up the majority of the Illinois River basin.

Watershed Simulation Model - SWAT

SWAT, which is developed for USDA's Agricultural Research Service (ARS), is a result of more than thirty years of nonpoint source modeling with contributions to various aspects of the model from several federal agencies and numerous universities worldwide. It has become one of the most widely-applied watershed models in the U.S and elsewhere. SWAT is a physically based, continuous-time hydrologic and water quality model that is developed to predict the long-term impacts of land management practices on water, sediment and agricultural chemical yields in watersheds with varying soils, land use, and management conditions (Neitsch et. al, 2011). For watershed simulation, SWAT requires explicit information regarding weather, topography, soil properties, vegetation, and land management practices to simulate the physical and chemical processes including surface and subsurface flows, sediment transport, nutrient transport and cycling, transformation and movement of chemicals, and crop growth. SWAT has a GIS Extension called ArcSWAT2012 that facilitates model development, in terms of visualization and processing of model inputs including topography, land use and soils, watershed delineation into subbasins and HRU (hydrologic response unit) definition. Data required for model development is predominantly available from government agencies free of charge.

In modeling with SWAT, a watershed is delineated into subbasins. Based on unique intersection of land use, soil and slope categories, a number of hydrologic response units (HRUs) can be defined in each subbasin. In HRUs, which are the smallest modeling units, the water balance is represented by storage volumes for snow, soil profile (less than 2 meters below the surface), shallow aquifer (2-10 meters), and deep aquifer (greater than 20 meters). Flow, sediment, nutrient and pesticide loadings generated in the HRUs are added and routed through channel networks, reservoirs, ponds and/or wetlands to the watershed outlet.

Figure 5-1. Location of the Illinois River basin and its major watersheds

Modeling Major Watersheds of the Illinois River

Hydrologic and water quality models for major watersheds of the Illinois River basin are being developed watershed by watershed. Major steps of the watershed model development includes but not limited to:

- Spatial data processing of topography, land use and soils as model inputs
- Delineating the watershed and its subbasins, and defining hydrologic response unit (HRU) within the subbasins
- Climate data processing and preparation of model inputs including precipitation, maximum/minimum temperature, relative humidity, solar radiation and wind speed,
- Identifying land management conditions.

SWAT-CUP (Abbaspour et al, 2007), which is a collection of calibration and uncertainty programs for SWAT, has been used for calibrating the watershed models with observed flow and sediment. It provides a framework for both manual and automatic calibration, allowing better understanding of the watershed processes, model parameters and their sensitivity to the watershed responses being simulated. Observed flow and sediment data were obtained from USGS website and they are processed and formatted for use in the SWAT-CUP calibration projects.

SWAT watershed models have been developed for Spoon, Mackinaw, La Moine, Iroquois, Kankakee, Vermillion, Upper Sangamon and Upper Fox River watersheds of the Illinois River basin. Preliminary model calibrations to monthly streamflows and sediment loads were completed for Spoon, Mackinaw, La Moine, Iroquois and Kankakee. Streamflow calibrations were also done for Vermillion, Upper Sangamon and Upper Fox River watersheds. Next, sediment calibrations will follow depending on data availability. The ultimate goal is to complete SWAT models for major watersheds of the Illinois River for simulating flow and sediment and evaluating impacts of conservation efforts in the basin. In addition, these models could be useful to study watershed responses to changing climate and land use conditions. In the following section, model development for Spoon River watershed, which is one of the major tributary watersheds of the Illinois River, is briefly discussed and preliminary modeling results are also presented.

Spoon River Watershed Model

The Spoon River watershed, which is located in west-central Illinois, has a total drainage area of 1867 square miles. It has altitudes ranging from 950 feet in the northern part of the watershed to 420 feet at the confluence with Illinois River. Its climate is humid continental with cold, relatively dry winters and warm summers and the watershed's average annual precipitation is about 37.5 inches (950 mm). The majority of the soils in the watershed are loess and about three-fourths of the soils in the watershed exhibit moderate infiltration capacity, belong to hydrologic soil group B. The watershed is predominantly agricultural with croplands accounting for approximately 80 percent.

Input Data: Topographic information including National Elevation Data (NED) and National Hydrographic Data (NHD) that are required for watershed delineation were downloaded from EPA's BASINS website (available at http://www.epa.gov/waterscience

/ftp/basins/gis_data/huc/). The 2011 National Land Cover Dataset (NLCD) were used for general classification of the watershed's land use as shown in Figure 5-2 and it was obtained from Multi-Resolution Land Characteristics Consortium (MRLC) project (available at http://www.mrlc.gov/nlcd2011.php). Crop Data Layers (CDLs) generated by the USDA's National Agricultural Statistics Service (available at http://nassgeodata.gmu.edu-/CropScape/) were used to capture the annual variations of the land uses in the watershed. Soil characteristics of the watershed were extracted from SURRGO soil maps obtained from USDA's web soil survey site (available at http://websoilsurvey.sc.egov.usda.gov). Precipitation and temperature data were obtained from Midwest Regional Climate Center (MRCC) for 19 stations within and near the watershed. For calibrating and validating the watershed model, stream flow and sediment data were obtained from USGS for Spoon River at Seville (5570000), which is the nearest gauging station to the watershed outlet.

Herbaceous Wetlands

Figure 5-2 Land uses of Spoon River watershed

Model Setup, Calibration and Validation: Using ArcSWAT2012, the Spoon river watershed model was set up through delineation of the watershed into 45 subbasins using a threshold critical source area equal to 1.5 percent of the watershed area (see Figure 5-3). This threshold defines the detail of the stream network in the model and thereby determines the number of subbasins. Reach outlet is added to represent the calibration gauging station in the watershed model, thereby allowing extracting simulated watershed responses for comparison with observed ones. The subbasins were further subdivided into 444 HRUs based on unique combination of land use, soil and slope categories and a minimum threshold area of 10 percent was used for representing a given land use, soil or slope category in the model.

Sub-basins

Figure 5-3 Spoon River watershed delineation into subbasins

Using SWAT-CUP, multi-variable model calibration (i.e., simultaneous calibration of flow and sediment) followed by validation were done using observed flow and sediment data for Spoon River at Seville. The flow calibration and validation periods were 1986-2000 and 2001-2010, respectively. Sediment was calibrated for 2003-2010 period and validated for 1993-1997 period so that the longer continuous period of sediment record be used for model calibration, rather than validation. Performance evaluation metrics including Nash-Sutcliffe efficiency (NSE, Nash and Sutcliffe, 1970) and percent bias (PBIAS) were calculated for model simulations of the watershed responses. Preliminary calibration and validation results for Spoon River at Seville are presented in Figure 5-4 for flow and sediment, respectively. The minimum NSE and the worst PBIAS obtained were 0.8 and -15.5% for flow, and 0.57 and -14.5% for sediment simulations, respectively, indicating good model performance.

