



Illinois Environmental Protection Agency

Bureau of Water • 1021 N. Grand Avenue E. • P.O. Box 19276 • Springfield • Illinois • 62794-9276

Division of Water Pollution Control ANNUAL FACILITY INSPECTION REPORT

for NPDES Permit for Storm Water Discharges from Separate Storm Sewer Systems (MS4)

This fillable form may be completed online, a copy saved locally, printed and signed before it is submitted to the Compliance Assurance Section at the above address. Complete each section of this report.

Report Period: From March, 2023 To March, 2024

Permit No. ILR40 0454

MS4 OPERATOR INFORMATION: (As it appears on the current permit)

Name: City of St. Charles Mailing Address 1: 2 E. Main Street

Mailing Address 2: _____ County: Kane

City: St. Charles State: IL Zip: 60174 Telephone: 630-377-4400

Contact Person: Chris Gottlieb Email Address: cgottlieb@stcharlesil.gov
(Person responsible for Annual Report)

Name(s) of governmental entity(ies) in which MS4 is located: (As it appears on the current permit)

Kane County DuPage County

THE FOLLOWING ITEMS MUST BE ADDRESSED.

A. Changes to best management practices (check appropriate BMP change(s) and attach information regarding change(s) to BMP and measurable goals.)

- | | | | |
|--|--------------------------|---|--------------------------|
| 1. Public Education and Outreach | <input type="checkbox"/> | 4. Construction Site Runoff Control | <input type="checkbox"/> |
| 2. Public Participation/Involvement | <input type="checkbox"/> | 5. Post-Construction Runoff Control | <input type="checkbox"/> |
| 3. Illicit Discharge Detection & Elimination | <input type="checkbox"/> | 6. Pollution Prevention/Good Housekeeping | <input type="checkbox"/> |

B. Attach the status of compliance with permit conditions, an assessment of the appropriateness of your identified best management practices and progress towards achieving the statutory goal of reducing the discharge of pollutants to the MEP, and your identified measurable goals for each of the minimum control measures.

C. Attach results of information collected and analyzed, including monitoring data, if any during the reporting period.

D. Attach a summary of the storm water activities you plan to undertake during the next reporting cycle (including an implementation schedule.)

E. Attach notice that you are relying on another government entity to satisfy some of your permit obligations (if applicable).

F. Attach a list of construction projects that your entity has paid for during the reporting period.

Any person who knowingly makes a false, fictitious, or fraudulent material statement, orally or in writing, to the Illinois EPA commits a Class 4 felony. A second or subsequent offense after conviction is a Class 3 felony. (415 ILCS 5/44(h))

Owner Signature:

5/16/24

Date:

Chris Gottlieb, P.E.

Printed Name:

Public Works Manager - Engineering

Title:

EMAIL COMPLETED FORM TO: epa.ms4annualinsp@illinois.gov

or Mail to: ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
WATER POLLUTION CONTROL
COMPLIANCE ASSURANCE SECTION #19
1021 NORTH GRAND AVENUE EAST
POST OFFICE BOX 19276
SPRINGFIELD, ILLINOIS 62794-9276

This Agency is authorized to require this information under Section 4 and Title X of the Environmental Protection Act (415 ILCS 5/4, 5/39). Failure to disclose this information may result in: a civil penalty of not to exceed \$50,000 for the violation and an additional civil penalty of not to exceed \$10,000 for each day during which the violation continues (415 ILCS 5/42) and may also prevent this form from being processed and could result in your application being denied. This form has been approved by the Forms Management Center.

Illinois Environmental Protection Agency
2024 Annual Facility Inspection Report
for NPDES Permit for Stormwater Discharges from
Municipal Separate Storm Sewer Systems (MS4)

City of Saint Charles, IL

MS4 Permit No. ILR400454
Reporting Period March 1, 2023 to February 29, 2024

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Attachment A. Kane County MS4 Annual Facility Inspection Report

Attachment B. Illinois State Water Survey Water Quality Trend Analysis for the Fox River Watershed

Part A. Changes to Best Management Practices

Information regarding the status of BMPs and measurable goals is provided in the following table.

Note: “X” indicates BMPs that were implemented in accordance with the MS4’s SMPP
✓ indicates BMPs that were changed during the reporting year

A. Public Education and Outreach	
X	A.1 Distributed Paper Material
X	A.2 Speaking Engagement
X	A.3 Public Service Announcement
X	A.4 Community Event
X	A.5 Classroom Education Material
X	A.6 Other Public Education
B. Public Participation/Involvement	
X	B.1 Public Panel
	B.2 Educational Volunteer
X	B.3 Stakeholder Meeting
	B.4 Public Hearing
X	B.5 Volunteer Monitoring
	B.6 Program Coordination
X	B.7 Other Public Involvement
C. Illicit Discharge Detection and Elimination	
X	C.1 Storm Sewer Map Preparation
X	C.2 Regulatory Control Program
	C.3 Detection/Elimination Prioritization Plan
X	C.4 Illicit Discharge Tracing Procedures
X	C.5 Illicit Source Removal Procedures
X	C.6 Program Evaluation and Assessment
X	C.7 Visual Dry Weather Screening
X	C.8 Pollutant Field Testing
	C.9 Public Notification
	C.10 Other Illicit Discharge Controls

D. Construction Site Runoff Control	
X	D.1 Regulatory Control Program
X	D.2 Erosion and Sediment Control BMPs
X	D.3 Other Waste Control Program
X	D.4 Site Plan Review Procedures
	D.5 Public Information Handling Procedures
X	D.6 Site Inspection/Enforcement Procedures
X	D.7 Other Construction Site Runoff Controls
E. Post-Construction Runoff Control	
X	E.1 Community Control Strategy
X	E.2 Regulatory Control Program
	E.3 Long Term O&M Procedures
	E.4 Pre-Const Review of BMP Designs
X	E.5 Site Inspections During Construction
X	E.6 Post-Construction Inspections
	E.7 Other Post-Const Runoff Controls
F. Pollution Prevention/Good Housekeeping	
X	F.1 Employee Training Program
X	F.2 Inspection and Maintenance Program
	F.3 Municipal Operations Storm Water Control
X	F.4 Municipal Operations Waste Disposal
X	F.5 Flood Management/Assess Guidelines
X	F.6 Other Municipal Operations Controls

Part B. Status of Compliance with Permit Conditions

The City implements several stormwater Best Management Practices (BMP) to comply with the conditions of the MS4 Permit. In addition, Kane County implements stormwater BMPs and provides MS4 services for all residents of the County, including within St. Charles. This section summarizes the BMPs and MS4 related activities implemented by the City during the reporting year. The BMPs and services provided by the County are summarized in Part E.

BMPs were implemented within the six MS4 Permit program areas:

- A. Public Education and Outreach
- B. Public Participation/Involvement
- C. Construction Site Runoff Control
- D. Post-Construction Runoff Control
- E. Illicit Discharge Detection and Elimination
- F. Pollution Prevention/Good Housekeeping.

A. Public Education and Outreach

BMP No. A1 Distributed Paper Material

Measurable Goal(s):

- Distribute information sheets regarding stormwater BMPs, water quality BMPs, and proper hazardous waste use and disposal.
- Maintain a water quality/stormwater section on the City website.
- Maintain the City website, which offers links to additional educational information, and ways to contact City of St. Charles personnel.

Milestone:

- Continue performing the above-mentioned activities as they pertain to Public Education and Outreach.

BMP Status:

- MS4 informational materials are available from the City and are posted to the City's website
- The City actively pursues educational sheets prepared by the County, IEPA, USEPA, Center for Watershed Protection, Chicago Metropolitan Agency for Planning "CMAP" (previously Northeastern Illinois Planning Commission "NIPC"), University of Wisconsin Extension, Solid Waste of Kane County (Kane County Environmental Management) and other agencies and organizations.
- The City lists the Public Works Engineering Division phone number on all City outreach publications (print and web) to encourage residences to contact the City with environmental concerns.

BMP No. A2 Speaking Engagement

Measurable Goal(s):

- The County provides educational presentations related to stormwater management on a regular basis through involvement in local watershed groups and other environmental committees, ensuring that a minimum of one public presentation is given per year.
- The County tracks the number of speaking engagements, locations, and topics presented.

BMP Status:

- See Part E.

BMP No. A3 Public Service Announcement

Measurable Goal(s):

- A public service announcement for the “Clean Water for Kane” campaign was developed in 2014, and continues to be made available to the community through the County website, special showings, and other digital media outlets.

BMP Status:

- See Part E.

BMP No. A4 Community Event

Measurable Goal(s):

- The City attends and/or sponsors outreach events and scheduled meetings with the general public.
- Events are held on an as-needed or as-requested basis.
- Audiences may include homeowners associations, lake associations, businesses, and neighborhood groups.
- The County educates residents and other stakeholder groups on stormwater Best Management Practices through participation in environmental and watershed special events in the community, and regular community education/training events including the annual well and septic seminar hosted by the County Health Department.
- The County coordinates a minimum of one public educational workshop per year and participates in other community events.
- The County tracks the number of events, locations, and information distributed.

Milestone:

- Both the City and County to make available to the community the above-mentioned community events.

BMP Status:

- The City participated in annual Fox River Cleanup on 9/16/2023
- The City hosted a presentation on 7th Ave. Creek water quality improvements for the Fox River Ecosystem Partnership
- See Part E.

BMP No. A5 Classroom Education Material

Measurable Goal(s):

- The City participates in classroom education at local schools with the County. The County prepares presentation materials with the support of the City.
- The County updates the classroom educational material database on an annual basis.

BMP Status:

- See Part E.

BMP No. A6 Other Public Education

Measurable Goal(s):

- The City maintains a web site that includes stormwater quality specific elements such as water quality, solid waste and hazardous material, stormwater, and general environmental health.
- The City updates the website and tracks the number of visitors to the website.
- The City provides a significant amount of information through links to other educational and informational sites.
- Install signage or stamped covers on storm water inlets.

Milestone:

- Provide the above-mentioned public education material.

BMP Status:

- The City has continued providing the public education material via the City website.
- All new inlets contain stamps stating that they drain to waterway

B. Public Participation/Involvement

BMP No. B.1 Public Panel

Measurable Goal(s):

- The City accepts comments on the Stormwater Management Program Plan (SMPP) through the City website, phone calls, or other media.
- The City evaluates comments and incorporates them, as appropriate, into the next revision of the SMPP.

Milestone:

- The City to accept comments on the SMPP and evaluate them for inclusion, as appropriate, in the next revision of the SMPP.

BMP Status:

- The City has continued accepting comments on the SMPP and evaluates comments for inclusion and incorporates comments into the next revision of the SMPP, as appropriate.

BMP No. B.3 Stakeholder Meeting

Measurable Goal(s):

- The City participates, and encourages the participation of local stakeholders, in Kane County stormwater program meetings or other sponsored watershed planning events.
- The City will adopt Watershed Plans per the direction and in coordination with Kane County.

Milestone:

- The City to be involved in watershed planning and management efforts with input from watershed stakeholders.

BMP Status:

- The City has continued to be involved in watershed planning and management efforts with input from watershed stakeholders.

BMP No. B.5 Volunteer Monitoring

Measurable Goal(s):

- Participate within the Fox River Watershed Monitoring Network, and the Fox River Study Group (FRSG) stream monitoring program.
- The County continues to take a multi-level approach to supporting stream monitoring efforts by holding a leadership role in watershed groups carrying out monitoring work, as well as by providing financial support for local volunteer monitoring programs and river monitoring via USGS stream gauges.
- The City supports the activities of the FRSG

Milestone:

- Continue to participate within the Fox River Watershed Monitoring Network, and the FRSG stream monitoring program.

BMP Status:

- Participated within the Fox River Watershed Monitoring Network, and the FRSG stream monitoring program.
- The City continues to support the FRSG
- See Part E for County activities.

BMP No. B.7 Other Public Involvement

Measurable Goal(s):

- Review potential environmental justice areas within the City and involve the public as warranted.

Milestone:

- Perform review of environmental justice areas once per permit period and involve the public as warranted.

BMP Status:

- The City utilized the IEPA and USEPA environmental screening tools and determined that no action was required at this time.
- The City will re-review during the next permit period.

C. Illicit Discharge Detection and Elimination

BMP No. C.1 Storm Sewer Map Preparation

Measurable Goal(s):

- Maintain and update the Outfall Inventory Map on an annual basis to incorporate permitted outfalls associated with new developments.
- The City performs an outfall inventory in an effort to search for new outfalls.

Milestone:

- The City to maintain and update its Outfall Inventory Map on an annual basis.

- The City to perform an outfall inventory on an annual basis.

BMP Status:

- The City continued to maintain and update its Outfall Inventory Map.
- The City continued to perform an outfall inventory on an annual basis.

BMP No. C.2 Regulatory Control Program

Measurable Goal(s):

- The County Watershed Development Ordinance allows the City to require inspection deposits, performance bonds, and to adopt/enforce violation procedures, which assist in achieving compliant construction sites.

Milestone:

- Enforce the Watershed Development Ordinance

BMP Status:

- The City continues to enforce the Watershed Development Ordinance

BMP No. C.4 Illicit Discharge Tracing Procedures

Measurable Goal(s):

- The City utilizes procedures to trace detected illicit discharges, which includes visual examination as well as methods of testing such as dye testing, smoke testing, and/or remote video inspections.

Milestone:

- The City to utilize procedures to trace detected illicit discharges.

BMP Status:

- The City continues to trace detected illicit discharges as detected.

BMP No. C.5 Illicit Source Removal Procedures

Measurable Goal(s):

- The City utilizes an eight step procedure to identify and remove an illicit discharge to the storm sewer system.

Milestone:

- The City to utilize procedures to remove illicit discharges to the storm sewer system.

BMP Status:

- The City continues to remove illicit discharges to the storm sewer system as detected.

BMP No. C.6 Program Evaluation and Assessment

Measurable Goal(s):

- The City evaluates the effectiveness of the illicit discharge detection and elimination program in an effort to determine the effectiveness of the program on a long-term basis and show ongoing improvement through a reduced number of outfalls having positive indicators of

potential pollutants. The City intends to have the majority of dry-weather pollution sources eliminated after several years of annual screening.

Milestone:

- The City to evaluate the effectiveness of the illicit discharge detection and elimination program annually.

BMP Status:

- The City evaluated the effectiveness of the illicit discharge detection and elimination program in an effort to determine the effectiveness of the program on a long-term basis and show ongoing improvement through a reduced number of outfalls having positive indicators of potential pollutants.

BMP No. C.7 Visual Dry Weather Screening

Measurable Goal(s):

- The City implements a Direct Connection Illicit Discharge Program consisting of three principal components: program planning, outfall screening, and follow-up investigation and program evaluation.
- The City determines if there are outfalls that require a follow up investigation, target sewer system areas for detailed investigation and then conducts field investigations to identify potential sources.

Milestone:

- The City to implement a Direct Connection Illicit Discharge Program
- The City to conduct dry weather screening.

BMP Status:

- The City continues to implement a Direct Connection Illicit Discharge program.
- The City continues to perform dry weather screening every year on priority outfalls and once every five years for all others. Inspections are managed and tracked through the City's GIS system.

BMP No. C.8 Pollutant Field Testing

Measurable Goal(s):

- Perform pollutant field testing to identify the nature of pollution and identify potential sources.

Milestone:

- Perform pollutant field testing as needed

BMP Status:

- The City continues to perform pollutant field testing as needed

D. Construction Site Runoff Control

BMP's No. D.1/D.2/D.3/D.4/D.6/D.7

Measurable Goal(s):

- The City enforces the Kane County Stormwater Ordinance and Technical Manual, which addresses requirements of the Construction Site Runoff Control Measures.

Milestone:

- The City to enforce the Kane County Stormwater Ordinance and Technical Manual.

BMP Status:

- The City is a Certified Community for the review, permitting, inspection and enforcement of the provisions of the Technical Manual. The City has adopted and enforces the Kane County Stormwater Ordinance and Technical Manual. The County Technical Manual addresses requirements of the Construction Site Runoff Control Measures.

E. Post-Construction Runoff Control

BMP's No. E.1/E.2/E.5/E.6

Measurable Goal(s):

- The City enforces the Kane County Stormwater Ordinance and Technical Manual, which addresses requirements of the Post-Construction Runoff Control Measures.

Milestone:

- The City to enforce the Kane County Stormwater Technical Manual.

BMP Status:

- The City, which is a Certified Community for the review, permitting, inspection and enforcement of the provisions of the Technical Manual, has adopted and enforces the Kane County Stormwater Ordinance and Technical Manual. The County Technical Manual addresses requirements of the Construction Site Runoff Control Measures.

F. Pollution Prevention/Good Housekeeping

BMP No. F.1 Employee Training Program

Measurable Goal(s):

- The City provides on-going education and training to staff to ensure that all of its employees have the knowledge and skills necessary to perform their functions effectively and efficiently.

Milestone:

- The City to provide on-going education and training to City staff. This can be achieved through webinars, training conferences, or in house training sessions.

BMP Status:

- Training was provided to City staff through County events, professional conferences, webinars, and in-house training sessions.

BMP No. F.2 Inspection and Maintenance Program

Measurable Goal(s):

- The City performs the following activities as part of its Inspection and Maintenance Program:
 - Street sweeping operations approximately 10 to 15 times per year, to reduce potential illicit discharges and to provide a clean environment,
 - The City's Detention/Retention Pond Checklist is used to determine inspection locations before and during a forecasted storm event. Observed obstructions are cleared and debris is hauled to the spoil waste area.
 - The City adheres to the Roadway Culvert/Bridge Checklist for inspection and maintenance of culverts and bridges.
 - The City maintains a Storm Sewer Atlas, which is used to track the inspection and cleaning of catch basins.
 - The City documents observed or reported erosion or sediment accumulation within swales and overland flow paths and performs remediation or initiates remediation through coordination with property owners, as necessary.

Milestone:

- The City to continue conducting inspections and performing its maintenance programs.

BMP Status:

- The City has continued providing inspection and maintenance.

BMP No. F.4 Municipal Operations Waste Disposal

Measurable Goal(s):

- The City performs the following activities as part of its Municipal Operations Waste Disposal:
 - Maintains its general facilities, municipal roads, associated maintenance yards, and other public areas.
 - Ensures that landscape contractors are provided with training and/or other information to ensure that they adhere to the City's SMPP.
 - Adheres to snow removal and ice control procedures that aim to use the minimal amount of salt and de-icing chemicals necessary for effective control,
 - Adheres to vehicle and equipment fueling procedures and practices designed to minimize or eliminate the discharge of pollutants to the stormwater management system,
 - Adheres to vehicle maintenance procedures and practices designed to minimize or eliminate the discharge of petroleum-based pollutants to the storm water management system,
 - The City's Waste Management program helps prevent the release of waste materials into the stormwater management system including receiving waters, and
 - The City's Water Conservation practices minimize water use and help to avoid erosion and/or the transport of pollutants into the stormwater management system.

Milestone:

- The City to continue following its procedures for Municipal Operations Waste Disposal.

BMP Status:

- The City has continued following its procedures for Municipal Operations Waste Disposal.

BMP No. F.5 Flood Management/Assessment Guidelines

Measurable Goal(s):

- The County implements the Kane County Hazard Mitigation Program.

BMP Status:

- See Part E

BMP No. F.6 Other Municipal Operations Controls

Measurable Goal(s):

- The City will implement road salt application and storage BMPs to minimize salt runoff into waterways, train staff on deicing and salt management procedures on an annual basis, and track the number of training events and participants each year.

Milestone:

- Implement road salt application and storage BMP procedures.

BMP Status:

- The City performed:
 - Ongoing training on salt application and storage procedures.
 - Salt storage under cover to minimize concentrated salt runoff into waterways.

Part C. Information and Data Collection Results

The City collects water quality samples annually and supplies the analysis results to the Fox River Study Group (FRSG). FRSG implements a regional water quality monitoring program and the City, as a member, has access to all of FRSG watershed scale monitoring information. The monitoring results inform both local MS4 program implementation and support regional water quality planning. Results are available from the FRSG website. <https://www.foxriverstudygroup.org/resources> In 2019 the Illinois State Water Survey Prairie Research Institute submitted a report on water quality trends in the Fox River that was commissioned by the FRSG. This report is attached.

Part D. Summary of Future Stormwater Activities

The City intends to implement the BMPs described in Part B of this report during the next implementation and reporting year. Any changes to the BMPs determined necessary or beneficial to the City program will be noted within the next annual report.

Part E. Notice of Relying on another Government Entity

Kane County implements stormwater BMPs throughout the County, and provides MS4 services for all residents of the County, including within St. Charles. Attachment A summarizes the BMPs and MS4 related services implemented by the County that supplement the City's program.

Part F. Construction Projects Conducted During the Reporting Year

Project Name	Project Size (acres)	Construction Start Date	Construction End Date
St. Charles Riverside Lift Station Replacement – ILR10ZB49, ILR10ZC2J	2.13	7/1/22	Ongoing
Thorntons St. Charles – ILR10ZB54	1.52	6/9/2023	Ongoing
Springs at St. Charles – ILR10ZBUU	27.5	9/30/22	Ongoing
GW St. Charles LLC – ILR10ZBW9	2.35	7/22/2022	Completed (12/31/2023)

Illinois Environmental Protection Agency
ANNUAL FACILITY INSPECTION REPORT
 for NPDES Permit for Storm Water Discharges
 from Municipal Separate Storm Sewer Systems (MS4)

Kane County, Illinois (NPDES Permit No. ILR400259)

March 1, 2023 - February 29, 2024

I. CHANGES TO BEST MANAGEMENT PRACTICES

There are no changes to the Best Management Practices for the six minimum control measures as described in the Notice of Intent for Kane County submitted on May 28, 2021.

II. STATUS OF COMPLIANCE WITH PERMIT CONDITIONS

Kane County submitted a Notice of Intent on May 28, 2021, which initiated a new 5-year permit cycle. The BMPs listed in the 2016 Notice of Intent were selected to meet NPDES Phase II program requirements and minimize nonpoint source pollution in Kane County, Illinois.

The implementation progress for each of these BMPs is summarized below in sections A—F. All BMPs described in Kane County’s 2021 Notice of Intent have been implemented on or ahead of schedule, with the exception of select items noted in their descriptions below.

A. PUBLIC EDUCATION AND OUTREACH

1. BMP A.1—Distributed Paper Material

MEASURABLE GOALS	Include “Water Wise Corner” in the <i>Kane County Recycles Green Guide</i> , which is developed and distributed throughout Kane County on an annual basis. Revise “Water Wise Corner” every spring. Track the total number of recipients each year.
RESULTS	A Recycling Program postcard with a QR code directing to the County Environmental and Water Resources website was printed and distributed in the spring of 2023. 20,000 postcards were sent out and distributed at community events (see A.4 Community Events). Additionally, the “Clean Water for Kane” section was included in the <i>Kane County Recycles Green Guide</i> for 2024. During this reporting year, 1,800 print copies were mailed to residents in Feb 2024 and 987 residents downloaded the pdf version of the guide. The bulk of distribution (16,000 additional print copies and further downloads) will occur during the upcoming reporting year (March 2024 - Feb 2025).

USE LESS, USE WISELY

REDUCING CARBON FOOTPRINT



A personal or household carbon footprint is an index value that indicates how much greenhouse gas (typically, carbon dioxide and methane) a person or family generates through everyday activities. The average carbon footprint in the United States is three-to-four times higher than the global average. Here are some tips that residents can follow to tread more lightly on the Earth and save some money on energy costs too!

- Calculate your household footprint at www3.epa.gov/carbon-footprint-calculator/
- Turn off lights & appliances when not in use
- Switch lightbulbs to LEDs
- Install a smart thermostat at home
- Wash your clothes in cold water
- Upgrade to insulating curtains to keep the heat in
- Consider installing solar panels at home - more info: www.countyofkane.org/sustainability/pages/solar.aspx
- Choose reusable items like shopping bags, water bottles, coffee mugs, utensils and drinking straws
- Upgrade to high-efficiency/Energy Star appliances



CONSERVING & PROTECTING WATER



Stormwater runoff generated from rainwater and snowmelt can significantly contribute to water pollution. As water passes over impermeable surfaces, pollutants such as chemicals from vehicles, fertilizers, pesticides, sediment, and debris accumulate. These pollutants end up in streams, lakes, and other water bodies, contributing to poor water quality and posing potential risks to aquatic species. Here are some tips that residents can use to conserve water and reduce pollution:

- Install rain barrels to collect water from gutters; use collected rain to water the lawn and garden
- Upgrade to WaterSense fixtures (ComEd sells low-flow showerheads for as little as \$1 after rebates)
- Never dispose of medication, pesticides, or any other household chemicals down the drain (see pages 4&5)
- Plant drought-resistant native species
- Don't overwater - established landscaping only needs 1" per week to stay green in summer
- Always pick up after your pets
- Plant drought-resistant native plants and/or install a rain garden; lots of great info at theconservationfoundation.org
- Use salt and deicing products sparingly and always sweep up any spills; 1 cup is enough for most driveways!

RAIN BARRELS & COMPOST BINS

Available through Kane County's Spring Sale! More details on the Recycling website (see cover) in the spring. Or, call 630-208-8665 with questions!



For more information on energy & water conservation or County sustainability initiatives, please contact: Sarra Hinshaw, Sustainability Manager, hinshawsarra@kanecountyil.gov 630-208-8665

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Clean Water for Kane section of the Kane County Recycles Green Guide for 2024

2. BMP A.2—Speaking Engagement

<p>MEASURABLE GOALS</p>	<p>Provide educational presentations related to stormwater management on a regular basis through involvement in local watershed groups and other environmental committees, ensuring that a minimum of one public presentation is given per year. Track the number of speaking engagements, locations, topics presented, and number of attendees at each engagement.</p>
<p>RESULTS</p>	<p>Kane County Government developed a Climate Action Implementation Plan (CAIP) which included goals for stormwater.</p> <p>The presentations listed below were given by Kane County for the CAIP during the permit year of March 1, 2023 — February 29, 2024:</p> <p>The CAIP was presented to the public at the following: Geneva Public Library, February 6th, with around 100 attendees Gail Borden Public Library on February 7th with around 40 attendees Aurora Santoria Public Library on February 16th with around 25 attendees Hawthorne Nature Center on February 24th with around 40 attendees</p> <p>The CAIP was added to the Kane County Website and to date the link has been clicked 4054 times.</p> <p>KCDEWR Staff presented on “Kane County Stormwater Mapping and Tools” via webinar through the Illinois Wild Ones organization on Feb 20, 2024 with 40+ attendees. Video was viewed 117 times. https://www.youtube.com/watch?v=SBlyJSCMPrg</p>

3. BMP A.3—Public Service Announcement

<p>MEASURABLE GOALS</p>	<p>A public service announcement for the “Clean Water for Kane” campaign was developed in 2014, and is made available to the community through the Kane County website, special showings, and other digital media outlets. Track the number of PSA showings, locations, and audience reached each year.</p>
<p>RESULTS</p>	<p>During the permit year, the PSA was posted on the Kane County website at: http://www.countyofkane.org/Pages/commDisp.aspx?focusID=145. The Clean Water for Kane information and flyers were presented at:</p> <ol style="list-style-type: none"> 1. Climate Action Talk with Bill Foster on November 18th, 2023 in McHenry County.

	<div style="border: 1px solid black; padding: 5px;"> <div style="background-color: #003366; color: white; padding: 2px;"> Government A-Z Services Business Communities Calendar Maps Employment County Code Home </div> <div style="display: flex; justify-content: space-between; align-items: center; padding: 5px;"> <div style="text-align: center;"> <p>Kane County, Illinois</p> <p>719 Batavia Avenue, Geneva, Illinois 60134 / Phone: 630-232-3400</p> <p>www.countyofkane.org</p> </div> <div style="text-align: right;"> <input type="text" value="Google Custom Search"/> Select Language Font Size: A A A </div> </div> </div> <div style="display: flex; margin-top: 10px;"> <div style="width: 30%; background-color: #003366; color: white; padding: 5px;"> <p>Kane County News</p> <p>Meeting Agenda & Minutes</p> <p>Press Releases</p> <p>Article Archive</p> <p>Newsletter Sign-up</p> </div> <div style="width: 70%; padding: 5px;"> <div style="display: flex; align-items: center;"> <div style="margin-left: 10px;"> <p>Clean Water for Kane Video</p> <p>Check out Kane County's new PSA on how to conserve water!</p> </div> </div> <div style="margin-top: 10px;"> </div> </div> </div> <p style="text-align: center; margin-top: 10px;">PSA on Kane County website</p>
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4. BMP A.4—Community Event

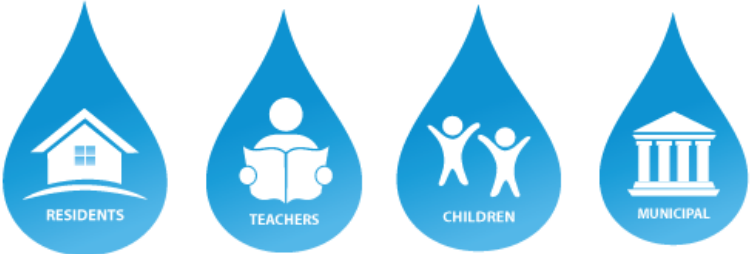
MEASURABLE GOALS	<p>Educate residents and other stakeholder groups on stormwater Best Management Practices through participation in environmental and watershed special events in the community, and regular community education/training events including the annual well and septic seminar hosted by the Kane County Health Department. Coordinate a minimum of one public educational workshop per year and participate in other community outreach events. Track the number of events, locations, information distributed, and number of participants for each event.</p>
RESULTS	<p>Kane County staff participated in the community events listed below during the permit year of March 1, 2023- February 29, 2024. Stormwater educational handouts—including <i>Green Guides</i> (see A.1 Distributed Paper Material), homeowner resource cards, and natural landscaping brochures—were distributed at these community events.</p> <p>Kane County staff participated in the community events listed below during the permit year of March 1, 2023 – February 29, 2024. Some community events were shifted online to “virtual events”. Stormwater educational handouts – including the Green Guides (see A.1 Distributed Paper Material) were distributed at the community events held in person, virtual links to the <i>Clean Water for Kane</i> website - which hosts all Kane County stormwater educational materials for the public (see A.6 Other Public Education) - were made available for virtual events.</p> <ul style="list-style-type: none"> • One Earth Film Festival [3/09/23, + 408 virtual and 37 in person registrants]

	<ul style="list-style-type: none"> • Kane County Rain Barrel Sale Webinar [4/25/2023, 12 attendees] • Elgin (60) and Geneva Earth Day events (75) [4/22/23, 135 attendees combined] <p>The Kane County Health Department hosted its annual Well & Septic educational event on April 27th. 8 county residents attended the event.</p>
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5. BMP A.5—Classroom Education Material

MEASURABLE GOALS	<p>Maintain a collection of stormwater-related educational materials for use in the classroom, and also reach students in the community through educational displays at libraries and other community venues. Update the classroom educational material database on an annual basis. Track the number of educational displays, locations, materials distributed, and number of students reached throughout the year.</p>
RESULTS	<p>During the permit year, the Kane County Department of Environmental & Water Resources updated the youth educational resource list available on the County website at: www.countyofkane.org/FDER/Pages/EnvironmentalResources/stormwaterEducation/children.aspx.</p> <p>Additionally, the Department provided educational materials—including water conservation coloring books and stickers, <i>Clean Water for Kane</i> rain gages, toilet leak detection tabs, pet waste tip cards, and outdoor water use brochures—to partner organizations, particularly the Forest Preserve District of Kane County and Friends of the Fox River for the Schweitzer Environmental Center.</p> <p>During the permit year, the Kane County Department of Environmental and Water Resources updated the youth educational resource list available on the county website: https://www.countyofkane.org/FDER/Pages/environmentalResources/waterResources/children.aspx as well as the teacher educational resource list available on the county website: https://www.countyofkane.org/FDER/Pages/environmentalResources/waterResources/teachers.aspx</p> <p>Additionally, Kane County Department of Environmental and Water Resources allocated \$500 of FY23 funding to Friends of the Fox River (FOFR) for their Classroom Educational Programming and pledges funding for FY24.</p> <p>For all of Kane County, Friends of the Fox River organized student education through 35 field trips, 28 campus lessons, virtual programs and public events with different schools and student groups having an overall reach during the reporting year as well as 10 adult audience water quality community programs.</p>

6. BMP A.6 – Other Public Education

<p>MEASURABLE GOALS</p>	<p>The Kane County Department of Environmental & Water Resources maintains a “Clean Water for Kane” website, and also develops seasonal stormwater-related informational articles that are distributed through the Kane County Connects e-newsletter, website, and social media pages. Update the “Clean Water for Kane” web pages on an annual basis. Track the number of stormwater-related articles in Kane County Connects, topics covered, and audience reach each year</p>
<p>RESULTS</p>	<p>During the permit year, the Kane County Department of Environmental & Water Resources updated the “Stormwater Education” pages on the County website.</p> <p style="text-align: center;">Stormwater Education</p> <hr style="width: 50%; margin: auto;"/> <div style="text-align: center;">  </div> <p style="text-align: center;"><i>Stormwater Education page of the Kane County website:</i> www.countyofkane.org/FDER/Pages/EnvironmentalResources/stormwaterEducation.aspx</p> <p>In addition, six water-related articles were published in <i>Kane County Connects</i>:</p> <ul style="list-style-type: none"> • Mapping the Flow of Stormwater Drainage and Why it Matters[6/12/23] https://www.kanecountyconnects.com/article/KaneCountyGovernment-Stormwater-Map • <i>Illinois EPA Invests Over a Half Billion Dollars in Drinking Water and Wastewater Projects Including Two in Kane County</i> [8/25/23] https://kanecountyconnects.com/article/Batavia-PingreeGrove-IEPA • <i>Illinois and FEMA Floodplain Management Webinars</i> [2/27/24] https://kanecountyconnects.com/article/StormwaterManager-KaneCountyDivisionofEnvironmentalandWaterResources • <i>Well Water Testing Kits Available For Purchase October 17-28</i> [9/27/22] https://kanecountyconnects.com/article/water-well-testing-kits • <i>Smart Salting for a Better Environment</i> [1/31/2024] https://kanecountyconnects.com/article/smartsalting-roadsalt-environment-deicing-ecosystem-waterquality

	<i>Kane County Connects</i> reaches 23,000 newsletter subscribers and over 901 followers on social media.
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7. BMP A.6 – Other Public Education

MEASURABLE GOALS	The Kane County Department of Environmental & Water Resources maintains a supply of “Kane County Streams” signs to be installed at road crossings throughout the County. Kane County will provide the signs to MS4 communities as requested for installation within their own municipal boundaries, and will maintain a database of signs manufactured and installed throughout the year.
RESULTS	During the permit year, no requests were made for additional stream signage and therefore no new signs were installed.

B. PUBLIC PARTICIPATION/INVOLVEMENT

1. BMP B.3—Stakeholder Meeting

MEASURABLE GOALS	Kane County is involved in watershed planning and management efforts that seek input from a variety of watershed stakeholders. Provide notice of stakeholder meetings on the Kane County website and distribute meeting information to stakeholder email lists. Track the number of watershed meetings hosted or co-hosted by the County, meeting locations, topics discussed, and participation numbers.
RESULTS	<p>During the permit year, the following stakeholder meetings were held/attended by Kane County:</p> <ul style="list-style-type: none"> • Tyler Creek Watershed Coalition meetings – [4/20/22 via Zoom; 5/17/23 via Zoom; 6/21/23 via Zoom; 7/19/23 via Zoom; 8/16/23 via Zoom; 9/20/23 via Zoom, 11/15/23 via Zoom;; 01/17/23 via Zoom; 2/21/23 via Zoom]

2. BMP B.5—Volunteer Monitoring

<p>MEASURABLE GOALS</p>	<p>Kane County continues to take a multi-level approach to supporting stream monitoring efforts by holding a leadership role in watershed groups carrying out monitoring work, as well as by providing financial support for local volunteer monitoring programs and river monitoring via USGS stream gages. Maintain Joint Funding Agreement with USGS and allocate funding for stream gages. Support local volunteer monitoring program. Track the number of leadership meetings attended and the funding provided on an annual basis.</p>
<p>RESULTS</p>	<p>Kane County staff served on the Board of Directors of the Fox River Study Group and as an advisor to the Fox River Ecosystem Partnership, attending the following meetings during the permit year:</p> <ul style="list-style-type: none"> • Fox River Study Group meetings held via Zoom [3/23/23, 4/27/23; 5/25/23, 6/22/23, 7/27/23, 8/24/23, 8/31/23, 9/28/23, 10/19/23, 11/09/23 (Annual Meeting), 11/16/23, 12/21/23, 1/18/24, 2/22/24] • Fox River Ecosystem Partnership meetings [3/16/23(Fox R. Summit), 4/12/23, 5/10/23, 9/13/23, 10/11/23, 11/8/23, 1/10/24, 2/14/24] <p>In addition, the Kane County Department of Environmental & Water Resources provided financial support of \$500 to the Friends of the Fox River for their volunteer monitoring program in November 2023. Friends of the Fox River organized monthly creek sampling at Tyler, Otter and Ferson Creeks.</p> <p>A Joint Funding Agreement between Kane County and the U.S. Geological Survey was signed on 12/20/2023 and passed by Kane County Board on 11/14/2023 to cover the time period October 1, 2023, through September 30, 2024. Kane County has committed \$69,290 of FY24 funding to support five stream gages and four precipitation gages.</p>

3. BMP B.7—Other Public Involvement

MEASURABLE GOALS	Kane County will provide technical and financial support to the Friends of the Fox River and other local watershed groups to ensure that opportunities exist for public involvement in stream cleanup efforts. Allocate funding to support stream cleanups on an annual basis. Track the number of planning meetings or cleanup events attended by Kane County staff each year.
RESULTS	The Kane County Department of Environmental & Water Resources provided \$500 in January 2024 to the Friends of the Fox River to support stream cleanups throughout the county. Friends of the Fox River organized 52 Watershed weekly publications, 365 Facebook posts with 4900 follower and averages 4300 hits per month hits on their home website. In addition FOFR had 6 river cleanups in Kane County, with a total of 360 reported volunteers. In September 2023 FOFR coordinated their 5 th annual “It’s our Fox River Day” and reported over 37 separate events covering 200 miles of the Fox River. Nearly 2000+ participants volunteered for the cleanup event and over forty organizations and municipalities partnered with FOFR for the event. 37 cleanups produced mounds of trash from in and around the Fox River and its streams. Ecological restoration events included oak tree planting, shoreline planting of native species, and creekside clearing of invasive species. In

C. ILLICIT DISCHARGE DETECTION AND ELIMINATION

1. BMP C.1—Storm Sewer Map Preparation

<p>MEASURABLE GOALS</p>	<p>Kane County will update its storm sewer mapping in GIS to include the location and size of all County-owned stormwater outfalls to receiving streams in the urbanized area, and will distribute up-to-date mapping and information across County departments including the Facilities, Transportation, and Emergency Management departments. Update the stormwater system map layer on an annual basis to incorporate new stormwater outfalls identified.</p>
<p>RESULTS</p>	<p>During the permit year, the KCDEWR has made substantial improvements to the County’s stormwater mapping resources. The County’s stormwater mapping resources are now countywide (unincorporated and municipalities) and include all known storm sewers, culverts, drain tiles, and detention basins. Storm sewer mapping has expanded from 2617 miles in the last reporting period to more than 3125 miles in this reporting period. Mapped storm sewer, culvert & tile segments increased from 100,000 segments in 2023 to more than 140,000 in 2024. Additionally, storm structures such as catch basins, inlets, manholes, and flared end sections have been added to the mapping dataset and 125,000 structures have been included up through the 2023 reporting period. During the reporting period, mapped stormwater detention basins increased from 3,272 to 3,337.</p> <p>In February 2024, Kane County made public a stand-alone, on-line Stormwater Viewer, which is an interactive map of all stormwater infrastructure and related water resources data for the entire county (floodplains, wetlands, hydric soils, etc.). The viewer can be found at the link below:</p> <p>https://experience.arcgis.com/experience/094fedf250d34bf19cb22881ddb2d66d/</p> <p>The Stormwater Viewer also contains a high-resolution stormwater flow tracing tool that allows a user to accurately trace stormwater downstream to the major rivers (Fox River on the east; out to Kishwaukee River to the west). In 2024, the watershed delineation tool was also added which allows users to accurately map the upstream tributary area from any point in the county. These tools have a number of uses, but are particularly useful to persons conducting IDDE investigations and accidental spill mitigation.</p> <p>A Users Guide for how to access the stormwater map layers and use the tools is accessible on the Stormwater Viewer’s start-up disclaimer page.</p>

2. BMP C.2—Regulatory Control Program

<p>MEASURABLE GOALS</p>	<p>Kane County will utilize regulatory authority to prohibit, inspect, and follow-up with enforcement for illegal discharges into the County's MS4 by following established procedures at the Kane County Health Department. Track the number of illicit discharges identified on an annual basis and document the actions taken to eliminate the discharges.</p>																			
<p>RESULTS</p>	<p>The Kane County Health Department has continued to enforce its regulatory authority to prohibit, inspect, and follow-up with enforcement for illegal discharges into the County's MS4. The Health Department investigated 27 septic system complaints.</p> <p>KC Environmental & Water Resources Dept investigated 6 potential illicit discharges during the reporting period.</p> <p style="text-align: center;">KANE COUNTY ILLICIT DISCHARGE INCIDENT TRACKING Period: March 2023 - February 20243</p> <table border="1" data-bbox="451 886 1495 1812"> <thead> <tr> <th data-bbox="451 886 591 932">Date</th> <th data-bbox="591 886 820 932">Location</th> <th data-bbox="820 886 1049 932">Issue</th> <th data-bbox="1049 886 1495 932">Outcome</th> </tr> </thead> <tbody> <tr> <td data-bbox="451 932 591 1218">4/16/23</td> <td data-bbox="591 932 820 1218">45W254 Dietrich Rd, Hampshire Township</td> <td data-bbox="820 932 1049 1218">Landowner reported suspected illicit discharge emanating from farm field tile outfall into agricultural channel</td> <td data-bbox="1049 932 1495 1218">KCDEWR staff investigated on 5/15/23 and confirmed our suspicion that the discharge was ag drainage and "oily" substance was biological and not manmade chemical (sheen broke like glass).</td> </tr> <tr> <td data-bbox="451 1218 591 1503">5/6/23</td> <td data-bbox="591 1218 820 1503">9N189 Muirhead Rd</td> <td data-bbox="820 1218 1049 1503">Adjacent neighbor called about black residue percolating from ground in vicinity of the landowner's septic system and flowing onto his property</td> <td data-bbox="1049 1218 1495 1503">Property was dye tested by KC Health Dept and no connection between the discharge and the septic was found. Black substance appeared to be dark & decaying algae coming from an unmapped drain tile in the rear of the property.</td> </tr> <tr> <td data-bbox="451 1503 591 1812">5/15/23</td> <td data-bbox="591 1503 820 1812">860 N. Lyle Ave, City of Elgin</td> <td data-bbox="820 1503 1049 1812">Residents reported a potential sanitary sewer discharge into Tyler Creek</td> <td data-bbox="1049 1503 1495 1812">Incident was reported to City of Elgin for investigation and correction as this was within municipal boundary.</td> </tr> </tbody> </table>				Date	Location	Issue	Outcome	4/16/23	45W254 Dietrich Rd, Hampshire Township	Landowner reported suspected illicit discharge emanating from farm field tile outfall into agricultural channel	KCDEWR staff investigated on 5/15/23 and confirmed our suspicion that the discharge was ag drainage and "oily" substance was biological and not manmade chemical (sheen broke like glass).	5/6/23	9N189 Muirhead Rd	Adjacent neighbor called about black residue percolating from ground in vicinity of the landowner's septic system and flowing onto his property	Property was dye tested by KC Health Dept and no connection between the discharge and the septic was found. Black substance appeared to be dark & decaying algae coming from an unmapped drain tile in the rear of the property.	5/15/23	860 N. Lyle Ave, City of Elgin	Residents reported a potential sanitary sewer discharge into Tyler Creek	Incident was reported to City of Elgin for investigation and correction as this was within municipal boundary.
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	10/1/23	1797 N LaFox St in Village of South Elgin	Resident reported a suspicious discharge into a channel that flows into the Fox River. Channel received drainage from an adjacent property under development	Believed to be construction site stormwater runoff. Incident was reported to Village of South Elgin Public Works for investigation as this was within their municipal boundary.
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3. BMP C.10—Other Illicit Discharge Controls

MEASURABLE GOALS	Kane County's Environmental Health staff are trained to identify potential illicit discharges to the County's MS4 and to follow the established procedures for eliminating the discharges. Conduct illicit discharge detection training for Environmental Health staff on an annual basis. Track the number of staff trained and total hours of training received.
RESULTS	Kane County Health Department held one well and septic staff training during the reporting period on 1/24/2024. Two staff attended (the only two staff with responsibilities for inspecting septic systems and investigating potential related illicit discharges).

D. CONSTRUCTION SITE RUNOFF CONTROL

1. BMP D.1—Regulatory Control Program

MEASURABLE GOALS	The Kane County Stormwater Management Ordinance addresses all requirements of the Construction Site Runoff Control measures, D.1-D.7. Implement and enforce the Kane County Stormwater Ordinance, maintaining and updating program documentation annually.
RESULTS	During the permit year, 52 Stormwater Permit Applications were submitted to the County. All of these proposed projects were reviewed with consideration of Construction Site Runoff under the requirements of the Kane County Stormwater Management Ordinance. Permits are digitally tracked in the Kane County – CityView system, in addition to a digital copy, the County maintains a complete folder of the permits and plans for Stormwater Permit Applications.

E. POST-CONSTRUCTION RUNOFF CONTROL

1. BMP E.2—Regulatory Control Program

MEASURABLE GOALS	The Kane County Stormwater Management Ordinance addresses all requirements of the Post-Construction Runoff Control measures, E.1-E.7. Implement and enforce the Kane County Stormwater Ordinance, maintaining and updating program documentation annually.
RESULTS	During the reporting period, 34 Stormwater Permits were issued. Post-Construction Runoff Control measures were implemented on these projects under the requirements of the Kane County Stormwater Management Ordinance. Permits are digitally tracked in the Kane County – CityView, in addition to a digital copy the County maintains a complete set of the permits and plans for Stormwater Permit Applications.

F. POLLUTION PREVENTION/GOOD HOUSEKEEPING

1. BMP F.1—Employee Training Program

MEASURABLE GOALS	Kane County will provide stormwater management training opportunities to County staff as well as other MS4 communities by coordinating a regular “MS4 Corner” e-newsletter, as well as by hosting webcasts. Maintain an email contact list for MS4 community representatives, and distribute the e-newsletter on a minimum of a quarterly basis. Host stormwater informational webcasts as relevant, tracking the number of trainings provided and the number of attendees.
RESULTS	During the permit year, the Kane County Department of Environmental & Water Resources regularly updated the MS4 contact list. Five issues of the “MS4 Corner” newsletter were created and distributed to the contact list during the reporting period [Distributed on: 5/05/23, 7/07/23 and 9/09/23 with a MS4 News alert on 9/16/23].



September 2023 Edition

Hazard Mitigation in Kane County

Are you prepared for the next disaster? Let the County know! Kane County residents and businesses can help the county update its emergency preparedness plans by participating in a voluntary online questionnaire. Feedback from the confidential 10-minute survey will enable the Kane County Office of Emergency Management to better serve residents and businesses before, during and after an emergency or disaster. Please post this survey on your local website or electronic newsletter.

To fill out the questionnaire, go to:
<http://kane.preparedness.alchemer.com/s3/>

The survey will remain open until September 30, 2023.

Upcoming Illinois Floodplain Management Webinars

Example

issue of MS4 Corner

During the permit year, Kane County hosted the following webcasts from the Center for Watershed Protection virtually:

- *Non Structural BMPs: Addressing Runoff from Residential Areas* [6/21/23;
- *Behavior Change For Stormwater and Wastewater* [7/19/23; 7 attendees, 6 Kane County staff]
- *Methods to Address Pollution Sources from Municipal Practices* [10/25/23; 7 attendees, 6 Kane County staff]

In addition, Kane County Environmental & Water Resources staff participated in the following training opportunities provided by other entities:

- Illinois Association of Floodplain & Stormwater Management Annual Conference in Tinley Park IL [3/14/23-3/15/23; 4 staff attended]

2. BMP F.2—Inspection and Maintenance Program

<p>MEASURABLE GOALS</p>	<p>Kane County will continue its established Operation and Maintenance Program – which includes the Department of Transportation clearing roadside swales once a year, and inspecting and cleaning catch basins and storm inlets quarterly. Kane County will also develop and adhere to an annual inspection and maintenance schedule for BMPs installed on County properties, and will utilize available tools to implement a BMP Inventory & Evaluation Program. Inspect and maintain roadside swales, catch basins and storm inlets, and BMPs on County properties according to schedule, documenting pollutant load reduction on an annual basis.</p>
<p>RESULTS</p>	<p>During 2023, the Kane County Department of Transportation swept approximately 100 miles of curbing and 40 bridge decks. Sweeping was done twice – once in the spring and once in the fall.</p> <p>KDOT cleaned out approximately 400 catch basins on south Randall Rd and Orchard Rd.</p> <p>KCDEWR continues to update its BMP Inventory & Evaluation spreadsheet (see section III) to track data for BMPs installed on Kane County owned properties.</p>

3. BMP F.4—Municipal Operations Waste Disposal

<p>MEASURABLE GOALS</p>	<p>Kane County will follow established procedures to maintain buildings, fleet vehicles, and equipment. Procedures include the proper disposal of wastes from municipal operations, in compliance with all local, State, and Federal regulations. Kane County departments will continue to recycle all types of used oil, antifreeze, oil filters, tires, batteries, scrap metal, and cardboard. Perform fleet inspections and recycle hazardous materials on an ongoing basis, documenting compliance with the procedures annually.</p>
<p>RESULTS</p>	<p>The Kane County Department of Transportation continues to follow established vehicle maintenance and proper waste disposal procedures, maintaining internal records of these activities using CFA (Computerized Fleet Analysis) Software for fleet tracking.</p> <p>KDOT vehicles are inspected according to the following schedule:</p> <ul style="list-style-type: none"> • Heavy trucks (snow plows, etc.)—every 2000 miles or 180 days • Light trucks and cars—every 5000 miles or 90-180 days • Heavy off-road equipment—every 50 hours or 180 days • Light off-road equipment—every 50 hours or 180 days <p>KDOT also took part in a county organized tire recycle program, recycling over 100 tires from either KDOT fleet vehicles or tires found in the county right-of-</p>

	way.
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4. BMP F.5—Flood Management/Assessment Guidelines


MEASURABLE GOALS	Kane County will continue to implement the Kane County Hazard Mitigation Program as outlined in the Plan. Host two Hazard Mitigation Committee meetings per year to coordinate ongoing implementation of the plan.
RESULTS	<p>The Kane County Emergency Management Department and Kane County Department of Environmental & Water Resources continue to coordinate the implementation of the <i>Kane County Natural Hazards Mitigation Plan</i>, which was first adopted in 2003 and updated in 2015. The Natural Hazards Mitigation Planning Committee along with a Consultant, paid for through an HPMG grant fund awarded by FEMA to the County, has updated the 2015 Plan and will adopt the Plan in Spring of 2024. The Plan was approved by FEMA on April 1, 2024.</p> <p>The Committee held webinars for all participating communities and the public in May and June 2023 and in-person workshops in late June of 2023 . 27 Communities participated and 108 Community members attended.</p> <p>In addition, the Kane County Department of Environmental & Water Resources completed 1 cost-share project to reduce flooding on unincorporated residential properties (Boyer Rd Drainage Improvement Project).</p>

5. BMP F.6—Other Municipal Operations Controls

MEASURABLE GOALS	Kane County will implement Road Salt Application and Storage procedures to minimize salt washoff into the County’s MS4. Train staff on deicing and salt management procedures on an annual basis. Track the number of training events and participants each year.
RESULTS	<p>The Kane County Department of Transportation provides continual training on salt application and storage procedures via staff manuals. All KDOT winter truck staff attended the 2023 deicing workshop for sensible salting. Supervisors attended the APWA Winter maintenance supervisor workshop. KDOT calibrates trucks yearly to insure the proper salt dispensing rate, equips each salt truck with a reference table the driver can use to determine the optimal rate of pounds of salt dispensed per lane mile, and stores salt indoors throughout the year to minimize concentrated salt wash off into the MS4. KDOT responded to 28 winter events using 4,500 tons of salt for the season. KDOT supervisors also utilize GPS software to track salt usage to minimize salt over-application.</p> <p>The Kane County Department of Environmental & Water Resources also worked</p>


with The Conservation Foundation to host a virtual winter road maintenance training that was open to all MS4 communities in the region.

- Public Roads Deicing Workshops were held on September 26, October 4, and October 10, 2023. The links were sharable so the webinars could be viewed individually or in groups. A survey was provided at the end of each webinar to those who had signed in asking for the number of attendees from each agency and for an evaluation of the webinar. Thirty four Kane County representatives participated in the three Public Roads webinars, KCDOT staff, supervisors and snow plow operators attended the webinar.
- The Parking Lots and Sidewalks Deicing Workshop webinars were held on October 3 and October 17, 2023 with Fortin Consulting, Inc. presenting. Three Kane County staff viewed the webinars.



VIRTUAL WORKSHOPS

Registration will be available at SaltSmart.org in August








SAVE THE DATE



2023 Virtual Deicing Workshops

Public Roads	Parking Lots & Sidewalks
September 26	October 3
October 4	October 17
October 10	8 am—12pm
8 am—12 pm	

Hosted by:



Outreach Sponsors:



Kane County Parking Lots and Sidewalks Deicing Workshop flyer

III. RESULTS OF INFORMATION COLLECTED AND ANALYZED

No monitoring data was collected and analyzed during the reporting period. Per Attachment B. of the 2016 Notice of Intent, Kane County has elected to implement a BMP Inventory & Evaluation Program in lieu of monitoring (Note: Kane County continues to participate in the Fox River Study Group, Inc., a non-profit organization who is performing on-going watershed-wide water quality monitoring and modeling to address impairments in the Fox River <https://www.foxriverstudygroup.org/>)

During the permit year, the “MS4 Non-Point Source Control Measure Tracking Tool” provided by the Fox River Study Group was used to calculate annual pollutant load reduction for the following BMPs on Kane County government-owned properties. Previously constructed BMPs (wet detention basins) were added into the inventory. Six new structural BMPs were constructed on Kane County government-owned property in Mar 2023 – Feb 2024. These were wetland-style stormwater detention basins – 4 in Big Rock Township built for the Dauberman Road Extension Project and 2 in Blackberry Township for the Bliss Road Roundabout Project (see table below).

MS4 Non-Point Source Control Measure Tracking Tool

Fox River Watershed, Illinois

MS4	Project Name	Project Cost	Project Type	Total Area Captured (acres)	% Urban High Density	% Low-Medium Density	% Urban Open Space	Area-Weighted UAL (lb/acre/yr)	Load (lb)	Removal Efficiency	Total Load Removed (lb/yr)	Cost per Pound P Removed (\$/lb)
Kane county	KC Govt Center PICP Parking Lot	\$250,000	Bioretention	0.99	100%	0%	0%	0.98	1.0	65%	0.6	\$398,408
Kane county	KC Govt Center Rain Garden	\$25,000	Bioretention	0.4	75%		25%	0.79	0.3	65%	0.2	\$121,768
Kane county	KC Circuit Court Clerk Parking Lot Bioretention Basins (2)	\$35,000	Bioretention	1.3	95%		5%	0.94	1.2	65%	0.8	\$44,156
Kane county	KDOT Building Expansion Detention Basin	\$25,000	Dry detention	1.1	75%		25%	0.79	0.9	26%	0.2	\$110,698
Kane county	KDOT Storage Yard Detention Basin	\$15,000	Dry detention	3.25	100%			0.98	3.2	26%	0.8	\$18,204
Kane county	KC Judicial Center Pond	\$250,000	Wet detention	250	20%		80%	0.38	95.4	68%	64.9	\$3,854
Kane county	KDOT Detention at Big Timber & Tood Farm Rd in Elgin Twp	\$25,000	Dry detention	27	90%		10%	0.90	24.3	26%	6.3	\$3,953
Kane county	KC Multi-Use Facility Detention Basin	\$430,000	Wet detention	6	75%		25%	0.79	4.7	68%	3.2	\$133,467
Kane county	KDOT Stearns Rd Det 09-0009	\$100,000	Wet detention	7.25	40%		60%	0.53	3.8	68%	2.6	\$38,274
Kane county	KDOT Stearns Rd Det 09-0010	\$250,000	Wet detention	17.8	40%		60%	0.53	9.4	68%	6.4	\$38,973
Kane county	KDOT Stearns Rd Det 09-0011	\$100,000	Dry detention	5.9	30%	30%	40%	0.53	3.1	26%	0.8	\$122,444
Kane county	KDOT Stearns Rd Det 09-0012	\$100,000	Wet detention	6.6	30%		70%	0.46	3.0	68%	2.0	\$48,887
Kane county	KDOT Stearns Rd Det 09-0013	\$150,000	Wet detention	11.4	40%		60%	0.53	6.0	68%	4.1	\$36,511
Kane county	KDOT Stearns Rd Det 09-0014	\$100,000	Wet detention	22.6	40%		60%	0.53	12.0	68%	8.1	\$12,278
Kane county	KDOT Fabyan Pkwy Det 12-003	\$50,000	Wet detention	3.8	100%			0.98	3.7	68%	2.5	\$19,843
Kane county	KDOT Fabyan Pkwy Det 12-004	\$75,000	Wet detention	2	50%		50%	0.60	1.2	68%	0.8	\$91,278
Kane county	KDOT LM Pkwy Det 03-001	\$150,000	Wet detention	18.5	50%		50%	0.60	11.2	68%	7.6	\$19,736
Kane county	KDOT LM Pkwy Det 03-002	\$100,000	Wet detention	6	85%		15%	0.86	5.2	68%	3.5	\$28,373
Kane county	KDOT LM Pkwy Det 03-003	\$150,000	Wet detention	17.3	75%		25%	0.79	13.7	68%	9.3	\$16,147
Kane county	KDOT LM Pkwy Det 03-004	\$75,000	Wet detention	5	75%		25%	0.79	3.9	68%	2.7	\$27,935
Kane county	KDOT LM Pkwy Det 03-005	\$50,000	Wet detention	3.8	75%		25%	0.79	3.0	68%	2.0	\$24,504
Kane county	KDOT LM Pkwy Det 03-006	\$150,000	Wet detention	19.5	30%		70%	0.46	8.9	68%	6.0	\$24,820
Kane county	KDOT LM Pkwy Det 03-007	\$150,000	Wet detention	18.5	85%		15%	0.86	16.0	68%	10.9	\$13,803
Kane county	KDOT LM Pkwy Det 03-008	\$200,000	Wet detention	13.4	70%		30%	0.75	10.1	68%	6.9	\$29,166
Kane county	KDOT Dauberman Rd Det 13-001	\$200,000	Wet detention	6.9	85%		15%	0.86	6.0	68%	4.1	\$49,344
Kane county	KDOT Dauberman Rd Det 13-002	\$200,000	Wet detention	5.75	85%		15%	0.86	5.0	68%	3.4	\$59,213
Kane county	KDOT Dauberman Rd Det 13-003	\$150,000	Wet detention	2.7	85%		15%	0.86	2.3	68%	1.6	\$94,577
Kane county	KDOT Dauberman Rd Det 13-004	\$225,000	Wet detention	5.2	85%		15%	0.86	4.5	68%	3.1	\$73,661
Kane county	KDOT Bliss Rd Det 11-001	\$100,000	Wet detention	10.1	85%		15%	0.86	8.7	68%	5.9	\$16,855
Kane county	KDOT Bliss Rd Det 11-002	\$100,000	Wet detention	9.7	85%		15%	0.86	8.4	68%	5.7	\$17,550

An electronic copy of this inventory is available upon request.

IV. SUMMARY OF ANTICIPATED ACTIVITIES DURING NEXT REPORTING CYCLE

During the upcoming permit year, Kane County staff will continue work to implement the LEED for Cities and Communities monitoring and reporting platforms, which include components on water quality, ecosystem health, waste management, and resiliency. This will provide Kane County the opportunity to further articulate efforts being made to improve water quality and the connection of these efforts to other initiatives throughout the County.

V. RELIANCE ON ANOTHER GOVERNMENTAL ENTITY

Kane County is not relying on another governmental entity to satisfy NPDES permit obligations.

VI. CONSTRUCTION PROJECT LIST

The following Kane County road construction projects were active during the permit year of March 2023—February 2024:

Project Name
Resurfacing #1 & #2
Paint Pavement Markings
Urethane Pavement Markings
Asphalt Rejuvenator
Countryside Ave Widening
Crack Sealing
Bliss/Main/Fabyan Roundabout
ADA Ramp Improvements
Allen Rd Chipseal
Dauberman Road Extension and Grade Separation
Fabyan Parkway under Fox River Bridge Embankment Grading
Guardrail Replacement
Harmony Road Culvert Replacement
Harter Road – Main St Rd to Lovell Drainage Improvements
Joliet Rd Culvert Replacement
Keslinger Rd Drain Tile Improvements west of Meredith Rd
Longmeadow Parkway C-2A Soil Remediation & Removal
Montgomery Rd at Virgil Gilman Trail
Orchard Rd Concrete Patching
Orchard Rd at US 30
Plank Rd Shoulder Widening

Water Quality Trend Analysis for the Fox River Watershed: Stratton Dam to the Illinois River

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February 2019



I ILLINOIS

Illinois State Water Survey

PRAIRIE RESEARCH INSTITUTE

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by

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Prairie Research Institute
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Prepared for
Fox River Study Group

February 2019

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Drs. Momcilo Markus and Zhenxing Zhang reviewed the report. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the Illinois State Water Survey, Prairie Research Institute, or the University of Illinois.

Executive Summary

This report presents a trend analysis conducted for nutrient-related water quality parameters collected at monitoring stations located on the Fox River main stem and tributaries and compiled and maintained in a database, FoxDB. An exploratory data analysis (EDA) was performed on a total of 141 water quality parameters across the 18 monitoring stations to summarize and extract the characteristics of the water quality data. Based on the EDA analysis, the Seasonal Kendall Test (SKT) for trends was selected as the core analysis method, and the EnvStats software R-package was used to perform the water quality trend analysis and EDA. A suite of procedures and workflows that use the EnvStats library of codes for the analysis were written using R programming language to extract selected water quality data from the FoxDB (i.e., the water quality database for the Fox River watershed) and perform the analysis. In addition to the nonparametric analysis using the SKT method, trend analyses of water quality concentration and fluxes (loads) were conducted for one Fox River main stem and two tributary monitoring stations that have not only long-term concentration data, but also the corresponding continuous daily discharge data. A total of 19 parametric models using concentration and flow data across the three stations were developed using the Weighted Regression on Discharge, Time, and Season (WRTDS) method for estimating trends in flow-normalized concentration and fluxes.

For all monitoring stations, the SKT trend analysis generally showed that most of the nutrient-related water quality parameters exhibited either a decreasing or no trend across all seasons. No upward annual trend was exhibited for organic nitrogen (Org-N), ammonia nitrogen, total suspended solids (TSS), or chlorophyll-A (CHL-A) at any of the monitoring stations. At the most downstream station on the main stem, the Fox River at Yorkville, no increasing trend was detected, with most of the water quality parameters showing a decreasing trend across all seasons. Most of the upward trend was detected for dissolved phosphorus (DP), particularly in spring and summer months. In comparison, total phosphorus (TP) showed an increasing annual trend only for Poplar Creek near the Mouth-Elgin station. For more than half of the stations, the pH showed a downward or no trend. In the case of pH, an upward or downward trend from the median, which is within the pH limits for freshwater, would indicate a declining water quality. All remaining water quality parameters exhibited decreasing longitudinal trends downstream of the Fox River at Algonquin, indicating improvement of the river's water quality, except for dissolved oxygen (DO), which rather implies a declining water quality trend.

The results of the trend analysis conducted using the WRTDS method generally indicate that flow-normalized concentration and fluxes (loads) of most water quality parameters decreased across all seasons from 2006 to 2016 for the Fox River at Montgomery, which is the only station in the main stem with the required concentration and flow data. A few exceptions were concentration and fluxes of total suspended solids (TSS) in spring and chlorophyll A (CHL-A) in summer, which showed increasing trends. If not in the percentage amount, the flux and concentration trends are largely similar for this station (i.e., they are in the same downward or upward direction). The only difference observed was between the spring ammonia nitrogen (NH₃-N) concentration and its corresponding flux, which showed opposing trends, indicating that concentration trends are not necessarily informative of flux trends. Large decreases in summer DP, NH₃-N, and nitrate nitrogen (NO₃-N); winter TP, TSS, and CHL-A; and spring for DO, Org-N, and total kjeldahl nitrogen (TKN) concentrations were obtained for the Fox River at Montgomery station. A decreasing trend in concentration across all seasons, unlike for DO, is

indicative of an improving water quality trend. In comparison with other water quality parameters, flow-normalized fluxes of TP and DP also appeared to have larger decreases across all seasons between 2006 and 2016. Similar downward trends of nitrate nitrogen (NO₃-N) fluxes were obtained in summer and fall seasons.

For the two tributaries, Blackberry Creek at Rt. 47 and Poplar Creek near Mouth-Elgin, most of the water quality concentration and fluxes showed larger upward trends with a few exceptions. The NH₃-N concentration exhibited the largest annual and seasonal increasing trends at both stations. Concentrations of TP, DP, and DO showed decreasing annual and seasonal trends for Blackberry Creek at Rt. 47, except in fall for DO and in summer for TP and DO concentrations. For Poplar Creek near Mouth-Elgin, the DP and DO concentrations showed improving water quality trends across all seasons. The flow-normalized DP and TKN fluxes exhibited decreasing annual and seasonal trends for Poplar Creek near Mouth-Elgin and Blackberry Creek at Rt. 47, respectively. The seasonal concentration trends largely conform to the annual trends for all three monitoring stations.

In addition to water quality trends, flow durations and trends of selected streamflow statistics including mean, 7-day minimum, and 1-day maximum flows are calculated to evaluate their changes through the years as they relate to water quality. The flow durations allow characterizing the ranges of flows in the river that are common or extreme during an entire year or season. The results indicate that the highest and lowest flow variability occurred in summer and spring seasons, respectively. The mean flow provides information about the central tendency of the multiyear hydrologic variability, whereas the minimum and maximum flow trends may explain part of the increase or decrease in constituent concentrations and fluxes. However, to explicitly attribute the change in water quality trends to some changes in hydrologic factors, the extent of other potential factors influencing water quality, such as conservation efforts, land use changes, etc., also need to be examined. Between 2006 and 2016, the mean and 7-day minimum flows exhibited an increasing trend with varying magnitudes across all seasons except for the spring 7-day minimum flow. Generally, the annual and seasonal 7-day minimum flows seem to show large increases during the period of analysis. The annual and seasonal 1-day maximum flows show increasing trends for Blackberry Creek at Rt. 47. For Poplar Creek near Mouth-Elgin, however, the 1-day maximum flow exhibited a decreasing trend in winter, spring, and fall seasons, whereas its annual and summer values had increased.

1. Introduction

This report presents a trend analysis of nutrient-related water quality data that have been collected throughout the Fox River watershed downstream of the Stratton Dam. A compilation of water quality data collected by the Fox River Study Group (FRSG), Illinois Environmental Protection Agency (IEPA), Fox Metro Water Reclamation District (Fox Metro), United States Geological Survey (USGS), Fox River Water Reclamation District (FRWRD), Illinois State Water Survey (ISWS), and Deuchler Environmental, Inc. (DEI) was stored in the environmental database, FoxDB, and used to construct the time series data for this analysis, spanning a period from 1997 to 2016. The FoxDB was created and is maintained by ISWS for compiling water chemistry and related data, such as sediment and flow in the Fox River watershed (McConkey et al., 2004).

The objectives of this analysis were to identify the presence or absence of trends in several nutrient-related water quality data collected in the Fox River watershed and to estimate rates of change if trends exist. Establishing the cause of a trend, if any, is beyond the scope of this study and requires a different study design that investigates the hydrologic processes, aquatic biogeochemistry, land uses, and anthropogenic activities in its entirety within the watershed. Streamflow histories were analyzed to provide insight into how flow variability, durations, and trends may have affected the water quality concentration and/or fluxes in the Fox River watershed. Long-term water quality data were required to conduct a trend analysis. In United States Environmental Protection Agency (USEPA) TechNotes 6 by Meals et al. (2011), monthly data of a five-year period has been suggested as the minimum for monotonic trend analysis. Most monitoring stations used in this study have five or more years of water quality data. Therefore, the core method of analysis used in this study is the Seasonal Kendall Test (SKT), which is a nonparametric test for monotonic trends (upward or downward trends). In cases where corresponding flow data are available in addition to long-term concentration data, a parametric test using the Weighted Regression on Time, Discharge, and Season (WRTDS) method has been implemented to evaluate trends in water quality concentrations and fluxes (loads), complementing the SKT analysis, which is used only for trends in water quality concentrations.

In the FoxDB, 18 monitoring stations in the Fox River and its tributaries were identified as meeting the minimum of at least five years of data for the trend analysis. The location of these monitoring stations, station ID, and descriptions are presented in Table 1 and in Figure 1, respectively. To be consistent, the same station ID numbers in the FoxDB are used in this report. The number of water quality parameters in each monitoring station varies from 2 to 10, and it includes total phosphorus (TP), dissolved phosphorus (DP), organic nitrogen (Org-N), ammonia nitrogen (NH₃-N), nitrate-nitrogen (NO₃-N), total kjeldahl nitrogen (TKN), dissolved oxygen (DO), pH, total suspended solids (TSS), and chlorophyll-A (CHL-A).

Exploratory data analysis (EDA) was performed on a total of 141 water quality parameters across the 18 monitoring stations to uncover the underlying data structure. EDA allows the thorough examination of data of interest to explore patterns, gaps, and trends. Summary statistics for each water quality parameter were computed to describe the information contained in the data in terms of its central tendency, spread, skewness, etc. The EDA analysis results for each water quality parameter can be used to evaluate the status of Fox River water quality in comparison with use-specific water quality standards. In Table 2, existing and additional water quality standards and criteria for the Illinois portion of the Fox River and its

tributaries are provided. Some of the water quality standards in the table are extracted from Part 302 (water quality standards) of Title 35 of the Illinois Administrative Code, provided by the Illinois Pollution Control Board at

<https://pcb.illinois.gov/SLR/IPCBandIEPAEnvironmentalRegulationsTitle35>.

Based on the results of the EDA analysis, the SKT method (Helsel and Hirsch, 2002) was selected as the primary process for conducting trend analyses on water quality concentration data. SKT is a distribution-free test, which is suitable for datasets that exhibit seasonality, autocorrelation, and missing values. The SKT analysis was performed for each of the 141 water quality parameters. The EnvStats R-package for environmental statistics (Millard, 2013) was used to perform the EDA and SKT analyses. EnvStats includes some of the major statistical methods and uses the R software environment, facilitating the programming of workflows and access to other features of R, such as plotting.

For three of the monitoring stations, the water quality concentration data have corresponding continuous flow data. Therefore, for those stations, trend analyses of both water quality concentration and fluxes (loads) were explored using the WRTDS method (Hirsch et al., 2010). The WRTDS method allows the estimation of long-term trends, not only of concentration, but also flux, and this procedure is part of the Exploration and Graphics for RivEr Trends (EGRET) software, which is an R-package developed by the USGS.

Table 1. Water Quality Parameters Analyzed by Monitoring Stations

Station ID	Station name	Water quality parameters by Station									
236	<i>Nippersink Cr at Spring Grove</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
1	<i>Nippersink Cr above Wonder Lake</i>	TP	DP	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
23	Fox River at Rt 176	TP	DP	-	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	-
258	Fox River at Oakwood Hills	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	TP	DP	-	NH ₃ -N	-	TKN	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
24	Fox River at Algonquin	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
268	<i>Tyler Cr at Rt. 31-Elgin</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
25	<i>Poplar Cr near Mouth-Elgin</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
26	Fox River at South Elgin	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
14	<i>Ferson Cr at Rt 34</i>	TP	DP	-	NH ₃ -N	-	TKN	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
40	Fox River at Geneva	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
27	Fox River at Montgomery	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
34	Fox River at Yorkville	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
28	<i>Blackberry Cr at Rt 47</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
287	<i>Blackberry Cr near Mouth</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A

Note: Stations are in upstream-to-downstream order, and are in bold for Fox River main stem and in italics for tributaries.

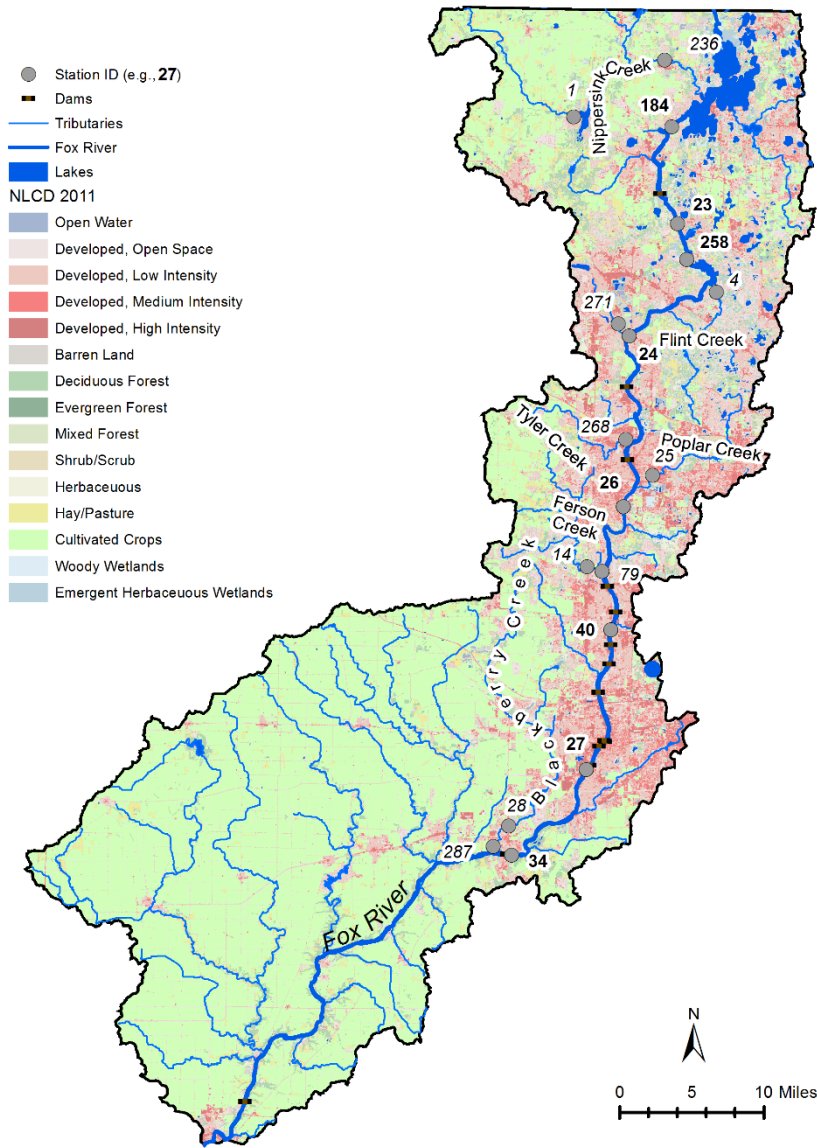


Figure 1. Fox River watershed – Stratton Dam to Illinois River

Table 2. Fox River Water Quality Standards

Water Quality Parameter	Existing Water Quality Standards for Fox River and its tributaries in Illinois	Other Water Quality Standards & Criteria
Total P (TP)	None	<ul style="list-style-type: none"> Illinois lakes > 20 acres, including the Chain O'Lakes and other lakes within the Fox River watershed shall not exceed 0.05 mg/L (see Part 302.205) The Wisconsin portion of the Fox River has a phosphorus standard of 0.1 mg/L. (available at https://dnr.wi.gov/topic/SurfaceWater/phosphorus.html) Ecoregional criterium for Region VI Corn Belt and N Great Plains: 0.07625 mg/L. (https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)
Dissolved P (DP)	None	
Organic-N (Org-N)	None	
Ammonia N (NH ₃ -N)	<ul style="list-style-type: none"> Total NH₃-N must in no case exceed 15 mg/L. Acute standard is dependent on pH. Mean pH values in the Fox River range from 7.85 to 8.48. The acute standard at pH 8.2 is 5.73 mg/L. Chronic standard differs for periods when Early Life Stage is present (March-October) and absent. It is dependent on temperature and pH. For pH 8.2, the Early Life Stage present value at 24C is 0.97 mg/L. For pH 8.2, the Early Life Stage absent value at 10C is 2.40 mg/L. The 30-day average concentration must not exceed the chronic standard except in those waters in which mixing is allowed. 	<ul style="list-style-type: none"> The most recent 2013 USEPA criterion document recognizes the sensitivity of freshwater mussels to ammonia levels. These new standards have not yet been adopted in Illinois. For pH 8.2 and 24C, the acute criterion is 1.9 mg/L (1-hour average). For pH 8.2 and 24C, the chronic criterion is 0.44 mg/L (30-day rolling average). Not to be exceeded more than 1 in 3 years on average. (https://www.epa.gov/wqc/aquatic-life-criteria-ammonia)
Nitrate N (NO ₃ -N)	<ul style="list-style-type: none"> Public and food processing water supply standard. Waters of the State are generally designated for public and food processing use: 10 mg/L 	
TKN	None	
Total N (= TKN+NO ₃ -N)	None	<ul style="list-style-type: none"> USEPA recommends 2-6 mg/L of Total N. (https://www.epa.gov/sites/production/files/2015-09/documents/totalnitrogen.pdf) Ecoregional criterium for Region VI Corn Belt and N Great Plains: 2.18 mg/L. (See https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)
Dissolved Oxygen (DO)	<ul style="list-style-type: none"> All waters except enhanced DO stretch below: Mar-July: not less than 5.0 mg/L at any time, 6.0 as daily mean avg'd over 7 days. Aug-Feb: not less than 3.5 mg/L at any time, 4.0 as daily minimum avg'd over 7 days, 5.5 as daily mean avg'd over 30 days. Enhanced DO stretch (LAT/LONG): 41° 37' 3.7194"/-88° 33' 21.0162" to 41° 45' 59.5296"/-88° 18' 36.0858" Mar-July: not less than 5.0 mg/L at any time, 6.25 as daily mean avg'd over 7 days. Aug-Feb: not less than 4.0 mg/L at any time, 4.5 as daily minimum avg'd over 7 days, 6.0 as daily mean avg'd over 30 days. 	
pH	6.5 to 9.0	
TSS	None	
Cholorophyll-A (CHL-A)	None	<ul style="list-style-type: none"> Ecoregional criterium for Region VI Corn Belt and N Great Plains: 2.70 µg/L. (https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)

2. Exploratory Data Analysis

Exploratory data analysis (EDA) is a graphical examination of the water quality data to detect any existing temporal patterns, such as seasonality, trends, step-changes, gaps, and outliers in the datasets. In this study, the EDA analysis was performed for all water quality parameters using the EnvStats R package and batches of R scripts. In addition, several other libraries of R-programs such as RODBC (<https://cran.r-project.org/web/packages/RODBC/index.html>), which implements open database connectivity (ODBC), were used in conjunction with EnvStats. The RODBC provides functions that allow direct access to a database file (in this particular case the FoxDB), eliminating the need to create intermediate data files with different formats and querying and manipulation of the required data for further analysis.

The availability of nutrient-related water quality parameters varies throughout the watershed. Only three stations have all ten of the water quality parameters: Fox River at Algonquin, Elgin, and Montgomery. Ten of the 18 stations have all the water quality parameters except TSS, which is available only for 7 stations. Phosphorus data are available for all monitoring stations, and NH₃-N and TKN are available for all but one station.

In Table 3, the period of record used in the EDA analysis for each water quality parameter is presented for each monitoring station, ranging from 5 to 20 years, excluding data gaps. It must be noted that the period of record for Blackberry near Mouth (station 287) includes data collected both before (2004–2011) and after the dam removal (2011–2016). The mean and median values of the water quality parameters are shown in Table 4; for DO, TSS, and all nutrient data, the unit is the concentration in milligrams per liter (mg/L). For CHL-A and pH data, the units are micrograms per liter (µg/L) and the standard unit, respectively. The mean and median values differ since the water quality data are generally skewed to the right, with the exception of pH, which tends to have similar means and medians. As shown in Table 4, the median values are typically less than that of the mean values because of the right-skewedness of the water quality data distribution. Summary statistics for 141 water quality parameters across the 18 monitoring stations are presented in Tables A.1 to A.10 in Appendix A.

Table 3. Periods of Records by Water Quality Parameter and Monitoring Station

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	1997-2016	1997-2016	-	1997-2016	-	1997-2016	1997-2015	1999-2015	2003-2016	-
1	<i>Nippersink Cr above Wonder Lake</i>	1997-2009	1997-2001	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	1997-2016	2002-2016	2002-2016	1997-2016	1997-2016	2002-2016	1997-2016	2002-2016	-	2002-2016
23	Fox River at Rt 176	1997-2016	1997-2016	-	1997-2016	1997-2011	1997-2016	1997-2015	1999-2015	2003-2016	-
258	Fox River at Oakwood Hills	1997-2016	2003-2016	2003-2016	1997-2016	1997-2016	2003-2016	1997-2016	2003-2016	-	2003-2016
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	2000-2011	2000-2011	-	2002-2011	-	2000-2011	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	-	2003-2016
24	Fox River at Algonquin	1997-2016	1997-2016	2002-2016	1997-2016	1997-2016	1997-2016	1997-2012	1999-2016	2003-2016	2002-2016
268	<i>Tyler Cr at Rt. 31-Elgin</i>	1997-2012	2003-2012	2002-2012	1997-2012	1998-2012	1998-2012	1997-2012	2003-2012	-	2003-2012
25	<i>Poplar Cr near Mouth-Elgin</i>	1997-2016	1997-2016	-	1997-2011	-	1997-2016	1997-2015	1999-2015	2003-2016	-
26	Fox River at South Elgin	1997-2016	1997-2016	1998-2016	1997-2016	1998-2016	1997-2016	1997-2016	1999-2016	2003-2016	2001-2016
14	<i>Ferson Cr at Rt 34</i>	2000-2012	2000-2012	-	2000-2011	-	2000-2012	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	2003-2016	-	2003-2016
40	Fox River at Geneva	2002-2016	2002-2016	2002-2016	2002-2016	2002-2016	2002-2016	2002-2016	2002-2016	-	2002-2016
27	Fox River at Montgomery	1997-2016	1997-2016	2002-2016	1997-2016	1997-2016	1997-2016	1997-2016	1997-2016	2003-2016	2002-2016
34	Fox River at Yorkville	2002-2016	2002-2016	2002-2016	1997-2016	2002-2016	2002-2016	1997-2016	1997-2016	-	2002-2016
28	<i>Blackberry Cr at Rt 47</i>	1997-2016	1997-2016	-	1997-2016	-	1997-2016	1997-2015	1999-2015	2003-2016	-
287	<i>Blackberry Cr near Mouth</i>	2004-2016	2004-2016	2004-2016	2004-2016	2004-2016	2004-2016	2004-2016	2004-2016	-	2004-2016

Note: Stations are in upstream-to-downstream order, and are in bold for Fox River main stem and in italics for tributaries.

Table 4. Mean and Median Values of the Water Quality Parameters

Station ID	Station Name	TP (mg/L)	DP (mg/L)	Org-N (mg/L)	NH ₃ -N (mg/L)	NO ₃ -N (mg/L)	TKN (mg/L)	DO (mg/L)	pH (su)	TSS (mg/L)	CHL-A (µg/L)
236	<i>Nippersink Cr at Spring Grove</i>	0.13/0.12	0.04/0.03	-	0.15/0.11	-	0.98/0.87	10.48/10.18	8.12/8.12	29.82/25	-
1	<i>Nippersink Cr above Wonder Lake</i>	0.17/0.09	0.05/0.03	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	0.16/0.14	0.05/0.04	1.69/1.53	0.08/0.06	1.04/0.76	1.75/1.61	10.84/10.5	8.48/8.5	-	81.63/70.2
23	Fox River at Rt 176	0.14/0.12	0.03/0.02	-	0.1/0.06	1.26/0.93	1.65/1.6	10.48/10.2	8.27/8.3	27.01/25	-
258	Fox River at Oakwood Hills	0.17/0.16	0.05/0.04	1.76/1.62	0.07/0.05	0.86/0.61	1.84/1.68	10/9.61	8.26/8.42	-	94.06/85.65
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	0.29/0.24	0.21/0.15	-	0.11/0.07	-	1.96/1.7	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	0.5/0.32	0.43/0.25	0.94/0.82	0.09/0.07	3.77/3.42	1/0.9	9.2/8.48	8.11/8.2	-	29.74/18.85
24	Fox River at Algonquin	0.18/0.16	0.06/0.04	1.72/1.68	0.1/0.06	1.29/1.01	1.67/1.6	10.05/9.93	8.17/8.23	32.88/30	92.56/86.2
268	<i>Tyler Cr at Rt. 31-Elgin</i>	0.14/0.11	0.06/0.05	0.79/0.68	0.07/0.06	2.39/1.78	0.83/0.77	11.49/11.15	8.2/8.2	-	9.69/8.6
25	<i>Poplar Cr near Mouth-Elgin</i>	0.09/0.07	0.03/0.02	-	0.08/0.04	-	1.1/1	10.83/10.36	7.85/7.85	12.18/8	-
26	Fox River at South Elgin	0.29/0.23	0.16/0.12	1.63/1.54	0.11/0.06	1.72/1.51	1.66/1.58	10.22/9.63	8.35/8.39	31.11/30	86.68/78.8
14	<i>Ferson Cr at Rt 34</i>	0.15/0.12	0.06/0.05	-	0.08/0.03	-	1.42/1.2	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	0.11/0.1	0.06/0.05	0.75/0.67	0.06/0.05	1.15/0.86	0.79/0.71	9.93/9.43	7.95/8.01	-	13.26/10.7
40	Fox River at Geneva	0.33/0.27	0.16/0.13	1.66/1.52	0.07/0.04	1.67/1.5	1.73/1.6	11.24/10.58	8.2/8.28	-	105.3/87.95
27	Fox River at Montgomery	0.32/0.27	0.16/0.13	1.59/1.46	0.08/0.04	1.67/1.46	1.6/1.52	9.45/9.29	8.34/8.33	34.12/33	99.88/80.05
34	Fox River at Yorkville	0.48/0.41	0.3/0.25	1.62/1.46	0.09/0.05	2.08/1.86	1.67/1.51	10.24/9.9	8.33/8.3	-	98.15/80
28	<i>Blackberry Cr at Rt 47</i>	0.12/0.09	0.04/0.03	-	0.1/0.05	-	1.01/0.83	10.03/9.74	7.92/7.97	28.23/20	-
287	<i>Blackberry Cr near Mouth</i>	0.12/0.11	0.05/0.05	0.75/0.69	0.07/0.05	1.28/1.01	0.8/0.75	10.72/10.24	7.99/7.98	-	12.84/10.55

Note: Stations are in upstream-to-downstream order, and are in bold for Fox River main stem and in italics for tributaries.

To further illustrate the EDA analysis, total phosphorus (TP) data for the Fox River at Montgomery (station ID 27) were used, as the station has long-term data that various agencies collected. In addition, station 27 has flow data, which allowed to conduct parametric trend test for water quality fluxes (loads) in addition to concentration. Figure 2 shows one-dimensional scatter plots of the TP concentration data collected by various agencies, including FRSG, IEPA, FRWRD, ISWS, and DEI from 1997 to 2016. As shown by the number of data points (n) in the figure, FRSG and IEPA collected the largest number of TP concentration samples for this station. The mean and standard deviation of TP concentration samples (mg/L) collected by the different agencies range from 0.2 to 0.4 and 0.1 to 0.2, respectively, representing varying data periods as illustrated in Figure 2.

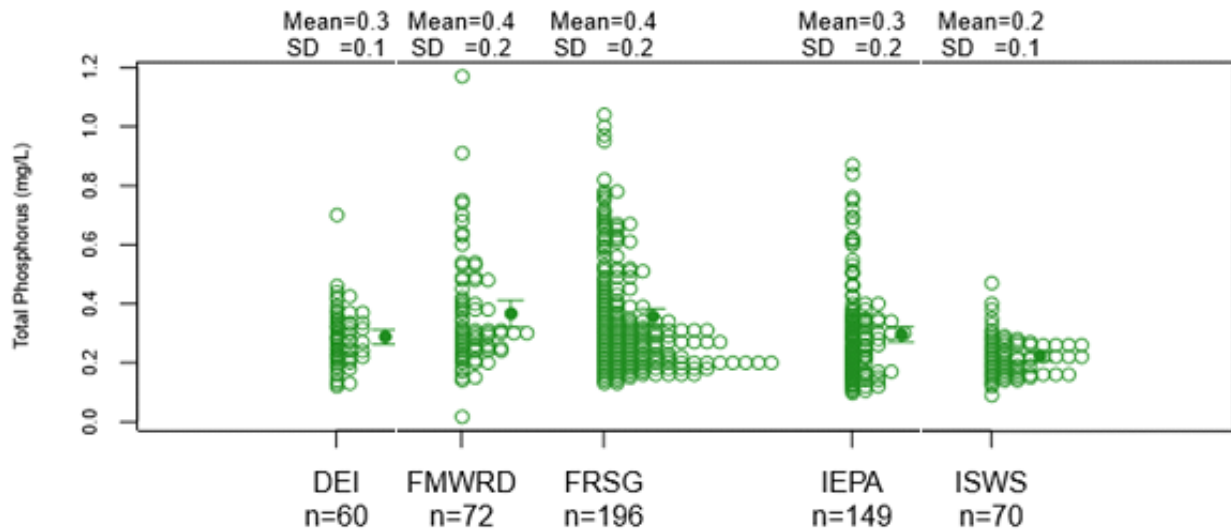
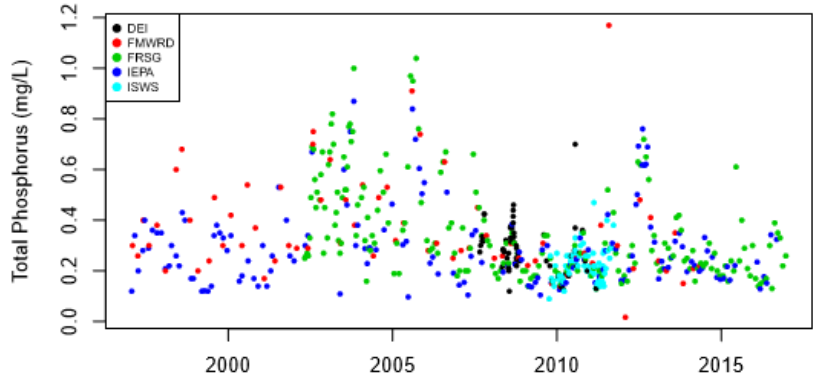


Figure 2. Strip plots of TP concentrations for Fox River at Montgomery

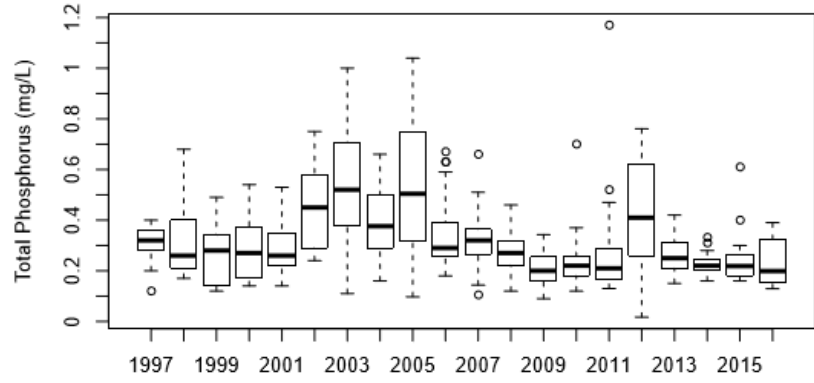
In Figure 3, the EDA results for TP concentrations at Fox River at Montgomery are presented and include (a) the combined time series of the samples collected by the different agencies; (b) yearly boxplots; (c) annual minimum, maximum, and mean values; and (d) monthly boxplot. The combined time series of the observation data and monthly time series data constructed using all the observations were used in the parametric and nonparametric trend analyses, respectively. The seasonality of the TP concentration data is clearly evident in the time series and monthly boxplots, which is true for nearly all water quality parameters analyzed in this study. This EDA analysis provided useful information for selecting an appropriate method of analysis for trends that account for the underlying data structure; for example, the seasonality exhibited in the TP concentration data. The yearly boxplot could provide preliminary insights into the existence of a trend or no trend. In the boxplots, the median concentration is shown by a line in the box that represents the interquartile range (IQR) between the first and the third quartile of the TP data in a month or year. Outliers are shown in circles and are defined as observations lying beyond 1.5 times the IQRs. The monthly boxplot shows that the median of the TP concentration is the highest in summer months, with the maximum occurring in August. The yearly boxplot generally indicates that the TP concentration exhibits a decreasing trend through

the years since 2005. Low flows during the drought of 2012 may have caused the increase in TP concentration for that year.

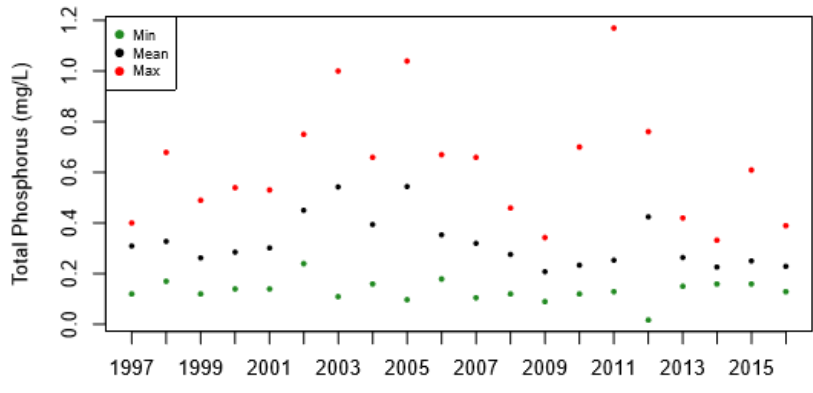
For water quality stations with corresponding flow data, including Fox River at Montgomery, a parametric trend test was conducted which required that the water quality data or its log transformation be normally-distributed. As part of the EDA analysis, the Shapiro-Wilk Goodness-of-Fit test based on Chen and Balakrisnan (1995) was done for the TP concentration data, fitting it with a lognormal distribution. The result is presented in Figure 4. As shown in the figure, the histogram, plots of quantiles of TP versus quantiles of log-normal distribution (Q-Q), and the empirical cumulative density functions (CDFs) indicate that TP concentration observations could be assumed to have come from a lognormal distribution with at least a 99% confidence level.



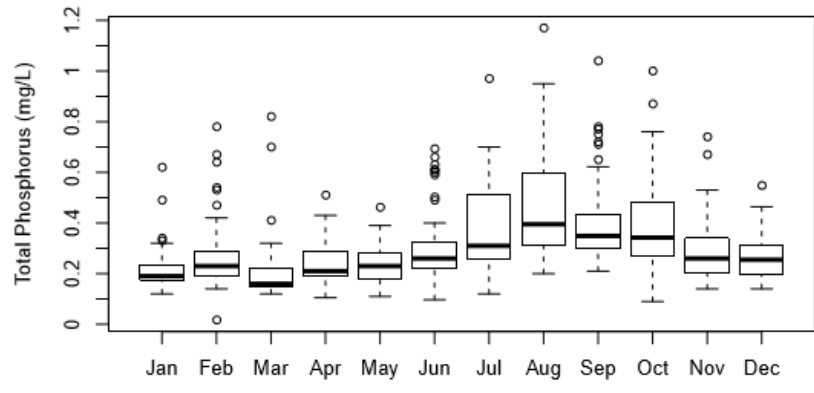
(a) Observation data



(b) Boxplot by year

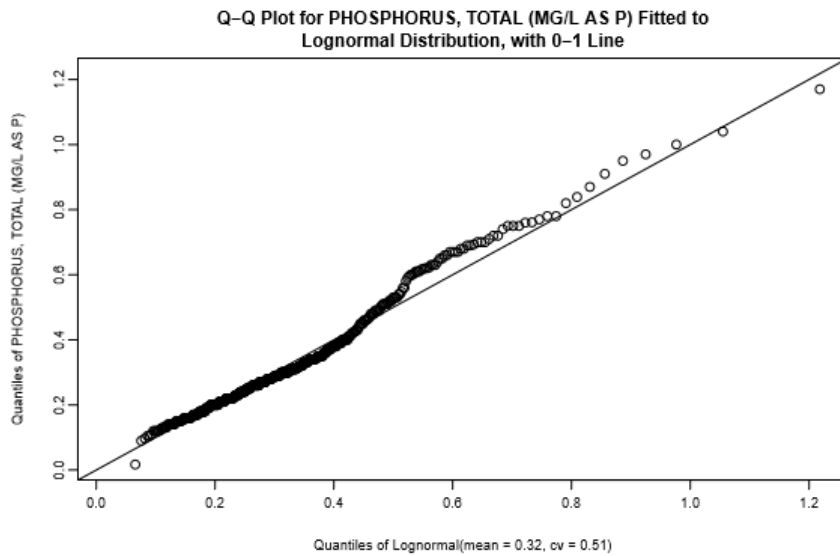
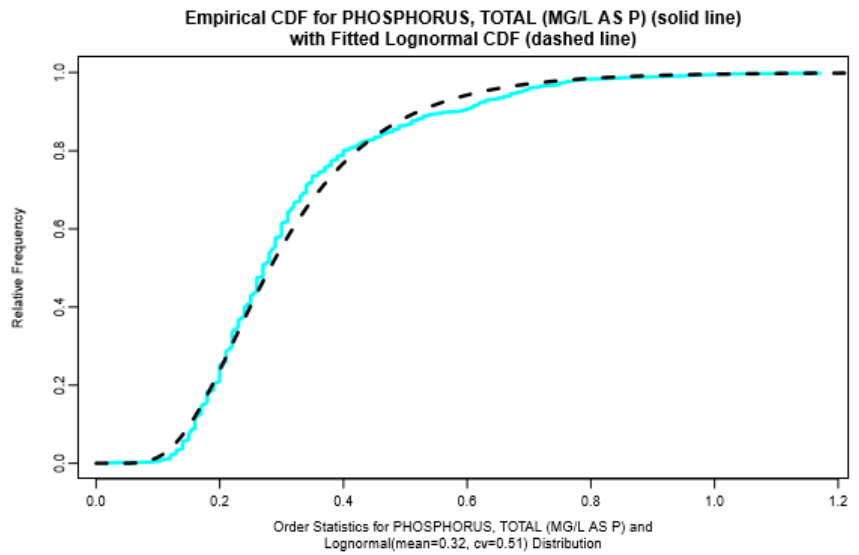
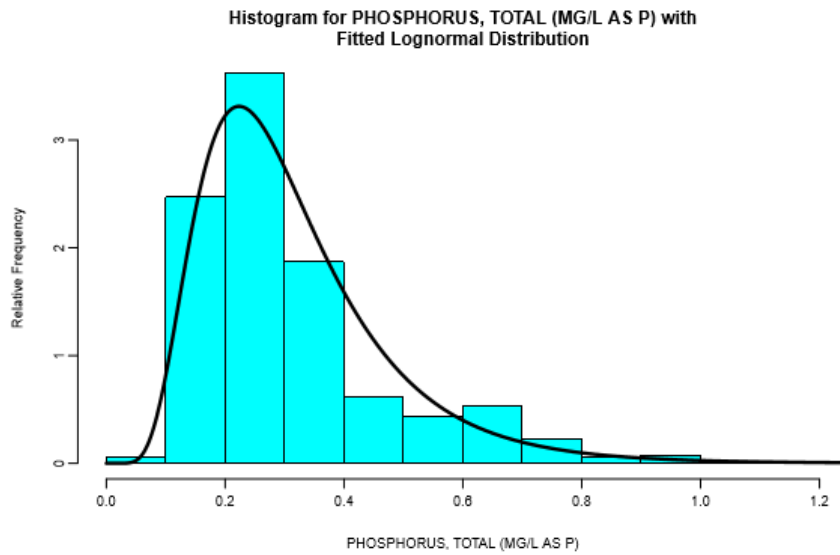


(c) Annual values



(d) Boxplot by month

Figure 3. EDA results showing TP concentrations for Fox River at Montgomery



Shapiro-Wilk GOF

Hypothesized Distribution:	Lognormal
Estimated Parameters:	mean = 0.32 cv = 0.51
Data:	PHOSPHORUS, TOTAL (MG/L AS P)
Sample Size:	546
Test Statistic:	W = 0.97
Test Statistic Parameter:	n = 546
P-value:	9.9e-09

Figure 4. Goodness-of-Fit test results for TP at Fox River at Montgomery

3. Water Quality Trend Analysis

The objectives of this analysis was to identify the presence or absence of trends in nutrient-related water quality data collected in the Fox River watershed and to estimate rates of change if trends exist. Establishing the cause of a trend, if any, is beyond the scope of this study and requires a different study design, including analysis of the hydrologic processes, aquatic biogeochemistry, land uses, and anthropogenic activities within the watershed. Eighteen monitoring stations in the FoxDB met the minimum monthly data of a five-year period for monotonic trend analysis. Most stations have five or more years of water quality data. Therefore, the core method of analysis used in this study is the Seasonal Kendall Test (SKT) method, which is a nonparametric test for monotonic trends. In cases in which corresponding flow data are available, a parametric test using the Weighted Regression on Time, Discharge and Season (WRTDS) method is implemented to evaluate trends in water quality concentrations and fluxes, complementing the SKT analysis for trends in water quality concentrations. Brief descriptions of the two methods of analyses selected for trend tests are presented in the following sections.

3.1 Seasonal Kendall Test for Trend

The Seasonal Kendall Test (Hirsch and Slack, 1984) is a test for monotonic (upward or downward) trends in time series data that are expected to change in the same direction for one or more seasons. A season could be defined as a single month or a couple of months (e.g., June to August as summer months). A monotonic upward or downward trend indicates a consistently increasing or decreasing pattern in the variable of interest for a given season that may not necessarily be linear. The SKT, which is the generalized form of the Mann-Kendall test, is a nonparametric test for a trend that does not require the time series data to be distributed normally. It can be used in cases where there exist seasonality and serial correlation in the data. The method is also applicable if the time series includes missing data points and/or data with detection limits.

A brief description of the SKT method is given as follows. In a SKT test, the null hypothesis H_0 states that there is no trend (i.e., for each season, the time series data are randomly ordered over the years), whereas the alternative hypothesis H_a is that an upward or downward monotonic trend exists over the years for one or more seasons. To describe the SKT method, a season is assumed to be a month. Let $X = (X_1, X_2, \dots, X_i, \dots, X_{12})$ be the time series data (X_i) collected over the years for i^{th} month and $X_1 = (x_{1,1}, x_{1,2}, \dots, x_{1,k}, \dots, x_{1,n1})$ to $X_{12} = (x_{12,1}, x_{12,2}, \dots, x_{12,k}, \dots, x_{12,n12})$ be a subset of January to December data over the years. Note that $n1$ and $n12$ are the number of data points over the years for the months of January and December, respectively, and different months can have a different number of data points. The SKT test begins by calculating the Kendall tau for each month. The following are steps involved in the analysis:

1. List the data collected for the i^{th} month in order of years of data collection and calculate the sign of all possible differences (i.e., a total of $ni(ni - 1)/2$ pairs of $(x_{i,j} - x_{i,k})$ for $j > k$) between data points for the i^{th} month:

$$sgn(x_{i,j} - x_{i,k}) = 1 \text{ if } (x_{i,j} - x_{i,k}) > 0;$$

$$= 0 \text{ if } (x_{i,j} - x_{i,k}) = 0 \text{ or}$$

if $(x_{i,j} - x_{i,k})$ cannot be determined; or

$$= -1 \text{ if } (x_{i,j} - x_{i,k}) < 0$$

For example, if $(x_{i,j} - x_{i,k}) < 0$, this would mean that the concentration value measured for the i^{th} month of j^{th} year is less than the value for the same month of k^{th} year.

2. Determine S_i , which is calculated as the number of positive differences minus the number of negative differences for the i^{th} month, and its variance, $Var(S_i)$. If $S_i > 0$, then the i^{th} month observations made in the later years are greater than those of earlier years for the same month, and vice-versa. S_i and $Var(S_i)$ are calculated as

$$S_i = \sum_{k=1}^{ni-1} \sum_{j=k+1}^{ni} \text{sgn}(x_{i,j} - x_{i,k})$$

$$Var(S_i) = \frac{1}{18} \left[ni(ni - 1)(2ni + 5) - \sum_{l=1}^{L_i} t_{i,l}(t_{i,l} - 1)(2t_{i,l} + 5) \right]$$

where $\text{sgn}()$ is defined as the sign function returning a value of 1, -1, or 0 for positive, negative, or zero value, respectively; L_i is the number of tied groups for the i^{th} month and $t_{i,l}$ is the number of data points in the l^{th} group for the i^{th} month. When ties exist because of equal data values or detection limits, the variance is adjusted for the ties. The Kendall tau (τ_i), which is the direction and magnitude of the trend and the Theil-Sen slope estimate (β_i) for i^{th} month can be expressed as

$$\tau_i = \frac{2S_i}{ni(ni-1)} \quad \text{and} \quad \beta_i = \text{median} \left(\frac{x_{i,j} - x_{i,k}}{j - k} \right)$$

Next, aggregate S_i and $Var(S_i)$ into S' and $Var(S')$, respectively, for m number of seasons (e.g., $m=12$ when the season is a month or $m = 52$ when the season is a week) as

$$S' = \sum_{i=1}^m S_i \quad \text{and} \quad Var(S') = \sum_{i=1}^m Var(S_i)$$

Overall τ' and β' are computed as weighted averages of the seasonal estimates and the median of all two-point slope estimates within each season, or month in this particular case.

3. Finally, compute the SKT statistic, Z_{skt} that indicates the tendency of the data to increase or decrease (a positive or negative Z_{skt}), calculated as

$$Z_{skt} = \frac{S' - 1}{\sqrt{Var(S')}} \quad \text{if } S' > 0$$

$$= 0 \text{ if } S' = 0$$

$$= \frac{S' + 1}{\sqrt{\text{Var}(S')}} \text{ if } S' < 0$$

To determine if a trend is statistically significant, a p-value (α) associated with Z_{skt} will be calculated, where α is the tolerable probability of rejecting the null hypothesis (i.e., no monotonic trend over time in this particular case). For this study, a p-value of $\alpha = 0.1$ is used, allowing a confidence level of 90% (i.e., $100(1 - \alpha)$ percentile) to accept the presence of a trend.

3.2 SKT Results and Discussion

As SKT is the core method of trend analysis chosen for this study, it is applied to all nutrient-related water quality data observed at the 18 monitoring stations in the Fox River watershed. The SKT analysis conducted is demonstrated here using monthly total phosphorus (TP) data for the Fox River at Montgomery, as shown in Figures 2 and 3. Below is the result of the SKT trend analysis for the TP concentration using EnvStats:

Null Hypothesis: All 12 values of **tau** (τ_i) = 0 (i.e., no monotonic trend).

Alternative Hypothesis: The seasonal taus are not all equal.

(Chi-Square Heterogeneity Test)

At least one seasonal tau is not equal to 0 and all non-zero taus have the same sign (Z_{skt} Trend Test)

Test Name: Seasonal Kendall Test for Trend

Estimated Parameter(s): **Overall tau** (τ') = **-0.236431**

Overall slope (β') = **-0.005576**

Intercept = 12.675937500

Sample Sizes for each month (1 to 12): 18, 20, 17, 19, 19, 20, 19, 20, 18, 17, 20, 18

Total Sample Size: 225

Test Statistics: Chi-Square (Het) = 4.309498

Z_{skt} (Trend) = -4.838630

Test Statistic Parameter (degree of freedom): df = 11

P-values: **Chi-Square (Het) = 9.599737e-01**

Z_{skt} (Trend) = 1.307374e-06

Confidence Interval for Slope (CL > 90%): **LCL = -0.007500; UCL = -0.003518**

Kendall S-Statistic (S_i) and its variance $\text{Var}(S_i)$:

month: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

S_i : -50, -59, -22, -33, -31, -7, -43, -31, -51, -38, -80, -28

$\text{Var}(S_i)$: 696.0, 949.0, 589.3, 817.0, 817.0, 949.0, 817.0, 949.0, 697.0, 589.3, 950.0, 696.0

Seasonal (monthly) Estimates:

month	tau (τ_i)	slope (β_i)	intercept
1	-0.32679739	-0.006428571	13.110357
2	-0.31052632	-0.007316964	14.912489
3	-0.16176471	-0.004048611	8.318111
4	-0.19298246	-0.002500000	5.225000
5	-0.18128655	-0.003047619	6.351238
6	-0.03684211	-0.000665733	1.632627
7	-0.25146199	-0.007750000	15.903000
8	-0.16315789	-0.005892857	12.241518
9	-0.33333333	-0.005818182	12.036125
10	-0.27941176	-0.013333333	27.115833
11	-0.42105263	-0.007171429	14.656971
12	-0.18300654	-0.006800000	13.921000

The value of Z_{skt} (Trend) = **-4.838630** and its associated p-value of **1.307374e-06** indicate that the TP concentration exhibits a decreasing trend of **-0.005576 mg/L per year** (i.e., **overall slope, β'**) with more than a 90% confidence level. The lower and upper confidence levels for the estimated rate of change lie between **LCL = -0.007500** and **UCL = -0.003518**. The monthly estimates of tau (τ_i) and slope (β_i) show decreasing trends for all months, with the maximum rate of change for the month of October, which is **-0.013333 mg/L per year**. The Chi-Square Heterogeneity Test was also performed to determine if the trend varies for different months and its p-value of **9.599737e-01** indicates no evidence of varying monthly trends.

Similarly, the SKT trend analysis was performed for all water quality parameters. The results are summarized in Tables 4–8, showing annual and seasonal trends in water quality concentrations and pH for all stations. For all water quality parameters, the SKT trend results are illustrated in Figures B.1 to B.10 in Appendix B.

Nutrients

Nutrient data used in the trend analysis include two forms of phosphorus and four forms of nitrogen. These are total phosphorus (TP), dissolved phosphorus (DP), organic nitrogen (Org-N), ammonia nitrogen (NH₃-N), nitrate nitrogen (NO₃-N), and total kjeldahl nitrogen (TKN). As shown in Table 2, nutrient concentration data were available for most of the 18 stations. The Org-N, NH₃-N, NO₃-N, and TKN data are available for more than 10 stations, and all of the 18 stations have TP and DP concentration data. The record length of the nutrient data generally varies from 5 to 20 years with a majority of the stations having 12 or more years of data and only one station with 3 years of NO₃-N data.

The TP and DP concentration data are available for all 18 stations used in the trend analysis. The mean TP concentration ranges from 0.026 mg/L Poplar Creek near Mouth-Elgin to 0.427 mg/L for Crystal Creek at Rt. 31 at Algonquin. The minimum TP concentration of 0.002 mg/L was observed at Poplar Creek near Mouth-Elgin, Fox River at Algonquin, and Fox River at Rt. 176, whereas the maximum TP concentration value of 3.59 mg/L was recorded at the Fox River at the South Elgin station. Across the stations in the Fox River watershed, the mean DP concentration ranges from 0.053 mg/L for Blackberry near Mouth to 0.499 mg/L for Crystal Creek at Rt. 31 at Algonquin. The minimum DP concentration of 0.009 mg/L was observed at

Blackberry near Mouth, whereas the maximum concentration value of 3.59 mg/L was recorded at Fox River at South Elgin. Currently, no water quality standard exists for TP and DP in the Fox River and its tributaries. There is, however, a TP standard of less than 0.05 mg/L for Illinois lakes with a total surface area of 20 acres, including Chain O'Lakes and others in the Fox River watershed.

The mean Org-N concentration varies from 0.748 mg/L at Ferson Creek near Mouth-Elgin to 1.76 mg/L at the Fox River at Oakwood Hills. The maximum Org-N concentration of 6.48 mg/L was observed at Crystal Creek at Rt. 31, whereas the minimum concentration of 0.03 mg/L was recorded at Fox River at Yorkville. There is no water quality standard for Org-N in the Fox River watershed.

All 18 stations except Nippersink Creek above Wonder Lake have NH₃-N concentration data, the majority of which have 20 years of record. The mean NH₃-N concentration ranges from 0.061 mg/L at Ferson Creek near Mouth-Elgin to 0.15 mg/L at Nippersink Creek at Spring Grove, both of which are monitoring stations in the Fox tributaries. The minimum and maximum NH₃-N concentrations of 0.005 and 1.58 mg/L were observed at the Fox River at Montgomery and Fox River at Algonquin, respectively. The maximum NH₃-N concentration for the analysis period is well below the acute standard of 5.73 mg/L for the Fox River and its tributaries.

The NO₃-N concentration data are available for 12 of the 18 stations, a majority of which have more than 10 years of record. The range of the mean NO₃-N concentration lies between 0.864 mg/L for Fox River at Oakwood Hills and 3.766 mg/L for Crystal Creek at Rt. 31 at Algonquin. The minimum and maximum NO₃-N concentrations of 0.01 mg/L and 14.3 mg/L were recorded at the Fox River at Montgomery and Fox River at Algonquin stations, respectively. The maximum NO₃-N concentration at the Fox River at Algonquin is above 10 mg/L, which is the water quality standard for public and food processing use.

The TKN concentration data are available for all but one station with the same period of record as that of the NH₃-N data. The mean TKN concentration ranges from 0.792 mg/L at Ferson Creek near Mouth-Elgin to 1.959 mg/L at Flint Creek at Kelsey Rd-Lk Barrington. The Fox River at Algonquin and Flint Creek at Kelsey Rd-Lk Barrington have the minimum and maximum TKN concentrations of all gaging stations used in the trend analysis (i.e., 0.01 mg/L and 27.8 mg/L), respectively. Although there is no TKN water quality standard, the USEPA recommends a water quality standard of 2 to 6 mg/L for the Total Nitrogen (TN) concentration, which is a summation of TKN and NO₃-N.

Annual, Seasonal, and Longitudinal Trends

Total Phosphorus

In Figures 5 and 6, the annual and seasonal TP concentration trends and estimated values of change in mg/L per year, respectively, are presented. The TP concentration showed decreasing, increasing, and no trends in five, one, and two of the monitoring stations on the Fox River main stem, respectively. For the decreasing trend, the decrease in TP concentration ranges from 1.4% per year (0.003 mg/L per year) at Fox River at South Elgin to 4.9% per year (0.02 mg/L per year) at Fox River at Yorkville, which is the most downstream station on the main stem. The percentage change per year is computed as a function of the median concentration. The increasing TP trend of 1.6% per year (0.002 mg/L per year) was estimated for Fox River at

Rt. 176, an upstream monitoring station. No trend was detected on seven of the ten Fox tributary stations. Decreasing trends of TP were estimated for Crystal Creek at Rt. 31 (21.9% per year or 0.07 mg/L per year) and Tyler Creek at Rt. 31-Elgin (3% per year or 0.003 mg/L per year).

The seasonal TP trend largely conforms to the annual trend. The winter, fall, spring, and summer months used in computing seasonal trends are December to February, March to May, June to August, and September to November, respectively. Only two stations on the Fox River main stem and two on its tributaries exhibited decreasing TP trends in summer. No summer TP trend was detected in the remaining 12 of the 18 stations. Crystal Creek at Rt. 31 showed decreasing trends for all seasons with the maximum TP reduction of 0.085 mg/L per year (26.6% per year) occurred in summer. Fox River at Rt. 176 and Poplar Creek near Mouth-Elgin experienced increasing TP trends in at least one or more seasons, with the maximum reduction of 0.004 mg/L per year (5.4%) in spring. Only two stations on the Fox River, namely Fox River at Yorkville and Fox River at Montgomery, showed decreasing trends in all seasons with a TP reduction ranging from 0.009 to 0.032 mg/L per year.

Downstream of Fox River at Rt. 176, there seems to be a decreasing annual or seasonal TP trend along the Fox River. For most stations, no longitudinal TP trend was detected in summer.

Dissolved Phosphorus

Decreasing and increasing annual trends for DP were detected in four and three stations, respectively. For the increasing TP trend, the reduction ranges from 2.1% per year for Fox River at Johnsbury to 4.4% per year for Fox River at Rt. 176, whereas the decreasing rate of change was estimated between 1 and 4.9% per year. No annual DP trend was detected for Fox River at Oakwood Hills. The DP concentration in the tributaries showed no annual trend in two of the ten stations but indicate either a decreasing or increasing trend in the remaining stations. The annual trend at Crystal Creek at Rt. 31 showed the maximum reduction of 25.5% per year (or 0.064 mg/L per year), whereas the maximum increasing trend of 4% per year (0.002 mg/L) was calculated for Ferson Creek near Mouth-Elgin.

The DP concentration exhibited variations of upward, downward, or no seasonal trend. For stations in the Fox River main stem, the fall DP trend showed a decreasing trend downstream of Algonquin but no trend upstream. The most downstream station exhibited a decreasing DP trend of 10.2% (0.026 mg/L per year) in the fall, which is the maximum rate of change for any of the seasonal trends along the Fox River. Upstream of Fox River at South Elgin, an increasing DP trend was detected in spring, summer, and winter for most of the stations on the Fox River, which also conforms to the annual DP trend. The DP concentration for Crystal Creek at Rt. 31 shows the largest decreasing trend in all seasons with the maximum reduction of 31.6% per year (0.079 mg/L) in the fall. The winter DP concentration on the tributaries showed either a decreasing or no trend.

Showing some longitudinal trends, all stations downstream of Fox River at Algonquin exhibited a decreasing annual trend with the maximum DP reduction occurring at Fox River at Yorkville, which is 0.012 mg/L per year (4.9% per year). The fall DP trend conforms to the annual trend along the Fox River main stem. In all seasons, either a decreasing or no DP trend was detected for stations downstream of the Fox River at Algonquin.

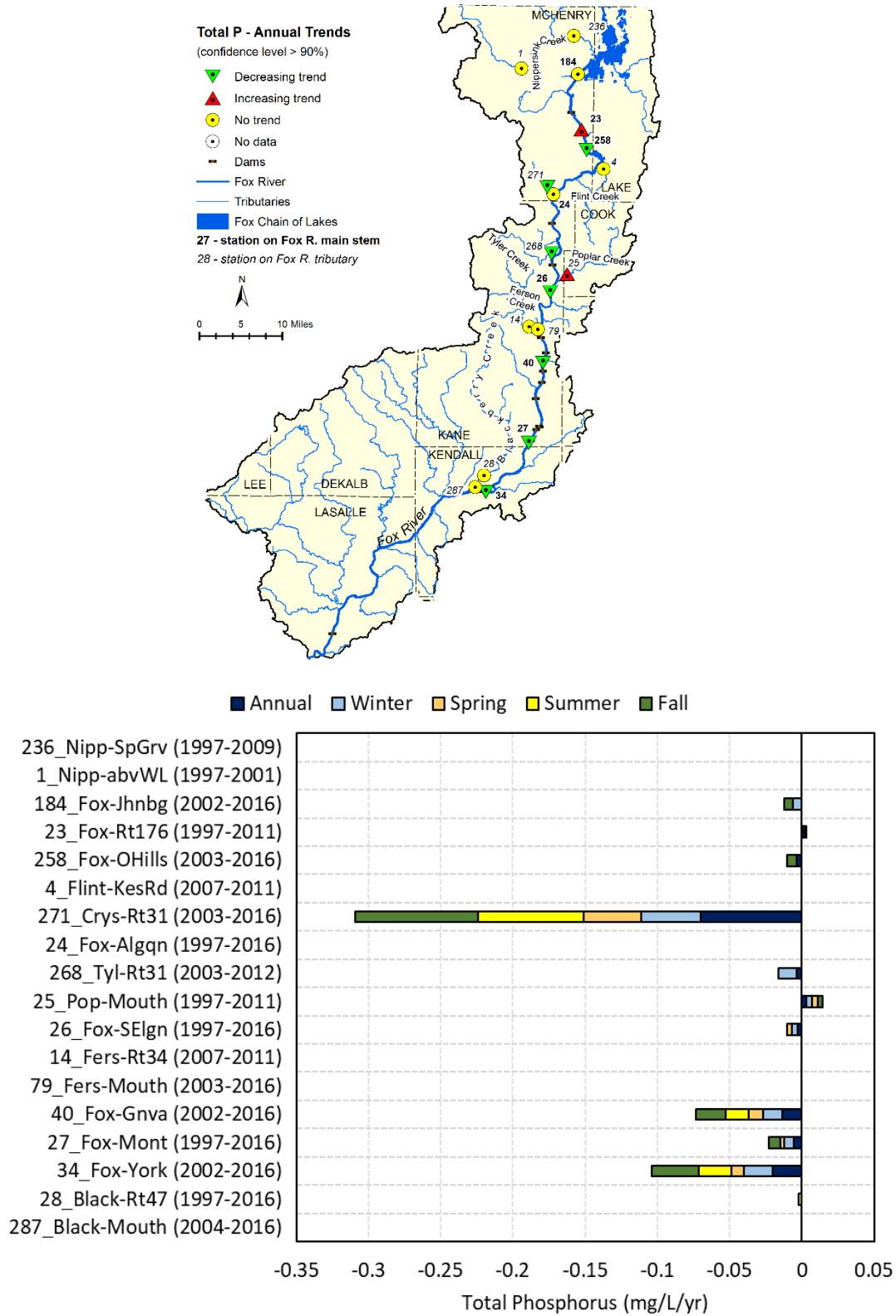


Figure 5. Annual trends of total phosphorus (TP) in the Fox River watershed

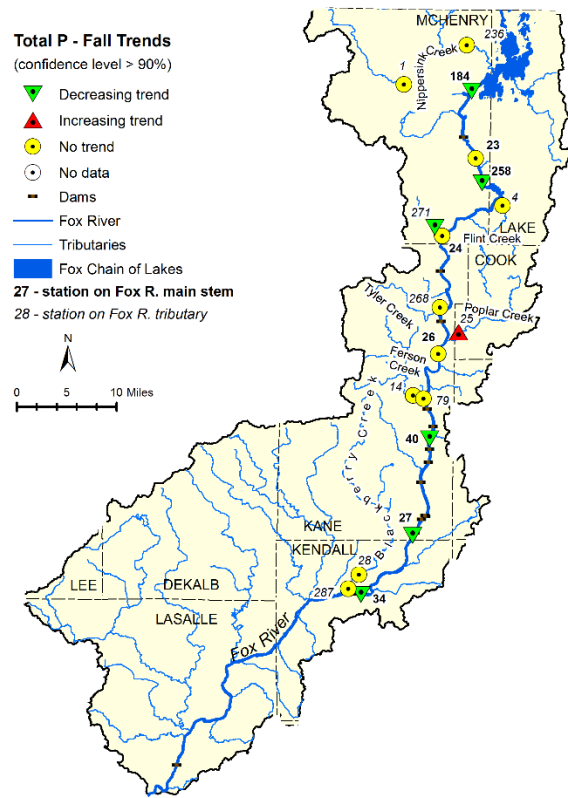
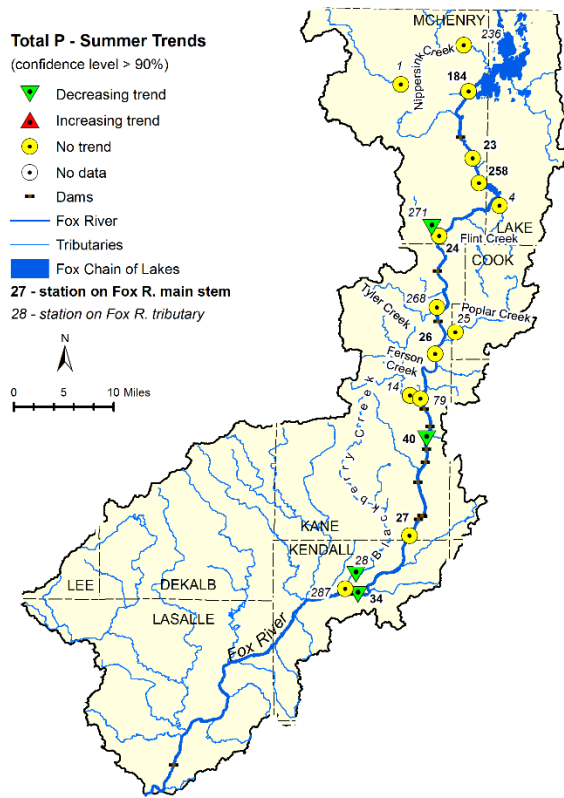
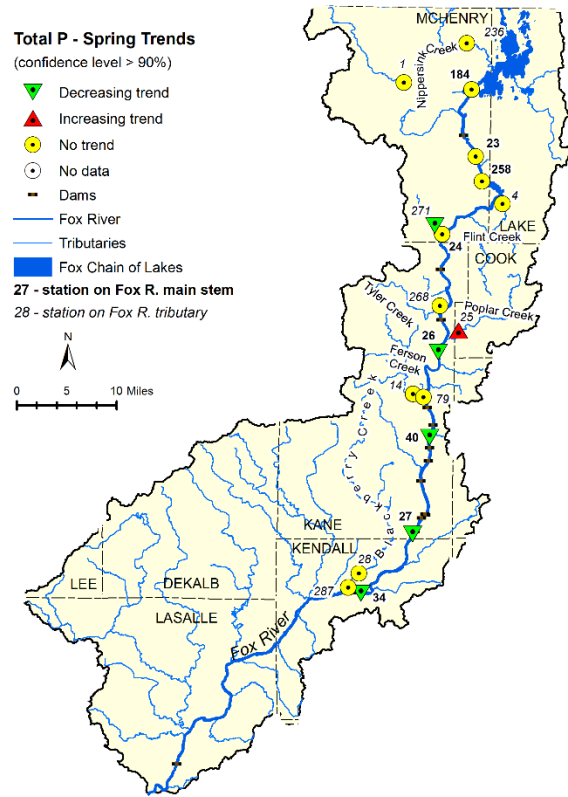
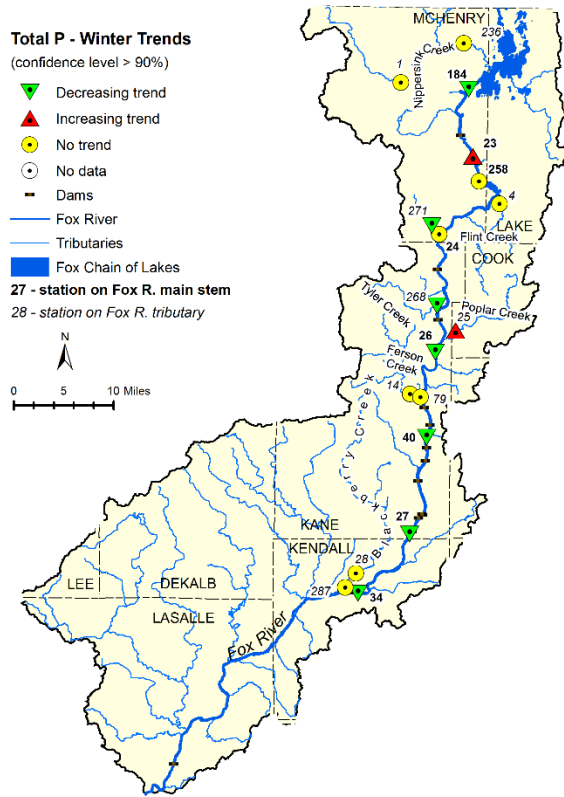


Figure 6. Seasonal trends of total phosphorus (TP) in the Fox River watershed

Organic Nitrogen

The Org-N concentration along the Fox River main stem shows a decreasing annual trend in five of the eight stations with a maximum reduction of 2% per year (0.03 mg/L per year) at the Fox River at Montgomery. In contrast, no trend is detected at the remaining two stations, namely Fox River at Algonquin and Fox River at Oakwood Hills. Similarly, none of the four stations in the Fox River tributaries with Org-N data shows any trend.

The Org-N concentration trends showed seasonal variations. For example, no winter trend was detected for Org-N, with the exception of Tyler Creek at Rt. 31-Elgin, which showed the maximum reduction of 12.5% per year (0.085 mg/L per year) of all seasons. In contrast, this same station exhibited the only increasing trend (i.e., 5.34% per year for the summer Org-N concentration). At Blackberry Creek at Rt. 47, the Org-N showed a decreasing summer trend of 9.8% per year (0.066 mg/L per year), but no annual or other seasonal trend was detected for the same station. For the remaining stations, the fall, spring, and summer trends conform to the annual trends.

Along the Fox River, the annual and seasonal Org-N concentration showed a decreasing trend, with the exception of Fox River at Johnsbury, which showed no spring, summer, or winter trends.

Ammonia Nitrogen

For only two of the eight stations in the Fox River, namely Fox River at Algonquin and Fox River at Rt. 176, no annual trend for the NH₃-N concentration was detected. All the remaining stations showed decreasing annual trends of NH₃-N concentration, with the largest decrease of 5.2% per year (0.002 mg/L) obtained for Fox River at Montgomery. In the tributaries, the NH₃-N concentration showed a decreasing annual trend at only three stations with the rest showing no trend. The largest decrease was 5.3% per year, which was for Blackberry Creek near Mouth. In contrast, no trend was detected for Blackberry Creek at Rt. 47, which is an upstream station on the same creek.

Despite exhibiting an annual trend for Fox River at Johnsbury, no seasonal NH₃-N trend was detected. In all other cases in which annual trends exist, there is at least one or more seasons with a similar trend. For the most part, fall and summer trends conform to annual trends with some exceptions. For example, the fall NH₃-N concentration showed an increasing trend of 4.3% per year for Tyler Creek at Rt. 31-Elgin, while no trend was detected annually or for any other season. The largest increasing trend of 11.8% per year was detected for the spring NH₃-N concentration at Blackberry Creek at Rt. 47. This station also exhibited one of the summer's largest decreasing trends (13.2% per year). In all of the monitoring stations upstream of Fox River at Montgomery, no spring trend was detected, with the exception of Nippersink Creek at Spring Grove, which showed a decreasing trend of 10.4% per year.

NH₃-N concentrations generally showed decreasing annual and seasonal trends along the Fox main stem for at least four of the eight stations. The winter NH₃-N concentration shows larger decreasing trends ranging from 8.3% per year for Fox River at South Elgin to 21% per year for Fox River at Yorkville.

Nitrate Nitrogen

The NO₃-N concentration showed a decreasing trend in six of the eight stations in the Fox River main stem with the maximum NO₃-N reduction of 4.6% (0.028 mg/L per year for Fox River at Oakwood Hills). An increasing or no trend was detected in two of the remaining stations; Fox River at Rt. 176 showed an increasing trend of 5.1% per year (0.047 mg/L of NO₃-N). Only four tributary stations have NO₃-N concentration data, and a decreasing trend of 9.6% per year (0.066 mg/L per year) was estimated for Blackberry Creek near Mouth, which was found to be the largest decrease in NO₃-N concentrations. An increasing trend was obtained for Crystal Creek at Rt. 31 and no trend was detected for the remaining two tributary stations.

Fox River at Rt. 176 showed an increasing NO₃-N trend in fall (6.2% per year), spring (9.2% per year), and winter (67.7% per year), but no trend in summer. Its winter increasing trend amounted to 0.63 mg/L per year. No seasonal trend was obtained for Crystal Creek at Rt. 31, which showed an increasing annual trend of 2.2% (0.075 mg/L per year). All of the remaining stations on the Fox River or its tributaries exhibited either a decreasing or no trend. The largest seasonal decrease of 37.4% per year (0.258 mg/L per year) was estimated for the winter NO₃-N concentration at Blackberry Creek near Mouth. There was no seasonal trend for the most downstream station on the Fox main stem (Fox River at Yorkville), in spite of detecting a decreasing annual trend.

All stations downstream and upstream of Fox River at Rt. 176 except one exhibited decreasing trends of NO₃-N concentrations, indicating that a decreasing longitudinal trend exists. Mostly, the fall and summer longitudinal trends follow the annual trend, whereas most of the spring and winter NO₃-N concentrations showed no trend.

Total Kjeldahl Nitrogen

All eight stations along the Fox River main stem did not show a statistically significant trend in TKN concentrations, whereas five of the nine tributary stations with TKN data exhibited a decreasing annual trend ranging from 0.4% (0.004 mg/L per year) at Nippersink Creek at Spring Grove to 12.6% per year (0.015 mg/L per year) at Ferson Creek at Rt. 34. In contrast, an increasing trend of TKN concentrations by 1.8% per year (0.017 mg/L per year) was estimated for Poplar Creek near Mouth-Elgin.

With few exceptions, no seasonal TKN trend was detected for most monitoring stations in the Fox River main stem, largely conforming to that of the annual trend. A decreasing spring trend of 0.82% per year (0.012 mg/L per year of TKN) was estimated for Fox River at Montgomery. In contrast, Fox River at Oakwood Hills showed an increasing winter trend of 2.1% per year (0.036 mg/L of TKN). In the tributaries, the seasonal TKN concentration showed an increasing trend in some stations and a decreasing or no trend in others. For example, Poplar Creek near Mouth-Elgin exhibited an increasing winter trend of TKN (3.8% per year or 0.038 mg/L per year), which is the largest increasing trend estimated for TKN concentrations in the tributaries or the Fox main stem. On the other hand, the largest decreasing trend of TKN concentrations was estimated in winter for Ferson Creek at Rt. 34 at 59.6% per year (0.715 mg/L per year). Fall TKN concentrations in the Fox main stem showed no trend. In contrast, results showed decreasing trends for Flint Creek at Kelsey Rd-Lk Barrington (15.7%) and Nippersink Creek at Spring Grove (0.6%); increasing trends for Blackberry Creek at Rt. 47 (0.7%), Ferson

Creek at Rt. 34 (0.8%), and Poplar Creek near Mouth-Elgin (3.1%); and no trends for the remaining four tributary stations.

In general, no annual or seasonal longitudinal trend was detected along the Fox River. A decreasing spring trend was detected for Fox River at Montgomery, despite no trends in all the stations upstream. An increasing winter trend at Fox River at Oakwood Hills did not translate into any trend downstream.

Dissolved Oxygen

Out of the 18 gaging stations used in the trend analysis, 13 stations have 13 to 20 years of DO concentration and pH data. These include all 8 stations on the Fox River main stem and 5 on the tributaries (see Table 3). The mean DO concentration on the Fox River and its tributaries ranges from 9.2 mg/L at Crystal Creek-Rt. 31 to 11.5 mg/L at Tyler Creek at Rt. 31-Elgin. The minimum and maximum DO levels of 0.82 and 27.6 mg/L were recorded at Nippersink Creek at Spring Grove and Fox River at Johnsbury, respectively. The Fox River and its tributaries have detailed water quality standards that vary by location, season, and number of consecutive days, as presented in Table 2. The DO water quality standards can be compared with the DO time series and monthly boxplots provided for each monitoring station in Appendix A.

Annual, Seasonal, and Longitudinal Trends

The DO concentrations exhibited a decreasing trend for most stations along the Fox River watershed, with the exception of station 258 (Fox River at Oakwood Hills). In contrast, no DO trend was detected for most of the gaging stations in the summer months. However, a decreasing trend was obtained at Tyler Creek-Rt. 31 at Elgin, Blackberry Creek near Mouth, Fox River at Yorkville, and the Algonquin stations.

The annual DO levels along the Fox River main stem showed a decreasing trend in six of the eight stations with the largest decrease of 1.7% per year (0.17 mg/L per year) at the most downstream station in the Fox main stem (Fox River at Yorkville). No trend in DO levels was exhibited at Fox River at Johnsbury, and an increasing trend of 0.7% per year (0.06 mg/L per year) was estimated at Fox River at Oakwood Hills. The annual DO levels in the Fox River tributaries indicate a decreasing trend in four out of seven stations analyzed, with the largest decrease of 1.6% per year (0.15 mg/L per year) at Blackberry Creek near Mouth. However, no statistically significant trend was detected at Blackberry Creek at Rt. 47, which is located a few miles upstream in the same creek.

The DO trends vary from season to season. In summer, the DO levels show a decreasing trend in only 4 out of the 13 stations, namely, Tyler Creek at Rt. 31-Elgin, Blackberry Creek near Mouth, Fox River at Yorkville, and Fox River at Algonquin. At Fox River at Geneva, the DO levels increased by 1.4% per year (0.145 mg/L per year) during the summer. In spring, most of the stations showed a decreasing trend in DO levels. Throughout the watershed, the largest seasonal decrease of 10.2% (0.98 mg/L per year) was calculated for Blackberry Creek near Mouth in winter, whereas the smallest decrease in DO levels was 0.6% (0.05 mg/L per year) in the fall for the Fox River at South Elgin. Longitudinally along the Fox River, the annual and seasonal trend results consistently indicate that DO levels are generally declining at varying levels.

pH

All of the stations with DO data also have pH data. The mean and median pH values ranged from 7.8 to 8.5 on both the Fox main stem and tributaries, which is within the pH limit for freshwater (6.5 to 9.0). The minimum and maximum pH values of 6.0 and 13.4 were observed at Fox River at Oakwood Hills and Blackberry Creek near Mouth, respectively. All but two stations showed some violations of the pH limit. These two stations are Fox River at Oakwood Hills and Fox River at Montgomery, both located on the Fox River main stem.

Annual, Seasonal, and Longitudinal Trends

For all monitoring stations, the central tendencies of all pH values, as expressed in their mean and median values, are within the pH limits for freshwater; thus a decreasing or increasing pH trend would indicate a declining water quality. The majority of the stations on the Fox River main stem do not show any trend in pH values, as the values were stable. Decreasing pH trends were seen only at Fox River at Montgomery and Fox River at Yorkville, whereas an increasing pH trend was exhibited at Fox River at Johnsbury. Decreasing pH trends were detected at Crystal Creek-Rt. 31, Blackberry Creek near Mouth, and Blackberry Creek at Rt. 47. In contrast, increasing pH trends were seen at Tyler Creek at Rt. 31-Elgin and Ferson Creek near Mouth-Elgin.

The majority of the stations showed no seasonal trend in pH values, which also indicates stable pH values in all seasons. For the most part, the spring pH trends are in line with the annual decreasing trends. The fall pH values showed no trend for most stations, but the increasing trend in two stations (Ferson Creek near Mouth-Elgin and Fox River at Johnsbury) conforms to the annual pH trends. In summer, there was a decreasing pH trend at Fox River at Yorkville, Poplar Creek near Mouth-Elgin, and Blackberry Creek near Mouth. The winter pH values showed an increasing trend at Ferson Creek near Mouth-Elgin, whereas these values showed decreasing trends at Fox River at Montgomery and Fox River at Yorkville. For either decreasing or increasing pH trends detected, the maximum change per year was less than 1%. The pH values showed a decreasing trend downstream of the Fox River at Geneva Park-Fabyan.

Total Suspended Solids

The TSS concentration data are available for only seven stations, of which four are on the Fox main stem and three are on its tributaries. The mean TSS concentrations across these stations vary from 12.2 mg/L for Poplar Creek near Mouth-Elgin to 34.1 mg/L for Fox River at Montgomery. The minimum and maximum TSS concentrations are 1.0 and 203 mg/L, with both recorded at Blackberry Creek at Rt. 47. No water quality standard is currently available for TSS.

Annual, Seasonal, and Longitudinal Trends

Out of the four stations on the Fox River main stem with TSS data, two showed no annual TSS trend, and the remaining two downstream stations exhibited a decreasing TSS trend with a maximum reduction of 0.65 mg/L per year (2% per year) at the Fox River at Montgomery. No annual trend was seen in any of the three stations on Fox tributaries with TSS data.

No TSS trend was detected in the Fox River main stem or tributaries for fall or spring except for Fox River at Montgomery, which showed a decreasing fall trend of 2.67 mg/L per

year (8.1% per year). Increasing winter trends were detected for Fox River at Rt. 176 and Poplar Creek near Mouth-Elgin, which were 2.0 and 3.3 mg/L per year, respectively, but neither station showed an annual TSS trend. Poplar Creek near Mouth-Elgin also exhibited a decreasing summer TSS trend of 1.2 mg/L per year. An increasing trend for summer TSS concentrations was detected at Blackberry Creek at Rt. 47, but all remaining stations show no trend for the summer months.

A longitudinal TSS trend seems to appear along the Fox River because both stations downstream of Algonquin showed a reduction in TSS concentrations. The fall TSS trend conforms to the annual trend along the Fox River. No distinct longitudinal trend was observed for other seasons.

Chlorophyll-A

Only 11 out of the 18 stations have CHL-A concentration data, the majority of which are located in the Fox main stem (i.e., seven stations). The mean CHL-A concentration across these stations has a range of 95.6 µg/l with higher and lower concentrations on the Fox main stem and tributaries, respectively. The mean concentration on the main stem ranges from 81.6 µg/l at Fox River at Johnsburg to 105.3 µg/l at Fox River at Geneva. In contrast, the mean CHL-A concentration in the tributaries varies from 9.7 µg/l at Tyler Creek at Rt. 31-Elgin to 29.7 µg/l at Crystal Creek at Rt. 31. The range of CHL-A concentration on the Fox main stem and tributary stations is 478.8 µg/l, with the lowest concentration of 0.63 µg/l observed at Ferson Creek near Mouth-Elgin and Blackberry Creek near Mouth. The maximum CHL-A concentration in the tributaries is 244.4 µg/l for Crystal Creek at Rt. 31. Currently, there is no CHL-A standard for Fox River and its tributaries.

Annual, Seasonal, and Longitudinal Trends

The CHL-A concentration showed a decreasing annual trend in all seven stations with observed data in the Fox River main stem, ranging from 1.37 µg/l per year (1.7% per year) for Fox River at South Elgin to 2.87 µg/l (3.4% per year) for Fox River at Oakwood Hills. In contrast, no annual trend was detected for all four tributary stations with CHL-A records.

No trend was detected for summer CHL-A concentrations. Fall and spring trends conform to annual trends with the maximum decreasing fall trend of 4.8 µg/l per year (6% per year) for Fox River at Yorkville. Despite having no annual CHL-A trend for Ferson Creek near Mouth-Elgin, an increasing winter trend of 5.2% (0.56 µg/l) was detected. Along the Fox River, CHL-A concentrations clearly showed decreasing annual, fall, and spring trends.

Summaries of the annual, winter, spring, summer, and fall trends are presented in Tables 5 through 9, showing increasing, decreasing, no trend, or ‘-’ for no data. Furthermore, insufficient data for conducting the annual or seasonal trend analysis falls under the no data category. Improving, stable, and declining trends are shown in green, yellow, and red colors. In the tables, the stations are listed in upstream (Nippersink Creek at Spring Grove) to downstream (Blackberry Creek near Mouth) order and tributaries (in italics) appear in the order of their confluence with the Fox River (in bold).

Table 5. Annual Water Quality Trends

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	No Trend	Decreasing	-	Decreasing	-	No Trend	No Trend	No Trend	No Trend	-
1	<i>Nippersink Cr above Wonder Lake</i>	No Trend	No Trend	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	No Trend	Increasing	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Increasing	-	Decreasing
23	Fox River at Rt 176	Increasing	Increasing	-	No Trend	Increasing	No Trend	Decreasing	No Trend	No Trend	-
258	Fox River at Oakwood Hills	Decreasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	Increasing	No Trend	-	Decreasing
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	Decreasing	Decreasing	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing	-	No Trend
24	Fox River at Algonquin	No Trend	Increasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend	Decreasing
268	<i>Tyler Cr at Rt. 31-Elgin</i>	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	Decreasing	Increasing	-	No Trend
25	<i>Poplar Cr near Mouth-Elgin</i>	Increasing	Increasing	-	No Trend	-	Increasing	No Trend	No Trend	No Trend	-
26	Fox River at South Elgin	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	No Trend	Decreasing	Decreasing
14	<i>Ferson Cr at Rt 34</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	No Trend	Increasing	No Trend	Decreasing	Decreasing	No Trend	Decreasing	Increasing	-	No Trend
40	Fox River at Geneva	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	-	Decreasing
27	Fox River at Montgomery	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
34	Fox River at Yorkville	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	-	Decreasing
28	<i>Blackberry Cr at Rt 47</i>	No Trend	Decreasing	-	No Trend	-	No Trend	No Trend	Decreasing	No Trend	-
287	<i>Blackberry Cr near Mouth</i>	No Trend	No Trend	No Trend	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	-	No Trend

Note: Color code – “red” declining trend; “green” improving trend; “yellow” stable; “-” no data.

Table 6. Winter Water Quality Trends

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	No Trend	No Trend	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
1	<i>Nippersink Cr above Wonder Lake</i>	No Trend	Decreasing	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	-	No Trend	-	No Trend
23	Fox River at Rt 176	Increasing	Increasing	-	No Trend	Increasing	No Trend	No Trend	No Trend	-	-
258	Fox River at Oakwood Hills	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	-	-	-	No Trend
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	-	-	No Trend
24	Fox River at Algonquin	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing
268	<i>Tyler Cr at Rt. 31-Elgin</i>	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	No Trend	No Trend	-	-	No Trend
25	<i>Poplar Cr near Mouth-Elgin</i>	Increasing	No Trend	-	No Trend	-	Increasing	No Trend	No Trend	Increasing	-
26	Fox River at South Elgin	Decreasing	Decreasing	No Trend	Decreasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	Decreasing
14	<i>Ferson Cr at Rt 34</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing	Increasing	-	Increasing
40	Fox River at Geneva	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend	-	No Trend
27	Fox River at Montgomery	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend
34	Fox River at Yorkville	Decreasing	Decreasing	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing	-	Decreasing
28	<i>Blackberry Cr at Rt 47</i>	No Trend	Decreasing	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
287	<i>Blackberry Cr near Mouth</i>	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	Decreasing	-	-	No Trend

Note: Color code – “red” declining trend; “green” improving trend; “yellow” stable; “-” no data.

Table 7. Spring Water Quality Trends

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	No Trend	Decreasing	-	Decreasing	-	No Trend	No Trend	No Trend	No Trend	-
1	<i>Nippersink Cr above Wonder Lake</i>	No Trend	No Trend	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	No Trend	Increasing	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	-	Decreasing
23	Fox River at Rt 176	No Trend	Increasing	-	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	-
258	Fox River at Oakwood Hills	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	-	Decreasing
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	-	No Trend
24	Fox River at Algonquin	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing
268	<i>Tyler Cr at Rt. 31-Elgin</i>	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	-	No Trend
25	<i>Poplar Cr near Mouth-Elgin</i>	Increasing	Increasing	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
26	Fox River at South Elgin	Decreasing	No Trend	Decreasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend	Decreasing
14	<i>Ferson Cr at Rt 34</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	No Trend	Increasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	-	No Trend
40	Fox River at Geneva	Decreasing	Decreasing	Decreasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	-	Decreasing
27	Fox River at Montgomery	Decreasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	Decreasing
34	Fox River at Yorkville	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	Decreasing	-	Decreasing
28	<i>Blackberry Cr at Rt 47</i>	No Trend	No Trend	-	Increasing	-	No Trend	No Trend	Decreasing	No Trend	-
287	<i>Blackberry Cr near Mouth</i>	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing	Decreasing	-	No Trend

Note: Color code – “red” declining trend; “green” improving trend; “yellow” stable; “-” no data.

Table 8. Summer Water Quality Trends

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	No Trend	No Trend	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
1	<i>Nippersink Cr above Wonder Lake</i>	No Trend	No Trend	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	No Trend	Increasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	-	No Trend
23	Fox River at Rt 176	No Trend	Increasing	-	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	-
258	Fox River at Oakwood Hills	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	-	No Trend
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	-	No Trend
24	Fox River at Algonquin	No Trend	Increasing	No Trend	No Trend	Decreasing	No Trend	Decreasing	No Trend	No Trend	No Trend
268	<i>Tyler Cr at Rt. 31-Elgin</i>	No Trend	No Trend	Increasing	No Trend	No Trend	Increasing	Decreasing	No Trend	-	No Trend
25	<i>Poplar Cr near Mouth-Elgin</i>	No Trend	Increasing	-	No Trend	-	No Trend	No Trend	Decreasing	Decreasing	-
26	Fox River at South Elgin	No Trend	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend	No Trend	No Trend	No Trend
14	<i>Ferson Cr at Rt 34</i>	No Trend	-	-	No Trend	-	No Trend	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	No Trend	Increasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend	-	No Trend
40	Fox River at Geneva	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Increasing	No Trend	-	No Trend
27	Fox River at Montgomery	No Trend	No Trend	Decreasing	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	No Trend
34	Fox River at Yorkville	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	Decreasing	-	No Trend
28	<i>Blackberry Cr at Rt 47</i>	Decreasing	No Trend	-	Decreasing	-	No Trend	No Trend	No Trend	Increasing	-
287	<i>Blackberry Cr near Mouth</i>	No Trend	No Trend	Decreasing	Decreasing	Increasing	Decreasing	No Trend	No Trend	-	No Trend

Note: Color code – “red” declining trend; “green” improving trend; “yellow” stable; “-” no data.

Table 9. Fall Water Quality Trends

Station ID	Station Name	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
236	<i>Nippersink Cr at Spring Grove</i>	No Trend	No Trend	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
1	<i>Nippersink Cr above Wonder Lake</i>	No Trend	No Trend	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	Decreasing	No Trend	Decreasing	No Trend	No Trend	Decreasing	No Trend	Increasing	-	Decreasing
23	Fox River at Rt 176	No Trend	No Trend	-	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	-
258	Fox River at Oakwood Hills	Decreasing	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend	-	No Trend
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	Decreasing	No Trend	-	No Trend
24	Fox River at Algonquin	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend	No Trend	Decreasing
268	<i>Tyler Cr at Rt. 31-Elgin</i>	No Trend	No Trend	No Trend	Increasing	No Trend	No Trend	No Trend	No Trend	-	No Trend
25	<i>Poplar Cr near Mouth-Elgin</i>	Increasing	No Trend	-	No Trend	-	Increasing	No Trend	No Trend	No Trend	-
26	Fox River at South Elgin	No Trend	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend
14	<i>Ferson Cr at Rt 34</i>	No Trend	No Trend	-	No Trend	-	No Trend	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	No Trend	Increasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	Increasing	-	No Trend
40	Fox River at Geneva	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	No Trend	-	Decreasing
27	Fox River at Montgomery	Decreasing	No Trend	Decreasing	Decreasing	Decreasing	No Trend	No Trend	No Trend	Decreasing	Decreasing
34	Fox River at Yorkville	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	Decreasing	-	Decreasing
28	<i>Blackberry Cr at Rt 47</i>	No Trend	No Trend	-	No Trend	-	No Trend	No Trend	No Trend	No Trend	-
287	<i>Blackberry Cr near Mouth</i>	No Trend	No Trend	No Trend	Decreasing	Decreasing	No Trend	Decreasing	No Trend	-	No Trend

Note: Color code – “red” declining trend; “green” improving trend; “yellow” stable; “-” no data.

3.3 Weighted Regression on Time, Discharge, and Season

The Weighted Regression on Time, Discharge, and Season (WRTDS) is a relatively new emerging method developed to provide a more accurate representation of long-term trends, and seasonal and discharge-related components of long-term water quality datasets. The WRTDS method is designed to provide estimates of actual and flow-normalized water quality concentrations and fluxes (loads). Estimating the actual history of concentrations and fluxes fosters the understanding of changes occurring in the stream or river water quality and related impacts on the aquatic ecosystem. The flow-normalized concentration and flux estimates are obtained by eliminating the influences of streamflow variability on the water quality parameter of interest, and thus the flux estimates are good indicators of water quality trends, measuring progress made toward load reduction affected by management practices implemented in the watershed.

The WRTDS model considers concentration to be a product of four components, including trend, seasonal, discharge, and random components. Therefore, the model divides the water quality datasets into these four components. The trend component is essentially a moving average of the time series data, indicating the gradual change in water quality condition through the years. The seasonal component depicts the annual cycle of water quality variation that is generally consistent but can gradually change from year to year in the WRTDS. The discharge and random components take into account the flow influences on water quality and the unexplained variation in concentration, respectively. Accounting for these components, the WRTDS equation (Hirsch et al., 2010) can be expressed as

$$\ln(c) = \beta_0 + \beta_1 t + \beta_2 \ln(Q) + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t) + \varepsilon$$

where c is the concentration, Q is discharge, t is the time in years, ε is the unexplained variation, and $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are fitted coefficients that vary through the record. Unlike common approaches, this method calibrates the parameters of the equation for every combination of Q and t where estimates are required. It must be noted that the weighted regression estimation system that calculates the expected value of the concentration (c) for a given Q and t is the integral part of the WRTDS method. The relevance of each observation to an estimation point determines its weight in the regression and is defined by a distance between the observation and the estimation point in terms of discharge and time data points. This distance between an observation and estimation point has three dimensions: time distance as measured by the difference in years; seasonal distance as measured by the difference in times of year; and discharge distance as measured by the difference in the natural log of the discharges. Using these distances, corresponding weights are calculated using a Tricube weight function, and the product will be the overall weight for each data point to be used in the weighted regression. The longer the distance of an observation from an estimation point in either time, season, or discharge, the smaller the chance of that observation being a part of the regression or the lesser its importance. Hirsch et al. (2010, 2015) provides a detailed description of the WRTDS method, which is also part of the USGS's R-package, known as Exploration and Graphics for RivEr Trends (EGRET) software. In addition to implementing the WRTDS method, EGRET provides a useful tool for analyzing long-term changes in water quality and streamflow, including a data-retrieval package that is designed to accept USGS data, EPA STORET, and user-specified text files.

3.4 WRTDS Results and Discussion

Although the SKT trend analysis presented earlier provides concentration trends and estimate changes in magnitude, year-to-year variations in hydrologic conditions may have impacted trends in water quality concentrations. Actual concentration and flux histories may suggest a worsening water quality for a pollutant concentration that increases with flow for a year or two near the end of the period of record, making it hard to detect if trends exist. The WRTDS method allows computing flow-normalized concentration and fluxes where flow-driven variability is eliminated, and thus existing trends, if any, can be identified. In addition, it provides histories of both actual and flow-normalized concentrations and fluxes.

Only four stations fulfill the requirement for conducting parametric trend analysis using the WRTDS method. Three of these stations (Fox River at Montgomery, Blackberry Creek at Rt. 47, and Poplar Creek near Mouth-Elgin) have concentration data along with the corresponding flow data that extend to the year 2016. All remaining stations have either no flow data, insufficient observations (<100 samples), or missing (discontinuous) discharge data, which are required to develop a WRTDS model. For nine of the ten nutrient-related water quality parameters, except pH, WRTDS models were developed. Fox River at Montgomery has all nine water quality parameters, whereas Blackberry Creek at Rt. 47 and Polar Creek at Elgin have only five of the nine parameters, excluding Org-N, NO₃-N, TSS, and CHL-A. In total, 19 WRTDS models were developed that account for the highly variable nature of water quality concentrations as a function of time, discharge, and season. The models were used to evaluate both flow-normalized concentrations and flux histories for the 19 water quality parameters obtained across the three stations.

In a WRTDS model, a flow-normalized concentration on a specific day is calculated as an integral part of the fitted estimates of concentration (i.e., a function of discharge and time) multiplied by the probability density function (pdf) of the discharge for that day of the year. When there are long-term data, the historical discharge sample data could be used in place of the pdf, as was the case in this study. For example, Fox River at Montgomery has 20 years of TP concentration data from 1997 to 2016 but has discharge data for only 14 of the 20 years from water year 2003 to 2016. To estimate a flow-normalized TP concentration and flux for any given date, say for January 1, 2003, all 14 of the January 1 discharge values in the dataset are assumed to have likely occurred on the estimation date (January 1, 2003). The WRTDS model then estimates 14 values of TP concentration for January 1, 2003, using each of the 14 January 1 discharge values, but with the time variable set to the estimation date. The mean of these 14 estimated TP concentration values will be the flow-normalized TP concentration. Similarly, the flow-normalized flux is computed as the product of the flow-normalized TP concentration and mean daily flow for the estimation date. Consequently, trends in concentration may not necessarily imply trends in flux because days of high discharges could strongly affect flux trends, but they have little influence on concentration trends. For percentage changes in concentration and flux to be the same, the changes in concentration across all ranges of discharge and for all seasons need to be identical. In WRTDS, trends are not restricted as being linear or monotonic, and thus the trends could be different across seasons and flows.

The 19 WRTDS models developed using concentration-discharge relationships were examined using graphical comparisons and computations of model biases, exploring the performance of the fitted model. For the Fox River at Montgomery, the output of the WRTDS model for TP is presented using eight panel graphics in Figure 7, showing the quality of the fitted

WRTDS model. The first four panels show WRTDS residuals (i.e., observed minus estimated values of concentration in natural log units, $\ln(c)$) as a function of estimated concentrations in natural log units, discharge, date, and months, respectively. For a good quality model, the WRTDS residuals need to be approximately symmetrical around the zero value line; in the case of the boxplot, the zero line is expected to pass through the middle of the boxes. In addition, these residuals should not show any substantial curvature in the first three panels, which would indicate either an over-prediction or under-prediction if the residuals are negative or positive, respectively. In this case, the TP WRTDS model residuals seem to be symmetrical around the value of zero with no apparent curvature. If there were single or multiple events that profoundly affected the TP concentration during the period of analysis, the third panel, which shows residuals versus time, would have shown these events. The fourth panel showing residuals versus the boxplot of concentration by month indicates that the model is accounting for seasonal differences in the TP concentration at Fox River at Montgomery because the boxes are symmetrical around the value of zero for nearly all months. The fifth panel, which shows a figure consisting of three boxplots of concentration based on sample day values, sample day estimates, and all day estimates, indicates a good performing model with nearly identical median and interquartile ranges of concentrations and similar distribution. It must be noted that the width of the boxplots is proportional to the square root of the sample size and thus, a wider boxplot for all of the day estimates is to be expected. The scatter plot of observed versus estimated concentration shown in panel six is clustered and symmetrical around the 1:1 line with no substantial departures from that line, indicating the model's good performance. The seventh panel shows boxplots of discharge values during sampled days and all days, providing insight into the distribution of discharges in the sampled days. In this case, the two boxplots being equivalent indicates that the TP sampling appears to cover ranges of discharges, which is particularly important in the estimation of fluxes and flux trends. The last and eighth panel is a scatter plot of observed versus estimated TP fluxes on all sampled days. Since the dots appear to be symmetrical around the 1:1 line, there is a close match between observed and estimated TP fluxes.

A flux bias statistic, which is defined as the difference between the sums of estimated and observed fluxes on all sampled days divided by the sum of estimated fluxes, is computed for TP at Fox River at Montgomery to be 0.0193 (an average error of 1.93% in flux estimates). The absolute flux bias statistic for all remaining water quality parameters, including DP, Org-N, $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, TKN, and TSS at Fox River at Montgomery, is below 0.065, except for CHL-A, which is calculated to be 0.166. For Blackberry Creek at Rt. 47 and Poplar Creek near Mouth-Elgin, the absolute flux bias for TP and TKN was found to be below 0.085, whereas it ranges between 0.2 to 0.4 for DP and $\text{NH}_3\text{-N}$ fluxes. A significant amount of the DP and $\text{NH}_3\text{-N}$ concentration data (20 to 35% of the sample data) for these two stations is below the detection limit and thus is incorporated as censored data in the model. As a result, larger biases were obtained and this poor model performance needs to be taken into account when examining DP and $\text{NH}_3\text{-N}$ concentration and flux estimates and trends in these two stations. Next, the WRTDS analysis results are presented for each monitoring station.

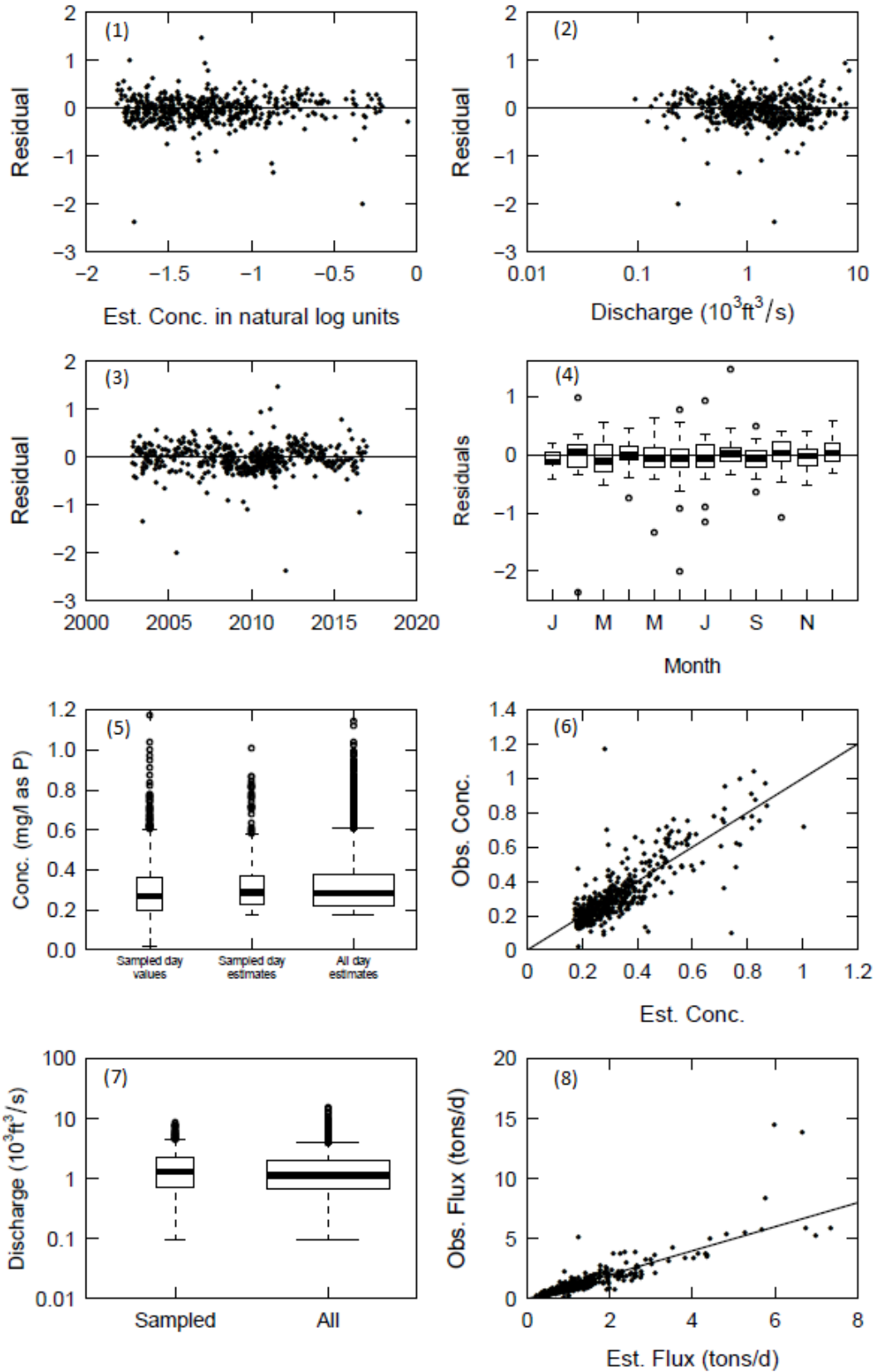


Figure 7. WRTDS model output for total phosphorus (TP) at Fox River at Montgomery

Trends in Flow-normalized Concentration

Annual and seasonal trends in flow-normalized concentration are estimated for Fox River at Montgomery, Blackberry Creek at Rt. 47, and Poplar Creek near Mouth-Elgin between 2006 and 2016. Changes in flow-normalized concentrations in milligrams per liter (mg/L) and percent (%) are presented in Tables 10 and 11, respectively. The annual values are based on a water year, which starts in October and ends in September of the following year, and the four seasons are winter (December to February), spring (March to May), summer (June to August), and fall (September to November).

The result of concentration trend analysis using the WRTDS method indicates that the flow-normalized concentrations of almost all water quality parameters analyzed showed decreasing trends across all seasons from 2006 to 2016 for Fox River at Montgomery, with the exception of spring TSS and summer CHL-A concentrations. Large concentration decreases at this station were obtained in summer for DP, NH₃-N, and NO₃-N; in winter for TP, TSS, and CHL-A; and in spring for DO, Org-N, and TKN. Unlike other water quality parameters, a decreasing DO concentration at Fox River at Montgomery across all seasons is indicative of a declining water quality trend. The changes in annual TP and DP concentrations between 2006 and 2016 are 27% and 28%, respectively, showing the largest decreases as compared to the remaining water quality parameters. In contrast, the decrease in the annual TKN, DO, and TSS concentrations was less than 10%.

For the two tributary monitoring stations (Blackberry Creek at Rt. 47 and Poplar Creek near Mouth-Elgin), NH₃-N concentrations exhibited the largest annual and seasonal increasing trends. TP, DP, and DO concentrations for Blackberry Creek at Rt. 47 showed decreasing annual and seasonal trends, except in fall for DO and in summer for TP and DO. Across all seasons, the TKN concentration at this station increased from 1.7% in winter to 38% in summer with an average annual decrease of 23% between 2006 and 2016. For Poplar Creek near Mouth-Elgin, the DP and DO concentrations show improving water quality trends across all seasons. For all three monitoring stations, the seasonal concentration trends largely conform to the annual trends.

Figure 8 illustrates the annual phosphorus and nitrogen trend results for Fox River at Montgomery, showing average annual and seasonal flow-normalized concentrations. Note that the dots in the figure represent the actual values of annual mean concentration, whereas the flow-normalized concentration is represented by a line. In this figure, although all concentrations show decreasing trends, there are differences between them. For example, the decrease in NO₃-N for the Fox River at Montgomery is more pronounced after 2010, as evidenced by a steeper slope in flow-normalized concentration, and the reverse is true for NH₃-N.

All annual and seasonal trend results for the remaining water quality parameters and the two tributary stations are included in Appendix D.

