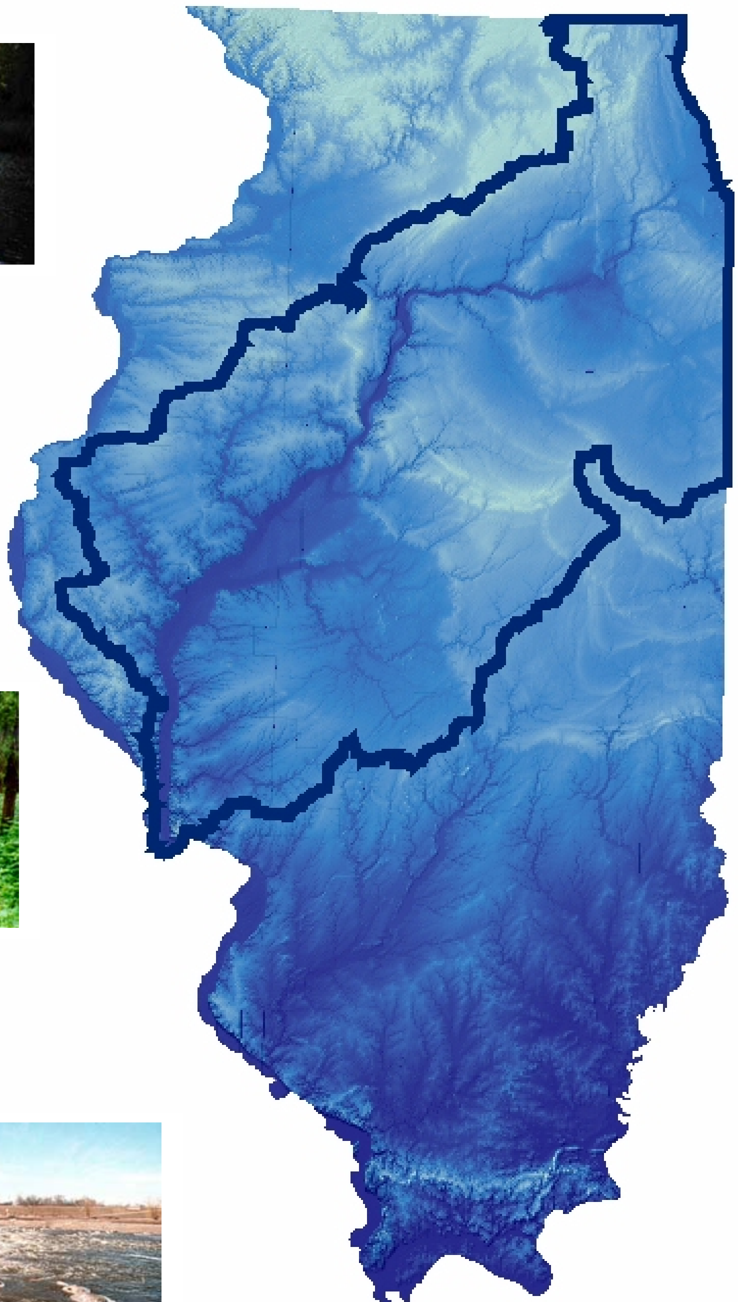
ILLINOIS

Conservation Reserve Enhancement Program
2004 Annual Report

A Partnership Between The USDA and the State of Illinois



THEN

NOW

Illinois Conservation Reserve Enhancement Program
(CREP)
Reporting Period: October 1, 2003 through September 30, 2004

The Illinois Conservation Reserve Enhancement Program (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.

Since the beginning, the program has been extremely well received by the landowners in the targeted area. The MOA was re-authorized by all the parties on December 18, 2002 increasing the eligible acreage for enrollment to 232,000 acres. Since that time, the state's program re-opened for a brief period of time to provide landowners already enrolled in the federal program the opportunity to enroll on the state's side. A total of 6,657.12 acres were enrolled in that time period.

CREP is being implemented through a federal-state-local partnership in the eligible area. The Agencies that are implementing the program are USDA - Farm Service Agency (FSA), USDA - Natural Resource Conservation Service (NRCS), the Illinois Department of Agriculture (IDOA), the Illinois Environmental Protection Agency (IEPA), the Illinois Department of Natural Resources (IDNR), and the County Soil and Water Conservation Districts (SWCDs) along with the Association of Illinois Soil and Water Conservation Districts (AISWCD) in the eligible area. Other agencies and organizations provide guidance and assistance for the program through the CREP Advisory committee, which is a subcommittee of the State Technical Committee.

ENROLLMENT SUMMARY:

For the reporting period of October 1, 2003 through September 30, 2004, the Federal CREP Program in Illinois was closed.

During the same reporting period, the State approved 114 contracts enrolling 6,657.12 acres into State options. A total of 5,996.92 acres or 90.1% of the acres in State Options are enrolled in permanent easements. Another 345 acres or 5.2% are in 35-year contract extensions, and 315.2 acres or 4.7% are in 15-year contract extensions. The average state incentive payment per acre for these enrollments is $483 per acre. The average cost to the State per acre is $637 per acre, which includes the incentive payment, cost-share, administrative expenses, state technical assistance and legal expenses.

TECHNICAL ASSISTANCE AND PROGRAM STAFF:

Technical assistance in this program is made up of three types:

1. Assistance to the landowners during the enrollment process in determining eligibility, options, and selecting approved practices;
2. Assistance to landowners in implementing the approved CREP practice once the property is enrolled in the program; and
3. Assistance to the SWCD and landowners in the state requirements for execution of the state easement documents.

The Farm Service Agency, Natural Resource Conservation Service, Department of

Natural Resources, and the County Soil and Water Conservation Districts provide primary technical assistance.

NON-FEDERAL CREP PROGRAM EXPENDITURES:

The State obligated $4,524,842 dollars for CREP expenditures to pay for the 114 State contracts (6,685.3 acres), State cost-share expenses, monitoring costs, SWCD administrative fees and other associated enrollment and easement costs. In addition, the IDNR has provided another $172,712.45 from its operational dollars to provide for CREP Administrative Expenses, bringing the total State dollars directly expended for CREP enrollments to $4,697,554.63.

State CREP Expenses
October 1, 2003 through September 30, 2004

State Bonus Payment for State Option	$ 3,214,847.11
State Cost-Share Payments	$ 649,204.72
Soil and Water Conservation District (SWCD) Administrative Fees	$ 303,148.15
DNR Administrative Expenses - Contract and Data Management, Technical Assistance, Reports, Training	$ 172,712.45
Additional Admin. Fees – Legal, Survey, filing costs	$ 74,333.78
Monitoring	$ 283,308.42
TOTAL	$ 4,697,554.63

The federal CREP Program was not open for enrollment during this time period. However, 41 contracts were finalized by August 31, 2004. This was the most current federal funding information available at the time of this report. A summary of these enrollments follows: The total federal annual rent payment for the 41 CREP contracts (684.6 acres) is $95,685. The total annual incentive payment is $22,293. The total federal annual rent plus incentive and maintenance over the life of the 15-year contracts is $1,427,156. The estimated total federal cost-share is $132,269.

The Memorandum of Agreement (MOA) for the Illinois CREP, as amended on December 18, 2002, details the formula to determine the overall costs of the program and to determine if the State has fulfilled its obligation to provide 20% of the total program costs. To determine the overall costs of CREP, the following costs are to be used: the total land retirement costs, which will include the CRP payments made by the Commodity Credit Corporation 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 will be annual payments, an 8 percent per annum discount rate (per the MOA) will be used to compare the CRP Payments with the State Bonus payment.

Annual CRP Payments
Discounted at 8% for 15 Years

Payment Year	Annual Payment	Payment Year	Annual Payment
Year 1	$95,685	Year 9	$49,107
Year 2	$88,030	Year 10	$45,179
Year 3	$80,988	Year 11	$41,564
Year 4	$74,509	Year 12	$38,329
Year 5	$68,548	Year 13	$35,180
Year 6	$63,064	Year 14	$32,366
Year 7	$58,019	Year 15	$29,776
Year 8	$53,378	TOTAL 15 Years	$852,722

Total Federal and State Expenditures
October 1, 2003 through September 30, 2004

CRP Payments (Before Discount)	$1,427,156	CRP Payment (Discounted 8%)	$ 852,722
Federal Cost-Share	$ 132,269	Federal Cost-Share	$ 132,269
State Payments for CREP Enrollments	$4,697,555	State Payments for CREP Enrollments	$4,697,555
Total Program Costs	$6,256,980	Total Program Costs	$5,682,546

The total Federal and State costs of the CREP from October 1, 2003 through September 30, 2004 was $6,256,980. The State's share of costs for the reporting period was $4,697,555. Using the 8% per annum discount rate per the MOA, the Federal costs to be used for comparison to the state expenditures are $852,722.

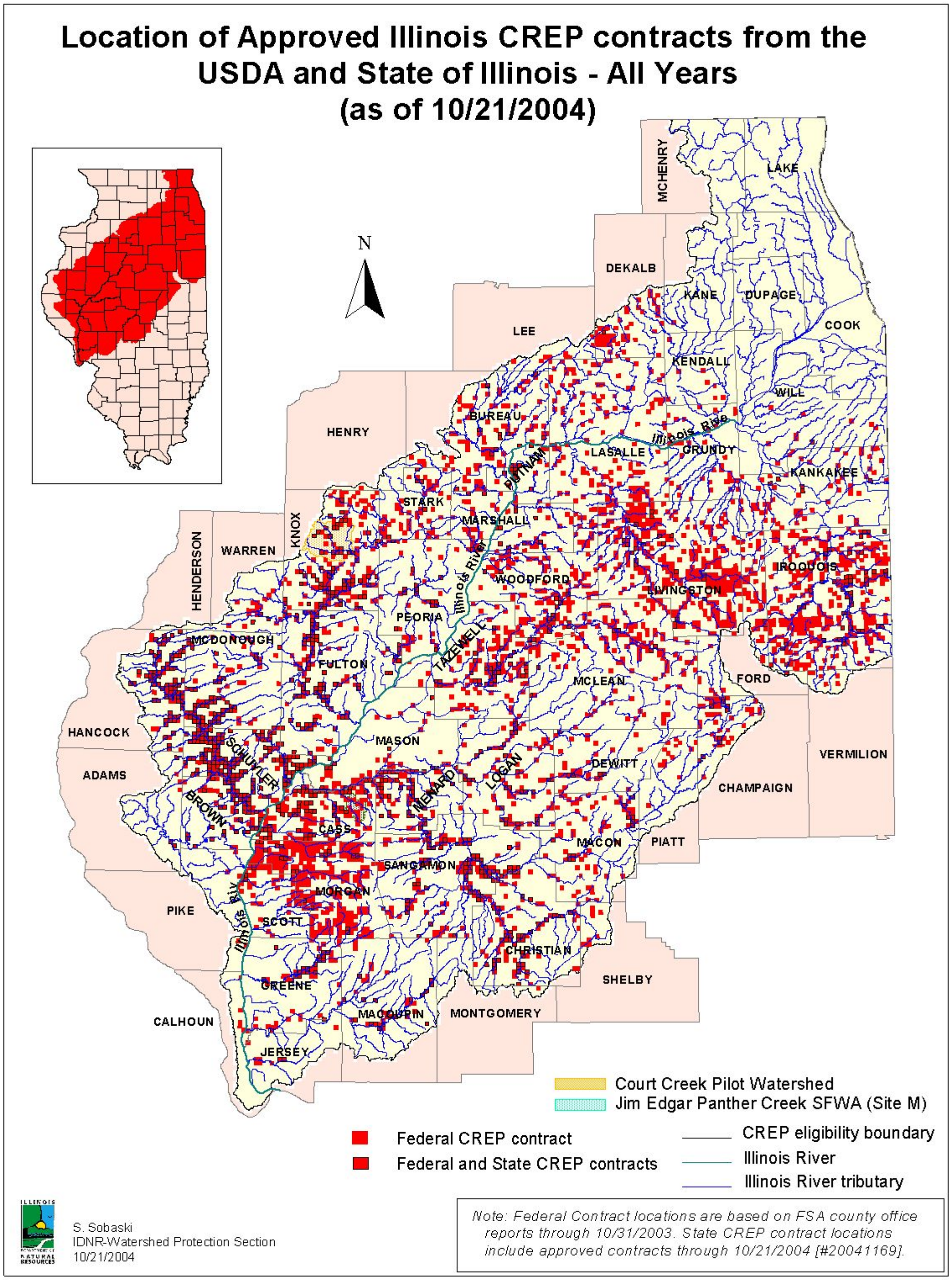
Per the December 18, 2002 Agreement, The State must contribute 20% from the Program inception in May 1998. Total Program discounted costs for this period are $227,937,571. The State contributed $50,453,655, or 22.13% of the total program costs after using the discount rate. The State has met the requirement for incurring 20% of the total Program costs.

PROGRAM ACTIVITIES AND ACCOMPLISHMENTS

Since the beginning of the CREP program on May 1, 1998 through the end of the current reporting period (September 30, 2004), CREP has restored and/or protected 110,854.3 acres of land either in existing native vegetation or in a previous CRP sign-up (See Map 1).

During that same time period, 73,120.98 acres were enrolled in the CREP State Options. Of these acres, 92% or 67,121.71 acres were enrolled in permanent easements; 5% or 3633.67 acres were enrolled in 15-year contract extensions; and 3% or 2365.60 acres were enrolled in 35-year contract extensions.

The CREP program is restoring and protecting large stretches of floodplain corridors both on the main stem of the Illinois River and along the major tributaries. It is helping landowners, who have only been able to produce crops in the area once or twice in the last decade, to retire these lands from agricultural production.


Location of Approved Illinois CREP contracts from the USDA and State of Illinois - All Years (as of 10/21/2004)
N
MCHENRY
LAKE
DEKALB
KANE
DUPAGE
COOK
LEE
KENDALL
WILL
HENRY
BUREAU
LASALLE
GRUNDY
PUTNAM
KANKAKEE
STARK
MARSHALL
KNOX
WARREN
HENDERSON
WOODFORD
IROQUOIS
LIVINGSTON
PEORIA
MCDONOUGH
TAZEWELL
FULTON
MCLEAN
FORD
HANCOCK
MASON
SCHUYLER
ADAMS
BROWN
MENARD
LOGAN
DEWITT
VERMILION
CHAMPAIGN
CASS
MACON
PIATT
SANGAMON
MORGAN
PIKE
SCOTT
CHRISTIAN
SHELBY
GREENE
MACOUPIN
MONTGOMERY
CALHOUN
JERSEY
Illinois River
Court Creek Pilot Watershed
Jim Edgar Panther Creek SFWA (Site M)
Federal CREP contract
Federal and State CREP contracts
CREP eligibility boundary
Illinois River
Illinois River tributary
S. Sobaski
IDNR-Watershed Protection Section
10/21/2004
Note: Federal Contract locations are based on FSA county office reports through 10/31/2003. State CREP contract locations include approved contracts through 10/21/2004 [#20041169].

MAP 1

Success Story: *State CREP*
A Tremendous Success in Sangamon County!

Although Sangamon County had just one year to enroll acres in the CREP program before it abruptly came to a close, we were successful in securing 2,548 acres in CREP permanent easements. This year we were fortunate to get another forty contracts approved for landowners who had been waiting since 2001 for this opportunity. When all of these contracts are completed, Sangamon County will have close to 4,500 State CREP acres. Ninety-nine percent of the acres will be in conservation permanent easements—protected forever!

As you look out over the floodplain bottomlands previously used for agricultural crop production, you now see acres and acres of trees and native grasses covering the area. Sedimentation reduction into the streams throughout the Sangamon River basin is improving significantly thanks to the conservation practices now in place on these CREP acres. And, last but not least, we hear from landowners how once disappearing wildlife is again flourishing in the habitat provided on these conservation acres.

A report, "Inventory of Sangamon County Natural Areas", recently completed by members of The Friends of the Sangamon Valley, highlights natural resource areas with ecological significance that need to be protected. It was interesting to note that several of these natural areas are already enrolled in the State CREP program and will be kept in their natural state in perpetuity.

The Springfield Sangamon County Regional Planning Commission recently contacted our office requesting GIS data layer information depicting the CREP acres in Sangamon County. By adding this information to their other GIS data layers, they will have an excellent tool to assist officials in making informed decisions regarding land use planning and development for the county. Thanks to the information technology resources now available, we are able to build partnerships by sharing information with other agencies that also have a key role in determining how our natural resources will be preserved.

It feels really good to know that the CREP program is not only helping to protect our environment, water quality and wildlife today, but also part of our local natural heritage for generations to come.

OTHER PROGRAMS AND PARTNERSHIPS

There are other state, federal and organizational programs that are contributing to the accomplishment of the goals of the Illinois CREP. The following highlights some of the programs that contributed to achieving the goals the State has set for the Illinois River Basin. Any state or non-federal dollars that have been expended in these programs have not been included in the previous section that describe and list the direct state expenditures for CREP match.

STATE SUPPORTING AGENCIES

ILLINOIS DEPARTMENT OF CONSERVATION - C2000

The Conservation 2000 (C2000) Ecosystems Program currently has 20 Ecosystems Partnerships in counties that comprise of the Illinois River watershed, which consist of Big Rivers, Chicago Wilderness, DuPage River Coalition, Fox River, Headwaters, Heart of the Sangamon, Illinois River Bluffs, Kankakee River, Lake Calumet, LaMoine River, Lower Des Plaines, Lower Sangamon Valley, Mackinaw River, North Branch of the Chicago River, Prairie Parklands, Spoon River, Thorn Creek, Upper Des Plaines, Upper Salt Creek, and Vermillion Watershed Task Force. Since 1996, these partnerships have been awarded over $10,000,000 for projects providing a variety of conservation practices.

Through the Ecosystems Program 22 projects in FY 04 were funded. These 22 projects restored a total of 2,134 acres. Projects consisted of 186 acres of wetland, 258 acres of prairie, 235 acres of riparian, and 1,455 acres of forest being restored. C2000 funds also helped in educating 258 teachers, 5,220 students, and numerous landowners and local officials on the importance of biodiversity in the Illinois River watershed.

The C2000 Ecosystems Program also awarded support and vision grants to partnerships in the CREP area. Support grants are available to partnerships to assist them in functioning effectively. Vision grants provide funds for vision plans used to guide future ecosystem planning and project implementation activities throughout the watershed. The Vermillion Watershed Task Force is currently working on their plan. In the future, other CREP area partnerships may also receive vision grants.

ILLINOIS DEPARTMENT OF AGRICULTURE

The Illinois Department of Agriculture administers numerous soil and water conservation programs that produce environmental benefits in the Illinois River Watershed.

As part of the Conservation 2000 Program for FY ’04, $1,464,682 has been spent on upland soil and water conservation practices in the 51 Soil and Water Conservation Districts (SWCD) that comprise the Illinois River watershed through November 1,2004. An additional $1,027,570 is earmarked for conservation practices now under construction.

The program, implemented by the Department and SWCDs, provides 60% of the cost of constructing eligible conservation practices that reduce soil erosion and protect water quality. Eligible conservation practices include such practices as terraces, grassed waterways, water and sediment control basins and grade stabilization structures, well-decommissioning, and nutrient management planning.

From July 2003 through November 1, 2004, approximately 1483 individual conservation projects were completed in the Illinois River watershed. Soil loss was reduced to T or tolerable levels, as well as control of gully erosion, on this land. In addition, about 100,000 tons of soil has been saved and will continue to be saved each year.

In FY 2004, the State of Illinois, through the Department of Agriculture, provided nearly $3.3 million to the 51 SWCDs in the Illinois River Watershed. Funds are used to provide financial support for SWCD offices, programs and employees' salaries. Employees in turn, provide technical and educational assistance to both urban and rural residents of the Illinois River Watershed. Their efforts are instrumental in delivering programs that reduce soil erosion and sedimentation, and protect water quality.

In an effort to stabilize and restore severely eroding streambanks that would otherwise contribute sediment to the Illinois River and its tributaries, the Department is administering the Streambank Stabilization and Restoration Program (SSRP). The SSRP, funded under Conservation 2000, provides monies to construct low cost, vegetative or bio-engineered techniques to stabilize eroding streambanks.

In FY 2004, 63 individual streambank stabilization projects, totaling $499,171 were constructed in 22 counties within the Illinois River watershed. In all, 34,304 linear feet of streambank, have been stabilized, thereby protecting adjacent water bodies.

The Department's Sustainable Agriculture Program provides research and educational grants to help protect our natural resources and improve the economic viability of farmers and rural communities. Improving water quality has been and continues to be an important aspect of the program. Grants are available to individuals, nonprofit organizations, agencies and universities to conduct on-farm research and demonstrations, outreach and education, and university research trials. In FY 2004, $403,877 was awarded to 16 recipients within the Illinois River Watershed. Projects addressed such topics as alternative crops, stream buffers, composting livestock waste, soil quality/health, organic production, and youth education. The research and education efforts will help to protect the Illinois River Watershed and the citizens who make a living from agriculture within its boundaries.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

The Illinois Environmental Protection Agency (IEPA) continues to support the Conservation Reserve Enhancement Program (CREP) and participates on the State CREP Advisory Committee. In FY 2004, IEPA continued to provide financial assistance to half of the CREP Soil and Water Conservation Districts (SWCD) to help them maintain staff to assist with CREP enrollment efforts.

The benefits derived through this financial support is not only efficiency in the sign-up process to increase CREP enrollment, but it also allows the existing SWCD and NRCS staff to continue to implement the other conservation programs so desperately needed to improve water quality in the Illinois River watershed.

The CREP complements the IEPA's Nonpoint Source Pollution Control program and is a positive step to help the state to meet water quality goals throughout the Illinois River Watershed. The program and partnerships created and reinforced through the implementation of CREP have been influential to help additional programs and partnerships merge programs that have parallel but different goals. Illinois has seen additional benefits in the areas of environmental education, water quality and habitat improvements.

IEPA continues to believe that this type of success demonstrates the need to provide assistance not only in counties with high landowner interest, but also in counties needing enhanced marketing of the program to improve sign-up.

FEDERAL PROGRAMS CONTRIBUTING TO THE GOALS
FOR THE ILLINOIS RIVER BASIN

NATURAL RESOURCES
CONSERVATION SERVICE

The EQIP program works to provide technical, financial, and educational assistance to farmers and private landowners who are faced with serious threats to soil, water and related natural Resources. Currently, the EQIP program has spent approximately $12.3 million for financial and educational assistance in the Illinois River Basin to treat Natural Resource concerns on approximately 344,083 acres working with approximately 2,185 landowners.

The Wildlife Habitat Incentive Program (WHIP) provides assistance to people who want to develop and improve wildlife habitat primarily on private lands. Statewide the program has worked with approximately 580 producers to improve wildlife habitat on approximately 15,838 acres. Approximately, $1,269,000 was spent to enhance or create wildlife habitat through this program. Approximately 25% of the WHIP financial assistance has been put in place in the Illinois River Basin.

The Wetland Reserve Program (WRP) increases wildlife habitat and improves water quality by providing increased wetland habitat, slowing overland flow and providing a natural pollution control. To date, approximately $14.9 million have been spent in the Illinois River Basin on Wetland Restoration, covering 10,367 acres and working with 23 producers.

The Forestry Incentives Program (FIP) provides an avenue of assistance to private landowners for planting trees, improving timber stands, as well as other non-industrial private forestland practices. In the Illinois River Basin, approximately $21,000 has been spent to treat approximately 520 acres and working with 21 producers. Approximately $15,800 will be spent on timber practices in the Illinois River Basin.

CRP enrollments beyond the CREP Program enrollments provide additional in-place conservation practices facilitating resource management in the Illinois River Basin.

The Grassland Reserve Program (GRP) is a new program available to agriculture producers to help them protect important grasslands. In the Illinois GRP has put approximately $1,355,473 in the Illinois River Basin to help protect approximately 2000 acres of grassland through easements and 20 and 30 year rental agreements, with 20 producers.

FISH AND WILDLIFE

As members of the Midwest Natural Resources Group seven federal agencies signed the Illinois River Focus Area Intergovernmental Partnership Agreement. The agencies agreed to cooperate and collaborate in the protection, restoration, and enhancement of wetlands and other habitat in the focus area; to reduce nutrient and sediment loading to the Illinois Mainstream and tributaries; and to explore and improve tools, methods and measures to accomplish the above goals.

The Fish and Wildlife Service approved Comprehensive Conservation Plans for the Illinois River Refuges and the Mark Twain Refuges setting the direction of these river refuges for the next 15 years.

The Illinois River Refuges' Partners for Wildlife and Fish helped to restore 6,000 acres of wetlands and other habitats in recent years.

Volunteers planted 120 acres of native mast trees on Emiquon Refuge. Ducks Unlimited, the Service, and the Illinois Conservation Foundation are partnering in developing a water distribution system for 1,000 acres of wetlands on Emiquon Refuge. The approved boundary for Emiquon Refuge is over 11,000 acres and includes all the land in The Nature Conservancy's Emiquon project. The Nature Conservancy's application to enroll 6,332 acres of their Emiquon project in WRP was approved.

The Corps of Engineers and Fish and Wildlife Service completed a $19 million partnership restoration project on Chautauqua National Wildlife Refuge. The project restored refuge infrastructure to enhance management capability on 3,200 acres of wetlands. Chautauqua Refuge is a Western Hemisphere Shorebird Network Site and was recently named a Globally Important Bird Area by the American Bird Conservancy and identified as an Important Bird Area by the Illinois Audubon Society. Summer shorebird counts may exceed 10,000 individuals and waterfowl counts often exceed 100,000 ducks of a dozen species.

The Service partnered with Ducks Unlimited, the Rice Foundation, the Buchanan Family Foundation, NAWCA Joint Venture, and the Illinois Migratory Waterfowl Fund to restore the 328-acre Weis Lake on the Cameron Unit of Chautauqua Refuge in Marshall County.

THE FOLLOWING IS A SPECIAL SUPPLEMENT TO THE FWS COMMENTS EXPRESSING THE PERSONAL THOUGHTS OF ROSS ADAMS, FWS, AND CREP ADVISORY COMMITTEE MEMBER:

As manager of the Illinois River National Wildlife and Fish Refuges and leader of the Illinois River Focus Team of the Midwest Natural Resources Group for the past seven years, I have observed a transformation of the landscape in the Illinois River floodplain, and even more amazing, it all occurred on private lands. It is seldom that one can observe habitat restoration on such a grand scale in such a short span of years. From my vantage point, the Conservation Reserve Enhancement Program (CREP) appears to be the leader in restoration of wetland habitat along the Illinois River.

I attended the ceremony for the signature of the original CREP agreement in Peoria on March 30, 1998. Since that time approximately 120,000 acres of cropland were enrolled in CREP, most of which were signed up in the state side of the program with permanent easements.

One of the first projects that I watched undergo this incredible transformation was The Nature Conservancy's 1,100 acre Spunky Bottoms across the river from the Meredosia National Wildlife Refuge. Within a couple of years after the pumping stopped, aquatic and emergent plants colonized the clear waters from dormant seeds that remained in the soils. The birds and animals quickly followed. It was quite exciting working with TNC and IDNR biologists capturing wood ducks in lotus beds where just 3 years before corn and soybeans dominated the landscape.

Traveling north from Spunky Bottoms, wading birds and waterfowl can be seen foraging in the restored wetlands on the Gust Farm. Further north along Highway 100, the former Kelly Lake Drainage District is once again Kelly Lake. White pelicans were observed late into the summer on this restored lake raising the question of whether or not these birds may be nesting here in the near future.

Ducks Unlimited purchased 400 acres adjacent to IDNR's Spring Lake area and enrolled the property in CREP. The property is presently being restored to wetlands and will eventually be turned over to IDNR for management. One of the more exciting features of this project is the nearly unlimited source of water from Spring Lake for managing the wetlands.

Another exciting project worthy of praise is the Wetland Initiative's Hennepin-Hoper project. The first year after the pumps were turned off, muskrats were building feeding platforms among last years corn stubble. The IDNR killed the carp and stocked the waters with desirable fish, resulting in some of the clearest water in the river valley with abundant invertebrates and aquatic plants. The response of birds to this restoration has been awesome. The weekly aerial surveys of waterfowl by the Illinois Natural History Survey show that tens of thousands of waterfowl are using the restored wetlands. The November 8 survey listed 14,100 mallards, 11,750 pintail, 7,050 widgeon, 4,700 gadwall, 4,700 shovelers, 2,350 ring-neck ducks, and 500 ruddy ducks.

As a wildlife biologist and refuge manager observing conservation activities along the Illinois River, I can describe the success of Conservation Reserve Enhancement Program as incredible. Just absolutely incredible!

NON-GOVERNMENTAL PARTICIPANTS

ILLINOIS FARM BUREAU

Illinois Farm Bureau (IFB) continues to publicize and promote the Conservation Reserve Enhancement Program (CREP). In 2004, articles in FarmWeek provided information about aspects of the program. IFB also used our statewide radio network to highlight details of the program.
Information on CREP was sent directly to county Farm Bureaus (CFB) via e-mail and through our county Farm Bureau mail system. An Illinois Farm Bureau statewide workshop in 2004 on voluntary programs for farmers included information about CREP and other conservation programs through various agencies. Details about CREP were also provided to a statewide committee comprised of both agricultural and non-agricultural organizations.
Illinois Farm Bureau continues to provide input about the program through various groups and committees. IFB has also continued to voice support for future funding of the program. CREP is another tool producers can use that provides cost-share incentives and technical assistance for establishing long-term, resource-conserving covers and is a positive program in Illinois.

UNIVERSITY OF ILLINOIS - EXTENSION

Two full-time Educator positions designed to address educational needs of landowners, watershed groups, and organizations regarding CREP and watershed management are funded through a grant. The grant is a partnership between Illinois Department of Natural Resources (IDNR), Illinois Environmental Protection Agency (IEPA), and the University of Illinois. Educators coordinate CREP and watershed management information, education and research activities among Illinois Department of Natural Resources, Illinois Environmental Protection Agency, University of Illinois - Extension and other natural resource agencies and groups.

NATURE CONSERVANCY - RESEARCH UPDATE

(PLEASE SEE NEXT 4 PAGES)

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

research update

Fall 2003

Mackinaw River Paired Watershed Study — Progress Report

Jim Herkert
Director of Conservation Science
The Nature Conservancy in Illinois
301 SW Adams Street, Suite 1007
Peoria, Illinois 61602

Phone: [309] 636-3325
Fax: [309] 673-8986
E-mail: jherkert@tnc.org
nature.org/Illinois

Executive Summary

The Mackinaw River watershed in central Illinois contains some of the most productive agricultural land in the nation. The Nature Conservancy is in the final year of a five-year Paired Watershed study within the Mackinaw River watershed. The objective of the study is to:

- Determine whether or not focused outreach can persuade people to use suggested best management practices (BMPs);
- Determine whether or not the suggested BMPs are effective for improving hydrology, water quality and biological resources, such as fish and mussels; and,
- Determine the diversity and scale at which these efforts need to be implemented to show a positive impact on freshwater conservation at a broader level.

Preliminary results show that focused outreach has significantly increased acceptance and usage of BMPs, such as strip till agriculture and buffer strips, to protect water quality in adjacent streams. Increased BMP implementation in Bray Creek (the experimental watershed) has significantly reduced baseflow nitrate and suspended sediment concentrations compared to an adjacent watershed where no outreach was conducted.

The Mackinaw River

However, the study has also shown that surface BMPs alone will not be enough to improve the overall biological health of local streams and waterways. It will be necessary to build upon the findings of the study and focus efforts on achieving more comprehensive water quality improvements, especially reductions in sediment load.

Activities likely to aid in further improving the water quality and ecological health of these systems would include even broader use of traditional BMPs, establishment of additional types of BMPs known to improve water quality, such as wetlands, tile-biofilters, and streambank stabilization, and implementation of other farm conservation activities (such as nutrient management).

Project Overview

The Mackinaw River watershed contains some of the most highly productive agricultural land in the country. Within this agricultural setting, the Mackinaw River contains diverse aquatic communities relative to other regional rivers. In the statewide Biological Stream Characterization, the Mackinaw River had the highest number of "A" and "B" rated streams in Illinois (Page et al. 1992). With over 90% of the watershed currently in agriculture, any attempts to maintain and improve the condition of the natural resources in the watershed must be approached through the context of the agricultural community.

There are a variety of agricultural best management practices (BMPs) that are available to improve soil conservation and water quality. However, the adoption of these practices has only been moderately successful in many areas. In the Mackinaw River watershed, there is evidence that farmers have not embraced these programs for a variety of reasons including: complex application and sign-up procedures, frustration over changes in rules that govern these programs, information that is inconsistent or unreliable, and an unwillingness to take cropland out of production.

While the positive impacts of specific conservation practices have been documented for a given farm or field, there is little evidence to demonstrate that watershed-level improvements in water quality can occur as a result of these practices. Consequently, the influence of BMPs in improving soil and water conservation at large scales has been questioned. There is growing concern that site-specific improvements in water quality can be overwhelmed at larger scales.

The objective of the Mackinaw River Paired-Watershed study is to demonstrate the cumulative effects of BMPs in a subwatershed on hydrology, water quality and biological

Figure 1. Map of Bray Creek and Frog Alley Subwatersheds in the Upper Mackinaw River Basin. Bray Creek and Frog Alley compose the paired watershed study to assess BMP implementation in the Bray Creek subwatershed. Upstream and downstream (U & D) sampling stations and rain gage (red circles) locations are shown.

resources. In turn, this information will be used to suggest the diversity and scale at which these efforts need to be implemented to show a positive impact on freshwater conservation at a watershed level. The project is also designed to determine whether a concentrated outreach program can successfully increase the amount and diversity of BMPs in the study area.

Two small tributaries in the upper Mackinaw River subwatershed were identified for intensive monitoring as part of an initial five-year project: Bray Creek and Frog Alley (Figure 1). Both subwatersheds are of similar size (around 10,000 acres), are exclusively agricultural, and have similar climates and geology. A paired watershed approach was chosen to carry out this project. Bray Creek was selected as our target watershed to receive intensive outreach designed to promote BMPs, and Frog Alley was selected as a reference stream to receive no outreach.

The development and implementation of the outreach program involved the participation of The Nature Conservancy, The Mackinaw River Watershed Council (a citizen-based conservation group), The McLean County Soil and Water Conservation District (SWCD), the Natural Resources Conservation Service

(NRCS), and an outreach group of resident owner/operators assembled for the project. Outreach has been conducted throughout the duration of the study and provides landowners and farm operators with information about available cost-share programs, technical assistance, and implementation on BMPs through one-on-one meetings, community workshops, field demonstrations, and tours. Participation in cost-share programs, and the number and type of BMPs implemented are tracked within both paired watersheds. A survey administered in year one will be repeated at the end of the study to determine changes in landowner/operator attitudes, knowledge, and conservation practices. Data from each watershed will then be compared to determine the effectiveness of locally lead outreach initiatives.

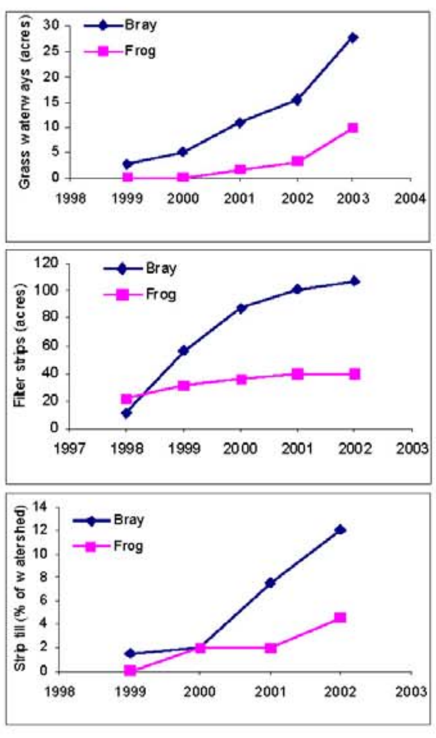


Figure 2. Implementation rates for grass waterways, filter strips, and strip-till farming in the paired watershed focused outreach stream, Bray Creek, and the reference stream with no focused outreach, Frog Alley.

Changes in stream systems are being monitored in partnership with the Illinois Natural History Survey, Illinois State University, University of Illinois, Illinois Department of Natural Resources (INDR), and the Illinois State Geological Survey. Monitoring of instream hydrology, water quality, and biological resources are being conducted in the target and reference watersheds. Hydrologic conditions are monitored through the use of electronic rain gauges and stream water-level gauges at one location in each watershed. Nutrient (nitrate, nitrite, ammonia, and orthophosphorous) concentrations are measured weekly in upstream and downstream sampling locations. Suspended sediment is measured every two weeks at upstream and downstream sites. Habitat surveys are conducted three times annually to detect changes in the physical structure. Fish and macroinvertebrates are sampled twice annually and mussels are sampled annually in each stream.

Results to Date

Analyses of BMP implementation rates for the two subwatersheds through 2003 clearly show that focused outreach has significantly increased acceptance and installation of BMPs. During four years of focused outreach, the Bray Creek subwatershed had significantly higher implementation rates for grass waterways, filter strips, and strip-till farming acreage than the reference watershed (Frog Alley), where no outreach was conducted (Figure 2).

In terms of water quality, initial analyses have now been completed for nutrients and suspended sediment under baseflow conditions. These analyses have shown that the increased BMP implementation in Bray Creek (the experimental watershed) has significantly reduced baseflow nitrate (Figure 3) and

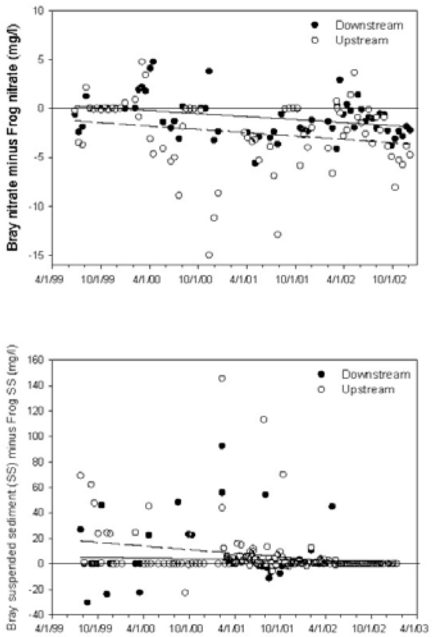


Figure 3. Trends in the difference in nitrate and suspended sediment concentrations between Bray Creek (target watershed) and Frog Alley (reference watershed) over time. Nitrate concentrations in Bray Creek declined relative to those in Frog Alley over time at both downstream and upstream sites (analysis indicates an overall statistically significant decline). Suspended sediment concentrations in Bray Creek also declined relative to those in Frog Alley over time at downstream and upstream sites, but the decline was much sharper at the upstream site (analysis indicates an overall statistically significant decline). These trends indicate that nitrate and suspended sediment concentrations are declining in Bray Creek relative to concentrations in Frog Alley due to higher levels of BMP implementation.

suspended sediment (Figure 3) concentrations compared to Frog Alley (the control watershed). No differences have been detected for nitrite, ammonia or orthophosphorus. Analyses of improvements in stream hydrology, biotic communities, and nutrients and suspended sediment during storm events are in progress.

Implications

Preliminary results indicate that (1) focused outreach can significantly increase acceptance and volunteer implementation of BMPs within highly productive agricultural landscapes, and (2) such efforts can result in significant improvements in water quality. While these results are very encouraging, nutrient concentrations in these subwatersheds still exceed levels set for maintaining ecological integrity (TNC 2002) and human health (EPA 2000). Thus while moving us toward ecological and human health goals, additional efforts will be required to achieve these targets. Activities likely to aid in further improving water quality and ecological health of these systems would include (1) implementation of even more traditional BMPs (grass waterways, filter strips, no-till, nutrient management plans), (2) establishment of additional types of BMPs well known to improve water quality, such as upland and riparian wetlands (Kovacik et al. 2000), tile-biofilters, and streambank stabilization, and (3) implementation of other farm conservation activities (such as nutrient management).

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RECOMMENDATIONS AND FUTURE PLANS OF THE CREP ADVISORY COMMITTEE

Setbacks from reductions in CREP appropriations have had a significant impact on not only enrollment, but the loss of momentum that had been achieved with the State's successful achievement of it's original goal, and the USDA approval of expanded acreage to 232,000 acres. This has resulted in the need to re-evaluate the future of the program and the development of new fiscal strategies.

FUTURE PLANS

1. Taking into consideration the source of Illinois CREP Funding, establish a long-term staffing and monitoring strategy to assure adequate staff and support for the proper administration of the program.

2. Hold training and workshops, as needed, for all field staff and SWCD's as a means of updating new and existing staff on issues, and refinement of the enrollment process. Update and keep the training manual up-to-date for field use.

3. The University of Illinois Extension (Extension) maintains the web site for the Illinois CREP Program. This site assists SWCDs and landowners with information on the program. This site should be maintained and updated either internally or through support from the Extension.

4. Continue to pursue long-term additional staff to assist all SWCDs in the administration of the CREP Program at the County level. Efforts to work with IEPA and other supporters need to continue and expand.

OTHER RECOMMENDATIONS

- Additional funding should continue to be sought for dedicated full-time staff to provide technical assistance to landowners in the following agencies: NRCS, DNR, and SWCDs.
- Evaluation of practices and lands eligible under the current CREP Program should be re-visited for possible inclusion of additional lands and practices such as Highly Erodible Lands (HEL).
- Review of Administrative rules to assure correctness and comprehension should be performed to assure adequate enforcement of rules.

MONITORING AND EVALUATION OF THE ILLINOIS RIVER

Assessment of Stream Remediation on the Aquatic Habitat and Fish Community of Cox Creek, Cass County, Illinois (Illinois River Basin)

Illinois Conservation Practices Tracking System (ICPTS) and CREP Assessment

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

The Illinois River Basin Hydrology Observatory - A Center for Understanding the Hydrologic Cycle of Intensively Managed Landscapes

ASSESSMENT OF STREAM REMEDIATION ON THE AQUATIC HABITAT AND FISH COMMUNITY OF COX CREEK, CASS COUNTY, ILLINOIS

Douglas A. Carney
Streams Biologist
Illinois Department of Natural Resources
Brighton, IL

EXECUTIVE SUMMARY

To address significant streambank erosion on Panther and Cox creeks in the Jim Edgar Panther Creek State Fish and Wildlife Area, the IDNR and USDA-NRCS, installed several instream or near-stream practices including riffle-weirs (i.e., Newbury weirs), lunker structures and dormant willow posts. These practices helped complement the ongoing implementation of numerous floodplain and upland conservation practices, including CREP and CRP.

The effects of these instream practices and their influence on instream habitat and fish were documented in pre- and post-implementation assessments. Habitat was evaluated by the Illinois EPA's Stream Habitat Assessment Procedure (SHAP), a 15-metric qualitative measure of habitat quality where higher values indicate better fish habitat. Practices were installed on Cox Creek allowing comparison with the adjacent Panther Creek.. SHAP values were significantly higher in post-project Cox Creek in comparison to Panther Creek. In both Cox Creek and Panther Creek, post-project SHAP scores were higher than observed in pre-project assessments. After riffle installation, some general, but important changes in channel morphology included increased water depth and width.

With the physical changes resulting from these practices, a corresponding change in fish assemblages was observed. In Cox Creek, fish abundance decreased and species richness increased following installation of practices. Increased species richness is unlikely to be a result of differing sample methods (change from backpack and minnow seine to electric seine) because increased stream size generally makes sampling less efficient. The trend towards increased fish species richness in post-project Cox Creek samples was evident but not observed in Panther Creek samples.

Species richness is a simple, but useful measure and an important aspect of biological integrity. Like the species richness trend, Index of Biotic Integrity (IBI) values generally increased in Cox Creek after project implementation. Statistical relationships between habitat and diversity or between habitat and biological integrity remain elusive in these streams, however. Overall, substantial improvements in habitat and fish assemblages resulted from these practices, including twelve fish species not previously collected in Cox Creek prior to project installation.

Illinois Conservation Practices Tracking System and CREP Assessment

Draft Executive Summary

The development of CREP and extensive enrollment of land within the Illinois River Basin is a useful measure of the immense popularity of this program with landowners. These enrollments provide a critical component to assisting the Program with addressing the four major CREP goals that include:

- Reducing silt and sedimentation entering the mainstem of the Illinois River by 20 percent.
- Reducing phosphorus and nitrogen in the Illinois River by 10 percent.
- Increasing in the Illinois River watershed, by 15 percent, the population of waterfowl, shorebirds, nongame grassland birds, and state and federally listed threatened and endangered species such as bald eagles, egrets and herons.
- Increasing the native fish and mussel stocks by 10% in the lower reaches of the Illinois River (Peoria, LaGrange, Alton reaches).

Although considerable information exists regarding acres enrolled, state and federal funds expended, practices applied and percent of program implemented, more information, especially spatial data, is needed to evaluate Illinois CREP's progress in achieving these four goals. To aid this evaluation, the IDNR developed a proposal to the USDA-Farm Service Agency (State Project CAFSA-01), to provide three key components. This agreement included:

- expansion of the number of counties covered by the Illinois Conservation Practices Tracking System (ICPTS) in order to document and more fully understand the nature, distribution, and efficacy of conservation practices implemented in the Illinois River basin through CREP and other USDA Farm Bill conservation programs.
- development of an instruction manual for ICPTS, especially for USDA-FSA county office staff and other potential users of the systems, to serve as a training and reference document for current and new staff who may be involved with using or adding data to ICPTS.
- application of current wildlife habitat models to develop a standard protocol for assessing the quality of wildlife habitat provided by wetland restorations implemented through Illinois CREP.