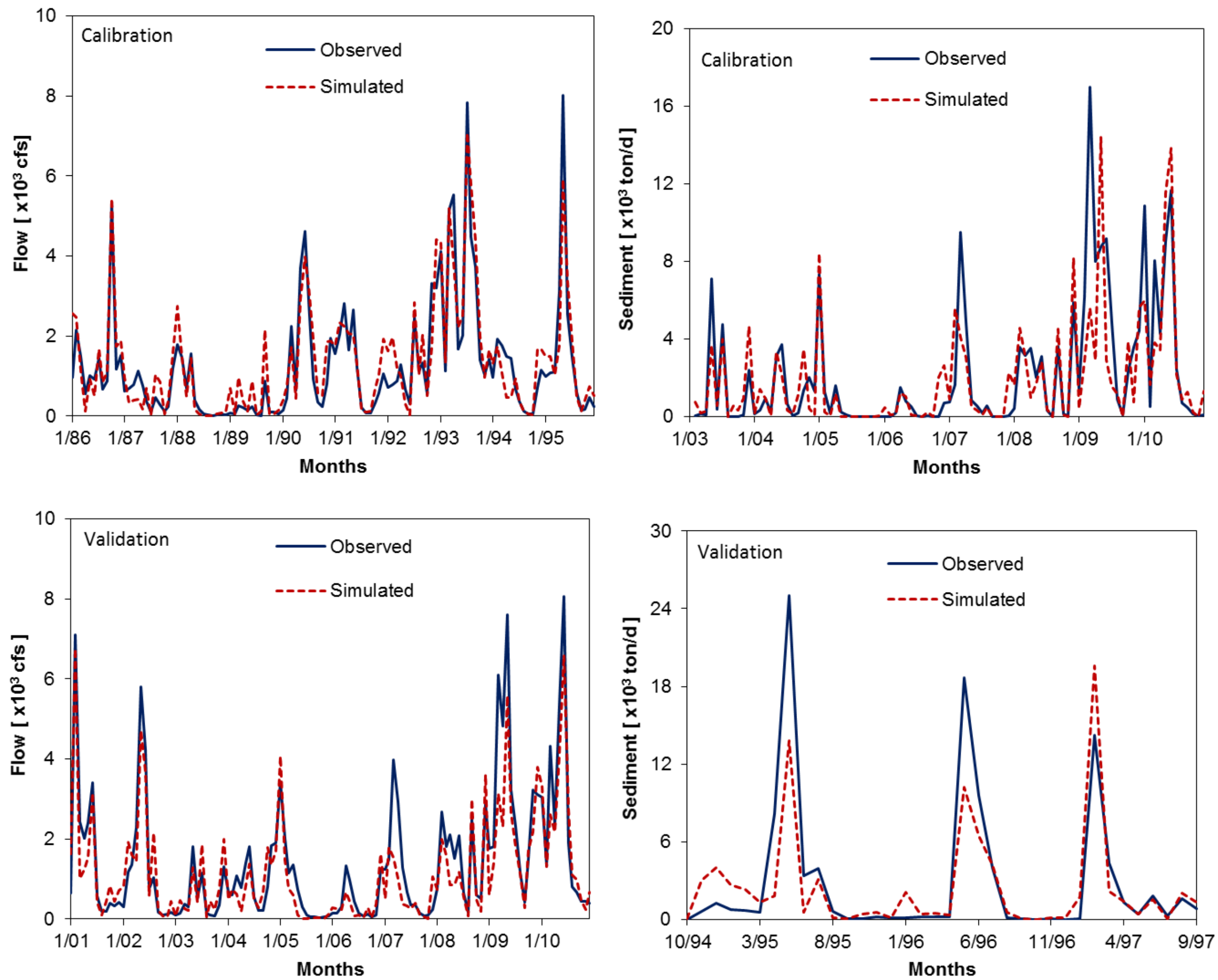


Figure. 5-4 Calibration and validation results for Spoon River at Seville

Developing Models for CREP Monitoring Watersheds

Hydrologic and water quality models are being developed for the 4 subwatersheds of Spoon River and 2 subwatersheds of Sangamon River, where there are 16 years of CREP monitoring data including flow, sediment and different species of nutrients. Detailed calibration and validation of these subwatersheds allow transferring model parameters to other ungauged parts of their respective watersheds with similar land use, soil and management conditions. The development of CREP monitoring watershed models will help evaluate the effectiveness of the CREP program in terms of reducing nonpoint source pollution. Furthermore, these models could be used to evaluate the water quality benefits of different best management practices such as cover crops in comparison with current practices. For illustration purposes, the Court Creek watershed model (Spoon River watershed), which is one of the CREP monitoring watershed models, is presented in the following section.

Court Creek Watershed Model: To develop SWAT model of Court Creek watershed, inputs including NED, land uses and soils were obtained from same sources as for the larger Spoon watershed model described above. In addition, information on acreage of CREP areas and associated enrollment periods were available for the watershed and thus, incorporated into the watershed model. In the model, the watershed was delineated into 26 subbasins that were further divided into 976 HRUs based on homogeneous land use, soil and slope categories. In addition, areas with unique CREP conservation practices were defined as HRUs. No or zero threshold area was used to define agricultural and CREP HRUs to preserve acreages of croplands or conservation practices in the model. For all other HRUs, a 10% threshold area was used for defining HRU land uses. Detailed management conditions were prepared for all agricultural HRUs and CREP conservation practices (e.g., CP21 is filter strip) were identified to simulate CREP HRUs. CREP enrollment duration was used to appropriately assign land operation schedules for those HRUs during the simulation period.

Hydrologic and water quality data obtained from CREP monitoring stations were used during model calibration and validation. Figures 5-5 and 5-6 illustrate graphical comparisons of observed and simulated flows, sediment, nitrate and TP loads for Court Creek watershed at station 301. Model calibrations for flow, sediment, nitrate and total phosphorus (TP) were done using many-objective optimization algorithms coupled with the watershed model, allowing simultaneous auto-calibration of the watershed responses. The calibration NSE values obtained for monthly flow, sediment, nitrate and TP are 0.77, 0.67, 0.57, and 0.56, respectively, and the corresponding PBIAS are 4.7%, 17.5%, 12.0% and -15.6%. For the validation period, the NSE values for flow, sediment, nitrate and TP simulations are 0.81, 0.72, 0.58, and 0.51, respectively, and the associated PBIAS are -4.1%, 4.2%, 0.2% and -22.5%. The performance evaluation ratings for validation period indicate a slight improvement over that of calibration period. Both calibration and validation results show good model performance for flow and sediment, and are satisfactory for nutrient simulations.

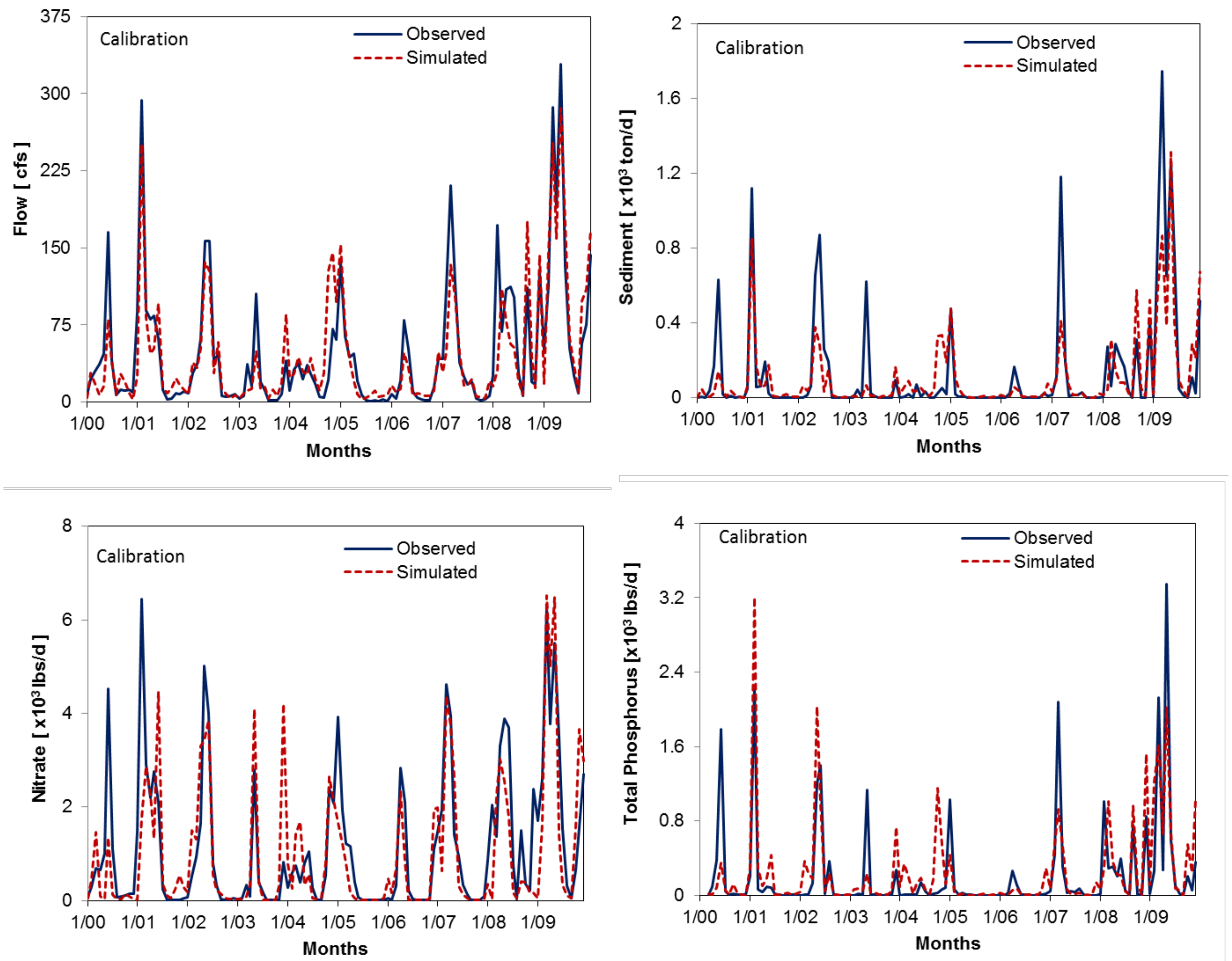


Figure 5-5 Calibration results for Court Creek watershed (#301)