Table 10. Changes in Flow-normalized Concentrations (mg/L) between 2006 and 2016

Station ID	Station Name		TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	TSS	CHL-A
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	1.900	-0.650	-	0.081	-	19.000	12.000	-	-
		Winter	0.091	-0.009	-	0.084	-	38.000	0.570	-	-
		Spring	0.019	-0.008	-	0.051	-	11.000	0.800	-	-
		Summer	-0.005	-0.013	-	0.140	-	-0.007	0.570	-	-
		Fall	0.063	-0.018	-	0.055	-	0.810	0.620	-	-
27	Fox River at Montgomery:	Annual	-0.099	-0.054	-0.180	-0.019	-0.390	-0.130	-1.000	-3.500	-0.011
		Winter	-0.110	-0.048	-0.110	-0.041	-0.400	-0.190	-1.900	-2.600	-0.012
		Spring	-0.059	-0.024	-0.260	-0.003	-0.290	-0.140	-1.100	1.100	-0.023
		Summer	-0.093	-0.069	-0.210	-0.008	-0.340	-0.050	-0.300	-1.400	0.008
		Fall	-0.120	-0.076	-0.070	-0.023	-0.570	-0.110	-0.820	-9.400	-0.011
28	<i>Blackberry Cr at Rt 47:</i>	Annual	0.011	0.017	-	0.280	-	-0.200	-0.088	-	-
		Winter	0.027	0.040	-	0.410	-	-0.010	-0.260	-	-
		Spring	0.024	0.019	-	0.400	-	-0.390	-0.880	-	-
		Summer	-0.012	0.002	-	0.230	-	-0.410	0.014	-	-
		Fall	0.004	0.009	-	0.100	-	-0.010	0.840	-	-

Note: "red" declining trend; "green" improving trend; "-" no data

Table 11. Percent Changes in Flow-normalized Concentrations between 2006 and 2016

Station ID	Station Name		TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	TSS	CHL-A
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	51	-35	-	109	-	52	3.8	-	-
		Winter	168	-60	-	59	-	110	4.1	-	-
		Spring	28	-35	-	99	-	22	7.2	-	-
		Summer	-5.3	-24	-	293	-	-0.73	7.2	-	-
		Fall	82	-65	-	99	-	92	6.3	-	-
27	Fox River at Montgomery:	Annual	-27	-28	-11	-23	-20	-7.7	-8.7	-9.6	-10
		Winter	-34	-23	-11	-31	-13	-16	-12	-15	-35
		Spring	-21	-22	-18	-4.3	-14	-9.2	-9.4	3	-28
		Summer	-22	-32	-9.2	-15	-38	-2.2	-3.4	-2.6	4.2
		Fall	-29	-31	-4	-31	-32	-5.9	-7.4	-25	-8.7
28	<i>Blackberry Cr at Rt 47:</i>	Annual	12	43	-	405	-	-23	-0.85	-	-
		Winter	42	161	-	382	-	-1.7	-1.9	-	-
		Spring	27	73	-	502	-	-34	-8.1	-	-
		Summer	-9.3	2.1	-	531	-	-38	0.18	-	-
		Fall	5.7	25	-	222	-	-1.6	8.8	-	-

Note: "red" declining trend; "green" improving trend; "-" no data

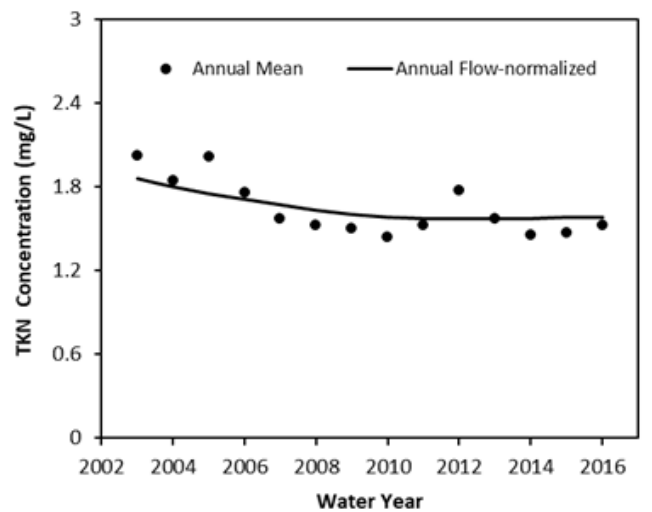
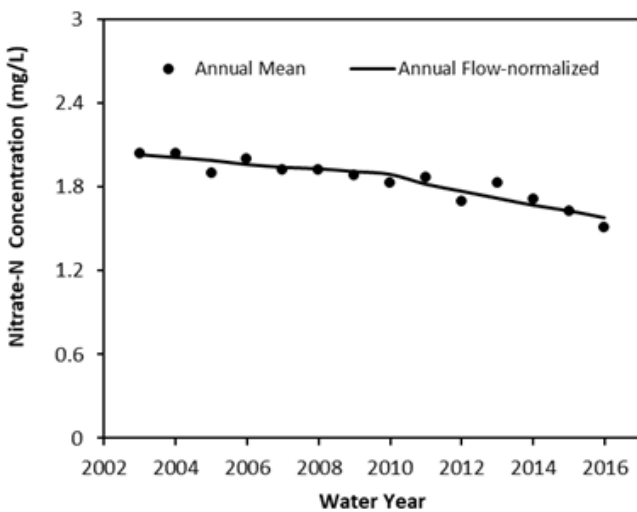
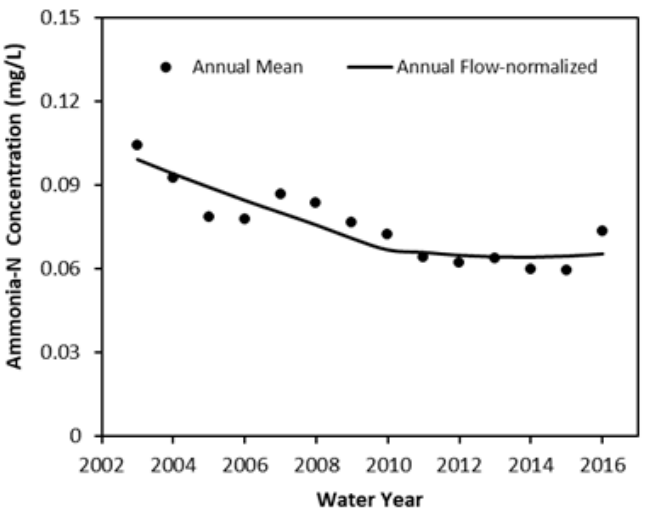
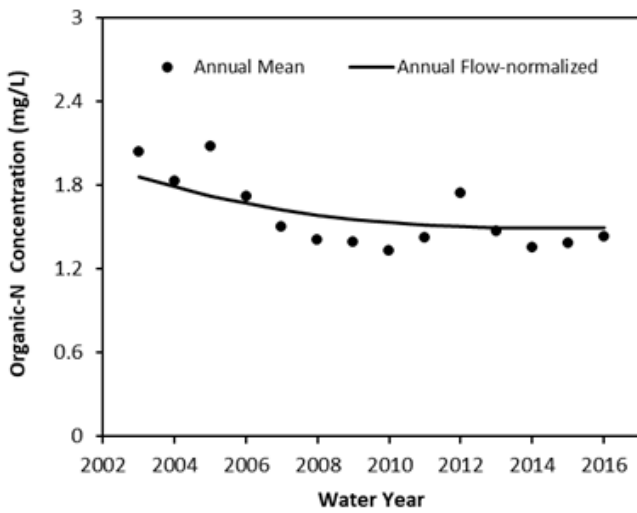
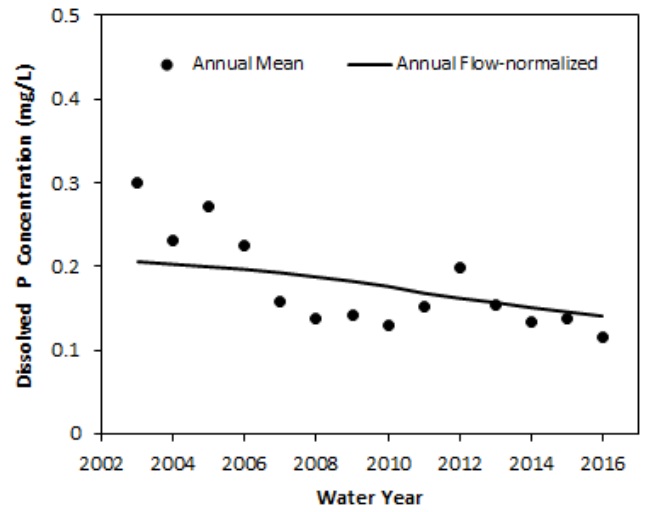
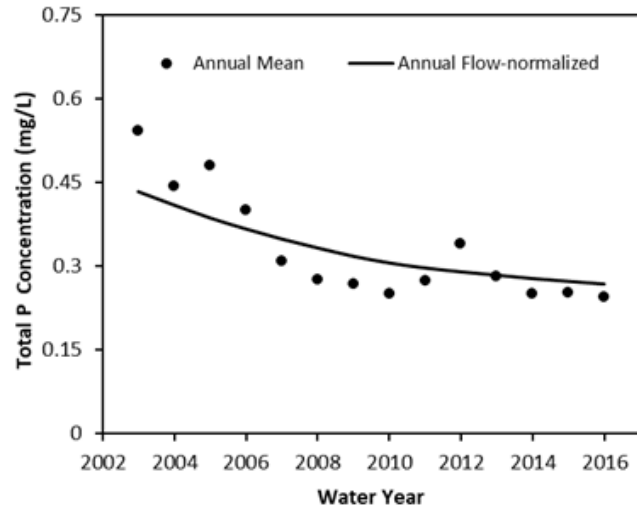


Figure 8. Actual and flow-normalized phosphorus and nitrogen concentrations for Fox River at Montgomery

Trends in Flow-normalized Flux

For the same water quality parameters, with the exception of DO, annual and seasonal trends in flow-normalized fluxes are also estimated for the three monitoring stations between 2006 and 2016. Changes in flow-normalized fluxes in pounds per year (lbs/yr) and percent (%) are presented in Tables 12 and 13, respectively.

Flow-normalized fluxes (loads) of most water quality parameters decreased across all seasons from 2006 to 2016 for the Fox River at Montgomery. An upward trend occurring around 2009-2010 was obtained only for spring fluxes of ammonia nitrogen (NH₃-N) and TSS and summer fluxes of CHL-A during the same period. In comparison with other water quality parameters, flow-normalized fluxes of TP and DP show a larger decrease across all seasons between 2006 and 2016. A similar downward trend of nitrate nitrogen (NO₃-N) fluxes were obtained for Fox River at Montgomery in the summer and fall months. For Fox River at Montgomery, the flow-normalized fluxes show a decreasing annual trend ranging from 6.3% for TSS (a difference of 8.49×10^6 lbs/yr between the 2006 and 2016 fluxes) to 25% (108×10^3 lbs/yr) for DP. From 2006 to 2016, the downward annual trends for TKN, CHL-A, and TSS fluxes were found to be less than 10%. The DP fluxes decreased by 20% to 31% across all seasons and similarly, the TP fluxes consistently reduced across all seasons by 16% to 30% with an average annual decrease of 20% (200.6×10^3 lbs/yr). All nutrient fluxes showed decreasing annual and seasonal trends, with the exception of the NH₃-N flux in spring that seemed to exhibit a slightly increasing trend (0.1% or 400 lbs/yr). A maximum upward trend of 6.7% (24.3×10^3 lbs/yr) from 2006 to 2016 was detected for the CHL-A flux in the summer. The TSS flux also increased by 4.2% (8.2×10^6 lbs/yr) in the spring. The maximum percentage change in flow-normalized fluxes was obtained for NO₃-N in the fall, which was 32% (1.13×10^6 lbs/yr). The 2016 summer NO₃-N flux also showed a large decrease in 2016 of 28% from that of 2006.

Trend analysis results showing actual and flow-normalized phosphorus and nitrogen fluxes for Fox River at Montgomery are illustrated in Figure 9. All annual and seasonal trend results for the remaining water quality parameters and the two tributary stations are included in Appendix D. Although the seasonal trends conform to annual trends in most cases, there are differences in seasonal and annual trends for some of the water quality parameters. For example, the spring NH₃-N flux showed a downward trend until 2009, followed by an upward trend thereafter. However, it exhibited a decreasing trend in summer, fall, and winter seasons that stabilized in the later years, conforming to the annual trend. Similarly, the TSS flux showed a downward trend, followed by an upward trend in spring. Although there is a difference in percentage changes, the flux and concentration trends are largely similar for this station (i.e., they are in the same downward or upward direction). The only difference observed was between spring NH₃-N concentration and flux, which showed opposing trends. The NH₃-N concentration decreased by 4.3% between 2006 and 2016, whereas its fluxes increased by 0.1% during the same time, showing that concentration trends do not necessarily translate into flux trends.

For Blackberry Creek at Rt. 47 and Poplar Creek near Mouth-Elgin, the WRTDS models were developed for five nutrient-related water quality parameters, namely NH₃-N, TKN, TP, and DP. All flow-normalized fluxes with few exceptions show larger upward trends for these two stations. The DP and TKN fluxes exhibited decreasing annual and seasonal trends for Poplar Creek near Mouth-Elgin and Blackberry Creek at Rt. 47, respectively. The NH₃-N, TKN, and TP fluxes for Poplar Creek near Mouth-Elgin showed increasing trends across all seasons from 2006 to 2016, ranging from 11% for summer TKN to 118% for fall TP fluxes. For this same station,

large increases of 51% to 118% were obtained for TKN and TP fluxes that are similar across all seasons. For this station, only DP fluxes showed a downward trend across all seasons ranging from 29% in winter to 41% in spring with an annual downward trend of 35% (1.43×10^3 lbs/yr). In contrast, for Blackberry Creek at Rt. 47, flow-normalized fluxes for $\text{NH}_3\text{-N}$, TP, and DP showed an upward trend across all seasons from 2006 to 2016. The maximum annual increase of 163% (24.3×10^3 lbs/yr) was obtained for the $\text{NH}_3\text{-N}$ flux, which is over a 100% increase across all seasons. Unlike Poplar Creek near Mouth-Elgin, both TP and DP showed a similar upward trend across all seasons ranging from 4.8% to 92% for TP and from 13% to 68% for DP fluxes. For this station, decreasing trends of TKN fluxes ranging from 0.04% in winter to 26% in summer were detected, with the exception of fall months that exhibited an upward trend of 2.7% in the TKN flux from 2006 to 2016.

Table 12. Changes in Flow-normalized Fluxes ($\times 10^3$ lbs/yr) between 2006 and 2016

Station ID	Station Name		TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	TSS	CHL-A
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	4.2	-1.4	-	1.5	-	41.9	-	-
		Winter	6.6	-1.0	-	2.9	-	83.8	-	-
		Spring	1.4	-1.8	-	1.1	-	24.3	-	-
		Summer	1.4	-2.1	-	1.4	-	8.6	-	-
		Fall	8.2	-0.9	-	0.6	-	63.9	-	-
27	<i>Fox River at Montgomery:</i>	Annual	-200.6	-108.0	-533.5	-39.7	-1009.7	-381.4	-8492.2	-22.0
		Winter	-229.3	-99.2	-231.5	-81.6	-1097.9	-463.0	-7149.6	-18.3
		Spring	-202.8	-88.2	-1051.6	0.4	-1155.2	-463.0	8218.8	-70.5
		Summer	-165.3	-132.3	-619.5	-22.0	-751.8	-229.3	-9352.0	24.3
		Fall	-176.4	-110.2	-103.6	-55.8	-1128.8	-280.0	-21550.2	-16.5
28	<i>Blackberry Cr at Rt 47:</i>	Annual	6.6	4.9	-	24.3	-	-19.2	-	-
		Winter	13.4	11.9	-	26.5	-	-0.04	-	-
		Spring	9.3	4.6	-	46.3	-	-44.1	-	-
		Summer	0.8	1.4	-	16.5	-	-35.3	-	-
		Fall	3.3	1.9	-	5.1	-	1.4	-	-

Note: "red" declining trend; "green" improving trend; "-" no data

Table 13. Percent Changes in Flow-normalized Fluxes between 2006 and 2016

Station ID	Station Name		TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	TSS	CHL-A
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	51.0	-35.0	-	21.0	-	52.0	-	-
		Winter	105.0	-29.0	-	22.0	-	110.0	-	-
		Spring	13.0	-41.0	-	12.0	-	22.0	-	-
		Summer	16.0	-36.0	-	46.0	-	11.0	-	-
		Fall	118.0	-30.0	-	19.0	-	99.0	-	-
27	Fox River at Montgomery:	Annual	-21.0	-25.0	-11.0	-14.0	-16.0	-7.8	-6.3	-8.8
		Winter	-30.0	-21.0	-8.2	-22.0	-13.0	-14.0	-13.0	-21.0
		Spring	-16.0	-20.0	-15.0	0.1	-11.0	-6.4	4.2	-20.0
		Summer	-16.0	-31.0	-11.0	-12.0	-28.0	-4.0	-4.7	6.7
		Fall	-25.0	-29.0	-3.5	-2.9	-32.0	-8.7	-26.0	-8.7
28	<i>Blackberry Cr at Rt 47:</i>	Annual	43.0	46.0	-	163.0	-	-15.0	-	-
		Winter	92.0	68.0	-	108.0	-	-0.04	-	-
		Spring	48.0	57.0	-	190.0	-	-20.0	-	-
		Summer	4.8	13.0	-	277.0	-	-26.0	-	-
		Fall	37.0	32.0	-	198.0	-	2.7	-	-

Note: “red” declining trend; “green” improving trend; “-” no data

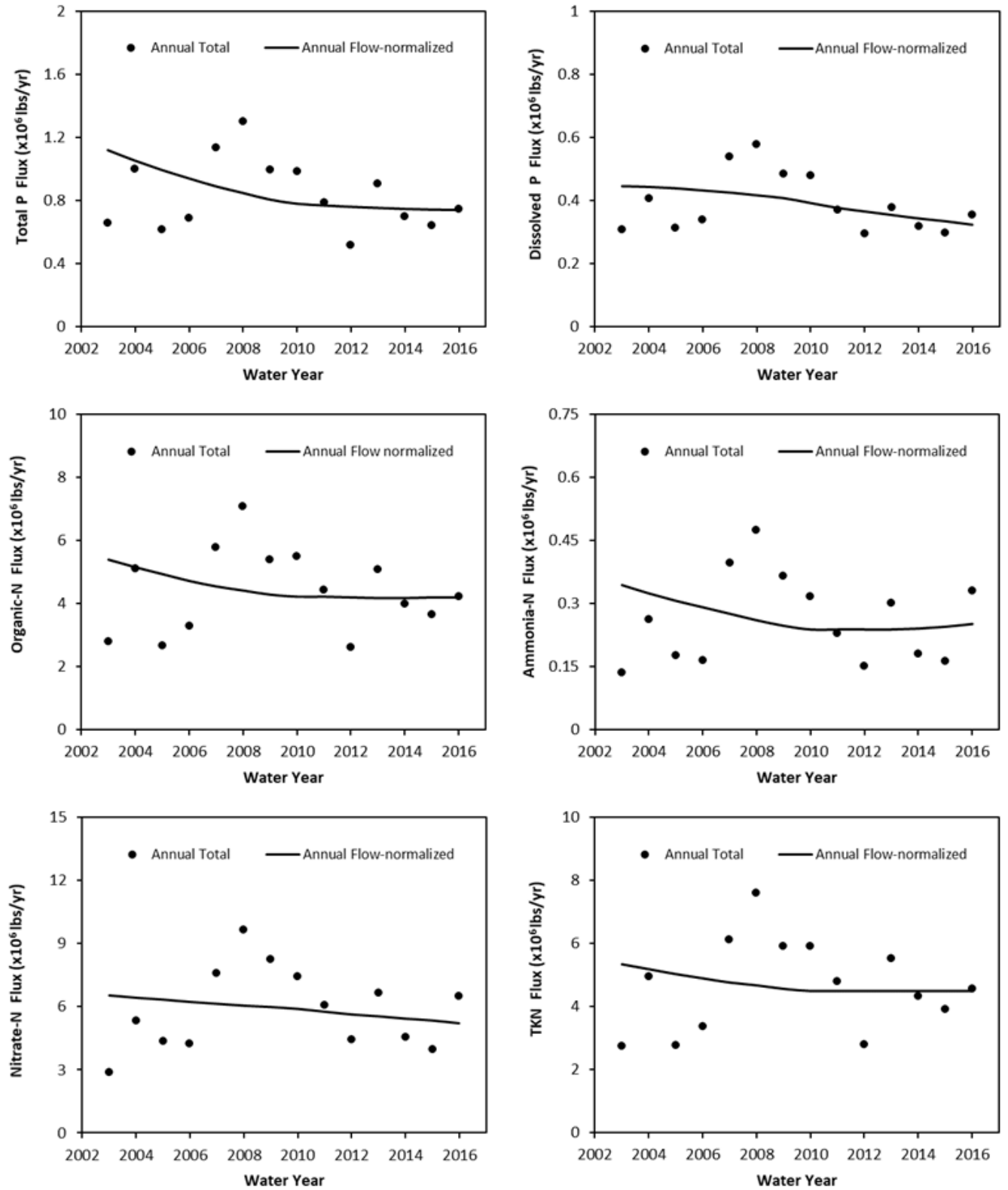


Figure 9. Actual and flow-normalized phosphorus and nitrogen fluxes for Fox River at Montgomery

3.5 Streamflow Durations and Trends

In addition to the water quality trends, selected streamflow statistics were evaluated for the periods of water quality data in an effort to characterize the annual and seasonal flow histories for the three monitoring stations. Figure 10 illustrates the annual and seasonal discharges in cubic feet per second (cfs) for Fox River at Montgomery, Poplar Creek near Mouth-Elgin, and Blackberry Creek at Rt. 47. The mean discharge for Fox River at Montgomery during the 2003-2016 period is 44.61 cfs with the minimum and maximum annual discharges occurring in 2003 and 2008, respectively. For Poplar Creek near Mouth-Elgin and Blackberry Creek at Rt. 47, the mean discharges for the period from 1997 to 2016 were 0.98 and 1.62 cfs, respectively. For both stations, the maximum annual discharges occurred in 2009, whereas the minimum annual discharges were obtained in 2006 for Poplar Creek near Mouth-Elgin and in 2003 for Blackberry Creek at Rt. 47. In all three stations, spring discharges were higher, whereas fall discharges were lower with few exceptions (e.g., 2008 fall discharges in the tributaries shown in green color).

Flow durations and trends (e.g., changes in mean, 7-day minimum, and 1-day maximum flows) were examined using continuous flow records available for periods of analysis. These streamflow statistics help provide insight into multi-year hydrologic variability and its potential influence on increasing or decreasing constituent concentrations and/or fluxes. However, to explicitly attribute the change in water quality trends to changes in hydrologic factors, the extent of other potential factors that affect water quality, such as conservation efforts, land use changes, and so forth, should also be examined.

Annual and seasonal flow durations were calculated as percentiles of flow exceedance for five periods of analysis, which include annual (October to September), fall (September to October), winter (December to February), spring (March to May), and summer (June to August). The 50th percentile flow represents the median flow value for the period of analysis (e.g., summer median flow), and it is the flow value that is exceeded 50% of the time over the period of analysis. Similarly, the 25th and 75th percentile flows are flow values that are less than or equal to the 25% and 75% of flows for each of the five periods of analysis, respectively. The range between the 25th and 75th percentiles, which is also called as interquartile range (IQR), represents 50% of the flow duration and provides insight into the distribution of the flow records, characterizing variations in flow values during the period of analysis. The smaller or larger the IQR is, the smaller or larger the variation in streamflow will be. To compare the IQRs for different periods of analysis, a coefficient of variation (COV) is calculated as a measure of the dispersion in flow values of interest.

Table 14 provides the annual and seasonal streamflow duration and the IQR and COV results for one station in the Fox main stem and two in the tributaries. The annual median flows for Poplar Creek near Mouth-Elgin, Fox River at Montgomery, and Blackberry Creek at Rt. 47 are 15.1, 1150, and 32.7 cfs, respectively. For all three stations, the largest median flow occurred in the spring season, whereas the smallest values were calculated for summer, except for Blackberry Creek at Rt. 47. The IQR is the highest in spring for all stations, indicating the flow variability in that season. However, in comparison to annual and other seasonal values, the spring season shows the smallest flow variations, as indicated in the lowest COV values. The largest flow variation occurred in the summer season for all stations, as evidenced by the largest COV values for each station.

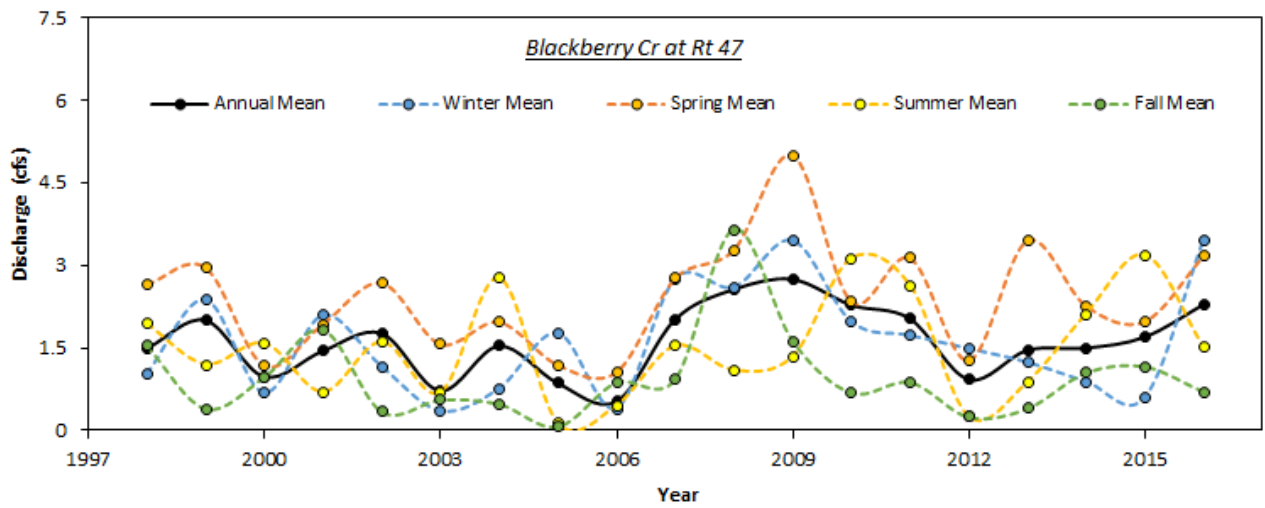
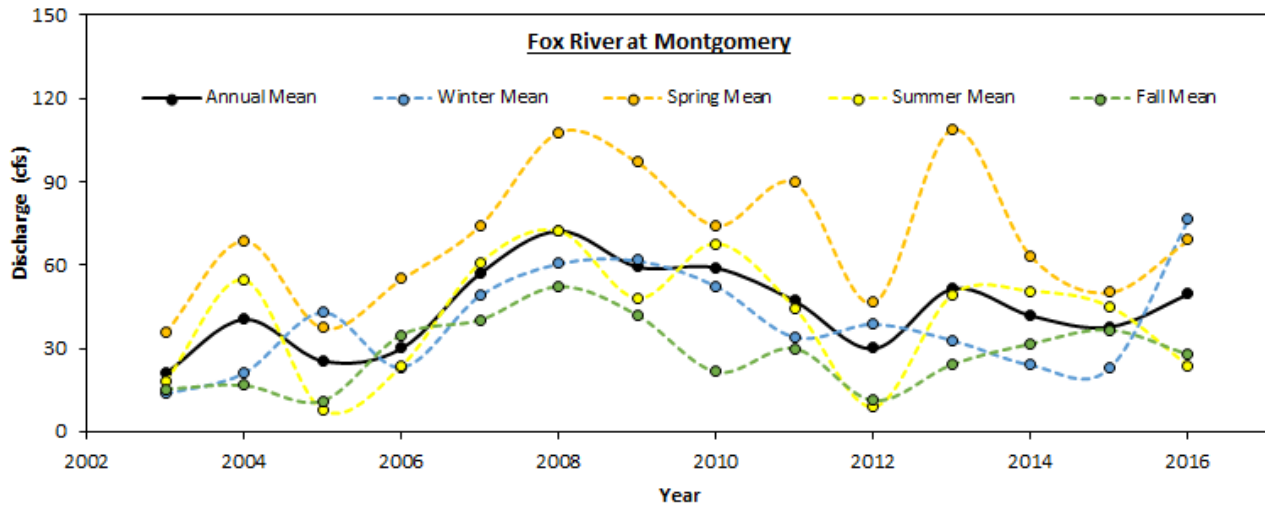
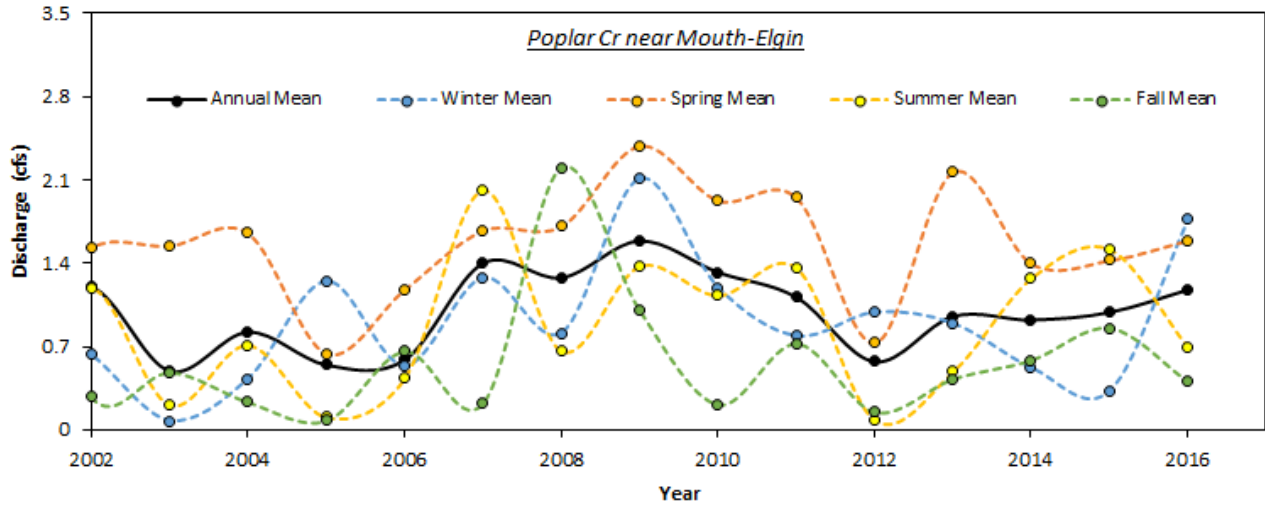


Figure 10. Annual, winter, spring, summer, and fall mean discharges for the three monitoring stations

Annual and seasonal trends of selected streamflow statistics, including mean, 7-day minimum, and 1-day maximum flows, are calculated to evaluate their changes through the years as they relate to water quality. It must be noted that the annual 1-day maximum flow is not identical to the annual peak discharge, which represents the instantaneous maximum discharge value for the year. The difference between the 1-day maximum and annual peak discharges is larger for smaller streams since the discharge could change from a very low to an annual maximum value in a given day. The mean provides the central tendency of the multi-year hydrologic variability. The minimum and maximum flow trends may help explain part of the increase or decrease in constituent concentration and fluxes.

Table 14. Annual and Seasonal Flow Durations (cubic-feet per second, cfs)

Station ID	Station Name	min	5%	10%	25%	50%	75%	90%	95%	max	IQR	COV	
25	<i>Poplar Cr near Mouth-Elgin:</i>	Period of analysis (1997-2016)											
		Annual	0.51	1.63	2.6	5.99	15.1	33.1	78.1	134	1400	27.11	1.8
		Winter	0.58	2.4	3.46	7.2	14.7	31.6	74	127	928	24.4	1.7
		Spring	0.7	7.4	11.7	19	29.9	55.1	123	176	1050	36.1	1.2
		Summer	0.56	1.29	1.79	3.88	9.31	24.4	60.5	111	1020	20.52	2.2
		Fall	0.51	1.3	1.85	3.64	8.07	18.5	39.6	78.6	1400	14.86	1.8
27	<i>Fox River at Montgomery:</i>	Period of analysis (2002-2016)											
		Annual	95.8	258	430	666	1150	2040	3280	4120	15500	1374	1.2
		Winter	243	440	500	707	1100	1770	2760	3310	8940	1063	1.0
		Spring	248	704	908	1430	2190	3210	4260	5260	14600	1780	0.8
		Summer	95.8	209	287	544	917	1850	3310	4550	13200	1306	1.4
		Fall	99.6	209	245	538	800	1230	1760	2170	15500	692	0.9
28	<i>Blackberry Cr at Rt 47:</i>	Period of analysis (1997-2016)											
		Annual	0.32	5.8	9.3	16.8	32.7	64.1	118	178	1970	47.3	1.4
		Winter	3.23	10.2	12	17.4	31.5	60.2	127	202	1600	42.8	1.4
		Spring	8.18	17.3	23.8	39	60.7	96.9	157	225	1530	57.9	1.0
		Summer	0.73	4.4	7.01	14.1	28	57	109	161	1030	42.9	1.5
		Fall	0.32	3.23	5.43	10.8	19.5	33.8	58.8	88.2	1970	23	1.2

For all five periods of analysis, changes in mean, 7-day minimum, and 1-day maximum flows between 2006 and 2016 in percent and cubic-feet per day are presented in Tables 15 and 16, respectively. The results presented in the figures and tables indicate that the mean and 7-day minimum flows exhibit an increasing trend with varying magnitudes across all seasons except for the spring 7-day minimum flow, which showed a 1.5% decrease between 2006 and 2016. Generally, the annual and seasonal 7-day minimum flows seem to show larger changes during the period of analysis, ranging from 32% for Blackberry Creek at Rt. 47 in winter to at least 108% for the Fox River at Montgomery and Poplar Creek near Mouth-Elgin in a climate year. The annual and seasonal 1-day maximum flows show increasing trends for Blackberry Creek at Rt. 47. In contrast, for Poplar Creek near Mouth-Elgin, the 1-day maximum flow exhibits a decreasing trend in winter, spring, and fall seasons, whereas its annual and summer values have increased.

Table 15. Changes in Selected Streamflow Statistics (cfs) between 2006 and 2016

Station ID	Station Name		7-day minimum	Mean	1-day Maximum
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	0.0015	0.005	0.035
		Winter	0.0032	0.0059	-0.012
		Spring	0.0015	0.0054	-0.0097
		Summer	0.0018	0.0078	0.071
		Fall	0.002	0.00094	-0.0076
27	Fox River at Montgomery:	Annual	0.25	0.47	1.1
		Winter	0.4	0.5	0.43
		Spring	0.56	0.59	0.54
		Summer	0.22	0.34	1.6
		Fall	0.27	0.29	-0.045
28	<i>Blackberry Cr at Rt 47:</i>	Annual	0.0032	0.012	0.22
		Winter	0.0049	0.011	0.022
		Spring	-0.00039	0.014	0.096
		Summer	0.0049	0.013	0.034
		Fall	0.0056	0.0045	0.011

Note: “blue” increasing flow trend; “orange” decreasing flow trend

Table 16. Percent Changes in Selected Streamflow Statistics between 2006 and 2016

Station ID	Station Name		7-day minimum	Mean	1-day Maximum
25	<i>Poplar Cr near Mouth-Elgin :</i>	Annual	109	16	6.5
		Winter	87	23	-6.2
		Spring	18	11	-3
		Summer	84	37	39
		Fall	86	5.9	-5.8
27	Fox River at Montgomery:	Annual	108	35	16
		Winter	79	45	15
		Spring	80	28	11
		Summer	65	32	49
		Fall	98	37	-1.7
28	<i>Blackberry Cr at Rt 47:</i>	Annual	53	24	39
		Winter	32	25	9.5
		Spring	-1.5	18	25
		Summer	52	34	16
		Fall	75	19	10

Note: “blue” increasing flow trend; “orange” decreasing flow trend

In Figures 11, 12, and 13, the streamflow statistics including 7-day minimum, mean, and 1-day maximum flow are plotted for Poplar Creek near Mouth-Elgin, Fox River at Montgomery, and Blackberry Creek at Rt. 47, respectively. The streamflow statistics are calculated as water depths over the drainage area of the monitoring stations and are expressed in units of millimeters per day (mm/d) for plotting purposes. This value can be converted to inches per day by dividing the values by 25.4 (1 inch = 25.4 mm). The circles and lines in the figures represent the streamflow statistics and their smoothed version (i.e., the locally weighted streamflow statistics). The smoothed version provides insight into streamflow trends by focusing on multi-year variability and changes in its central tendencies of these three streamflow statistics. It must be noted that the annual 7-day minimum is computed for a climate year (April to March), whereas the mean and 1-day maximum flow statistics are calculated for a water year (October to September). Using a climate year for low flow statistics avoids counting individual drought events twice in consecutive water years since a water year is bounded by typically low-flow months. The drainage areas of the monitoring stations in square miles are 1,732 for Fox River at Montgomery, 35.2 for Poplar Creek near Mouth-Elgin, and 70.2 for Blackberry Creek at Rt. 47.

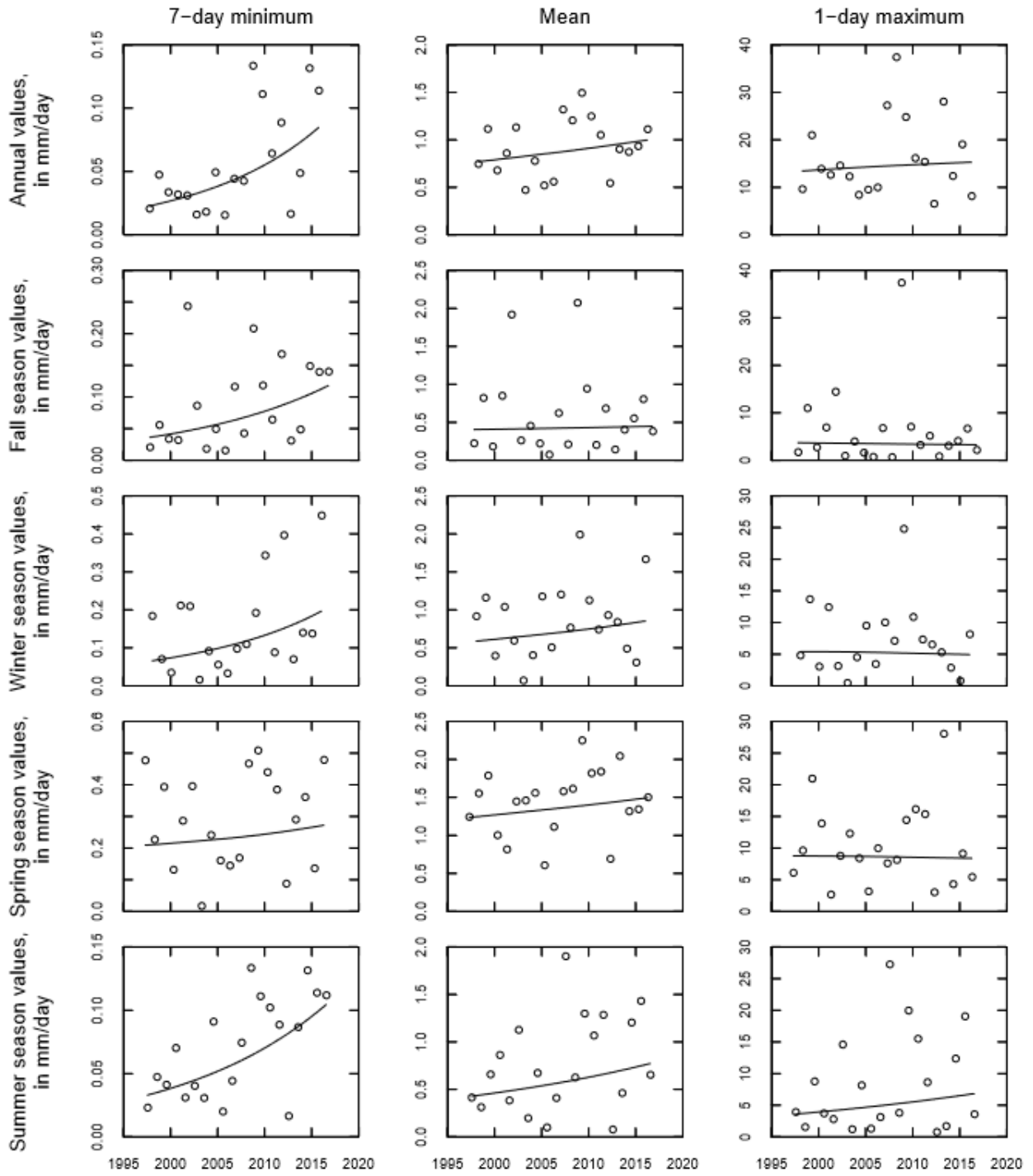


Figure 11. Annual and seasonal flow statistics for Poplar Creek near Mouth-Elgin

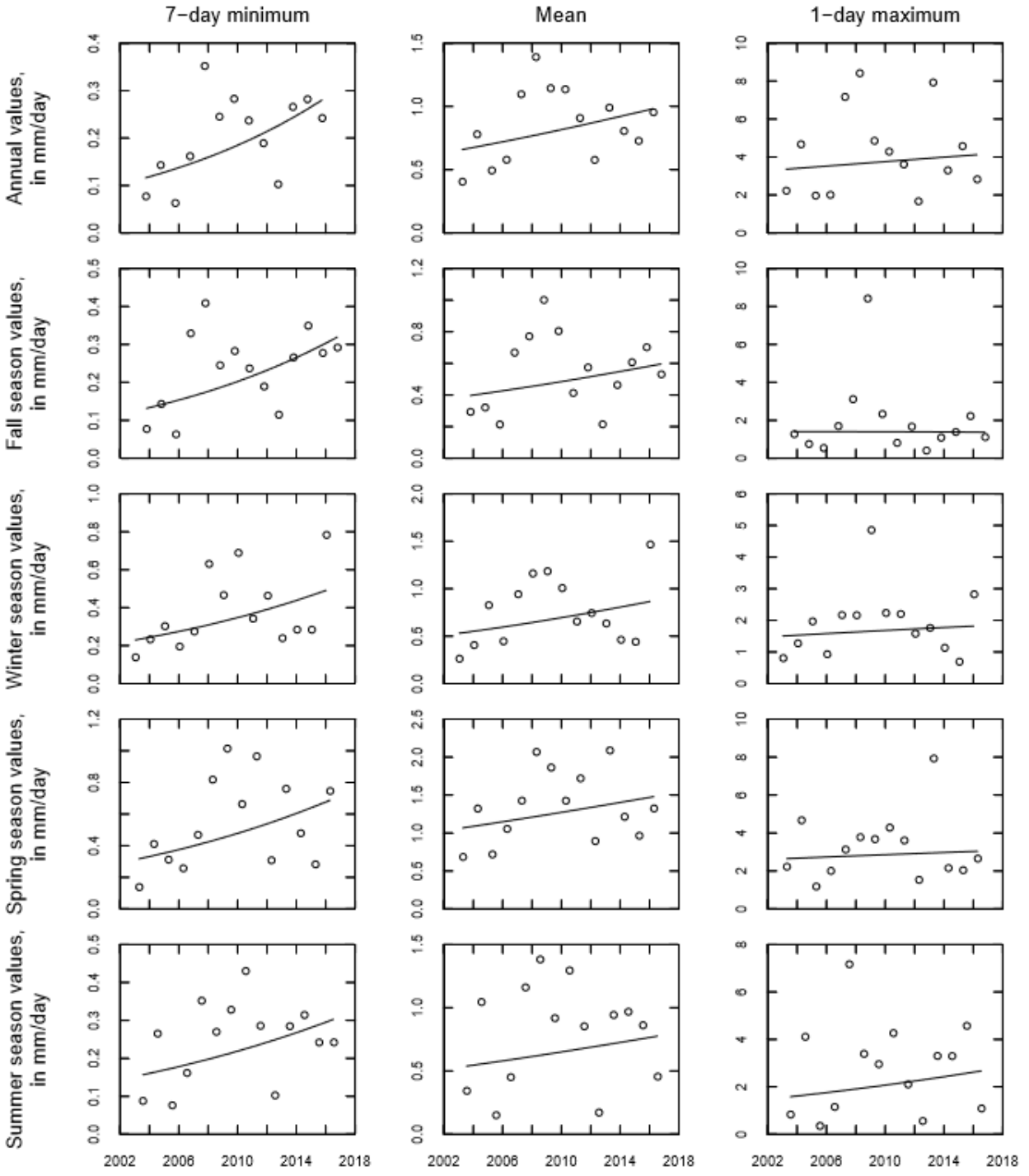


Figure 12. Annual and seasonal flow statistics for Fox River at Montgomery

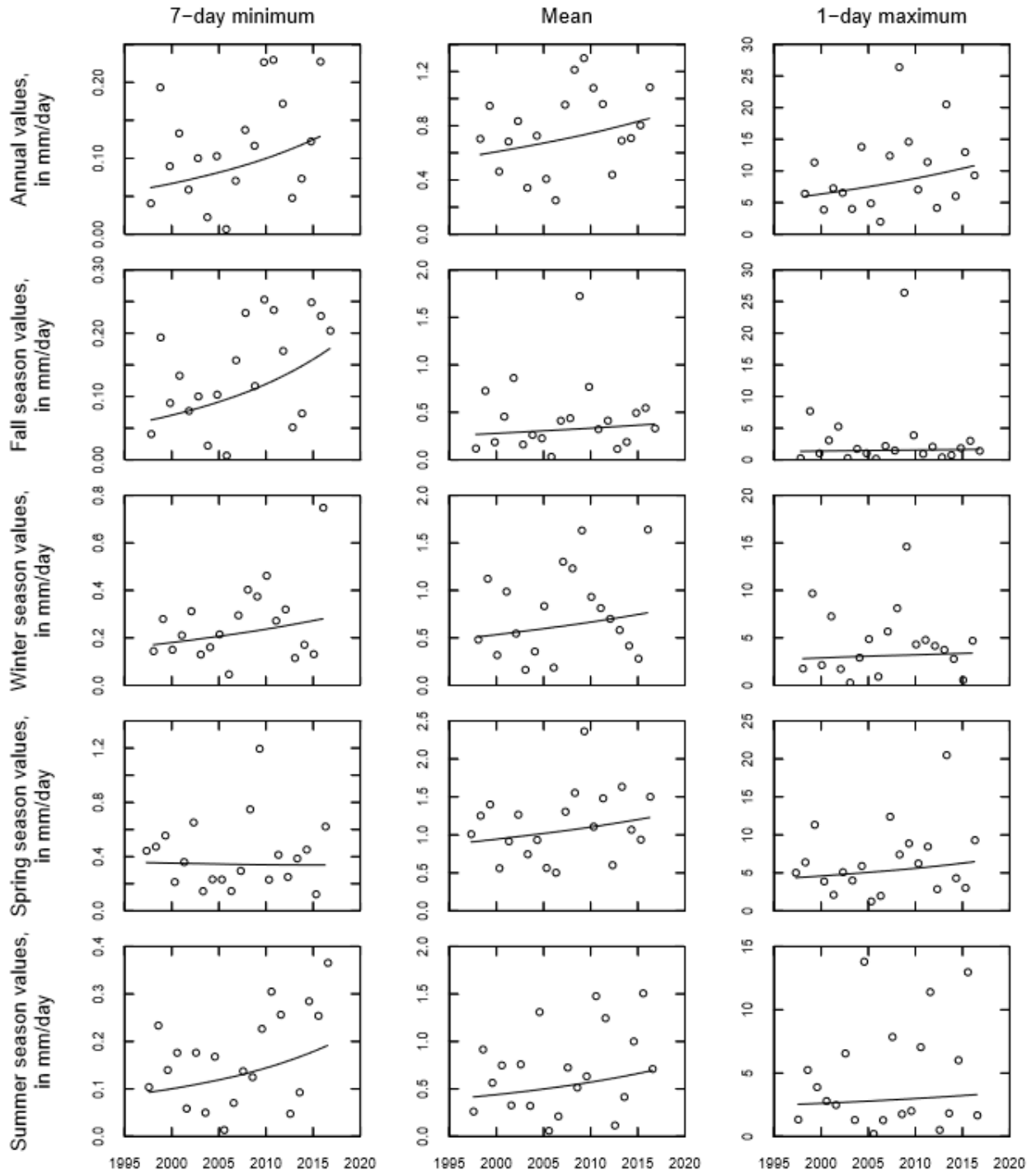


Figure 13. Annual and seasonal flow statistics for Blackberry Creek at Rt. 47

4. Summary

In this study, a trend analysis was conducted for nutrient-related water quality parameters obtained from 18 monitoring stations located in the Fox River main stem and tributaries. Exploratory data analysis (EDA) was performed for a total of 141 water quality parameters across the 18 monitoring stations to better understand the underlying characteristics of the water quality data. Based on the EDA analysis, the core method of analysis selected was the Seasonal Kendall Test (SKT) for trends. The EnvStats software R-package, which includes the SKT method as one of its algorithms, was used to perform the trend analysis based on data of water quality concentrations at each of the monitoring stations. A trend analysis for pH was also conducted. The trend analysis involved preparing computer codes using the R program with the EnvStats library of codes. Using the codes, selected water quality data were directly extracted from the FoxDB, which is the database containing all water quality and related data obtained from various agencies. In addition to the trend analysis for concentrations and pH using the SKT method, a trend analysis of water quality concentrations and fluxes (loads) using a parametric model was conducted for three stations (one Fox River main stem and two tributary stations), which have not only the long-term concentration data, but also the corresponding continuous daily discharge data. The analysis was performed using the Weighted Regression on Time, Discharge, and Season (WRTDS) method, and a total of 19 WRTDS models were developed using concentration and flow data across the three stations.

For all monitoring stations, the SKT trend analysis generally showed that most of the nutrient-related water quality parameters exhibit either a decreasing or no trend across all seasons. No upward annual trend was exhibited for organic nitrogen (Org-N), ammonia nitrogen, total suspended solids (TSS), or chlorophyll-A (CHL-A) at any of the monitoring stations. At the most downstream station on the main stem (Fox River at Yorkville), no increasing trend was detected, with most of the water quality parameters showing a decreasing trend across all seasons. Most of the upward trend was detected for dissolved phosphorus (DP), particularly in spring and summer months. In contrast, total phosphorus (TP) showed an increasing annual trend only for the Poplar Creek near Mouth-Elgin station. For more than half of the stations, the pH showed an upward or no trend. All water quality parameters exhibited a decreasing longitudinal trend downstream of the Fox River at Algonquin.

The results of the trend analysis conducted using the WRTDS method generally indicate that flow-normalized concentration and fluxes (loads) of most water quality parameters decreased across all seasons from 2006 to 2016 for the Fox River at Montgomery. A few exceptions were the concentration and fluxes of TSS in spring and CHL-A in summer, which showed increasing trends. Although there is a difference in the percentage changes, the flux and concentration trends are largely similar for this station (i.e., they are in the same downward or upward direction). The only difference observed was between the spring NH₃-N concentration and its corresponding flux, which showed opposing trends, indicating that concentration trends are not necessarily informative of flux trends. Large decreases in summer DP, NH₃-N, and NO₃-N; winter TP, TSS, and CHL-A; and spring for DO, Org-N, and TKN concentrations were obtained for the Fox River at Montgomery station. A decreasing trend in concentration across all seasons, unlike for DO, is indicative of an improving water quality trend. In comparison with other water quality parameters, flow-normalized fluxes of TP and DP also showed larger decreases across all seasons between 2006 and 2016. A similar downward trend of nitrate nitrogen (NO₃-N) fluxes were obtained in the summer and fall.

For the two tributaries (Blackberry Creek at Rt. 47 and Poplar Creek near Mouth-Elgin) most of the water quality concentrations and fluxes showed larger upward trends with a few exceptions. NH₃-N concentrations exhibited the largest annual and seasonal increasing trends at both stations. Concentrations of TP, DP, and DO showed decreasing annual and seasonal trends for Blackberry Creek at Rt. 47, except in fall for DO and in summer for TP and DO concentrations. For Poplar Creek near Mouth-Elgin, the DP and DO concentrations showed improving water quality trends across all seasons. The flow-normalized DP and TKN fluxes exhibited decreasing annual and seasonal trends for Poplar Creek near Mouth-Elgin and Blackberry Creek at Rt. 47, respectively. The seasonal concentration trends largely conform to the annual trends for all three monitoring stations.

In addition to water quality trends, flow durations and trends of selected streamflow statistics, including mean, 7-day minimum, and 1-day maximum flows, were calculated to evaluate their changes through the years as they relate to water quality. The flow durations allow characterizing the ranges of flows in the river that are common or extreme during an entire year or season. The results indicate that the highest and lowest flow variability occurred in summer and spring, respectively. The mean flow provides information about the central tendency of the multi-year hydrologic variability, whereas the minimum and maximum flow trends may explain part of the increase or decrease in constituent concentration and fluxes. However, to explicitly attribute the change in water quality trends to some changes in hydrologic factors, the extent of other potential factors influencing water quality, such as conservation efforts, land use changes, etc., also need to be examined. For all three stations, low flow appears to be increasing. Between 2006 and 2016, the mean and 7-day minimum flows exhibited an increasing trend with varying magnitudes across all seasons except for the spring 7-day minimum flow. Generally, the annual and seasonal 7-day minimum flows seemed to show large increases during the period of analysis. The annual and seasonal 1-day maximum flows showed increasing trends for Blackberry Creek at Rt. 47. In contrast, for Poplar Creek near Mouth-Elgin, the 1-day maximum flow exhibited a decreasing trend in winter, spring, and fall seasons, whereas its annual and summer values had increased.

5. Recommendations for Future Work

The majority of the water quality monitoring stations do not have corresponding flow data and, as a result, WRTDS models based on concentration and discharge relationships were developed only for water quality parameters in the three stations. However, flow estimates for most of these stations can be generated using the current Fox River watershed modeling efforts using (Hydrologic Simulation Program – Fortran (HSPF). A similar watershed model was previously developed by ISWS for the entire Fox River watershed including the Wisconsin portion. The hydrologic model was developed using Soil and Water Assessment Tool (SWAT), which is a physically-based, basin-scale model, to assess the impacts of potential climate change on water supply availability in the Fox River watershed (Bekele (Getahun) and Knapp, 2010; Bekele (Getahun) and Knapp, 2009). With additional modeling efforts, the SWAT-based Fox River watershed model can also be used to generate flow estimates for the water quality monitoring stations. A comparison between flow estimates of HSPF and SWAT could help in understanding the uncertainties in the estimates, thereby selecting the best flow estimates for use in WRTDS model development. The development of WRTDS models for those stations with longer water quality data allows estimating flow-normalized concentration and flux trends, complementing the current trend analysis. The additional modeling efforts for the SWAT-based Fox River watershed model can be further leveraged to include water quality components that would allow an evaluation of best management practices (e.g., scenarios proposed in the Illinois Nutrient Loss Reduction Strategy) in reducing nonpoint source pollution. Finally, by updating the FoxDB at least every three years, a meaningful trend analysis can be conducted that will provide insight into the water quality status of the Fox River and its tributaries.

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Appendices

This report includes four appendices that are compiled as a separate document. The appendices are:

Appendix A – Selected Outputs of Exploratory Data Analysis

Appendix B – Summary Statistics of the Water Quality Parameters

Appendix C – Water Quality Trend Maps

Appendix D – Annual and Seasonal Trends of Flow-normalized Concentration and Fluxes

Appendix A - Selected Outputs of the Exploratory Data Analysis

Table A.1 Water Quality Parameters Analyzed by Monitoring Stations

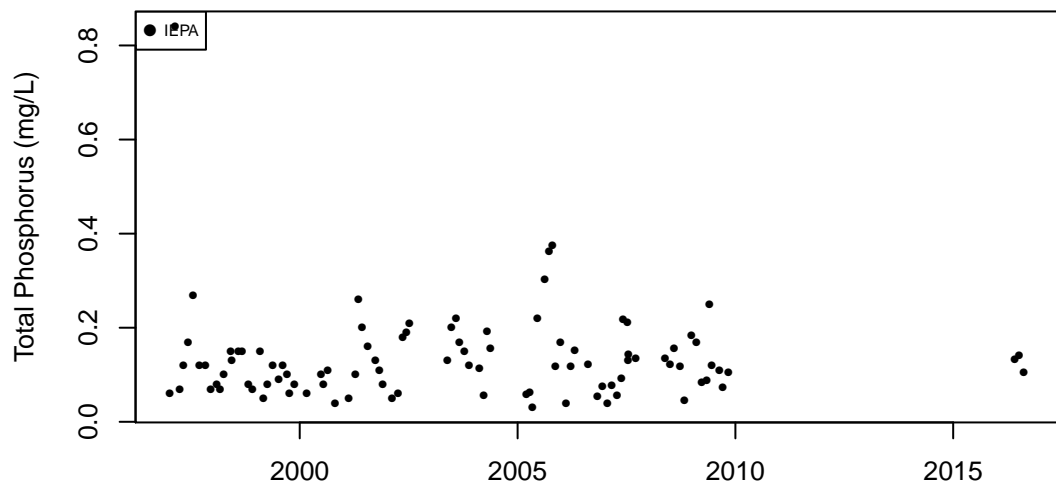
Station ID	Station name	Water quality parameters by Station									
236	<i>Nippersink Cr at Spring Grove</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
1	<i>Nippersink Cr above Wonder Lake</i>	TP	DP	-	-	-	-	-	-	-	-
184	Fox River at Johnsburg	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
23	Fox River at Rt 176	TP	DP	-	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	-
258	Fox River at Oakwood Hills	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
4	<i>Flint Cr at Kelsey Rd-Lk Barrington</i>	TP	DP	-	NH ₃ -N	-	TKN	-	-	-	-
271	<i>Crystal Cr at Rt 31</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
24	Fox River at Algonquin	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
268	<i>Tyler Cr at Rt. 31-Elgin</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
25	<i>Poplar Cr near Mouth-Elgin</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
26	Fox River at South Elgin	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
14	<i>Ferson Cr at Rt 34</i>	TP	DP	-	NH ₃ -N	-	TKN	-	-	-	-
79	<i>Ferson Cr near Mouth-Elgin</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
40	Fox River at Geneva	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
27	Fox River at Montgomery	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	TSS	CHL-A
34	Fox River at Yorkville	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A
28	<i>Blackberry Cr at Rt 47</i>	TP	DP	-	NH ₃ -N	-	TKN	DO	pH	TSS	-
287	<i>Blackberry Cr near Mouth</i>	TP	DP	Org-N	NH ₃ -N	NO ₃ -N	TKN	DO	pH	-	CHL-A

Note: Stations are in upstream-to-downstream order, and are in bold for Fox River main stem and in italics for tributaries.

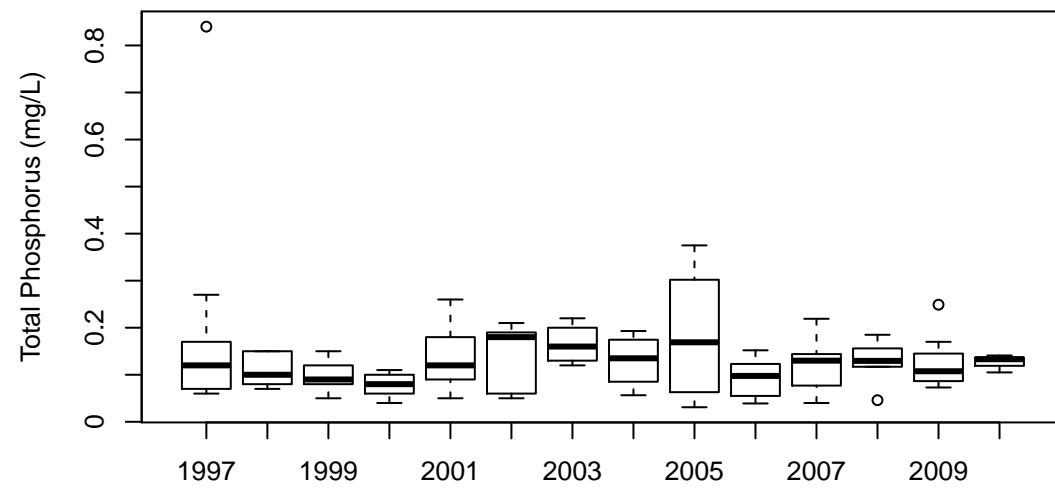
Table A.2 Fox River Water Quality Standards

Water Quality Parameter	Existing Water Quality Standards for Fox River and its tributaries in Illinois	Other Water Quality Standards & Criteria
Total P (TP)	None	<ul style="list-style-type: none"> • Illinois lakes > 20 acres, including the Chain O'Lakes and other lakes within the Fox River watershed shall not exceed 0.05 mg/L (see Part 302.205) • The Wisconsin portion of the Fox River has a phosphorus standard of 0.1 mg/L (available at https://dnr.wi.gov/topic/SurfaceWater/phosphorus.html) • Ecoregional criterium for Region VI Corn Belt and N Great Plains: 0.07625 mg/L (https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)
Dissolved P (DP)	None	
Organic-N (Org-N)	None	
Ammonia N (NH ₃ -N)	<ul style="list-style-type: none"> • Total NH₃-N must in no case exceed 15 mg/L. • Acute standard is dependent on pH. Mean pH values in the Fox River range from 7.85 to 8.48. The acute standard at pH 8.2 is 5.73 mg/L. • Chronic standard differs for periods when Early Life Stage is present (March-October) and absent. It is dependent on temperature and pH. For pH 8.2, the Early Life Stage present value at 24C is 0.97 mg/L. For pH 8.2, the Early Life Stage absent value at 10C is 2.40 mg/L. The 30-day average concentration must not exceed the chronic standard except in those waters in which mixing is allowed. 	<ul style="list-style-type: none"> • The most recent 2013 USEPA criterion document recognizes the sensitivity of freshwater mussels to ammonia levels. These new standards have not yet been adopted in Illinois. For pH 8.2 and 24C, the acute criterion is 1.9 mg/L (1-hour average). For pH 8.2 and 24C, the chronic criterion is 0.44 mg/L (30-day rolling average). Not to be exceeded more than 1 in 3 years on average. (https://www.epa.gov/wqc/aquatic-life-criteria-ammonia)
Nitrate N (NO ₃ -N)	<ul style="list-style-type: none"> • Public and food processing water supply standard. Waters of the State are generally designated for public and food processing use: 10 mg/L 	
TKN	None	
Total N (= TKN+NO ₃ -N)	None	<ul style="list-style-type: none"> • USEPA recommends 2-6 mg/L of Total N. (https://www.epa.gov/sites/production/files/2015-09/documents/totalnitrogen.pdf) • Ecoregional criterium for Region VI Corn Belt and N Great Plains: 2.18 mg/L. (See https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)
Dissolved Oxygen (DO)	<ul style="list-style-type: none"> • All waters except enhanced DO stretch below: Mar-July: not less than 5.0 mg/L at any time, 6.0 as daily mean avg'd over 7 days. Aug-Feb: not less than 3.5 mg/L at any time, 4.0 as daily minimum avg'd over 7 days, 5.5 as daily mean avg'd over 30 days. • Enhanced DO stretch (LAT/LONG): 41° 37' 3.7194"/-88° 33' 21.0162" to 41° 45' 59.5296"/-88° 18' 36.0858" Mar-July: not less than 5.0 mg/L at any time, 6.25 as daily mean avg'd over 7 days. Aug-Feb: not less than 4.0 mg/L at any time, 4.5 as daily minimum avg'd over 7 days, 6.0 as daily mean avg'd over 30 days. 	
pH	6.5 to 9.0	
TSS	None	
Cholorophyll-A (CHL-A)	None	<ul style="list-style-type: none"> • Ecoregional criterium for Region VI Corn Belt and N Great Plains: 2.70 µg/L. (https://www.epa.gov/nutrient-policy-data/ecoregional-criteria)

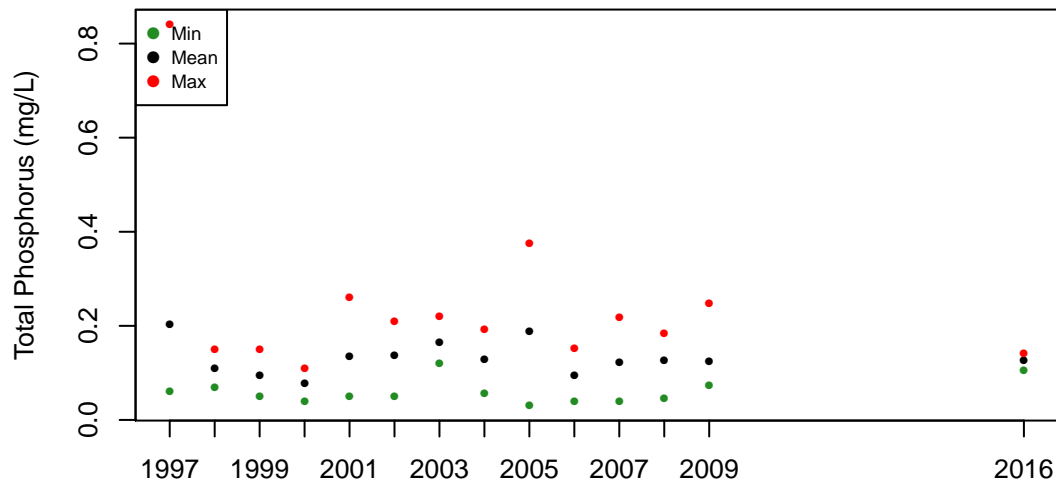
Nippersink Cr at Spring Grove (236): Total Phosphorus (mg/L)



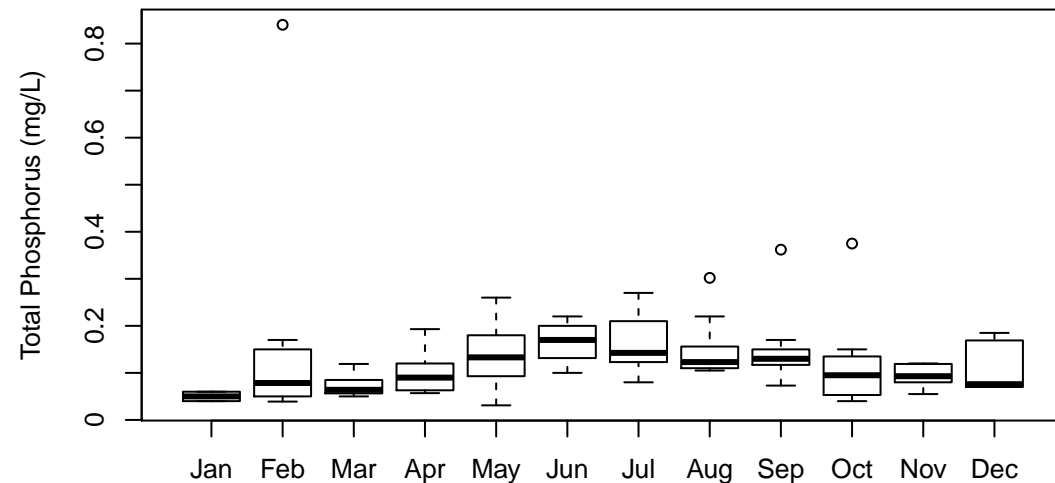
(a) Observation data



(b) Boxplot by year

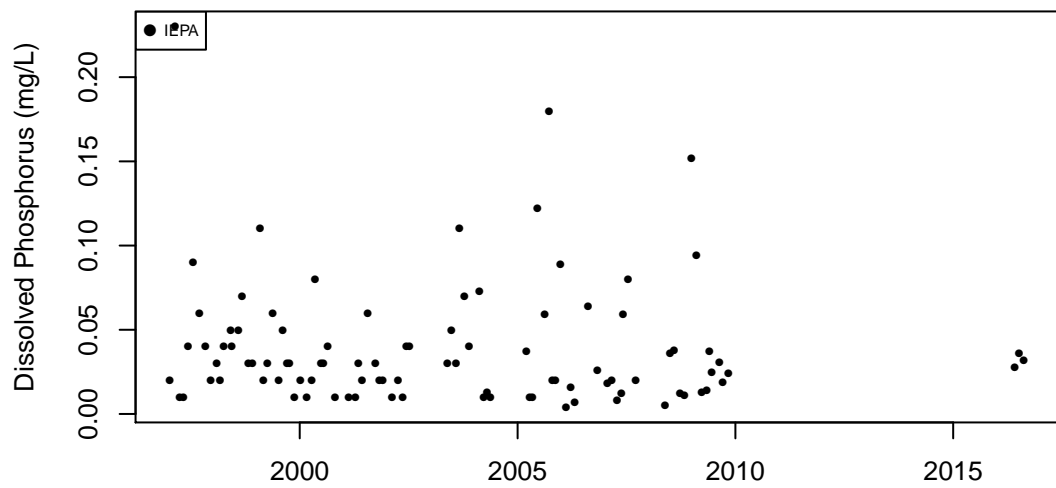


(c) Annual values

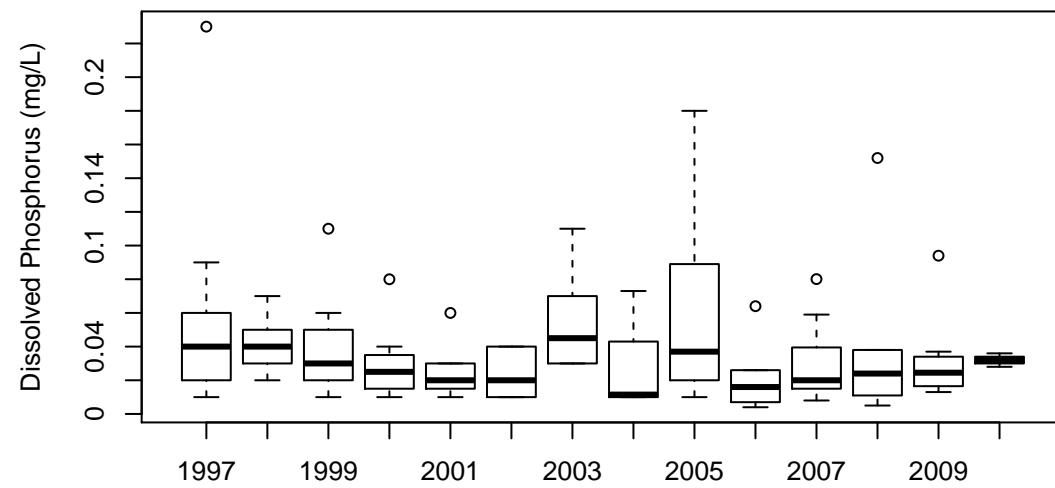


(d) Boxplot by month

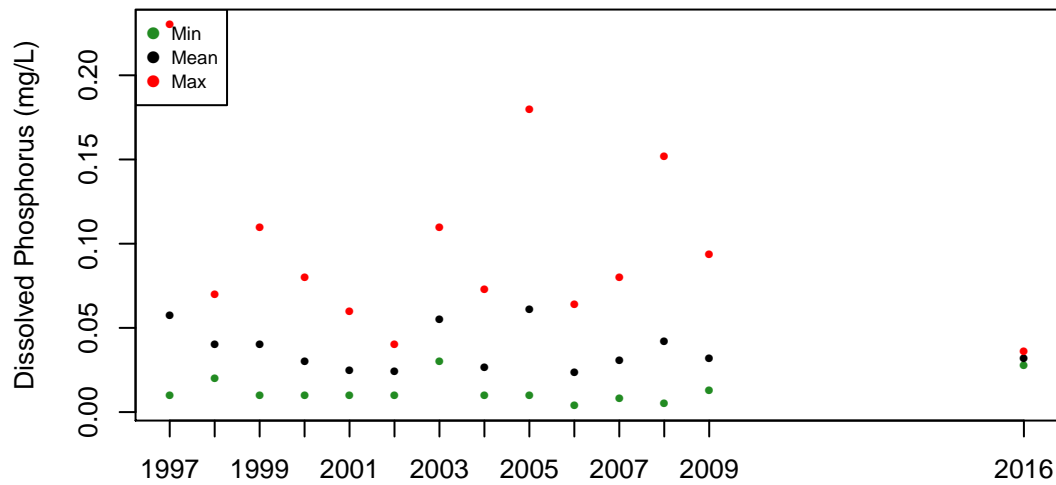
Nippersink Cr at Spring Grove (236): Dissolved Phosphorus (mg/L)



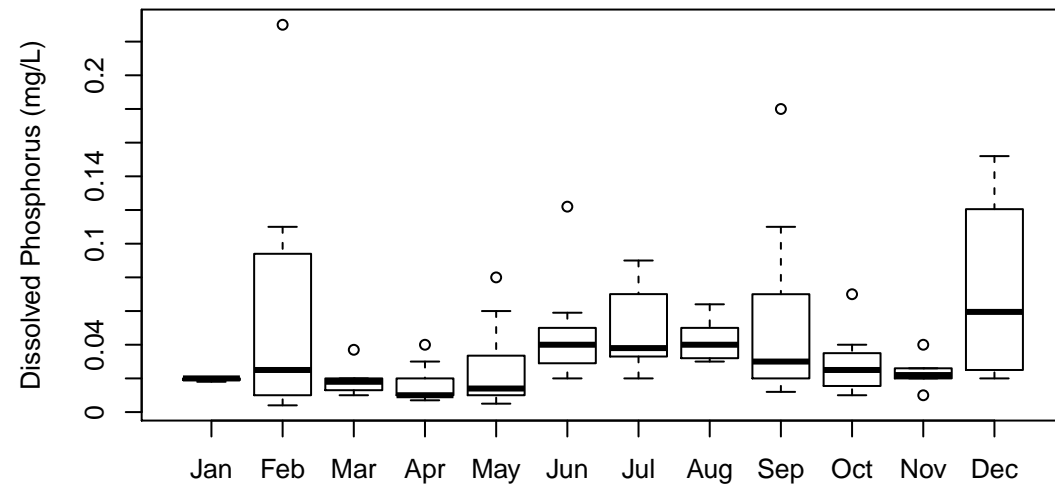
(a) Observation data



(b) Boxplot by year

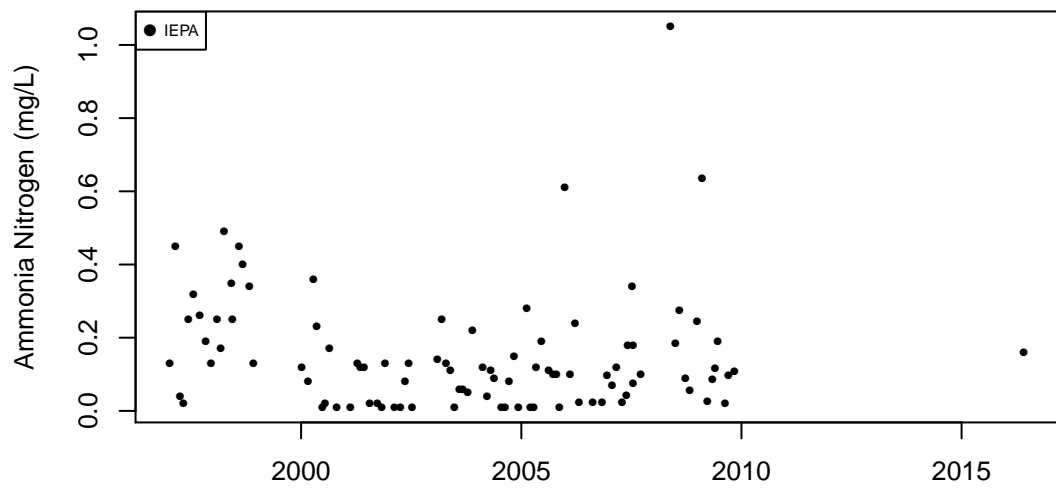


(c) Annual values

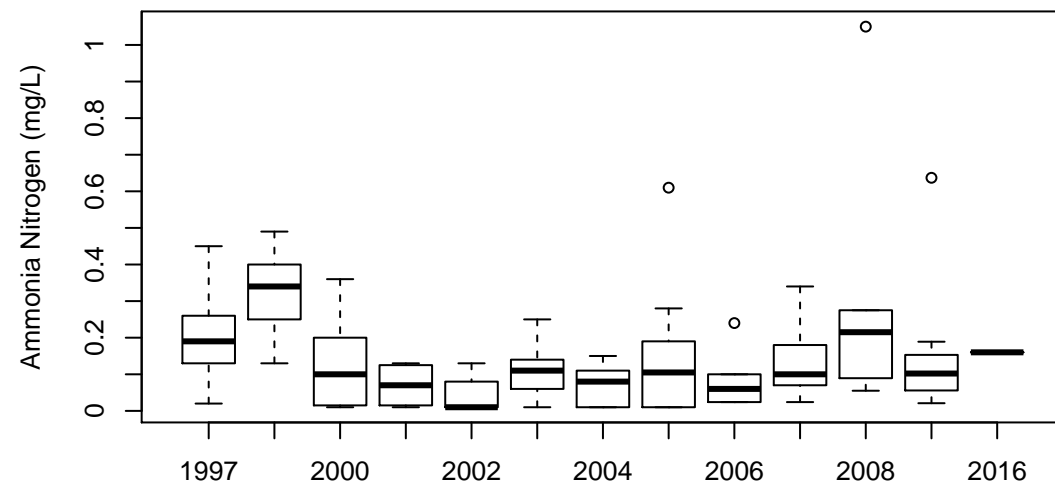


(d) Boxplot by month

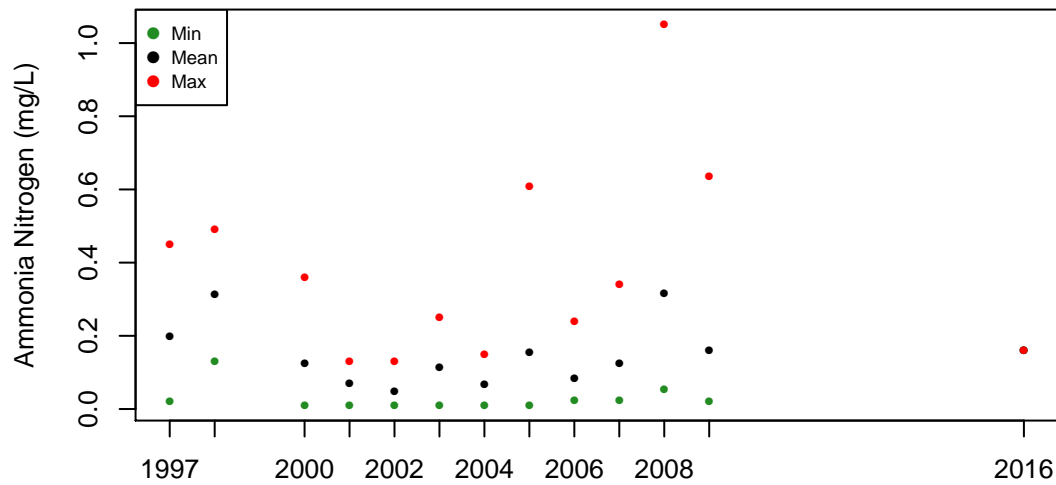
Nippersink Cr at Spring Grove (236): Ammonia Nitrogen (mg/L)



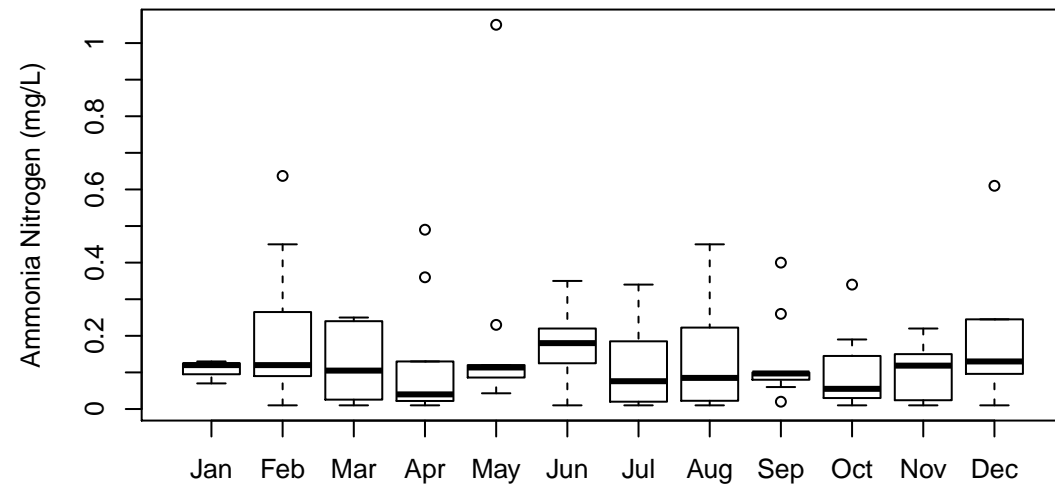
(a) Observation data



(b) Boxplot by year

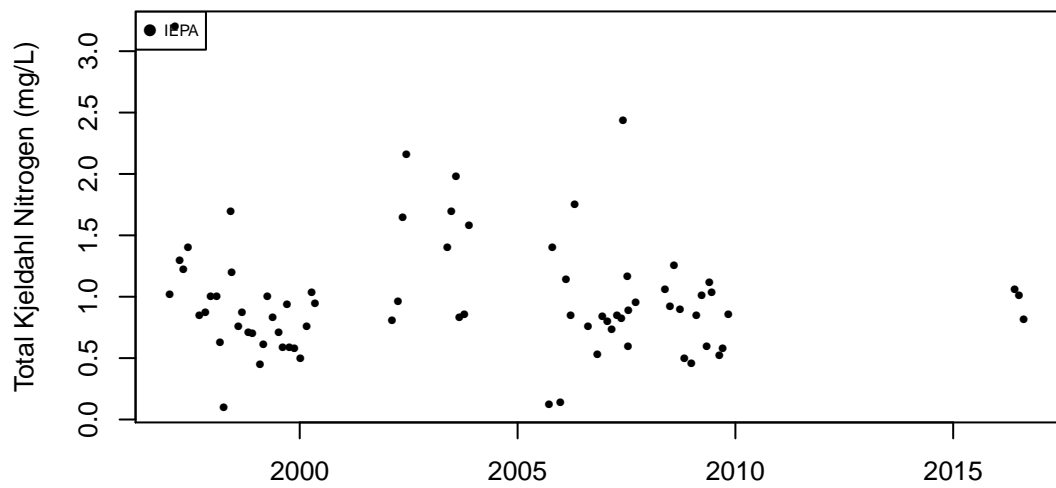


(c) Annual values

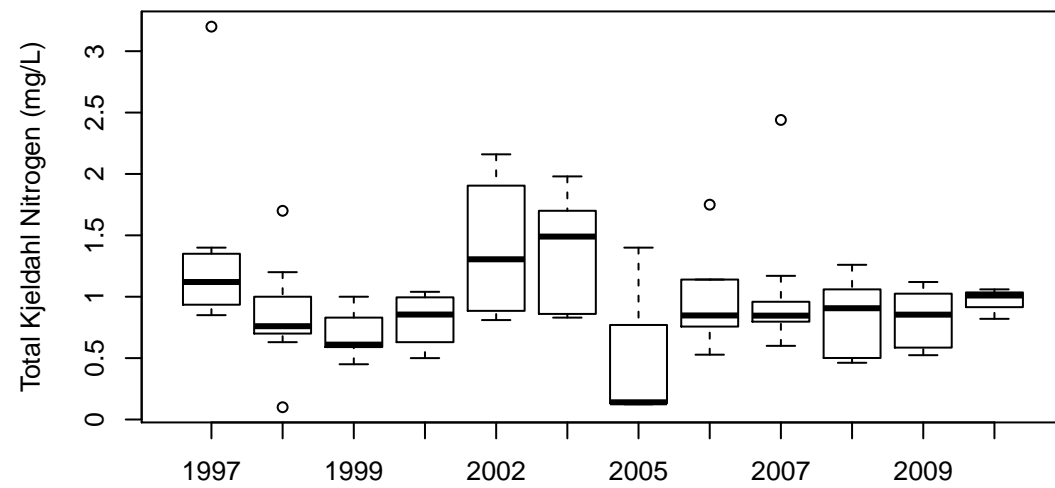


(d) Boxplot by month

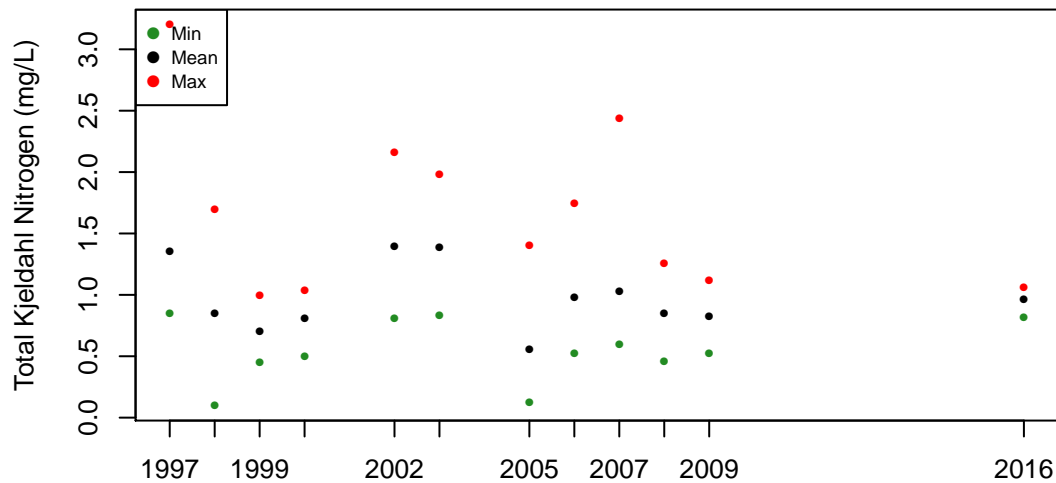
Nippersink Cr at Spring Grove (236): Total Kjeldahl Nitrogen (mg/L)



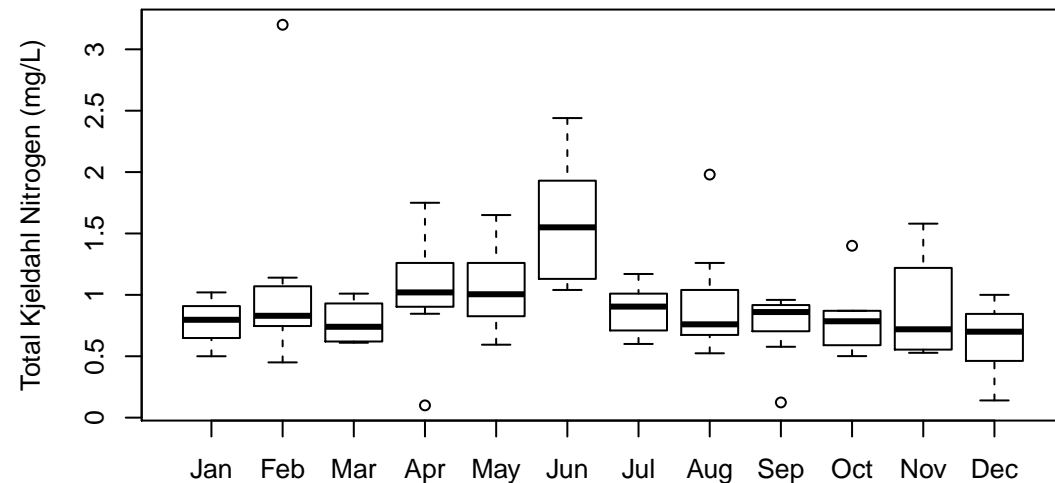
(a) Observation data



(b) Boxplot by year

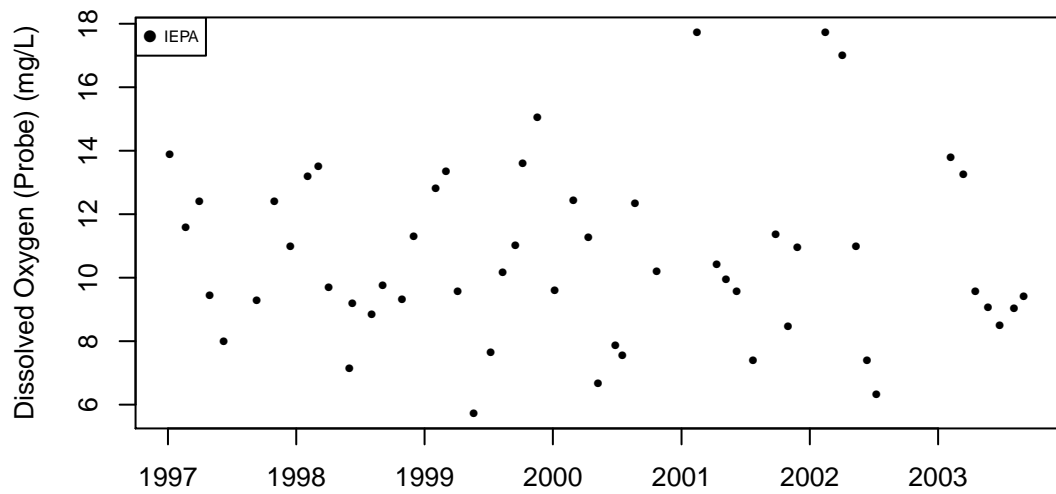


(c) Annual values

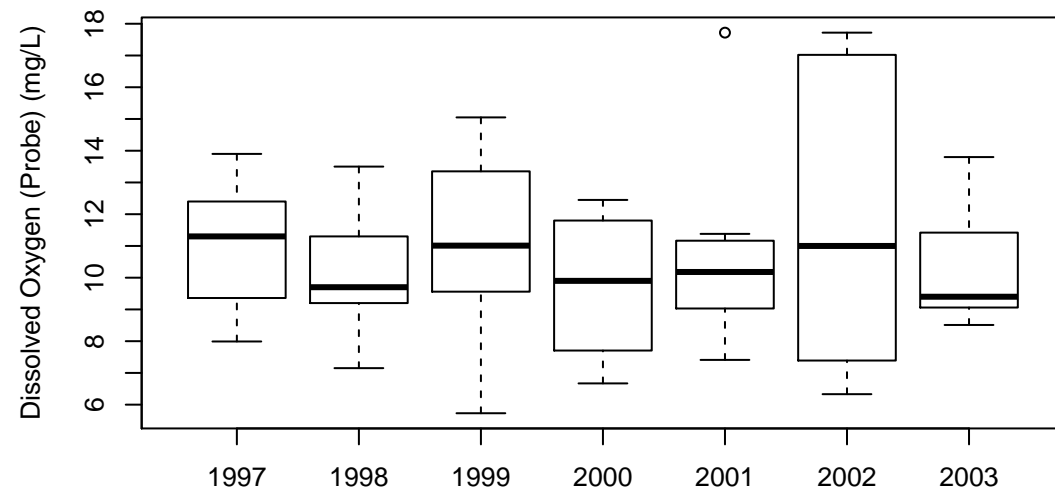


(d) Boxplot by month

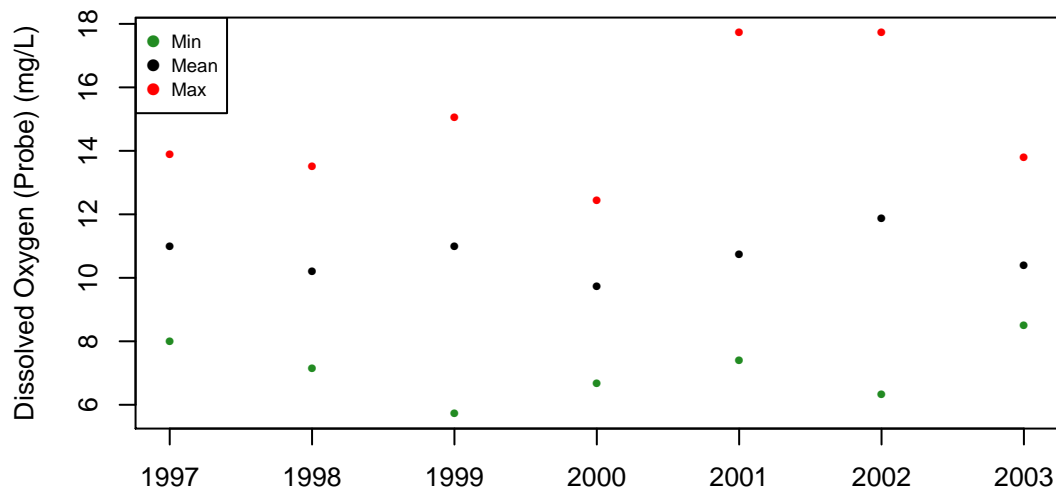
Nippersink Cr at Spring Grove (236): Dissolved Oxygen (Probe) (mg/L)



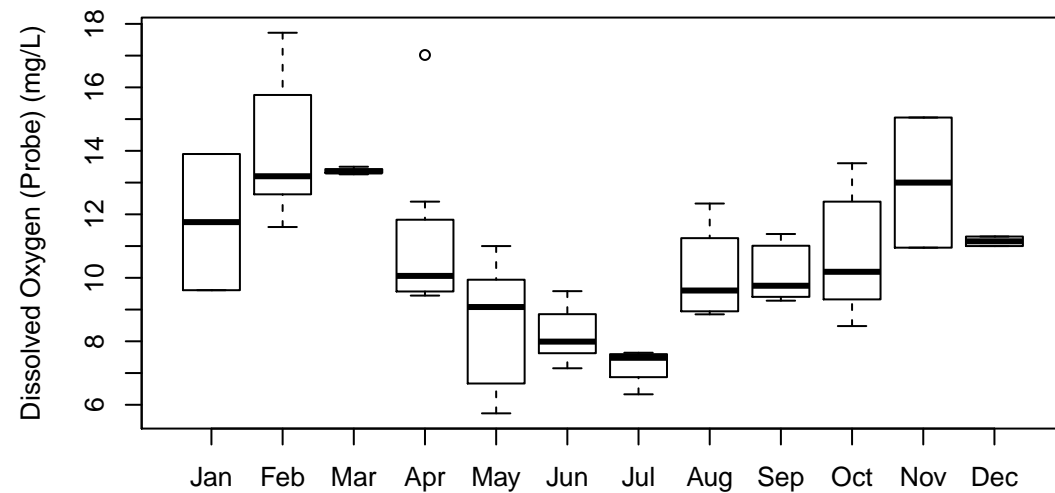
(a) Observation data



(b) Boxplot by year

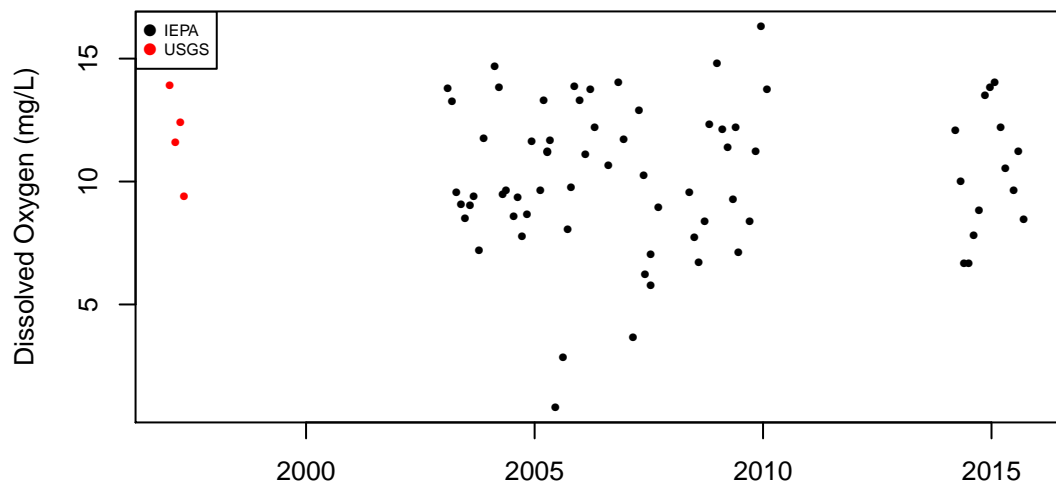


(c) Annual values

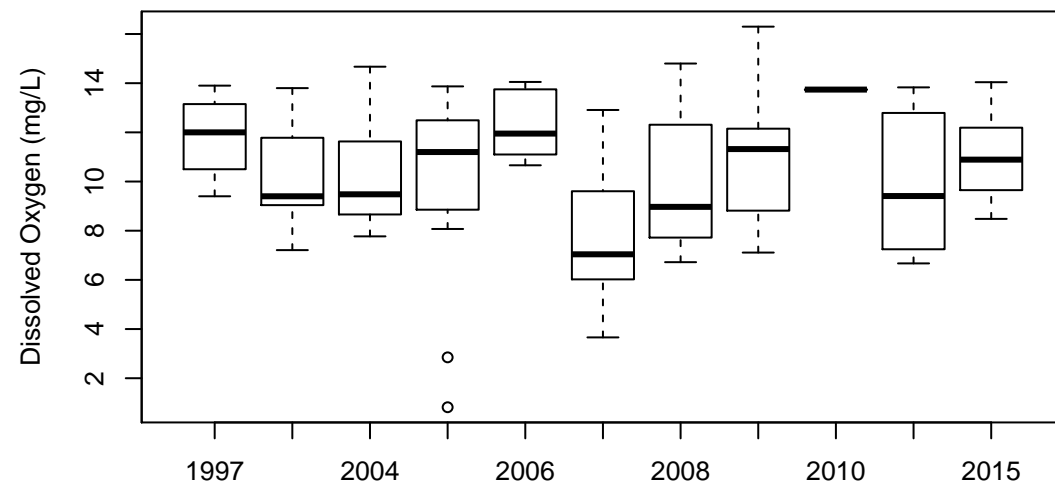


(d) Boxplot by month

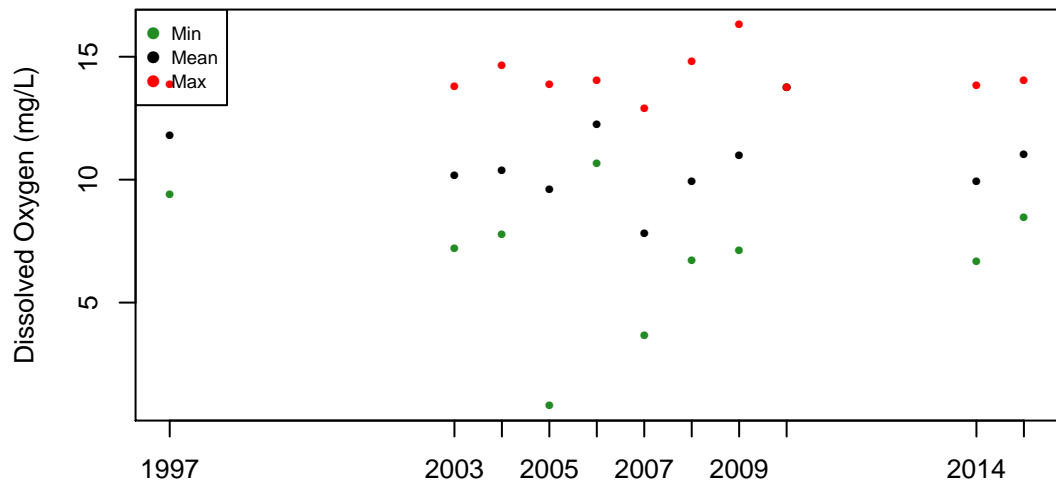
Nippersink Cr at Spring Grove (236): Dissolved Oxygen (mg/L)



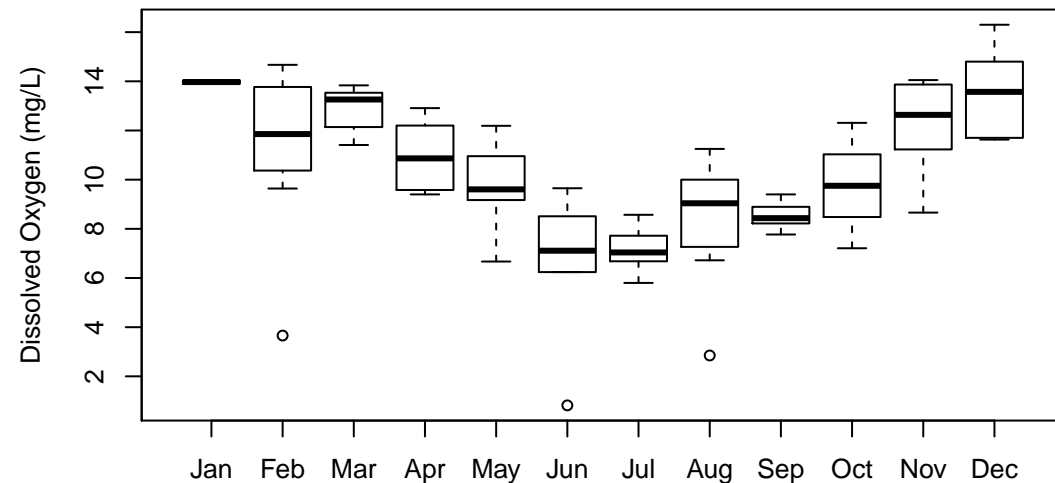
(a) Observation data



(b) Boxplot by year

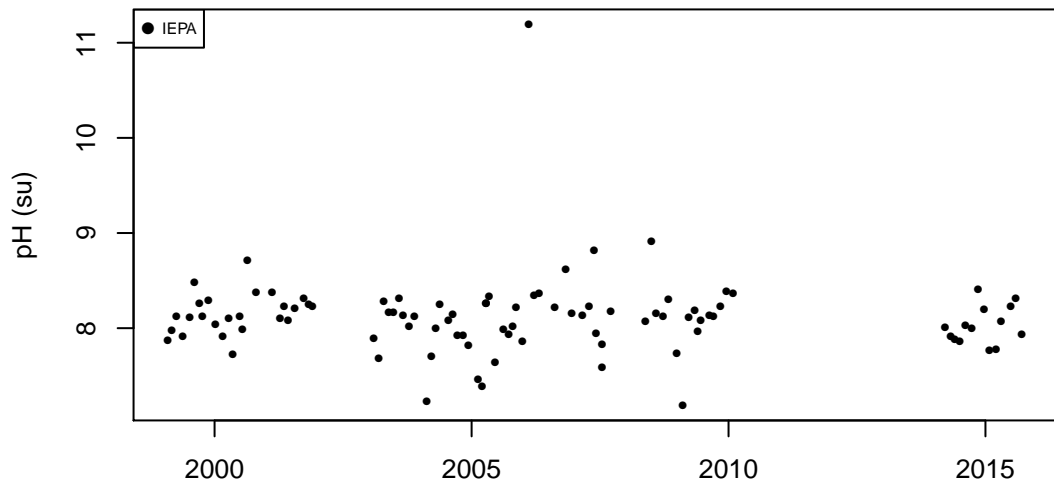


(c) Annual values

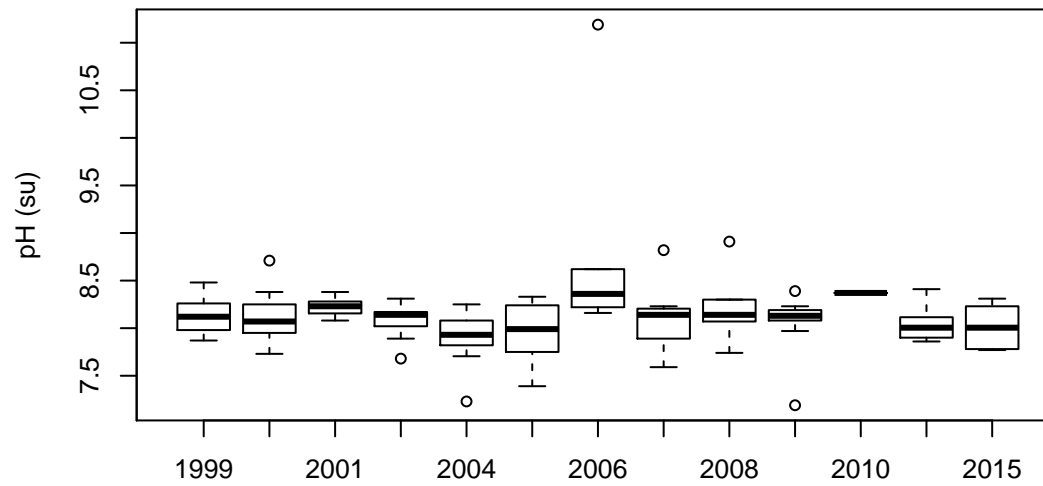


(d) Boxplot by month

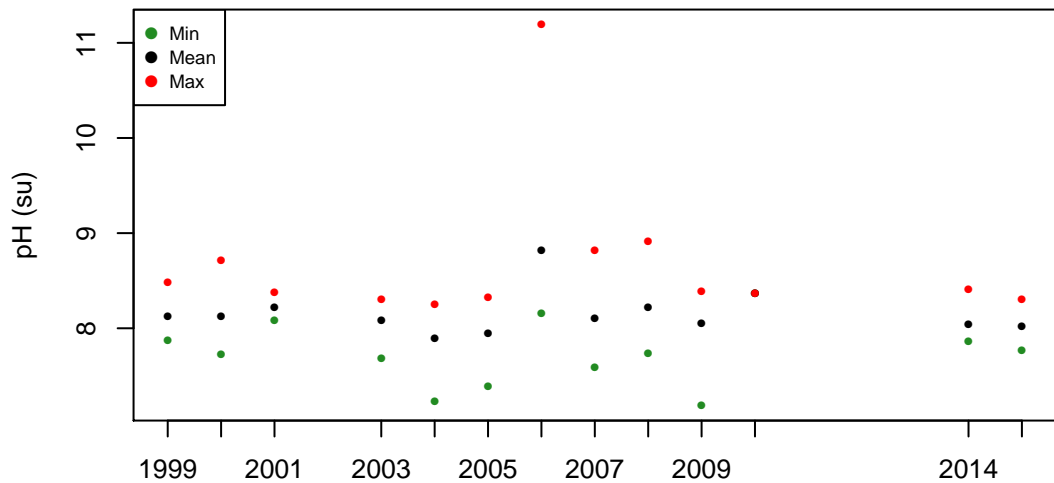
Nippersink Cr at Spring Grove (236): pH (su)



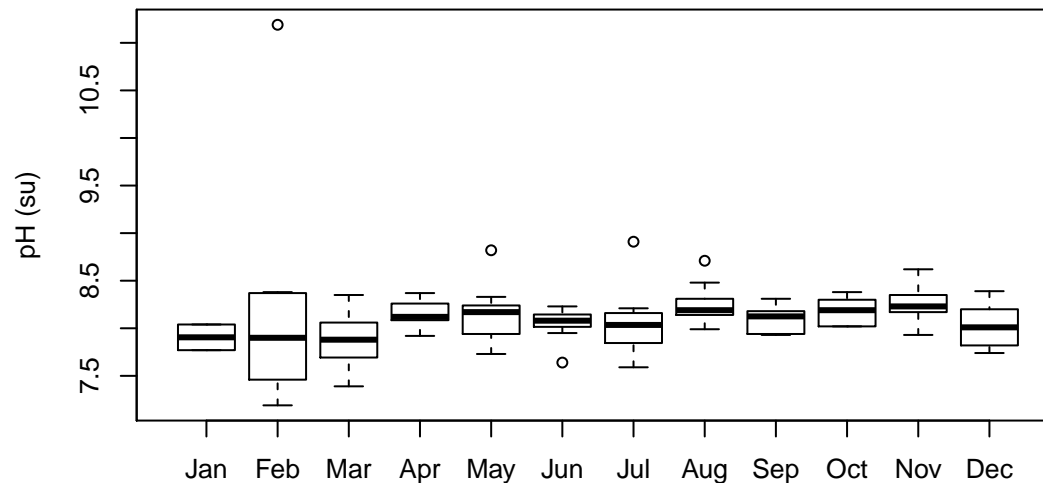
(a) Observation data



(b) Boxplot by year

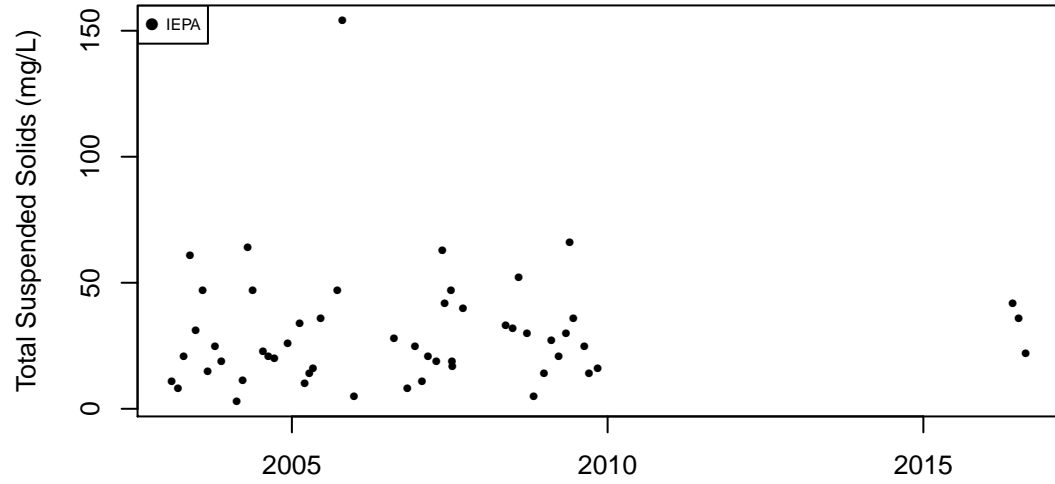


(c) Annual values

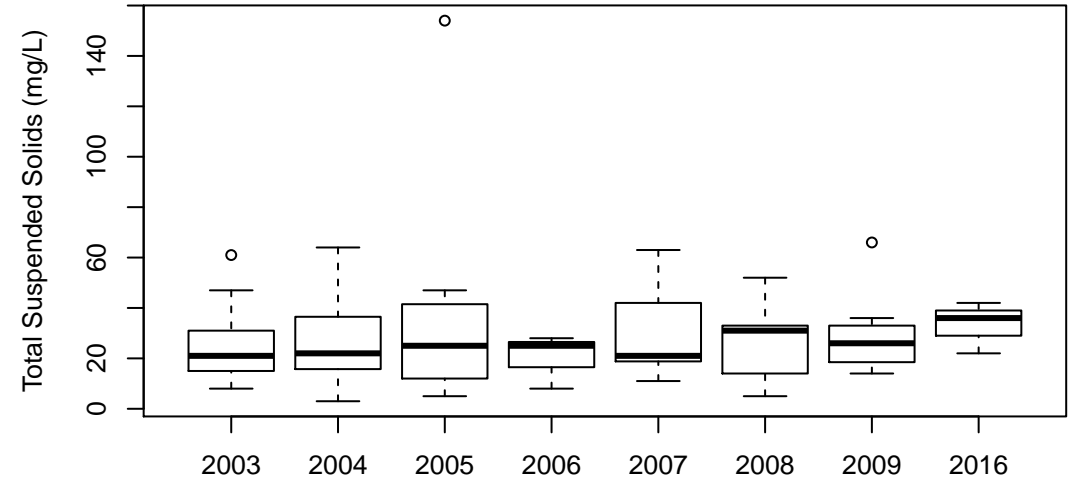


(d) Boxplot by month

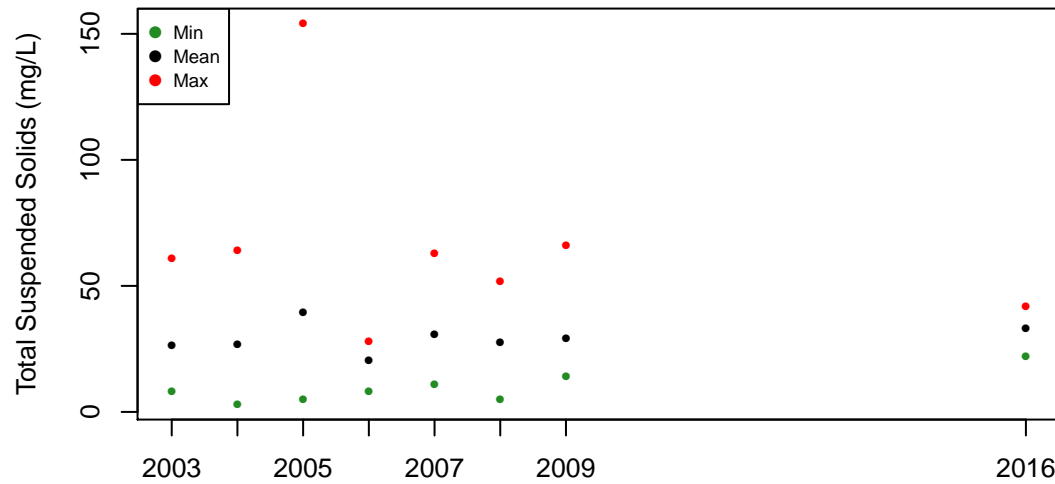
Nippersink Cr at Spring Grove (236): Total Suspended Solids (mg/L)



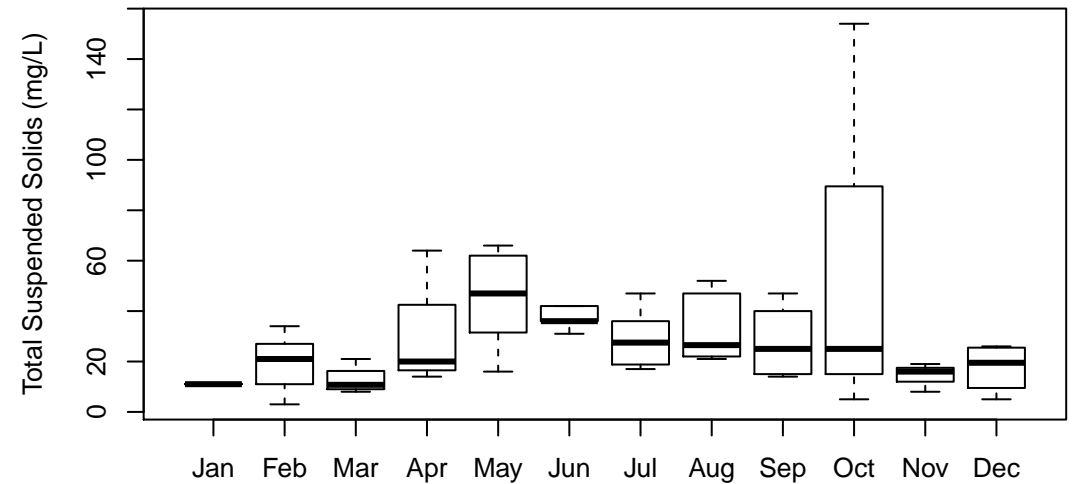
(a) Observation data



(b) Boxplot by year

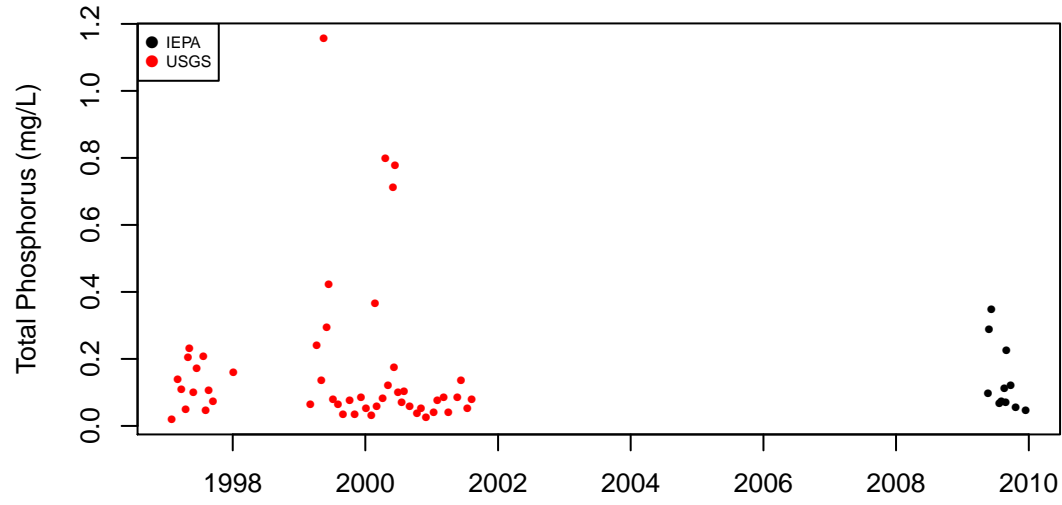


(c) Annual values

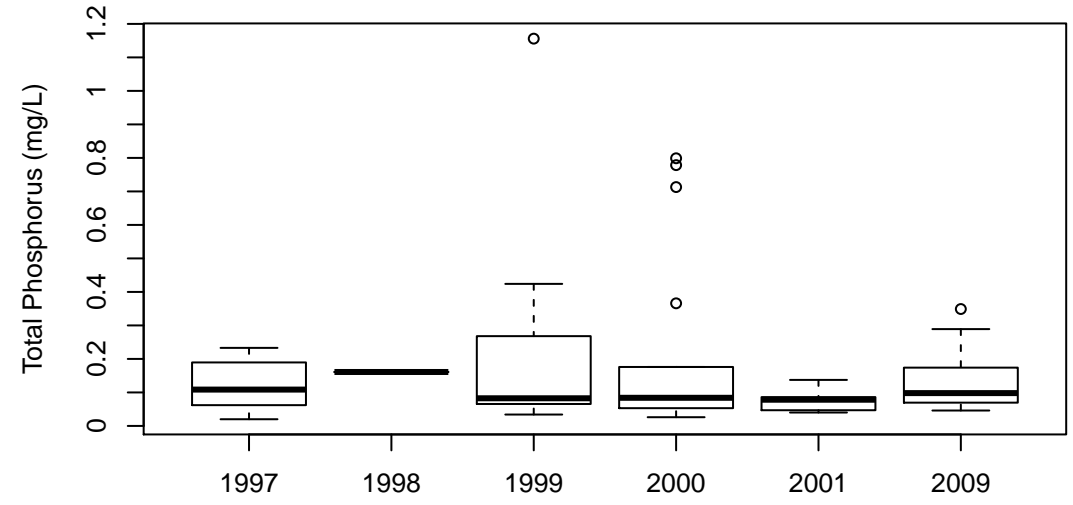


(d) Boxplot by month

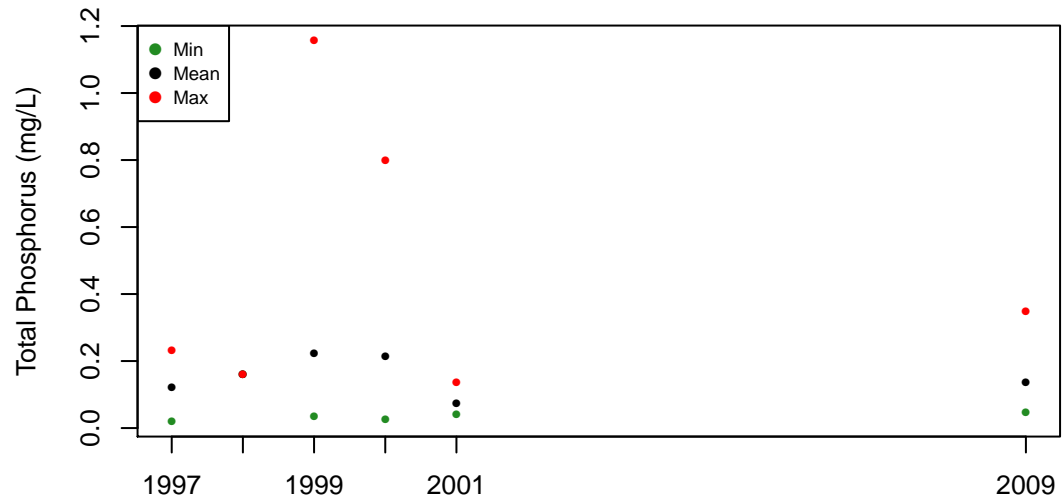
Nippersink Cr above Wonder Lake (1): Total Phosphorus (mg/L)



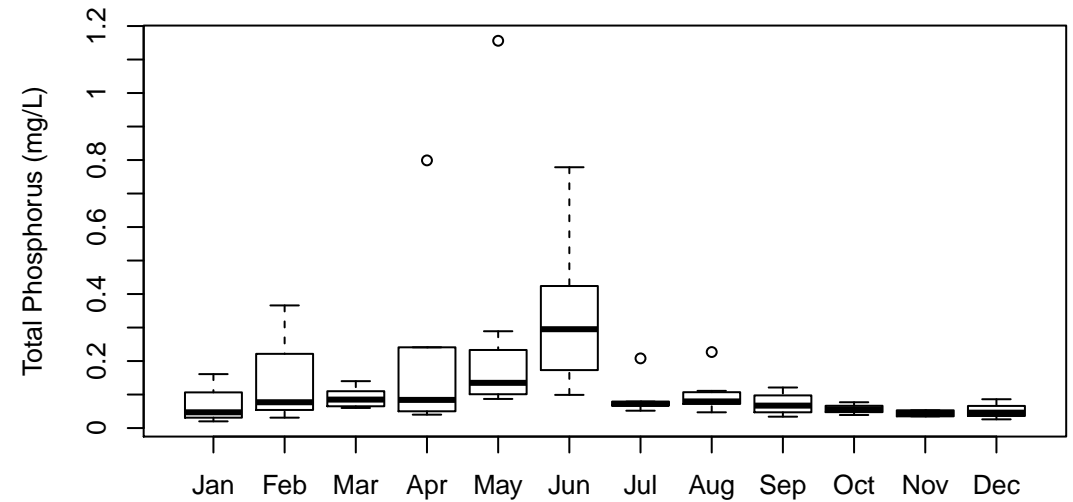
(a) Observation data



(b) Boxplot by year

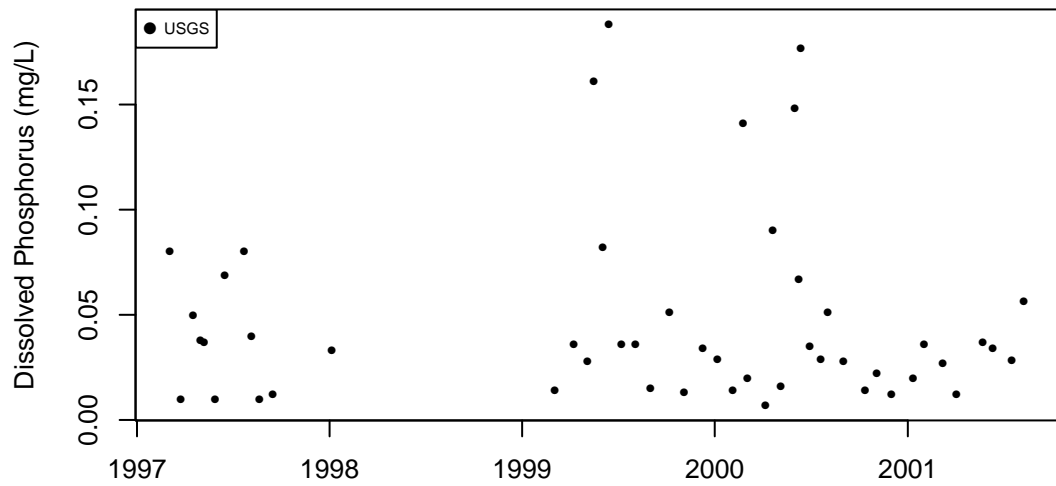


(c) Annual values

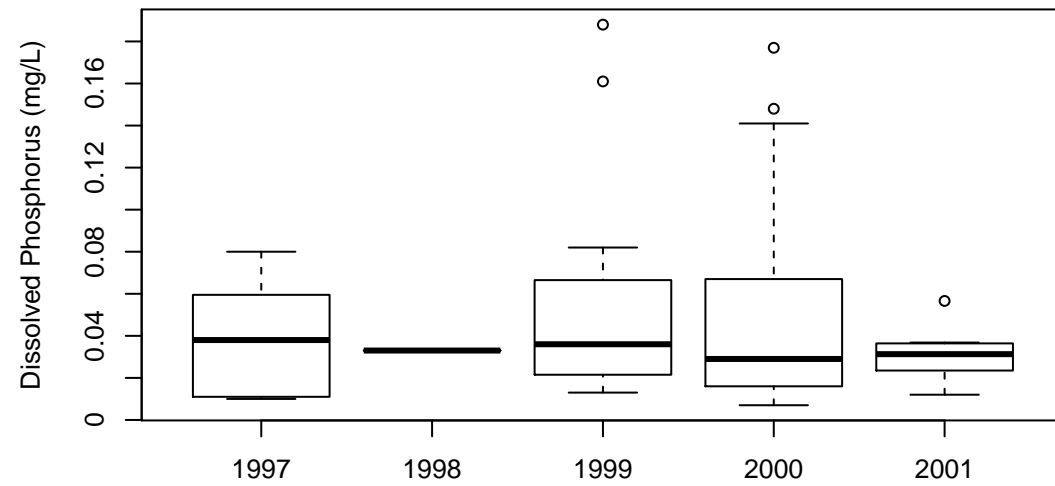


(d) Boxplot by month

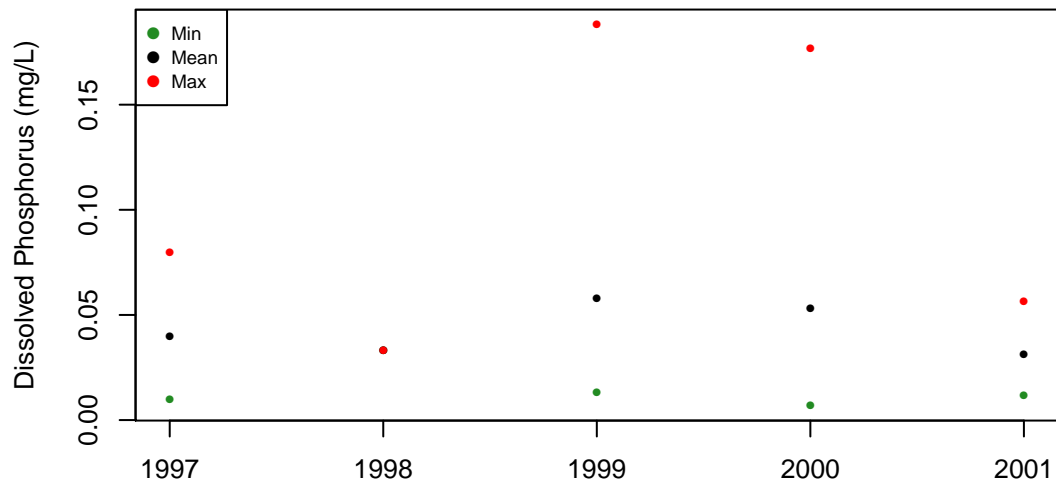
Nippersink Cr above Wonder Lake (1): Dissolved Phosphorus (mg/L)



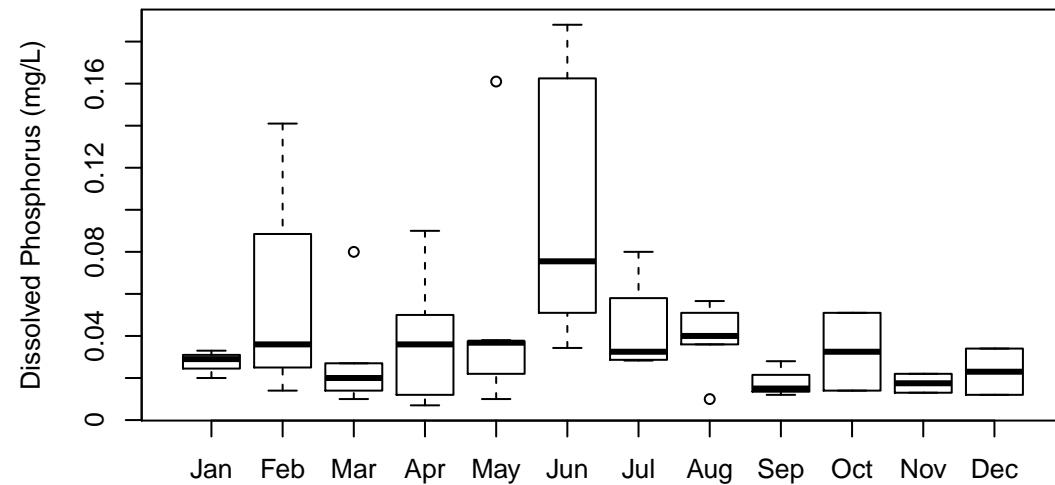
(a) Observation data



(b) Boxplot by year



(c) Annual values

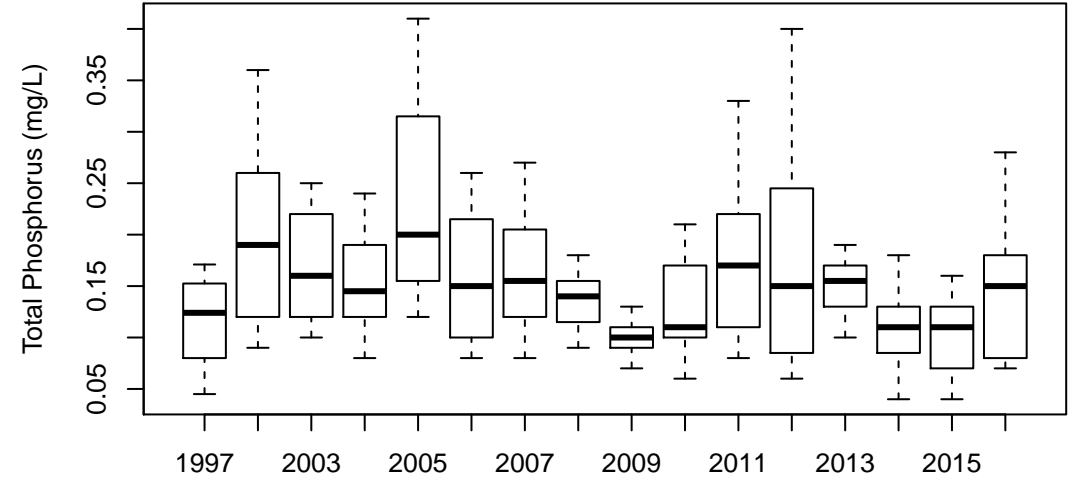


(d) Boxplot by month

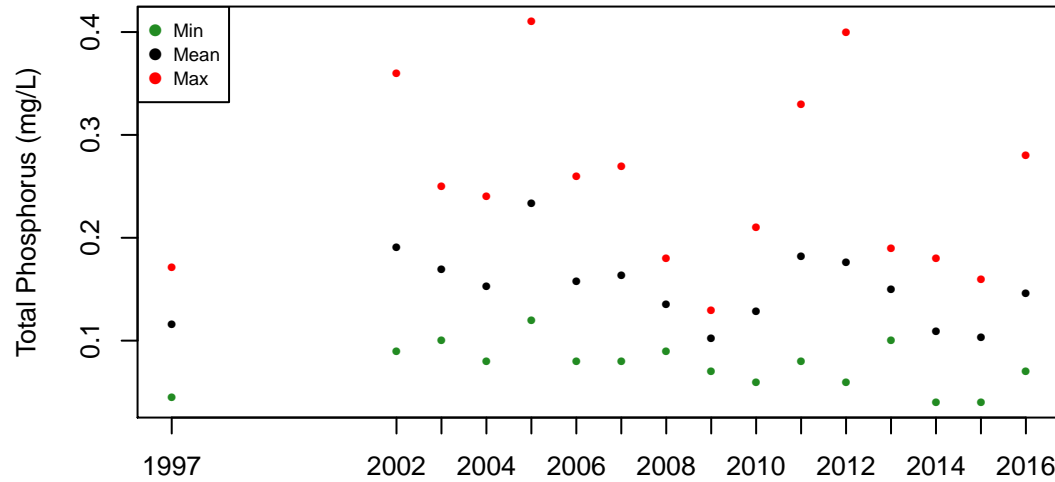
Fox River at Johnsburg (184): Total Phosphorus (mg/L)



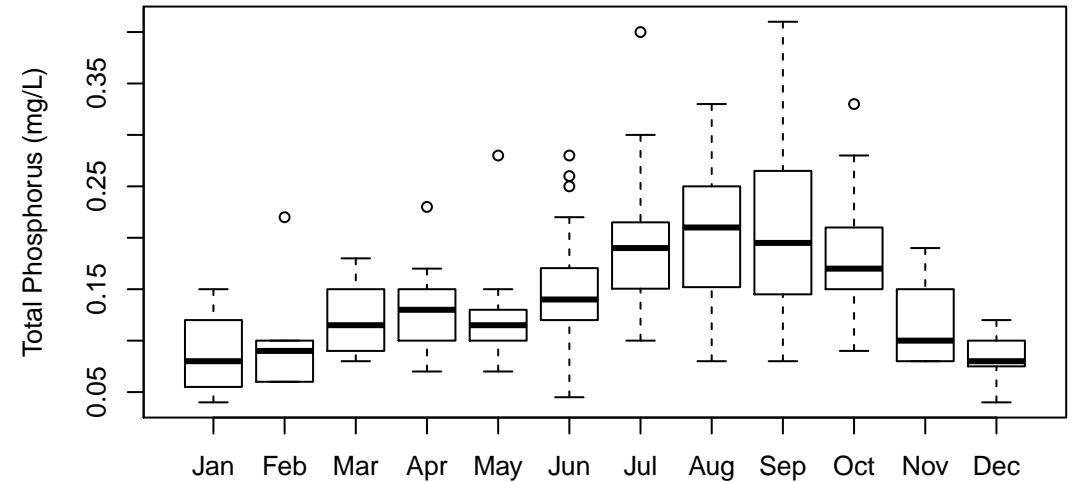
(a) Observation data



(b) Boxplot by year

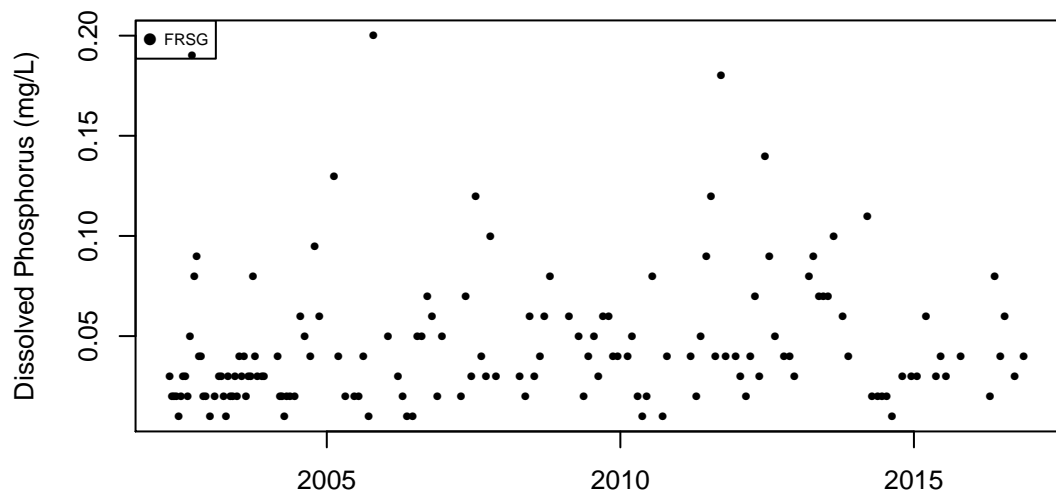


(c) Annual values

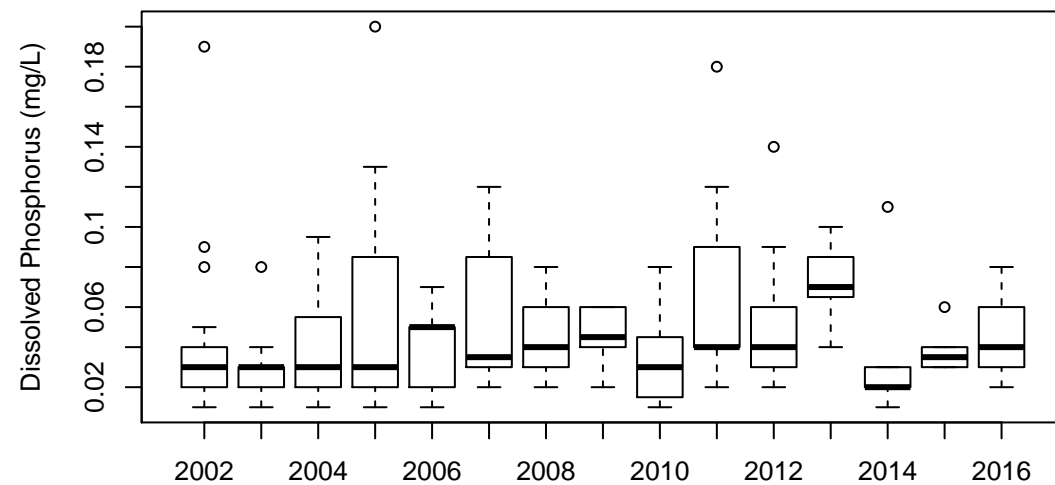


(d) Boxplot by month

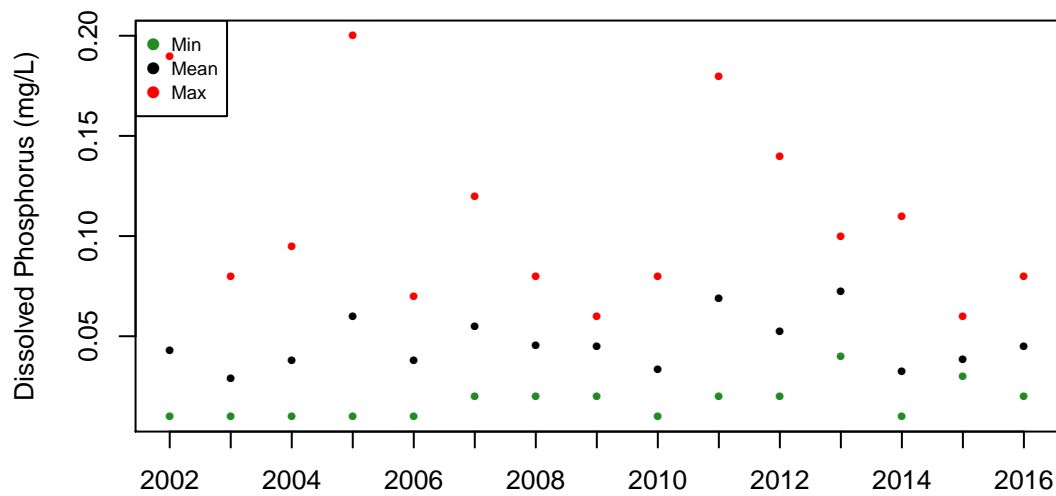
Fox River at Johnsburg (184): Dissolved Phosphorus (mg/L)



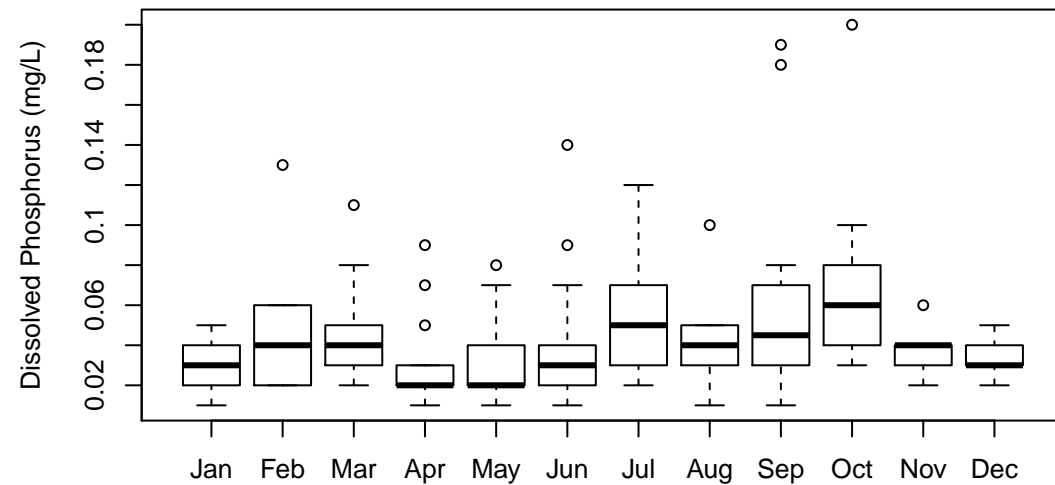
(a) Observation data



(b) Boxplot by year

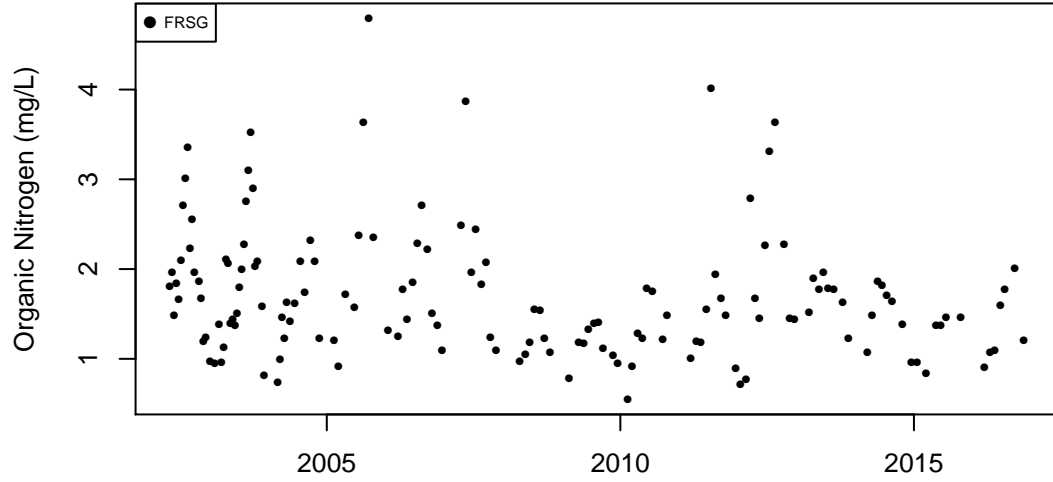


(c) Annual values

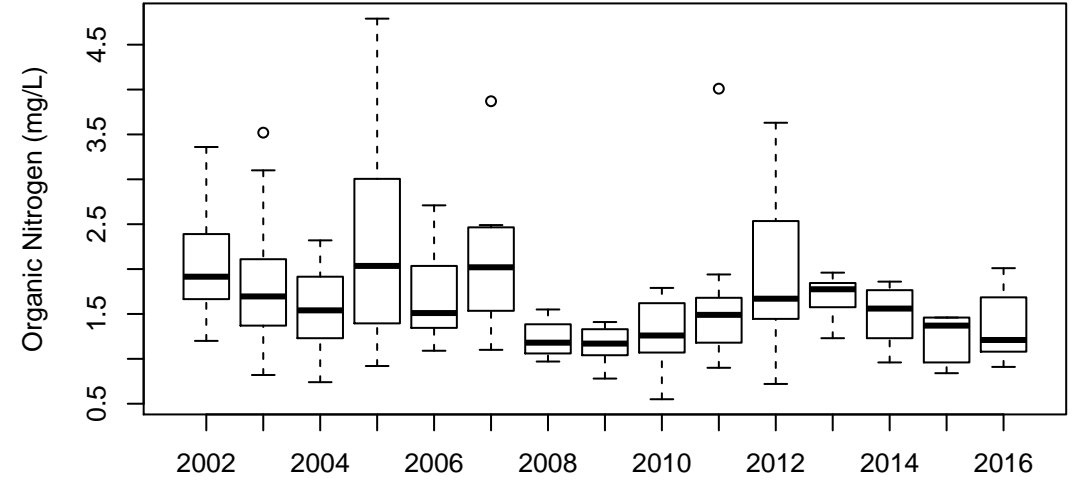


(d) Boxplot by month

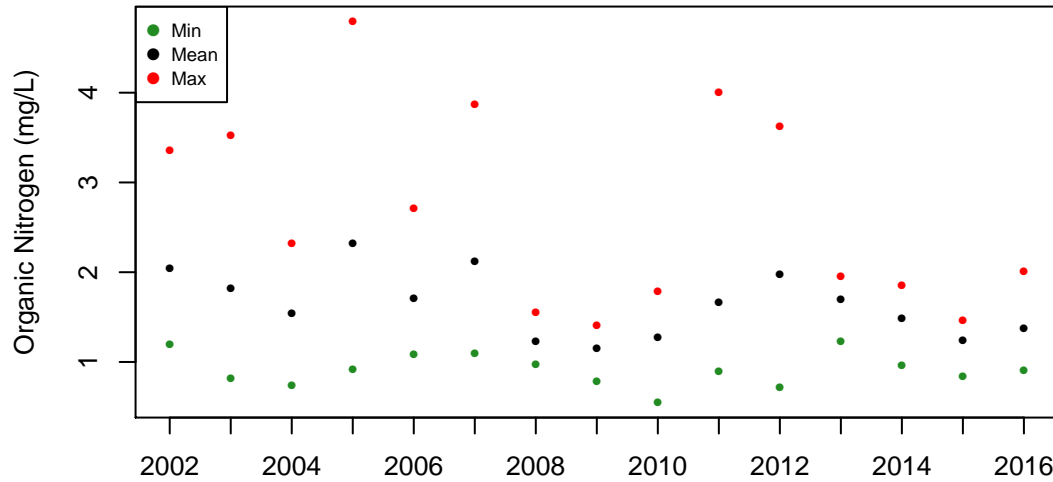
Fox River at Johnsburg (184): Organic Nitrogen (mg/L)



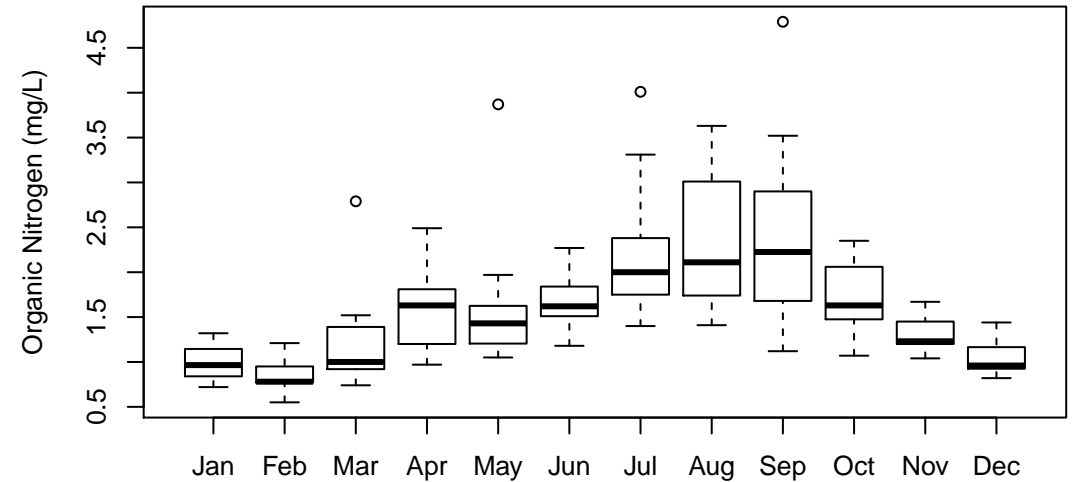
(a) Observation data



(b) Boxplot by year

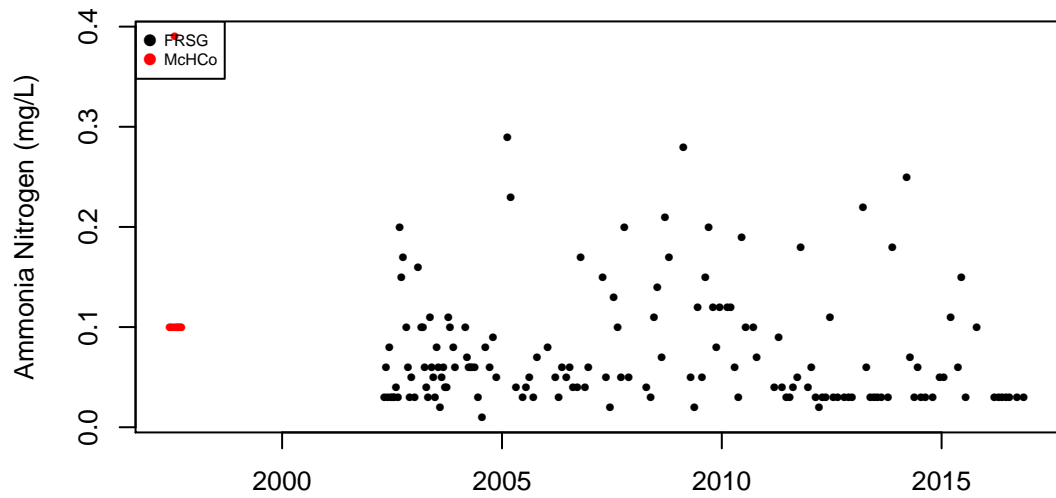


(c) Annual values

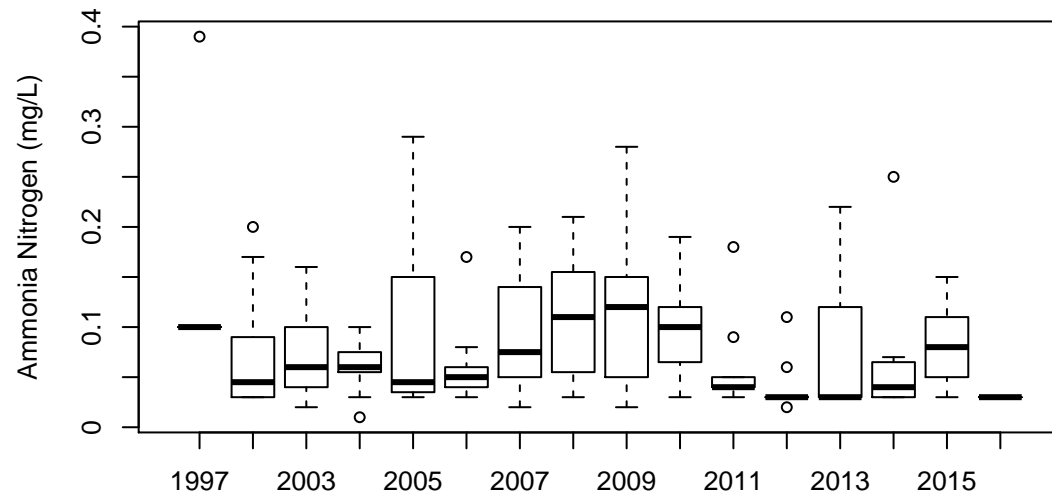


(d) Boxplot by month

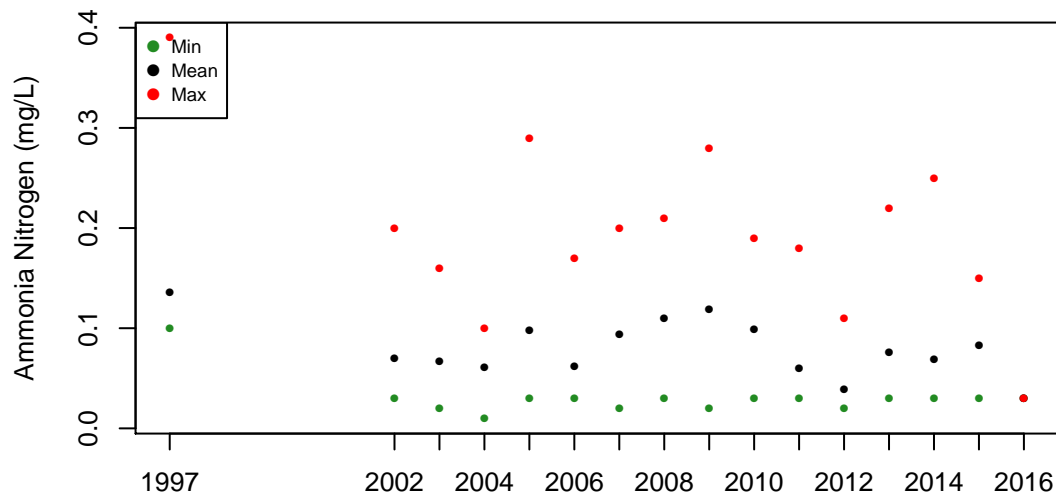
Fox River at Johnsburg (184): Ammonia Nitrogen (mg/L)



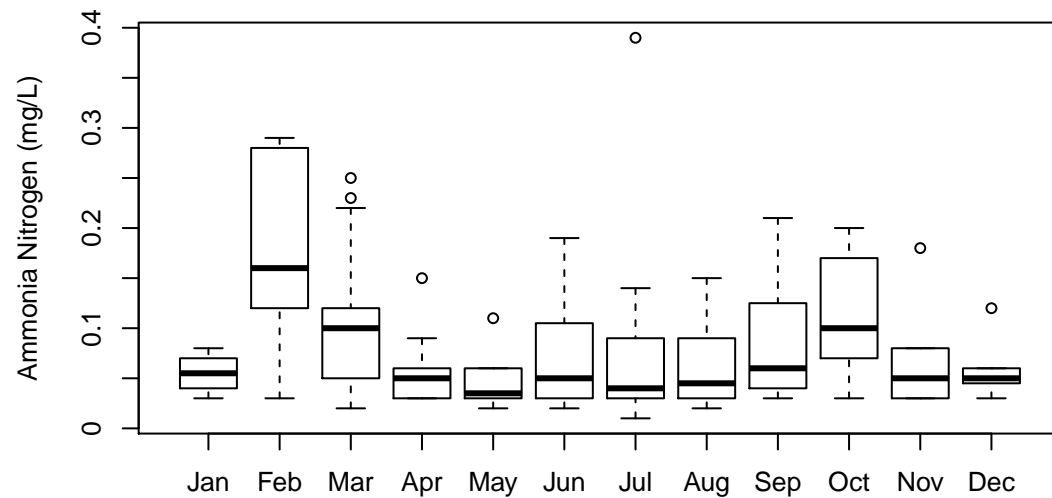
(a) Observation data



(b) Boxplot by year

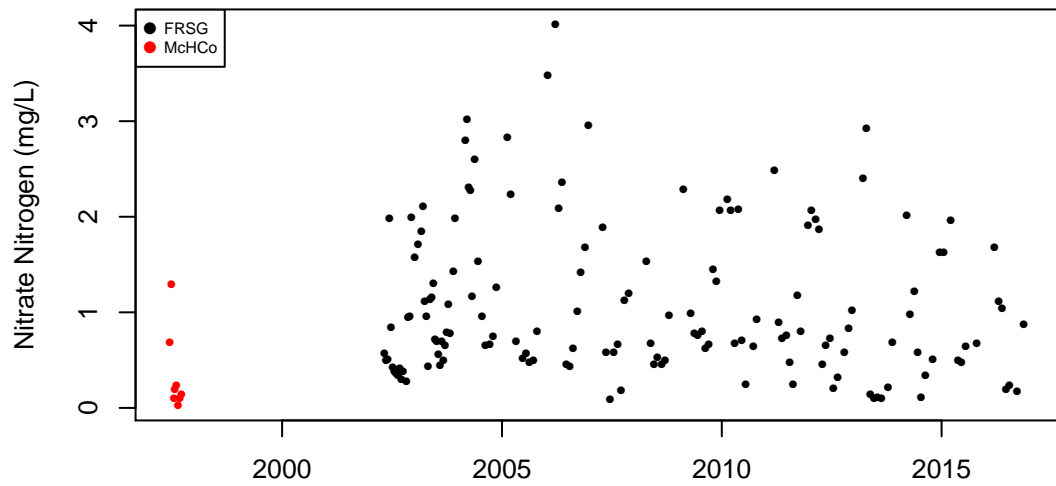


(c) Annual values

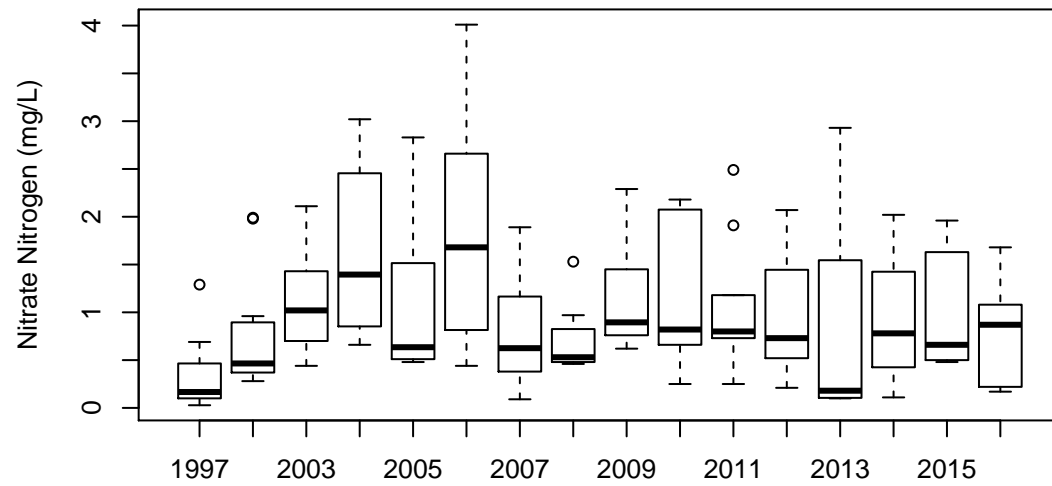


(d) Boxplot by month

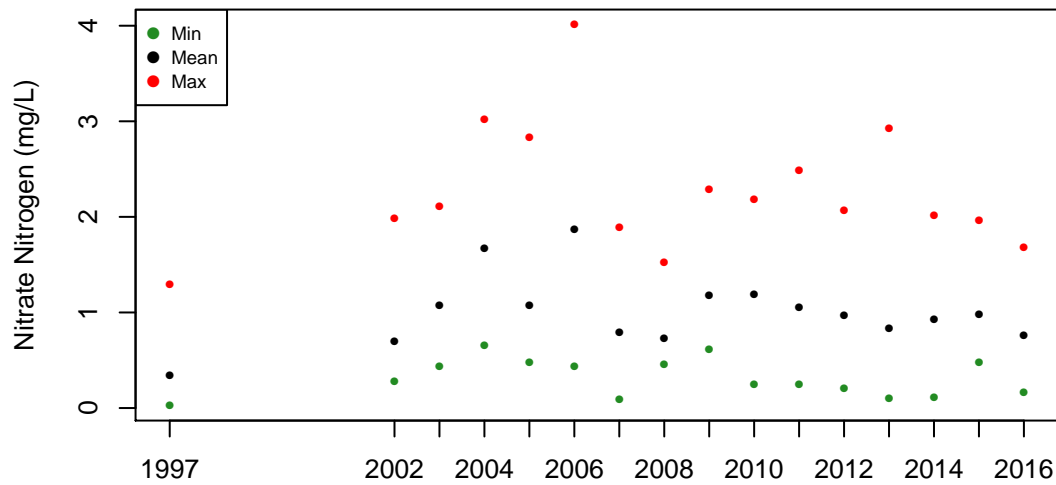
Fox River at Johnsburg (184): Nitrate Nitrogen (mg/L)



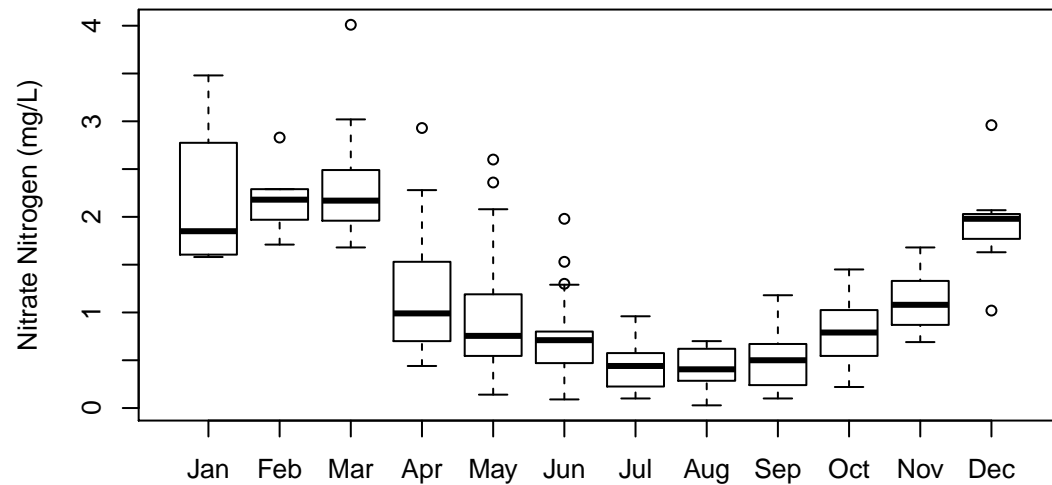
(a) Observation data



(b) Boxplot by year

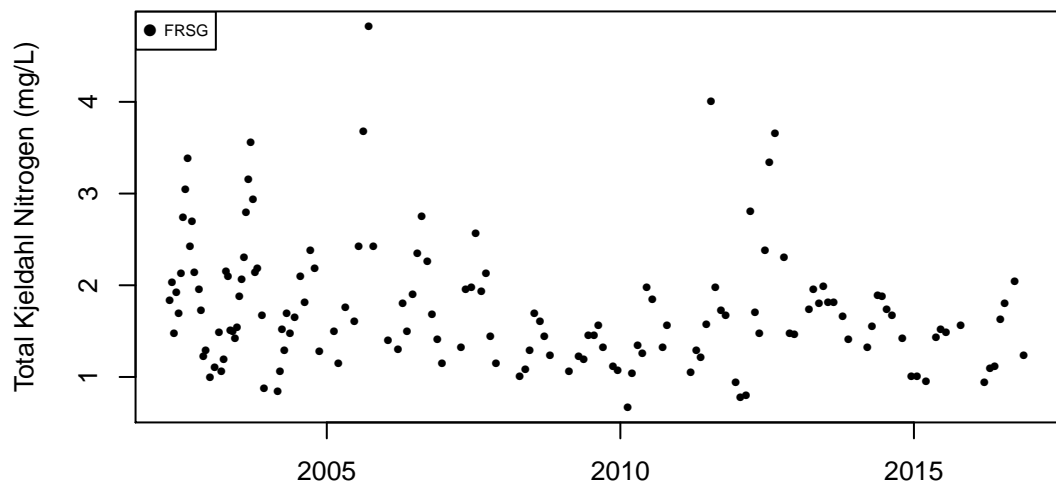


(c) Annual values

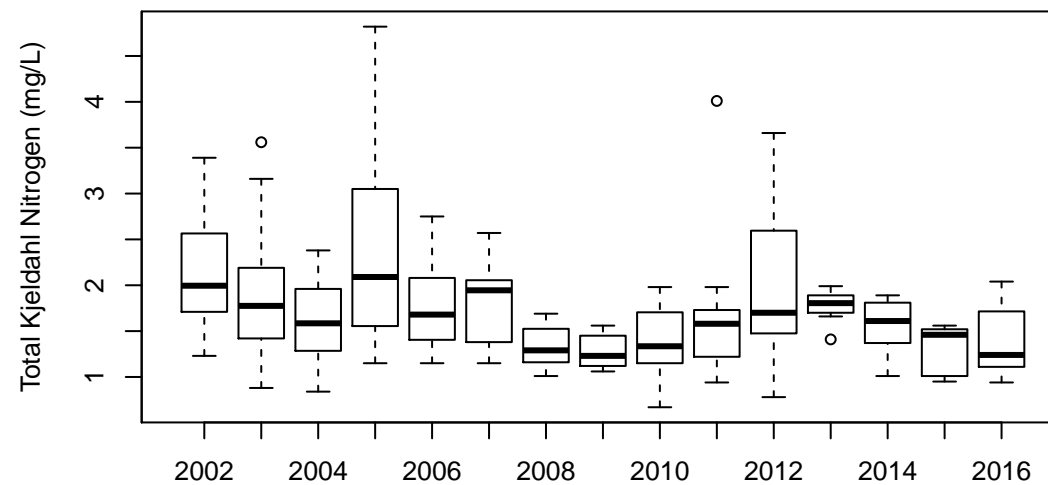


(d) Boxplot by month

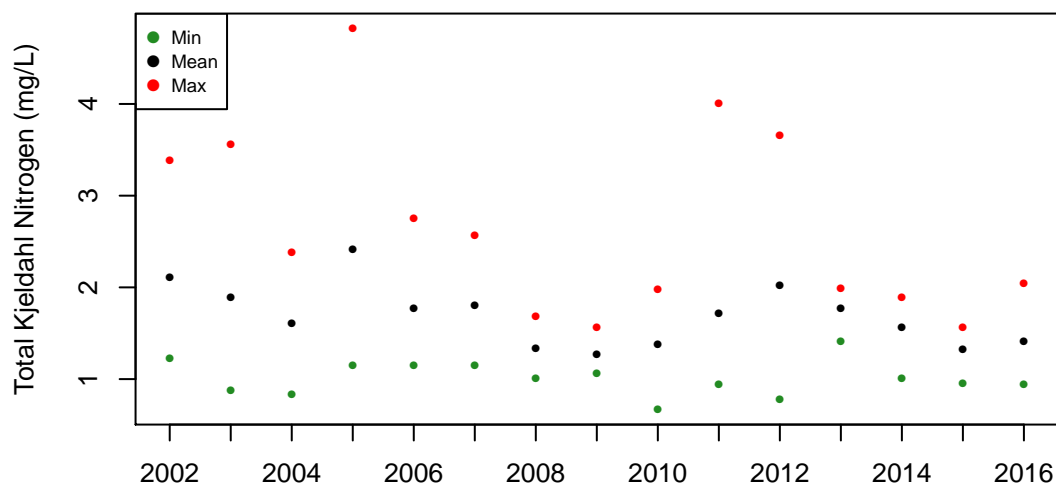
Fox River at Johnsburg (184): Total Kjeldahl Nitrogen (mg/L)



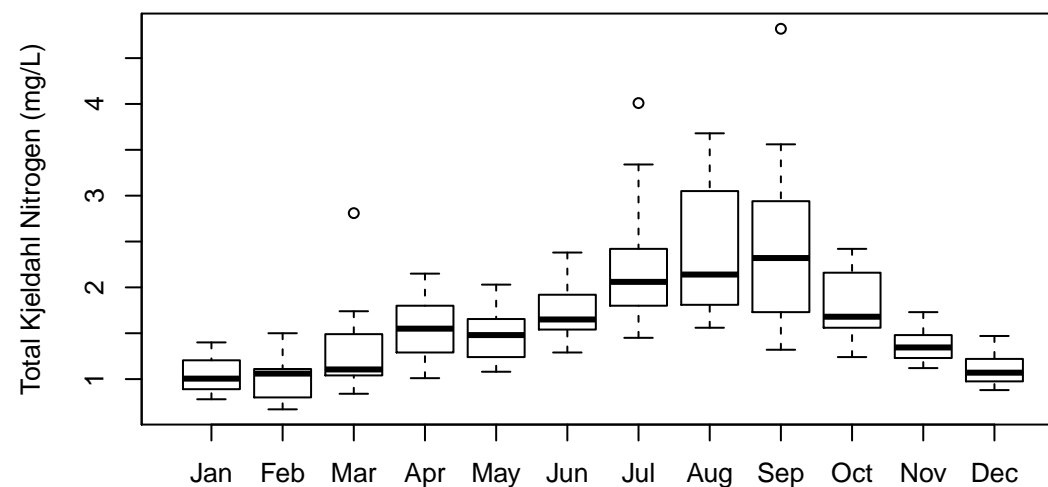
(a) Observation data



(b) Boxplot by year

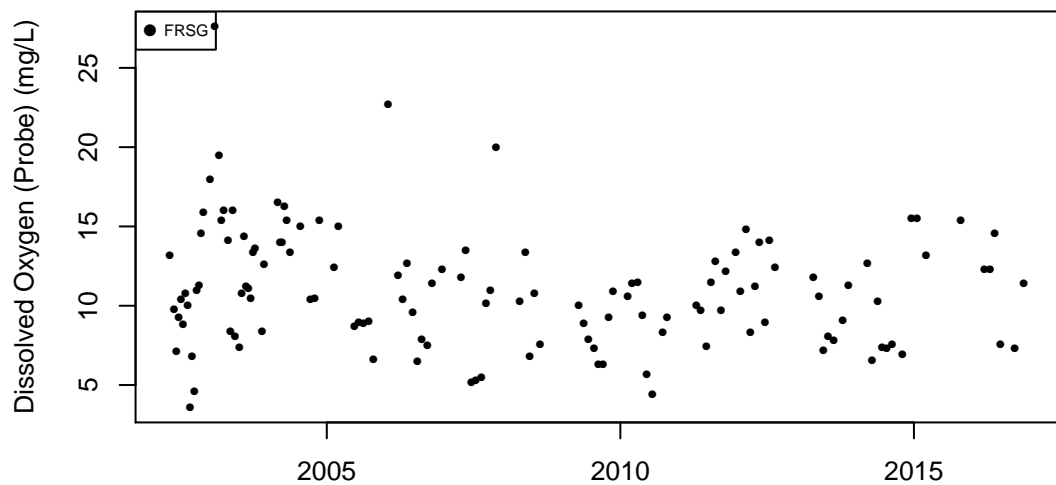


(c) Annual values

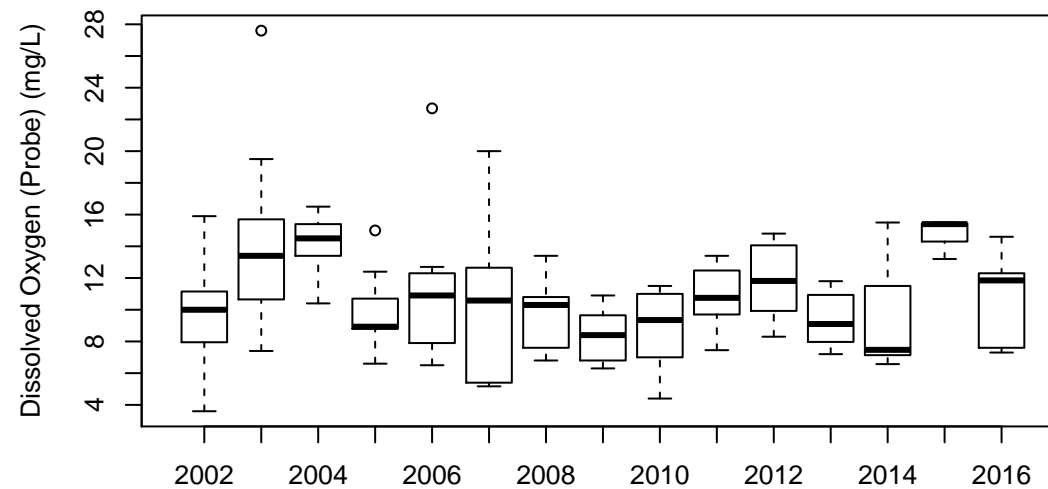


(d) Boxplot by month

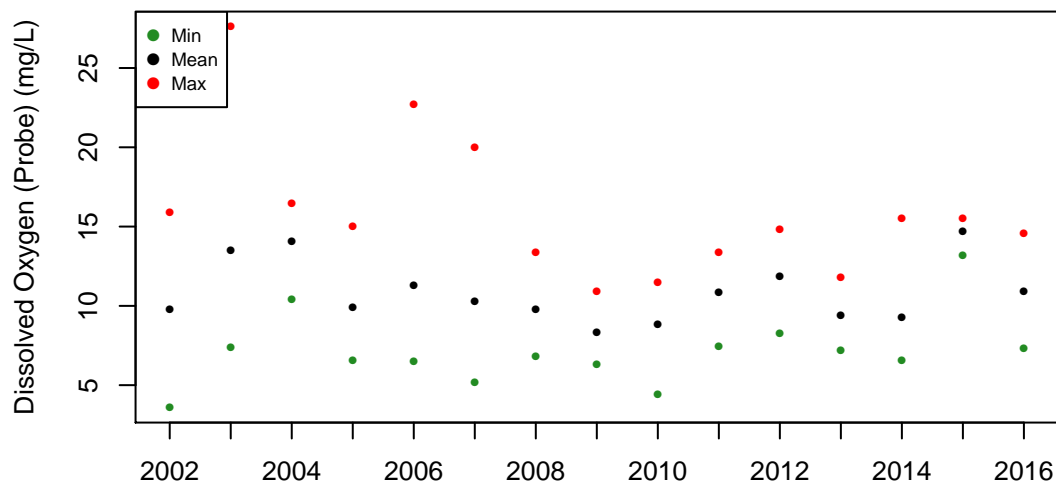
Fox River at Johnsburg (184): Dissolved Oxygen (Probe) (mg/L)