All of the above tasks have been completed under this agreement save for the final report, which is pending. During this project, spatial and descriptive data on all active USDA conservation program contracts in four additional CREP counties (i.e., Menard, Morgan, Christian and Sangamon) were incorporated in the ICPTS. County scale maps of all digitized conservation practices were developed and distributed to each county FSA office and to the State FSA office. The digital data in ESRI ArcView shapefile format were also provided to each of the counties USDA service center offices where data were gathered.

To assist local county FSA offices with the digitizing process, a detailed, step-by-step manual was developed (see Index to the manual below). With increasing use of geographic information systems (GIS) within the USDA and its partner agencies, such as IDNR, and given the complexity of the software, it is essential to have consistent and easily interpretable instructional materials. This manual provides guidance on the basic functions and protocols required by FSA personnel involved with digitizing CREP or other conservation practices in the Illinois Conservation Practices Tracking Systems or into similar databases such as the CRP layer of the Common Land Unit (CLU) database.

Index to the ICPTS Manual

(From report by Steve Niemann)

With the extensive number of acres enrolled in CREP, especially in wetland restoration projects, the use of assessment models is a valuable approach to evaluating the effect of the practices on wildlife populations. Under CAFSA-01, 92 CREP wetland restoration sites within a six county area of the middle Illinois River basin were evaluated for the quality of wildlife habitat that they provide using a multi-faceted approach which incorporated a wildlife suitability index, a floristic quality index and a hydrophyte index. Habitat cover data were also used during this project to evaluate the quality and potential usefulness of these sites as habitat for threatened, endangered and migratory vertebrate species. The findings indicate the three indices noted above had a significant positive relationship with size of the site and their proximity to sources of water, but these relationships did not show a temporal effect. In other words, larger wetland restoration sites generally provide for better wildlife habitat and sites with connectivity to hydrology, such as backwater areas, provided much better habitat than isolated wetland sites. The shift of CREP sites from agricultural production into wetland communities appeared to be negatively influenced by human impacts, drainage and nuisance plants. CREP is restoring a significant amount of wetland acres and creating critical wildlife habitat within the Illinois River basin. However, further research is needed to better assess the success of various wetland restoration techniques and siting decisions (i.e., which sites make for ideal restorations, which are less successful) in creating quality wildlife habitat, and, more specifically, to further quantify the influence of parcel size and their juxtaposition to other wetlands. If managed properly, with special consideration towards size of the wetland, hydrology and control of noxious species, these areas may develop into valuable habitats for wildlife. (Adapted from a report by Don Phillips, INHS Assessment of CREP Wetland Habitat Quality for Wildlife, 13 July, 2004.)

Illinois Conservation Practices Tracking System USDA and State Conservation Easements digitized Through December 2004

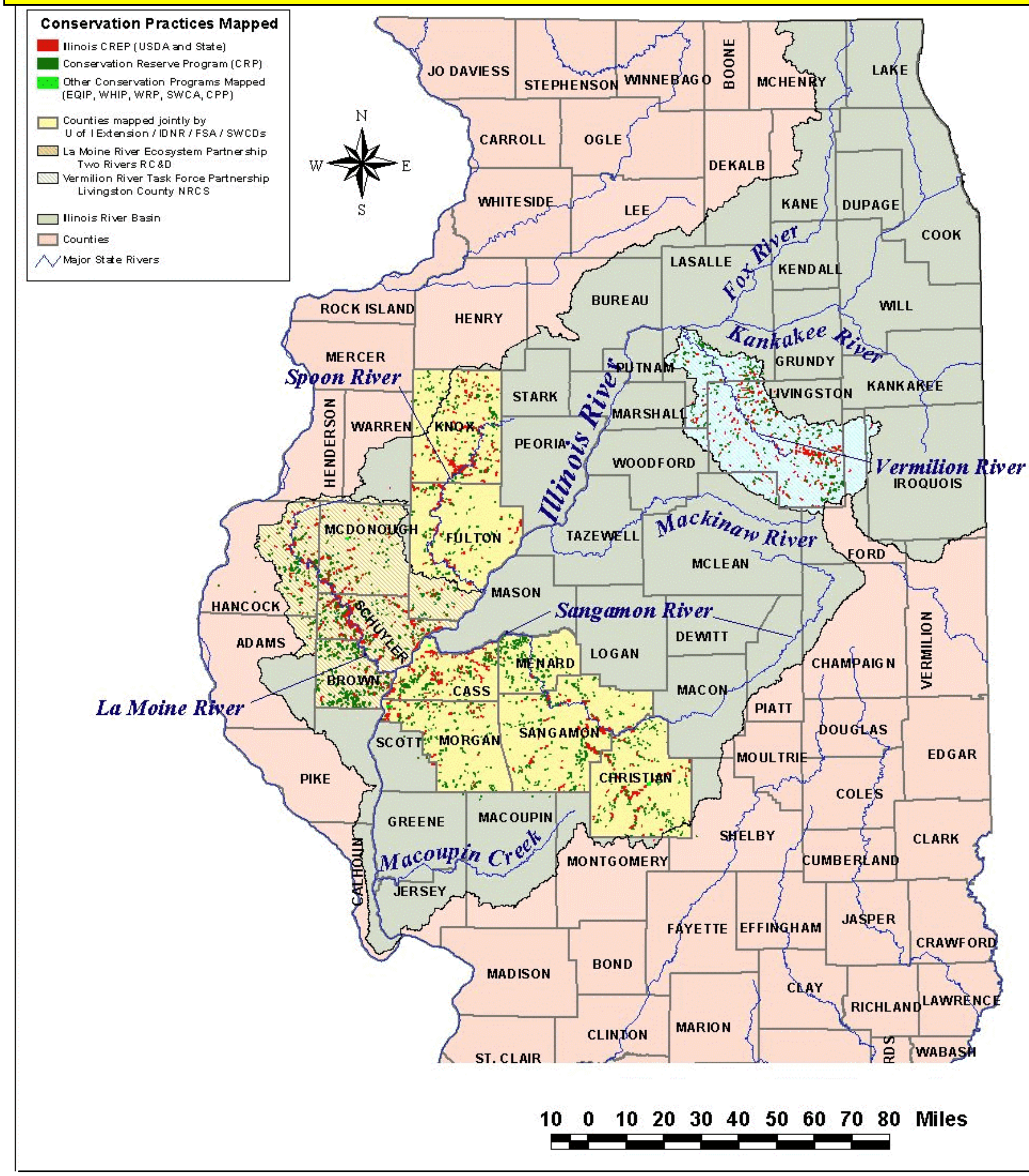


Figure 2. Extent of the over 8,000 conservation practice contracts from Illinois CREP eligible counties and subwatersheds mapped for the Illinois Conservation Practices Tracking System through December 2004.

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

by
Watershed Science Section
Illinois State Water Survey
Illinois Department of Natural Resources

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 phosphorous 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 and the Illinois State Water Survey 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.

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 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

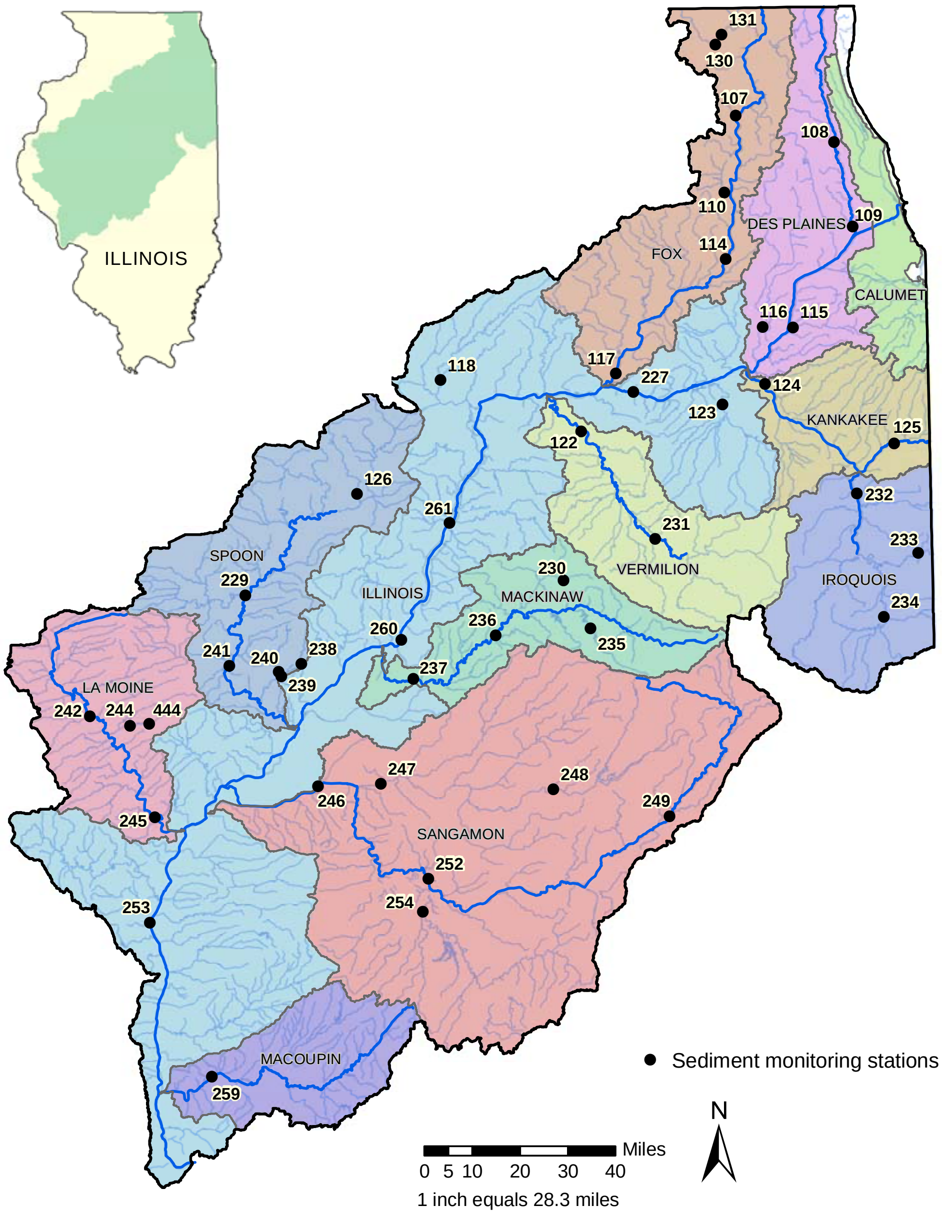


Figure 1. Locations of available in-stream sediment data within the Illinois River watershed, 1981-2000

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 and 3 and information about the monitoring stations is provided in table 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). This progress report presents some of the data that has been collected and analyzed at each of the monitoring stations.

Sediment Data

The suspended sediment concentrations observed at all the five monitoring stations from Water Year 2000 to Water Year 2003 are shown in figures 4 to 13. Over 6,000 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.

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

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

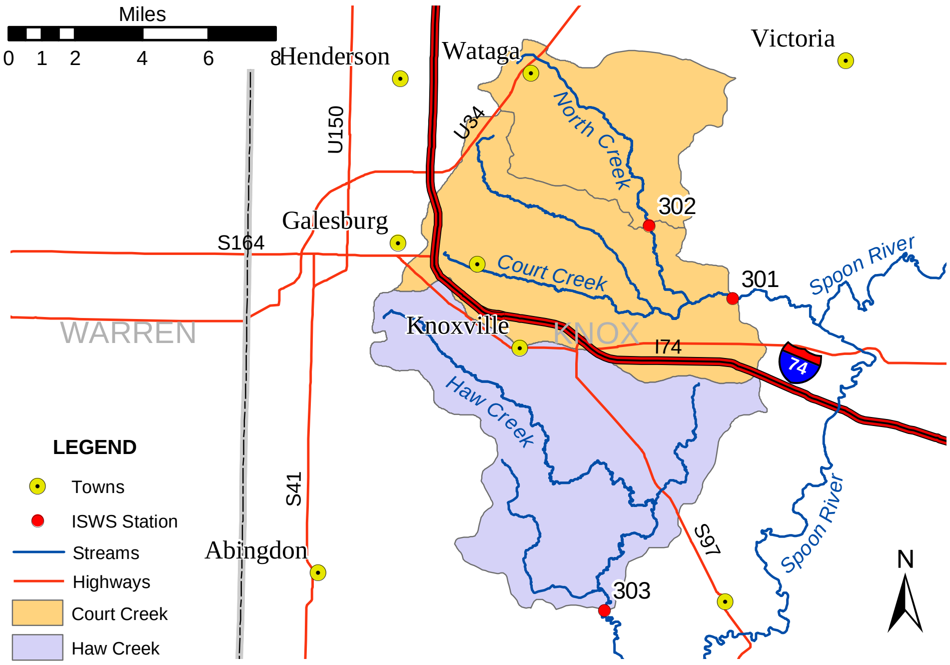


Figure 2. Locations of monitoring stations in the Court and Haw Creek watersheds

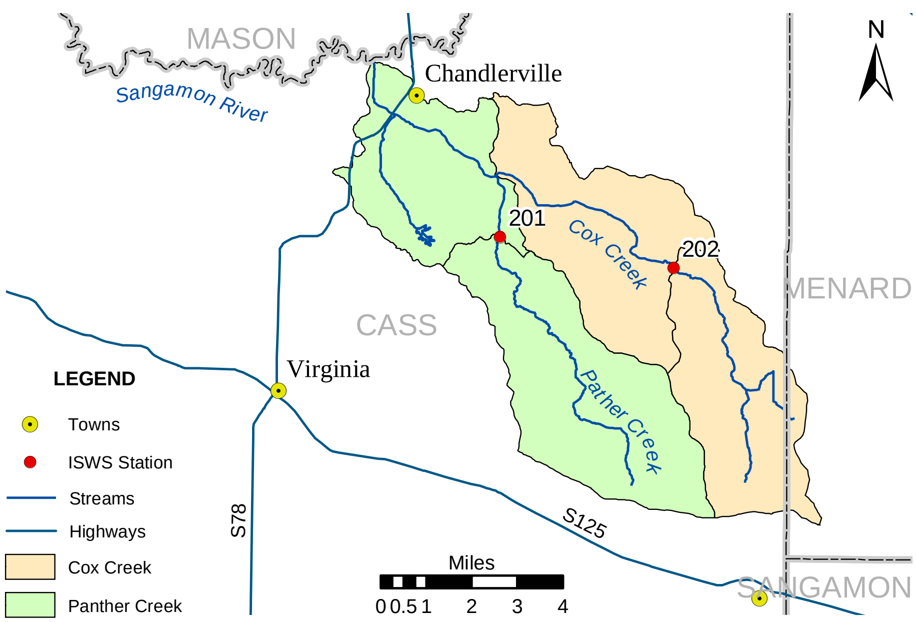
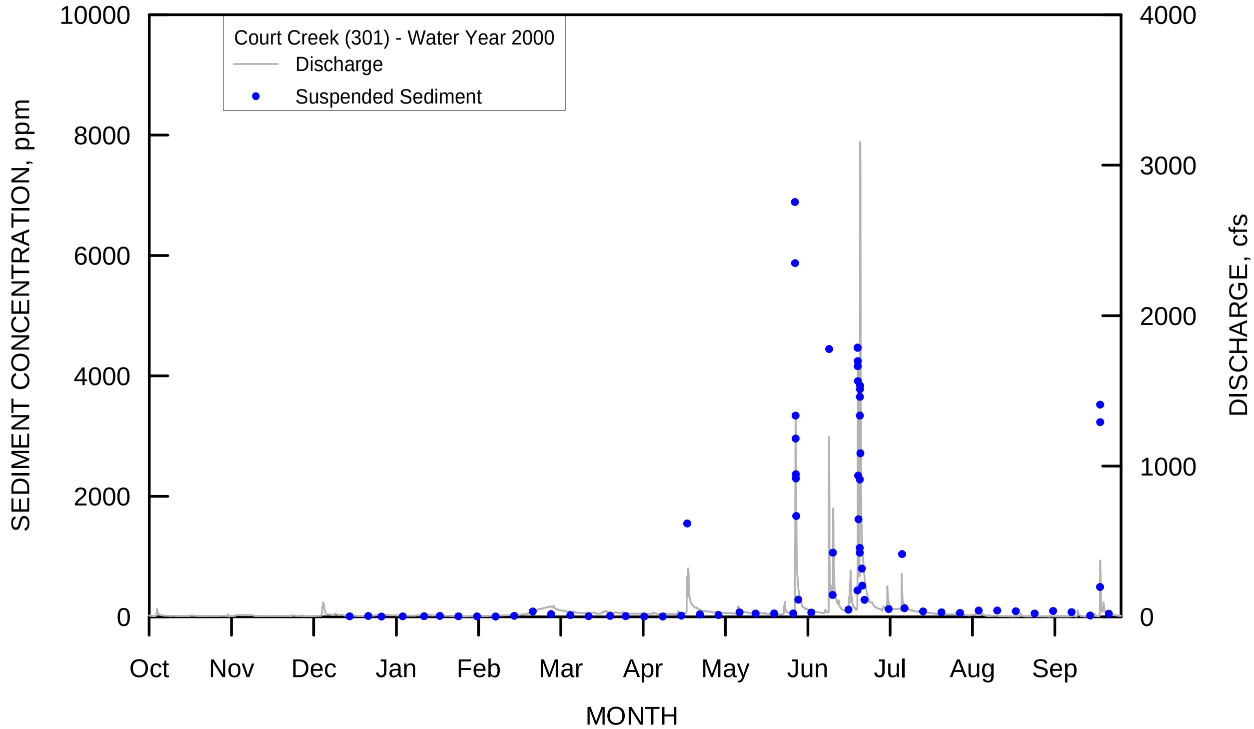


Figure 3. Locations of monitoring stations in the Panther and Cox Creek watersheds



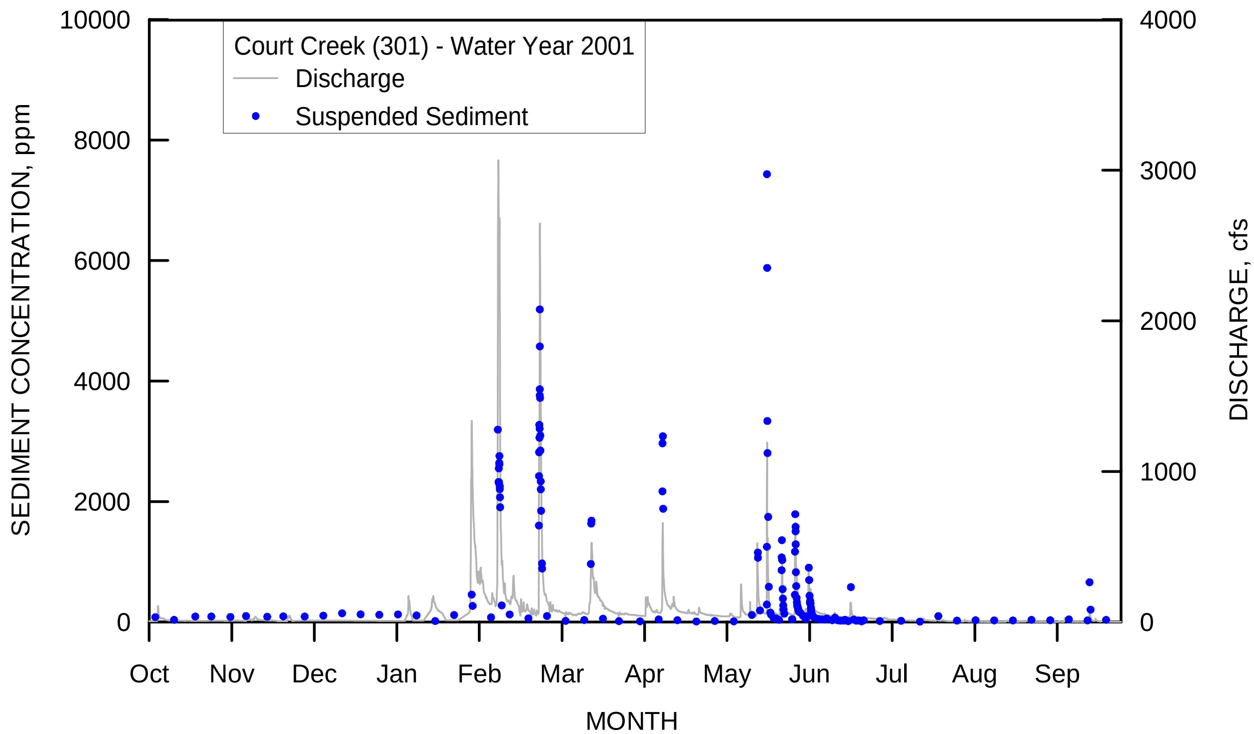
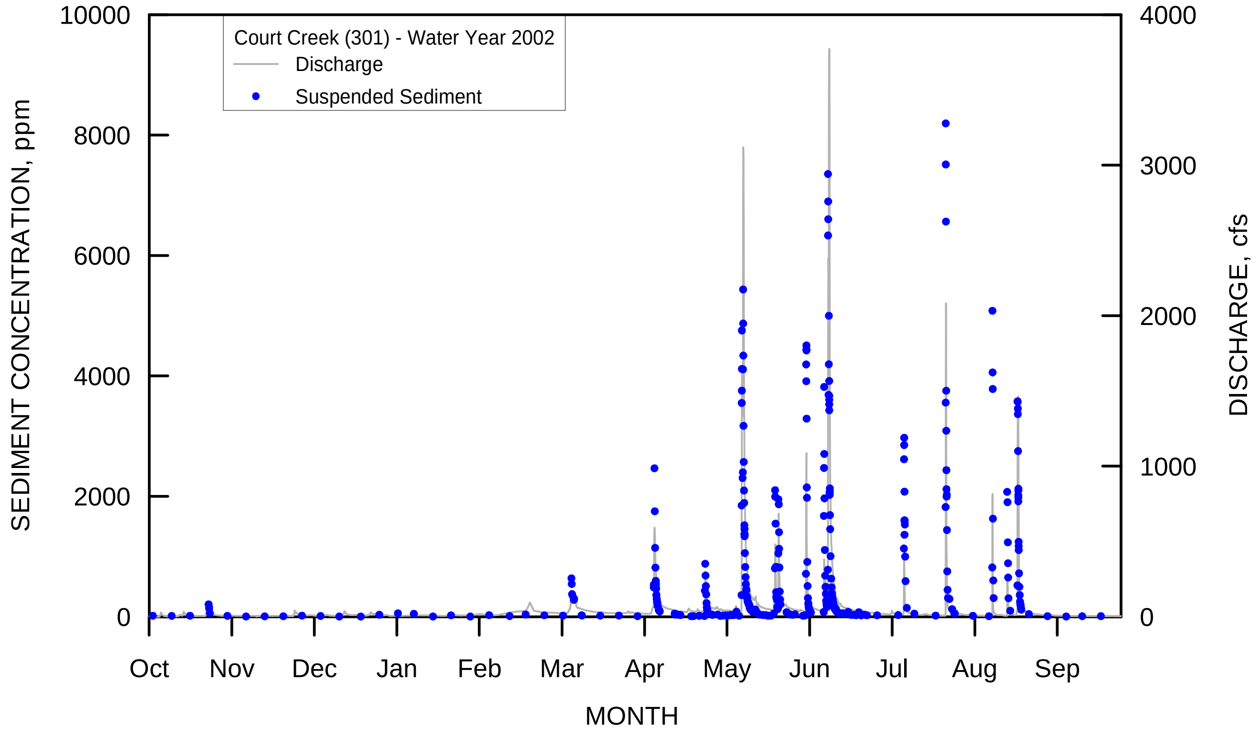


Figure 4. Suspended sediment concentrations and water discharge at Court Creek (301) – Water Years 2000 and 2001



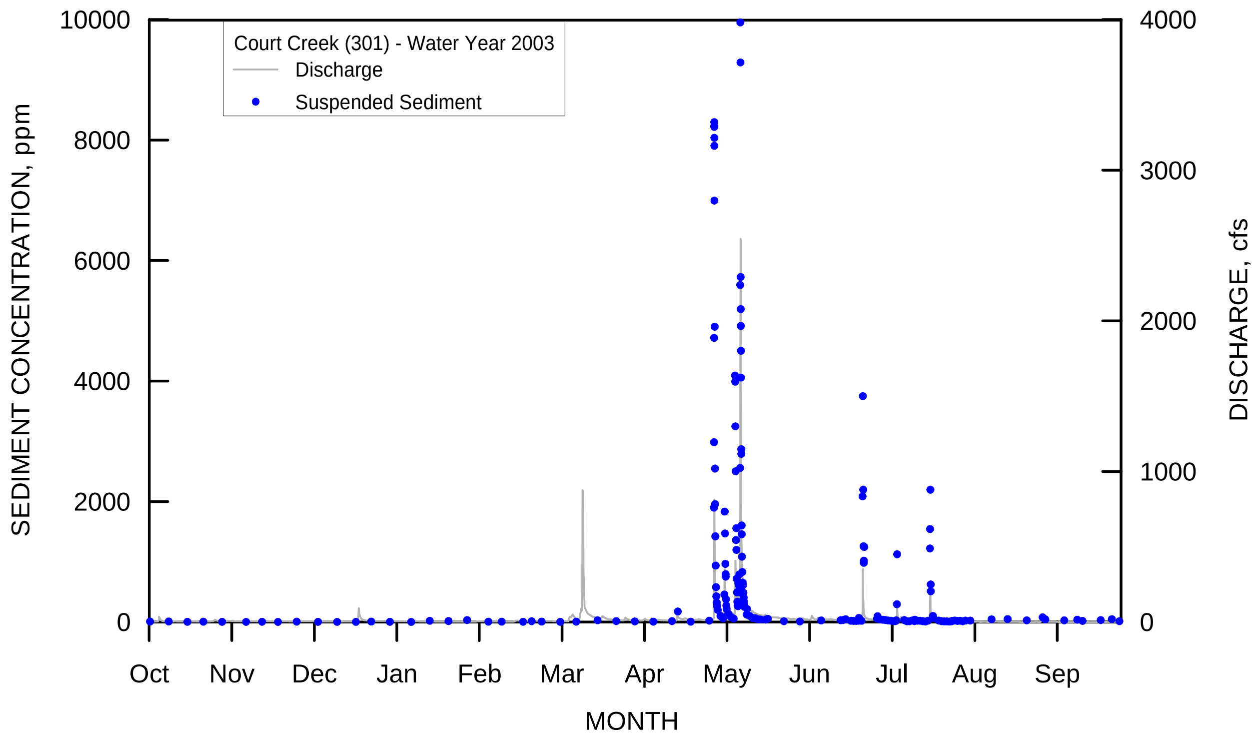
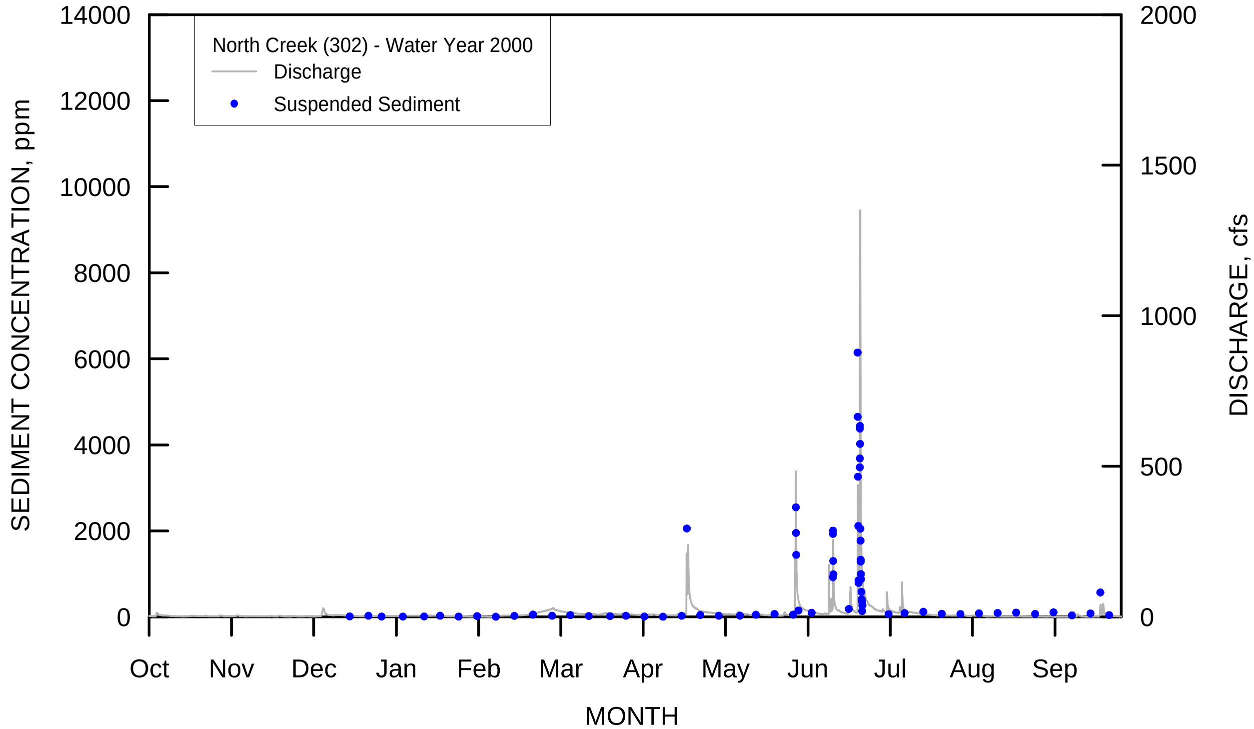


Figure 5. Suspended sediment concentrations and water discharge at Court Creek (301) – Water Years 2002 and 2003



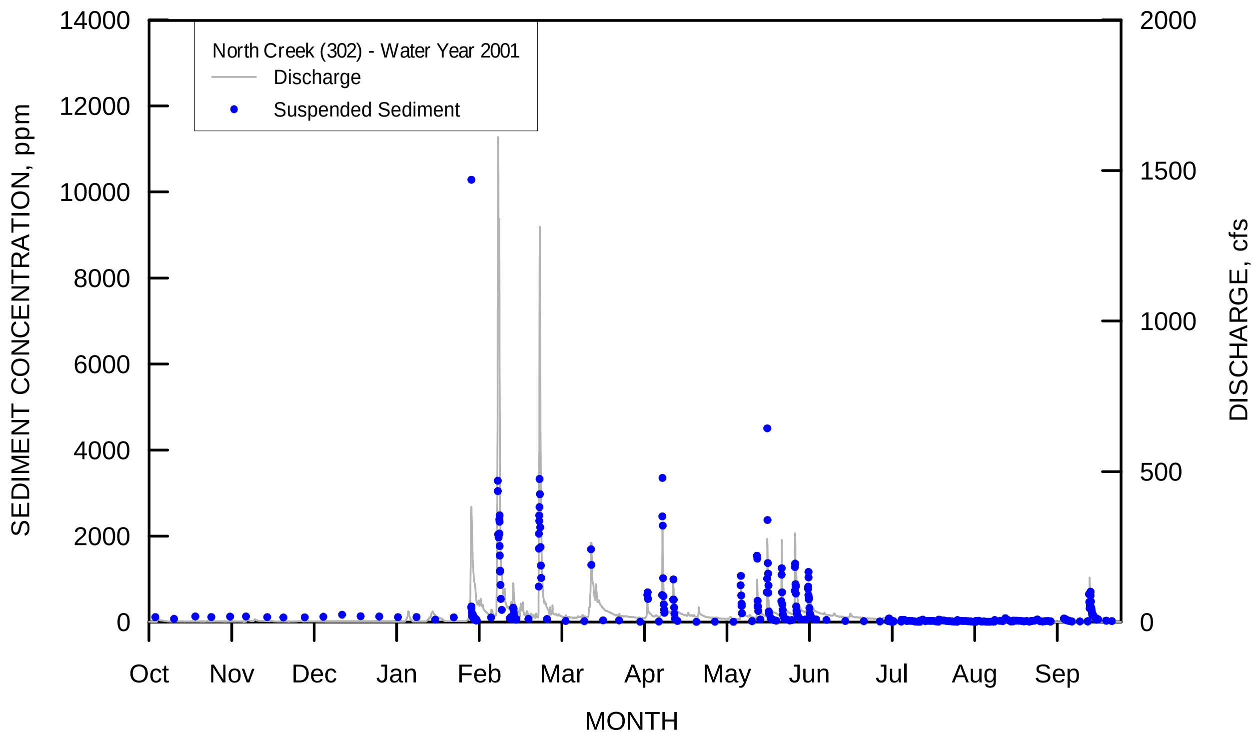
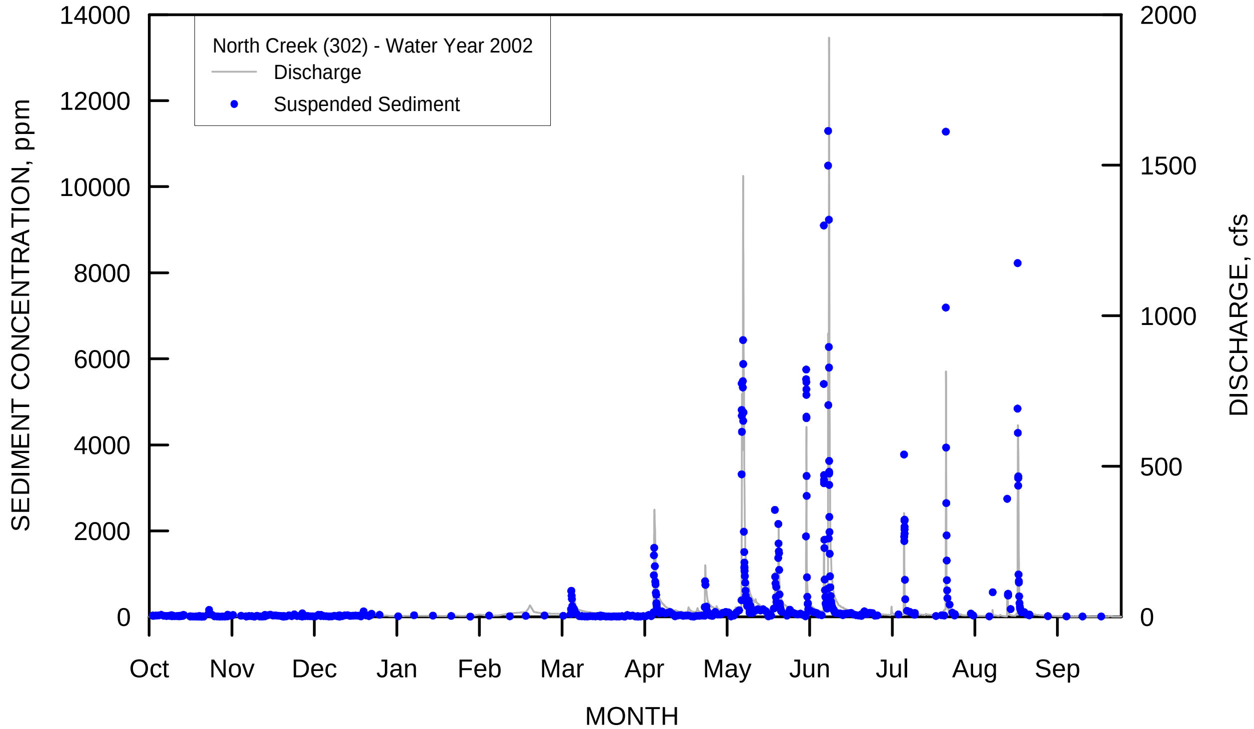


Figure 6. Suspended sediment concentrations and water discharge at North Creek (302) – Water Years 2000 and 2001



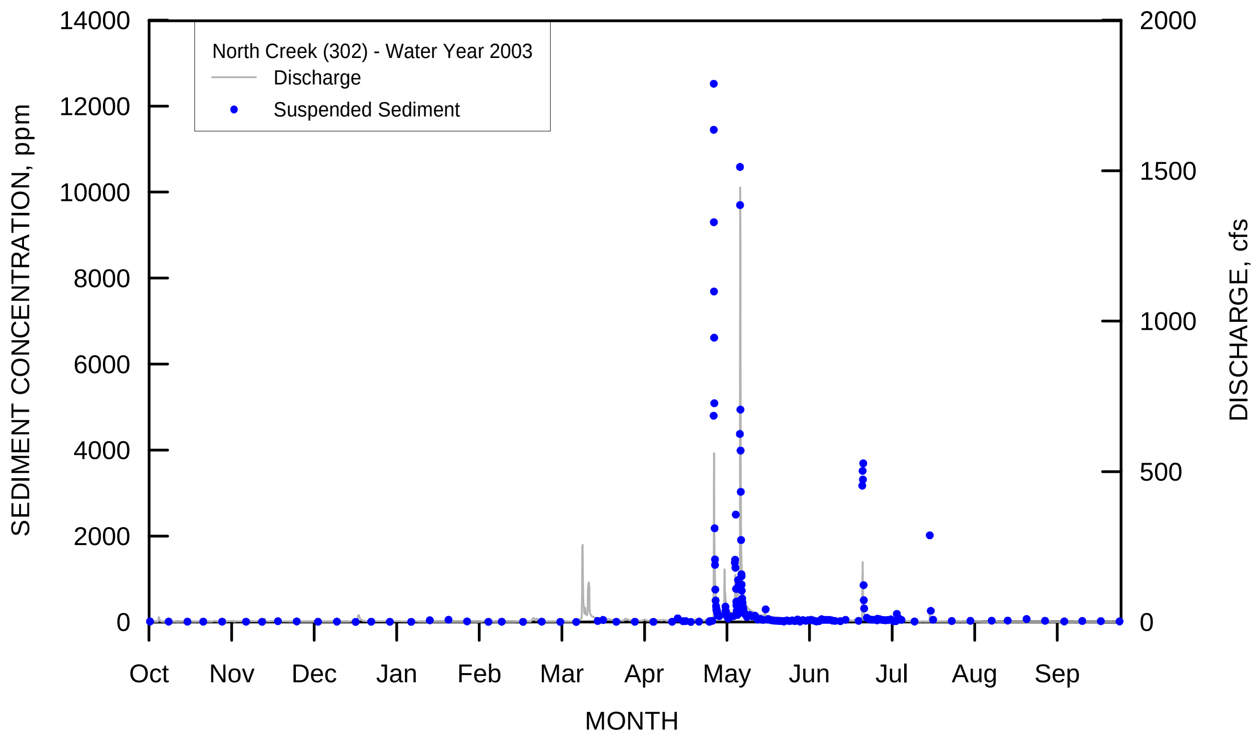
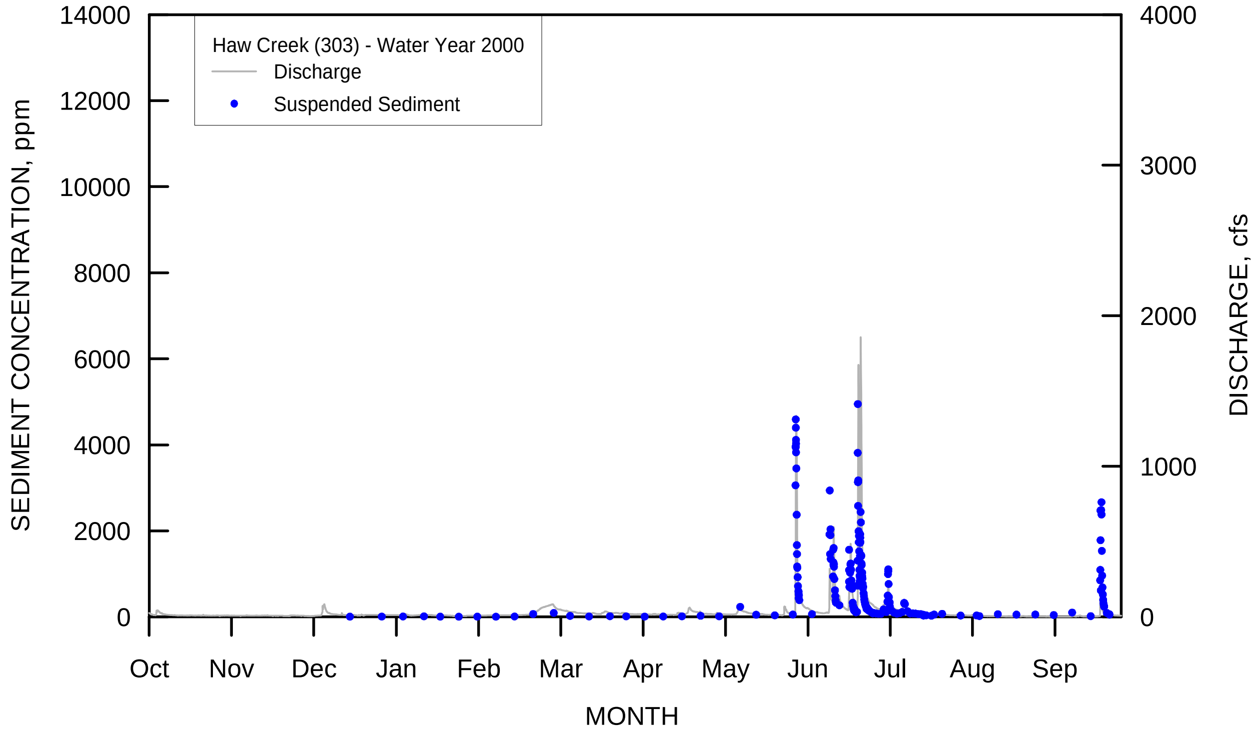


Figure 7. Suspended sediment concentrations and water discharge at North Creek (302) – Water Years 2002 and 2003



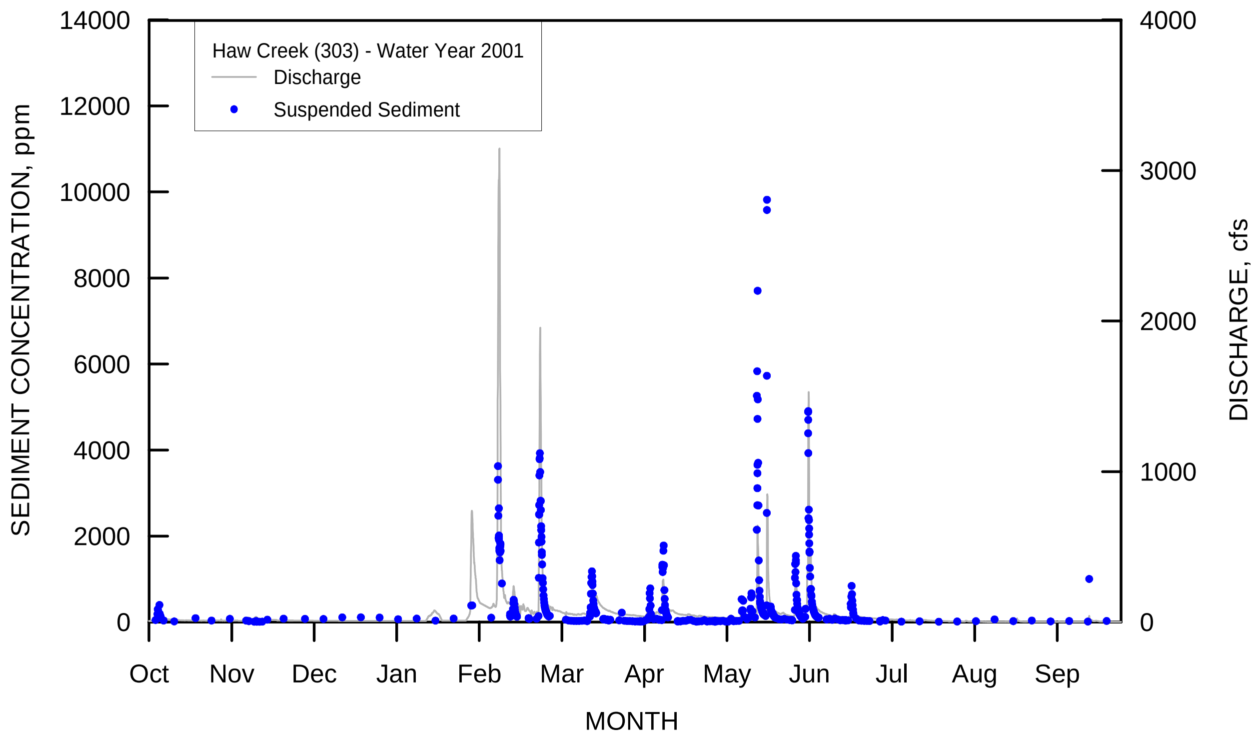
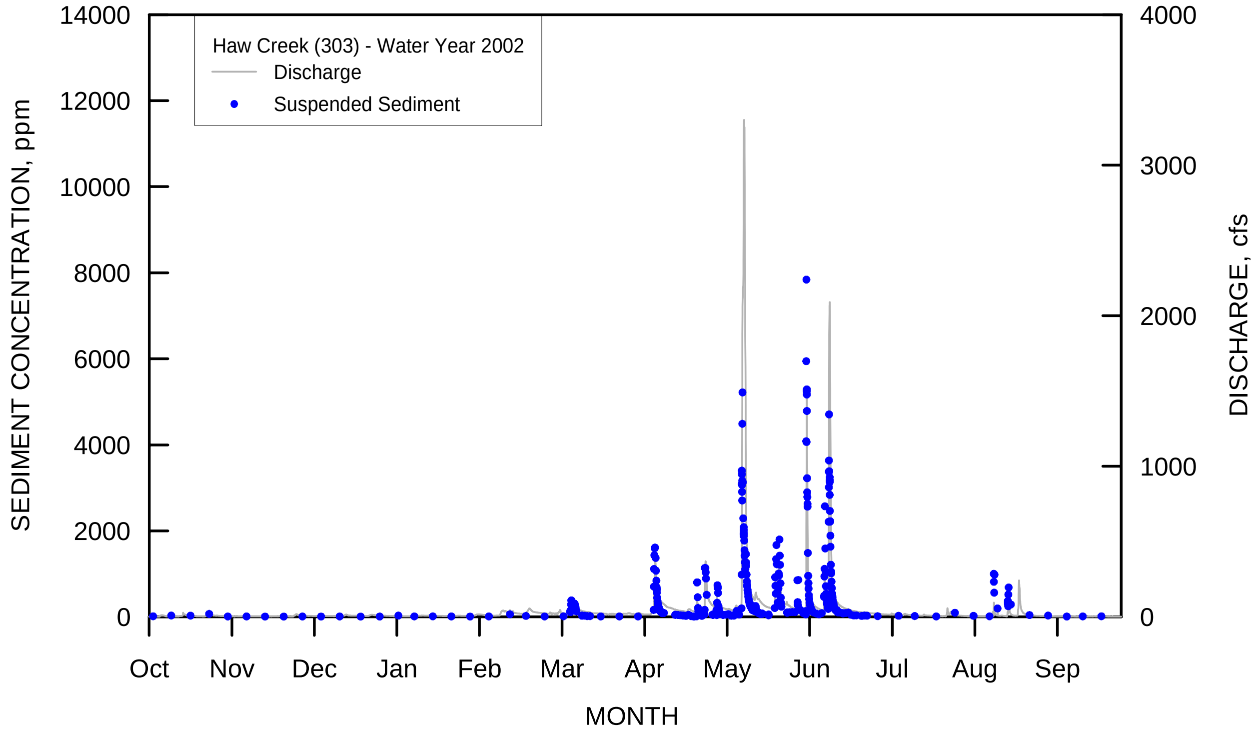