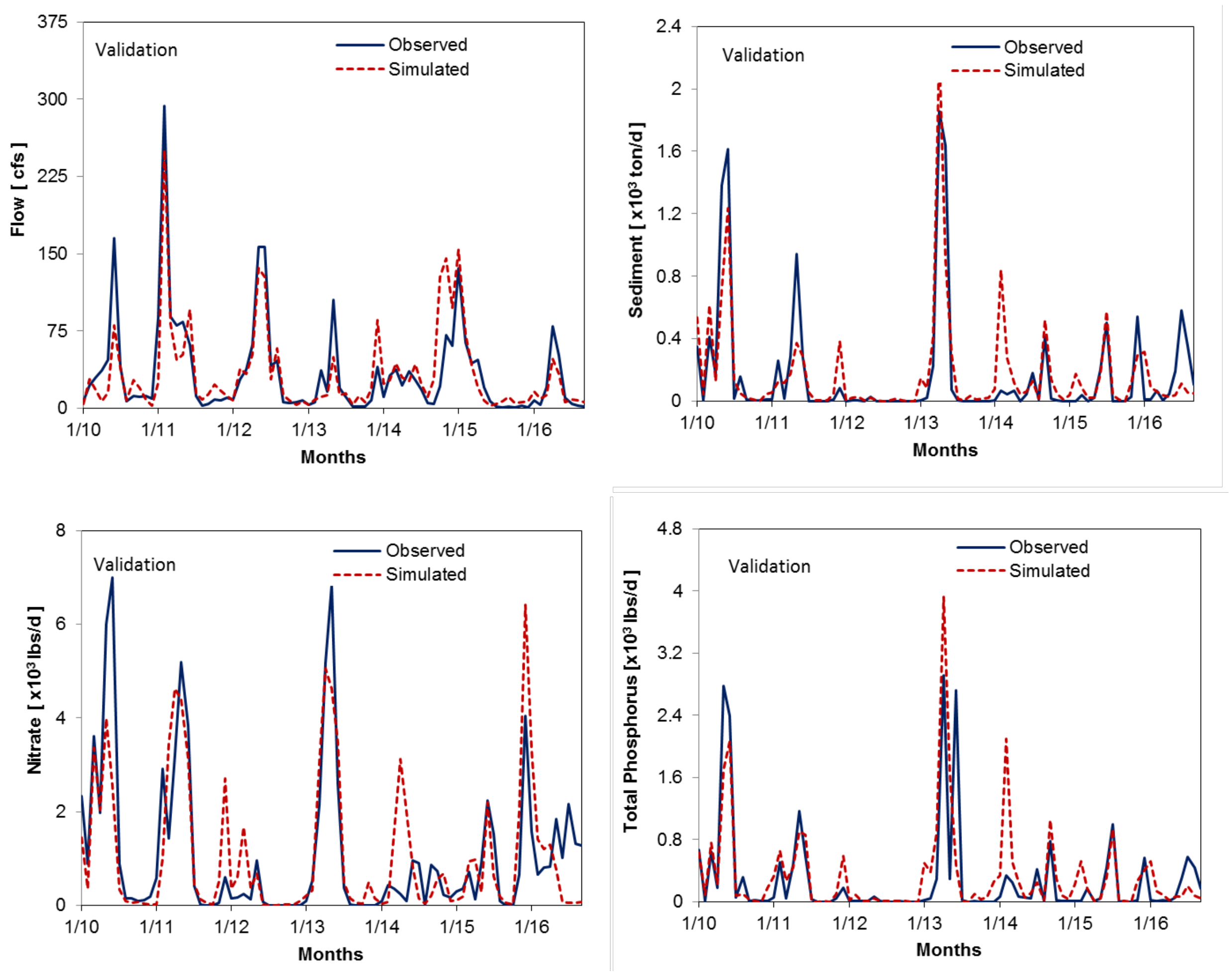


Figure 5-6 Validation results for Court Creek watershed (#301)

Water Quality Trend in CREP Monitoring Watersheds

Data analysis and modeling were conducted to evaluate the water quality trends in CREP monitoring watersheds. Sediment and nutrient fluxes were estimated through modeling the concentration-discharge relationships. Annual mean concentrations were calculated to perform inter-year comparisons, removing the impact of sampling frequency. To detect water quality trends, flow-normalized fluxes of sediment and nutrient were computed, eliminating the influence of annual flow variability and thereby providing more insight into the effectiveness of the conservation efforts. Preliminary results for annual trends for mean flow, sediment, nitrate and total phosphorus fluxes are shown in Figure 5-7 for Court Creek watershed (i.e. station# 301 at the watershed outlet). The mean daily flow shows an increasing trend where sediment and nutrient fluxes show a decreasing trend. All trends are statistically significant with at least 90% confidence level. The analysis results indicate the positive impact of increasing CREP enrollment in the Court Creek watershed through the years, in terms of reducing sediment and nutrient fluxes to downstream. The effectiveness of CREP could further be improved through optimal selection and placement of the conservation practices in the watersheds.

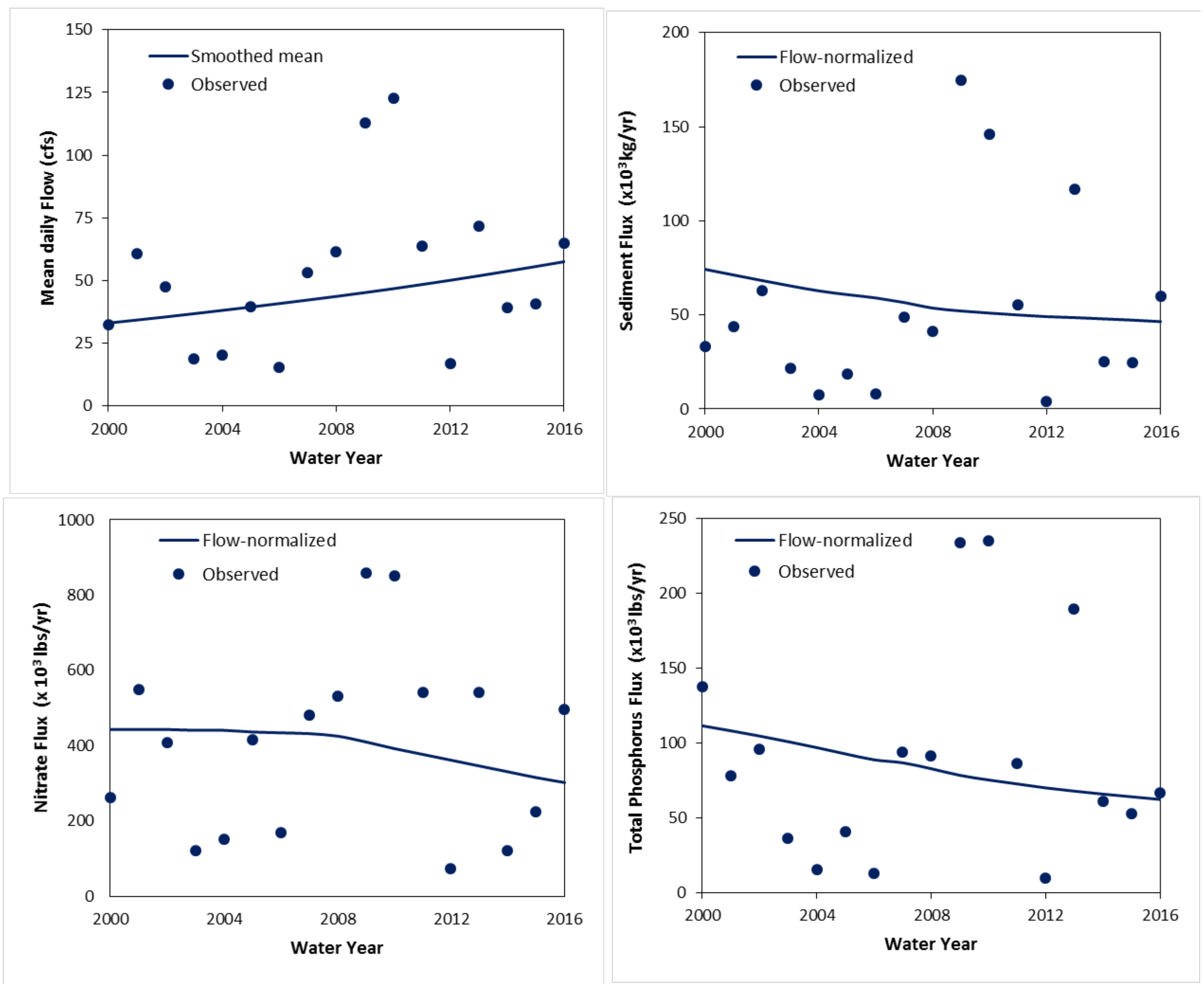


Figure 5-7 Annual trend analysis results for Court Creek watershed (#301)

6. Analyses and Discussion

Sediment Loadings

Based on sediment records since 1980, the Illinois River on the average receives approximately 13 million tons of sediment annually from tributary streams (Demissie et al., 2016). About 60 percent of the sediment delivered to the river (7.8 million tons) is deposited in the river, backwater lakes, and side channels along the river. Most of this sediment is generated in the tributary watersheds to the Lower Illinois River, with the Spoon and LaMoine River watersheds as the highest per unit area generators of sediment among the major tributaries. The smaller tributaries draining directly to the river also contribute significant sediment. Controlling the erosion processes that are producing excessive sediment and reducing sediment delivery to the Illinois River will be a long-term effort, since sediment storage and mobilization along major rivers is a slow process. It will take some time to flush the sediment already in the system. In the initial phase of a restoration project, the major goal is to stabilize the system so that the erosion process is not accelerating and generating more sediment. The readjustment processes will take a number of years to reach a dynamic equilibrium condition where the natural processes of erosion and sedimentation are in balance. The long-term goal of the Illinois River restoration projects is to reach such a state where continued excessive sedimentation is eliminated.