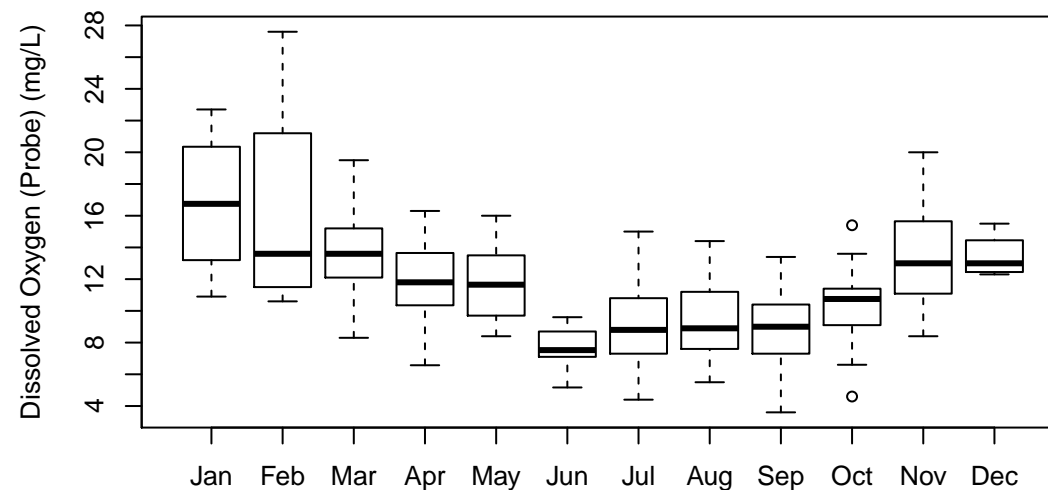
(a) Observation data



(b) Boxplot by year

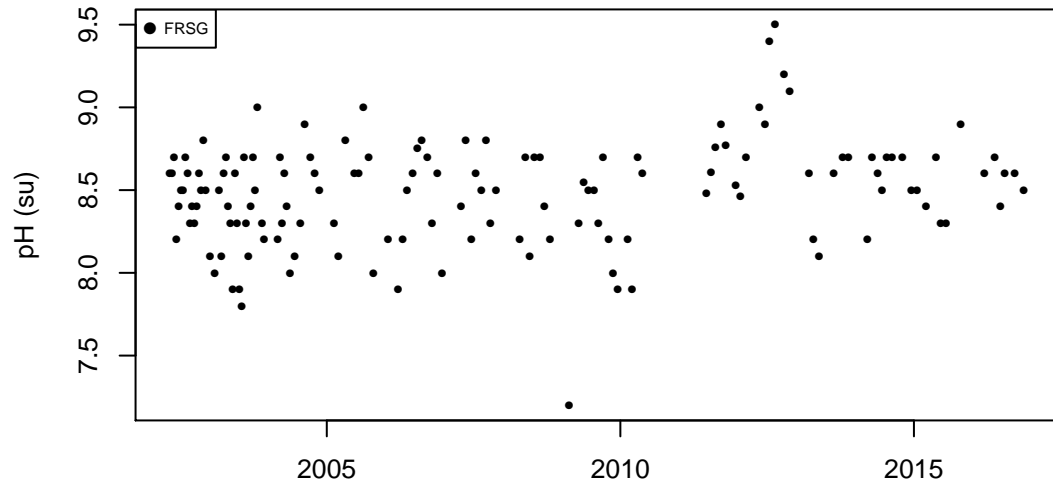


(c) Annual values

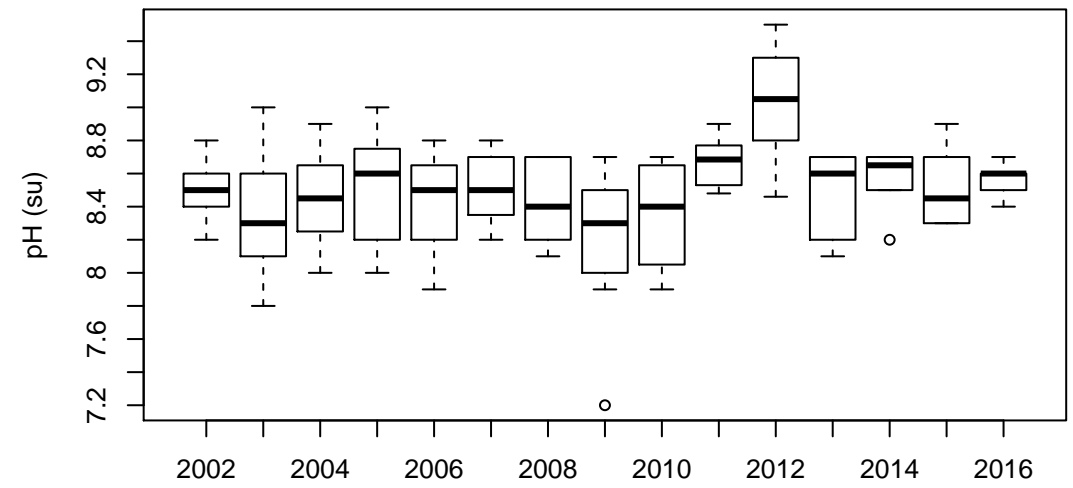


(d) Boxplot by month

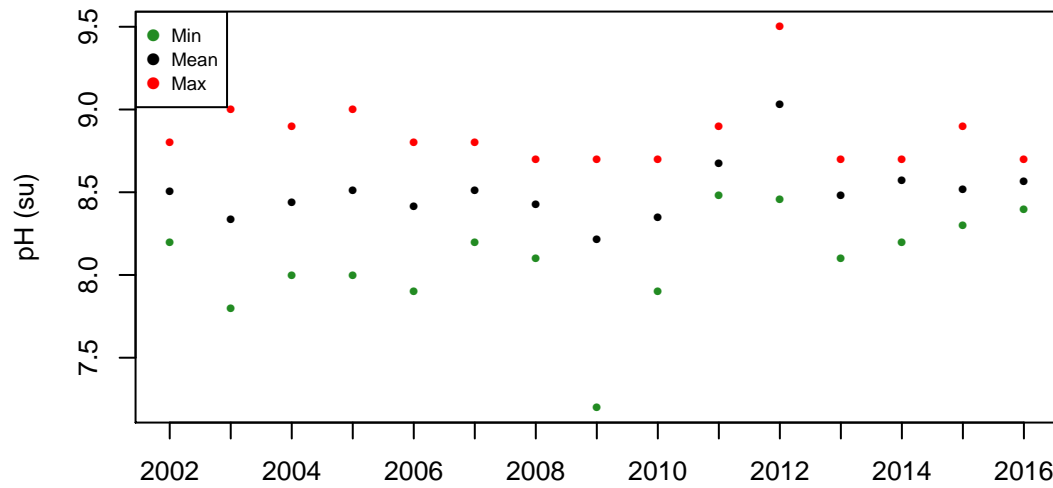
Fox River at Johnsburg (184): pH (su)



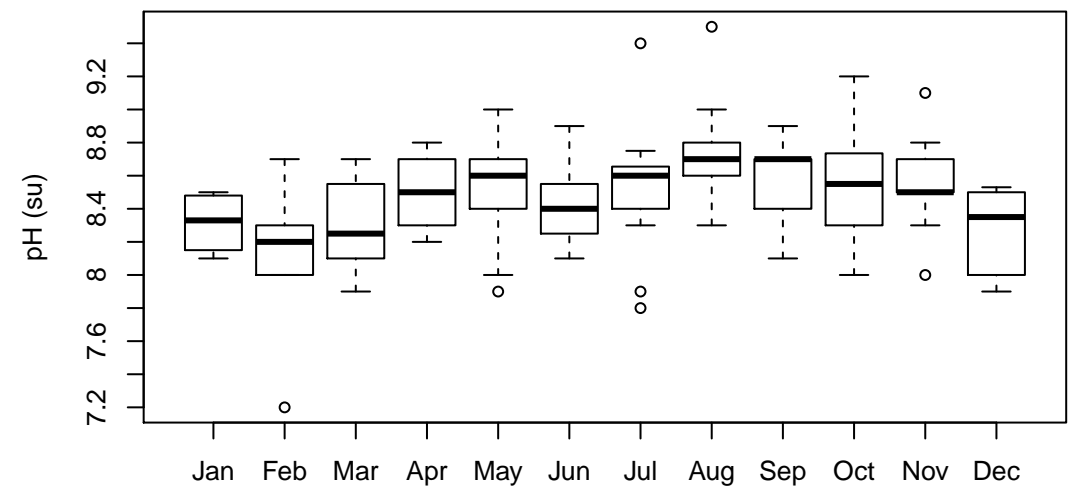
(a) Observation data



(b) Boxplot by year

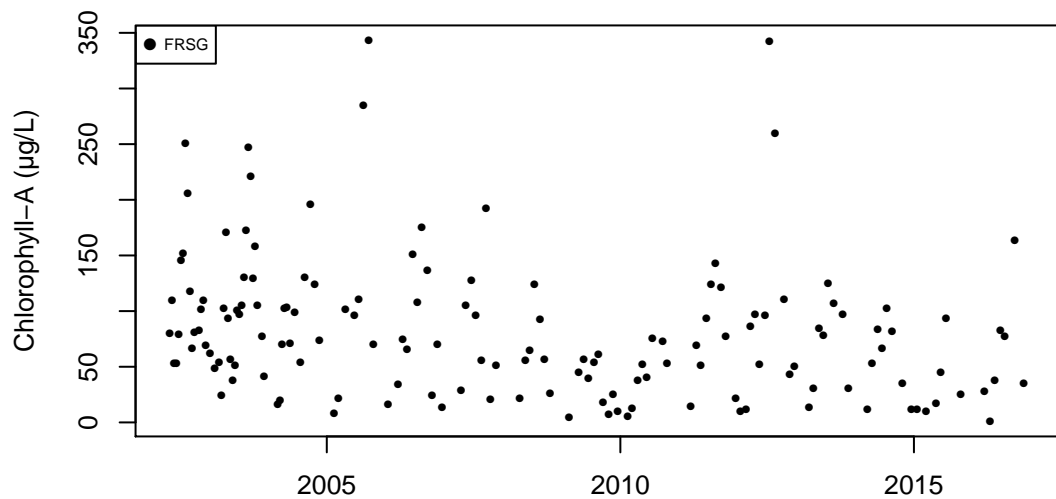


(c) Annual values

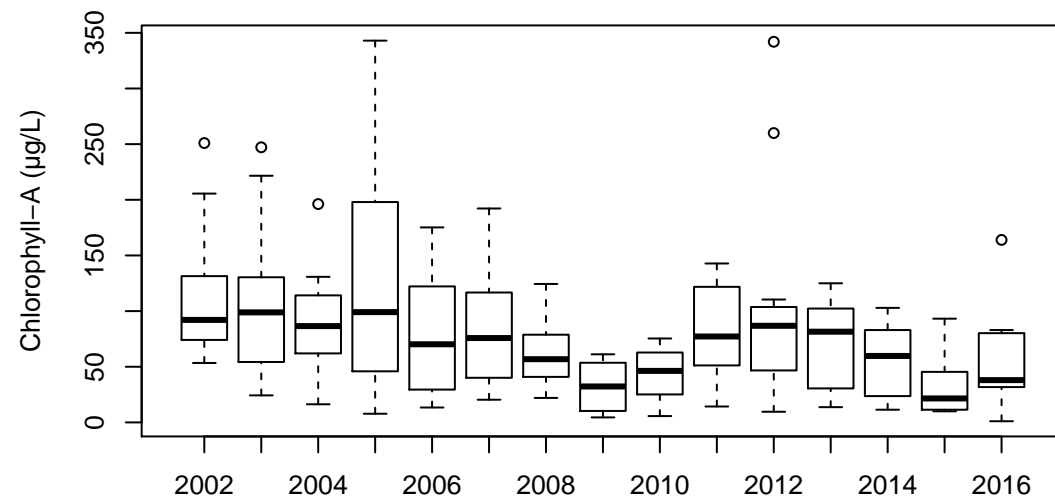


(d) Boxplot by month

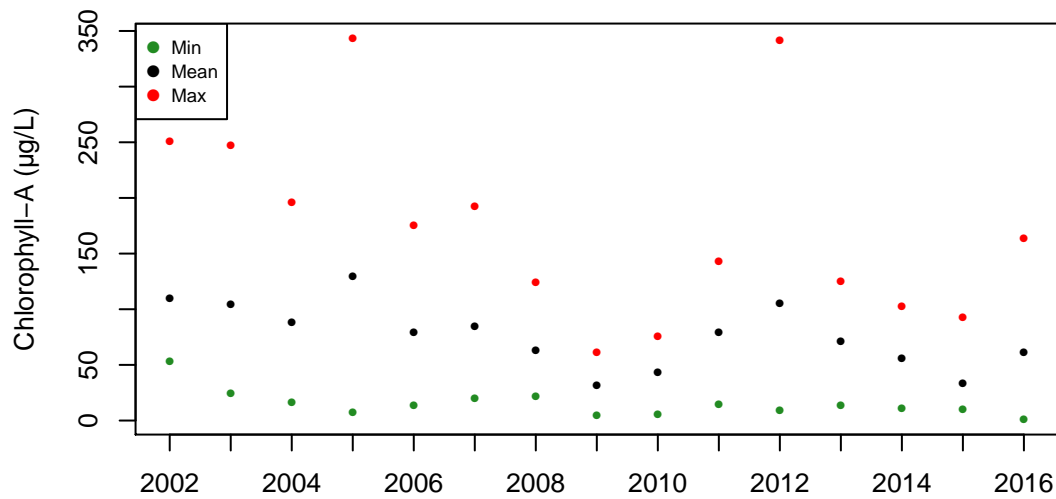
Fox River at Johnsburg (184): Chlorophyll-A ($\mu\text{g/L}$)



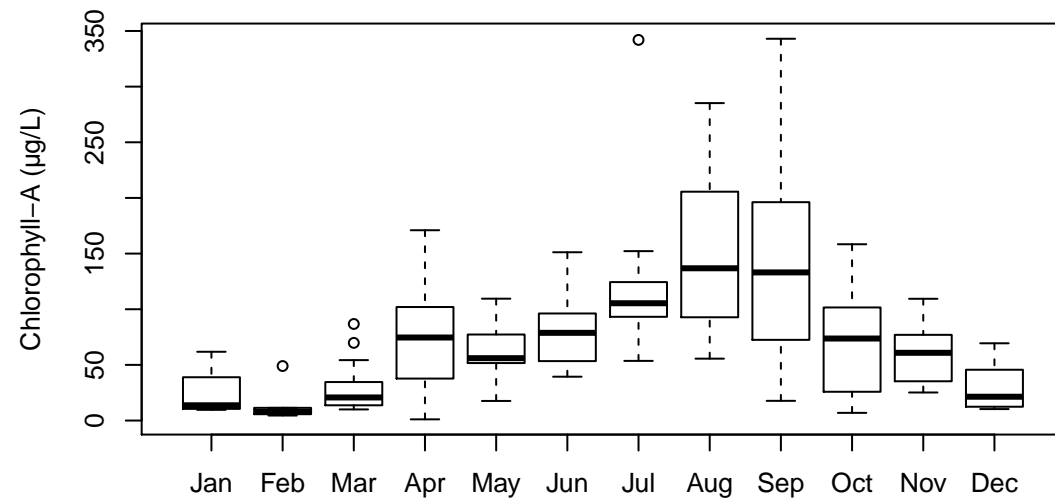
(a) Observation data



(b) Boxplot by year

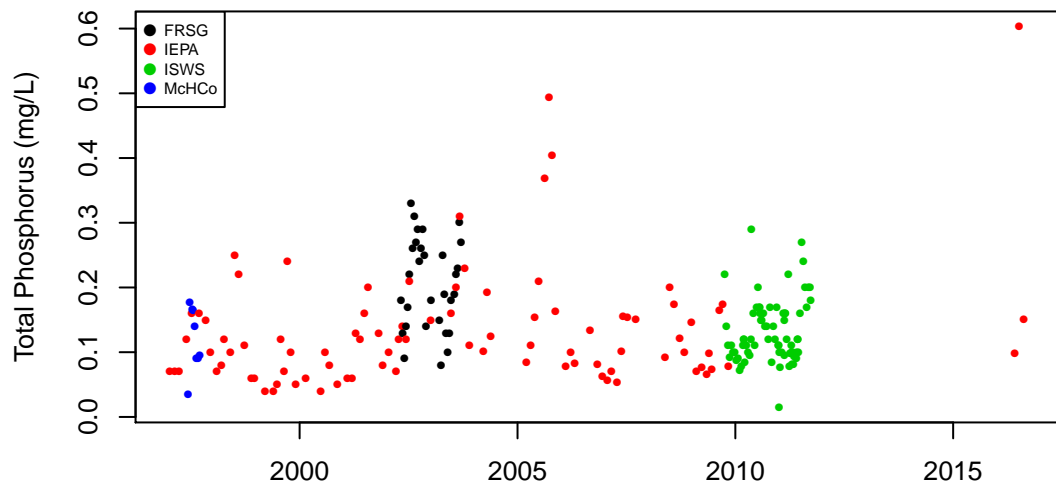


(c) Annual values

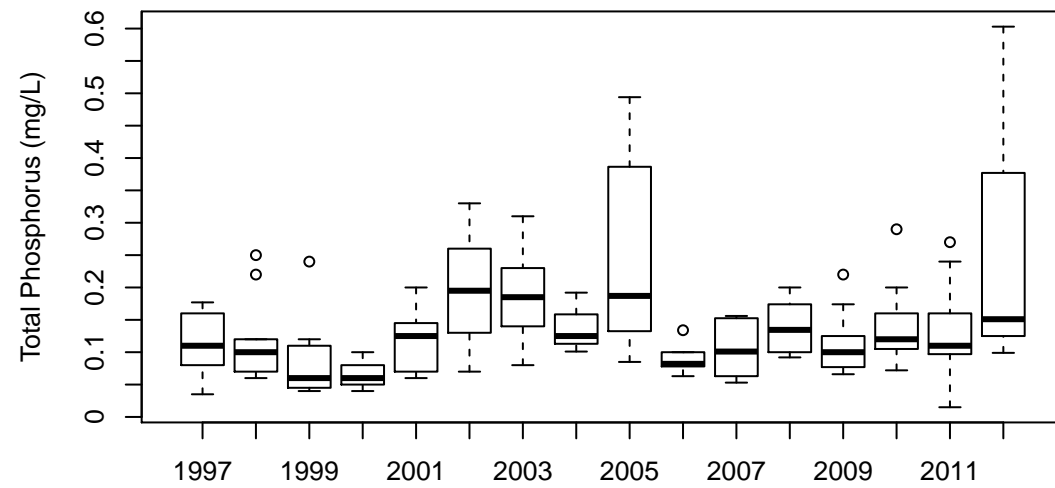


(d) Boxplot by month

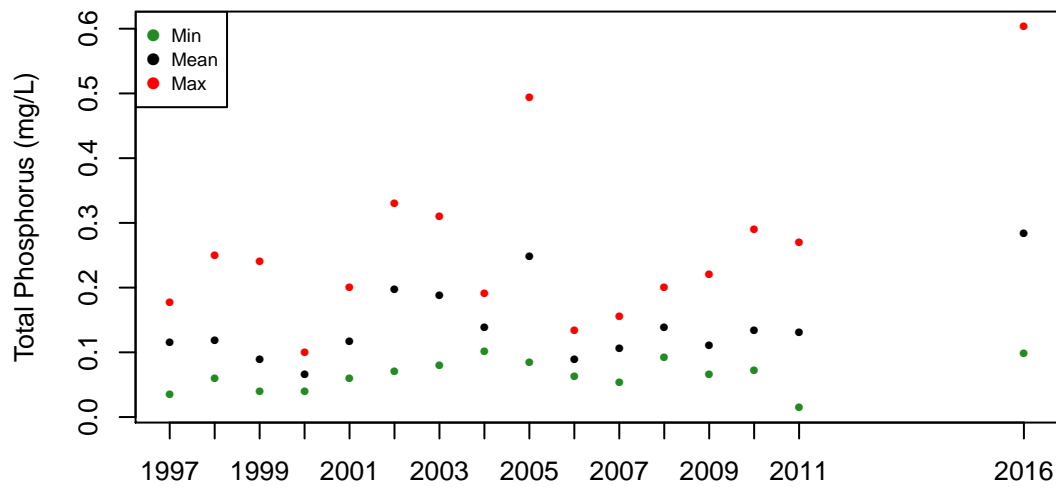
Fox River at Rt 176 (23): Total Phosphorus (mg/L)



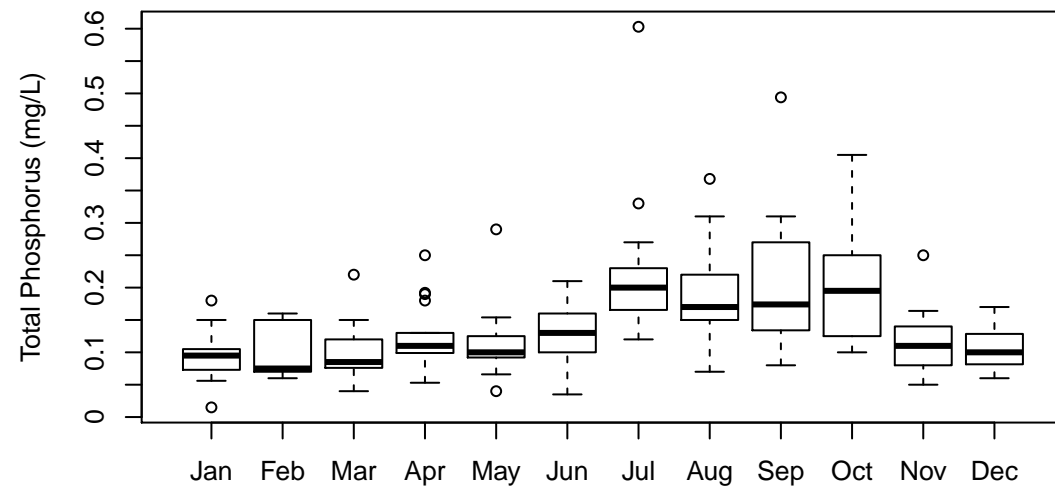
(a) Observation data



(b) Boxplot by year

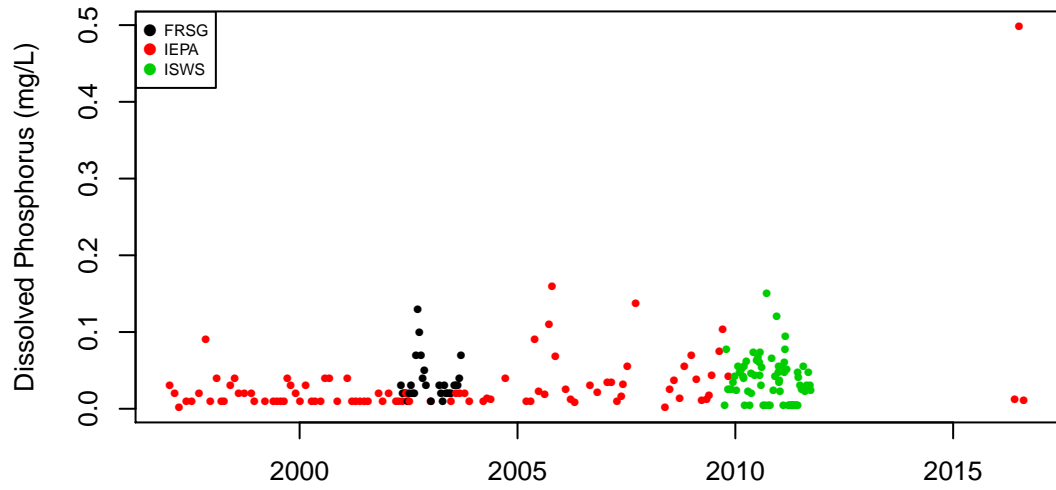


(c) Annual values

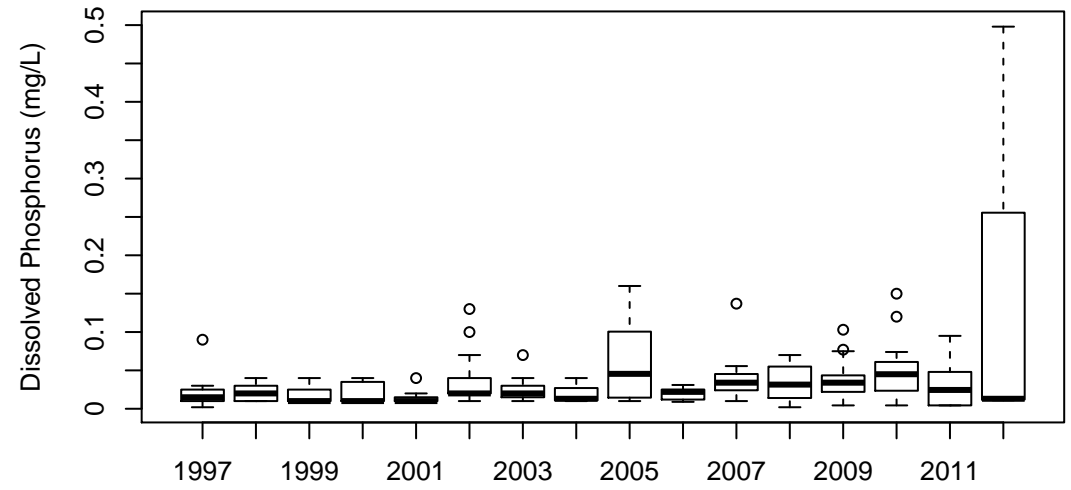


(d) Boxplot by month

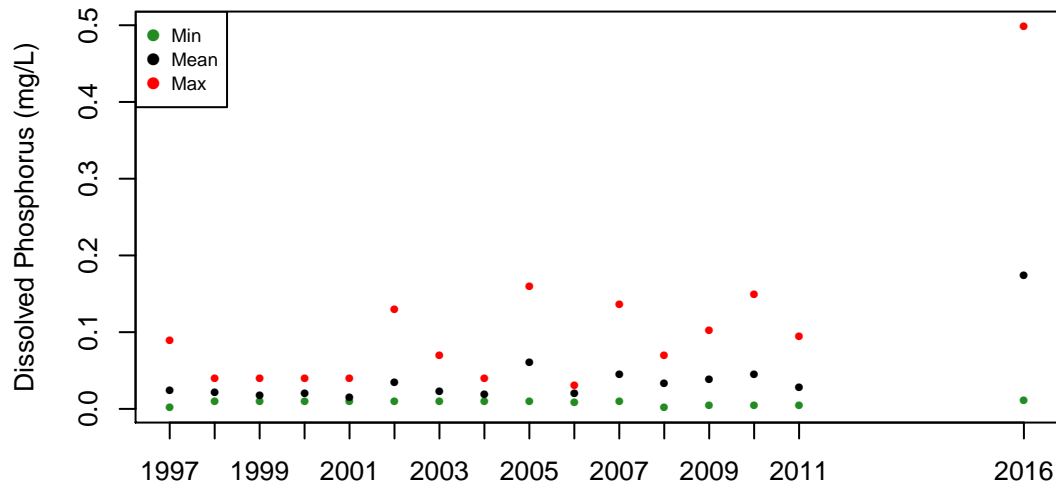
Fox River at Rt 176 (23): Dissolved Phosphorus (mg/L)



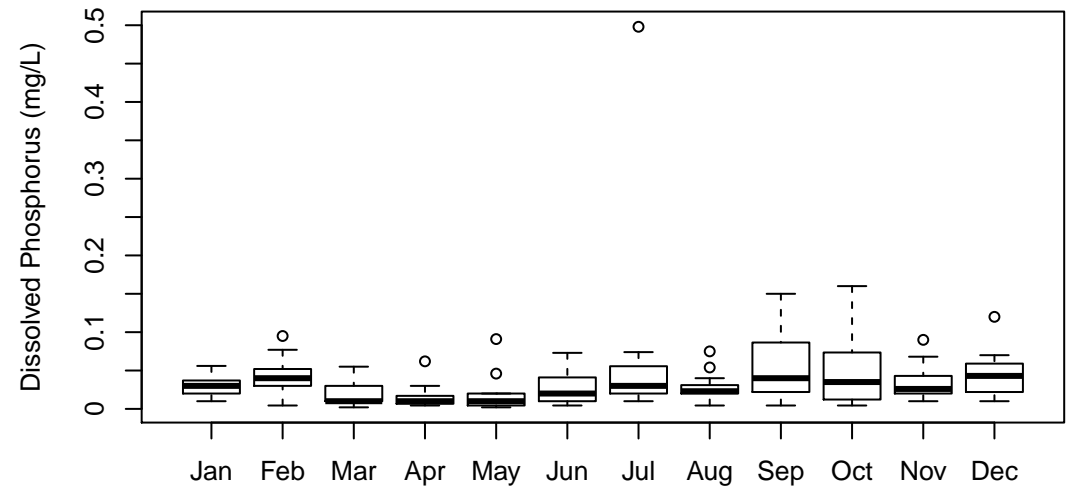
(a) Observation data



(b) Boxplot by year

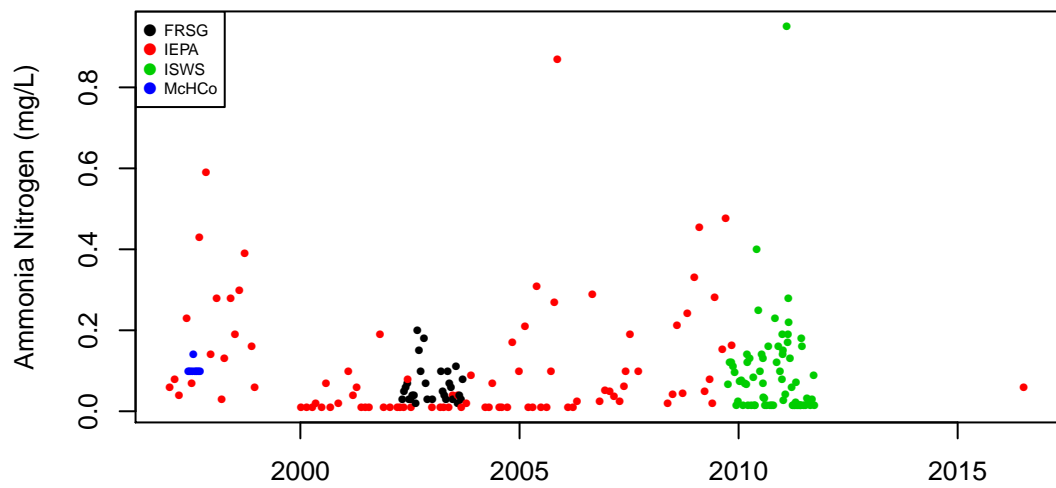


(c) Annual values

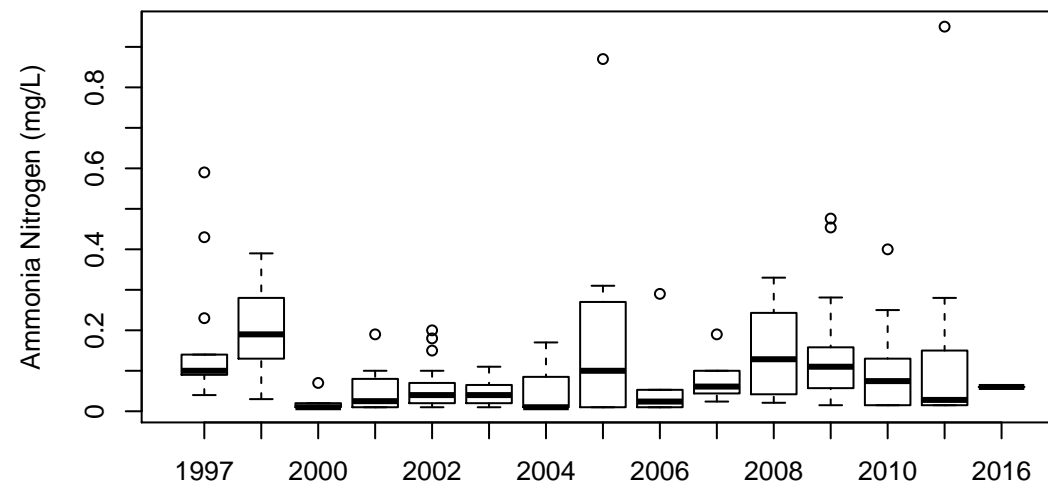


(d) Boxplot by month

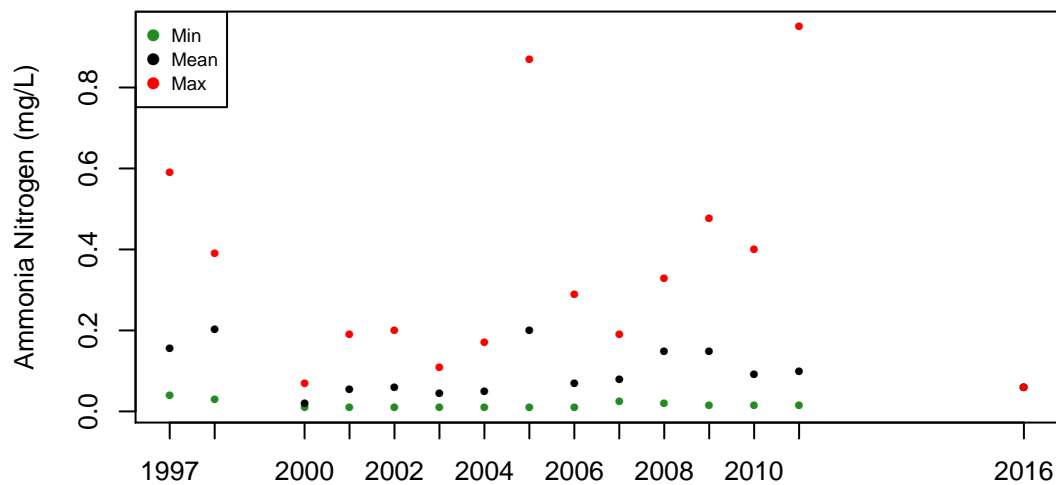
Fox River at Rt 176 (23): Ammonia Nitrogen (mg/L)



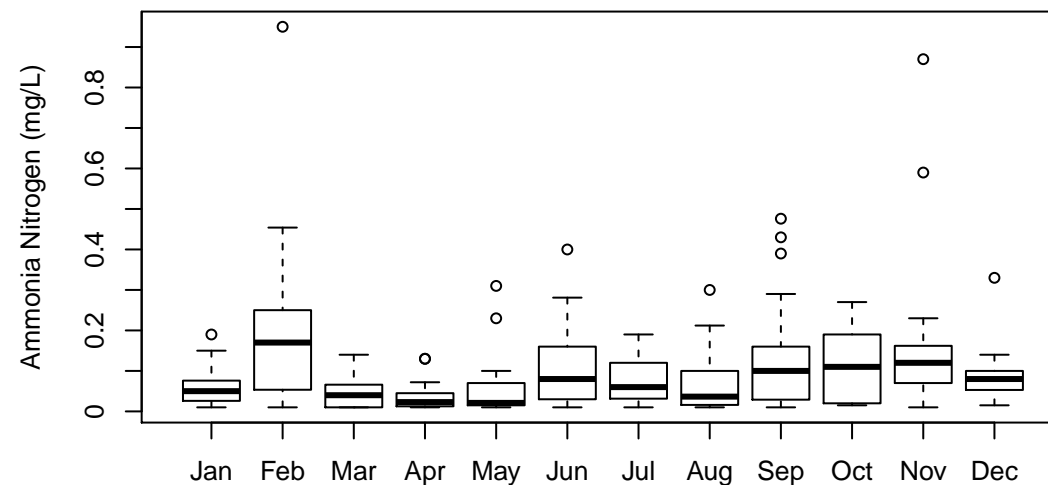
(a) Observation data



(b) Boxplot by year

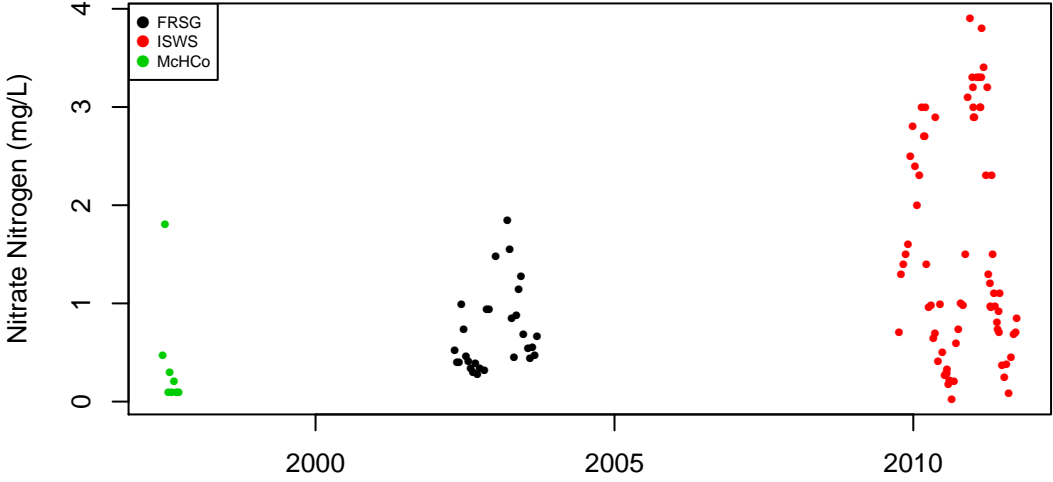


(c) Annual values

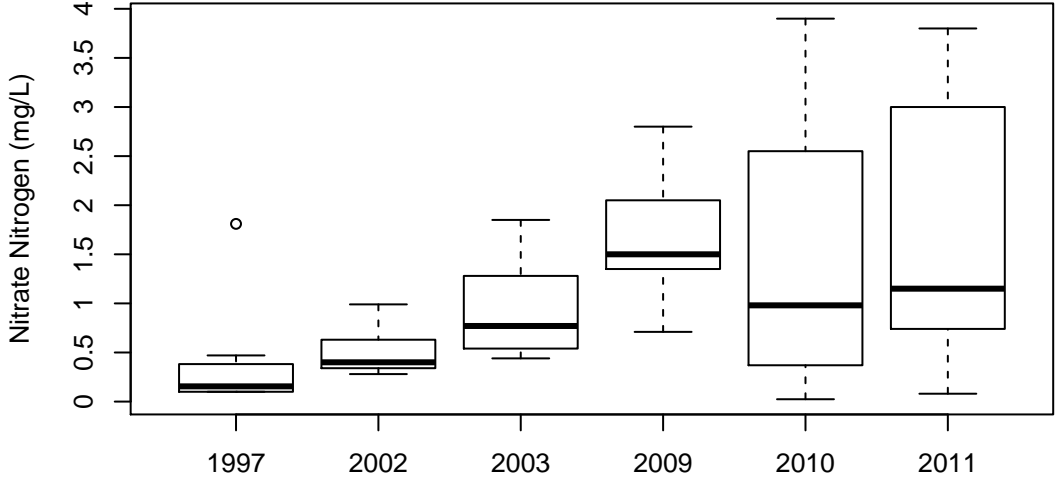


(d) Boxplot by month

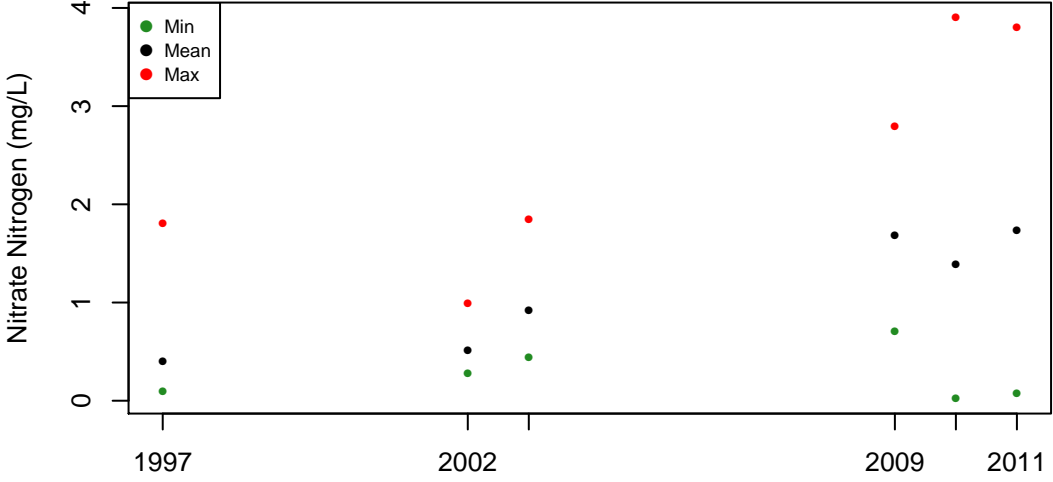
Fox River at Rt 176 (23): Nitrate Nitrogen (mg/L)



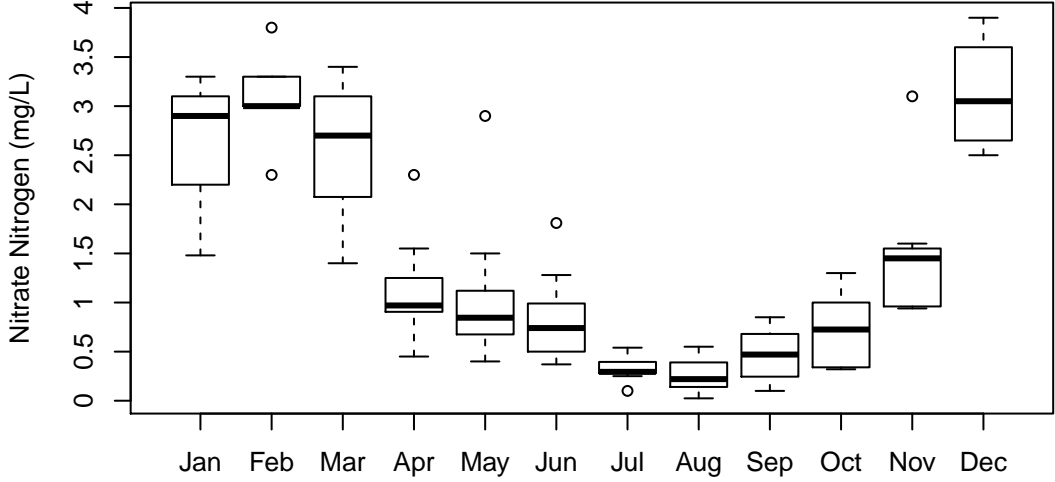
(a) Observation data



(b) Boxplot by year

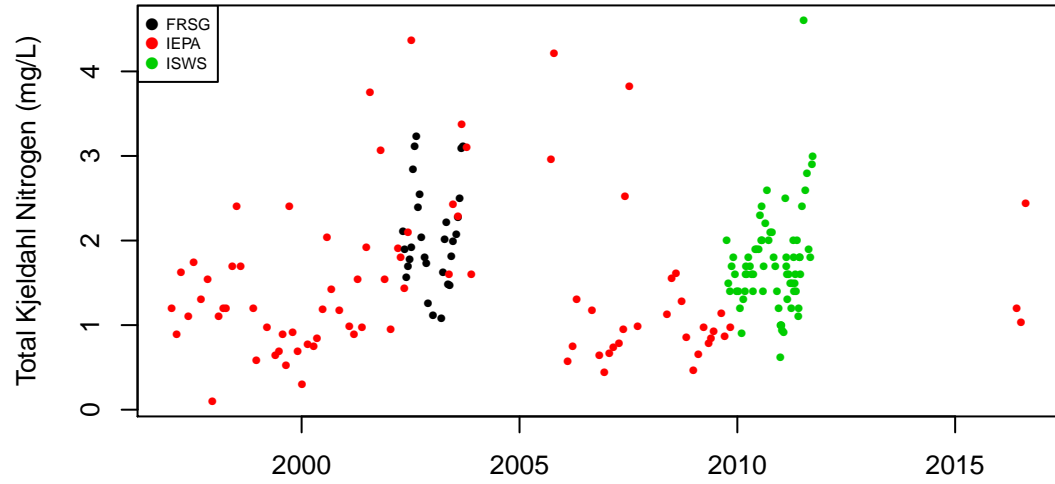


(c) Annual values

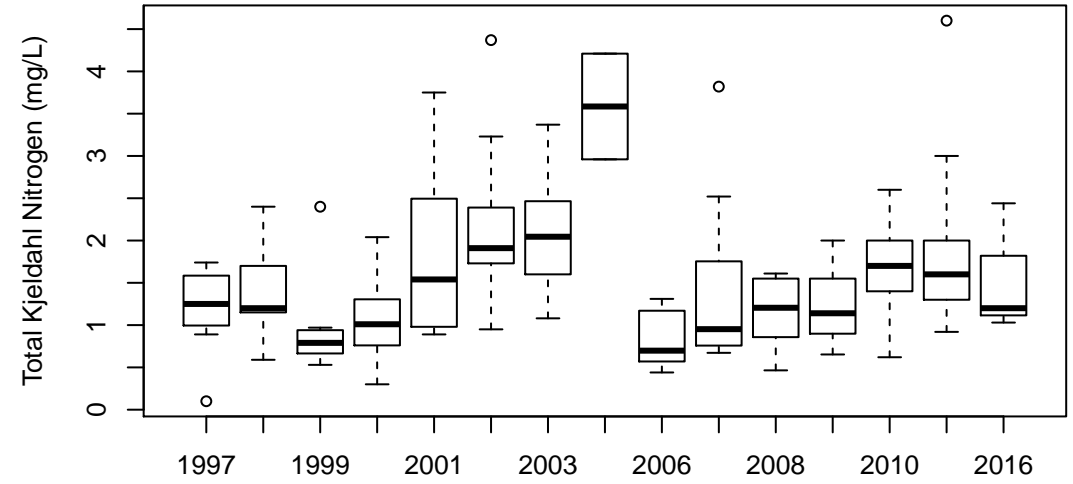


(d) Boxplot by month

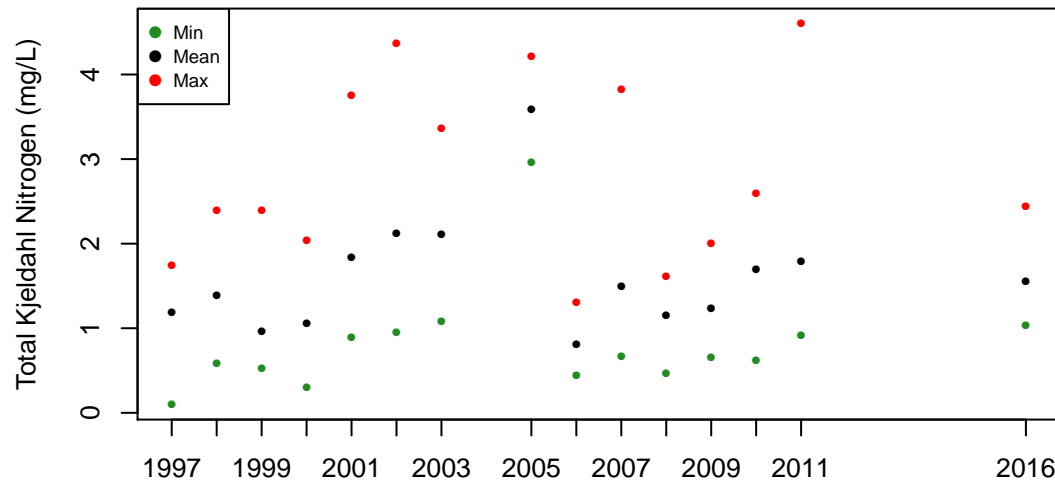
Fox River at Rt 176 (23): Total Kjeldahl Nitrogen (mg/L)



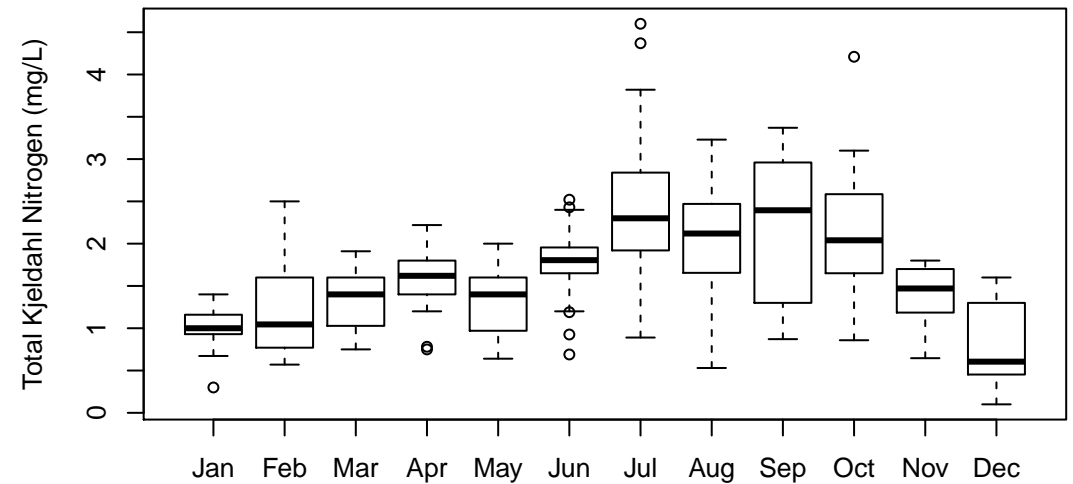
(a) Observation data



(b) Boxplot by year

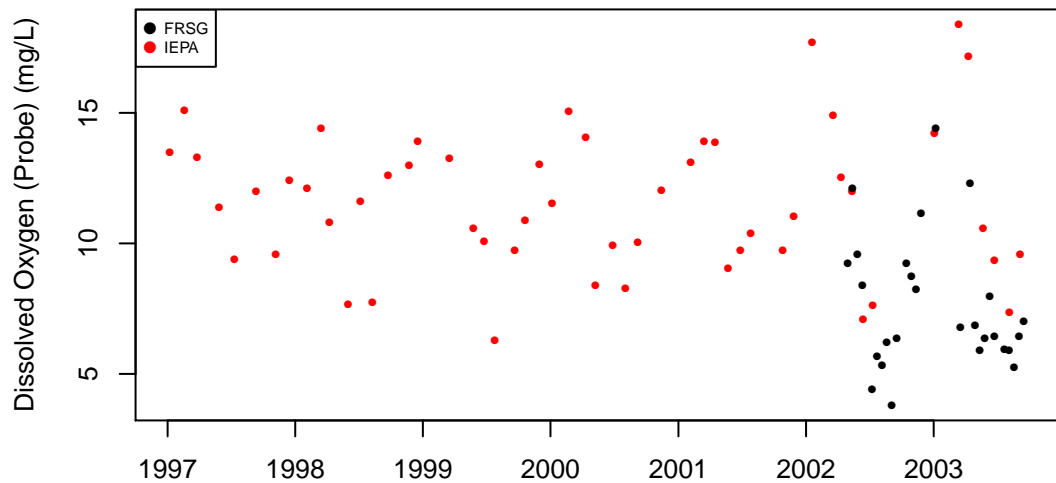


(c) Annual values

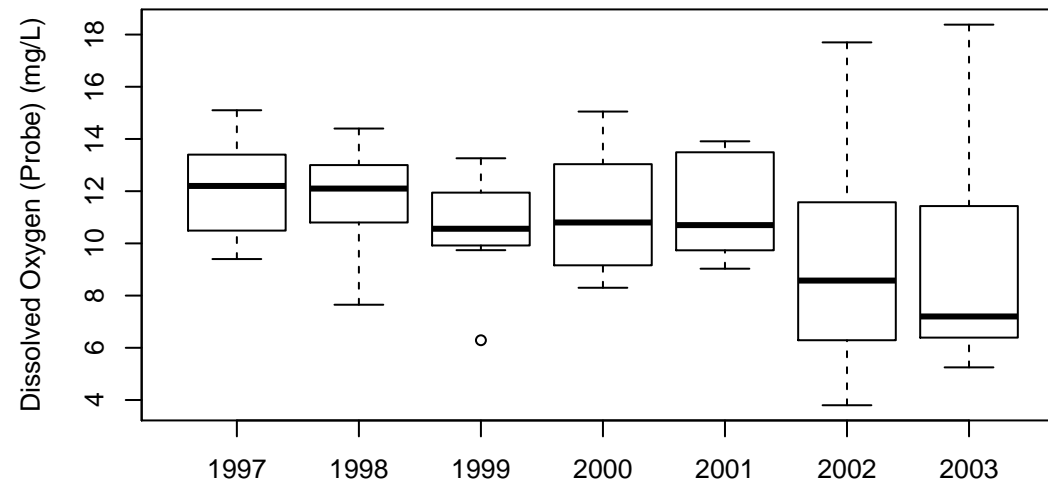


(d) Boxplot by month

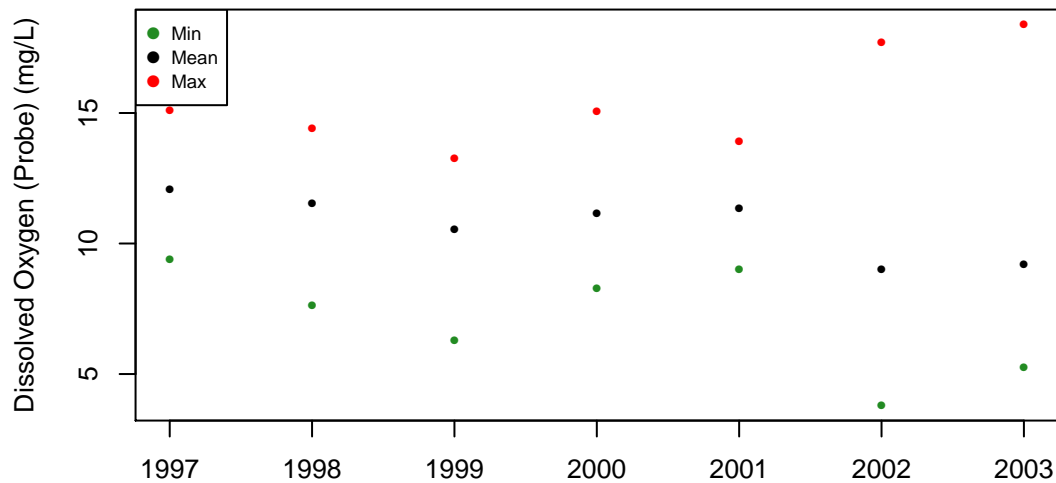
Fox River at Rt 176 (23): Dissolved Oxygen (Probe) (mg/L)



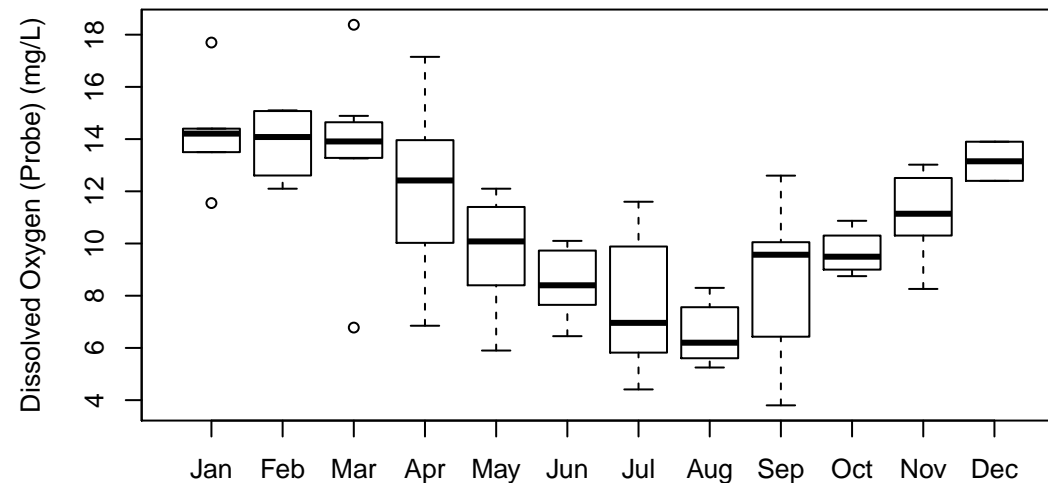
(a) Observation data



(b) Boxplot by year

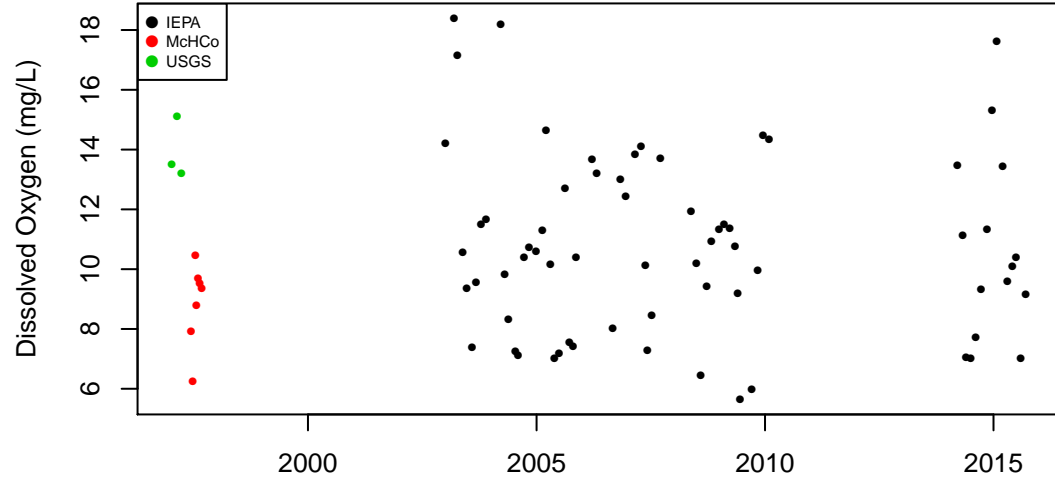


(c) Annual values

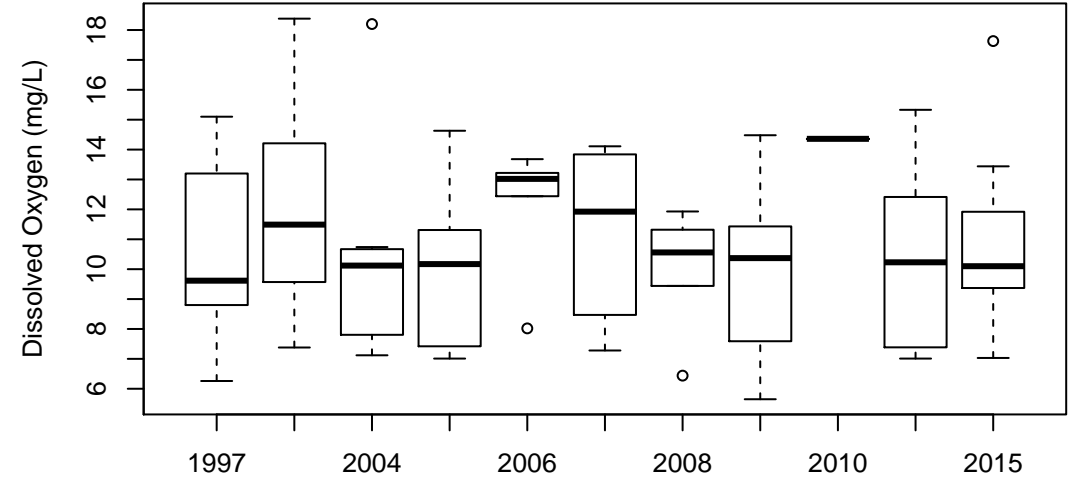


(d) Boxplot by month

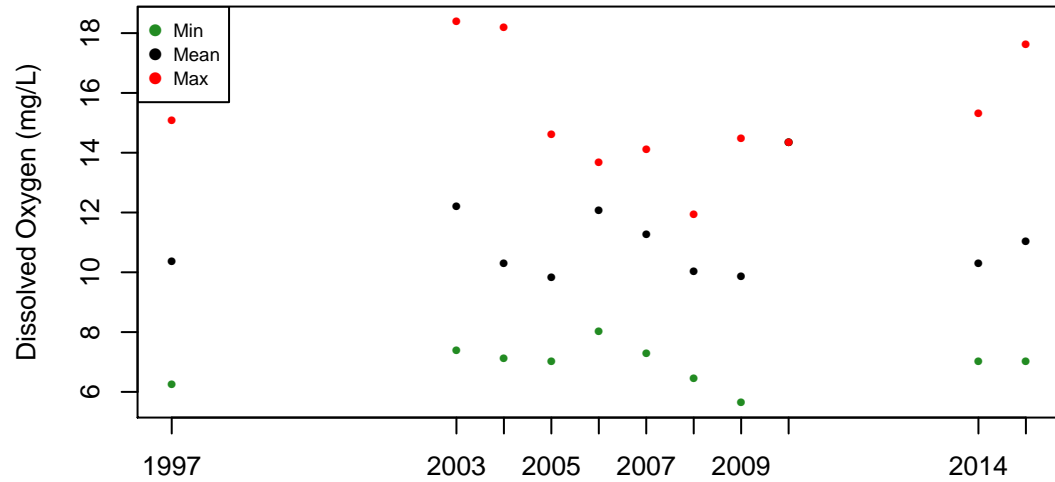
Fox River at Rt 176 (23): Dissolved Oxygen (mg/L)



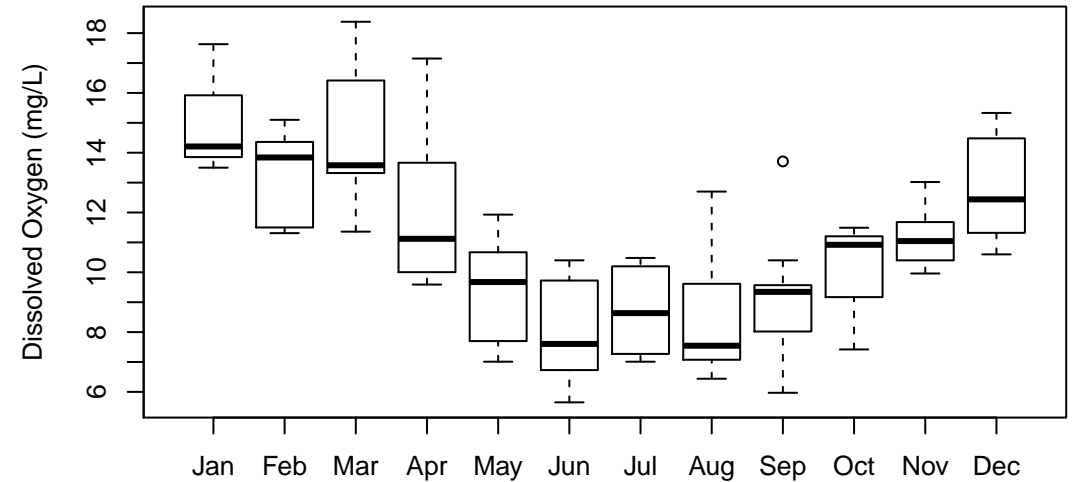
(a) Observation data



(b) Boxplot by year



(c) Annual values

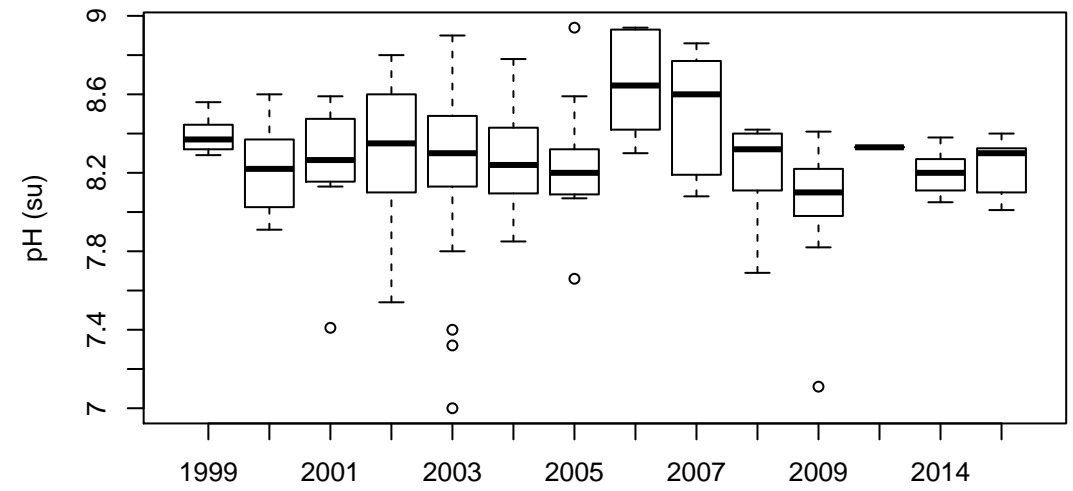


(d) Boxplot by month

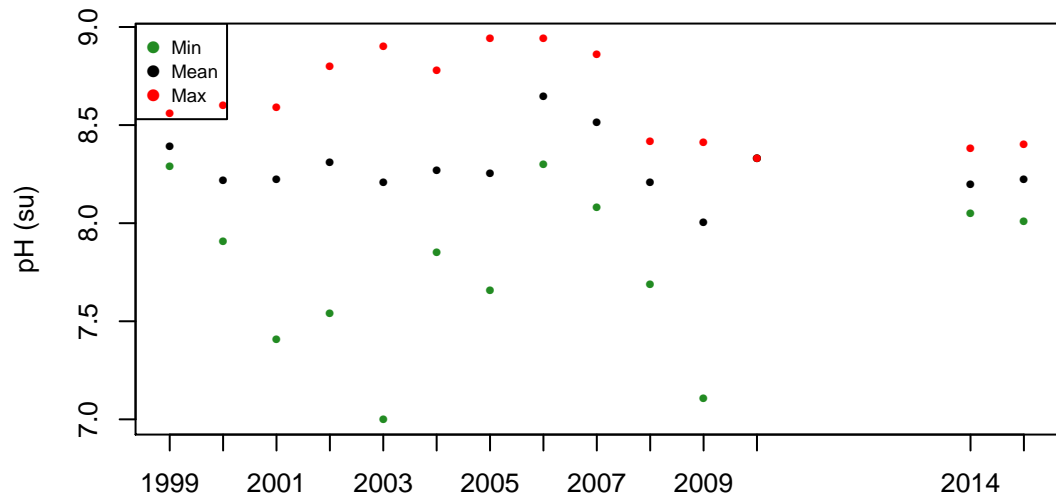
Fox River at Rt 176 (23): pH (su)



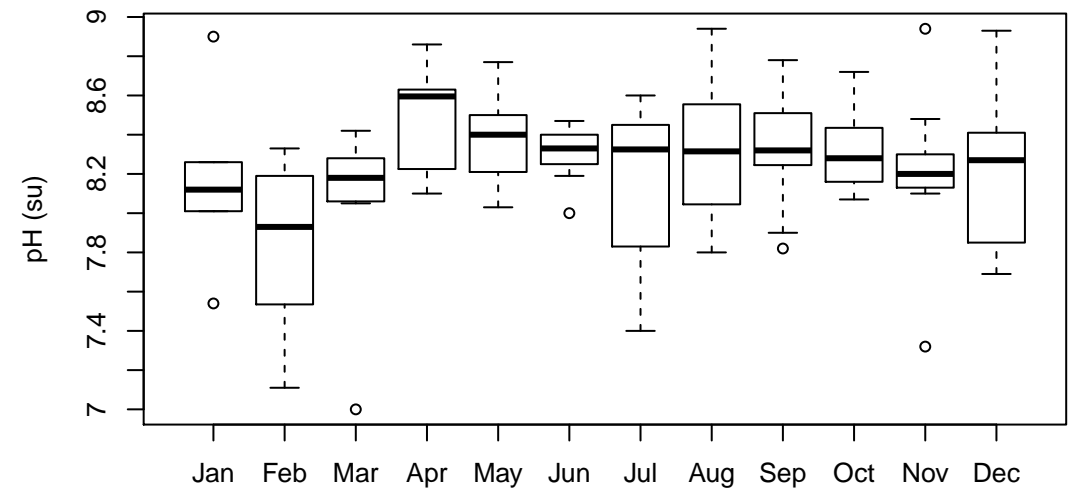
(a) Observation data



(b) Boxplot by year



(c) Annual values

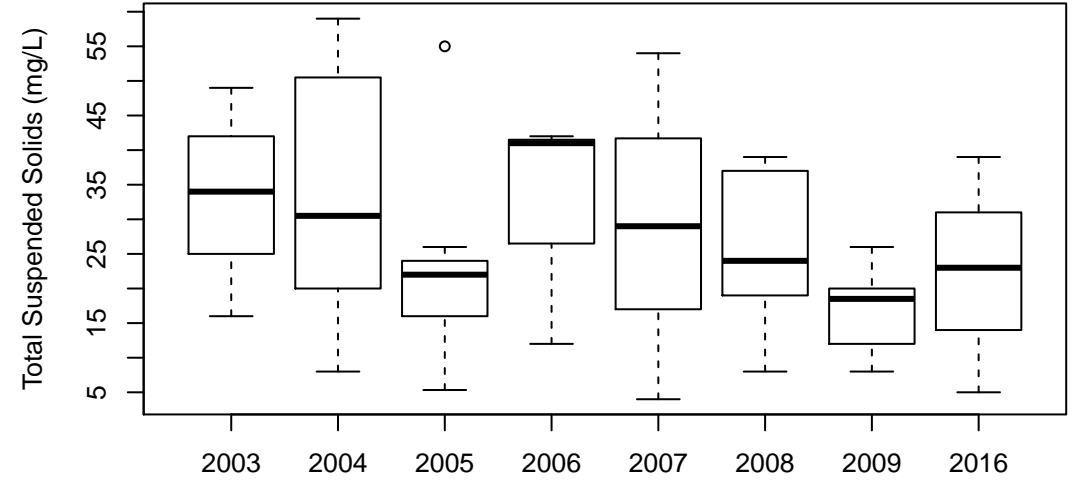


(d) Boxplot by month

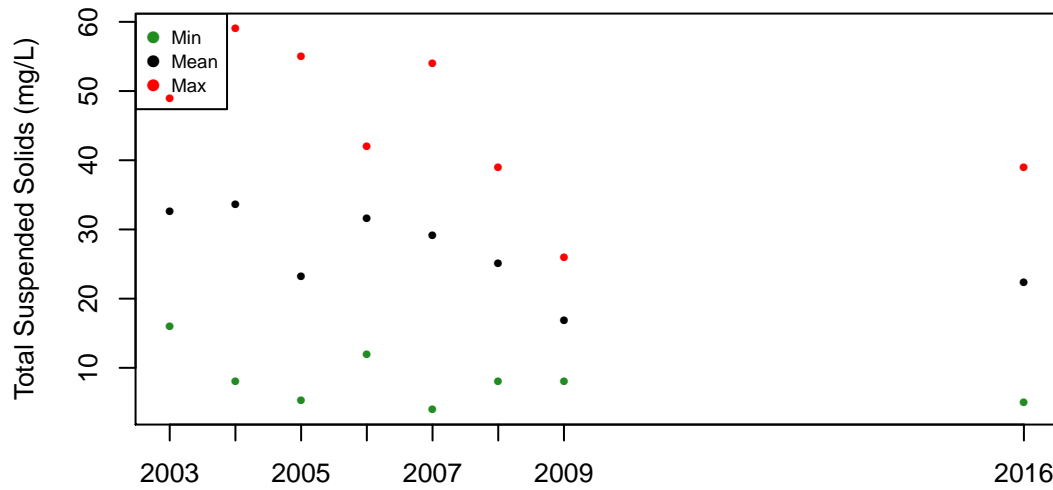
Fox River at Rt 176 (23): Total Suspended Solids (mg/L)



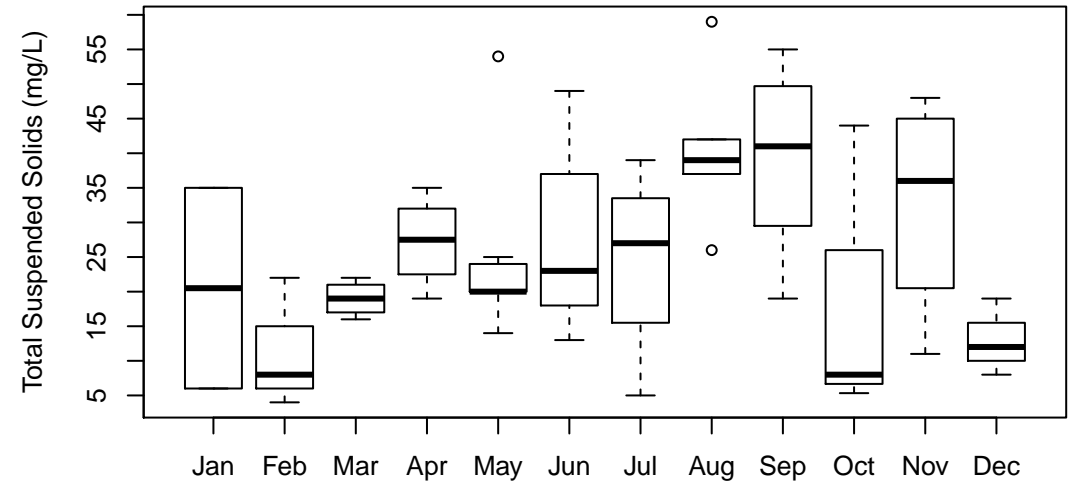
(a) Observation data



(b) Boxplot by year

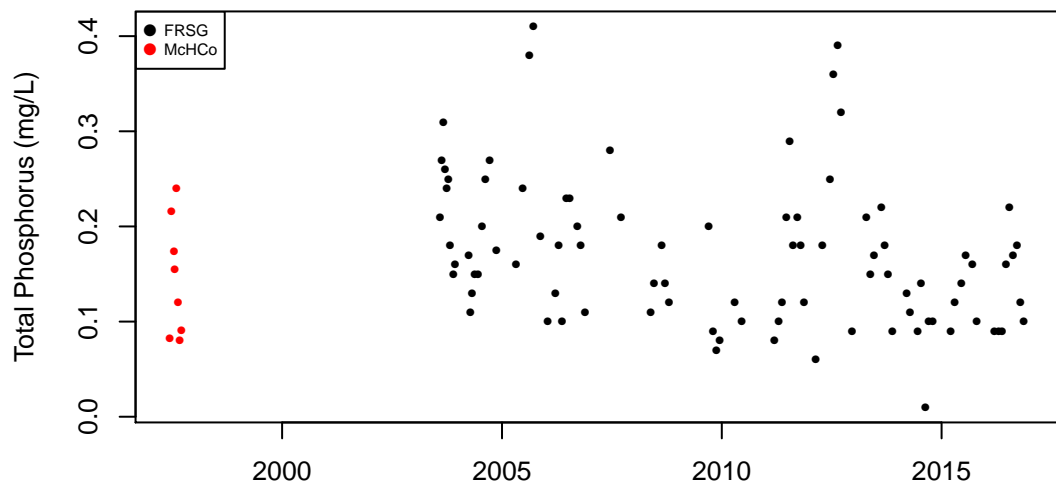


(c) Annual values

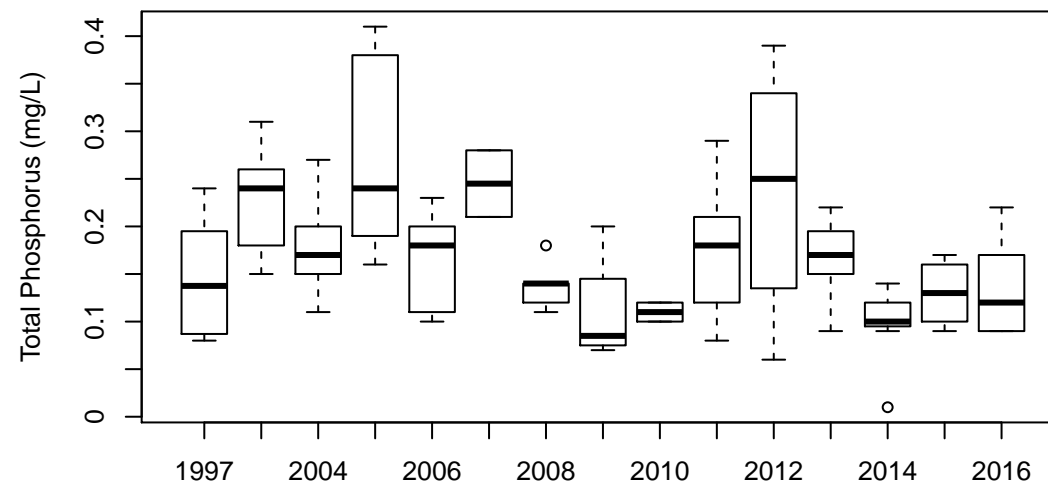


(d) Boxplot by month

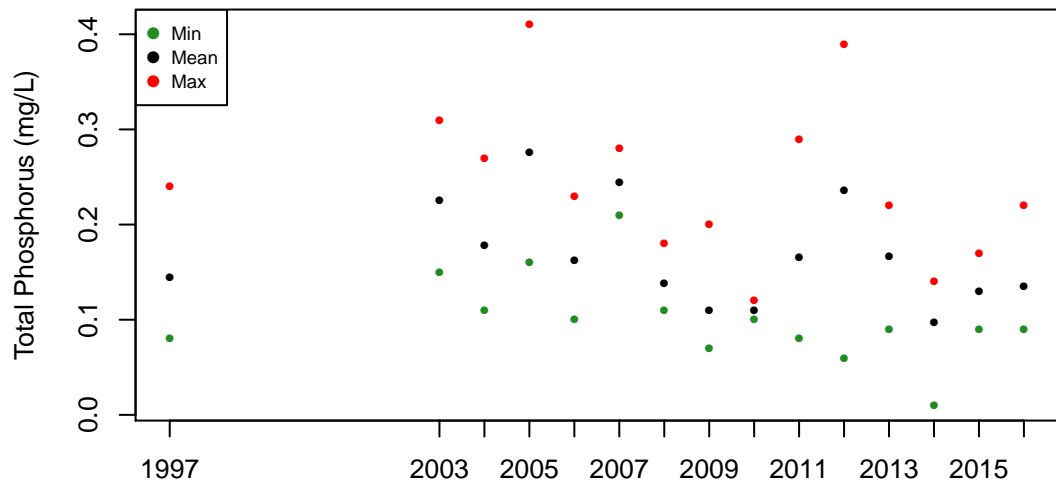
Fox River at Oakwood Hills (258): Total Phosphorus (mg/L)



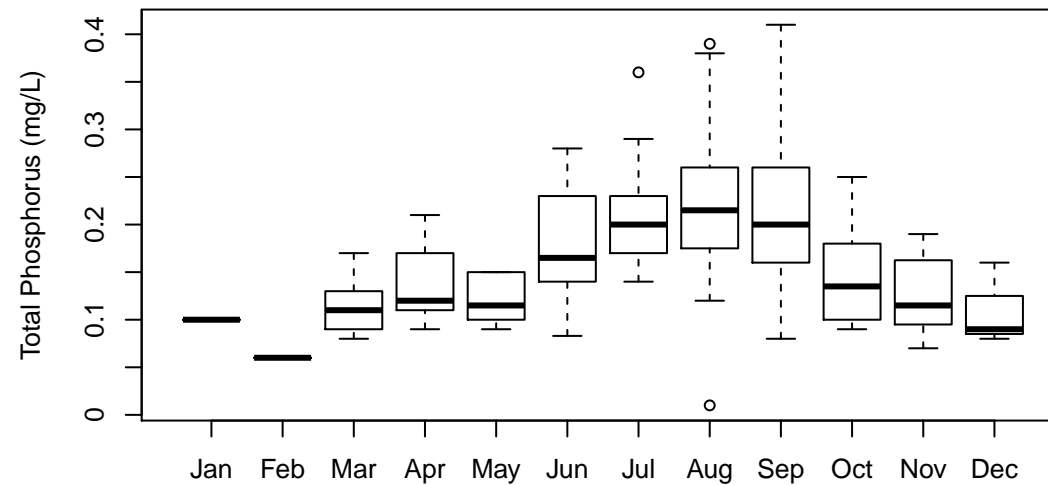
(a) Observation data



(b) Boxplot by year

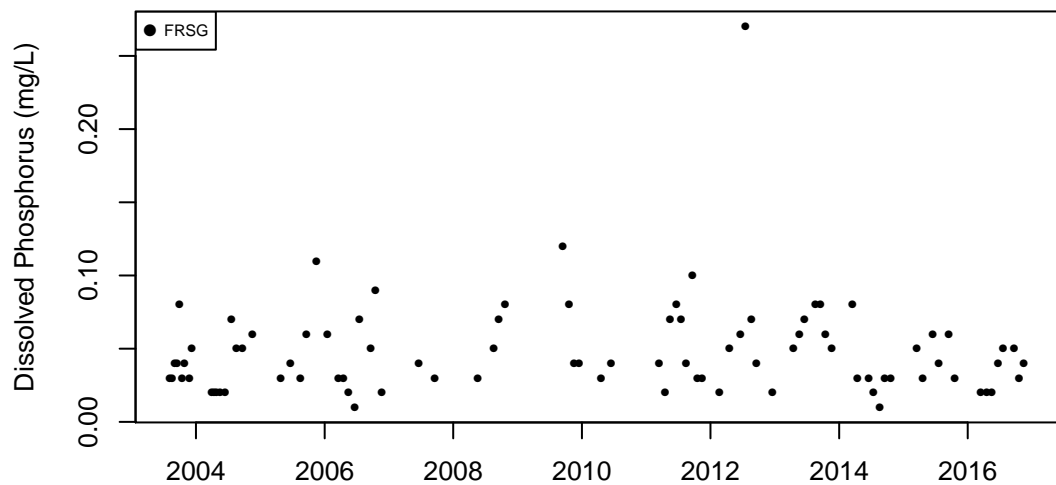


(c) Annual values

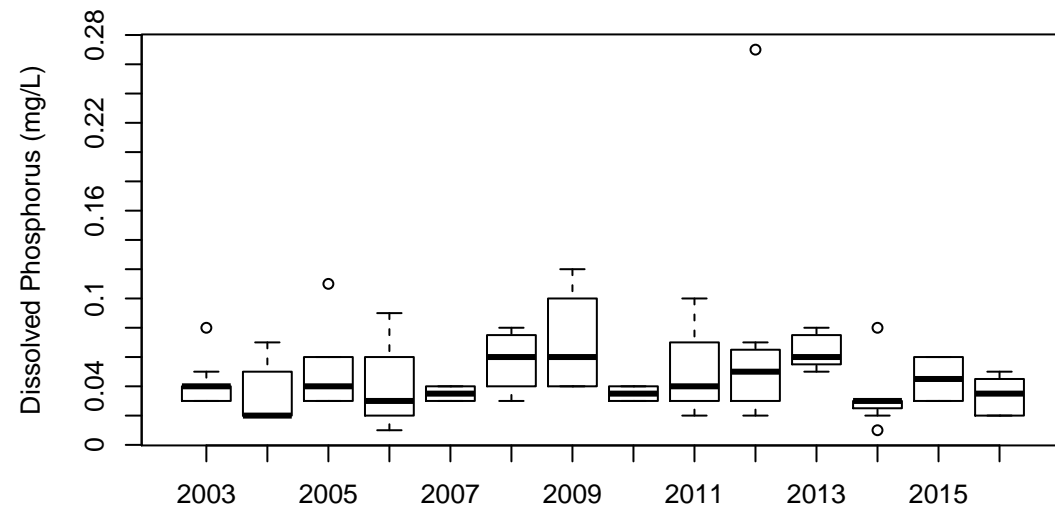


(d) Boxplot by month

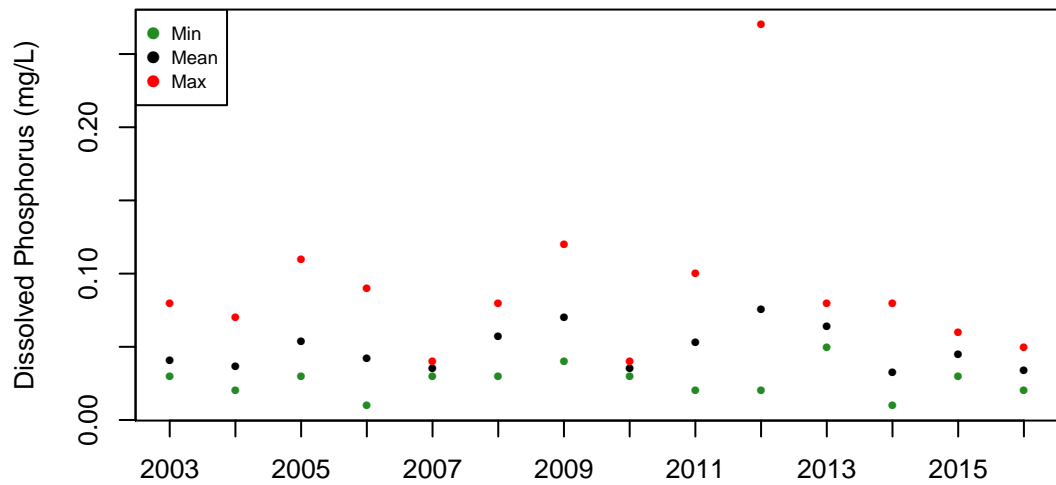
Fox River at Oakwood Hills (258): Dissolved Phosphorus (mg/L)



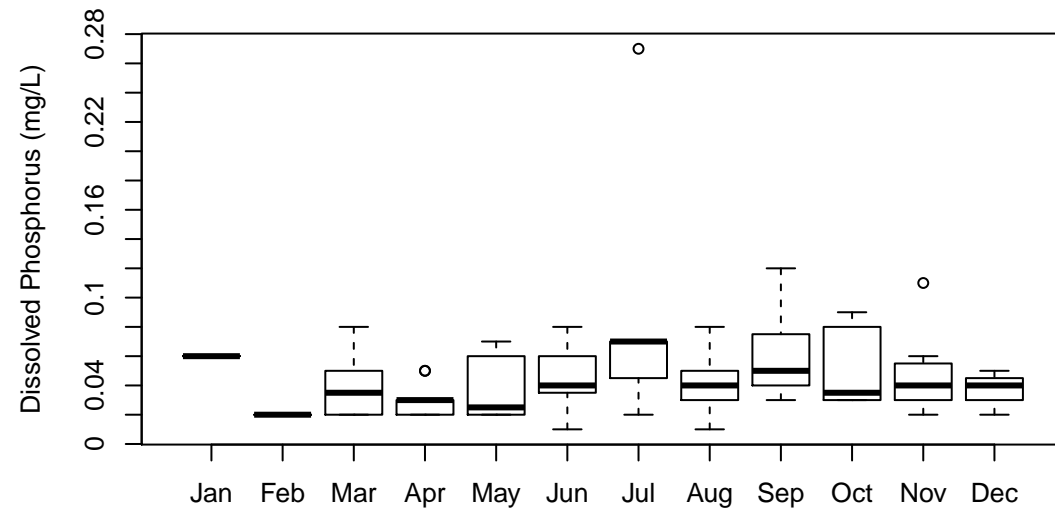
(a) Observation data



(b) Boxplot by year

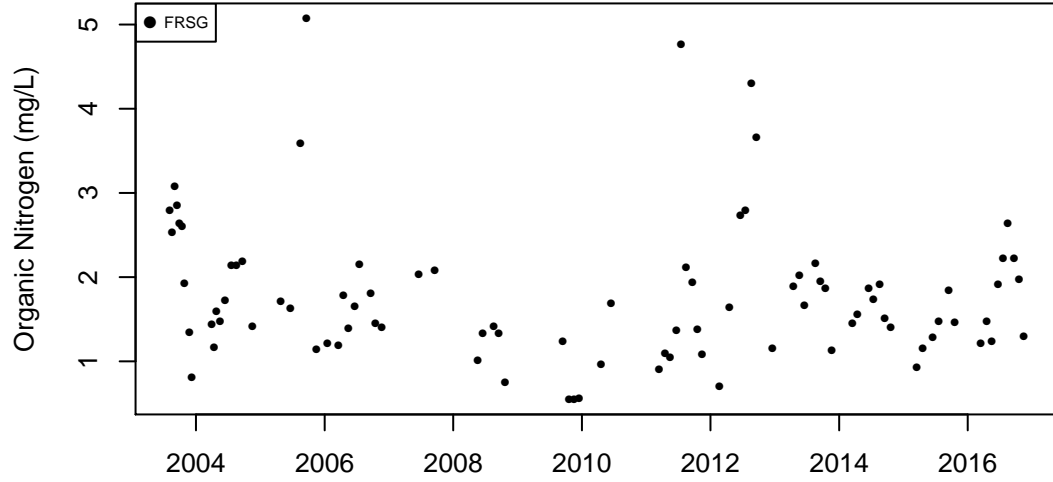


(c) Annual values

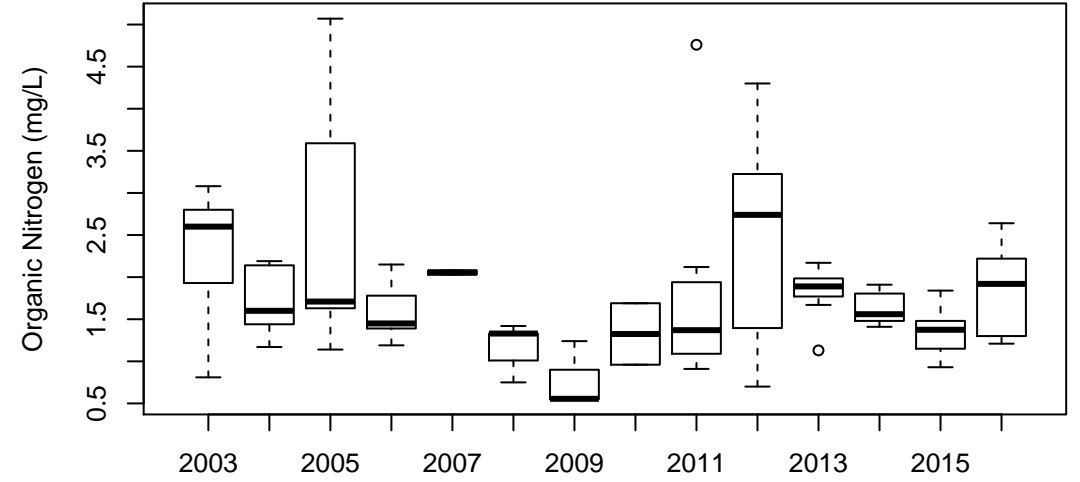


(d) Boxplot by month

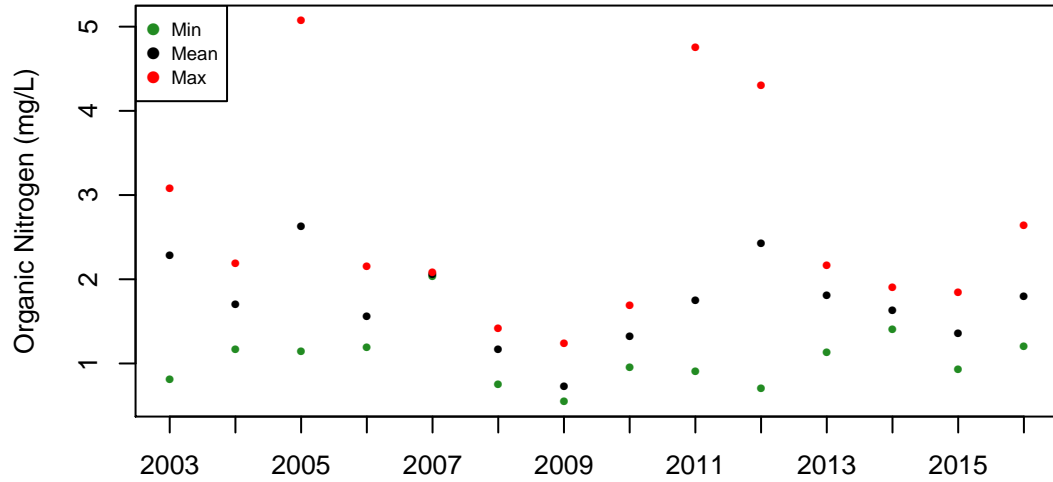
Fox River at Oakwood Hills (258): Organic Nitrogen (mg/L)



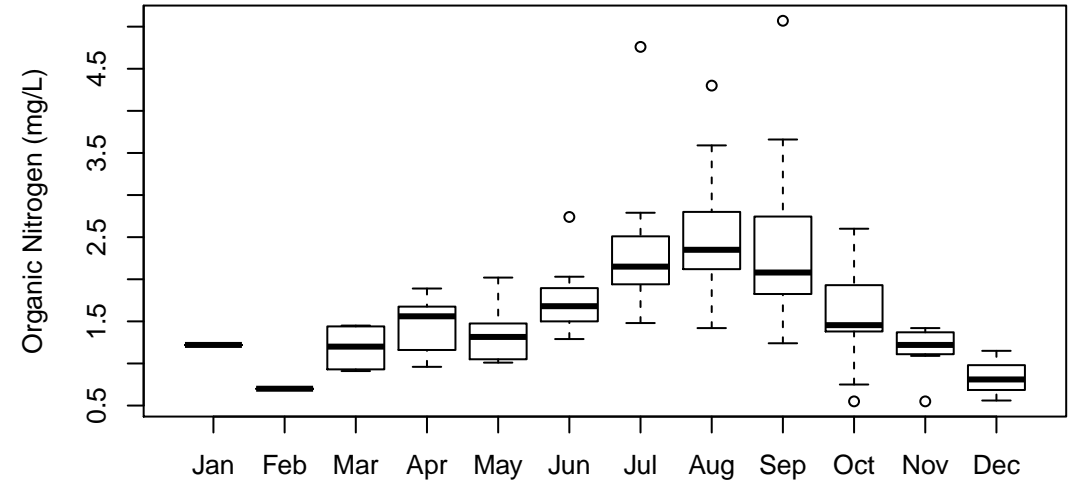
(a) Observation data



(b) Boxplot by year

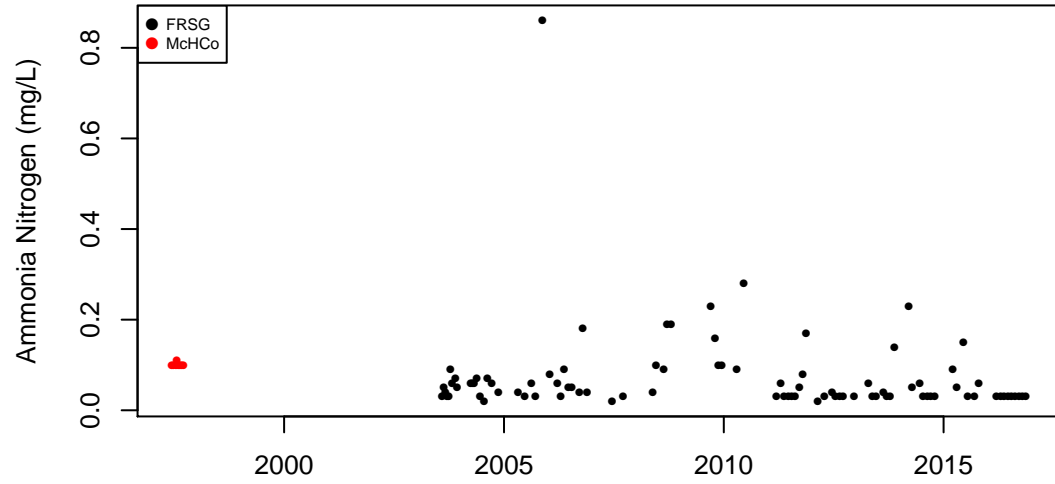


(c) Annual values

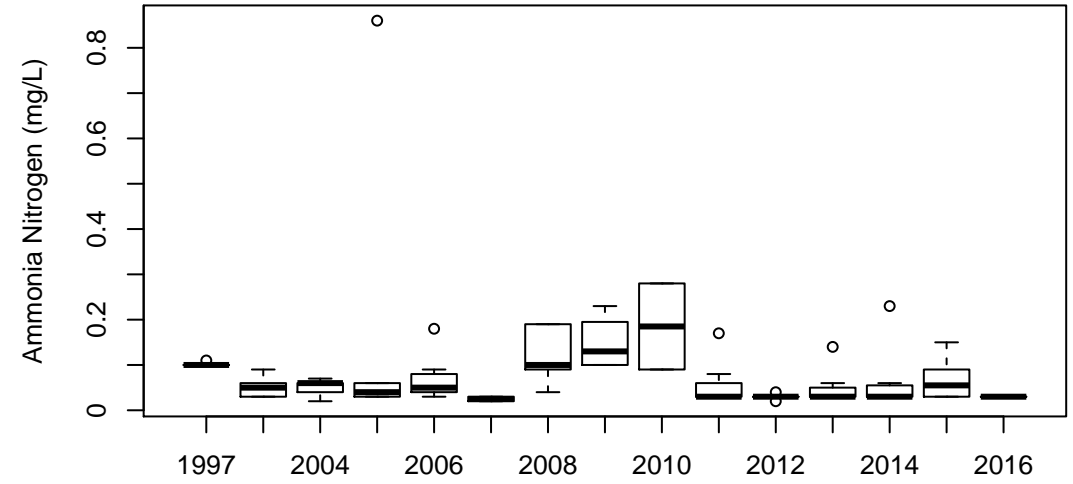


(d) Boxplot by month

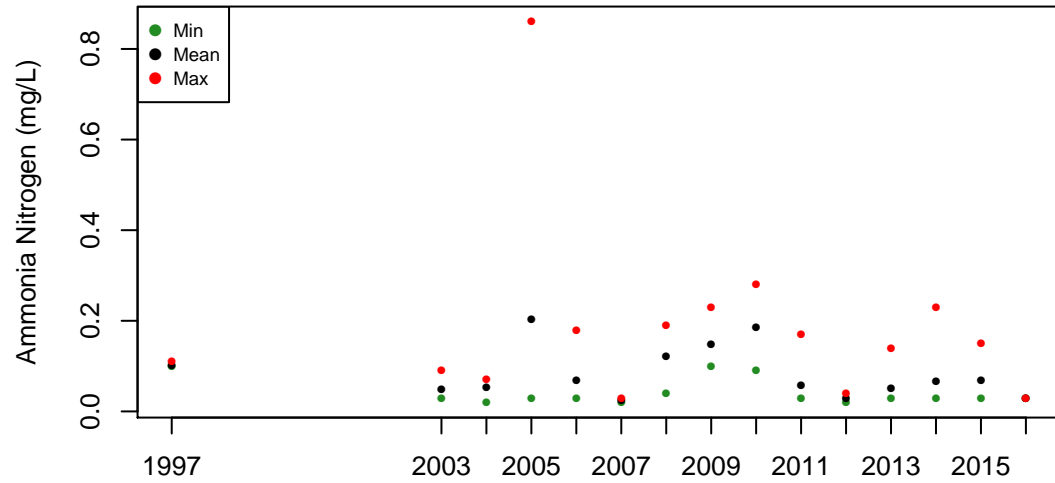
Fox River at Oakwood Hills (258): Ammonia Nitrogen (mg/L)



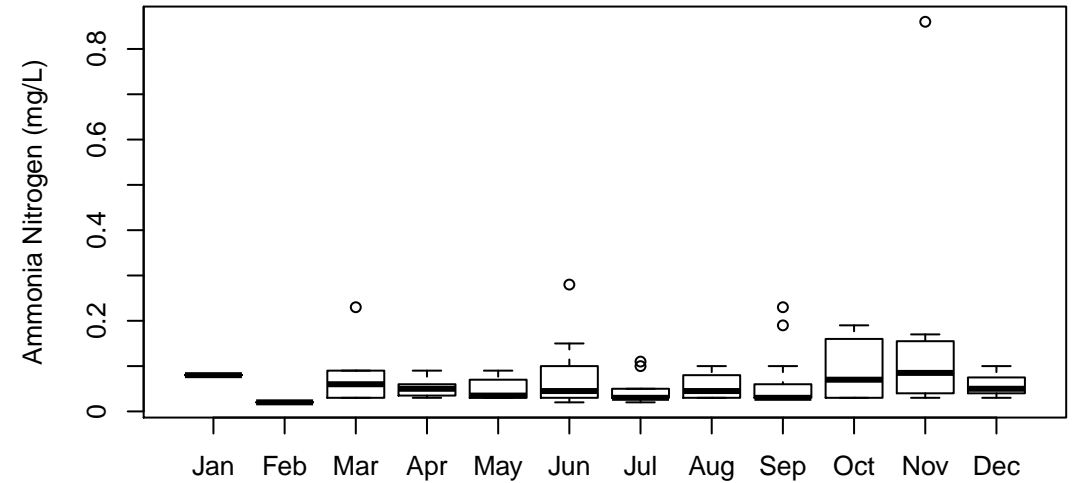
(a) Observation data



(b) Boxplot by year

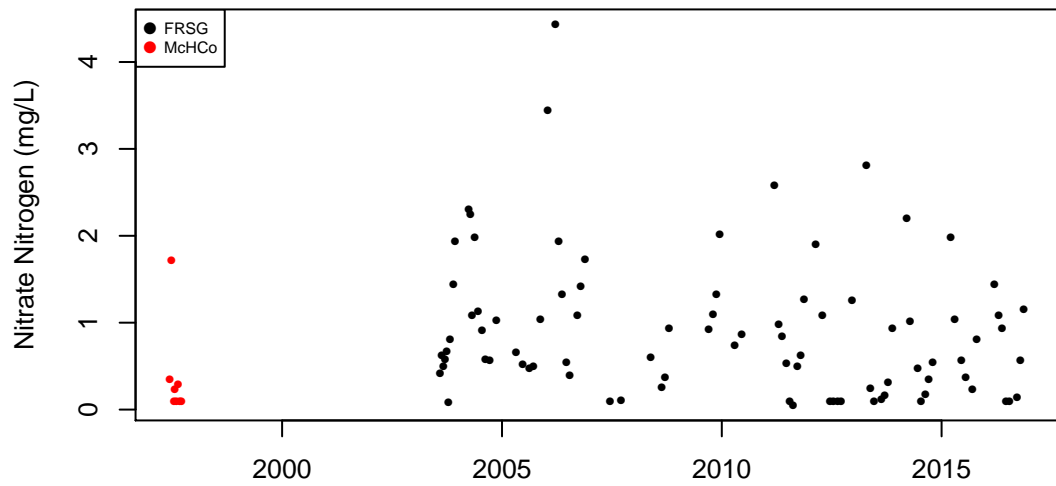


(c) Annual values

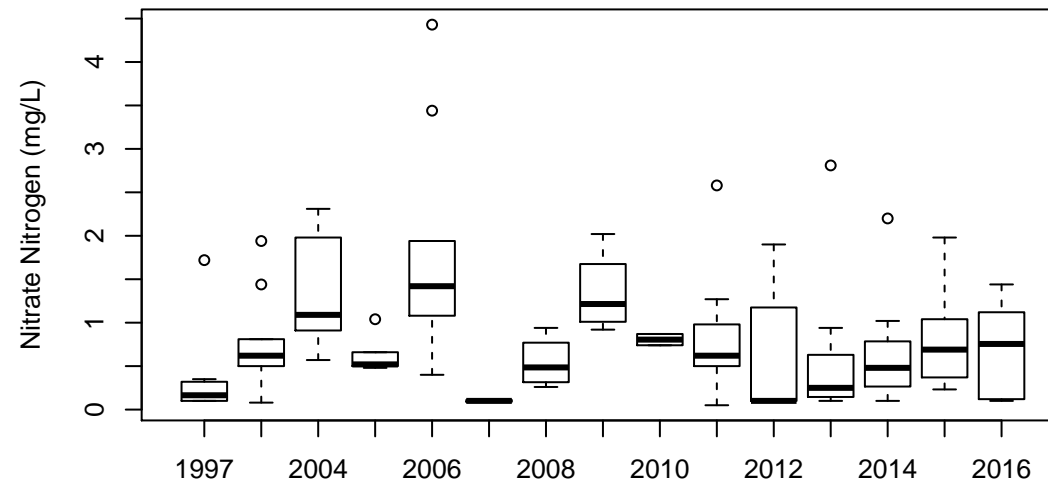


(d) Boxplot by month

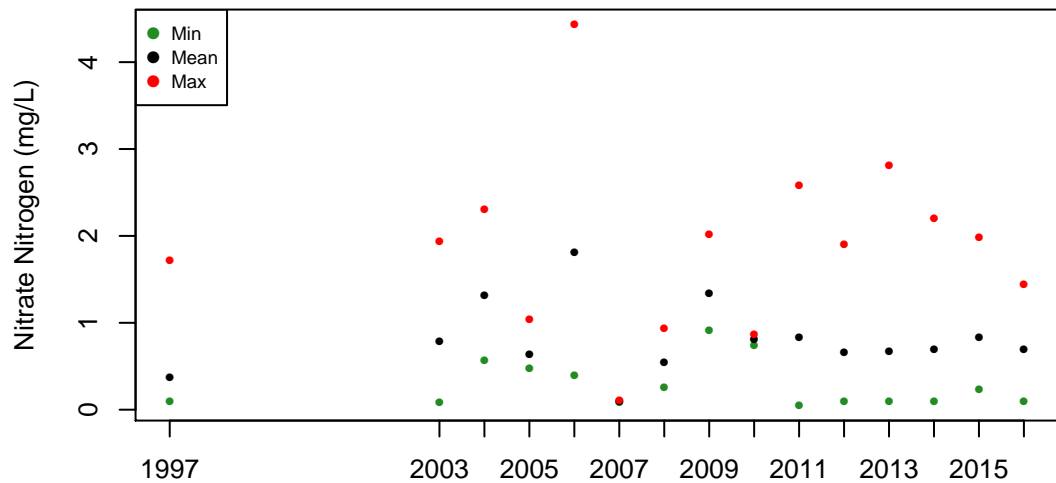
Fox River at Oakwood Hills (258): Nitrate Nitrogen (mg/L)



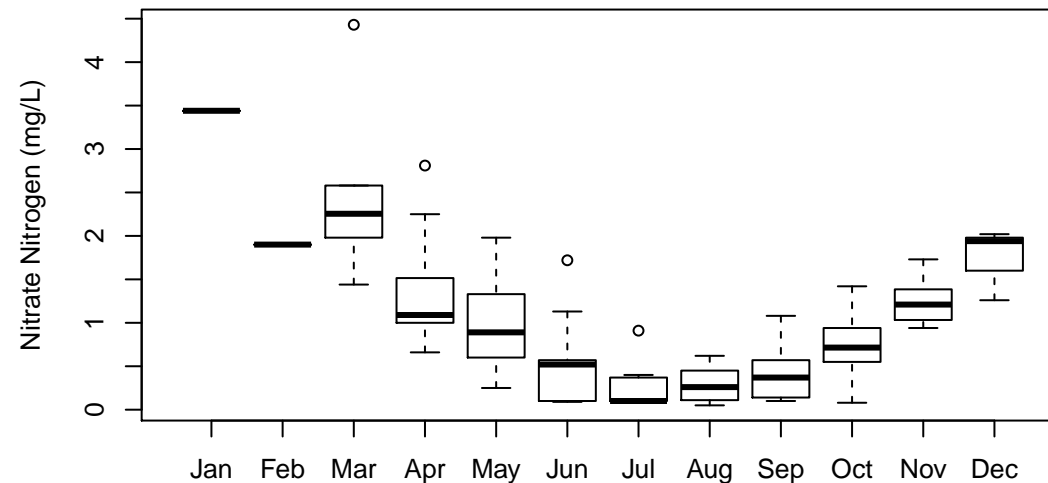
(a) Observation data



(b) Boxplot by year

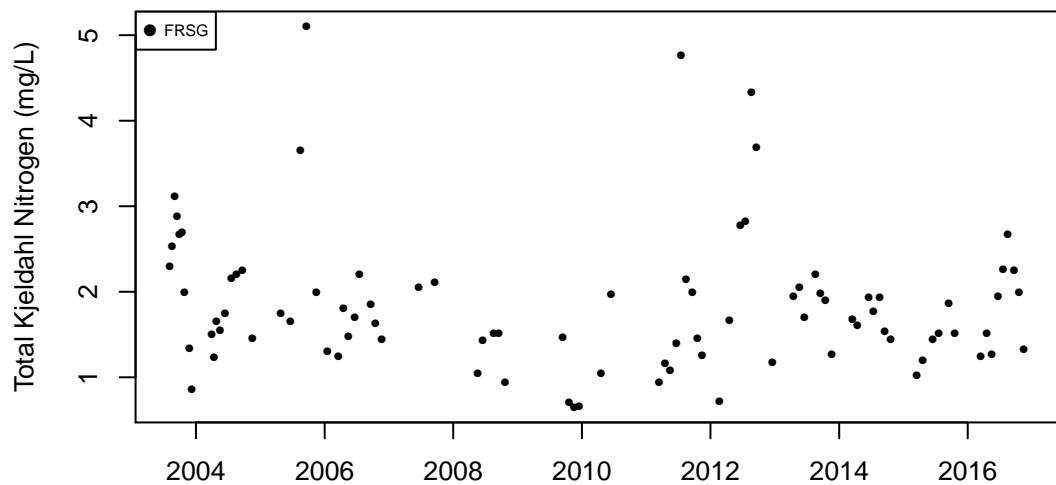


(c) Annual values

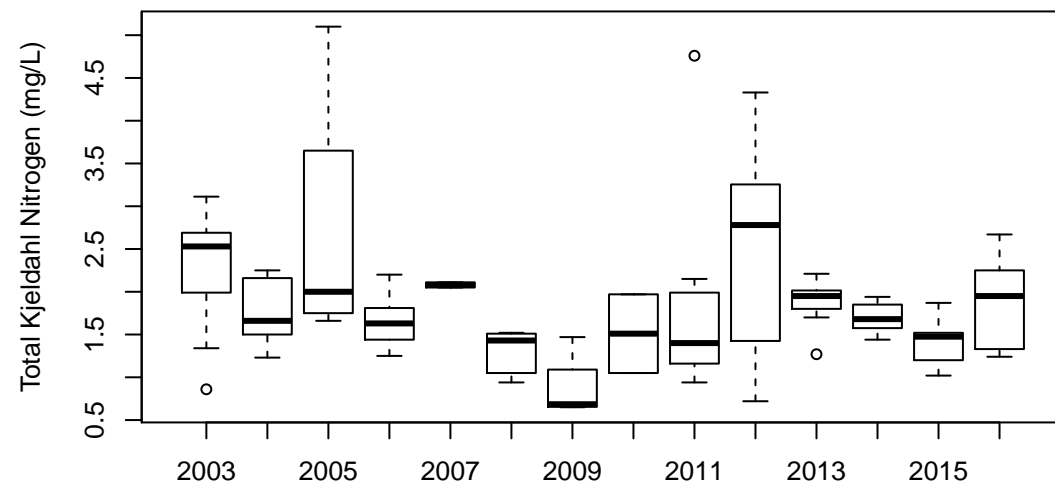


(d) Boxplot by month

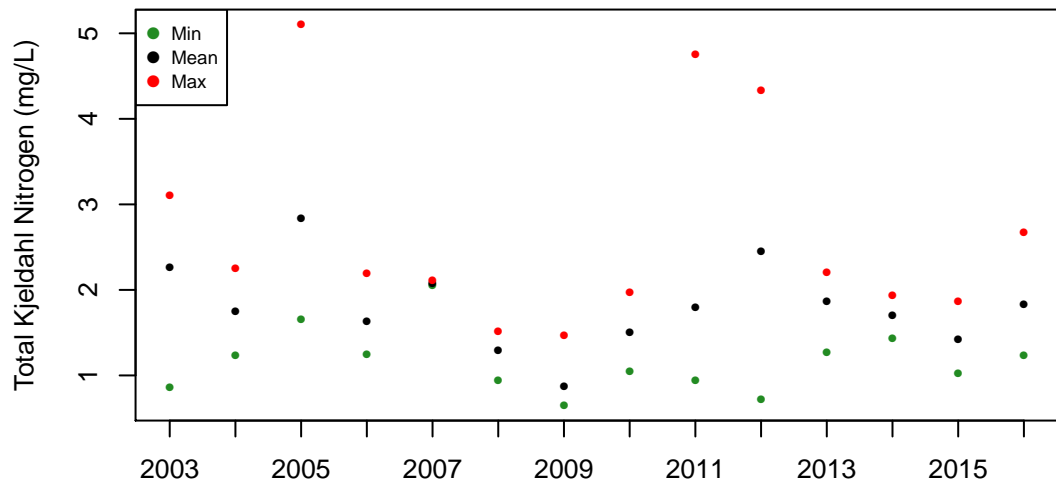
Fox River at Oakwood Hills (258): Total Kjeldahl Nitrogen (mg/L)



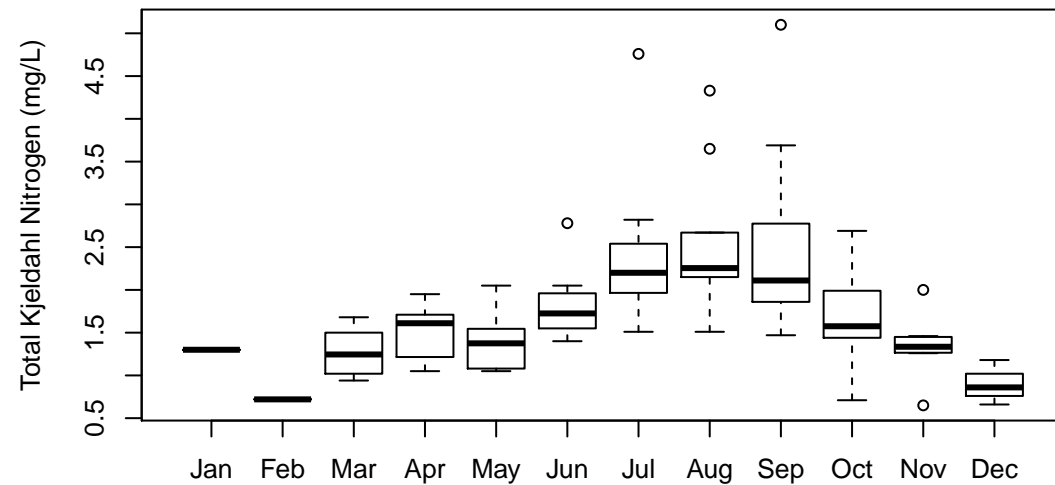
(a) Observation data



(b) Boxplot by year

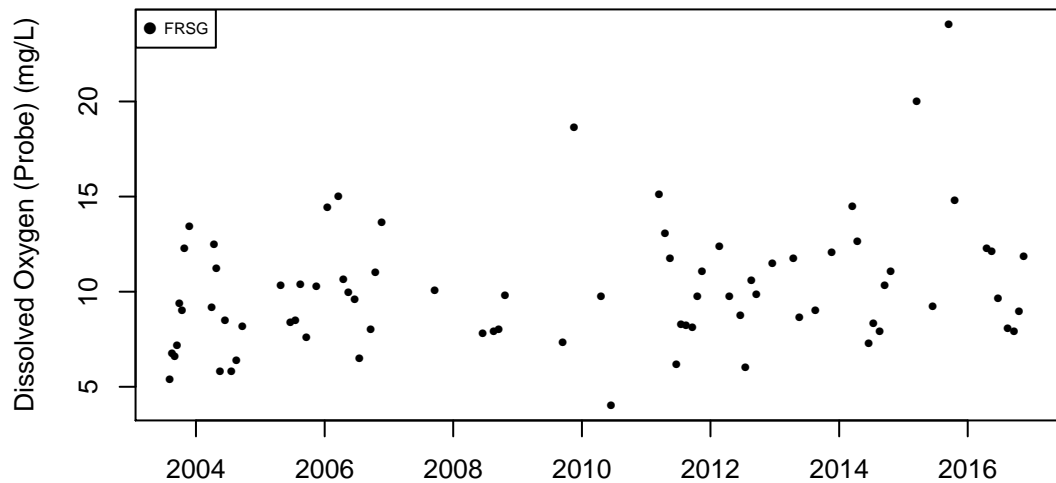


(c) Annual values

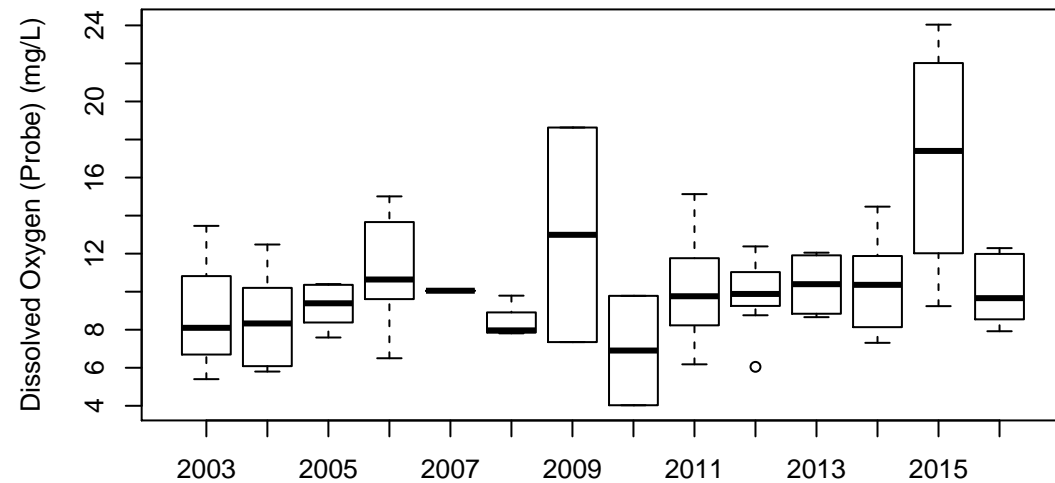


(d) Boxplot by month

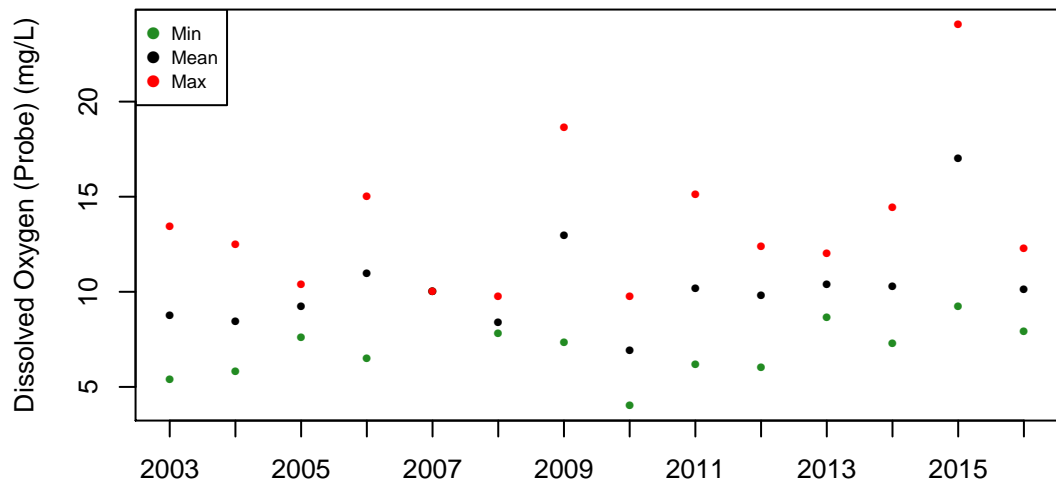
Fox River at Oakwood Hills (258): Dissolved Oxygen (Probe) (mg/L)



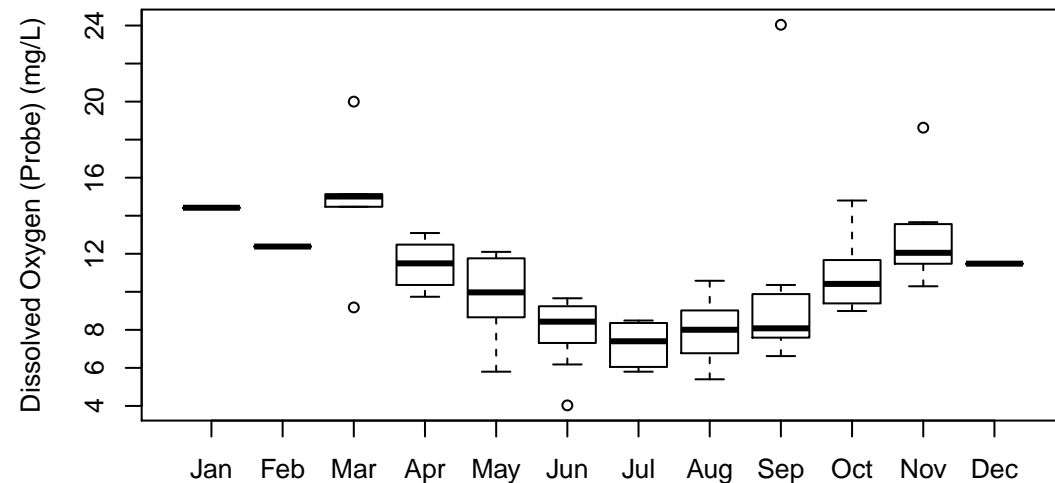
(a) Observation data



(b) Boxplot by year

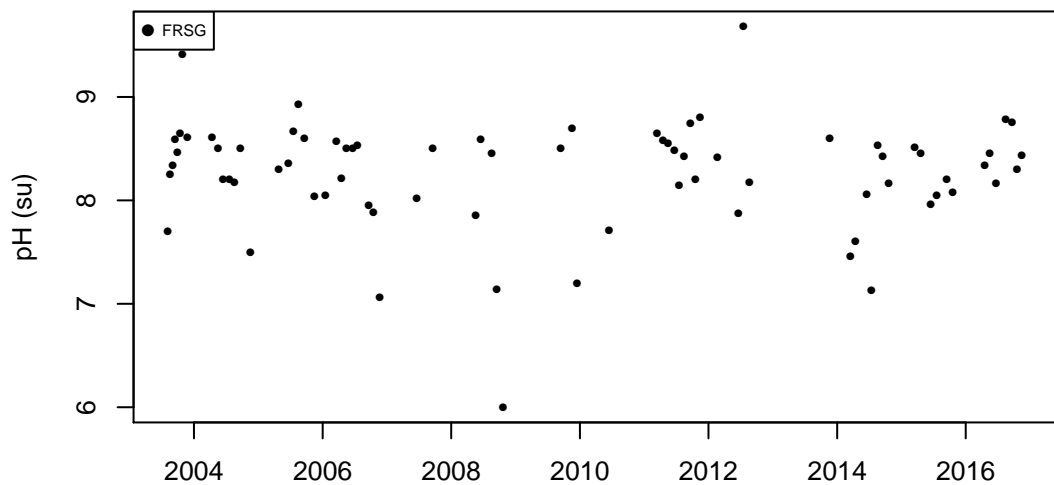


(c) Annual values

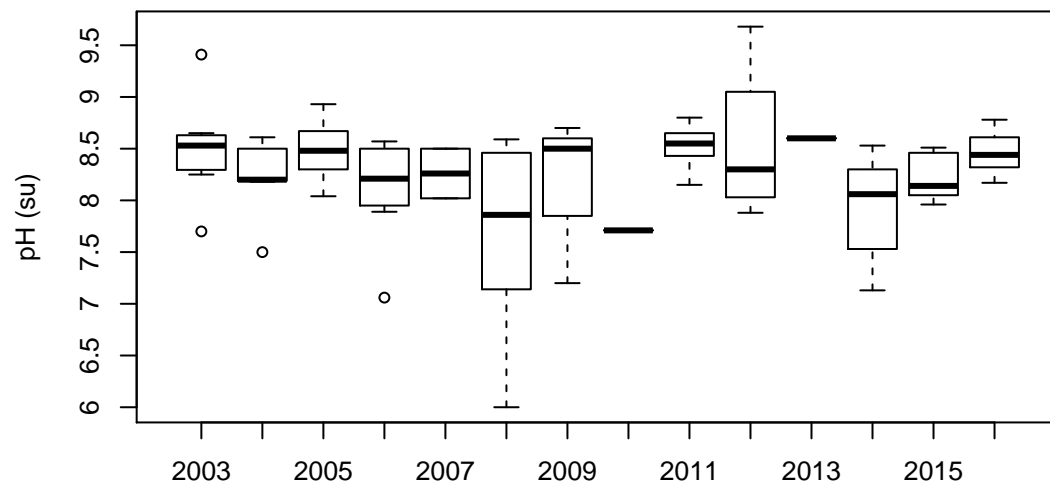


(d) Boxplot by month

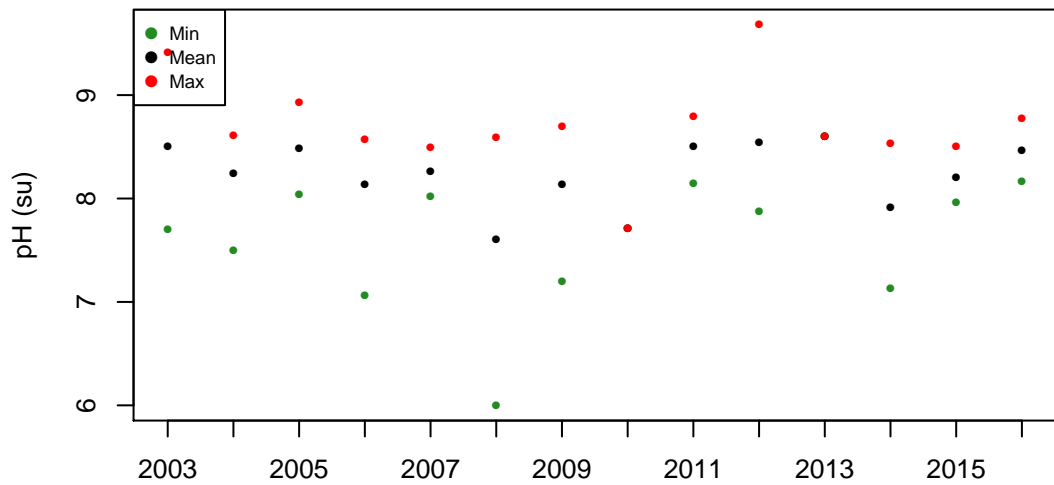
Fox River at Oakwood Hills (258): pH (su)



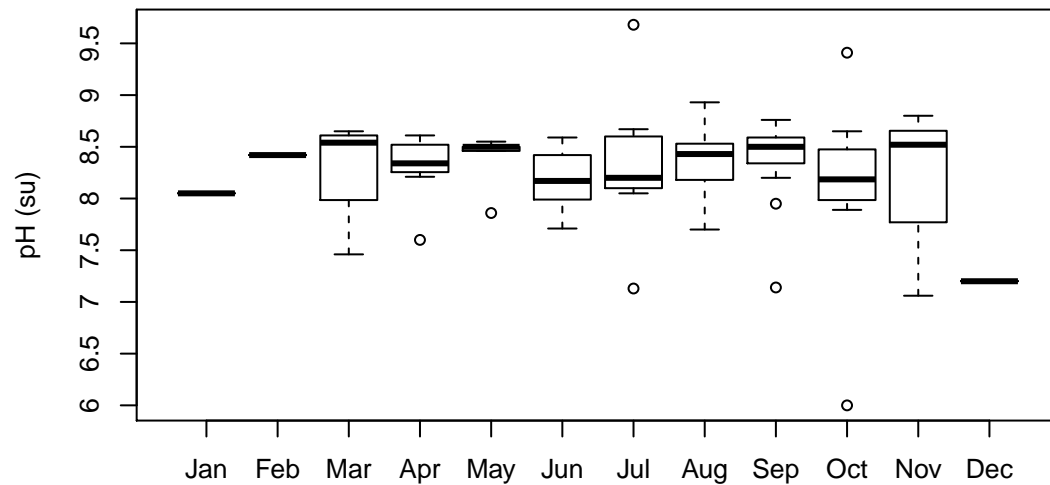
(a) Observation data



(b) Boxplot by year

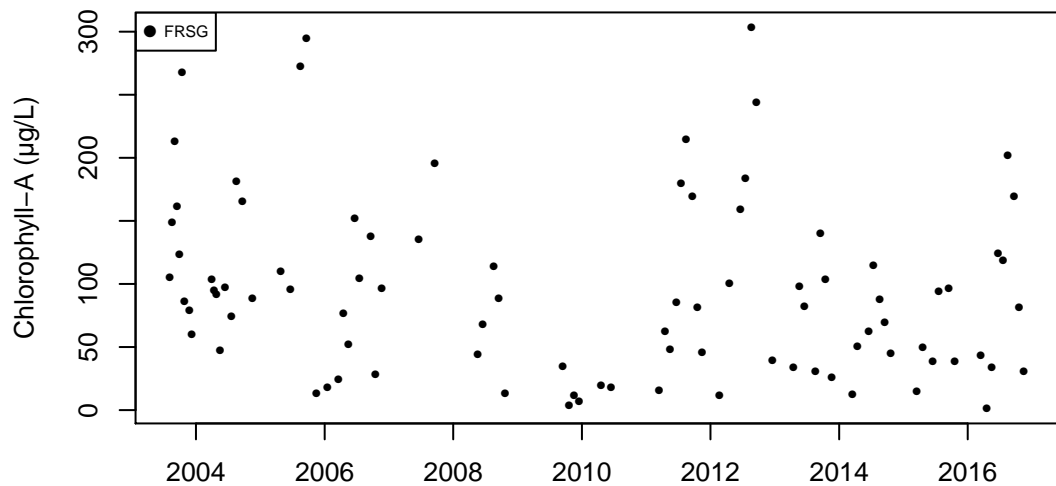


(c) Annual values

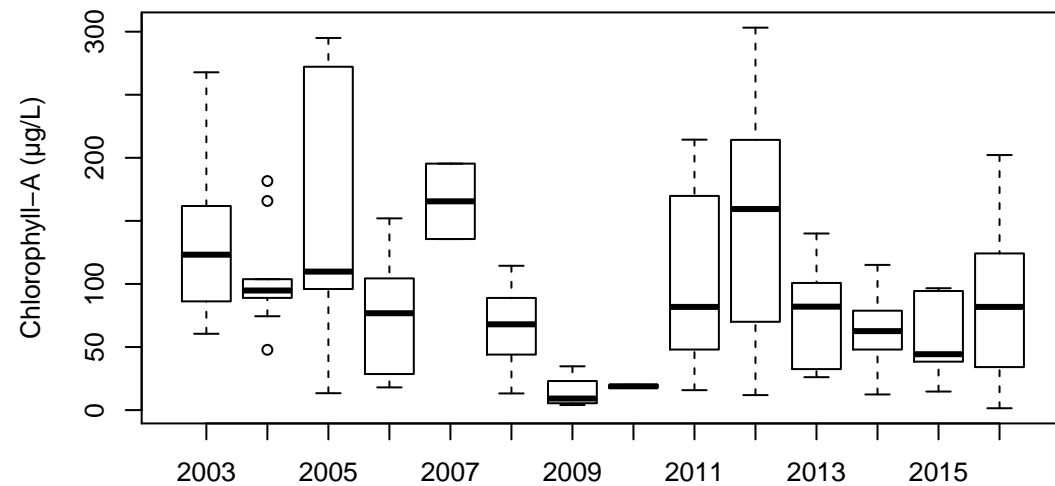


(d) Boxplot by month

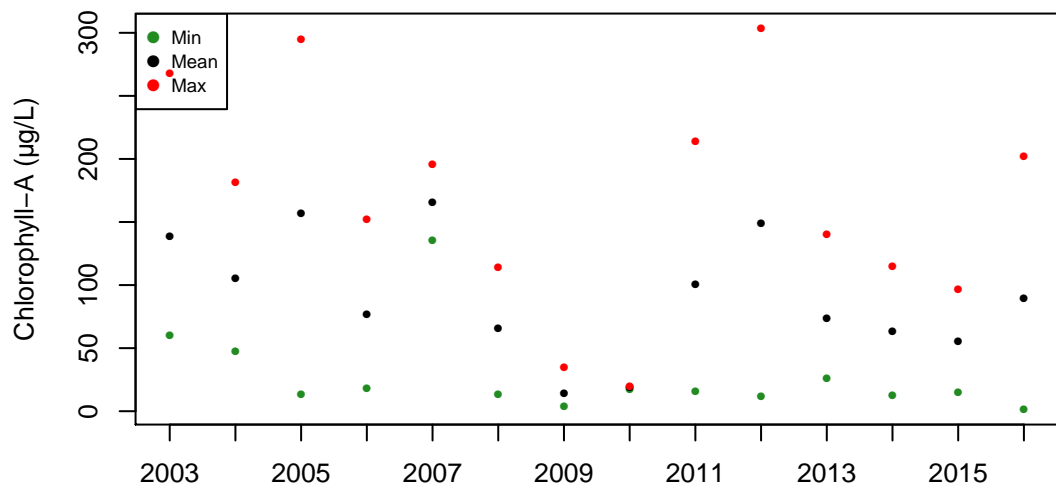
Fox River at Oakwood Hills (258): Chlorophyll-A ($\mu\text{g/L}$)



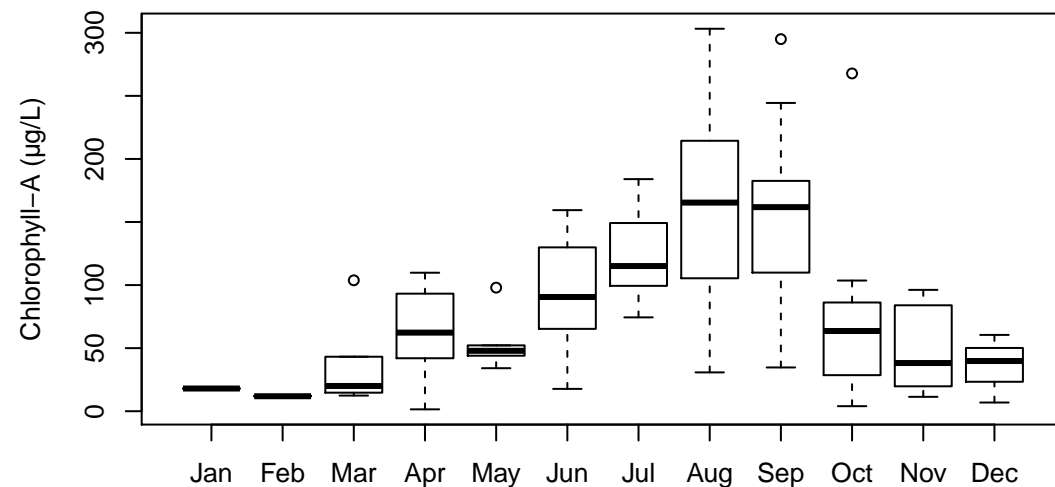
(a) Observation data



(b) Boxplot by year

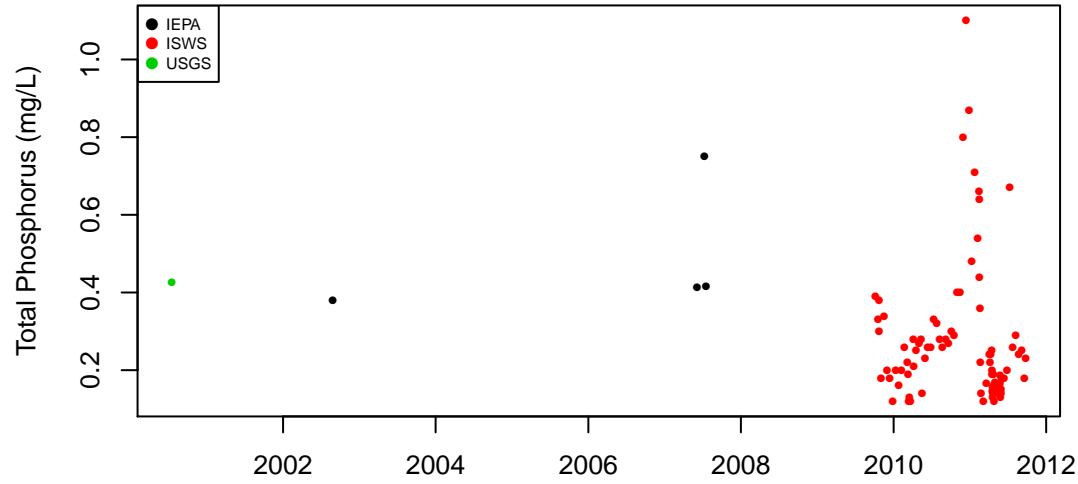


(c) Annual values

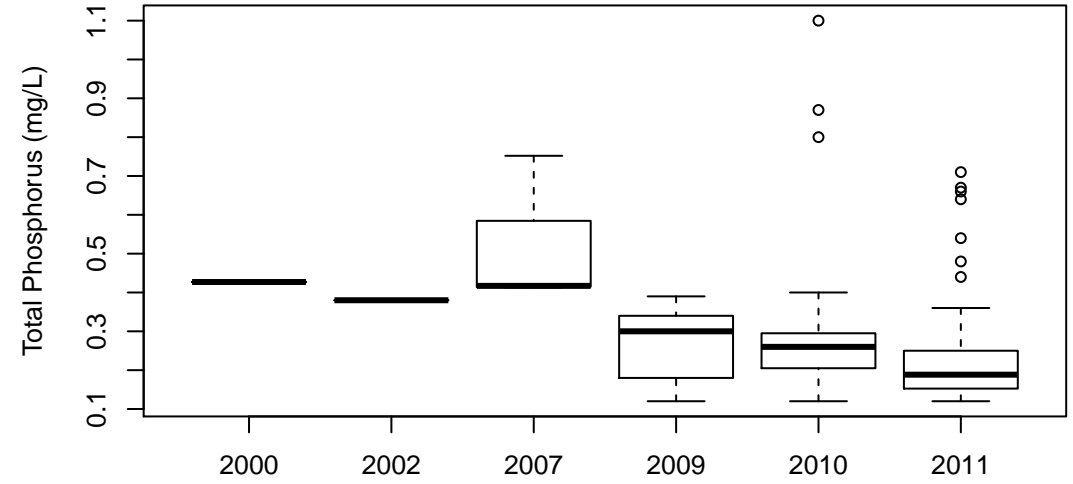


(d) Boxplot by month

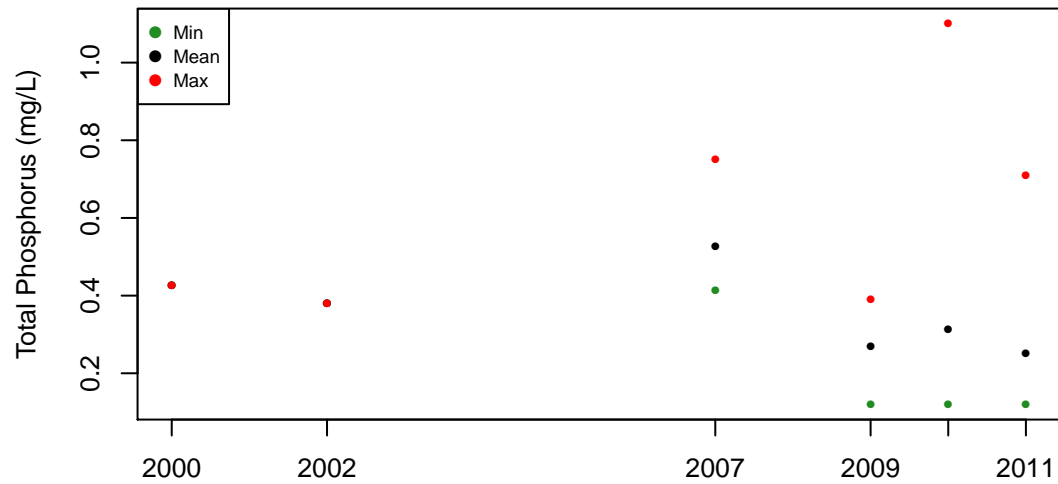
Flint Cr at Kelsey Rd-Lk Barrington (4): Total Phosphorus (mg/L)



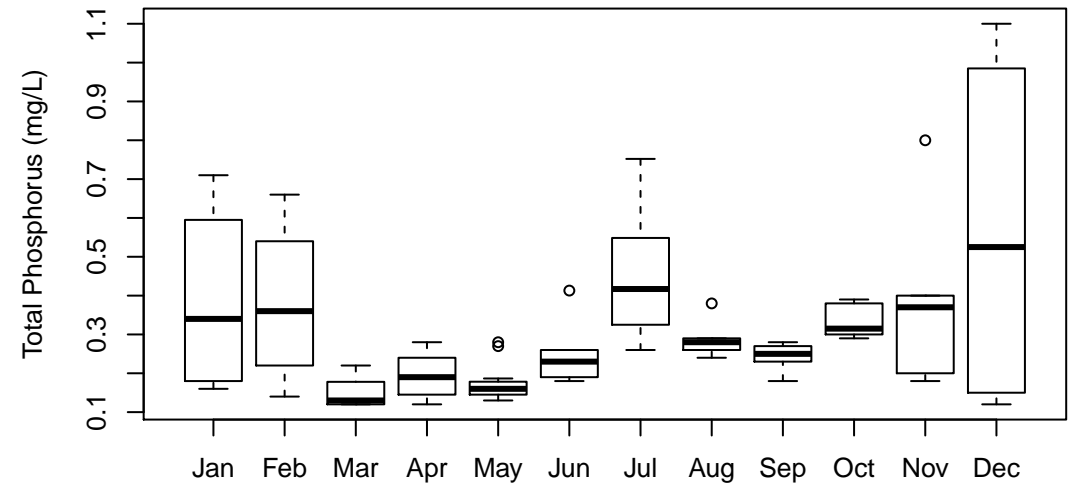
(a) Observation data



(b) Boxplot by year

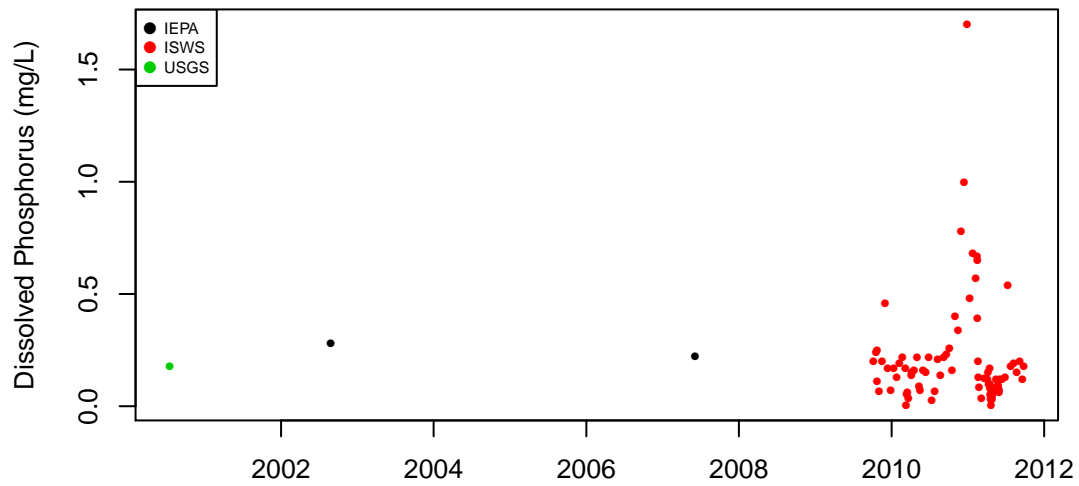


(c) Annual values

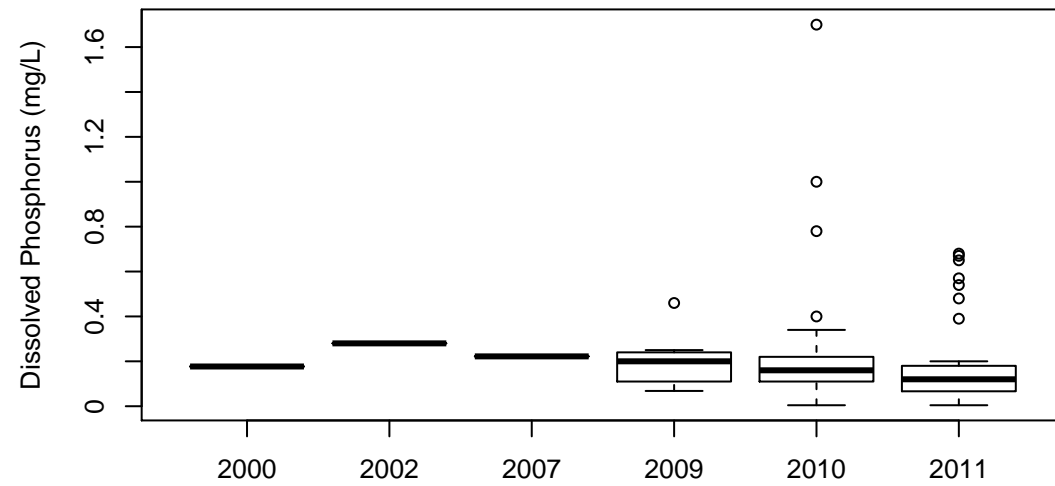


(d) Boxplot by month

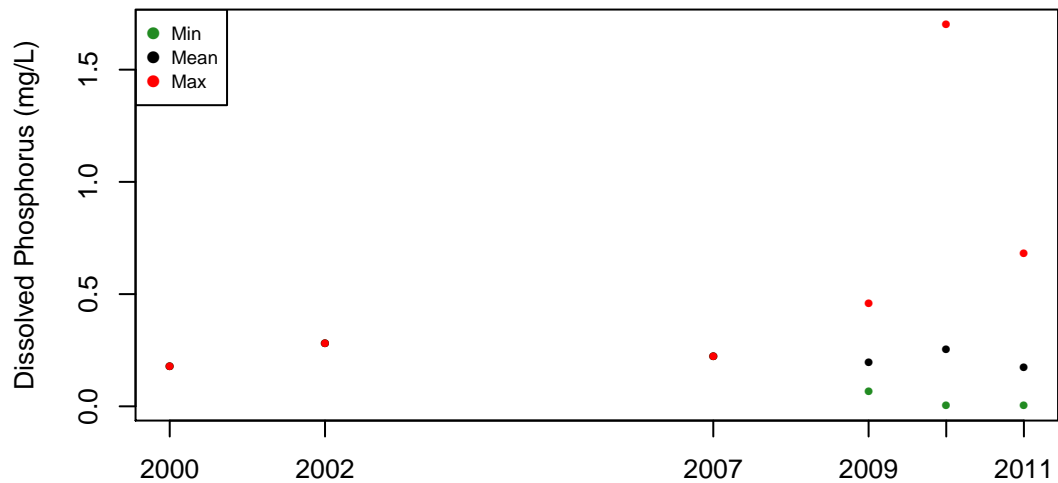
Flint Cr at Kelsey Rd–Lk Barrington (4): Dissolved Phosphorus (mg/L)



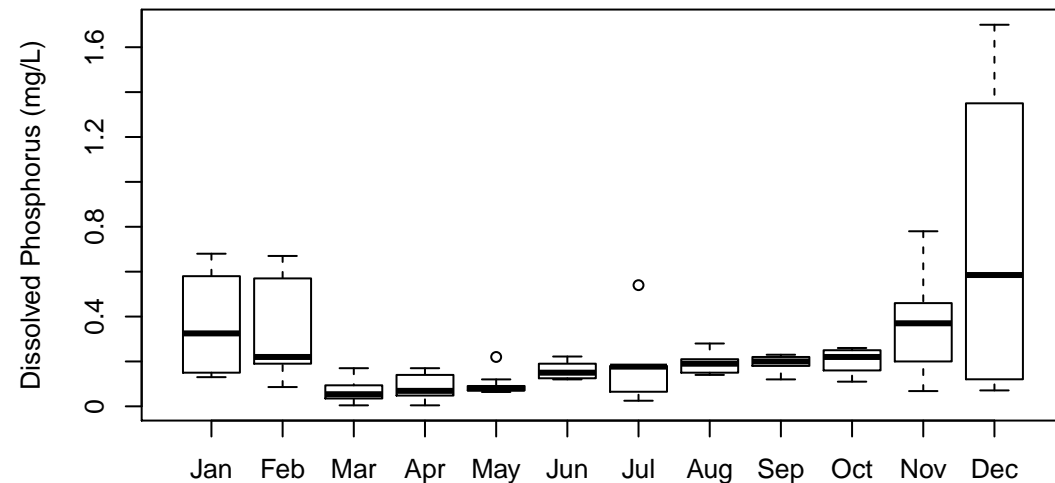
(a) Observation data



(b) Boxplot by year

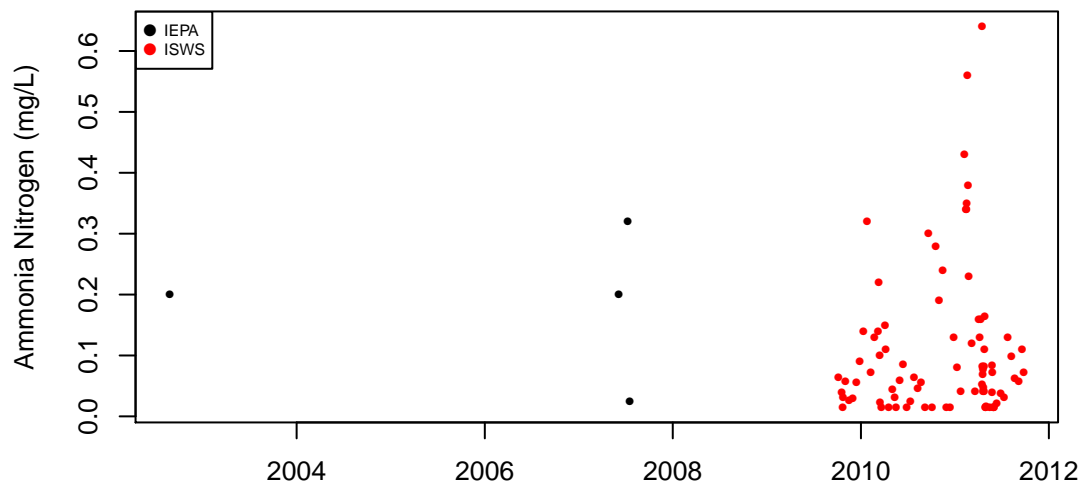


(c) Annual values

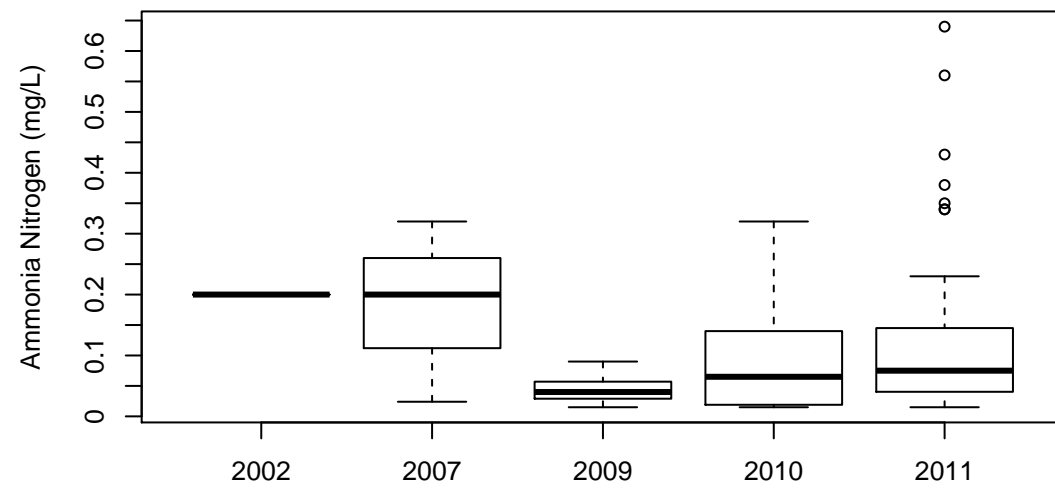


(d) Boxplot by month

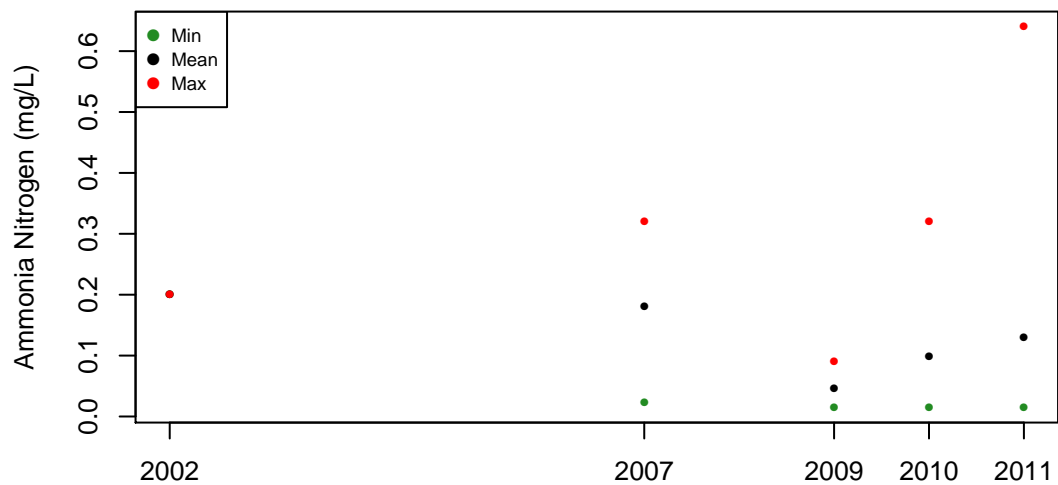
Flint Cr at Kelsey Rd-Lk Barrington (4): Ammonia Nitrogen (mg/L)



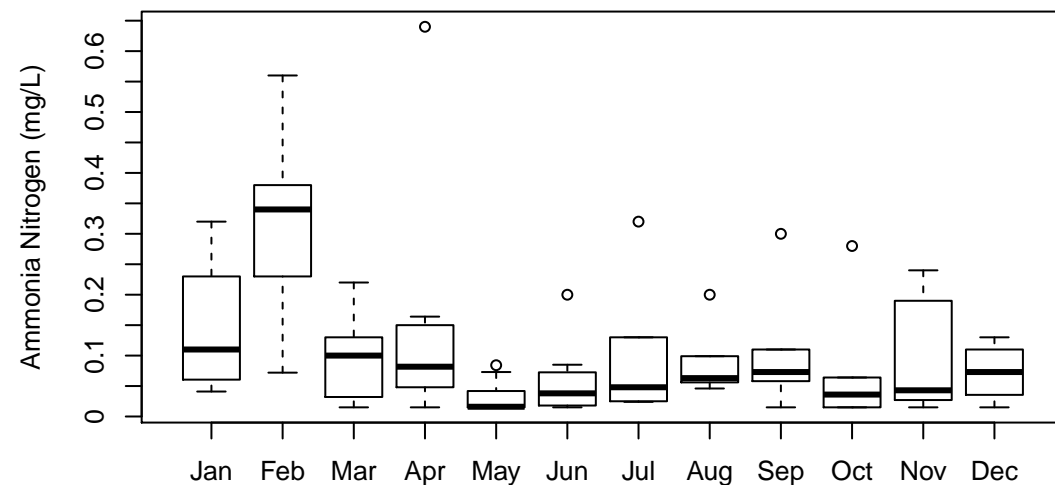
(a) Observation data



(b) Boxplot by year

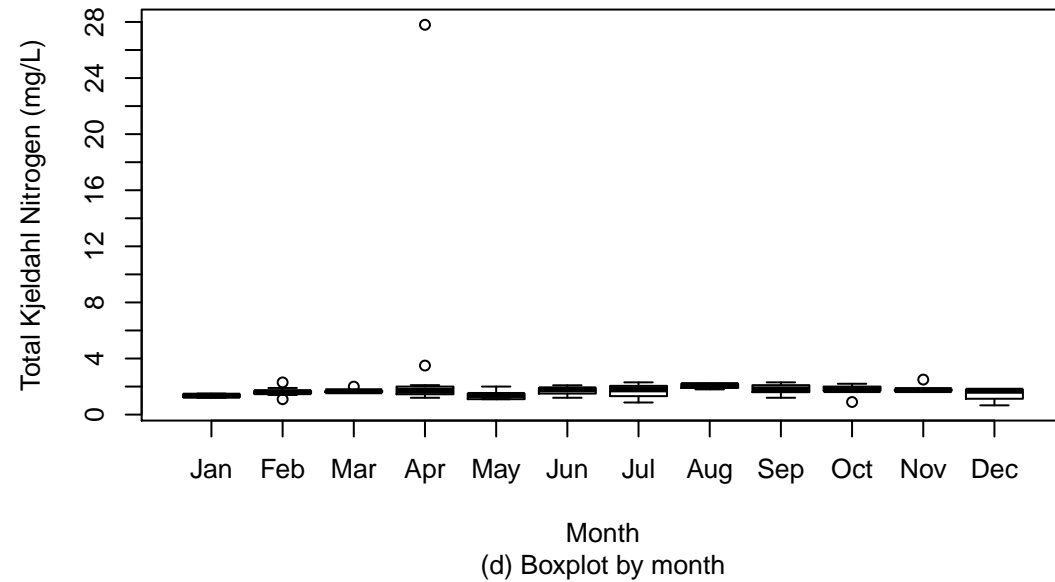
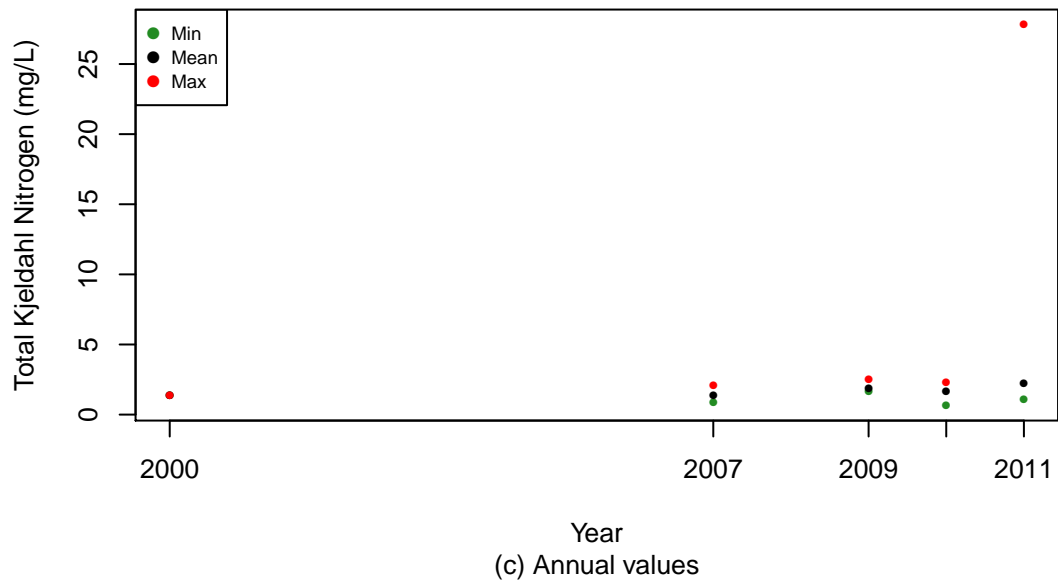
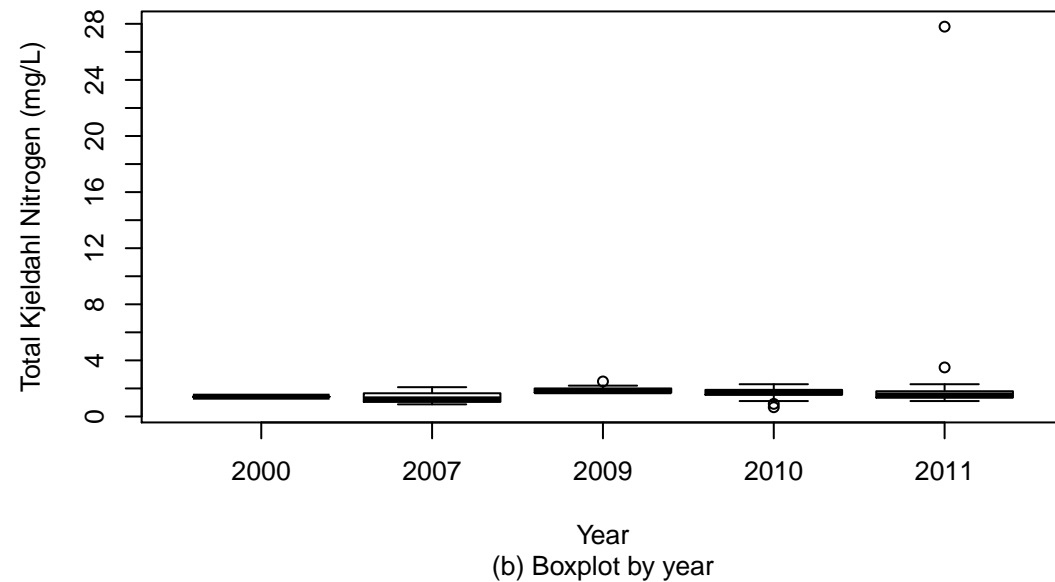
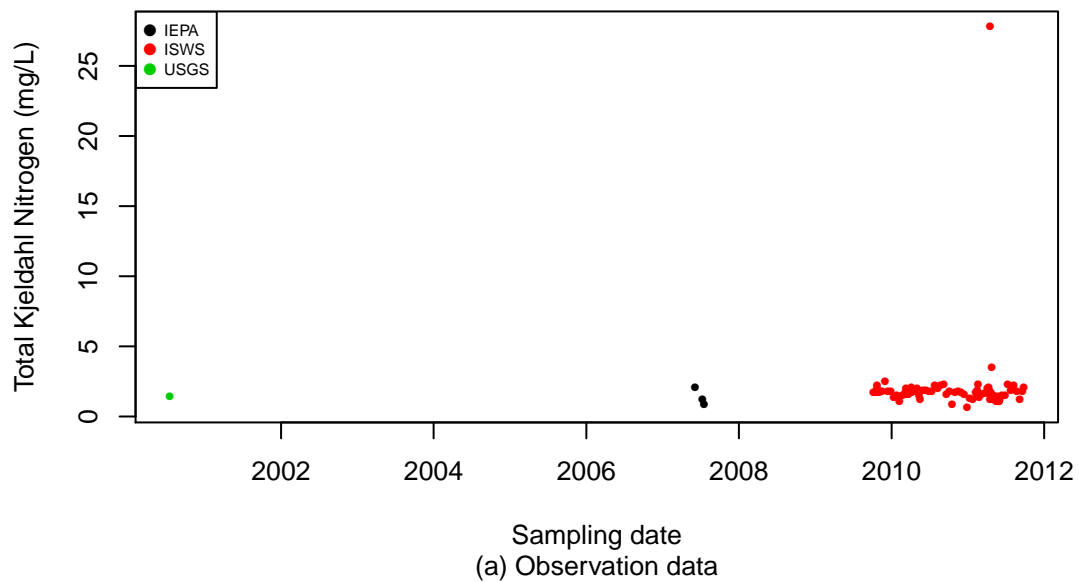


(c) Annual values

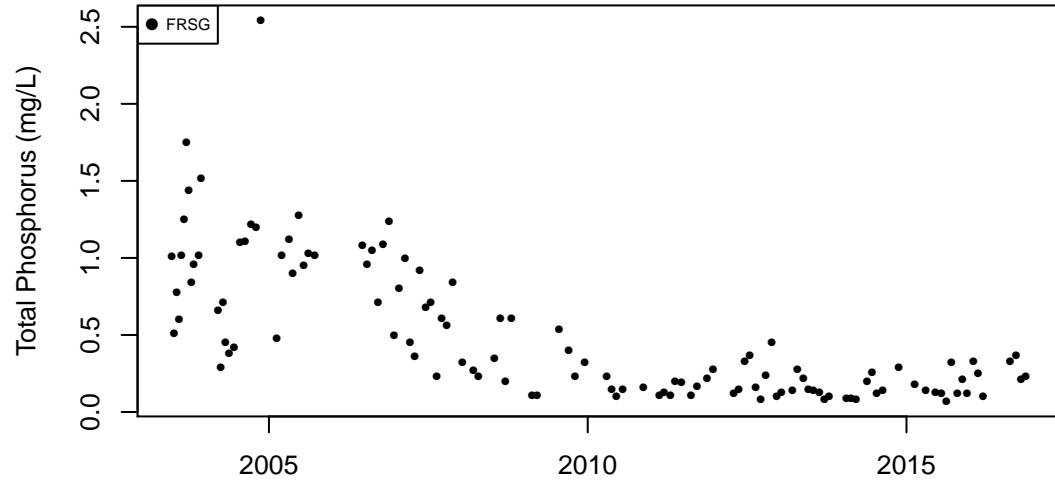


(d) Boxplot by month

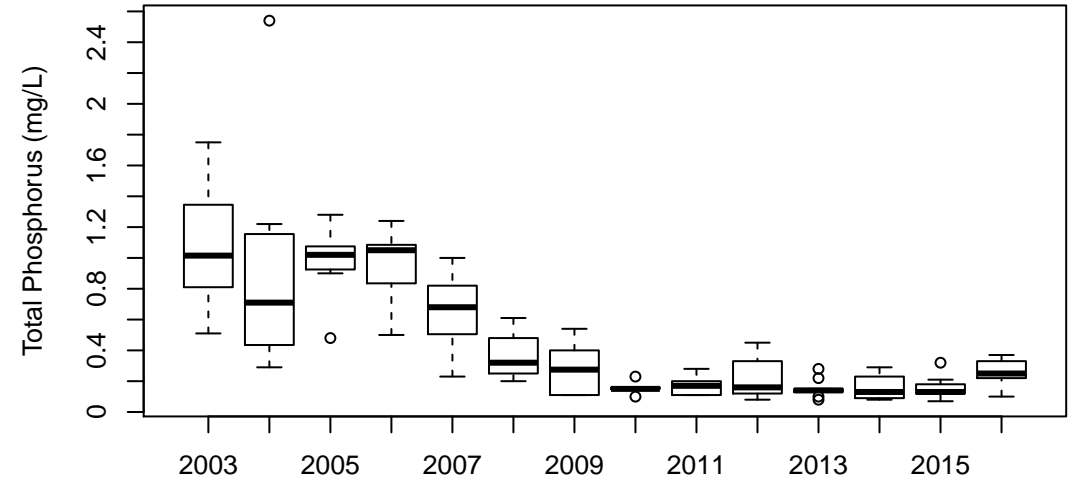
Flint Cr at Kelsey Rd–Lk Barrington (4): Total Kjeldahl Nitrogen (mg/L)



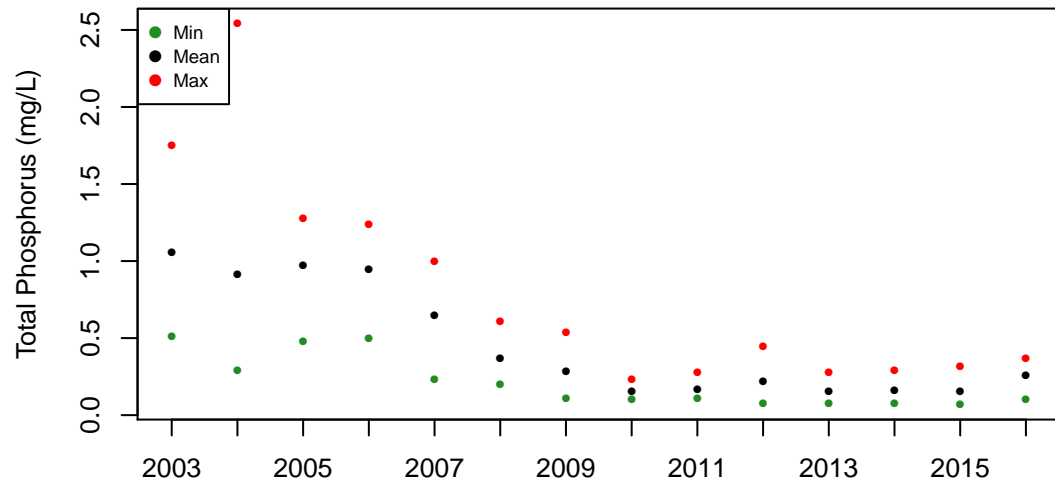
Crystal Cr at Rt 31 (271): Total Phosphorus (mg/L)