Figure 8. Suspended sediment concentrations and water discharge at Haw Creek (303) – Water Years 2000 and 2001



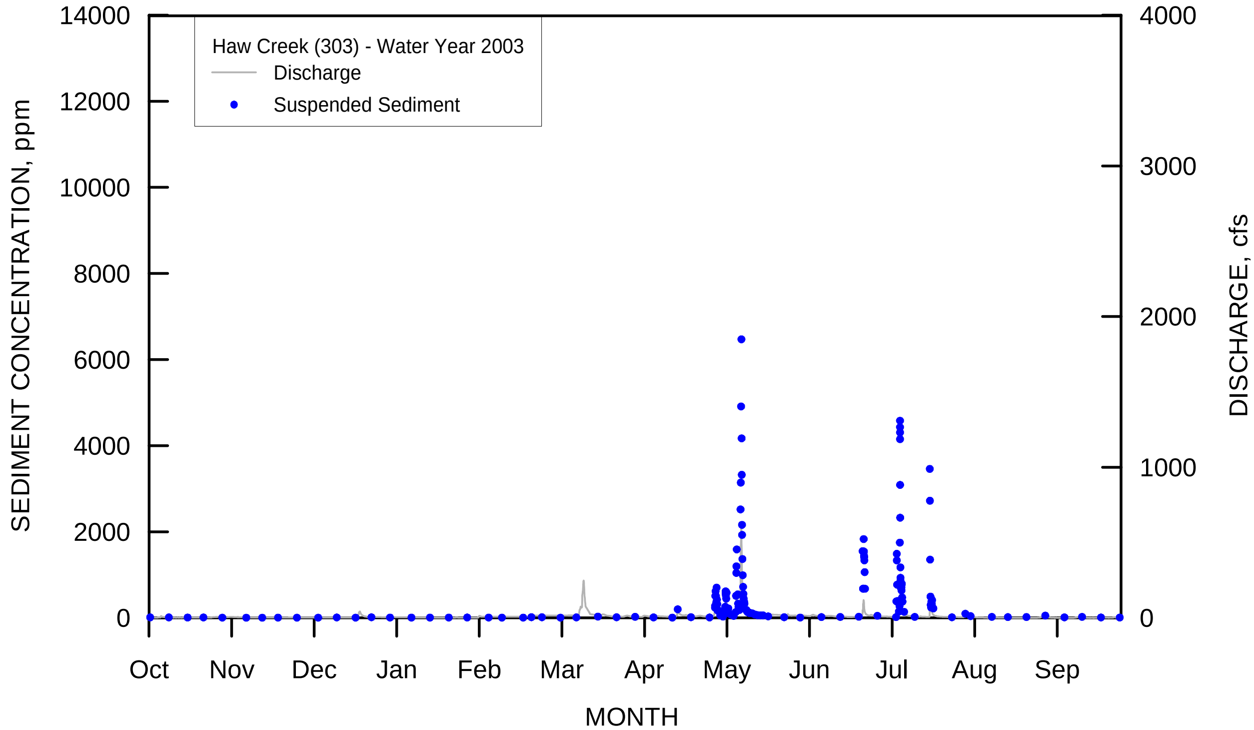
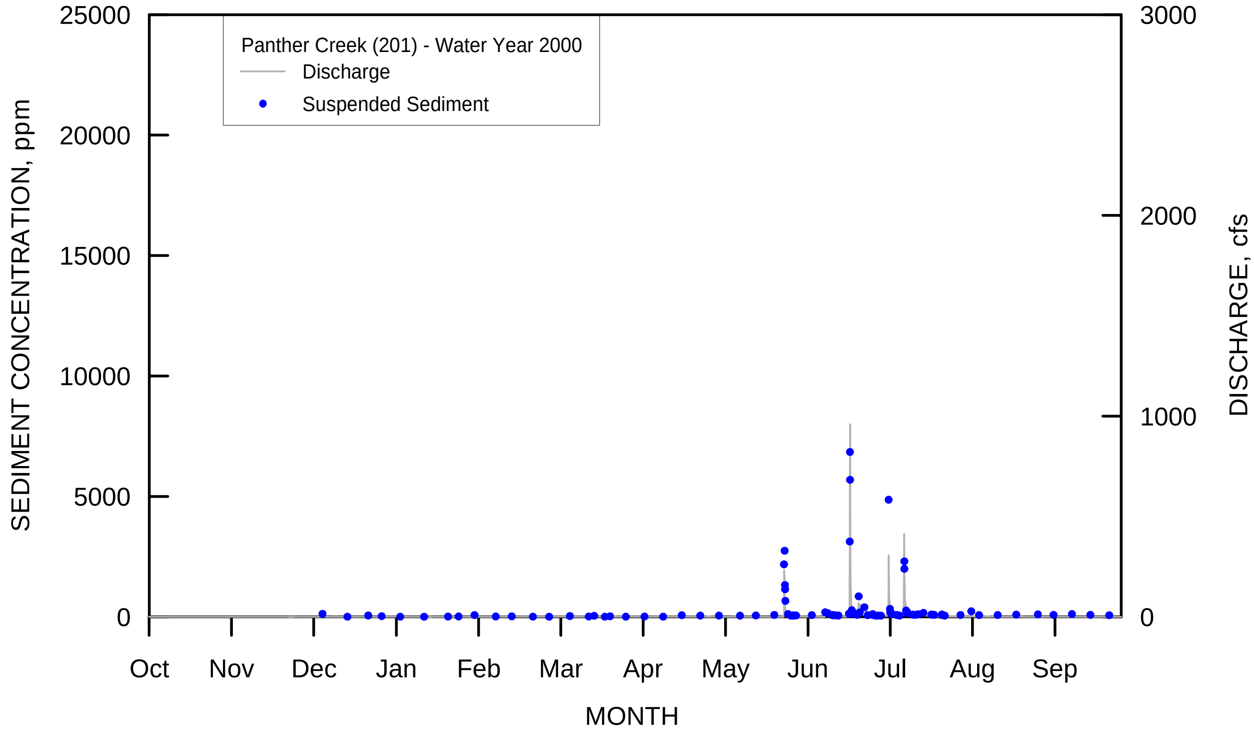


Figure 9. Suspended sediment concentrations and water discharge at Haw Creek (303) – Water Years 2002 and 2003



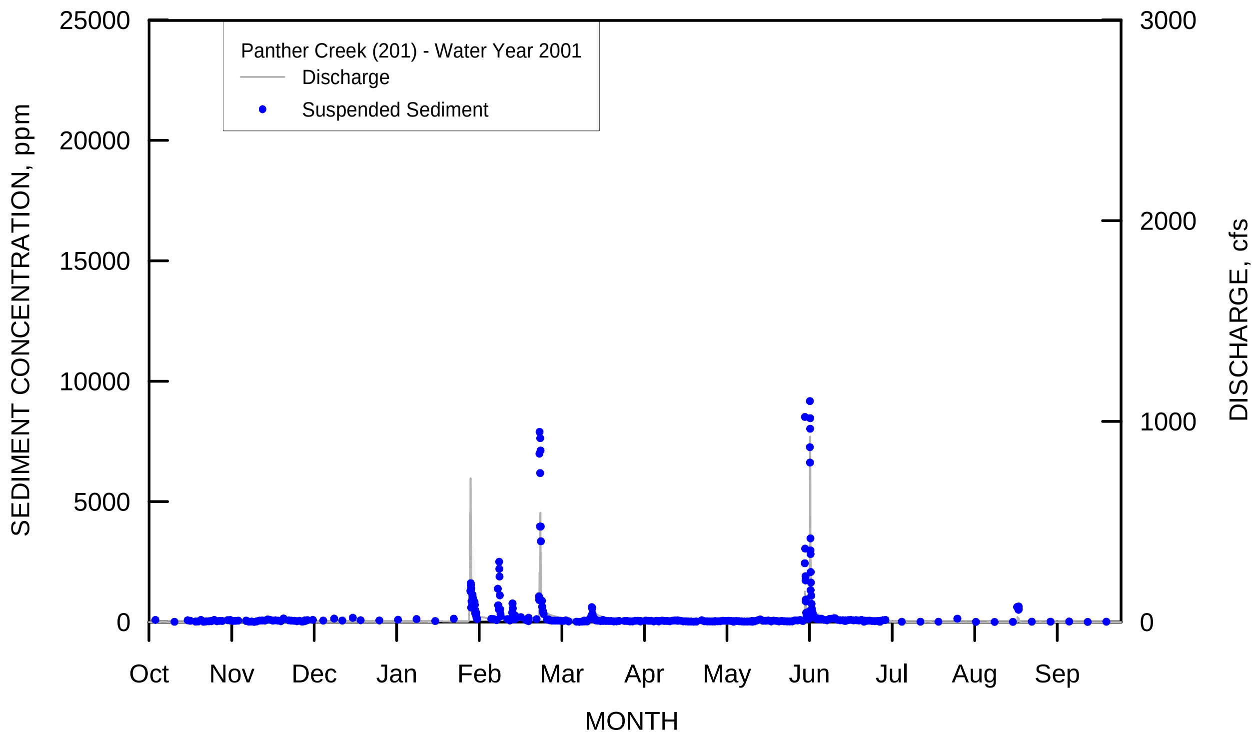
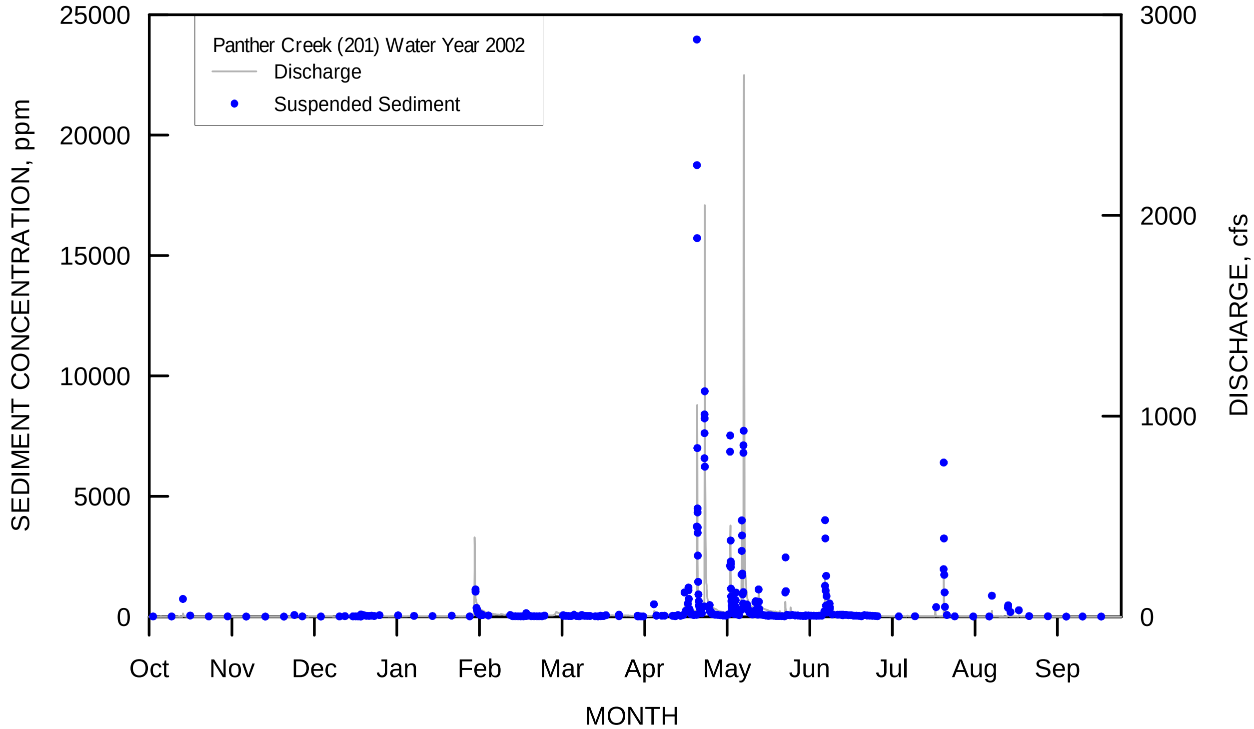


Figure 10. Suspended sediment concentrations and water discharge at Panther Creek (201) – Water Years 2000 and 2001



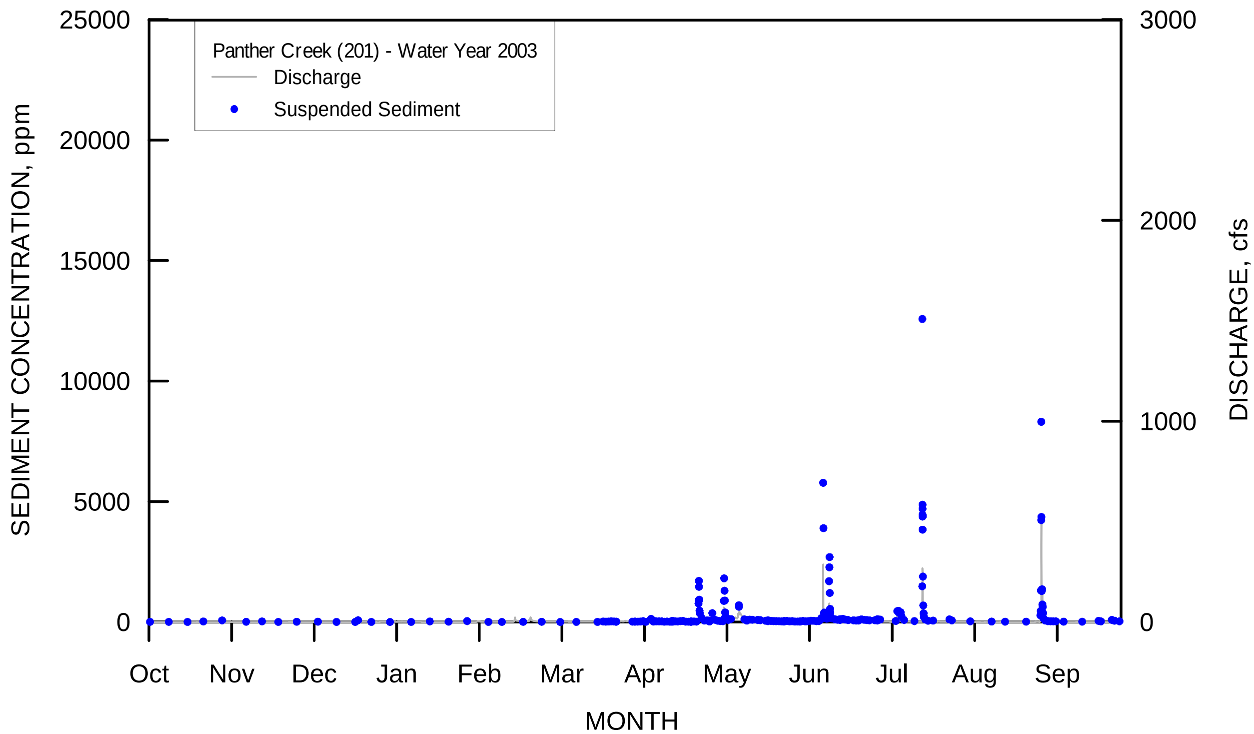
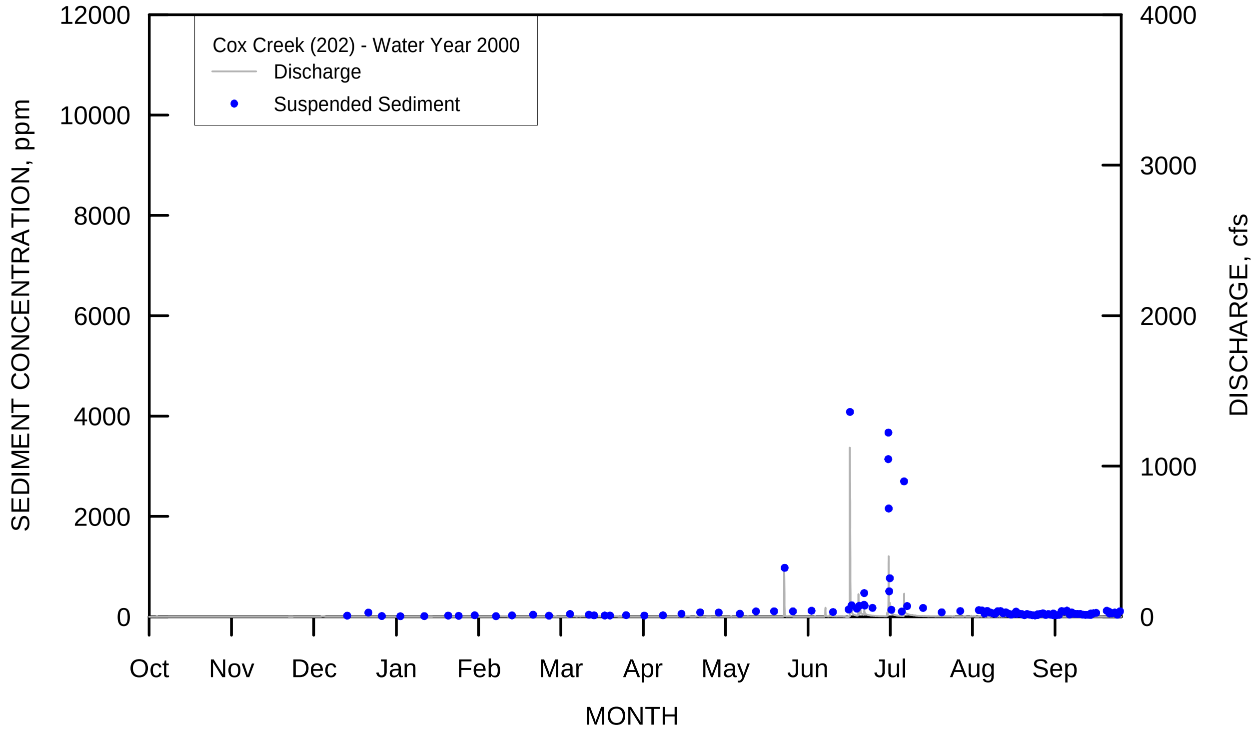


Figure 11. Suspended sediment concentrations and water discharge at Panther Creek (201) – Water Years 2002 and 2003



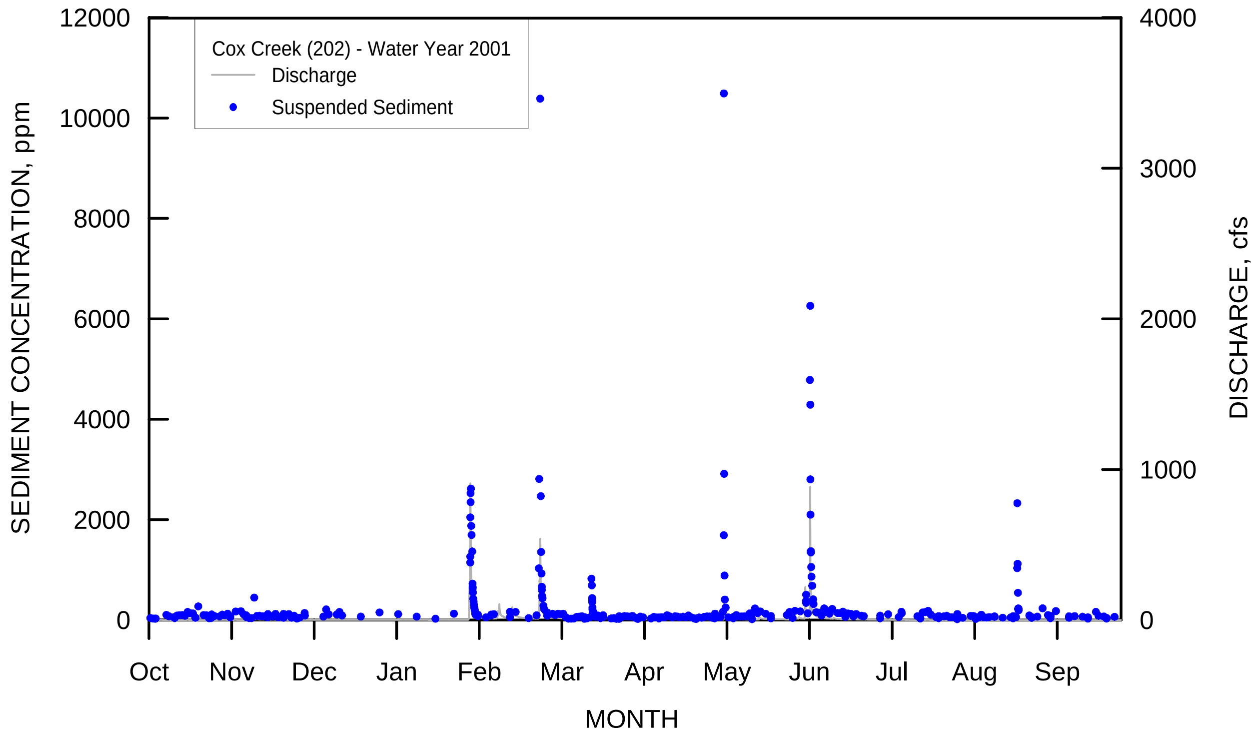
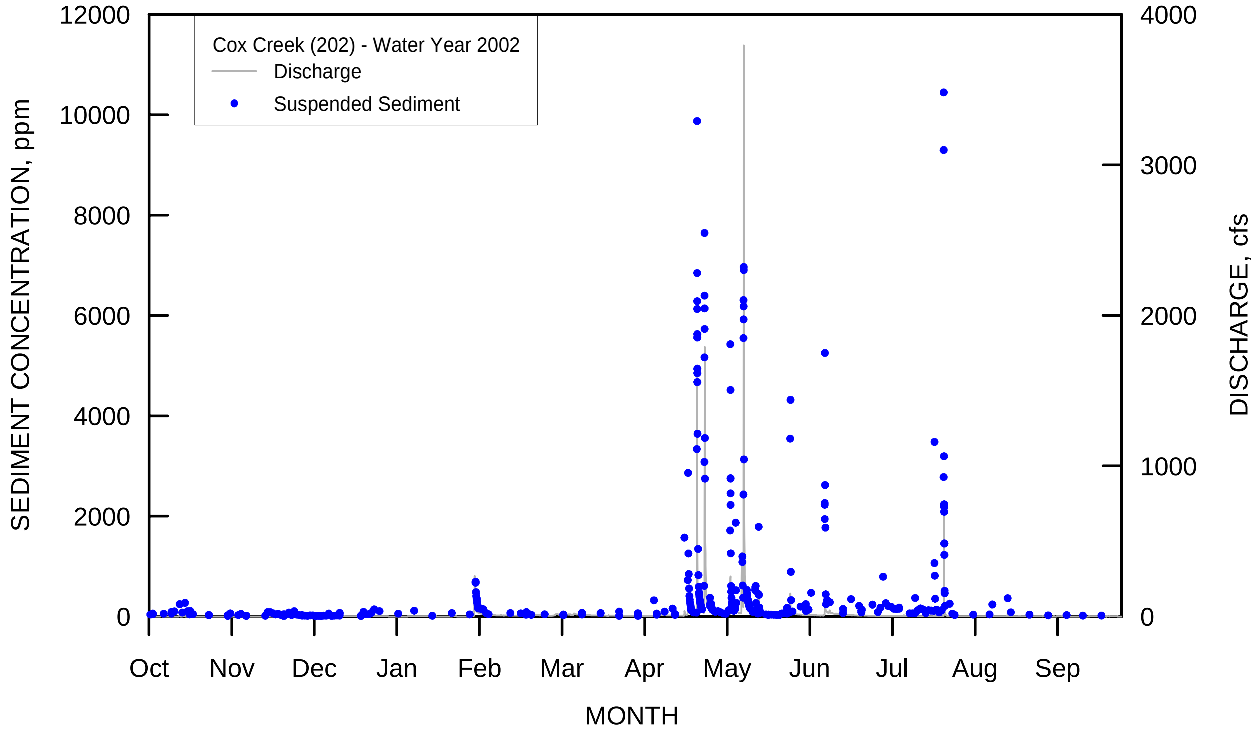


Figure 12. Suspended sediment concentrations and water discharge at Cox Creek (202) – Water Years 2000 and 2001



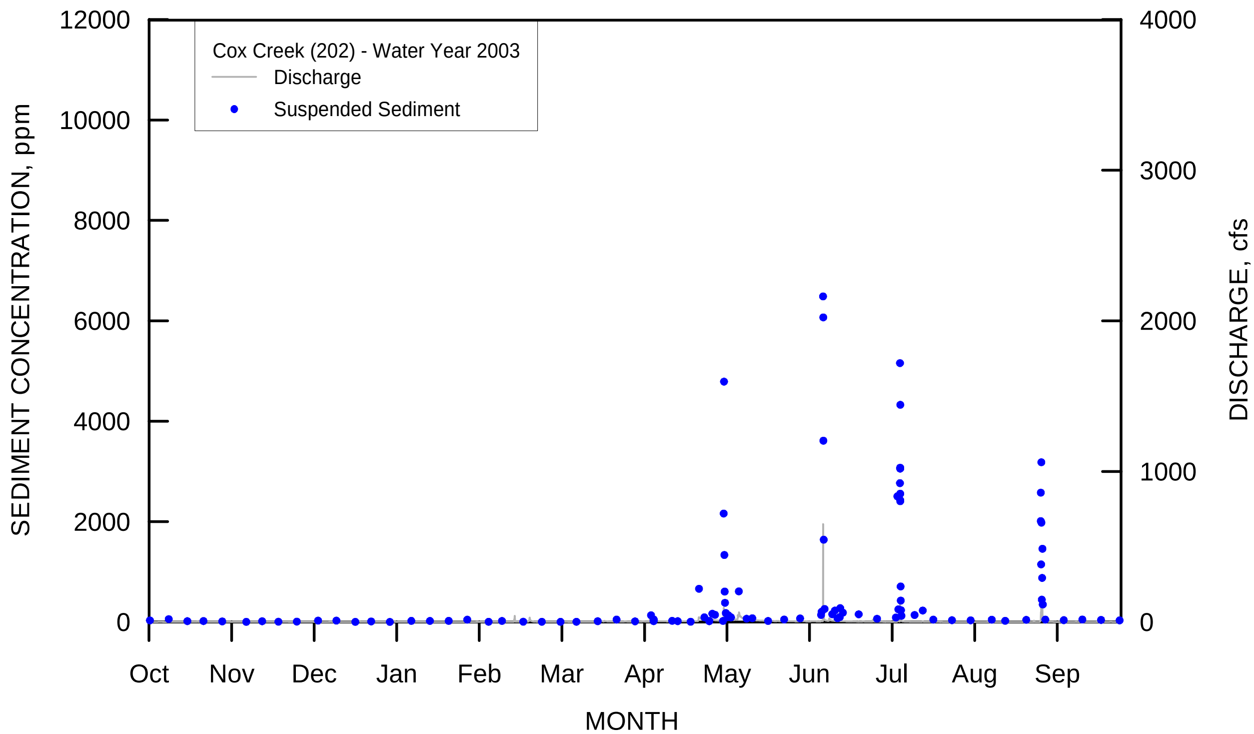


Figure 13. Suspended sediment concentrations and water discharge at Cox Creek (202) – Water Years 2002 and 2003

Nutrient Data

All the nutrient data collected and analyzed from Water Year 2000 through Water Year 2003 at the five monitoring stations are presented in figures 14 to 33. The nutrient data are organized into two groups: nitrogen species and phosphourous 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 phosphorous species include total phosphorous (TP), total dissolved phosphorous (TDP), and orthophosphate (P-ortho). Over 1,300 samples have been collected and analyzed for nitrate (NO_3-N), ammonium (NH_4-N) and orthophosphate (P-ortho). In addition, more than 500 samples have been analyzed for nitrate (NO_2-N), total Kjeldahl nitrogen (TKN), total phosphorous (TP), and total dissolved phosphorous (TDP). The data for the nitrogen species are shown in figures 14-23, while those for the phosphorous species are shown in figures 24-33.

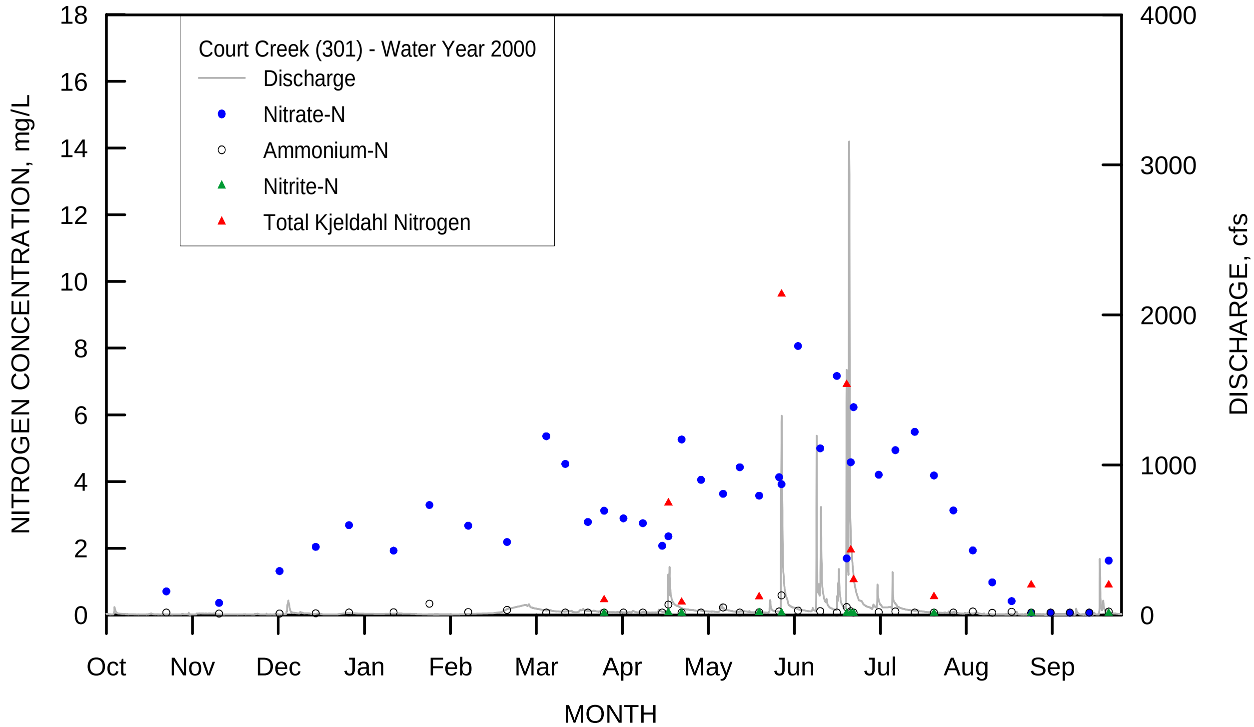
The data for the nitrogen species at all five monitoring stations show that the dominant form of nitrogen transported by the streams is nitrate-N. During storm events, the concentration of TKN rises significantly, sometimes exceeding the nitrate-N concentration. TKN is highly correlated to suspended sediment concentrations.

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

The data for the phosphorous species at all five monitoring stations show that most of the phosphorous load is transported during storm events. Concentrations of total phosphorous 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 phosphorous concentrations and loads. In terms of phosphorous concentrations, it does not appear there is any significant difference between the different monitoring stations form the Spoon and Sangamon River watersheds.

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 phosphorous. The daily loads are then compiled to compute monthly and annual loads. The result of those calculations are summarized in tables 2-6 for each of the five monitoring stations. Each table presents the annual water discharge, sediment load, nitrate-N load and the total phosphorous load for one of the stations. Similar calculations have been made for the other species of nitrogen and phosphorous but are not presented in this report to minimize report size. The annual sediment loads are highly correlated to the water discharge, and thus the wetter years, 2001 and 2002, generated more sediment at all stations as compared to drier years, 2000 and 2003. The annual loads ranged from a low of 1,820 tons in 2003 at Cox Creek to a high of 62,841 tons in 2002 at Court Creek. The nitrate-N loads ranged from a low of 10.3 tons in



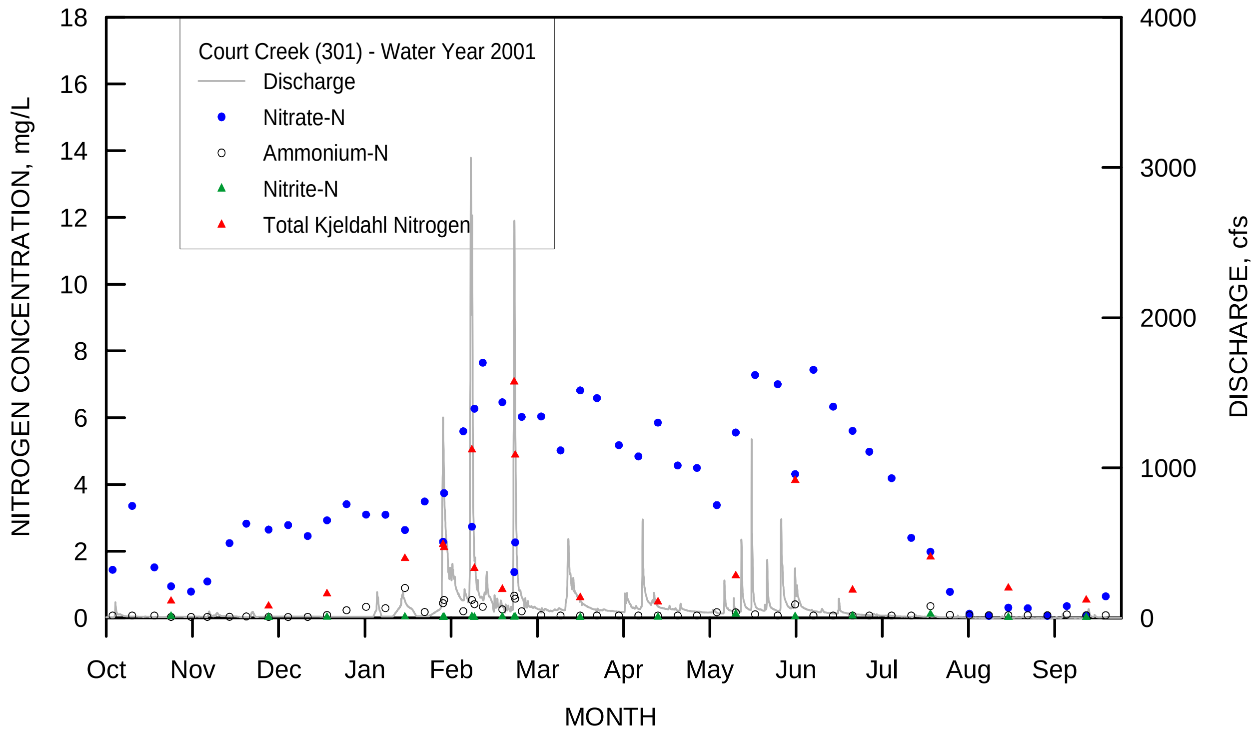
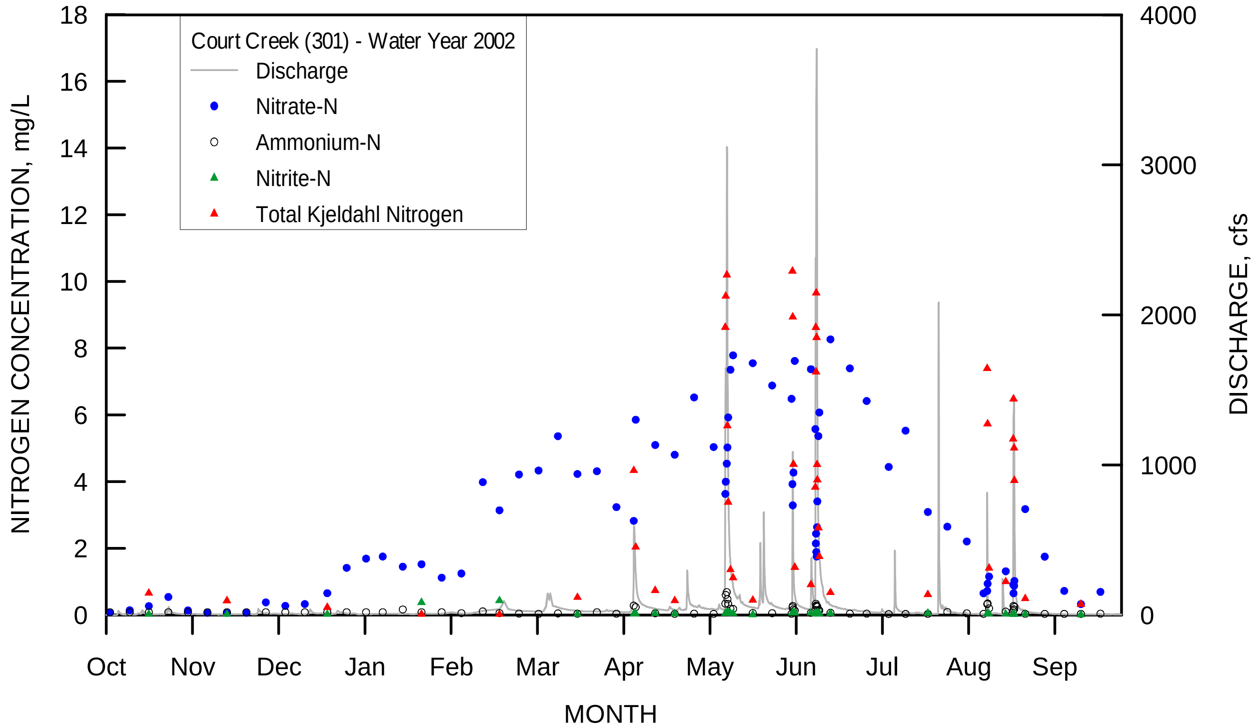


Figure 14. Concentrations of nitrogen species and water discharge at Court Creek (301) – Water Years 2000 and 2001



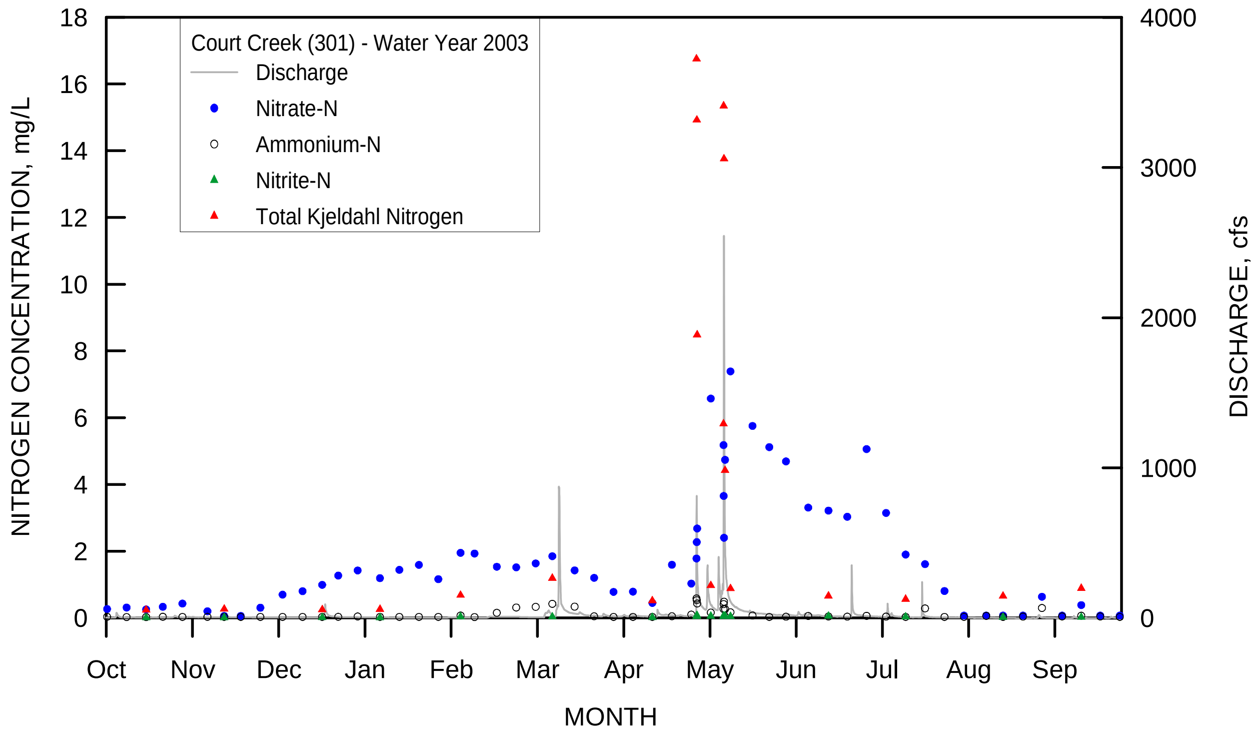
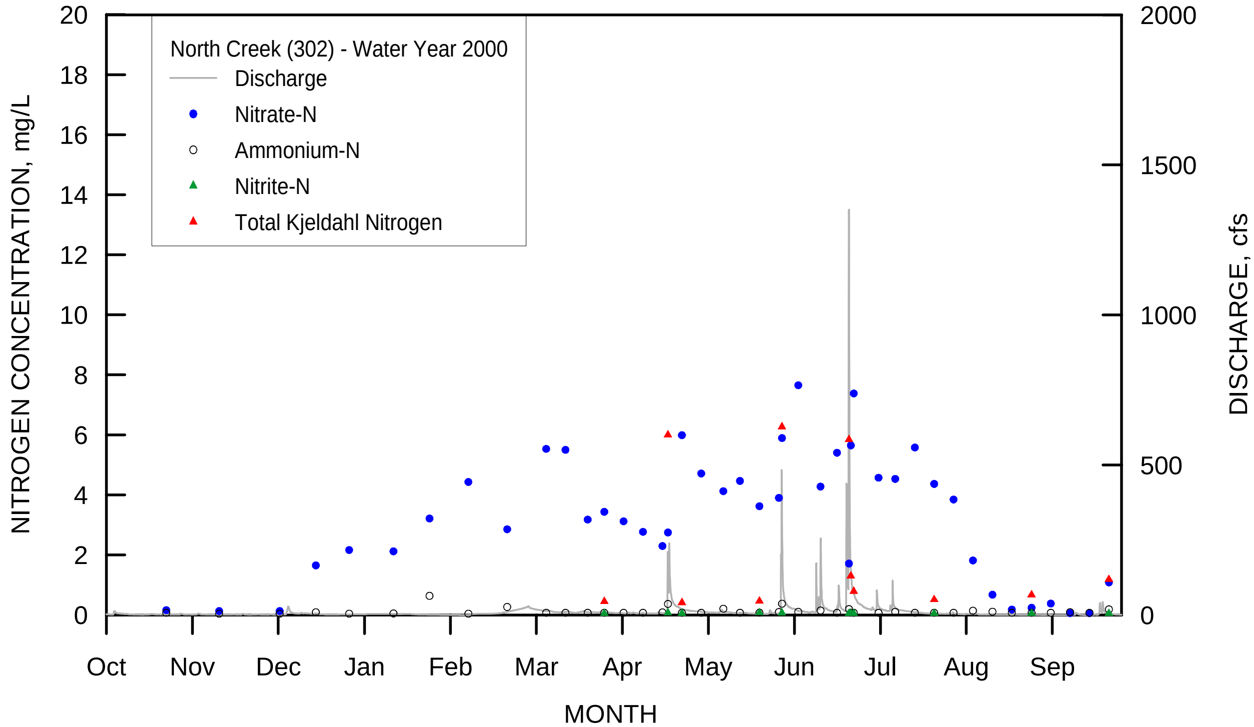