To assess these processes, long-term monitoring is needed. The CREP program has been collecting sediment data at selected watersheds to supplement other monitoring programs. The data collection for the CREP program started in 1999 and has generated seventeen years of data. The annual sediment load data for each of the five CREP monitoring stations have been presented in chapter 2. Because of the short duration of data collection program, this data cannot yet be used to assess long-term trends. However, to illustrate the character of sediment transport over time, figure 6-1 shows that sediment load per unit area was normalized by runoff in inches to account for the variability of runoff from year to year. Extreme wet years such as 2002 and 2008 stands out. The high values for Panther (201) and Cox (202) Creeks are due to one or two isolated intense storms. Also, the 2012 drought had a severe effect on loadings. In general there appears to be cycles in the yield characteristics and Again, any major climatic or hydrologic variability in the coming years could change the trends, as illustrated with the influence of 2008 on Panther and Cox Creeks. As we continue the monitoring program, the trends will be more clear and reliable as the duration of the monitoring period increases.

The data were also compared with historical data collected by the USGS for small watersheds in the Illinois River basin as shown in figure 6-2. As shown in the figure, the CREP dataset is consistent with the older dataset and will be used to develop improved sediment delivery estimates for small watersheds in the Illinois River basin and improve our assessment and evaluation capability.

To assess long-term trends, data collected by the USGS and ISWS since 1980 were used to compute sediment delivery for the major tributaries to the Lower Illinois River. For the USGS data, sediment delivery from the three major tributary watersheds to the Lower Illinois River was computed for the downstream gaging stations near the outlet of the watersheds using the same methods developed by Demissie et al. (2004). The outflow of sediment from the Illinois River basin is measured at Valley City. The sediment loads and the corresponding water discharges for

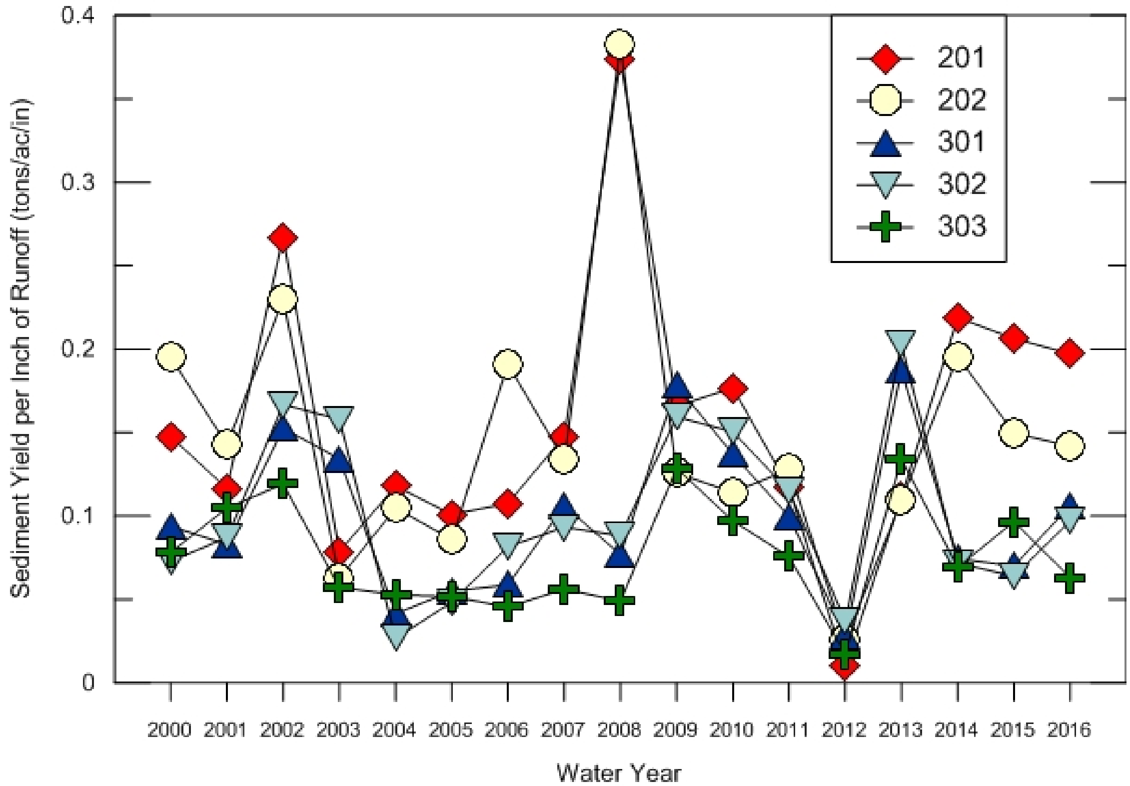


Figure 6-1. Variability of sediment yield per inch of runoff for CREP monitoring stations

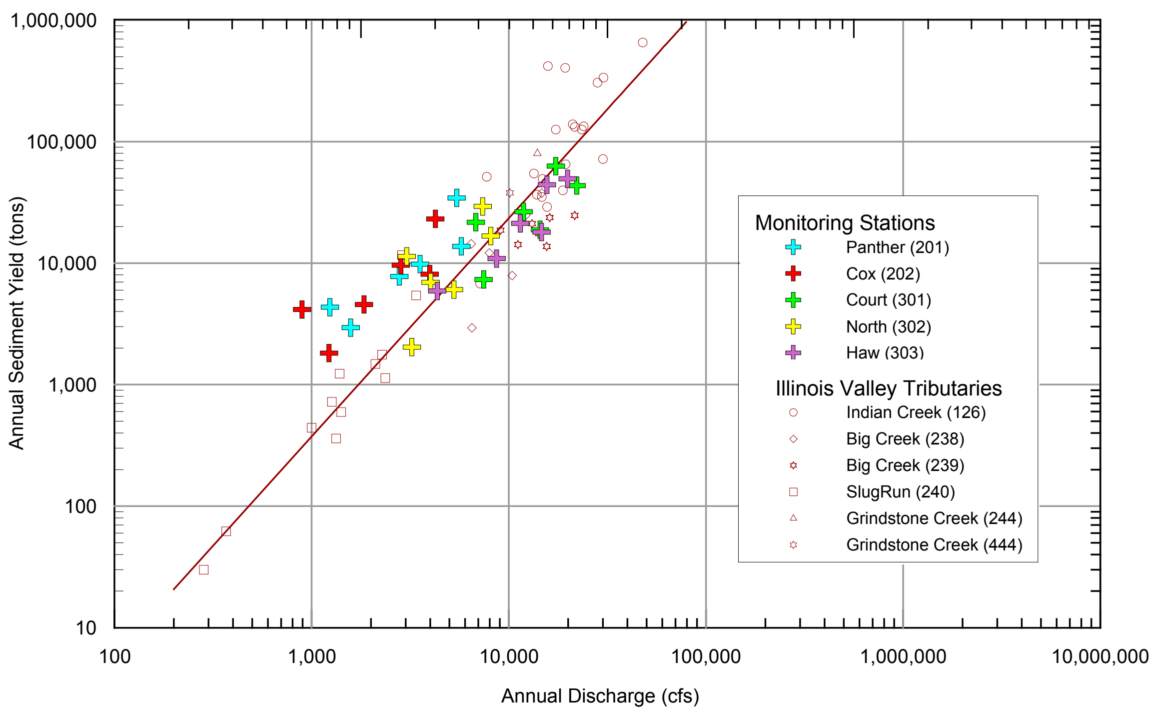


Figure 6-2. Comparison of sediment load from CREP monitoring stations with historical sediment data for small watersheds by the USGS

five-year increments 1980 to 2005 are shown in figure 6-3. This data has recently been updated through 2015 and analyses will be presented in the 2018 annual report.