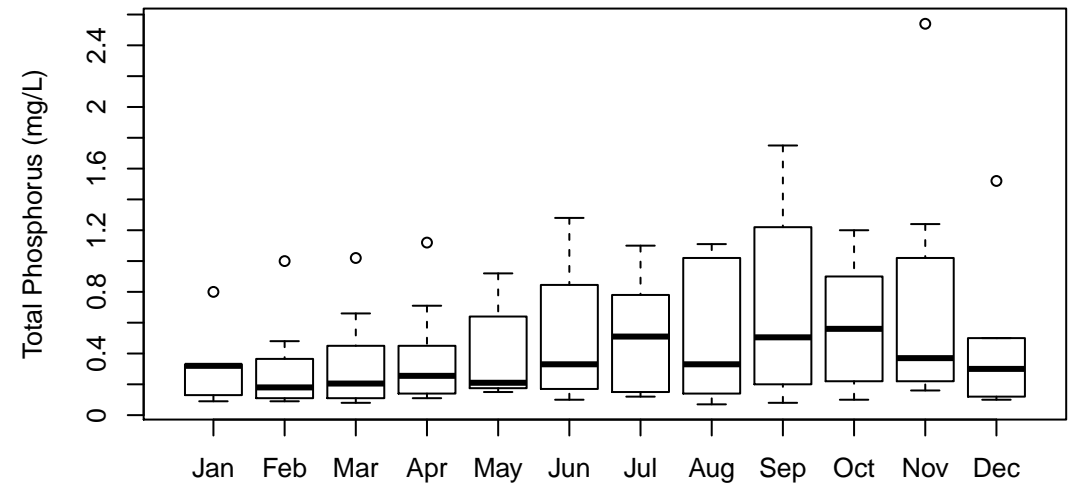
(a) Observation data



(b) Boxplot by year

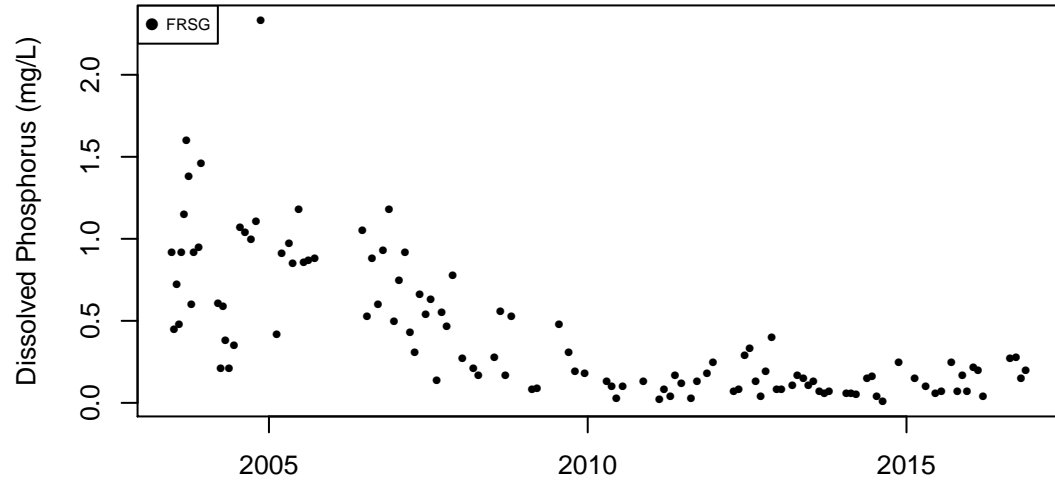


(c) Annual values

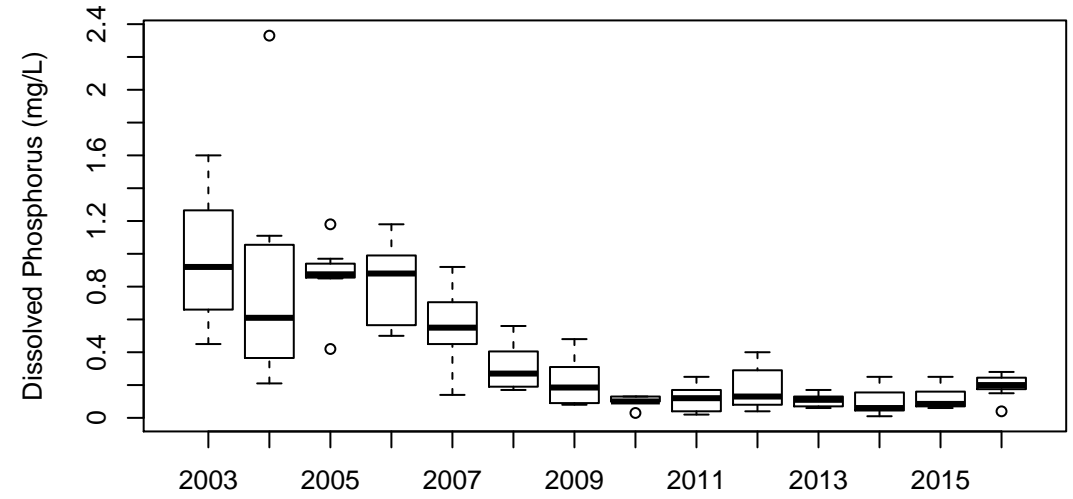


(d) Boxplot by month

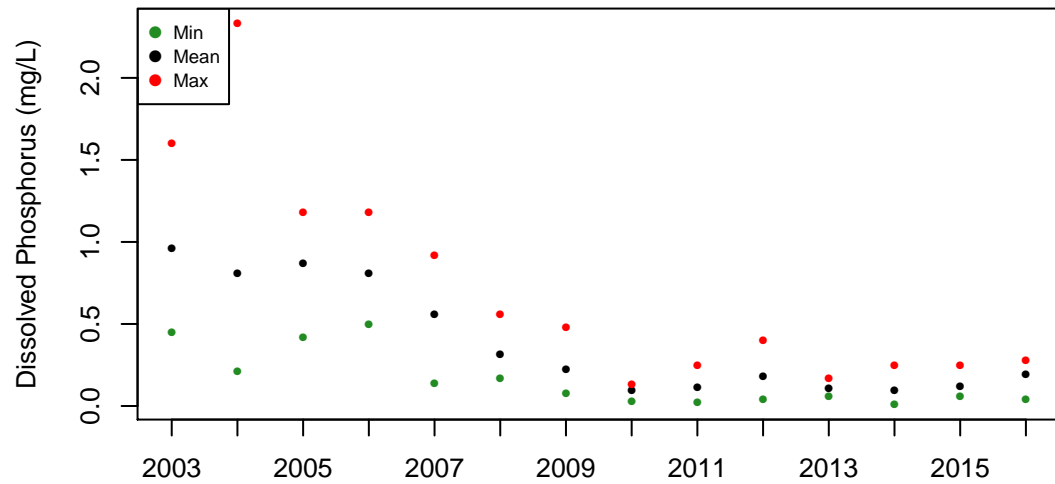
Crystal Cr at Rt 31 (271): Dissolved Phosphorus (mg/L)



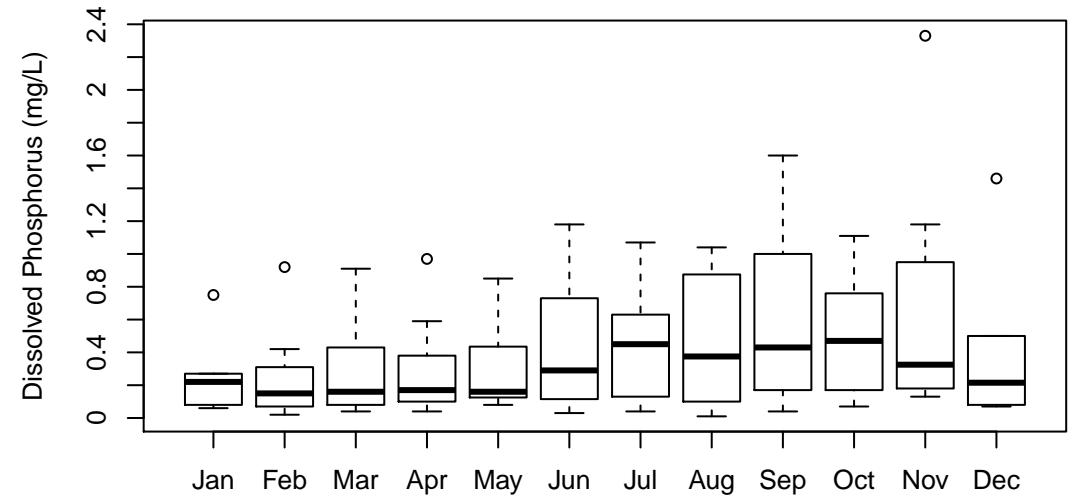
(a) Observation data



(b) Boxplot by year

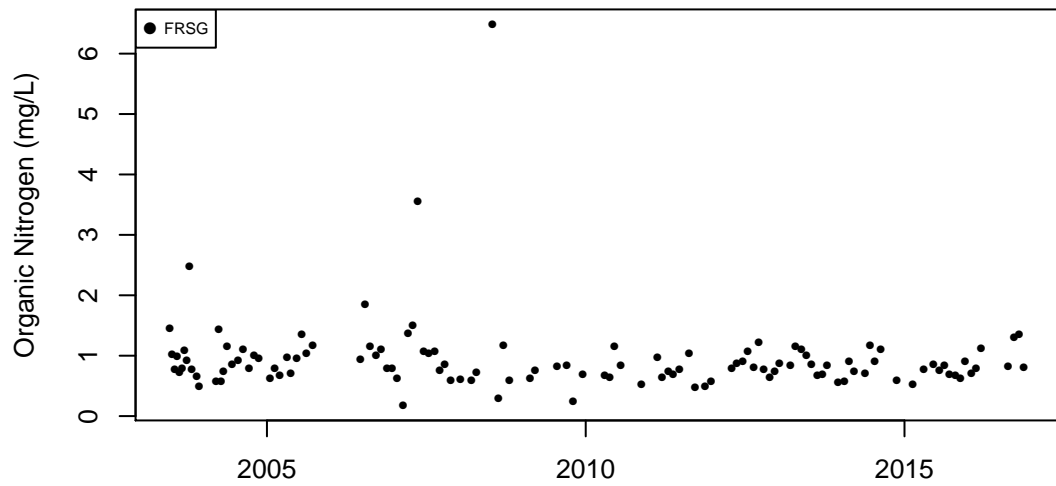


(c) Annual values

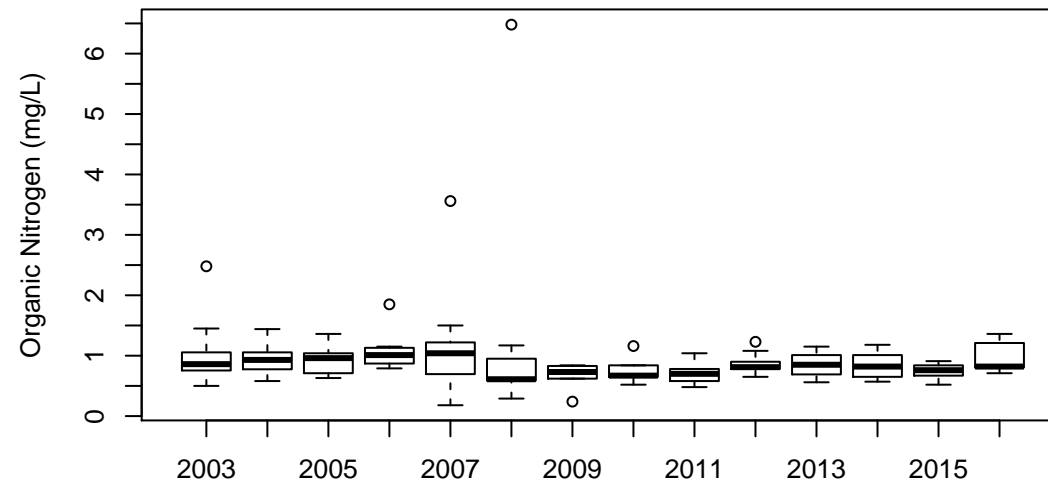


(d) Boxplot by month

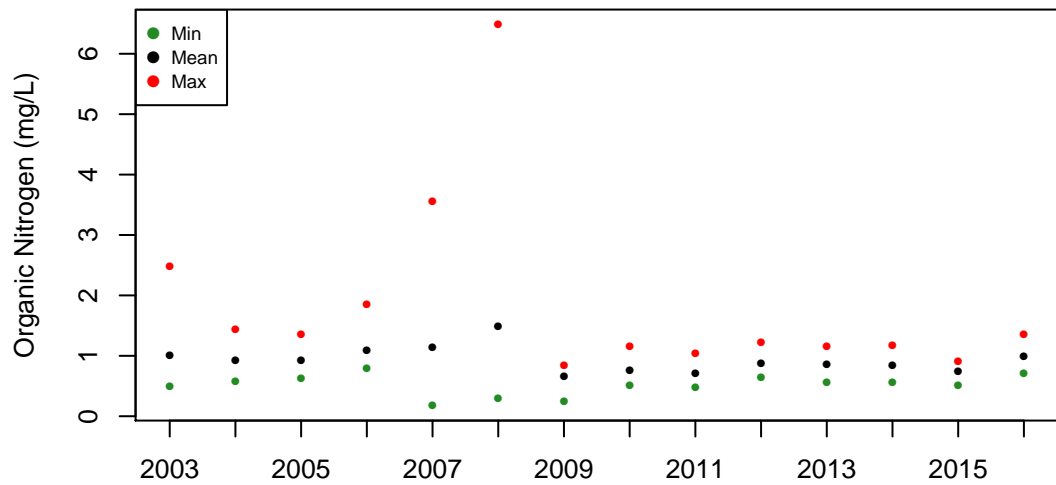
Crystal Cr at Rt 31 (271): Organic Nitrogen (mg/L)



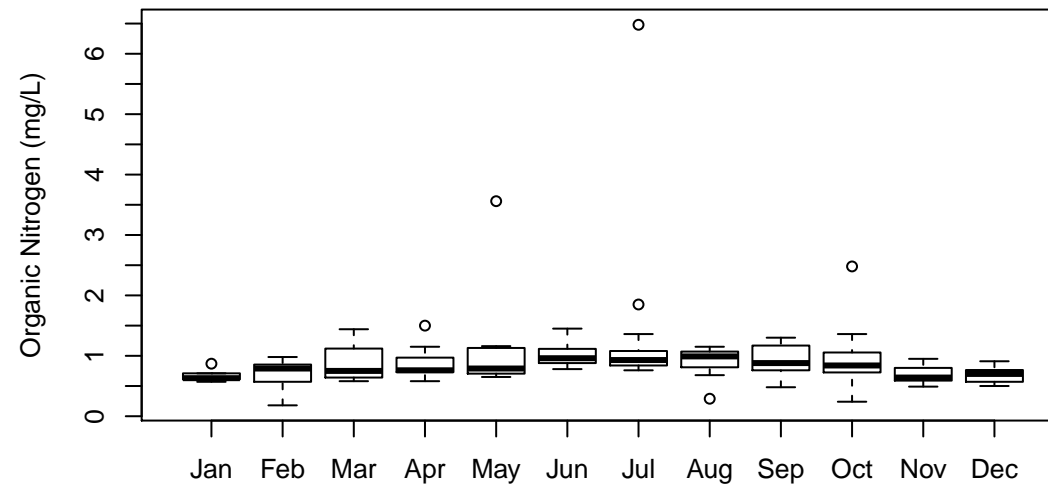
(a) Observation data



(b) Boxplot by year

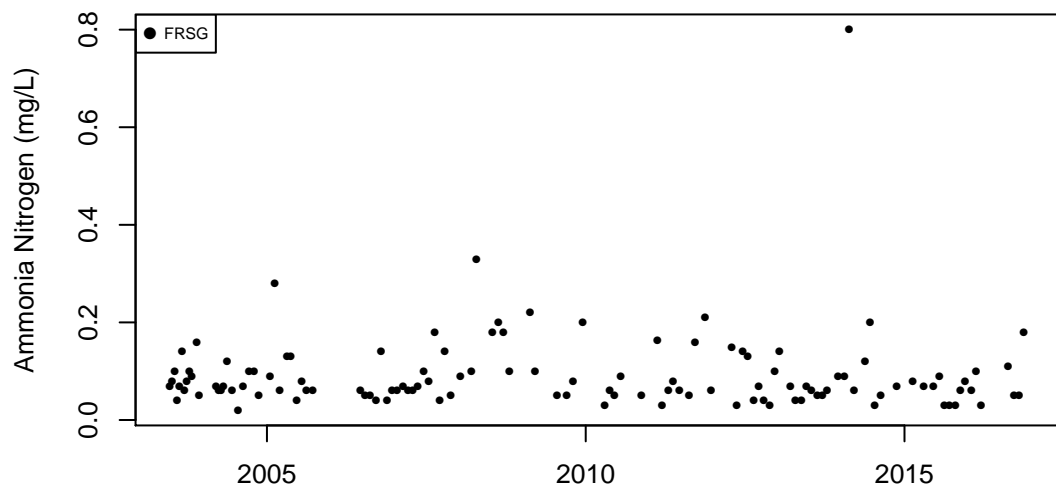


(c) Annual values

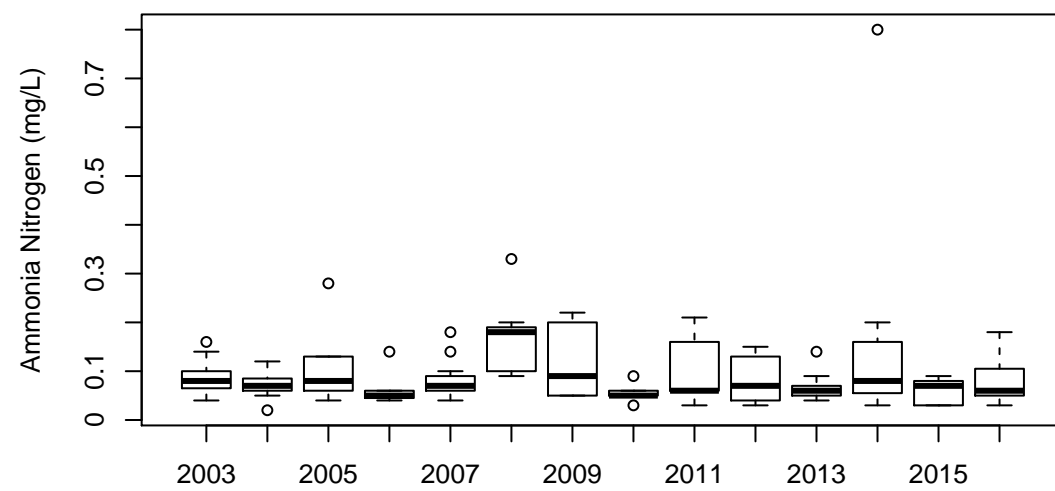


(d) Boxplot by month

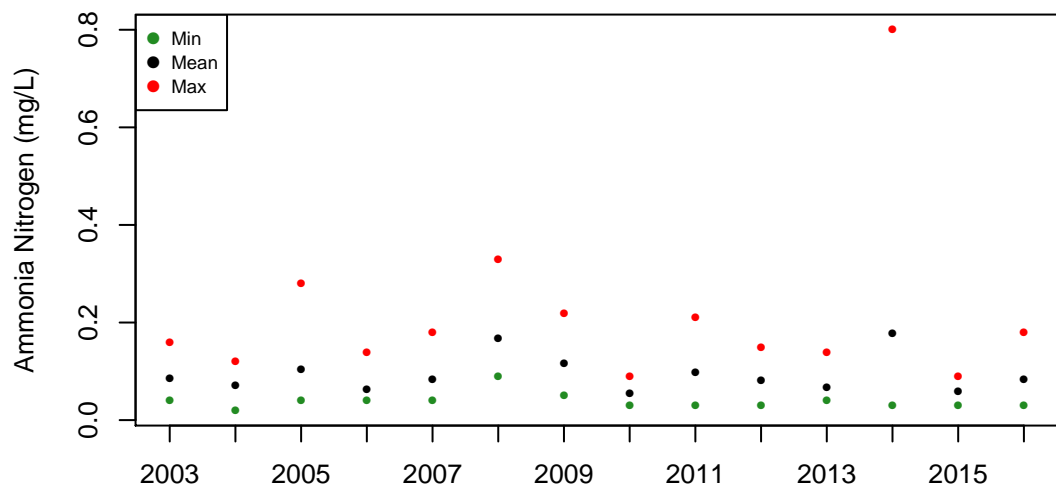
Crystal Cr at Rt 31 (271): Ammonia Nitrogen (mg/L)



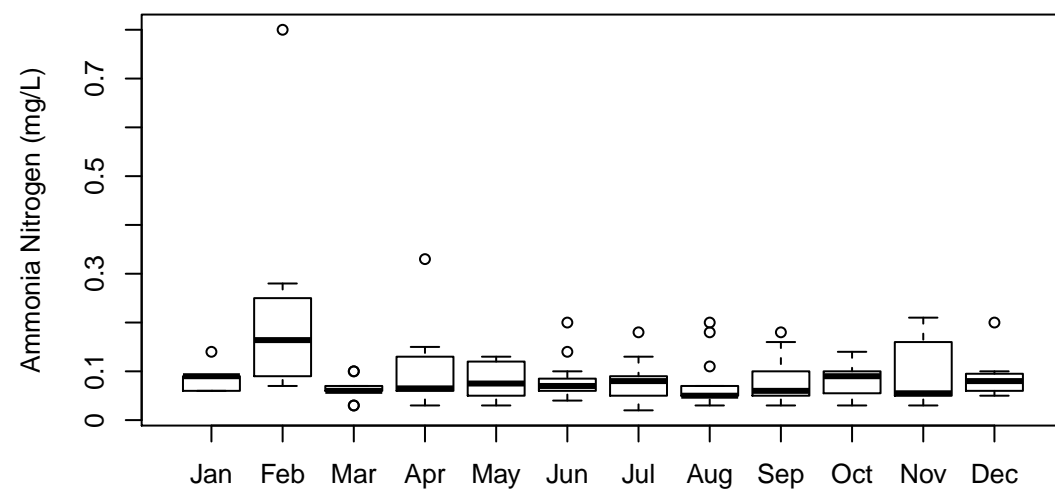
(a) Observation data



(b) Boxplot by year

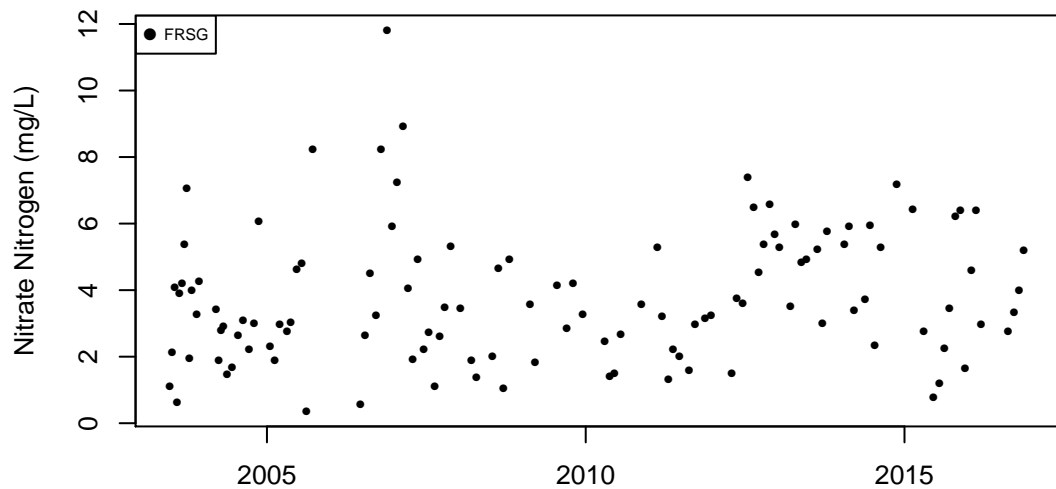


(c) Annual values

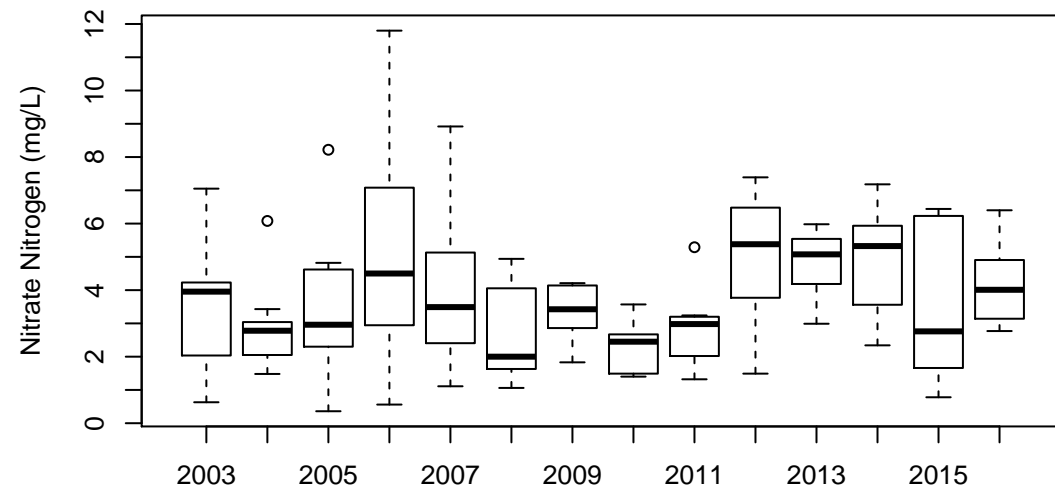


(d) Boxplot by month

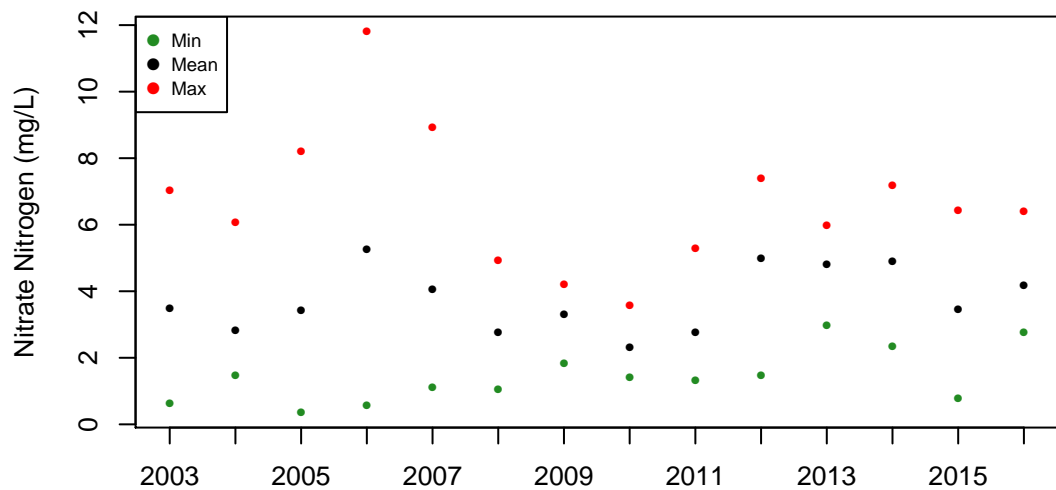
Crystal Cr at Rt 31 (271): Nitrate Nitrogen (mg/L)



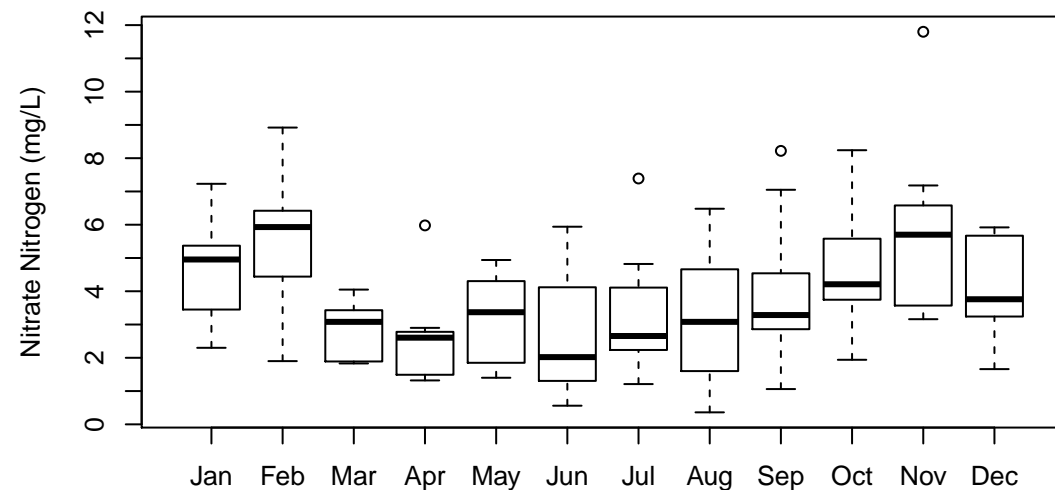
(a) Observation data



(b) Boxplot by year

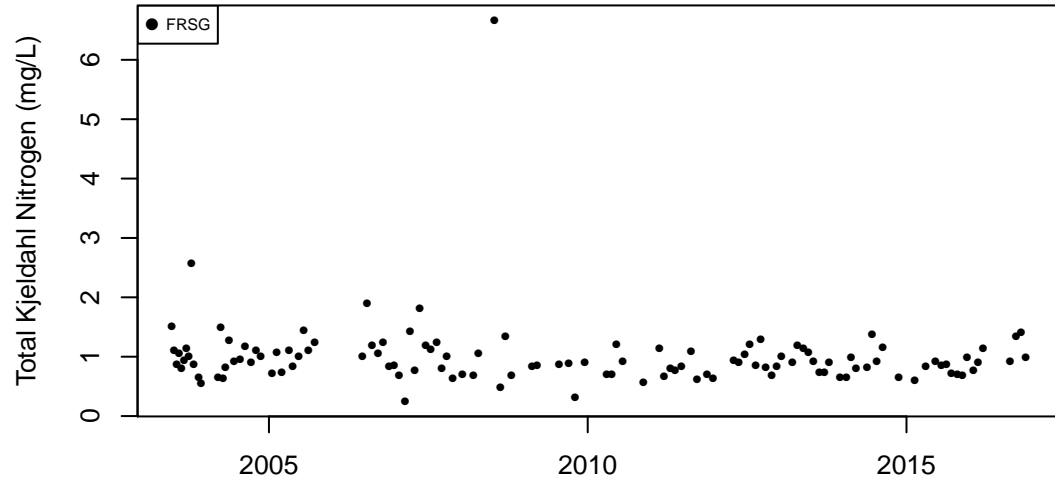


(c) Annual values

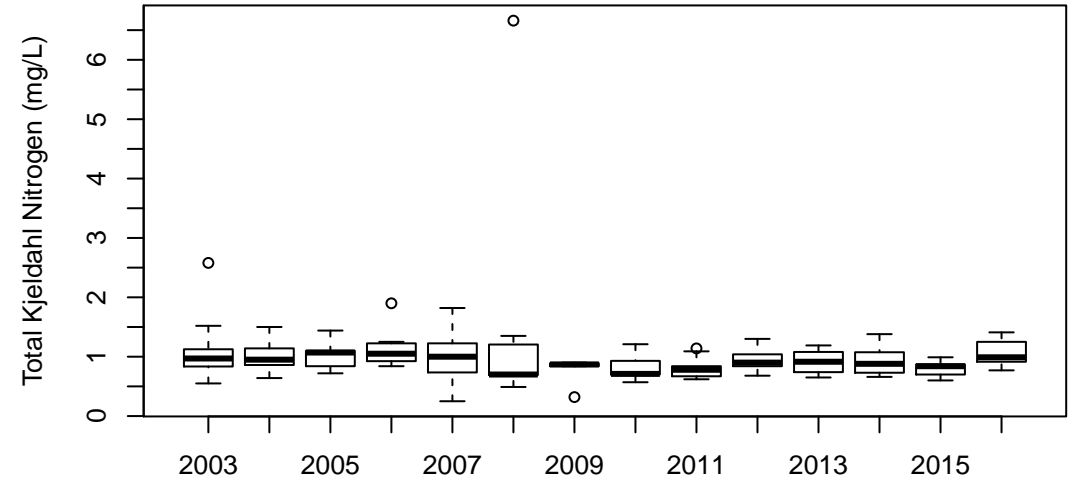


(d) Boxplot by month

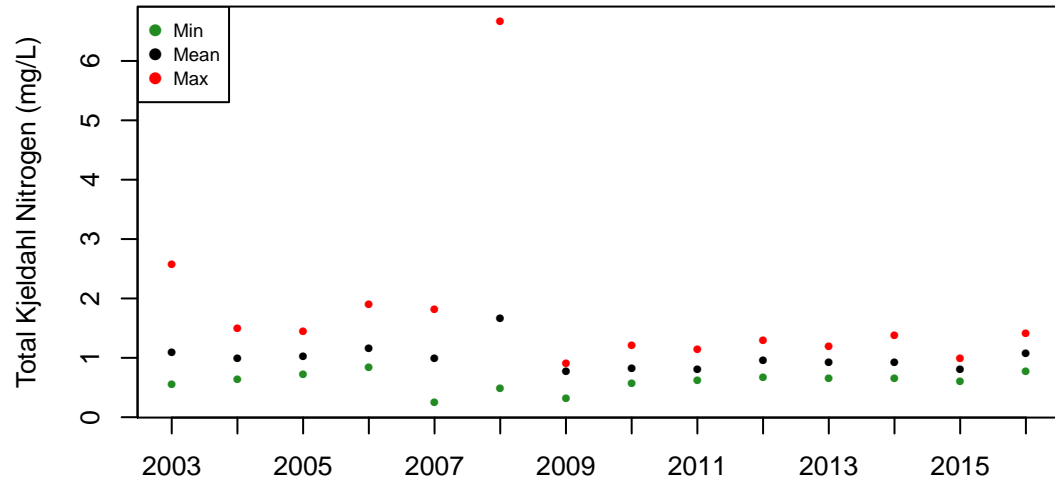
Crystal Cr at Rt 31 (271): Total Kjeldahl Nitrogen (mg/L)



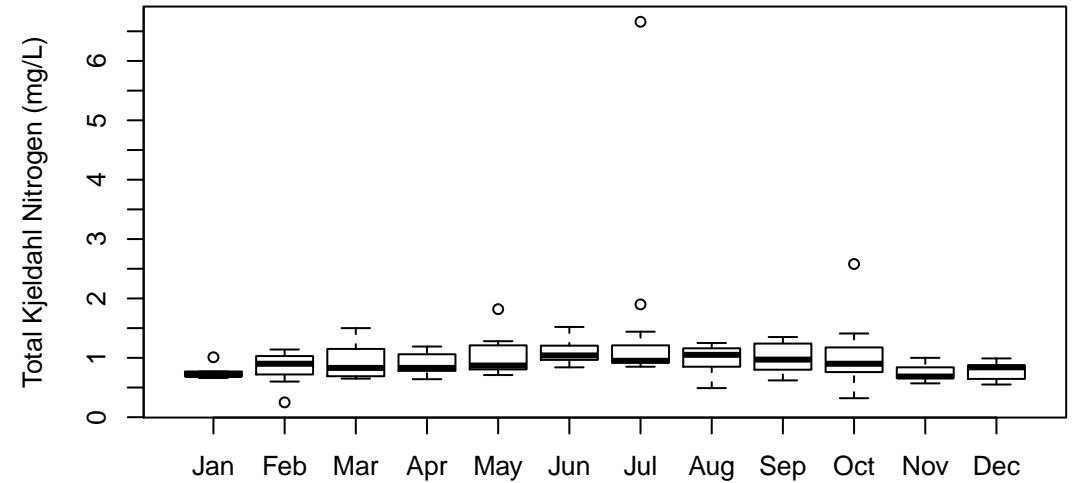
(a) Observation data



(b) Boxplot by year

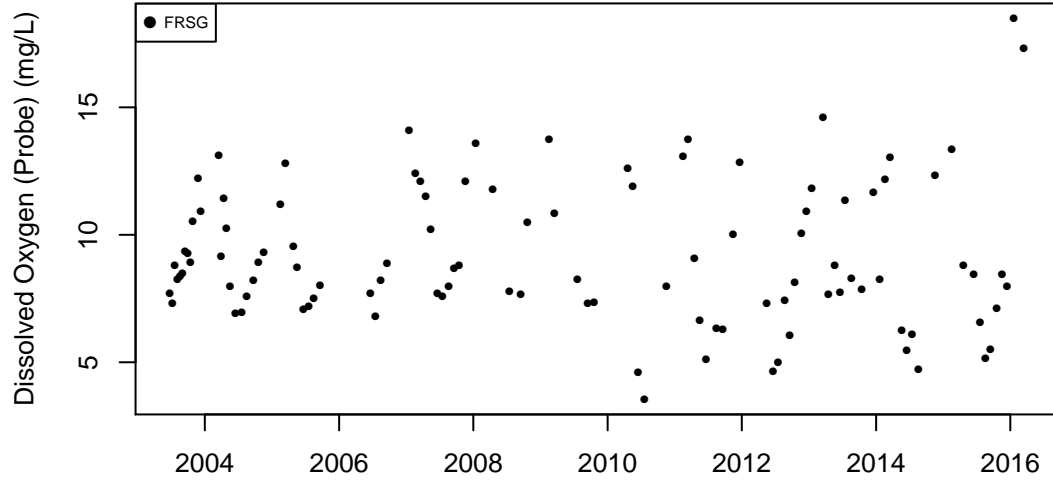


(c) Annual values

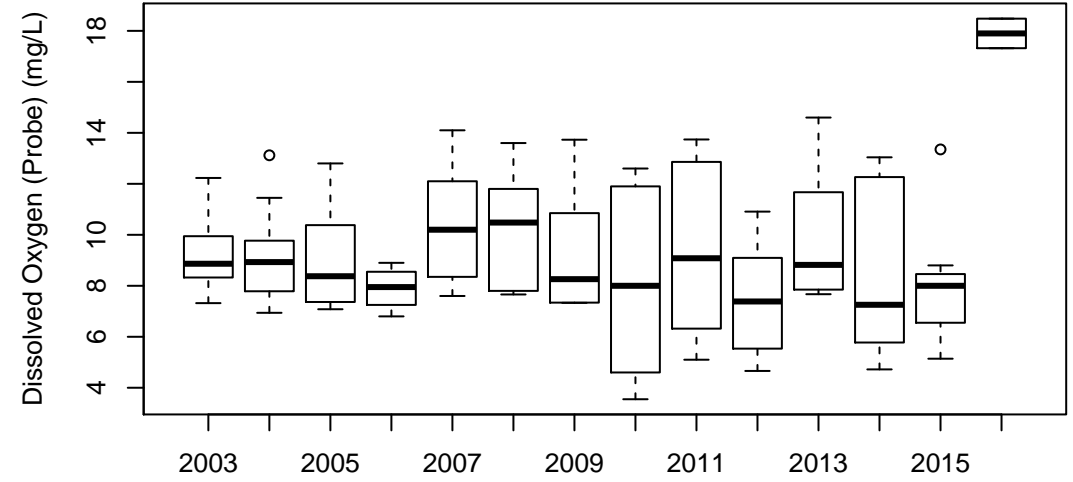


(d) Boxplot by month

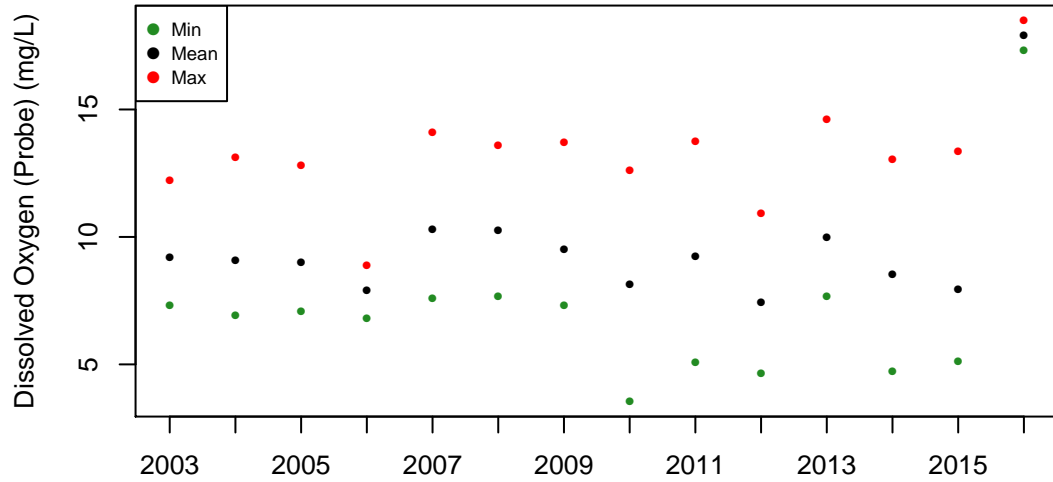
Crystal Cr at Rt 31 (271): Dissolved Oxygen (Probe) (mg/L)



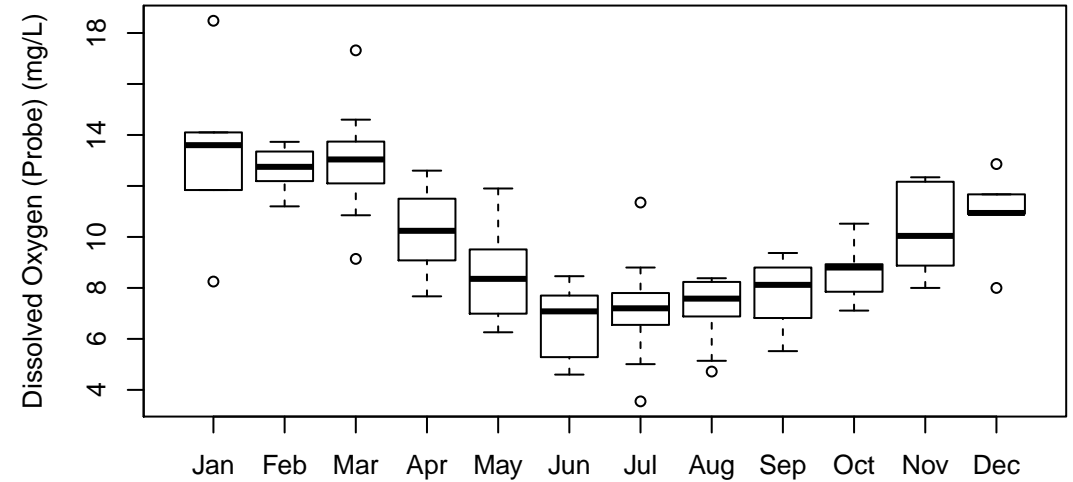
Sampling date
(a) Observation data



Year
(b) Boxplot by year

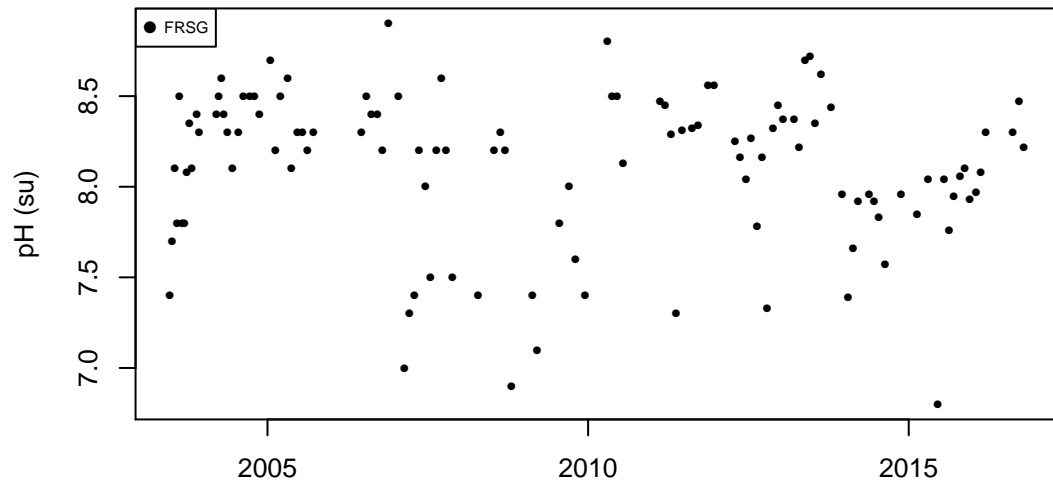


Year
(c) Annual values

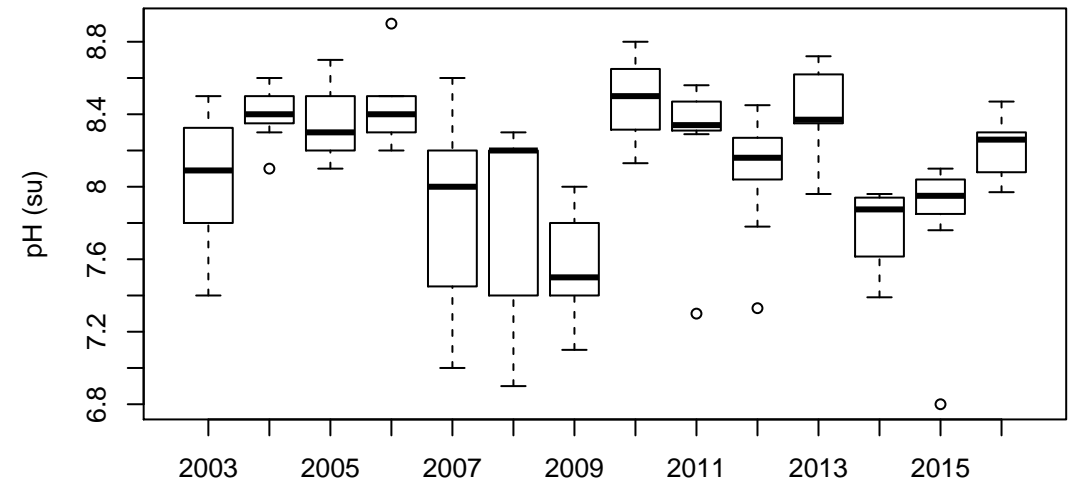


Month
(d) Boxplot by month

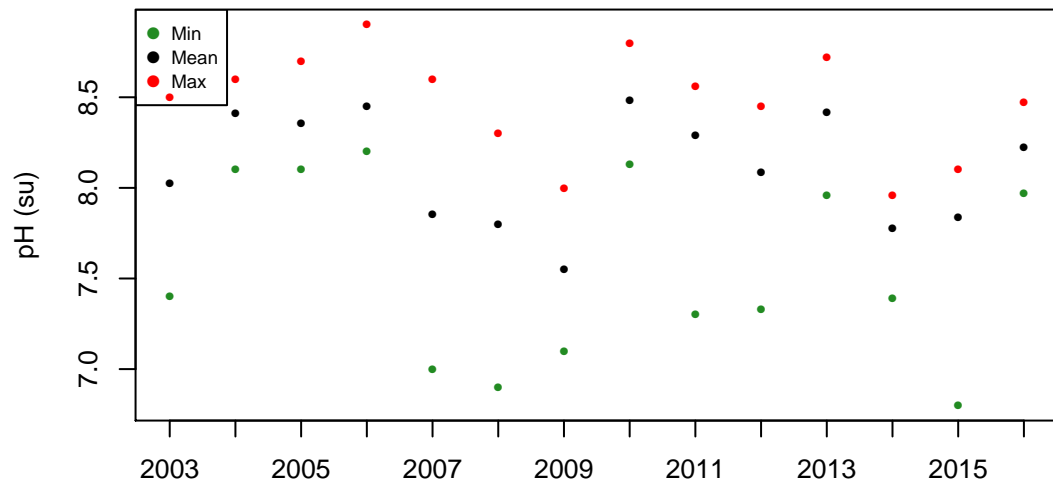
Crystal Cr at Rt 31 (271): pH (su)



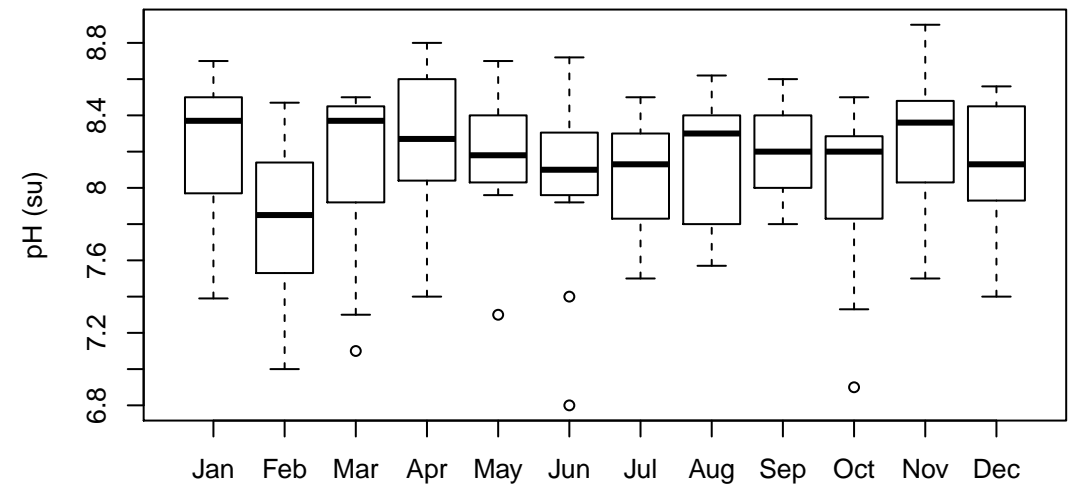
(a) Observation data



(b) Boxplot by year

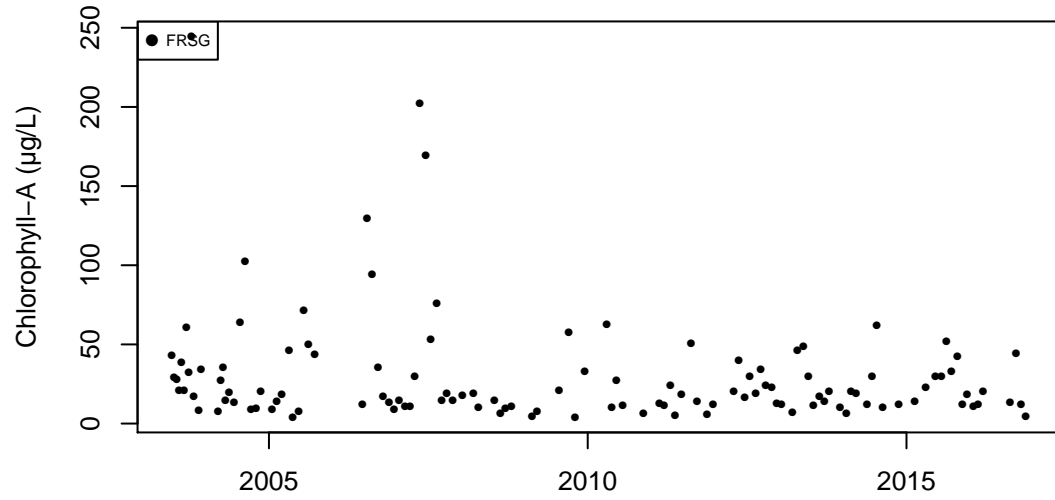


(c) Annual values

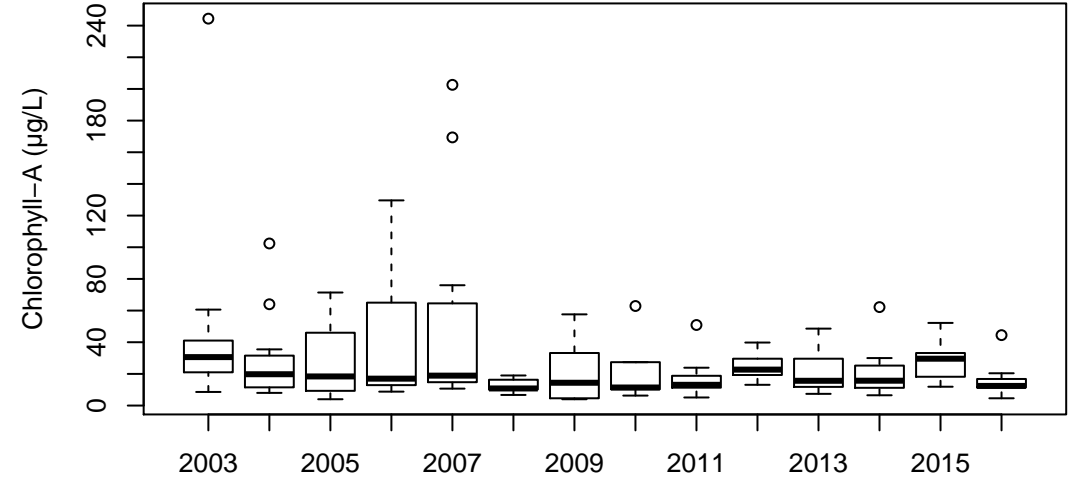


(d) Boxplot by month

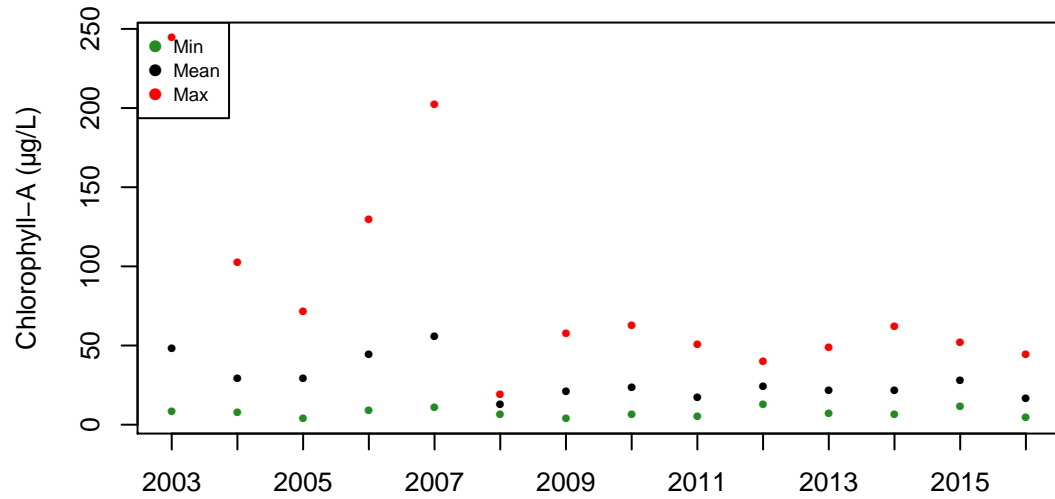
Crystal Cr at Rt 31 (271): Chlorophyll-A ($\mu\text{g/L}$)



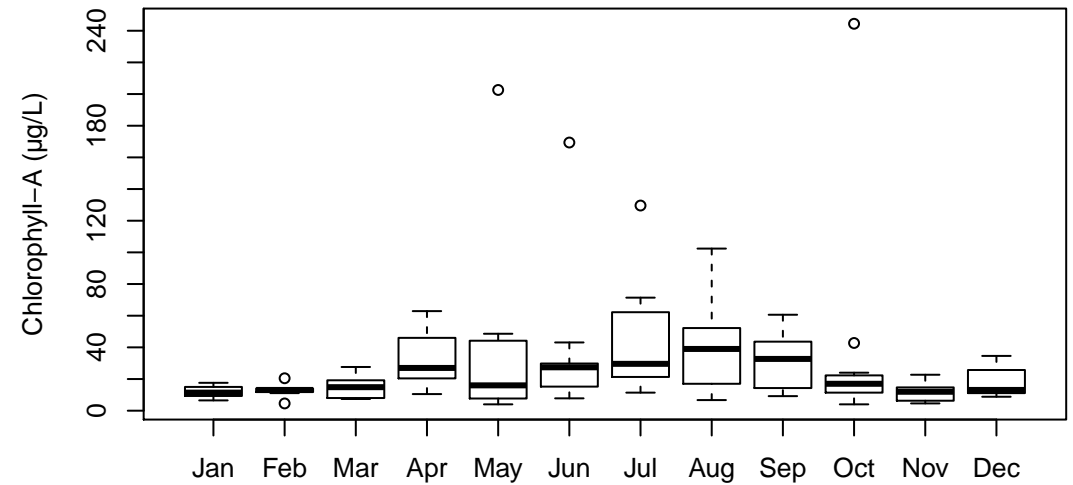
(a) Observation data



(b) Boxplot by year

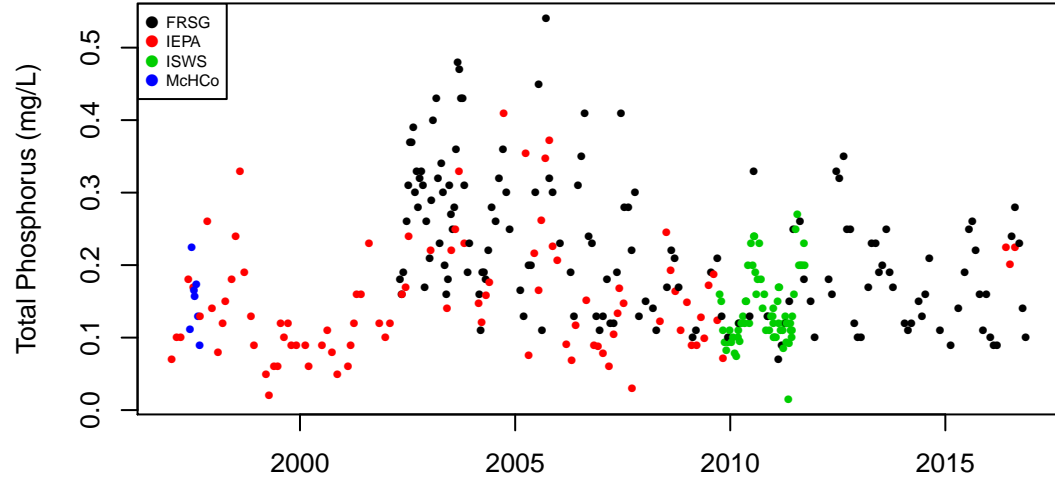


(c) Annual values

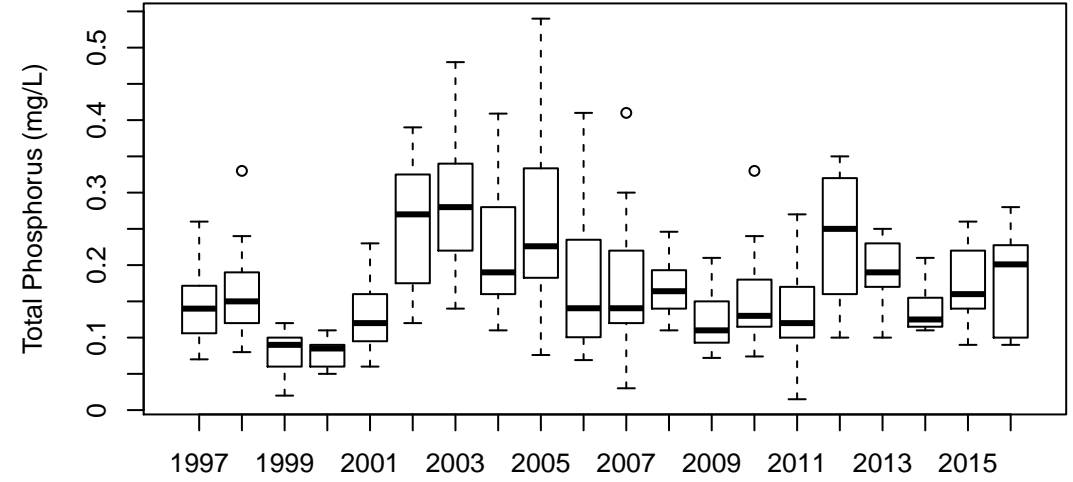


(d) Boxplot by month

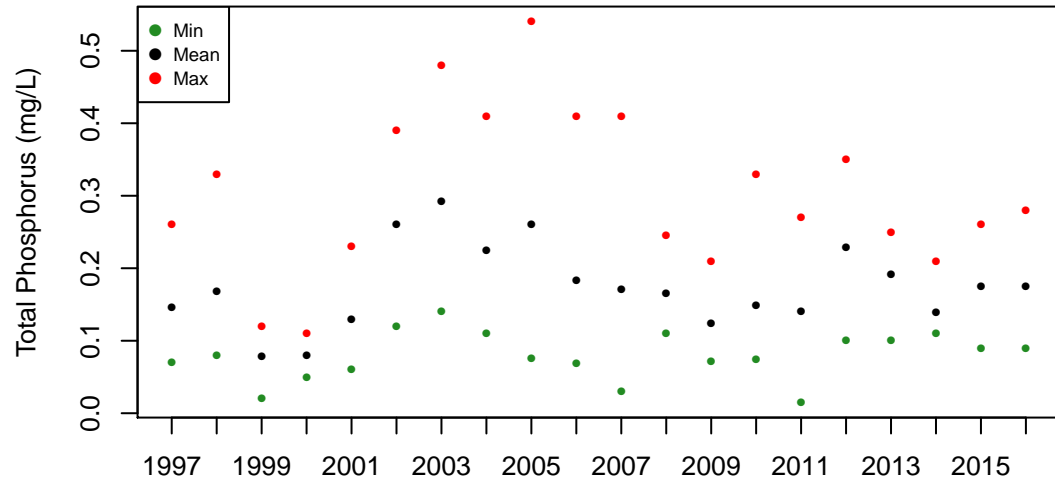
Fox River at Algonquin (24): Total Phosphorus (mg/L)



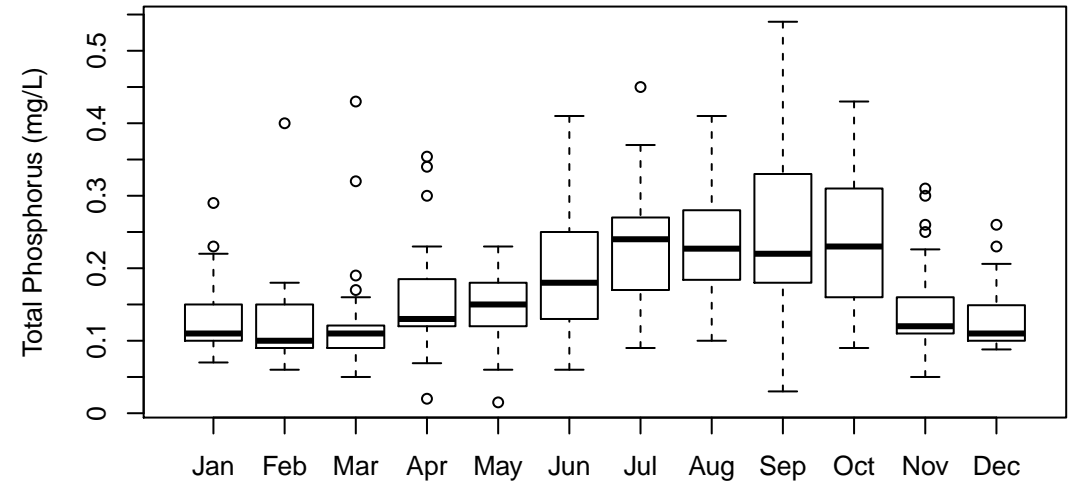
(a) Observation data



(b) Boxplot by year

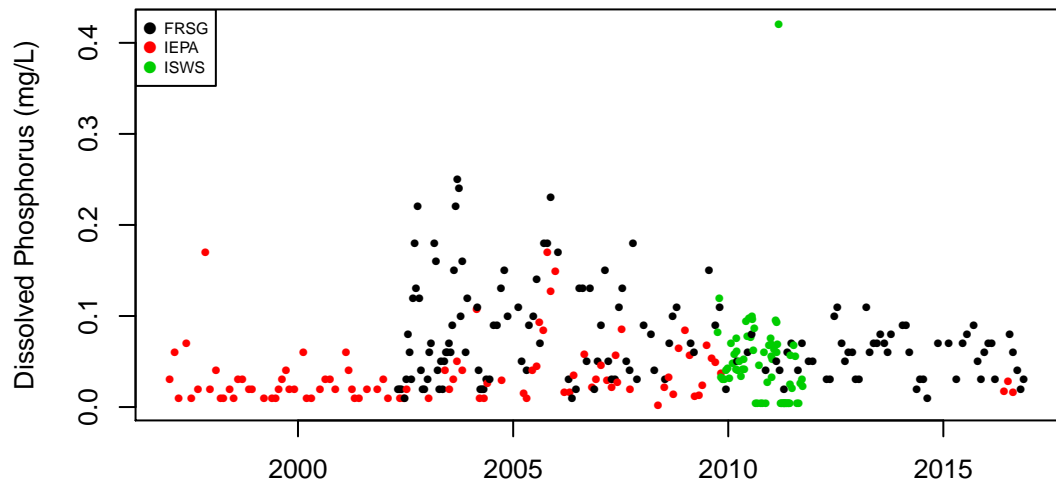


(c) Annual values

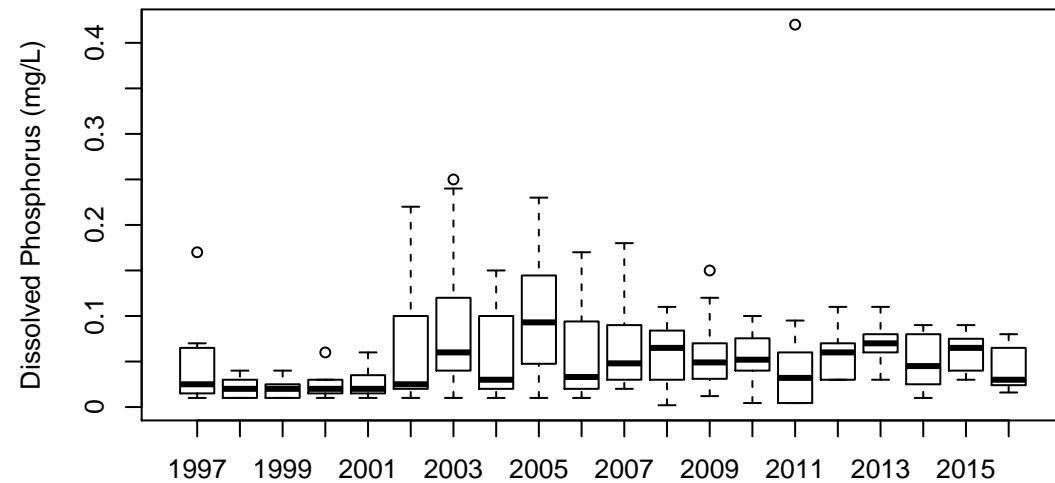


(d) Boxplot by month

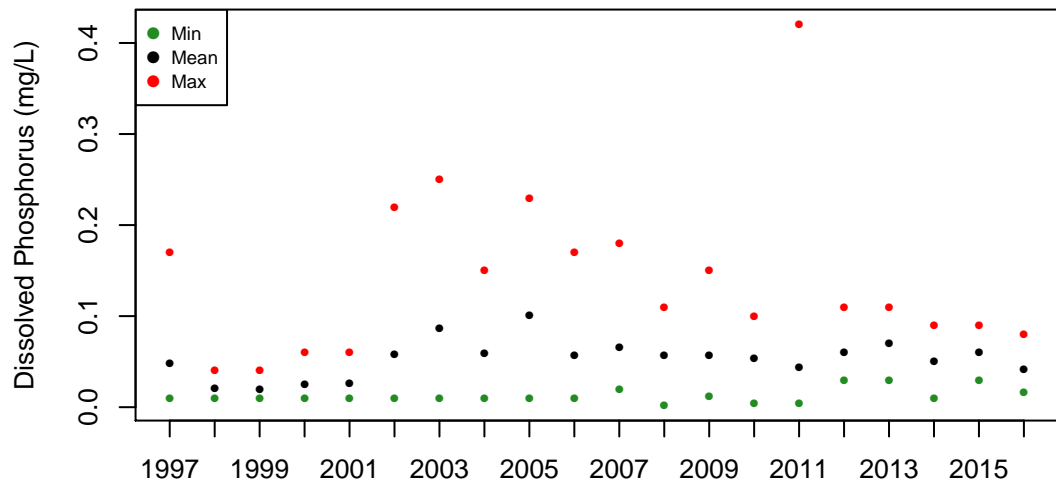
Fox River at Algonquin (24): Dissolved Phosphorus (mg/L)



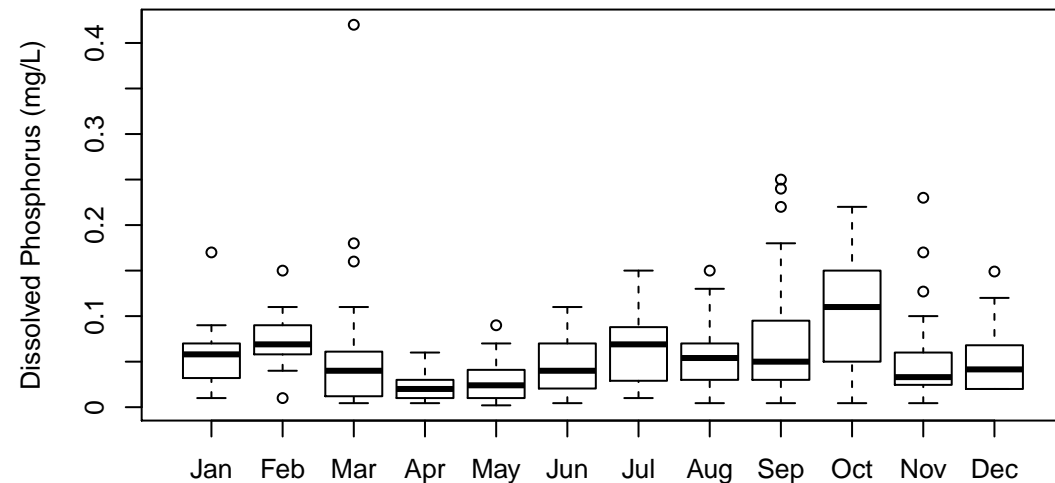
(a) Observation data



(b) Boxplot by year

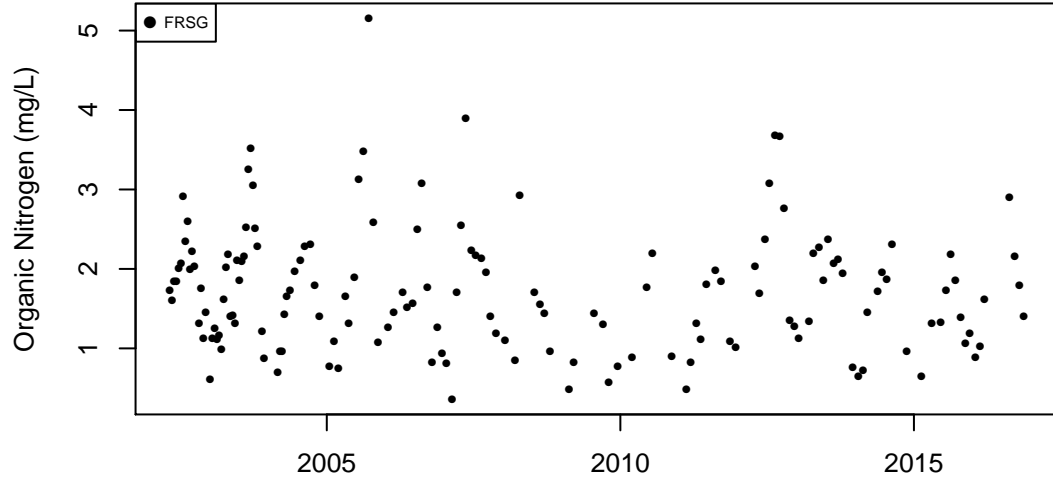


(c) Annual values

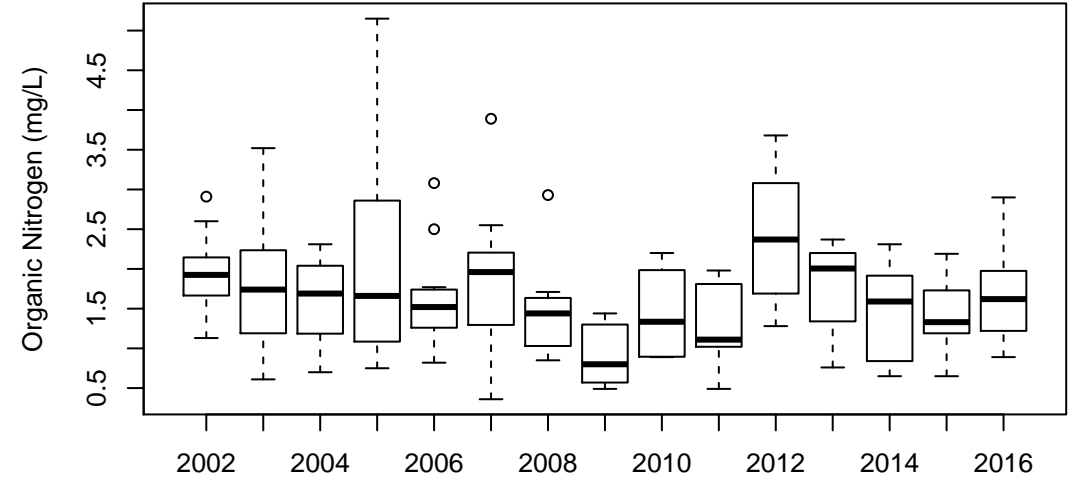


(d) Boxplot by month

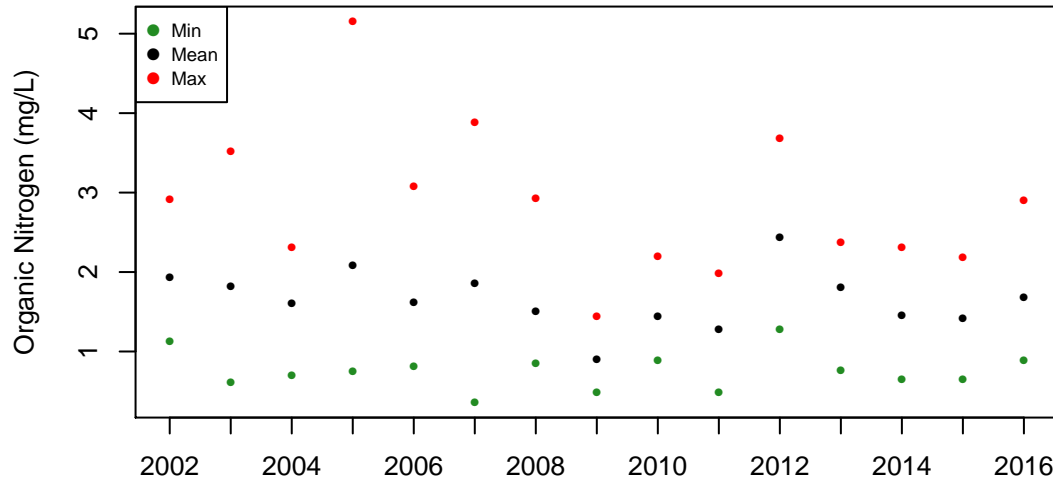
Fox River at Algonquin (24): Organic Nitrogen (mg/L)



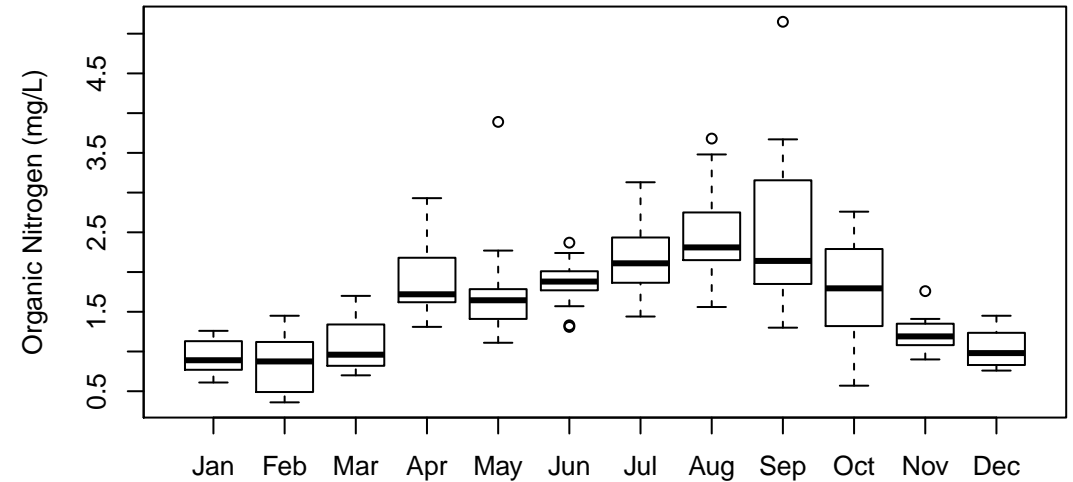
(a) Observation data



(b) Boxplot by year

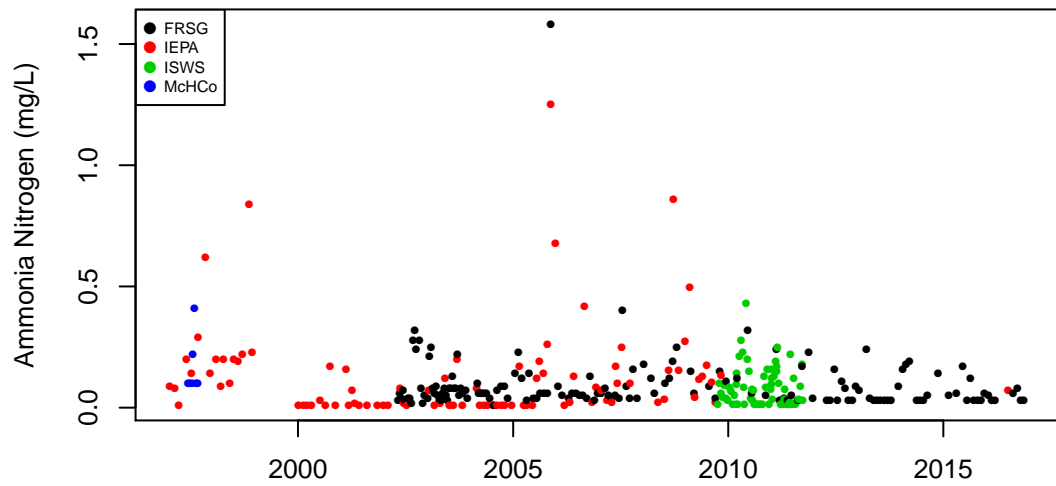


(c) Annual values

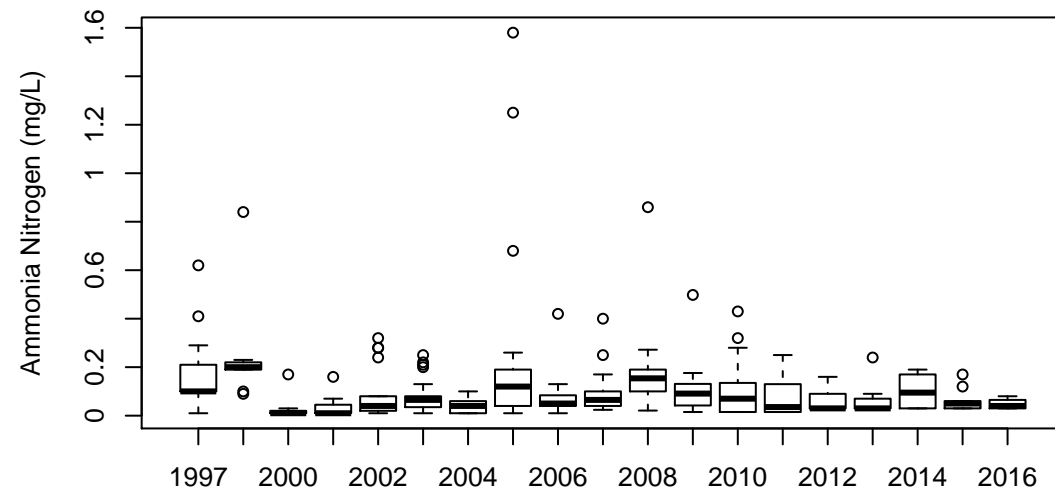


(d) Boxplot by month

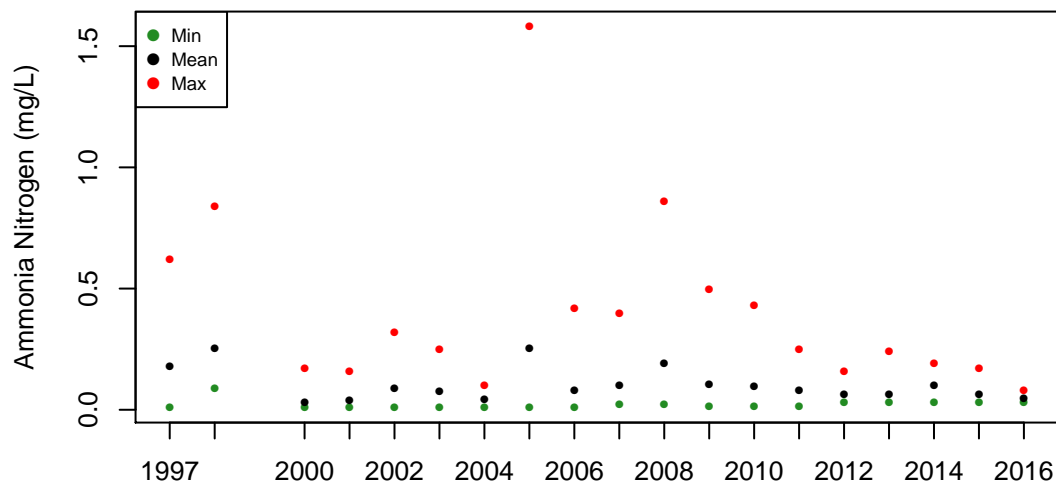
Fox River at Algonquin (24): Ammonia Nitrogen (mg/L)



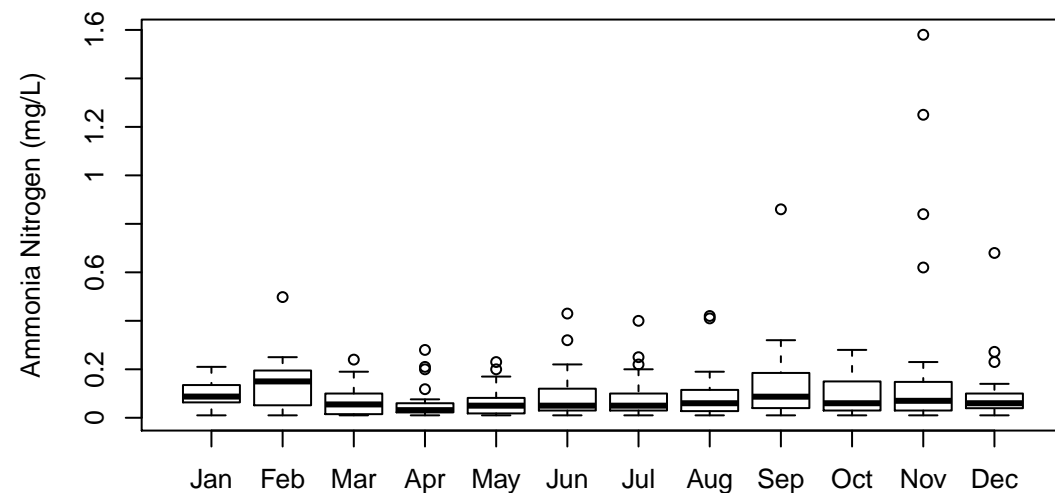
(a) Observation data



(b) Boxplot by year

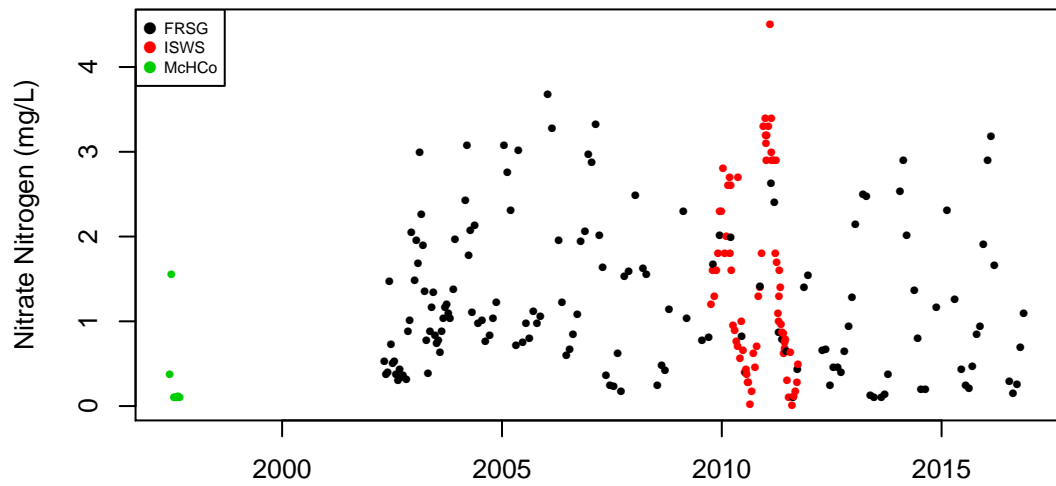


(c) Annual values

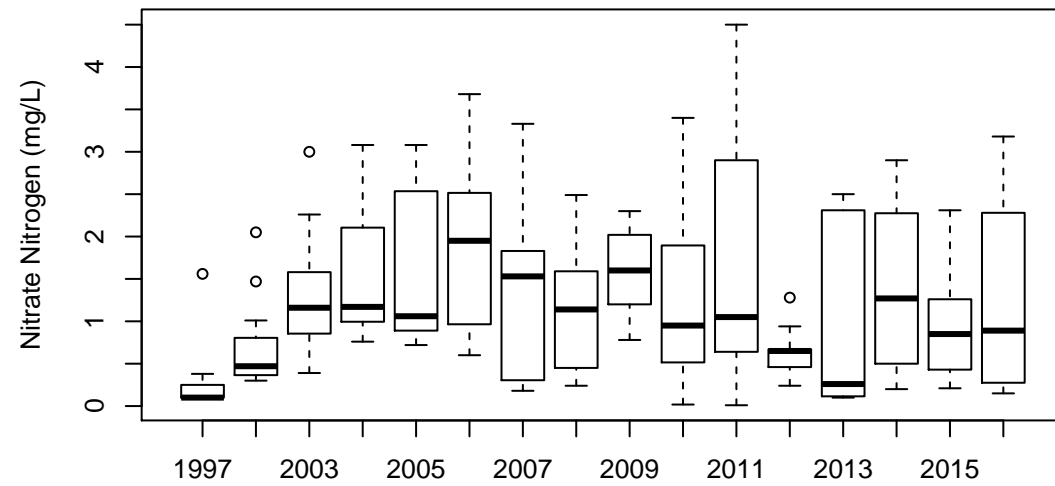


(d) Boxplot by month

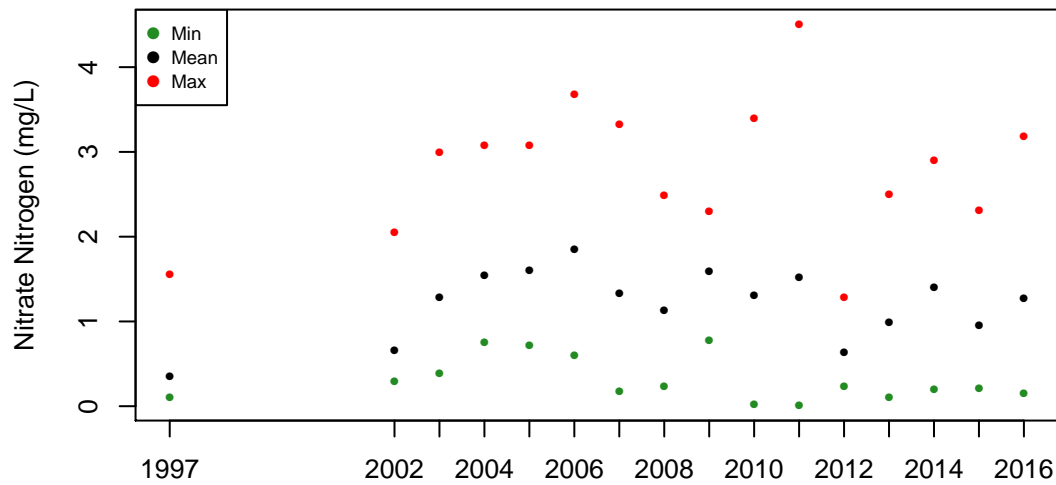
Fox River at Algonquin (24): Nitrate Nitrogen (mg/L)



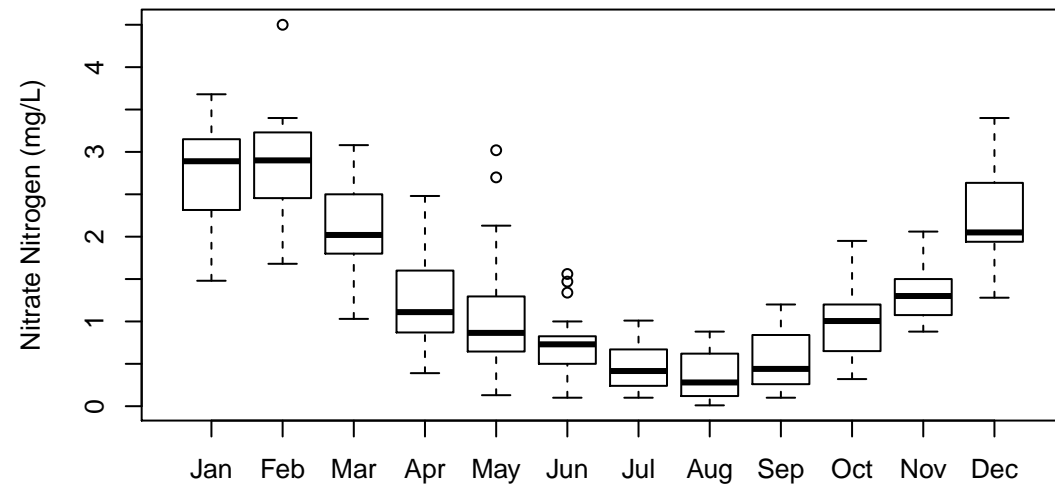
(a) Observation data



(b) Boxplot by year

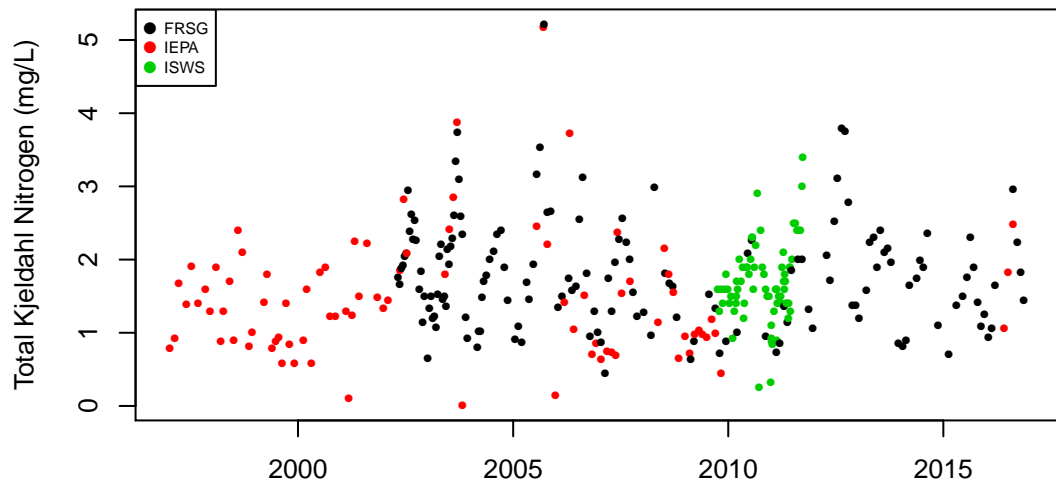


(c) Annual values

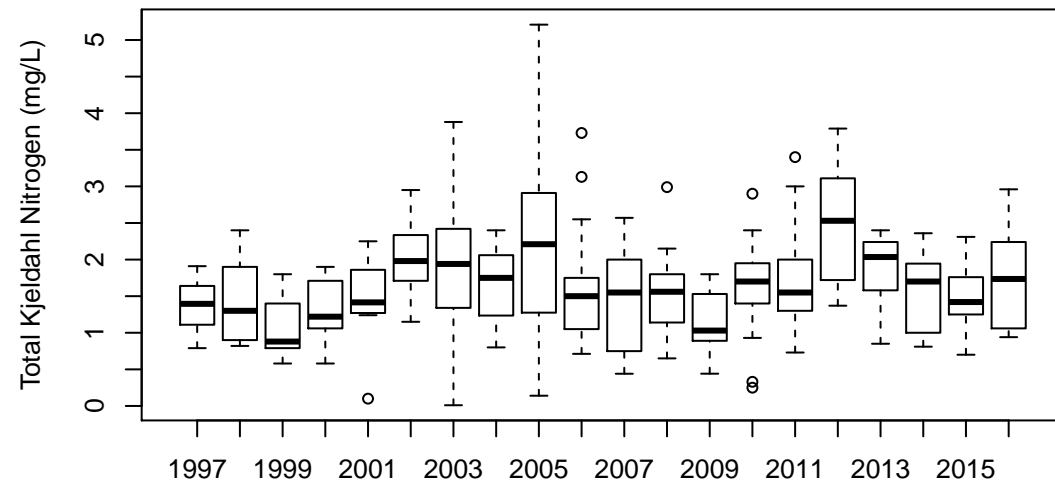


(d) Boxplot by month

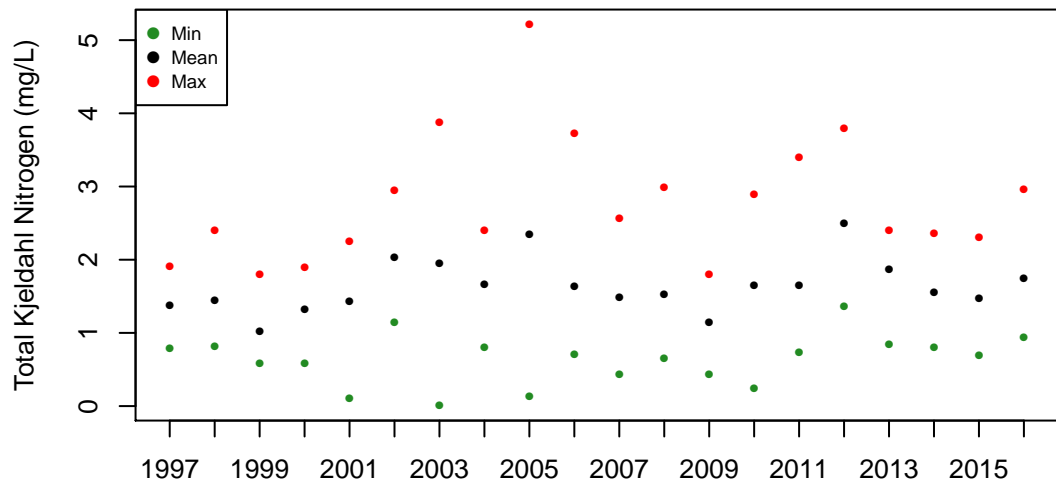
Fox River at Algonquin (24): Total Kjeldahl Nitrogen (mg/L)



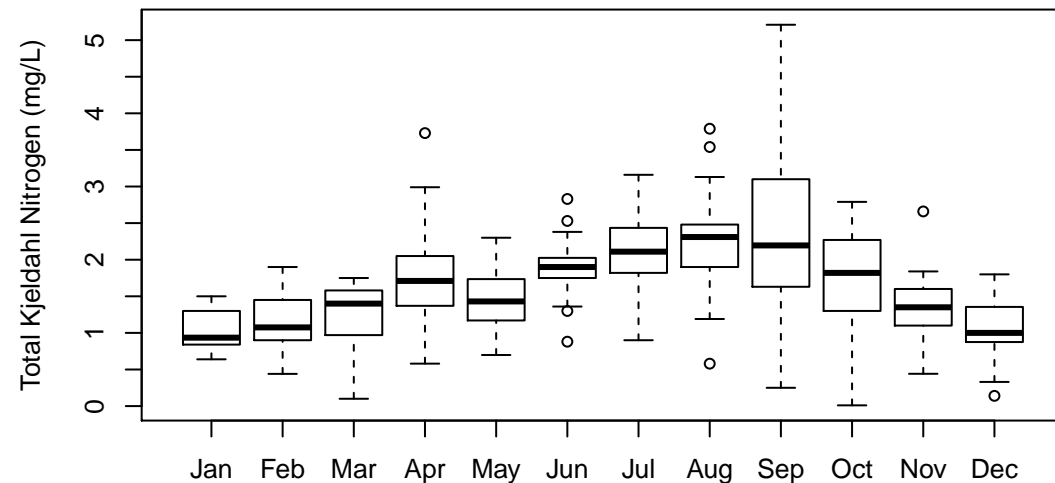
(a) Observation data



(b) Boxplot by year

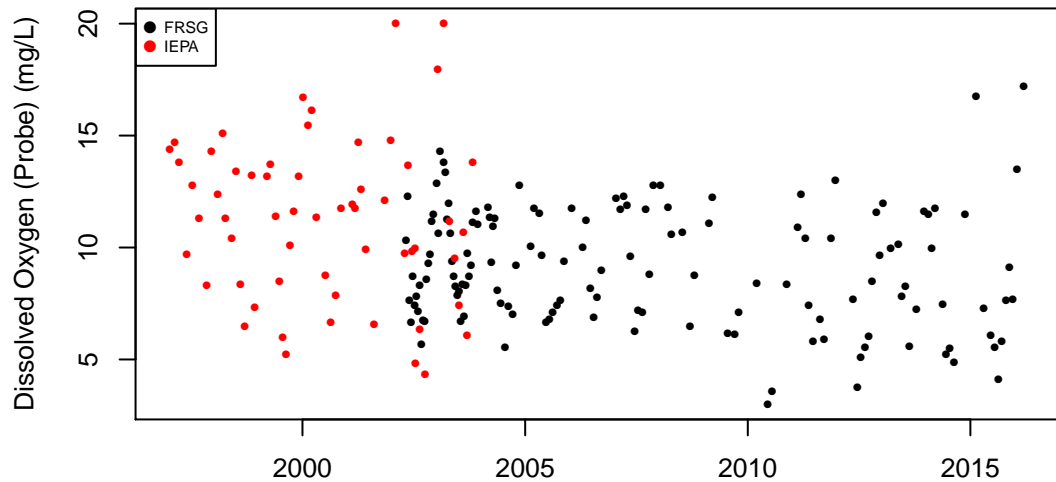


(c) Annual values

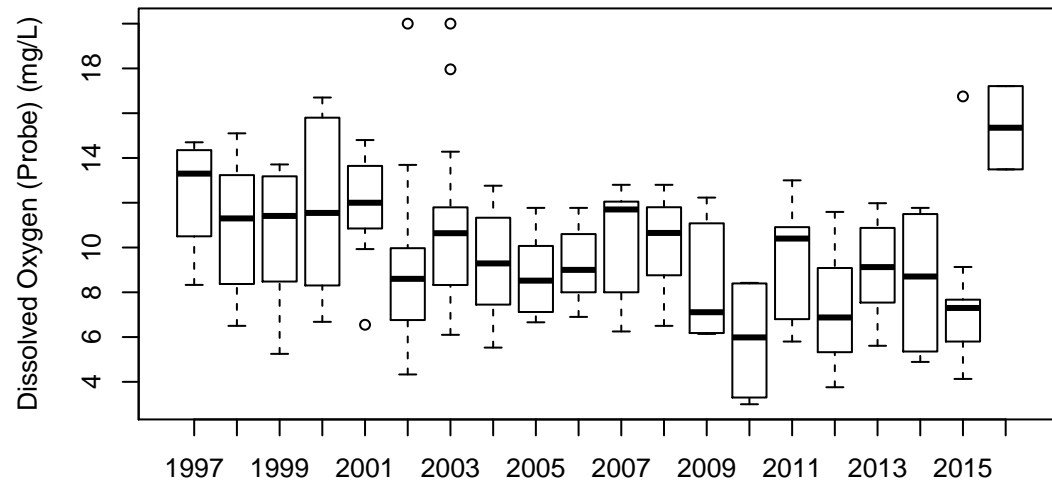


(d) Boxplot by month

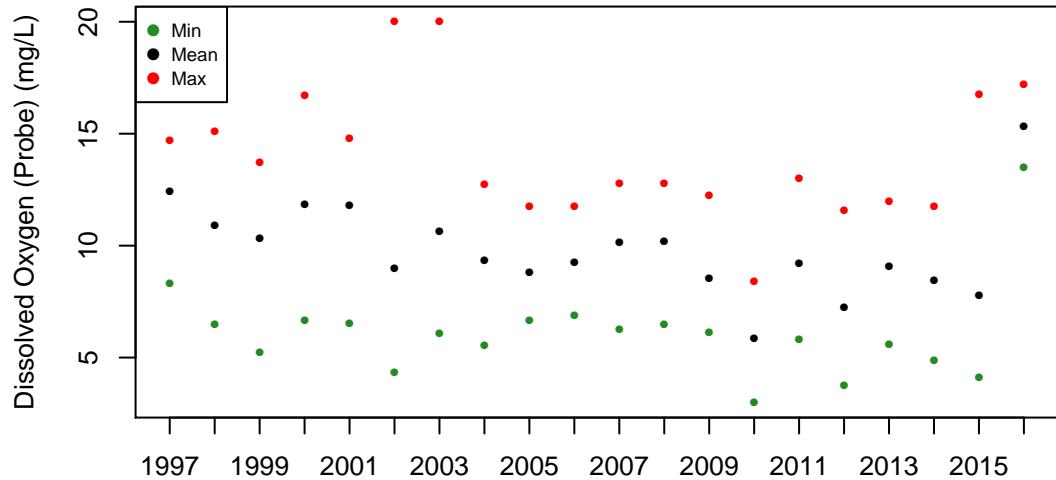
Fox River at Algonquin (24): Dissolved Oxygen (Probe) (mg/L)



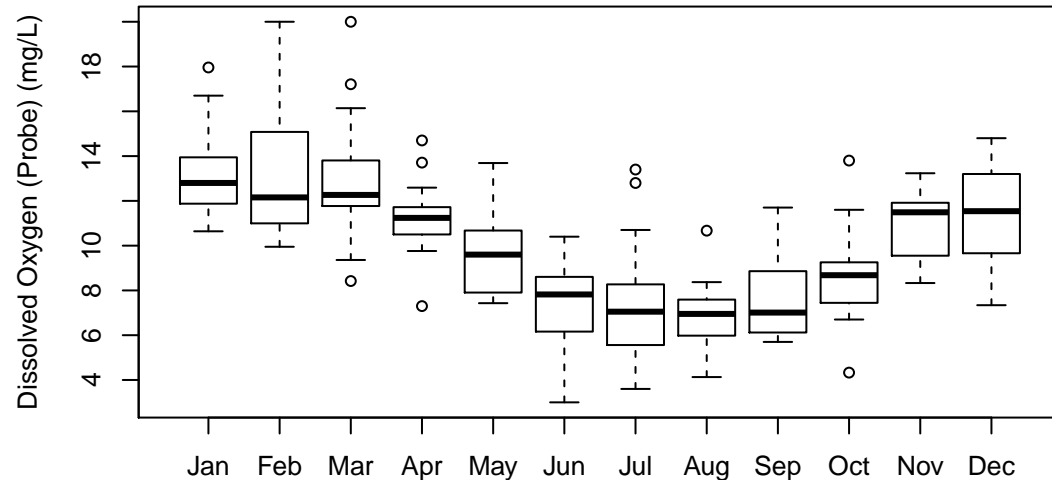
(a) Observation data



(b) Boxplot by year



(c) Annual values

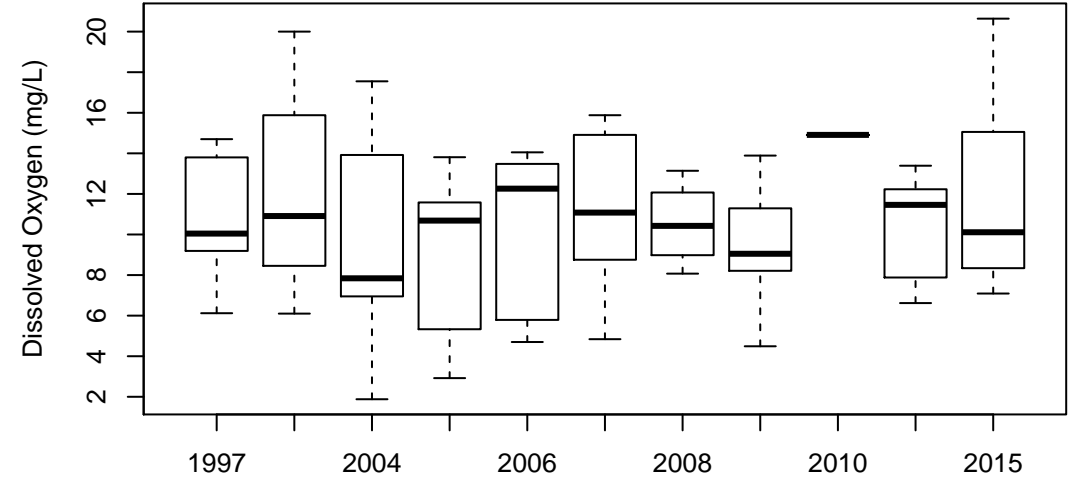


(d) Boxplot by month

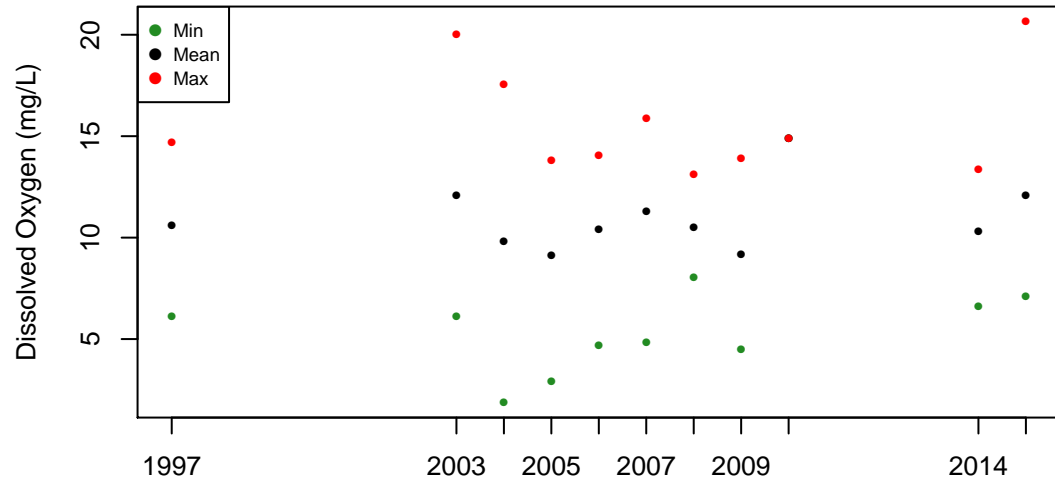
Fox River at Algonquin (24): Dissolved Oxygen (mg/L)



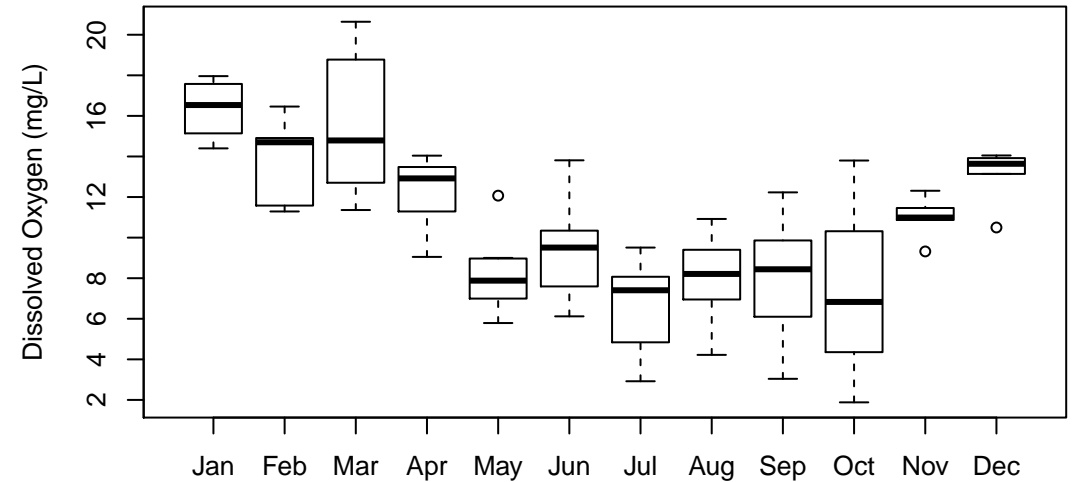
(a) Observation data



(b) Boxplot by year

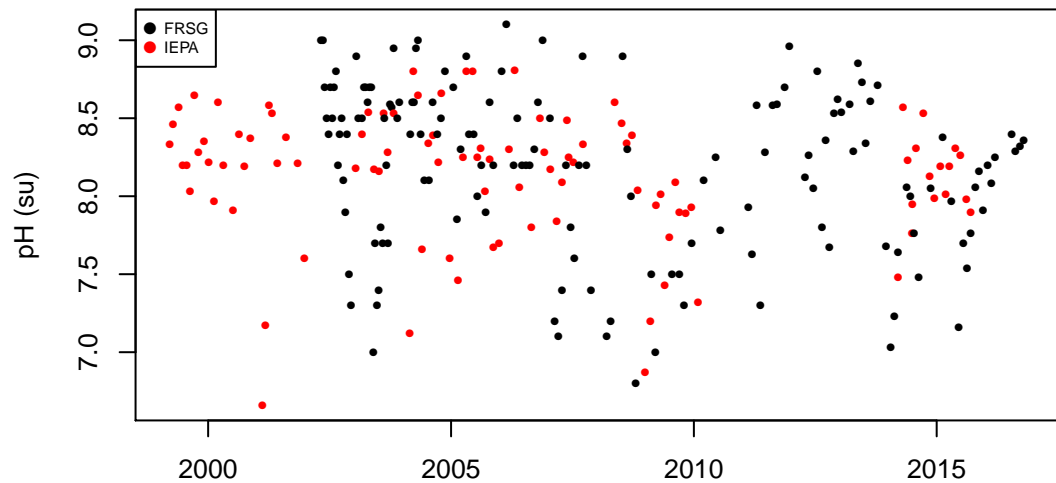


(c) Annual values

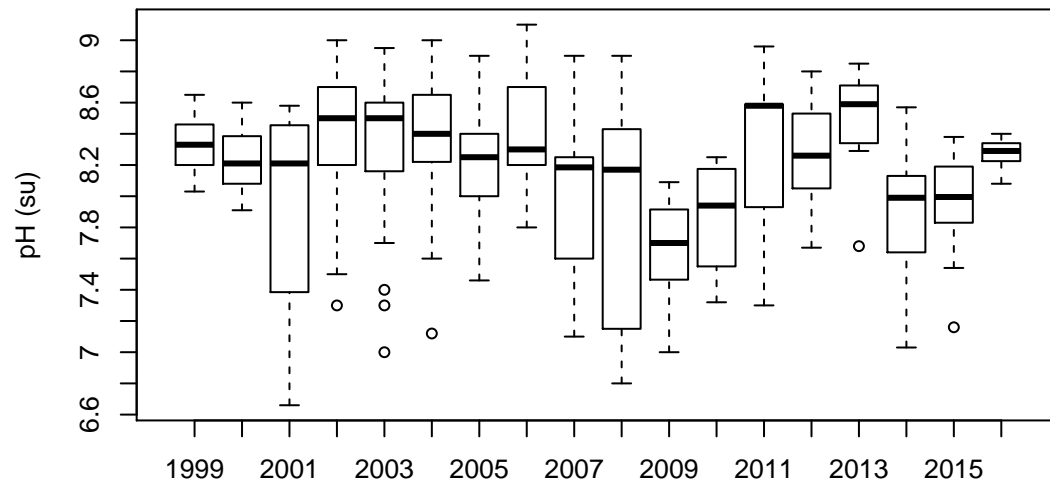


(d) Boxplot by month

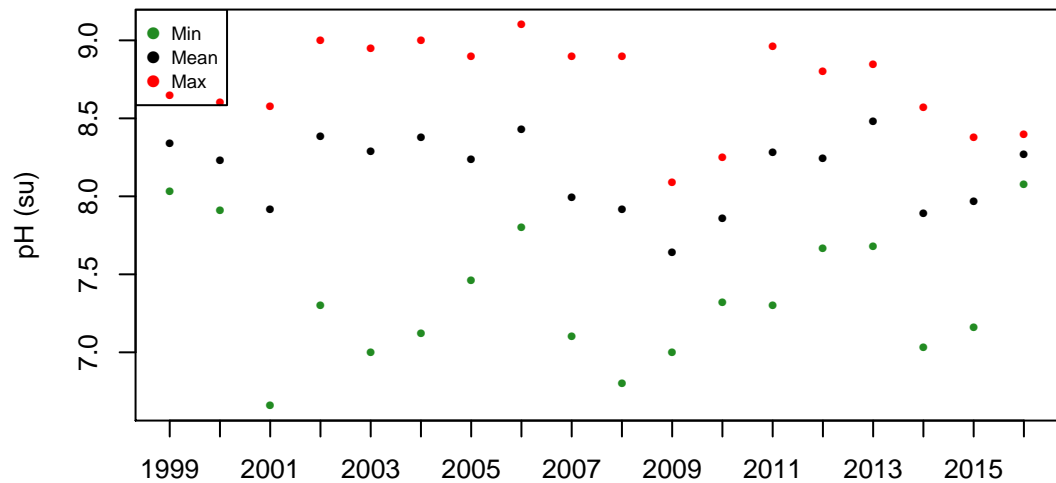
Fox River at Algonquin (24): pH (su)



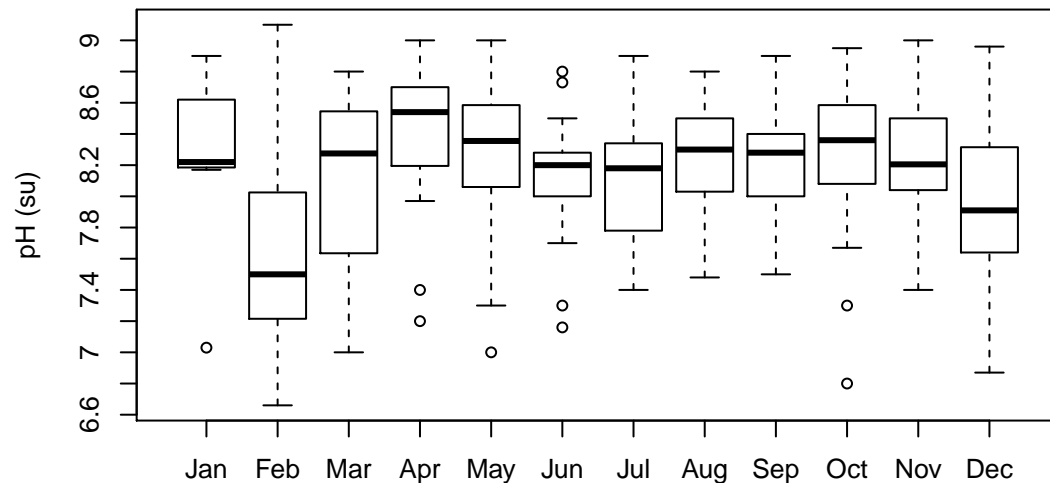
(a) Observation data



(b) Boxplot by year

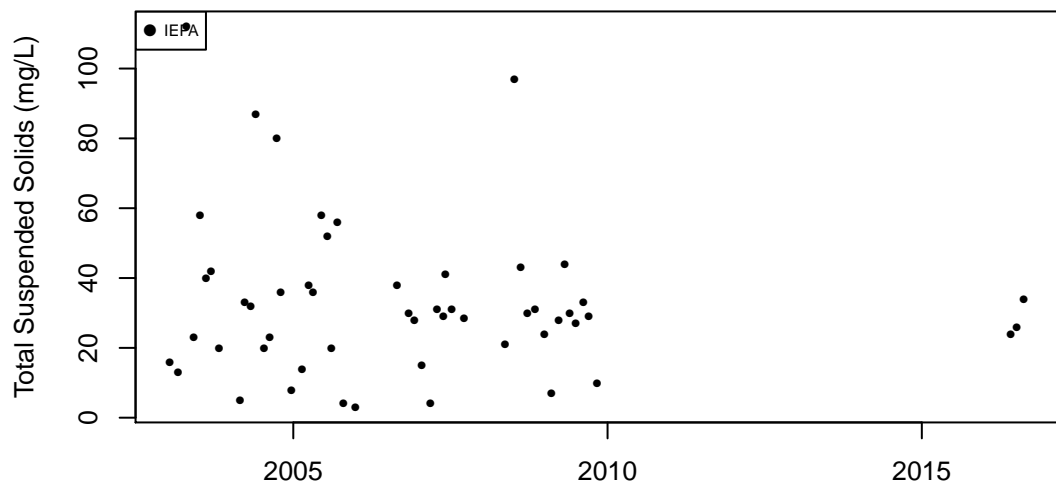


(c) Annual values

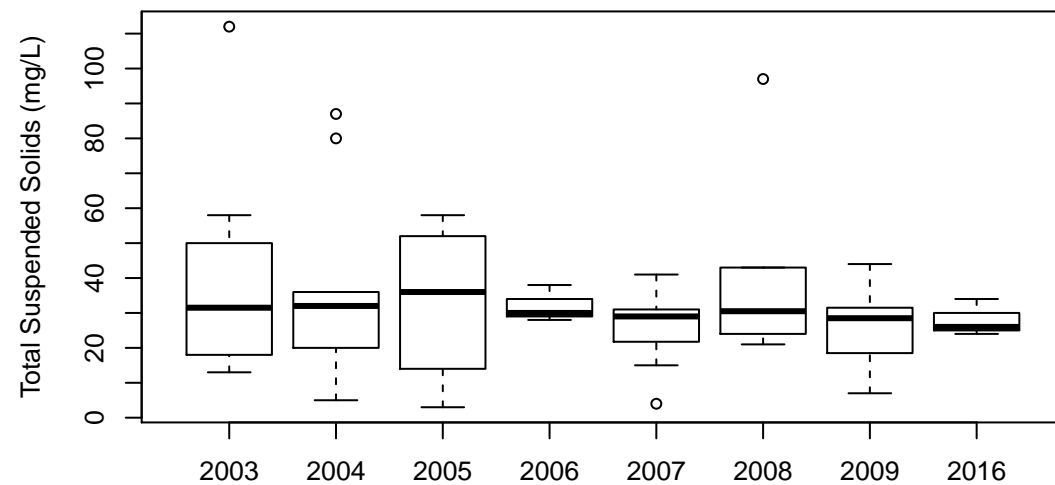


(d) Boxplot by month

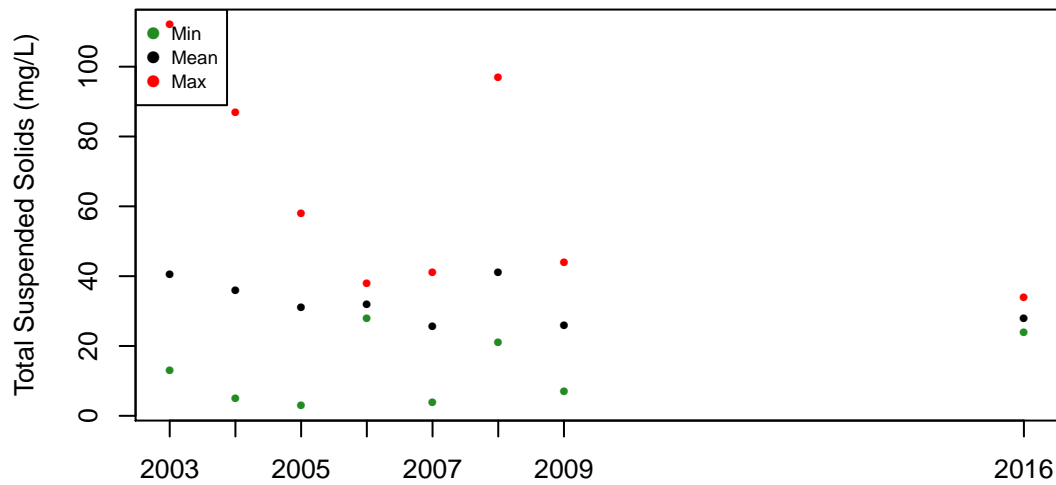
Fox River at Algonquin (24): Total Suspended Solids (mg/L)



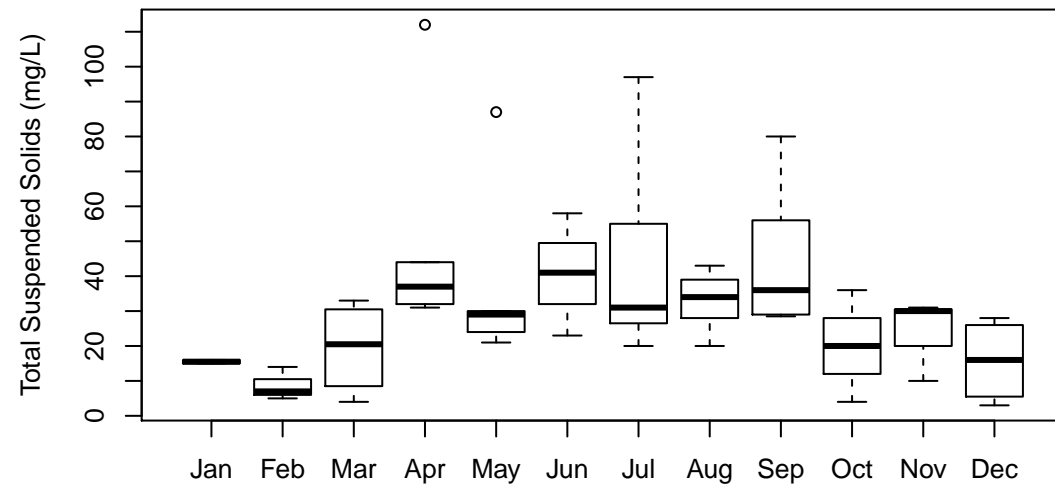
(a) Observation data



(b) Boxplot by year

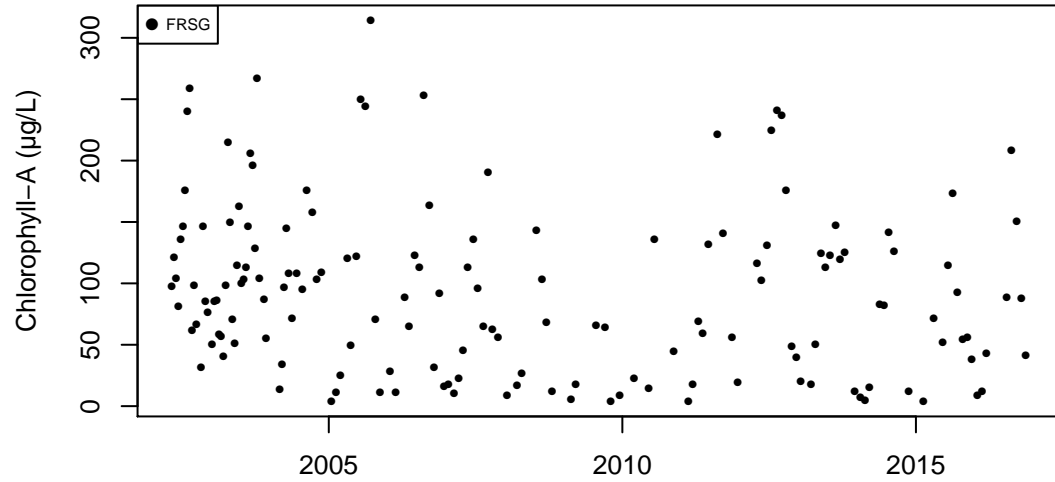


(c) Annual values

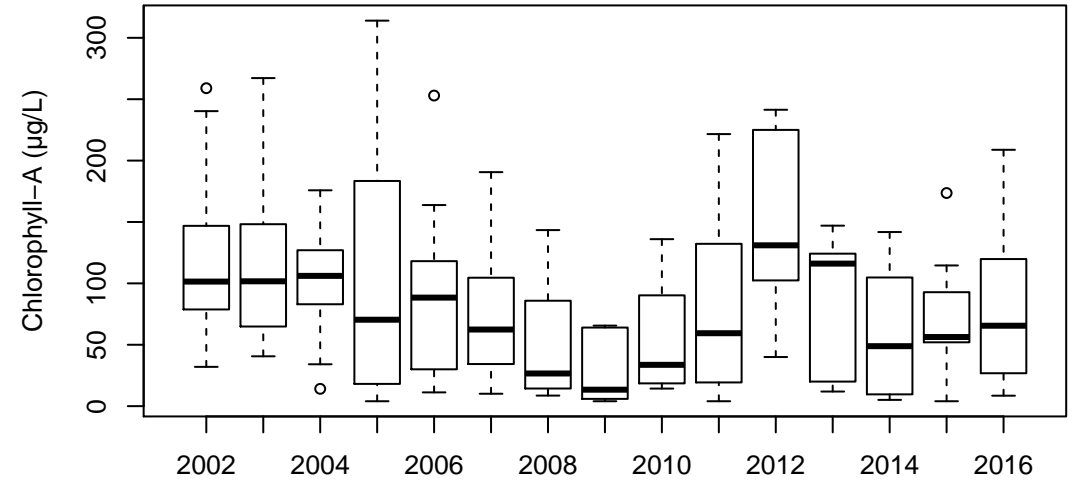


(d) Boxplot by month

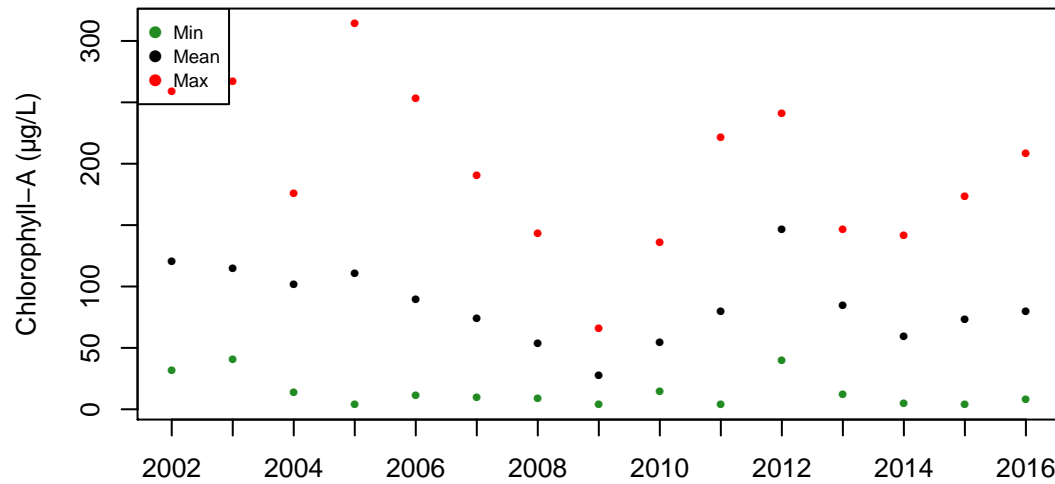
Fox River at Algonquin (24): Chlorophyll-A ($\mu\text{g/L}$)



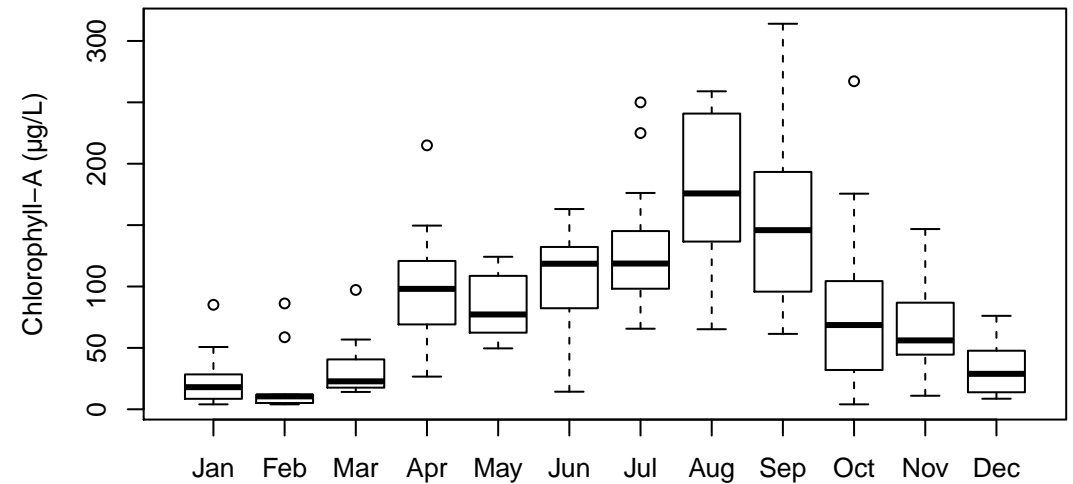
(a) Observation data



(b) Boxplot by year

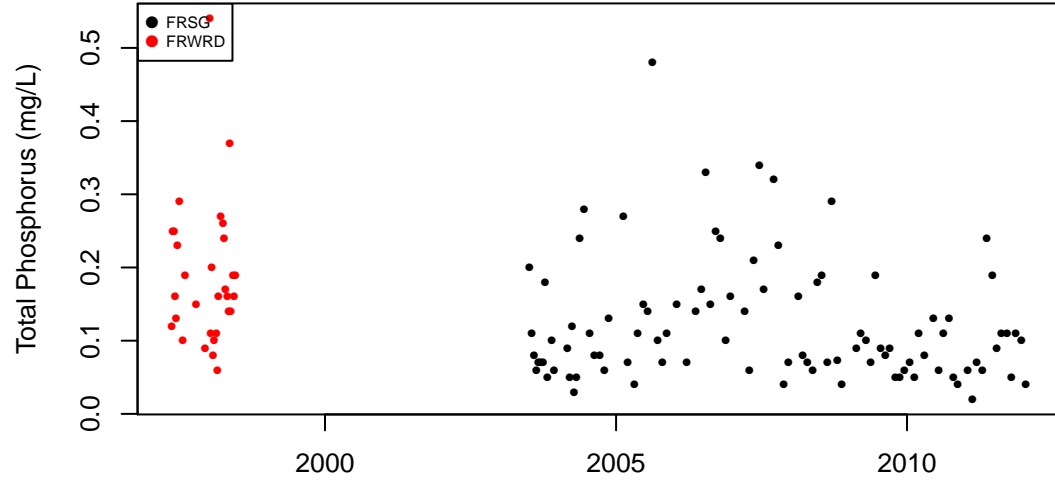


(c) Annual values

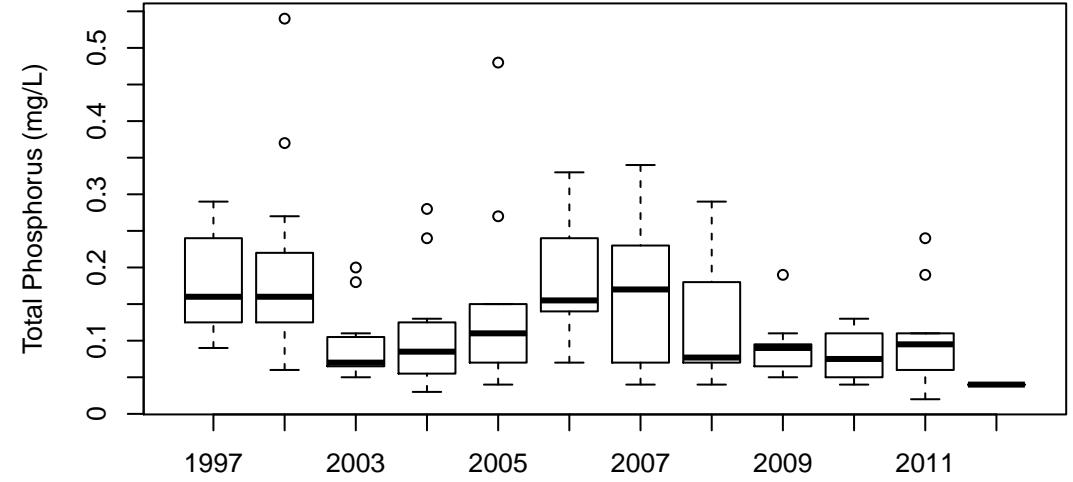


(d) Boxplot by month

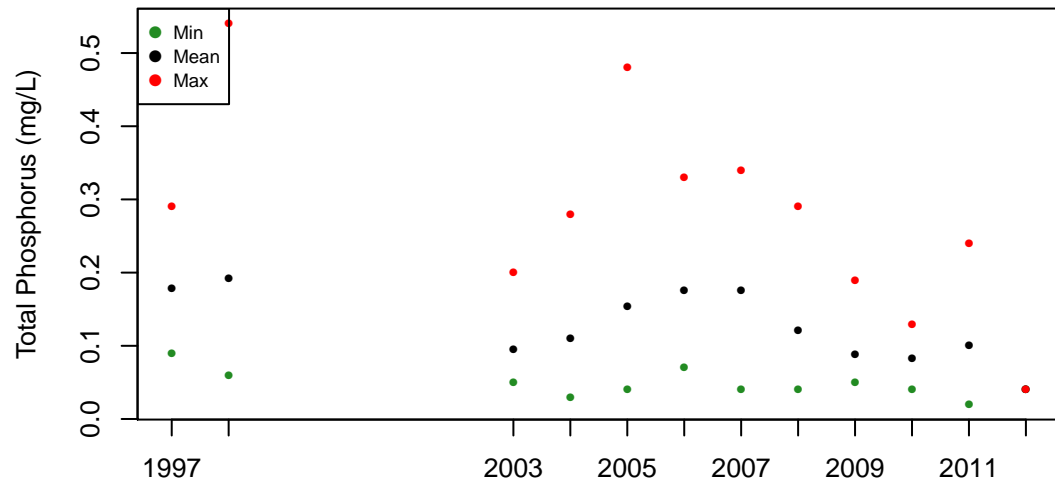
Tyler Cr at Rt. 31-Elgin (268): Total Phosphorus (mg/L)



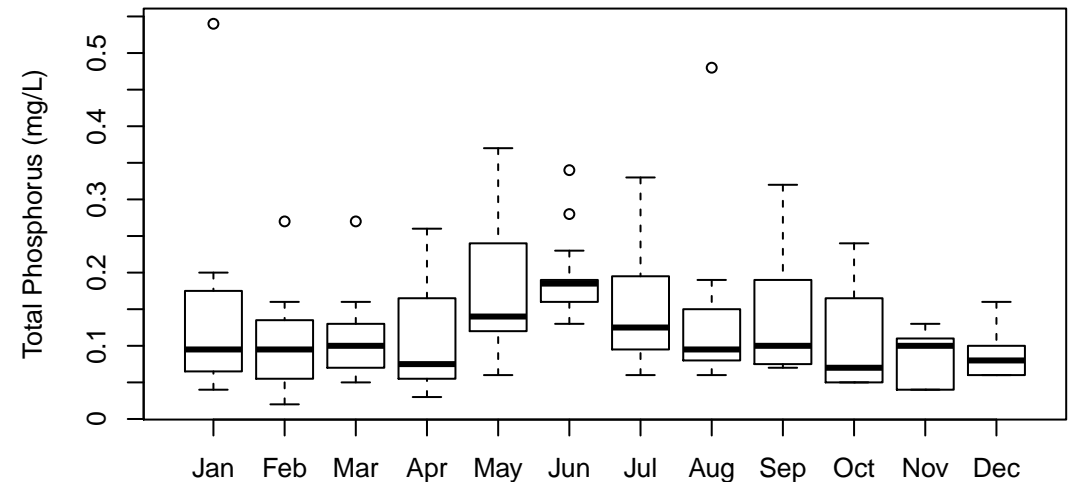
(a) Observation data



(b) Boxplot by year

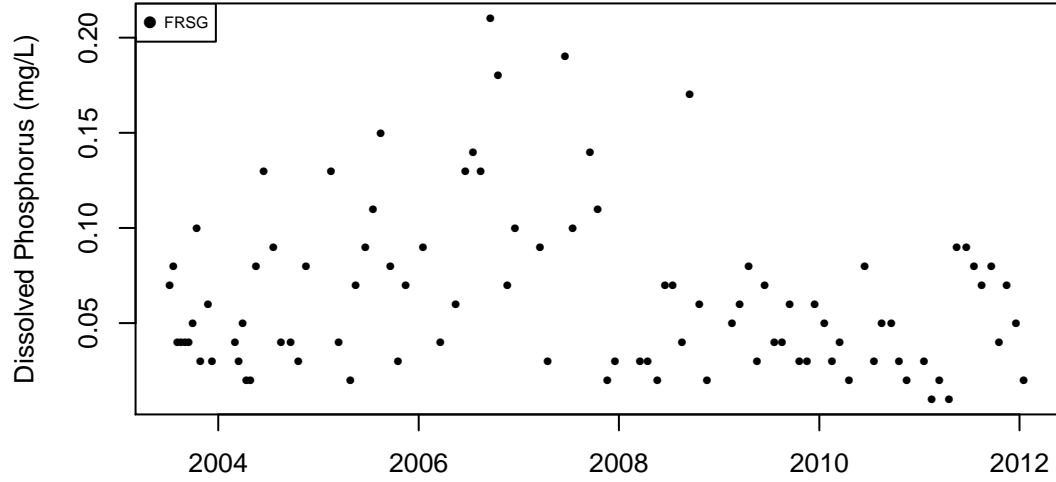


(c) Annual values

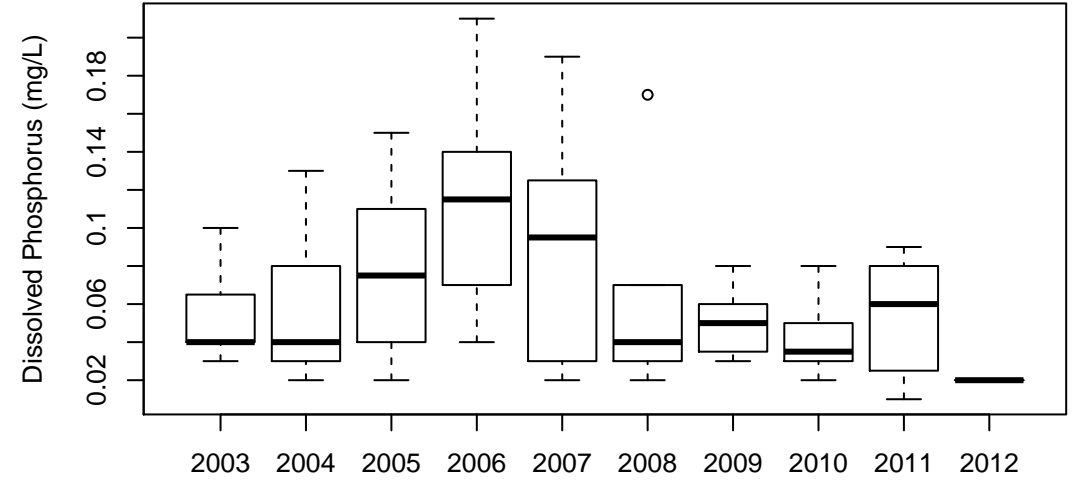


(d) Boxplot by month

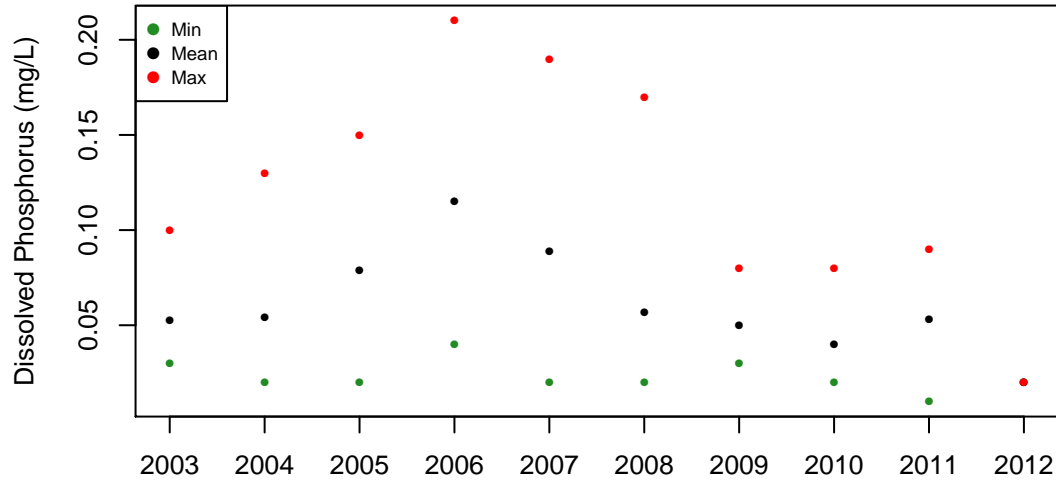
Tyler Cr at Rt. 31–Elgin (268): Dissolved Phosphorus (mg/L)



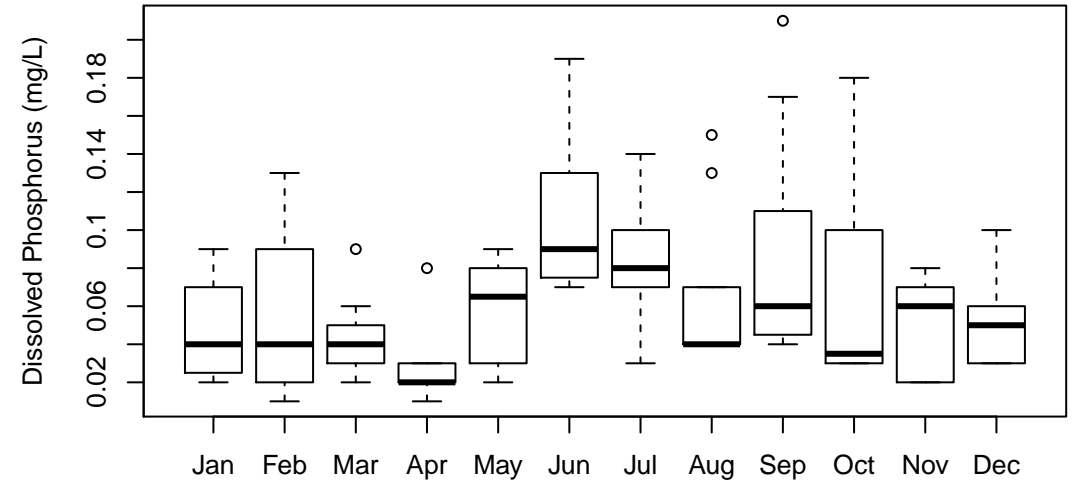
(a) Observation data



(b) Boxplot by year

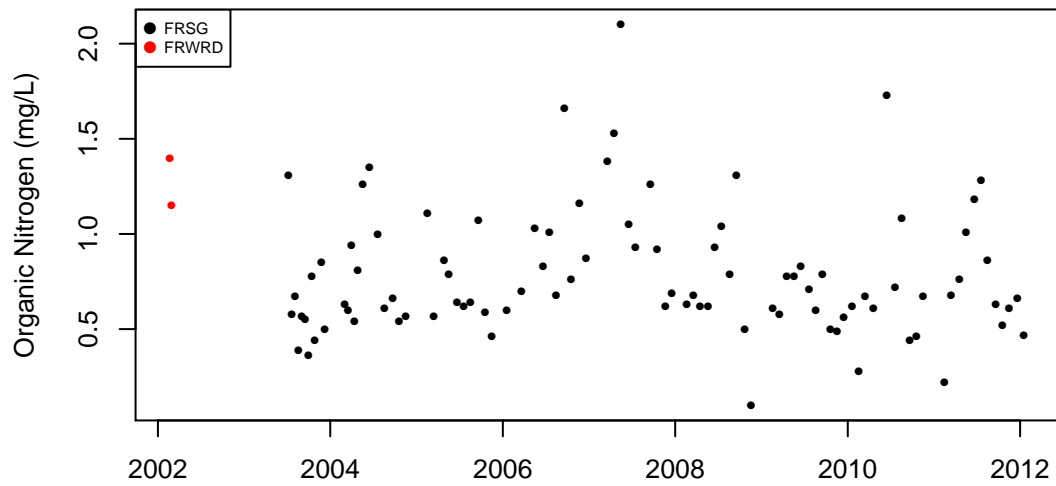


(c) Annual values

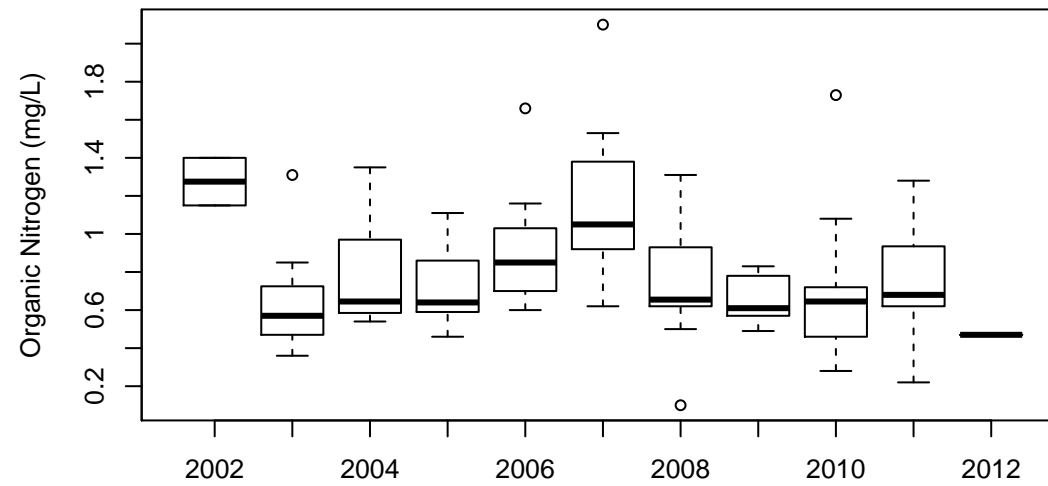


(d) Boxplot by month

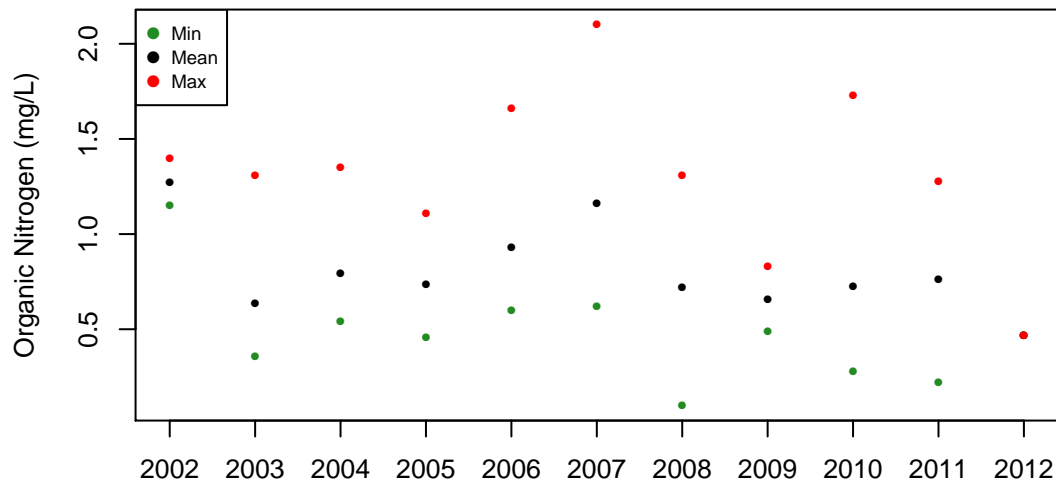
Tyler Cr at Rt. 31-Elgin (268): Organic Nitrogen (mg/L)



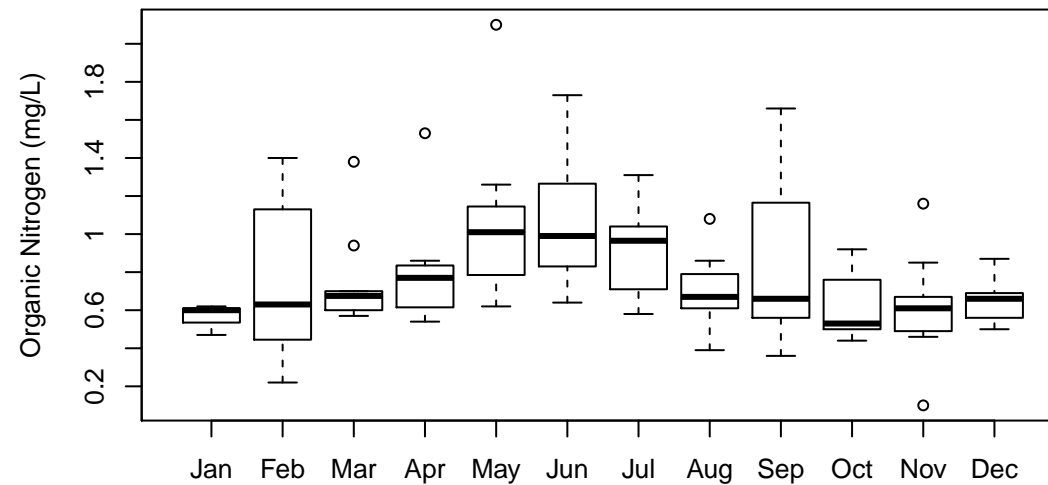
(a) Observation data



(b) Boxplot by year

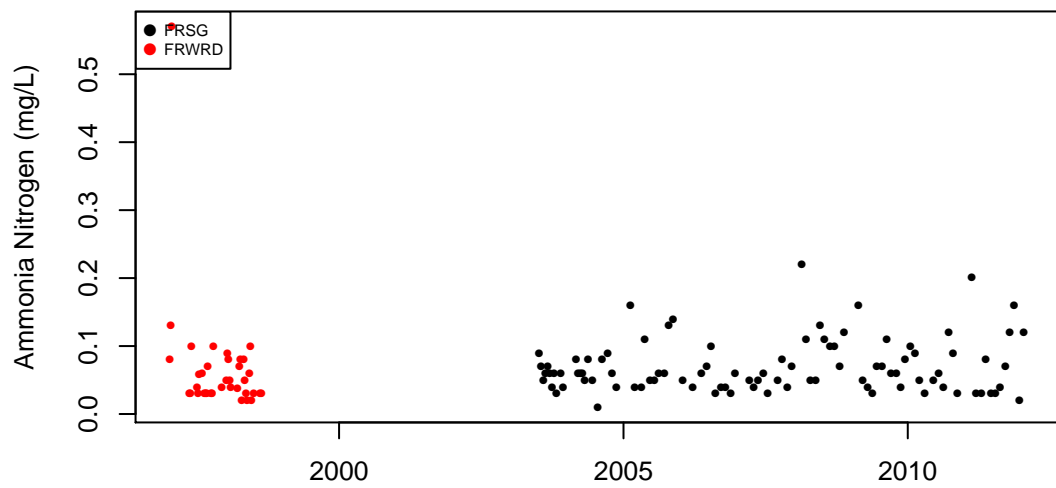


(c) Annual values

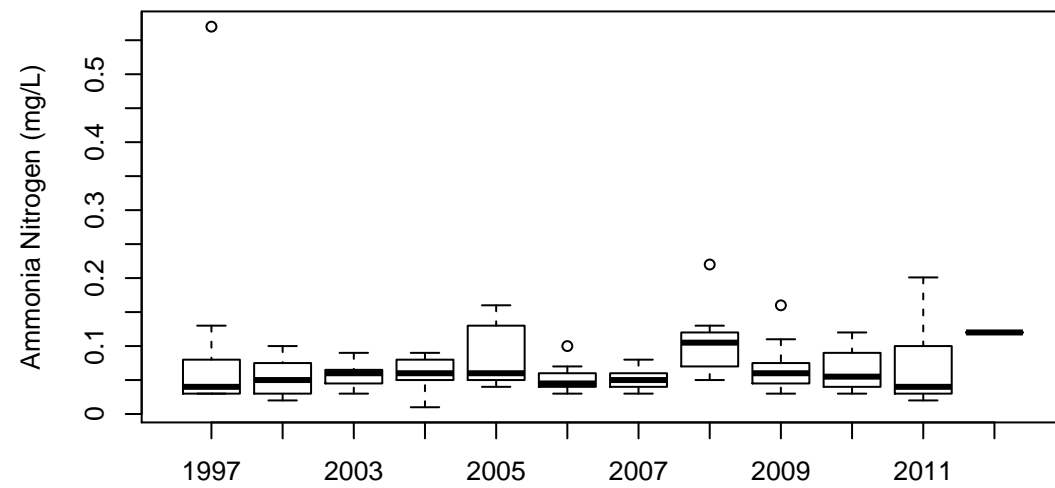


(d) Boxplot by month

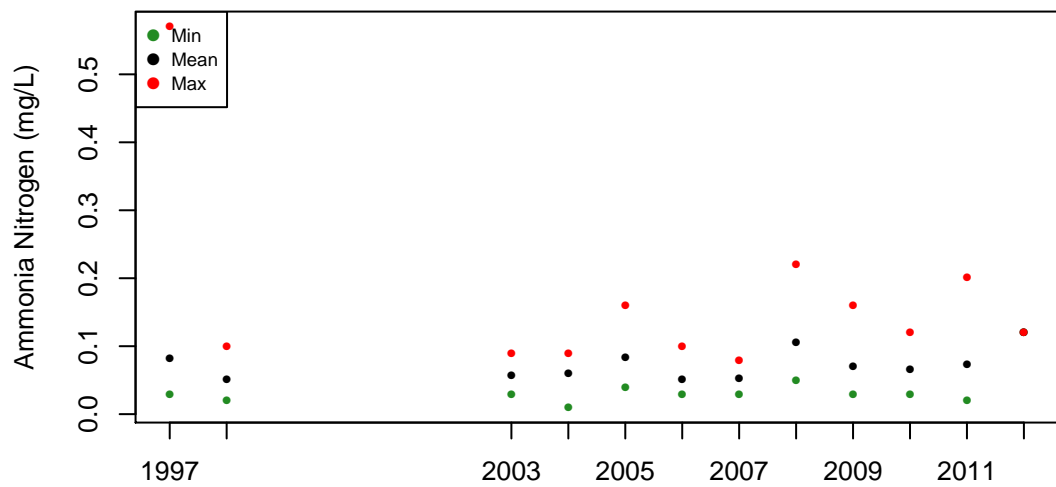
Tyler Cr at Rt. 31–Elgin (268): Ammonia Nitrogen (mg/L)



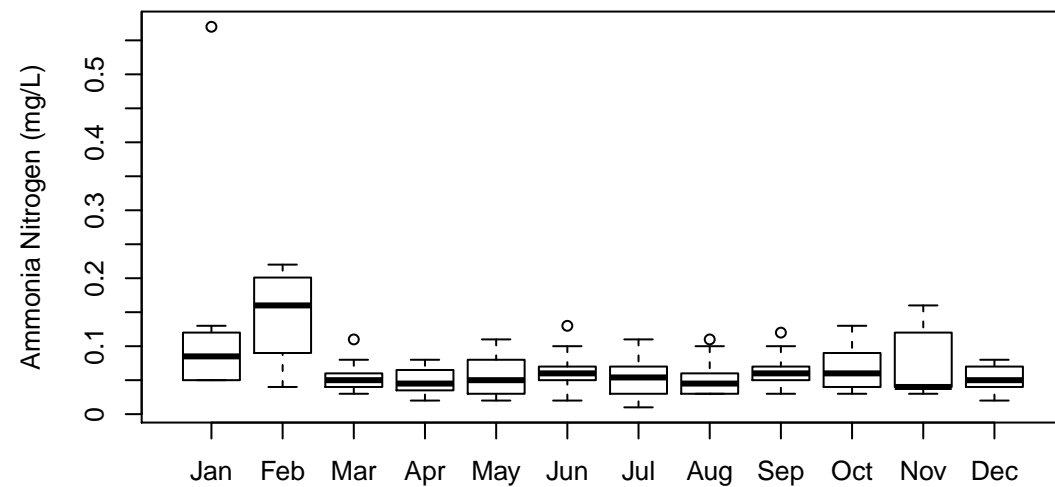
(a) Observation data



(b) Boxplot by year

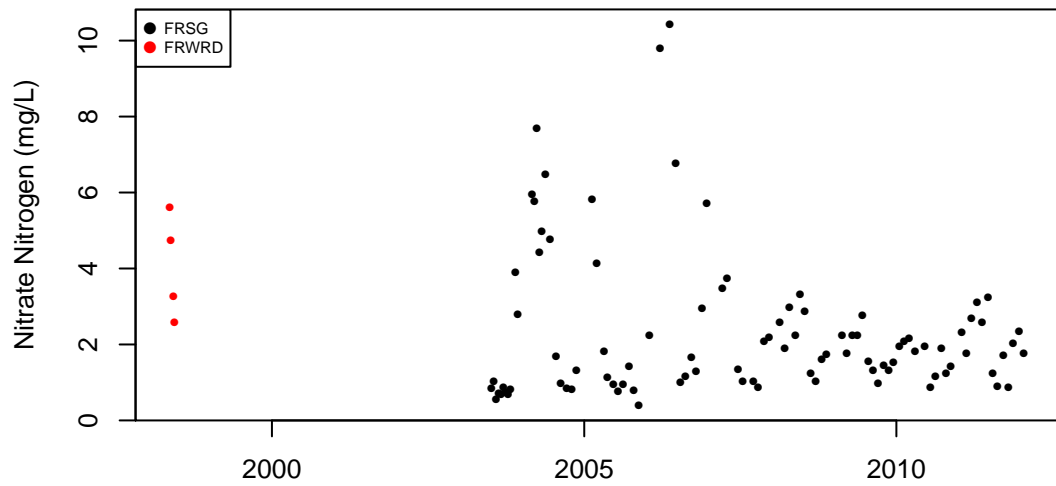


(c) Annual values

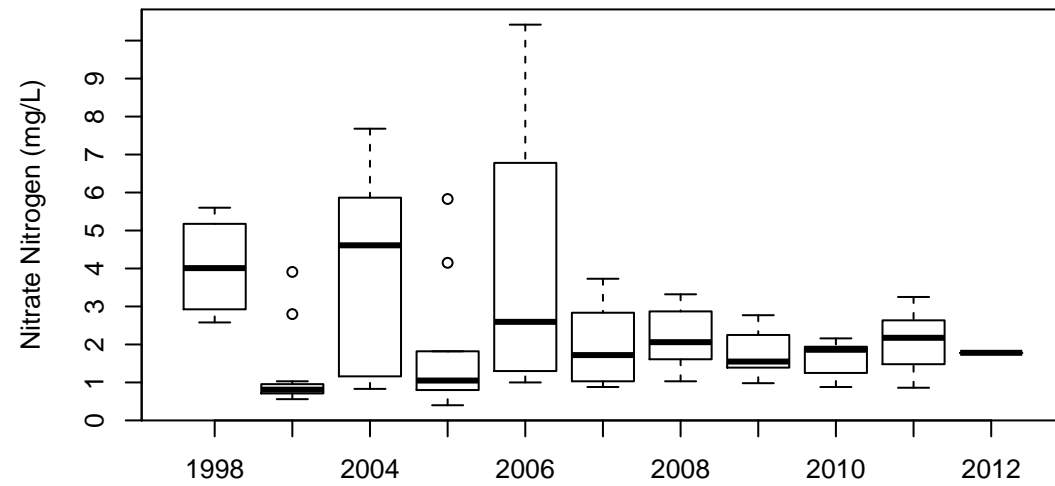


(d) Boxplot by month

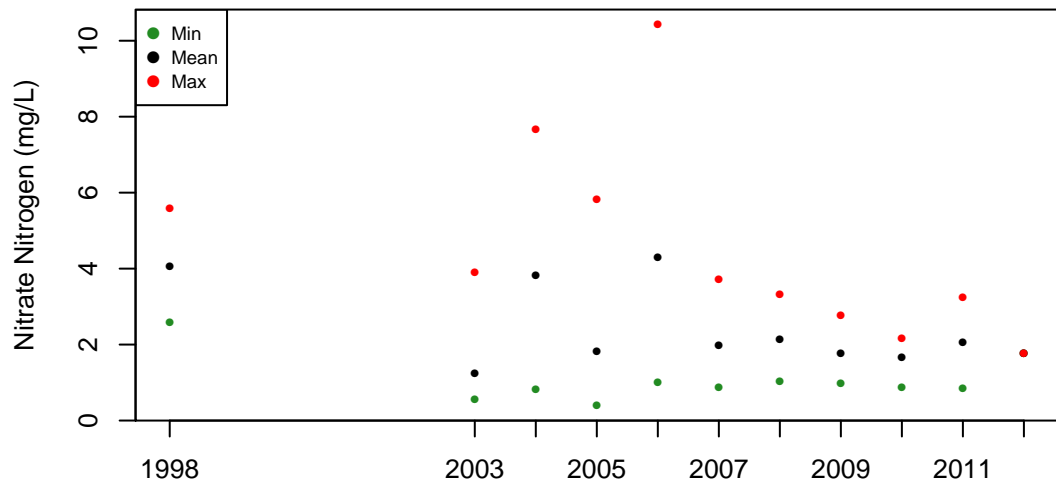
Tyler Cr at Rt. 31–Elgin (268): Nitrate Nitrogen (mg/L)



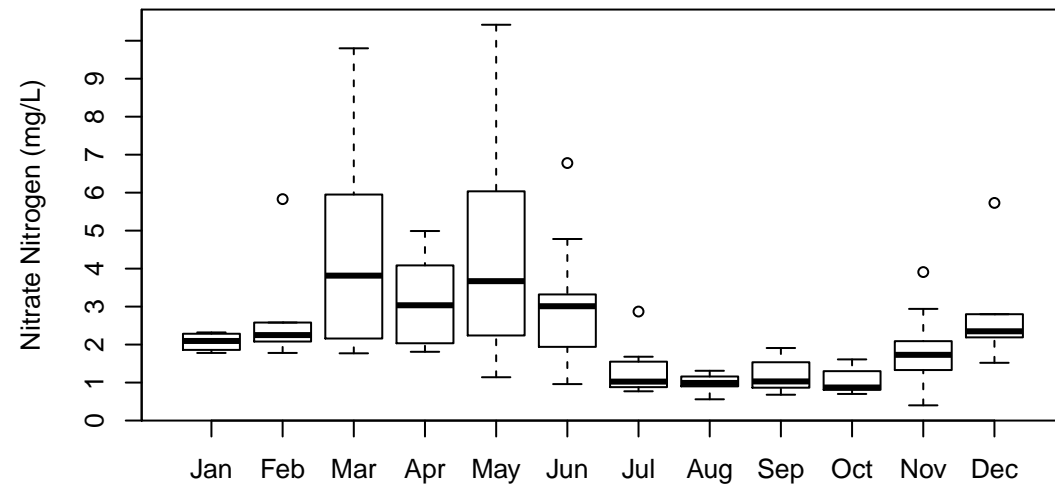
(a) Observation data



(b) Boxplot by year

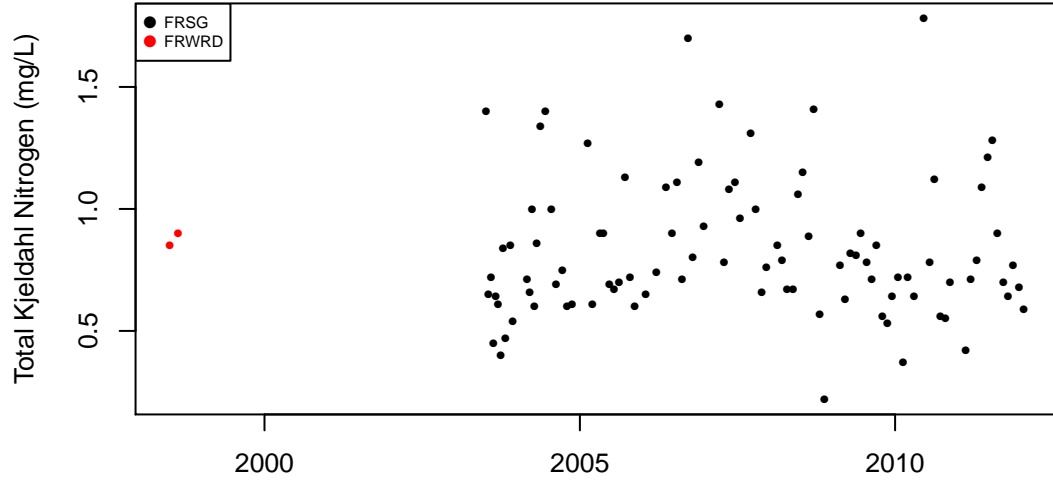


(c) Annual values

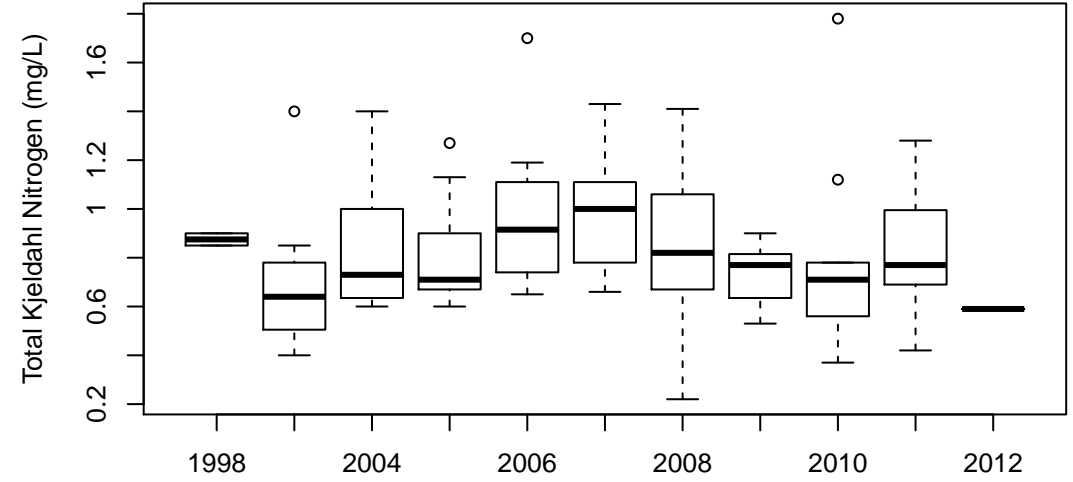


(d) Boxplot by month

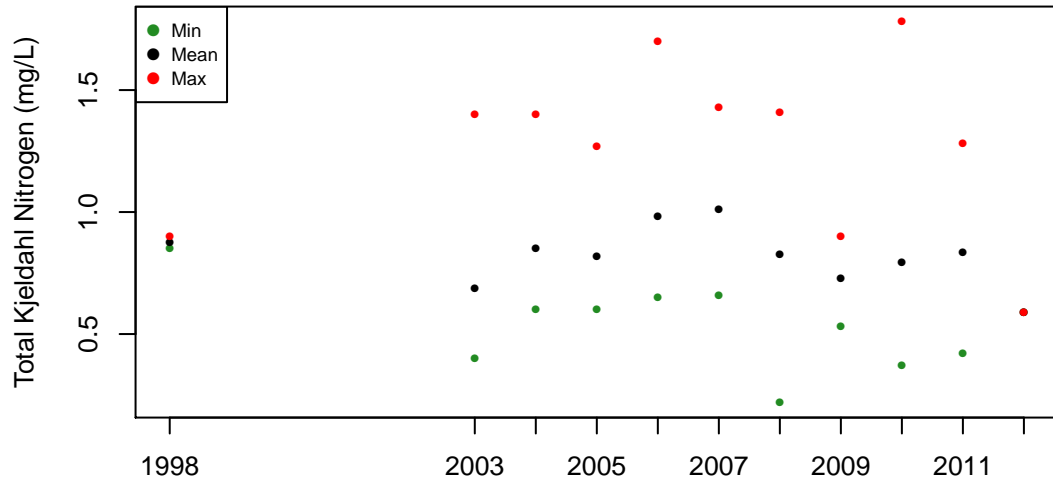
Tyler Cr at Rt. 31-Elgin (268): Total Kjeldahl Nitrogen (mg/L)



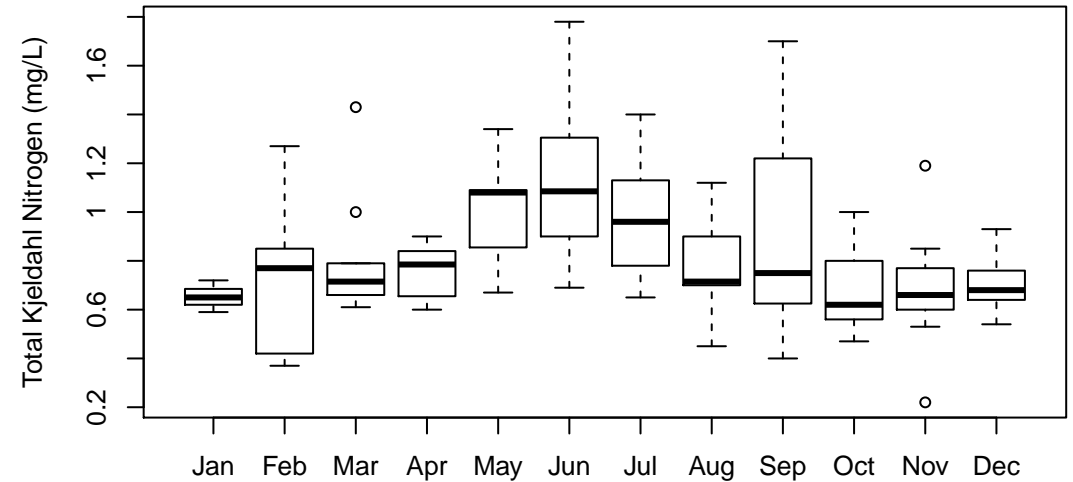
(a) Observation data



(b) Boxplot by year

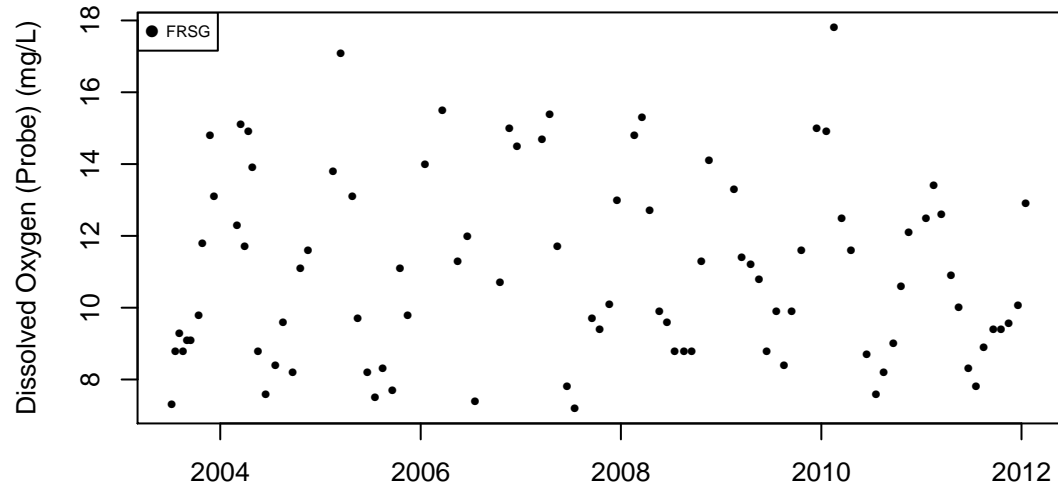


(c) Annual values

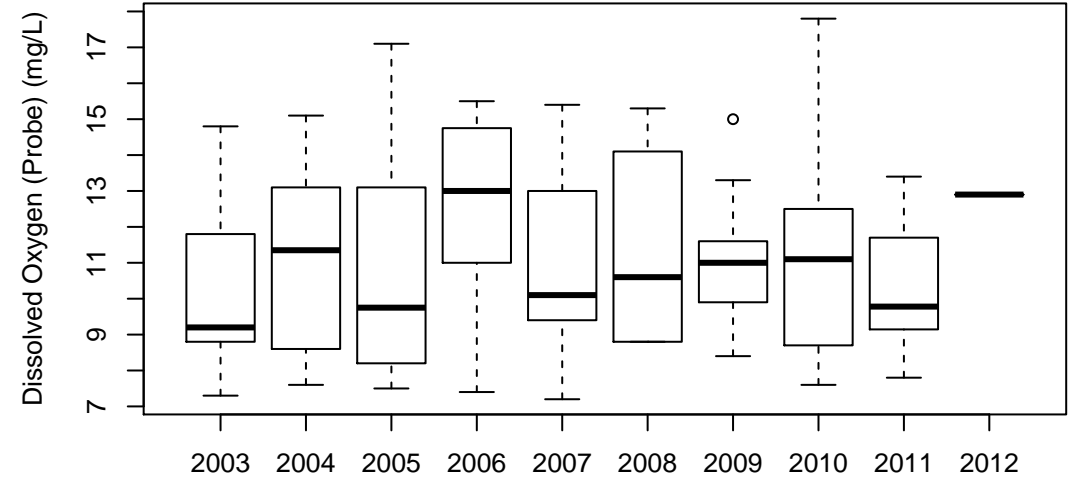


(d) Boxplot by month

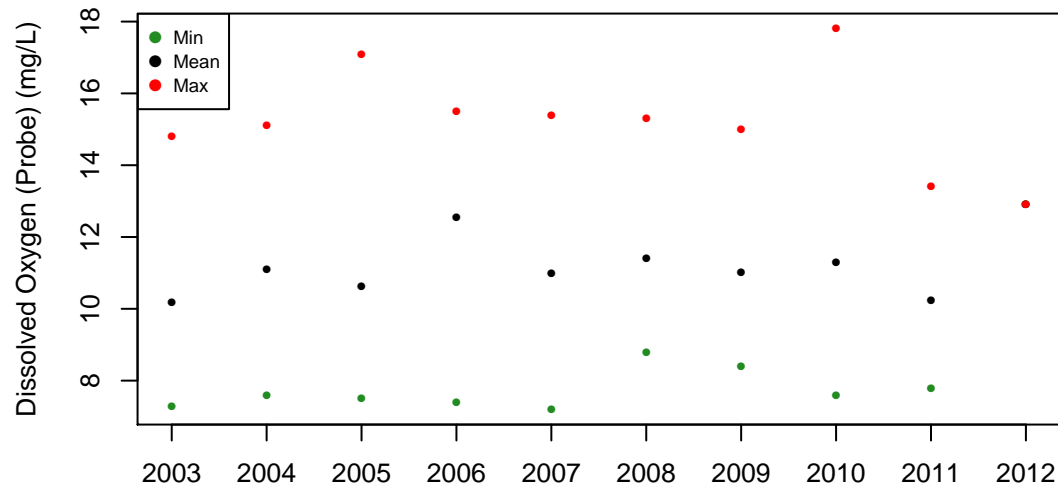
Tyler Cr at Rt. 31-Elgin (268): Dissolved Oxygen (Probe) (mg/L)