Figure 15. Concentrations of nitrogen species and water discharge at Court Creek (301) – Water Years 2002 and 2003



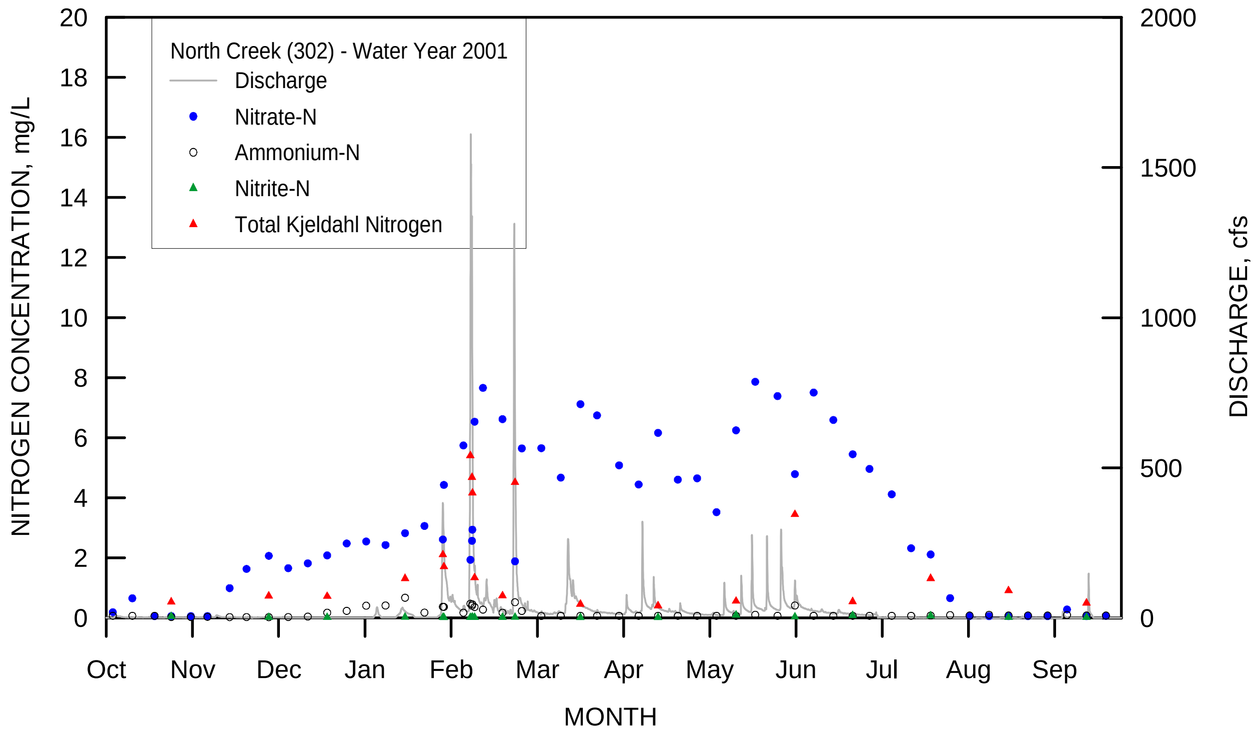
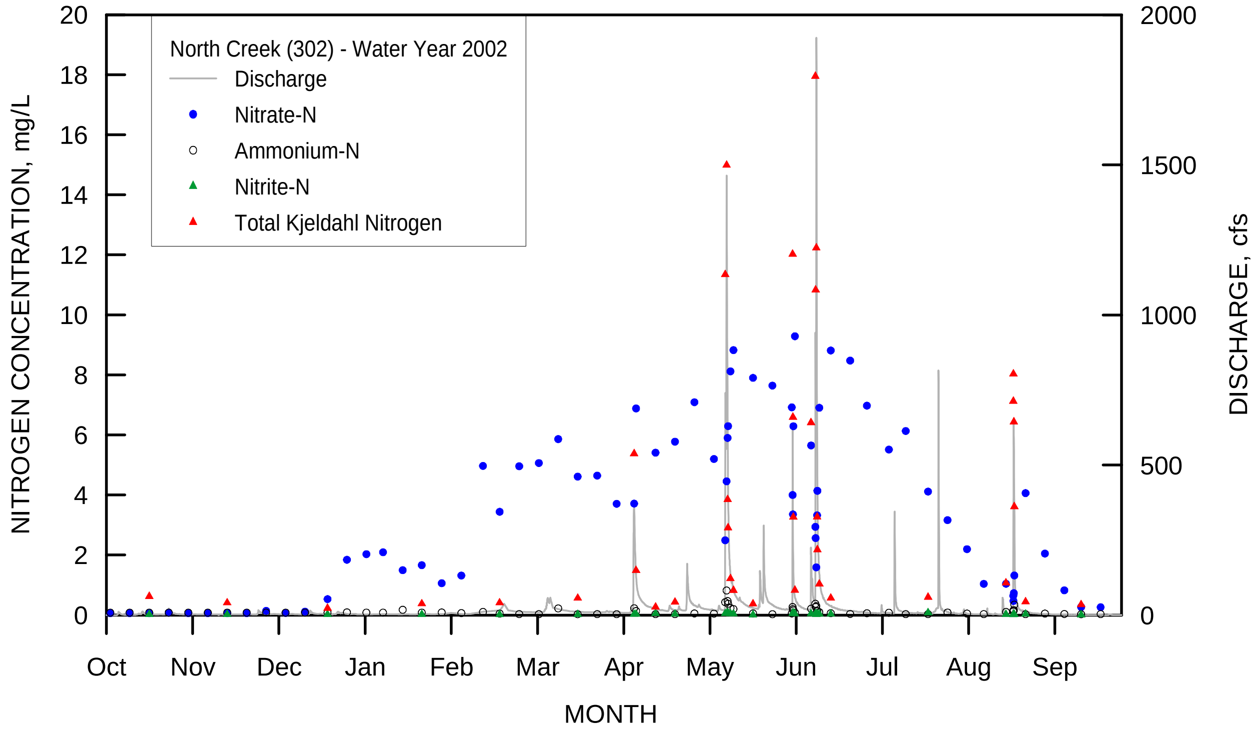


Figure 16. Concentrations of nitrogen species and water discharge at North Creek (302) – Water Years 2000 and 2001



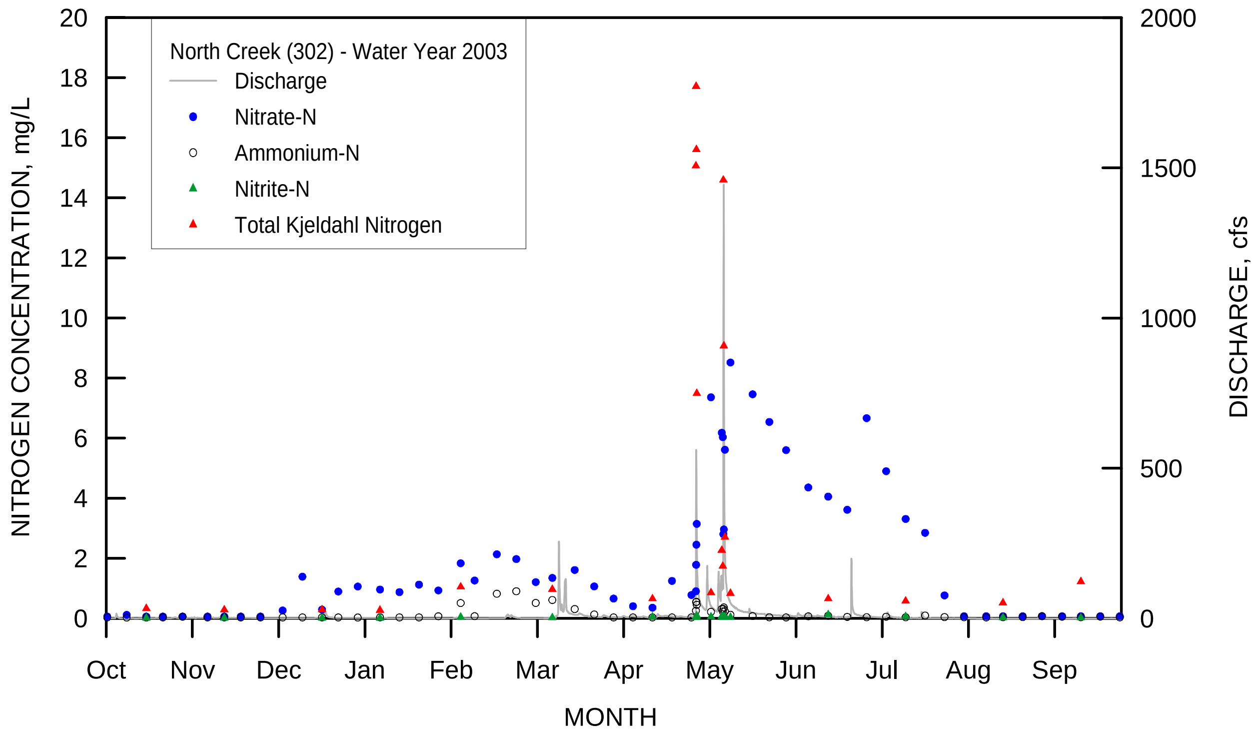
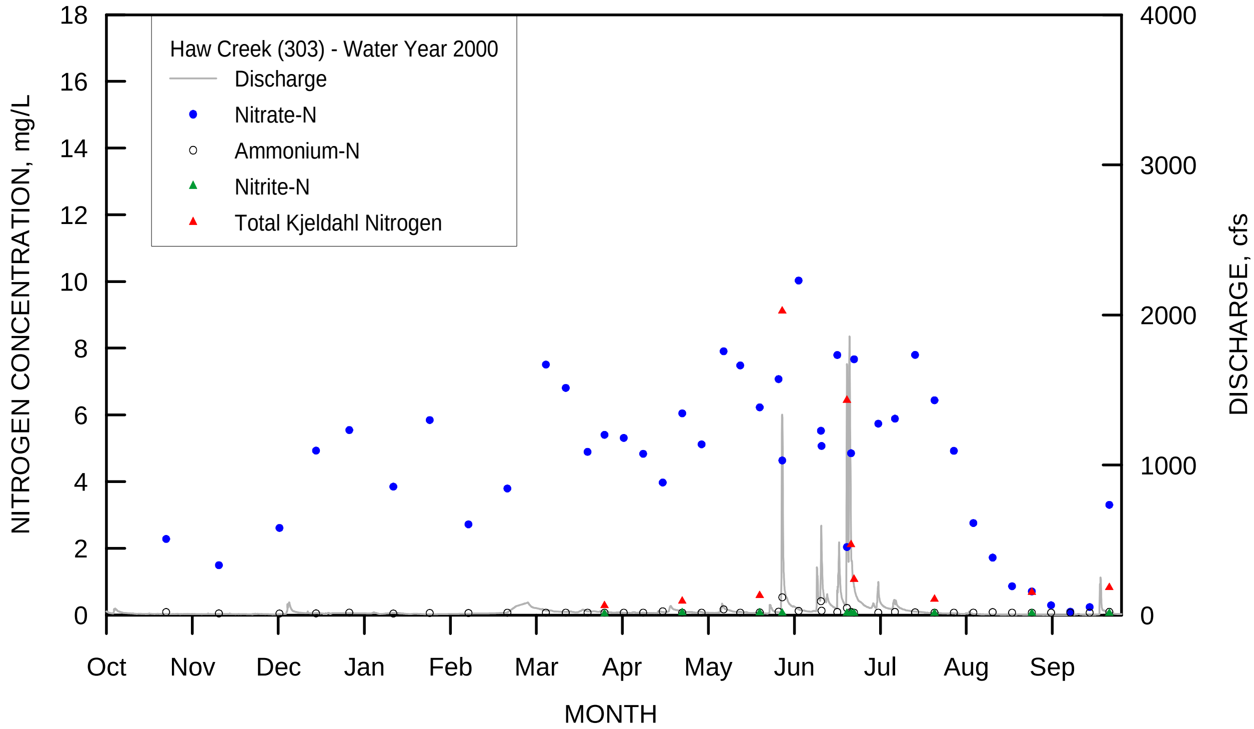


Figure 17. Concentrations of nitrogen species and water discharge at North Creek (302) – Water Years 2002 and 2003



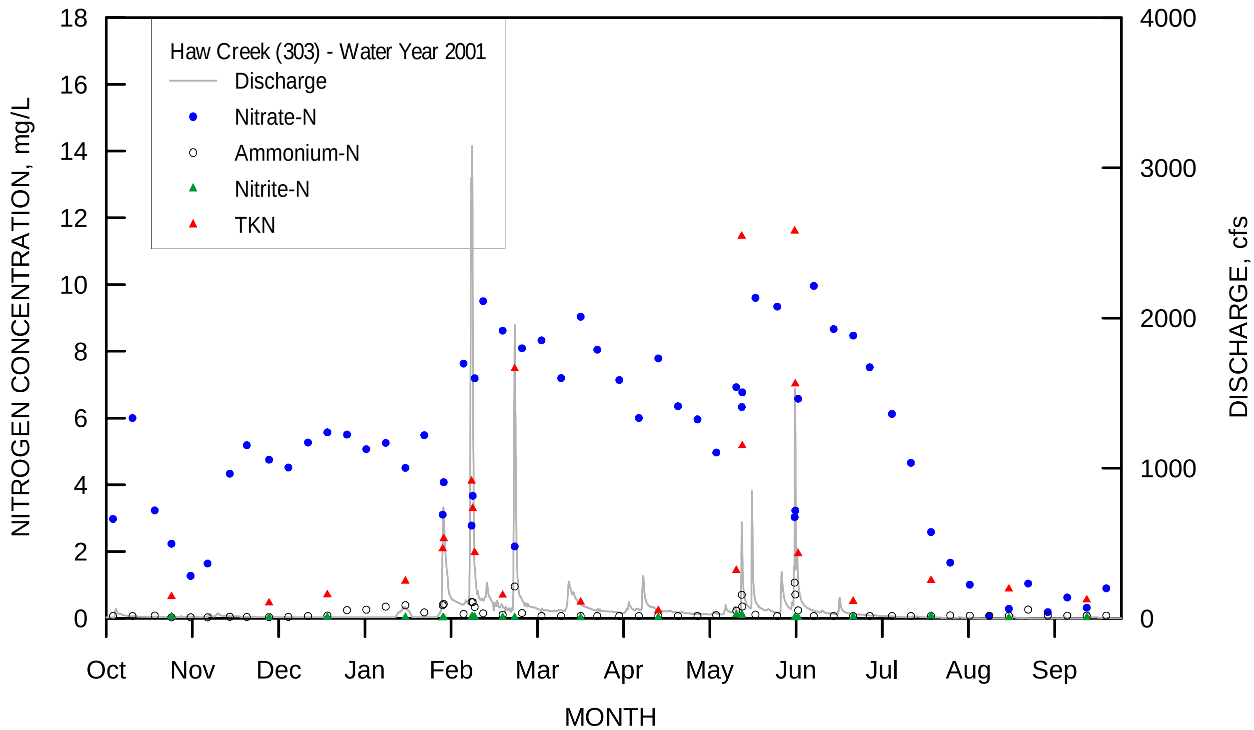
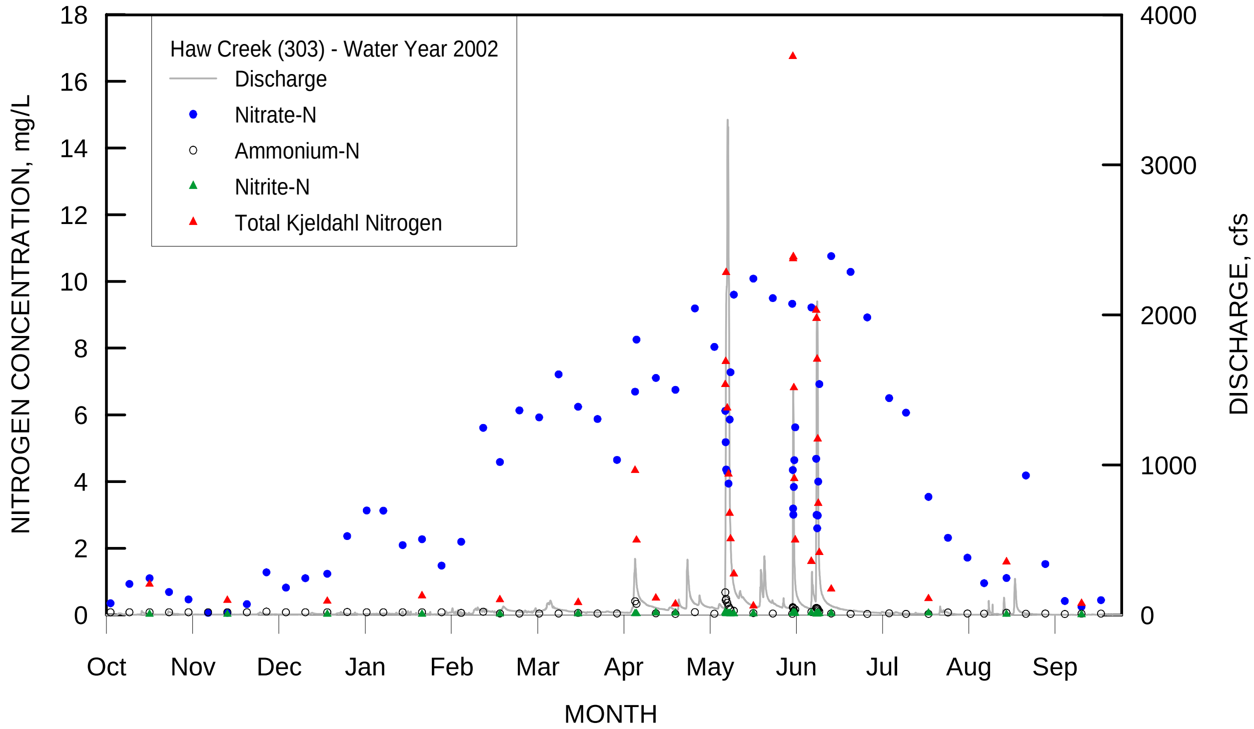


Figure 18. Concentrations of nitrogen species and water discharge at Haw Creek (303) – Water Years 2000 and 2001



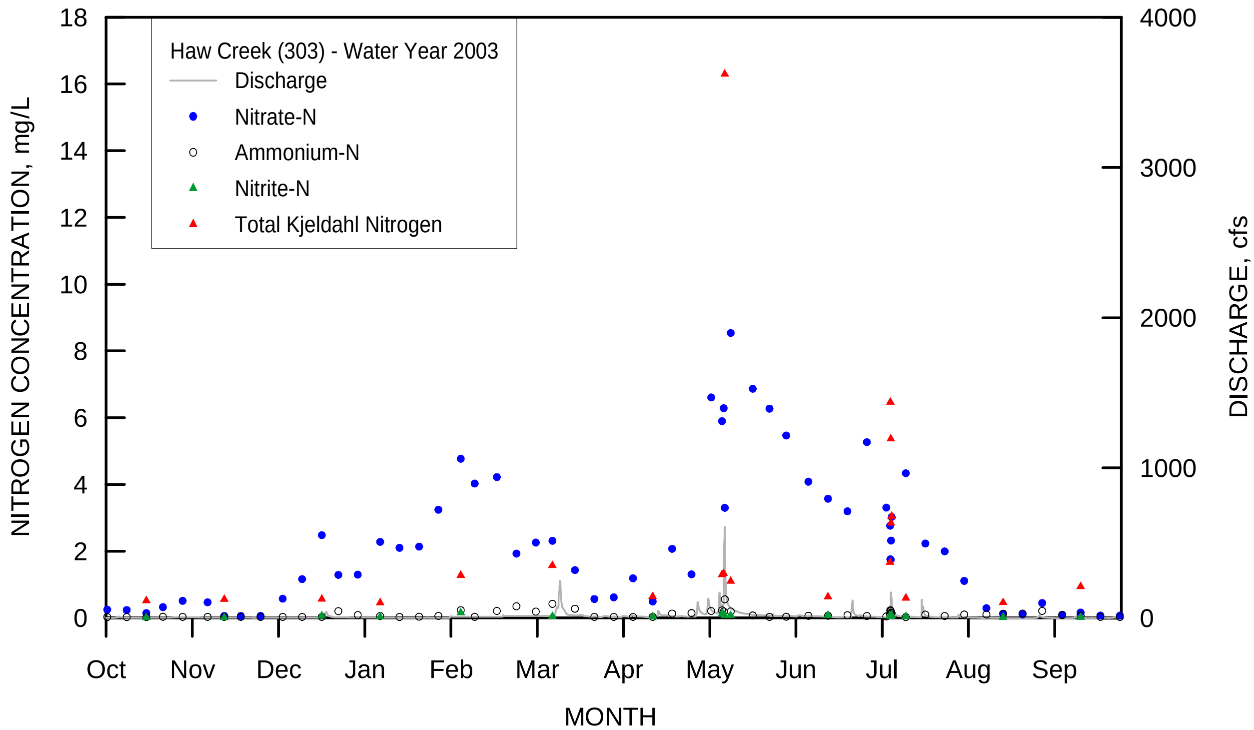
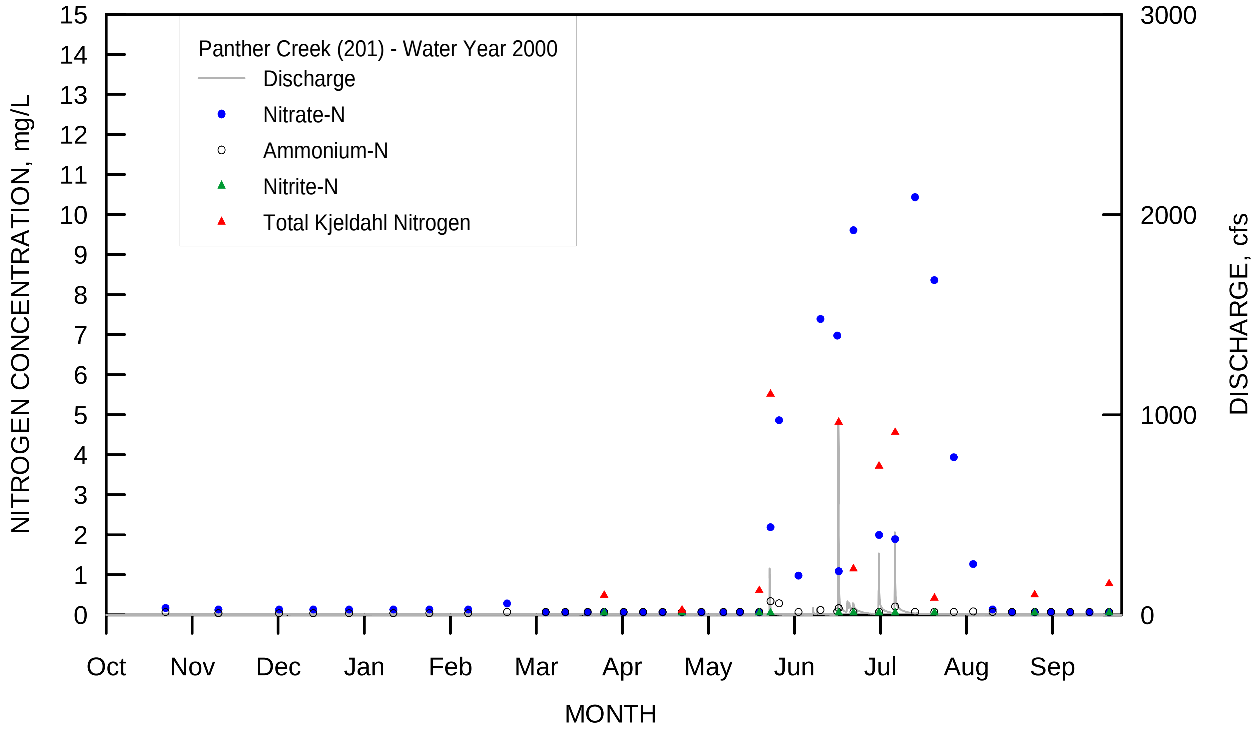


Figure 19. Concentrations of nitrogen species and water discharge at Haw Creek (303) – Water Years 2002 and 2003



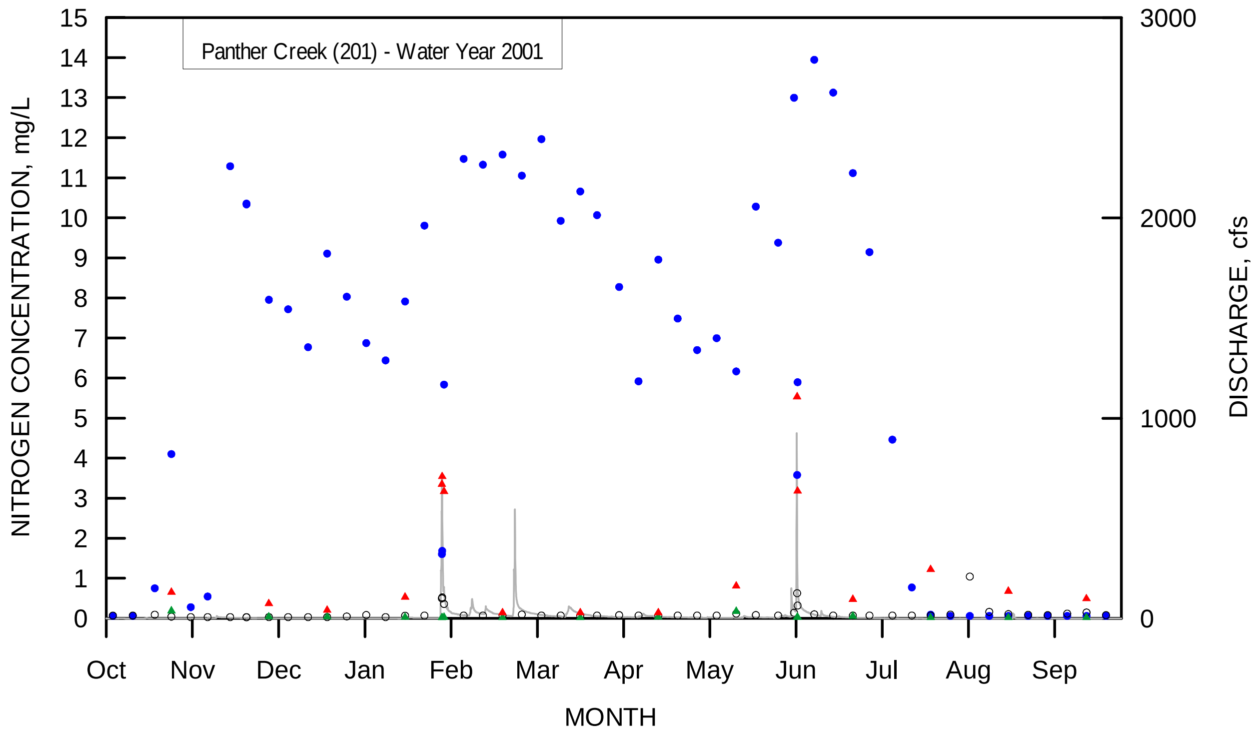
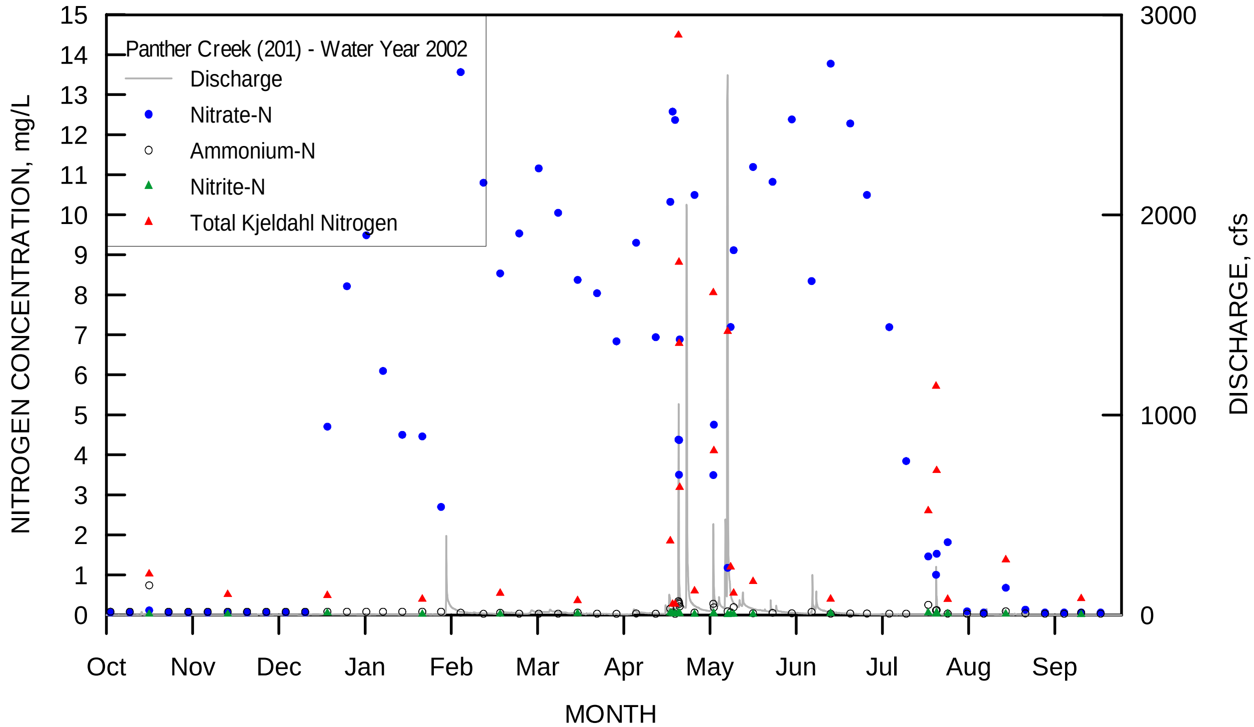


Figure 20. Concentrations of nitrogen species and water discharge at Panther Creek (201) – Water Years 2000 and 2001



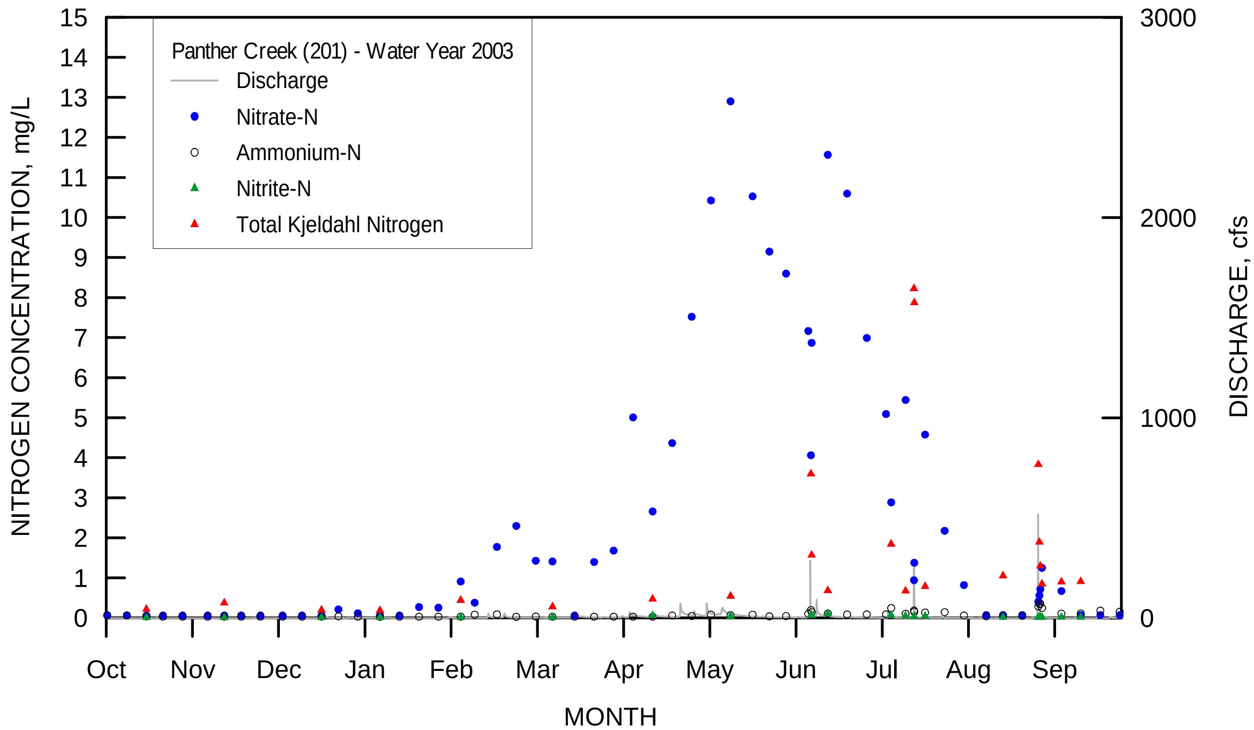
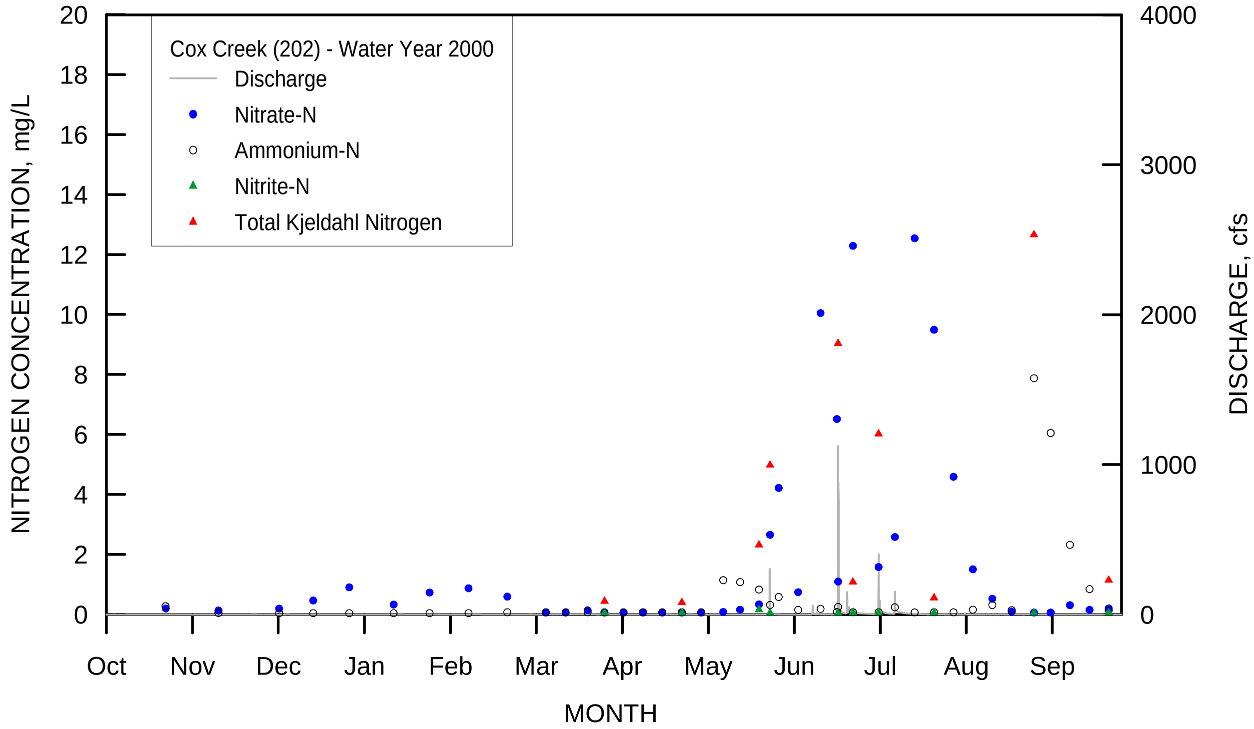


Figure 21. Concentrations of nitrogen species and water discharge at Panther Creek (201) – Water Years 2002 and 2003



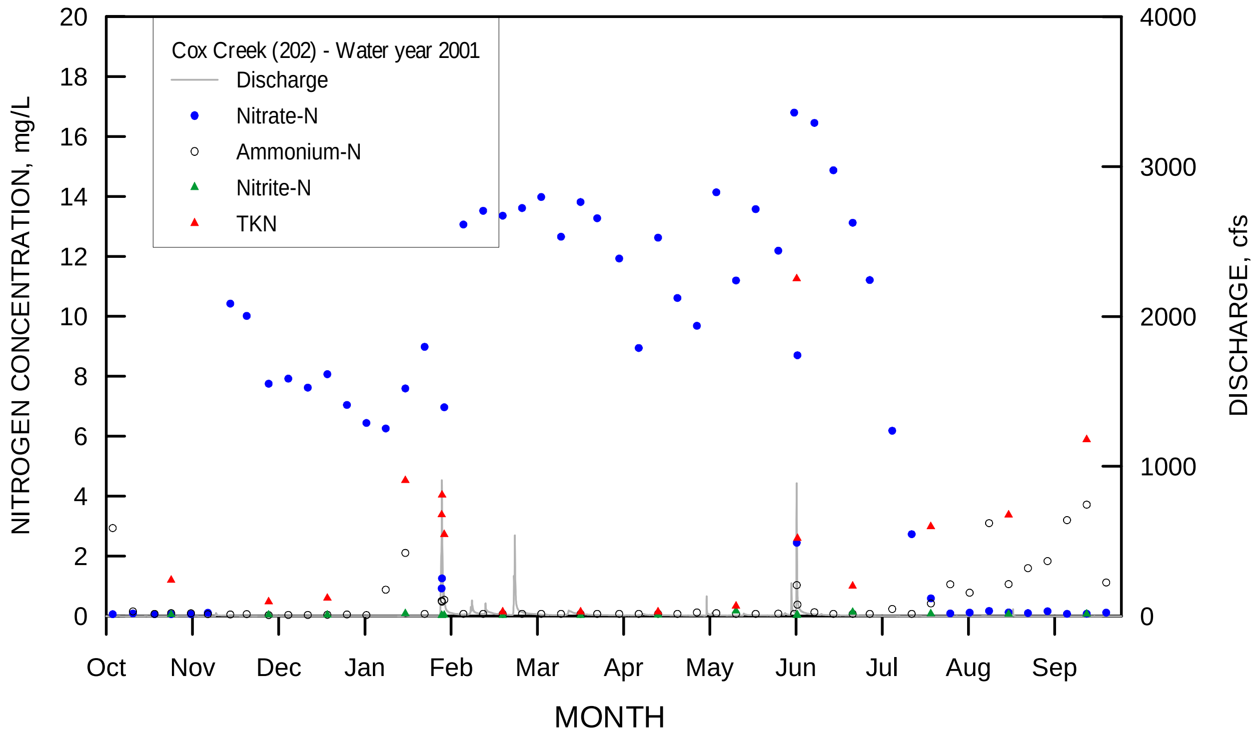
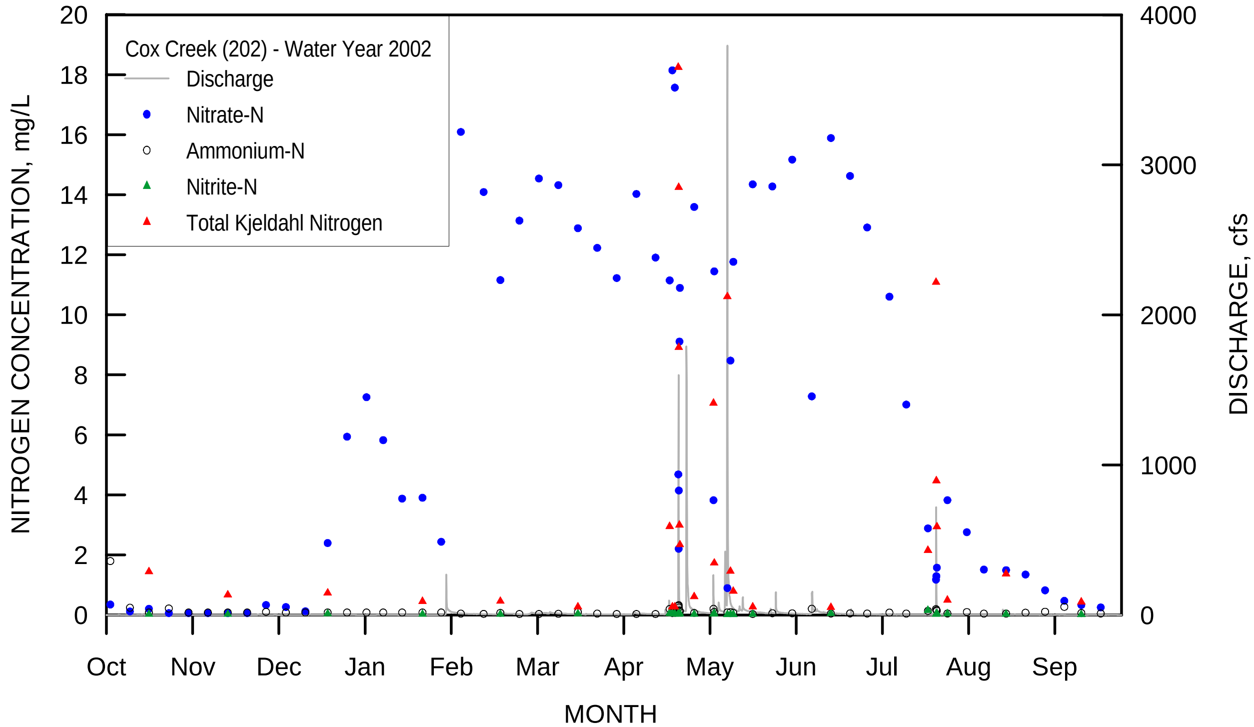


Figure 22. Concentrations of nitrogen species and water discharge at Cox Creek (202) – Water Years 2000 and 2001



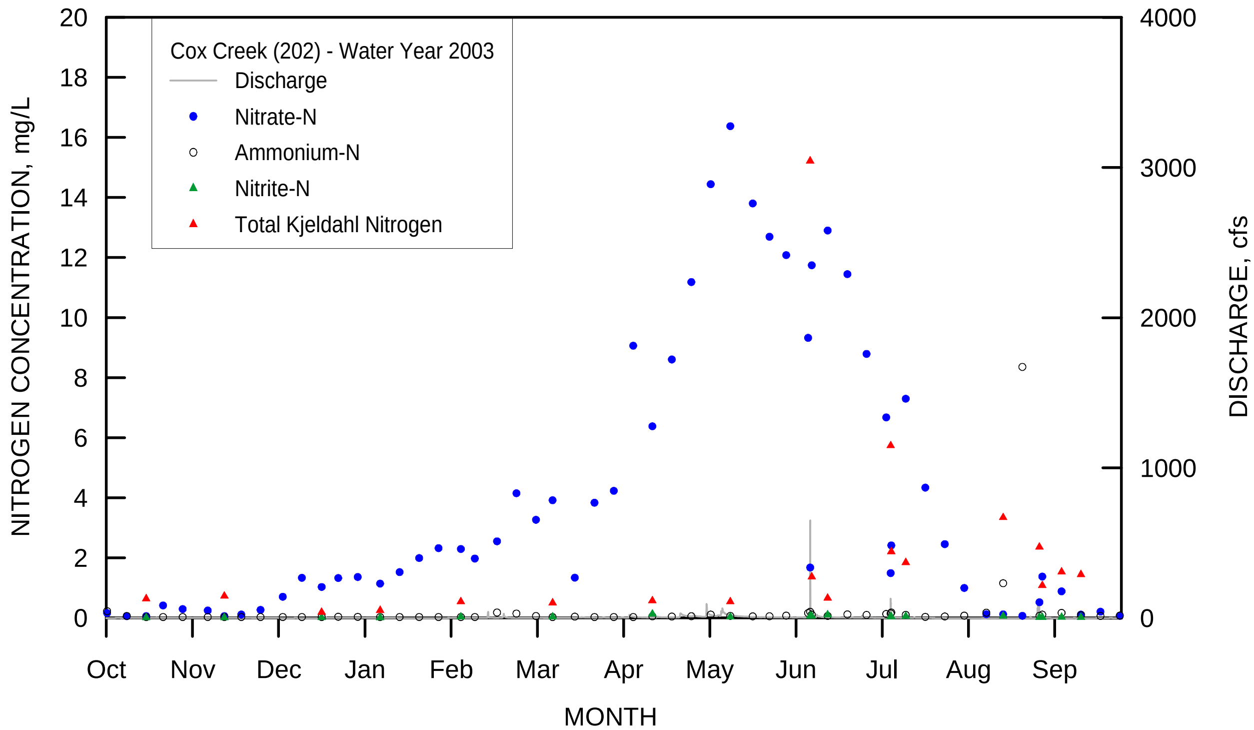
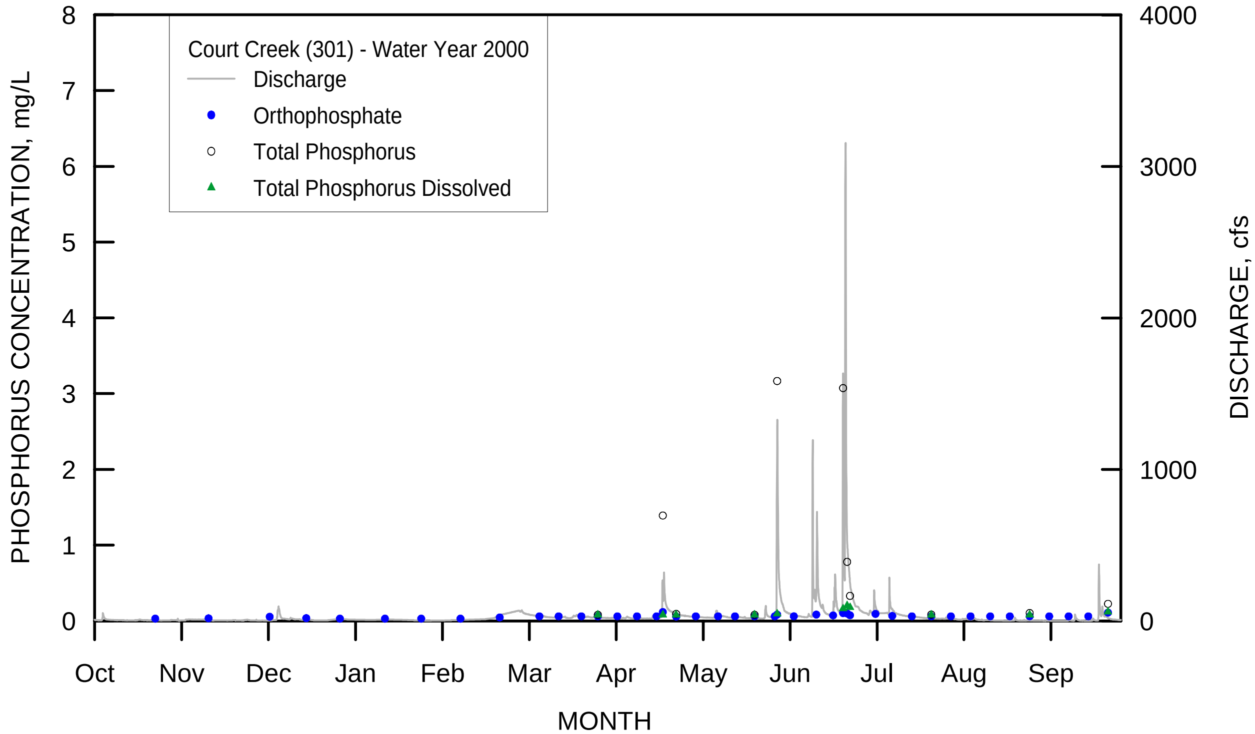