The Benchmark Sediment Monitoring Program has been collecting weekly sediment data at selected monitoring stations throughout the state since 1980 (Allgire and Demissie, 1995). The data collected over that last 35 years have been processed and analyzed to observe trends in sediment concentrations and loads. Figures 6-4 to 6-5 show the trend in sediment load since 1980 for the Kankakee River near Wilmington near the upper (eastern) portion of the Illinois River Basin and the Spoon River at London Mills which is the the lower (western) portion of the Illinois River Basin, respectively. Both stations appear to have decreasing trend since 1980. However, it is not statistically significant. Further analyses of this data in context with other long-term data sources is continuing.

Nutrient Loadings

To assess trends in nutrient loadings as conservation practices are implemented, the ISWS has been collecting nutrient data at the five CREP monitoring stations since 1999, providing seventeen water years of information. Even though there are some low and high nutrient load years, the dataset is not considered statistically long enough to assess long-term trends in nutrient loading. However, the short-term trends based on the data collected so far are shown in figures 6-6 and
6-7 for nitrate-N and total phosphorus yields per inch of runoff (yield/runoff) respectively. The nutrient yield values (total load per unit area) were divided by the inches of runoff to partly remove the effect of the variability of runoff from year to year. However, the variability in the spatial distribution of precipitation for smaller watersheds cannot be completely removed. As shown in figure 6-6, the nitrate-N yield/runoff show a gradual decline since 2006 for all stations except for a spike in 2013 for stations 201, 202 and 303 following a major drought in 2012. Figure 6-7 shows no significant trend for total phosphorus over the whole monitoring period except for the jump in yield/runoff in 2000 and 2008 for stations 201 and 202,a significant drop for all the stations in 2012 due to the drought and, similar to nitrate-N, spike in 2013 for 301, 302 and 303. However, some observations can be made with this short-term data. As can be seen in Figure 6-6, except for 2000 and 2012, nitrate-N yield/runoff is highest every year at station 202 (Cox Creek). Most years, yield/runoff is lowest at stations 301 and 302 (Court Creek). Similar observations cannot be made for total phosphorus.

Long-term data collected by the Illinois EPA as part of their Ambient Water Quality Monitoring Network can, however, provide a fair indication of the general long-term trend in nutrient delivery to the Illinois River. Figure 6-8 shows the 1975-2014 annual nitrate-N yields in tons per square mile from the three major tributaries of the Lower Illinois River (Spoon, Sangamon, and LaMoine Rivers). Nitrate-N represents about 70 percent of the total nitrogen load in most of Illinois' agricultural watershed, and thus is a good surrogate for total nitrogen load. As can be seen in the figure, the nitrate yields can range from almost zero during a drought year like 1989 to a high of about 11 tons per square mile during a major wet period like the 1993 flood year. Therefore, climatic factors do play a major role in nutrient transport and delivery. The most important observation that can be made for the figure is the slow decreasing trend of nitrate-N yield from the major tributary watersheds. Even though it is very difficult to measure how much of the change is due to the CREP program, it appears that conservation practices in

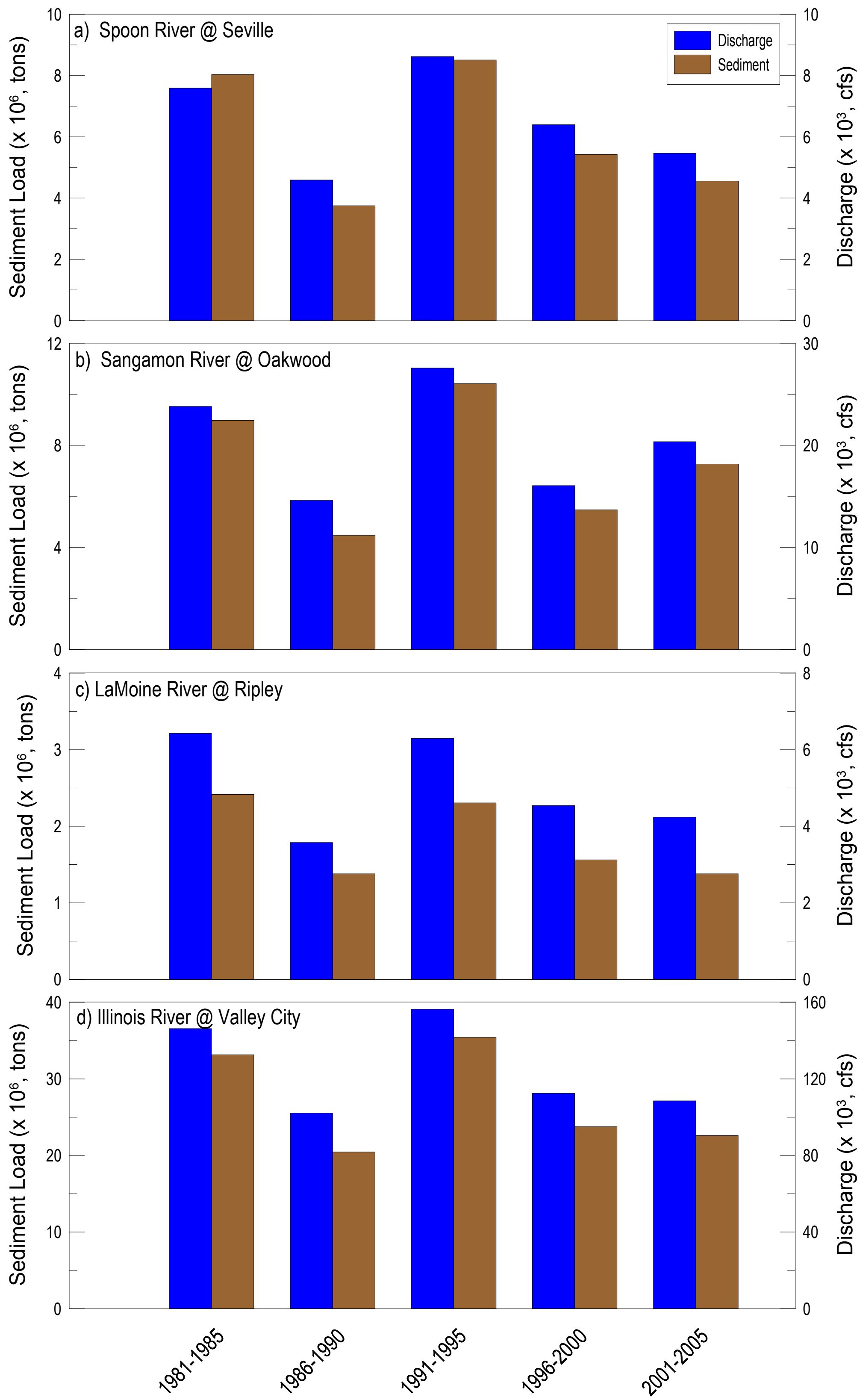


Figure 6-3. Sediment delivery from the three major tributary watersheds to the Illinois River and sediment outflow from the Illinois River at Valley City