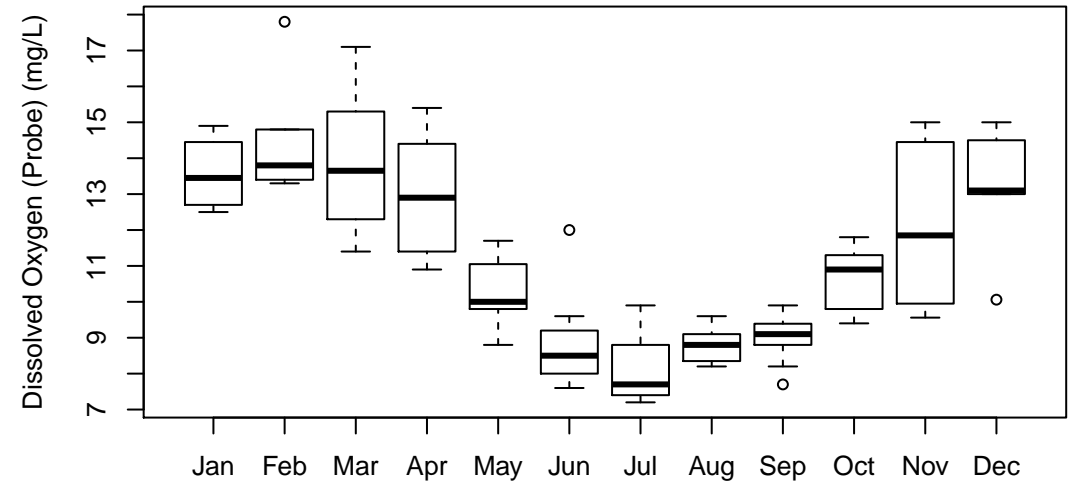
(a) Observation data



(b) Boxplot by year

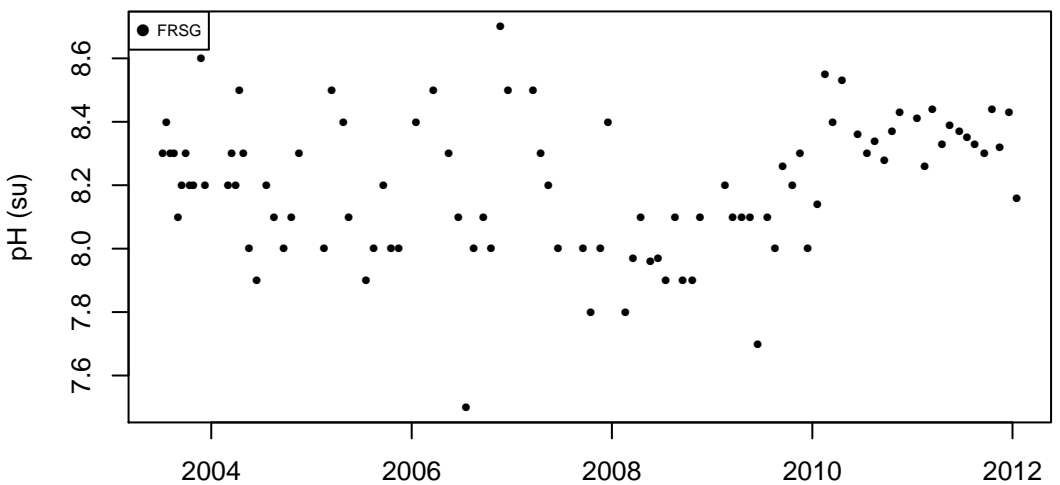


(c) Annual values

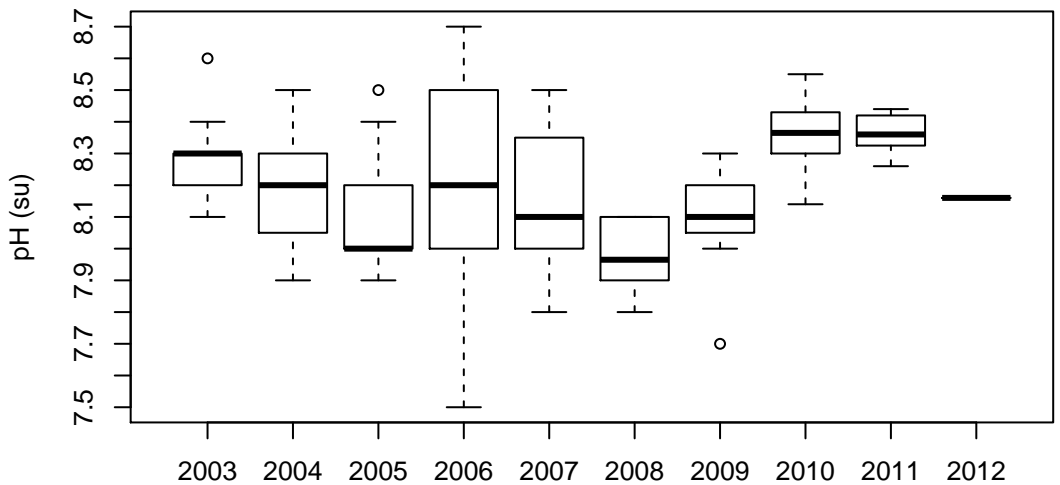


(d) Boxplot by month

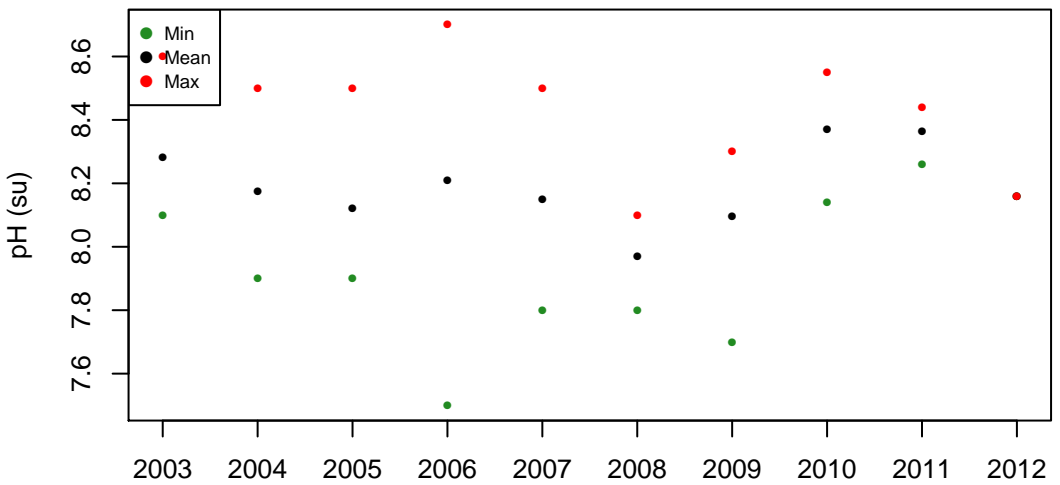
Tyler Cr at Rt. 31-Elgin (268): pH (su)



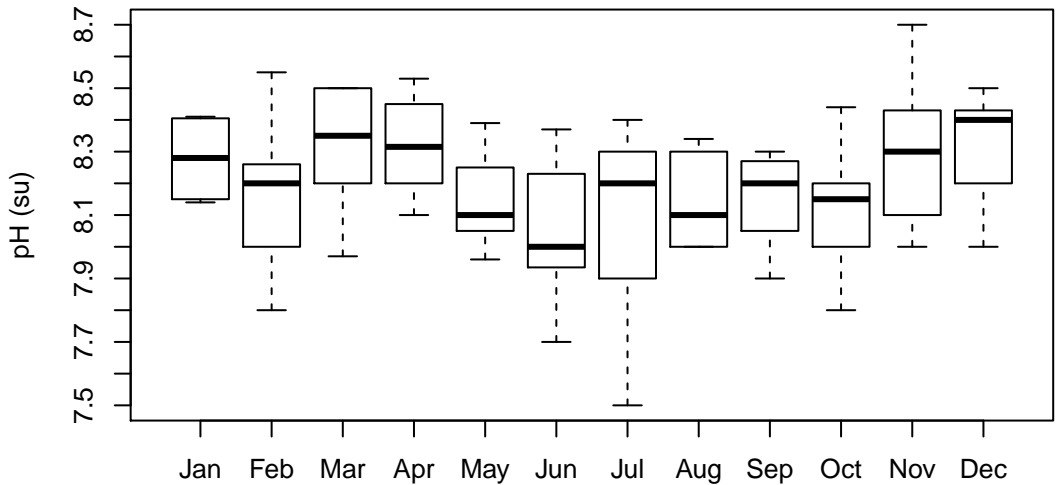
(a) Observation data



(b) Boxplot by year

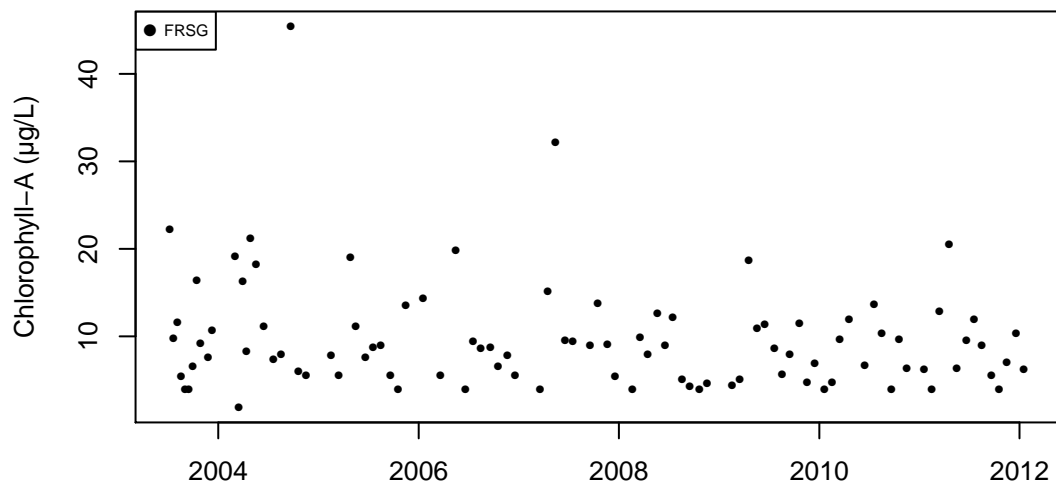


(c) Annual values

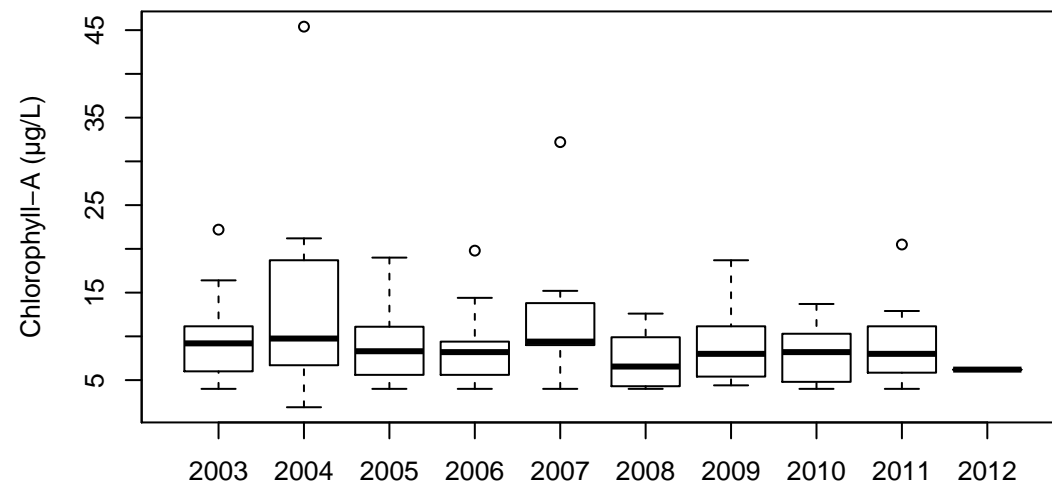


(d) Boxplot by month

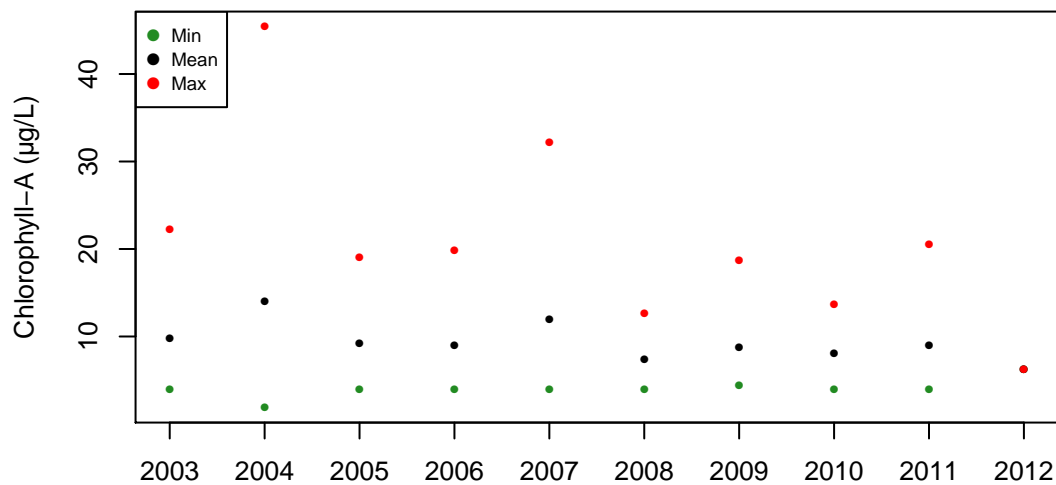
Tyler Cr at Rt. 31-Elgin (268): Chlorophyll-A ($\mu\text{g/L}$)



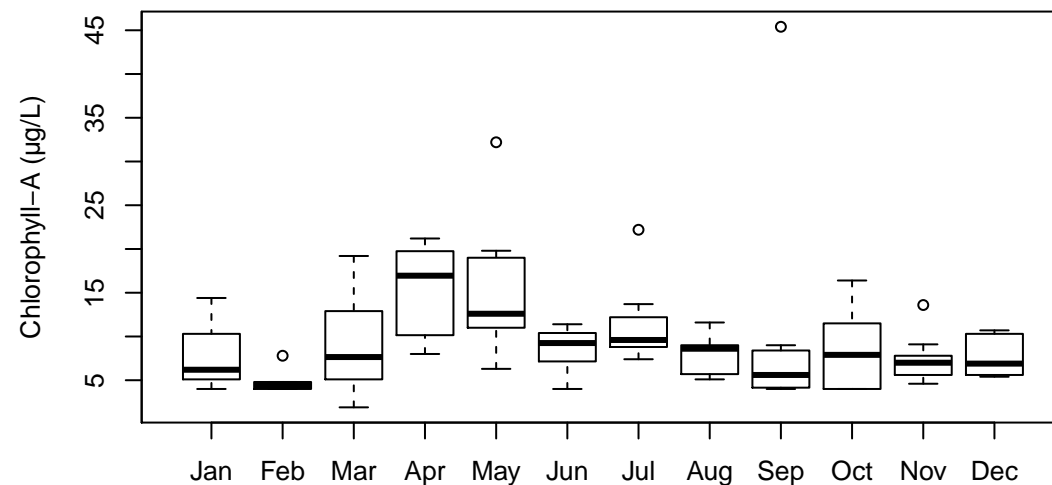
Sampling date
(a) Observation data



Year
(b) Boxplot by year

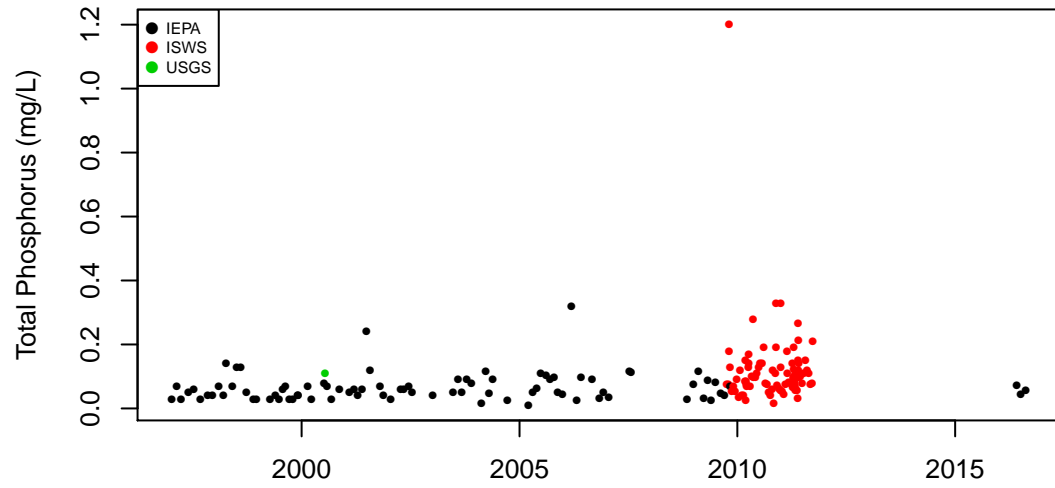


Year
(c) Annual values

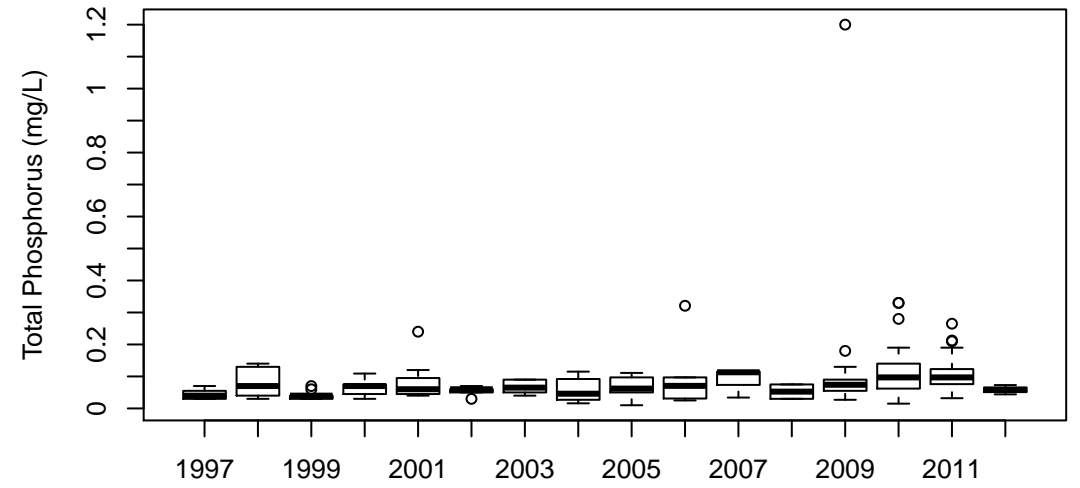


Month
(d) Boxplot by month

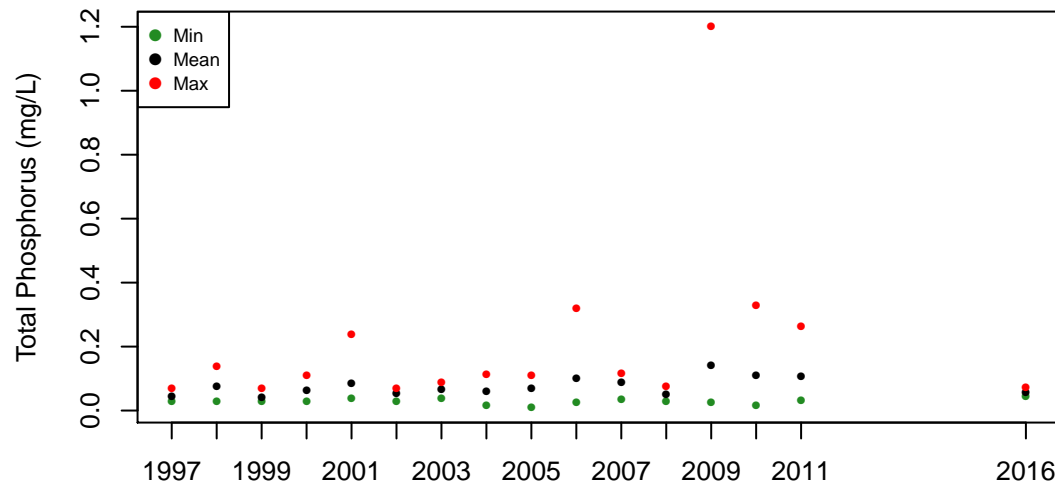
Poplar Cr near Mouth-Elgin (25): Total Phosphorus (mg/L)



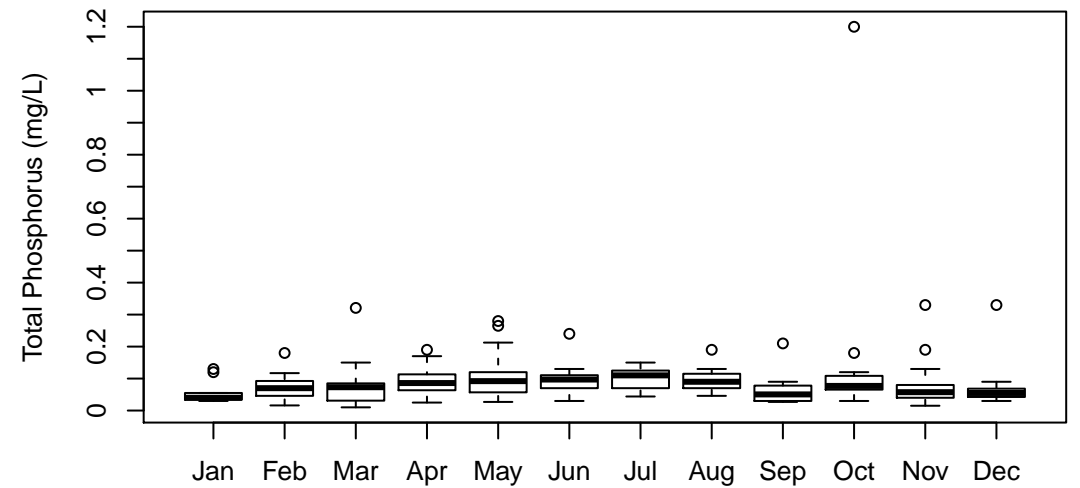
(a) Observation data



(b) Boxplot by year

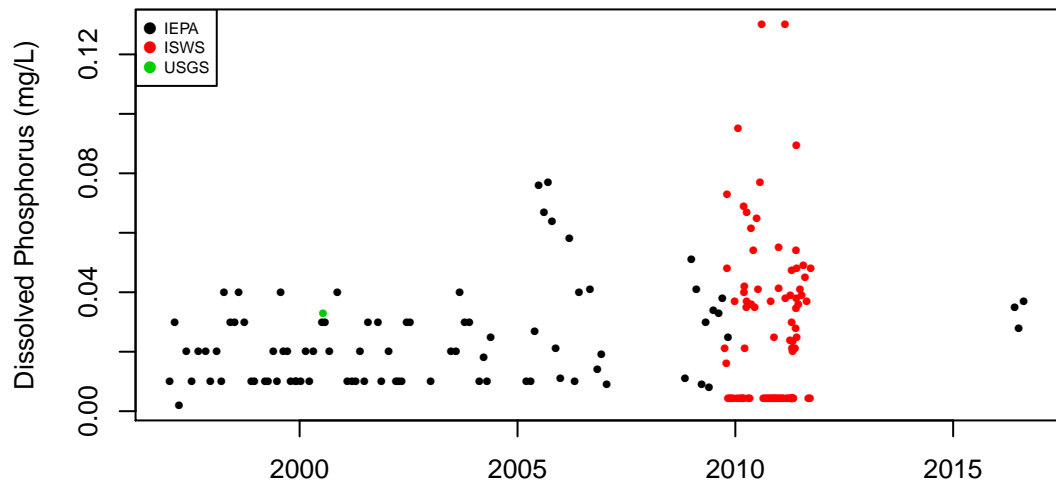


(c) Annual values

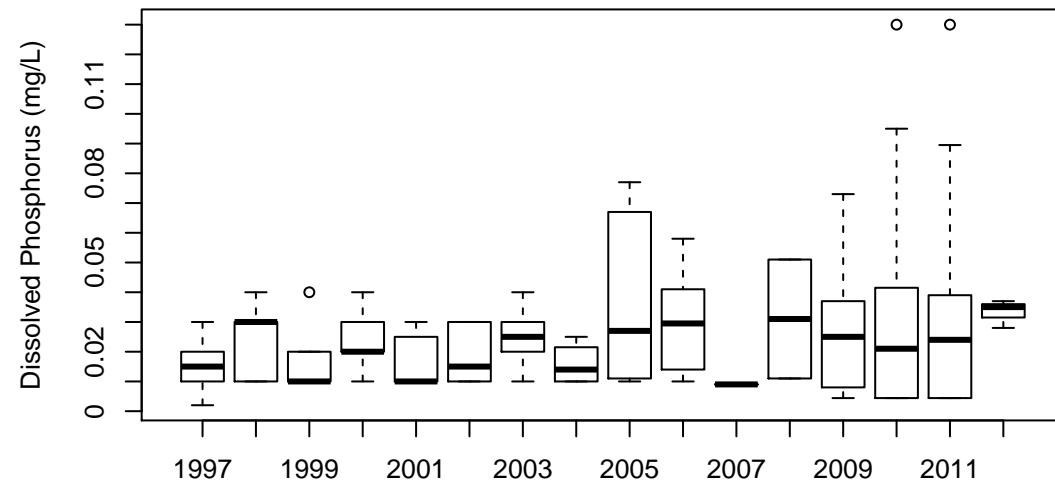


(d) Boxplot by month

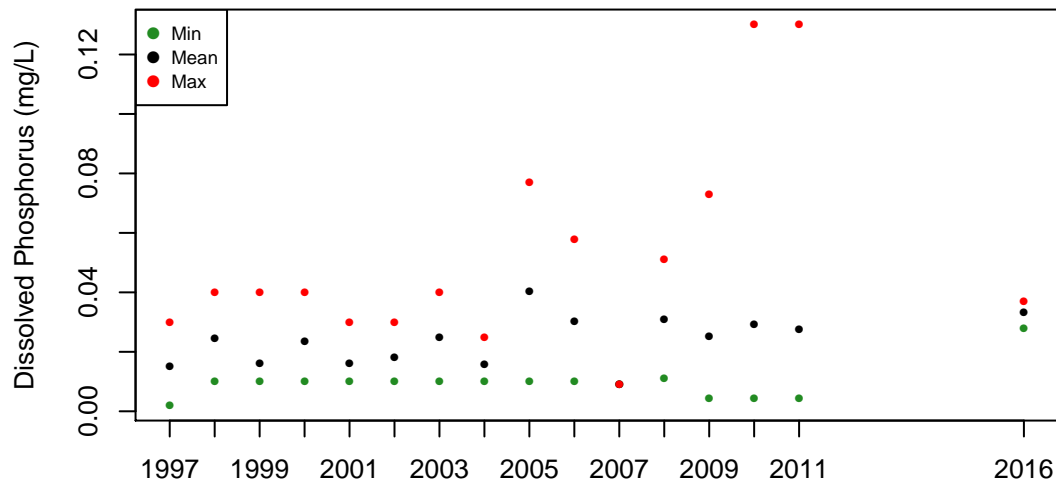
Poplar Cr near Mouth–Elgin (25): Dissolved Phosphorus (mg/L)



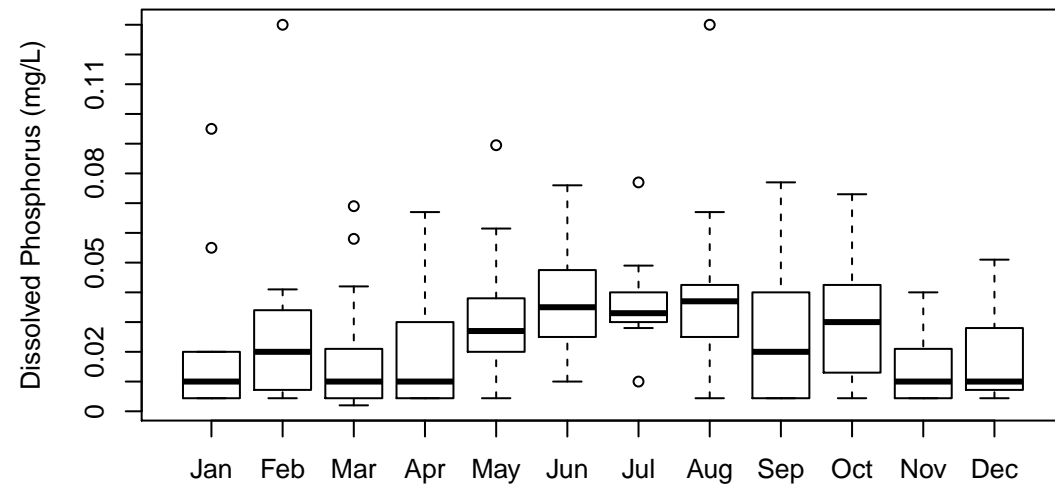
(a) Observation data



(b) Boxplot by year

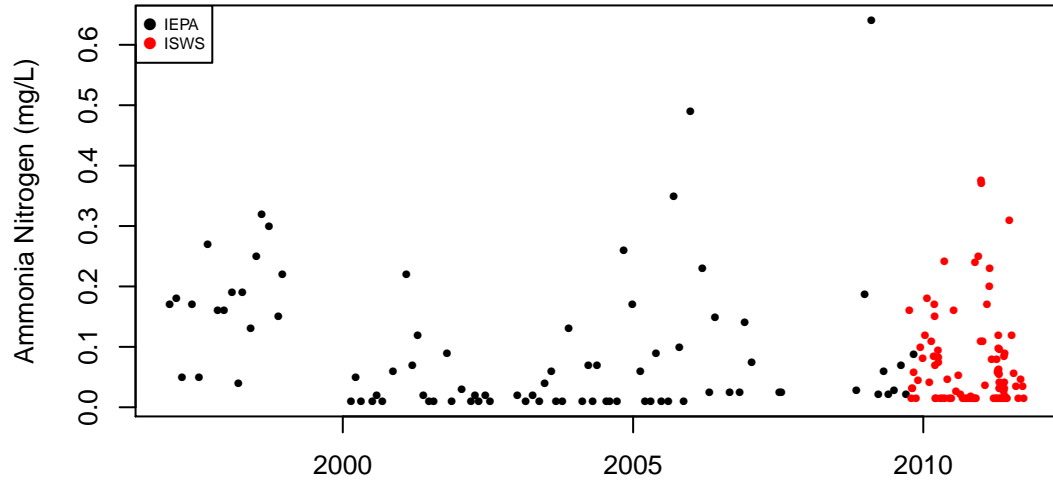


(c) Annual values

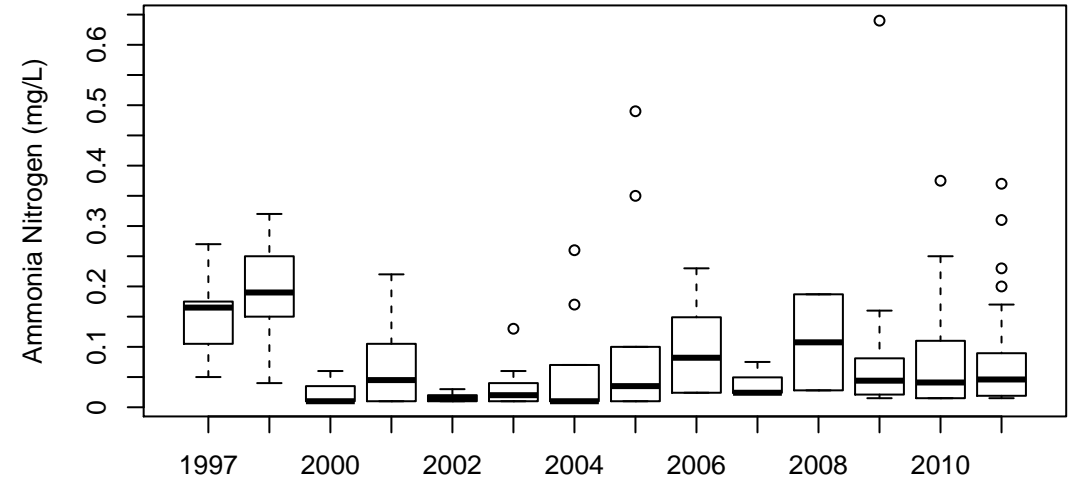


(d) Boxplot by month

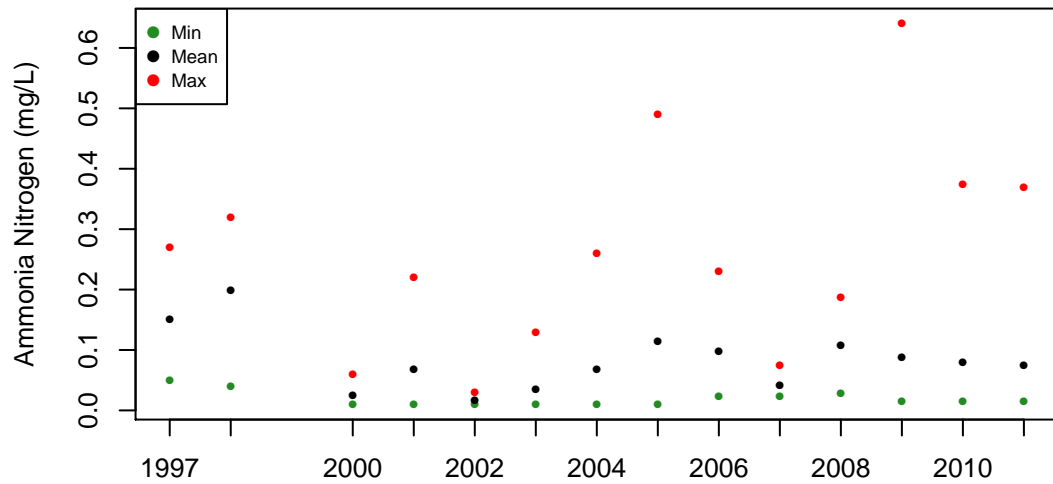
Poplar Cr near Mouth-Elgin (25): Ammonia Nitrogen (mg/L)



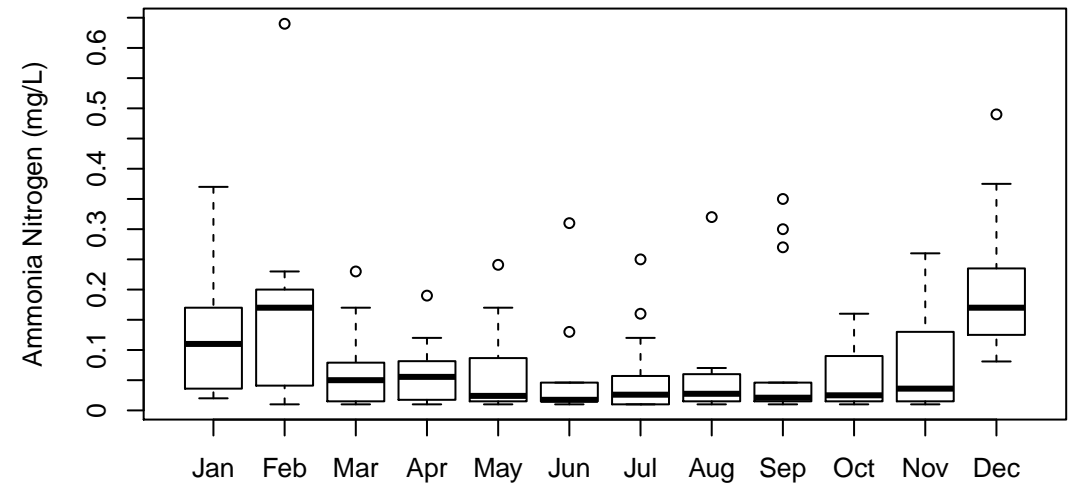
(a) Observation data



(b) Boxplot by year

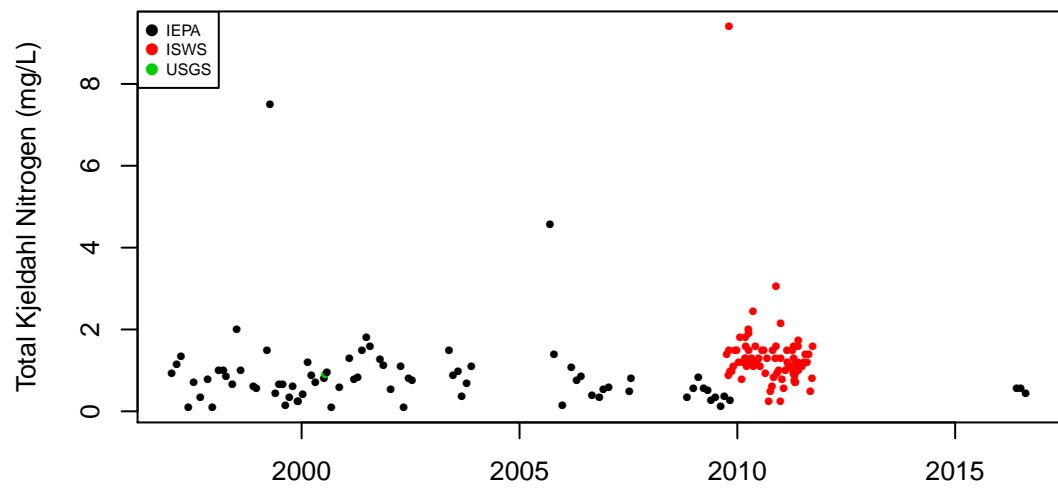


(c) Annual values

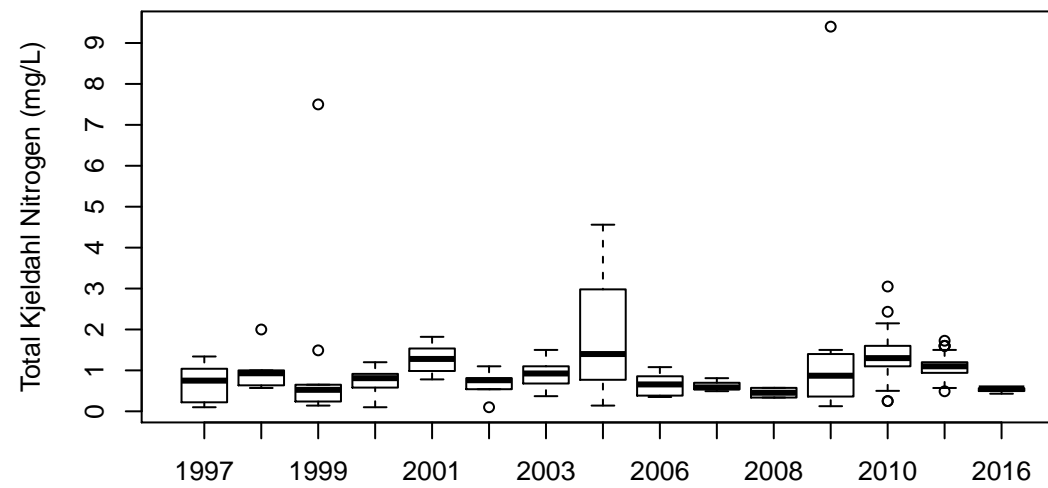


(d) Boxplot by month

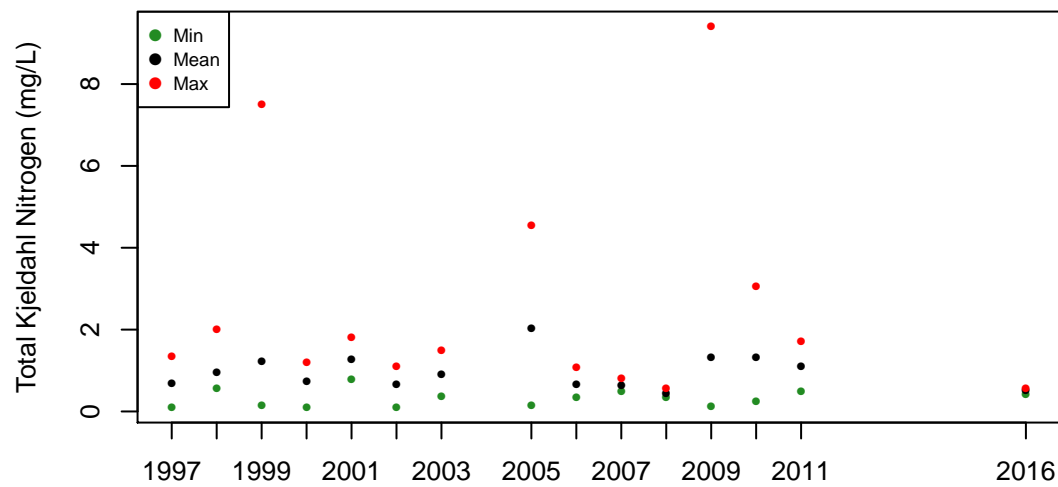
Poplar Cr near Mouth–Elgin (25): Total Kjeldahl Nitrogen (mg/L)



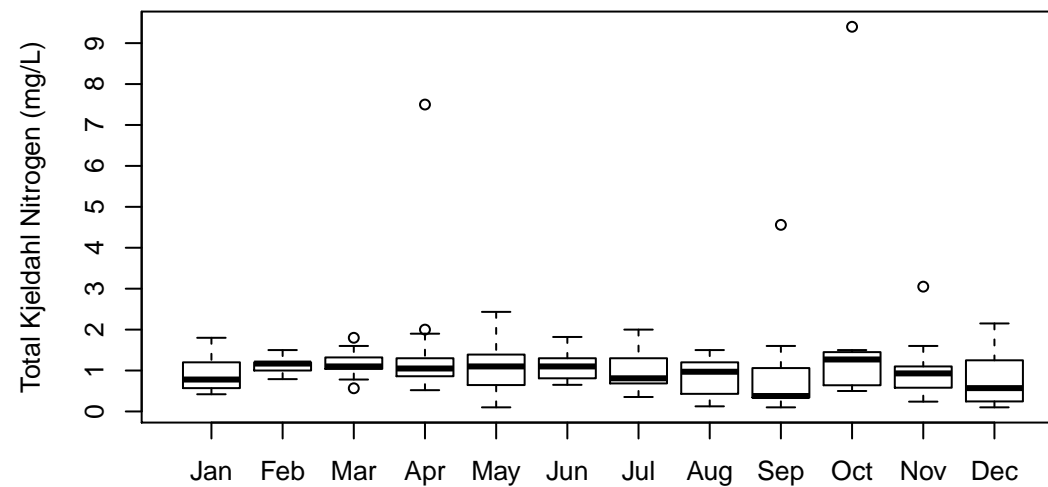
(a) Observation data



(b) Boxplot by year

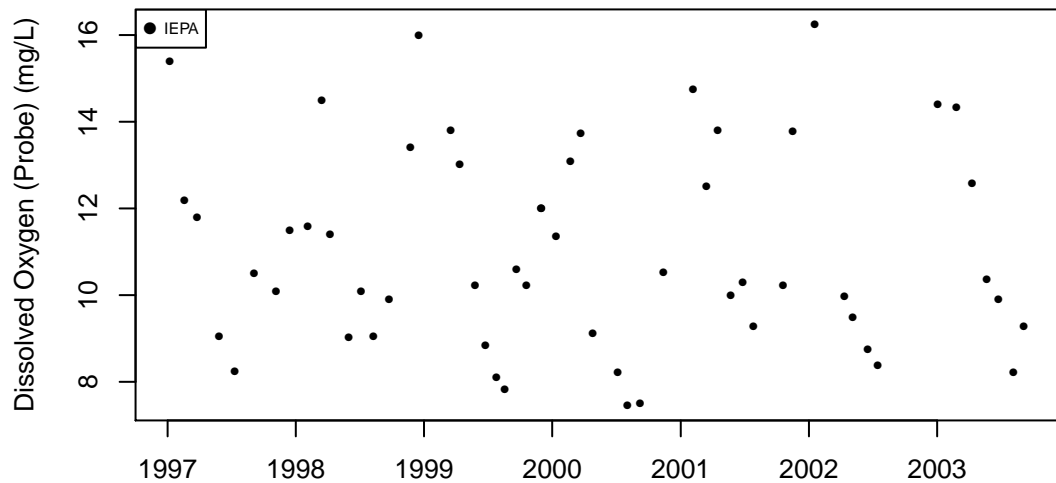


(c) Annual values

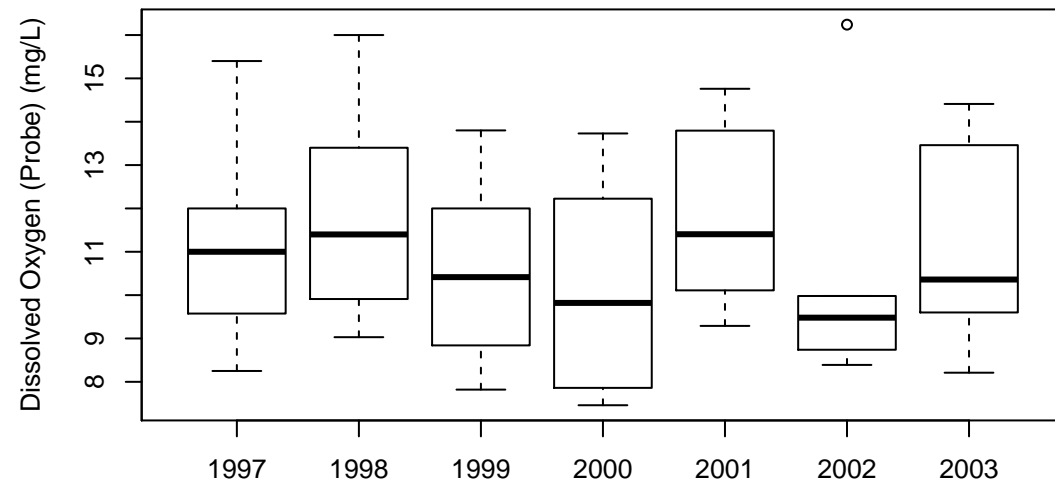


(d) Boxplot by month

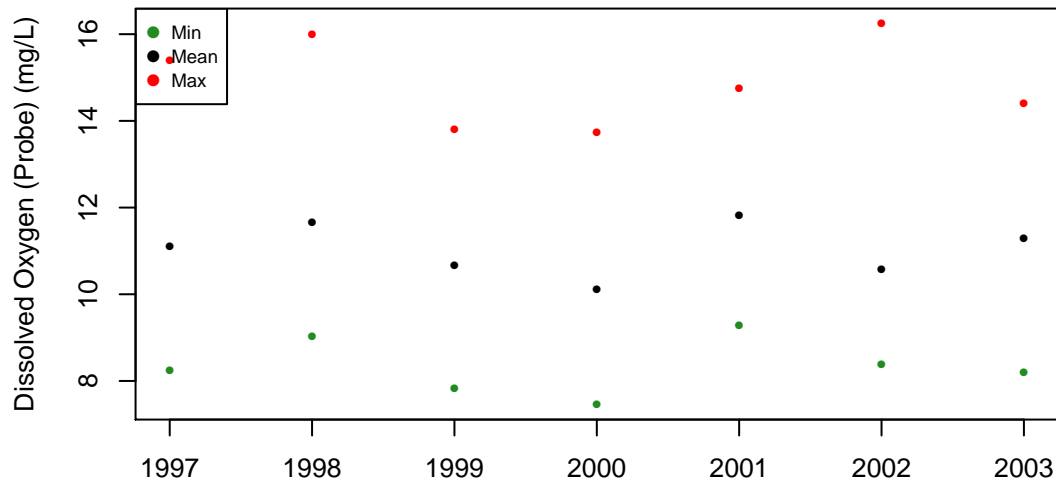
Poplar Cr near Mouth-Elgin (25): Dissolved Oxygen (Probe) (mg/L)



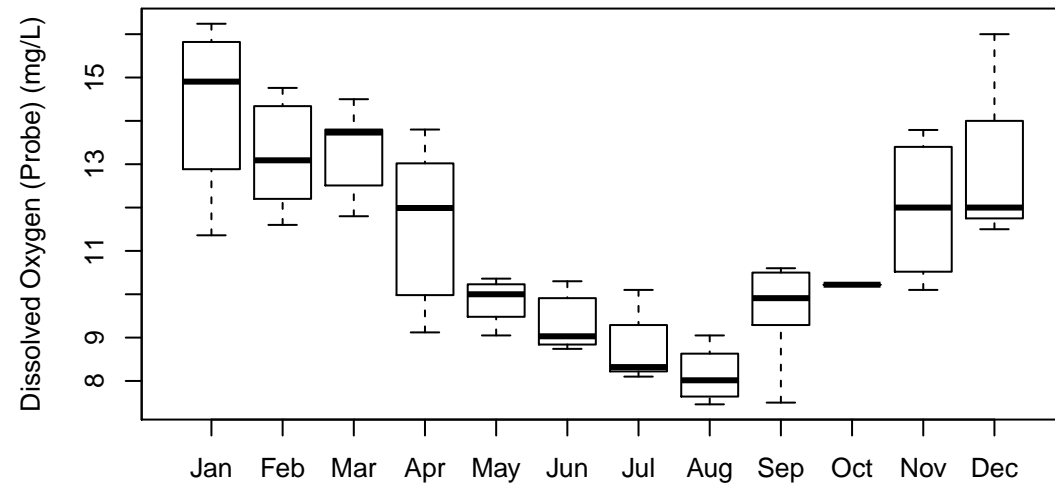
(a) Observation data



(b) Boxplot by year

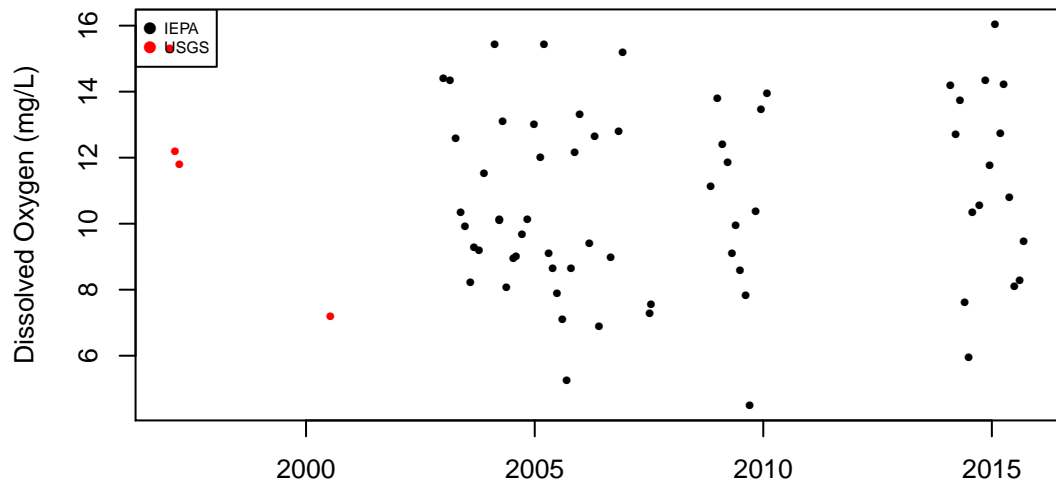


(c) Annual values

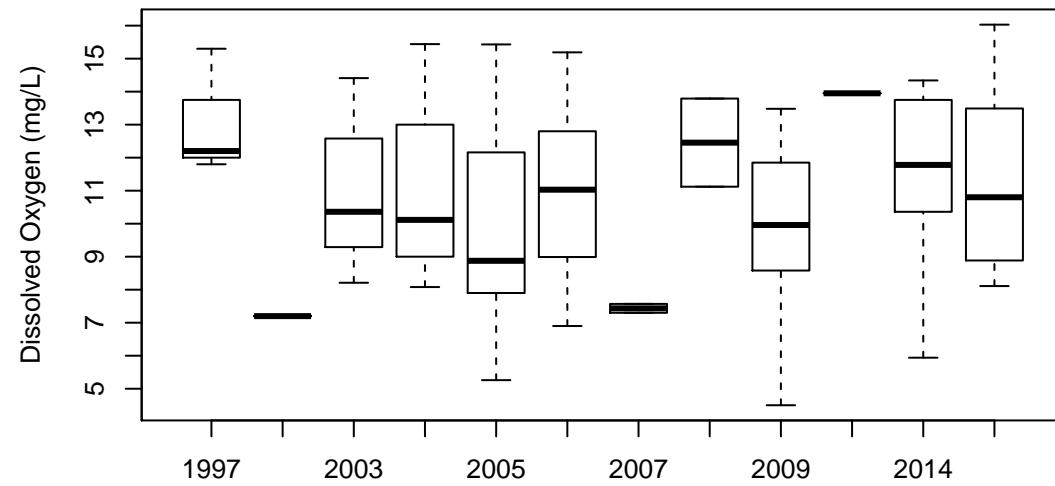


(d) Boxplot by month

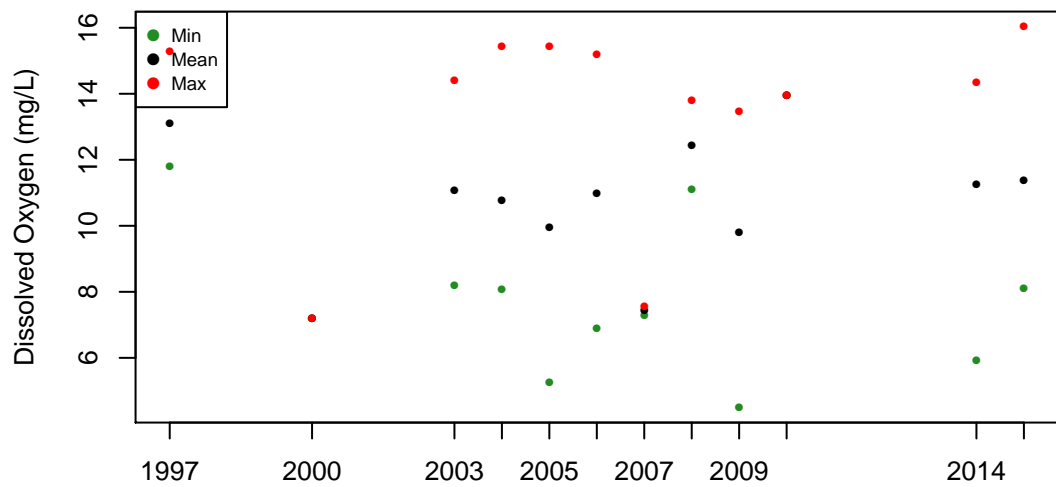
Poplar Cr near Mouth–Elgin (25): Dissolved Oxygen (mg/L)



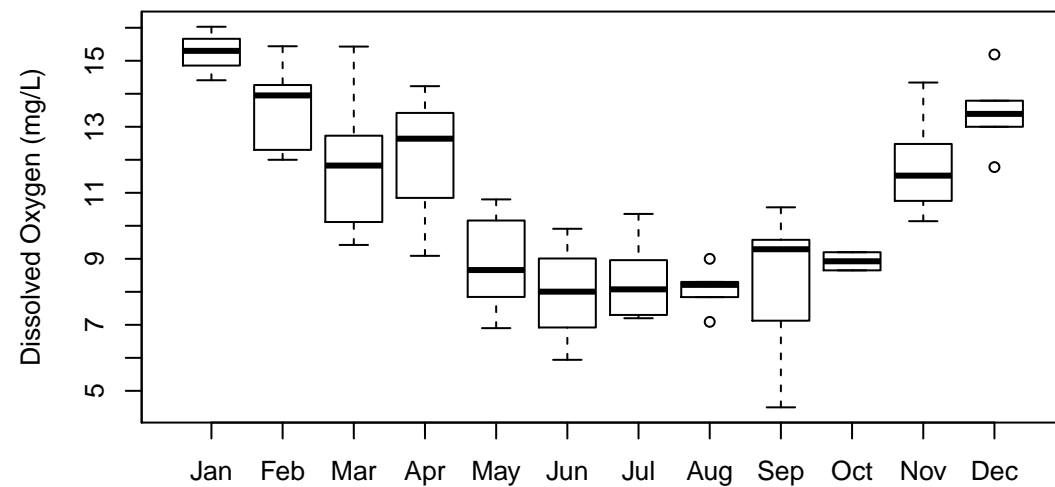
(a) Observation data



(b) Boxplot by year

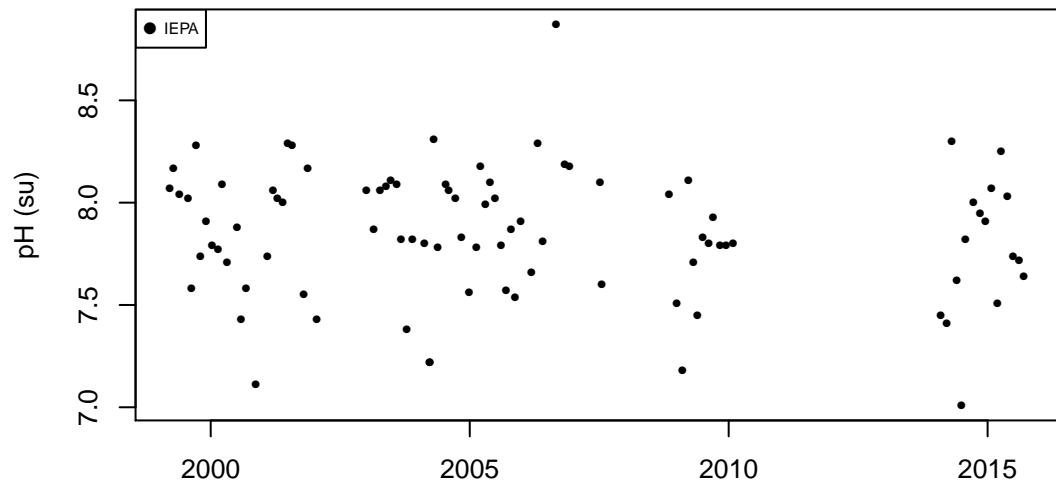


(c) Annual values

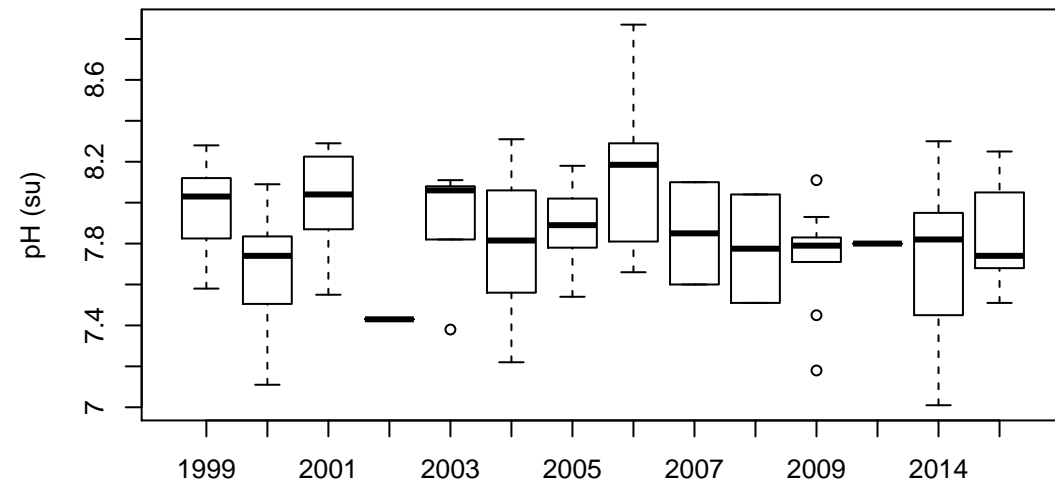


(d) Boxplot by month

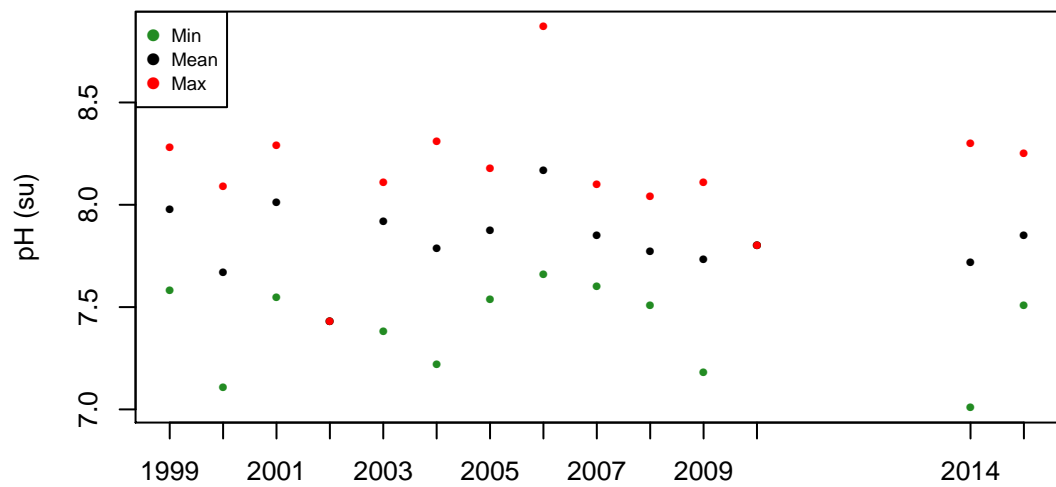
Poplar Cr near Mouth-Elgin (25): pH (su)



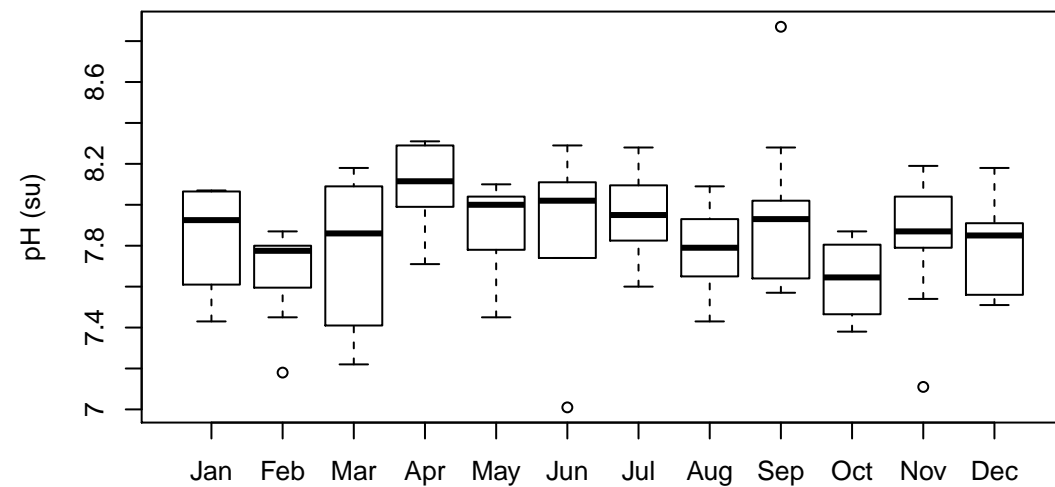
(a) Observation data



(b) Boxplot by year

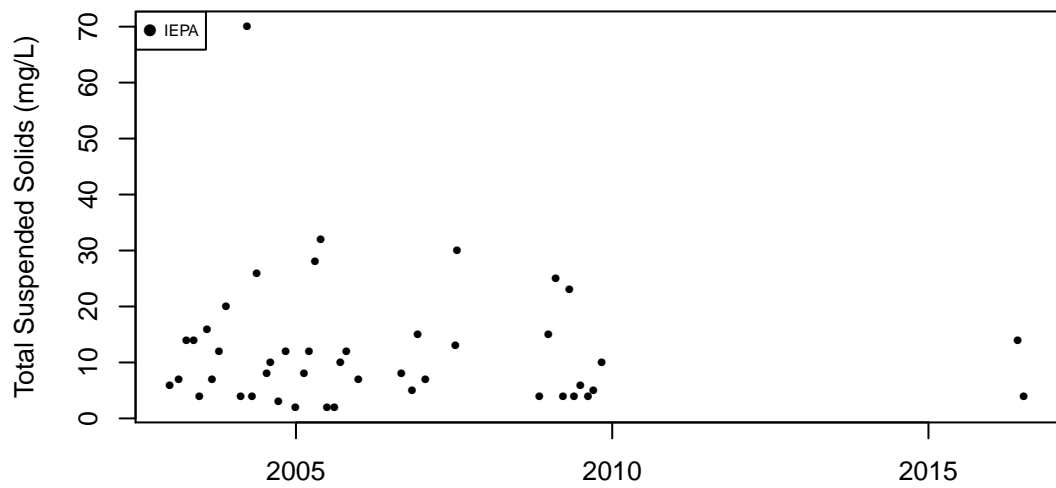


(c) Annual values

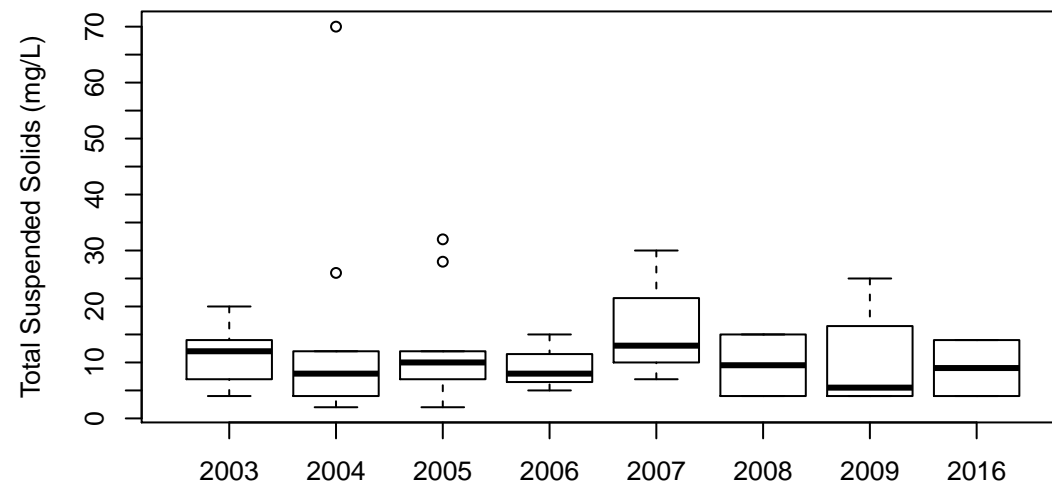


(d) Boxplot by month

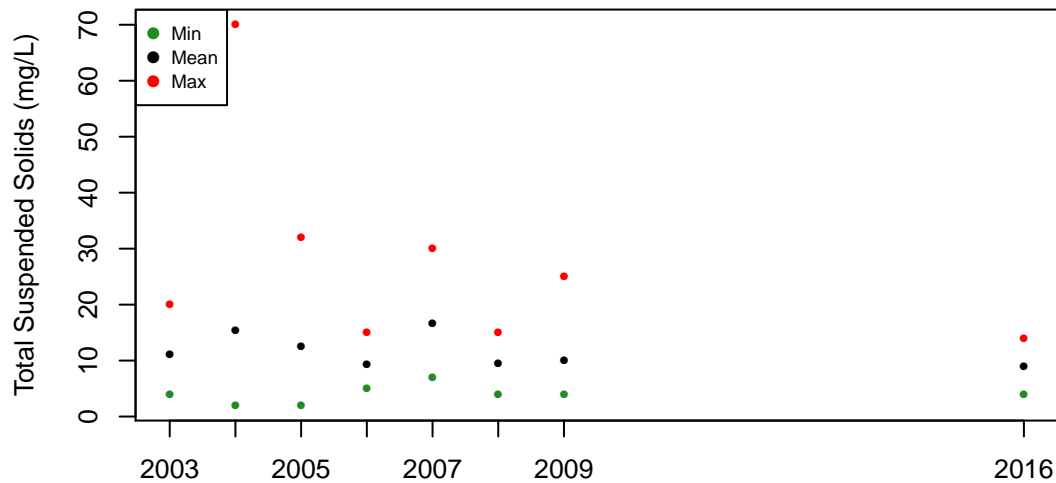
Poplar Cr near Mouth-Elgin (25): Total Suspended Solids (mg/L)



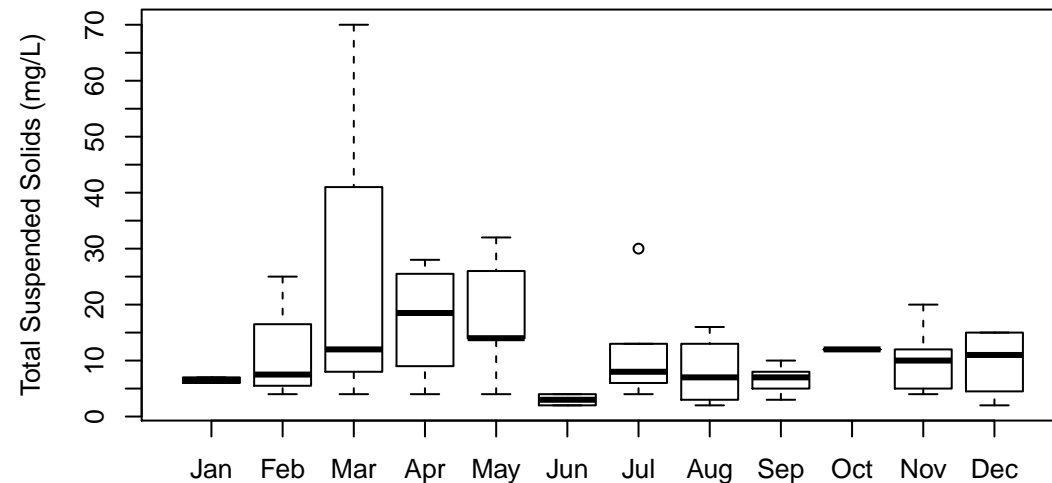
(a) Observation data



(b) Boxplot by year

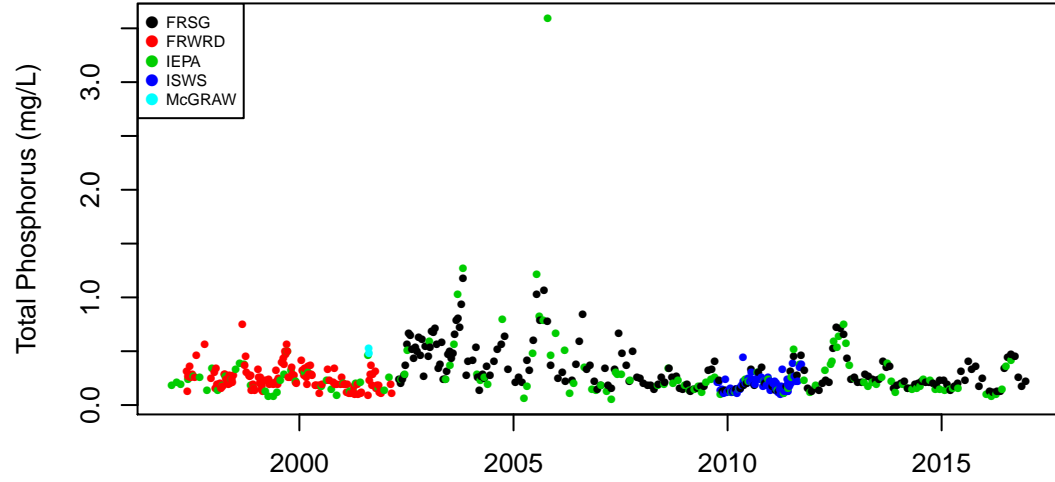


(c) Annual values

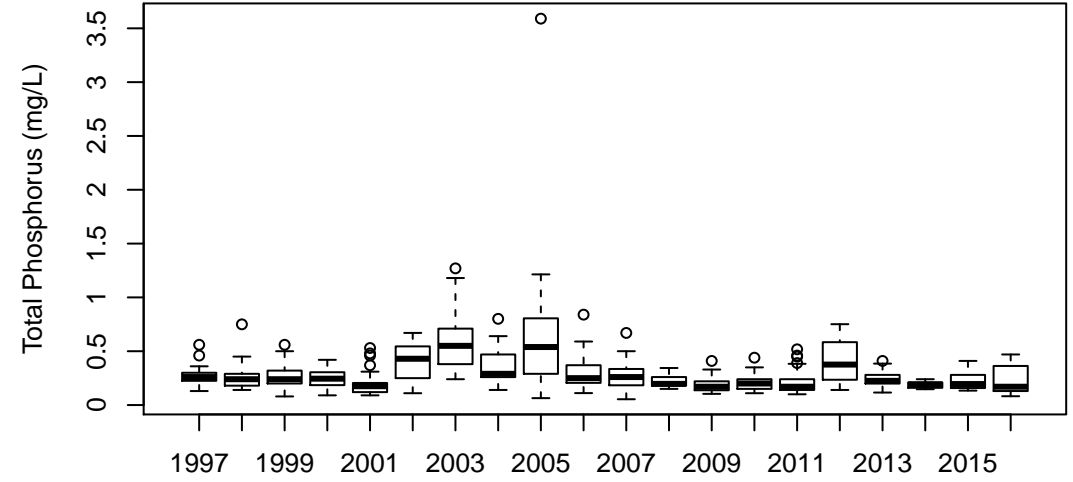


(d) Boxplot by month

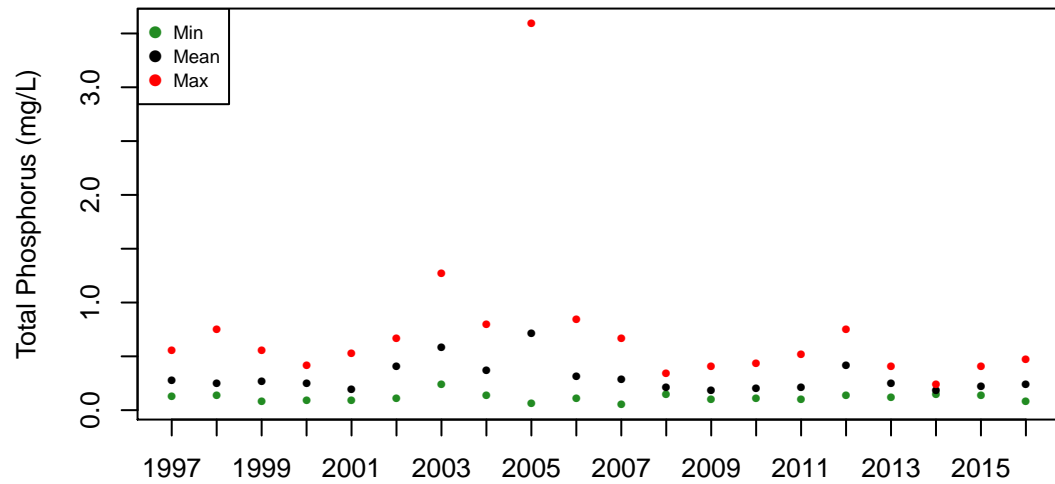
Fox River at South Elgin (26): Total Phosphorus (mg/L)



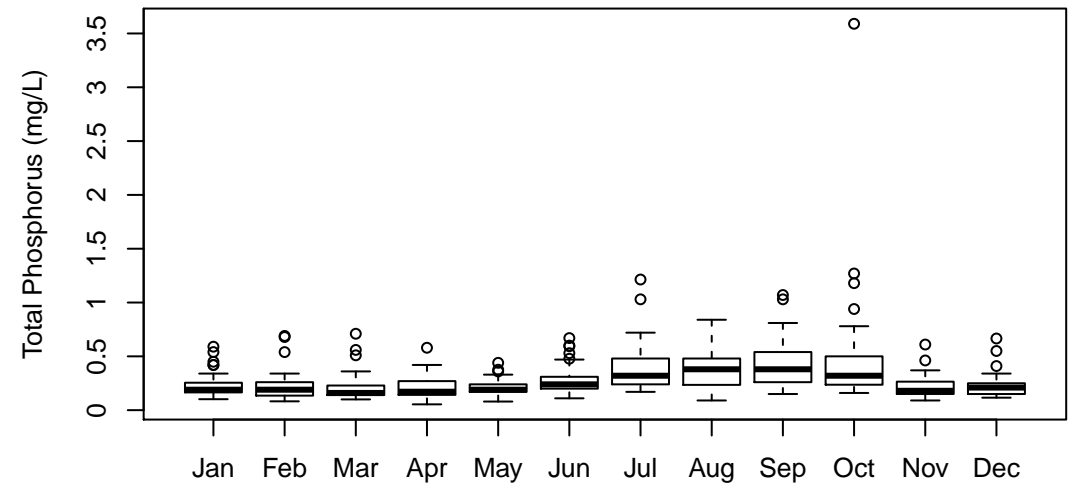
(a) Observation data



(b) Boxplot by year

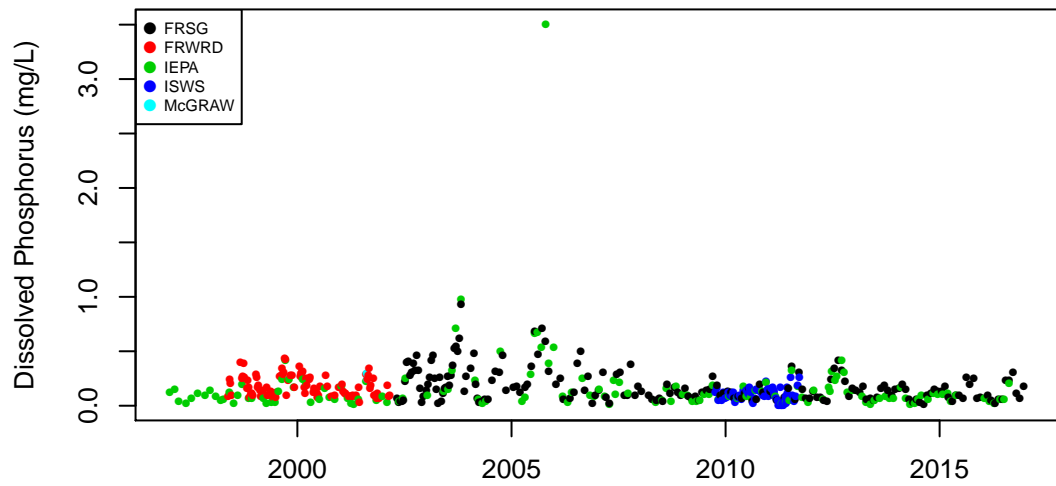


(c) Annual values

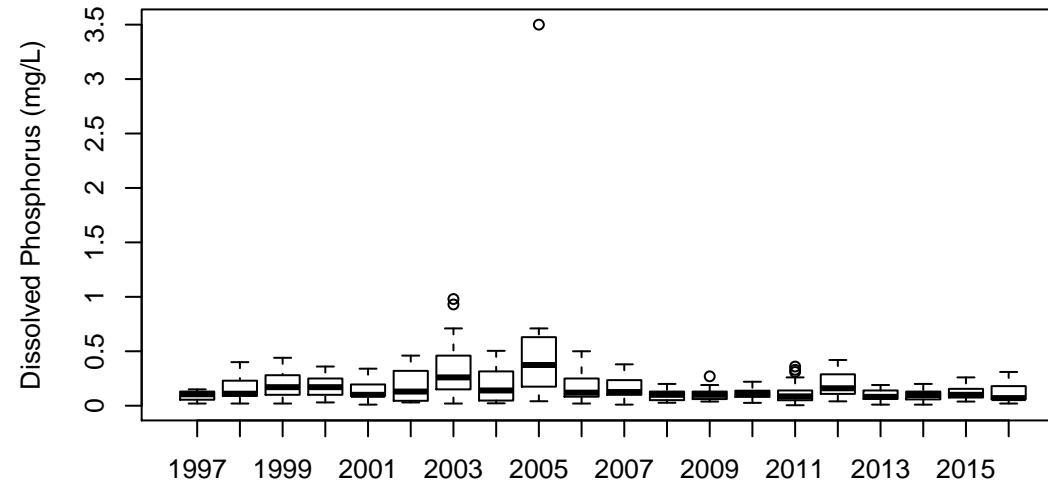


(d) Boxplot by month

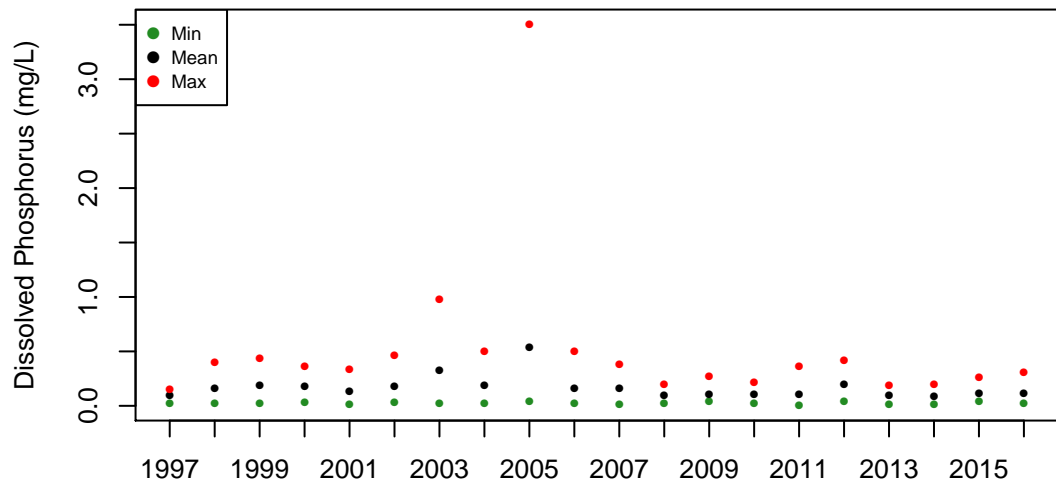
Fox River at South Elgin (26): Dissolved Phosphorus (mg/L)



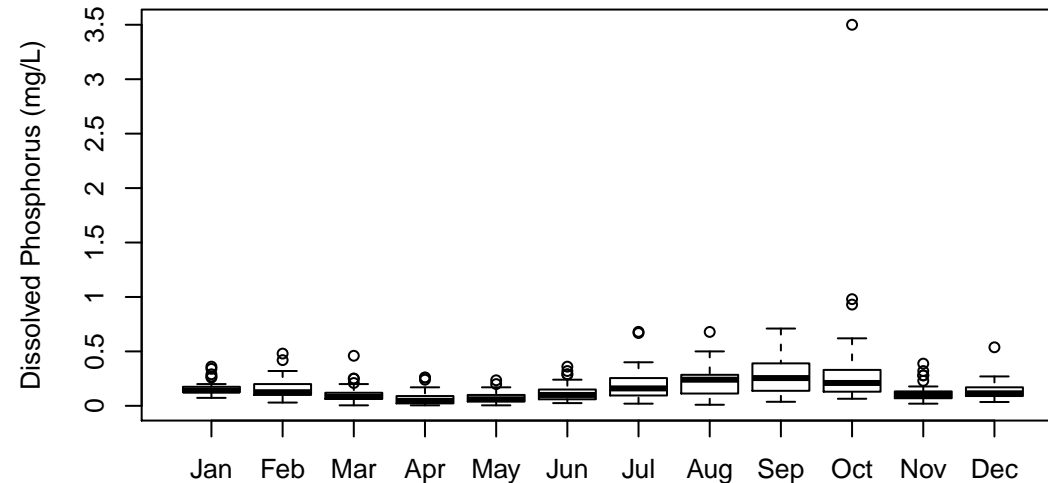
(a) Observation data



(b) Boxplot by year

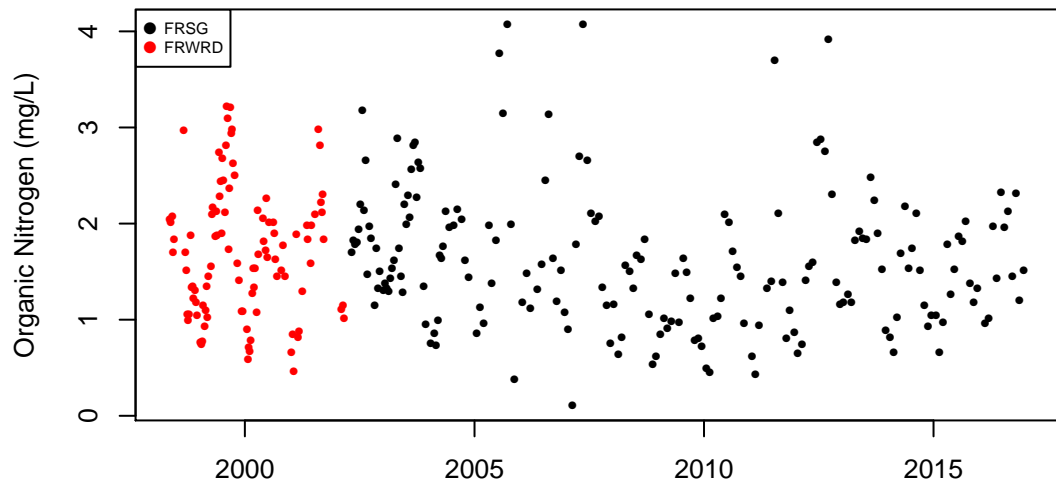


(c) Annual values

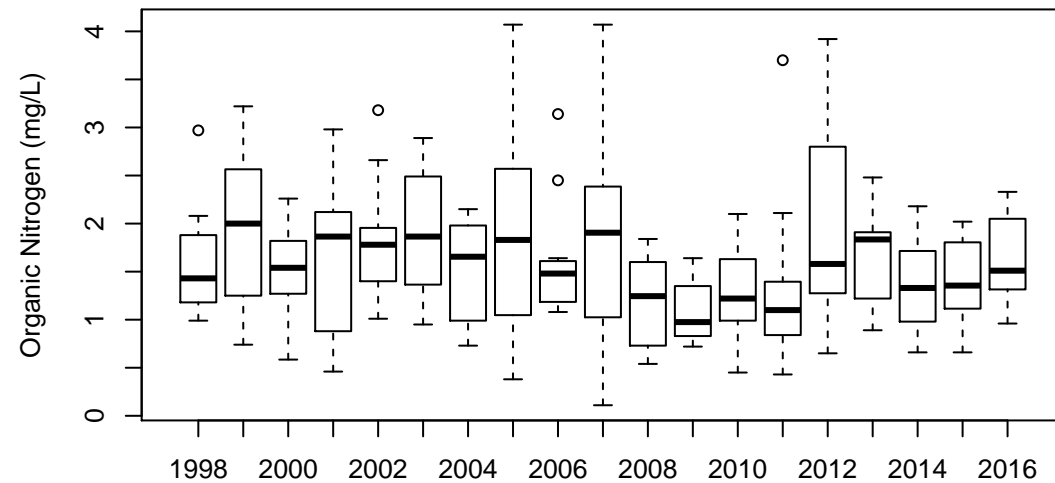


(d) Boxplot by month

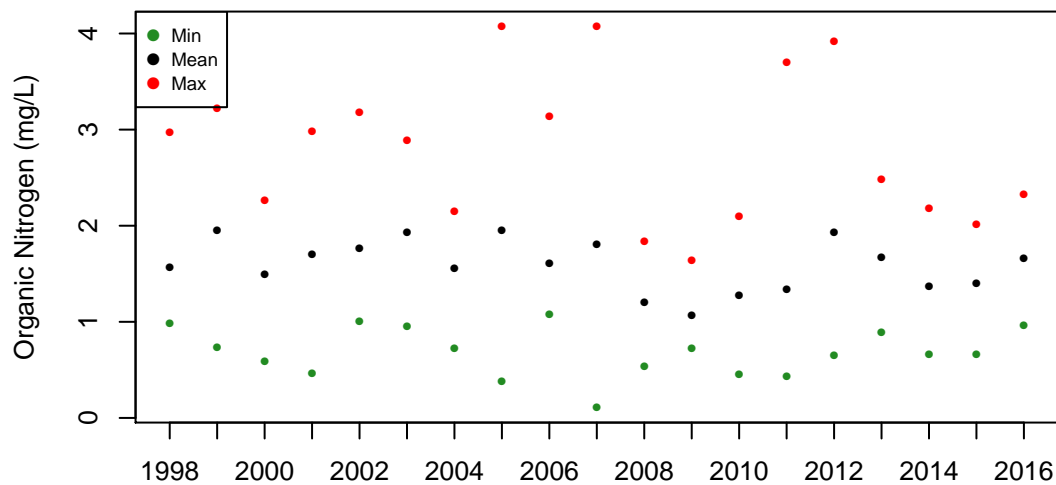
Fox River at South Elgin (26): Organic Nitrogen (mg/L)



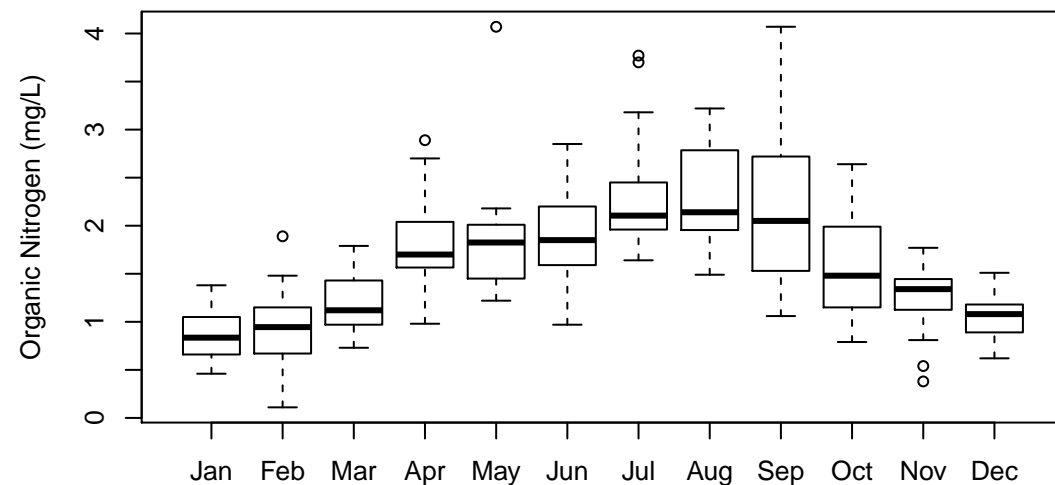
(a) Observation data



(b) Boxplot by year

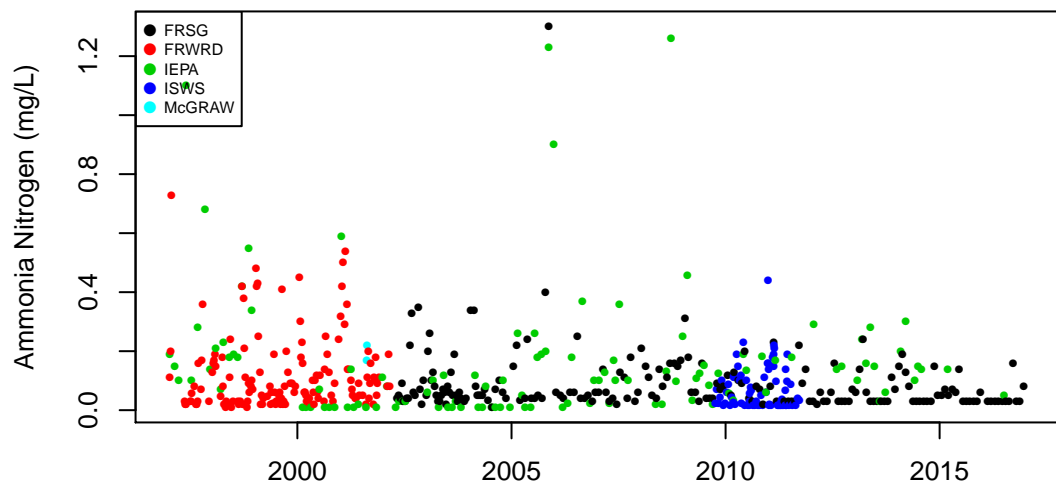


(c) Annual values

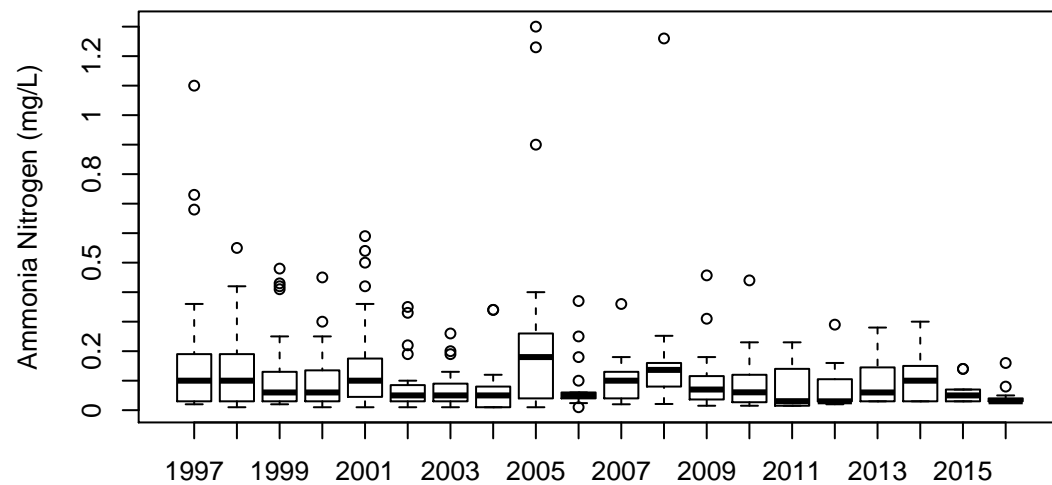


(d) Boxplot by month

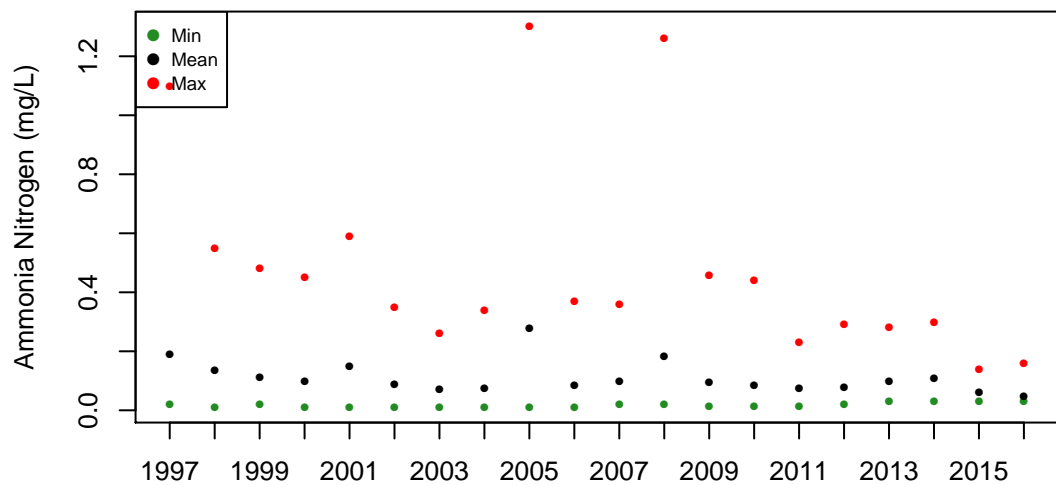
Fox River at South Elgin (26): Ammonia Nitrogen (mg/L)



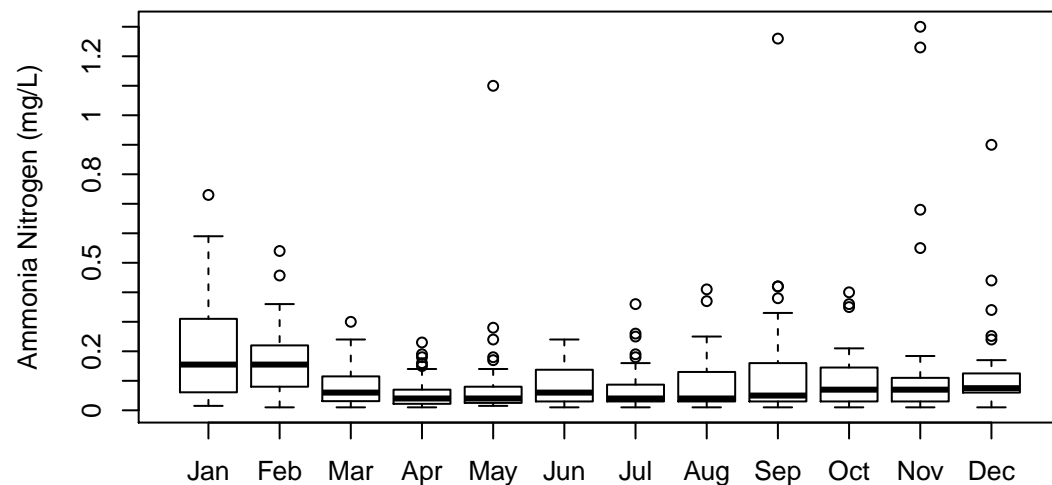
(a) Observation data



(b) Boxplot by year

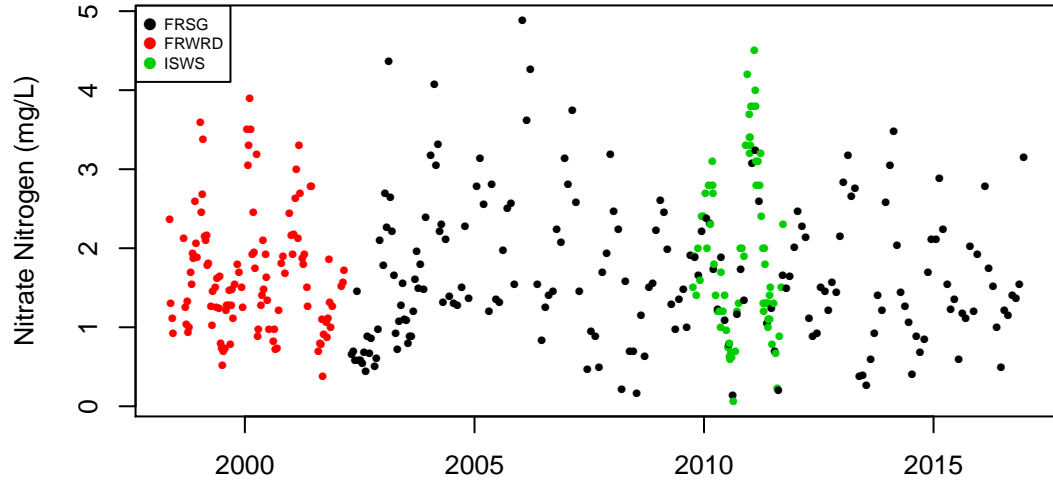


(c) Annual values

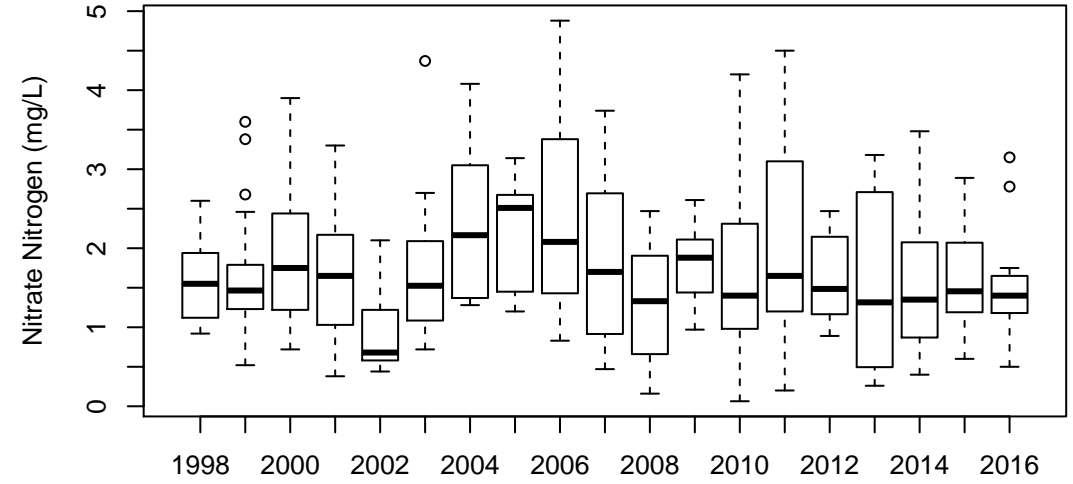


(d) Boxplot by month

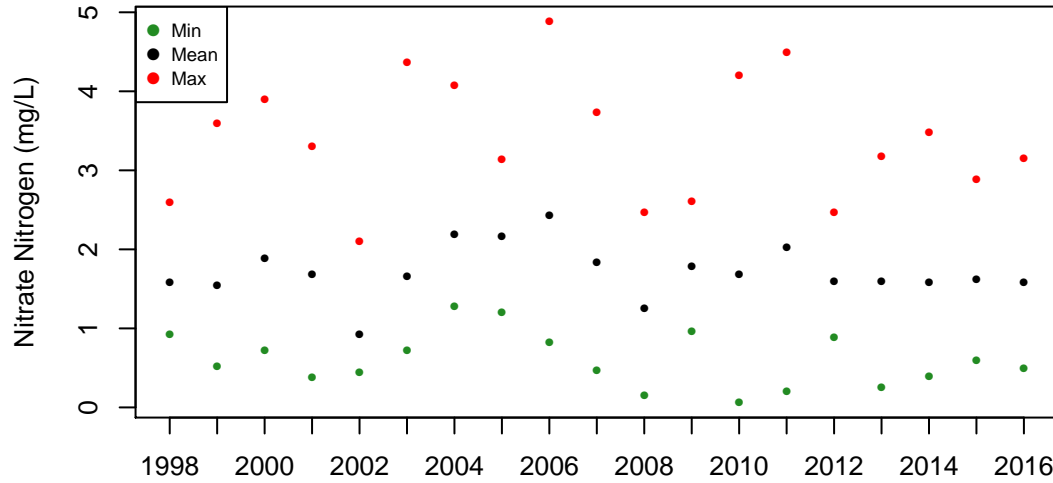
Fox River at South Elgin (26): Nitrate Nitrogen (mg/L)



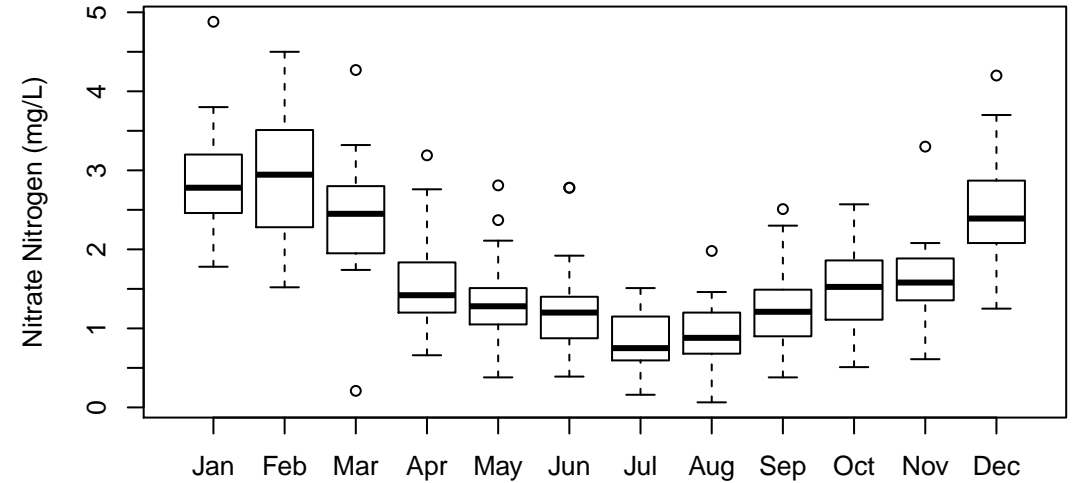
(a) Observation data



(b) Boxplot by year

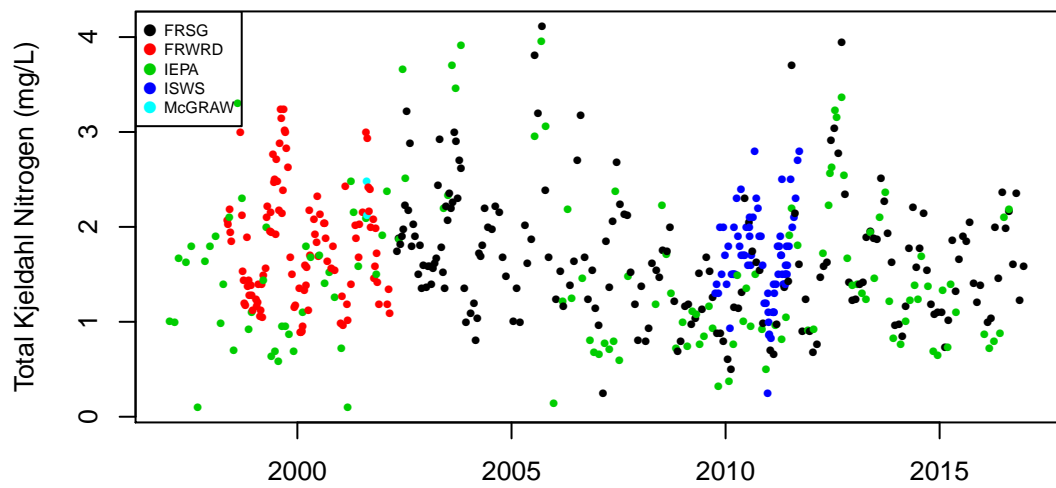


(c) Annual values

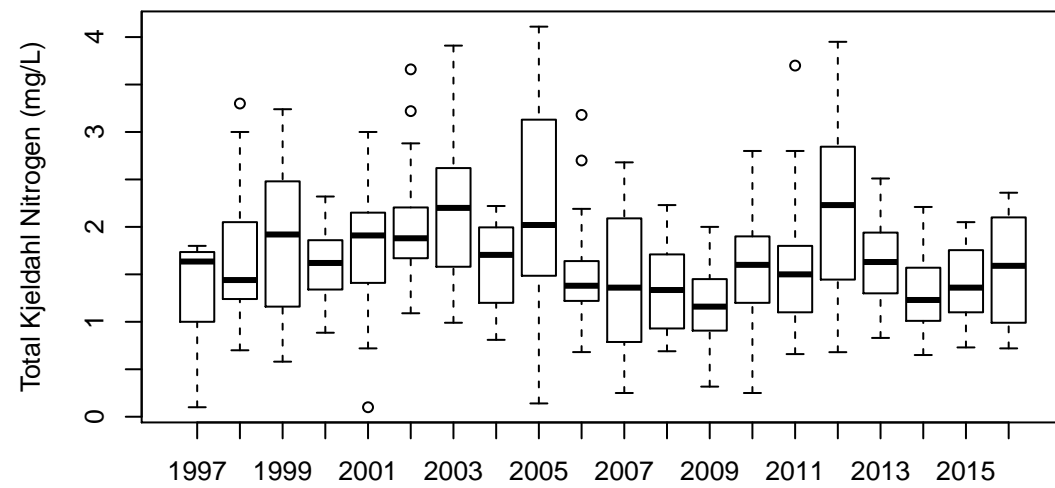


(d) Boxplot by month

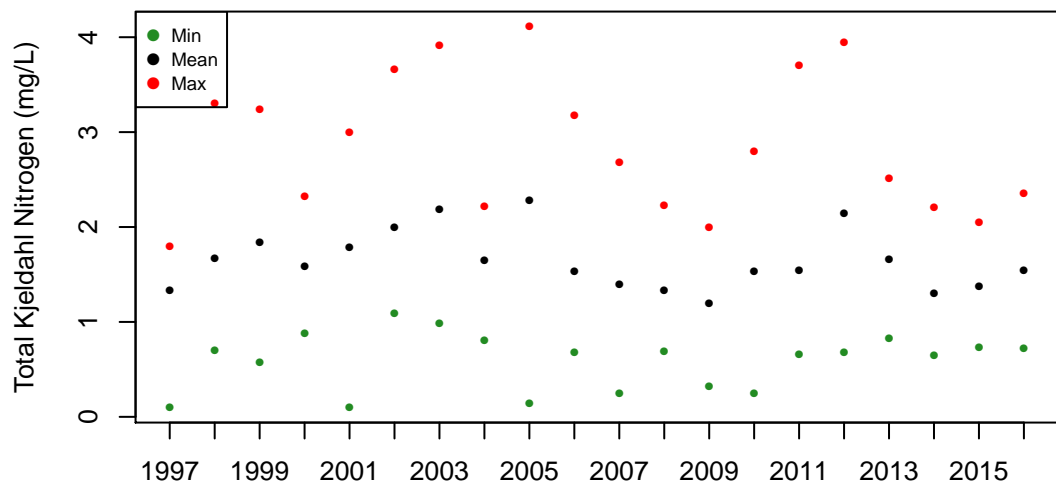
Fox River at South Elgin (26): Total Kjeldahl Nitrogen (mg/L)



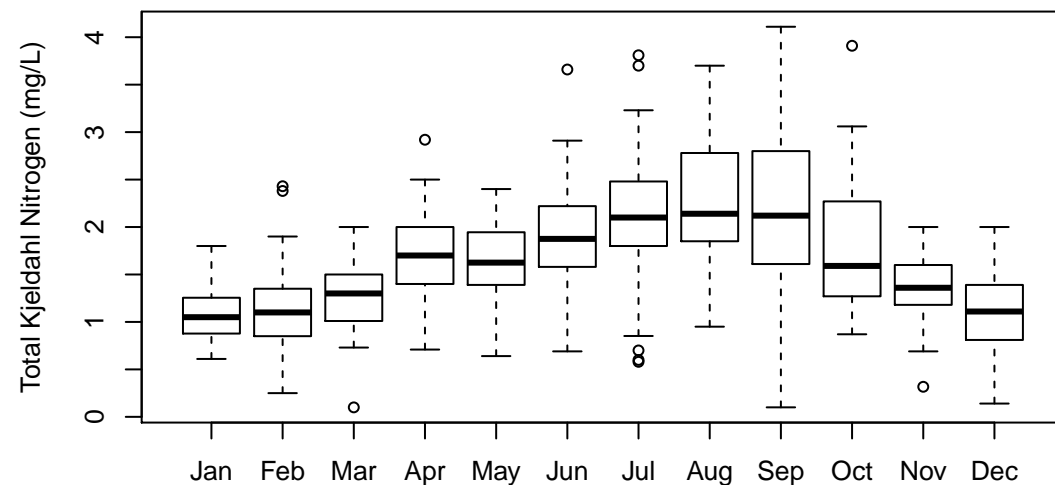
(a) Observation data



(b) Boxplot by year

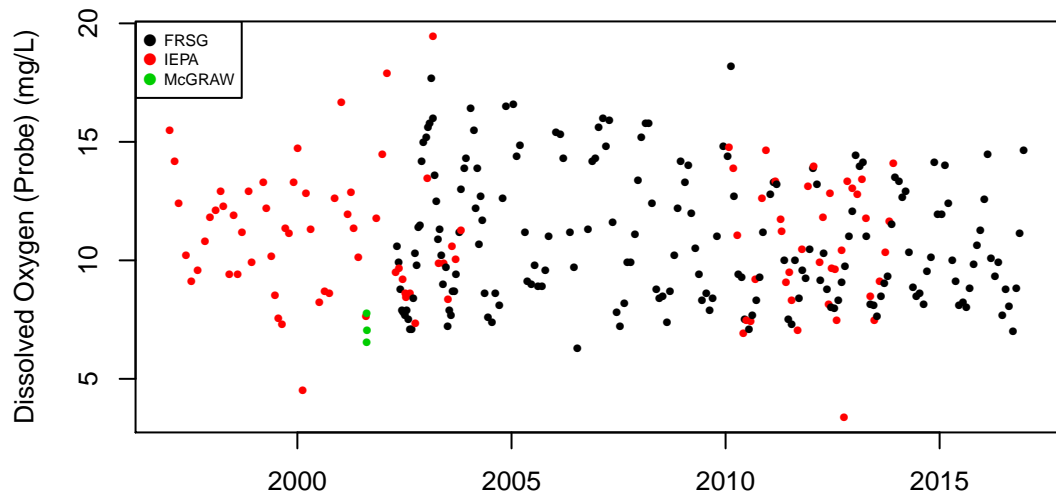


(c) Annual values

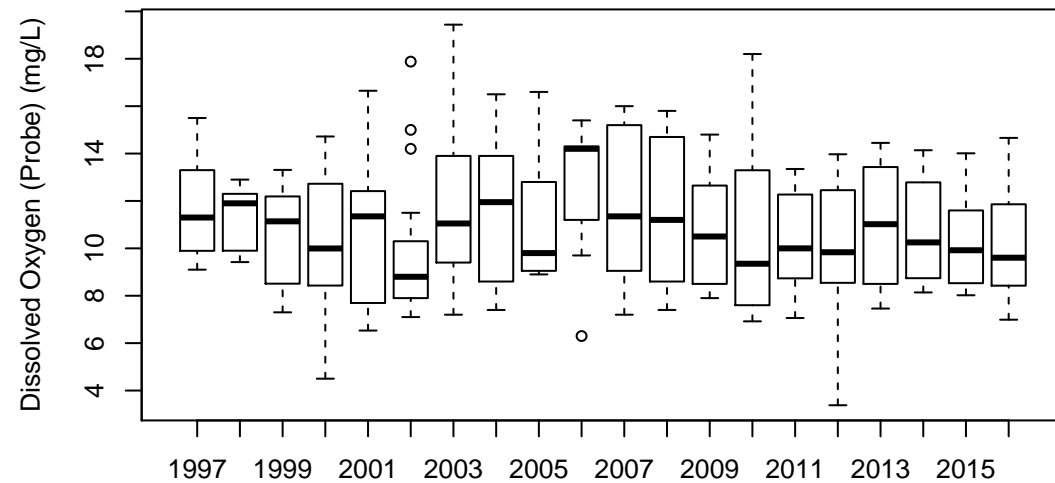


(d) Boxplot by month

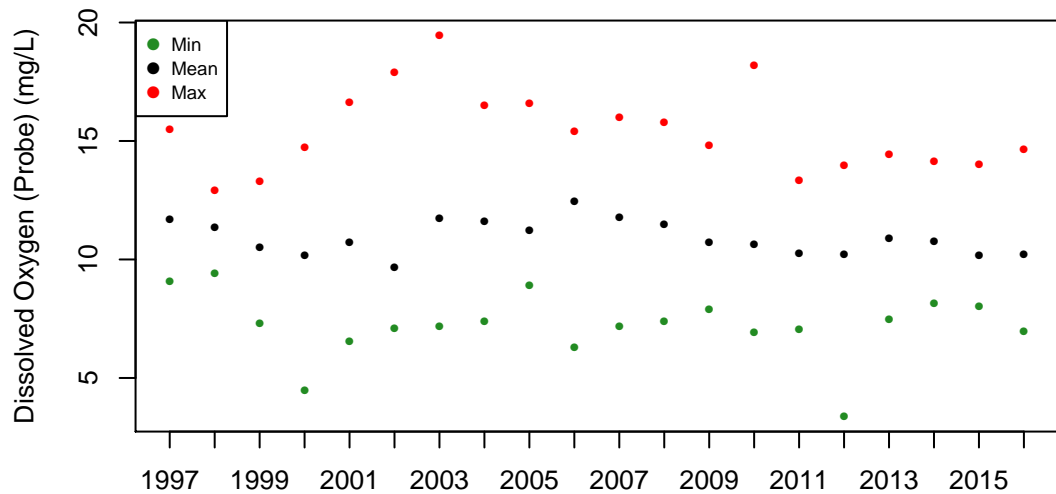
Fox River at South Elgin (26): Dissolved Oxygen (Probe) (mg/L)



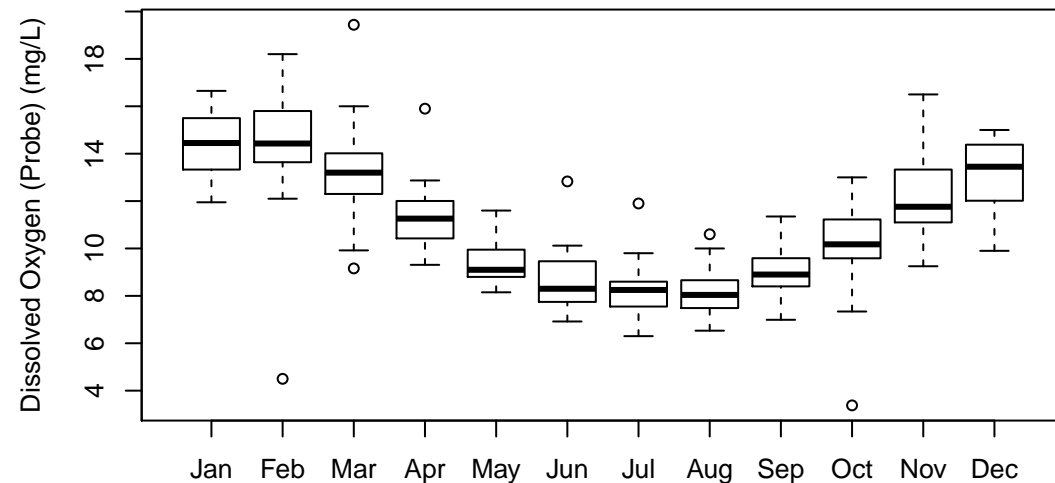
(a) Observation data



(b) Boxplot by year

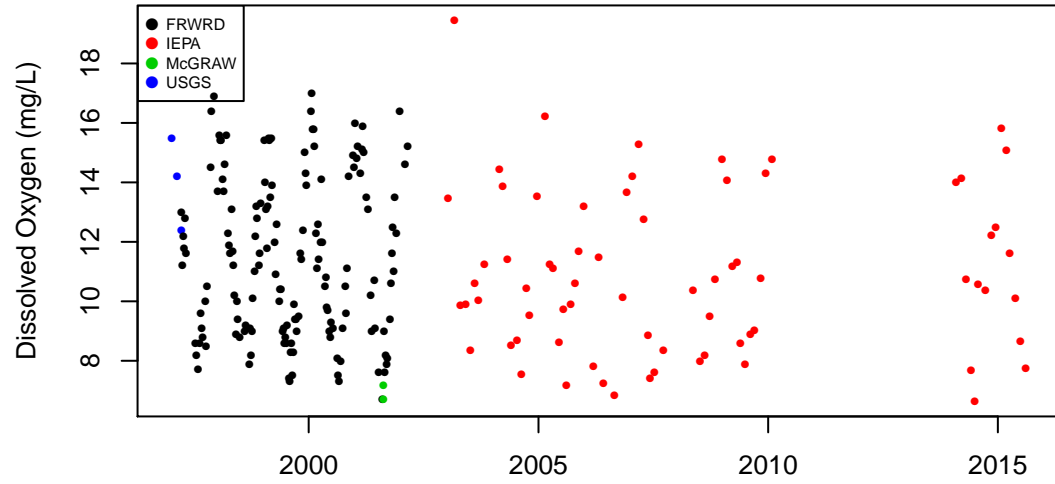


(c) Annual values

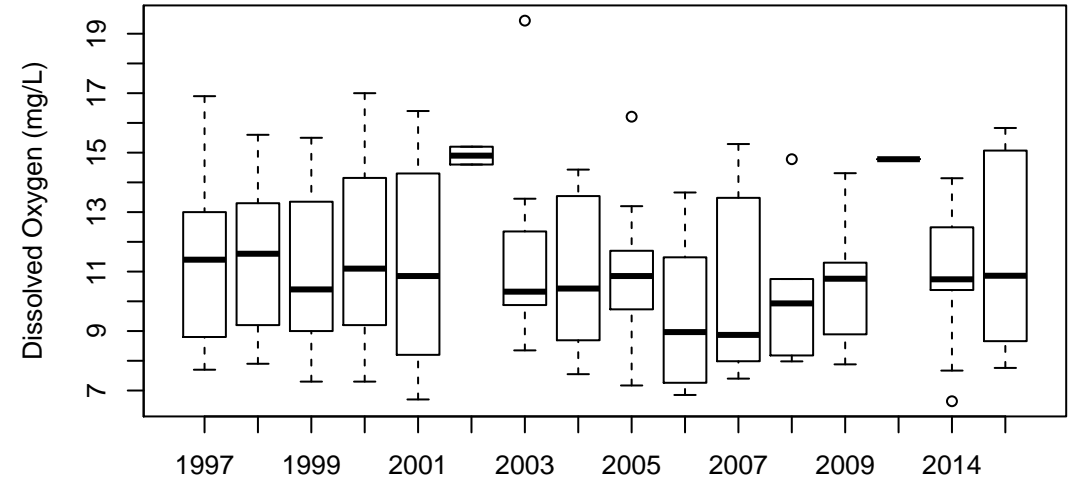


(d) Boxplot by month

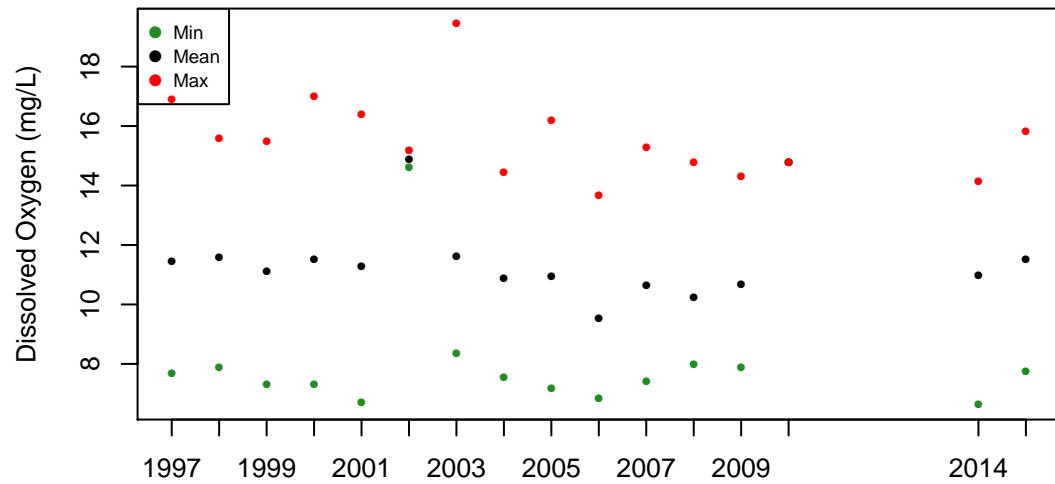
Fox River at South Elgin (26): Dissolved Oxygen (mg/L)



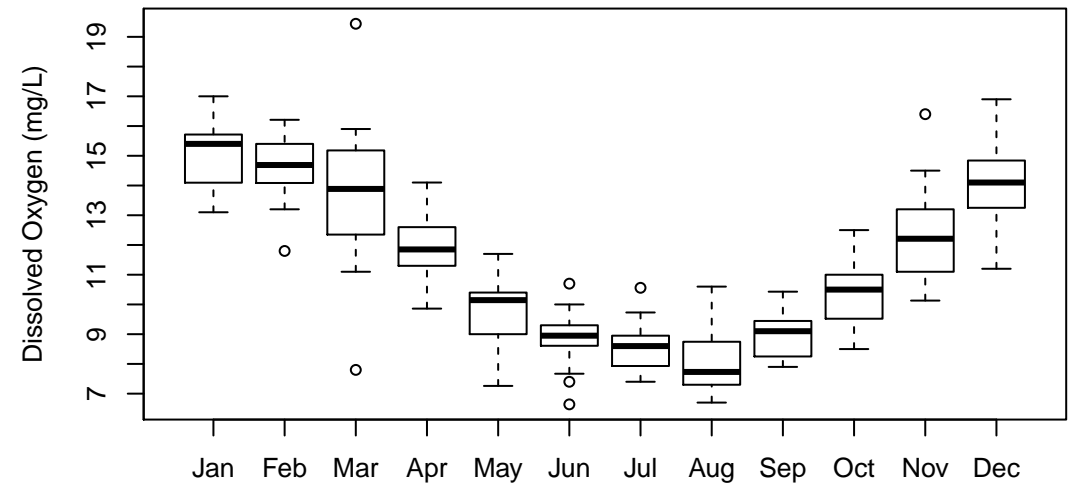
(a) Observation data



(b) Boxplot by year



(c) Annual values

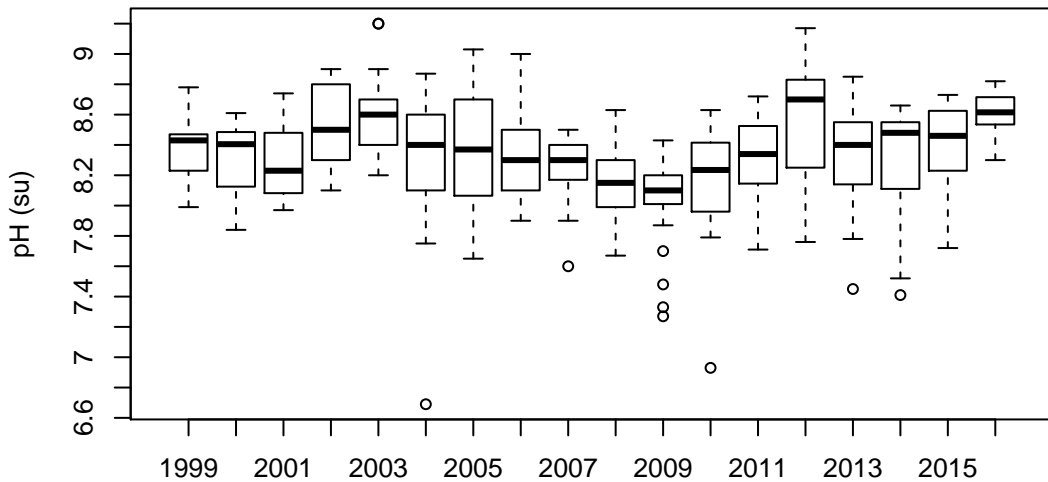


(d) Boxplot by month

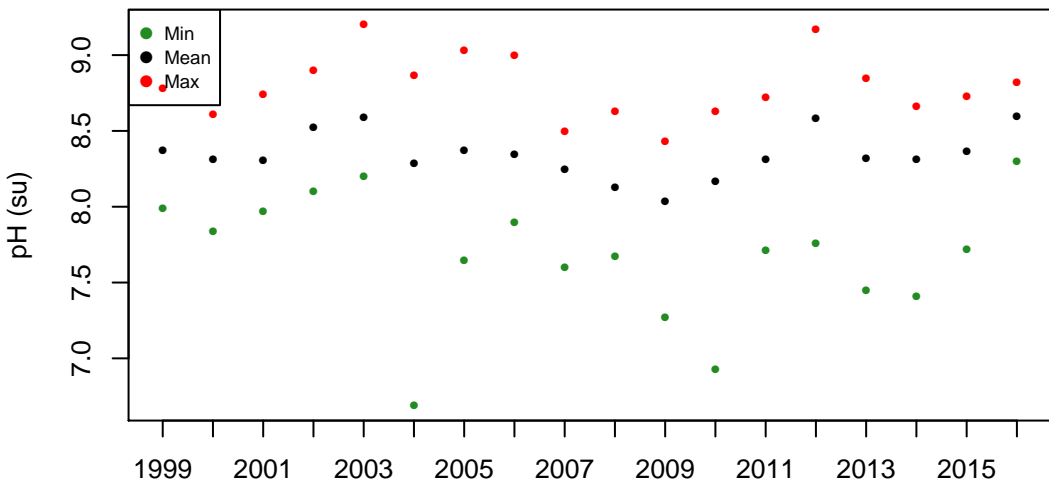
Fox River at South Elgin (26): pH (su)



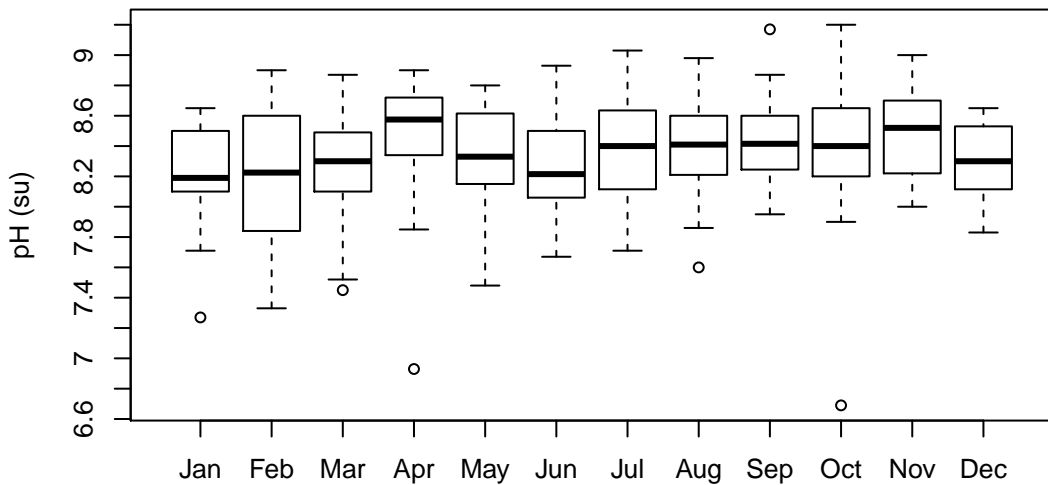
(a) Observation data



(b) Boxplot by year

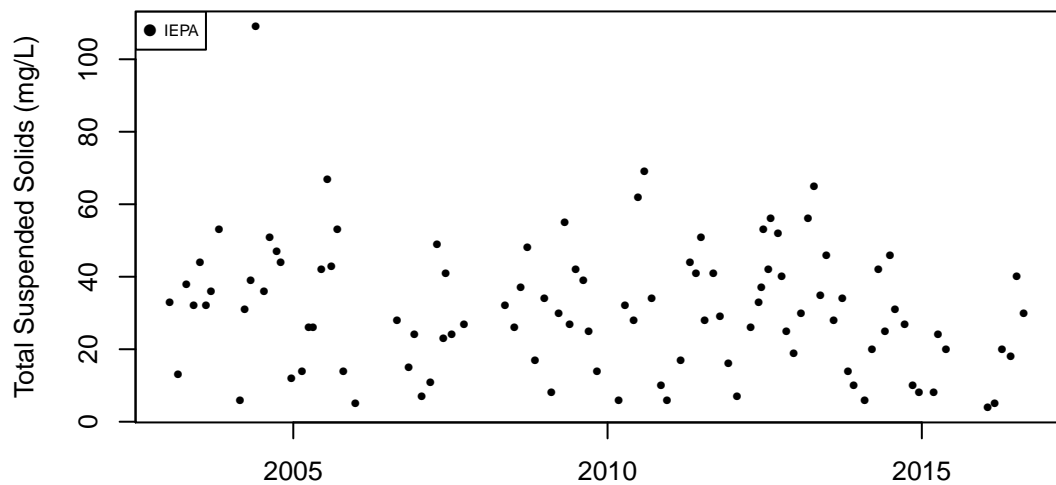


(c) Annual values

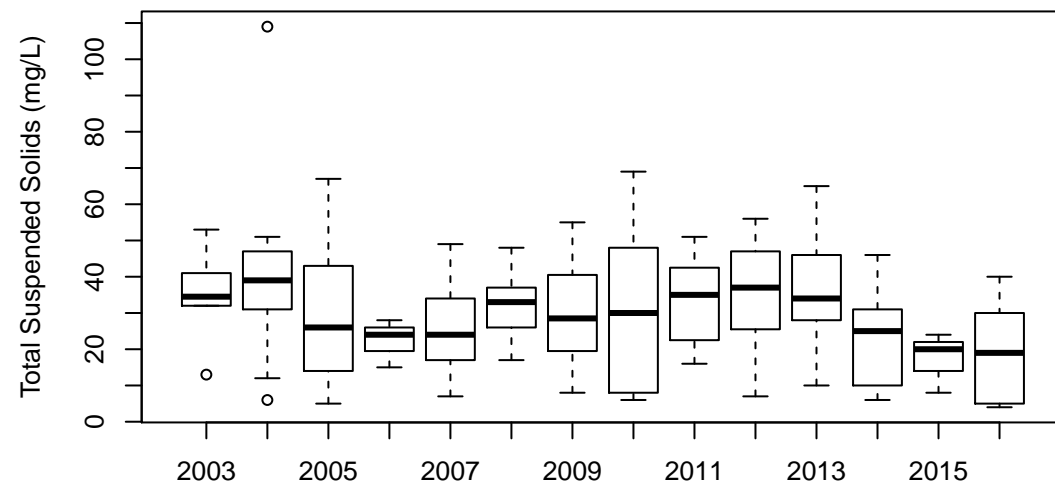


(d) Boxplot by month

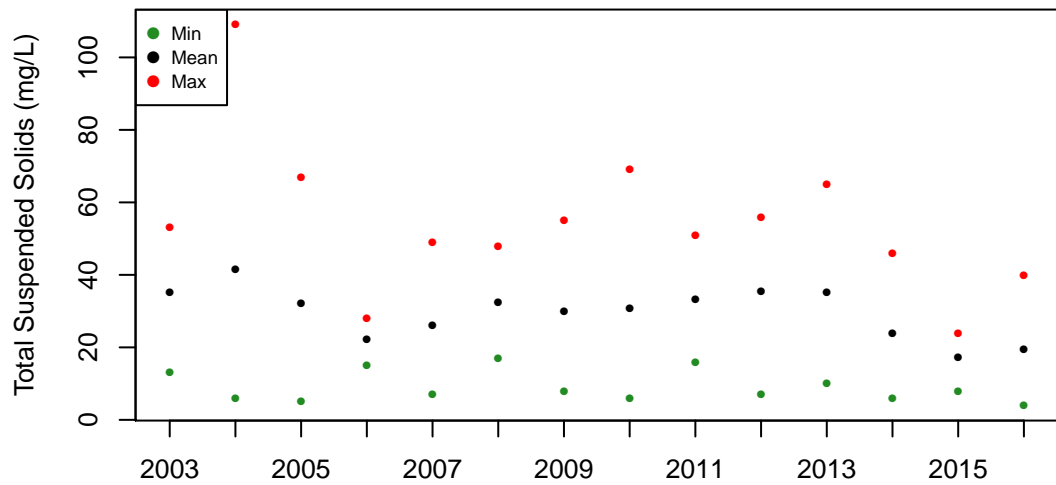
Fox River at South Elgin (26): Total Suspended Solids (mg/L)



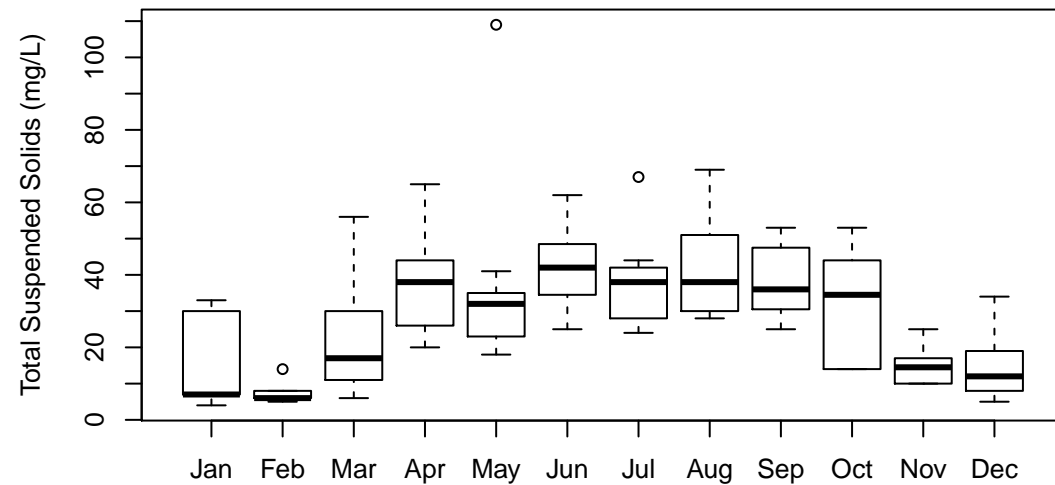
(a) Observation data



(b) Boxplot by year

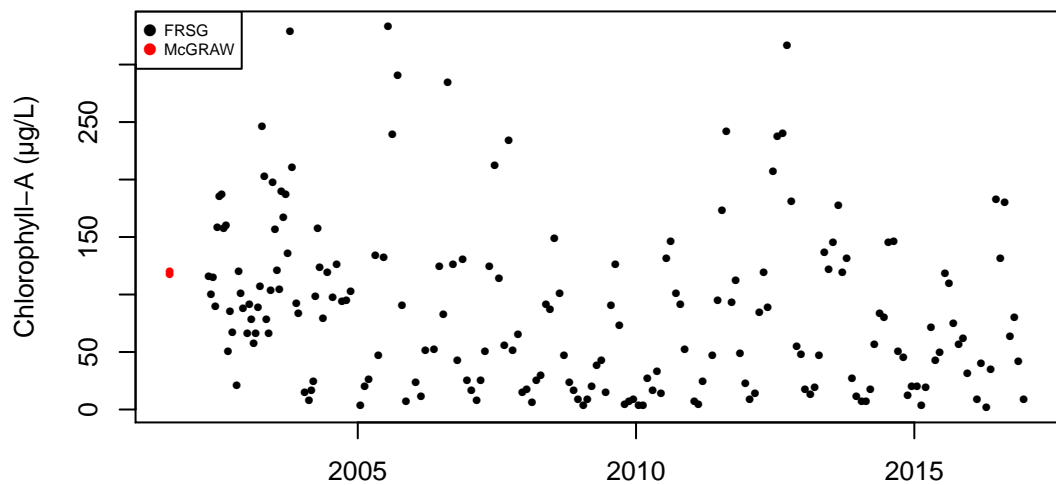


(c) Annual values

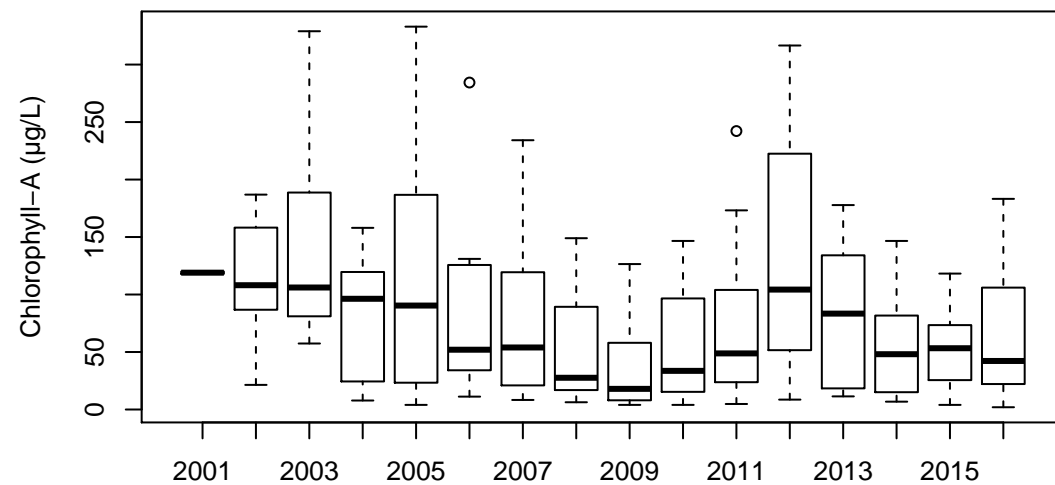


(d) Boxplot by month

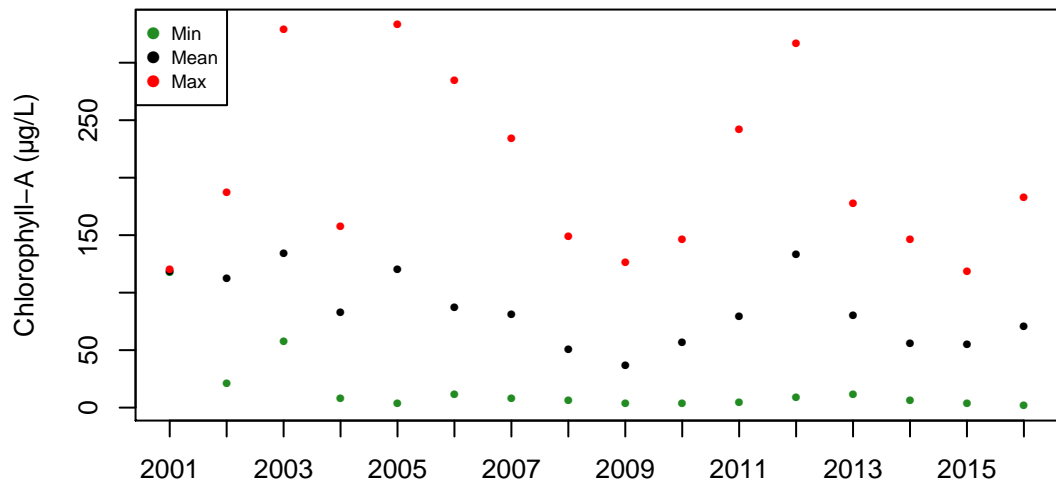
Fox River at South Elgin (26): Chlorophyll-A ($\mu\text{g/L}$)



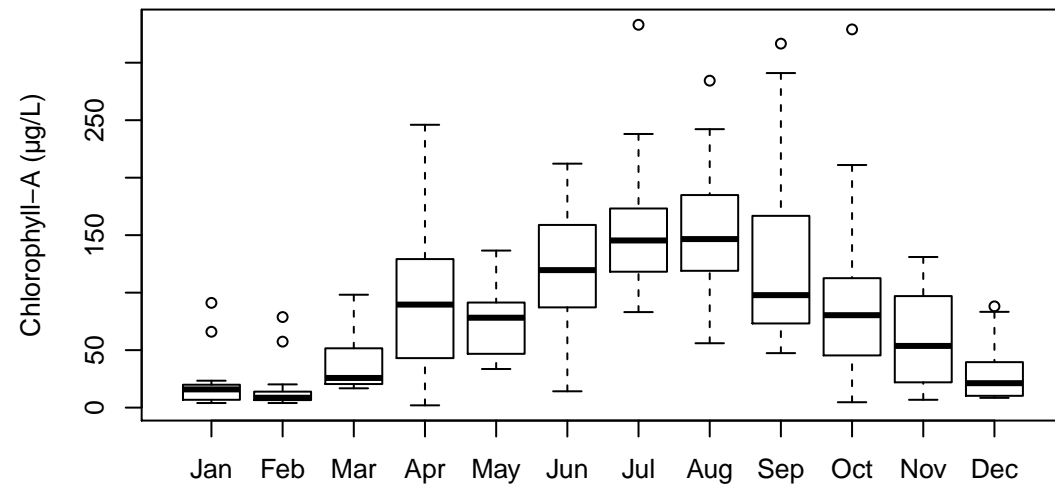
(a) Observation data



(b) Boxplot by year

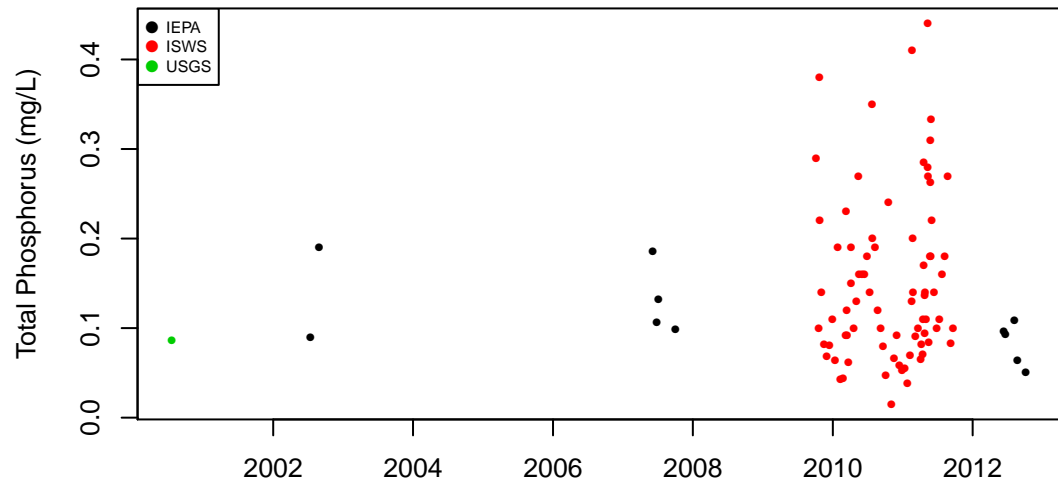


(c) Annual values

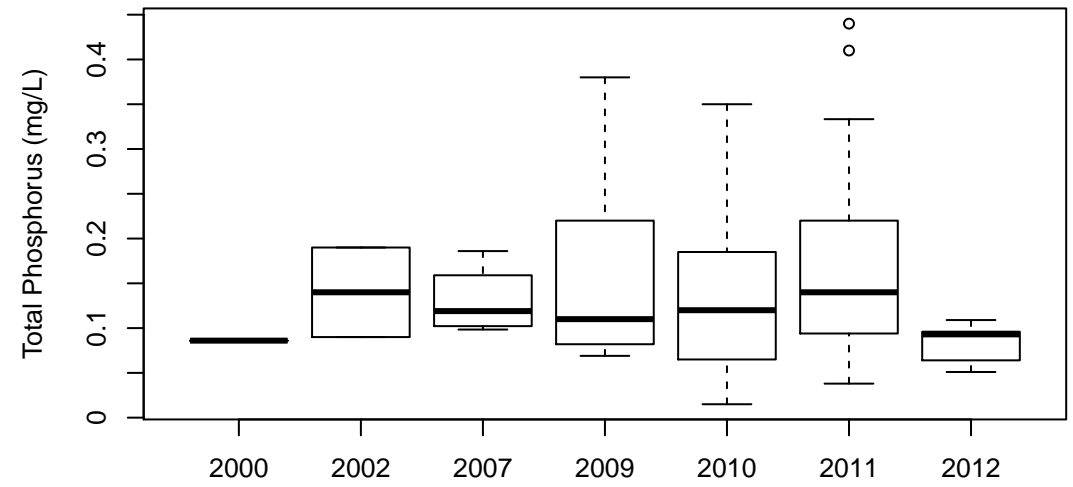


(d) Boxplot by month

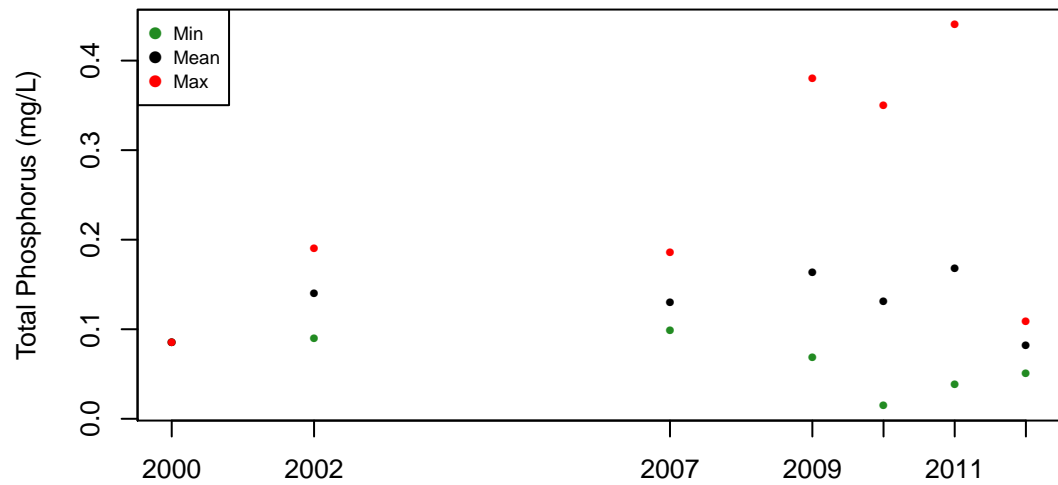
Ferson Cr at Rt 34 (14): Total Phosphorus (mg/L)



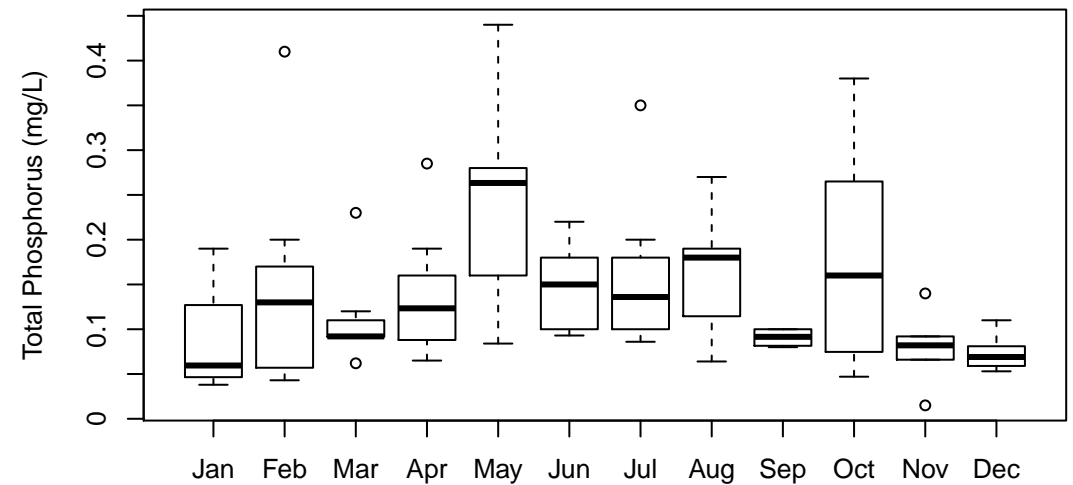
(a) Observation data



(b) Boxplot by year

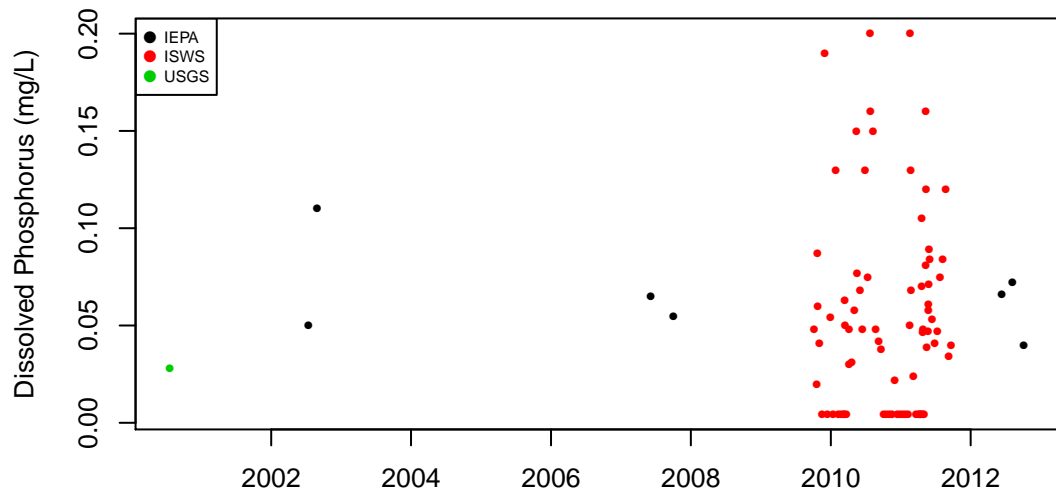


(c) Annual values

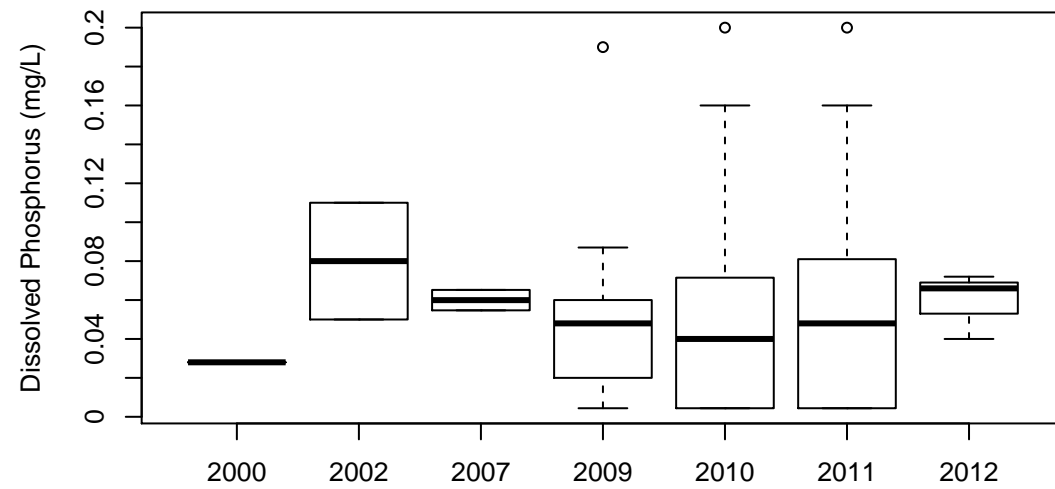


(d) Boxplot by month

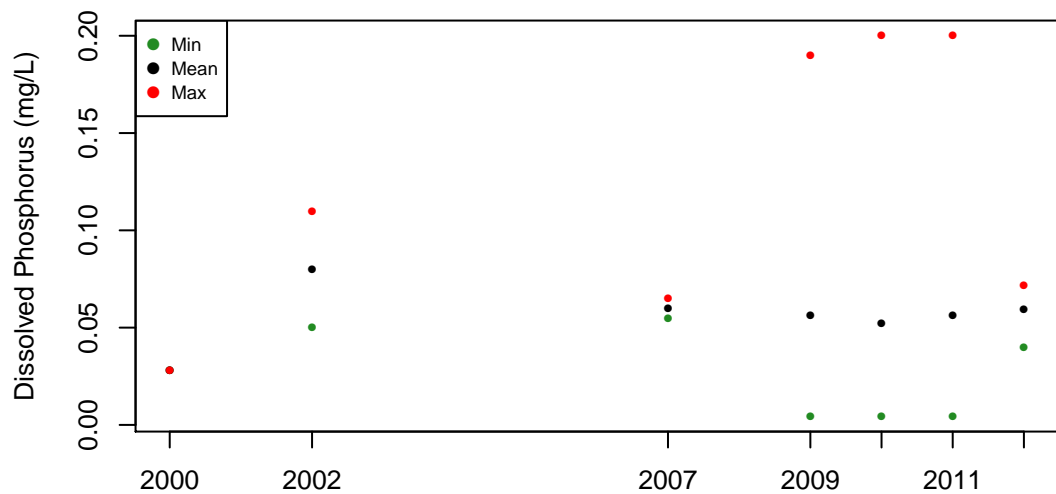
Ferson Cr at Rt 34 (14): Dissolved Phosphorus (mg/L)



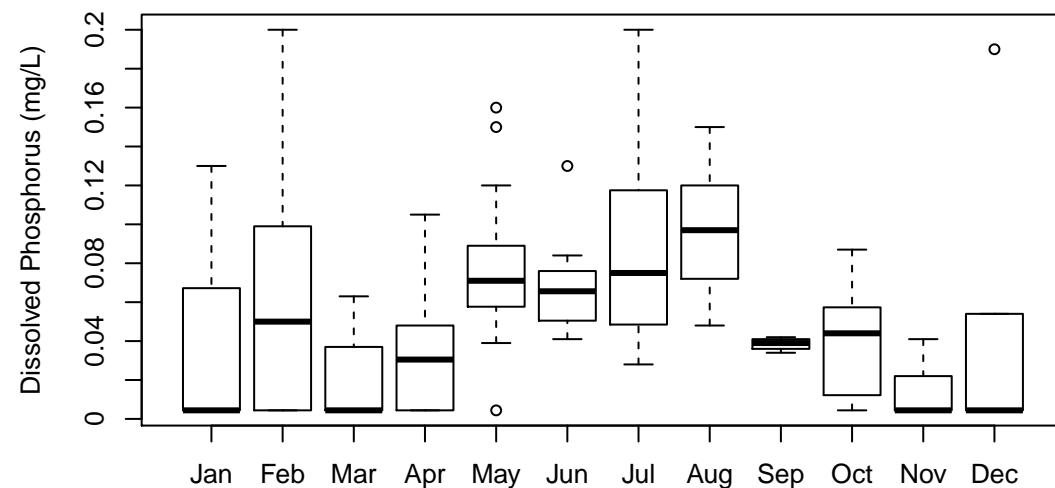
(a) Observation data



(b) Boxplot by year

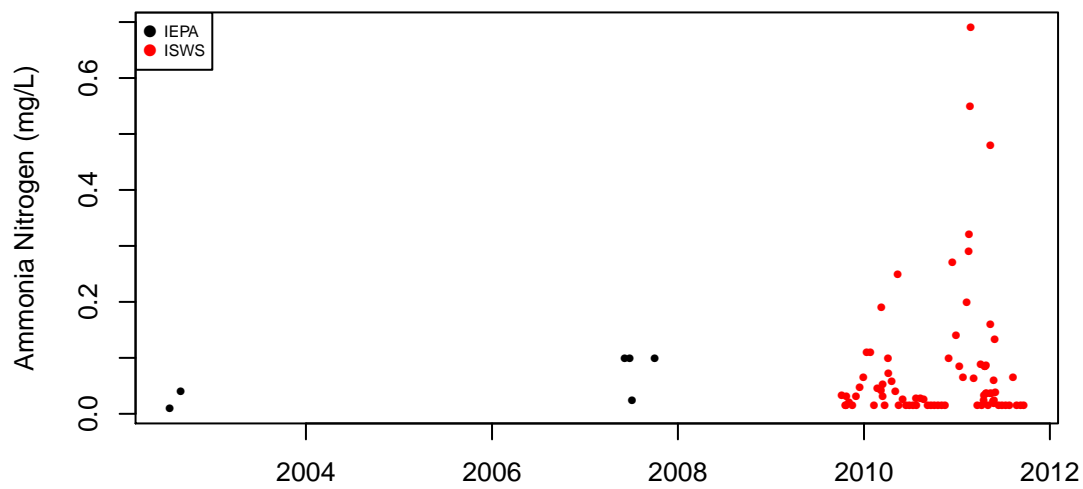


(c) Annual values

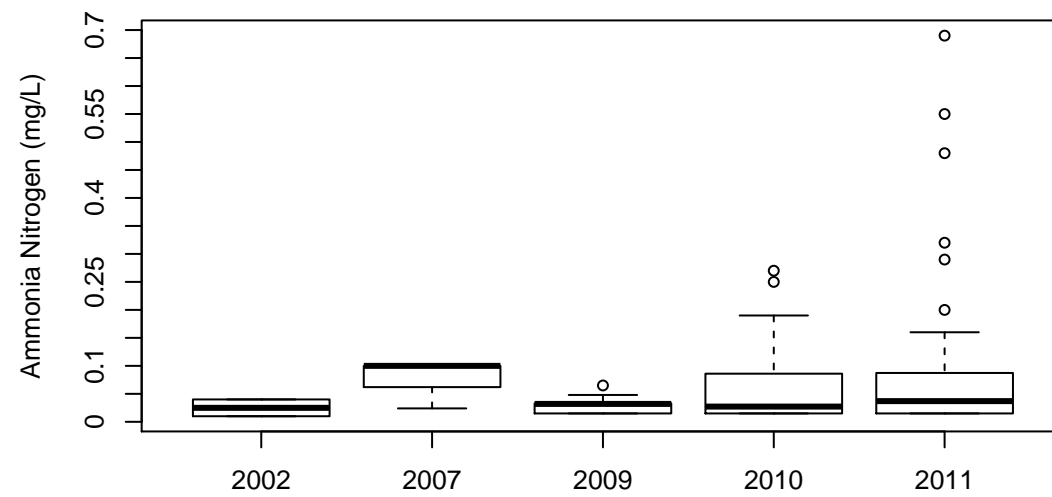


(d) Boxplot by month

Ferson Cr at Rt 34 (14): Ammonia Nitrogen (mg/L)



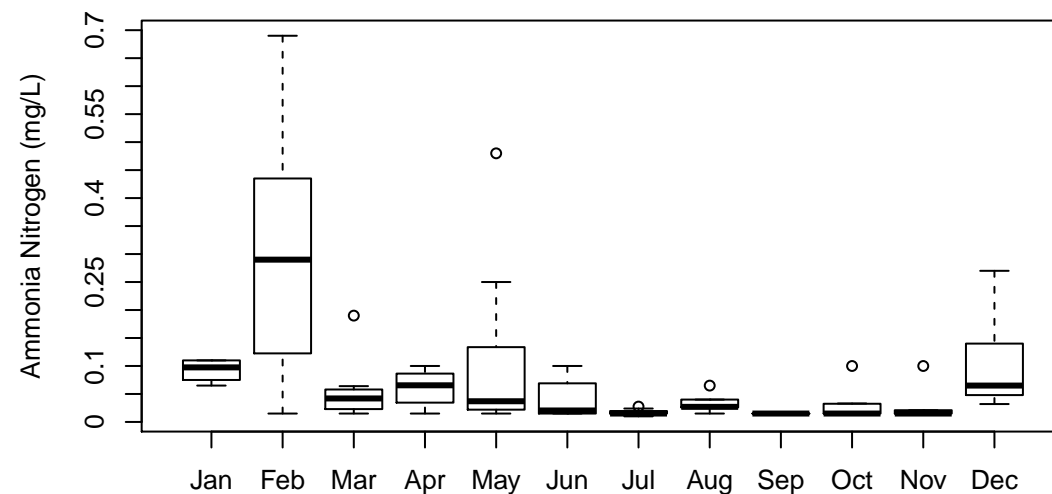
(a) Observation data



(b) Boxplot by year

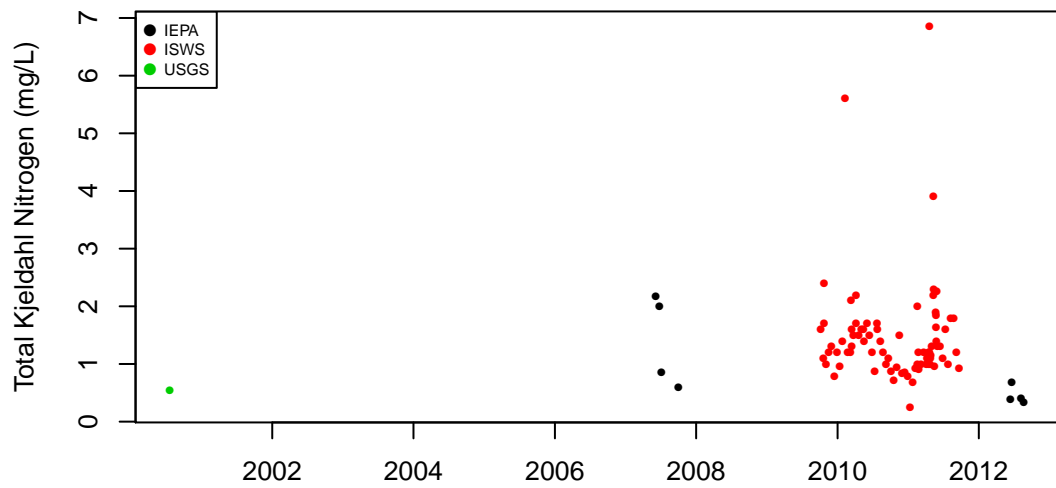


(c) Annual values

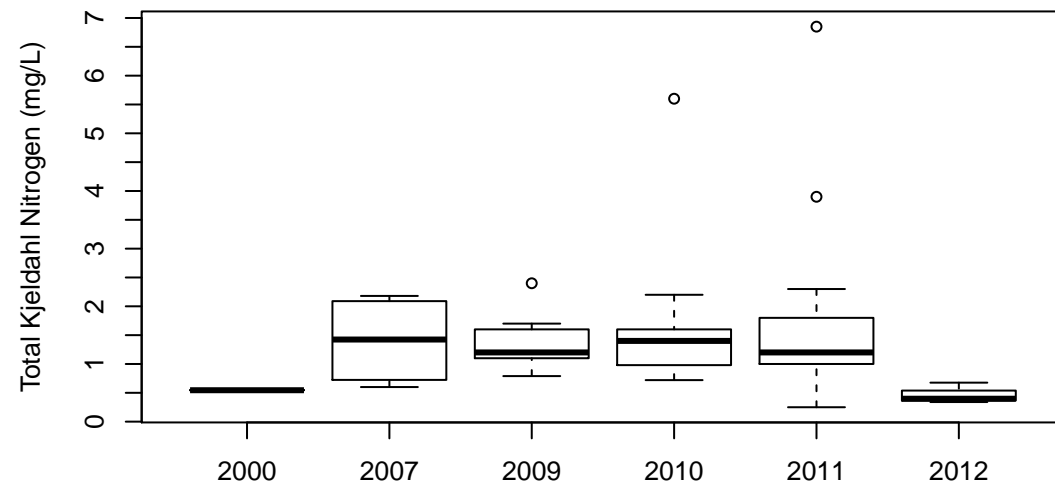


(d) Boxplot by month

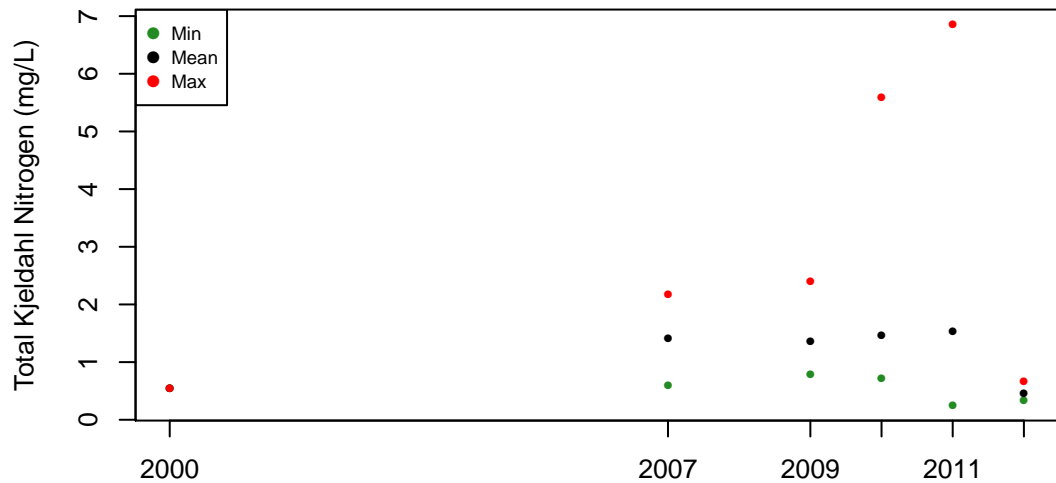
Ferson Cr at Rt 34 (14): Total Kjeldahl Nitrogen (mg/L)