Figure 23. Concentrations of nitrogen species and water discharge at Cox Creek (202) – Water Years 2002 and 2003



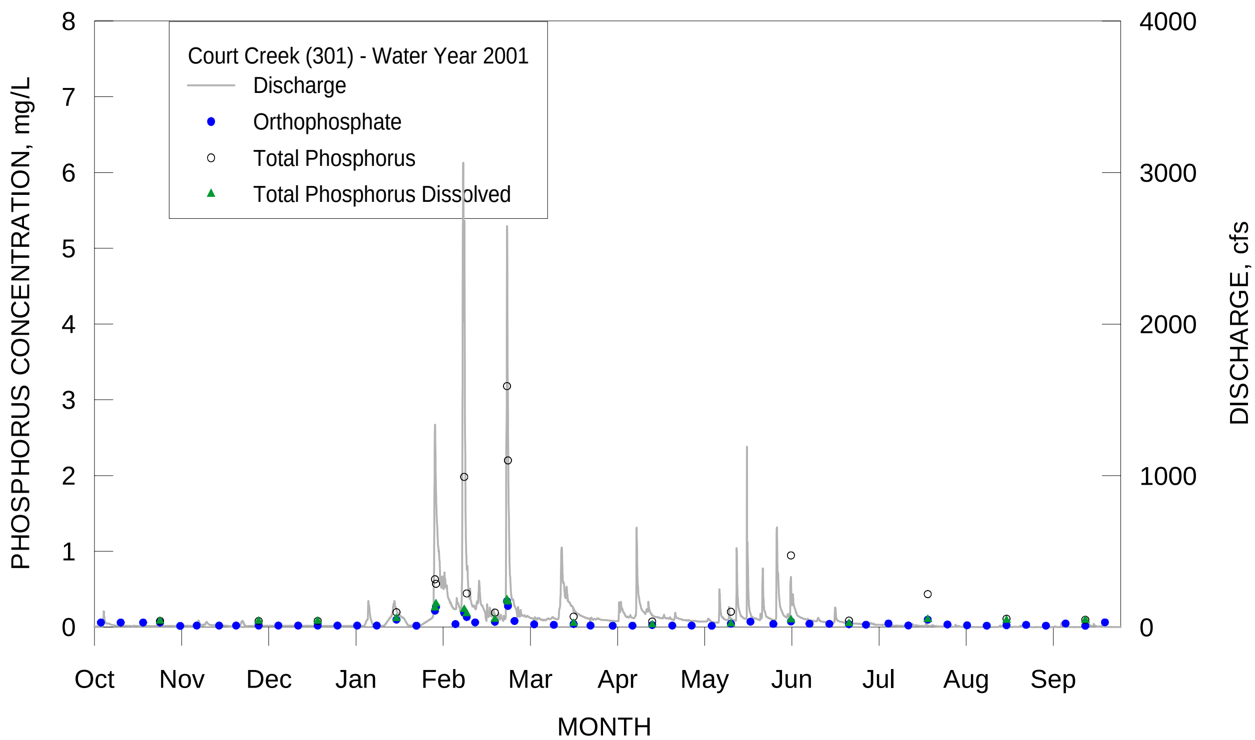


Figure 24. Concentrations of phosphorous species and water discharge at Court Creek (301) – Water Years

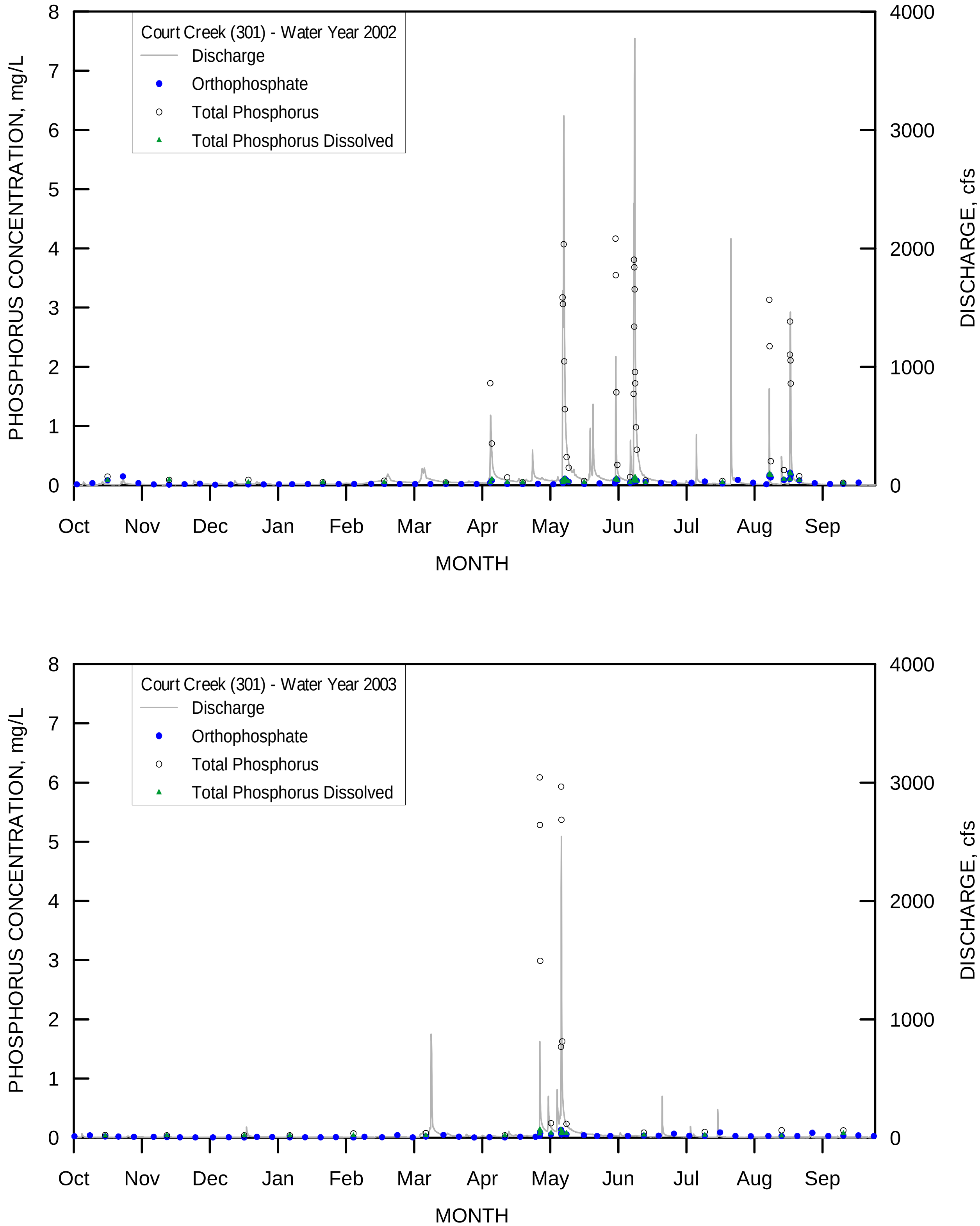
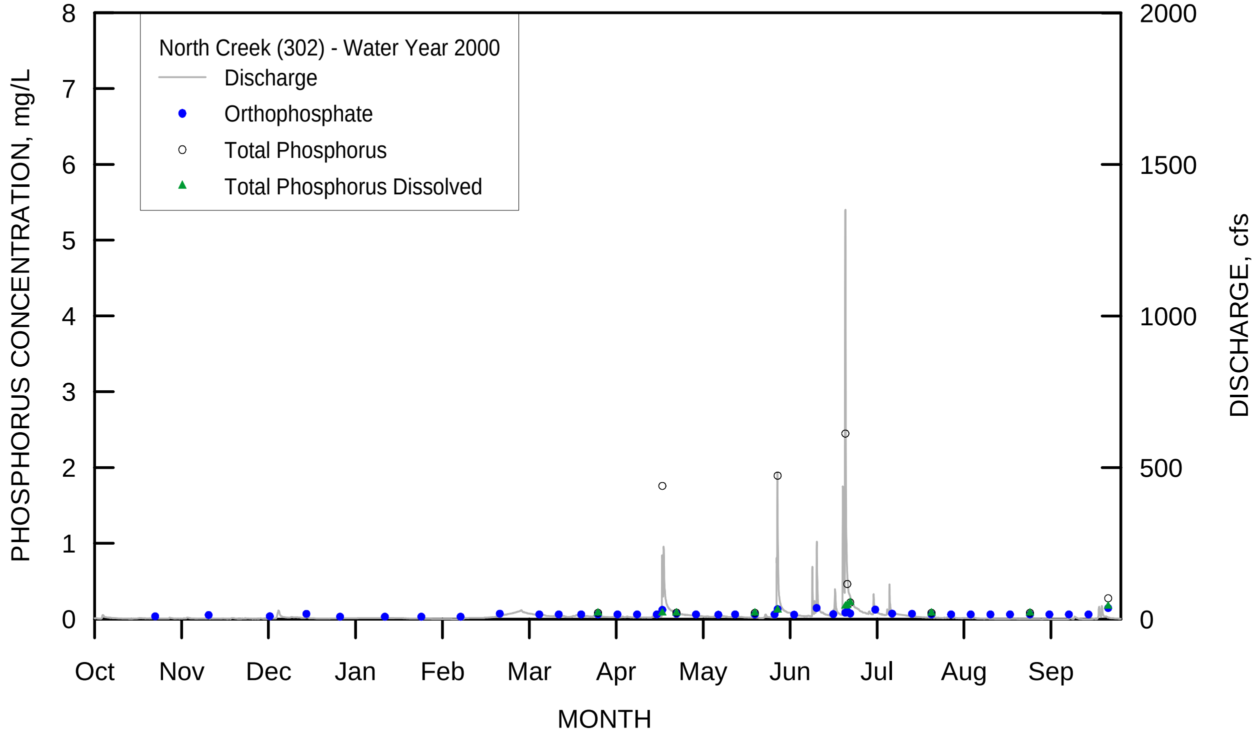


Figure 25. Concentrations of phosphorous species and water discharge at Court Creek (301) – Water Years 2002 and 2003



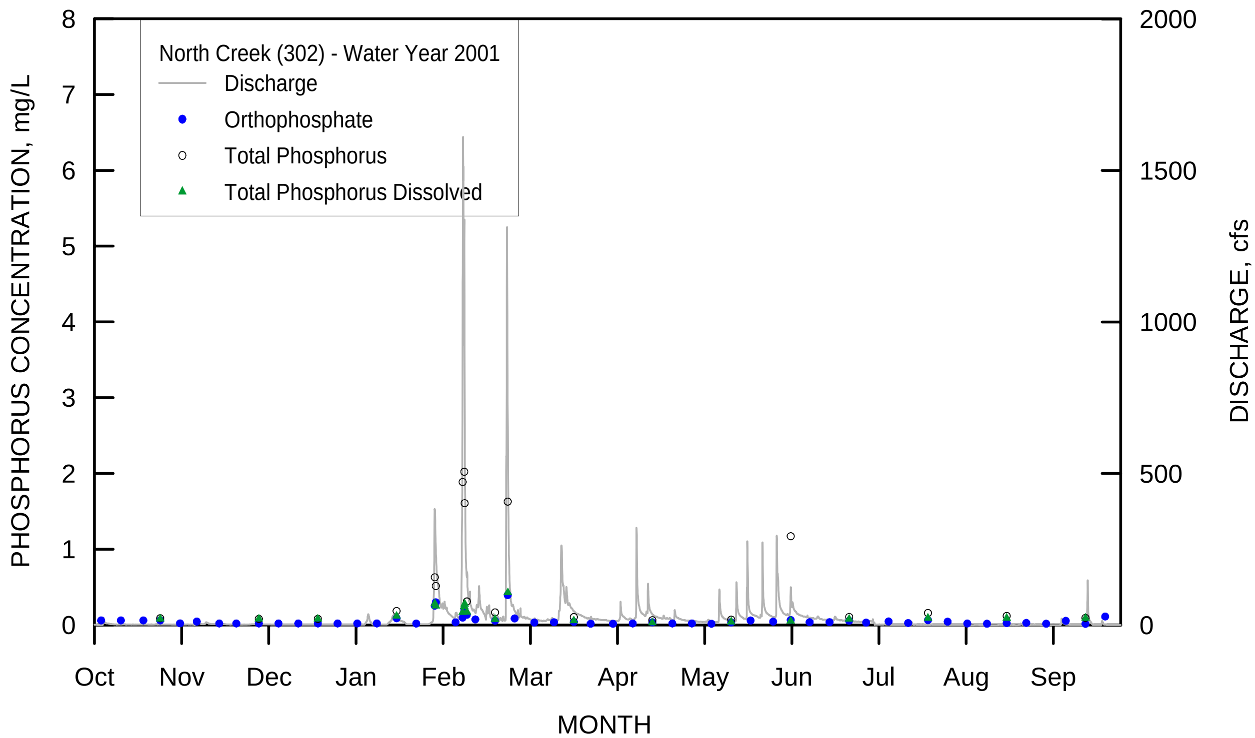
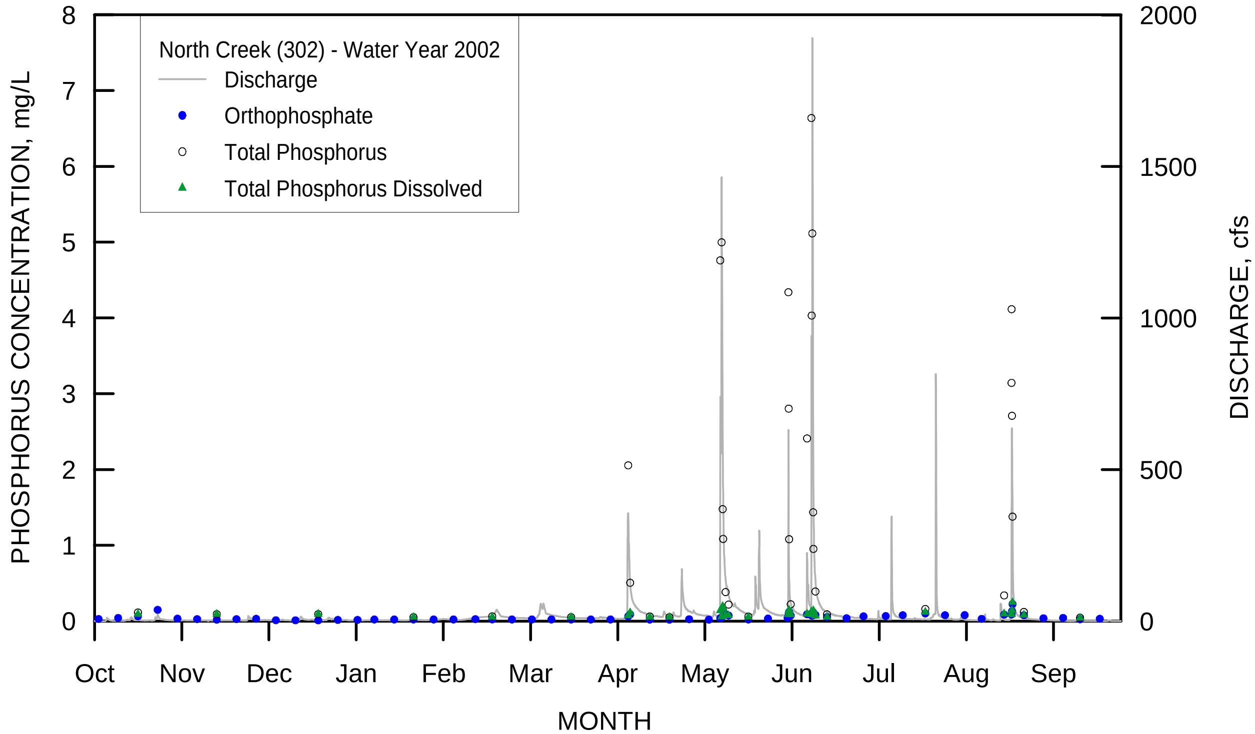


Figure 26. Concentrations of phosphorous species and water discharge at North Creek (302) – Water Years 2000 and 2002



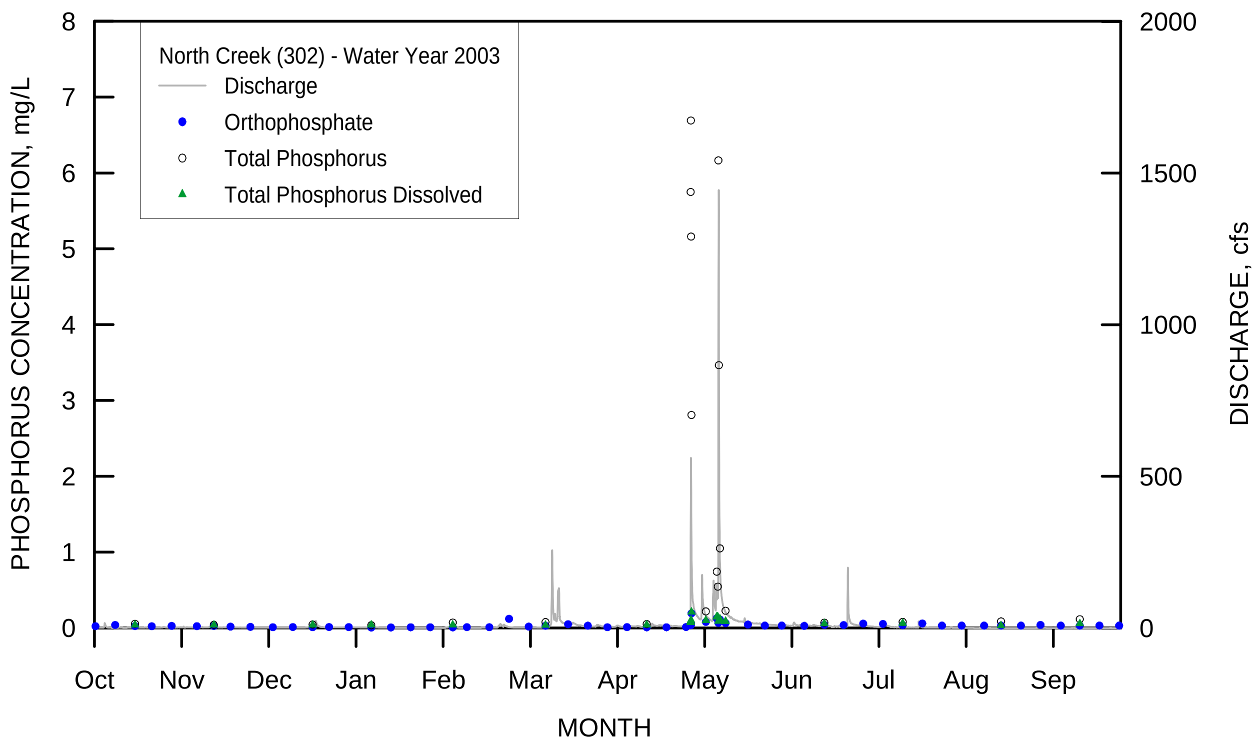
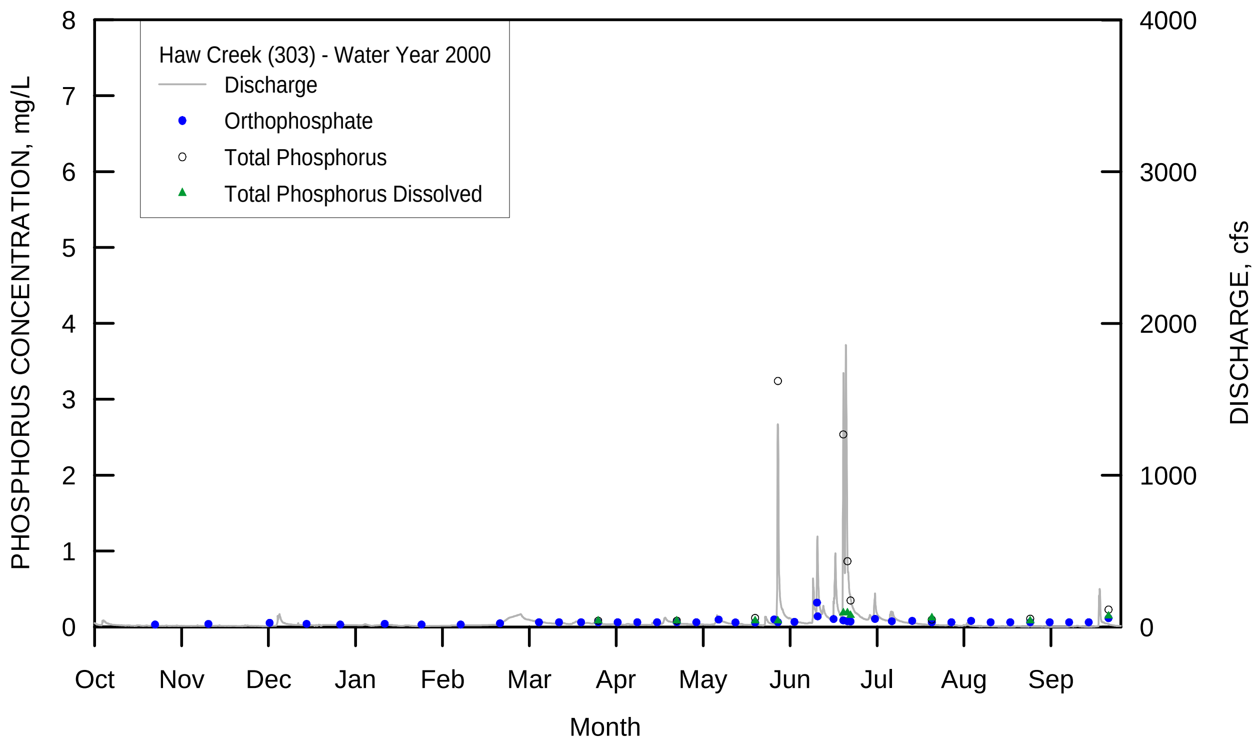


Figure 27. Concentrations of phosphorous species and water discharge at North Creek (302) – Water Years 2002 and 2003



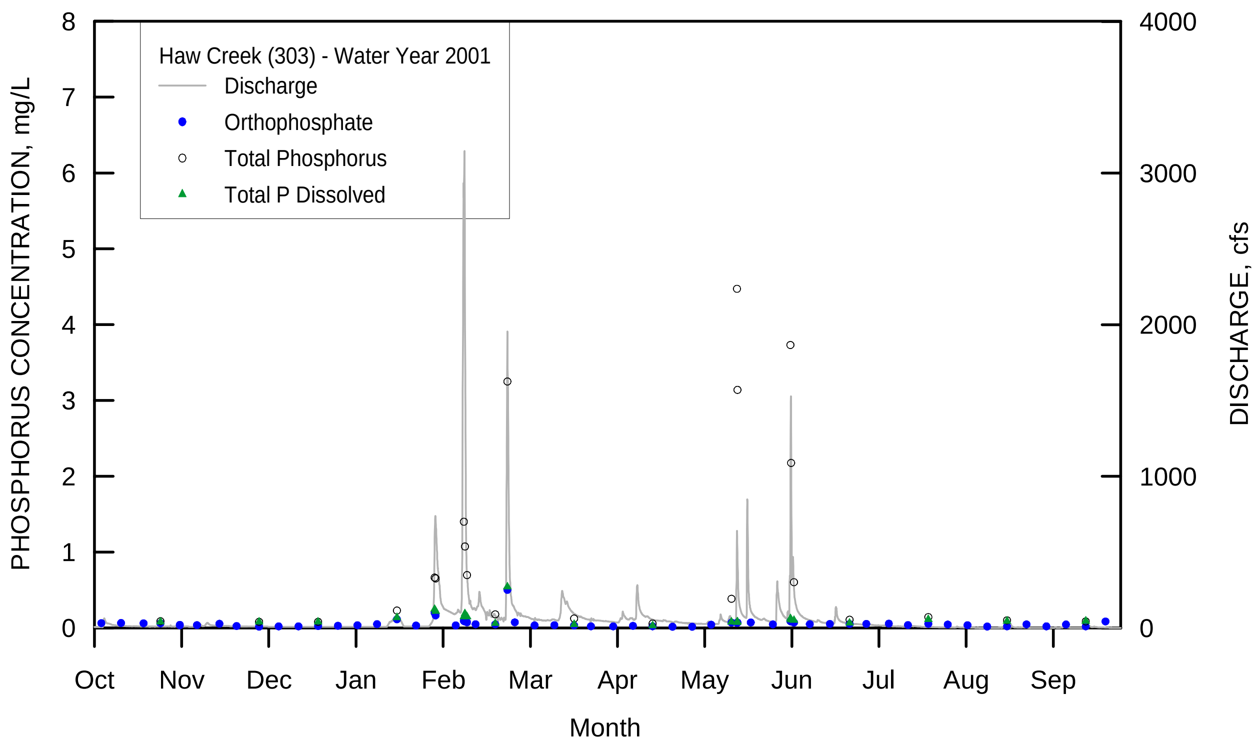
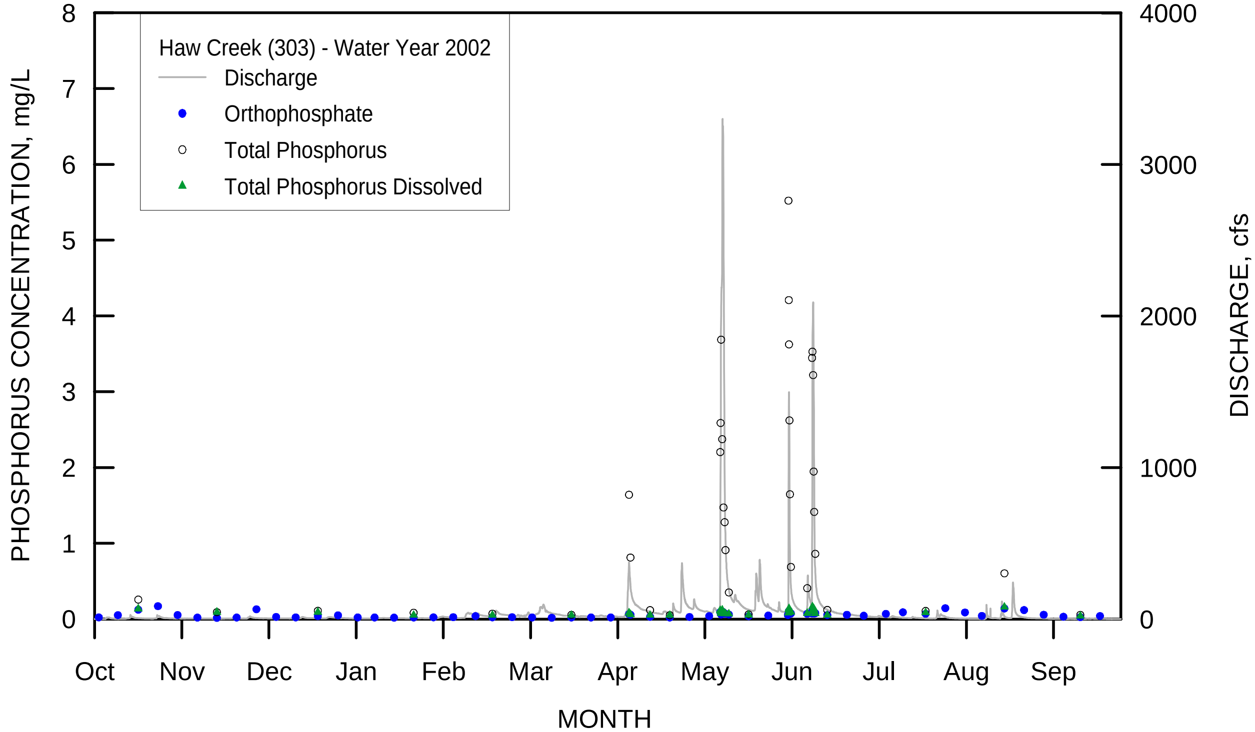


Figure 28. Concentrations of phosphorous species and water discharge at Haw Creek (303) – Water Years 2000 and 2001



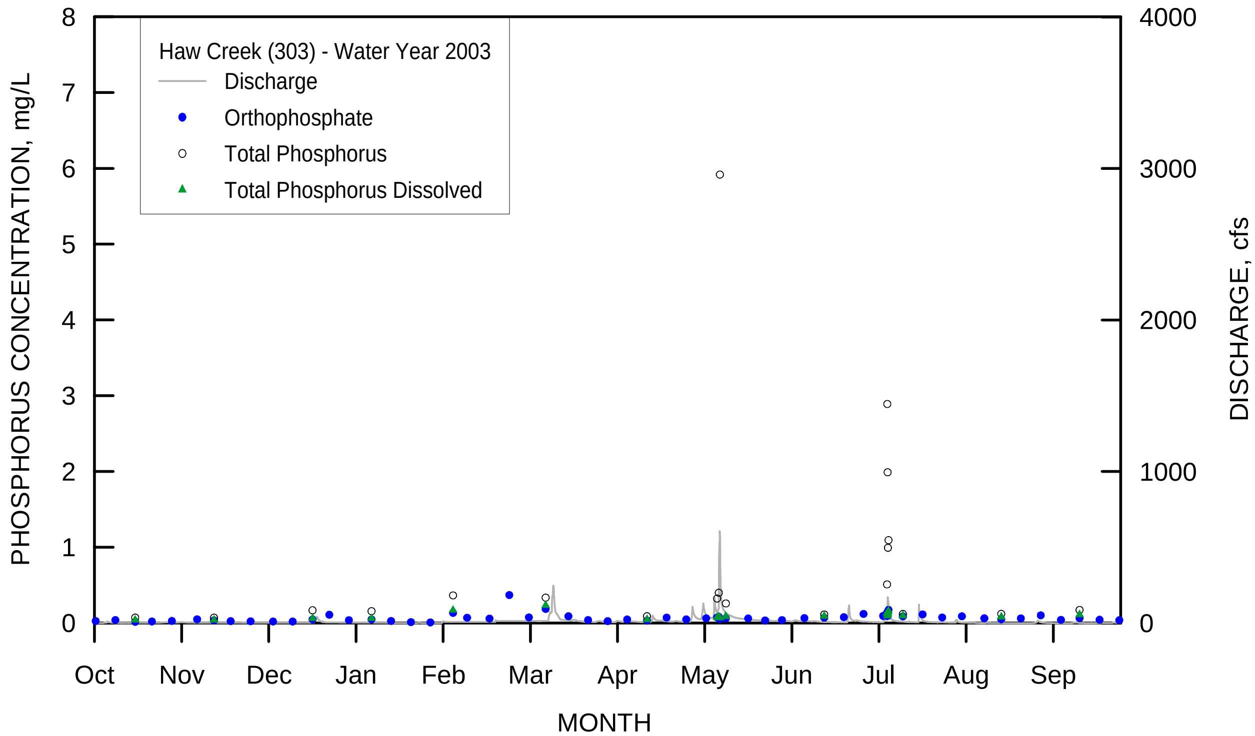
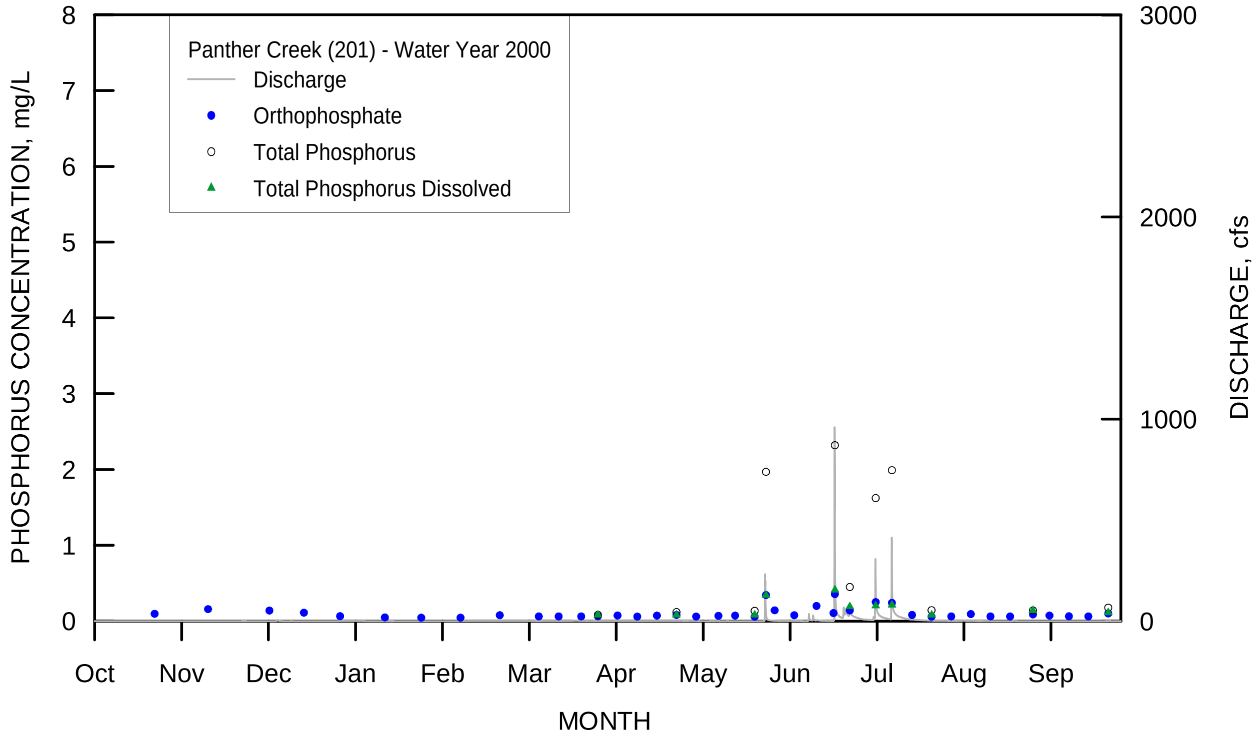


Figure 29. Concentrations of phosphorous species and water discharge at Haw Creek (303) – Water Years 2002 and 2003



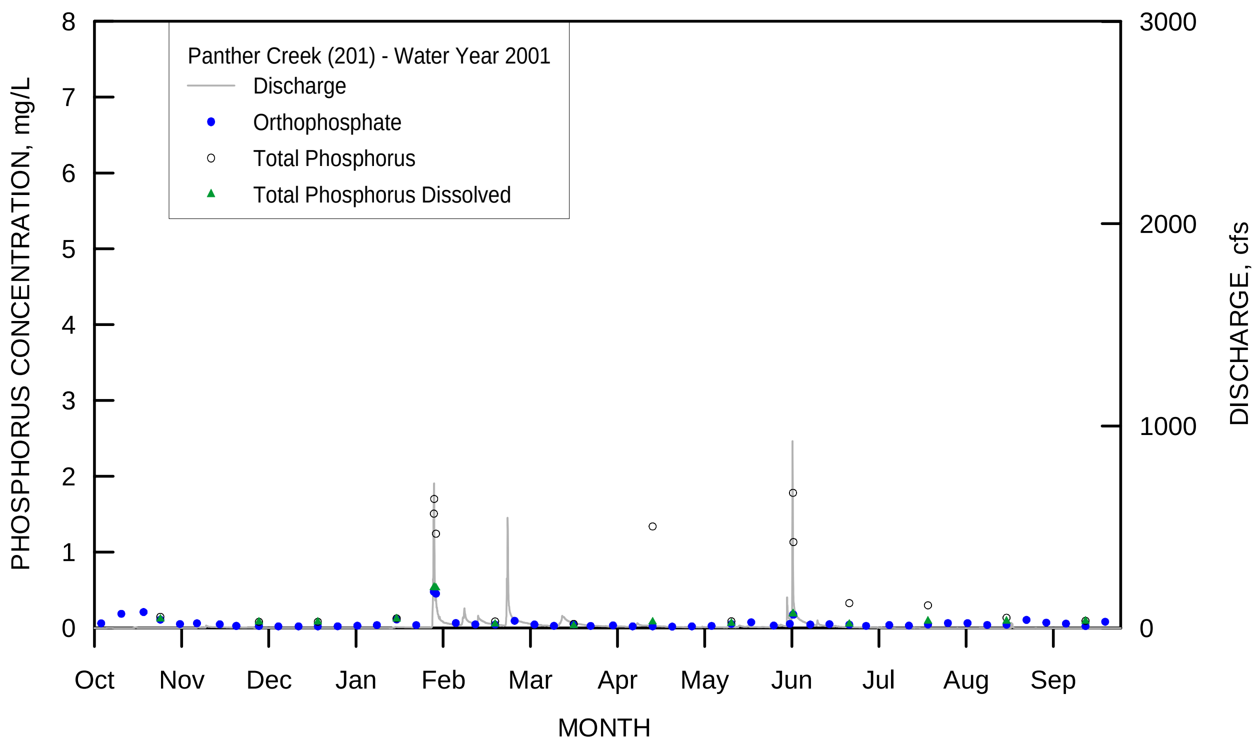
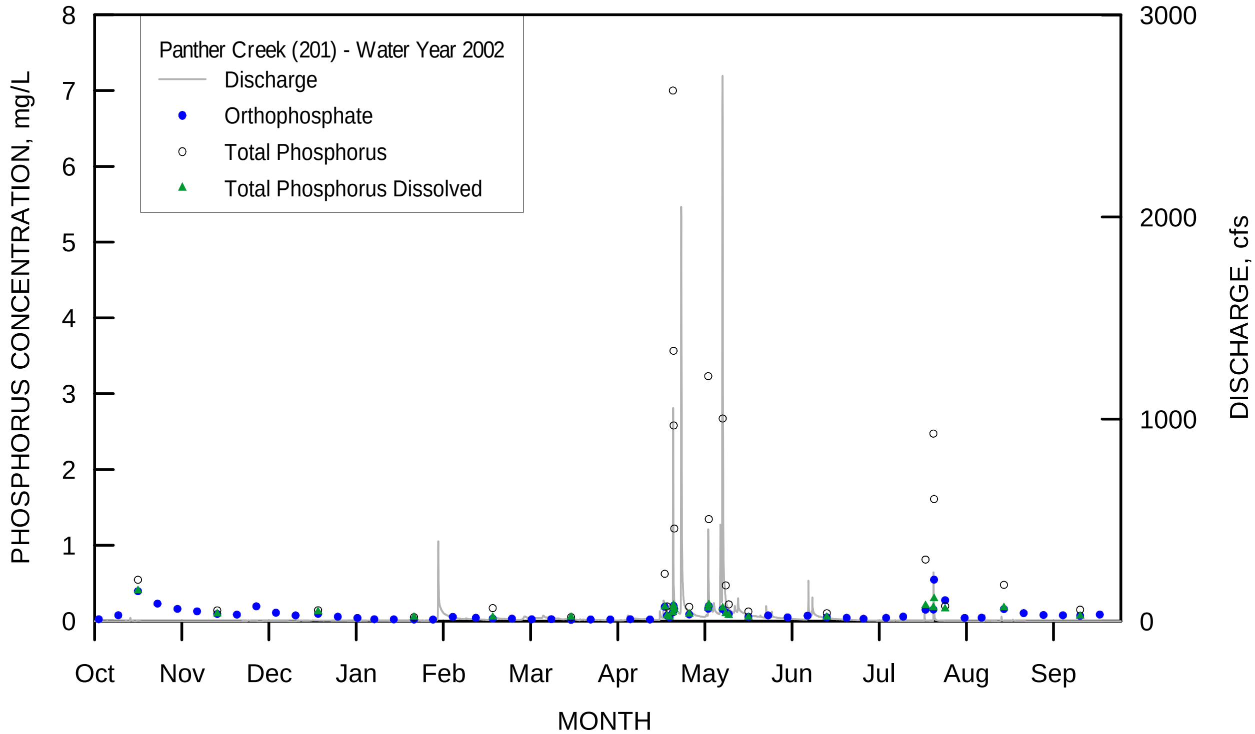


Figure 30. Concentrations of phosphorous species and water discharge at Panther Creek (201) – Water Years 2000 and 2001



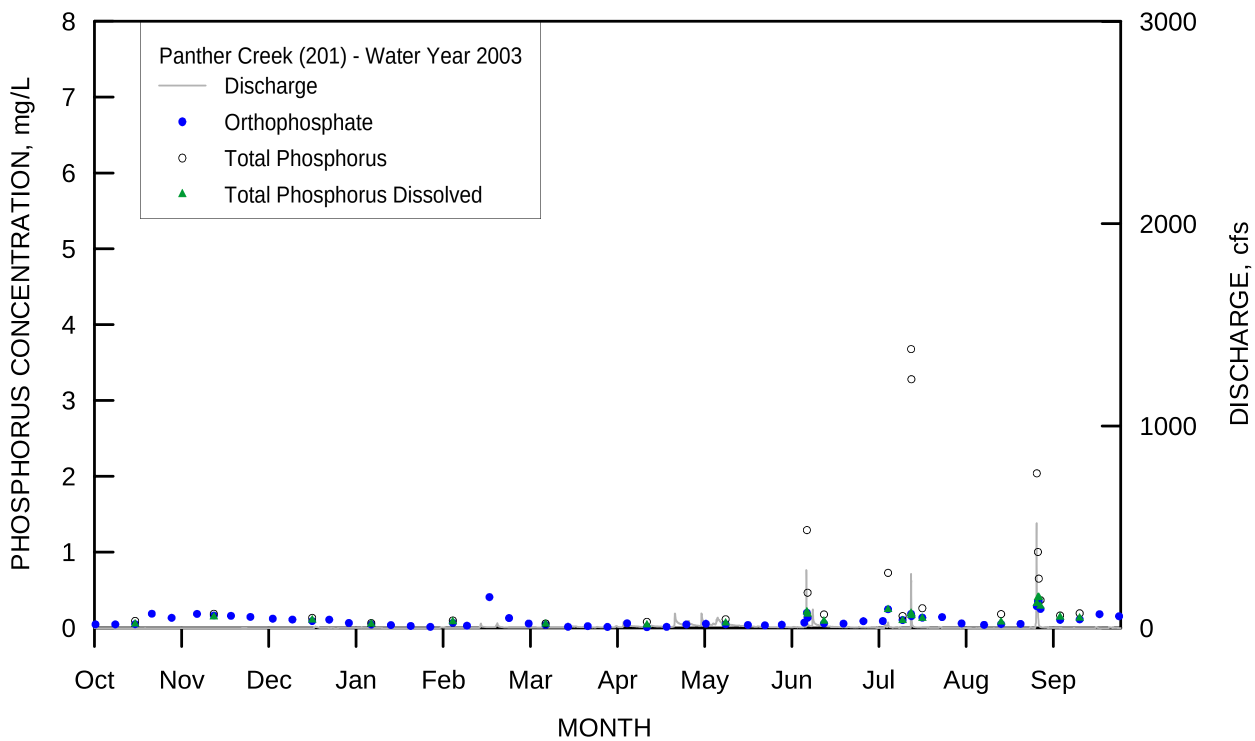
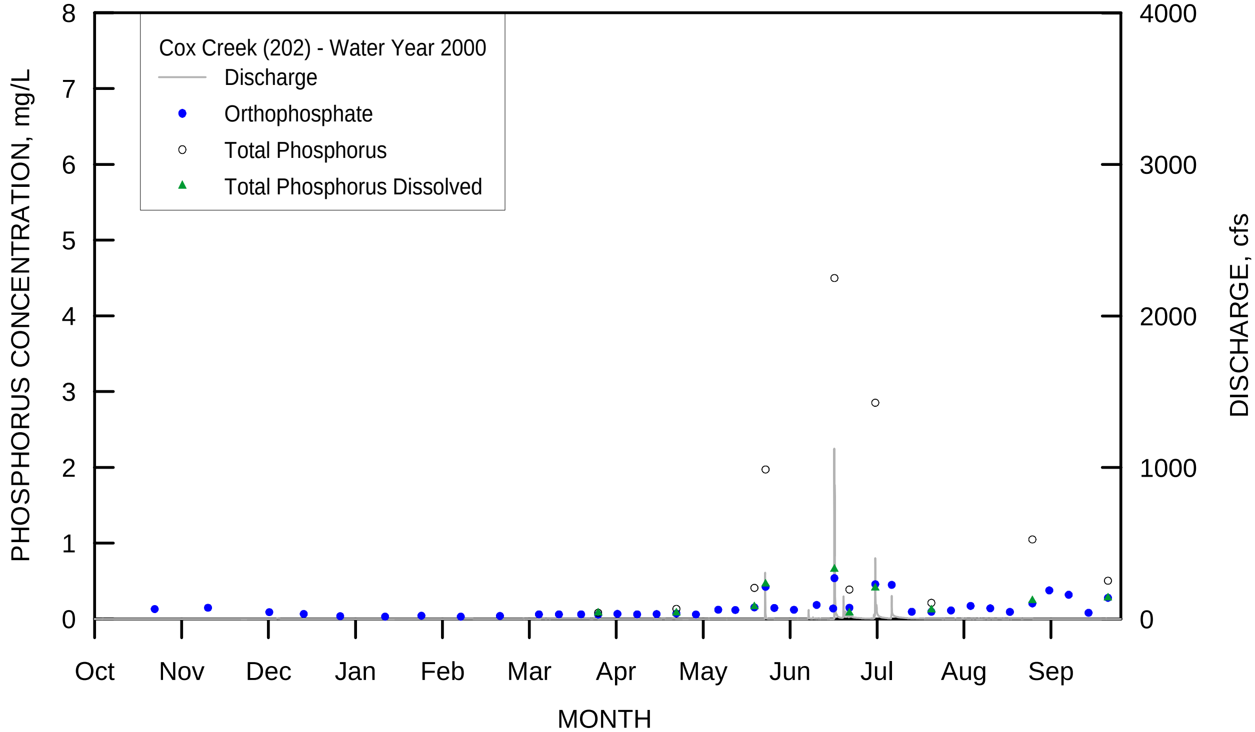