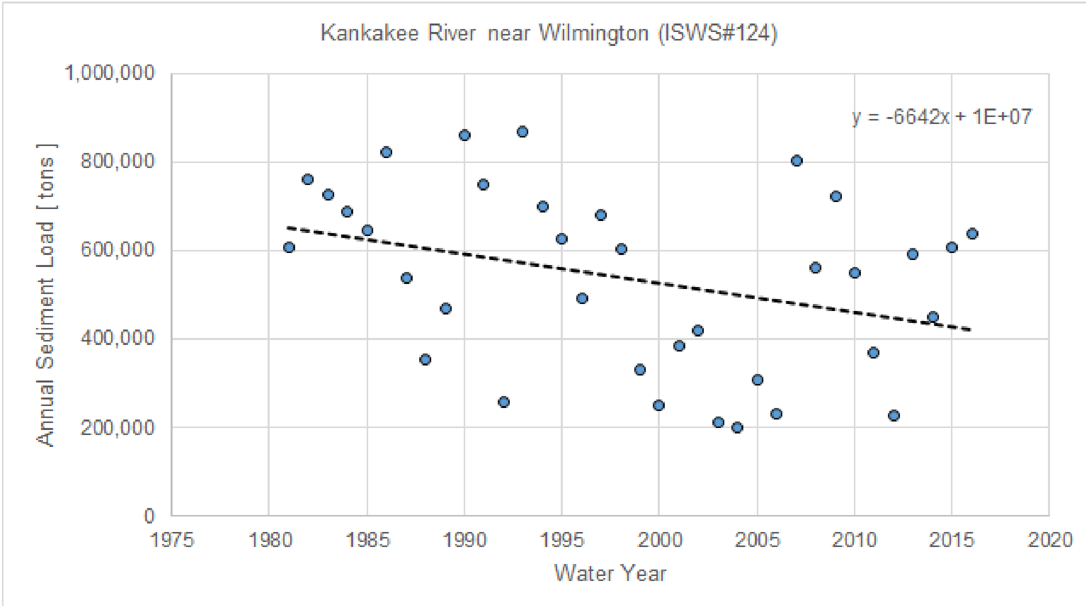


Figure 6-4. Trends in sediment load at Kankakee River near Wilmington, IL

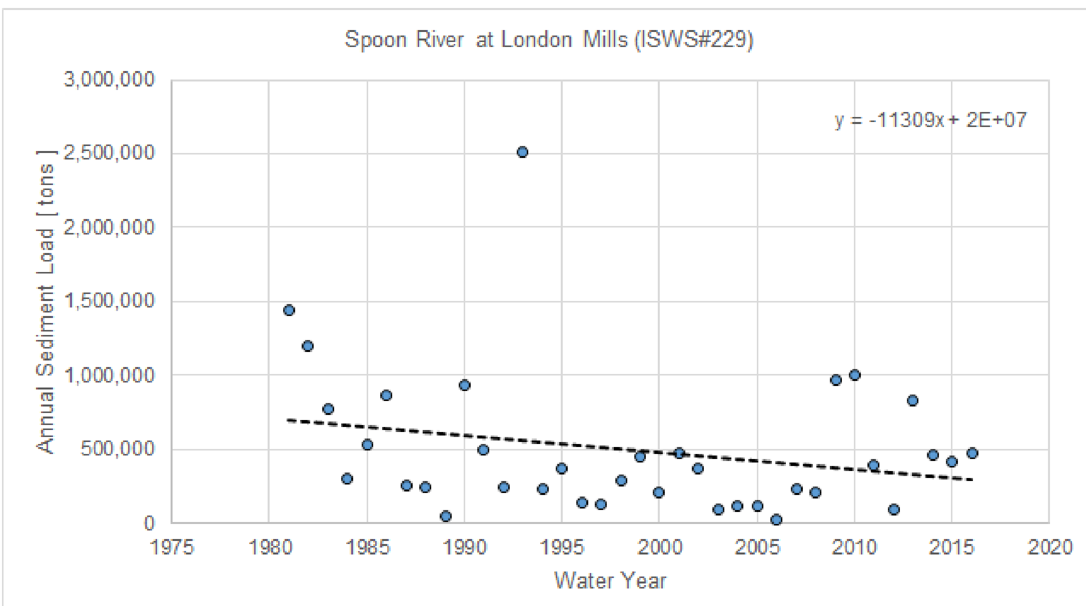


Figure 6-5. Trends in sediment load at Spoon River at London Mills, IL

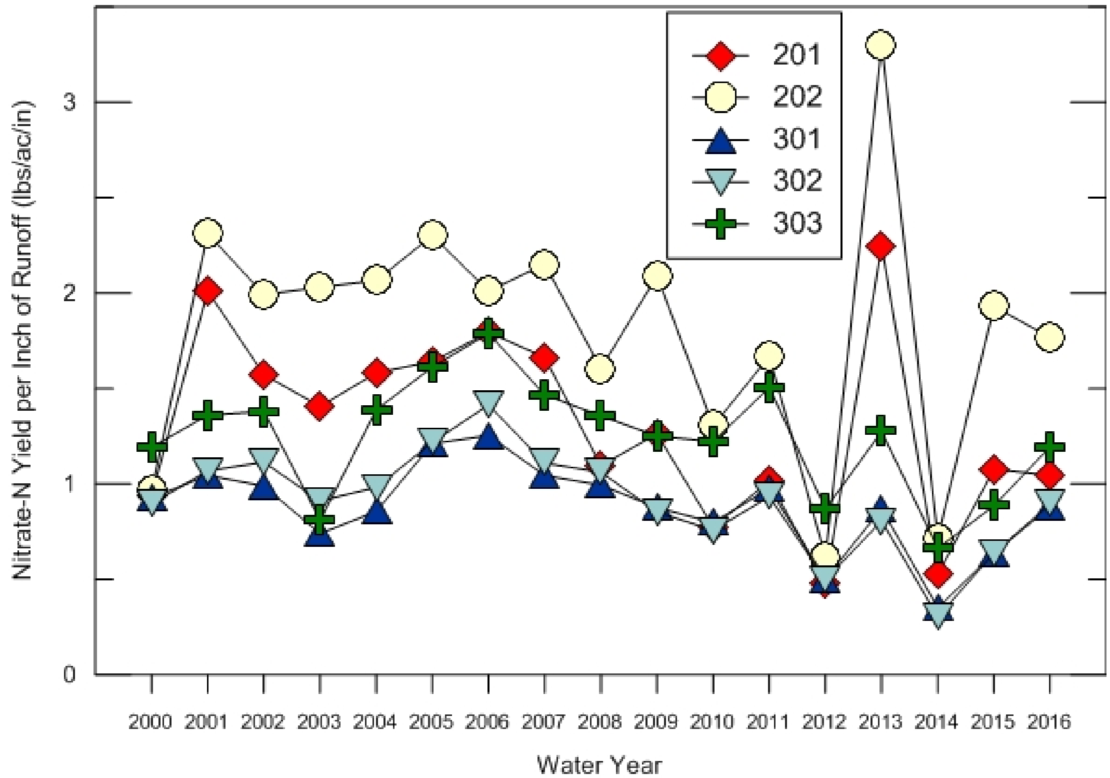


Figure 6-6. Variability of nitrate-N yield per inch of runoff for CREP monitoring stations

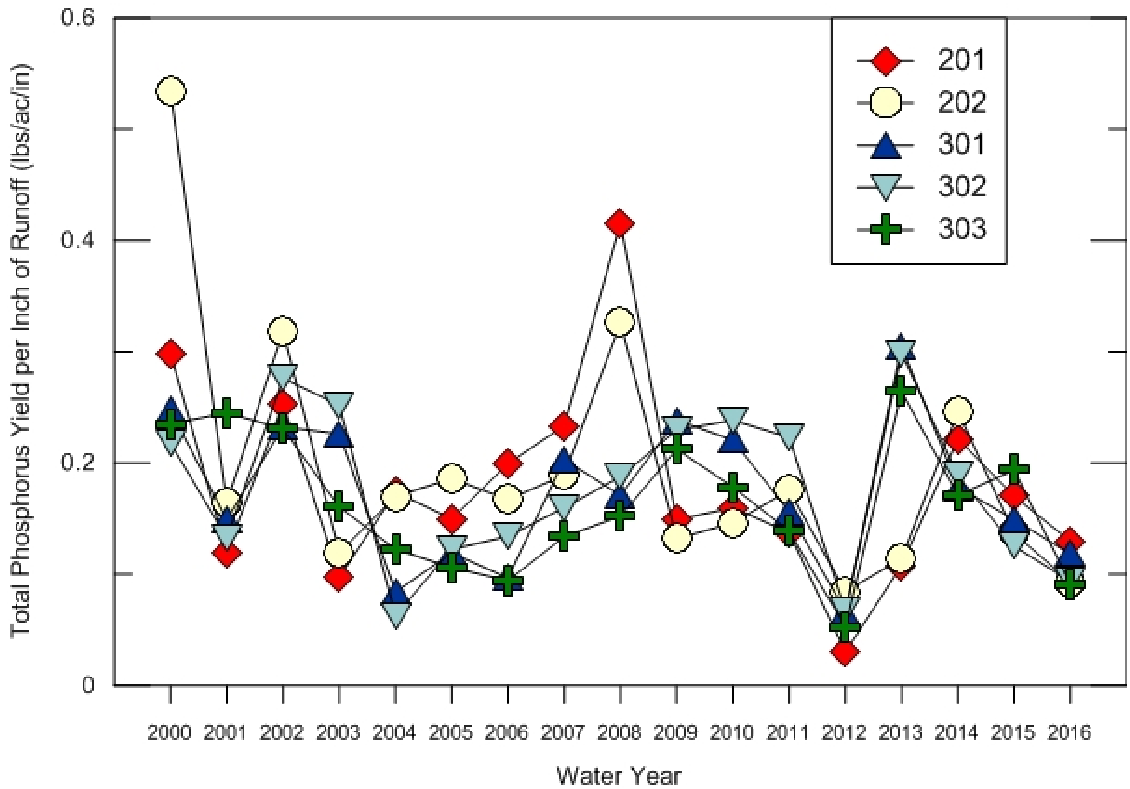


Figure 6-7. Variability of total phosphorus yield per inch of runoff for CREP monitoring stations

these watersheds, where most of the CREP lands are located, are making a difference in nitrogen delivery to the Illinois River. This current analyses uses data through 2014 and will be updated for the next annual report.