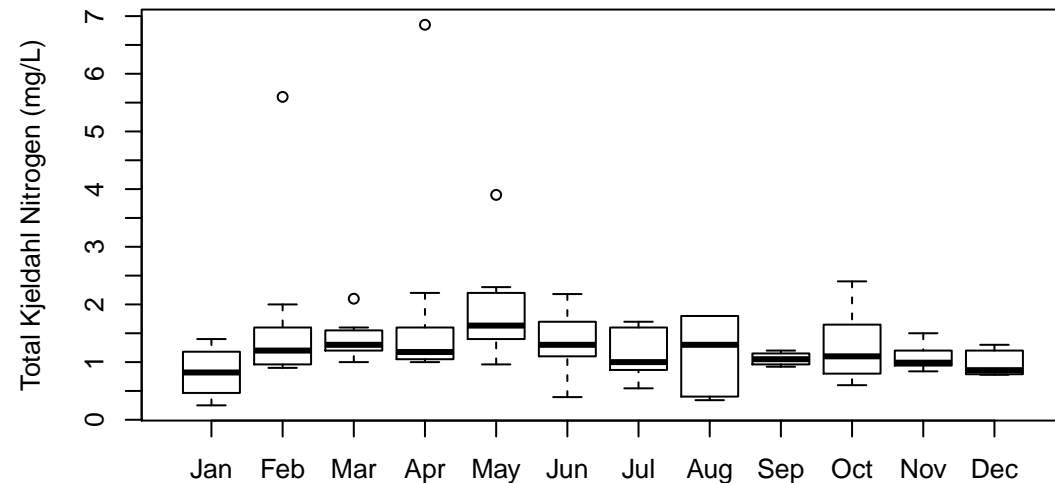
(a) Observation data



(b) Boxplot by year

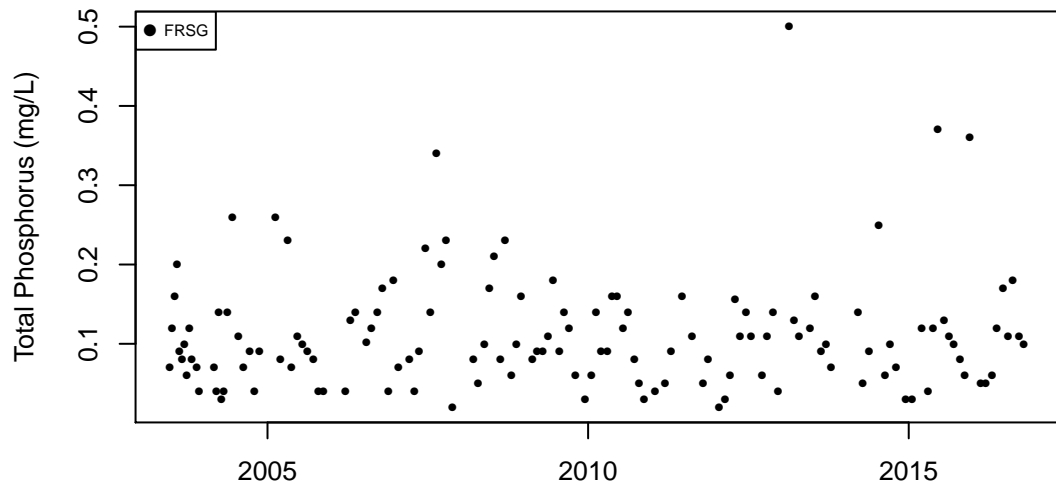


(c) Annual values

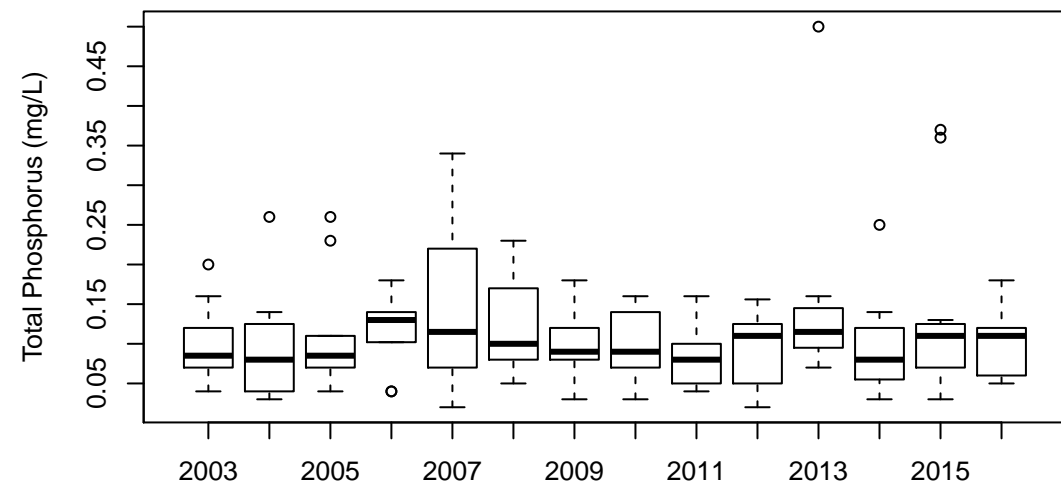


(d) Boxplot by month

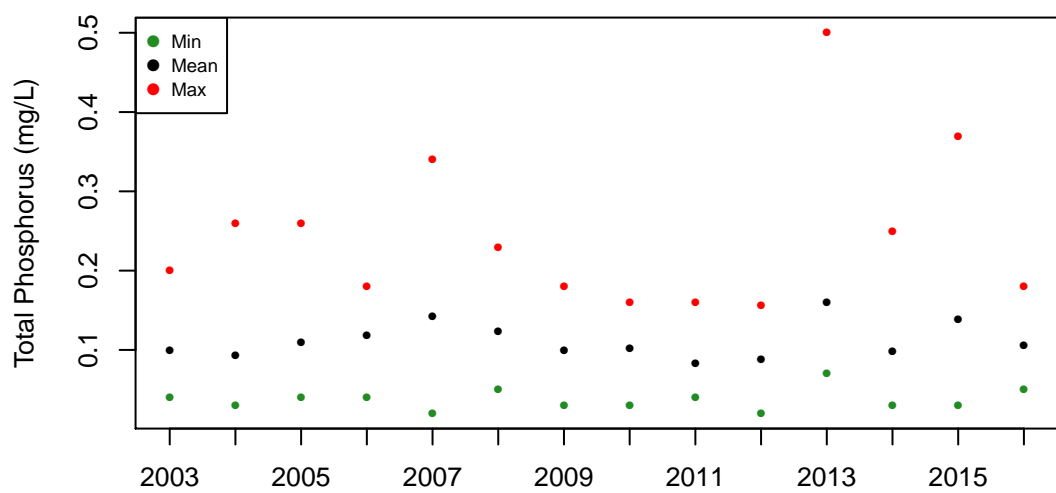
Ferson Cr near Mouth-Elgin (79): Total Phosphorus (mg/L)



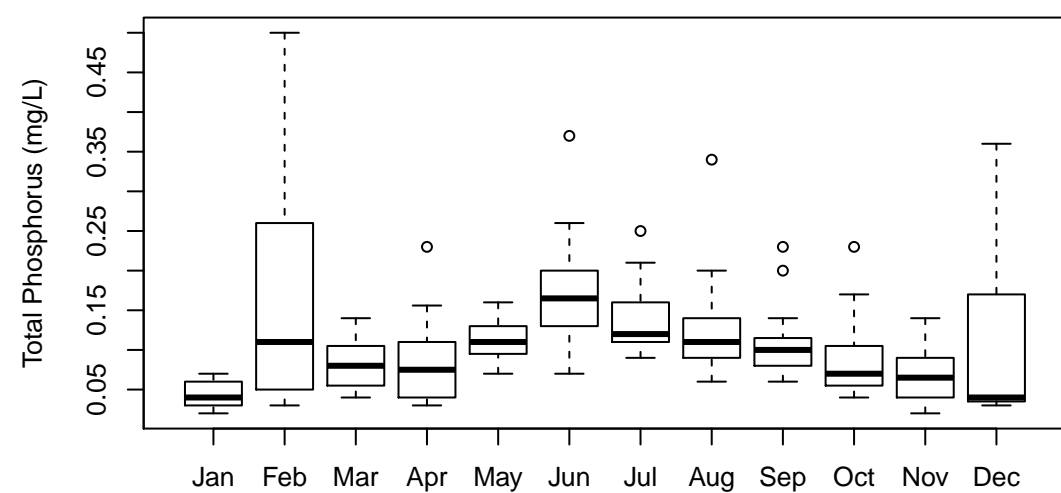
(a) Observation data



(b) Boxplot by year

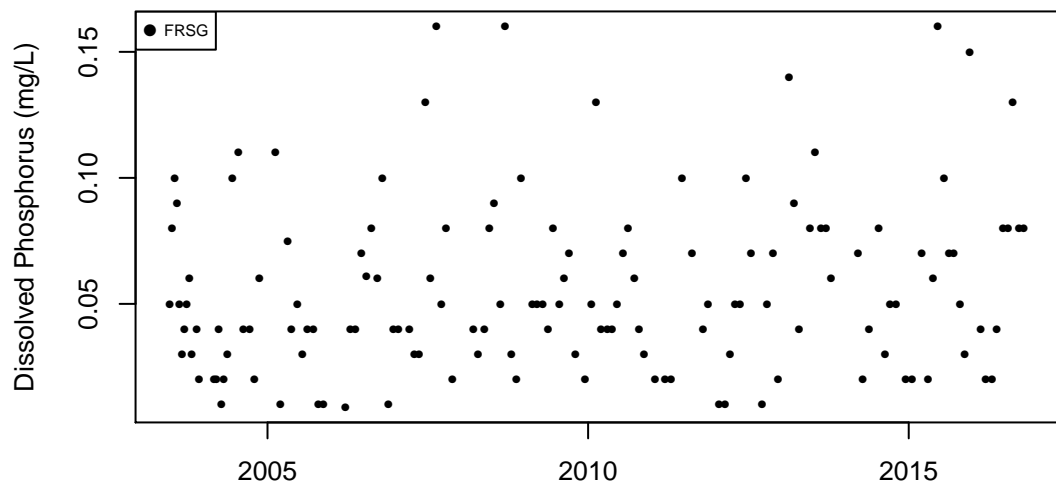


(c) Annual values

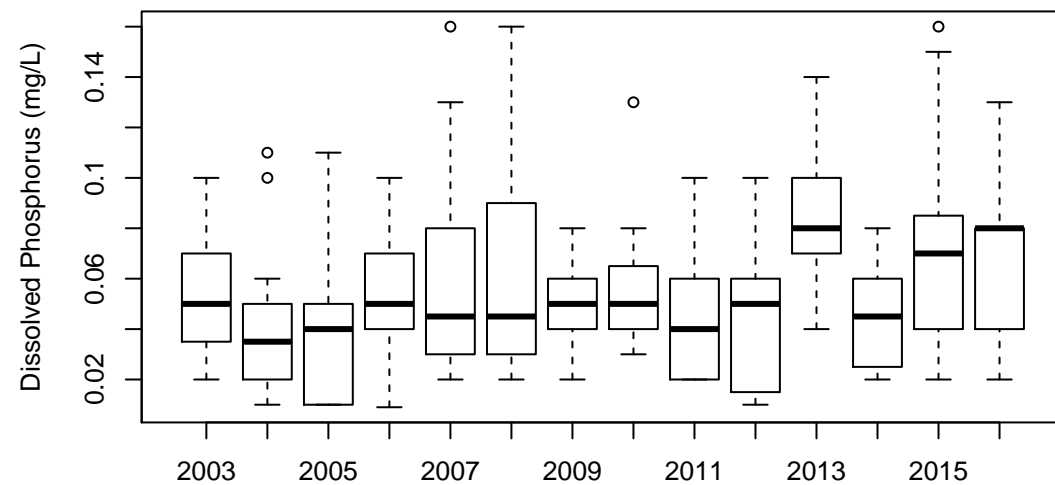


(d) Boxplot by month

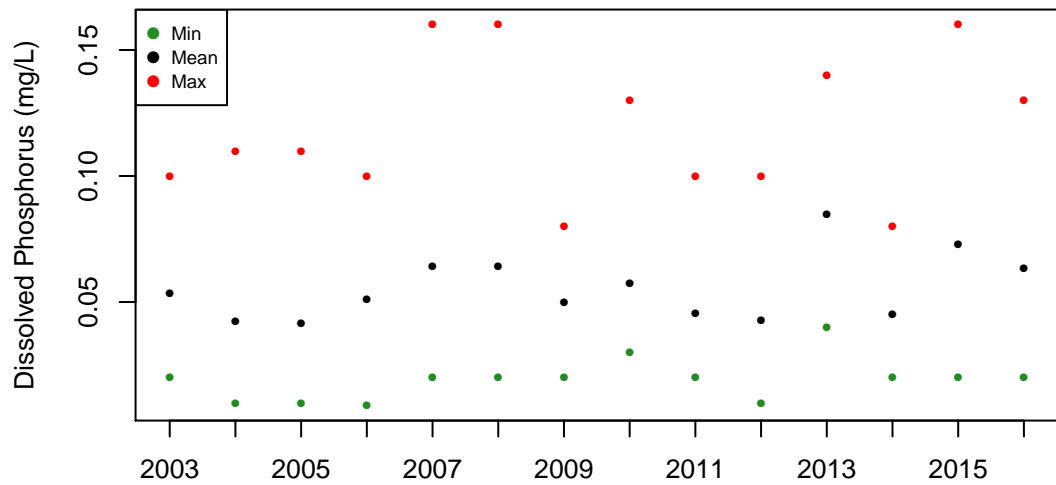
Ferson Cr near Mouth-Elgin (79): Dissolved Phosphorus (mg/L)



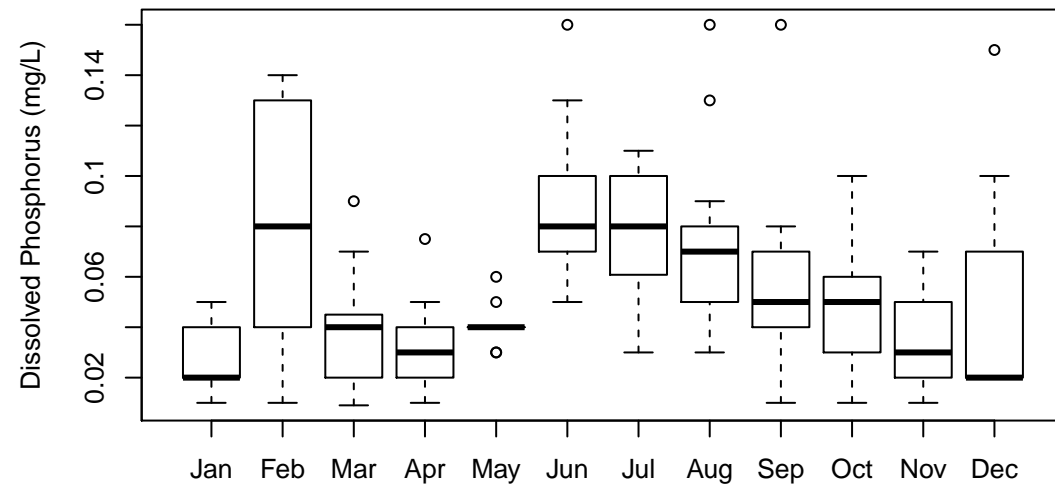
(a) Observation data



(b) Boxplot by year

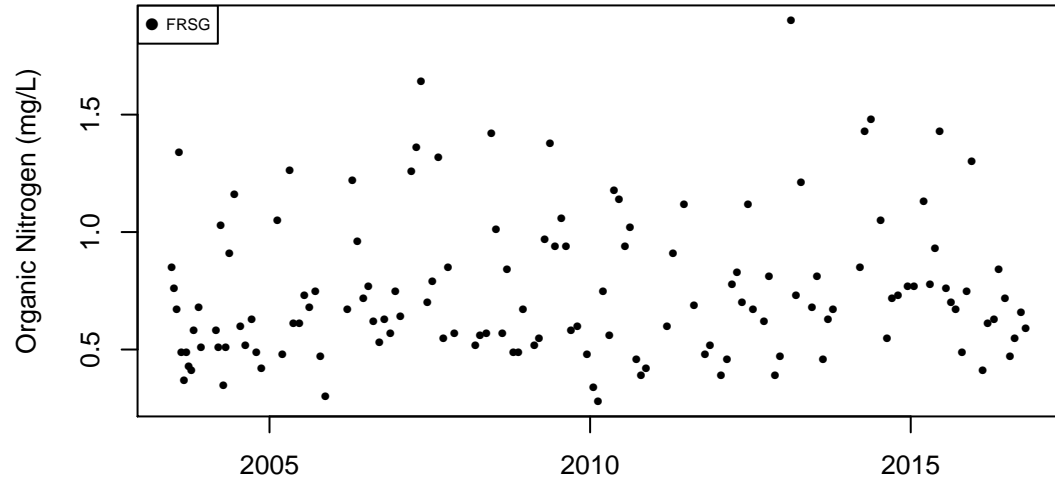


(c) Annual values

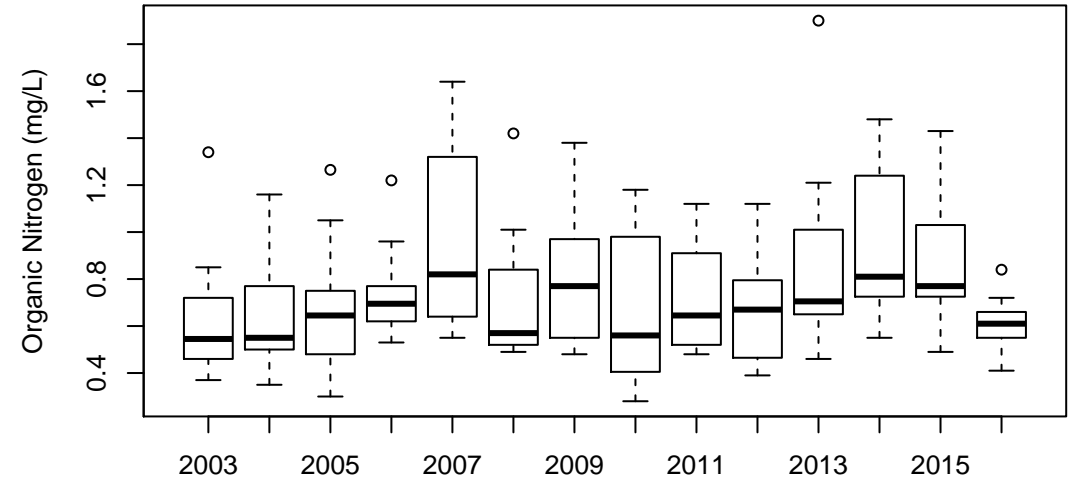


(d) Boxplot by month

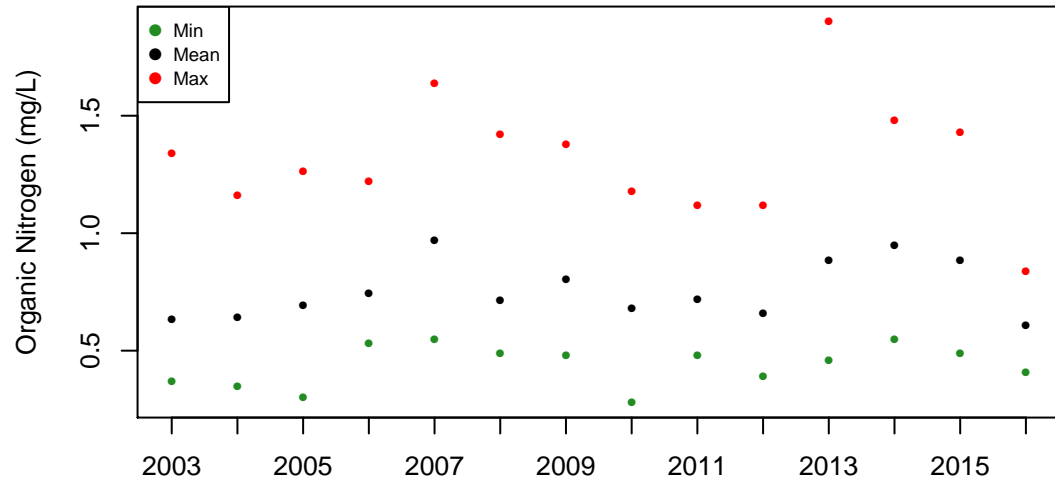
Ferson Cr near Mouth-Elgin (79): Organic Nitrogen (mg/L)



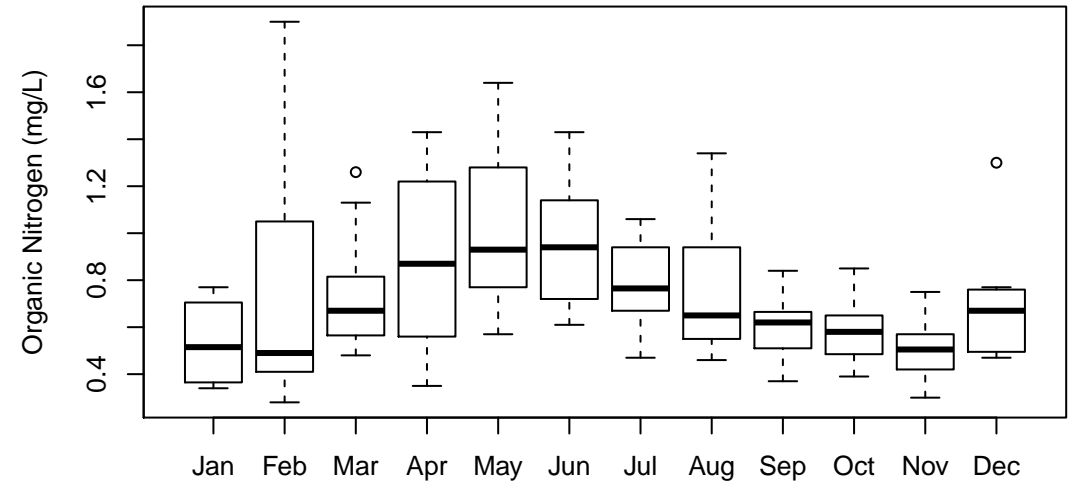
(a) Observation data



(b) Boxplot by year

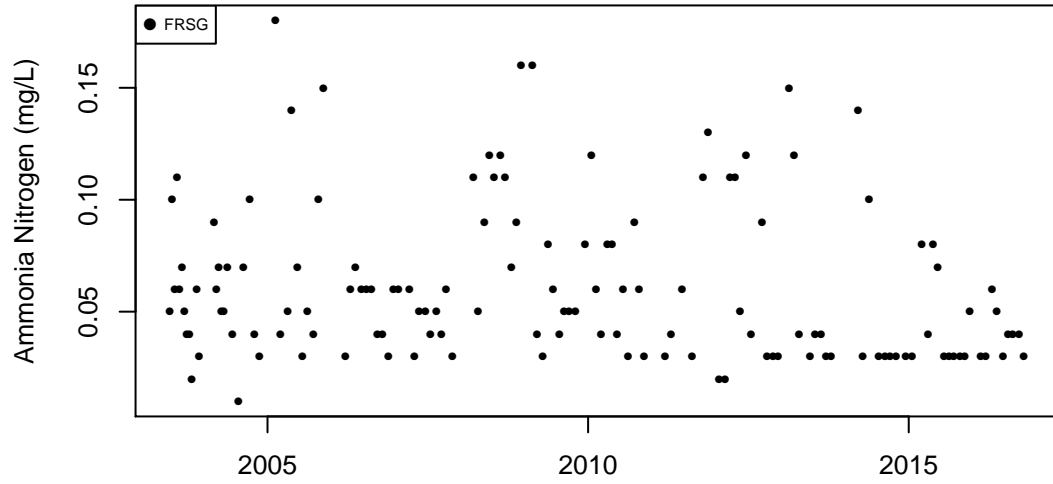


(c) Annual values

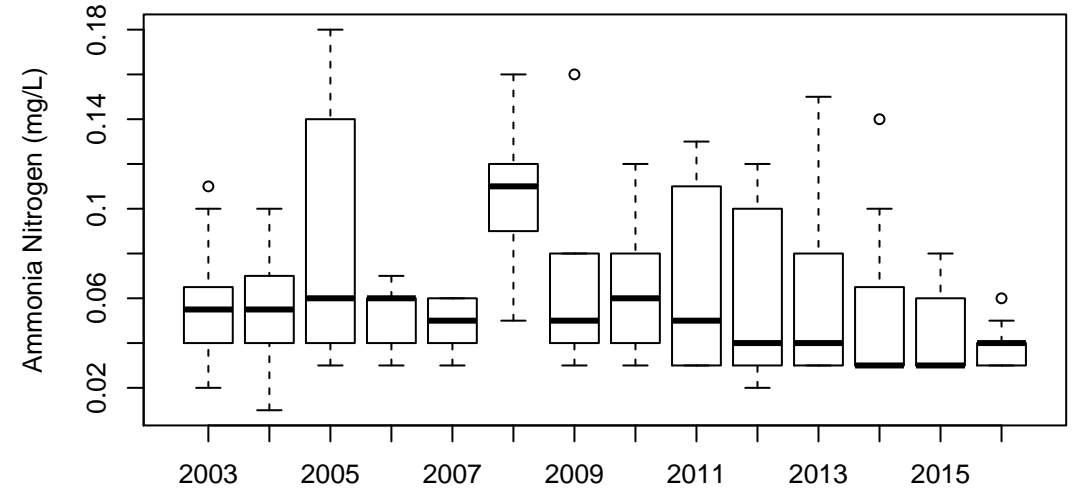


(d) Boxplot by month

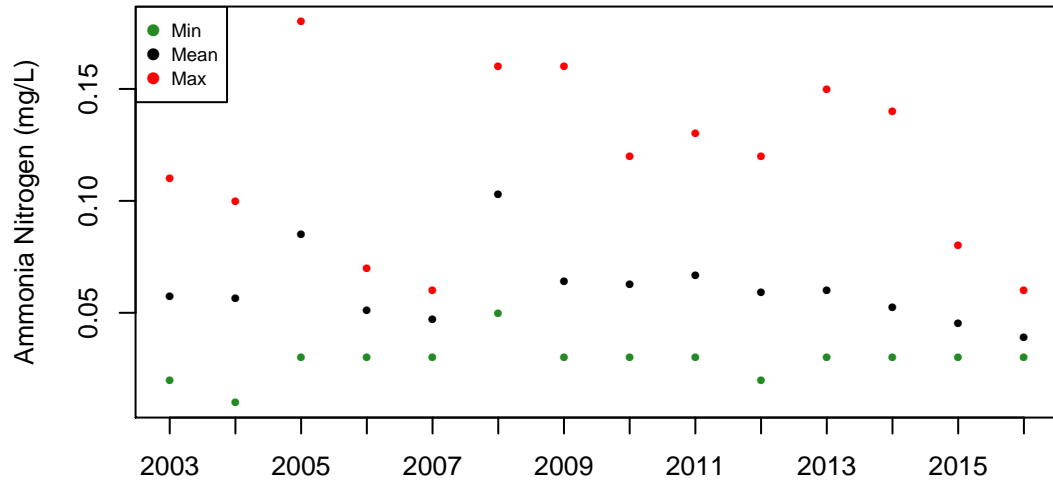
Ferson Cr near Mouth-Elgin (79): Ammonia Nitrogen (mg/L)



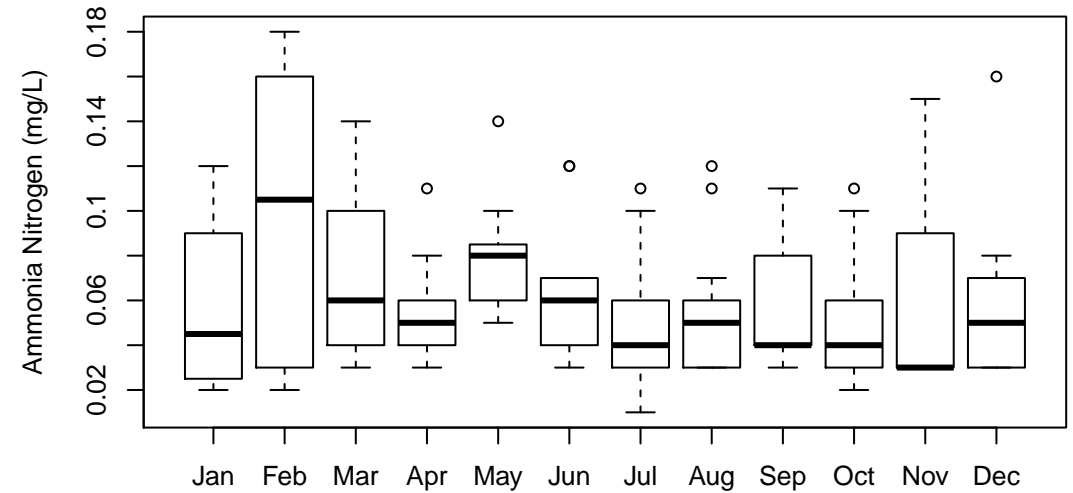
(a) Observation data



(b) Boxplot by year

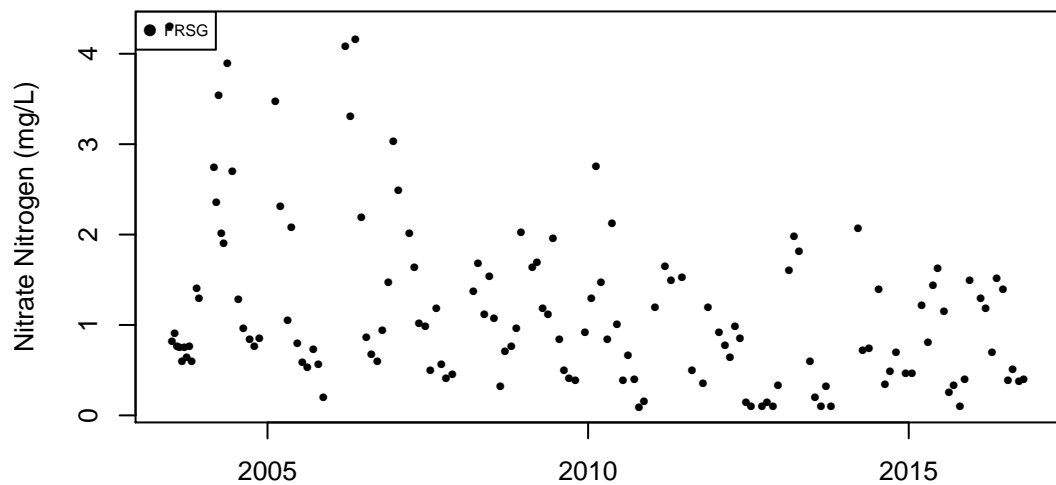


(c) Annual values

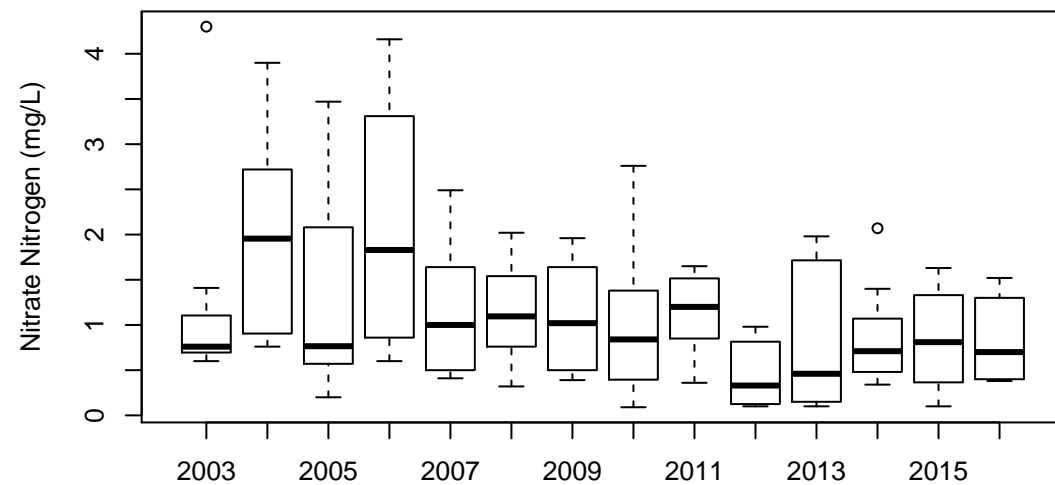


(d) Boxplot by month

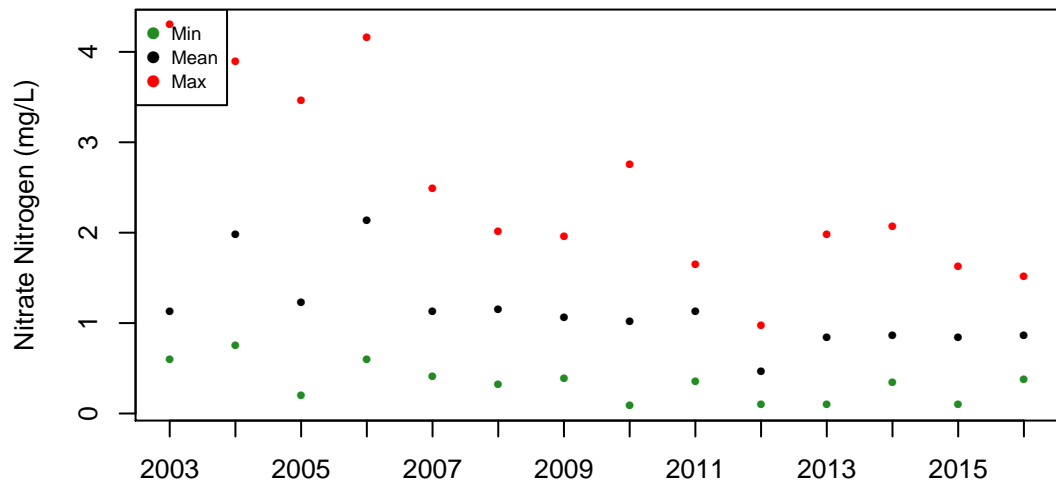
Ferson Cr near Mouth-Elgin (79): Nitrate Nitrogen (mg/L)



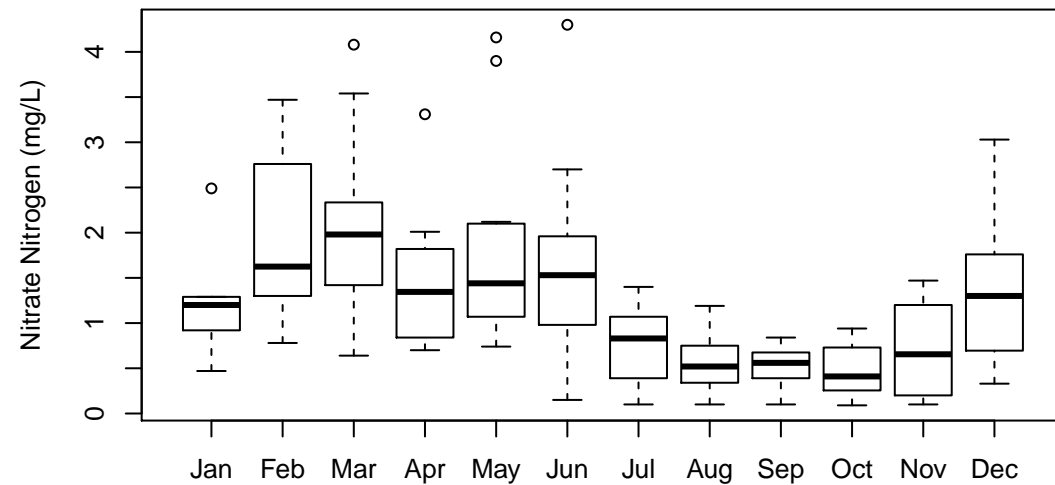
(a) Observation data



(b) Boxplot by year

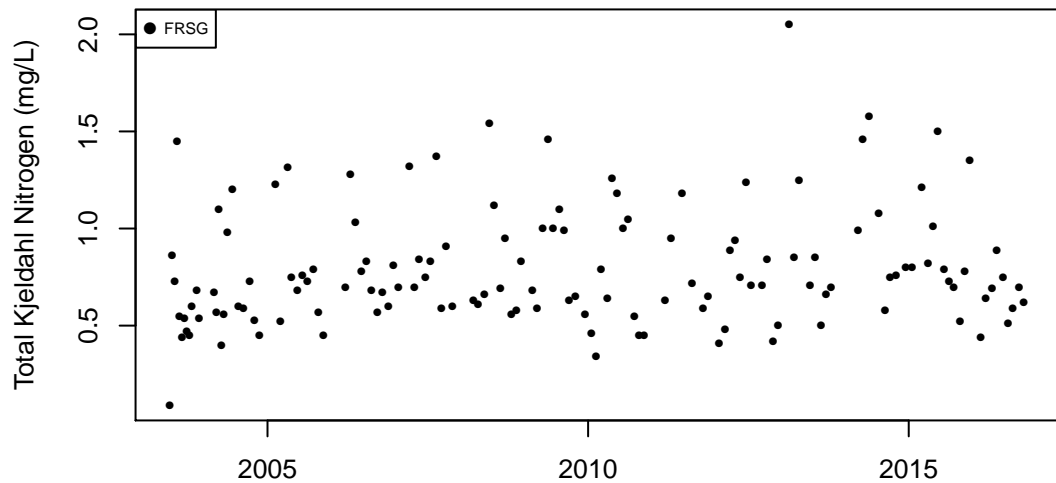


(c) Annual values

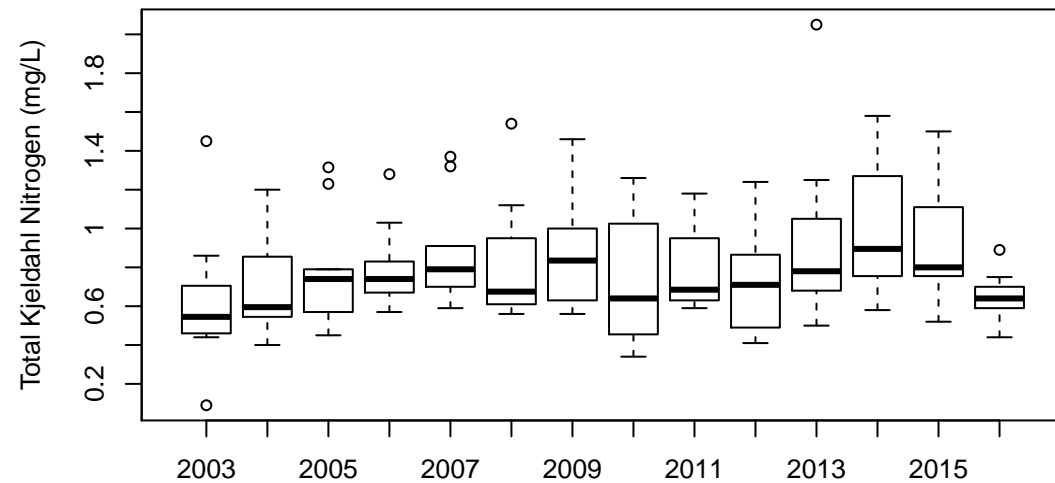


(d) Boxplot by month

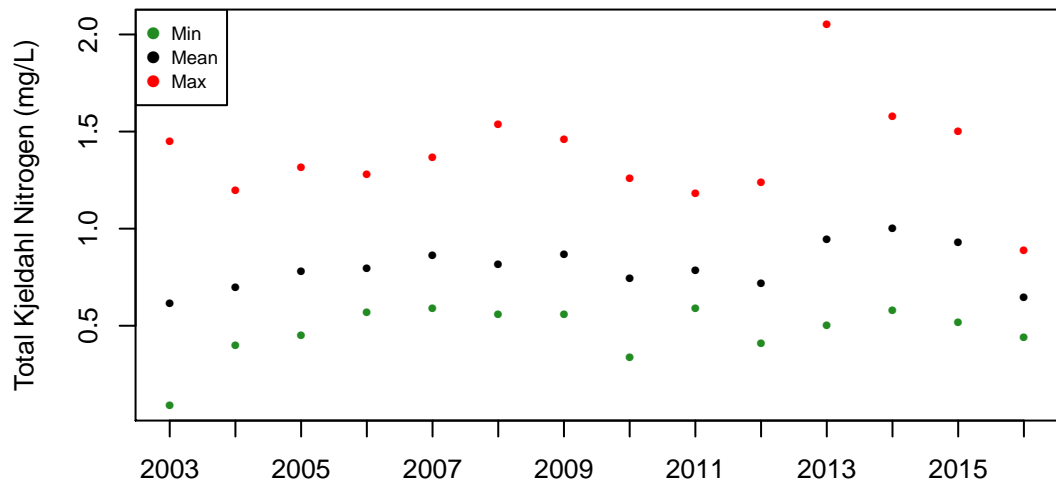
Ferson Cr near Mouth–Elgin (79): Total Kjeldahl Nitrogen (mg/L)



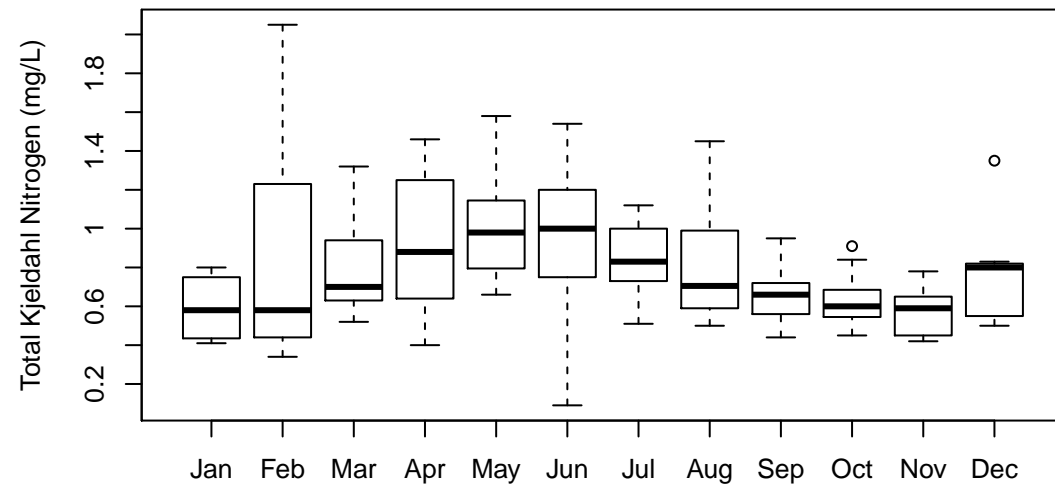
(a) Observation data



(b) Boxplot by year

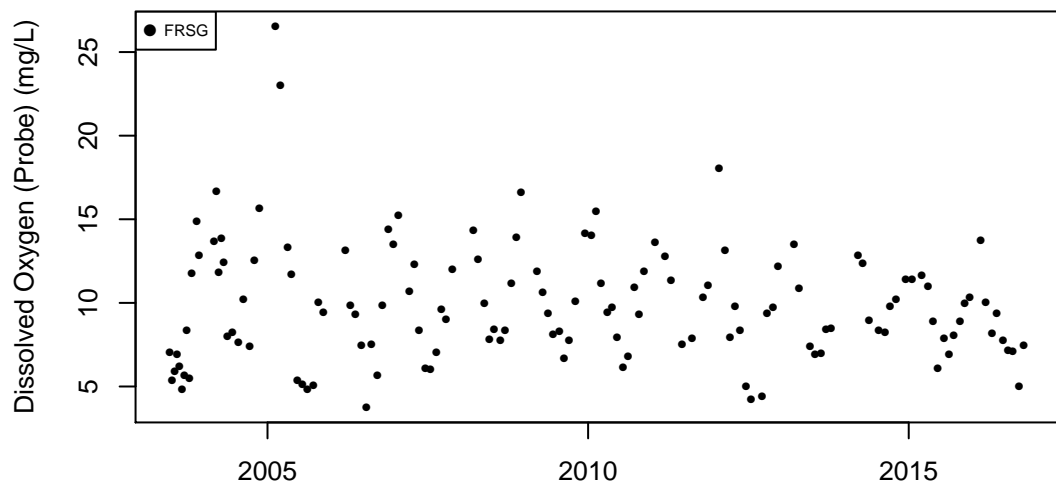


(c) Annual values

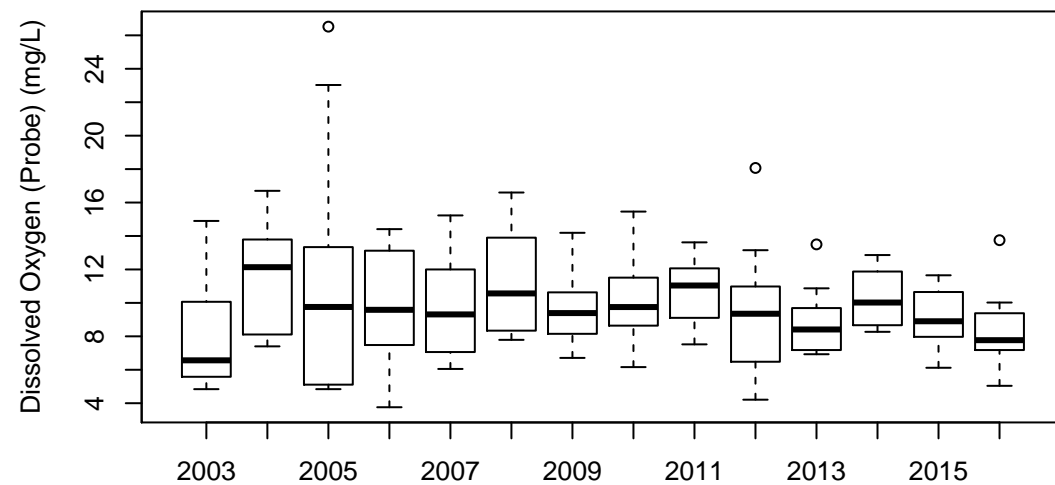


(d) Boxplot by month

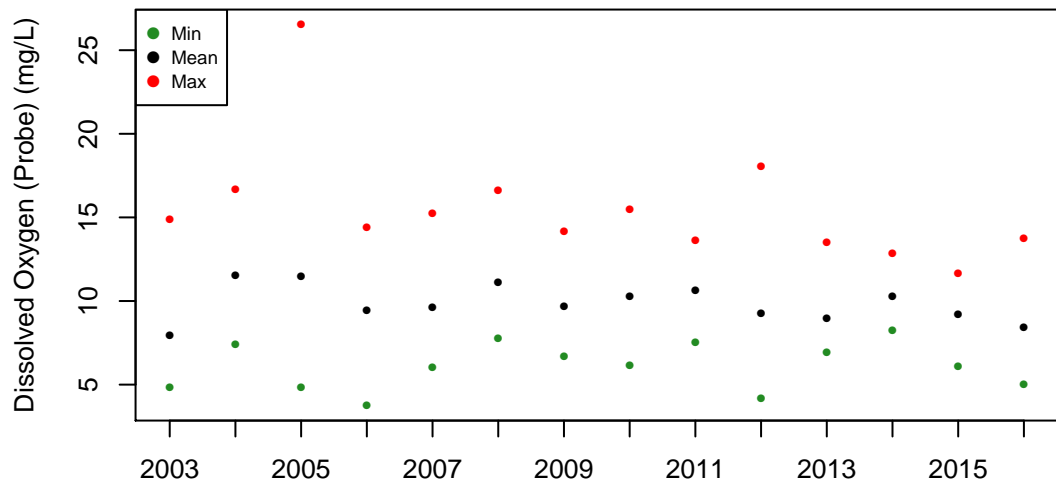
Ferson Cr near Mouth-Elgin (79): Dissolved Oxygen (Probe) (mg/L)



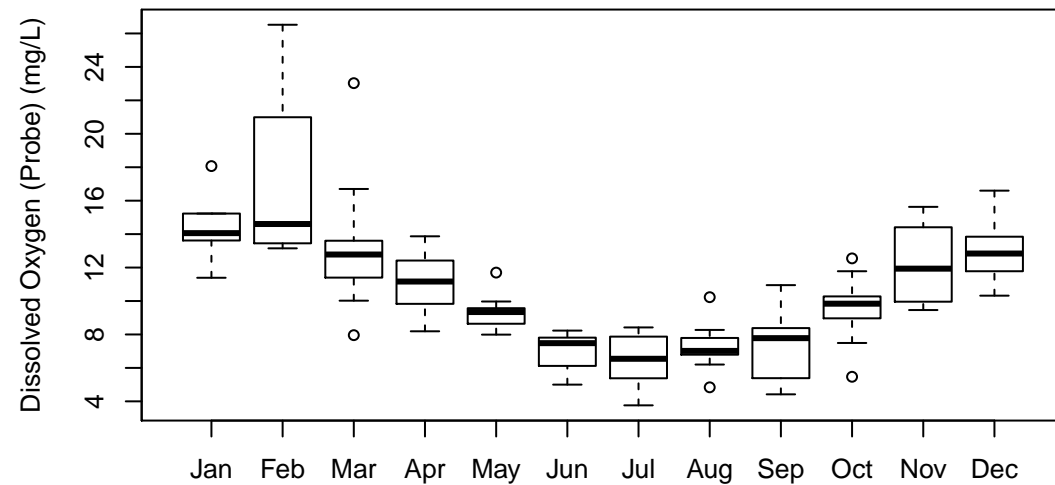
(a) Observation data



(b) Boxplot by year

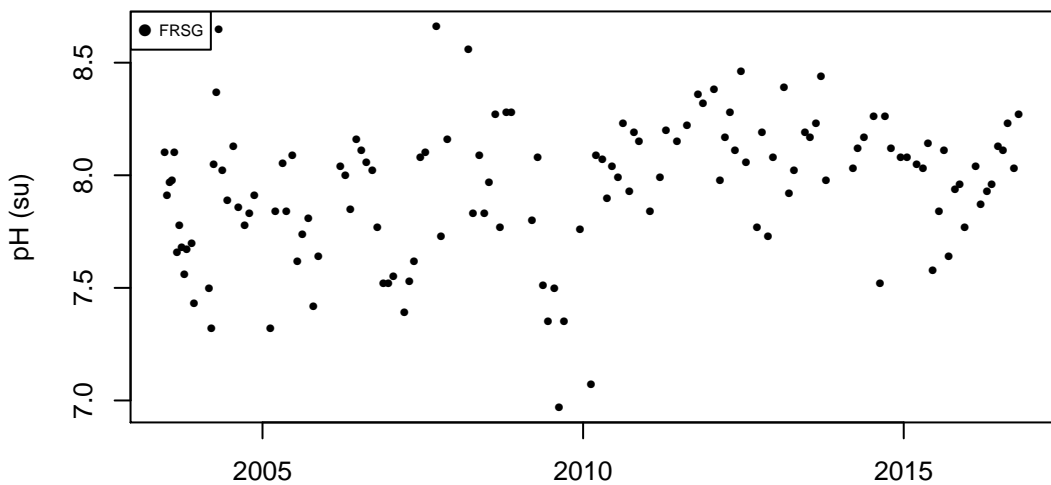


(c) Annual values

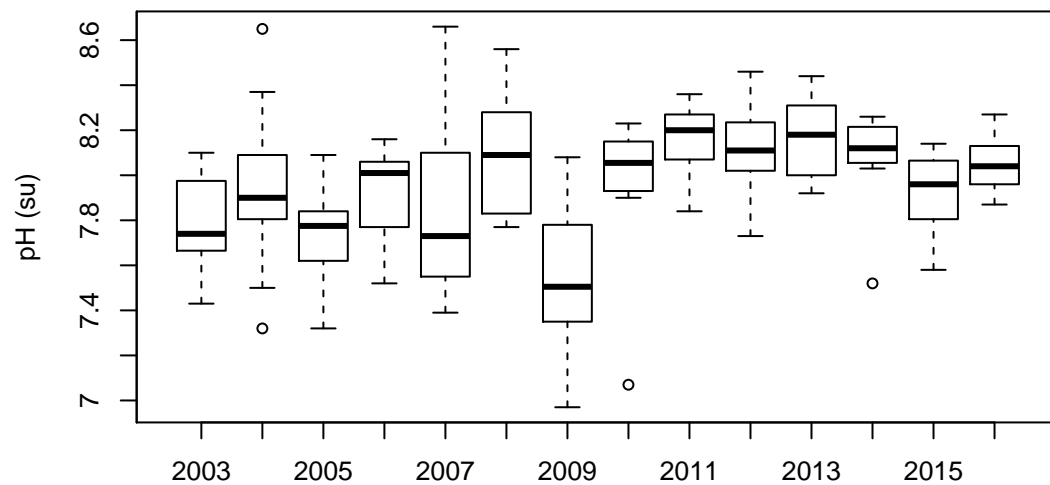


(d) Boxplot by month

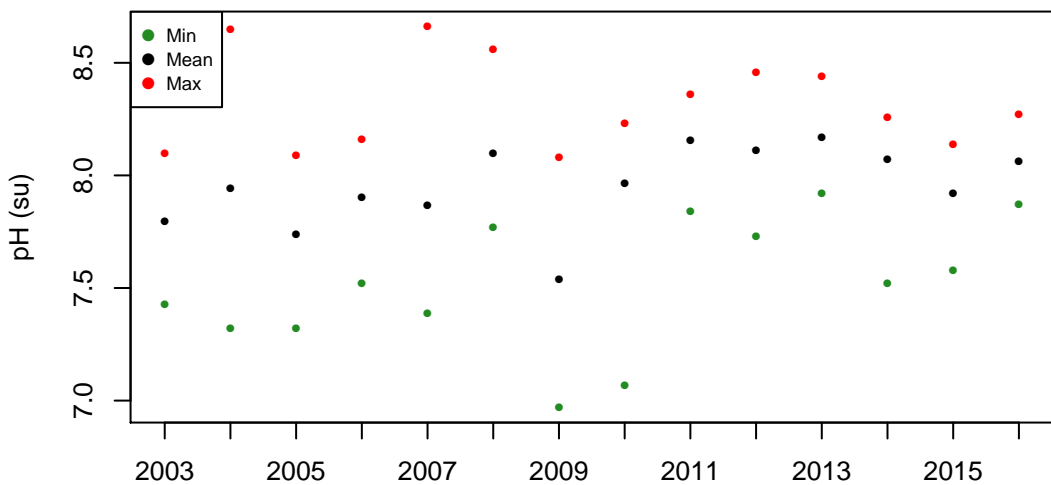
Ferson Cr near Mouth-Elgin (79): pH (su)



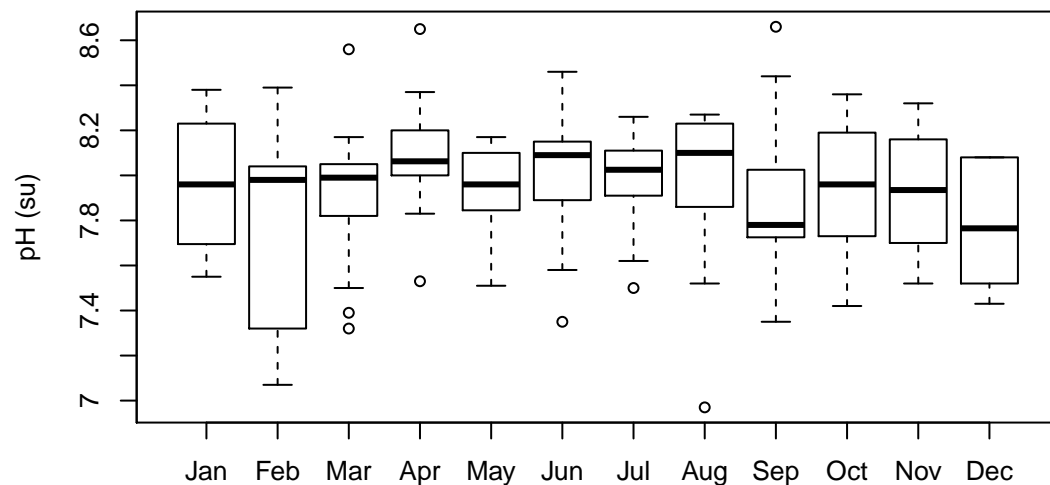
(a) Observation data



(b) Boxplot by year

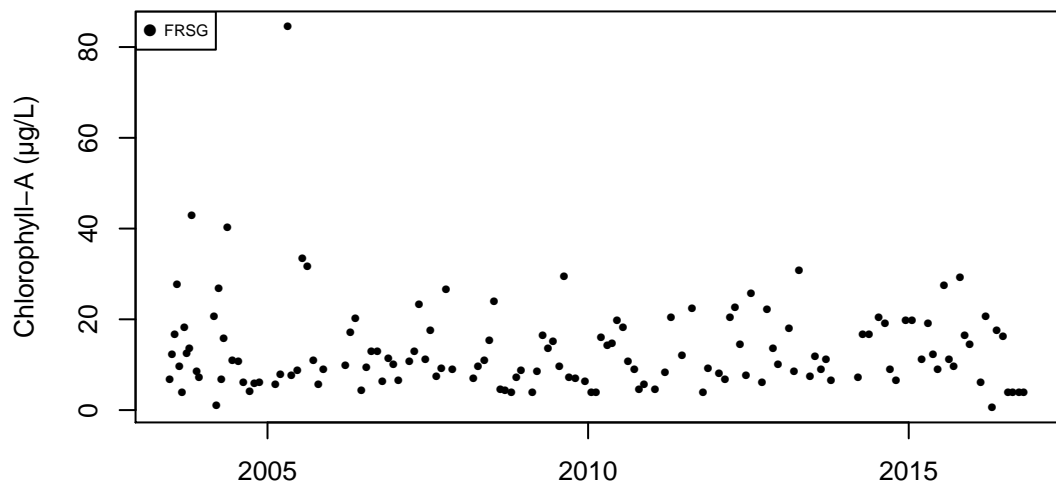


(c) Annual values

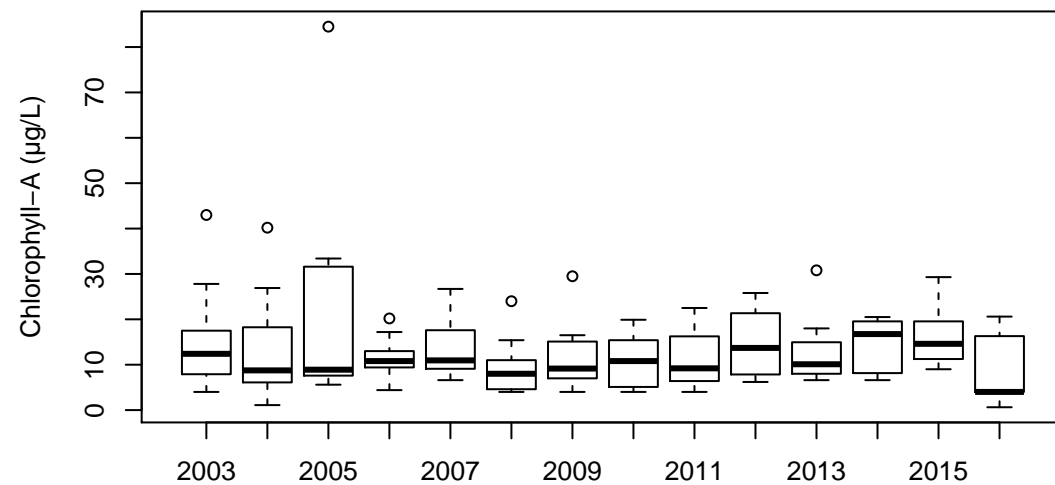


(d) Boxplot by month

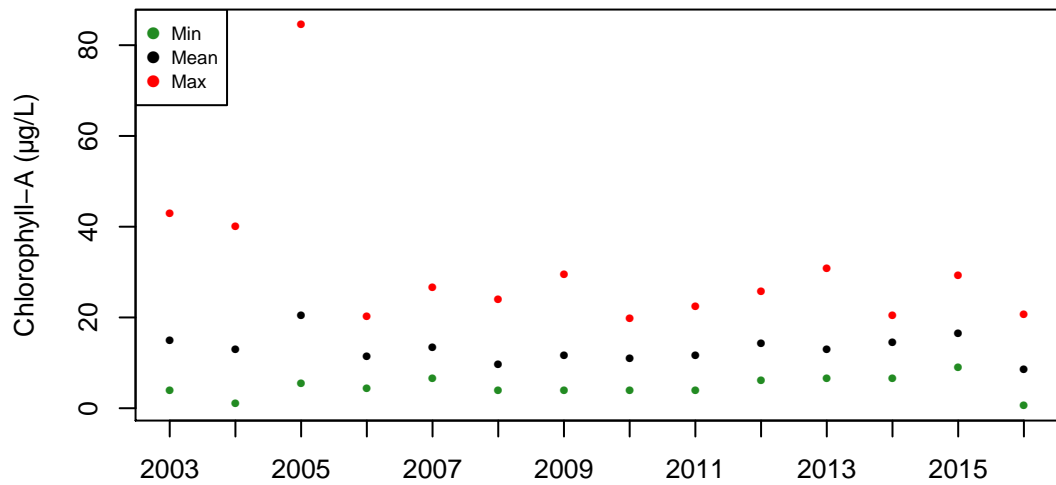
Ferson Cr near Mouth-Elgin (79): Chlorophyll-A ($\mu\text{g/L}$)



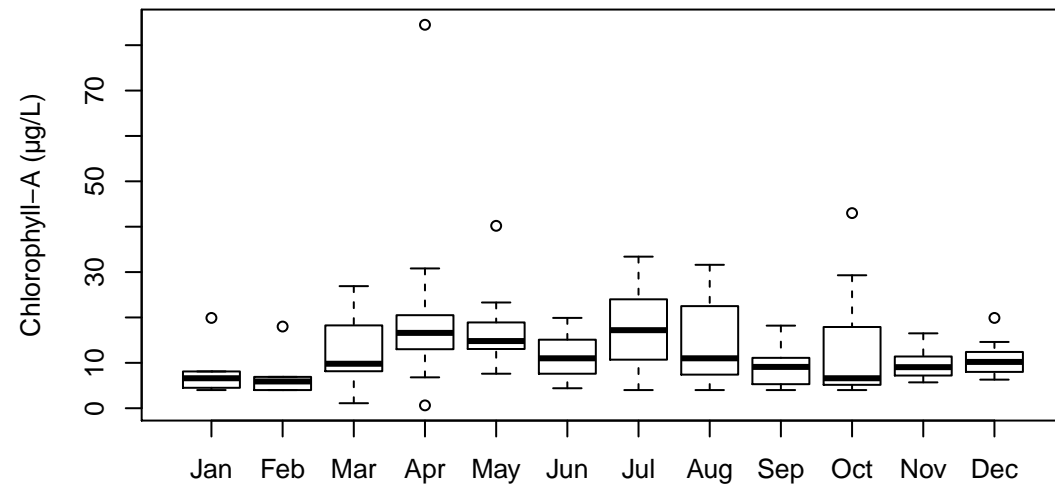
(a) Observation data



(b) Boxplot by year

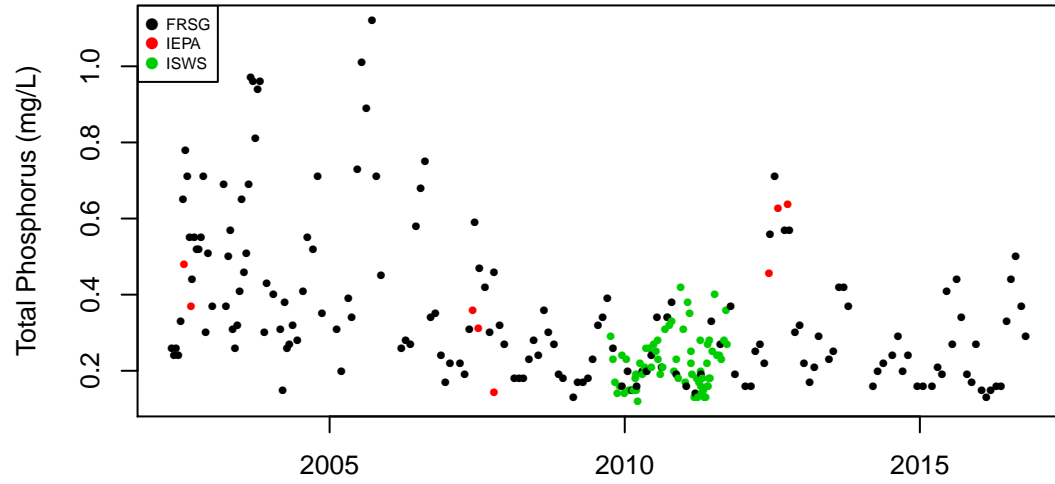


(c) Annual values

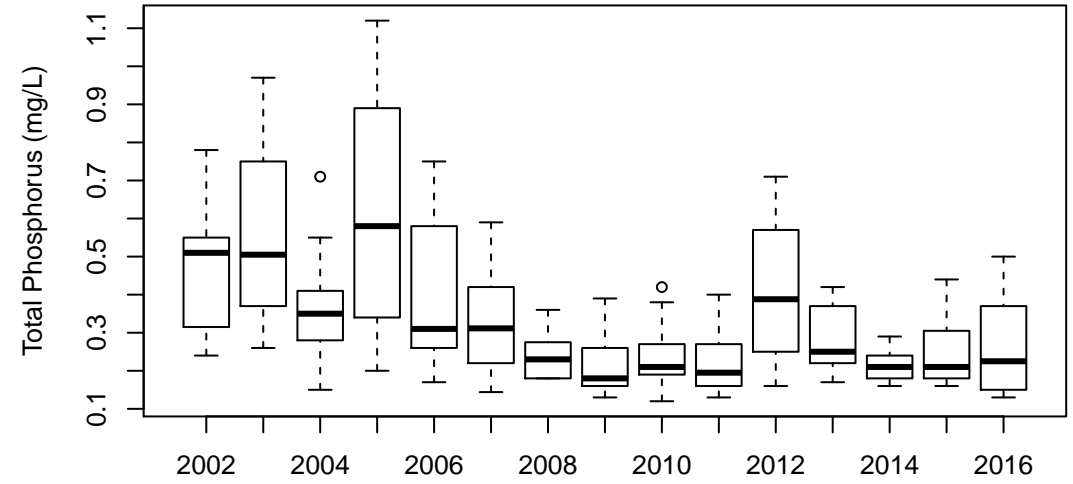


(d) Boxplot by month

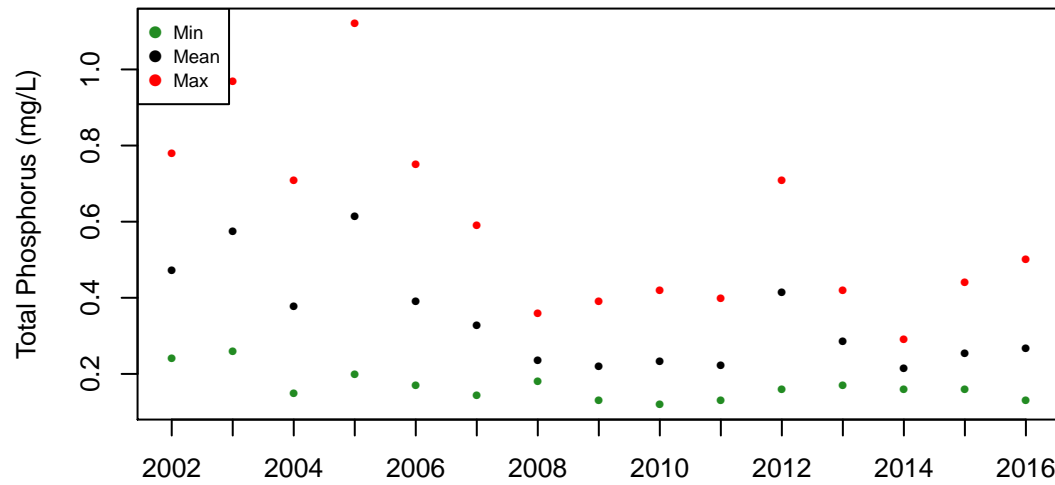
Fox River at Geneva (40): Total Phosphorus (mg/L)



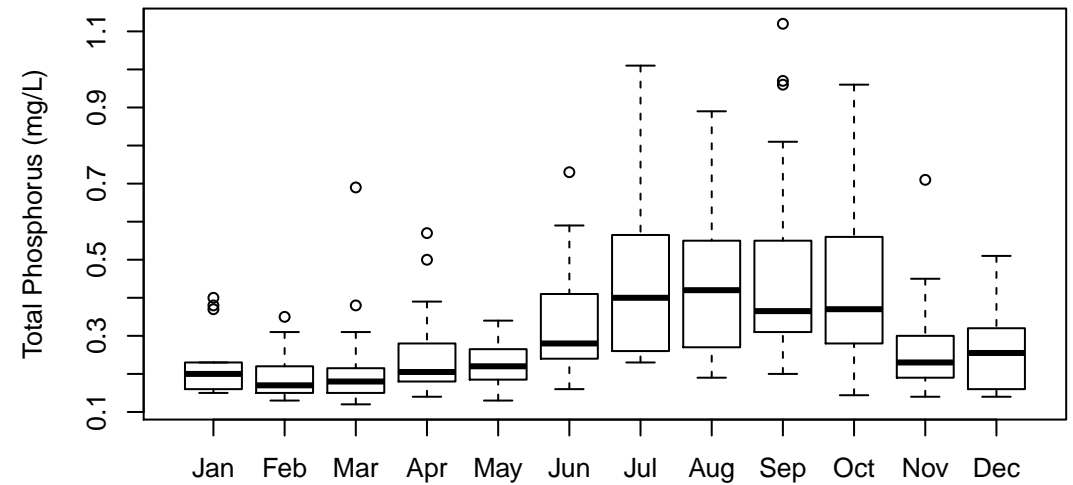
(a) Observation data



(b) Boxplot by year

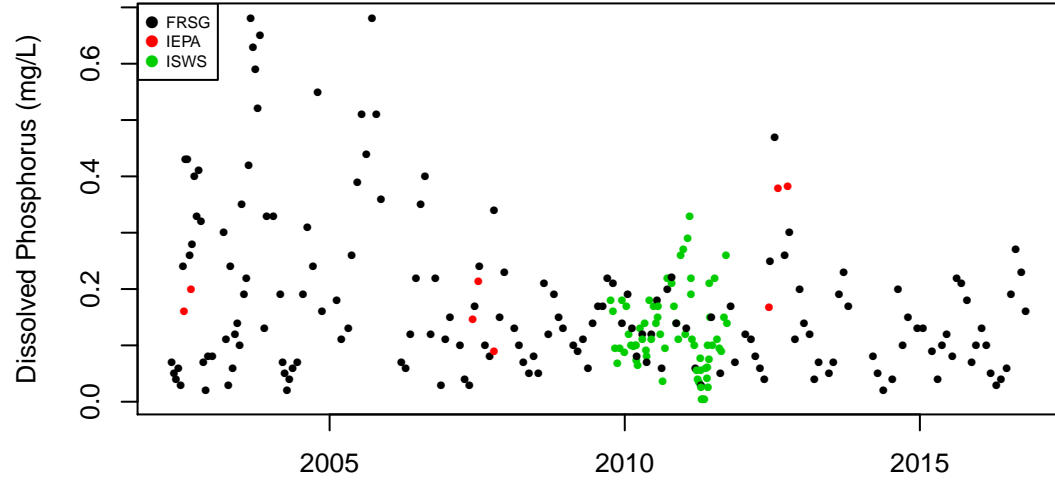


(c) Annual values

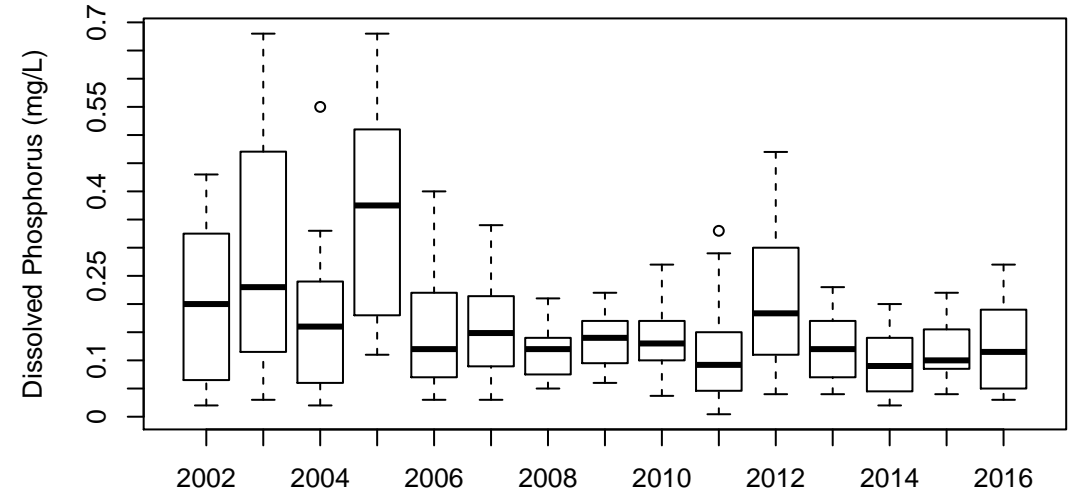


(d) Boxplot by month

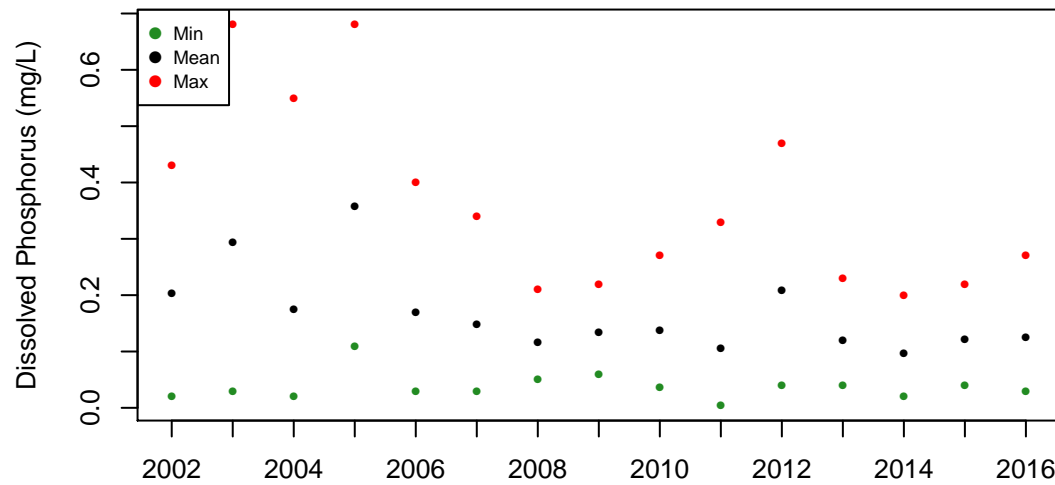
Fox River at Geneva (40): Dissolved Phosphorus (mg/L)



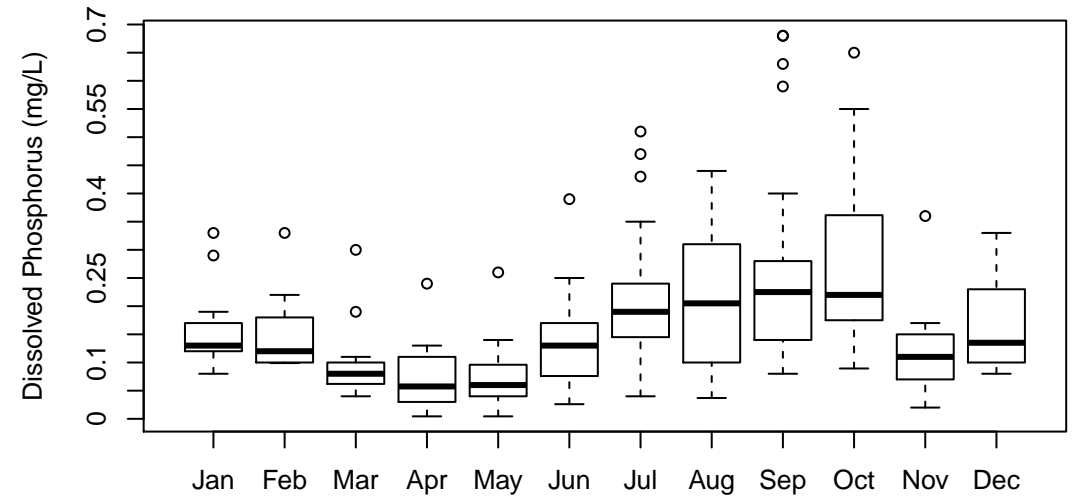
(a) Observation data



(b) Boxplot by year

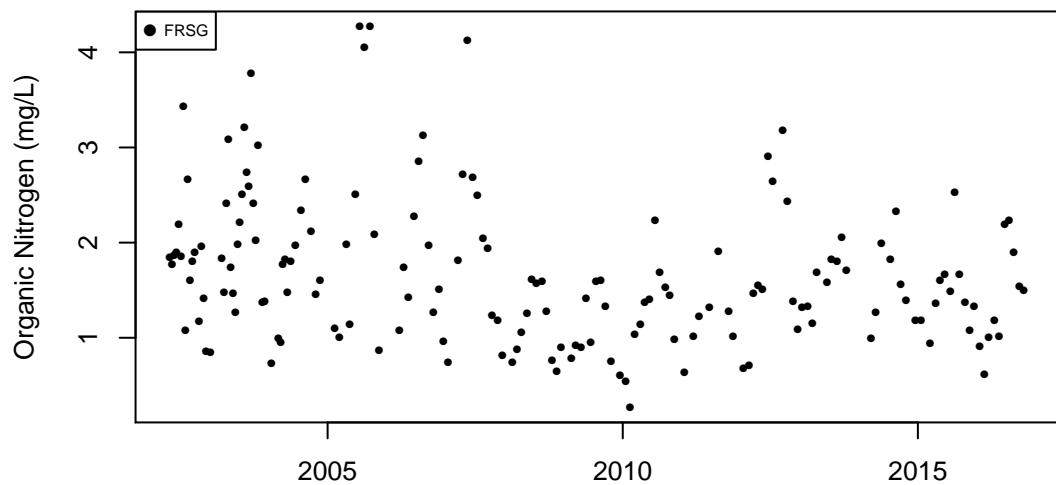


(c) Annual values

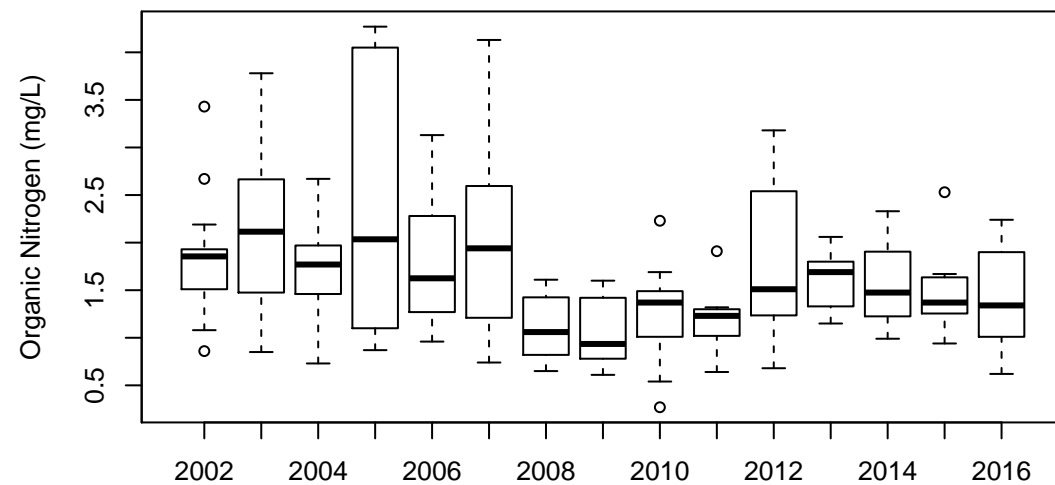


(d) Boxplot by month

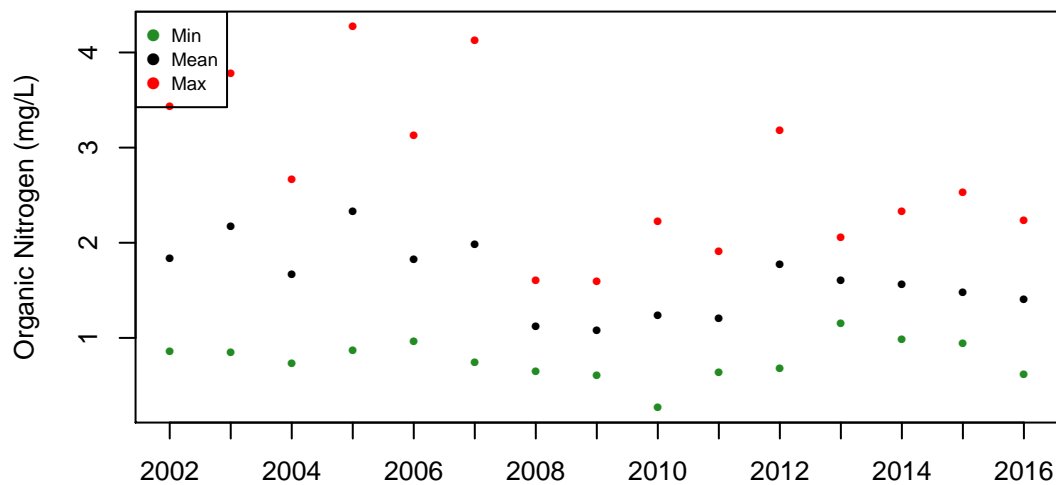
Fox River at Geneva (40): Organic Nitrogen (mg/L)



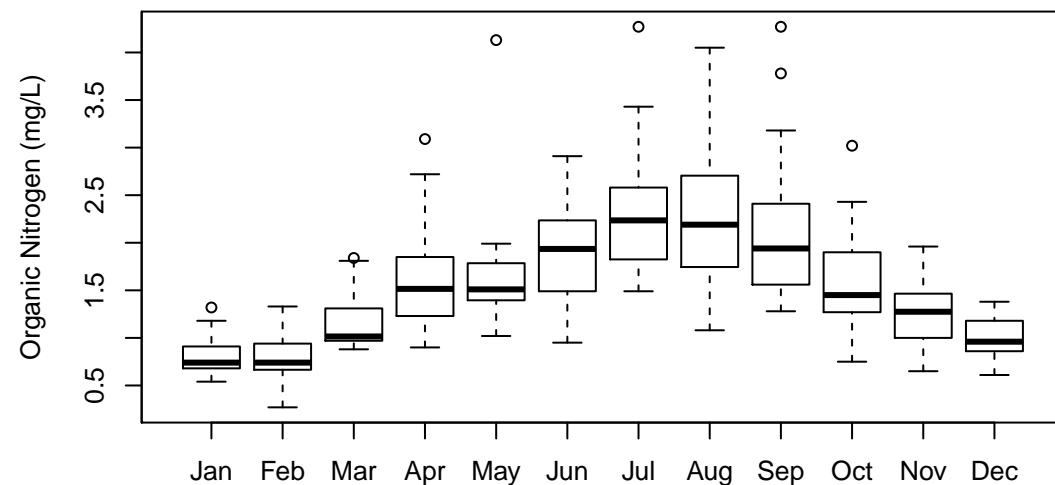
(a) Observation data



(b) Boxplot by year



(c) Annual values

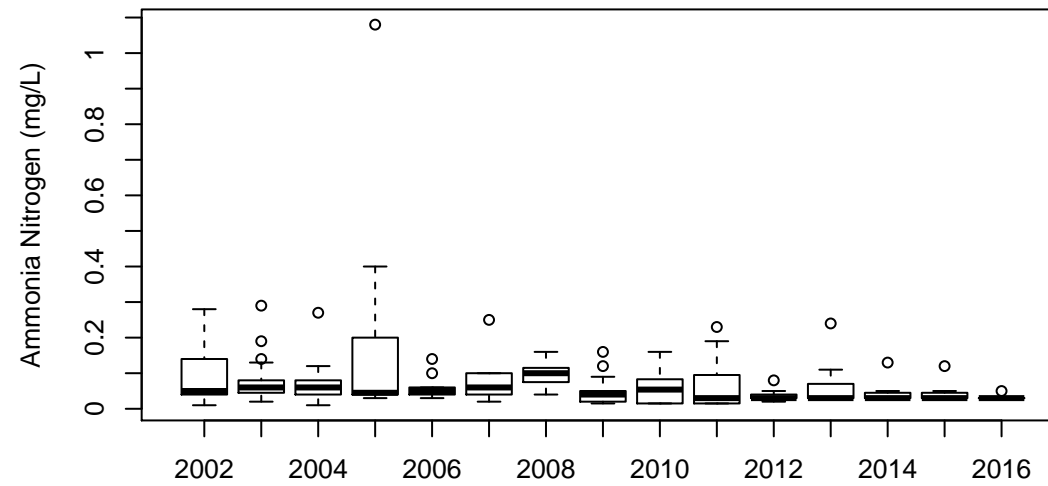


(d) Boxplot by month

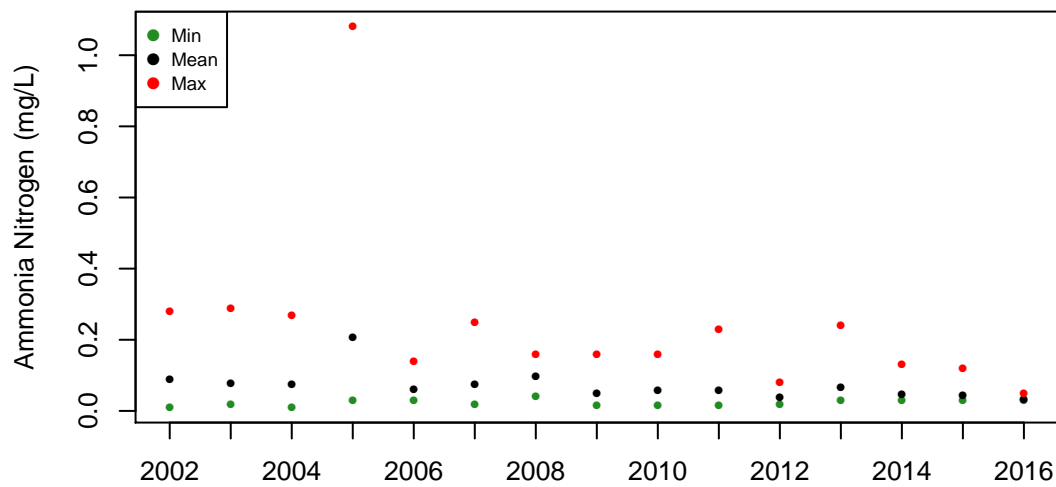
Fox River at Geneva (40): Ammonia Nitrogen (mg/L)



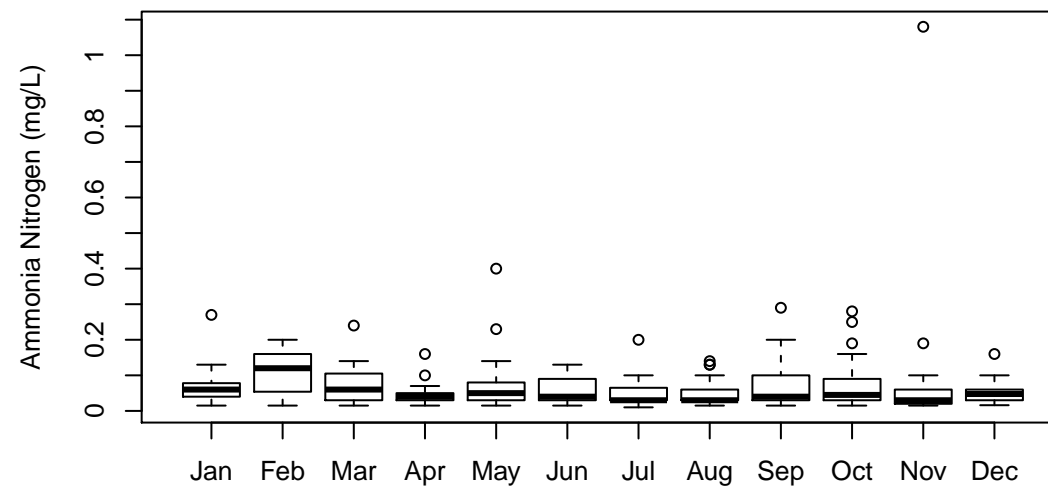
Sampling date
(a) Observation data



Year
(b) Boxplot by year

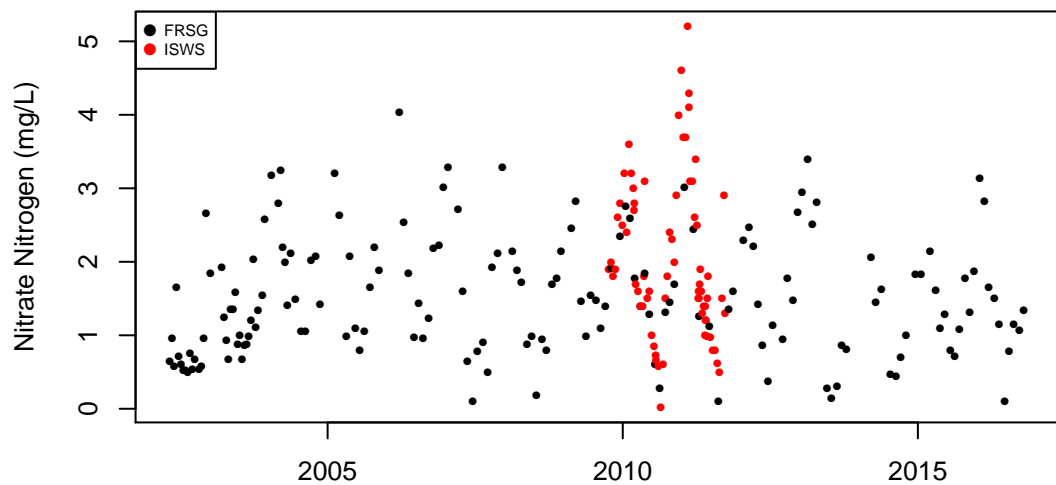


Year
(c) Annual values

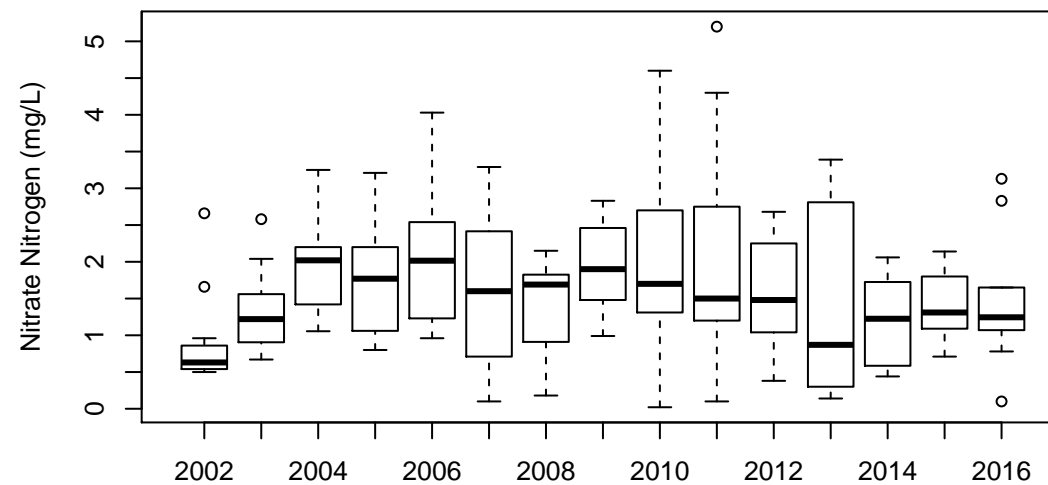


Month
(d) Boxplot by month

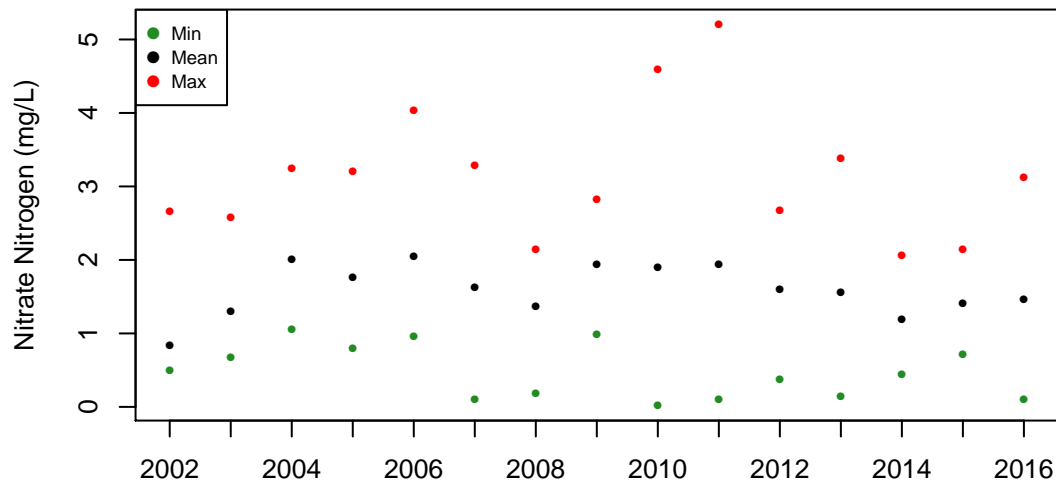
Fox River at Geneva (40): Nitrate Nitrogen (mg/L)



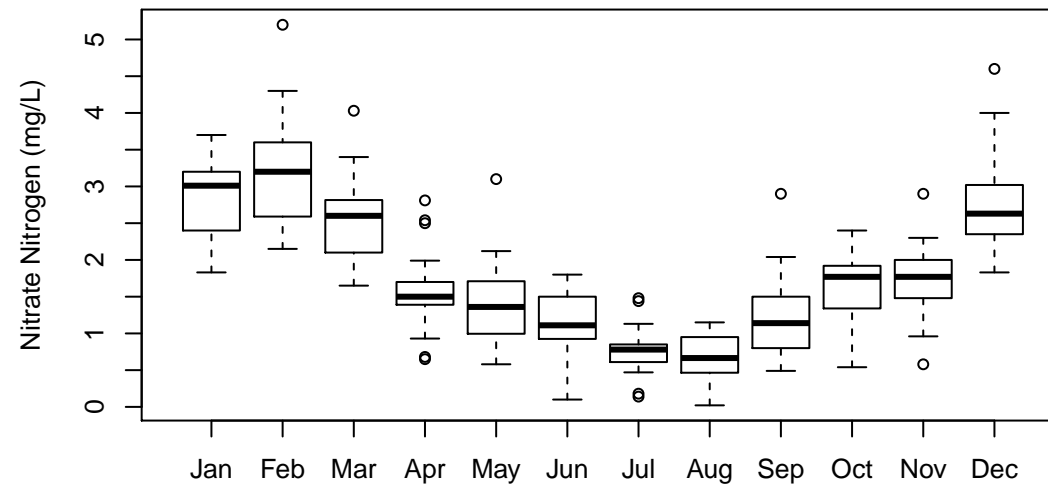
(a) Observation data



(b) Boxplot by year

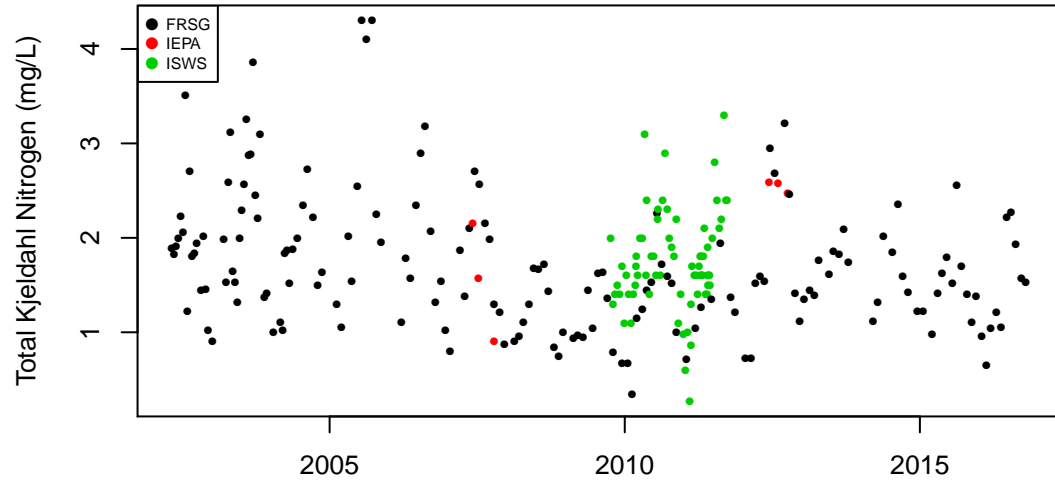


(c) Annual values

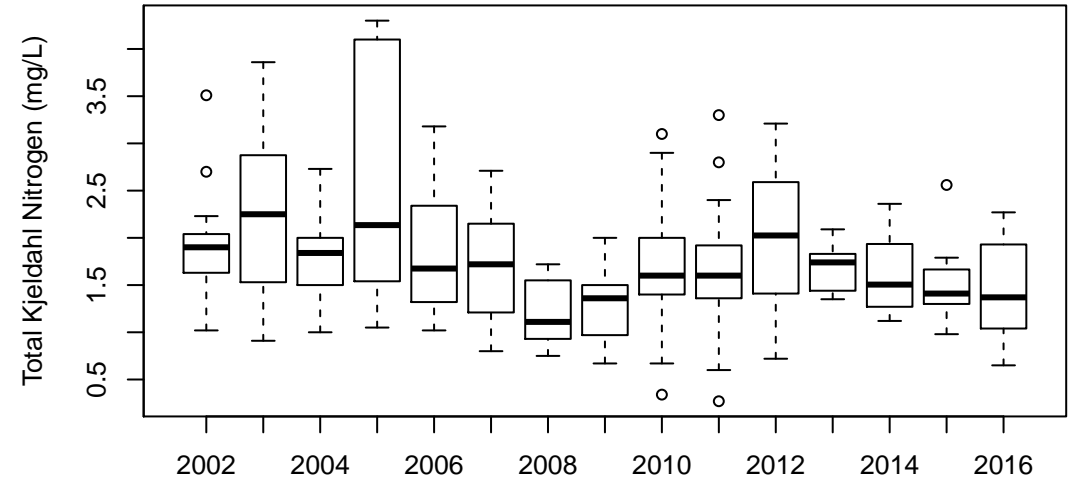


(d) Boxplot by month

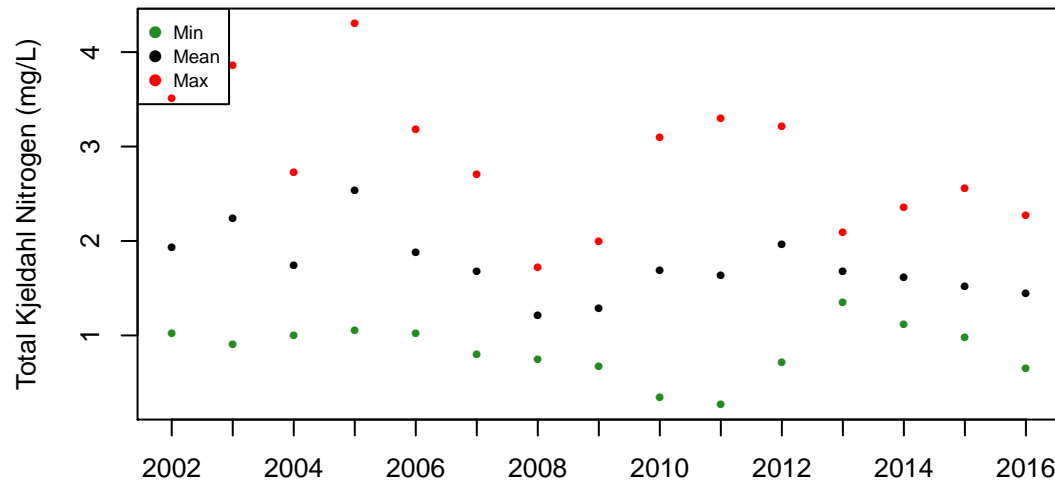
Fox River at Geneva (40): Total Kjeldahl Nitrogen (mg/L)



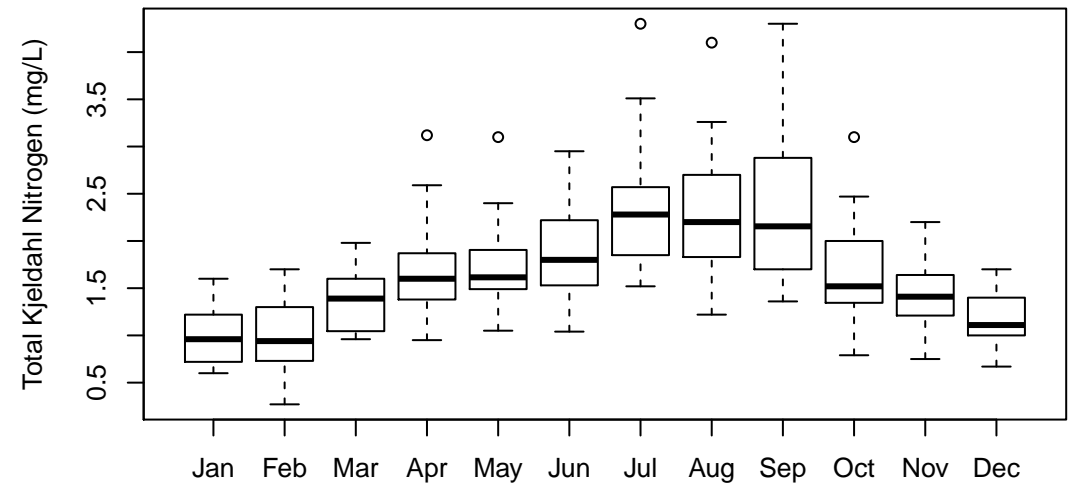
(a) Observation data



(b) Boxplot by year

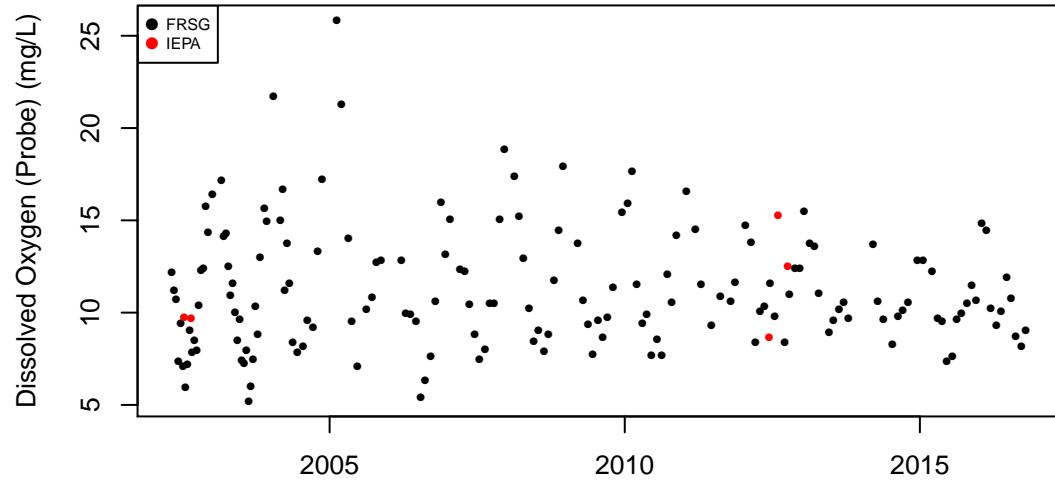


(c) Annual values

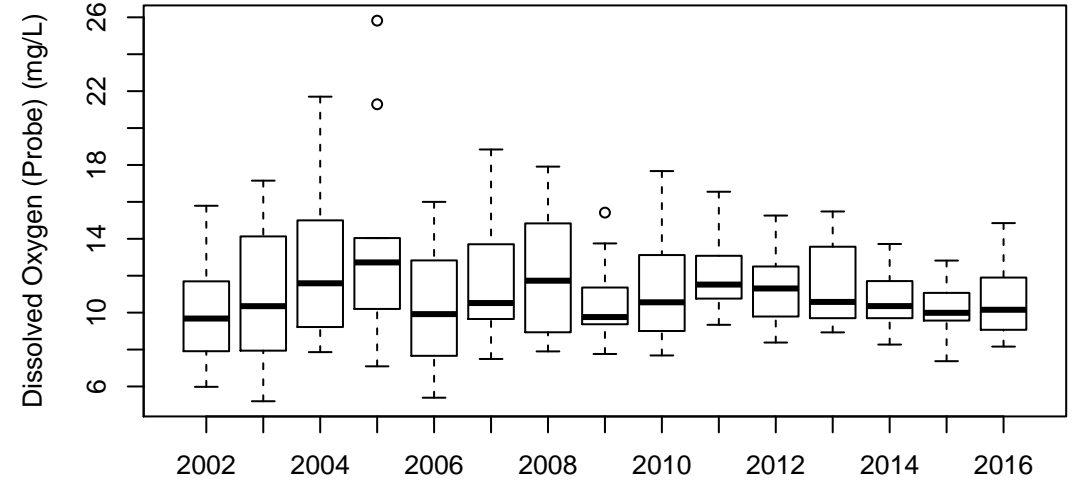


(d) Boxplot by month

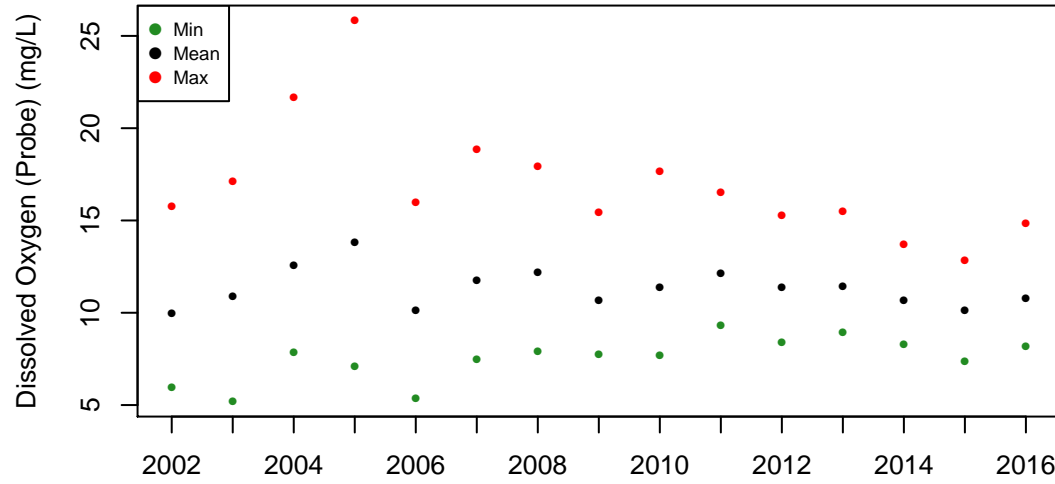
Fox River at Geneva (40): Dissolved Oxygen (Probe) (mg/L)



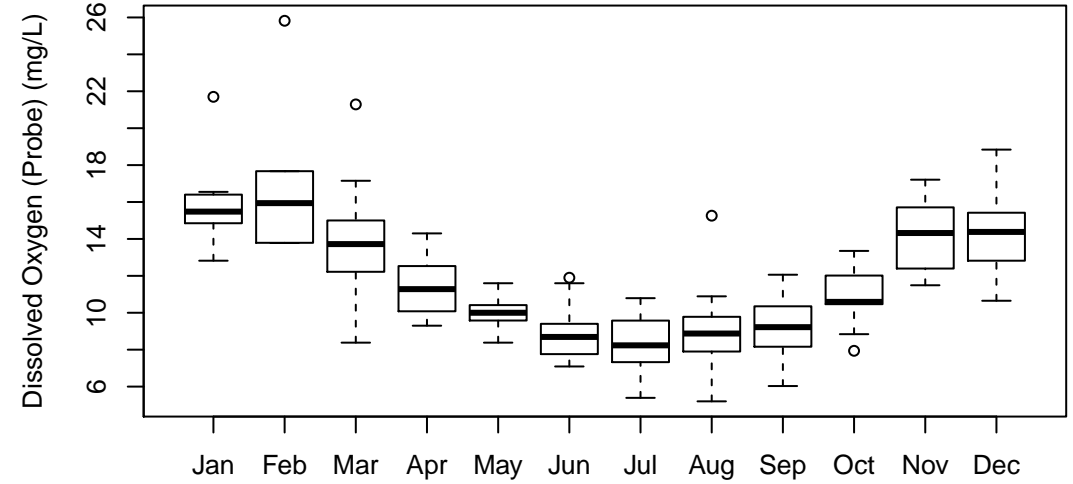
(a) Observation data



(b) Boxplot by year

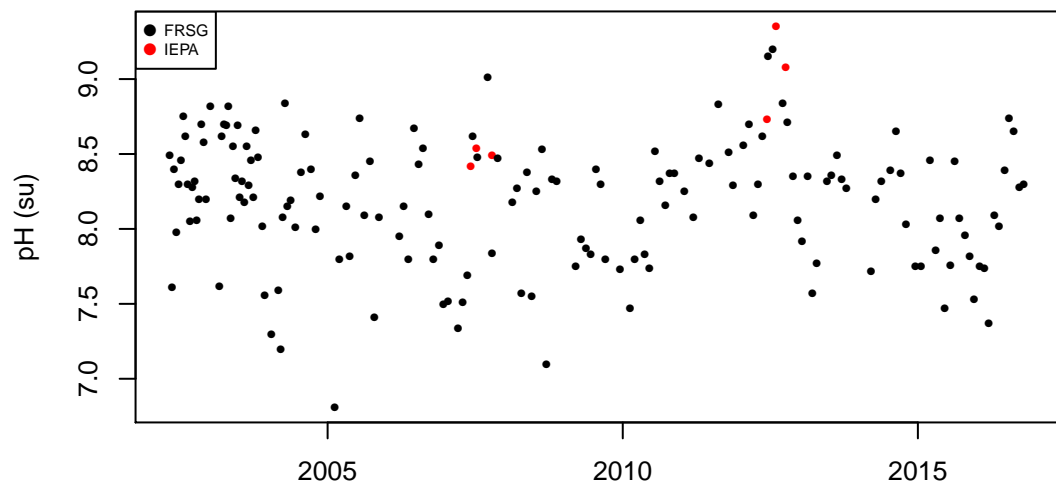


(c) Annual values

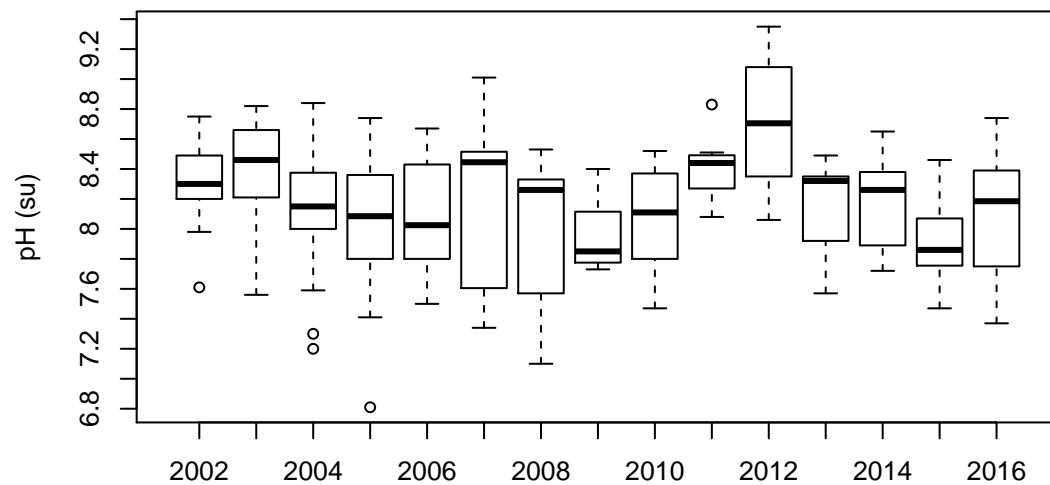


(d) Boxplot by month

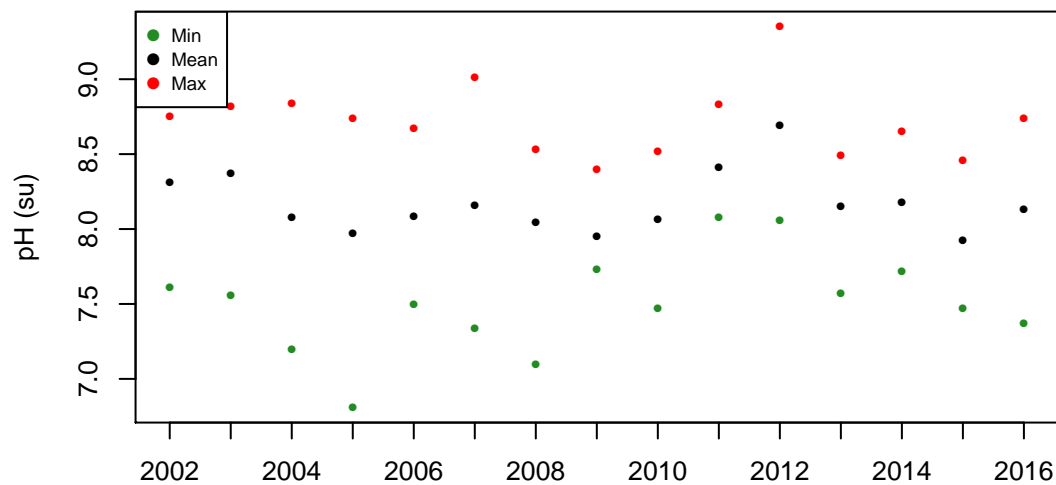
Fox River at Geneva (40): pH (su)



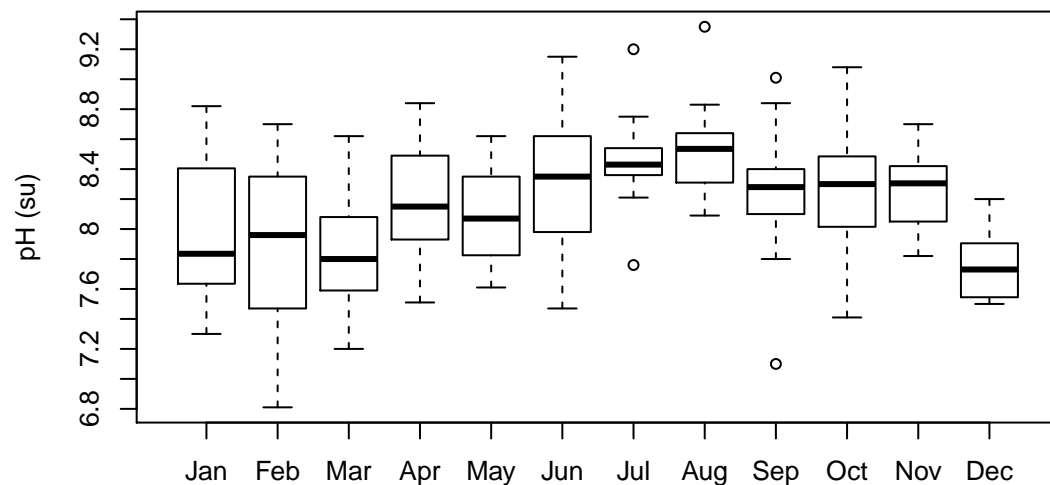
(a) Observation data



(b) Boxplot by year

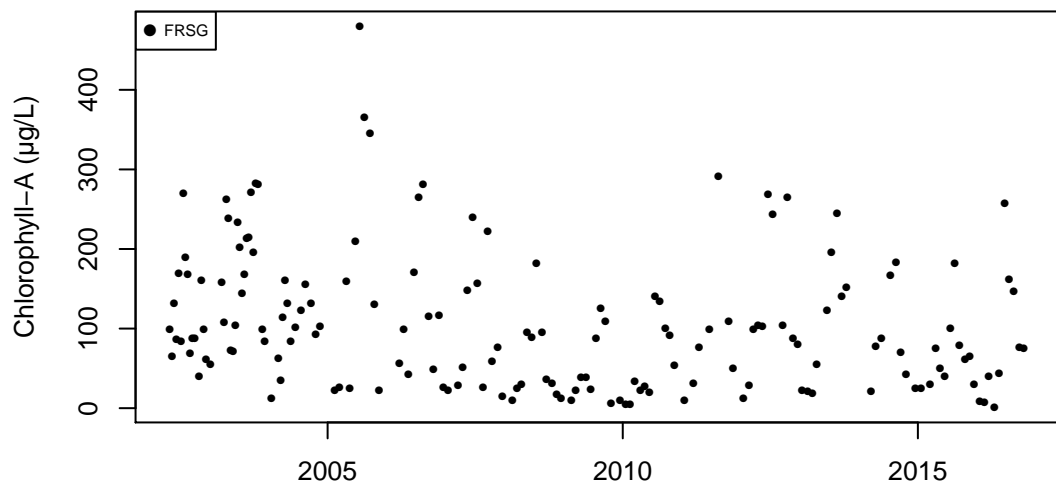


(c) Annual values

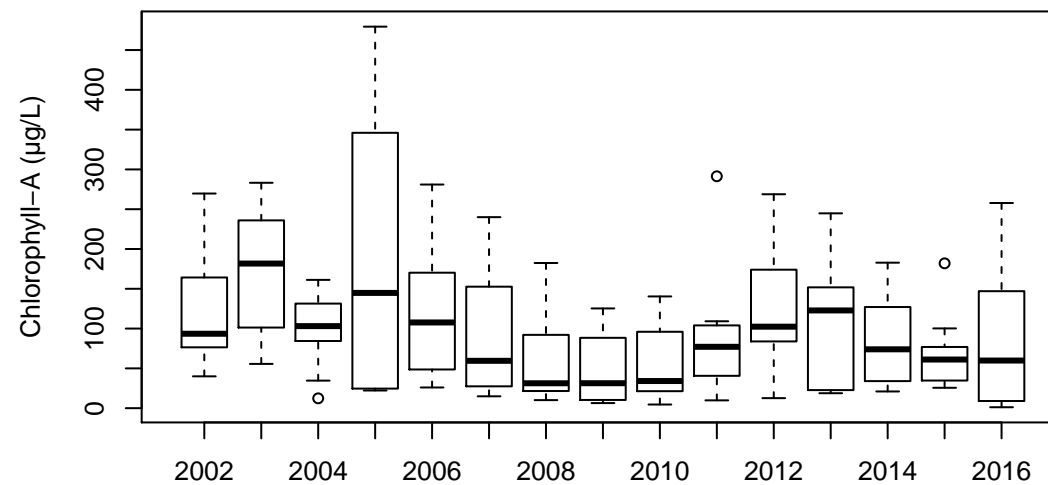


(d) Boxplot by month

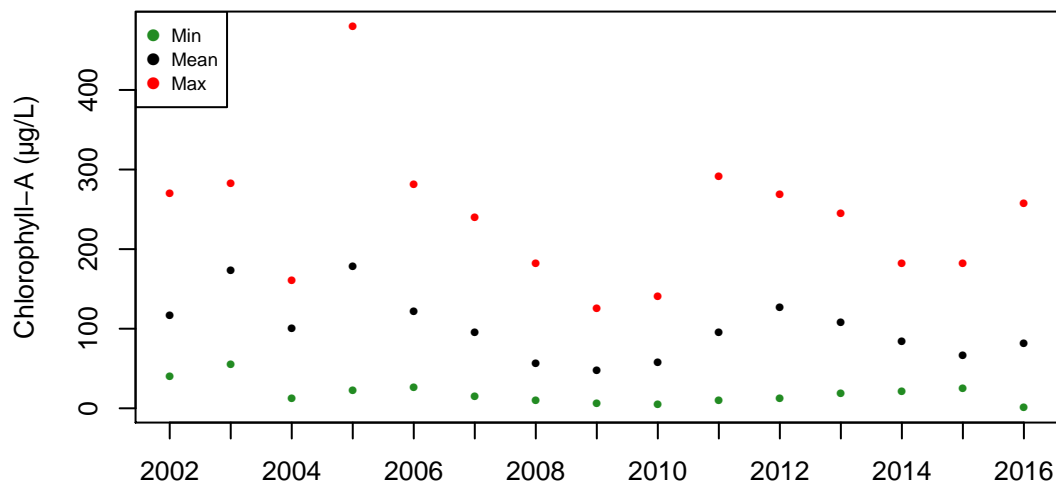
Fox River at Geneva (40): Chlorophyll-A ($\mu\text{g/L}$)



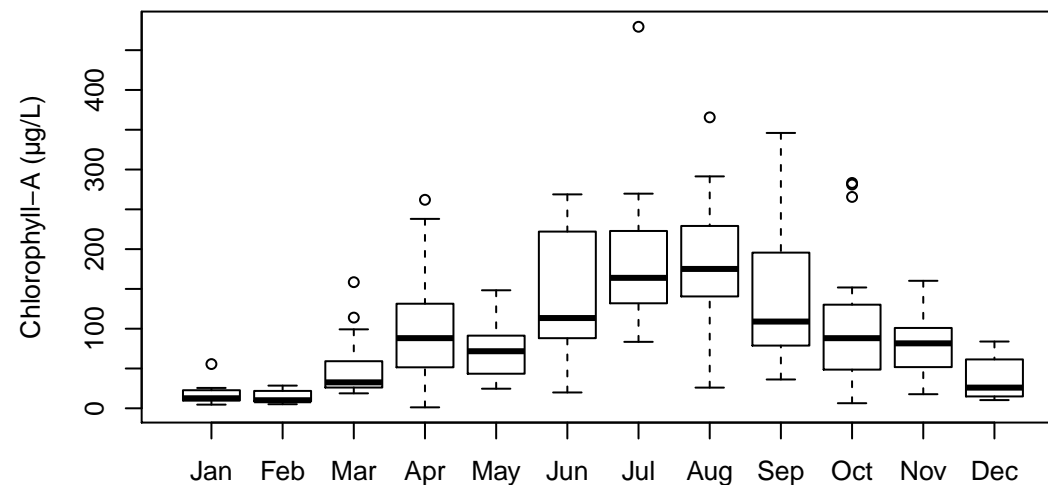
(a) Observation data



(b) Boxplot by year

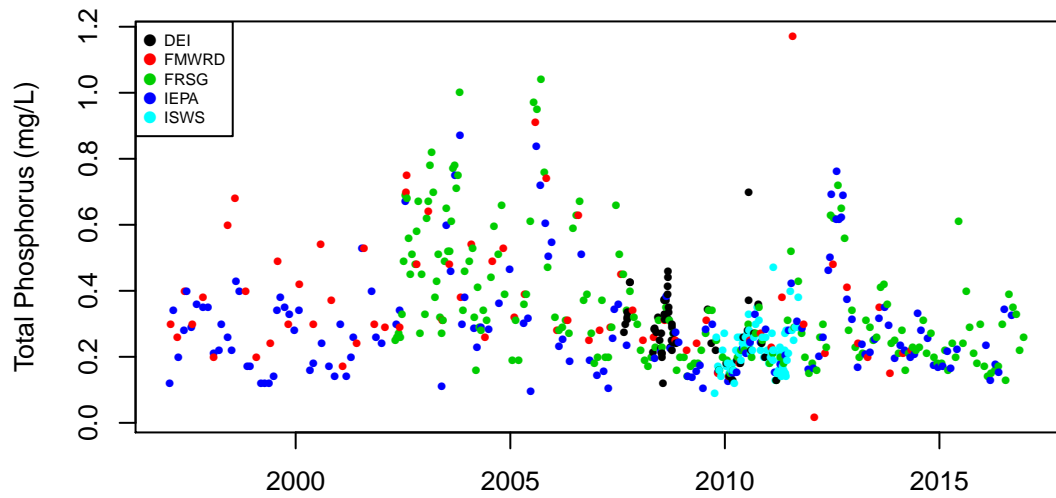


(c) Annual values

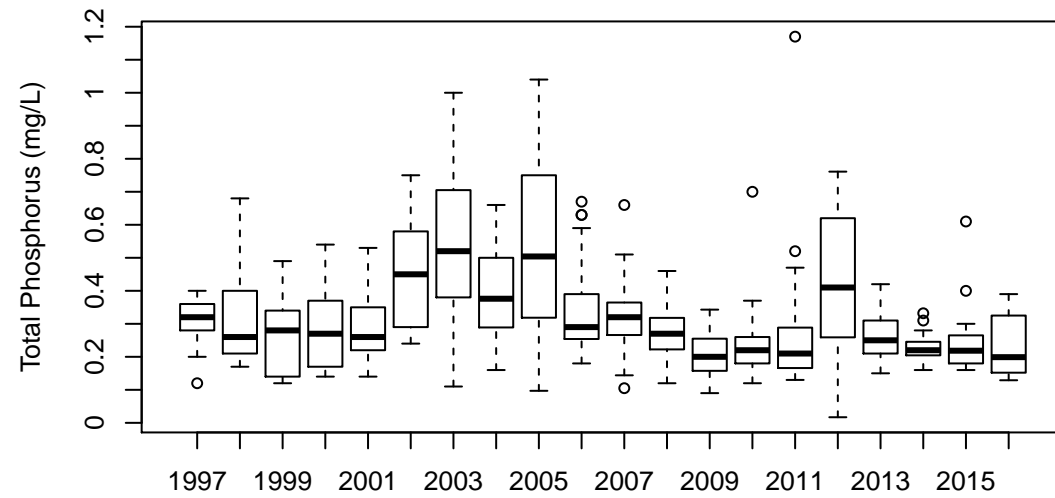


(d) Boxplot by month

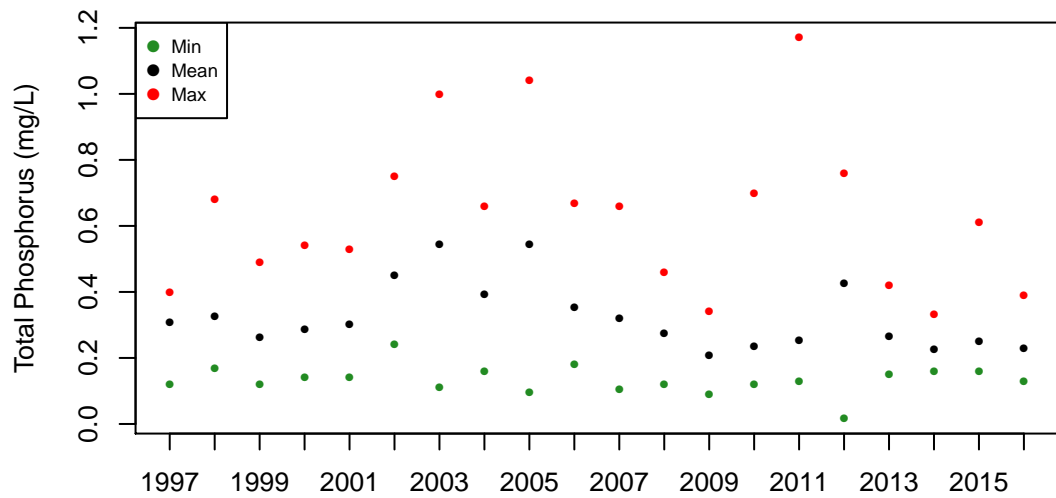
Fox River at Montgomery (27): Total Phosphorus (mg/L)



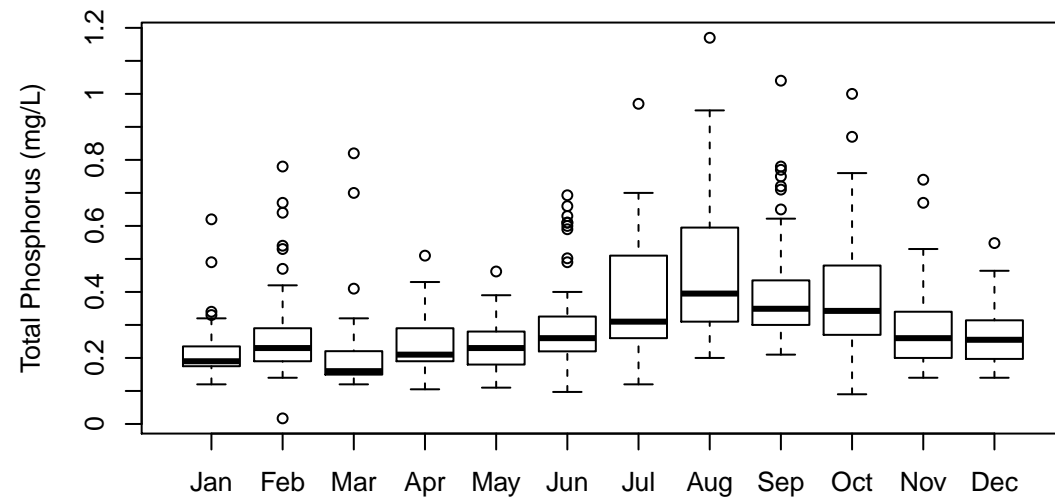
(a) Observation data



(b) Boxplot by year

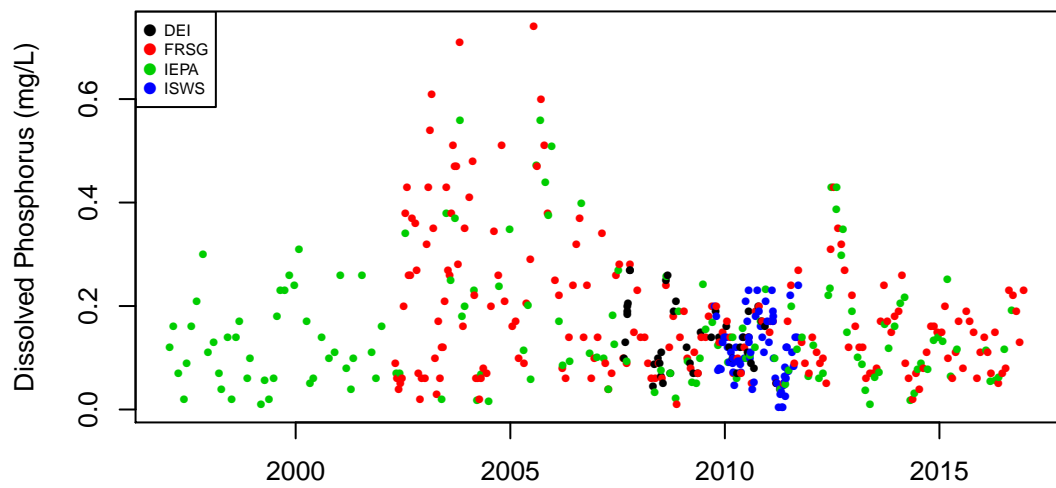


(c) Annual values

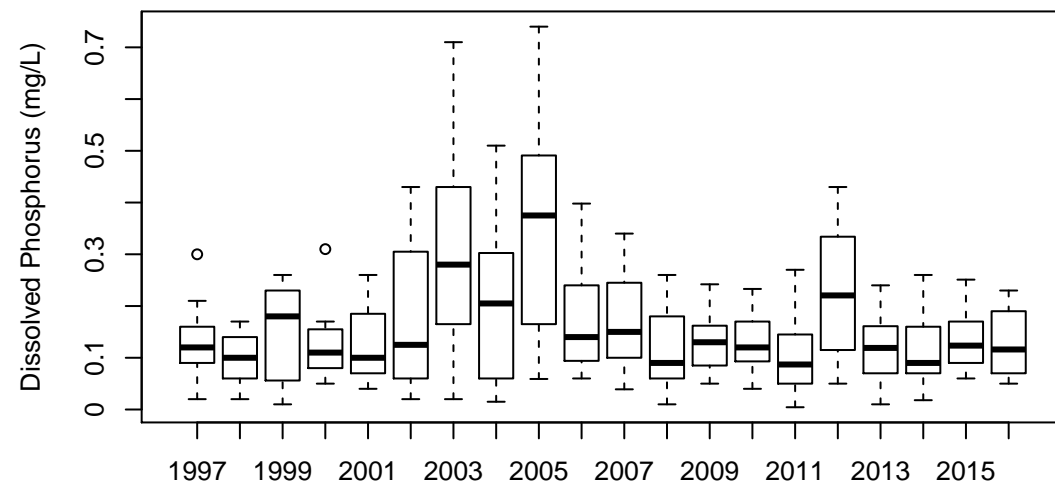


(d) Boxplot by month

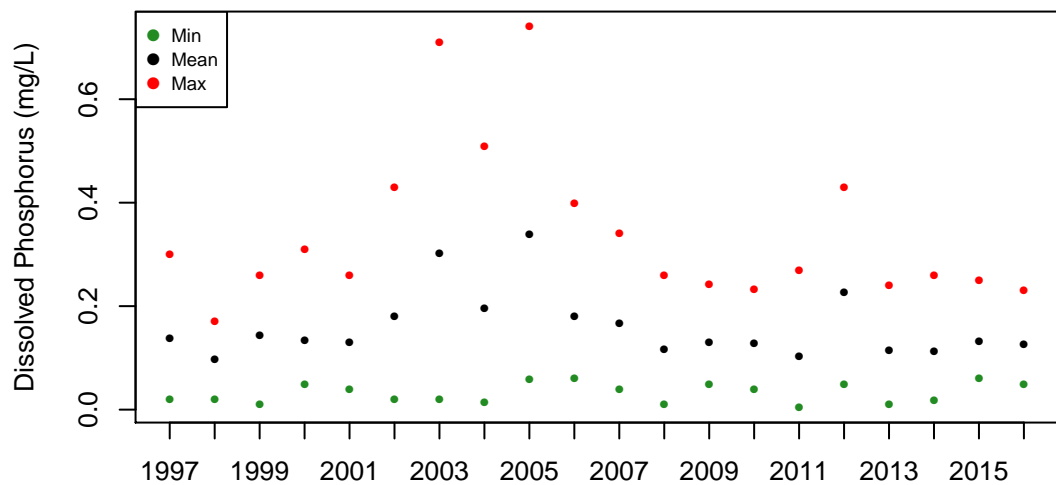
Fox River at Montgomery (27): Dissolved Phosphorus (mg/L)



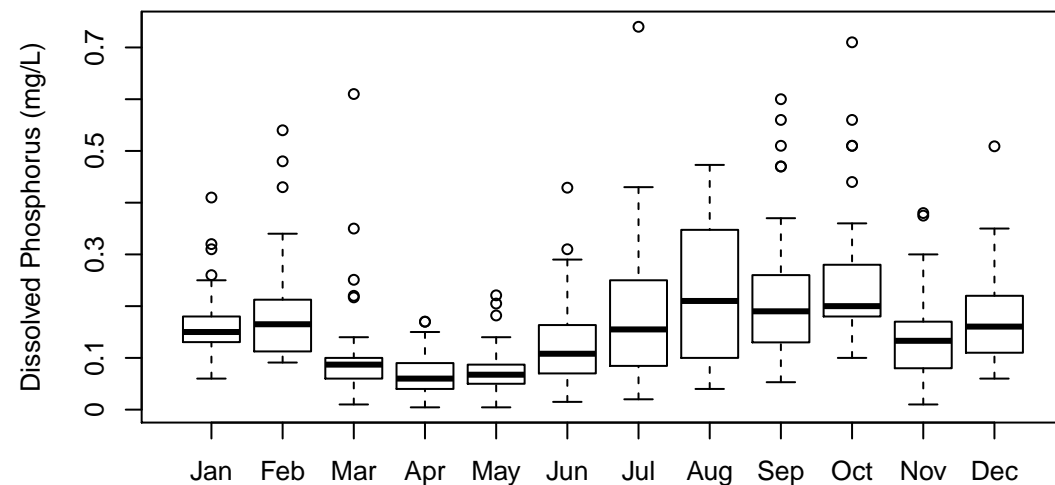
(a) Observation data



(b) Boxplot by year

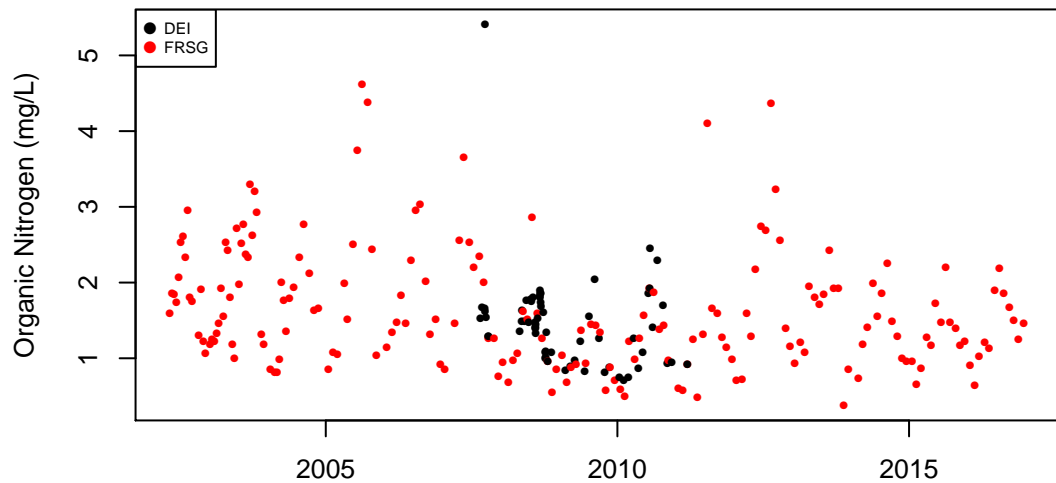


(c) Annual values

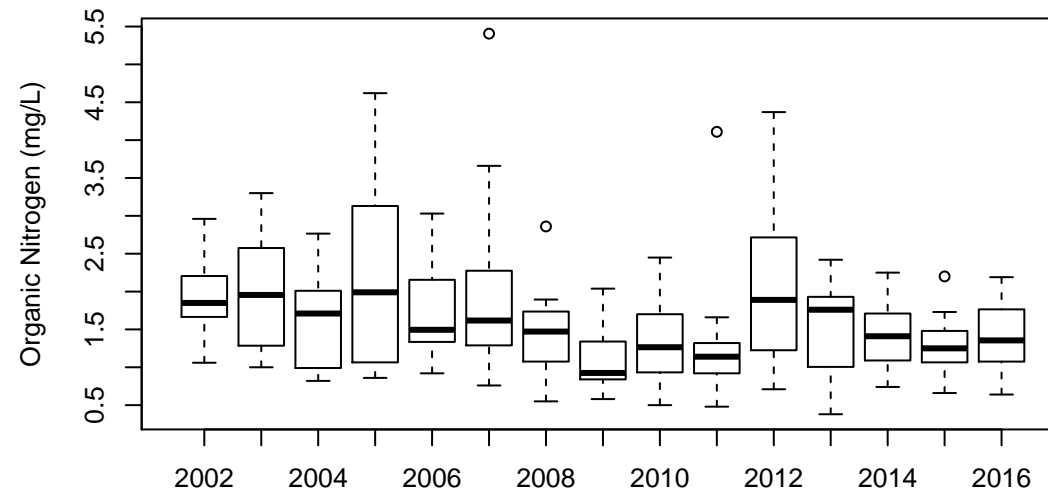


(d) Boxplot by month

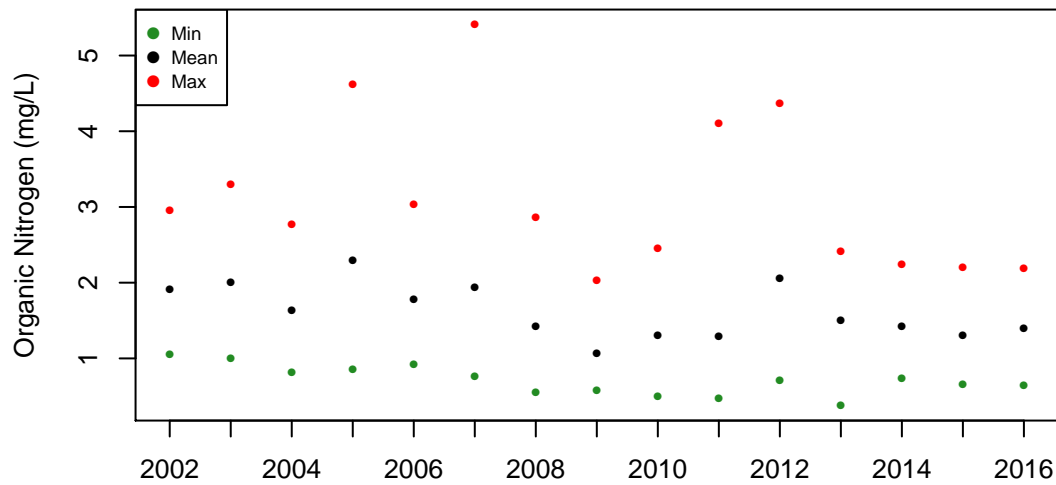
Fox River at Montgomery (27): Organic Nitrogen (mg/L)



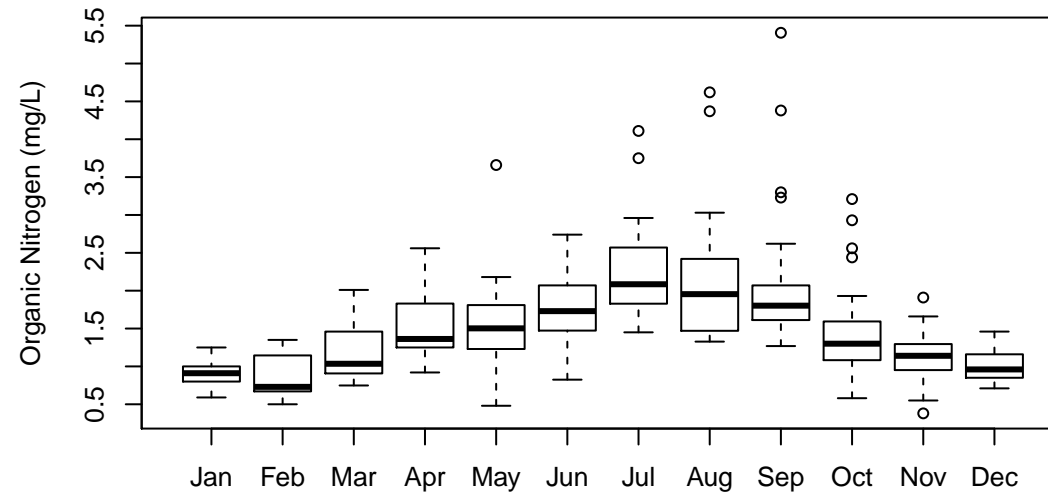
Sampling date
(a) Observation data



Year
(b) Boxplot by year

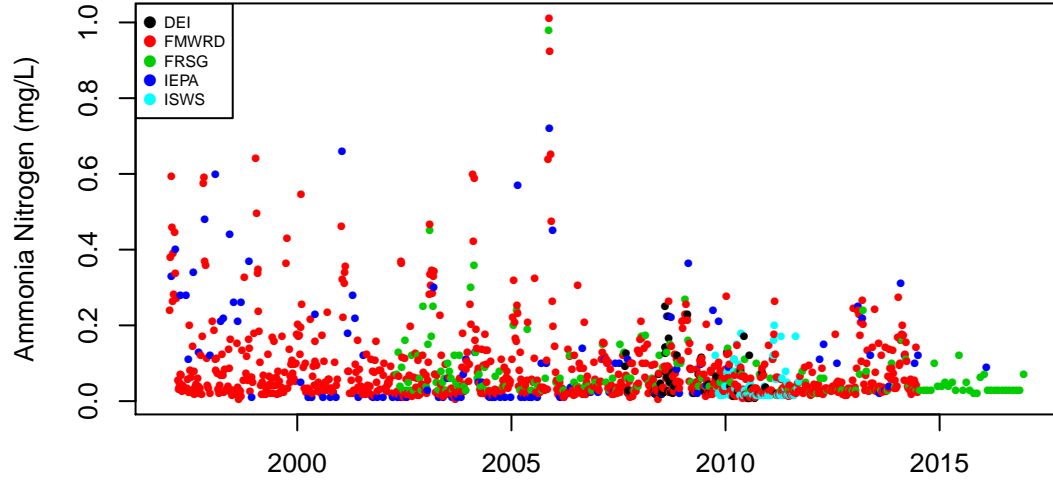


Year
(c) Annual values

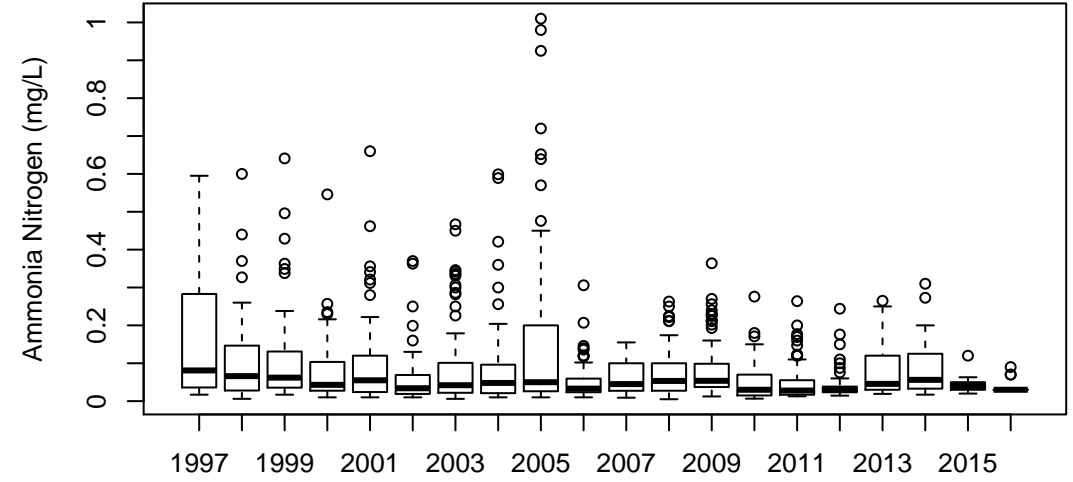


Month
(d) Boxplot by month

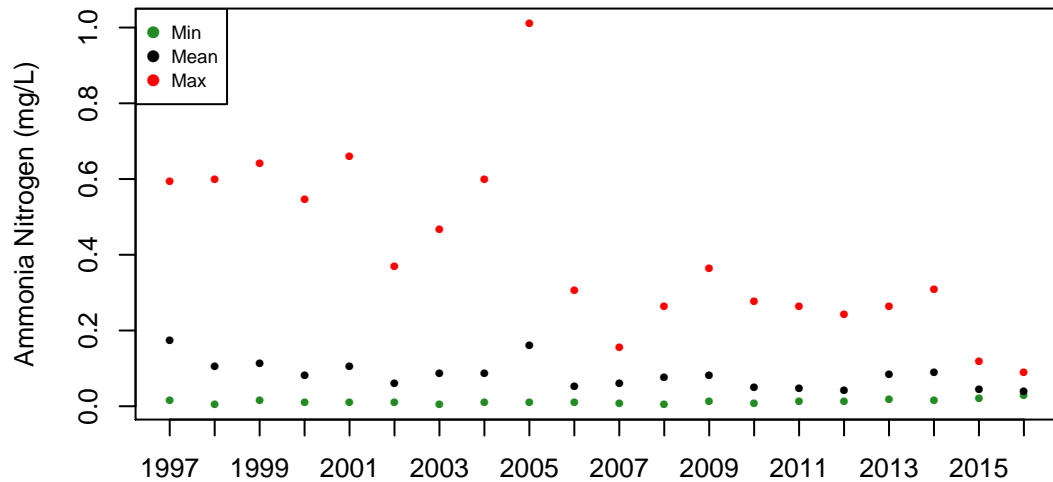
Fox River at Montgomery (27): Ammonia Nitrogen (mg/L)



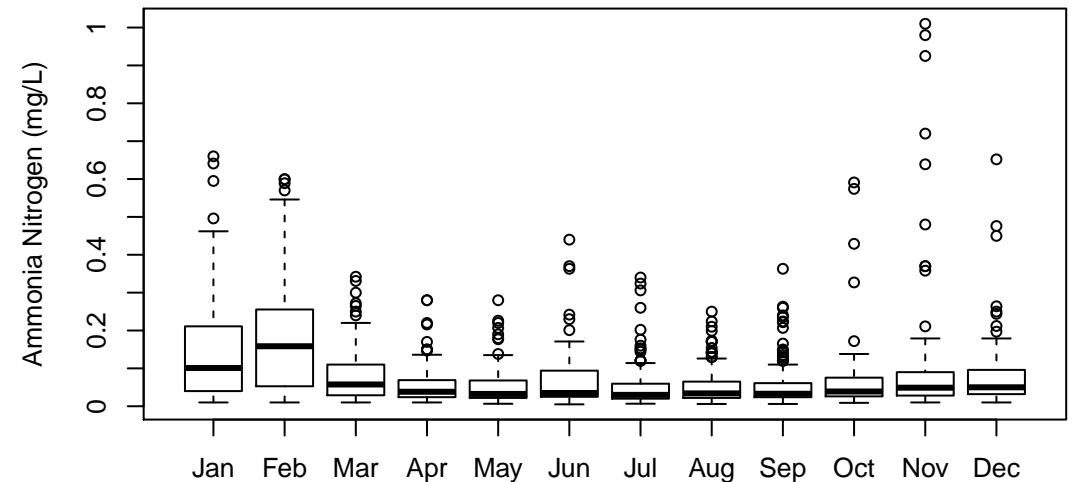
(a) Observation data



(b) Boxplot by year

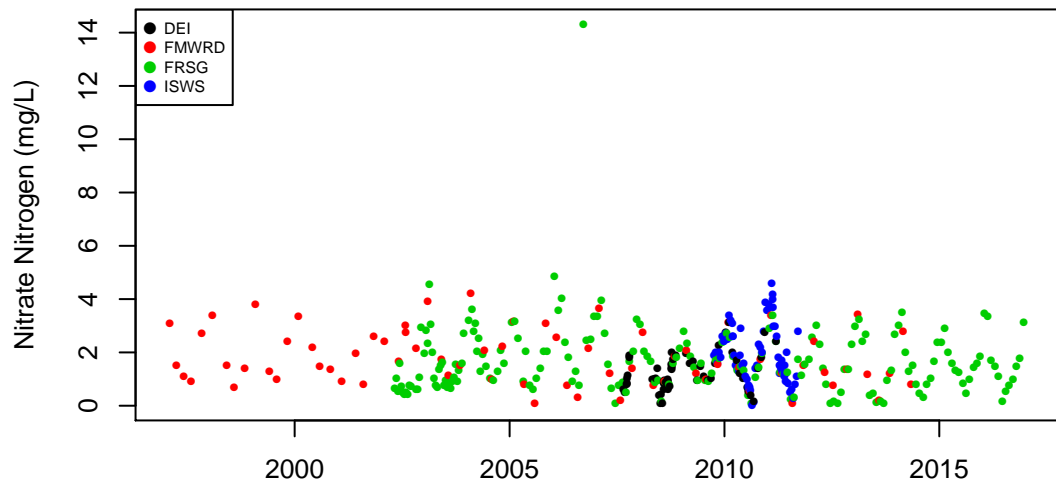


(c) Annual values

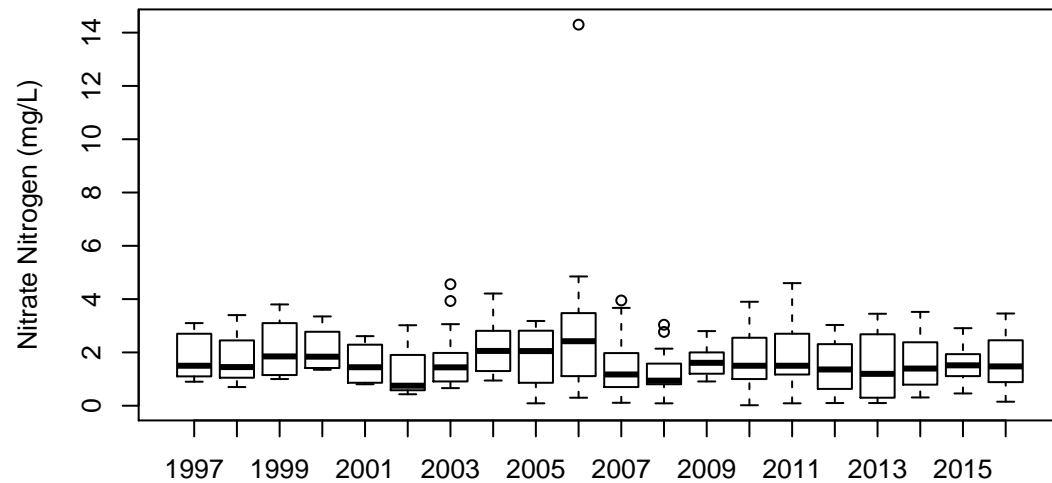


(d) Boxplot by month

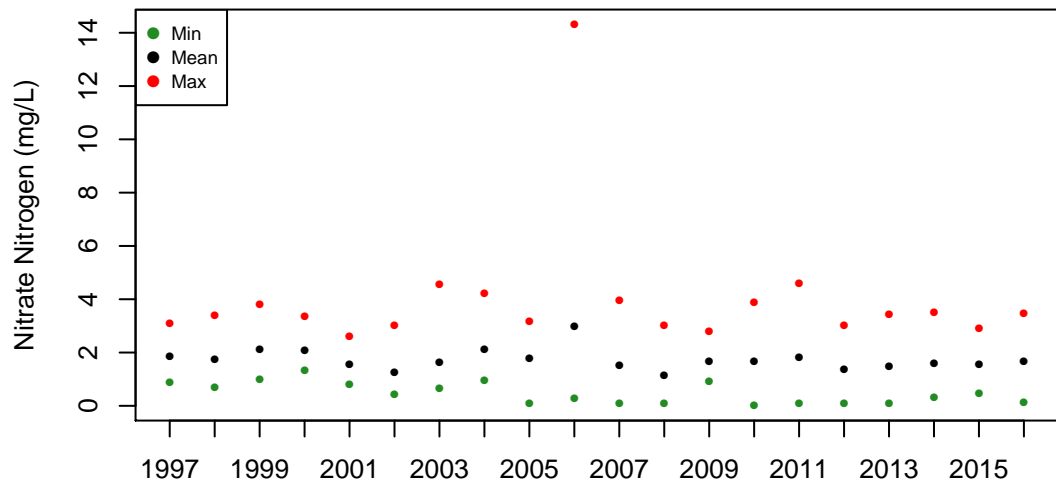
Fox River at Montgomery (27): Nitrate Nitrogen (mg/L)



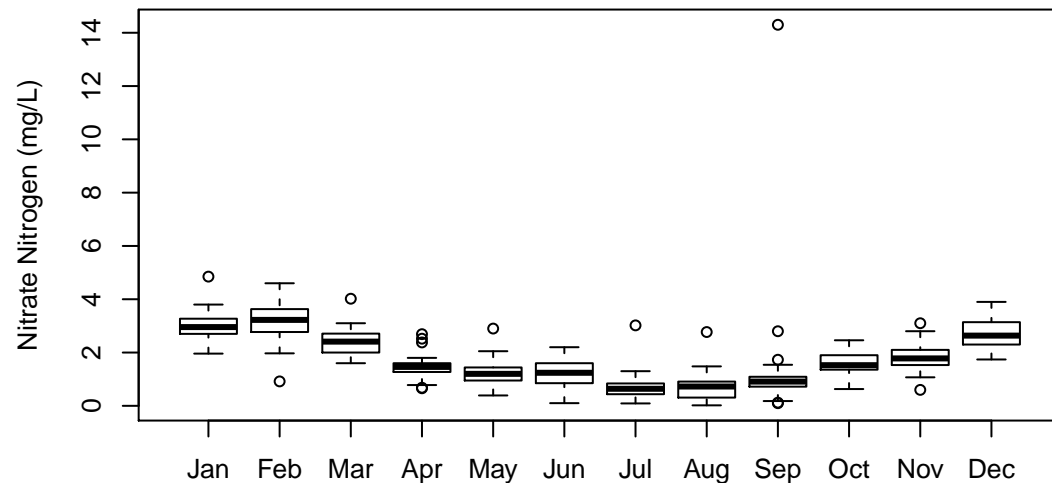
(a) Observation data



(b) Boxplot by year

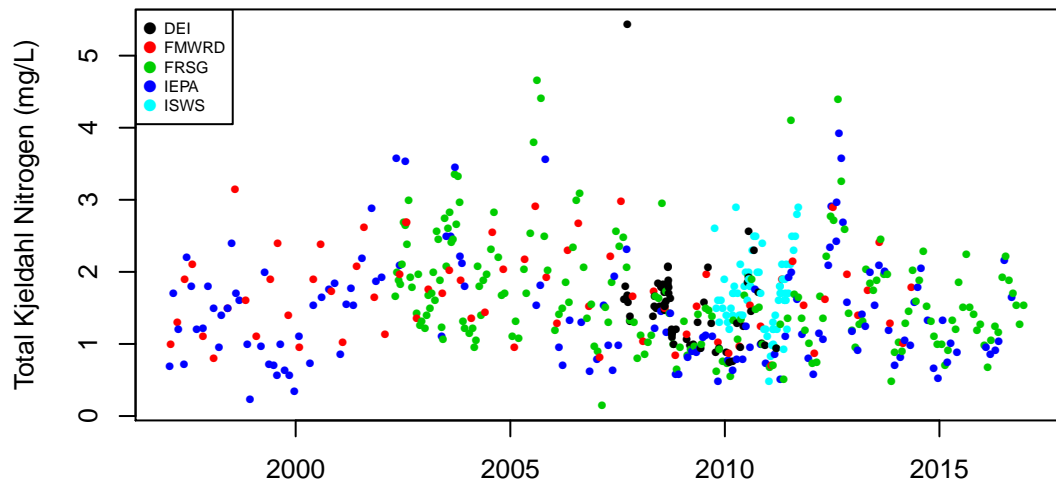


(c) Annual values

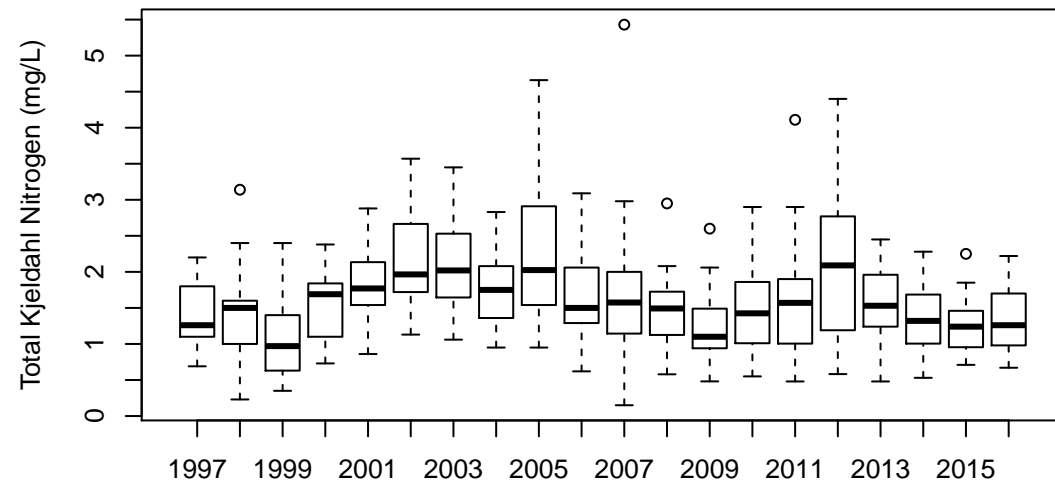


(d) Boxplot by month

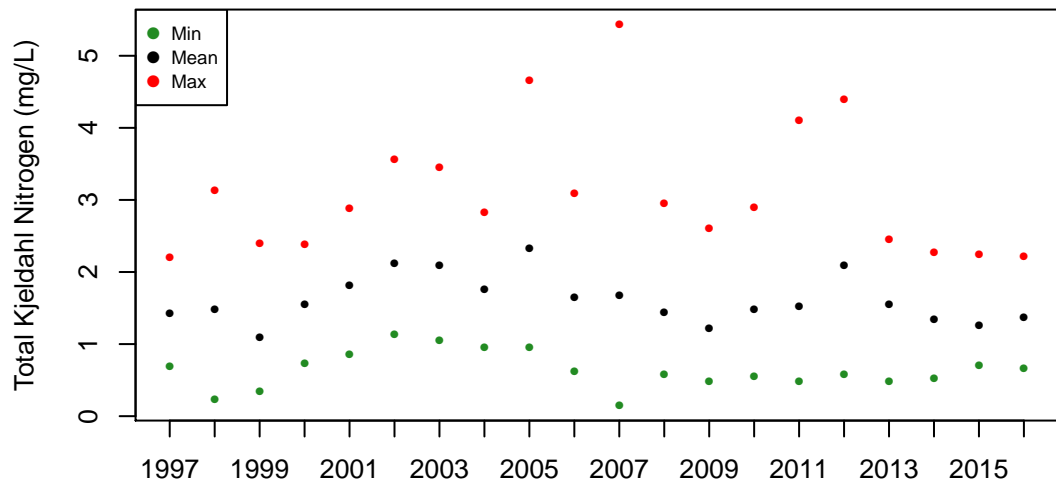
Fox River at Montgomery (27): Total Kjeldahl Nitrogen (mg/L)



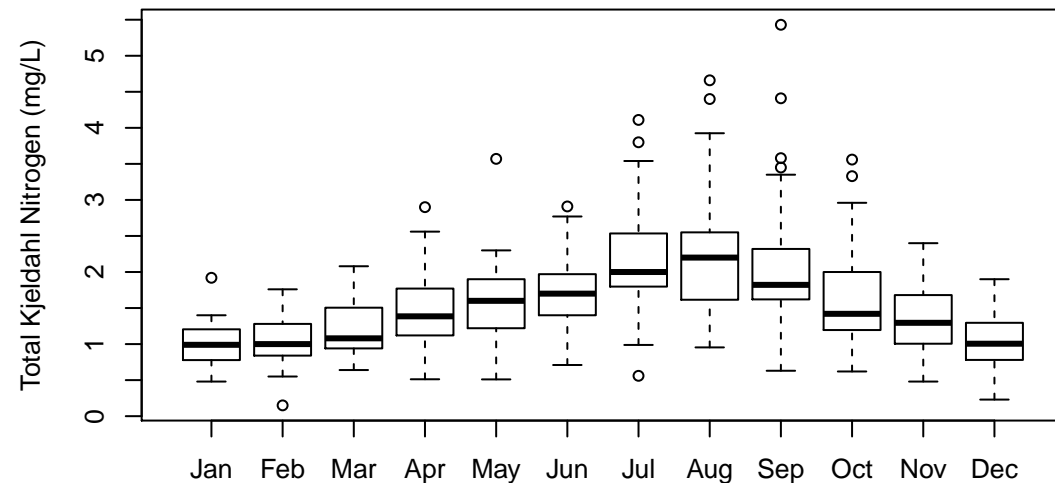
(a) Observation data



(b) Boxplot by year

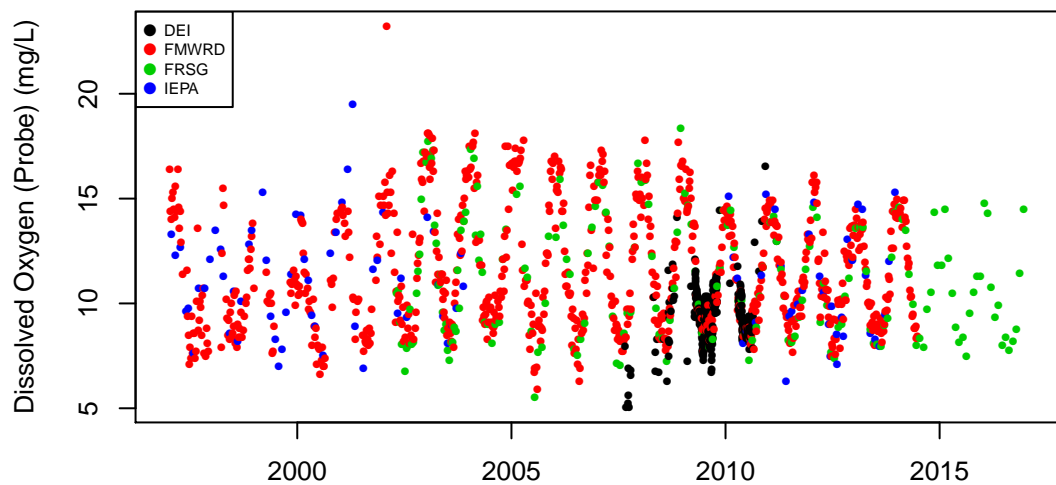


(c) Annual values

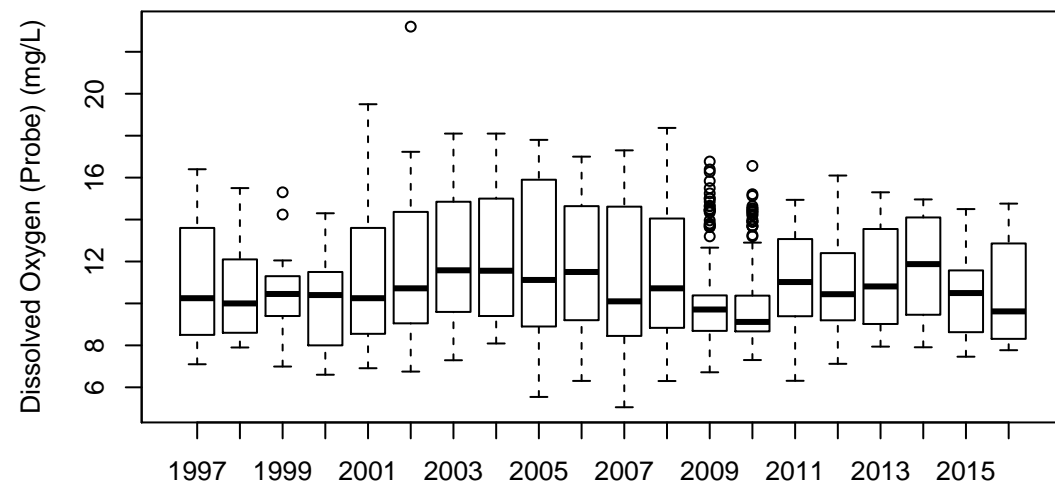


(d) Boxplot by month

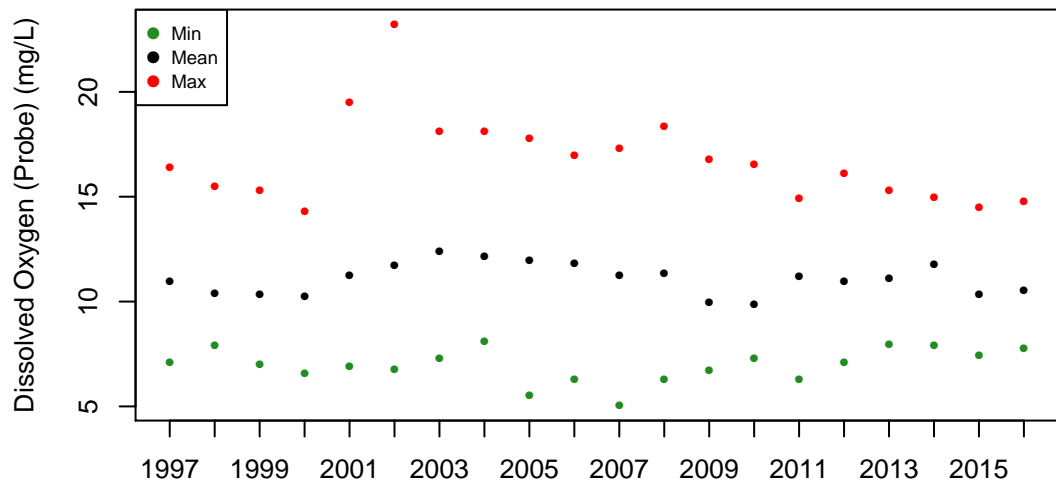
Fox River at Montgomery (27): Dissolved Oxygen (Probe) (mg/L)