Figure 31. Concentrations of phosphorous species and water discharge at Panther Creek (201) – Water Years 2002 and 2003



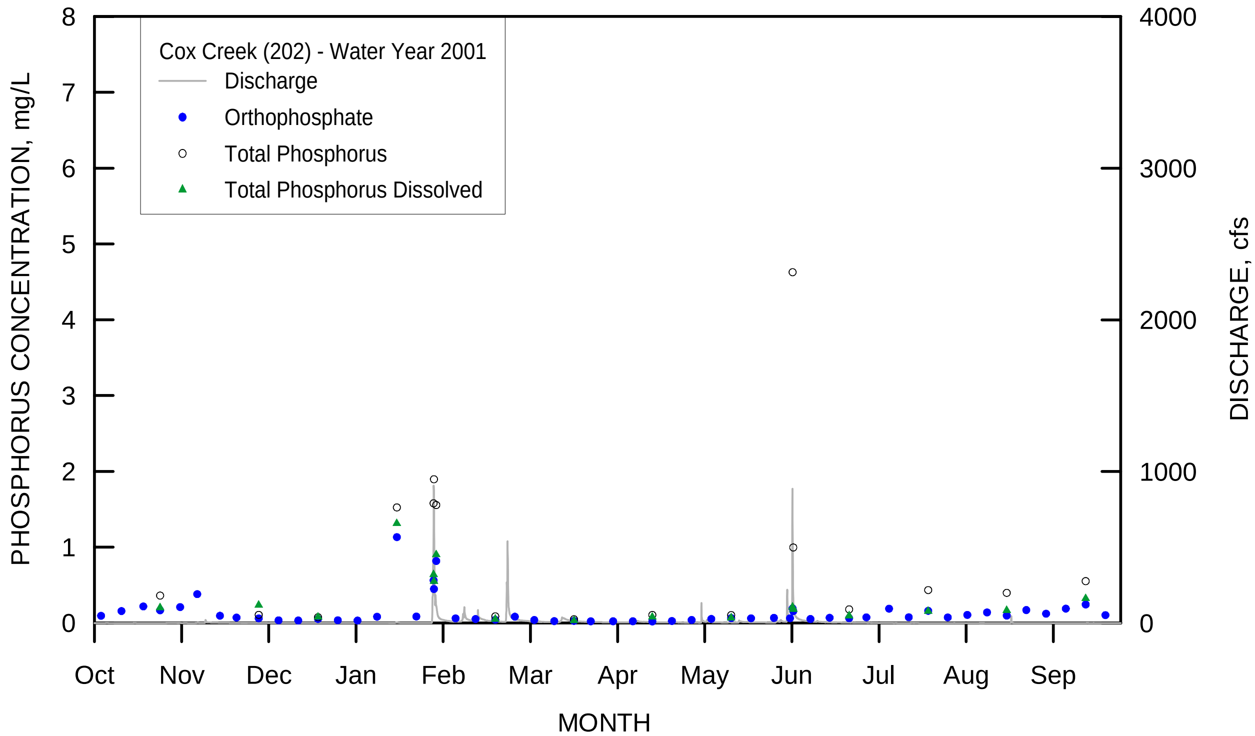
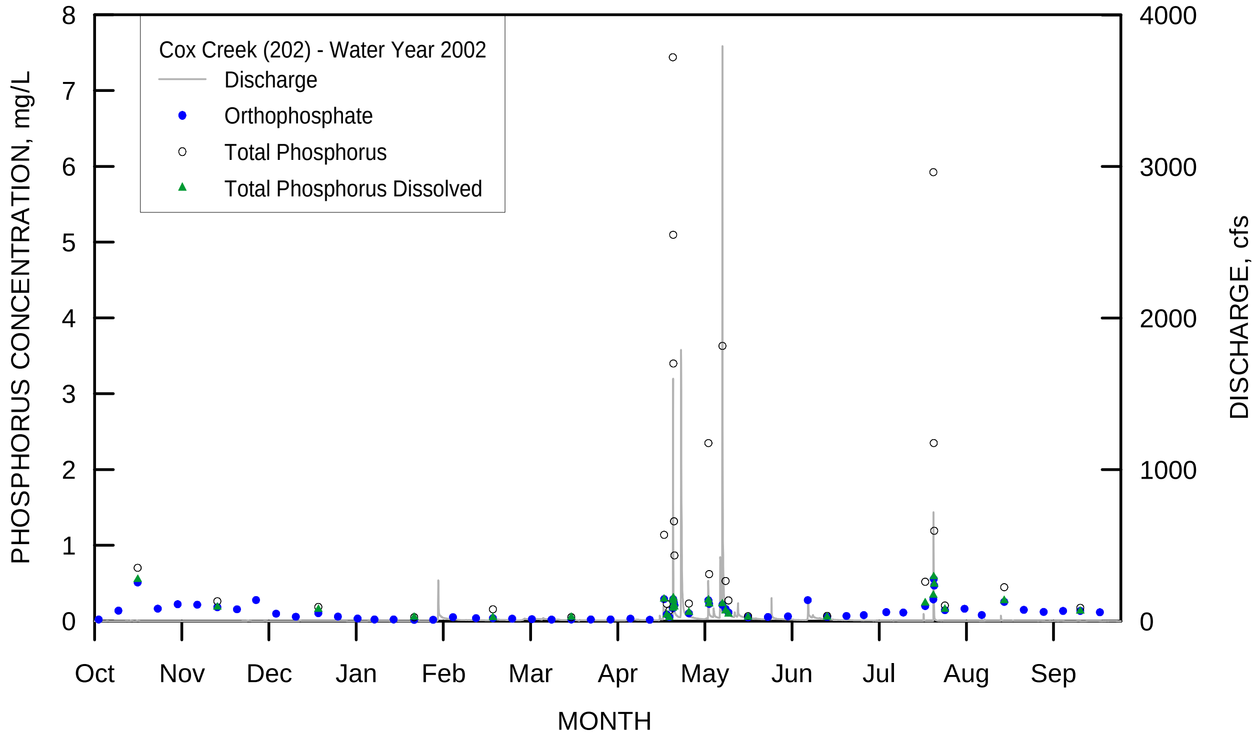


Figure 32. Concentrations of phosphorous species and water discharge at Cox Creek (202) – Water Years 2000 and 2001



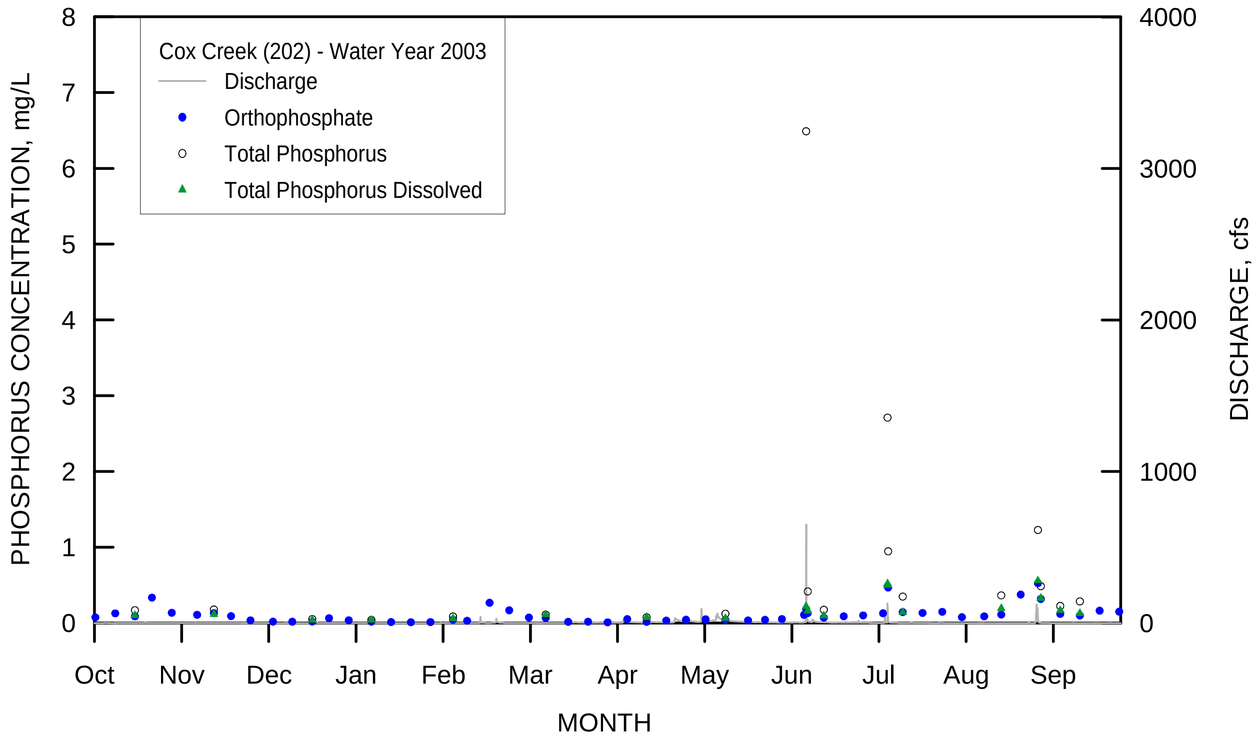


Figure 33. Concentrations of phosphorous species and water discharge at Cox Creek (202) – Water Years 2002 and 2003

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

		Load		
Water Year	*Water Discharge*	*Sediment*	*Nitrate-N*	*Total phosphorous*
	(cfs)	*(tons)*	*(tons)*	*(tons)*
2000	11,880	26,504	131.2	35.0
2001	22,100	43,511	274.8	39.2
2002	17,320	62,841	203.7	47.9
2003	6,805	21,725	59.9	18.3

Table 3. Summary of Annual Water Discharges, Sediment and Nutrient Loads at North Creek Monitoring Station (302)

		Load		
Water Year	*Water Discharge*	*Sediment*	*Nitrate-N*	*Total phosphorous*
	(cfs)	*(tons)*	*(tons)*	*(tons)*
2000	4,009	6,954	42.8	10.4
2001	8,091	16,718	102.9	12.7
2002	7,372	29,266	97.8	24.2
2003	3,039	11,381	32.9	9.1

Table 4. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Haw Creek Monitoring Station (303)

		Load		
Water Year	*Water Discharge*	*Sediment*	*Nitrate-N*	*Total phosphorous*
	(cfs)	*(tons)*	*(tons)*	*(tons)*
2000	11,433	21,258	162.2	32.0
2001	19,878	49,403	322.0	58.0
2002	15,603	44,148	256.5	42.8
2003	4,337	5,896	41.7	8.3

Table 5. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Panther Creek Monitoring Station (201)

		Load		
Water Year	*Water Discharge*	*Sediment*	*Nitrate-N*	*Total phosphorous*
	(cfs)	*(tons)*	*(tons)*	*(tons)*
2000	1,236	4,337	13.8	4.4
2001	3,550	9,806	84.9	5.1
2002	5,440	34,384	101.8	16.4
2003	1,578	2,946	26.4	1.8

Table 6. Summary of Annual Water Discharges,
Sediment and Nutrient Loads at Cox Creek Monitoring Station (202)

		Load		
Water Year	*Water Discharge*	*Sediment*	*Nitrate-N*	*Total phosphorous*
	(cfs)	*(tons)*	*(tons)*	*(tons)*
2000	894	4,149	10.3	5.7
2001	2,833	9,609	77.9	5.5
2002	4,242	23,143	100.6	16.1
2003	1,226	1,820	29.6	1.7

2000 at Cox Creek to a high of 322 tons in 2001 at Haw Creek. The total phosphorous loads ranged from a low of 1.7 tons in 2003 at Cox Creek to a high of 58 tons in 2001 at Court Creek. For comparison purposes, the water discharges, sediment, nitrate-N, and total phosphorous loads (for the five monitoring stations) are shown in figures 34-37. 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, per unit area Panther and Cox generate more sediment than Court, North, and Haw Creeks. For Nitrate-N load, Cox Creek was the highest per unit area load followed by Haw and Panther Creeks. Court and North Creek had lower per unit area nitrate-N load. The load per unit area for total phosphorous is very similar for all the five monitoring stations.

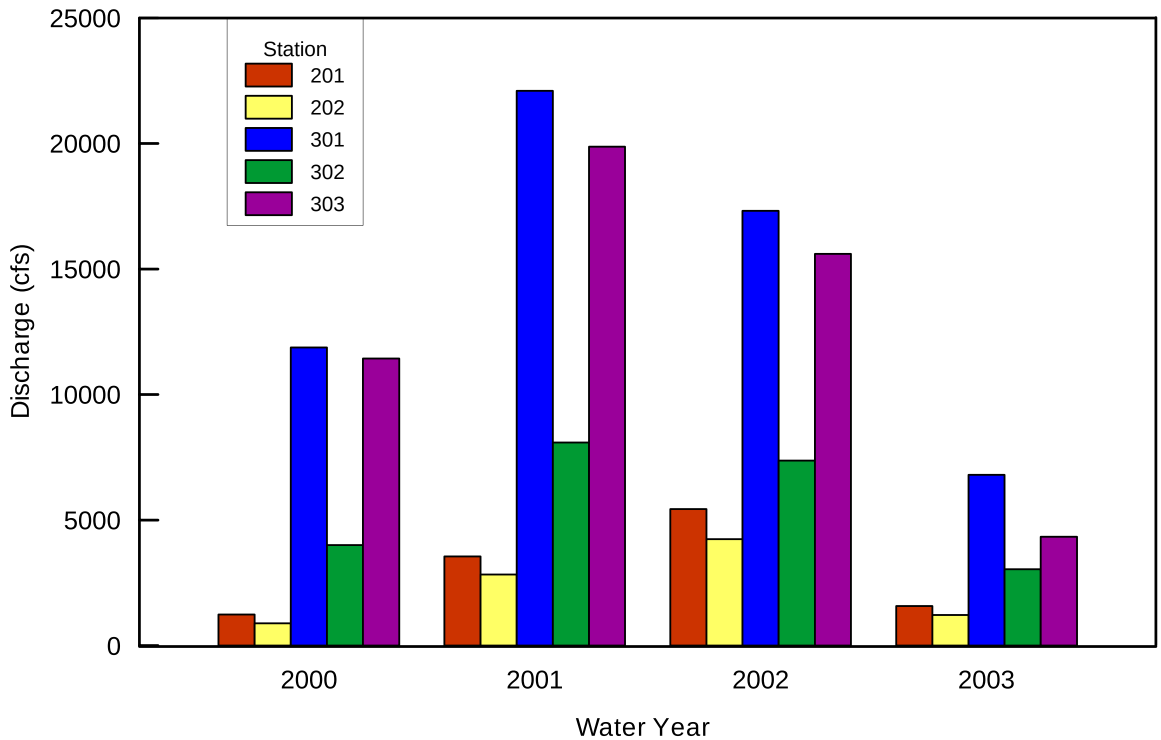


Figure 34. Annual water discharges at the five CREP monitoring stations

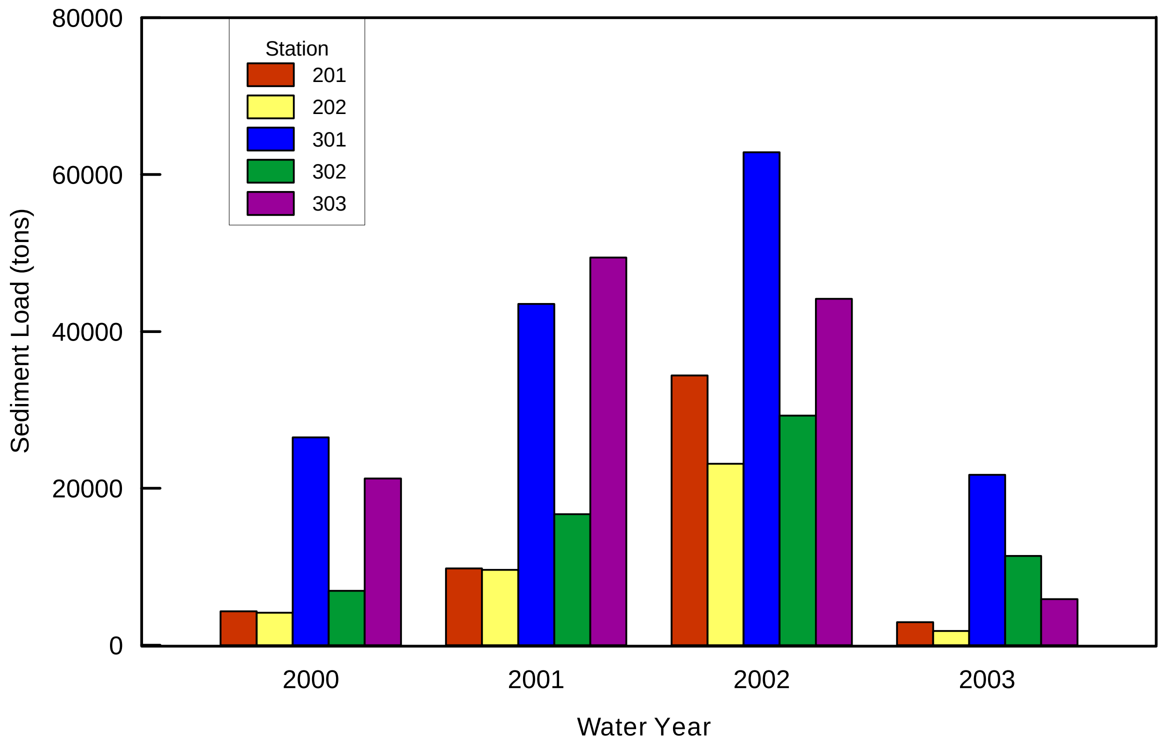


Figure 35. Annual suspended sediment load at the five CREP monitoring stations

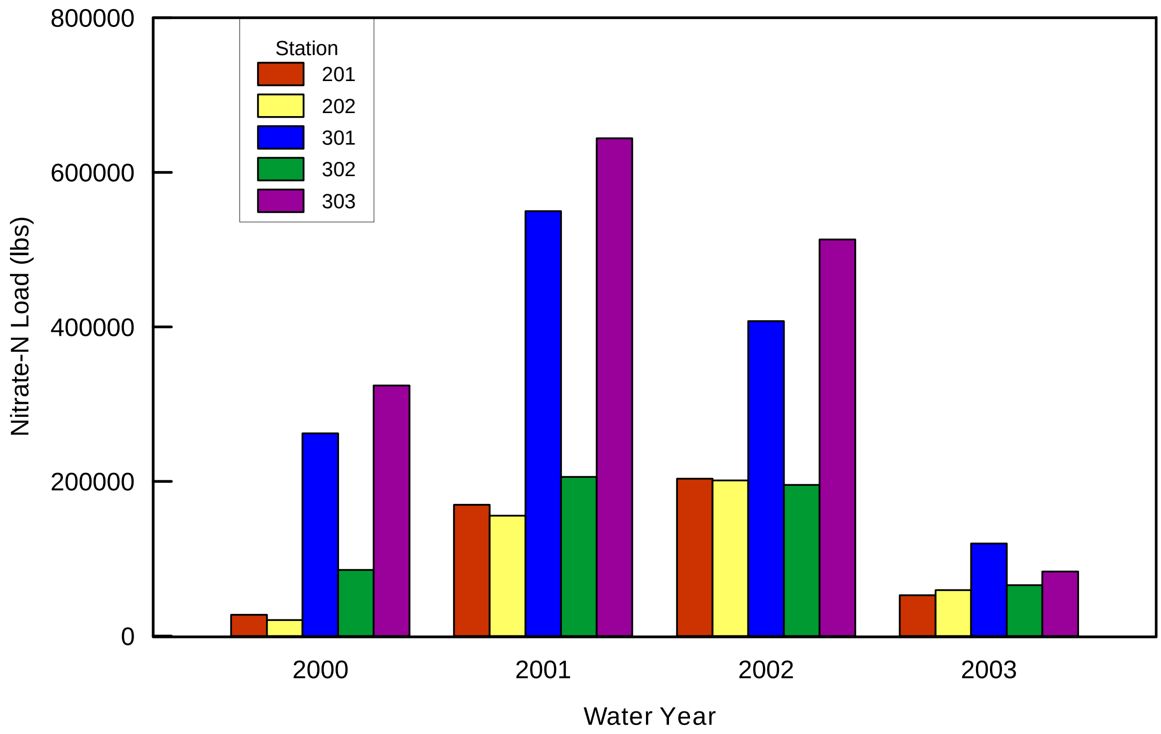


Figure 36. Annual nitrate-N load at the five CREP monitoring stations

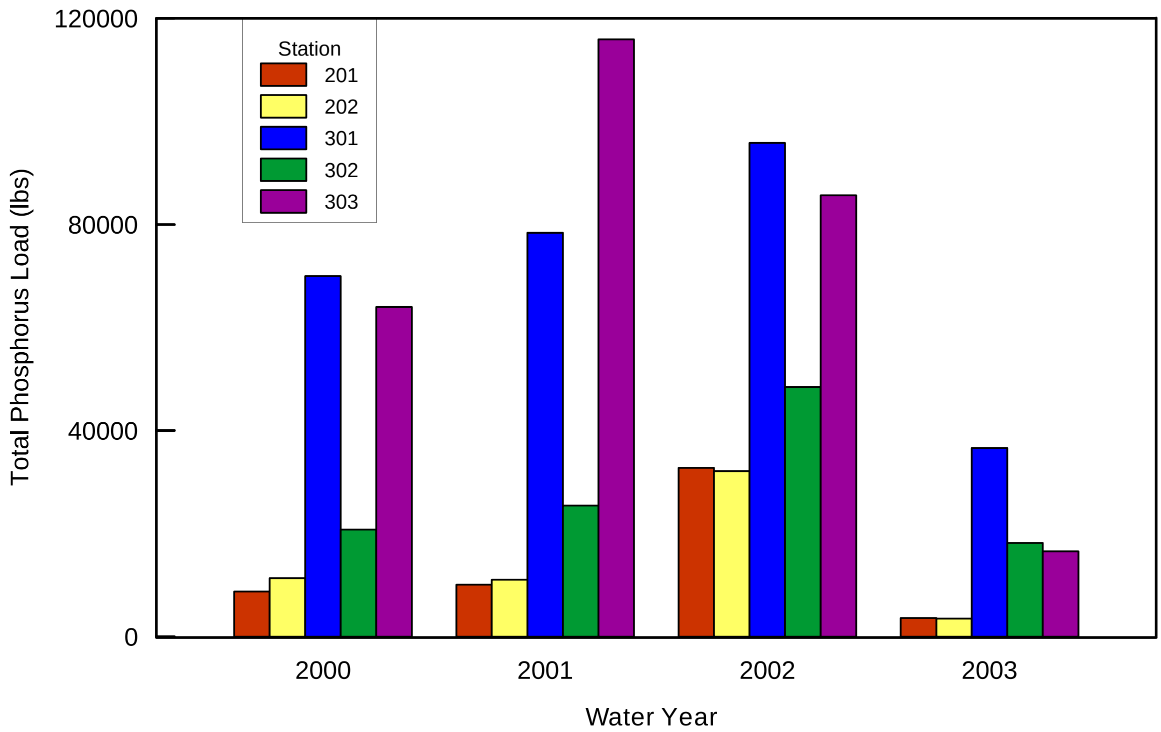


Figure 37. Annual total phosphorous load at the five CREP monitoring stations

Land Use Practices

Outside of natural factors such as the physical settings and climate variability, land use practices are the main driving factors that affect watershed's hydrology, erosion, and sedimentation, and water quality. It is therefore important to document and analyze changes in land use practices in 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.

Historical agricultural land use practices and the recent conservation efforts including CREP are briefly discussed in the following paragraphs.

Historical Agricultural Land Use Trends in Illinois

To provide a historical perspective to changes in land use practices in the Illinois River basin, we have compiled and analyzed historical land use data from different sources for the whole state. The earliest land use data is based on the Illinois Agricultural Statistics (IAS) records. The IAS data shows that in 1866 approximately 23 percent of the state's land area was in agricultural crop production. In 2003, agricultural production has increased to 65 percent of the state's land. As can be seen in figure 38a, there are two periods of significant changes in crop production. From 1866 through to the 1920s, crop production increased by 57 percent mostly due to a three-fold increase in small grain (wheat, oats, and hay) acreage. The other change occurred in the 1920s when small grain acreage declined in favor of soybeans. Essentially, from this period to present, a steady reversal in acreage has occurred between small grains and soybeans such that current soybean acreage is the same as was small grains were in the 1920s. From the 1920s to 2003, total Illinois land area in crop production increased by 35 percent. The dominant crops in 1866 were corn and small grains, whereas corn and soybeans (row crops) acreage was 93 percent of the total crop acreage in 2003. During the period of record (1866-2003), corn acreage has remained fairly steady at 9.2 million acres. Corn was harvested on 4.9 million acres in 1866 but increased to the long-term average acreage by 1881. Acreage peaked in1976 at 11.6 million acres and was almost at that level in 2003 at 11.2 million acres.

In 1925, IAS began delineating agricultural crop production data by county, rather than as a state total, which allows for the estimation of crop acreage by basins. The Illinois River Basin (IRB) is nearly half of the Illinois land area, and occupies over 18 million acres when the watershed area in the states of Indiana and Wisconsin are included. Figure 38b shows similar trends in crop production as was seen for the State of Illinois. In 1925, 50 percent (9.2 million acres) of the IRB land area was in crop production while in 2003, 63 percent (11.5 million acres) was in crop production. The same reversal of small grain and soybean acreage is also seen. Corn acreage is fairly steady for the period of record, averaging 5.5 million acres, increasing from 4.4 to 7.0 million acres from 1925 to 1984, and slightly decreasing to 6.2 million

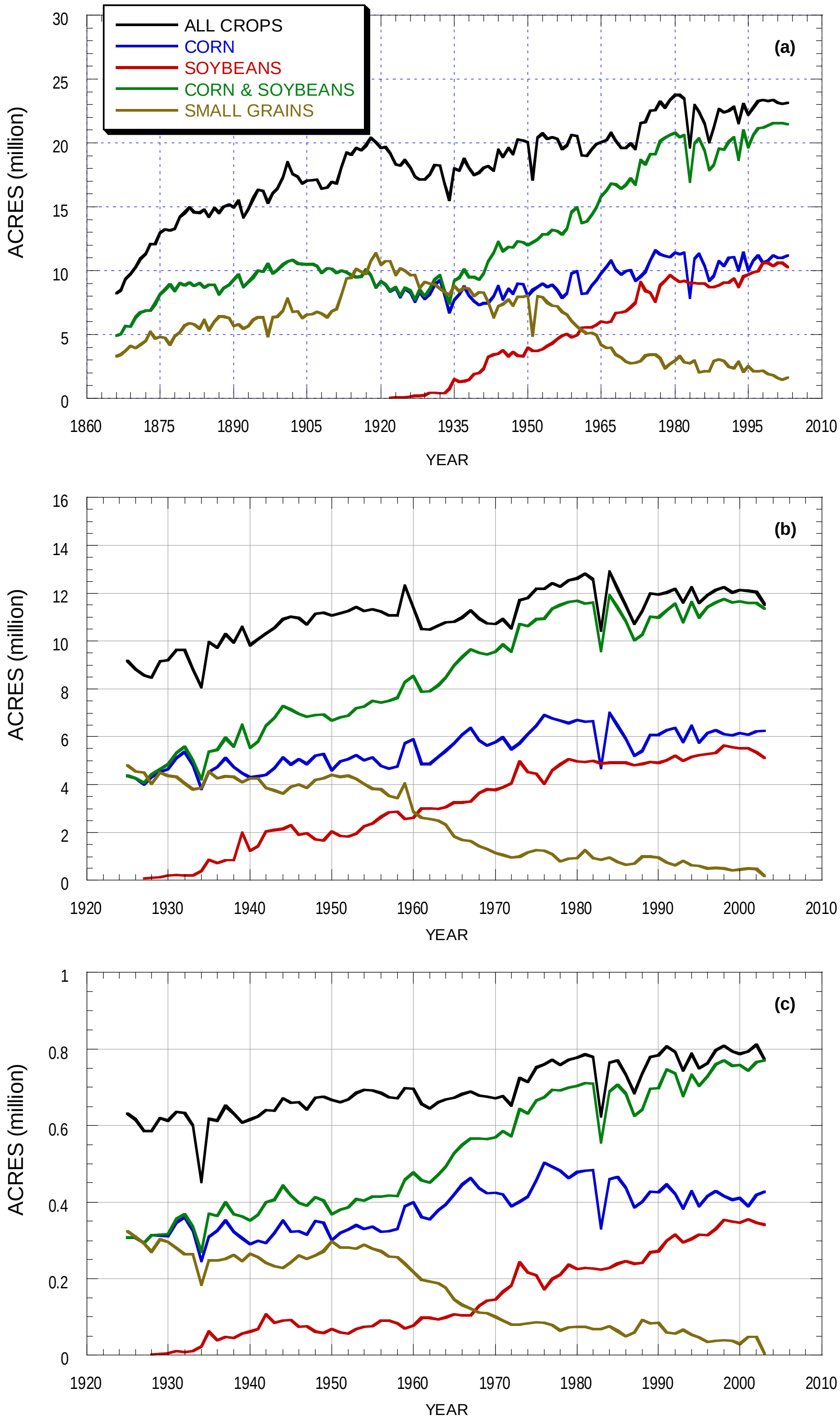


Figure 38. Acreage of agricultural land uses in Illinois: a) State of Illinois, 1866-2003; b) Illinois River Basin, 1925-2003; and c) Spoon River Watershed, 1925-2003

acres in 2003. Total IRB watershed area in crop production increased by 25 percent from 1925 to 2003, which is smaller than the 35 percent increase for the whole State of Illinois during the same period.

The Spoon River watershed is one of ten major tributaries to the Illinois River with a drainage area of 1.2 million acres (6.5 percent of the IRB drainage area). From 1925 to 2003, watershed area in crop production increased from 53 to 65 percent, which is similar to the increases in the IRB and the State of Illinois. Figure 38c shows that the trends in corn, small grains, and soybeans are also similar. Corn and small grain acreage was 0.63 million acres in 1925 and in 2003 corn and soybeans were 0.77 million acres. Corn acreage increased by 65 percent from 1925 to 1976 and then decreased by 15 percent through 2003. The total Spoon River watershed area in crop production increased by 22 percent during 1925-2003 period and is only slightly below that of the increase in the IRB.

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. IDNR has established different programs to document and track conservation practices in Illinois. The major initiative is known as the Illinois Conservation Practices Tracking System (ICPTS). The ICPTS is developing “a comprehensive database documenting the precise location, nature, and planned duration of conservation practices being implemented through Illinois CREP as well as other conservation incentive programs within the Illinois River basin,” (State of Illinois, Department of Natural Resources, 2002). The database will be very useful for assessing and evaluating the effectiveness of different programs in meeting their objectives. The land use data from the ICPTS database will be used along with the sediment and nutrient data being collected under the monitoring program to evaluate how conservation practices are influencing sediment and nutrient delivery to the Illinois River. Two examples of information and data on land use are shown in figures 39 and 40.

Figure 39 shows the location of approved Illinois CREP contracts from the USDA and state of Illinois from 1999 through 2003. 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 land use changes on sediment and nutrient delivery. It is also possible to extract much more detailed land use information from the ICPTS as shown in figure 40 where the total acres in conservation practices are provided for small watersheds like Court and Haw Creeks on annual basis. The data shows the significant rate of increase in conservation practices in the Court and Haw Creek watersheds since 1997. This type of data will be extremely useful for assessing and evaluating the effectiveness of CREP and other conservation practices .

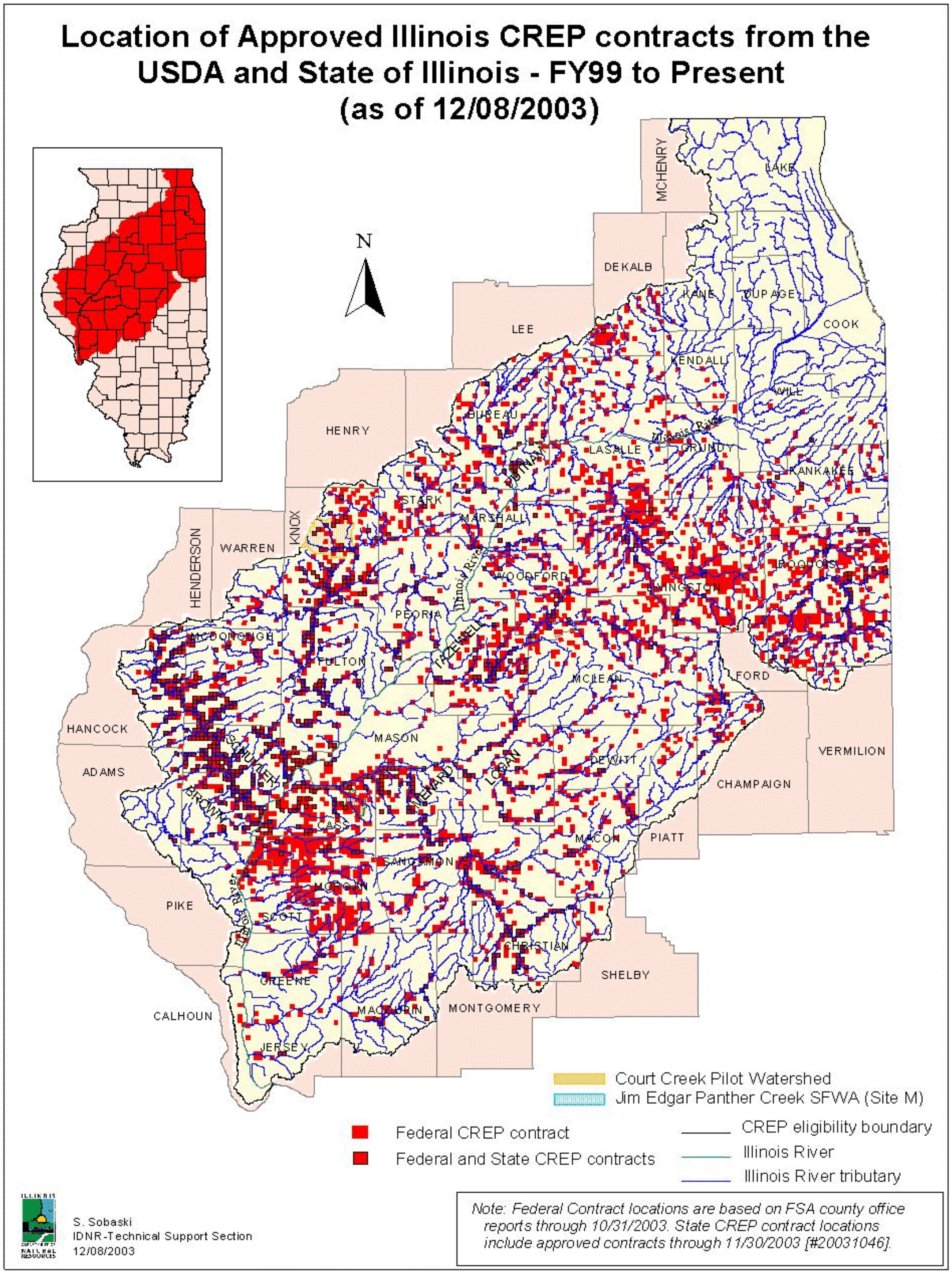


Figure 39. Location of approved Illinois CREP contracts from the USDA and State of Illinois – FY99 to 12/08/2003 (from S. Sobaski, IDNR)

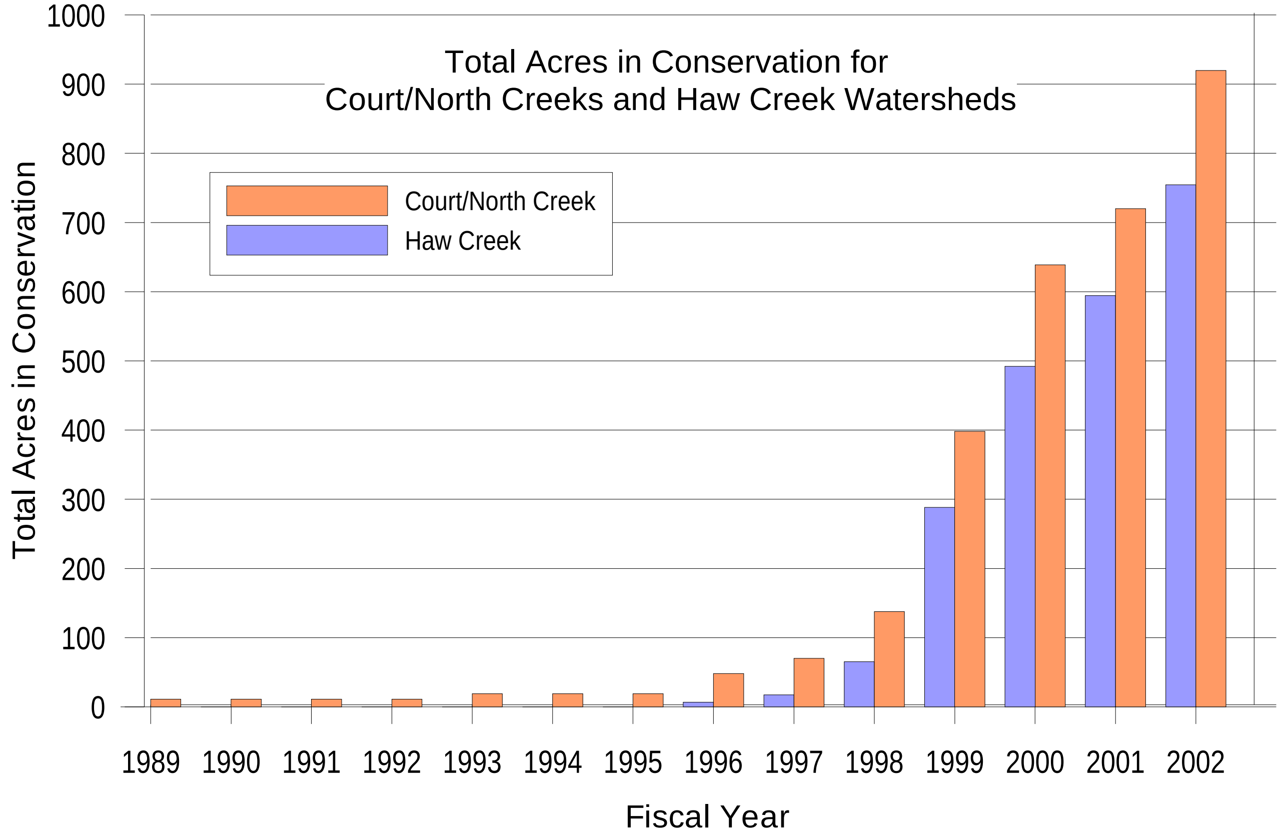


Figure 40. Total acres in conservation in Court, North and Haw Creek watersheds within the Spoon River watershed

Model Development and Application

The Illinois State Water Survey has been developing a watershed model for the Illinois River basin in support of the Illinois River Ecosystem project. In the initial phase, a hydrologic model of the entire Illinois basin has been developed and used to evaluate potential impacts of land use changes and climate variability on streamflow in the Illinois River basin. The model is based on the U.S. Environmental Protection Agency's BASINS 3.0 modeling system. The Hydrologic Simulation Program – FORTRAN or HSPF (Bicknell et al., 2001) which is part of BASINS was used to simulate the hydrology of the Illinois River basin. The HSPF is a comprehensive and dynamic watershed model that also has the capability to simulate water quality and sediment transport.

To make the model applicable for assessing and evaluating the impact of CREP and other land use changes on water quality and sediment transport, the Water Survey has been developing the sediment transport and water quality capabilities of the HSPF model for the Illinois River basin. The initial effort has focused on the Spoon River watershed (figure 41) where two of the four intensively monitored watersheds, Court and Haw Creek, are located. Streamflow, sediment, and water quality data being collected at three monitoring stations are being used to calibrate and test the model for the Spoon River watershed. Once the calibration and validation process are completed for the Spoon River watershed, the model parameters can be used to develop models for other similar watersheds to simulate the hydrology, sediment transport and water quality under different climatic and land use scenarios. Over time, as land use practices change significantly as a result of CREP and other conservation practices, the models being developed will provide the tools to evaluate and quantify changes in water quality and sediment delivery to the Illinois River.

The progress in model development for the Spoon River watershed is discussed in the following sections.

HSPF Model

The HSPF model is a conceptual, comprehensive, long term continuous simulation watershed scale model which simulates non-point source hydrology and water quality, combines it with point source contributions, and performs flow and water quality routing in the watershed and its streams. The HSPF model simulates land-surface portion of the hydrologic cycle by a series of interconnected storages – an upper zone, a lower zone, and a ground-water zone. The fluxes of water between these storages and to the stream or atmosphere are controlled by model parameters. The model uses a storage routing technique to route water from one reach to the next during stream processes.

For sediment simulation, the surface erosion component of the HSPF model performs processes such as sediment detachment from the soil matrix in the pervious land segments during rainfall event, washoff of this detached sediment, scour of the soil matrix, and reattachment or compaction of the sediment. Storage and washoff of sediments from the impervious surfaces is also considered. The sediment load and transport in the stream channel is dependent on the particle diameter, density, fall velocity, shear stress for deposition and scour, and erodibility. The

Figure 41. Location of the Spoon River watershed

noncohesive (sand) and cohesive (silt and clay) sediment transport is simulated in the model using different subroutines.

Nutrients in the watershed soil in the HSPF model are simulated either as attached to organic or inorganic solids, dissolved in the overland flow, or as concentrations in the subsurface flow reaching the streams laterally. For both nitrogen and phosphorous compounds, the processes simulated include immobilization, mineralization, nitrification/denitrification (nitrogen only), plant uptake, and adsorption/desorption. The nutrient loads from the watershed undergo further transformation in the stream reaches.

Model Input Data

The HSPF model requires spatial information about watershed topography, river/stream reaches, land use, soils, and climate. The hourly time-series of climate data required for hydrologic simulations using HSPF include precipitation, potential evapotranspiration (ET), potential surface evaporation, air temperature, dew-point temperature, wind speed, and solar radiation. The hourly precipitation data from the two ISWS gages, one each in Court Creek (ISWS31) and Haw Creek (ISWS32) watersheds, was used (figures 42 and 43). Daily precipitation data from the MRCC (Midwestern Regional Climate Center) gaging station at Galesburg (ID 113320) was also used after it was disaggregated into hourly data based on the hourly precipitation data from an ICN (Illinois Climate Network) station located in Monmouth (MON). The other time series of the climate inputs for the above three precipitation stations were obtained from the ICN station at Monmouth. Daily data from nine additional MRCC stations (figure 44) in or near the Spoon River watershed was also disaggregated into hourly data based on the hourly data from three stations at Peoria, Moline, and Augusta, as found in the BASINS database. These additional stations were used for the Spoon River watershed model.