Figure 6-9 shows the total phosphorus yield from the same three major tributary watersheds discussed in the previous figure. Annual phosphorus delivery ranges from a low of almost zero during the drought years 1989, 2006, and 2012 to a high of almost 1.7 tons per square mile for the extreme wet year of 1993. The data also show how extremely dependent phosphorus delivery is on climatic variability. Similar to the trends to the nitrate delivery, there was a slow but gradual decreasing trend in phosphorus yield from the Spoon and LaMoine Rivers until 2007 and an increase since then except for the drought year 2012. Overall, there is a gradual increase in phosphorus primarily driven by increases in dissolved phosphorus starting in 2007.

The trends in nutrient loads from the major tributaries are reflected in nutrients transported by the Illinois River. Analyses of the 1975-2014 data from the two downstream monitoring stations, Havana and Valley City, are shown in figure 6-10 for nitrate-N and total phosphorus. In general, the trend is a gradual decrease for nitrate-N for the whole period and a decreasing trend from 1975 to 2006 for phosphorus, but increased starting in 2007 primarily due to an increase in dissolved phosphorus loading. The cause for a sudden increase in dissolved phosphorus starting in 2007 disrupting a long-term decreasing trend from 1975 to 2006 needs to be studied closely to find the primarily cause. These observations are extremely important as to nutrient delivery from Illinois streams to the Mississippi River and eventually to the Gulf of Mexico. Illinois had been identified as one of the major sources of nutrients to the Gulf of Mexico, and the fact that nitrate delivery from Illinois has not increased and is gradually decreasing is good news not only to Illinois and the Illinois Nutrient Loss Reduction Strategy but to the Gulf of Mexico. Again, this data will be updated for the next annual report.

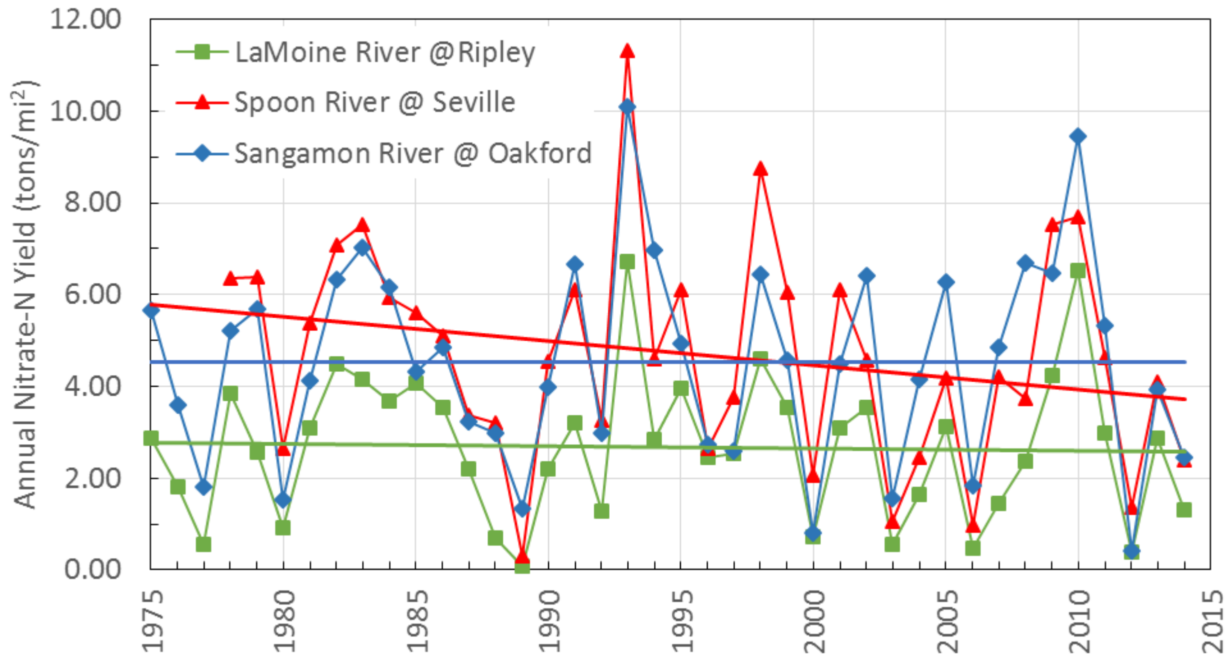


Figure 6-8. Annual nitrate-N loads for the three major tributary watersheds to the Lower Illinois River

-

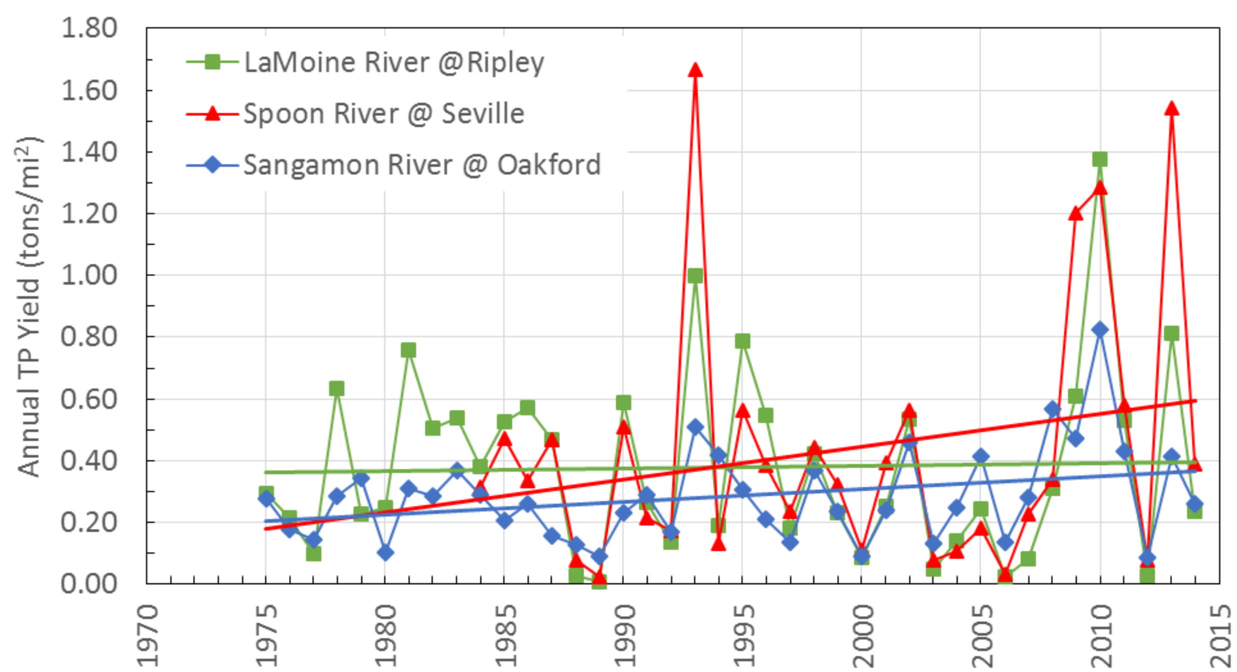


Figure 6-9. Annual total phosphorus loads for the three major tributary watersheds to the Lower Illinois River