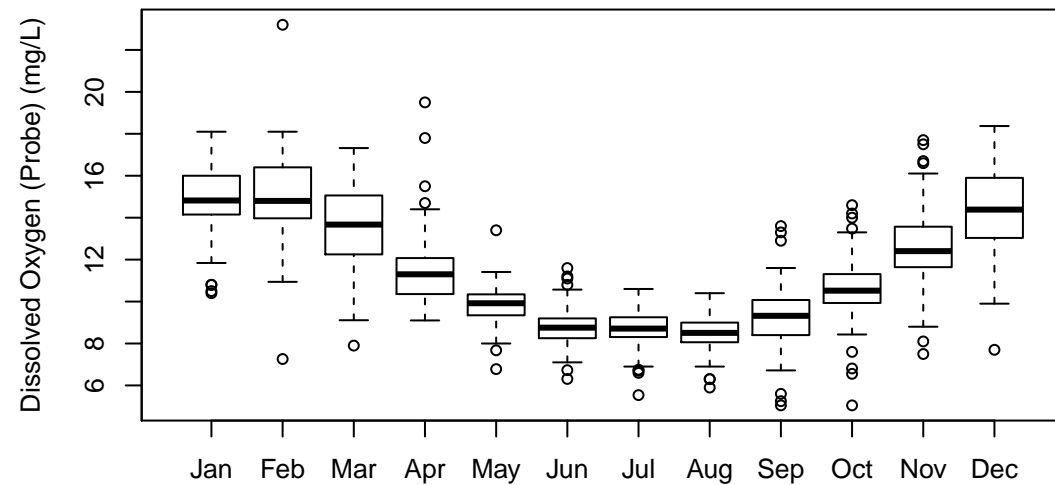
(a) Observation data



(b) Boxplot by year

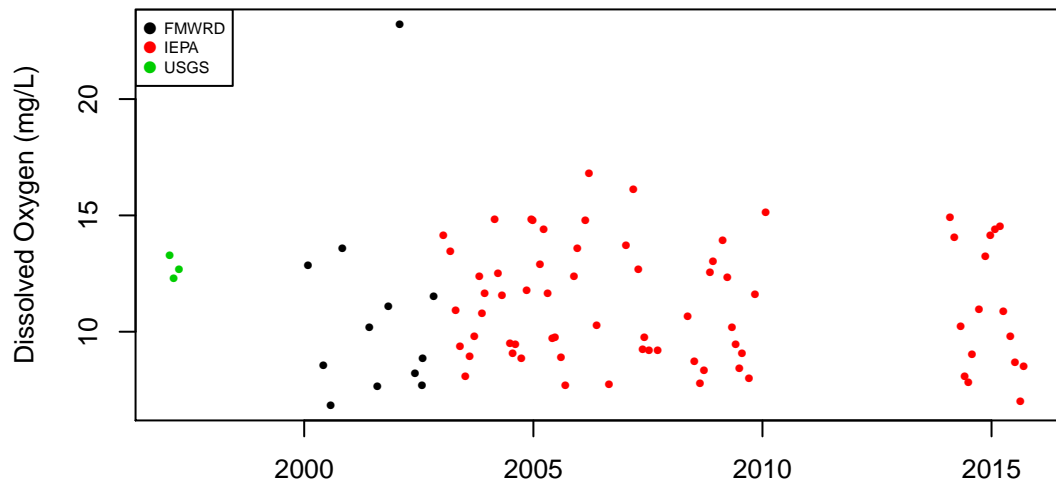


(c) Annual values

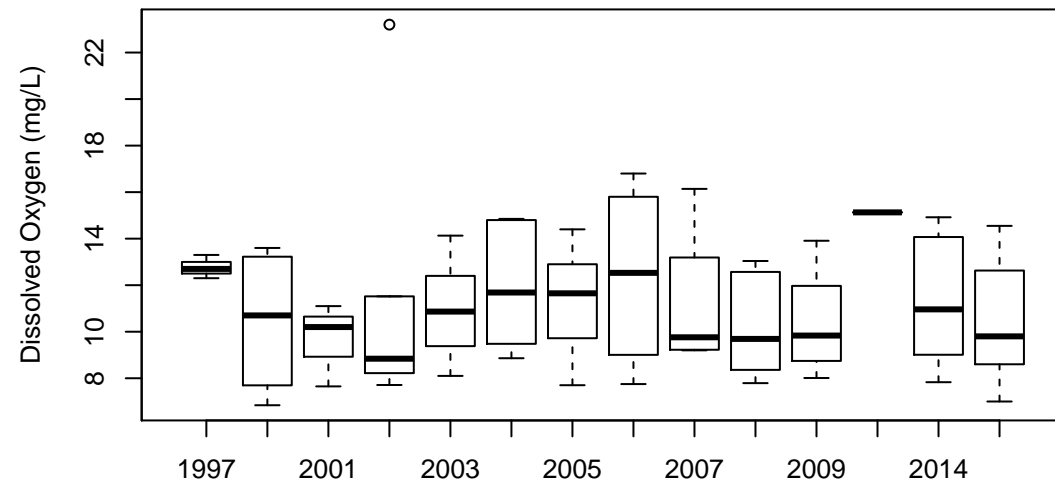


(d) Boxplot by month

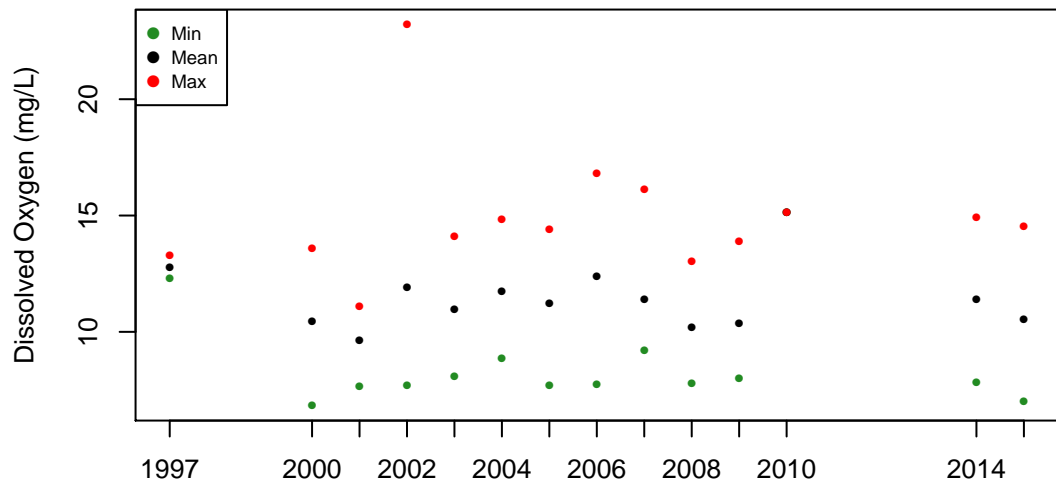
Fox River at Montgomery (27): Dissolved Oxygen (mg/L)



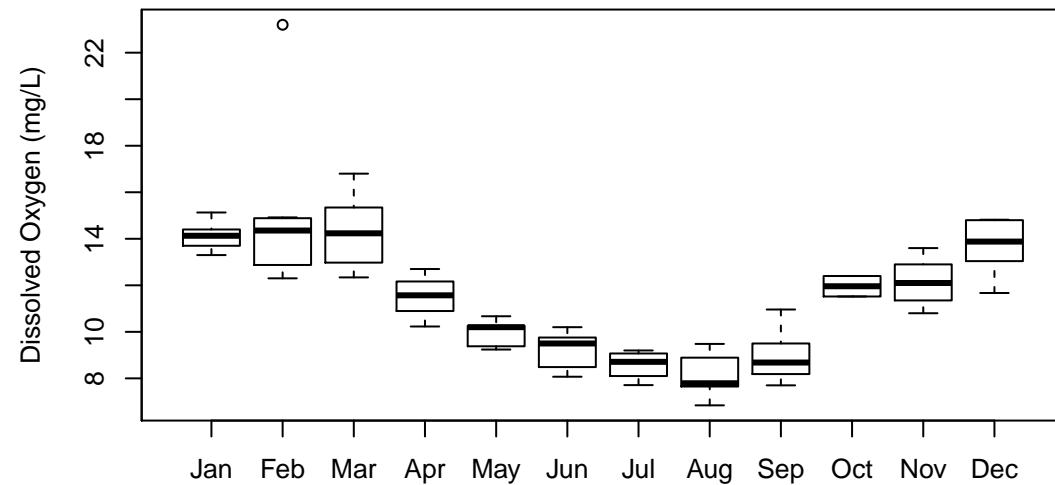
(a) Observation data



(b) Boxplot by year

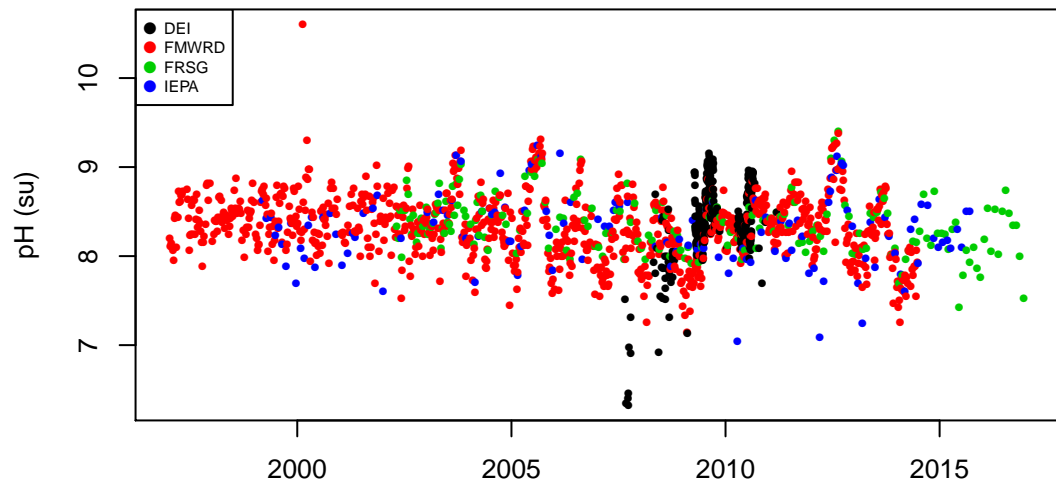


(c) Annual values

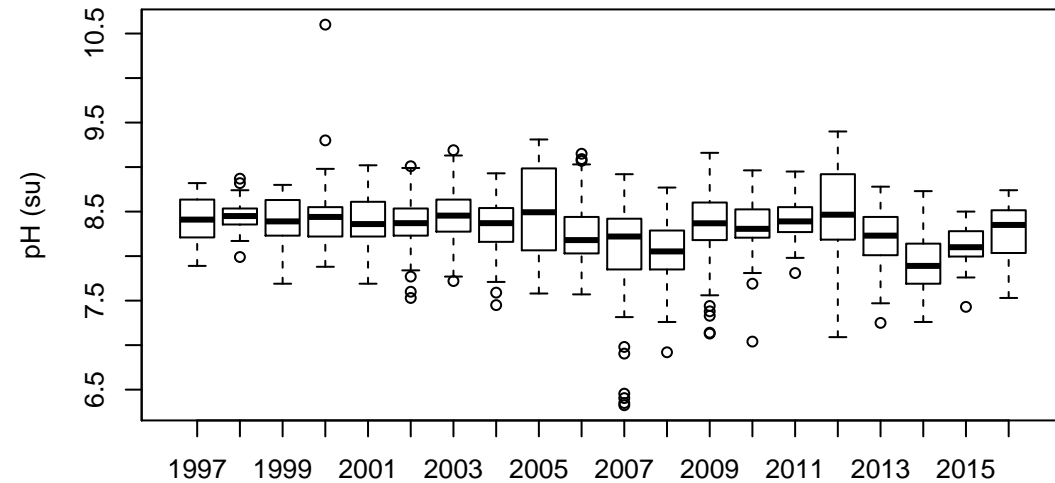


(d) Boxplot by month

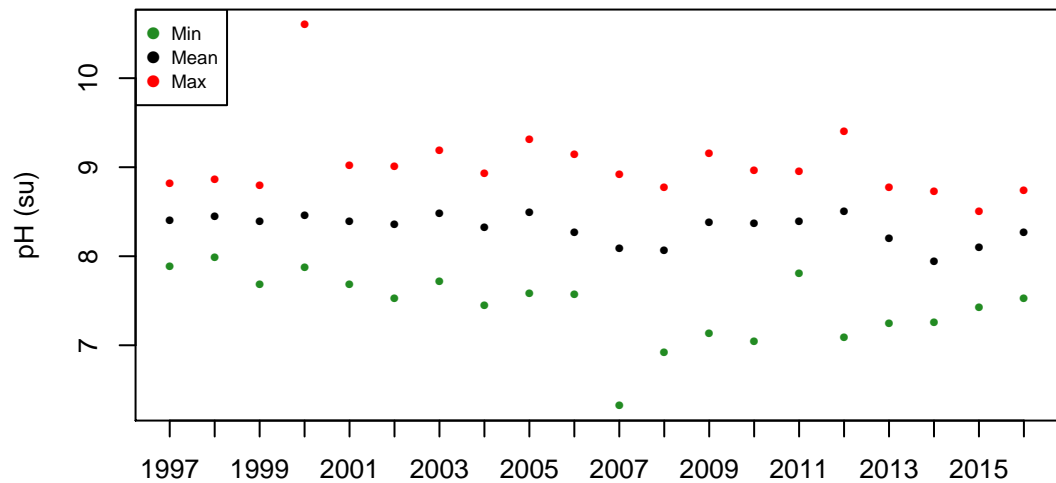
Fox River at Montgomery (27): pH (su)



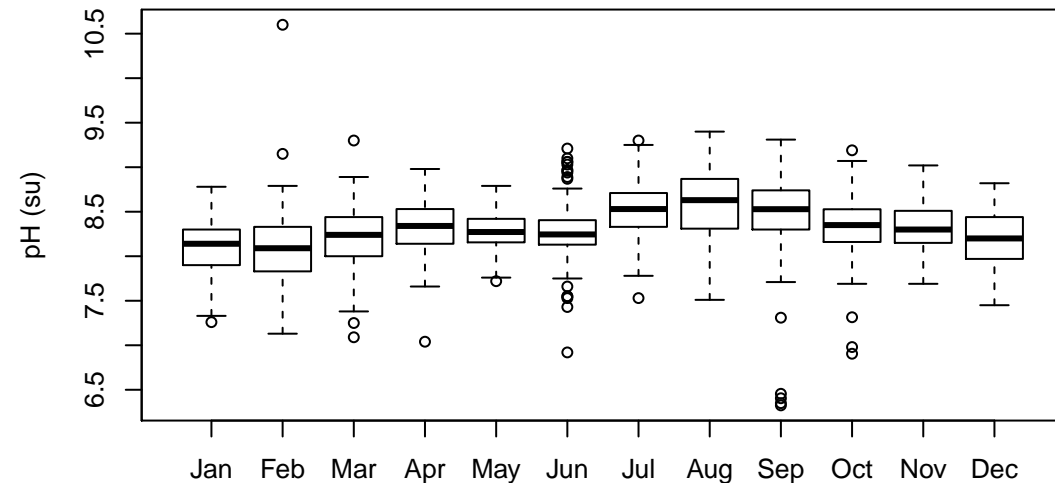
(a) Observation data



(b) Boxplot by year

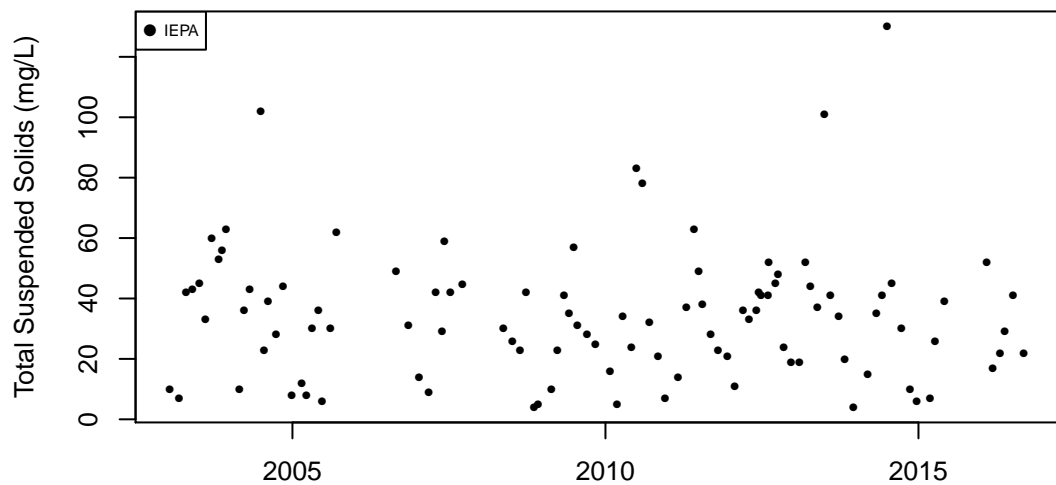


(c) Annual values

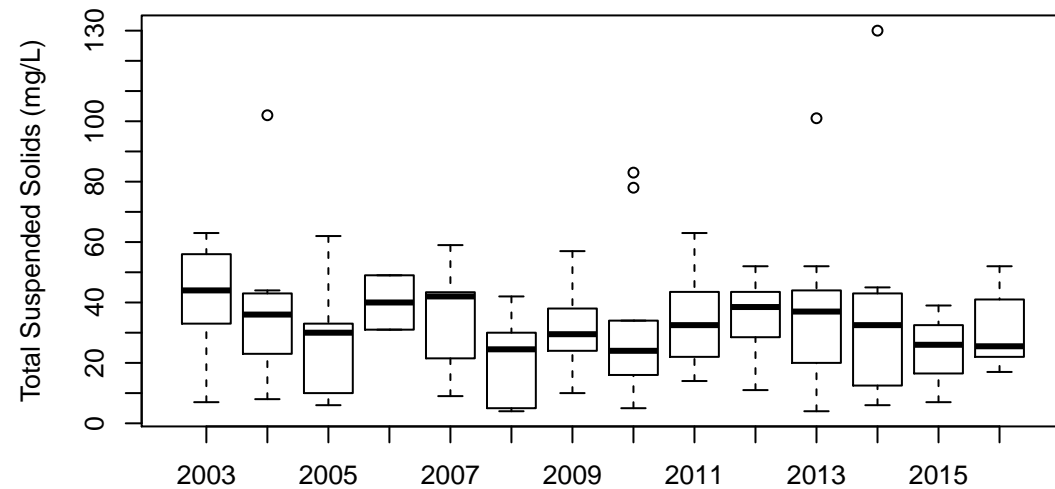


(d) Boxplot by month

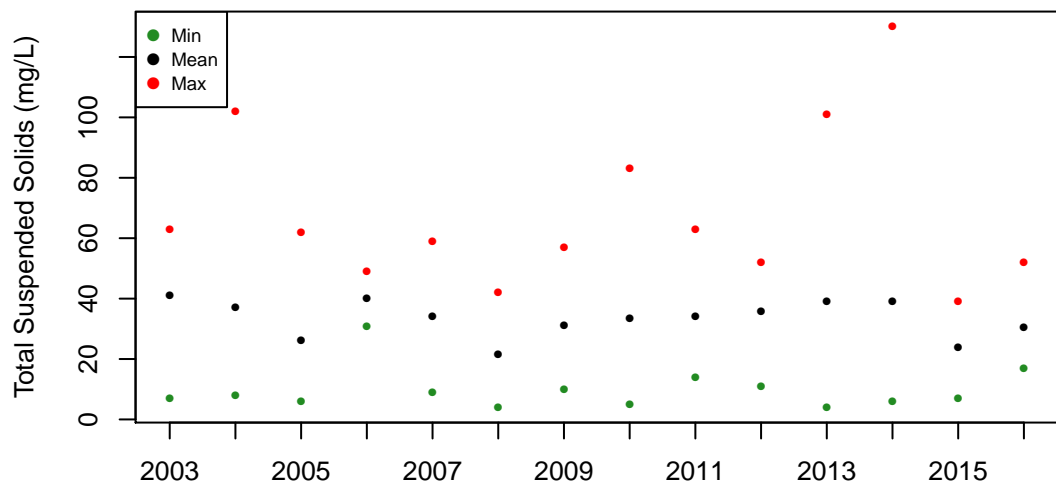
Fox River at Montgomery (27): Total Suspended Solids (mg/L)



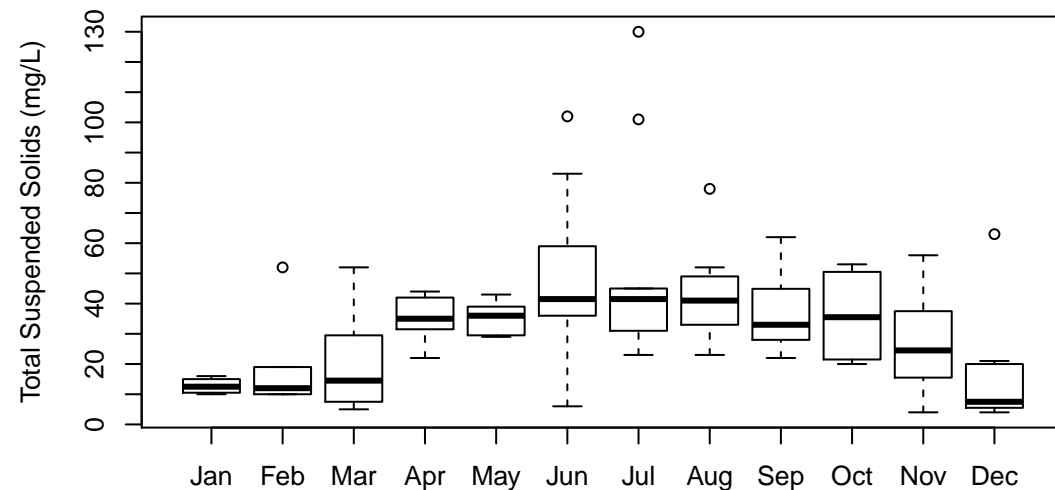
(a) Observation data



(b) Boxplot by year

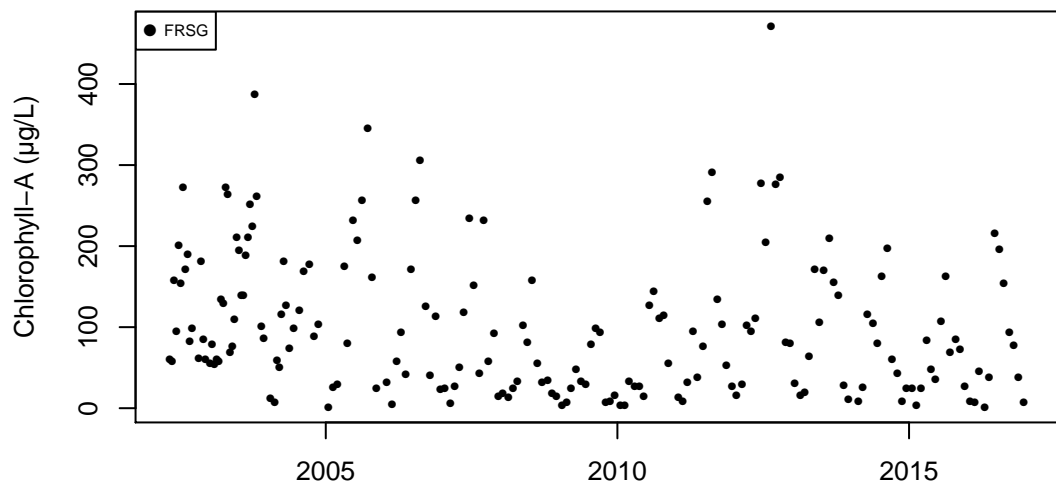


(c) Annual values

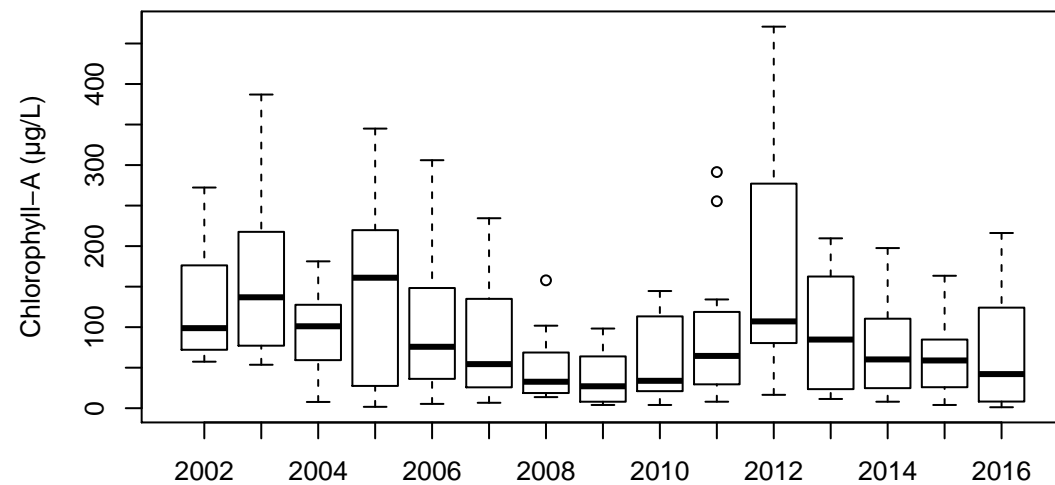


(d) Boxplot by month

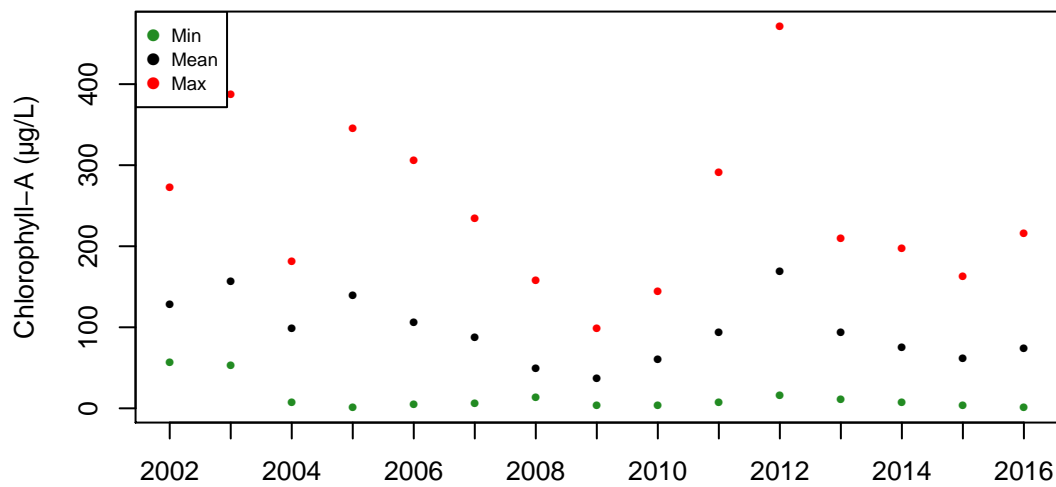
Fox River at Montgomery (27): Chlorophyll-A ($\mu\text{g/L}$)



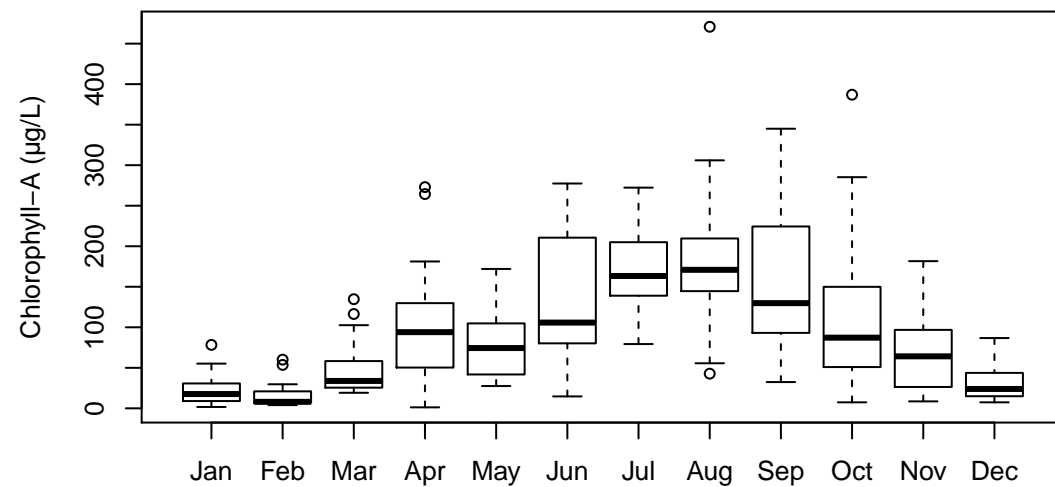
(a) Observation data



(b) Boxplot by year

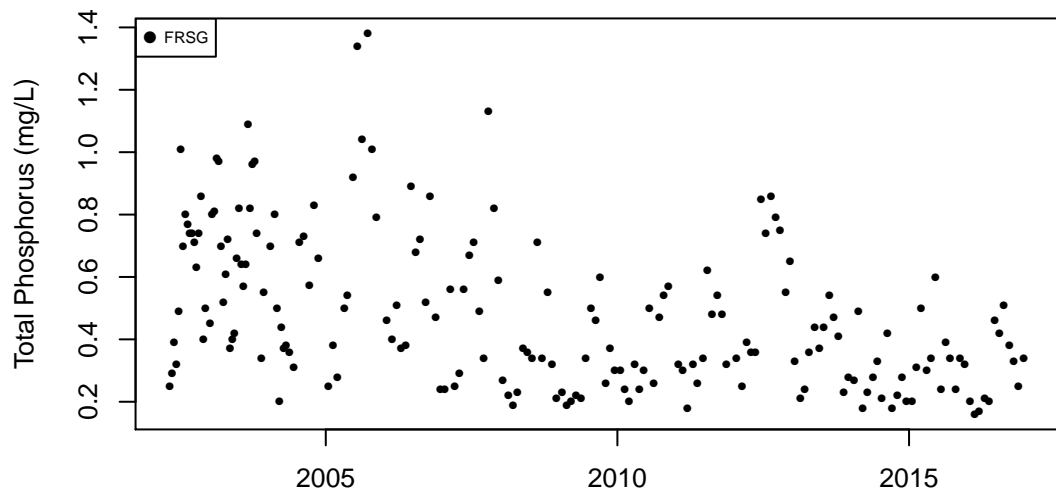


(c) Annual values

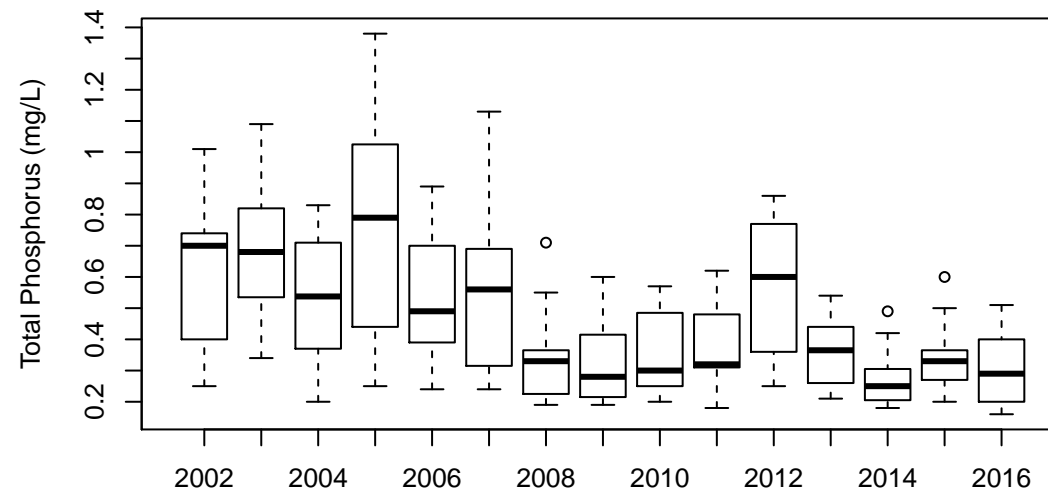


(d) Boxplot by month

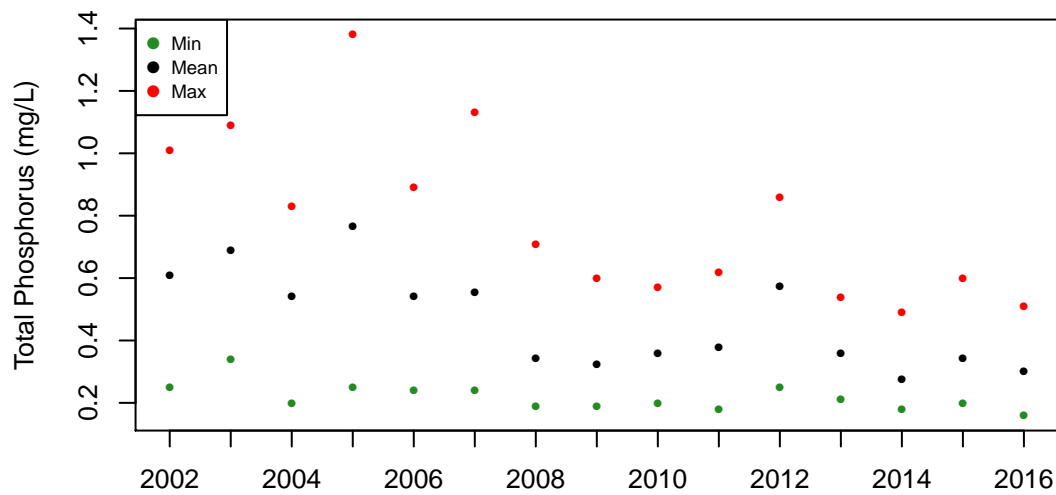
Fox River at Yorkville (34): Total Phosphorus (mg/L)



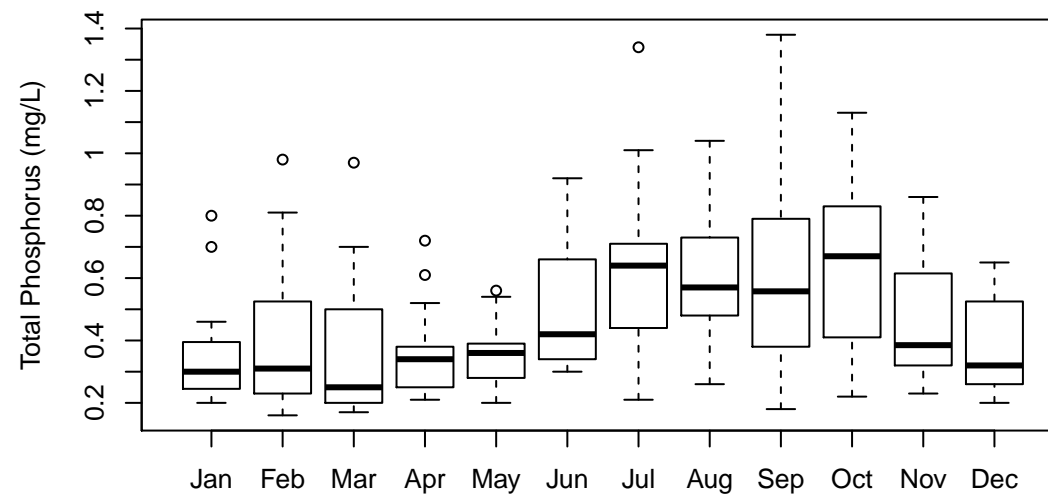
(a) Observation data



(b) Boxplot by year



(c) Annual values

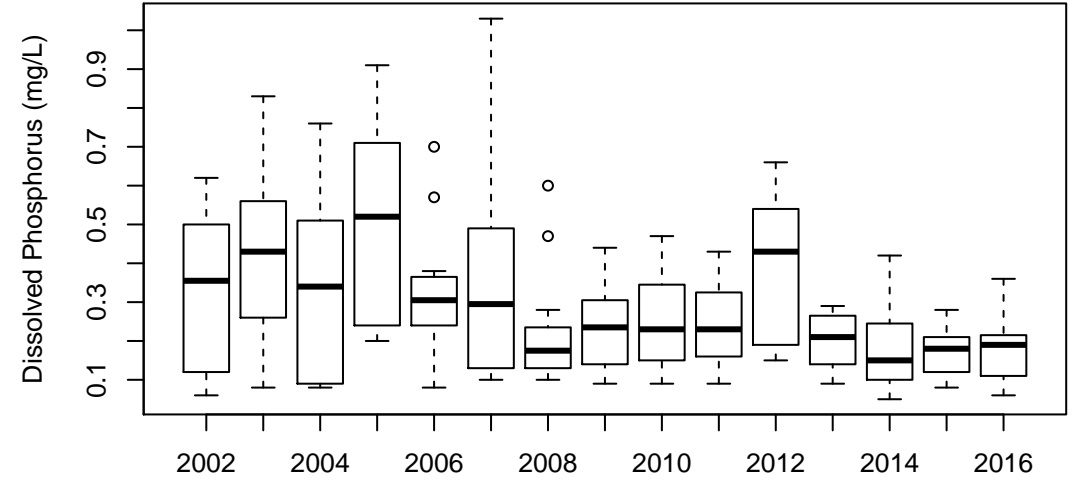


(d) Boxplot by month

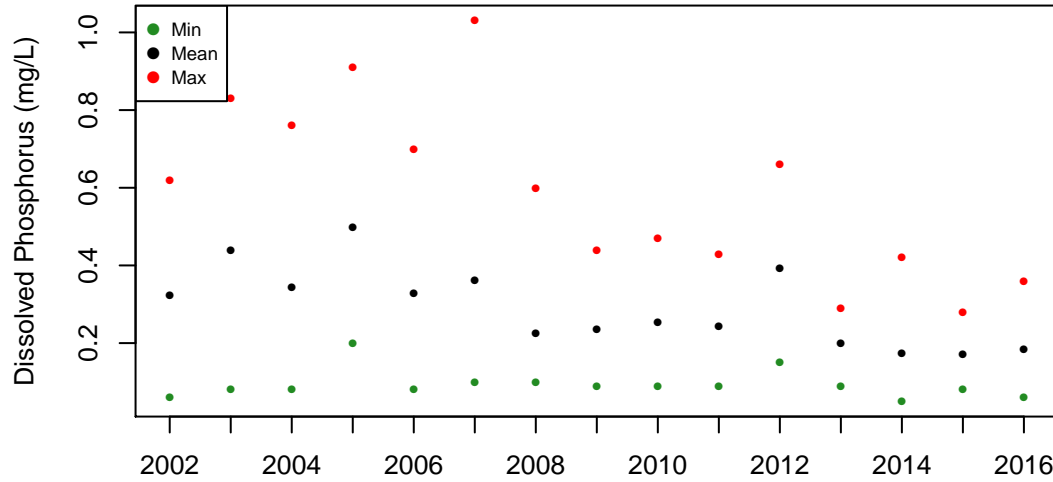
Fox River at Yorkville (34): Dissolved Phosphorus (mg/L)



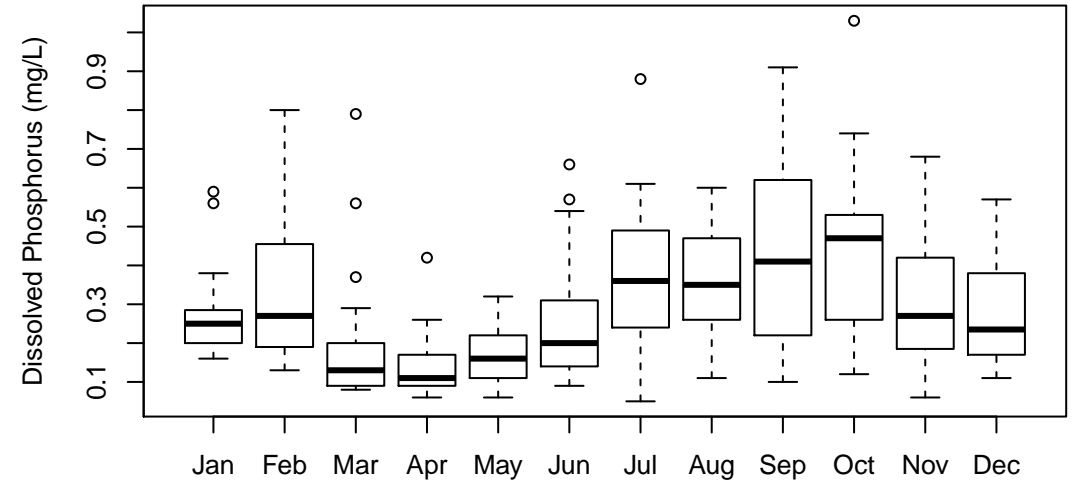
(a) Observation data



(b) Boxplot by year

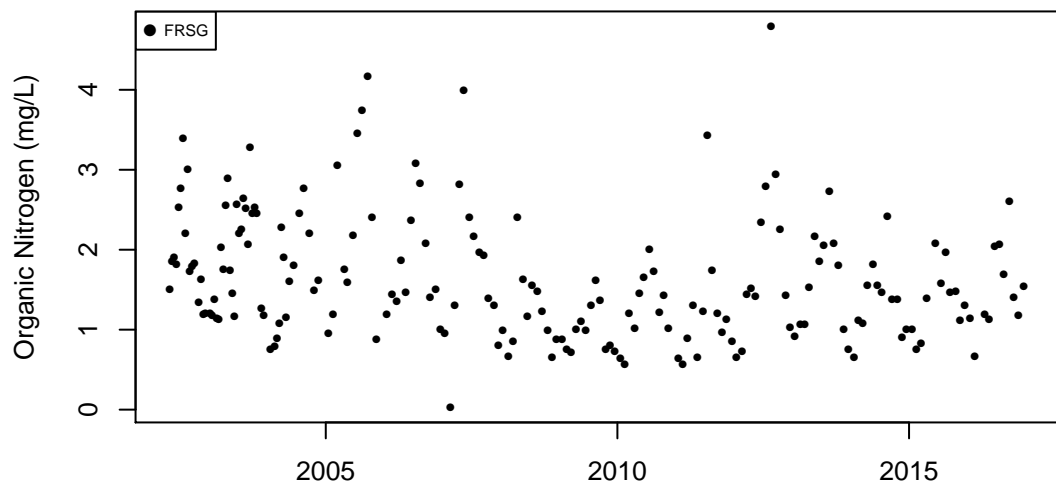


(c) Annual values

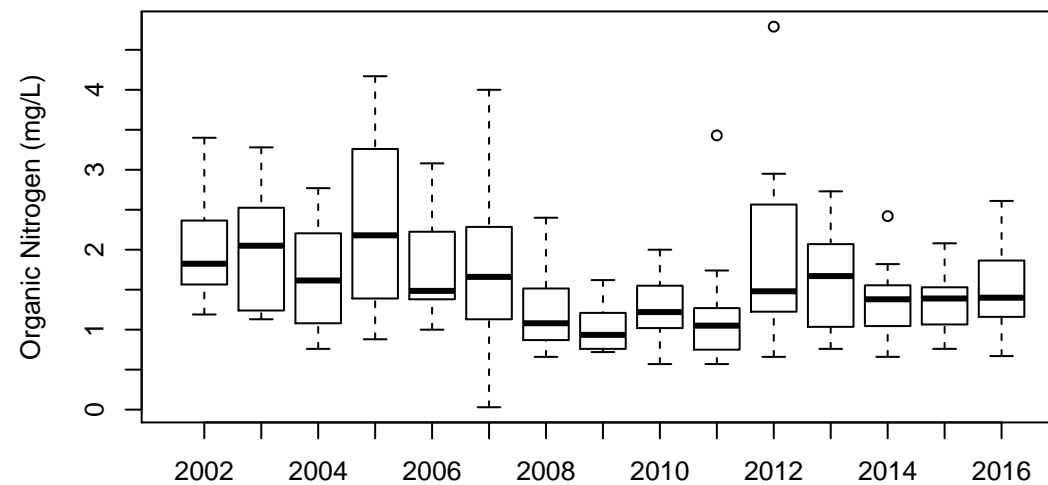


(d) Boxplot by month

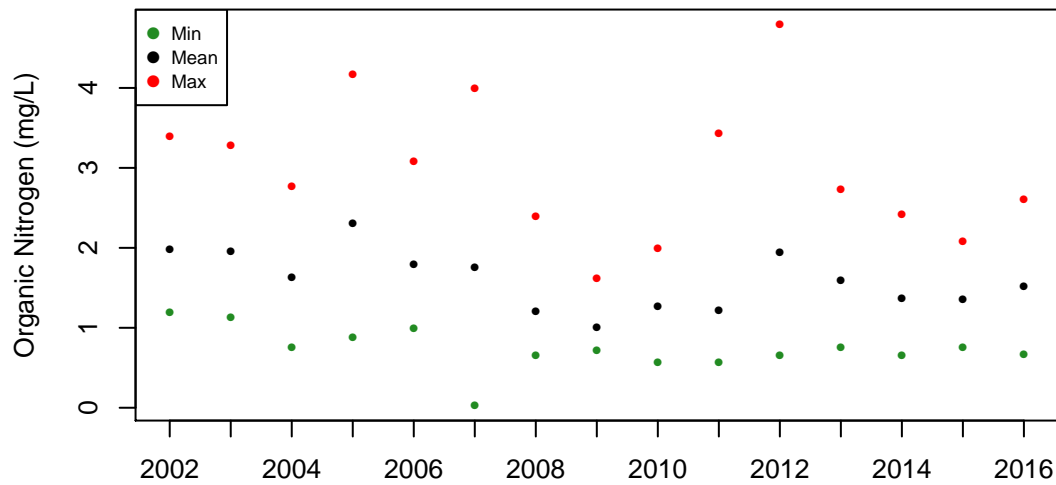
Fox River at Yorkville (34): Organic Nitrogen (mg/L)



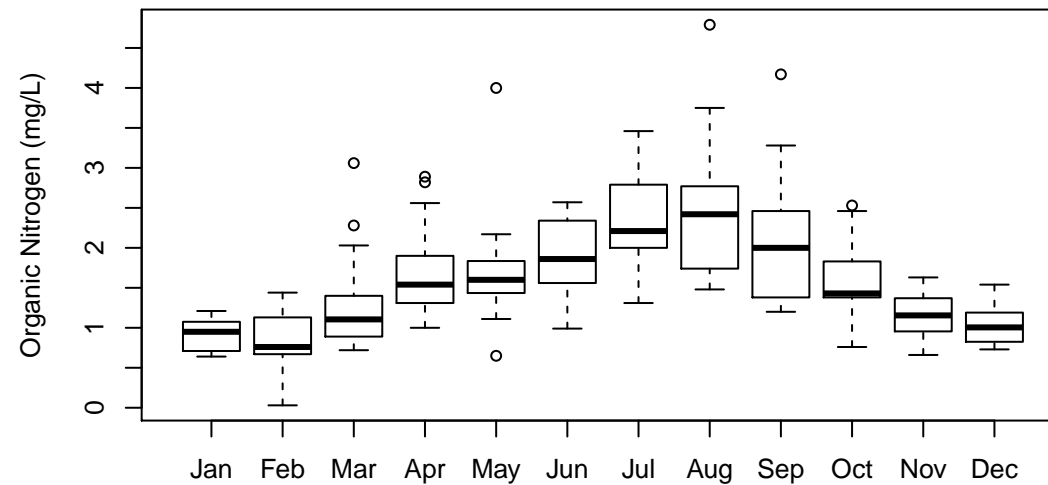
Sampling date
(a) Observation data



Year
(b) Boxplot by year

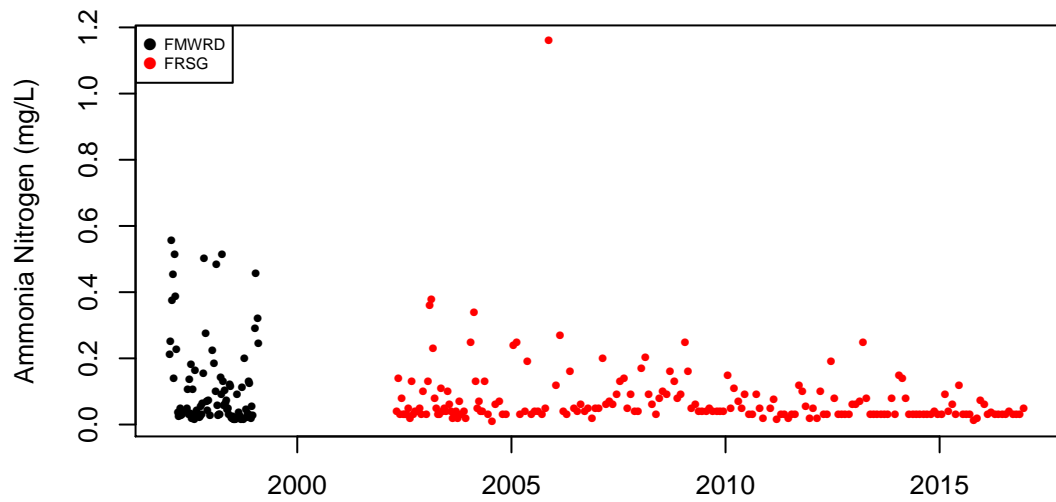


Year
(c) Annual values

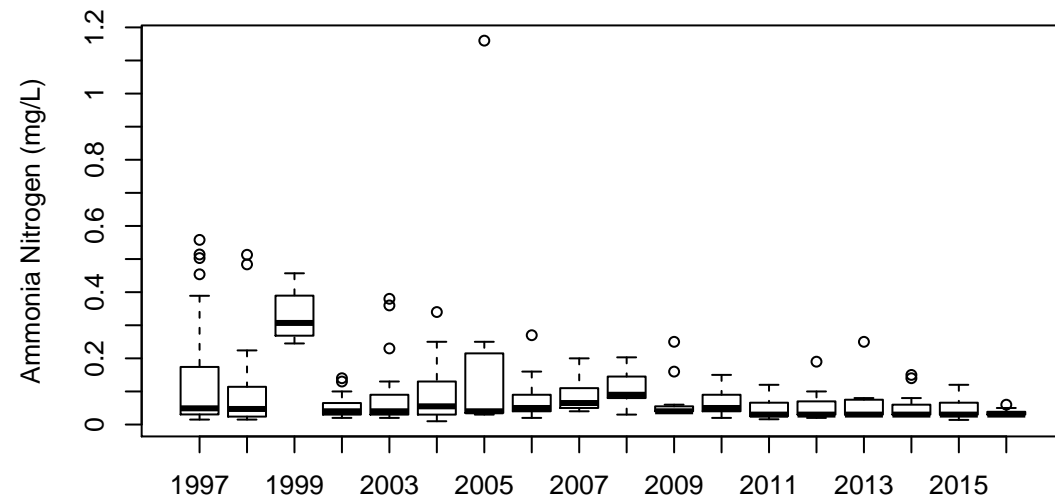


Month
(d) Boxplot by month

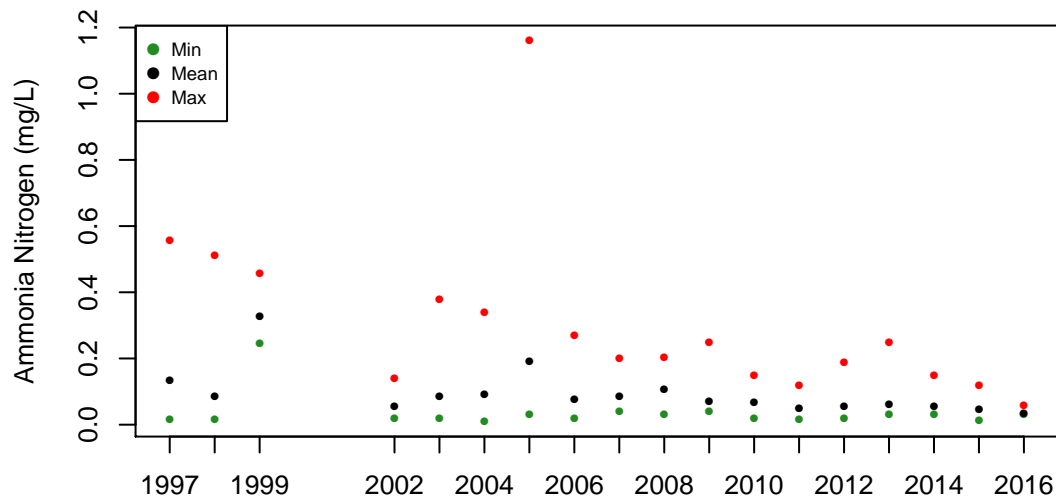
Fox River at Yorkville (34): Ammonia Nitrogen (mg/L)



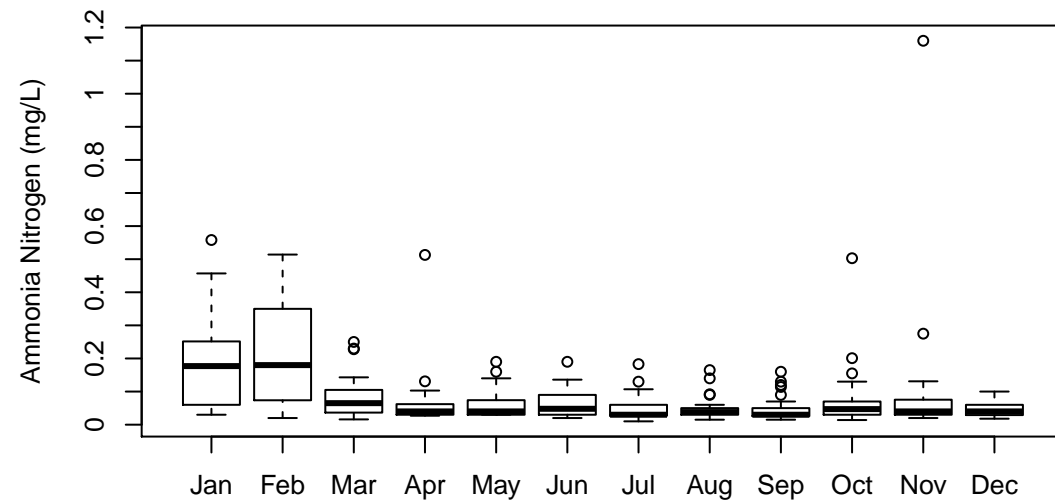
(a) Observation data



(b) Boxplot by year

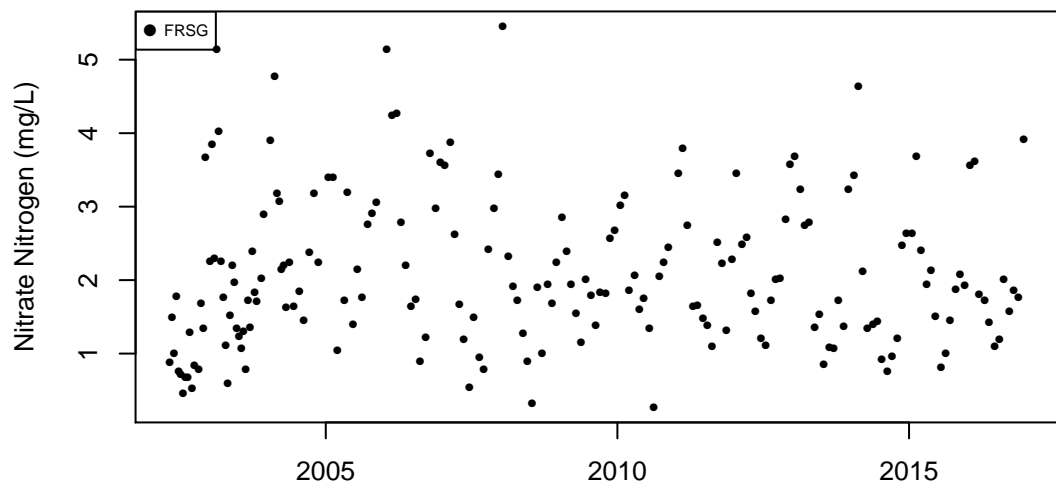


(c) Annual values

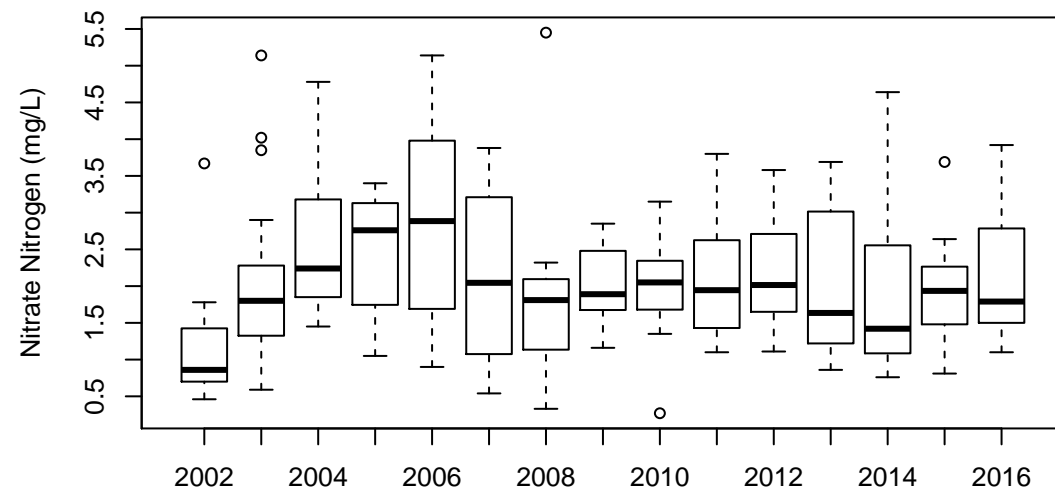


(d) Boxplot by month

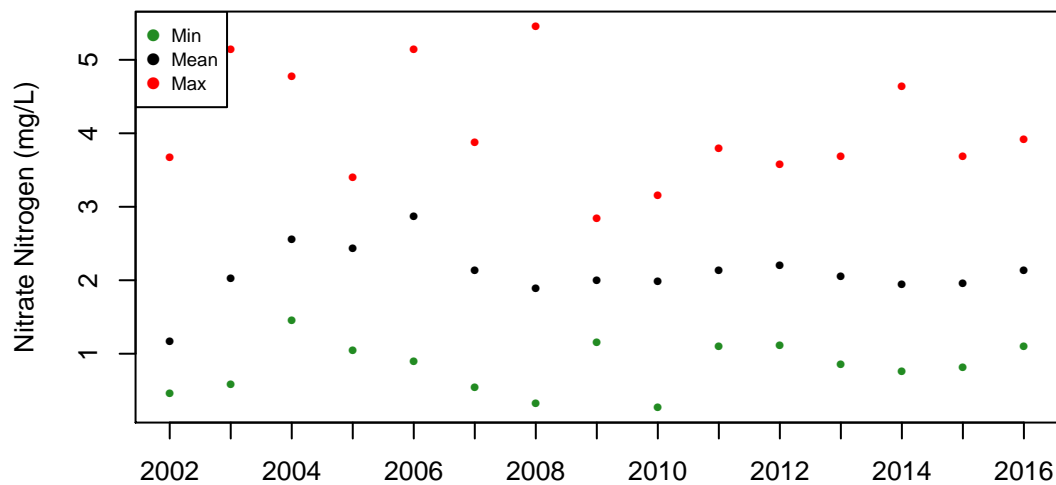
Fox River at Yorkville (34): Nitrate Nitrogen (mg/L)



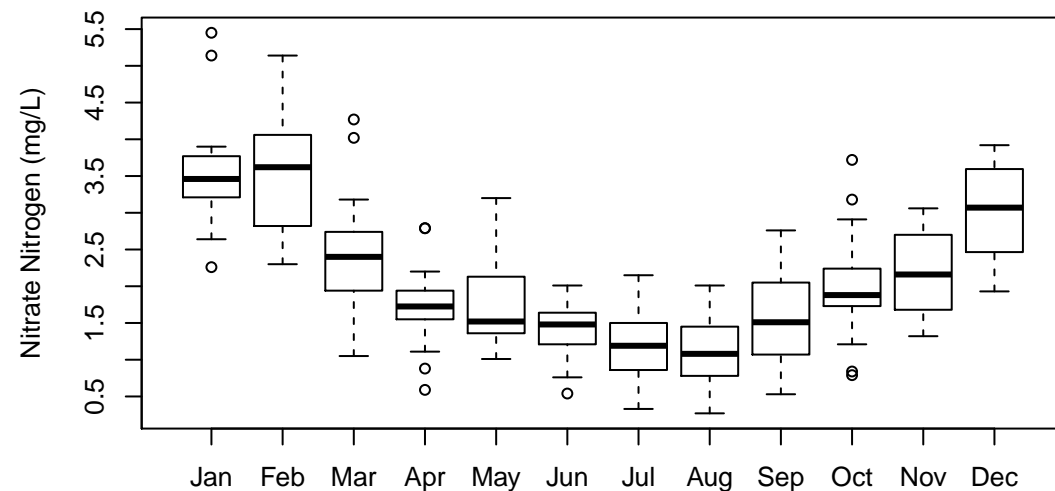
(a) Observation data



(b) Boxplot by year

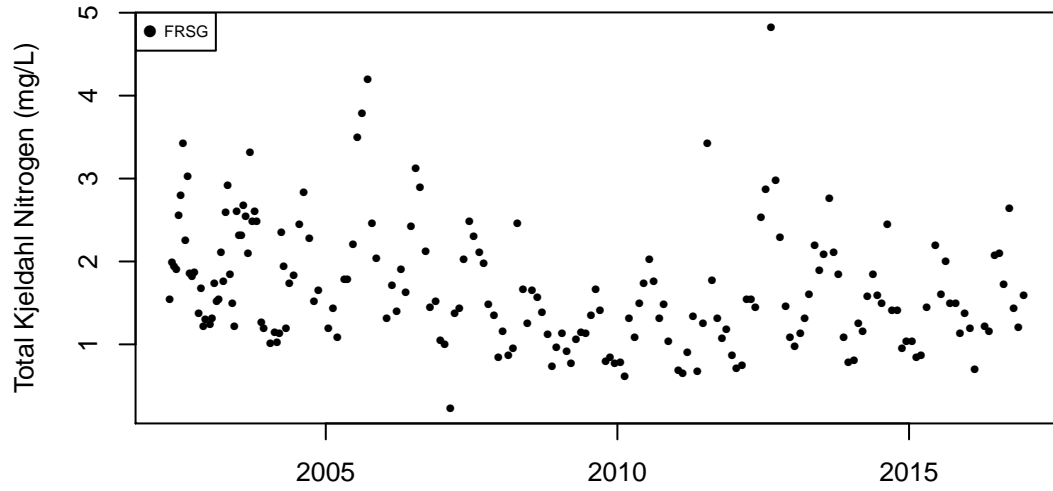


(c) Annual values

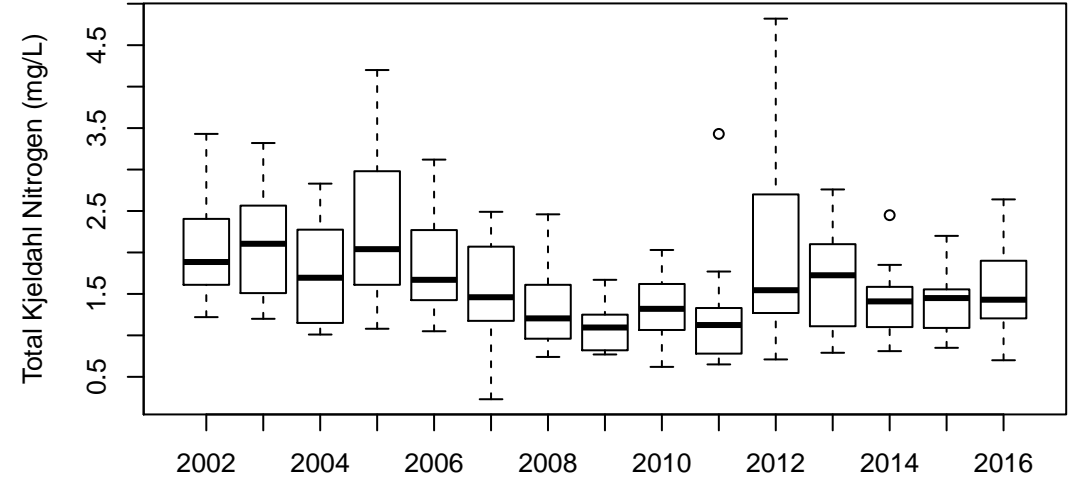


(d) Boxplot by month

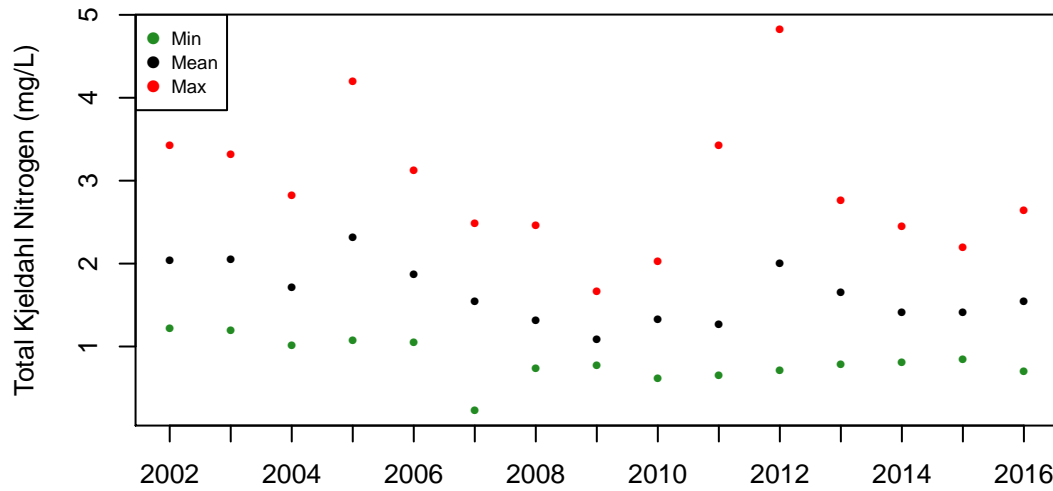
Fox River at Yorkville (34): Total Kjeldahl Nitrogen (mg/L)



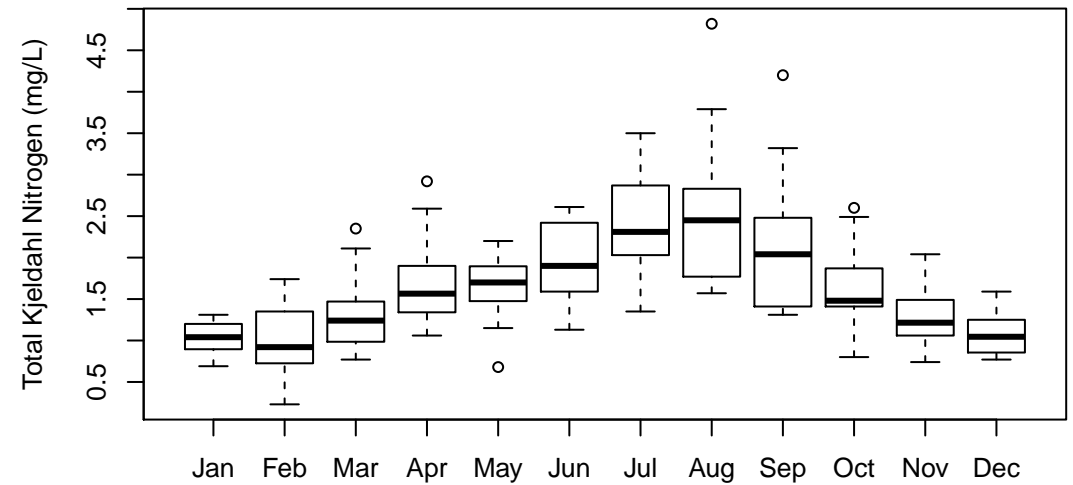
(a) Observation data



(b) Boxplot by year



(c) Annual values

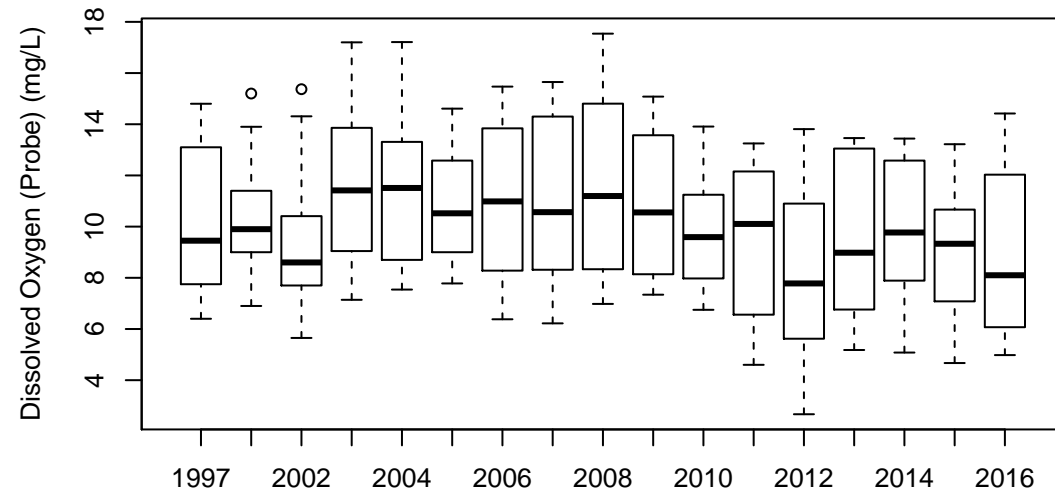


(d) Boxplot by month

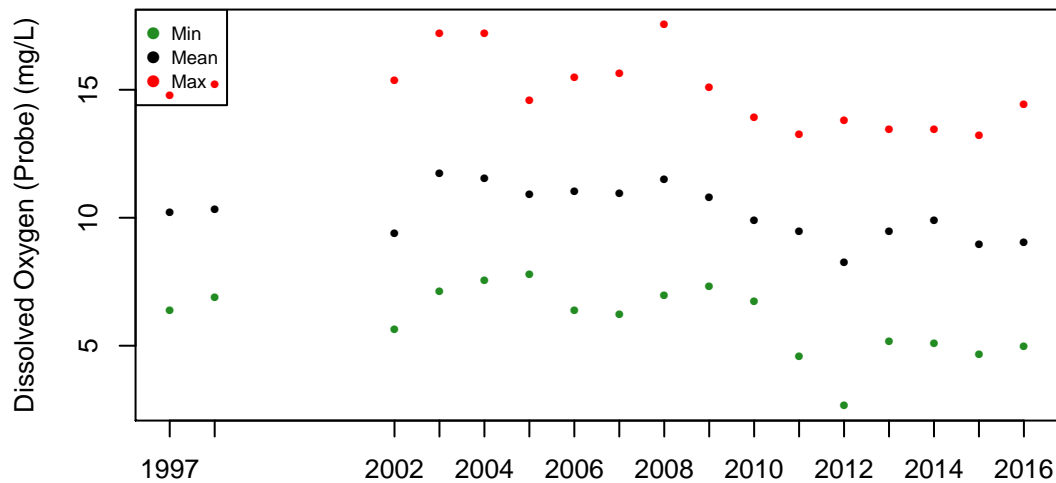
Fox River at Yorkville (34): Dissolved Oxygen (Probe) (mg/L)



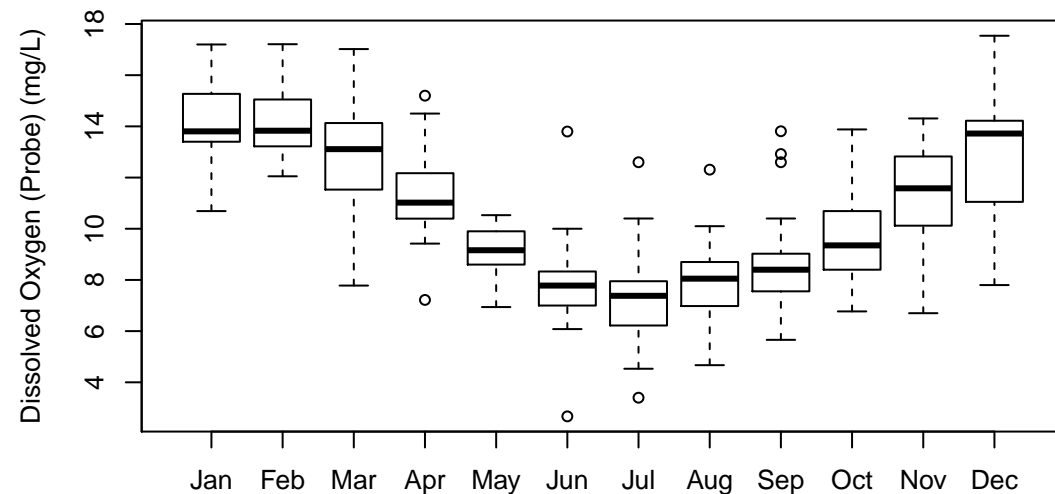
(a) Observation data



(b) Boxplot by year

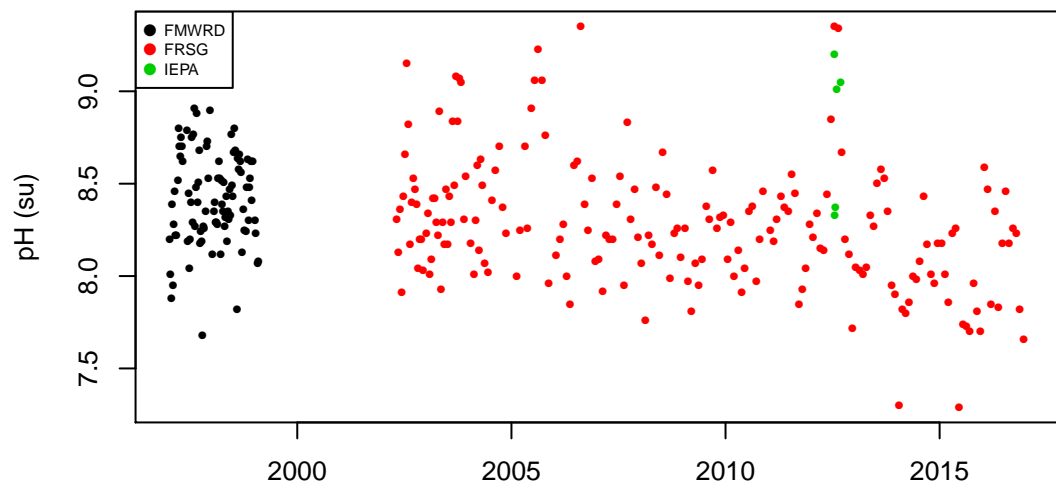


(c) Annual values

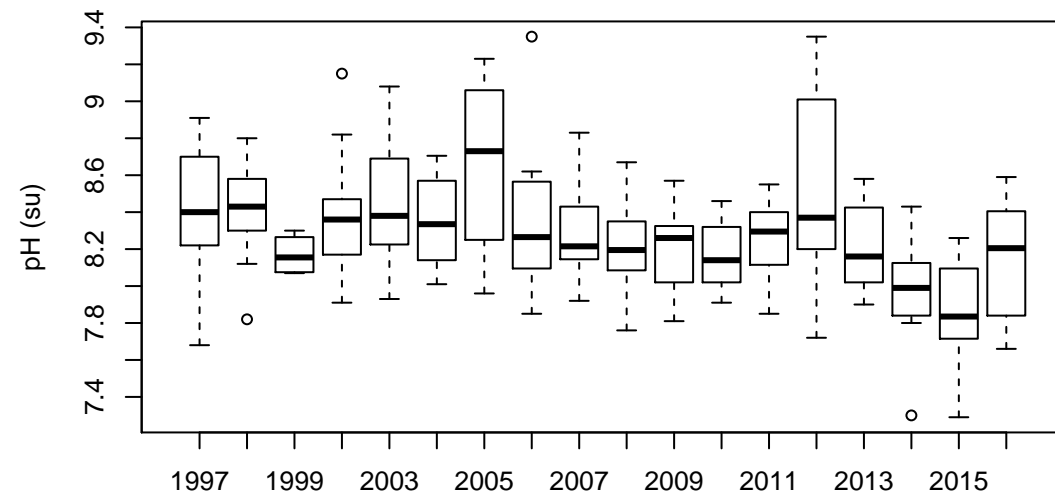


(d) Boxplot by month

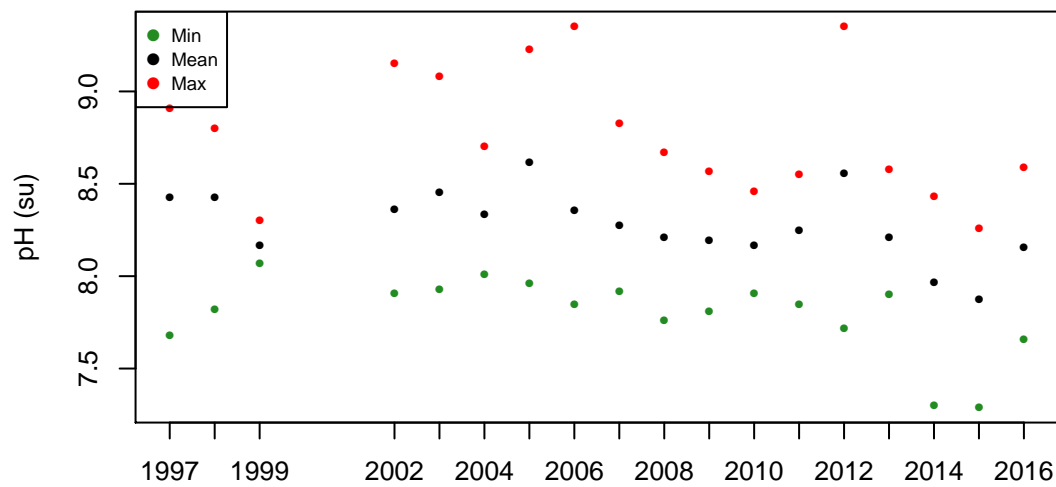
Fox River at Yorkville (34): pH (su)



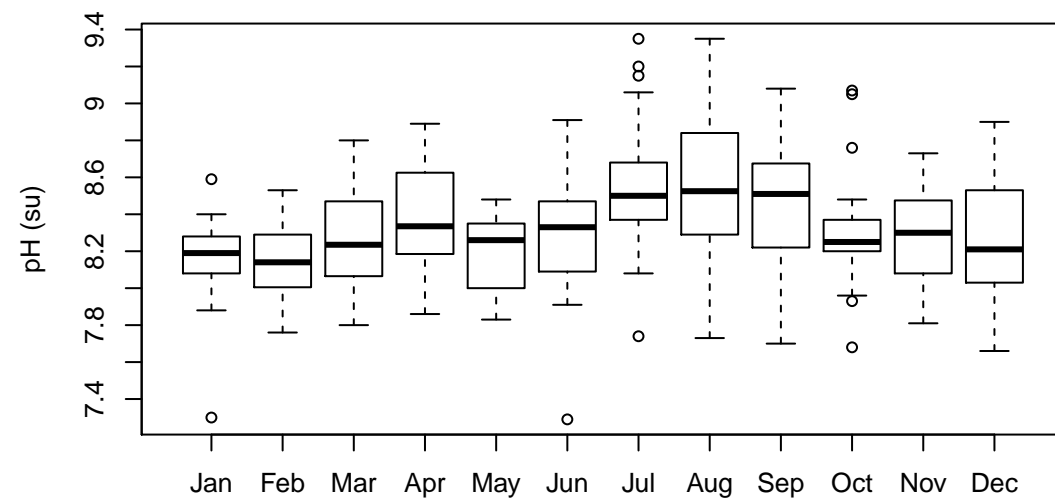
(a) Observation data



(b) Boxplot by year

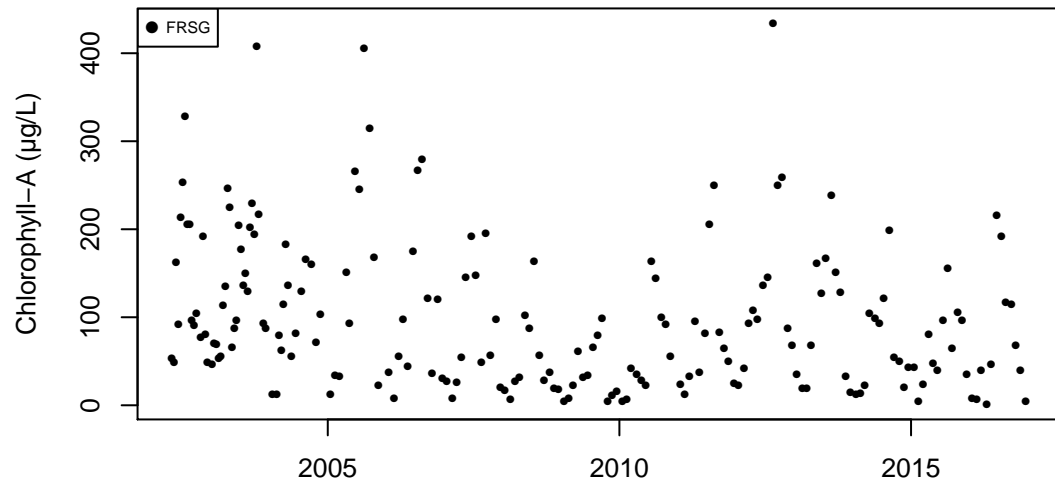


(c) Annual values

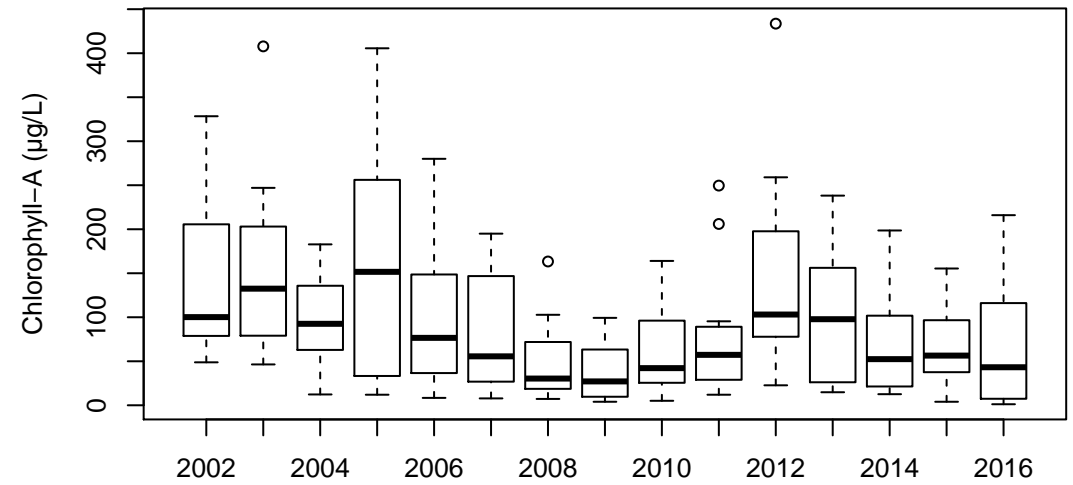


(d) Boxplot by month

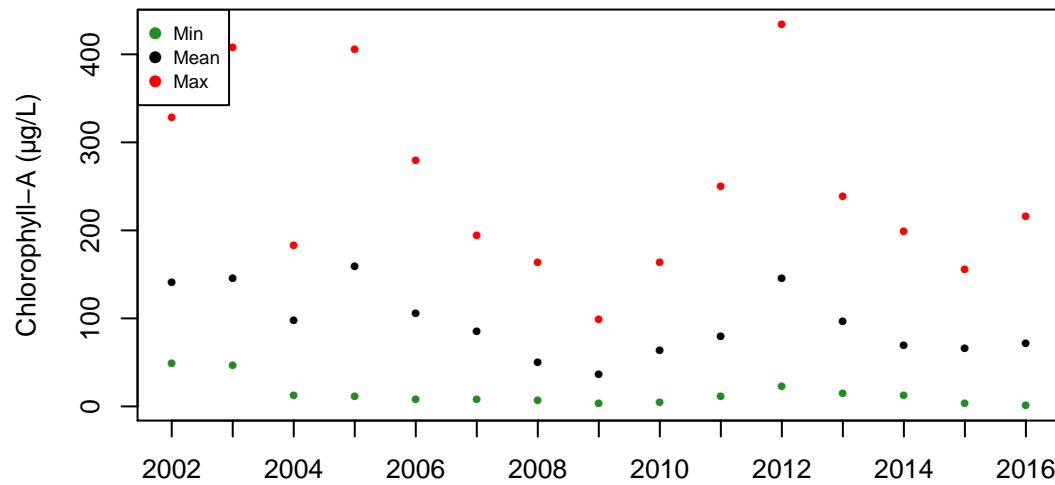
Fox River at Yorkville (34): Chlorophyll-A ($\mu\text{g/L}$)



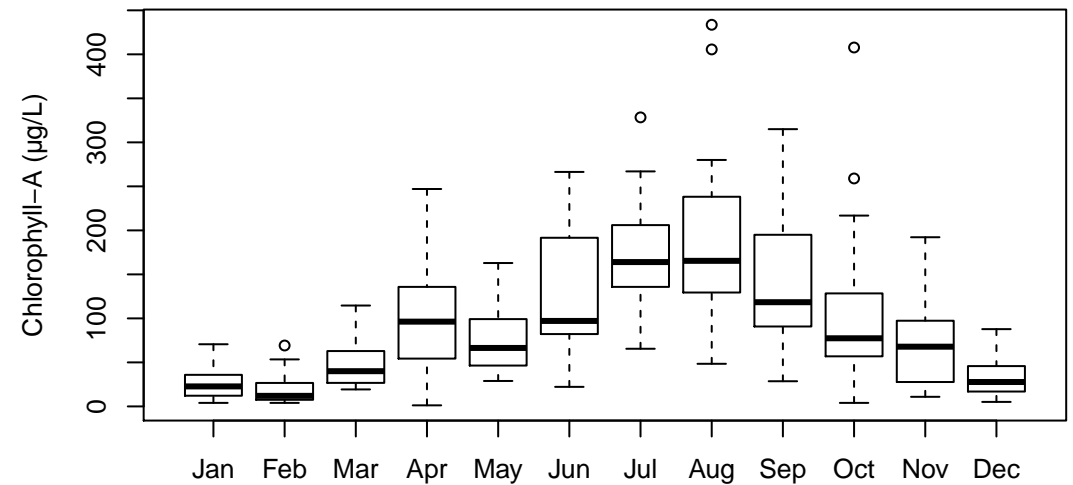
(a) Observation data



(b) Boxplot by year

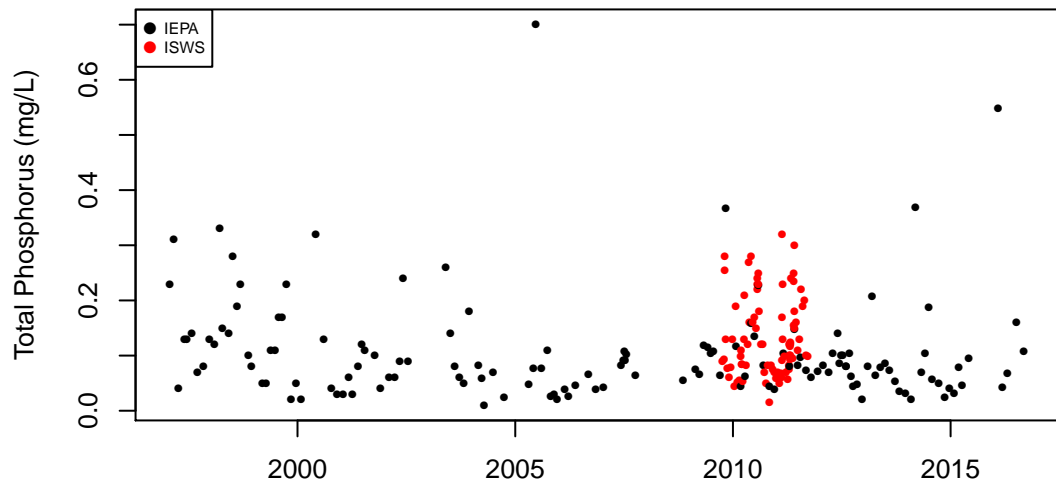


(c) Annual values

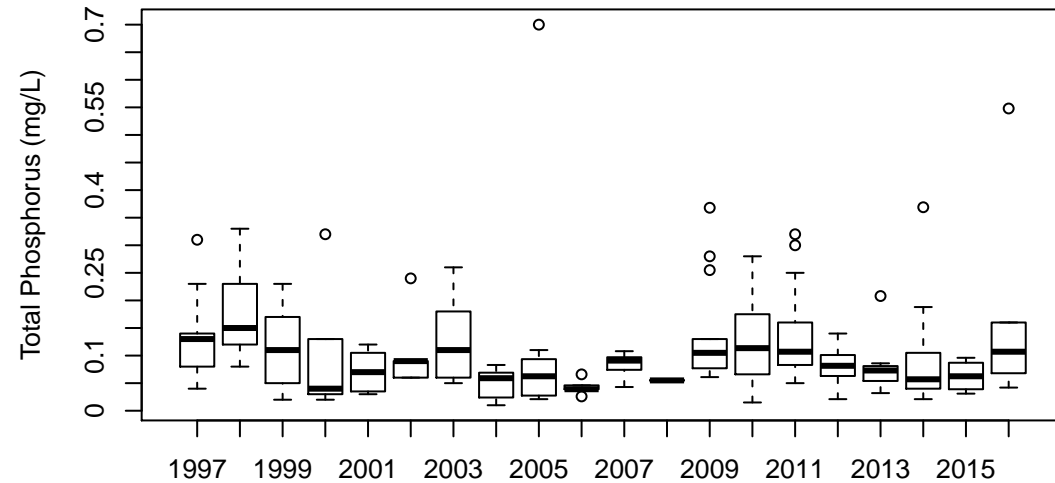


(d) Boxplot by month

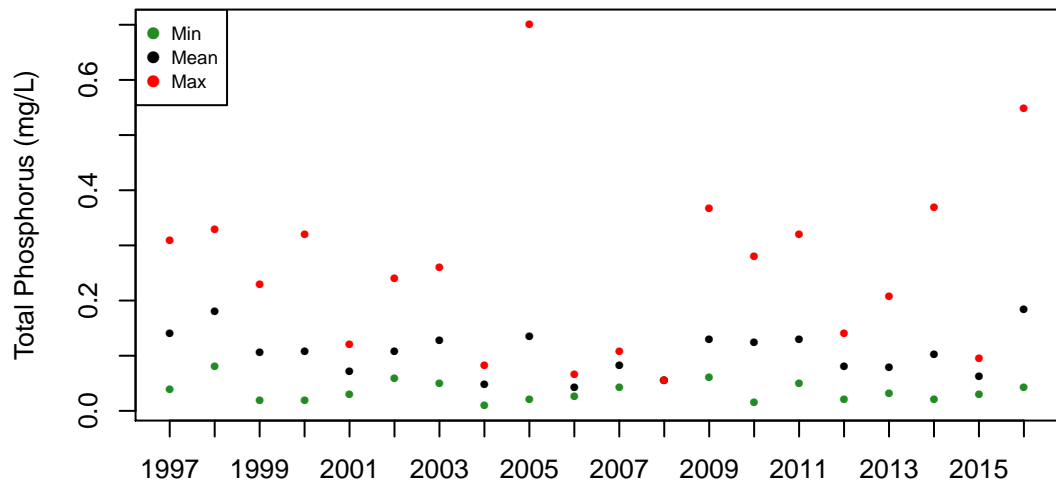
Blackberry Cr at Rt 47 (28): Total Phosphorus (mg/L)



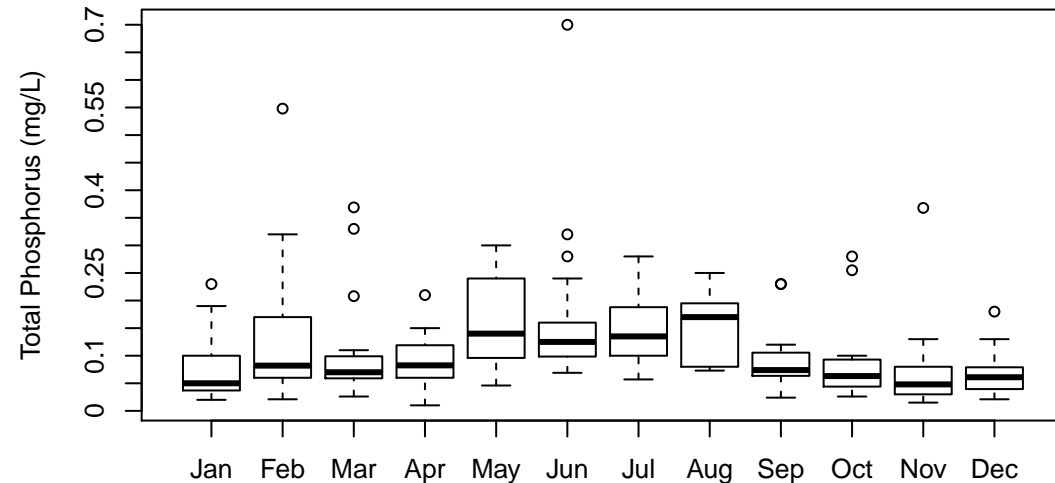
(a) Observation data



(b) Boxplot by year

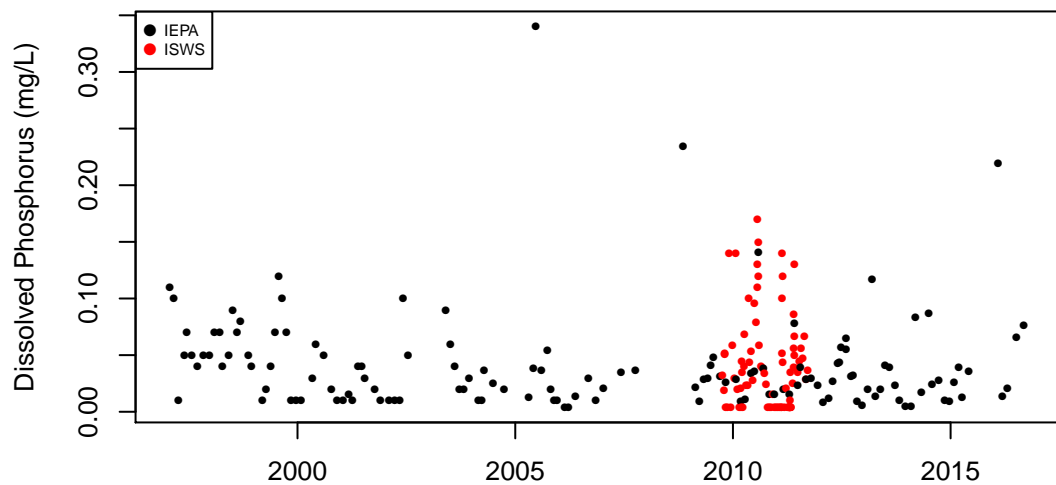


(c) Annual values

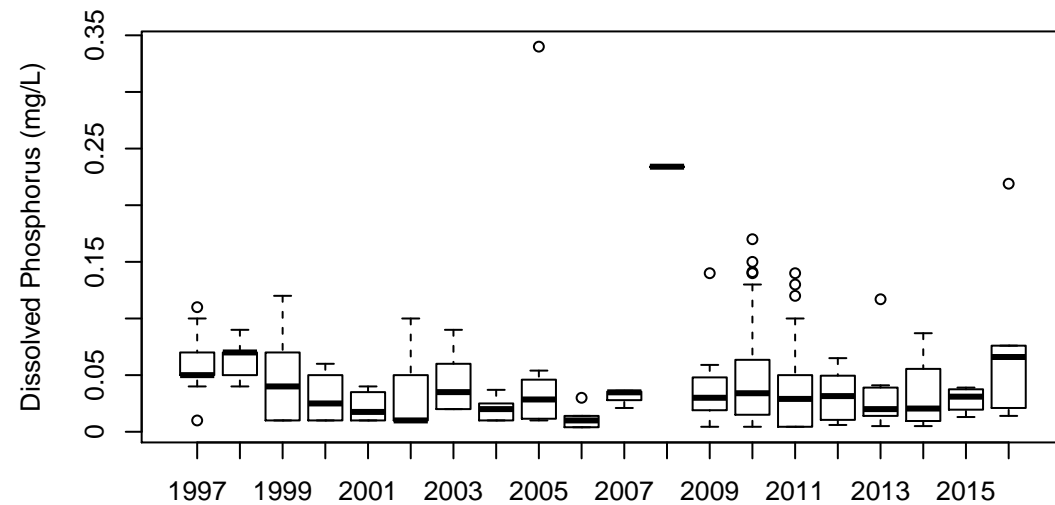


(d) Boxplot by month

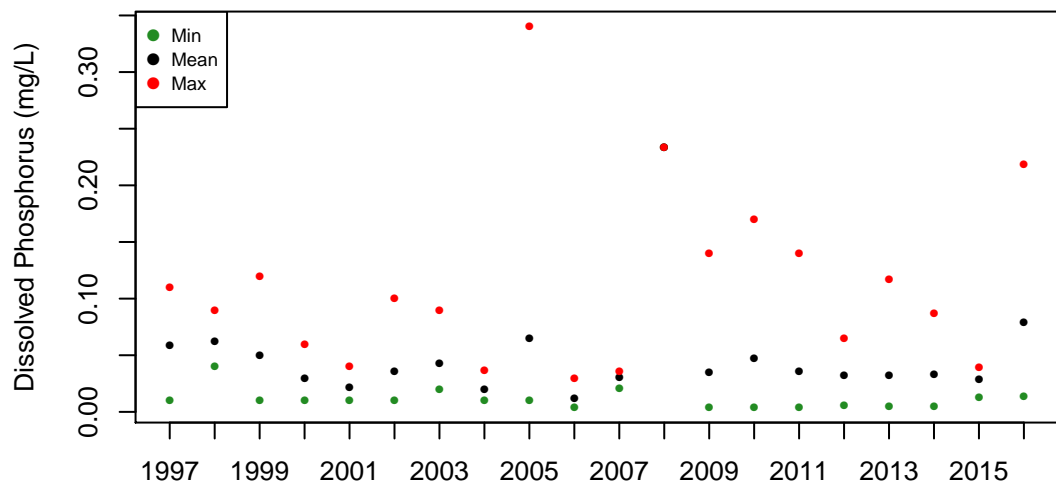
Blackberry Cr at Rt 47 (28): Dissolved Phosphorus (mg/L)



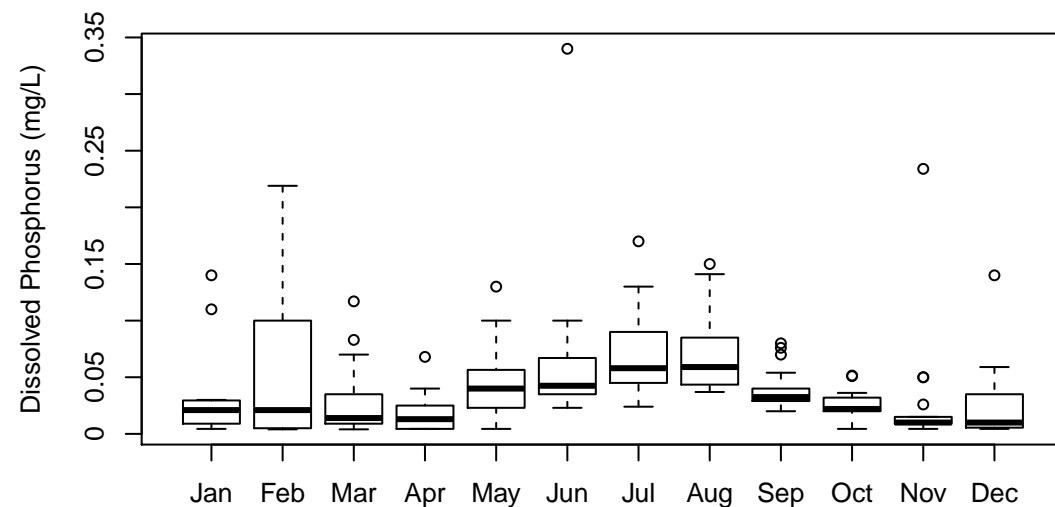
(a) Observation data



(b) Boxplot by year

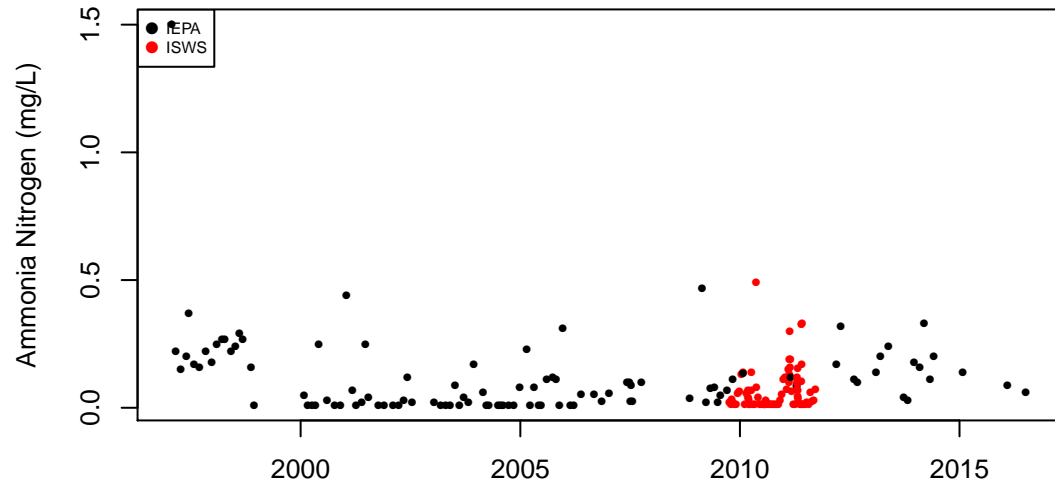


(c) Annual values

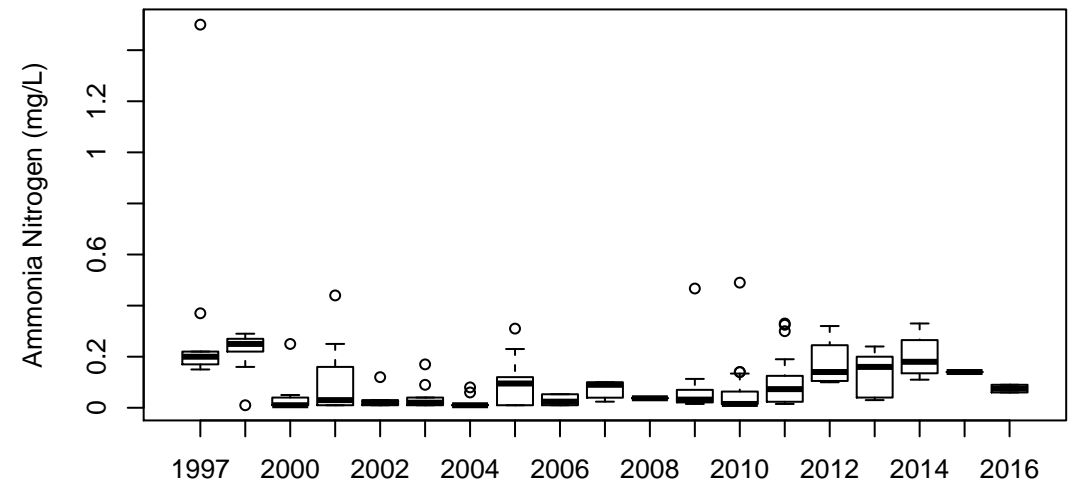


(d) Boxplot by month

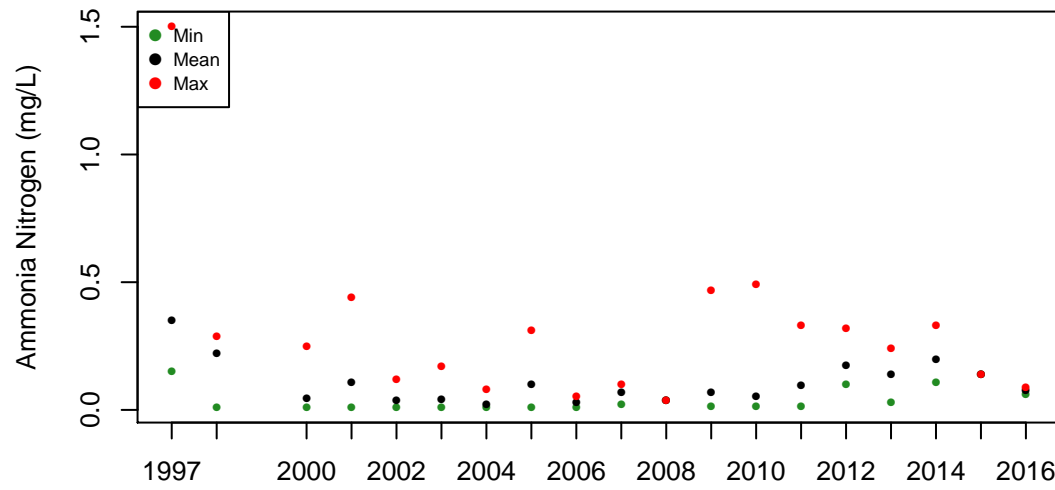
Blackberry Cr at Rt 47 (28): Ammonia Nitrogen (mg/L)



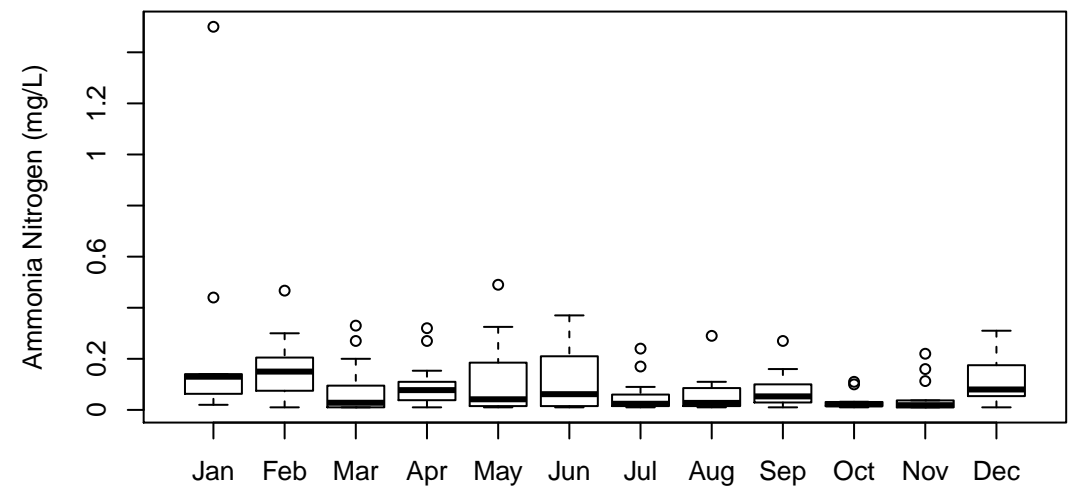
(a) Observation data



(b) Boxplot by year

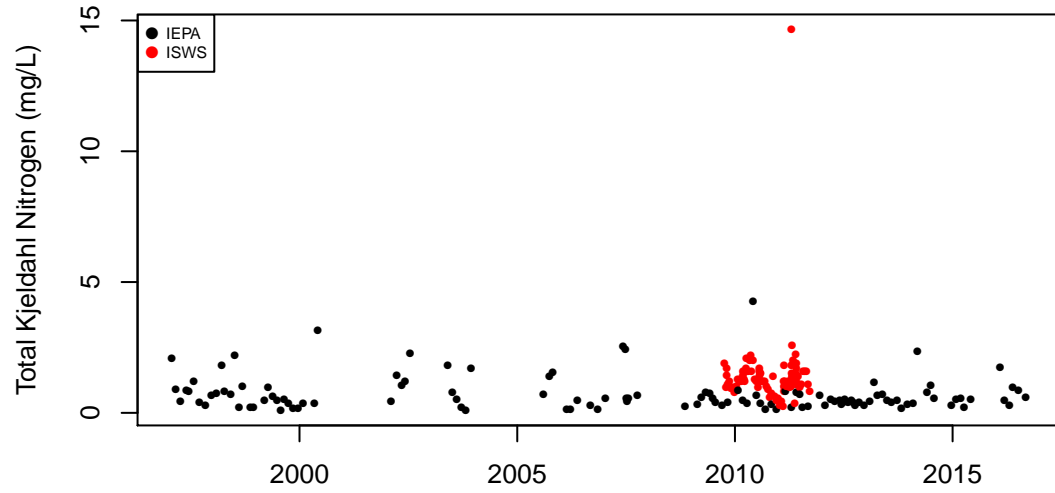


(c) Annual values

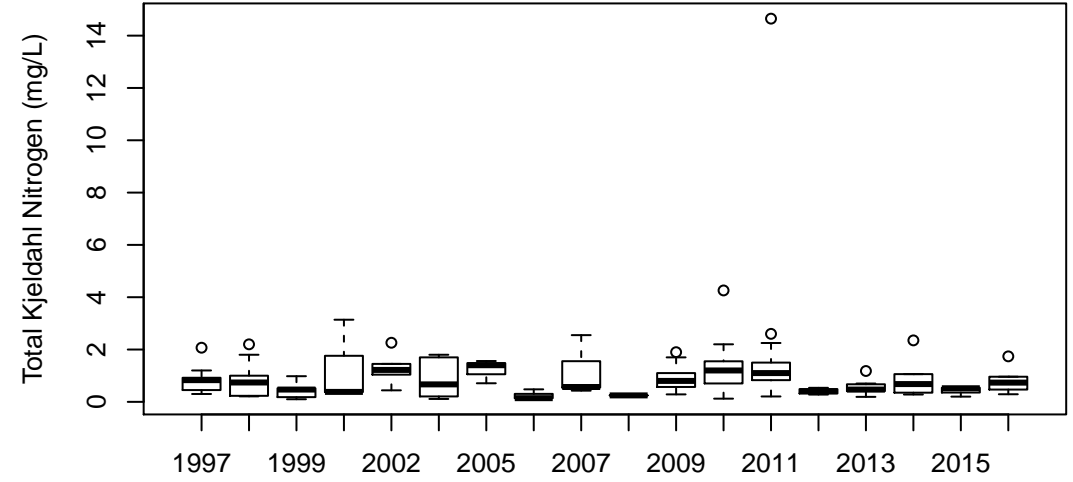


(d) Boxplot by month

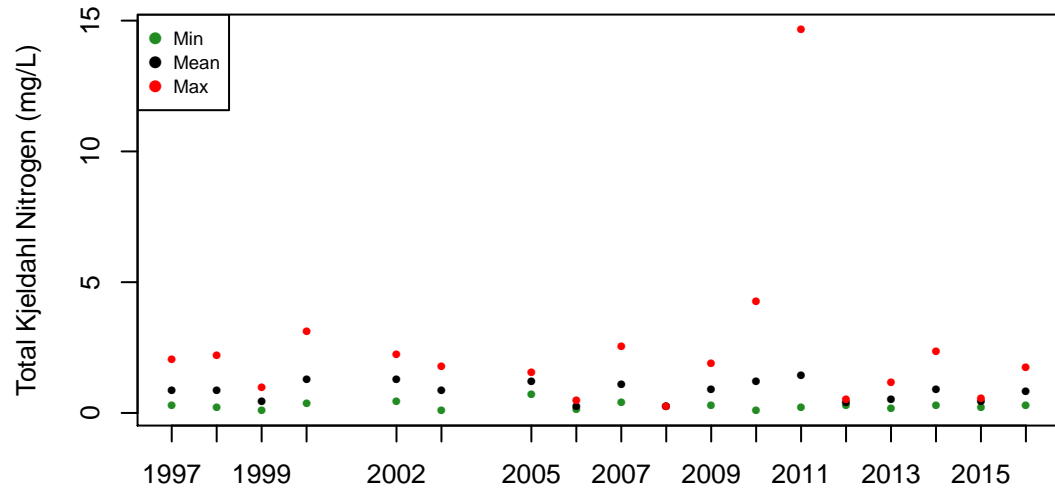
Blackberry Cr at Rt 47 (28): Total Kjeldahl Nitrogen (mg/L)



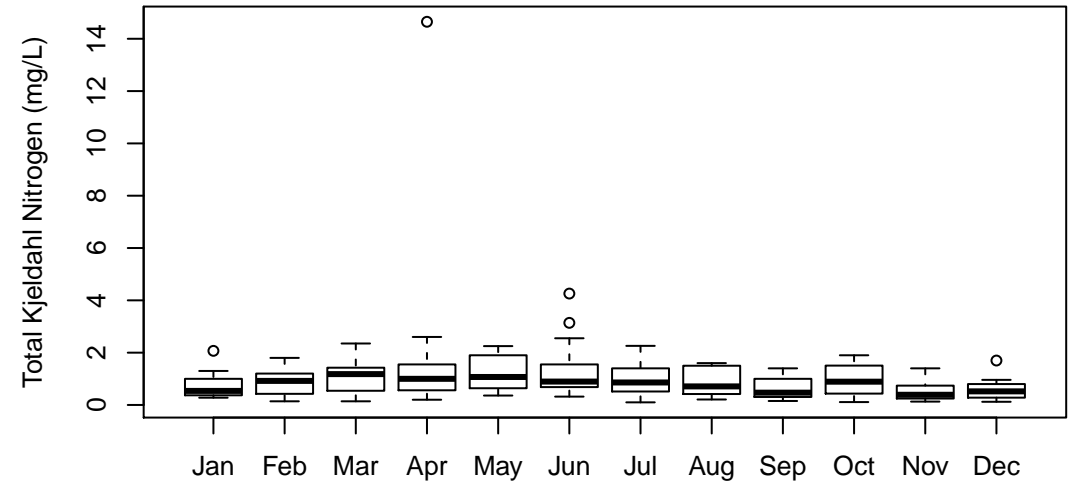
(a) Observation data



(b) Boxplot by year

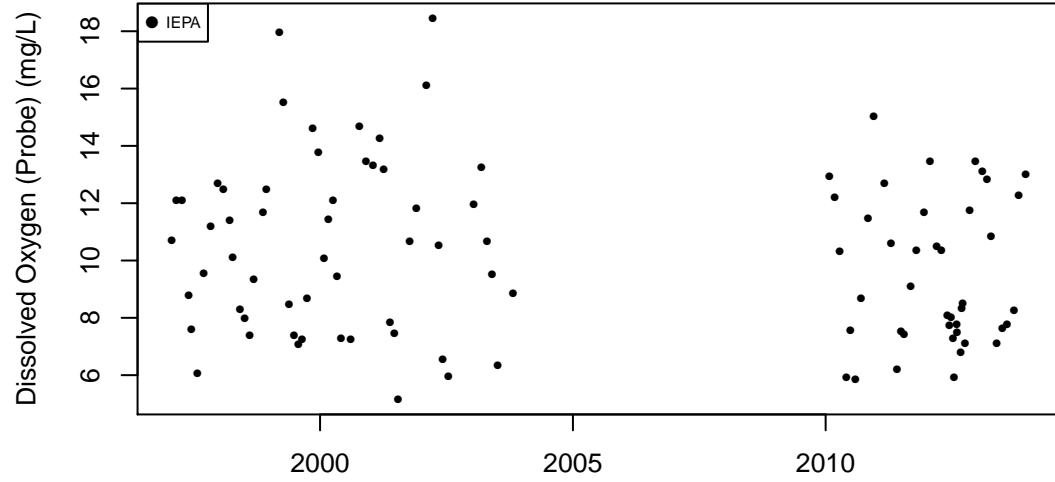


(c) Annual values

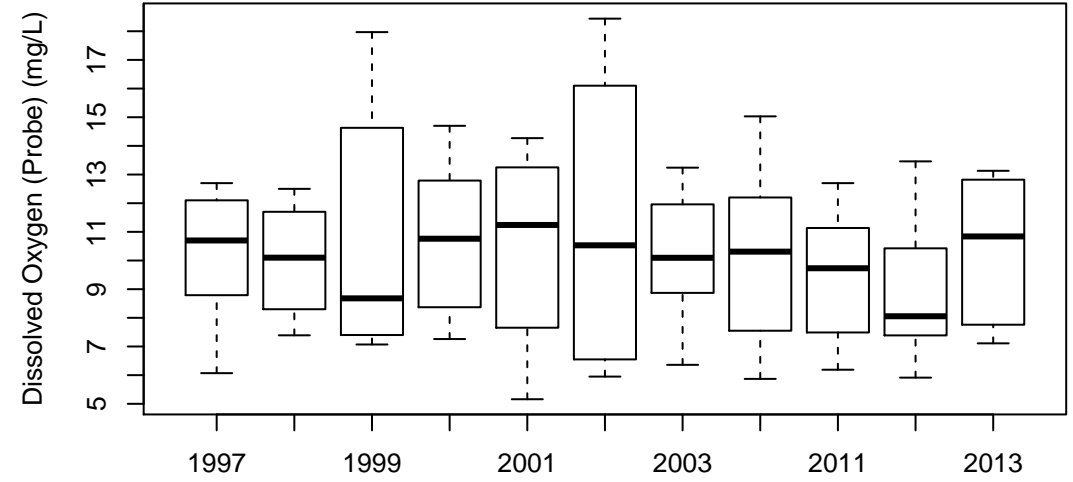


(d) Boxplot by month

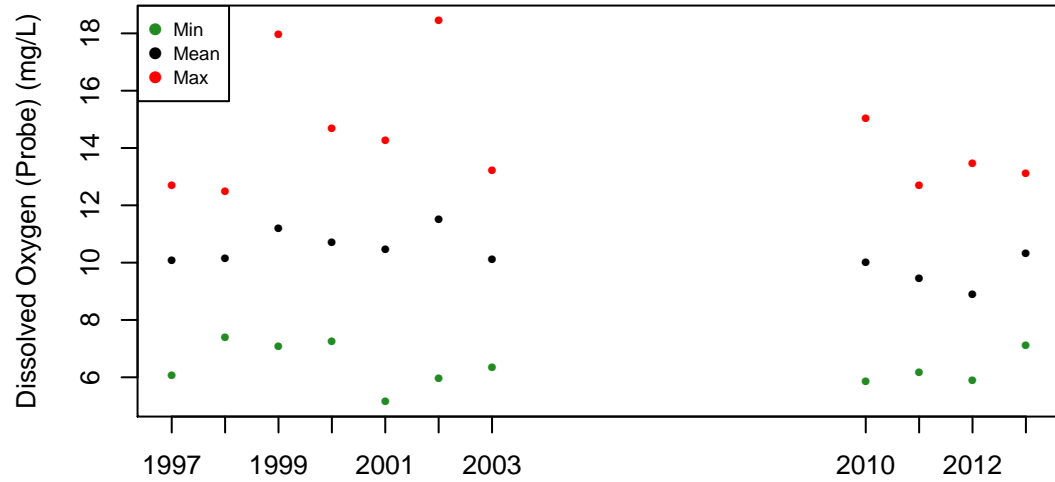
Blackberry Cr at Rt 47 (28): Dissolved Oxygen (Probe) (mg/L)



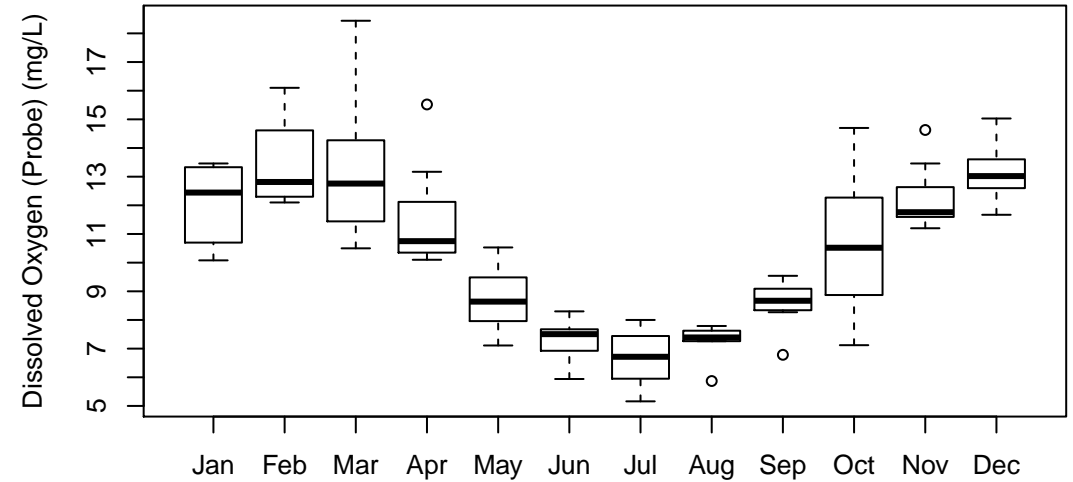
(a) Observation data



(b) Boxplot by year

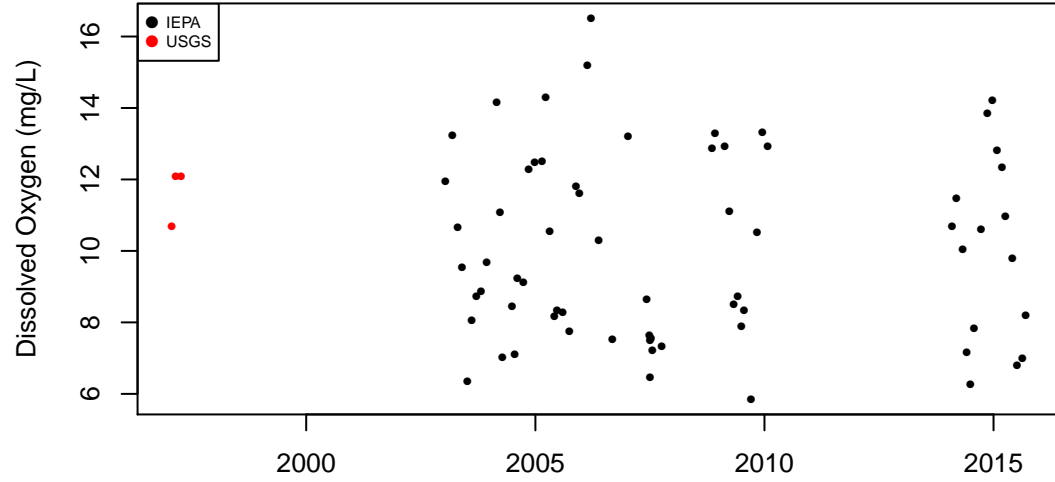


(c) Annual values

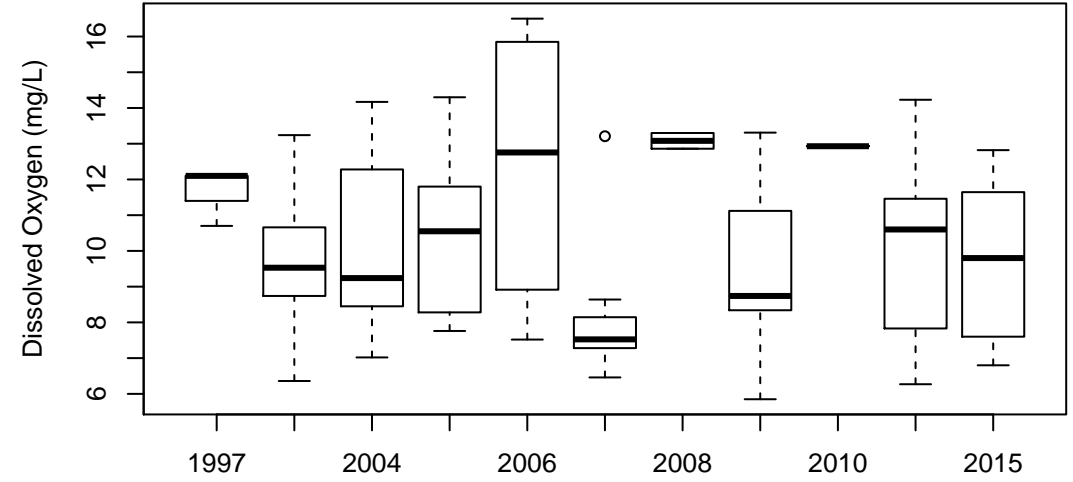


(d) Boxplot by month

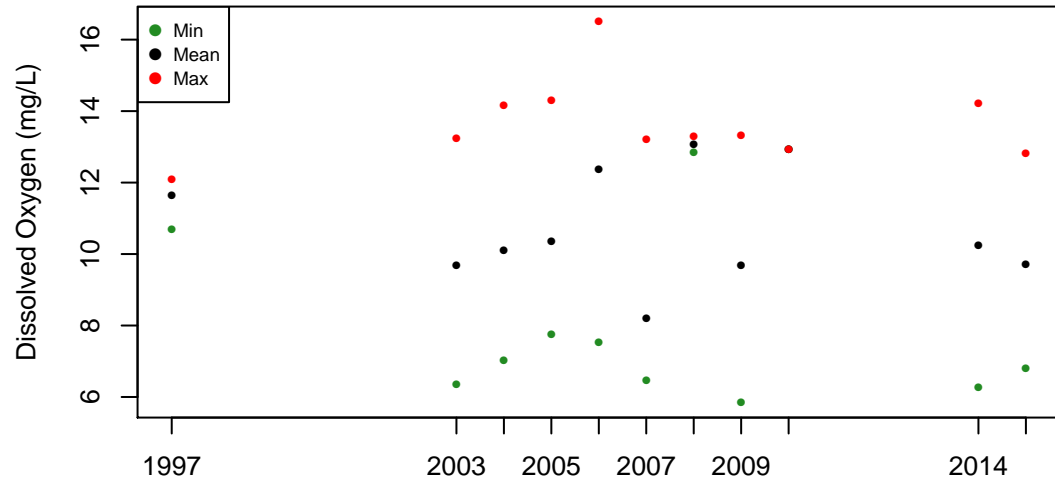
Blackberry Cr at Rt 47 (28): Dissolved Oxygen (mg/L)



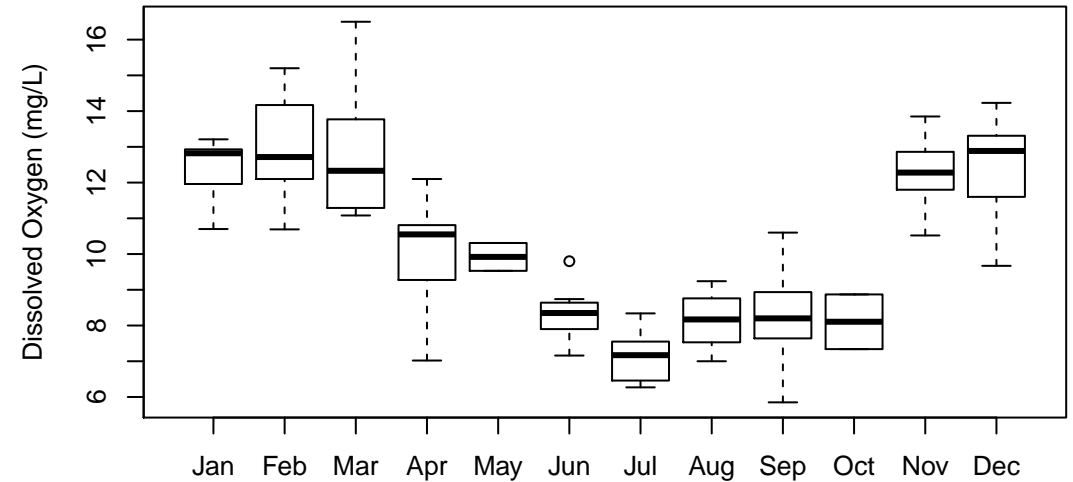
(a) Observation data



(b) Boxplot by year

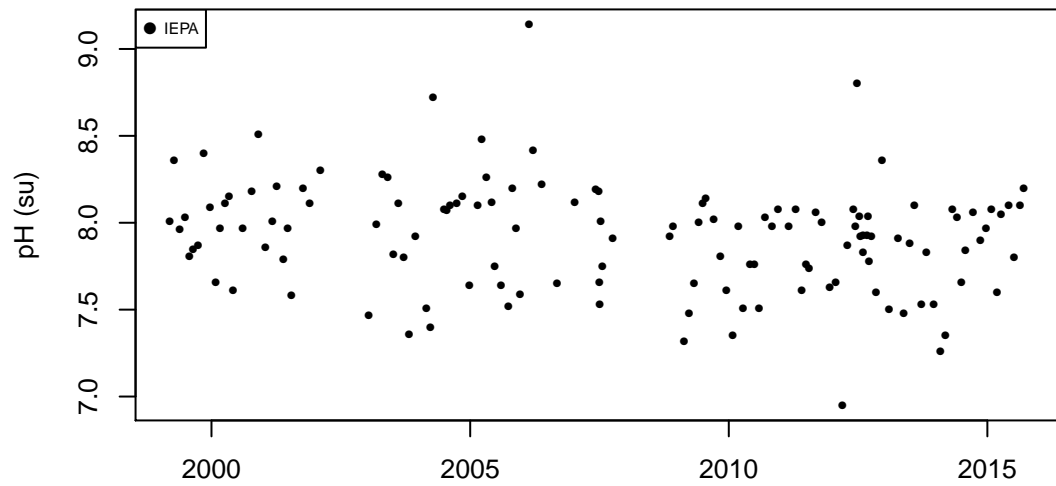


(c) Annual values

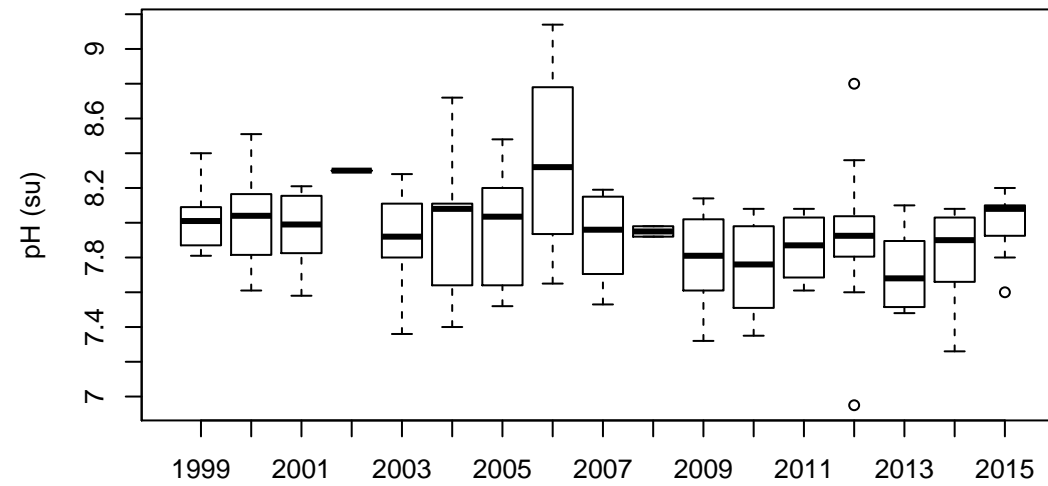


(d) Boxplot by month

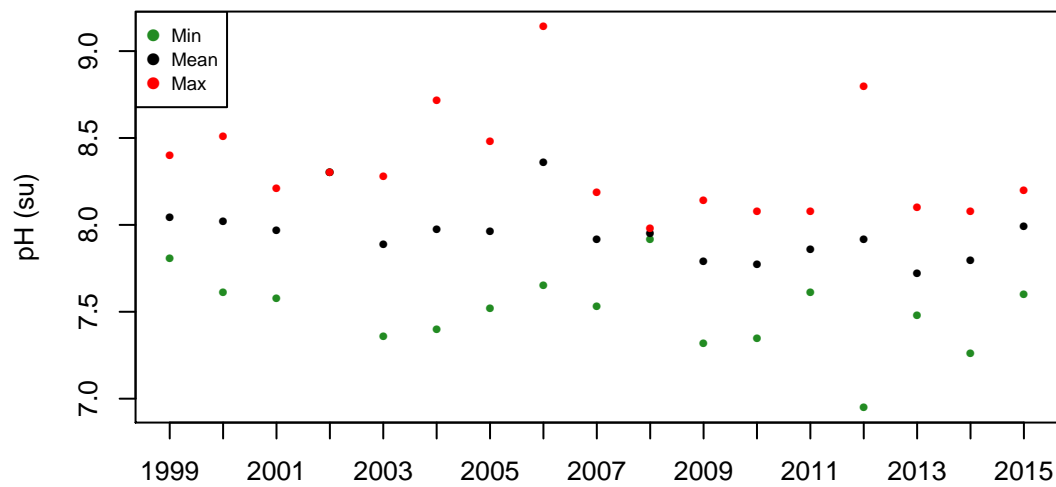
Blackberry Cr at Rt 47 (28): pH (su)



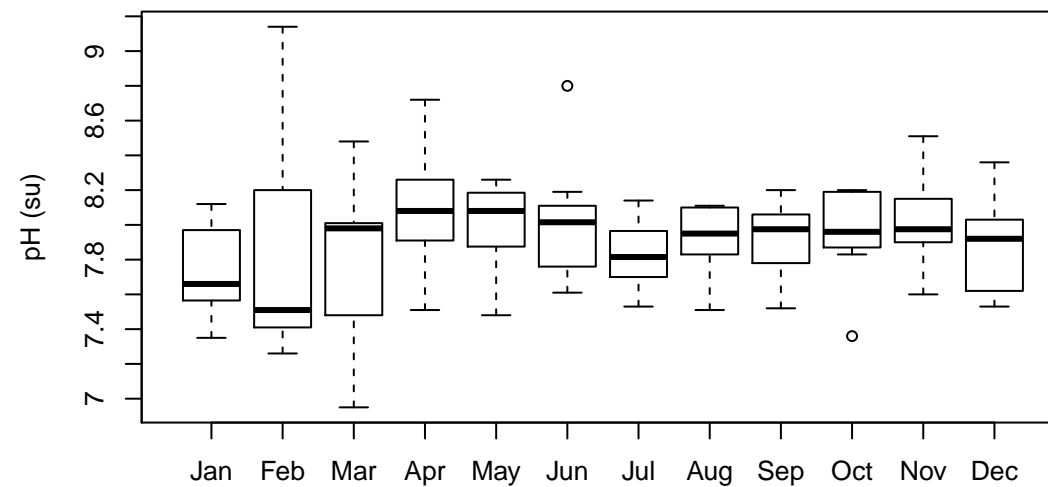
(a) Observation data



(b) Boxplot by year

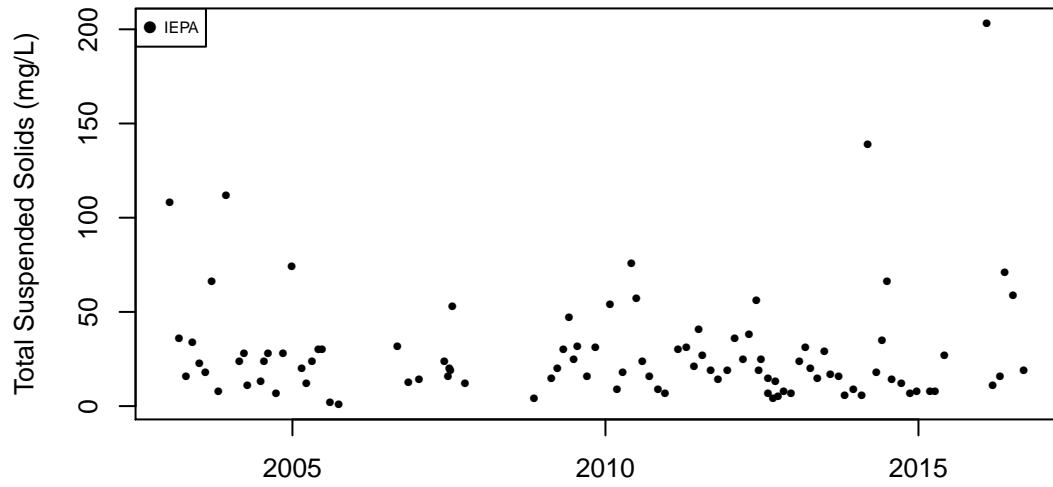


(c) Annual values

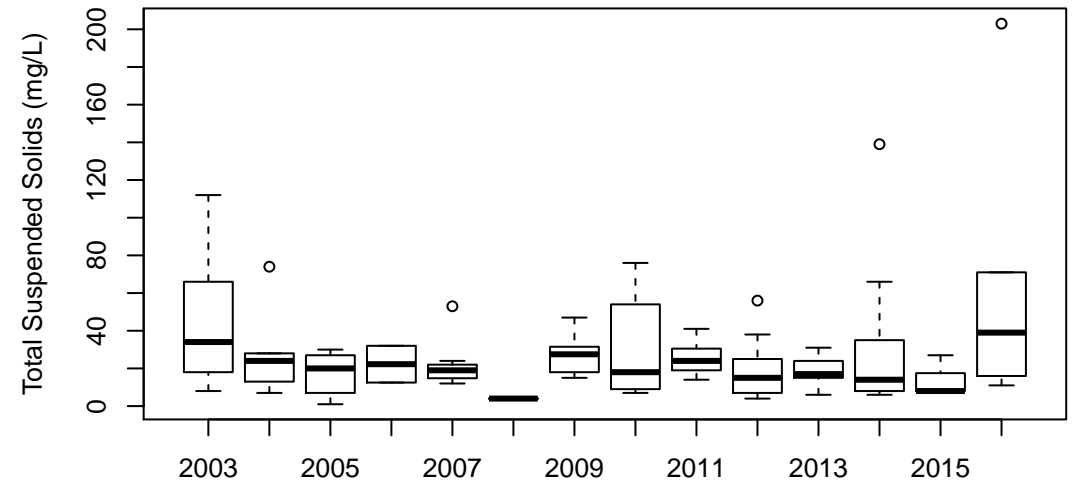


(d) Boxplot by month

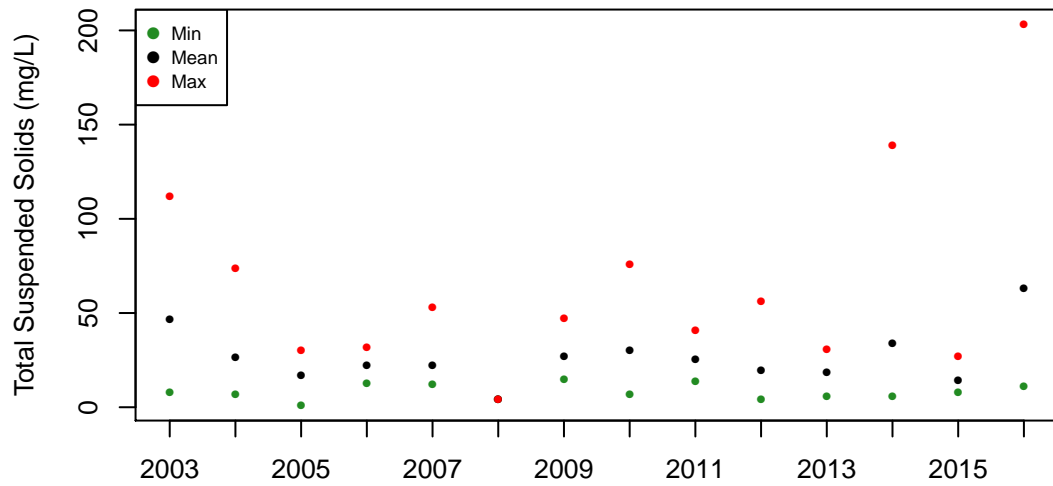
Blackberry Cr at Rt 47 (28): Total Suspended Solids (mg/L)



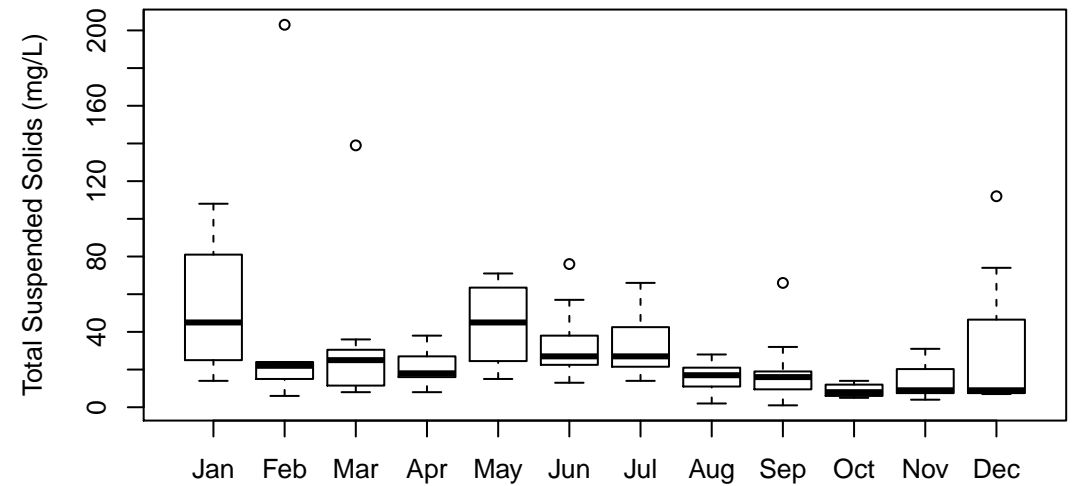
(a) Observation data



(b) Boxplot by year

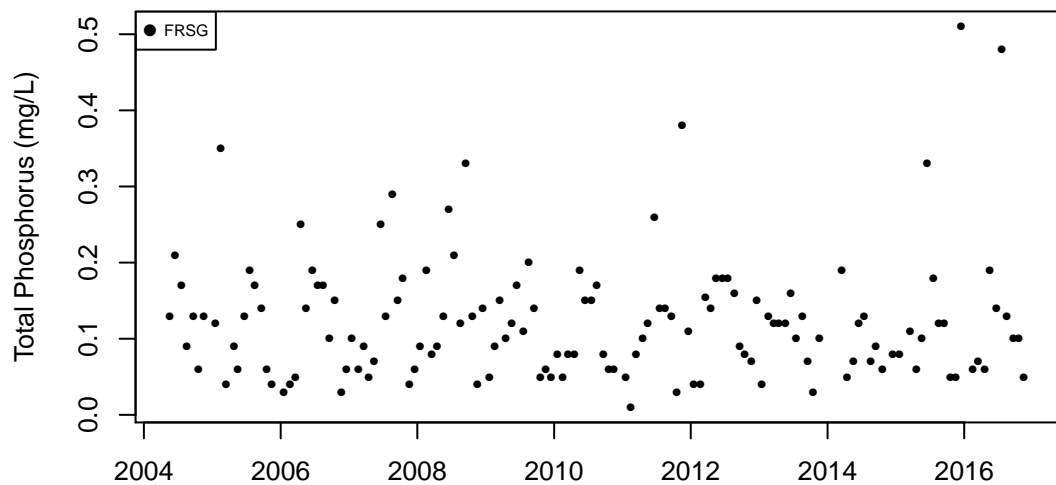


(c) Annual values

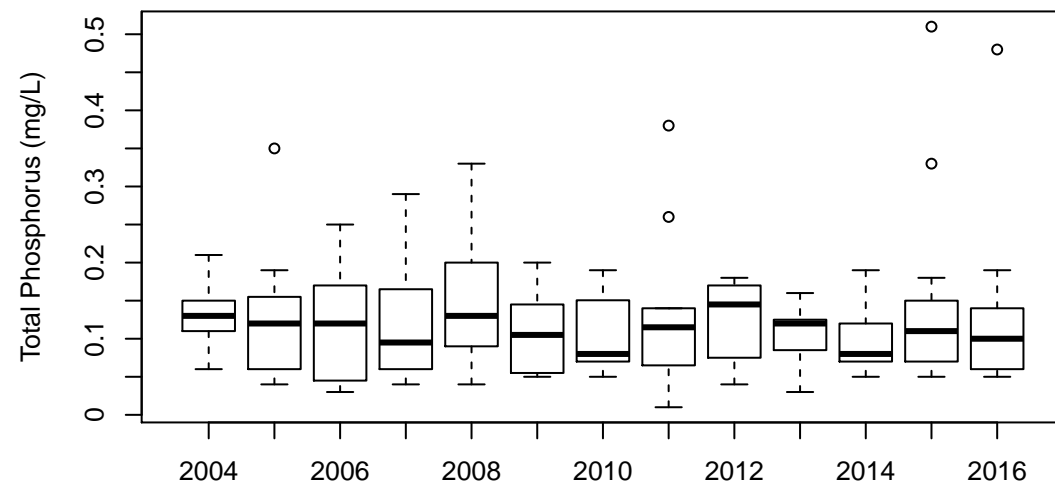


(d) Boxplot by month

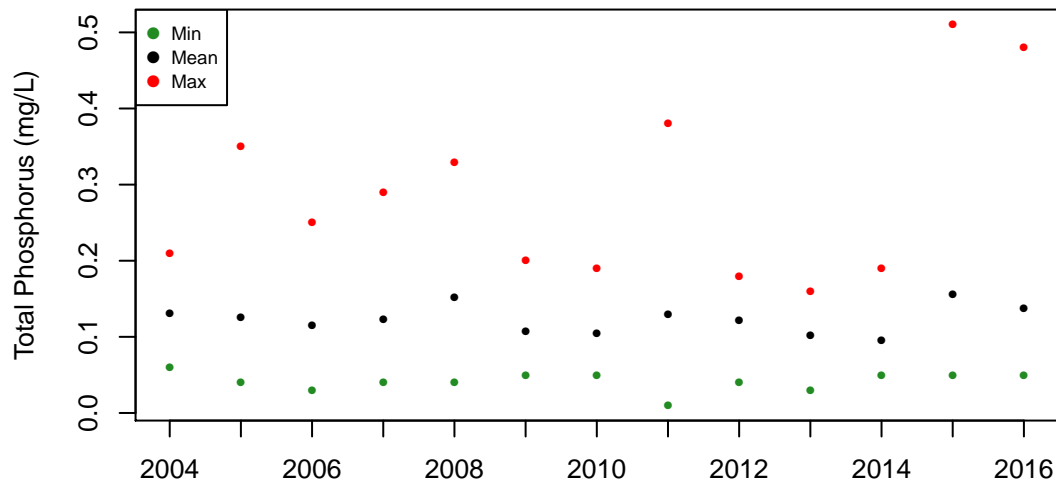
Blackberry Cr near Mouth (287): Total Phosphorus (mg/L)



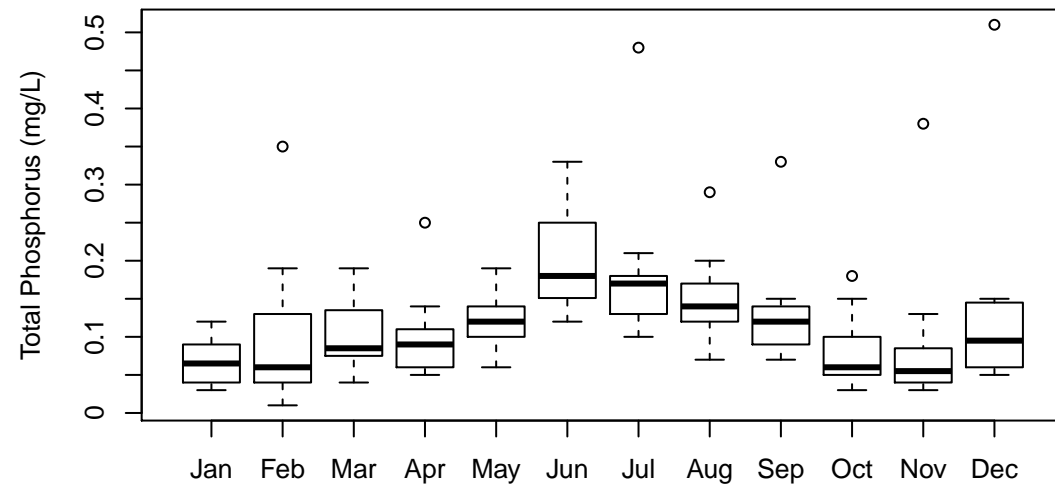
(a) Observation data



(b) Boxplot by year

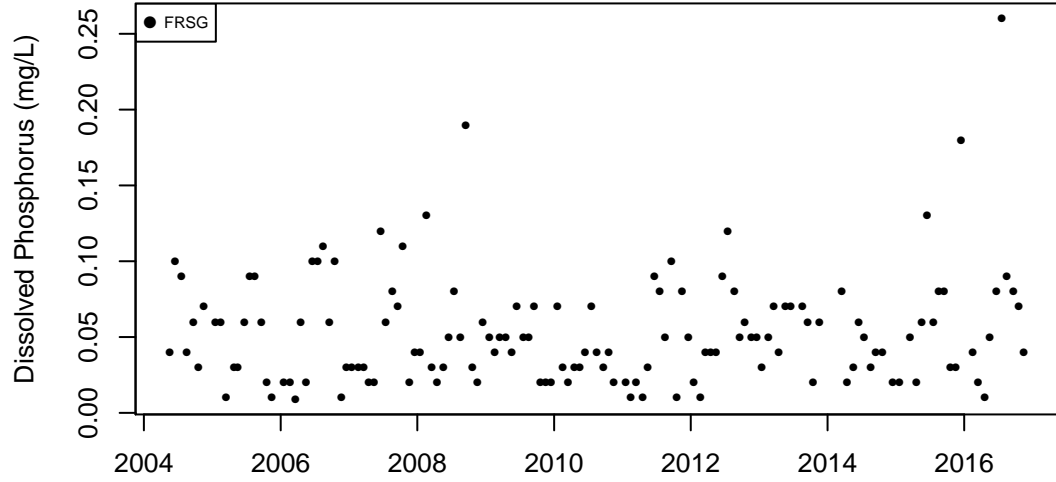


(c) Annual values

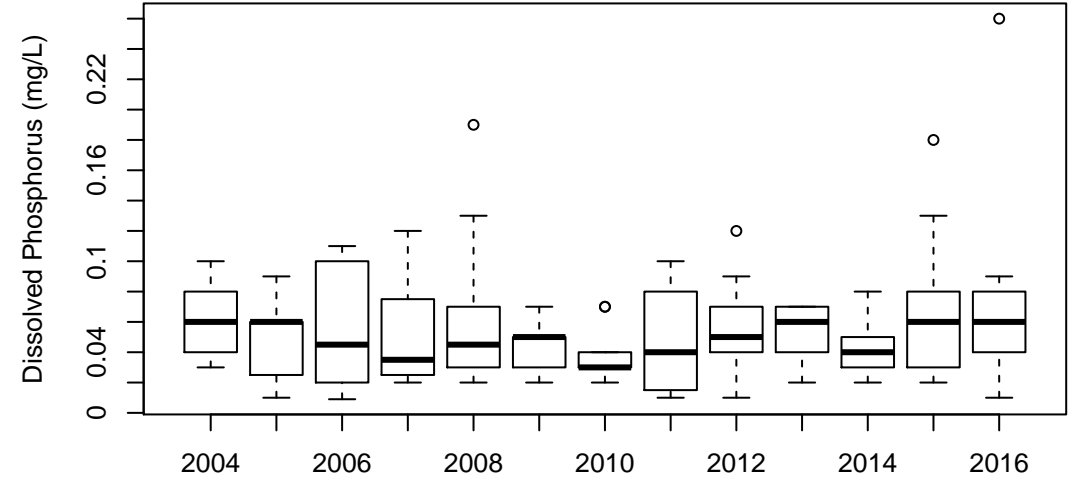


(d) Boxplot by month

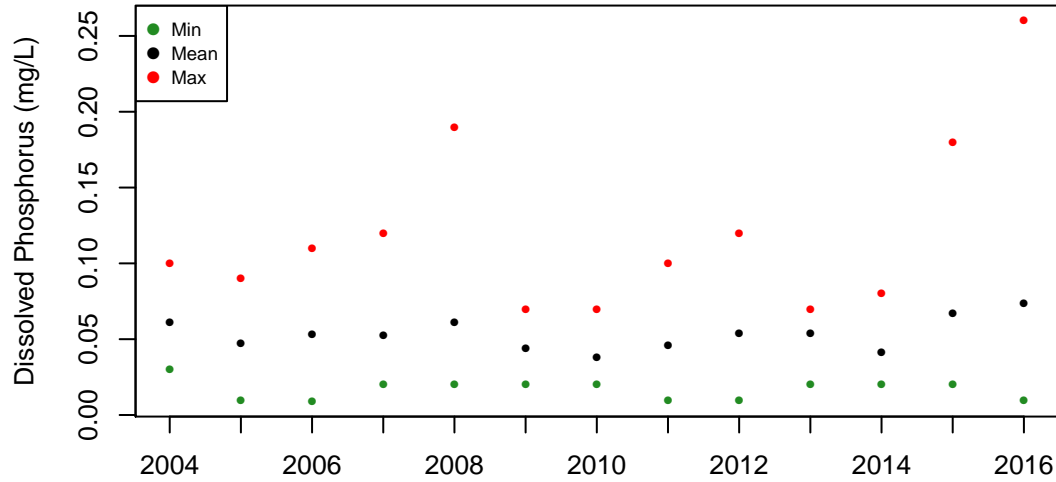
Blackberry Cr near Mouth (287): Dissolved Phosphorus (mg/L)



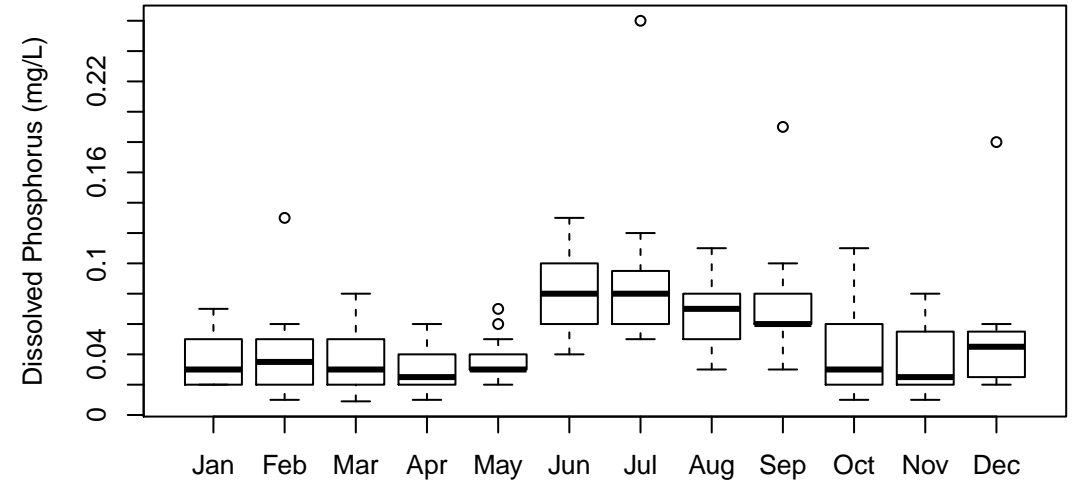
(a) Observation data



(b) Boxplot by year

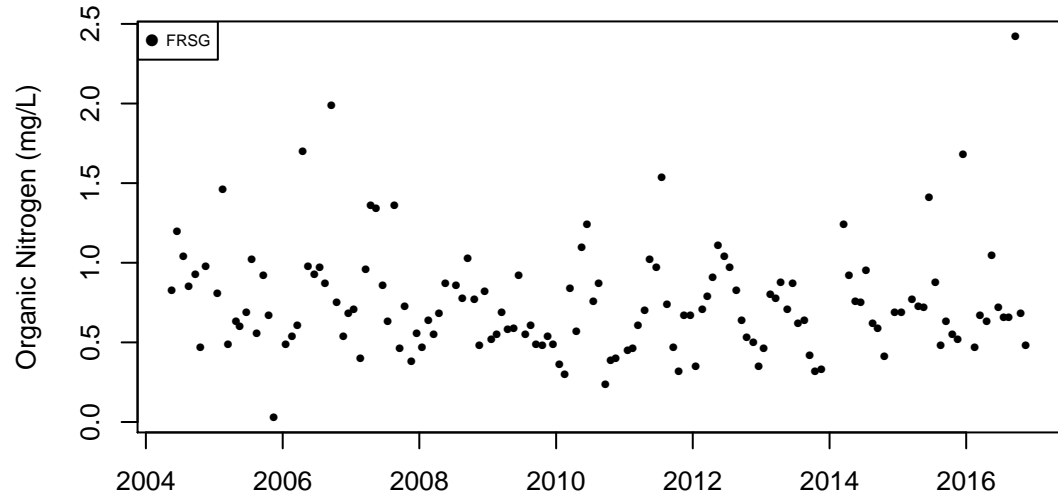


(c) Annual values

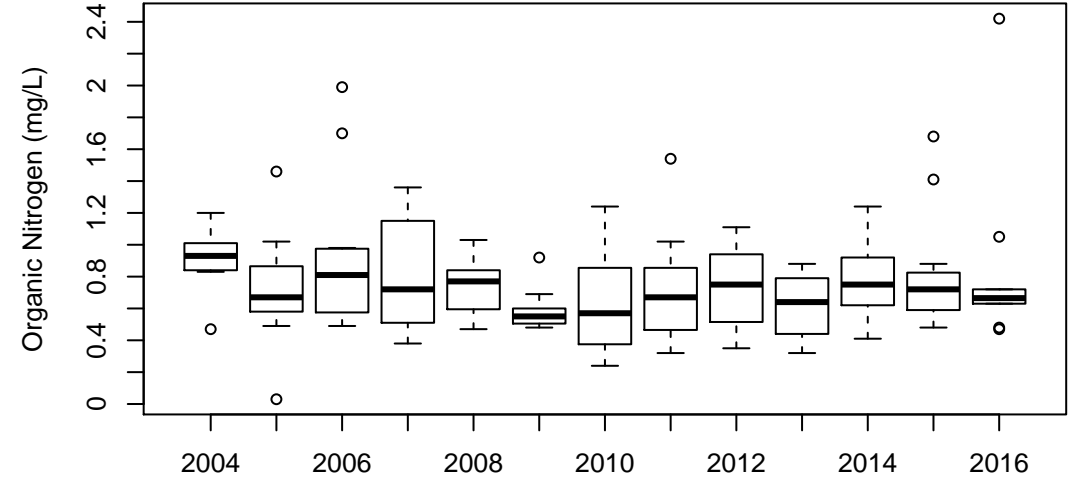


(d) Boxplot by month

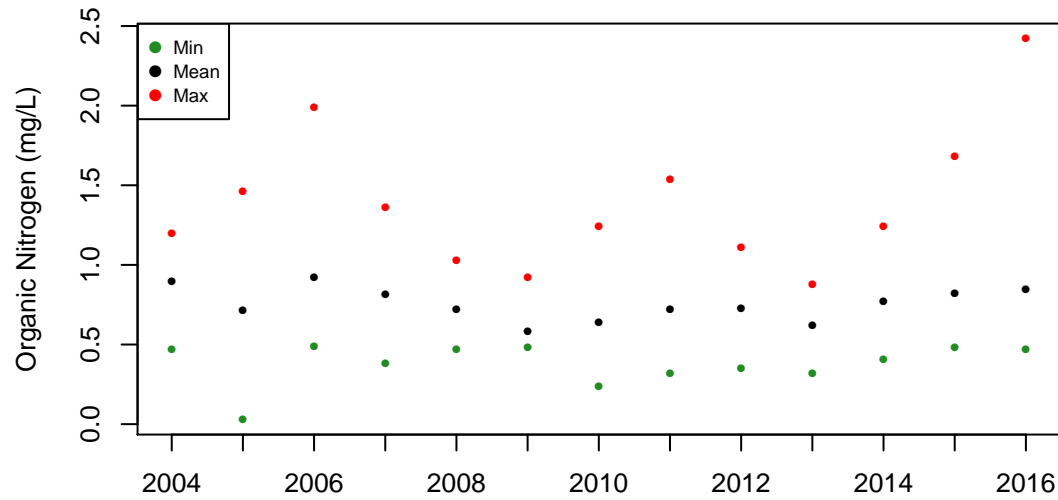
Blackberry Cr near Mouth (287): Organic Nitrogen (mg/L)



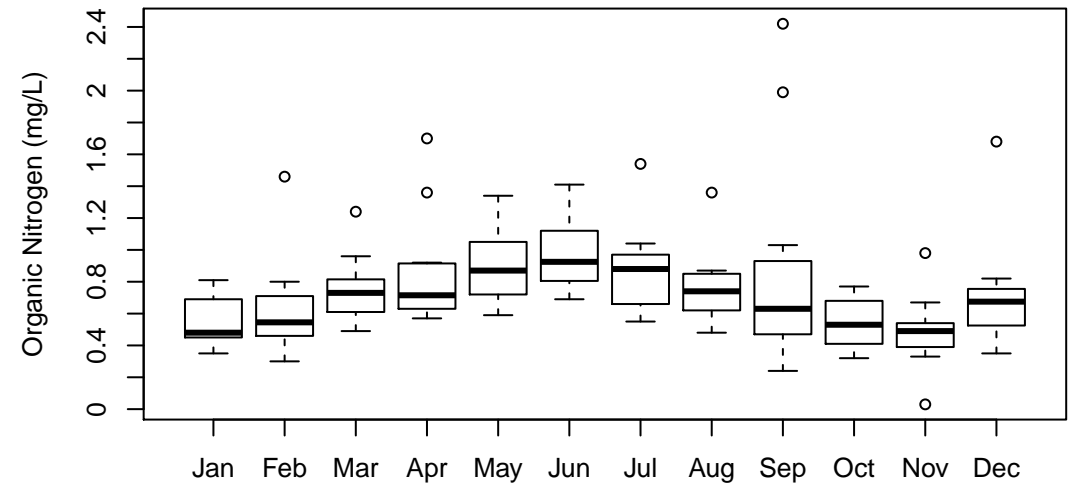
(a) Observation data



(b) Boxplot by year

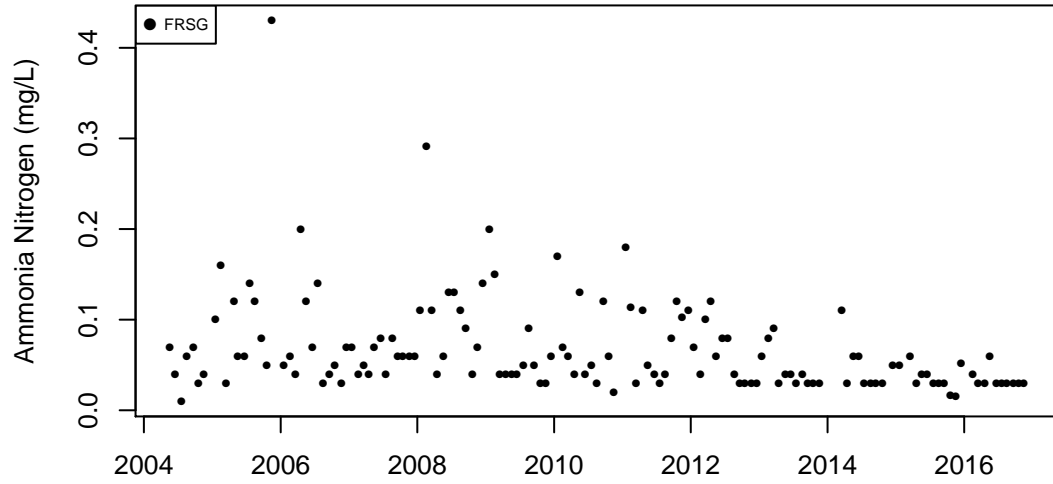


(c) Annual values

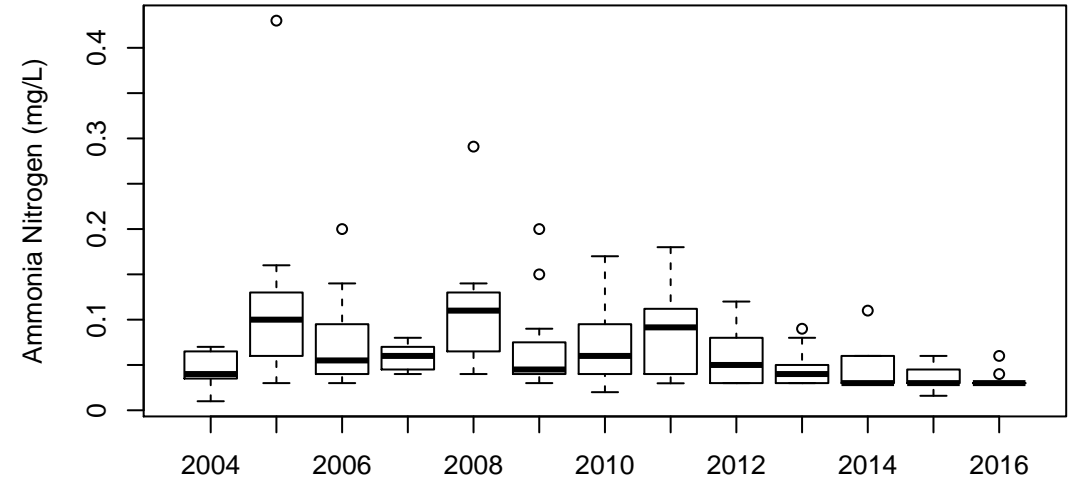


(d) Boxplot by month

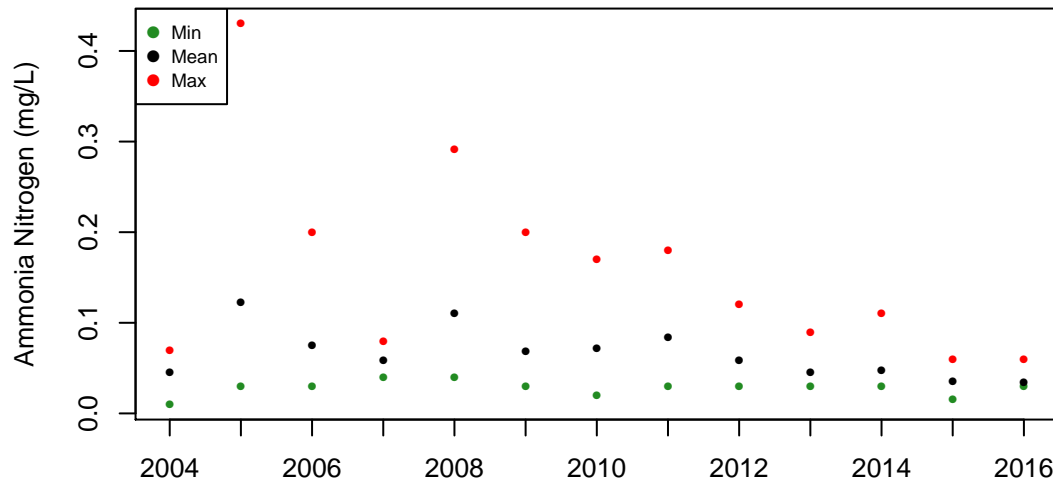
Blackberry Cr near Mouth (287): Ammonia Nitrogen (mg/L)



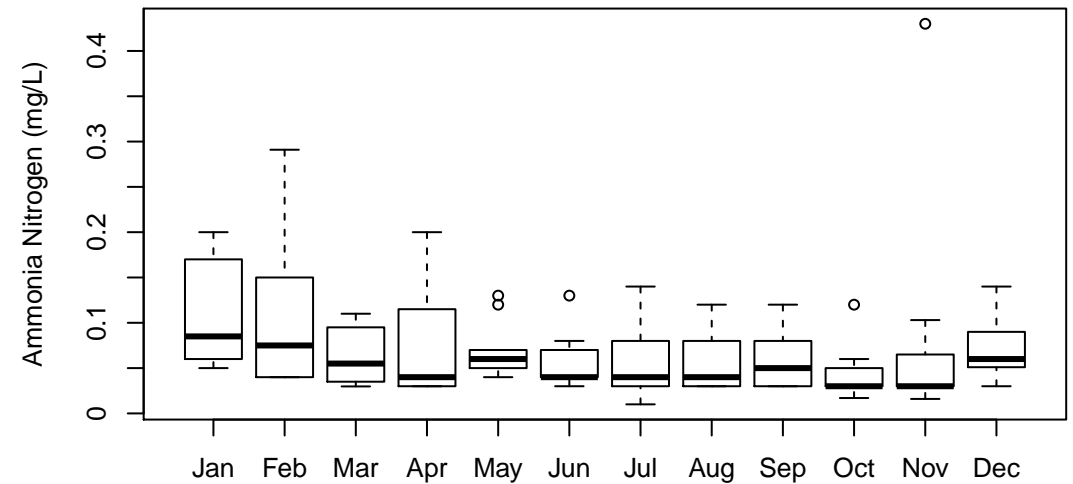
(a) Observation data



(b) Boxplot by year

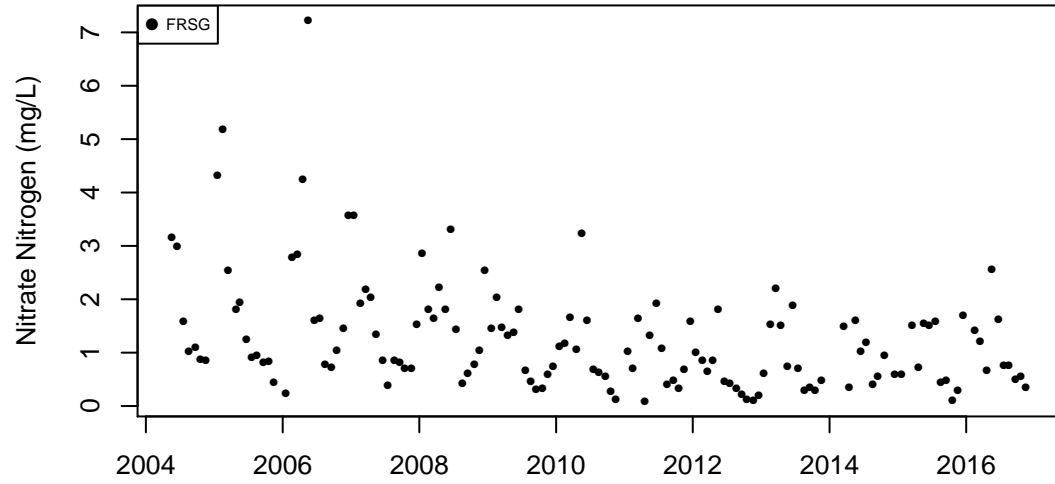


(c) Annual values

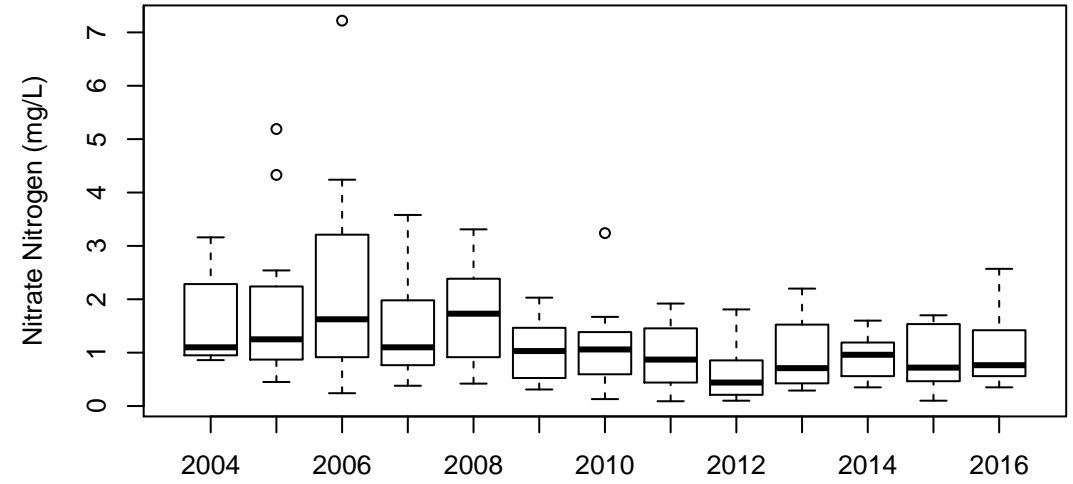


(d) Boxplot by month

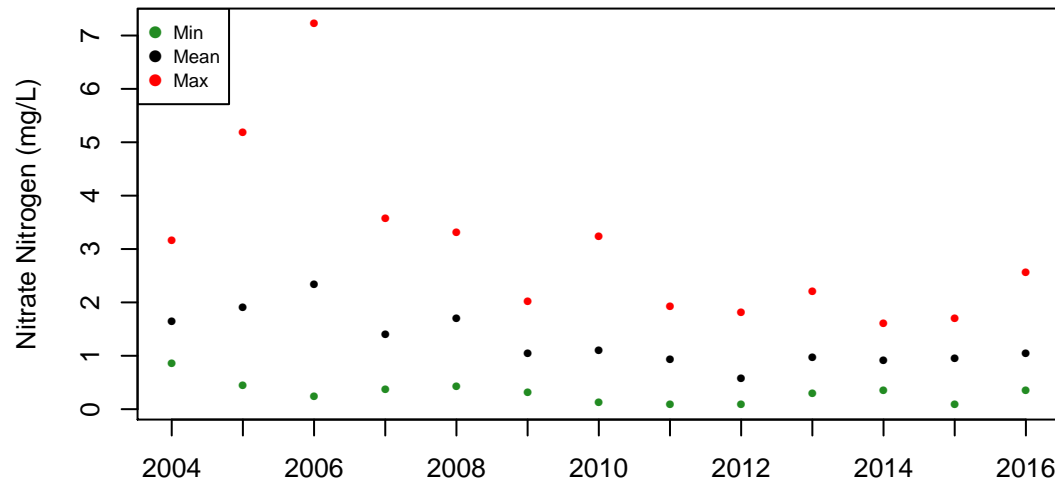
Blackberry Cr near Mouth (287): Nitrate Nitrogen (mg/L)