For topographic inputs, the 30-meter Digital Elevation Model (DEM) raster dataset produced by the Illinois State Geological Survey (ISGS) and the United States Geological Survey (USGS) was used. The high resolution National Hydrography Dataset (NHD) developed by the USGS was used to provide stream/river reach information to the model. The land use data was obtained from the Illinois Department of Agriculture which is based on the satellite imagery of the State of Illinois acquired from three dates during the spring, summer, and fall seasons of 1999 and 2000. Land use in the study watersheds was classified as corn, soybean, rural grassland, forest, urban, wetland and other (figures 45, 46, and 47). The soils data was based on digitized County Soil Association Maps of the Knox County and the STATSGO dataset (figure 48). The soil type for various parts of the study watersheds were determined spatially from the digitized soils maps, but the parameters corresponding to the soil type were manually entered during development of the HSPF model.

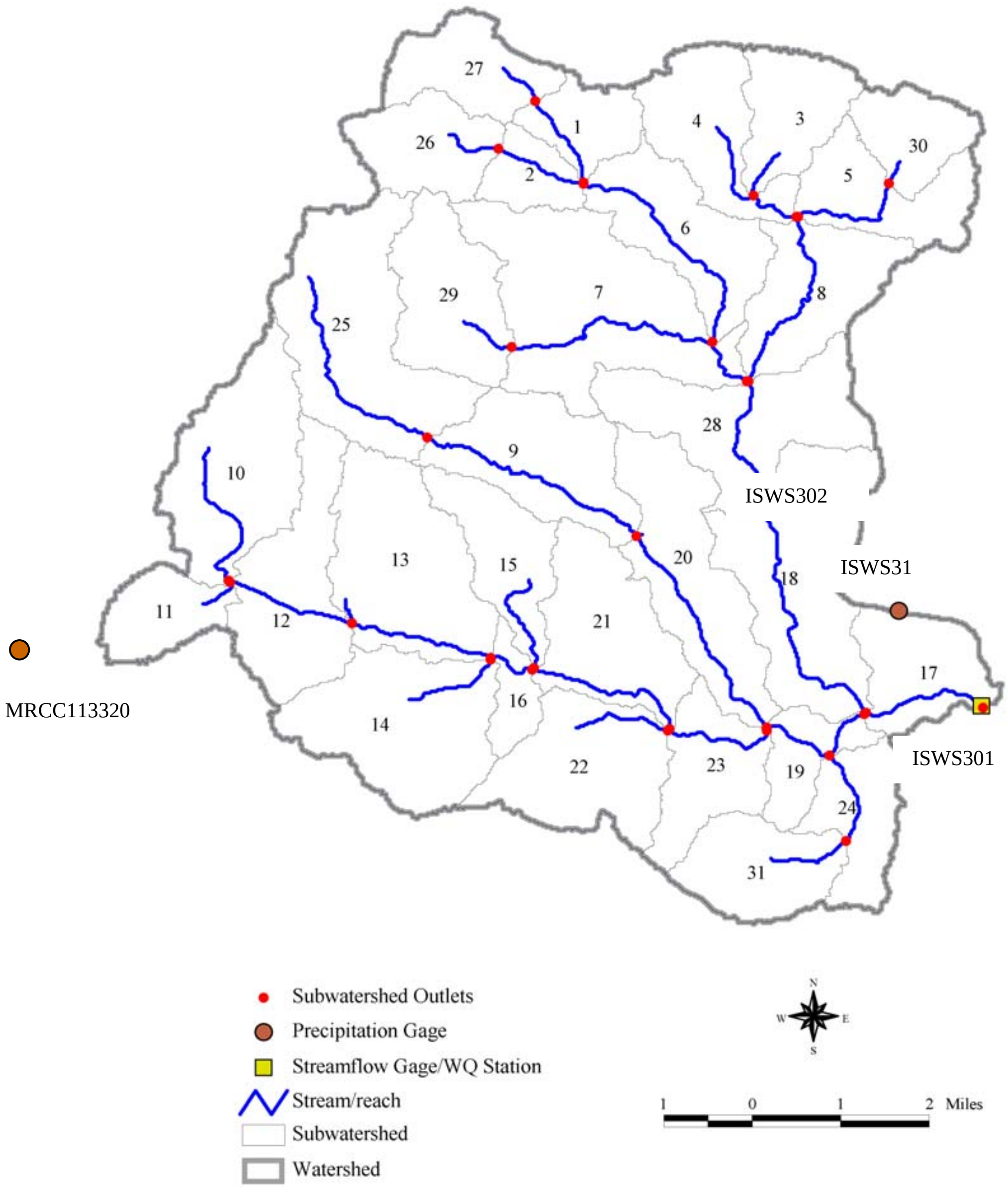


Figure 42. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Haw Creek model

Figure 43. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Haw Creek model

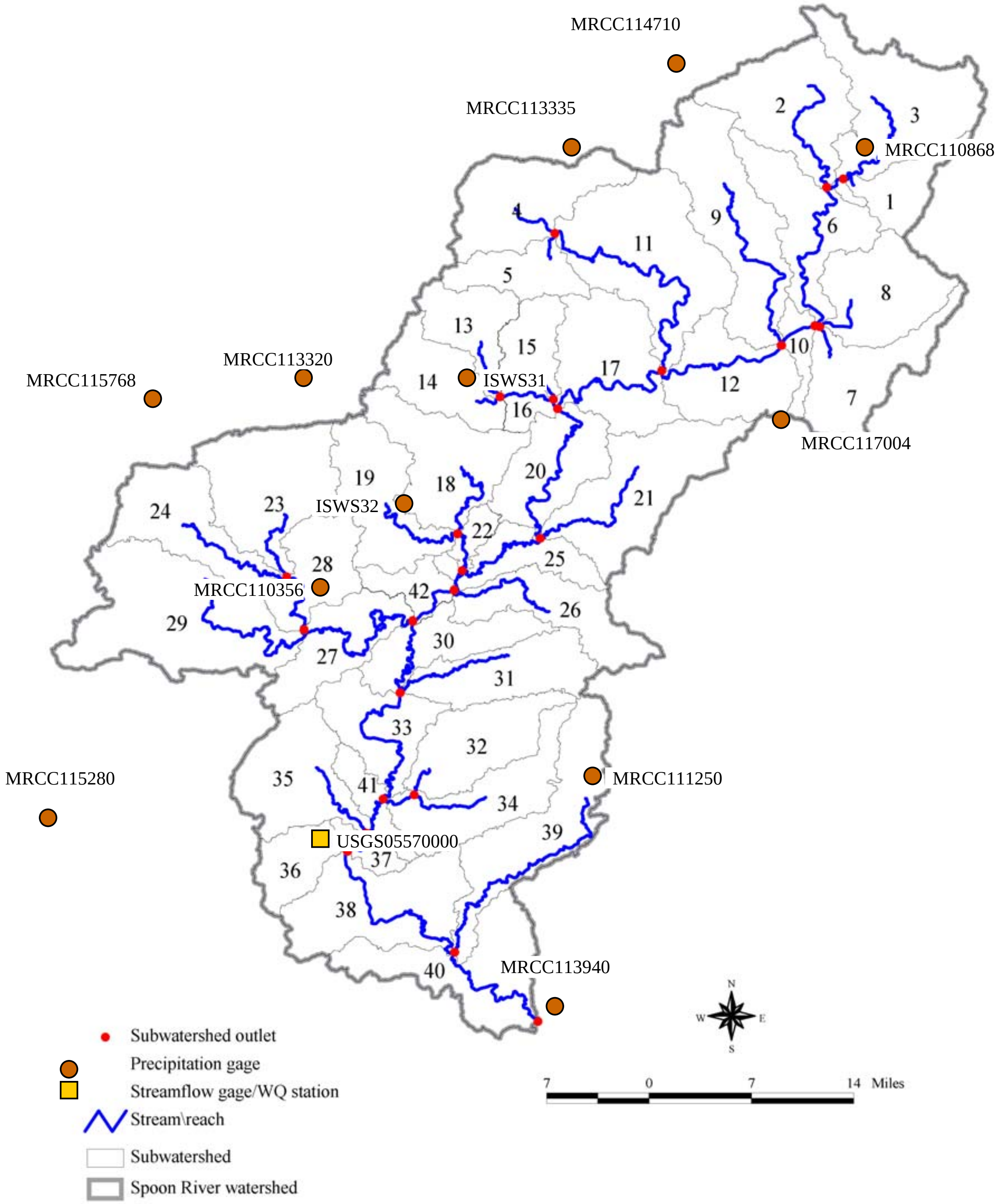


Figure 44. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Spoon River watershed model

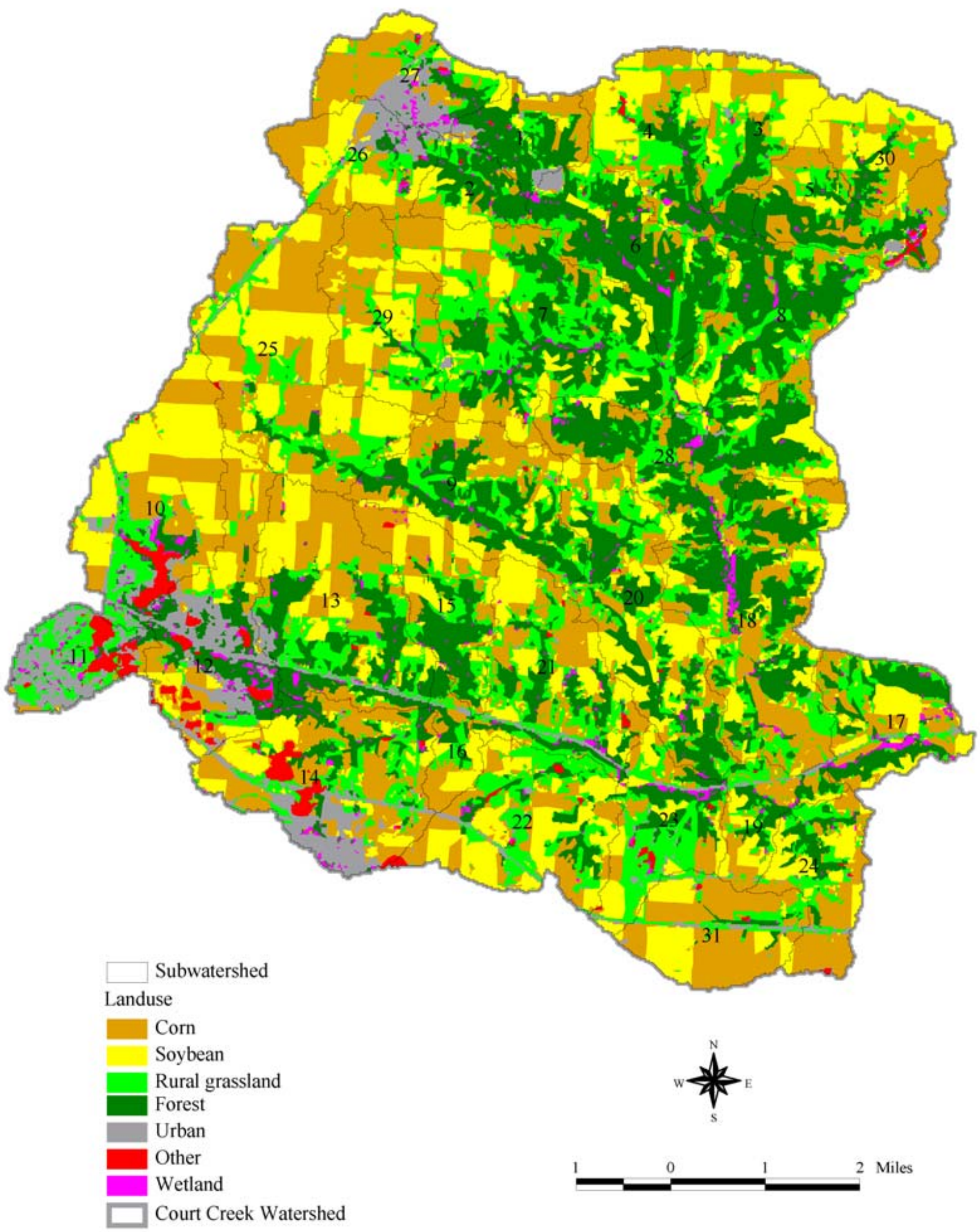


Figure 45. Land use in the Court Creek watershed

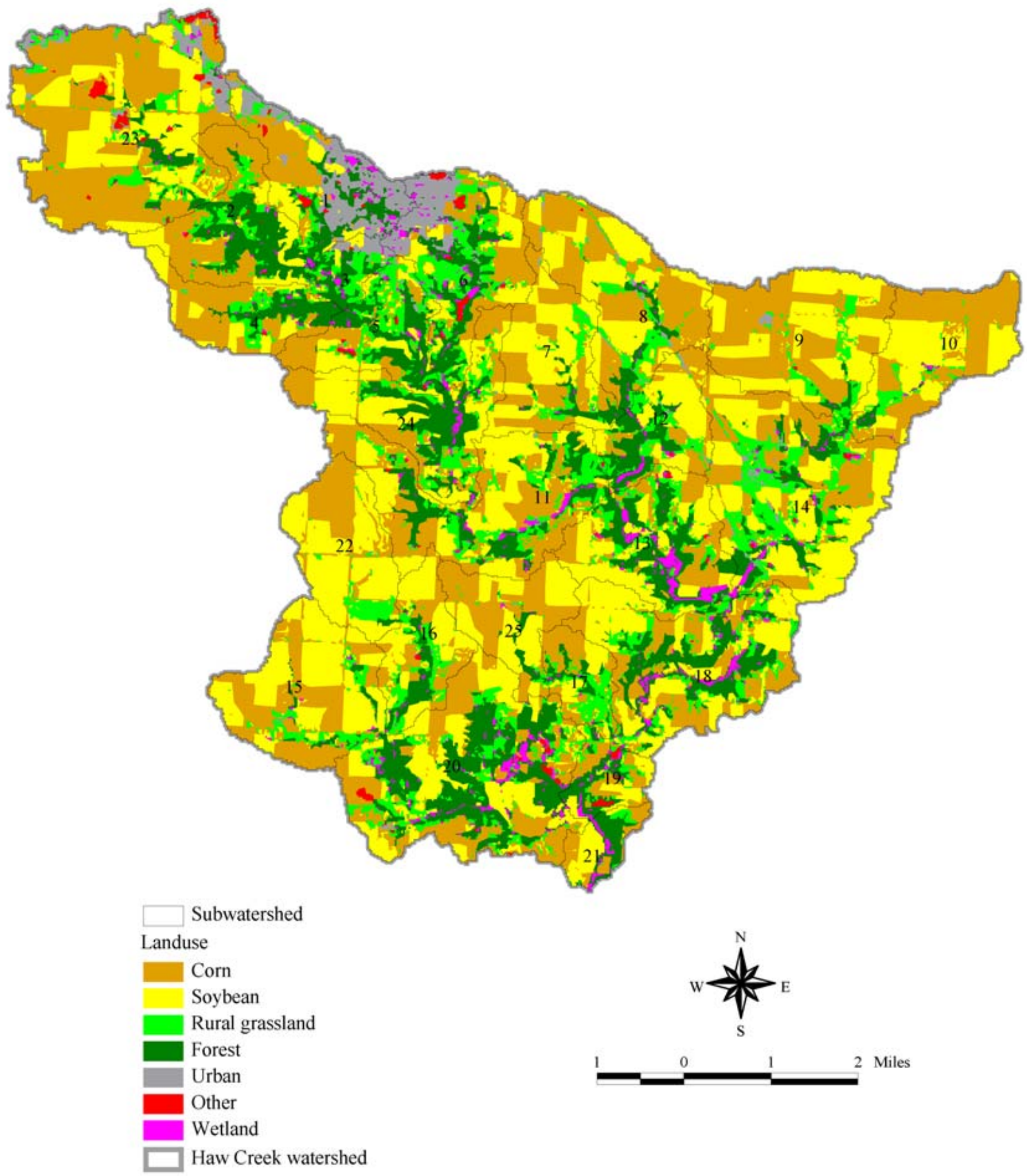


Figure 46. Land use in the Haw Creek watershed

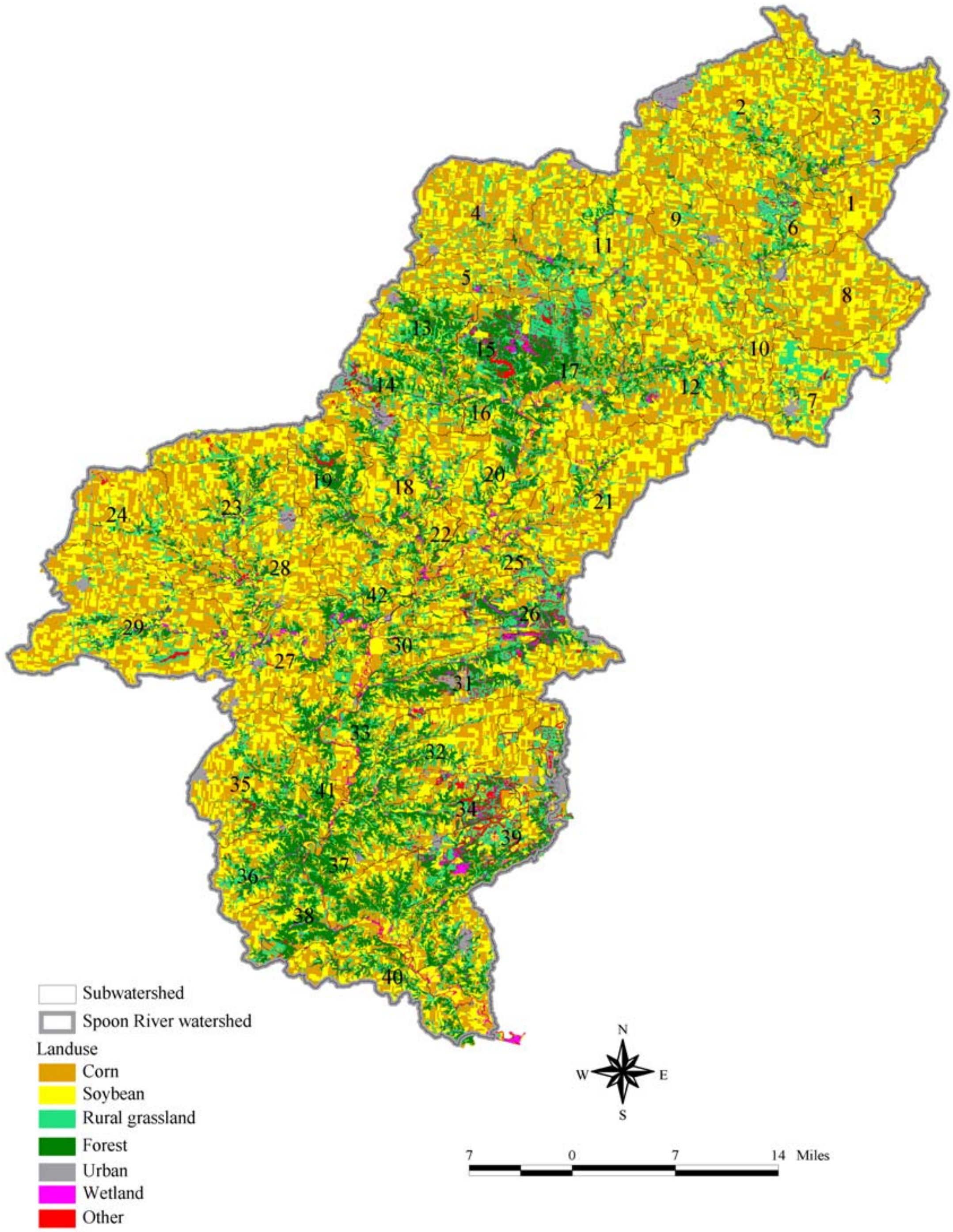


Figure 47. Land use in the Spoon River watershed

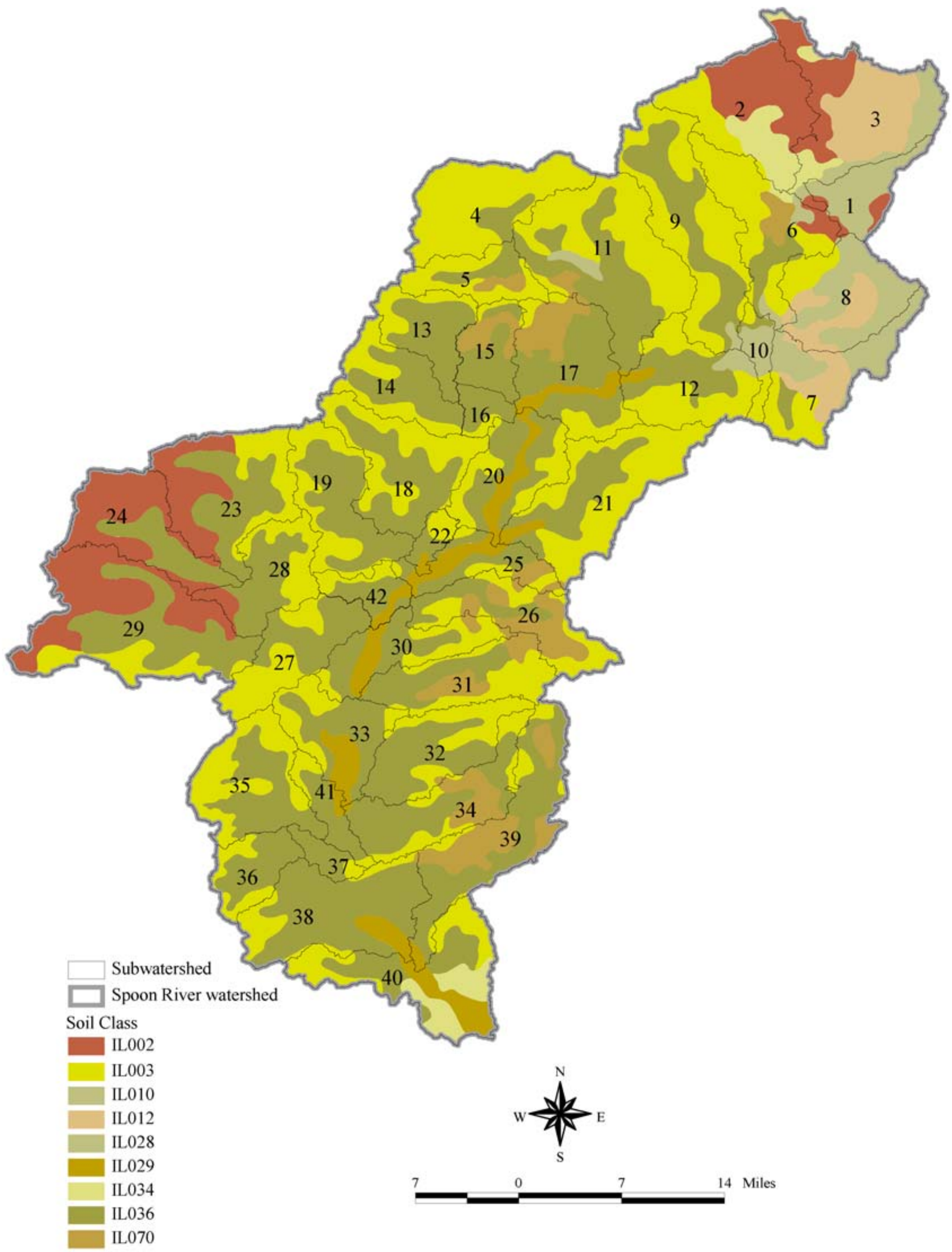


Figure 48. Soil types in the Spoon River watershed

Model Development

Based on the topographic and hydrographic data, the watersheds were subdelineated into smaller hydrologically-connected subwatersheds and stream reaches, and respective outlets. The Automatic Delineation procedure in BASINS with an option of ‘burning in’ existing streams was used. Subdelineation was done for representing spatially variable physical and other characteristics of a watershed in the HSPF model. The Court, Haw, and Spoon River watersheds were subdivided into 31, 25, and 42 subwatersheds, respectively (figures 42, 43, and 44). During subdelineation, outlets were specified in the models corresponding to the streamflow gaging/water quality monitoring stations on the North Creek (ISWS302), Court Creek (ISWS301), Haw Creek (ISWS303), and the USGS streamflow gaging station at Seville (USGS05570000) in the Spoon River watershed (figures 42, 43, and 44). The subwatersheds were further subdivided into Hydrologic Response Units (HRUs) based on land use, soil, and climate to account for the spatial variability of a basin’s physical and hydrologic characteristics at a finer scale. An HRU is an area within a watershed that is expected to have a similar hydrologic response to input of precipitation and evapotranspiration. Each HRU has a set of parameter values that must be determined through the calibration process to define runoff characteristics as well as loading of various constituents from that HRU. In the Court Creek watershed HSPF model, climate data from the Court Creek and Galesburg precipitation gages was input to different subwatersheds based on the proximity. Similarly, in the Haw Creek HSPF model data from the Haw Creek and Galesburg gages was input to various subwatersheds. In case of Spoon River watershed HSPF model, data from all ten MRCC stations was specified for different subwatersheds based on their proximity to the gages.

Model of the Court Creek watershed was developed first using two years (WY2001-WY2002) streamflow and sediment concentration data from the ISWS301 streamflow gage/WQ station on the Court Creek. Calibrated model parameters from this model were then used to populate the models of the Haw Creek and Spoon River watersheds. No further calibration of these two models was performed. Haw Creek watershed model was run for the same two year period as Court Creek watershed model and the model results were compared with the observed data from the ISWS303 gage on the Haw Creek. Since long term climate and streamflow data were available for the Spoon River watershed, this model was run for 1972-1995 period using data from the USGS05570000 at Seville.

Modeling Results

Values of a large number of HSPF model parameters can not be obtained from field data and need to be determined through model calibration exercise. The Court Creek watershed model was calibrated to assign best possible parameter values to each HRU and stream reach so that the model simulated daily streamflows and pollutant concentrations similar to the values observed at the gaging/monitoring stations. Calibration of the hydrologic component of the model was followed by the calibration of the water quality component for the sediment concentration. Model was run for hourly time step. For the two year calibration period of WY2001-WY2002, percent volume error between the model simulated and observed streamflows at gages ISWS301 on the Court Creek and ISWS302 on the North Creek were 1.2% overestimation, and 3.5% underestimation, respectively. Comparisons of the daily streamflows simulated by the model for

WY2001-WY2002 period with those observed at gages ISWS301 and ISWS302 are shown in figures 49a and 49b. The performance of this preliminary model is promising and overall the simulated streamflows follow the similar trend as the observed values. The timings and shape of the simulated streamflow hydrographs resemble the observed ones but some peak flows were underestimated by the model. In this study the model was not calibrated to match the individual stormflow events, rather it was calibrated to fit the long term and daily data over the two year calibration period. Also, data from only two precipitation gaging stations, both near the boundary of the watershed (figure 42), was used to spatially represent the precipitation over the entire watershed. It is possible that rainfall measured for a particular event at one of the gages did not represent the rainfall that actually occurred in different parts of the watershed, thereby resulting in discrepancies between the observed and simulated streamflow hydrographs. Thus, more precipitation gaging stations will help improve the performance of the hydrologic model by more accurately simulating the stormflow hydrographs.

For sediment simulation by the model in the Court Creek watershed, parameters controlling soil erosion on the surface and sediment transport in the stream channel were calibrated. Comparison of sediment concentration simulated by the model and those observed at gages ISWS301 and ISWS302 are shown in figure 50 for the WY2001-WY2002 period. The simulated values generally followed the same trend as the observed sediment concentration values at both gages. Since most soil erosion occurs during extreme runoff events, some high sediment concentrations were underestimated by the model as a result of poor estimation of the stormflow peaks by the model during hydrologic simulations.

Streamflow and sediment concentration simulation results from the Haw Creek watershed model are compared with the observed data as shown in figures 51 and 52, repectively. Similar results from the Spoon River watershed model are shown in figures 53 and 54. In this preliminary phase, the performances of these two models were similar to the calibrated model of the Court Creek watershed. Performance of these models can be improved in the future if climate, streamflow, and water quality data are available for more stations and longer time period to improve the model calibration.

Assessment and Evaluations

The methods that will be used to assess current and future conditions and to evaluate the progress the Illinois River CREP is making towards meeting the goals set for reducing sediment and nutrient delivery to the Illinois River will rely on data that is being collected in the basin and the watershed models that are being developed to compliment the data. For sediment delivery, the baseline condition has been prepared based on available data collected from 1981-2000 (Demissie et al. 2004). The sediment budget estimate for the Illinois River for the 1981-2000 period is shown in figure 55. The figure shows the average annual sediment delivery from tributary streams to the Illinois River. The estimate was based on data collected at some of the tributary streams and regression equations developed based on available data in the basin. In summary, the sediment budget estimate for the 1981-2000 period, shows that tributary streams delivered an average of 12.1 million tons of sediment to the Illinois River valley per year. The measured sediment load in the Illinois River at Valley City, 61.3 miles upstream of the junction

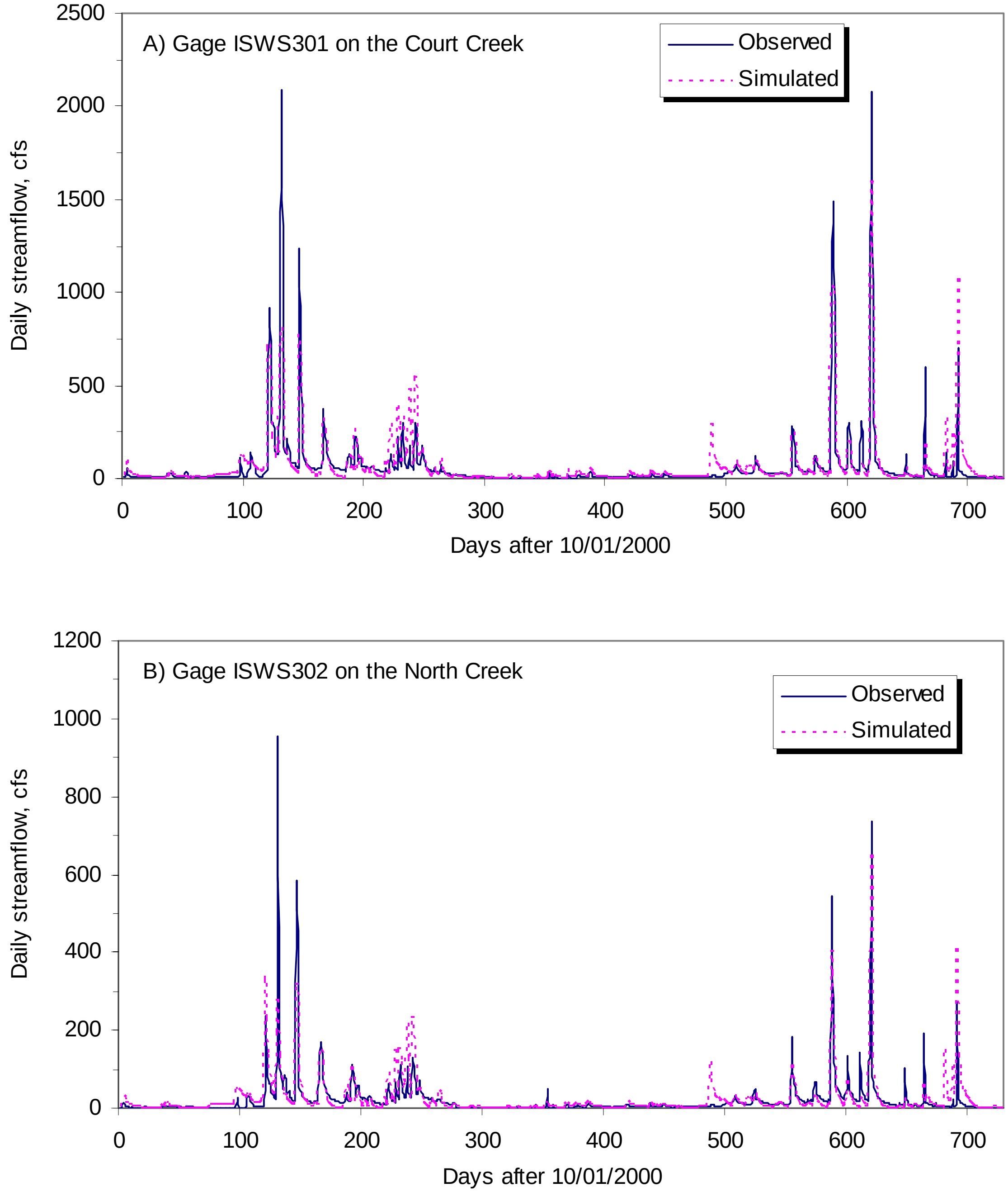
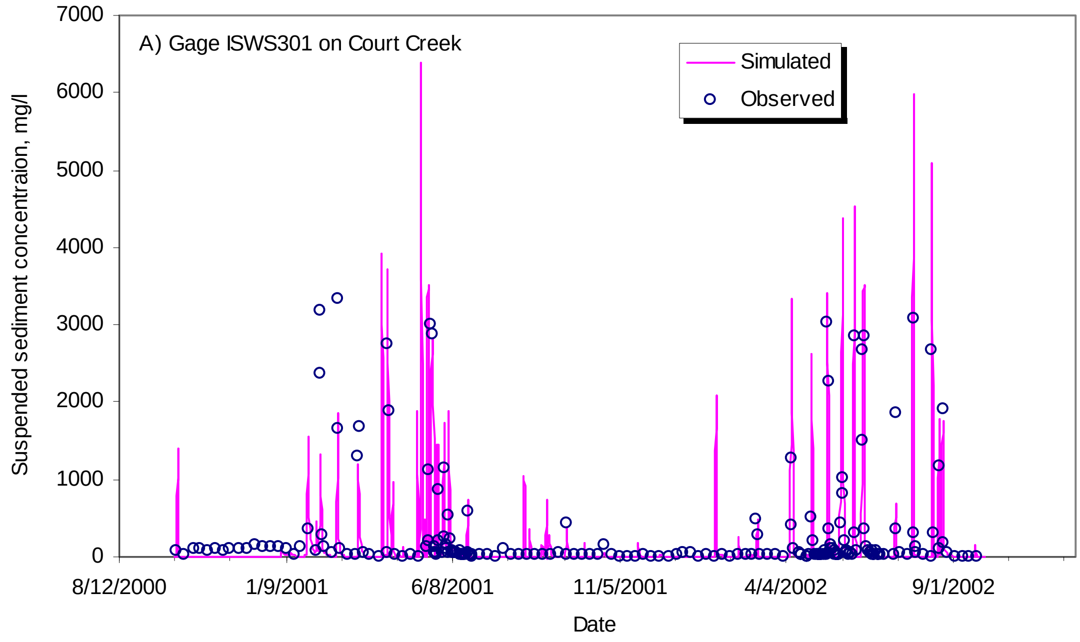


Figure 49. Results of model calibration for streamflow simulation for the Court Creek watershed



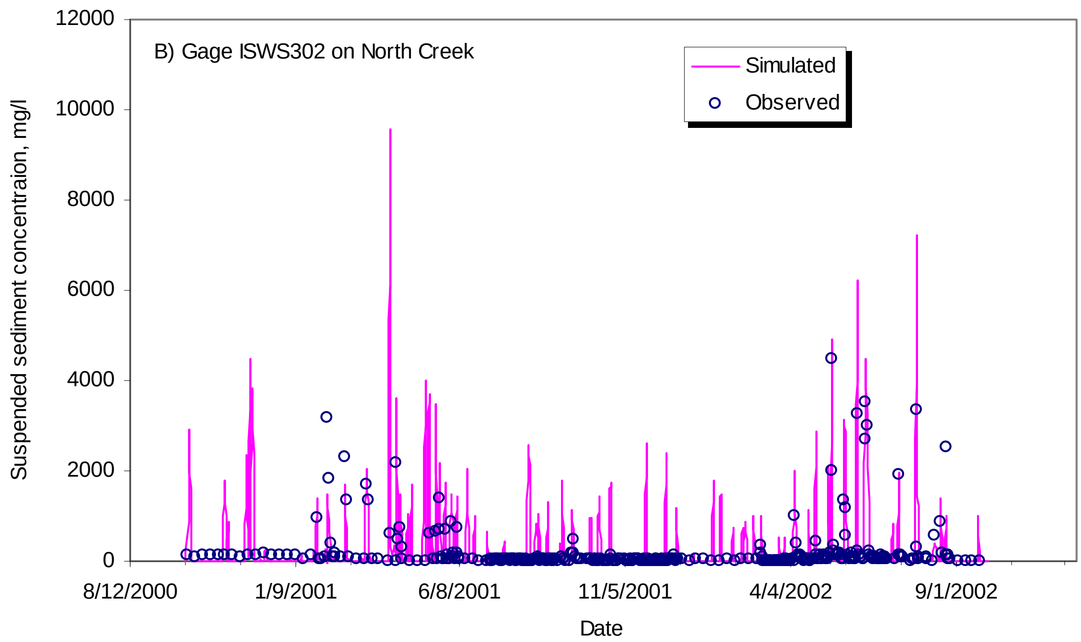


Figure 50. Preliminary results of model calibration for suspended sediment concentration simulation for the Court Creek watershed

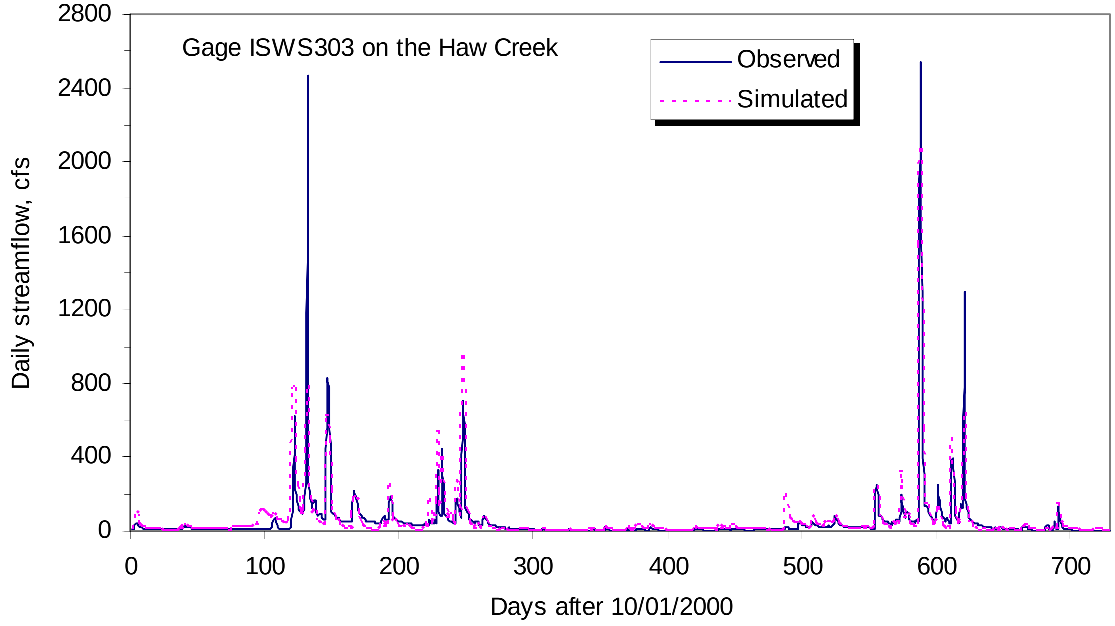


Figure 51. Comparison of observed and simulated streamflow by the Haw Creek watershed model developed using the calibrated parameters from the Court Creek watershed model

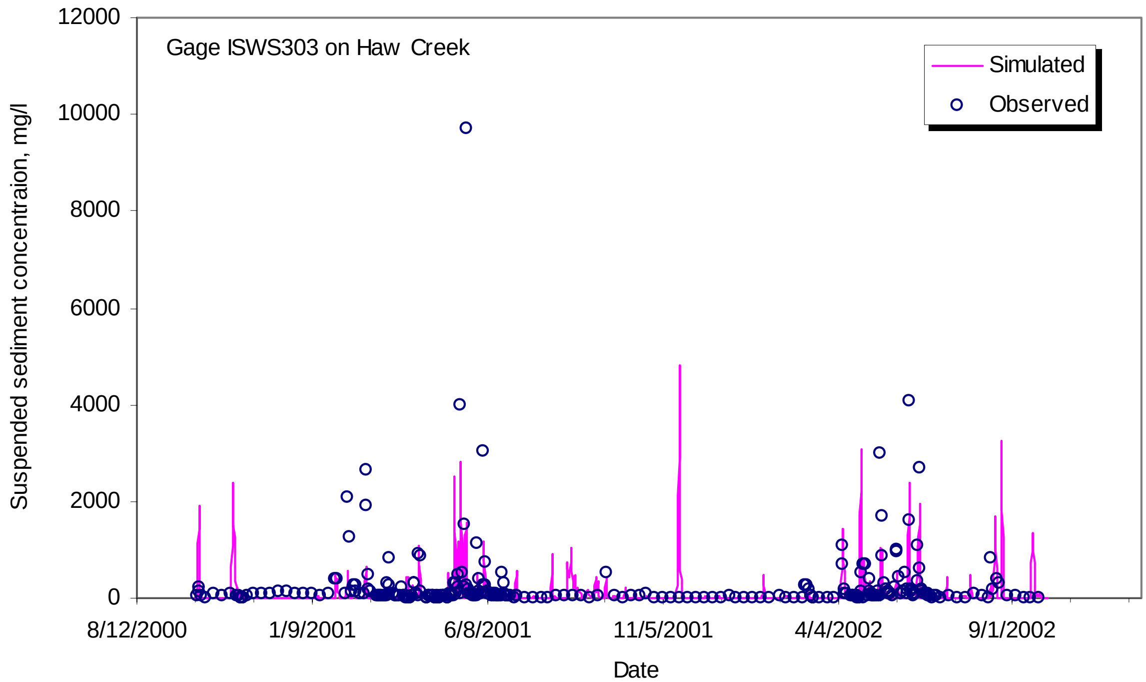


Figure 52. Preliminary results for suspended sediment concentration from the Haw Creek watershed model developed using the calibrated parameters from the Court Creek watershed model

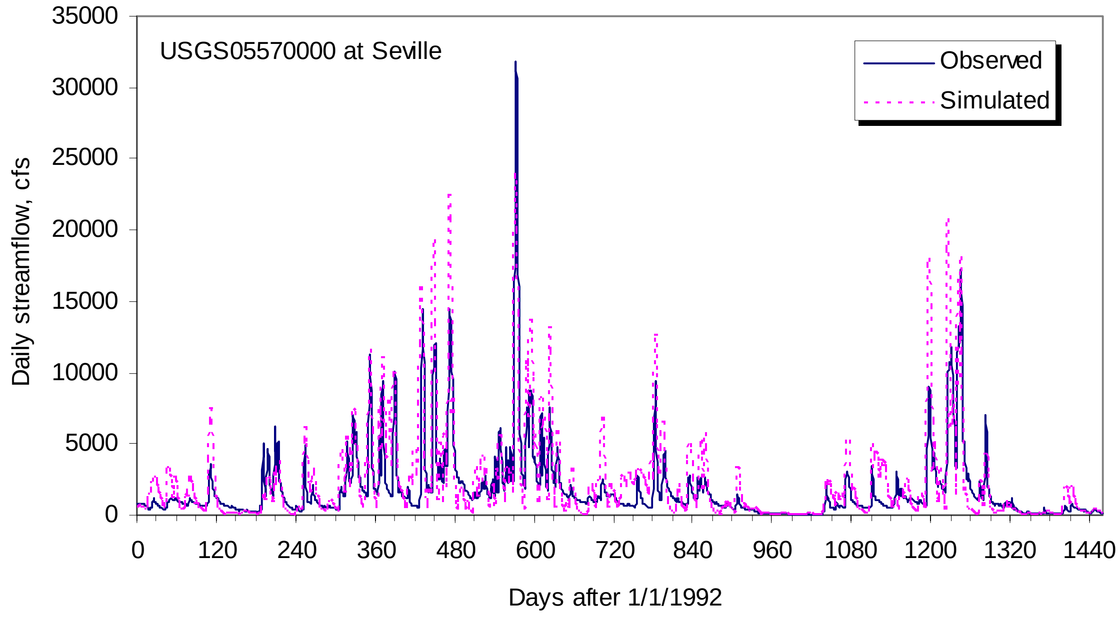


Figure 53. Comparison of observed and simulated streamflow simulation by the Spoon River watershed model developed using the calibrated parameters from the Court Creek watershed model.