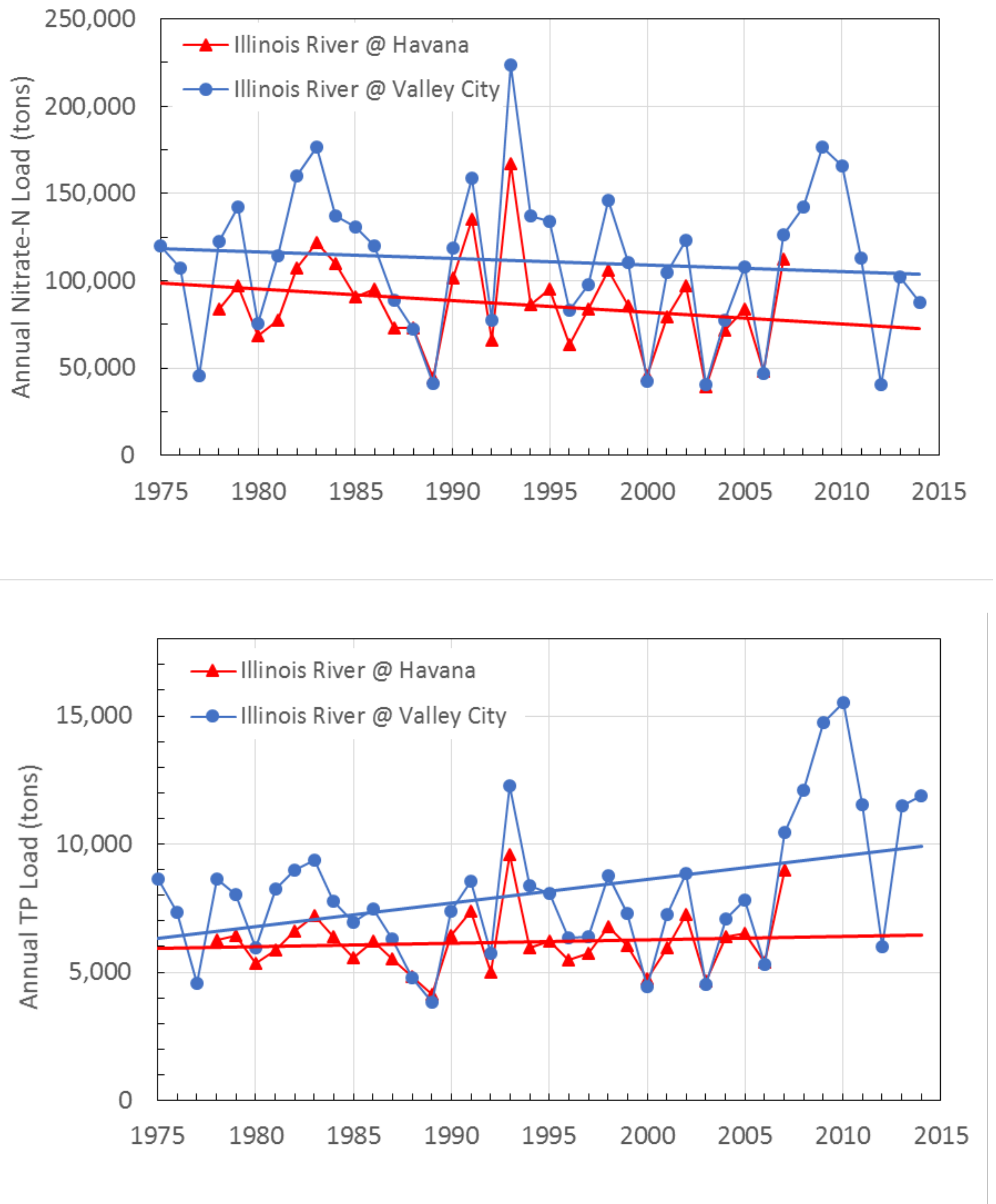


Figure 6-10. Nitrate-N and total phosphorus loads along the Lower Illinois River

7. Summary and Conclusions

The Illinois River Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois River Basin (IRB). Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the Illinois River were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois River CREP were to reduce the amount of silt and sediment entering the main stem of the Illinois River by 20 percent; and to reduce the amount of phosphorus and nitrogen loadings to the Illinois River by 10 percent. To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation.

The monitoring and data collection component consist of a program to monitor sediment and nutrient for selected watersheds within the Illinois River basin and also to collect and analyze land use data throughout the river basin. Historically, there are a limited number of sediment and nutrient monitoring stations within the Illinois River basin, and most of the available records are of short duration. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources has been funding the Illinois State Water Survey to establish and maintain a monitoring program to collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Illinois River basin that will assist in making a more accurate assessment of sediment and nutrient delivery to the Illinois River. Five small watersheds located within the Spoon and Sangamon River watersheds were selected for intensively monitoring sediment and nutrient within the Illinois River basin. The Spoon River watershed generates the highest sediment per unit area in the Illinois River basin, while the Sangamon River watershed is the largest tributary watershed to the Illinois River and delivers the largest total amount of sediment to the Illinois River.

As outlined in the Illinois River Basin Restoration Plan, the alternative of no-action in the Illinois River watershed would have resulted in increased sediment delivery to the Illinois River and habitats and the ecosystem would continue to degrade. However, analysis of the available long term data from different sources and the most recent data from the CREP monitoring program, indicate that sediment and nutrient loads from the tributary watersheds are gradually decreasing or stabilizing as a result of implementation of conservation practices in the watershed. We have also observed a recent rise in phosphorus delivery from the major tributaries since 2007 primarily driven by dissolved phosphorus. These increases are not observed from the CREP monitoring sites. With the knowledge that reduction in sediment delivery from large watersheds takes time to move through the system, the indication of stabilized sediment delivery shows progress is being made in restoring the Illinois River watershed. If the present trends continue for the next 10 to 15 years, sediment and nutrient delivery to the Illinois River will be significantly reduced, and lead to improved ecosystem in the river and tributary watersheds in the long-term.

8. References

Abbaspour K. C., M. Vejdani, and S. Haghighat. 2007. SWAT-CUP calibration and uncertainty programs for SWAT. In *Proc. Intl. Congress on Modelling and Simulation (MODSIM'07)*, 1603-1609. L. Oxley and D. Kulasiri, eds. Melbourne, Australia: Modelling and Simulation Society of Australia and New Zealand.

Allgire, R.L., and M. Demissie. 1995. *Benchmark Sediment Monitoring Program for Illinois Streams: Program Summary and Site Descriptions*. Illinois State Water Survey Circular 181.

Demissie, M., E. Getahun, and L. Keefer. 2016. *The Sediment Budget of the Illinois River: 1981-2015*. Illinois State Water Survey Report of Investigation 2016-122.

Demissie, M., L. Keefer, and J. Slowikowski, A. Russell, T. Snider, and K. Stevenson. 2001. *Sediment and Nutrient Monitoring at Selected Watersheds within the Illinois River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP).* Illinois State Water Survey Contract Report 2001-12.

Demissie, M., R. Xia, L. Keefer, and N. Bhowmik. 2004. The Sediment Budget of the Illinois River. Illinois State Water Survey Contract Report 2004-13.

Demissie, M., and N.G. Bhowmik. 1986. *Peoria Lake Sediment Investigation*. Illinois State Water Survey Contract Report 371.

Demissie, M. R. Xia, L. Keefer, and N. Bhowmik. 2004. *The Sediment Budget of the Illinois River.* Illinois State Water Survey Contract Report 2004-13.

Knapp, H.V. 2005. Analysis of Streamflow Trends in the Upper Midwest Using Long-Term Flow Records. *Proceedings of the 2005 Water and Environmental Resources Congress*. American Society of Civil Engineers, May 15-19, 2005, Anchorage, AK.

Luman, D.E., 2008, Assessment & Potential of the 2007 USDA-NASS Cropland Data Layer for Statewide Annual Land Cover Applications, unpublished report of investigations including five appendices, Illinois State Geological Survey, 17 pp. http://crystal.isgs.uiuc.edu/nsdihome/webdocs/landcover/nass07.html.

Luman, D. and T. Weicherding. *Land Cover of Illinois: 1999-2000*. 1999 January 1999 [cited 2003 November 1, 2003]; Available from: http://www.agr.state.il.us/gis/index.html.

Nash, J. E., and J. E. Sutcliffe. 1970. River flow forecasting through conceptual models: Part I. A discussion of principles. *J. Hydrol.* 10(3): 282-290.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2011. *Soil and water assessment tool: Theoretical documentation*. TR-406. Grassland, Soil and Water Research Laboratory, Agricultural Research Service, College Station, TX.

Ramamurthy, G.S., K.P. Singh, and M.L. Terstriep. 1989. *Increased Durations of High Flows Along he Illinois and Mississippi Rivers: Trends and Agricultural Impacts (Final Report)*. Illinois State Water Survey Contract Report 478.

Short, M.B. 1999. *Baseline Loadings of Nitrogen, Phosphorus and Sediments from the Illinois Watersheds*. Illinois Environmental Protection Agency, IEPA/BOW/99-020, Springfield, IL.

Singh, J., H. V. Knapp, Y. Lian, and M. Demissie. 2003. The Illinois River Basin Hydrologic Model. *Proceedings, 2003 Governor's Conference on the Management of the Illinois River System*. Oct. 2003, Peoria, IL, pp.73-84.

State of Illinois, Department of Natural Resources, 2002. Illinois Conservation Reserve Enhancement Program (CREP) 2002. Annual Report for Reporting Period October 2000 through September 2001, Springfield, IL.

U.S. Army Corps of Engineers. 2006. *(Draft) Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment*. Rock Island District, Rock Island, IL.