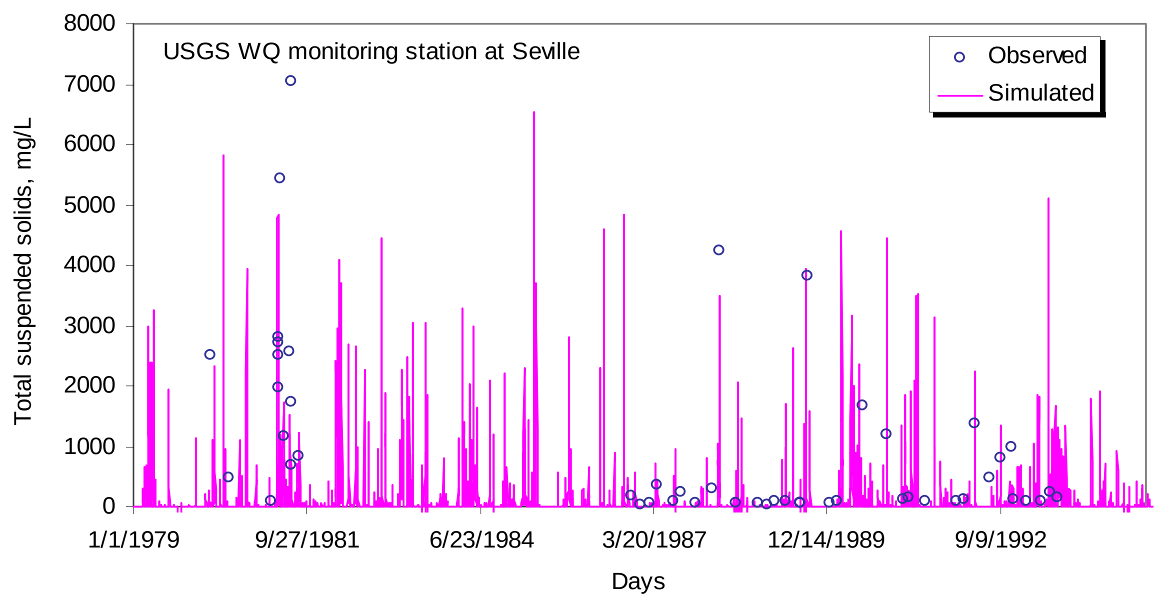


Figure 54. Peliminary results for suspended sediment concentration from the Spoon River watershed model developed using the calibrated parameters from the Court Creek watershed model.

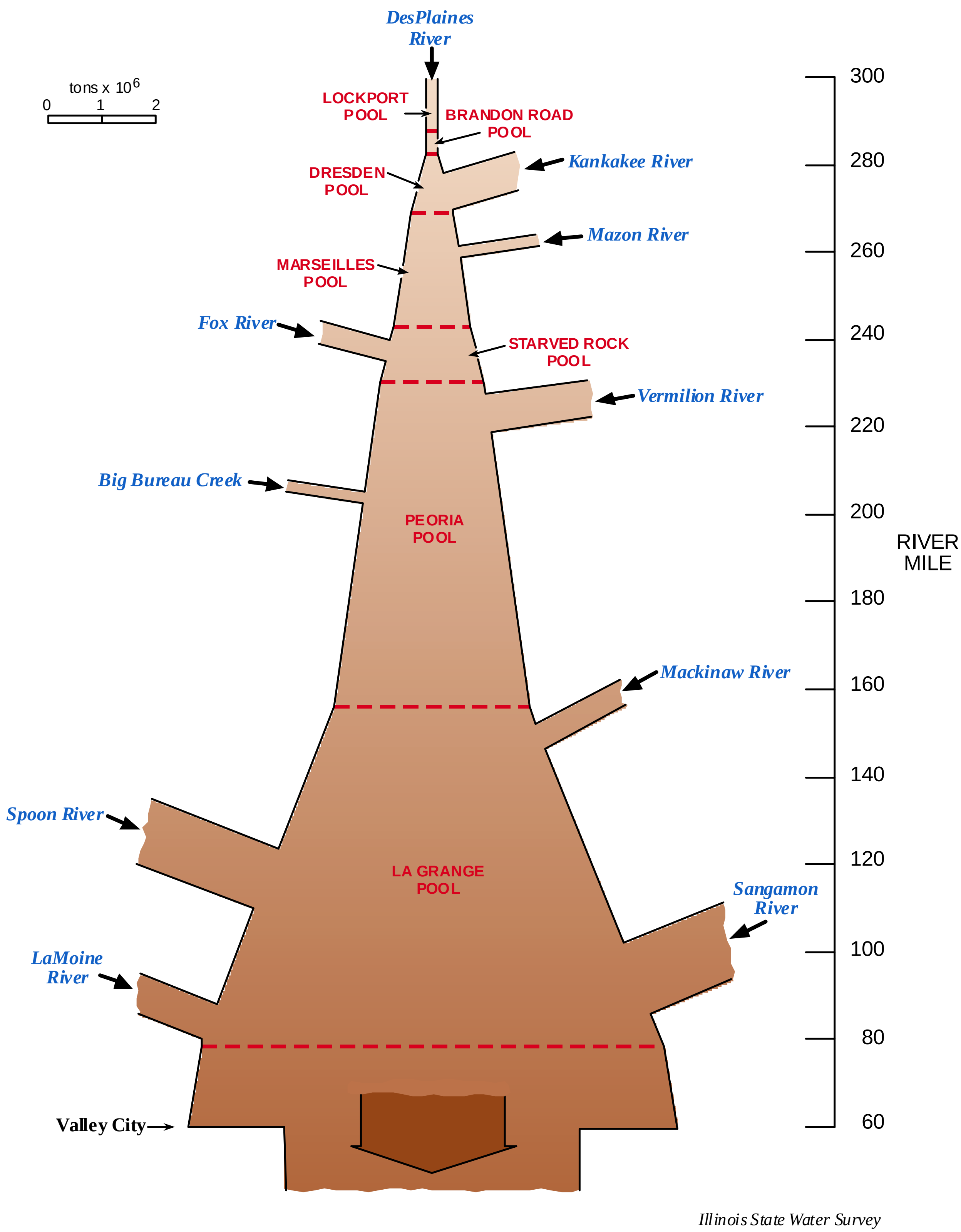


Figure 55. Sediment budget estimate for the Illinois River, 1981-2000

of the Illinois River with the Mississippi River, averaged 5.4 million tons per year. This left, on average, about 6.7 million tons or 55 percent of the sediment estimated to be delivered from tributary streams for deposition within the valley every year. As shown in the figure, most of the sediment flows into LaGrange Pool from the Spoon, Sangamon, LaMoine, and Mackinaw Rivers. The Spoon River delivers the most sediment per unit area among the major tributaries to the Illinois River. The Vermilion and Kankakee Rivers contribute significant sediment into Peoria and Dresden Pools, respectively. In general, the lower Illinois River receives much more sediment than the Upper Illinois River. It should however, be noted that Figure 55 is a cumulative sediment budget for the whole Illinois River valley. Sediment entrapment and thus deposition within each pool could not be calculated for each pool from available data. Therefore, only the estimated total sediment deposition within the Illinois River valley is shown at Valley City.

Having this information and data for the 1981-2000 period will enable us to assess and compare sediment delivery and sedimentation in the Illinois River valley for different periods. For example, if we continue to collect sediment data in the river basin up to the year 2010, we can construct a different sediment budget estimate for the period 2000-2010. Assuming climate conditions are relatively comparable, we can then assess if sediment delivered to the Illinois River has been reduced due to conservation practices including CREP. At the same time we can also evaluate the trend in sediment delivery from individual watersheds and identify where there is progress and where there are problems. The reliability of this method of comparing sediment budgets for different periods will depend on the availability of good quality data for the periods being compared.

A similar approach is also being developed for nutrients. A nutrient budget estimate for the Illinois River will be developed for the 1981-2000 period based on data collected by the Illinois Environmental Protection Agency (Short, 1999). Estimate of nutrient delivery from each of the major tributaries will be developed for the same period. Another budget estimate will be developed for the 2000-2010 period and compared to the 1981-2000 period. Any significant trend either from the overall nutrient budget or from the delivery from the different tributaries should be detected through the comparison.

Another method for evaluating the cumulative impact of land use changes (on sediment and nutrient delivery) is through the application watershed models that are capable of simulating sediment and nutrient transport. That capability is already being developed for the Illinois River basin and its tributaries as was discussed in the modeling section. Hydrologic, sediment and nutrient data being collected under the Illinois River CREP program will be used to calibrate and validate the models so that they could provide reliable results that could be used to assess the effectiveness of CREP and other conservation programs within the Illinois River basin.

Land use records are being collected and compiled so that they could be used as input to the watershed models. Significant changes in land use would be expected to result in changes in hydrology and in sediment and nutrient delivery.

By using both methods outlined here, it would be possible to assess and evaluate the changes in land use and sediment and nutrient deliveries and the relations between the two.

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THE ILLINOIS RIVER BASIN HYDROLOGIC OBSERVATORY

A Center for Understanding the Hydrologic Cycle of Intensively Managed Landscapes

The attached is a proposal to the National Science Foundation. Its overriding goal is to establish the Illinois River Basin as a Hydrologic Observatory for the study of critical water related issues associated with atmosphere, land, and water bodies in intensively managed landscapes.

This effort is being proposed through the collaboration of representatives from a group of universities in the region in partnership with a growing cast of state and federal agencies and stakeholders who value hydrologic science and the Illinois River Basin.

Overall objectives include:

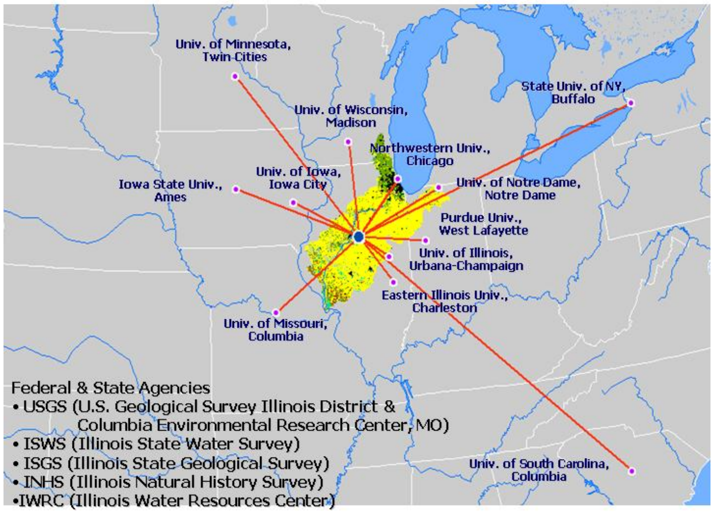
1. Enable interdisciplinary research by providing infrastructure that will attract scientists and water resource professionals to pursue research in the basin.
2. Answer interdisciplinary questions of high societal relevance around the broad themes of (i) hydrologic variability and extremes, (ii) biogeochemistry, (iii) ecology, (iv) contaminant transport, and (v) water resources management.
3. Develop stakeholder partnerships, and education and outreach programs for rapid dissemination of knowledge to derive immediate societal benefits for sustainable development.

The Observatory will provide improved scientific understanding of the hydrologic cycle and predictive capability to support better management and decision-making by stakeholders. The Observatory will provide an unparalleled environmental science resource to support the integrated study of rivers and lakes, water cycle, agriculture, ecosystems, and climate. Regional communities will benefit directly as critical environmental issues are studied and groundbreaking applications are developed in a local watershed. An alliance with parties who will benefit directly from the data resources and scientific investigations is being developed.

This effort has the potential to establish baseline data which will further efforts to measure and document the effectiveness of the CREP Program in the Illinois River Basin. In particular, information gathered on Sediment Flux will relate directly to the overall goals of the CREP Program and the State's monitoring efforts.

Illinois River Basin Hydrologic Observatory:
A Center for Understanding and Predicting the Complex Hydrologic Cycle of Intensively Managed Landscapes
A CUAHSI/NSF Proposal

The Illinois River Basin Hydrologic Observatory (IRB-HO) is being proposed through the collaboration of representatives from twelve universities in partnership with several state and federal agencies (Fig. 1). The Universities involved are Univ. of Illinois, Univ. of Wisconsin, Univ. of Minnesota, Univ. of Iowa, Univ. of Notre Dame, Univ. of South Carolina, Purdue Univ., Iowa Sate Univ., State Univ. of New York (Buffalo), Northwestern Univ., Eastern Illinois Univ. and Univ. of Missouri, Columbia. The following state and federal agencies are partners in this effort: United States Geologic Survey (USGS Illinois District and Columbia Environmental Research Center, Missouri) Illinois State Water Survey (ISWS), Illinois State Geologic Survey (ISGS), Illinois Natural History Survey (INHS), and Illinois Water Resources Center (IWRC).



Vision

We envision that the IRB-HO will be a center of excellence that provides improved scientific understanding of the hydrologic cycle with predictive capability to support better management and decision-making by stakeholders, in an intensively managed landscape. IRB is characterized by high productivity agriculture and rapid growth of urban areas, and located in northern temperate climate with low relief glaciated landscape. The observatory will address important questions that will lead to socially useful probabilistic assessments of future conditions in the basin. The IRB-HO will serve the following two functions:

a. Enable multi-scale interdisciplinary research by providing infrastructure that will attract scientists and water resource professionals to pursue research in the basin. Providing this "community science resource" will be an important function that attracts both remote and on-site participation by investigators from the hydrologic science community, nationally and internationally.
b. Answer fundamental interdisciplinary questions of high societal relevance as part of the core effort. The core science questions will be organized around the broad thrust areas of (i)

water, energy and sediment flux and dynamics, (ii) biogeochemistry, (iii) hydroecology, and (iv) water resources management.

The IRB-HO will be managed as a center with broad involvement of the community in conception, design and implementation. Further, the core data collected will be made publicly available immediately to realize maximum benefits from the HO. Education and outreach programs and effective partnerships with stakeholder organizations will be established to support management and policy decisions based on the scientific understanding and effective technology transfer.

Rationale for an Observatory in IRB

The Illinois River begins at the confluence of the Des Plaines and Kankakee rivers near Chicago, Illinois, and flows 380 km. southwest to the Mississippi River at Grafton, Illinois. It drains an area of over 80,000 sq. km. The topography in the basin is relatively flat with surface elevation ranging from 180 to 240 meters above mean sea level. Glacial features, originating in the Pleistocene Epoch are the major landforms in IRB. Several glacial advances covered the region, which have distinct effects on watershed characteristics. The climate of the basin is humid continental with cold and relatively dry winters, and warm, wet summers. The climate is well suited for agricultural production with little need for irrigation. The average annual precipitation in the basin is about 90 cm with an average snowfall of 65 cm. IRB experiences spring flooding during the months of March through May and occasionally in summer and autumn. Spring storm events and snowmelt create flood pulses connecting the stream and floodplain ecosystems. Extreme events such as floods (e.g. 1993) and droughts (e.g. 1988) have a significant human and economic impact on the region. Thousands of waterfowl and other migrant birds travel through the Mississippi flyway, in which the basin floodplains provide important resting and foraging sites for them.

Figure 1: IRB-HO partners.

A compelling case can be made for establishing an HO in the Illinois River Basin. First, the Illinois River, as part of the Upper Mississippi River system, is one of the most important navigable waterways in the world which grew from the need to meet the demand of transporting agricultural products from the region to national and international markets. Commercial barge traffic (Fig. 2 (left)) transports over 44 million tons of commodities with a total value of about $9.5 billion dollars per year. To accommodate this traffic, eight single-chamber lock and dam systems were constructed along the main stem of the Illinois River about 70 years ago. These structures have greatly modified the hydrology and hydraulics of the river. In addition, the main stem has been altered by the reversal of the Chicago River by the Chicago Sanitary and Ship Canal in the late 1800s to provide an outlet to dilute urban waste in this river by flushing it downstream into the Illinois River with water from Lake Michigan. The reversal of the Chicago River breached a continental divide between drainage to the Gulf of Mexico and to the Atlantic Ocean via the Great Lakes system. With the advent of modern waste-water treatment technology, the Chicago Sanitary and Ship Canal eventually became primarily a ship passage linking the Great Lakes and the Gulf of Mexico, but still constitutes a hydrological breach in the continental drainage divide. Further, the link between the Mississippi River and the Great Lakes has created a pathway for migration of invasive aquatic species across the two ecosystems. Thus the Illinois River waterway is of great socio-economic and ecological importance that depends upon appropriate control of main-stem hydrology. Seco

is River is representative of low-
nd, the watershed of the Illino

ciated landscapes of the Midwestern United States that is among the "most productive agricultural regions" in the world. Land use in this geologically young landscape is dominated by modern industrial agriculture, which encompasses about 80-85% of the basin area (Fig. 2 (right)). Prior to settlement much of the flat landscape was poorly drained and required artificial drainage to make it productive. In the process, over 80% of the natural wetlands and most prairie vegetation were destroyed, and seasonal hydrologic patterns became "flashier", with more frequent high and low streamflow and less frequent periods of moderate streamflow. Today, the hydrology of the watershed is influenced strongly by the land-drainage system, including subsurface drains (Fig. 3) and surficial drainage ditches. Subsurface drains consist of a network of perforated pipes installed at a prescribed depth below the surface. When the shallow water table rises to this level, the water drains away through these pipes. These elements of the land-drainage system connect directly with natural rivers and streams, many of which have been channelized to enhance their hydraulic efficacy. These changes have had a pronounced influence on the h

(Bottom) Color infrared aerial photograph of subsurface drains in a field.

Figure 2: (Left) Barge at Peoria lock, Ill.; (Right) Mosaic of corn and soybean fields in the IRB during July'04.

ive, massive inputs of chemicals to support industrial agriculture are an important consideration in this landscape. Each year farmers apply about 4 million tons of fertilizer on

Illinois farm lands including 962,000 tons of nitrogen and 391,000 tons of phosphorus. The downstream flux of nutrients, such as nitrogen and phosphorus, has been linked to pressing environmental concerns, such as eutrophication and hypoxia in the Gulf of Mexico. Nitrates have also been implicated in a number of health-related issues, including methemoglobinemia, non-Hodgkins lymphoma and stomach cancer. The nitrate issue, and other water quality issues related to agricultural activities, are a widespread problem throughout a large, populated, and economically critical area extending from Indiana and Illinois to Minnesota. Moreover, the

and rivers, has led to large downstream fluxes of sediment through the watershed system. This sediment is delivered to the Illinois River waterway where they have accumulated within backwater lakes on the floodplain and within the main stem of the river. Sediment dynamics within this watershed have been greatly altered by landscape-scale disturbance of uplands, modification of the hydrologic regime and stream channel characteristics, and the regulation of the main stem hydrologic properties through the construction of locks and dams. As an agricultural watershed representative of the Midwestern United States, the establishment of the Illinois River basin as a Hydrologic Observatory will provide insight into the hydrology, water quality and sediment dynamics of many similar watersheds throughout the Midwestern United States. Third, the feedback between land-surface and climat

reor example, atmospheric recycling of water vapor from transpiring crops and other vegetation is believed to make an important contribution to the generally abundant summer precipitation. This feedback is modulated by climate variability and is perhaps being fundamentally altered by climate and land use changes. Climate extremes such as droughts and extreme wetness are known to affect this feedback. For example, measurements taken during the 1988 drought along the eastern edge of the IRB indicated a 50% reduction in transpiration rates due to soil moisture deficiencies, likely contributing to the persistence of that event. Changes in land use from prairie to agricultural and urban, and loss of wetlands represent permanent alterations to this feedback of unknown magnitude. Alterations in the partitioning of rainfall and radiation received at the surface, due to artificial sub-surface drainage and increasing crop productivity (at the rate of about 1% per year historically) resulting from improving hybrids, are not well understood. Fourth, the Ill

necosystem, but is now the focus of a massive integrated-management initiative that seeks to improve ecological conditions while maintaining the needs of human communities in the watershed. This initiative includes federal, state and local government agencies, citizens groups and private companies. Current general management plans have been formulated based on focused scientific efforts. Further management decisions will have a continued need for comprehensive study of complex interconnections among components of the watershed system at various temporal and spatial scales. Since over 90% of the population of Illinois (12.5 Million) lives in the IRB, the challenges for environmental management in the face of human needs are great, but typical of the agricultural situation in watersheds throughout the Midwest. Management of the river involves contro

hydrological needs of riparian ecosystems. Often these two needs are in conflict and historically the preference given to meeting the needs of barge traffic has resulted in severe degradation of natural ecosystems. Some discussion has emerged about “controlled” experiments to meet hydrologic requirements of riparian ecosystems, ala controlled releases conducted recently for the Colorado River system, but thus far no decisions have been made about this type of action. Also, it is unlikely that this type of hydrologic experimentation will solve the problem of massive sediment accumulation within floodplain and main-stem habitats. Estimates of water fluxes to and from the groundwater system are essential to co

ents of the hydrologic cycle. The IRB includes several significant surficial and deep aquifers. These aquifers are the major water source for cities in east-central and northeastern Illinois, and the long-term sustainability of these systems will play a major role in the economic development of the state. Hence it is crucial to understand recharge and discharge fluxes for these aquifers, including the impacts of urbanization upon groundwater recharge, and conversely, the effects of increasing groundwater development on surface waters. Conditions in the basin are changing on multiple time scales and this will likely conti

of urban sprawl (particularly near Chicago but also in other urban areas) is substantial, changing hydrologic characteristics. Population, and associated water use, is increasing, putting pressure on existing water supplies. The watershed continues to adjust to land use changes initiated and modified since settlement. Ongoing changes in agriculture practices, such as reduced tillage and increasing plant densities, are also affecting hydrologic characteristics. Further, the conflicts among competing uses of the IRB are increasing. The frequency of intense precipitation events has been increasing, leading to more frequent flooding events. All of these trends may well continue into the future. There is a pressing need for better scientific understanding of these issues in order to better prepare for the future management of the IRB and other similar basins. From a watershed perspective, the hydrology of the landscape

-surface drainage systems, either in agricultural settings (subsurface drains and channelization) or urban/suburban settings (sewers). Management centers on the need to control better the downstream flux of nutrients, sediment and runoff from agricultural lands into streams, rivers and major waterways. Stream naturalization/restoration to mitigate the adverse effects of human modifications is an important consideration. However, such management should be based on sound scientific understanding of the temporal and spatial variability and trend of these fluxes, through integrated and sustained studies of a type that currently does not exist. The establishment of a Hydrological Observatory in the Illinois River basin would help to generate such understanding and the general principles will be transferable to many other watersheds throughout the Midwest. IRB offers a compelling opportunity in being a representative basin for the region yet distinguishes itself because it has the largest body of data and existing infrastructure to support the HO effort.

E

The rich institutional experience,
provided by the Illinois State Scientific Surveys (ISWS, ISGS, INHS), in existence for over 100 years, along with networks operated for national and regional purposes by federal agencies (e.g. USGS, NWS) presents a unique set of existing infrastructure in which to develop a HO. The existing infrastructure will provide a historical context for prevailing processes and would enhance the ability of the HO to focus on scientific issues. They will naturally facilitate a nesting approach to addressing issues of scale.

G

1. An extens

House maintained by ISGS. These include data related to surficial geology and elevation, bedrock geology and mining, hydrology and water resources, natural resources, and infrastructure. Illinois land cover historical data are available from the Illinois Department of Agr

3. A variety of environmental data are available from the Upper Midwest Environmental Scien

the USGS. Census data

5. Additional high resolution elevation data can be obtained from the Shuttle Radar Topography Mission a

ASTER DEM USGS National

7. Satellite data from TERRAAQUA, , and other platforms will be archived fo

them in a process and variable structure.

L

The IRB has extensive instru

ide long-term context for the HO. Some of these locations are depicted in Figs (4). These include observations for:

- Surface water quality (The UpperLower and
- Sediment (ISWS, USGS): Since 1981 ISWS has been monitoring suspended sediment trans

their Benchmark Sediment Monitoring program. Currently there are 8 stations in IRB collocated with USGS stream gaging stations that provide weekly data on concentration and particle size distribution. Biology (INHS, IEPA, IDNR): IEPA monitoring network and fish-community sampling

- Climate (ISWS and NWS)
- Groundwater levels and quality (ISWS, ISGS,
- Water use (annual public, industrial, commercial with

ISWS)

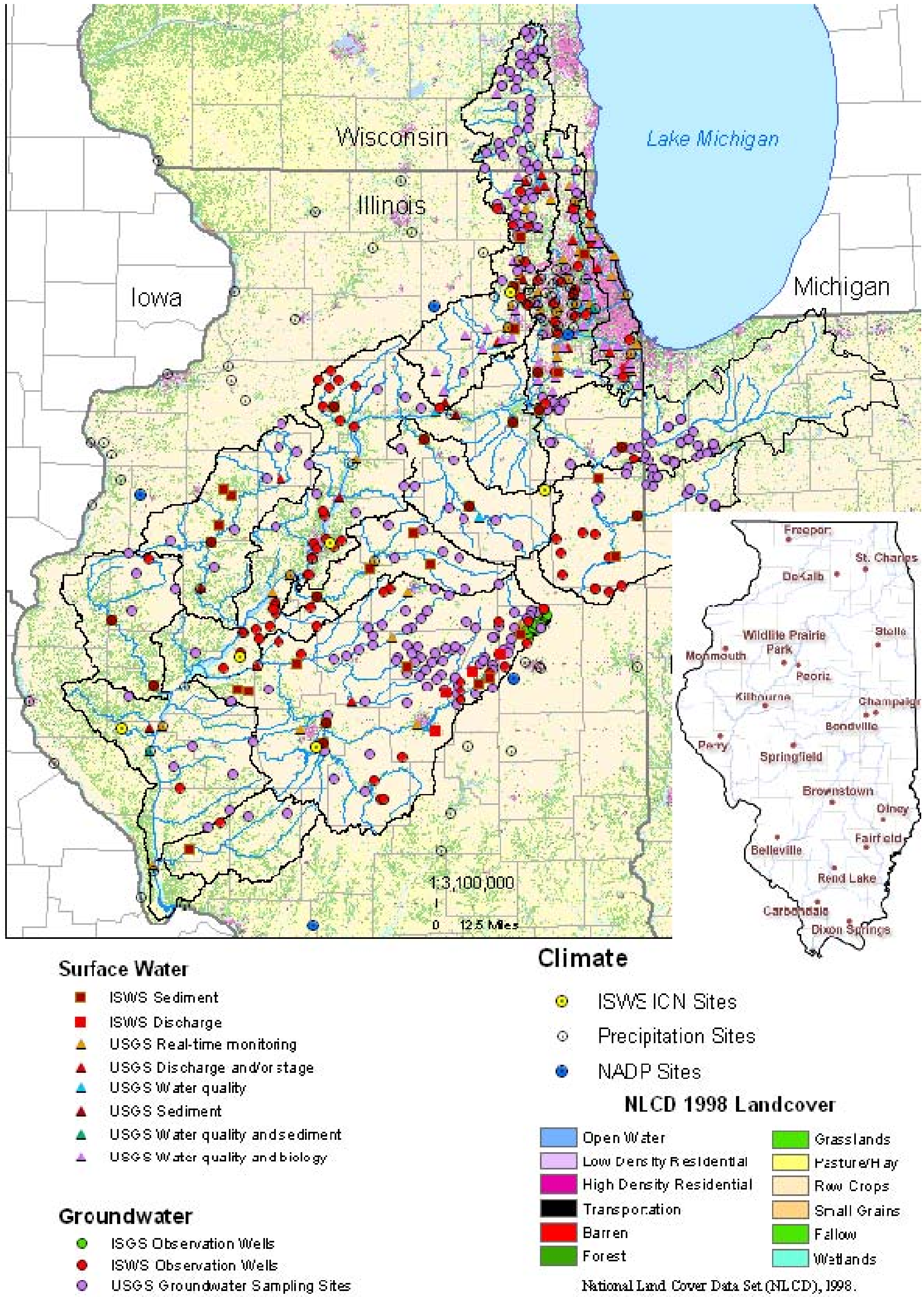
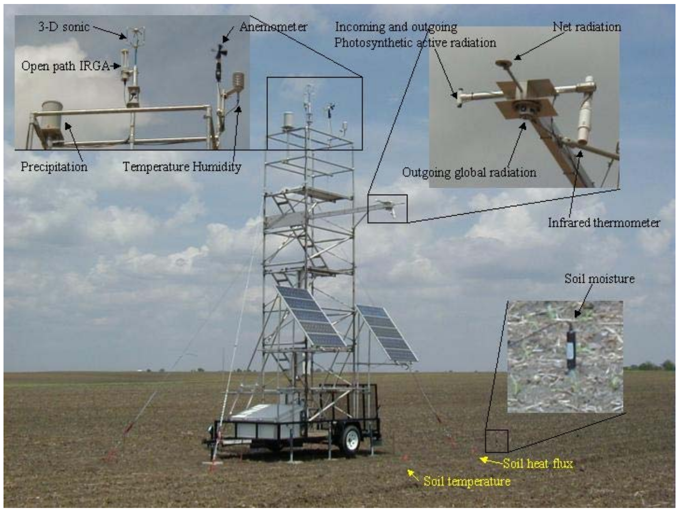


Figure 4: Sampling sites in the IRB. Inset shows the locations of the stations in the Illinois Climate Network (ICN).

- ISWS has extensive volumes of water and atmospheric data, some dating back over 100 years. The Water and Atmospheric Resource Monitoring (WARM) program collects and distributes these data including that form the Illinois Climate Network (ICN). ICN consists of a network of 19 climate stations (9 in and around IRB) that record hourly observations of air temperature relative humidity, precipitation, solar radiation, barometric pressure, wind speed and direction, and soil temperature and moisture profiles to a depth of 1 m and 1.5 m, respectively.



Additionally, a variety of national monitoring programs are operated in and around IRB. These include:

- National surface meteorological networks
- National atmospheric deposition program
- GOES sounding
- NOAA wind profiler network
- Doppler radar network
- The SURFRAD network for monitoring surface radiation with a site in Bondville, IL
- AmeriFlux network for ecosystem level exchanges of carbon and energy flux (with a site in Bondville, IL)

In addition to the ICN network and the AmeriFlux towers, the ISWS operates another flux tower, funded by DOE (Department of Energy) in support of the North American Flux program, to monitor carbon dioxide (CO_2), water vapor (H_2Ov), and energy balance fluxes along with atmospheric forcing variables (Fig. 5). These towers provide 30 minute year around measurements of CO_2 and H_2Ov fluxes over no-till corn and soybean fields. Both the flux towers are located on the eastern edge of the Sangamon watershed in the IRB. We propose enhancements to the current flux and ICN stations, and installation of additional flux stations for the Observatory to better evaluate the regional atmospheric forcing and the response of the hydrologic cycle on a regional scale.

There are major on-going efforts to develop large-scale groundwater models of important aquifers in the IRB. In particular, a model of the entire Mahomet Aquifer extending from

Indiana to the Illinois River is being developed. Over 60 observation wells have been drilled into the Mahomet Aquifer and water levels in those wells are routinely measured. Major chemical constituent chemistry also has been completed on these wells. Local-scale models are also being developed for several surficial aquifers in northeastern Illinois. These models are being nested in a regional-scale model encompassing aquifers from the surface to pre-Cambrian bedrock. These existing and developing models, being created without cost to the HO, will greatly enhance the IRB-HO by extending the value of the data collected into a capability for prediction.

Decision Support: The Illinois Scientific Surveys have developed and comtinue to maintain the Illinois Rivers Decision Support System (ILRDSS) to integrate and expand existing databases and numerical models of segments of the Illinois River into an integrated decision support system for the entire Illinois River watershed. The ILRDSS improves dissemination of scientific tools and information by using the Internet as the primary access to inventories of current and historical projects, data, simulations, and involved agencies/participants within Illinois watersheds.

Core Data for the Proposed HO:

The observatory design will be based on identifying (i) critical spatial and temporal gaps in the existing infrastructures at different scales, (ii) missing components for processes critical to the hydrology of the region, and (iii) key drivers for the hydrologic cycle of the region. The design will also be based on performing an integrated assessment of processes at the interfaces by appropriately collocating observations for different processes to capture both magnitudes and gradients. Examples of important aspects to be captured by the HO include the high spatial variability of warm season convective rainfall, surface energy budget variations resulting from different land uses, stream discharges and stream water quality from important sub-watersheds, and groundwater fluxes to and from the surface. The core data will include data from the existing infrastructure, described above, through appropriate partnership with the respective agencies, as well as new data obtained through the observatory effort. A nested multi-scale design will be adopted to capture a broad spectrum of spatial and temporal variability within selected sub-watersheds of the IRB. The categories of new data to be collected by the HO are described below:

Figure 5: Illustration of the flux tower and the instruments.

Radiation: The challenge of determining the spatial variations in the magnitude of the surface energy budget components will necessarily be met by a combination of in situ measurements to establish the fundamental behavior of major land use categories, and satellite remote sensing and modeling to extend coverage to the entire basin. A high percentage of the land use is for corn and soybean production and thus these two land use categories will be targeted for in situ measurements. Management practices, principally the difference between conventional tillage or some form of reduced tillage, introduce further substantial spatial variations in the surface energy budget. Existing and proposed ICN measurements and flux towers, and the SURFRAD measurements (which provide the full suite of radiation measurements, including upwelling and downwelling shortwave and longwave components) will provide the ground reference data necessary for estimating the surface energy balance in combination with remote sensing data and model assimilation.

Precipitation: Radars, particularly polarimetric, in combination with in-situ instruments, can provide high-resolution estimates of precipitation across the basin. Currently, the Illinois River basin is covered by the WSR-88D operational Doppler radar network as well as 100 NWS surface observation sites and two high density networks, one in the Chicago area and the other in the west-central part of the basin, operated by the ISWS. The NWS has plans to upgrade its radars to include polarization capability, although the timing for the upgrade is still undecided. Since these radars are used primarily for severe weather surveillance, the scan strategies and other aspects of their operation are not always ideal for precipitation studies. For this reason we propose an additional network of small polarimetric radars, vertically pointing radars, and disdrometers focusing on particular watersheds, for detailed hydrometeorological studies. In combination with the existing radar and rain gauge network, the new capabilities, when combined with modeling, should provide a much more accurate representation of the precipitation in the region.

Evapotranspiration: Evapotranspiration measurements require a network of instrumented meteorological towers located over various crop, grassland and forest areas. In addition to limits imposed by energy availability, evapotranspiration over land is also limited by the availability of soil moisture. During droughts, this depletion of soil moisture can become sufficiently large such that transpiration is sharply limited. However, in most years in Illinois, soil moisture remains adequate to maintain transpiration at or near the maximum rate possible. The combination of existing ICN and new towers will provide excellent point observations. These measurements will provide ground reference for the use of satellite remote sensing of soil moisture and leaf area coverage from AMSR-E and new instruments (e.g., SMOS) in analyses and data assimilation for complete coverage of the region.

Carbon: The new and upgraded ICN stations and the flux towers will provide a less costly method of monitoring the CO_2 and H_2Ov fluxes across the region. Continuous measurements from agricultural areas employing conventional (moldboard plowing followed by discing), reduced, and no-till farming practices with corn and soybean crops, as well as prairie and forest ecosystem, will be available for model validation of the hydrologic cycle. Additionally, IRB-HO will provide the much-needed data to determine the effect of different tillage practices on the atmosphere and the hydrologic cycle. While the number of hectares devoted to conventional tilling practices is decreasing, it is critical to conduct the flux measurements over this tillage type in order to evaluate how changing tillage practices may affect the climate and hydrology of the region. The flux measurements will also support the science program of the North American Carbon project, provide the infrastructure for the addition of ozone and trace gas measurements, and provide valuable data that can be used in other observation programs (such as NASA's earth observation program).

Atmospheric moisture flux: Determining the water vapor flux and convergence/divergence patterns requires high-resolution measurements and/or simulations of the wind and water vapor fields over and surrounding the basin. The recognition of the need for water vapor measurements to improve forecasts of precipitation has motivated a number of recent field studies (such as CAMEX-4 and IHOP) and have led to advances in the remote sensing of water vapor using technologies such as GPS and radar refractivity, which will be employed in the HO study, along with the routine radiosonde data that are collected in and around the region.

Soil-moisture and soil-temperature profile: The ICN network has collected moisture (temperature) profile at several depths since the early 1980s. These data, along with those collected by the additional stations and flux towers will be very important for intensive and long-term studies. This will also provide ground reference for utilizing remote sensing data in an assimilation system for prediction of spatial patterns.

Snow: Snow cover alters the surface energy budget through albedo increases, provides thermal insulation of the surface, and represents a reservoir of water. The average number of days with snow cover ranges from 25 in the south end of the IRB to about 50 in the north. Although the NWS climate network provides daily observations of snowfall and snow depth, there are no systematic measurements of albedo and snow water equivalent. The MODIS satellite data will be used to monitor spatial albedo variations. The ICN network will be supplemented with downward pointing pyranometers to provide point measurements of albedo. Snow water equivalent will be manually measured at selected sites using the Federal snow sampler.

Streamflow: Existing stream gauges currently fall into two categories: those managed by USGS and ISWS. Additional gages will be installed to fill critical gaps in the observational network and to provide hypothesis driven measurements. For instance, nested piezometers placed at various distances from ditches and streams will be used to partition streamflow into interflow, baseflow, subsurface drain (tile) flow and runoff, and to assess subsequent impacts on water quality. Further, stream discharge measurements will be obtained with IIHR's Large-Scale Particle Image Velocimetry (LSPIV) mobile unit that can be deployed at gauged and ungauged stream sites. The unit allows real-time remote free-surface velocity measurements over large-size areas and can be used in conjunction with bathymetry to determine stream discharges.

Sediment flux: The HO effort will enable us to quantify and characterize sediment sources (using sediment tracing), assessing fluxes and stores at multiple scales, and their relationship to relief, land use, soils, geology, and spatial and temporal variability. Model studies, parameterized and calibrated using these observations, will enable us to perform large scale predictions. The goal is to establish the role of both spatial/temporal hydrologic variability and other factors (climate, relief, land use, geology, channelization) controlling sediment stores and fluxes, and conversely to establish the role of sediments in mediating other important material cycles. Historical aerial photographs (obtained for Illinois every 5-6 years) will be analyzed to assess long term changes in channel planforms and lateral migration of rivers across floodplains.

Water quality: The design of the IRB-HO will build upon and augment on-going studies of nutrient fluxes and transformations. In addition, historical and on-going nutrient monitoring at sites in the IRB-HO provide a unique opportunity to compare results from the HO observations on much larger spatial and temporal scales than under previous research efforts. Subsurface drainage plays a crucial role in the dynamics of water quality. Effort will be made to map the subsurface drain locations in selected regions. Data specific to nutrient studies and other water quality studies will include:

a. Data to be collected at core sites will include pH, temperature, conductivity, dissolved oxygen in field; nitrate and total nitrogen; phosphorus (dissolved and particulate); suspended sediment; basic chemistry (ICP, IC data)
b. Existing dissolved flux data: including that from NAWQA studies will be compiled and made available on line in a coherent data base.
c. Analysis of water samples from the periodic sampling at the main gauging stations and maps of N loading

Groundwater-Surface Water Exchange: Measurement of fluxes at the groundwater- surface water interface is essential for estimating water budgets and understanding watershed response to storm events. To accomplish these measurement, several transects of monitoring wells will be established at strategic locations across stream channels. In many cases it will be necessary to install multi-level nested monitoring points to understand vertical flow dynamics. These wells will be equipped to record automatically water level and temperature. In addition, there will also be periodic sampling for key geochemical constituents and isotopes. River stage measurements at high spatial resolution will be required for the stream reaches between the monitoring well transects.

Recharge and Discharge of Major Aquifers: Understanding the water budgets of the major aquifers in the IRB is essential for investigations related to resource sustainability and management. We propose augmenting the existing observation well networks to measure vertical fluxes of water. Multi-level nests will be added in strategic locations in the deeper aquifers, in addition to wells in intermediate deposits and surficial water-table aquifers. These wells will continuously monitor piezometric head and temperature, and periodic samples for key geochemical parameters and isotopes will be taken. Surface and subsurface geophysical surveys will be conducted, as well as hydraulic testing, in selected locations to improve geologic and hydraulic definition of aquifer interconnections.

Lake levels: Reservoir levels are obtained from a network of cooperating reservoir operators who are contacted each month by Survey staff for the current water levels. The ISWS started collecting month-end water surface elevations at reservoirs over 15 years ago. The number of reporting stations has increased over time. The current month's average month-end water surface elevation for each reservoir is posted, where this value is the arithmetic average of the month-end levels for the period of record. The number of years of data is also tabulated.

Lake Sedimentation Surveys: The ISWS has performed sedimentation surveys for dozens of lakes within Illinois. These surveys provide trends in sediment delivery from Illinois watersheds and complement upstream sediment transport studies. Approximately 36 lakes were surveyed within the IRB and 7 in the Sangamon River basin. Many of these lakes were constructed in the 1920s-30s and many ISWS surveys began in the 1930s-40s. Most lakes have had 2-3 surveys with the most recent in the 1970s-80s. Two lakes within the Sangamon River have had 4-6 surveys. Key lakes could be resurveyed to provide sedimentation rates over the last 10-20 years.

Water resources: Water resource issues in the IRB generally pertain to private land management, water quantity and water quality management, as well as to meeting the navigational (main stem) and ecosystem demands. Studies in these areas will be supported by the data described above as well as economic and demographic data obtained from state and federal sources such as the ISWS Water Use Inventory Program (IWIP) and water use data from the USGS. Changes in water demand and supply will be monitored and correlated with demographic shifts and climate variability scenarios, land use change, crop pattern, and water use efficiency. Water use will be monitored at various levels, including river/reservoir diversion outlets, high-capacity wells, water distribution systems, and water use destinations such as agricultural irrigation of crop fields (supplied by both ground and surface water) and industrial and domestic supplies. Remote sensing can be used to estimate important agricultural water use parameters such as crop evapotranspiration and soil-moisture. Other data that are relevant for water resource management include: reservoir storage, detention pond (numbers, surface areas, storage and distribution), water withdrawals (diversions) from river or storage outlets, agricultural water use, non-agricultural water demand, stream status for navigation, and impacts of soil and water conservation measures.

Modeling and assimilation: Integrating the diverse measurements described above into a four-dimensional description of the hydrologic and atmospheric water system, and predicting the future state of that system, will be done with several modeling efforts, anchored with both hydrologic and atmospheric models. A key focus of the observatory will be the development and application of advanced data assimilation tools to integrate the diverse data sets collected by the observatory into balanced four-dimensional descriptions of the hydrologic/atmospheric system. Modeling will also be a key to the carbon cycle and storage analyses.

Science issues addressed by the observatory

Examples of important *science themes* that will be addressed by the observatory include:

- Quantitative estimates of fluxes and residence times, characterizing their pathways and transformations for water and nutrients.
- Relationship between water, energy, carbon and nutrient cycles for different vegetation types, and how they change in response to
  - Hydrologic extremes (droughts and floods)
  - Tillage and crop rotation practices
  - Demographic and land cover/land use changes
  - Climate variability
- Effects of sub-surface drainage control, at different spatial and temporal scales, on
  - Evapotranspiration and energy balance
  - Nutrient flux
  - Ground water recharge
  - Streamflow variability
- Interfacial control (land-atmosphere, surface-subsurface, groundwater-stream flow, hyporheic zones) on the water and nutrient dynamics
- Sediment and nutrient storage, flux and dynamics at different scales as functions of
  - Spatial and temporal variability of precipitation
  - Geology and hydrologic pathways
  - Land cover
  - Land use and management, including long term trends
  - Sewage and animal waste production and treatment

Understanding trends and patterns over historical time regarding
    Effects of climate variability and change
    Land use changes and their effect on the hydrologic cycle
    Human modifications of stream channels and their effect on ecosystem dynamics

Role of riparian zones, floodplain ecotones, and wetlands on improving water quality and flood mitigation, and ecosystems functions.

Dependence of ecosystem functions on hydrologic variability and connectivity, as a function of spatial and temporal scales and timing of events

Use of increased scientific understanding for predictive applications in support of practice, management decisions, and policy development, particularly water quality and quantity regulations

Optimal design of monitoring network using combined simulation models, optimization algorithms, and existing observations.

Transfer of the scientific knowledge from the observatory for practice, management decisions, and policy development

Sample *science questions* that are of significance to IRB-HO are:

How have resource intensive land use practices, associated with commercial agriculture and urban development, affected the spatial and temporal distribution of water, energy and nutrient cycles in the Illinois River basin? To what extent do such practices exacerbate the hydrologic response to climate variability, change and extreme events?

How does subsurface drainage of fields control solute fluxes and stores, and how do undrained fields compare to drained ones in their water quality impacts? This is understood to some extent in certain local areas, but current understanding must be scaled up through better understanding of how variability in drainage style, soil, topography and geology influence these fluxes.

How do wetlands and hyporheic zones affect nutrient fluxes? How much does chemical action in these zones improve water quality? What potential exists for improving water quality through changes in riparian ecosystems?

What are the relative roles of precipitation (rain and snow) from local to regional scales and in different forms (widespread, storms) in determining the HO watershed hydrologic and water quality variations?

How sensitive are sediment fluxes to hydrologic and land-cover changes associated with agricultural land use and urbanization, and how does this sensitivity vary with the type and intensity of land-use change, with geologic materials, and with watershed topography?

What is the relationship between the carbon and moisture fluxes to different agricultural practices and how does it change in response to extreme events, and climate variability and change?

What variables are important for the prediction of the water cycle for the region, and what is the predictability given the uncertainty and heterogeneity? What is the implication of this predictability, or limitation thereon, for management, legislative, and regulatory decisions?

How do variability and changes in the hydrologic regime of water quality and quantity impact aquatic habitats and ecosystem functions in the region?

For further information on this effort please contact:
Prof. Praveen Kumar, Department of Civil and Environmental Engineering, University of Illinois, 205 North Mathews Avenue, Urbana, Illinois 61801; e-mail: kumar1@uiuc.eduT; Ph# 217-333-4688