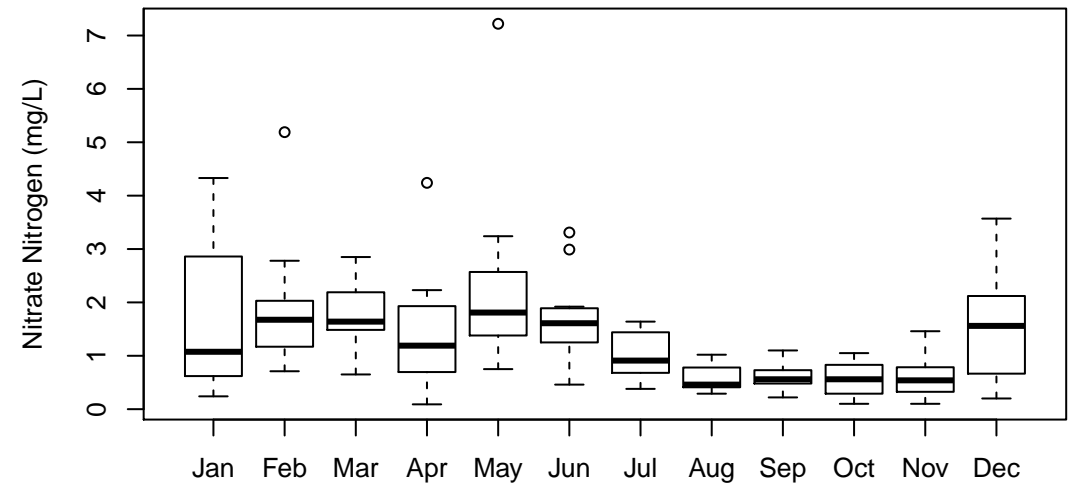
Sampling date
(a) Observation data



Year
(b) Boxplot by year

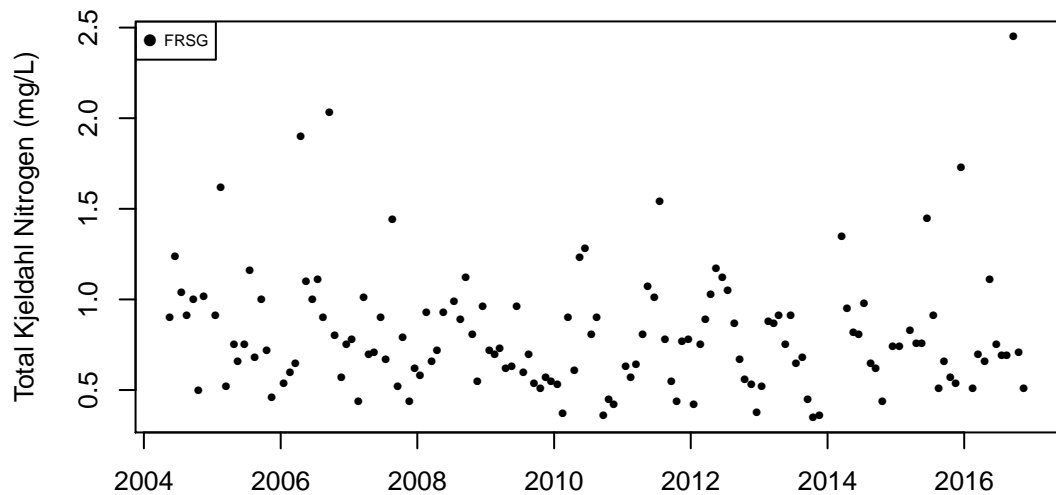


Year
(c) Annual values

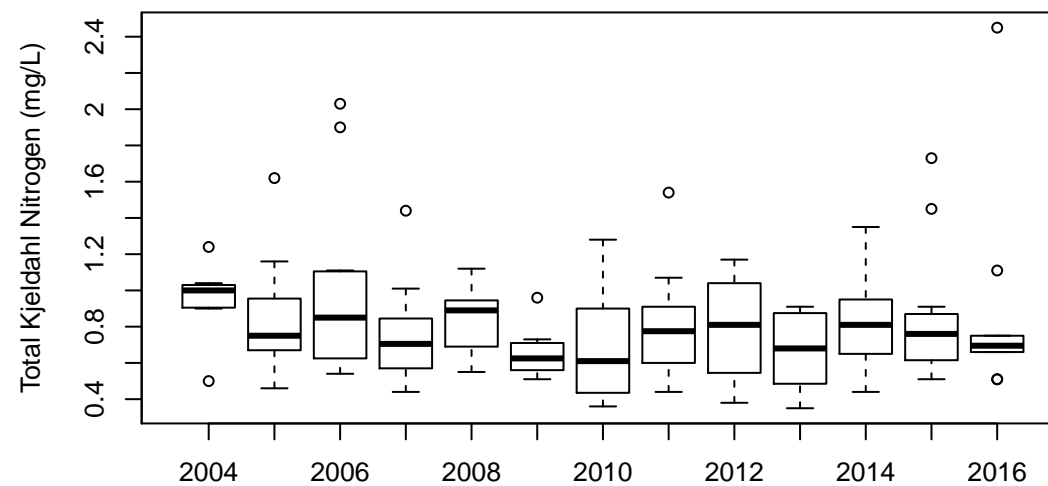


Month
(d) Boxplot by month

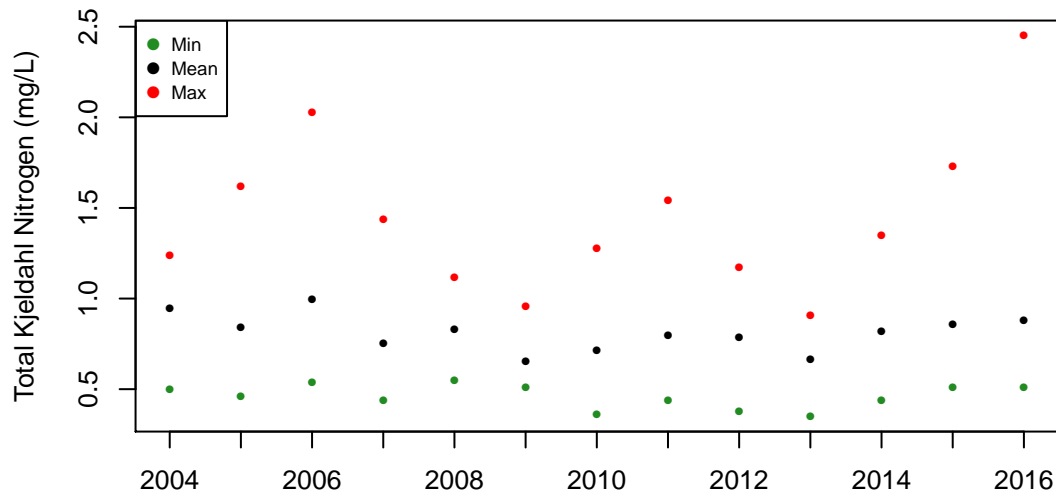
Blackberry Cr near Mouth (287): Total Kjeldahl Nitrogen (mg/L)



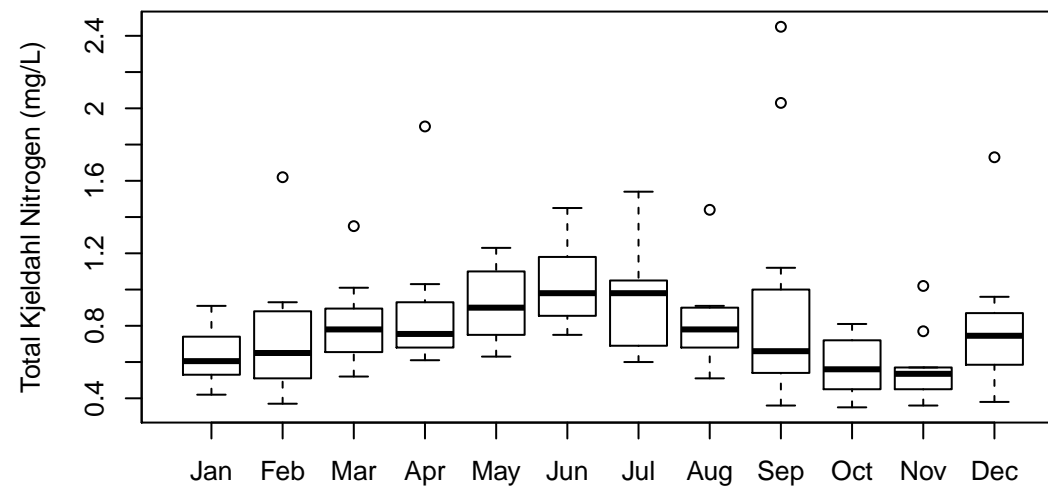
(a) Observation data



(b) Boxplot by year

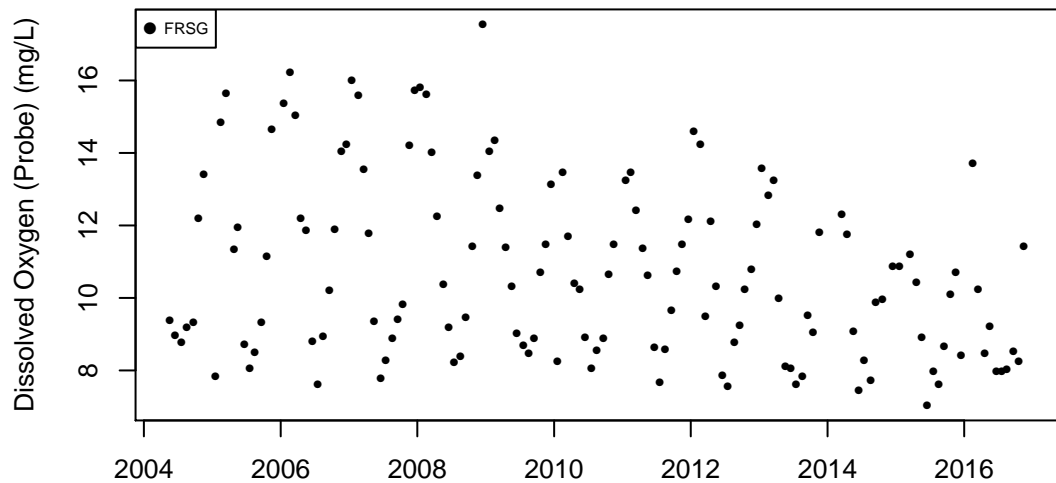


(c) Annual values

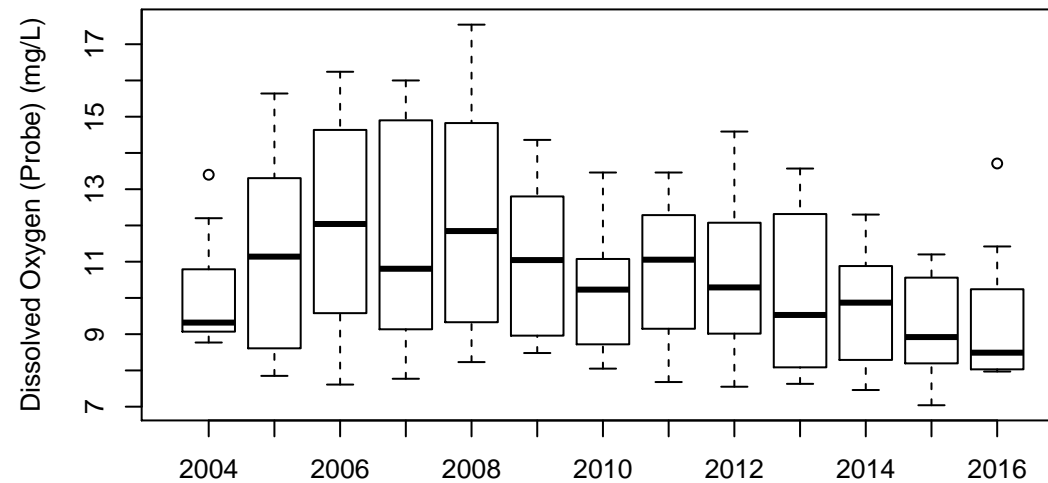


(d) Boxplot by month

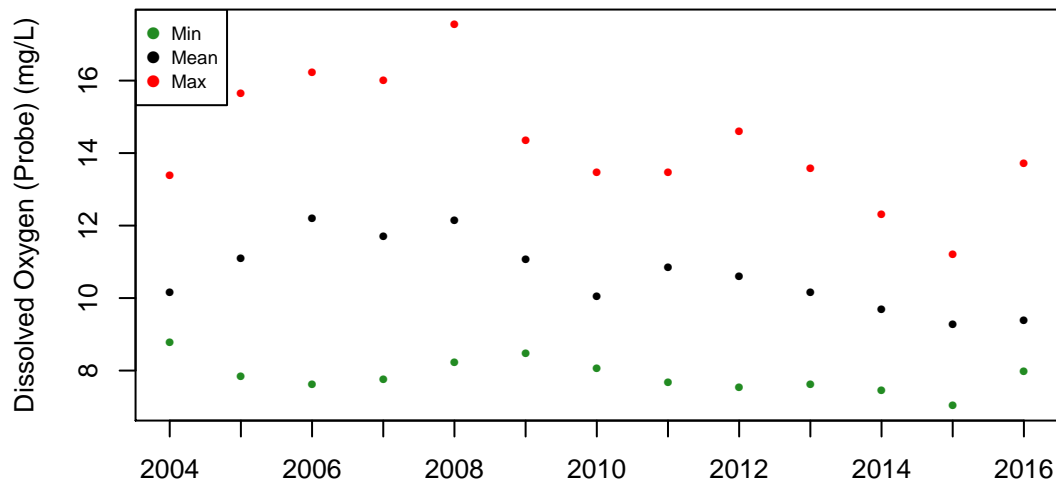
Blackberry Cr near Mouth (287): Dissolved Oxygen (Probe) (mg/L)



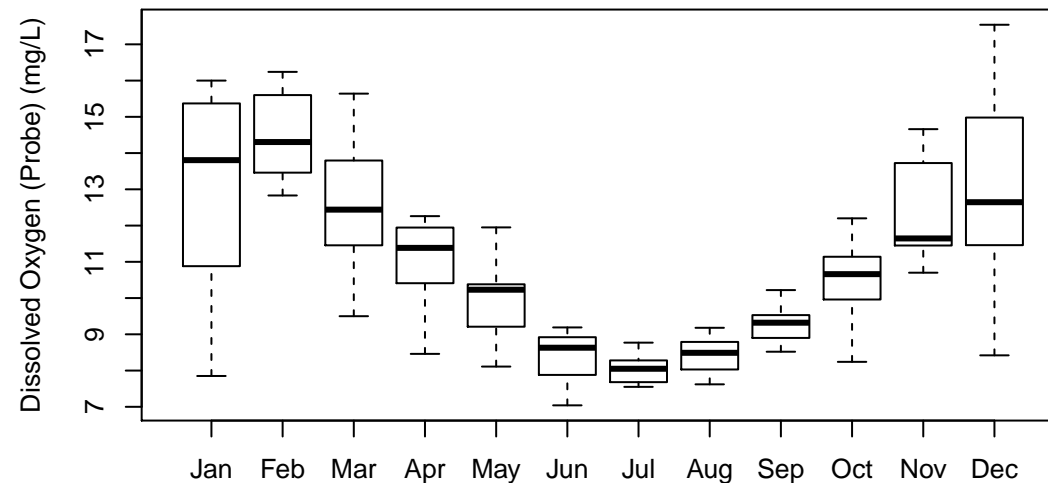
(a) Observation data



(b) Boxplot by year

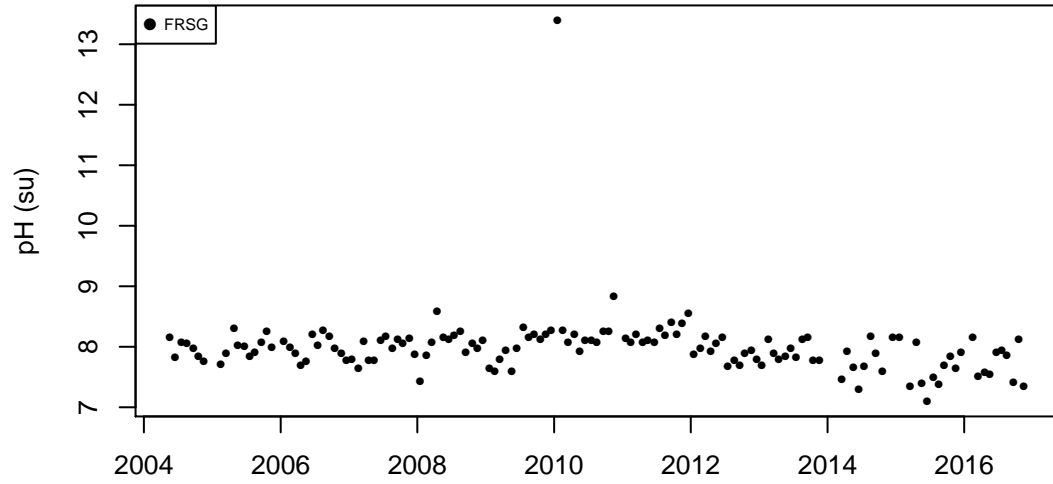


(c) Annual values

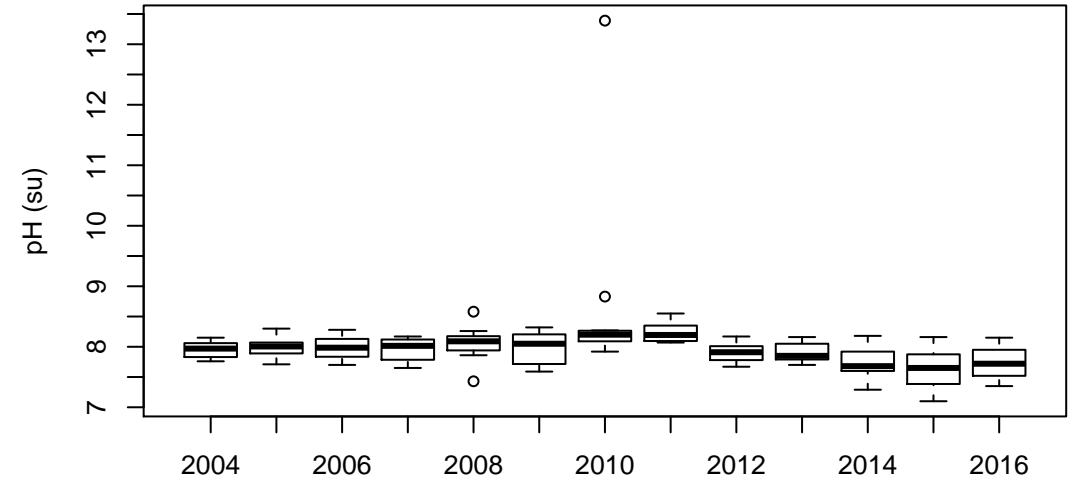


(d) Boxplot by month

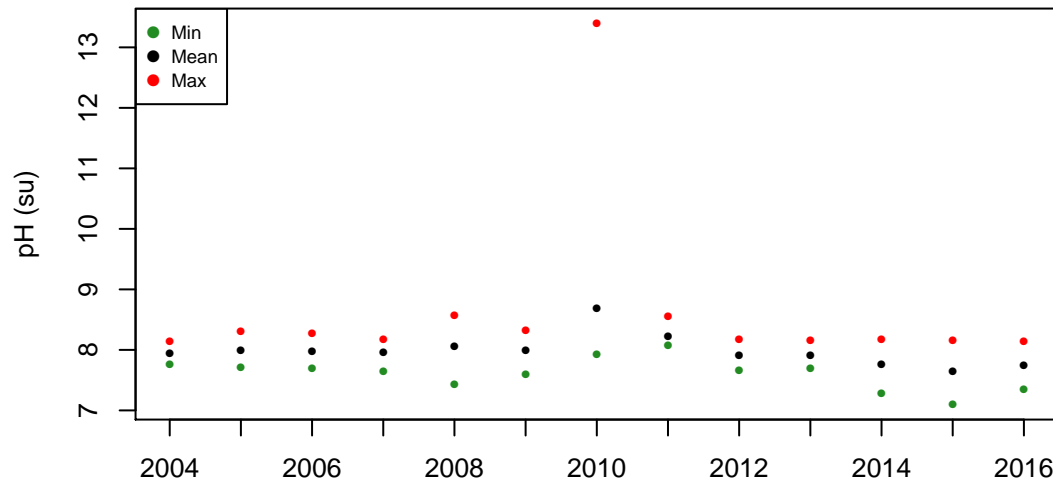
Blackberry Cr near Mouth (287): pH (su)



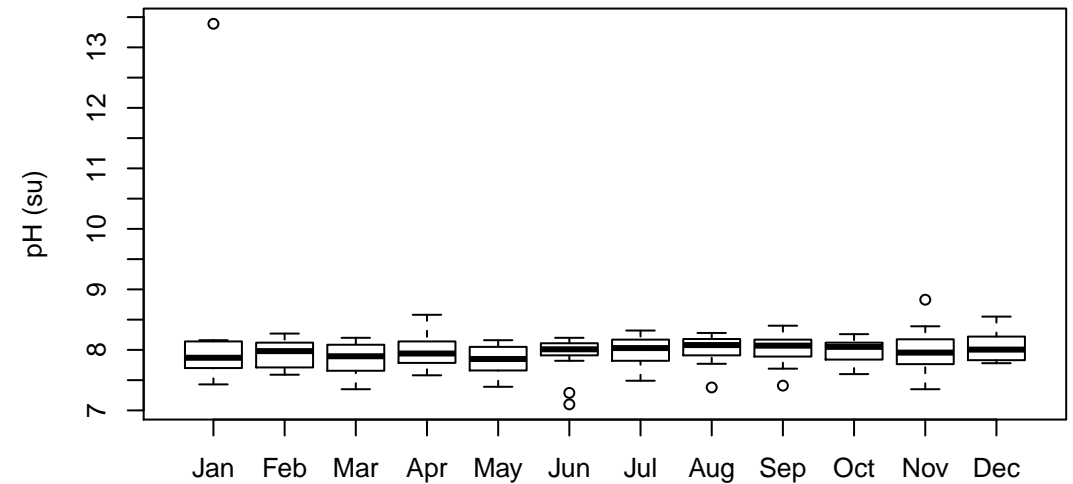
(a) Observation data



(b) Boxplot by year

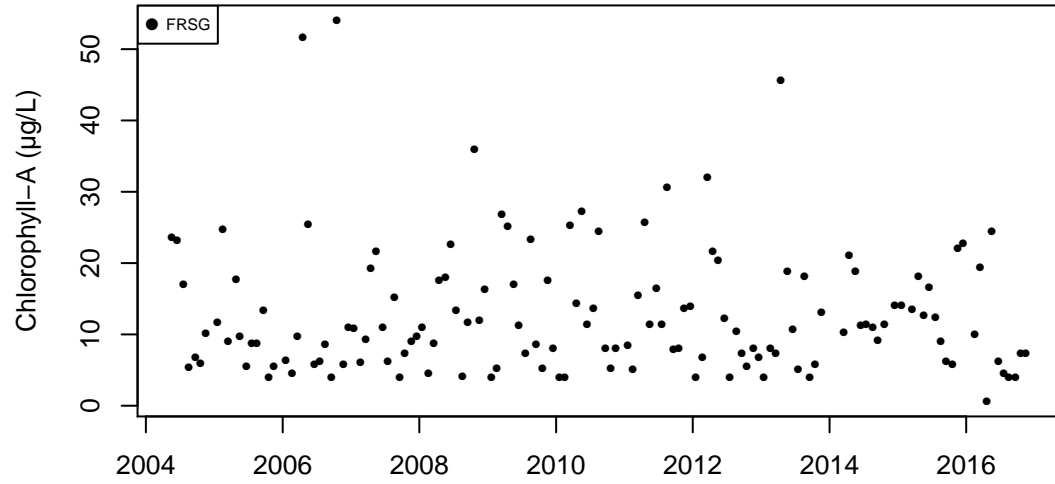


(c) Annual values

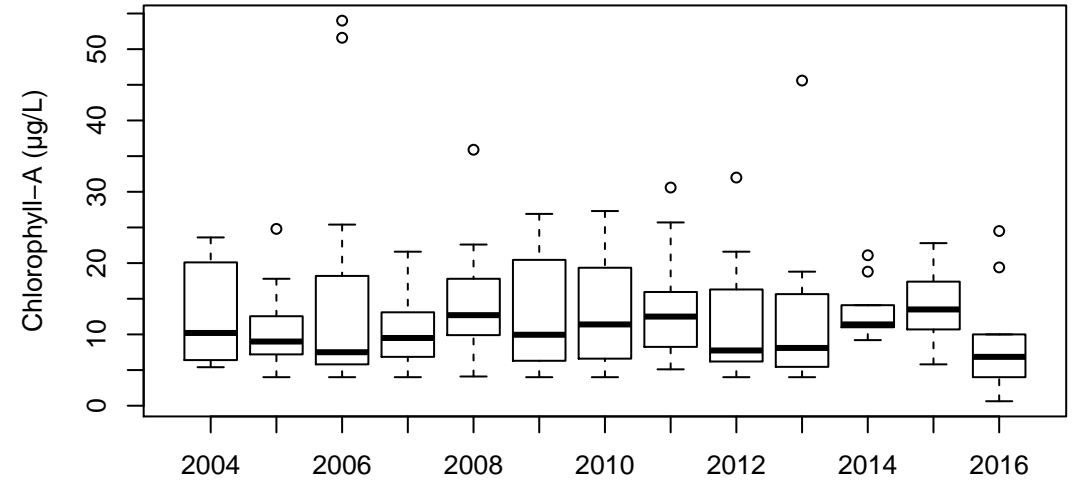


(d) Boxplot by month

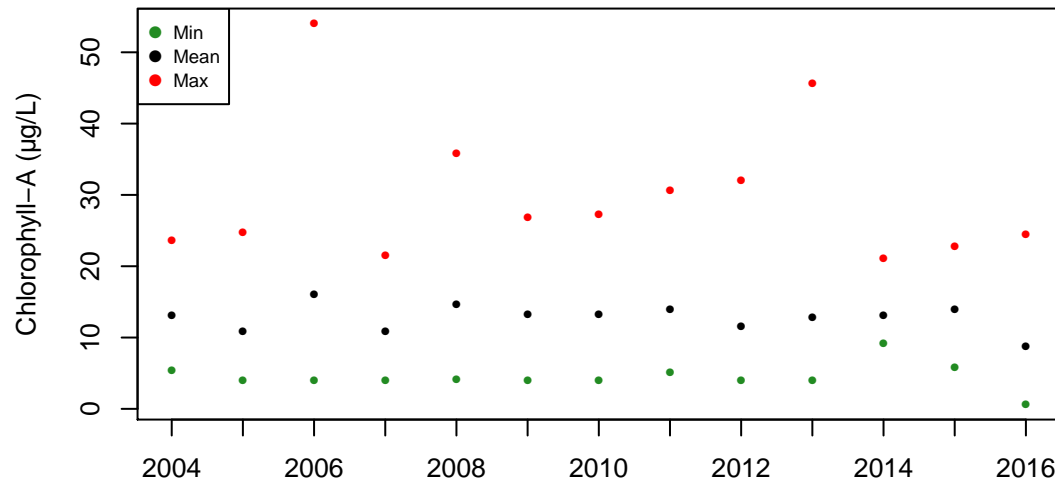
Blackberry Cr near Mouth (287): Chlorophyll-A ($\mu\text{g/L}$)



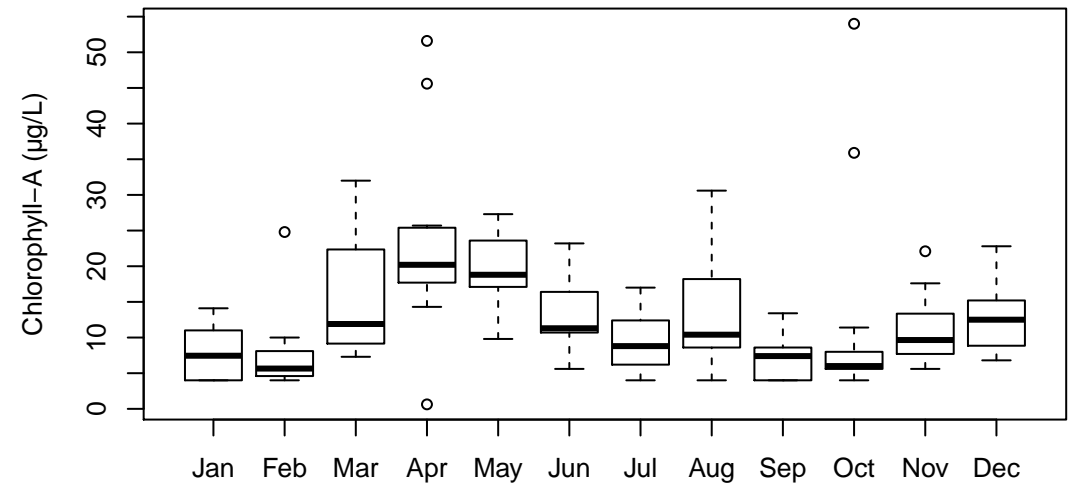
Sampling date
(a) Observation data



Year
(b) Boxplot by year



Year
(c) Annual values



Month
(d) Boxplot by month

Appendix B - Summary Statistics of the Water Quality Parameters

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Table B.1 Summary statistics of Total Phosphorus (TP) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	96	0.039	0.030	2.611	0.004	0.230	0.018	0.043	0.037
1	<i>Nipp-abvWL</i>	49	0.047	0.034	1.884	0.007	0.188	0.016	0.051	0.045
184	Fox-Jhnbg	151	0.045	0.040	2.183	0.010	0.200	0.020	0.060	0.033
23	Fox-Rt176	197	0.034	0.023	6.566	0.002	0.498	0.010	0.043	0.044
258	Fox-OHills	88	0.049	0.040	3.616	0.010	0.270	0.030	0.060	0.033
4	<i>Flint-KesRd</i>	87	0.208	0.150	3.557	0.004	1.700	0.074	0.220	0.244
271	<i>Crys-Rt31</i>	117	0.427	0.250	1.517	0.010	2.330	0.110	0.630	0.418
24	Fox-Algqn	315	0.057	0.043	2.294	0.002	0.420	0.020	0.073	0.051
268	<i>Tyl-Rt31</i>	94	0.064	0.050	1.322	0.010	0.210	0.030	0.080	0.042
25	<i>Pop-Mouth</i>	176	0.026	0.020	1.732	0.002	0.130	0.010	0.037	0.023
26	Fox-SElgn	513	0.165	0.120	9.902	0.004	3.500	0.070	0.200	0.199
14	<i>Fers-Rt34</i>	86	0.055	0.048	1.136	0.004	0.200	0.004	0.074	0.049
79	<i>Fers-Mouth</i>	139	0.056	0.050	1.066	0.009	0.160	0.030	0.078	0.034
40	Fox-Gnva	247	0.163	0.130	1.741	0.004	0.680	0.077	0.210	0.128
27	Fox-Mont	458	0.159	0.130	1.693	0.004	0.740	0.074	0.200	0.118
34	Fox-York	196	0.302	0.250	1.136	0.050	1.030	0.150	0.420	0.198
28	<i>Black-Rt47</i>	219	0.042	0.030	2.767	0.004	0.340	0.010	0.051	0.044
287	<i>Black-Mouth</i>	142	0.123	0.110	2.018	0.010	0.510	0.060	0.150	0.081

Table B.2 Summary statistics of Dissolved Phosphorus (DP) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	96	0.134	0.120	4.234	0.031	0.840	0.079	0.156	0.099
1	<i>Nipp-abvWL</i>	61	0.165	0.086	2.992	0.020	1.156	0.060	0.173	0.210
184	Fox-Jhnbg	159	0.157	0.144	1.099	0.040	0.410	0.100	0.190	0.072
23	Fox-Rt176	202	0.143	0.120	2.046	0.015	0.603	0.092	0.170	0.079
258	Fox-OHills	97	0.169	0.160	0.968	0.010	0.410	0.110	0.210	0.076
4	<i>Flint-KesRd</i>	89	0.287	0.240	2.123	0.120	1.100	0.166	0.330	0.184
271	<i>Crys-Rt31</i>	118	0.499	0.320	1.488	0.070	2.540	0.150	0.795	0.443
24	Fox-Algqn	323	0.182	0.160	1.057	0.015	0.540	0.110	0.230	0.091
268	<i>Tyl-Rt31</i>	126	0.136	0.110	1.669	0.020	0.540	0.070	0.178	0.090
25	<i>Pop-Mouth</i>	175	0.093	0.074	7.795	0.010	1.200	0.050	0.110	0.102
26	Fox-SElgn	543	0.290	0.230	6.646	0.054	3.590	0.170	0.335	0.227
14	<i>Fers-Rt34</i>	90	0.146	0.115	1.254	0.015	0.440	0.085	0.189	0.089
79	<i>Fers-Mouth</i>	137	0.112	0.100	2.128	0.020	0.500	0.060	0.140	0.073
40	Fox-Gnva	246	0.326	0.270	1.694	0.120	1.120	0.190	0.380	0.189
27	Fox-Mont	546	0.317	0.270	1.657	0.017	1.170	0.200	0.370	0.169
34	Fox-York	195	0.483	0.410	1.004	0.160	1.380	0.300	0.645	0.245
28	<i>Black-Rt47</i>	225	0.116	0.091	2.517	0.010	0.700	0.061	0.140	0.088
287	<i>Black-Mouth</i>	141	0.053	0.050	2.095	0.009	0.260	0.030	0.070	0.037

Table B.3 Summary statistics of Organic Nitrogen (Org-N) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	-	-	-	-	-	-	-	-	-
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	150	1.689	1.530	1.402	0.100	4.790	1.212	1.970	0.724
23	Fox-Rt176	-	-	-	-	-	-	-	-	-
258	Fox-OHills	90	1.760	1.615	1.568	0.100	5.070	1.240	2.068	0.850
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	120	0.937	0.815	6.215	0.180	6.480	0.688	1.040	0.641
24	Fox-Algqn	154	1.717	1.675	1.057	0.360	5.150	1.130	2.135	0.774
268	<i>Tyl-Rt31</i>	97	0.792	0.680	1.211	0.100	2.100	0.590	0.940	0.336
25	<i>Pop-Mouth</i>	-	-	-	-	-	-	-	-	-
26	Fox-SElgn	293	1.632	1.540	0.749	0.110	4.070	1.100	2.020	0.703
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	138	0.748	0.670	1.151	0.280	1.900	0.520	0.895	0.305
40	Fox-Gnva	168	1.660	1.520	1.126	0.250	4.270	1.098	1.980	0.766
27	Fox-Mont	256	1.585	1.460	1.603	0.240	5.406	1.048	1.876	0.759
34	Fox-York	194	1.619	1.455	1.073	0.030	4.790	1.072	2.068	0.776
28	<i>Black-Rt47</i>	-	-	-	-	-	-	-	-	-
287	<i>Black-Mouth</i>	141	0.749	0.690	1.715	0.030	2.420	0.540	0.880	0.336

Table B.4 Summary statistics of Ammonia Nitrogen (NH₃-N) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	97	0.150	0.110	2.592	0.010	1.050	0.040	0.190	0.161
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	159	0.077	0.060	2.014	0.010	0.390	0.030	0.100	0.061
23	Fox-Rt176	203	0.097	0.060	3.410	0.010	0.950	0.015	0.125	0.128
258	Fox-OHills	98	0.074	0.050	6.170	0.020	0.860	0.030	0.090	0.095
4	<i>Flint-KesRd</i>	88	0.113	0.067	2.052	0.015	0.640	0.031	0.140	0.124
271	<i>Crys-Rt31</i>	120	0.092	0.070	5.436	0.020	0.800	0.050	0.100	0.084
24	Fox-Algqn	324	0.104	0.060	5.393	0.010	1.580	0.030	0.130	0.152
268	<i>Tyl-Rt31</i>	132	0.069	0.060	5.502	0.010	0.570	0.040	0.080	0.057
25	<i>Pop-Mouth</i>	172	0.083	0.043	2.312	0.010	0.640	0.015	0.113	0.098
26	Fox-SElgn	531	0.111	0.060	4.313	0.010	1.300	0.030	0.140	0.148
14	<i>Fers-Rt34</i>	84	0.078	0.035	3.309	0.010	0.690	0.015	0.086	0.117
79	<i>Fers-Mouth</i>	138	0.061	0.050	1.263	0.010	0.180	0.030	0.078	0.035
40	Fox-Gnva	244	0.068	0.040	7.195	0.010	1.080	0.030	0.080	0.087
27	Fox-Mont	1335	0.082	0.041	3.560	0.005	1.010	0.026	0.100	0.105
34	Fox-York	288	0.089	0.048	4.257	0.010	1.160	0.030	0.100	0.116
28	<i>Black-Rt47</i>	190	0.097	0.054	5.721	0.010	1.500	0.015	0.130	0.141
287	<i>Black-Mouth</i>	142	0.068	0.050	3.208	0.010	0.430	0.030	0.080	0.053

Table B.5 Summary statistics of Nitrate Nitrogen (NO₃-N) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	-	-	-	-	-	-	-	-	-
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	159	1.038	0.760	1.167	0.028	4.010	0.490	1.490	0.786
23	Fox-Rt176	110	1.264	0.930	0.925	0.024	3.900	0.418	1.840	1.062
258	Fox-OHills	96	0.864	0.610	1.725	0.050	4.430	0.258	1.108	0.797
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	118	3.766	3.415	0.901	0.360	11.800	2.255	5.135	1.991
24	Fox-Algqn	231	1.285	1.010	0.804	0.010	4.500	0.495	1.930	0.952
268	<i>Tyl-Rt31</i>	99	2.391	1.780	2.004	0.400	10.420	1.035	2.835	1.922
25	<i>Pop-Mouth</i>	-	-	-	-	-	-	-	-	-
26	Fox-SElgn	380	1.720	1.505	0.797	0.064	4.880	1.098	2.232	0.898
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	139	1.148	0.860	1.511	0.090	4.300	0.505	1.510	0.897
40	Fox-Gnva	238	1.666	1.500	0.811	0.021	5.200	0.970	2.195	0.936
27	Fox-Mont	400	1.666	1.462	3.520	0.018	14.300	0.900	2.305	1.172
34	Fox-York	196	2.080	1.855	0.828	0.270	5.450	1.358	2.650	1.018
28	<i>Black-Rt47</i>	-	-	-	-	-	-	-	-	-
287	<i>Black-Mouth</i>	142	1.275	1.010	2.255	0.090	7.220	0.590	1.618	1.052

Table B.6 Summary statistics of Total Kjeldahl Nitrogen (TKN) (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	75	0.978	0.870	1.753	0.100	3.200	0.710	1.090	0.498
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	150	1.747	1.610	1.547	0.670	4.820	1.290	1.987	0.677
23	Fox-Rt176	186	1.645	1.600	1.085	0.100	4.600	1.100	2.000	0.771
258	Fox-OHills	90	1.839	1.675	1.777	0.650	5.100	1.355	2.095	0.807
4	<i>Flint-KesRd</i>	88	1.959	1.700	9.082	0.660	27.800	1.422	1.900	2.816
271	<i>Crys-Rt31</i>	120	1.000	0.900	7.180	0.250	6.660	0.740	1.100	0.604
24	Fox-Algqn	309	1.671	1.600	1.101	0.010	5.210	1.200	2.050	0.743
268	<i>Tyl-Rt31</i>	97	0.831	0.770	0.993	0.220	1.780	0.650	0.960	0.283
25	<i>Pop-Mouth</i>	167	1.096	1.000	5.489	0.100	9.400	0.625	1.300	0.991
26	Fox-SElgn	513	1.656	1.580	0.731	0.100	4.110	1.170	2.050	0.681
14	<i>Fers-Rt34</i>	87	1.418	1.200	3.638	0.250	6.850	0.975	1.600	0.927
79	<i>Fers-Mouth</i>	138	0.792	0.710	1.151	0.090	2.050	0.590	0.948	0.304
40	Fox-Gnva	244	1.732	1.600	1.009	0.270	4.300	1.320	2.030	0.671
27	Fox-Mont	538	1.604	1.520	1.231	0.150	5.430	1.100	1.938	0.702
34	Fox-York	194	1.673	1.510	1.145	0.230	4.820	1.160	2.085	0.721
28	<i>Black-Rt47</i>	201	1.013	0.830	8.309	0.100	14.650	0.440	1.300	1.163
287	<i>Black-Mouth</i>	141	0.806	0.750	1.887	0.350	2.450	0.580	0.930	0.329

Table B.7 Summary statistics of Dissolved Oxygen (DO) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	130	10.480	10.180	-0.146	0.820	17.720	8.700	12.400	2.839
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	138	10.840	10.500	1.075	3.600	27.600	8.150	13.100	3.655
23	Fox-Rt176	157	10.480	10.200	0.340	3.800	18.380	7.980	12.700	3.114
258	Fox-OHills	85	9.998	9.610	1.584	4.030	24.040	8.100	11.480	3.189
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	106	9.195	8.480	0.683	3.550	18.480	7.462	11.310	2.764
24	Fox-Algqn	295	10.050	9.930	0.446	1.880	20.640	7.405	12.140	3.416
268	<i>Tyl-Rt31</i>	132	11.490	11.150	0.382	7.200	17.800	9.200	13.580	2.649
25	<i>Pop-Mouth</i>	126	10.830	10.360	0.138	4.500	16.240	8.992	12.790	2.575
26	Fox-SElgn	664	10.220	9.630	0.547	3.380	19.440	7.698	12.490	2.974
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	139	9.928	9.430	1.242	3.760	26.520	7.530	11.930	3.564
40	Fox-Gnva	178	11.240	10.580	1.118	5.200	25.820	9.055	12.920	3.201
27	Fox-Mont	16450	9.449	9.290	1.599	4.800	23.200	8.470	10.190	1.440
34	Fox-York	276	10.240	9.895	0.221	2.670	17.540	7.990	12.830	2.966
28	<i>Black-Rt47</i>	170	10.030	9.735	0.458	5.160	18.440	7.620	12.180	2.777
287	<i>Black-Mouth</i>	142	10.720	10.240	0.663	7.040	17.540	8.708	12.200	2.441

Table B.8 Summary statistics of pH (su)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	97	8.117	8.120	3.872	7.190	11.190	7.940	8.250	0.423
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-JhnbG	139	8.481	8.500	-0.242	7.200	9.500	8.300	8.700	0.318
23	Fox-Rt176	121	8.265	8.300	-0.919	7.000	8.940	8.110	8.470	0.346
258	Fox-OHills	75	8.264	8.420	-1.247	6.000	9.680	8.055	8.560	0.530
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	114	8.110	8.200	-0.956	6.800	8.900	7.922	8.400	0.423
24	Fox-Algqn	246	8.166	8.225	-0.673	6.660	9.100	7.900	8.522	0.486
268	<i>Tyl-Rt31</i>	94	8.198	8.200	-0.349	7.500	8.700	8.000	8.348	0.213
25	<i>Pop-Mouth</i>	90	7.852	7.850	-0.211	7.010	8.870	7.672	8.068	0.311
26	Fox-SElgn	330	8.349	8.385	-0.769	6.690	9.200	8.140	8.600	0.350
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	134	7.947	8.010	-0.530	6.970	8.660	7.770	8.130	0.301
40	Fox-Gnva	170	8.196	8.275	-0.298	6.810	9.350	7.875	8.478	0.430
27	Fox-Mont	1570	8.335	8.330	-0.346	6.325	10.600	8.130	8.550	0.372
34	Fox-York	294	8.327	8.295	0.366	7.290	9.350	8.120	8.518	0.332
28	<i>Black-Rt47</i>	134	7.919	7.970	0.251	6.950	9.140	7.680	8.100	0.314
287	<i>Black-Mouth</i>	141	7.992	7.980	7.436	7.100	13.390	7.790	8.150	0.533

Table B.9 Summary statistics of Total Suspended Solids (TSS) concentration (mg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	54	29.820	25.000	3.023	3.000	154.000	16.000	36.000	23.400
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-Jhnbg	-	-	-	-	-	-	-	-	-
23	Fox-Rt176	51	27.010	25.000	0.388	4.000	59.000	18.000	38.000	14.660
258	Fox-OHills	-	-	-	-	-	-	-	-	-
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	-	-	-	-	-	-	-	-	-
24	Fox-Algqn	53	32.880	30.000	1.616	3.000	112.000	20.000	38.000	22.320
268	<i>Tyl-Rt31</i>	-	-	-	-	-	-	-	-	-
25	<i>Pop-Mouth</i>	45	12.180	8.000	2.971	2.000	70.000	4.000	14.000	11.830
26	Fox-SElgn	104	31.110	30.000	0.929	4.000	109.000	17.750	42.000	17.540
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	-	-	-	-	-	-	-	-	-
40	Fox-Gnva	-	-	-	-	-	-	-	-	-
27	Fox-Mont	104	34.120	33.000	1.454	4.000	130.000	20.750	43.000	21.520
34	Fox-York	-	-	-	-	-	-	-	-	-
28	<i>Black-Rt47</i>	100	28.230	20.000	3.285	1.000	203.000	12.380	31.000	29.300
287	<i>Black-Mouth</i>	-	-	-	-	-	-	-	-	-

Table B.10 Summary statistics of Chlorophyll A (CHL-A) concentration (µg/L)

Station ID	Station Name	N	Mean	Median	Skewness	Minimum	Maximum	1 st Quartile	3 rd Quartile	StdDev
236	<i>Nipp-SpGrv</i>	-	-	-	-	-	-	-	-	-
1	<i>Nipp-abvWL</i>	-	-	-	-	-	-	-	-	-
184	Fox-Jhnbg	151	81.630	70.200	1.637	1.070	343.000	37.800	105.500	63.230
23	Fox-Rt176	-	-	-	-	-	-	-	-	-
258	Fox-OHills	90	94.060	85.650	1.031	1.480	303.200	39.050	124.000	70.170
4	<i>Flint-KesRd</i>	-	-	-	-	-	-	-	-	-
271	<i>Crys-Rt31</i>	120	29.740	18.850	3.704	4.000	244.400	11.880	33.400	35.510
24	Fox-Algqn	155	92.560	86.200	0.827	4.000	314.000	40.300	127.300	67.780
268	<i>Tyl-Rt31</i>	96	9.694	8.600	2.706	1.900	45.400	5.600	11.420	6.284
25	<i>Pop-Mouth</i>	-	-	-	-	-	-	-	-	-
26	Fox-SElgn	195	86.680	78.800	1.094	1.970	333.000	24.650	124.500	71.510
14	<i>Fers-Rt34</i>	-	-	-	-	-	-	-	-	-
79	<i>Fers-Mouth</i>	139	13.260	10.700	3.229	0.630	84.500	7.000	17.000	9.946
40	Fox-Gnva	168	105.300	87.950	1.248	1.180	479.400	34.480	152.800	85.490
27	Fox-Mont	194	99.880	80.050	1.223	1.210	470.800	29.800	153.400	85.930
34	Fox-York	196	98.150	80.000	1.362	1.190	433.600	33.900	144.800	83.400
28	<i>Black-Rt47</i>	-	-	-	-	-	-	-	-	-
287	<i>Black-Mouth</i>	142	12.840	10.550	1.936	0.630	54.000	6.325	17.080	8.966

Appendix C – Annual and Seasonal Water Quality Trend Maps

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- Figure C.2 Seasonal trends of total phosphorus (TP) in the Fox River watershed
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- Figure C.7 Annual trends of ammonia nitrogen (NH₃-N) in the Fox River watershed
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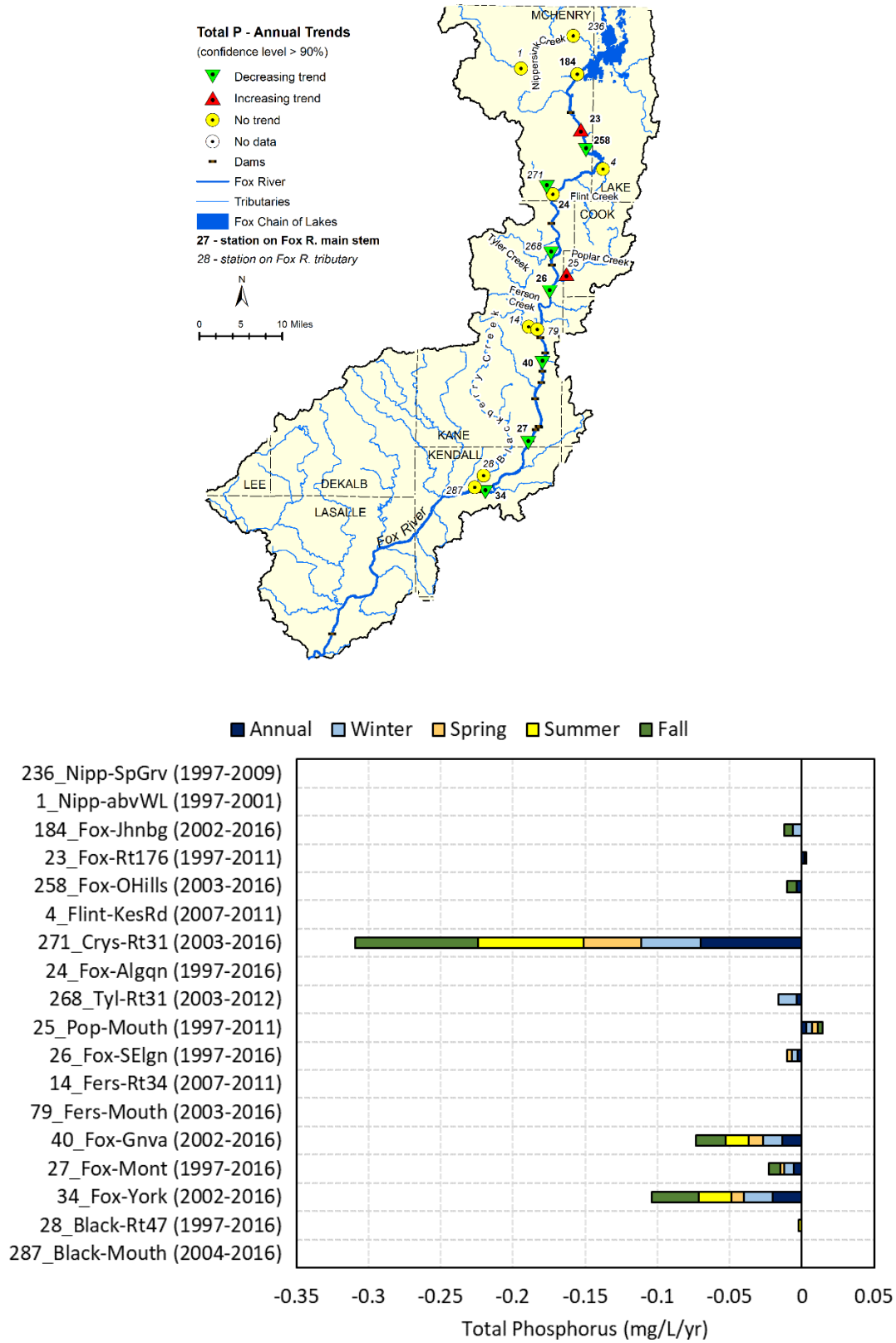


Figure C.1 Annual trends of total phosphorus (TP) in the Fox River watershed

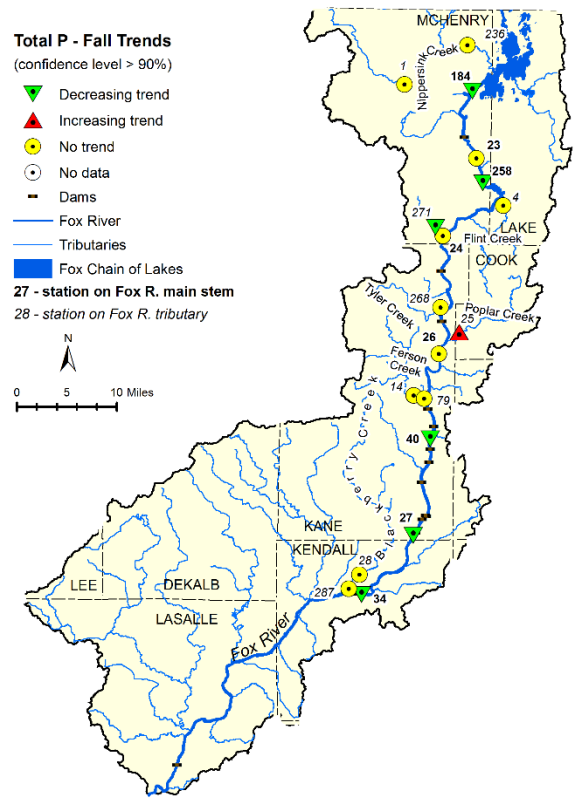
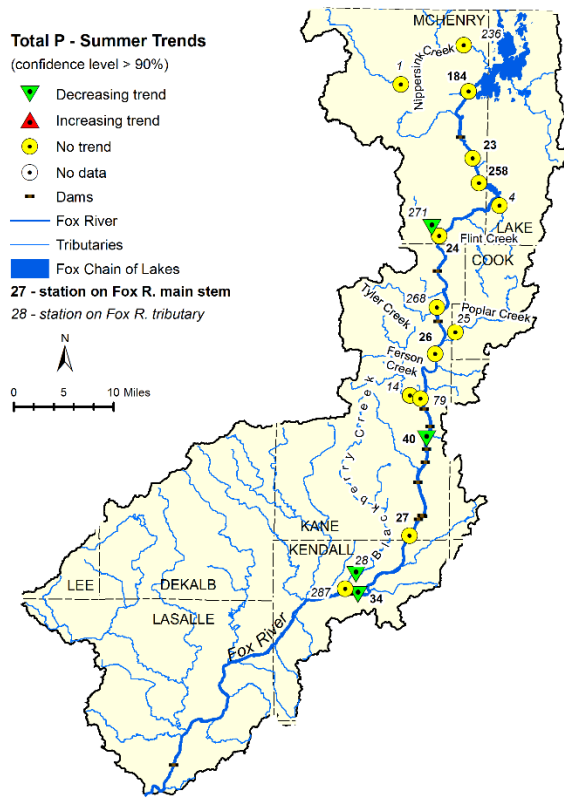
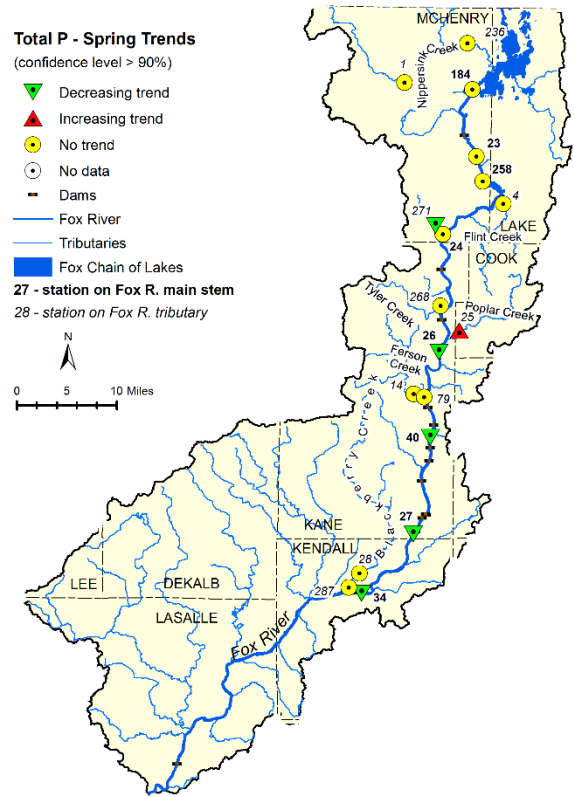
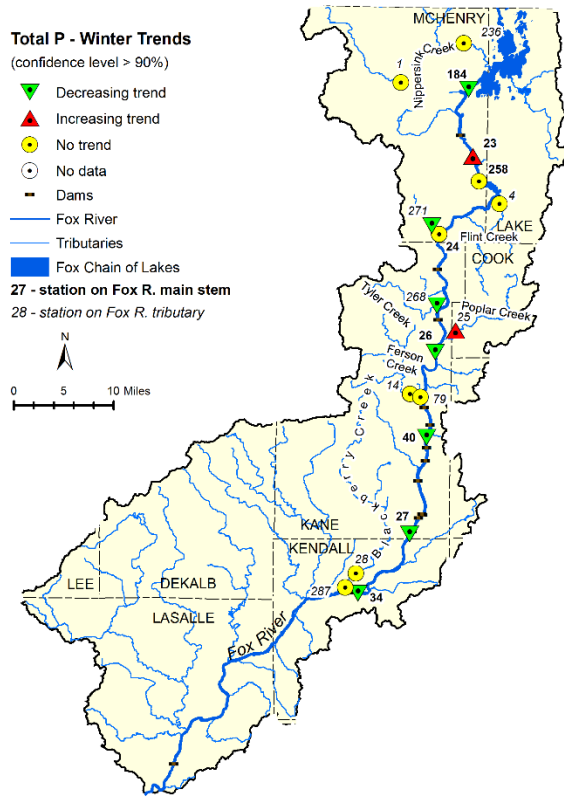


Figure C.2 Seasonal trends of total phosphorus (TP) in the Fox River watershed

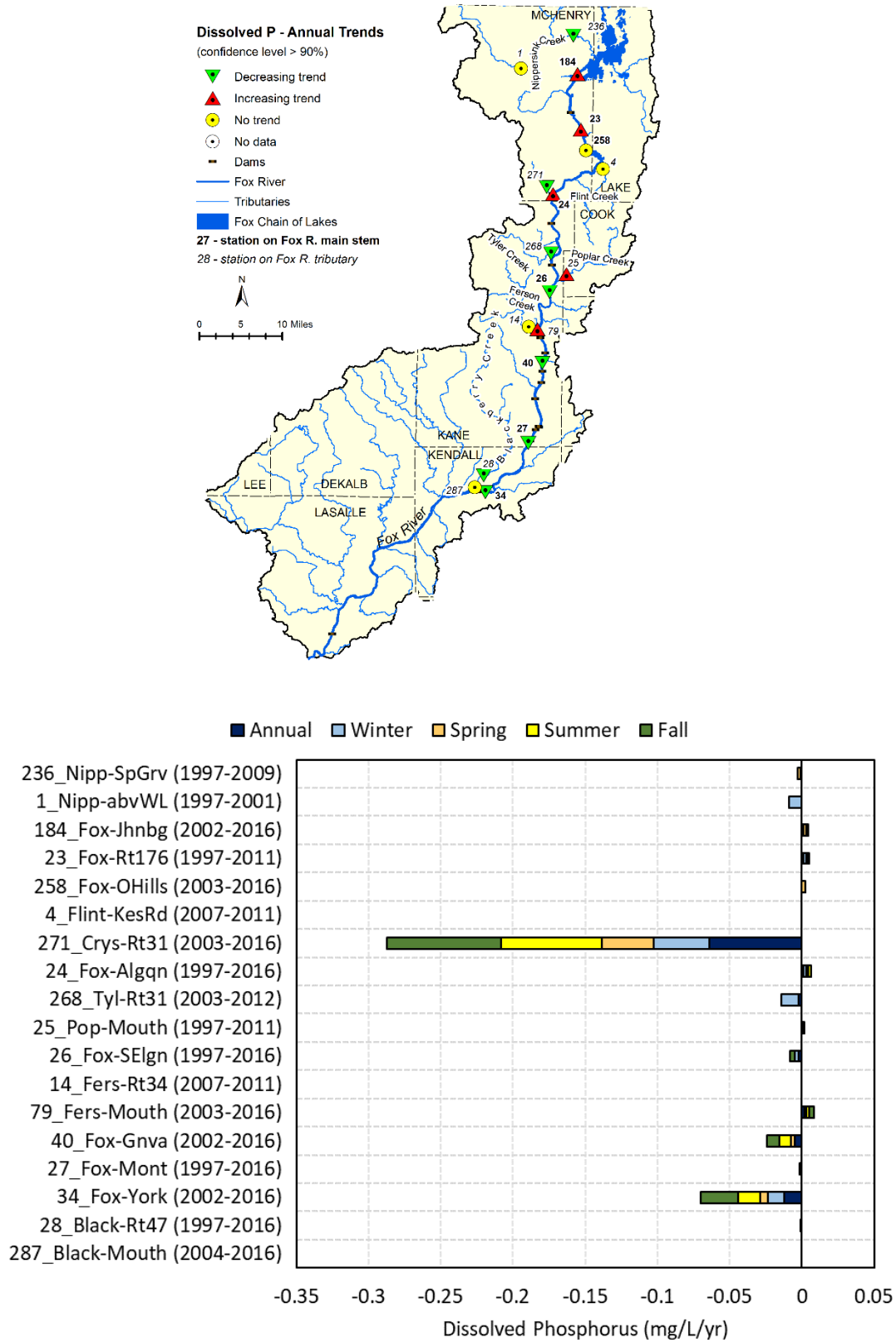


Figure C.3 Annual trends of dissolved phosphorus (DP) in the Fox River watershed

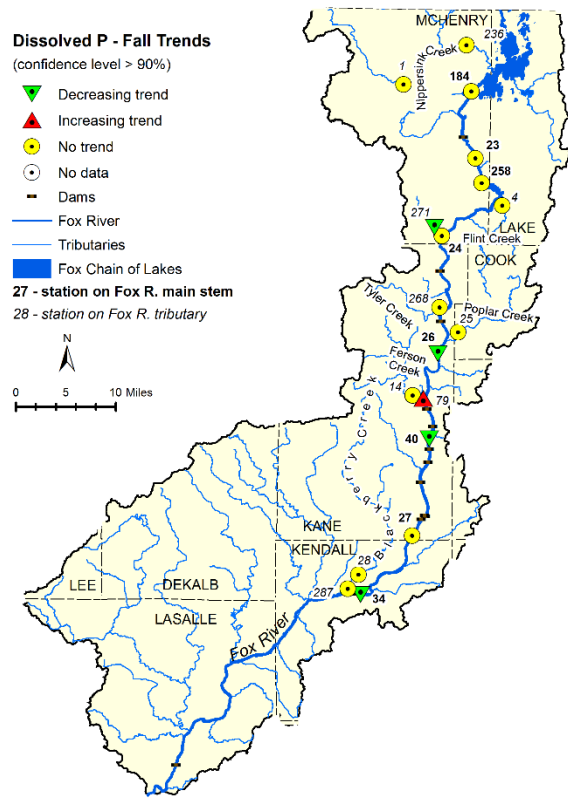
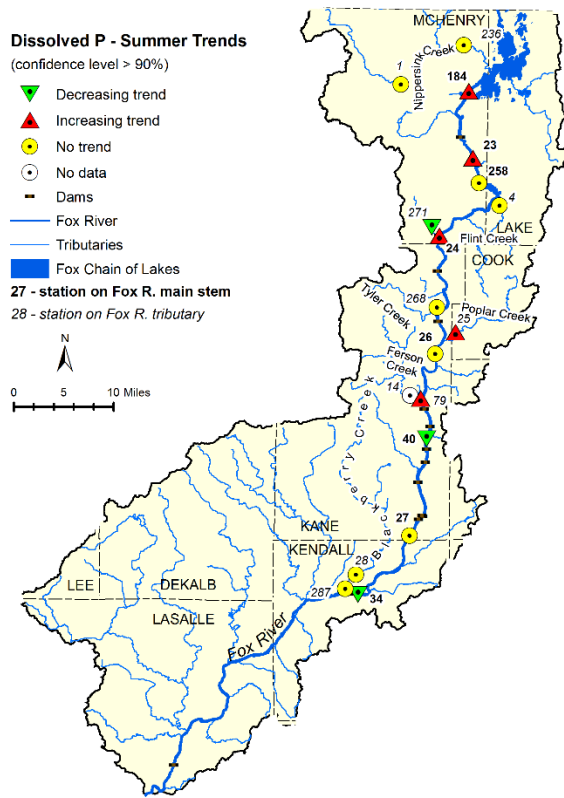
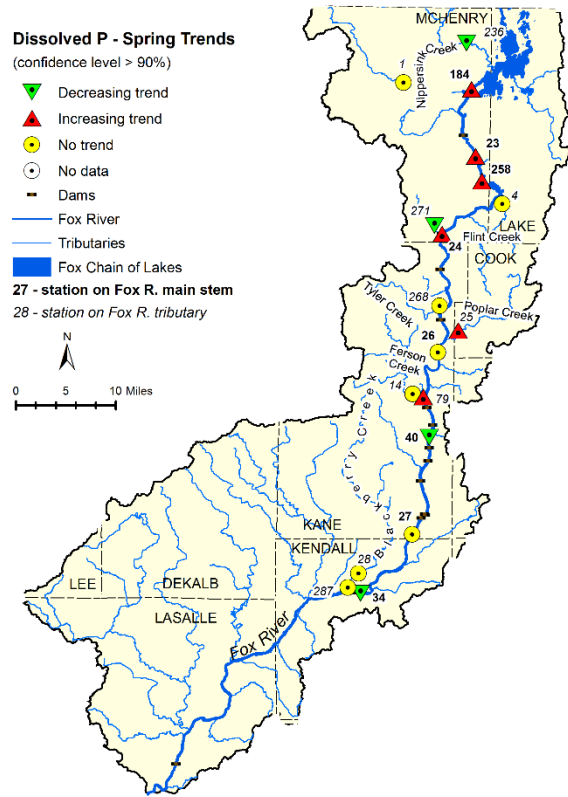
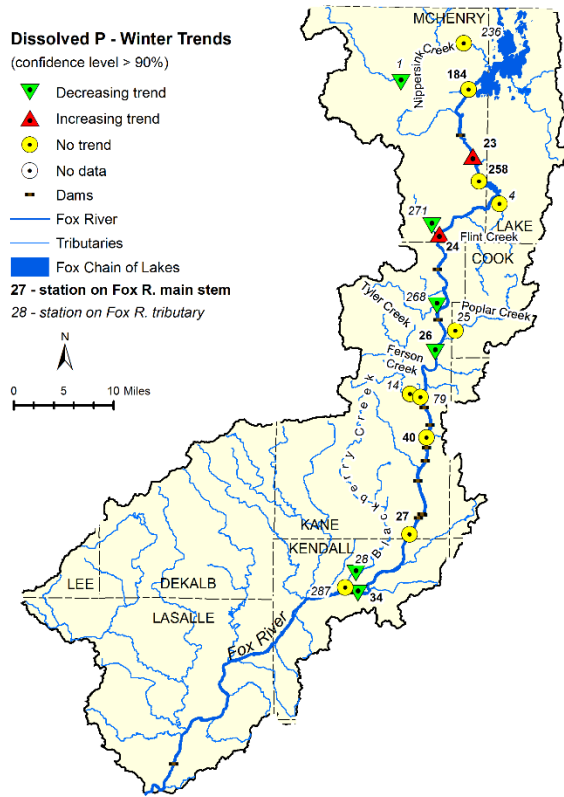


Figure C.4 Seasonal trends of dissolved phosphorus (DP) in the Fox River watershed

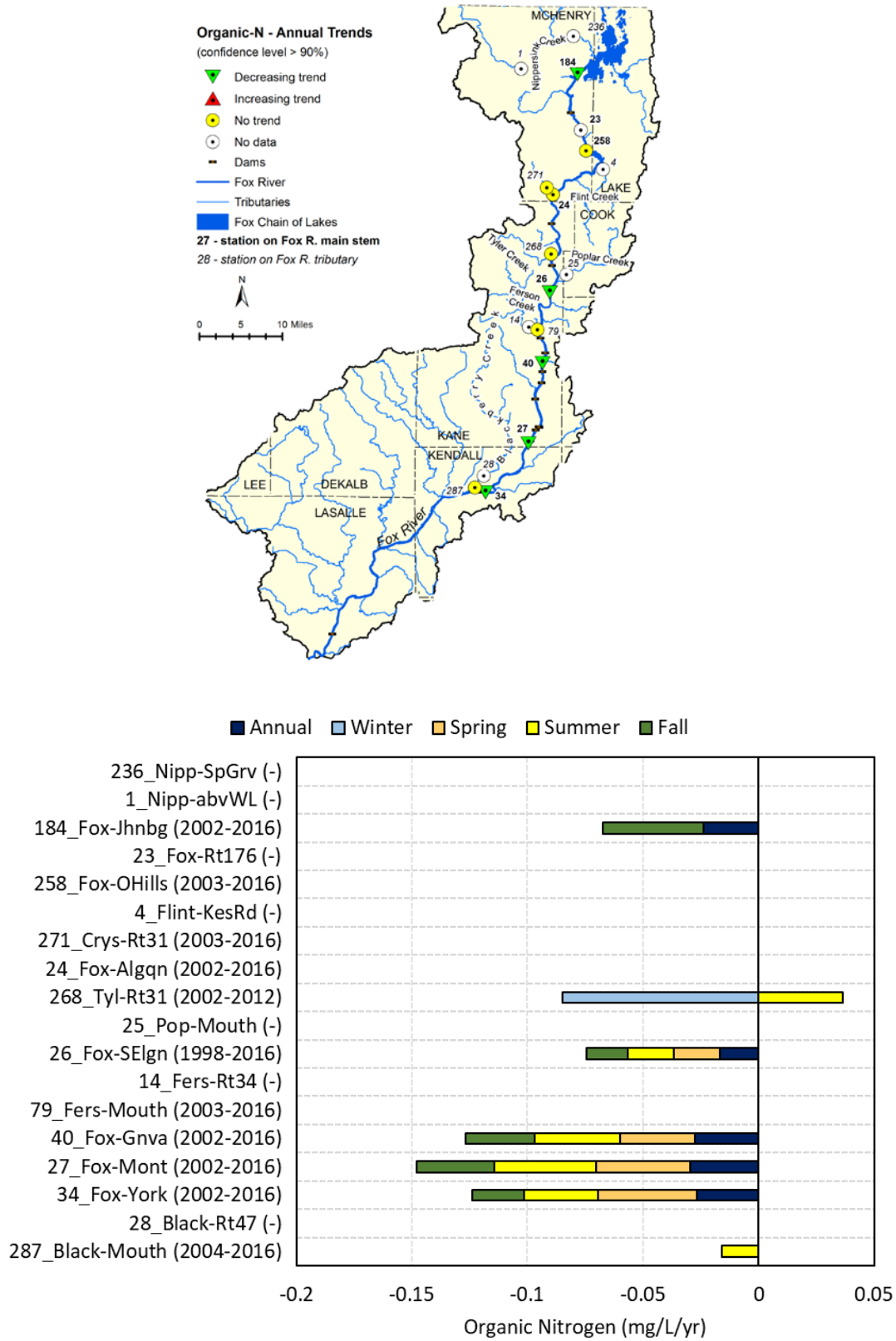


Figure C.5 Annual trends of organic nitrogen (Org-N) in the Fox River watershed

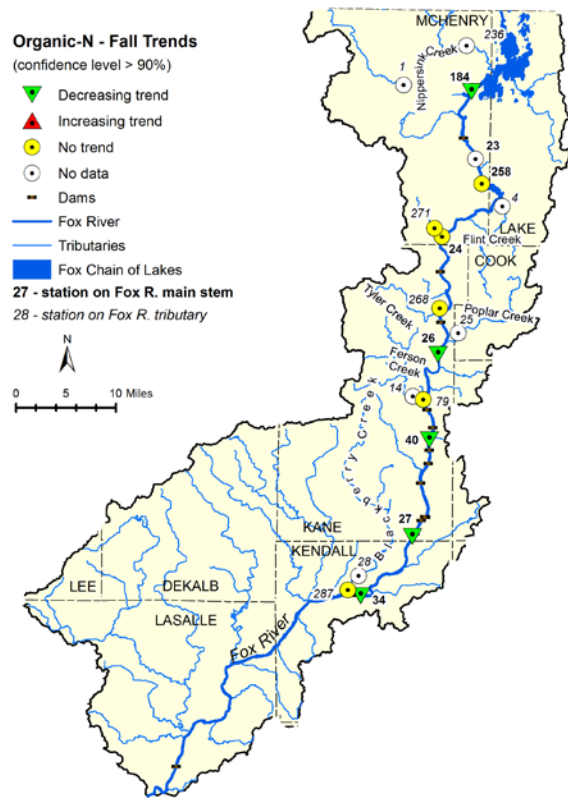
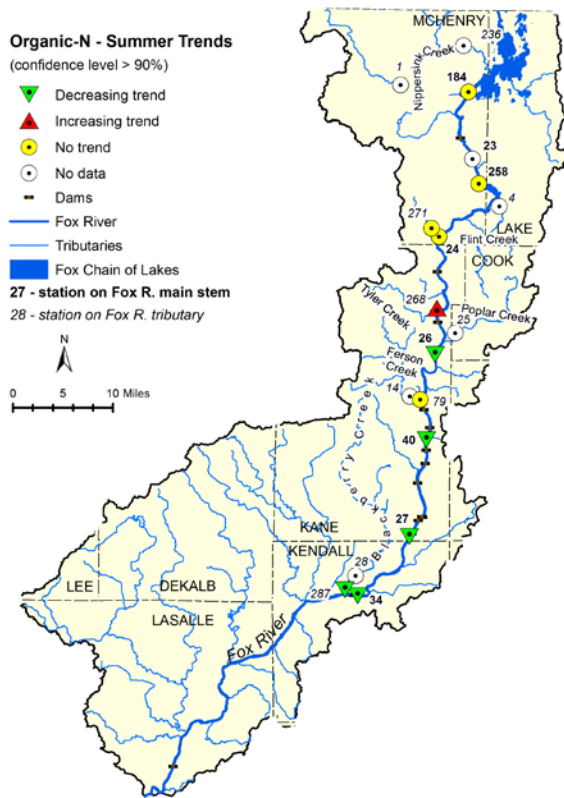
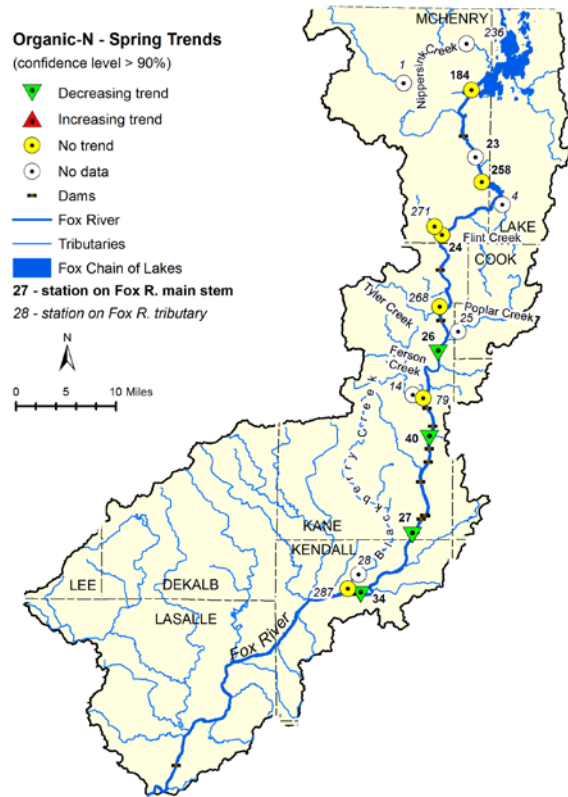
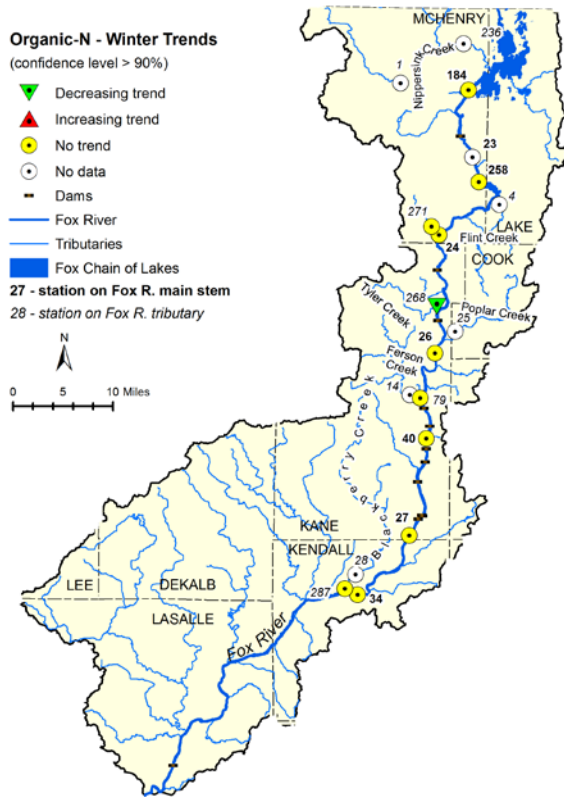


Figure C.6 Seasonal trends of organic nitrogen (Org-N) in the Fox River watershed

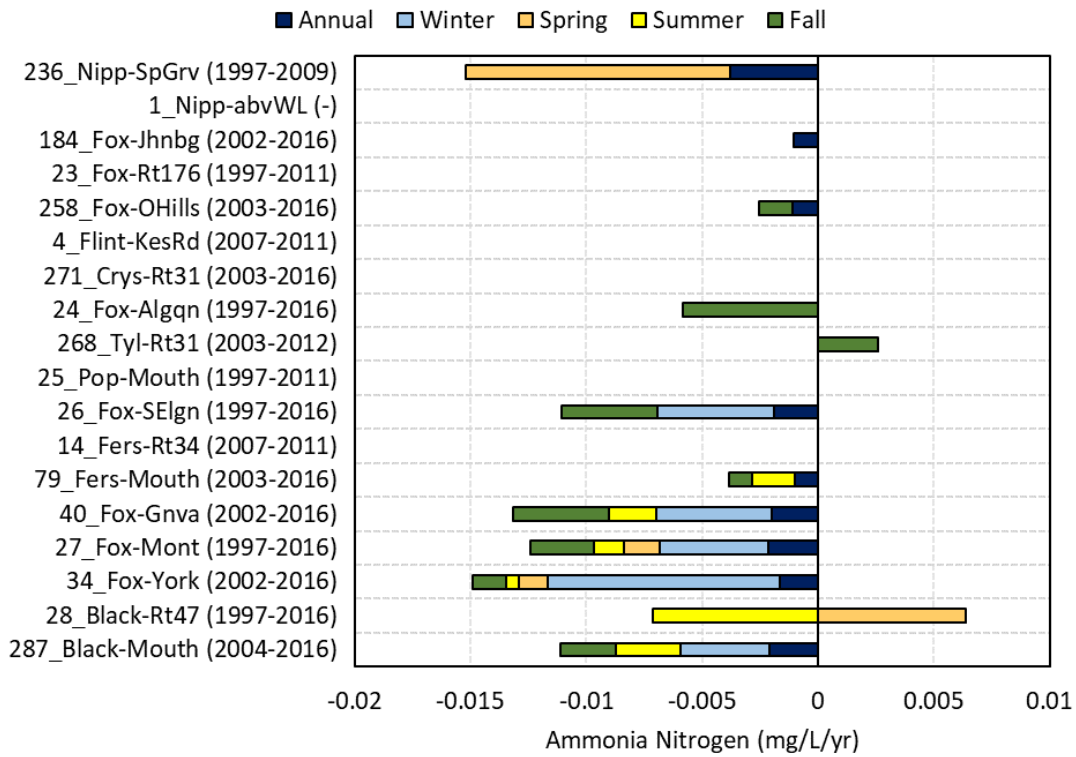
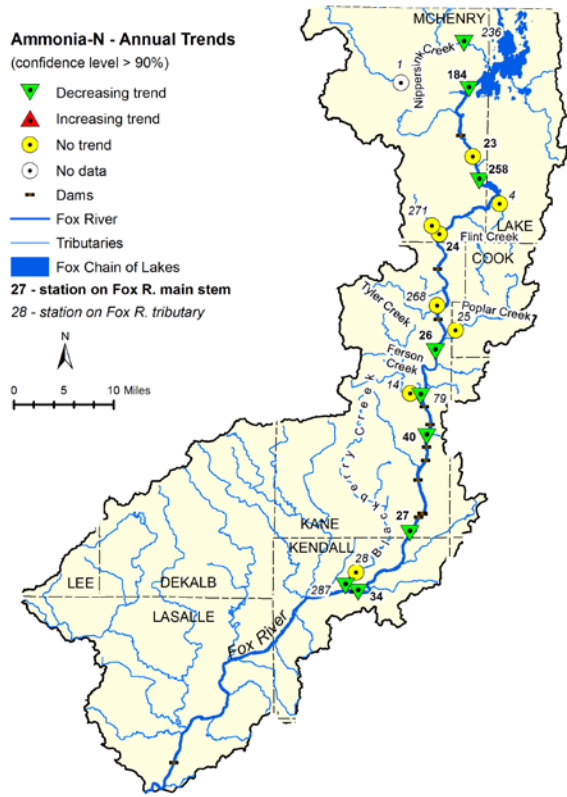


Figure C.7 Annual trends of ammonia nitrogen (NH₃-N) in the Fox River watershed

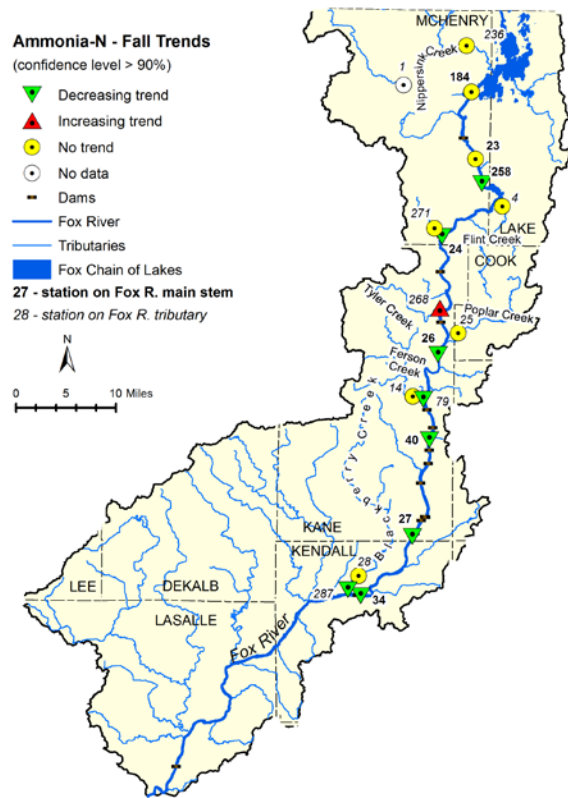
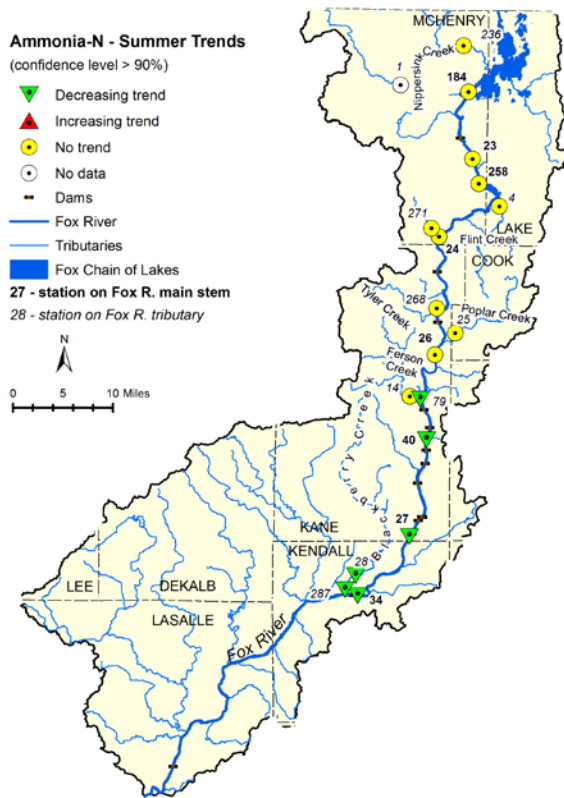
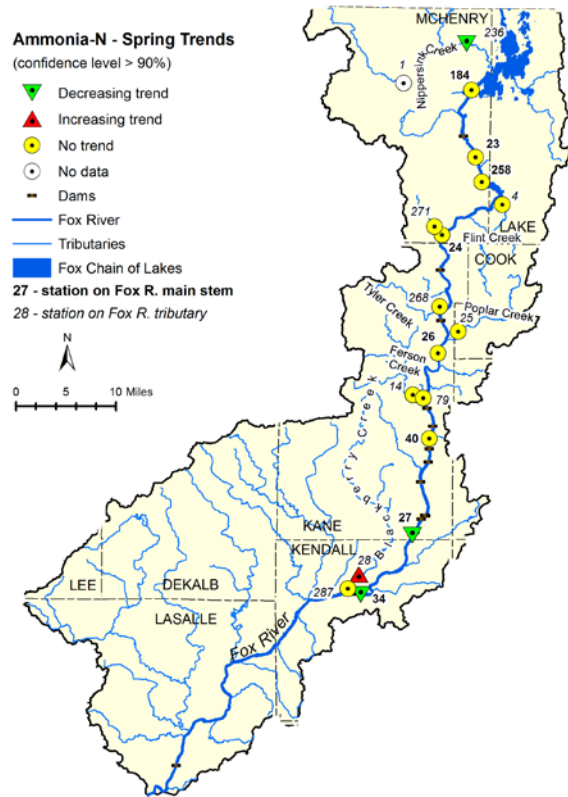
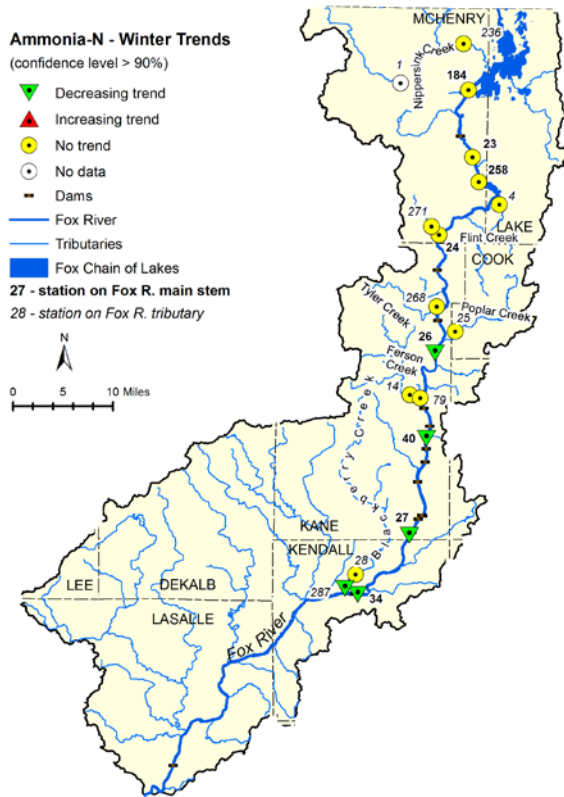


Figure C.8 Seasonal trends of ammonia nitrogen (NH₃-N) in the Fox River watershed

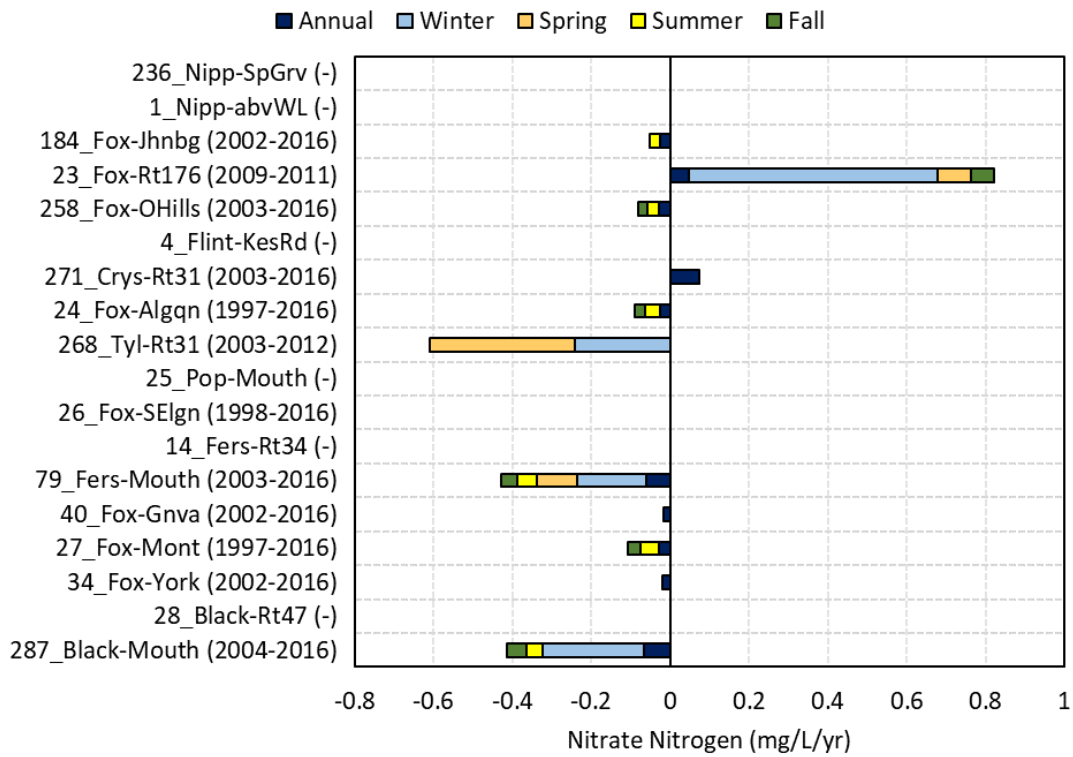
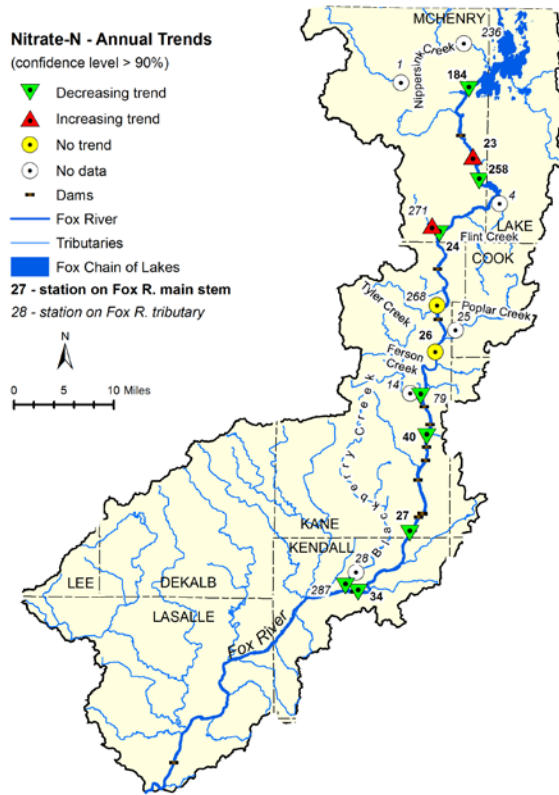


Figure C.9 Annual trends of nitrate nitrogen (NO₃-N) in the Fox River watershed

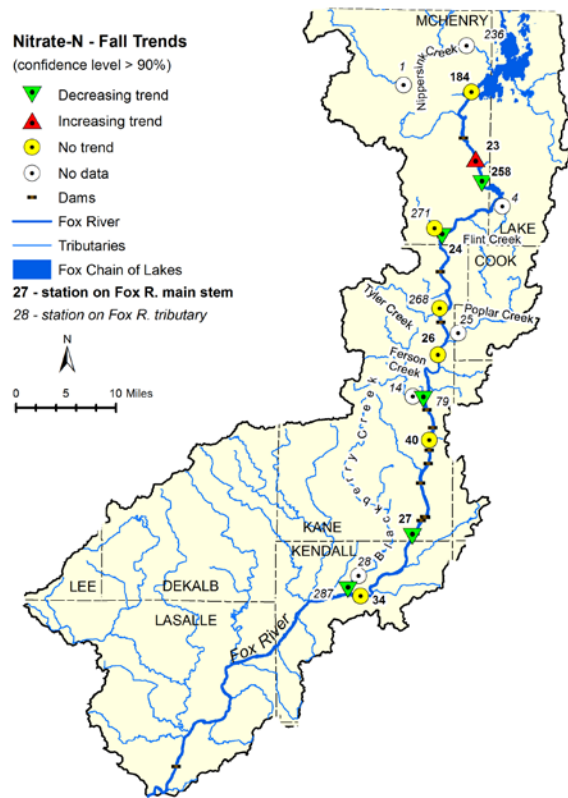
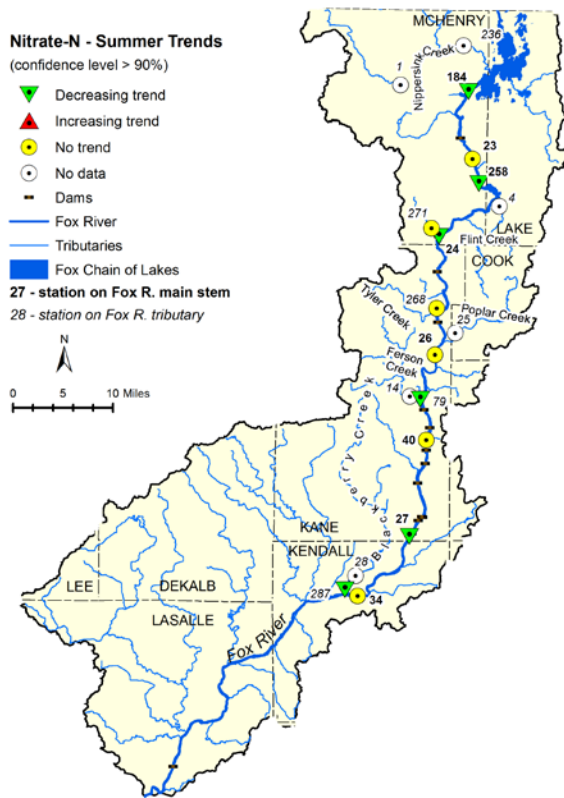
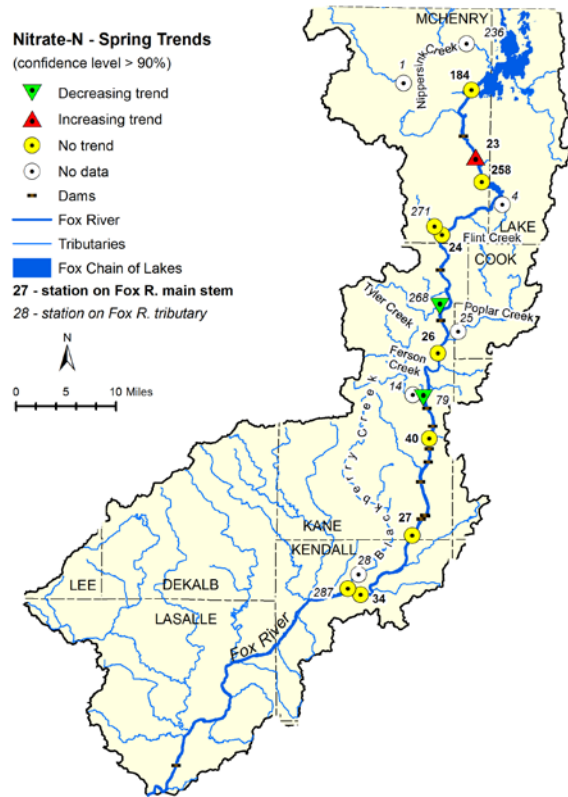
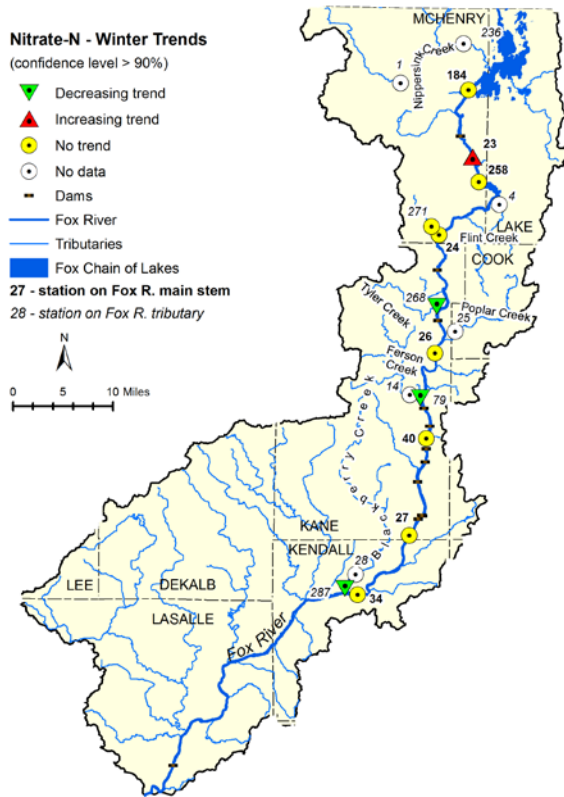


Figure C.10 Seasonal trends of nitrate nitrogen (NO₃-N) in the Fox River watershed

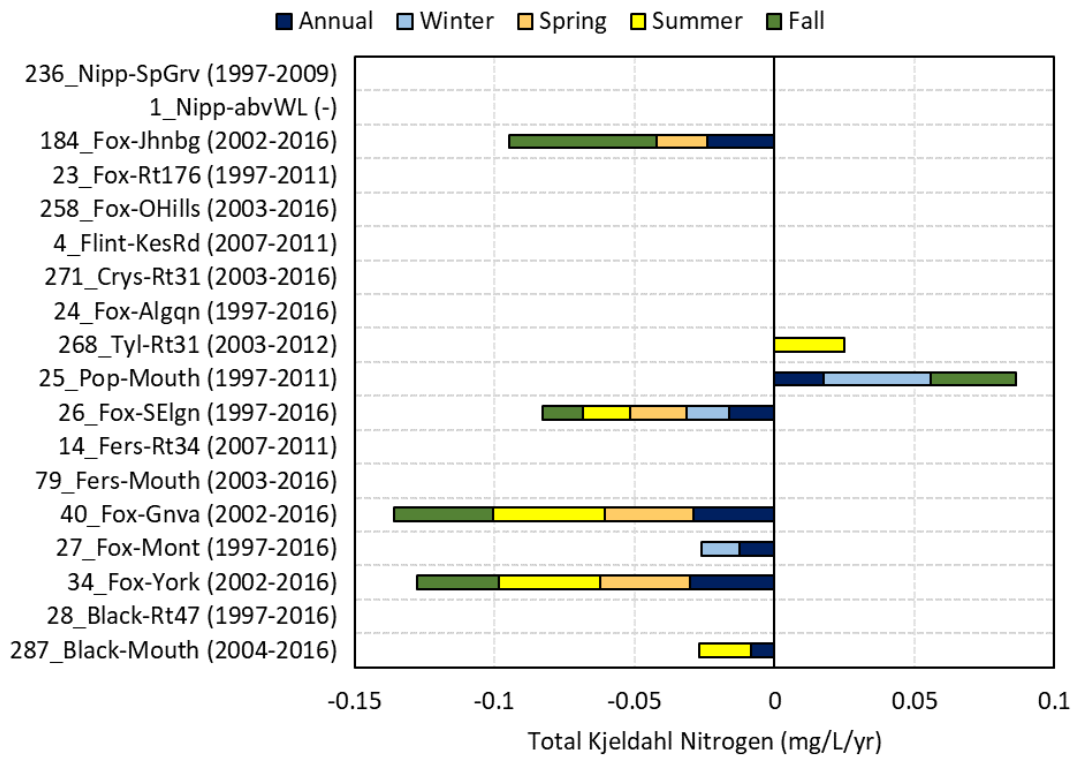
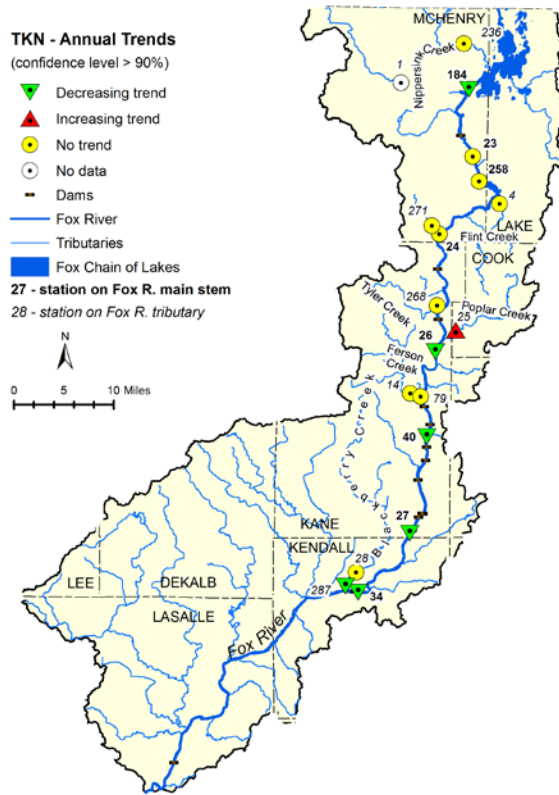


Figure C.11 Annual trends of total kjeldahl nitrogen (TKN) in the Fox River watershed

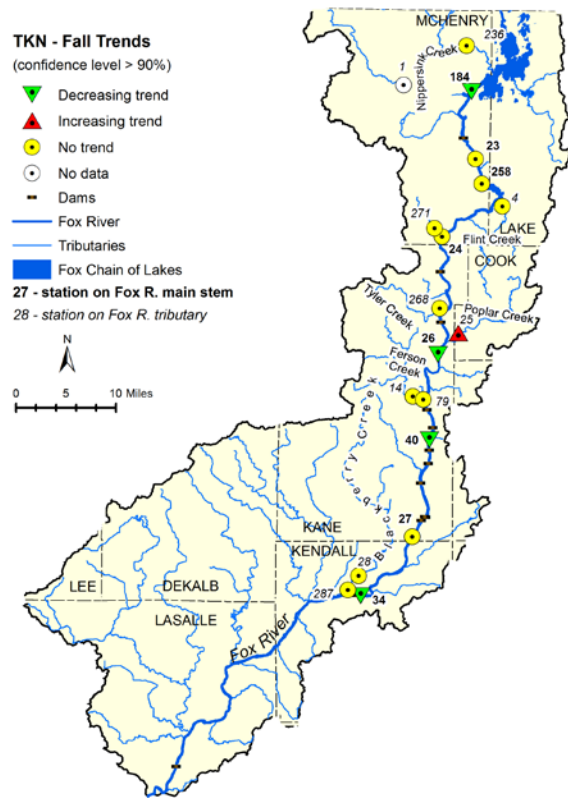
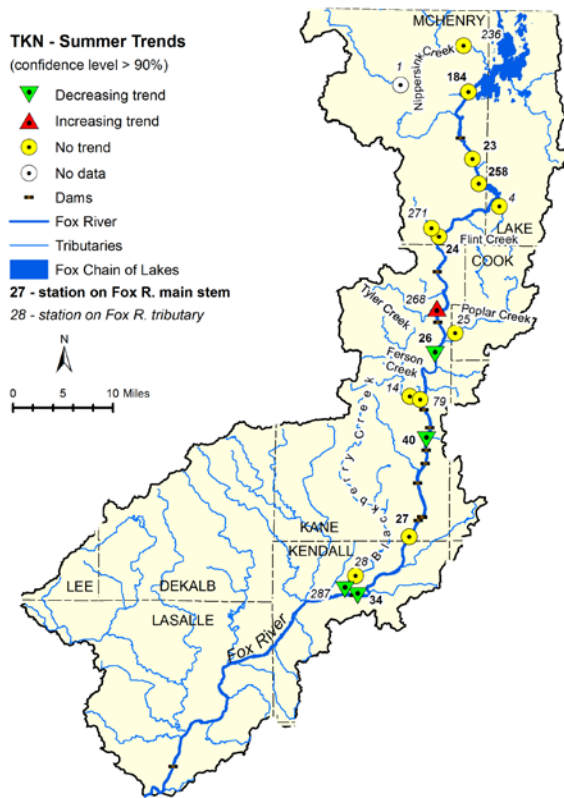
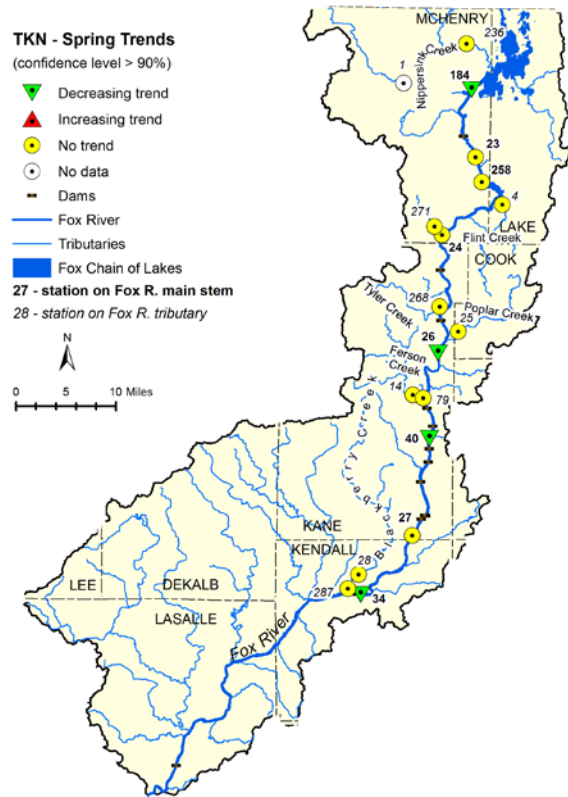
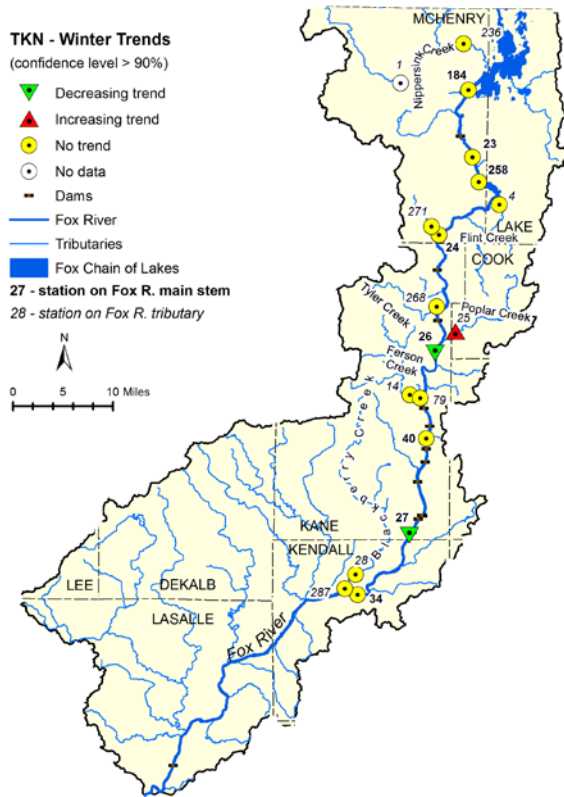


Figure C.12 Seasonal trends of total kjeldahl nitrogen (TKN) in the Fox River watershed

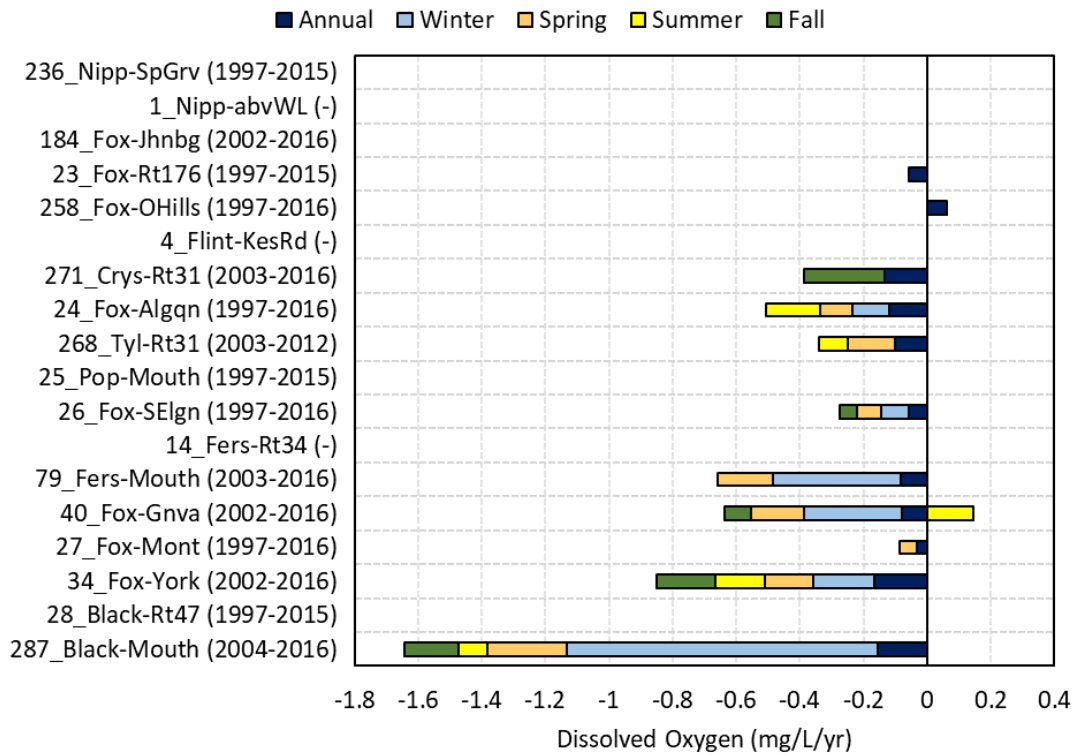
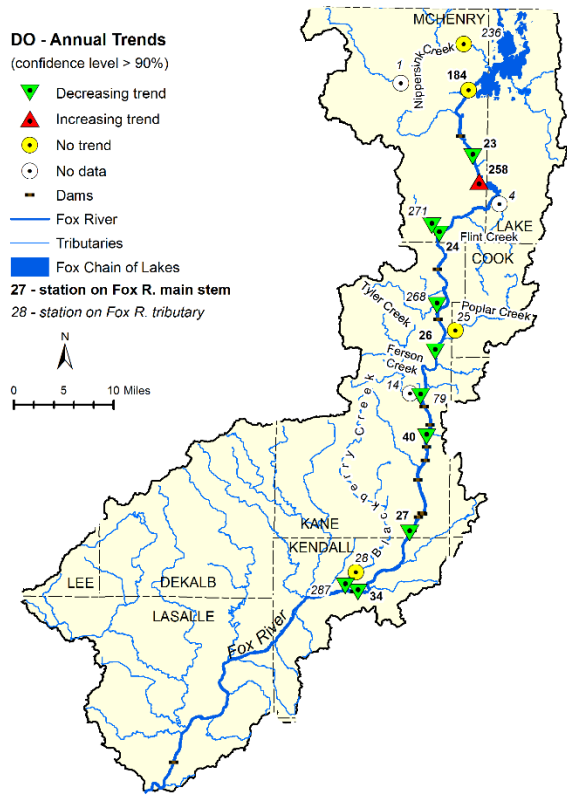


Figure C.13 Annual trends of dissolved oxygen (DO) in the Fox River watershed

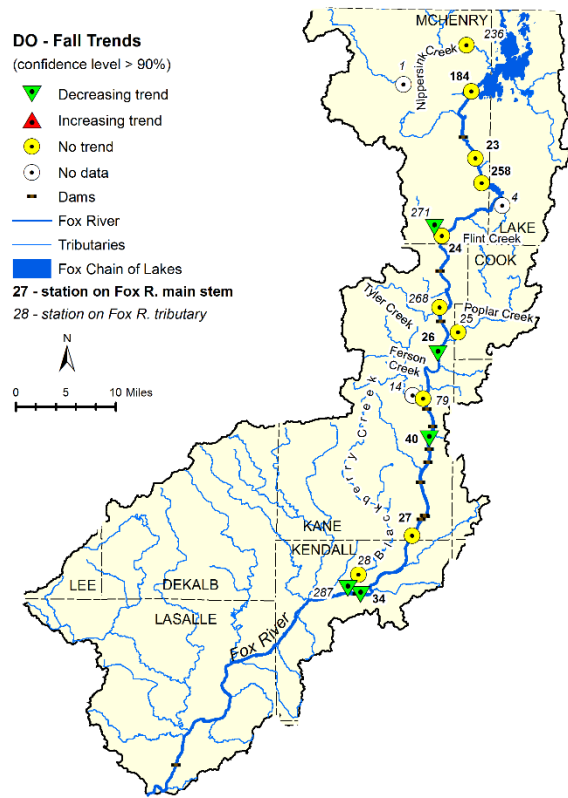
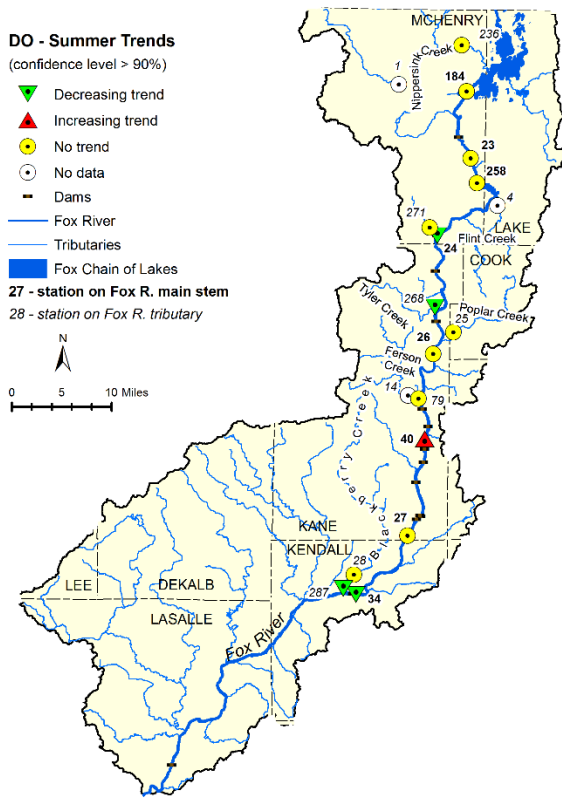
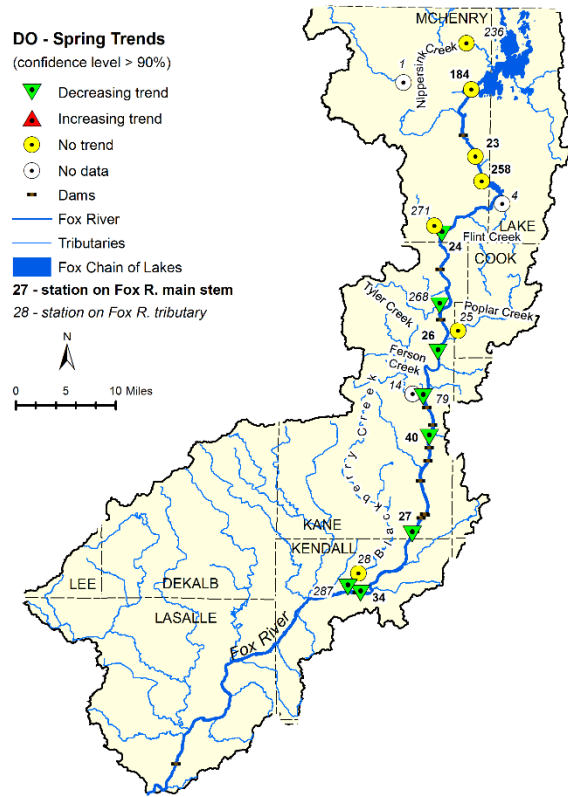
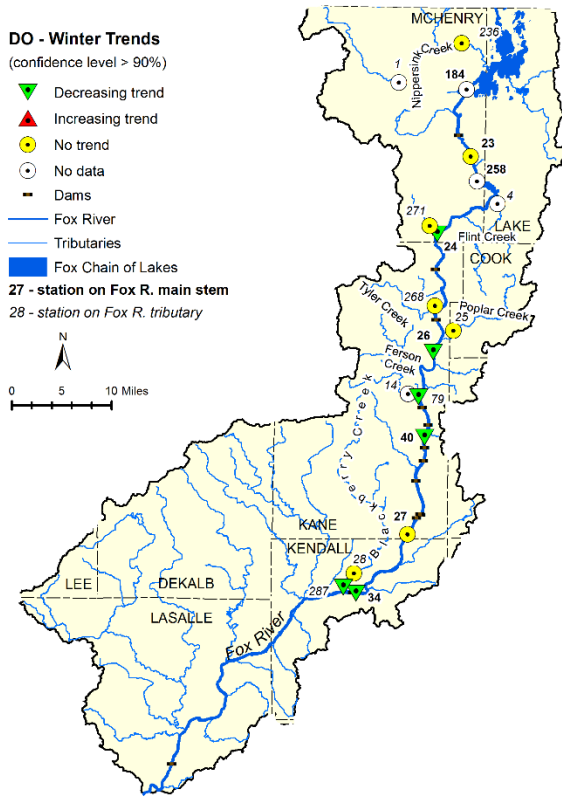


Figure C.14 Seasonal trends of dissolved oxygen (DO) in the Fox River watershed

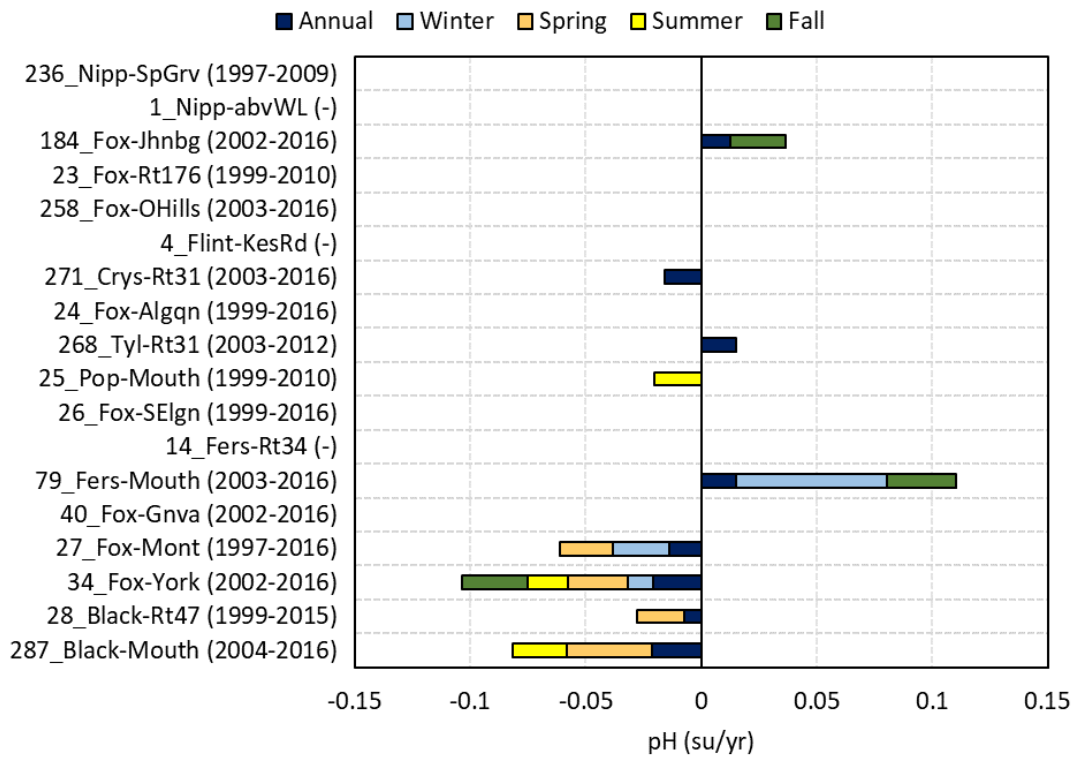
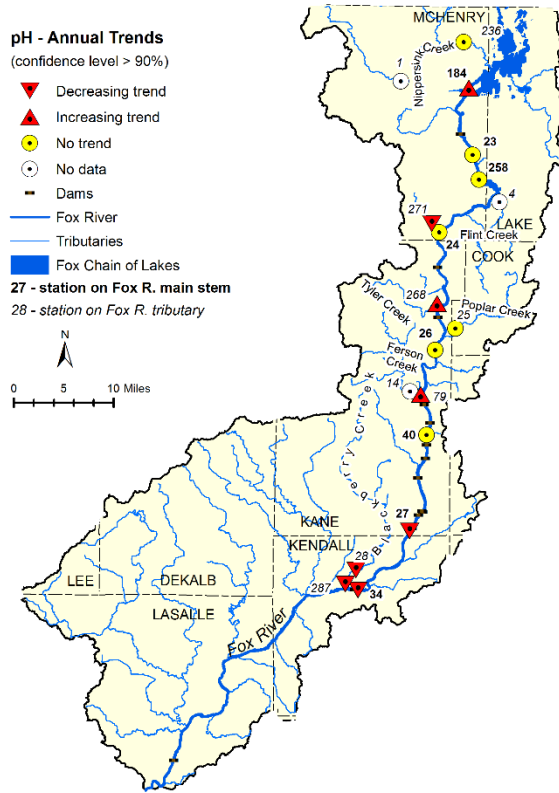


Figure C.15 Annual trends of pH in the Fox River watershed

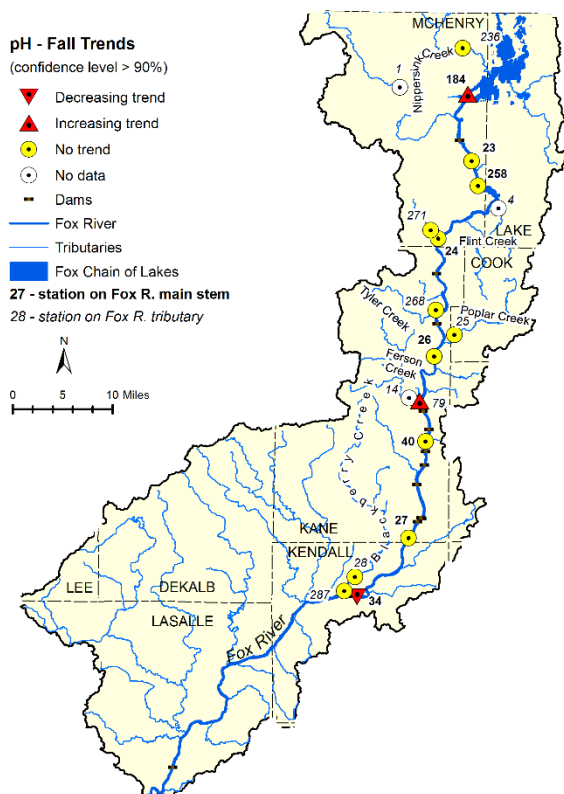
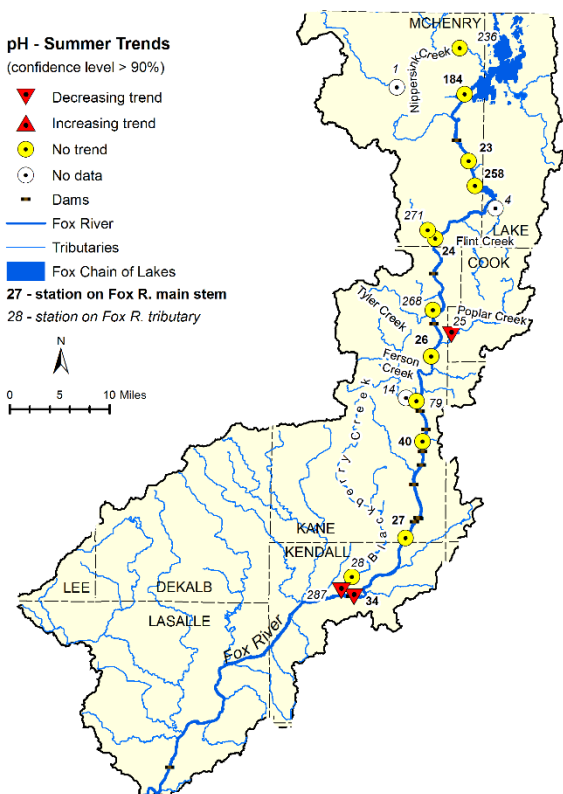
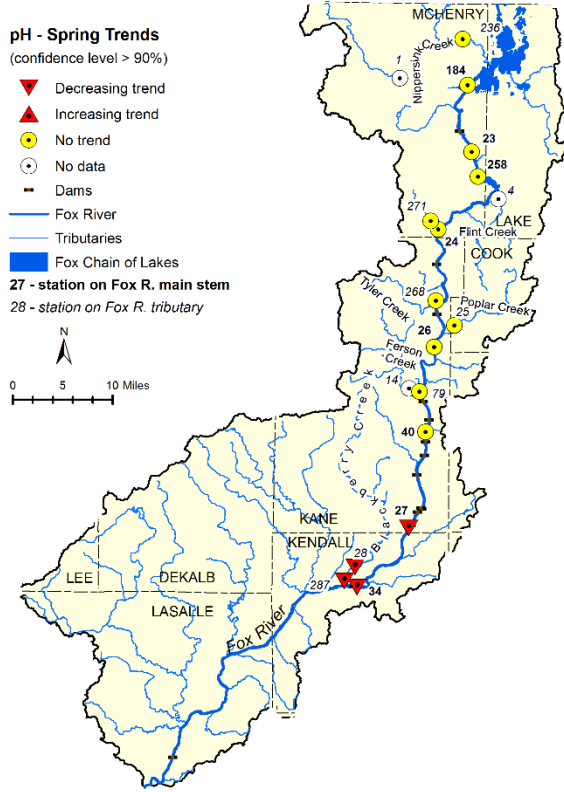
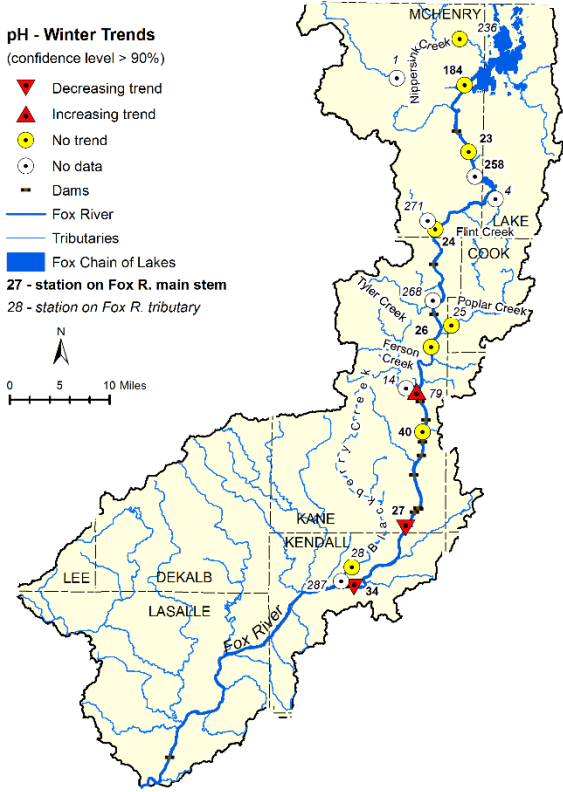


Figure C.16 Seasonal trends of pH in the Fox River watershed

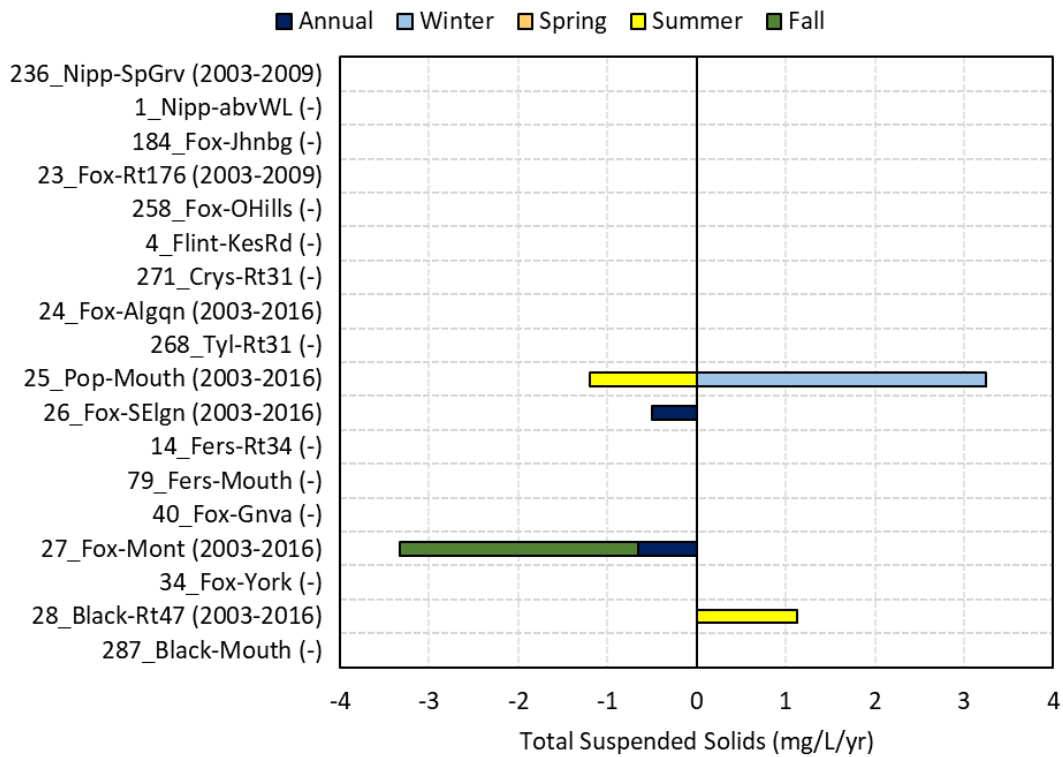
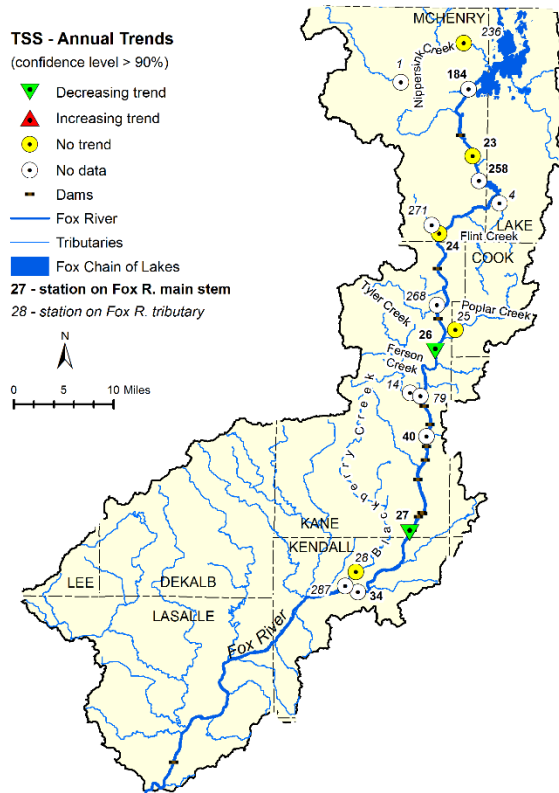


Figure C.17 Annual trends of total suspended solids (TSS) in the Fox River watershed

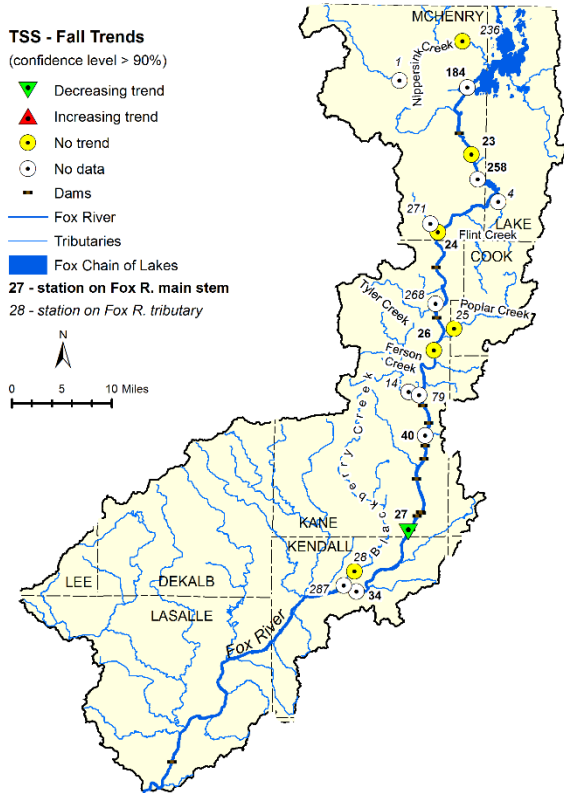
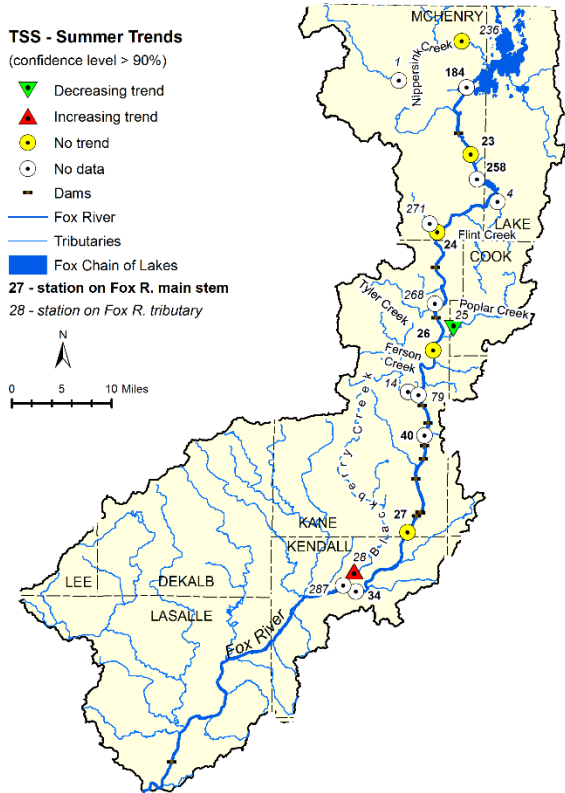
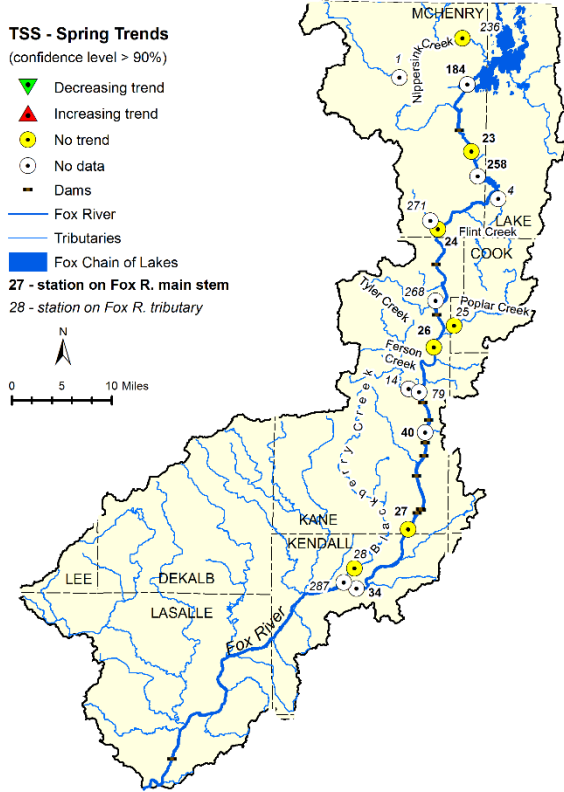
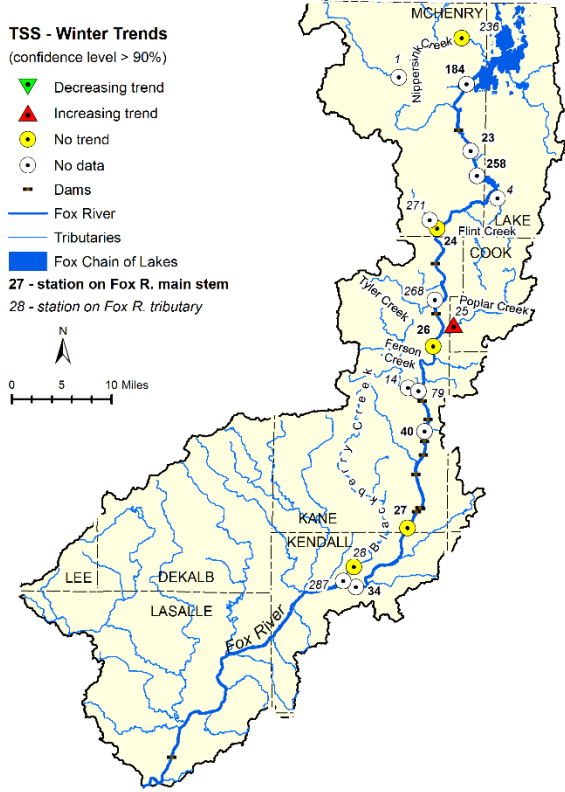


Figure C.18 Seasonal trends of total suspended solids (TSS) in the Fox River watershed

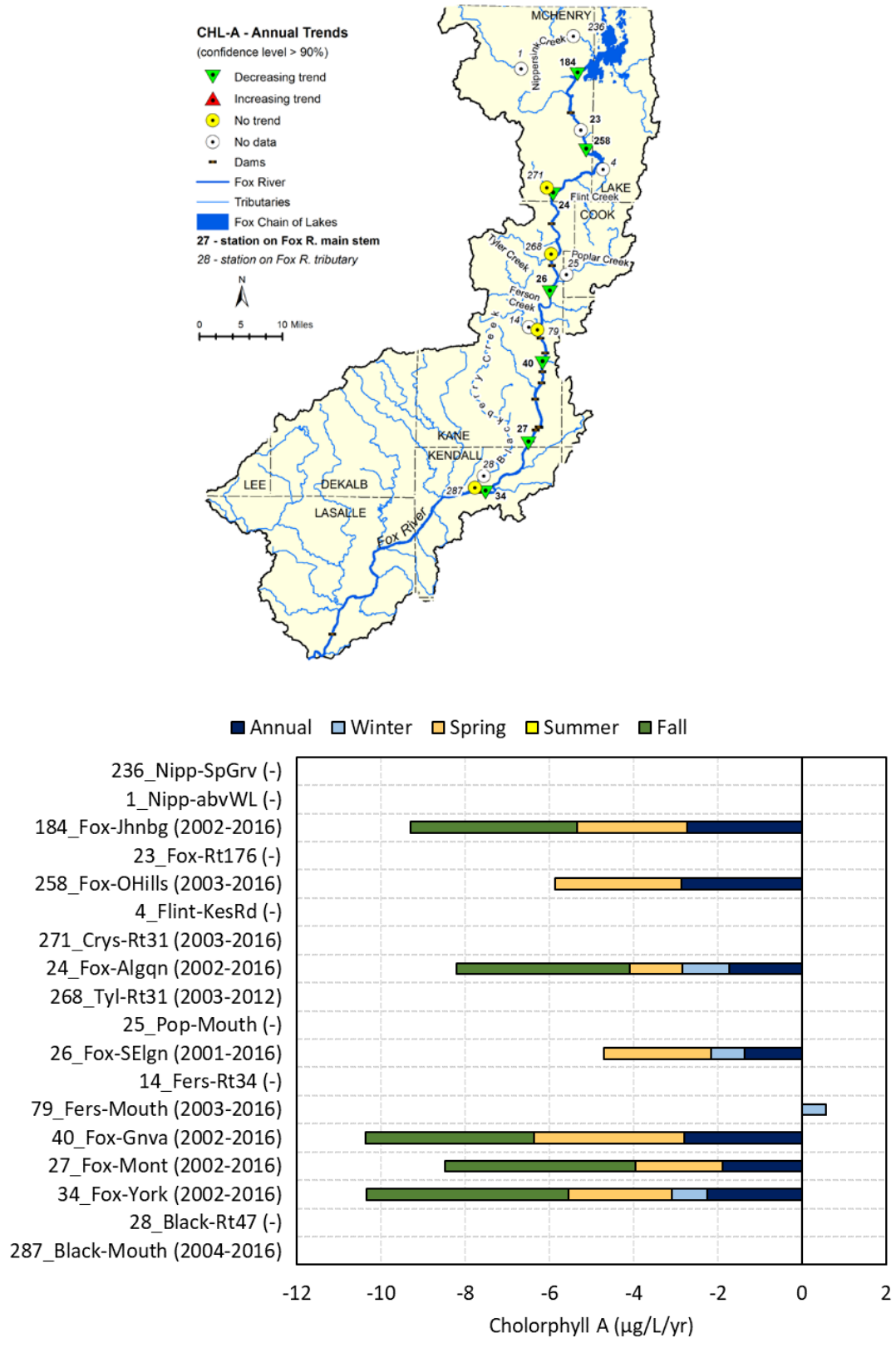


Figure C.19 Annual trends of chlorophyll-A (CHL-A) in the Fox River watershed

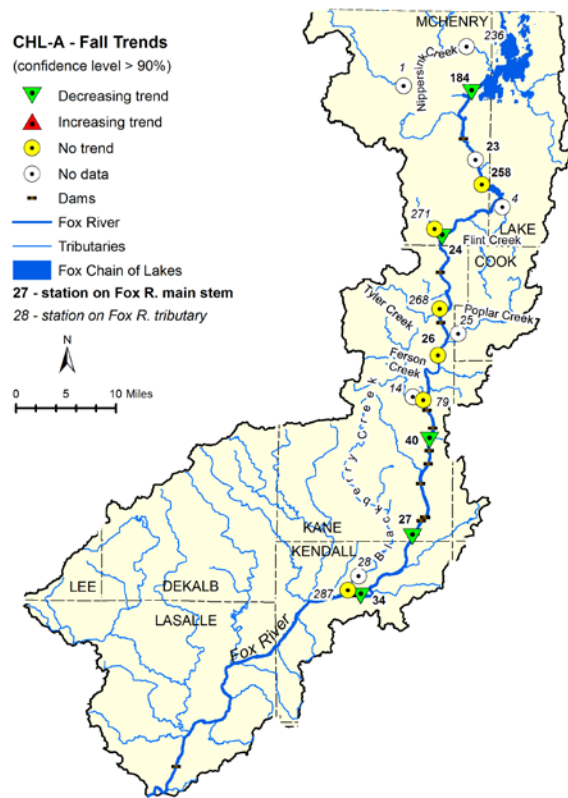
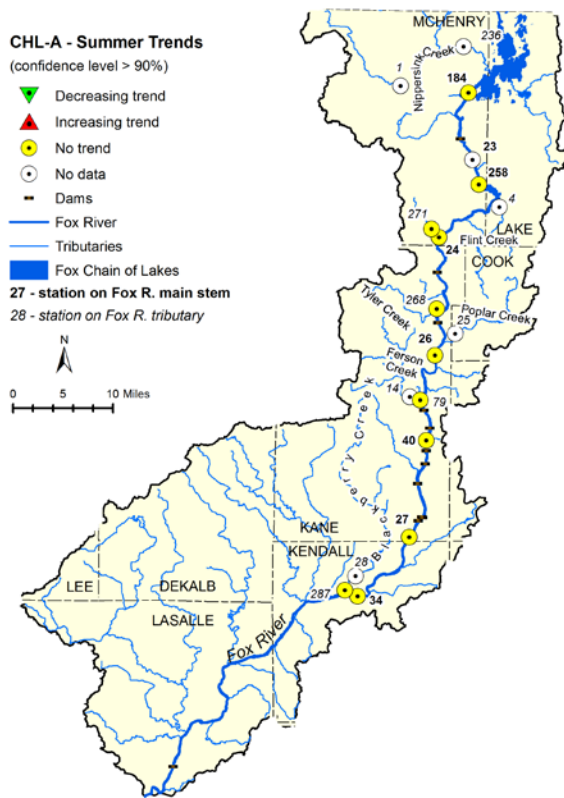
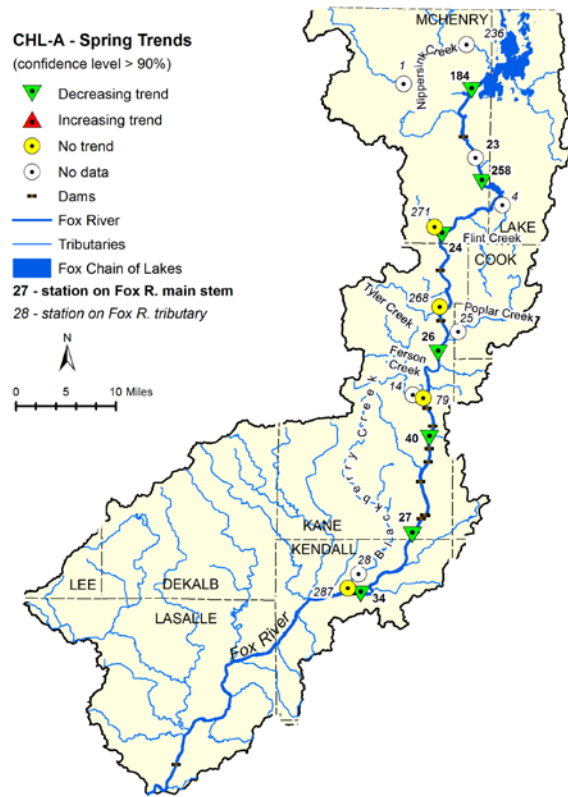
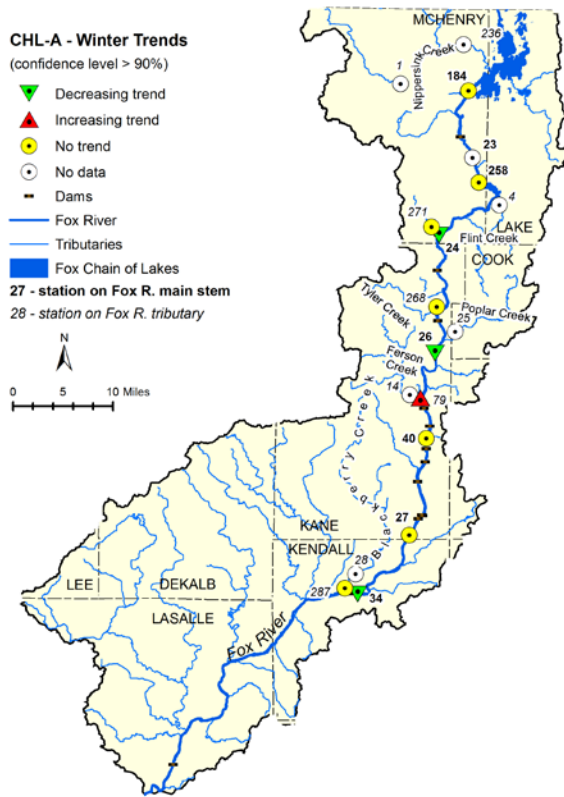


Figure C.20 Seasonal trends of chlorophyll-A (CHL-A) in the Fox River watershed

**Appendix D – Annual and Seasonal Trends of Flow-normalized
Concentrations and Fluxes**

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Annual Trends

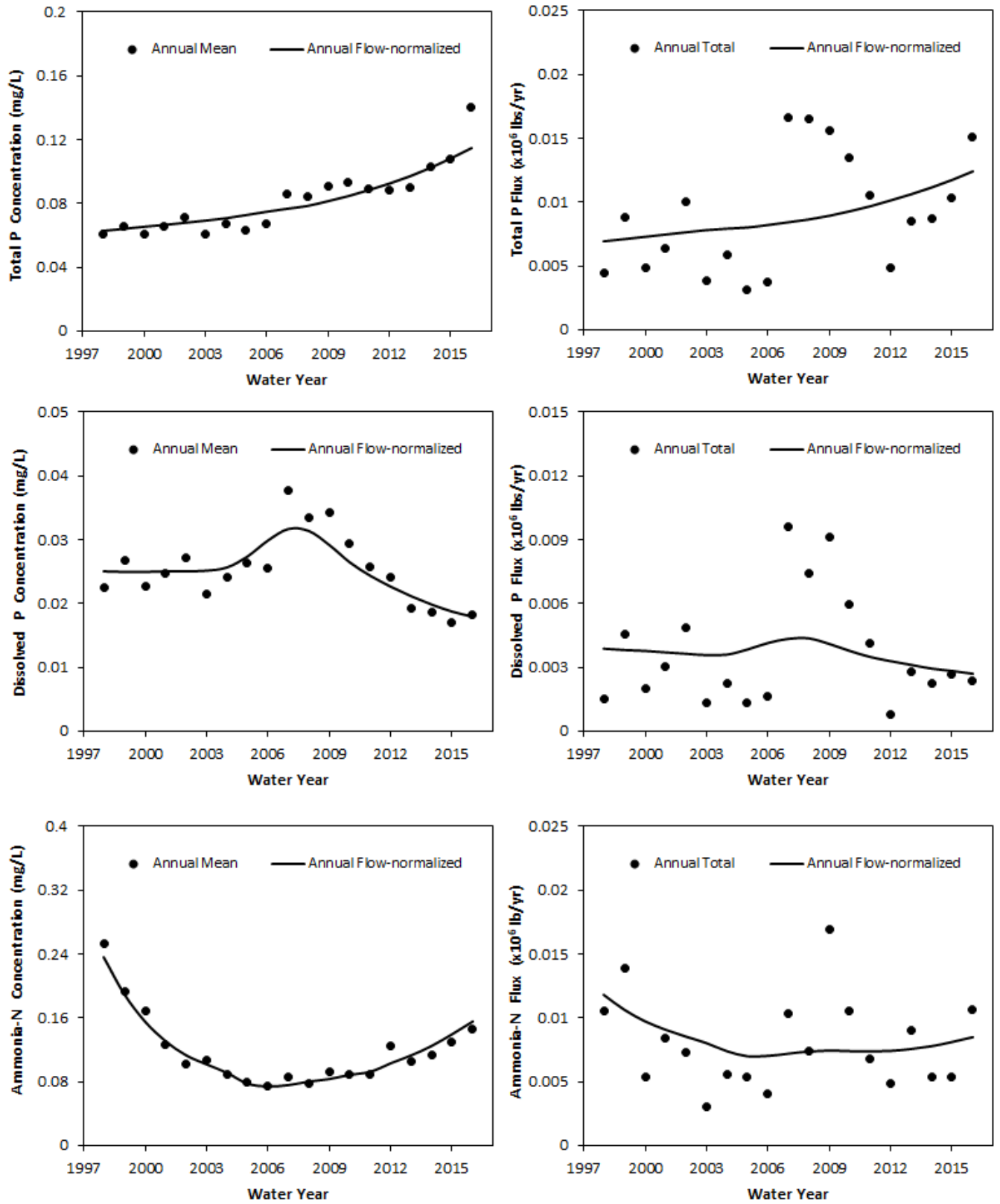


Figure D.1 Annual trends of TP, DP, and NH₃-N concentrations and fluxes for Poplar Cr near Mouth-Elgin

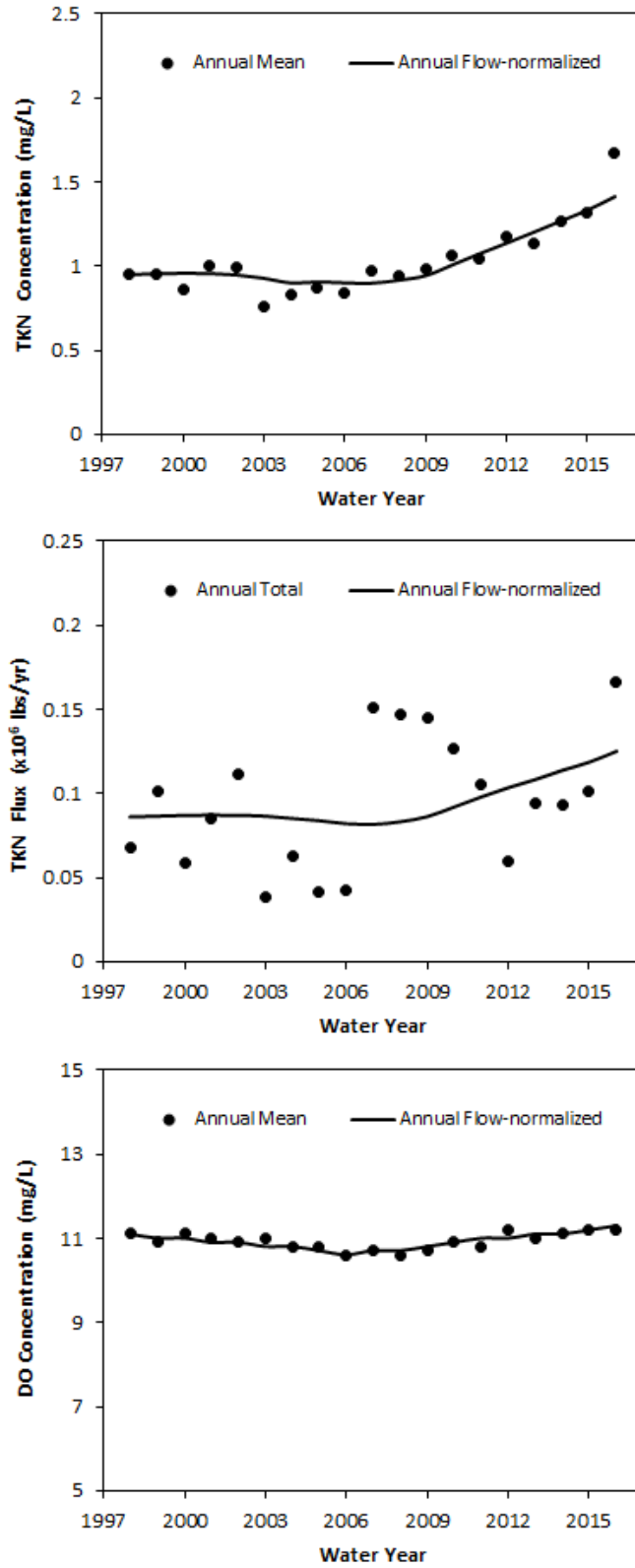


Figure D.2 Annual trends of TKN and DO concentrations and fluxes for Poplar Cr near Mouth-Elgin

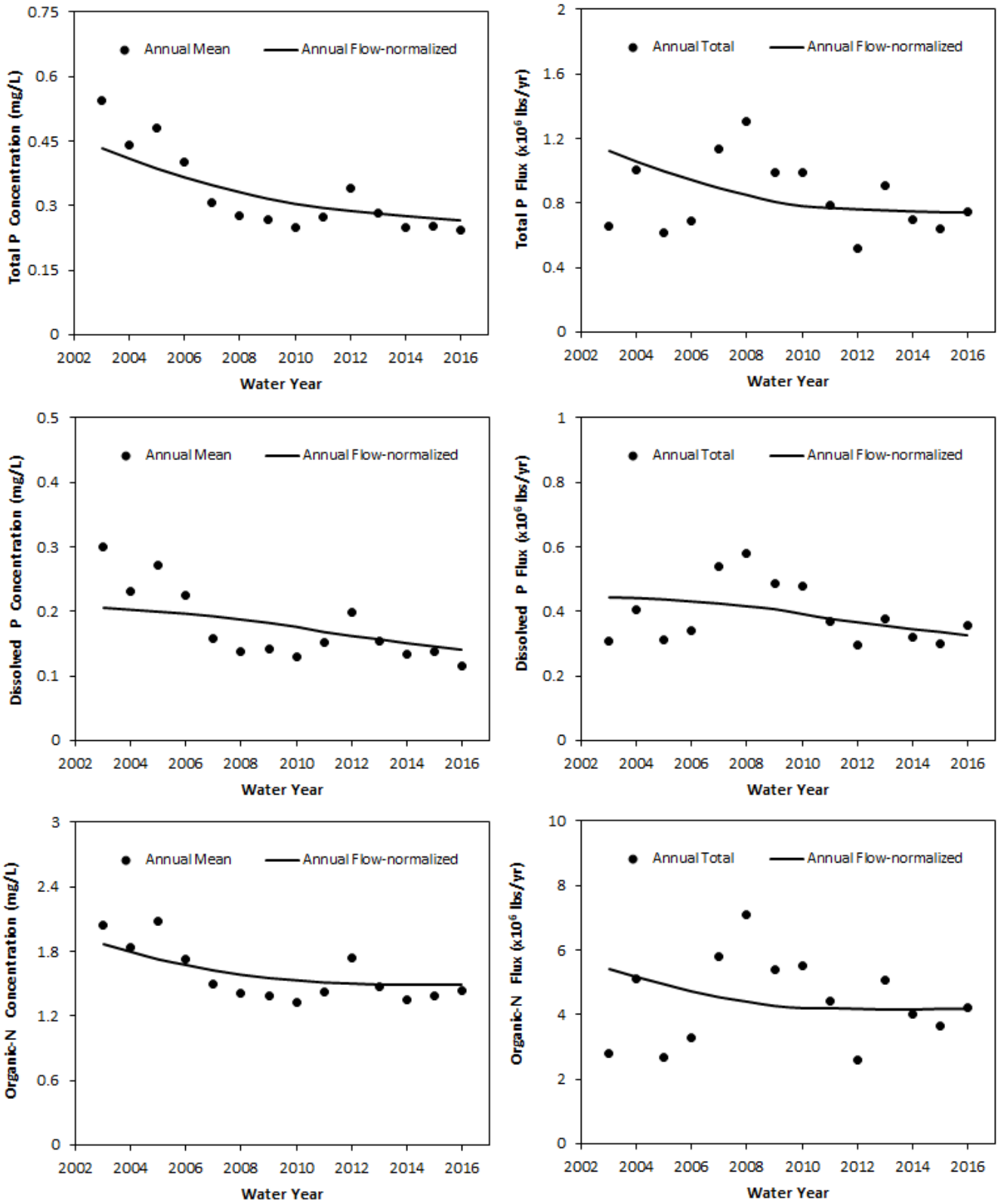


Figure D.3 Annual trends of TP, DP and Org-N concentrations and fluxes for Fox River at Montgomery

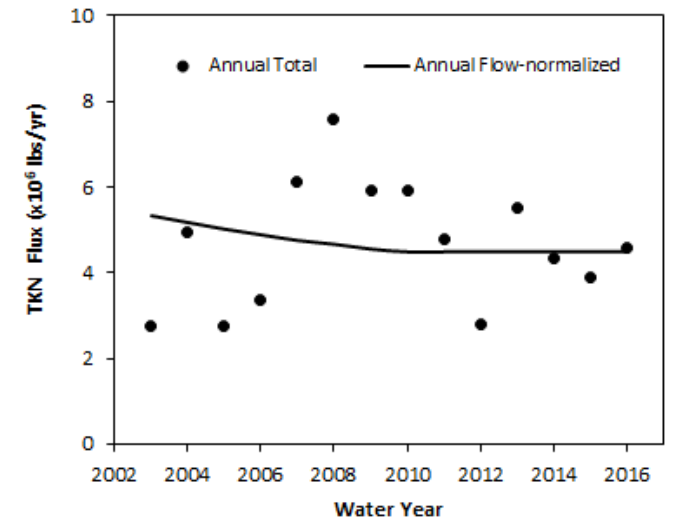
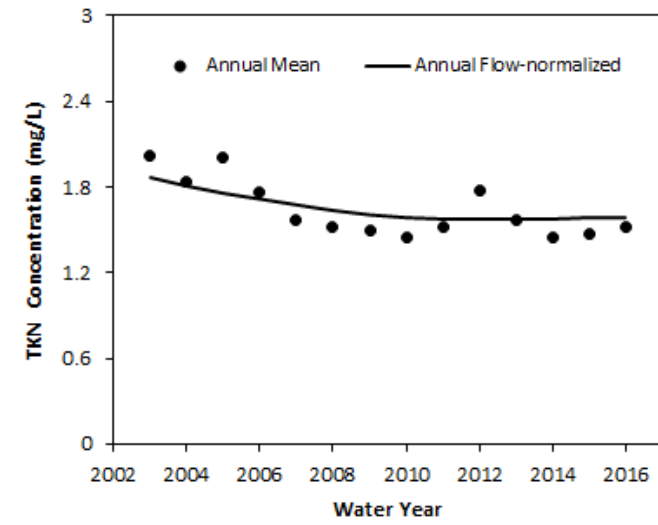
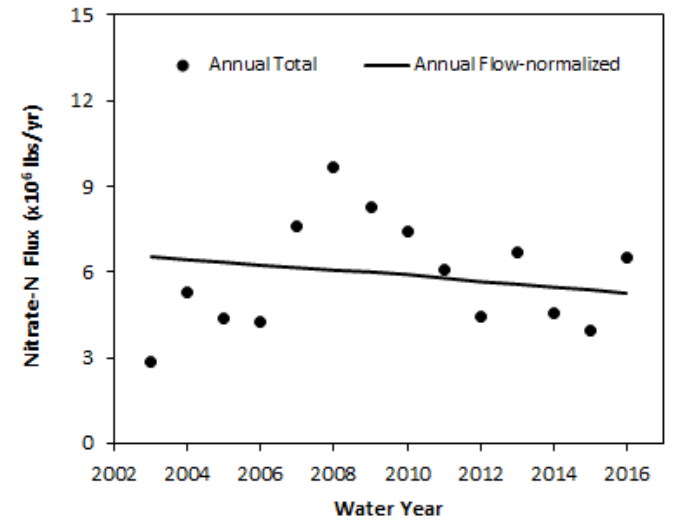
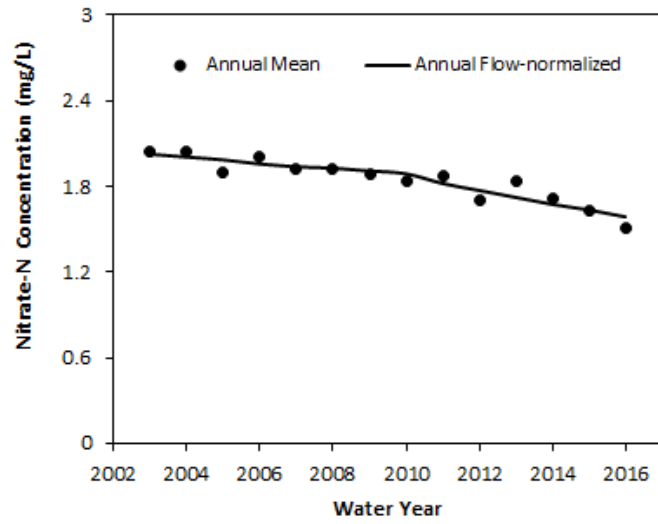
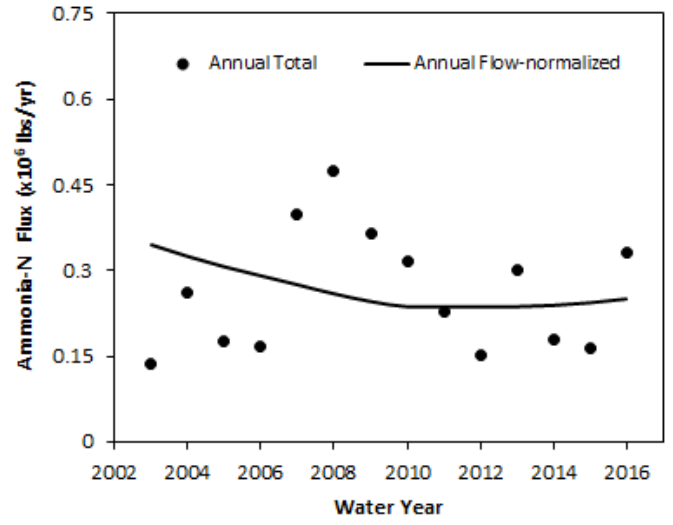
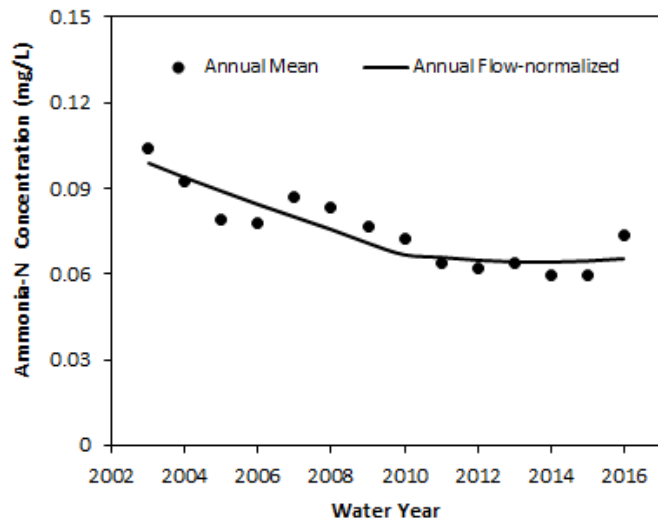


Figure D.4 Annual trends of $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$ and TKN concentrations and fluxes for Fox River at Montgomery

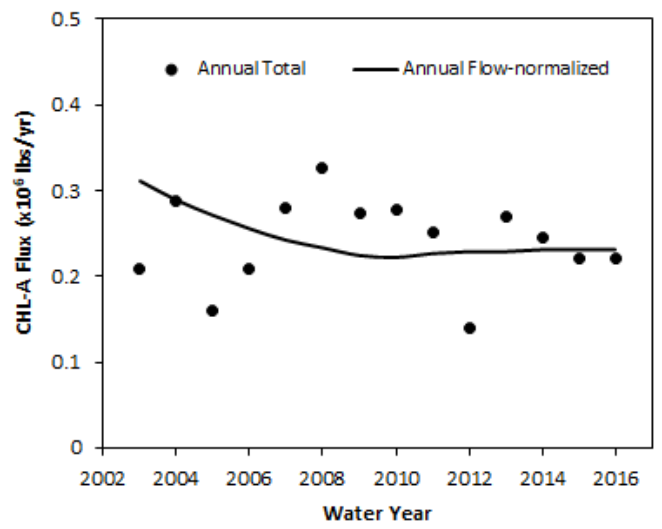
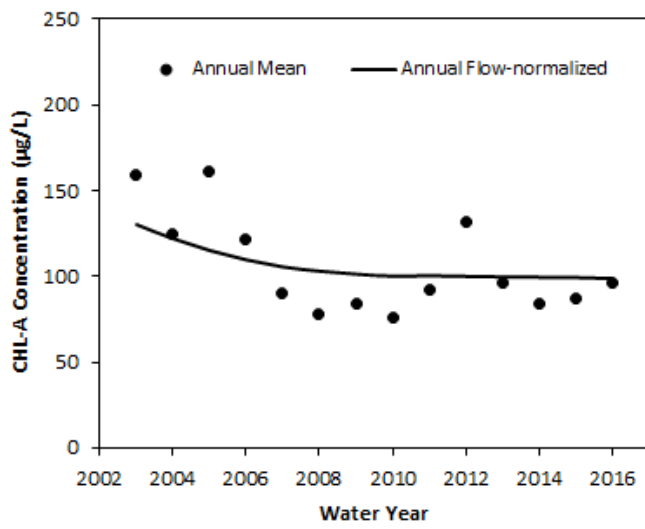
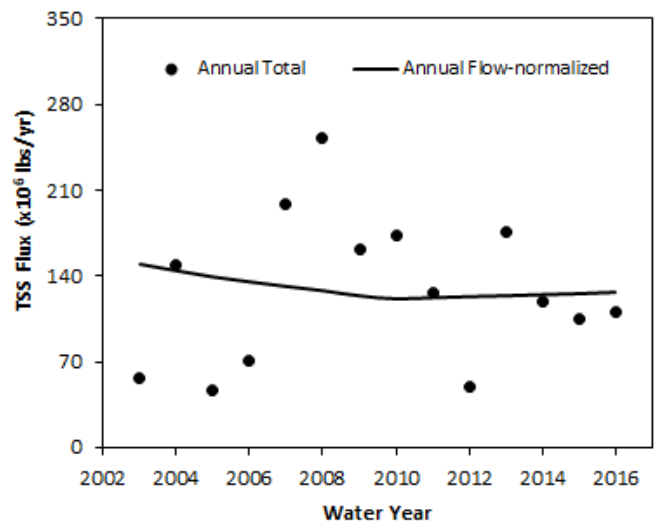
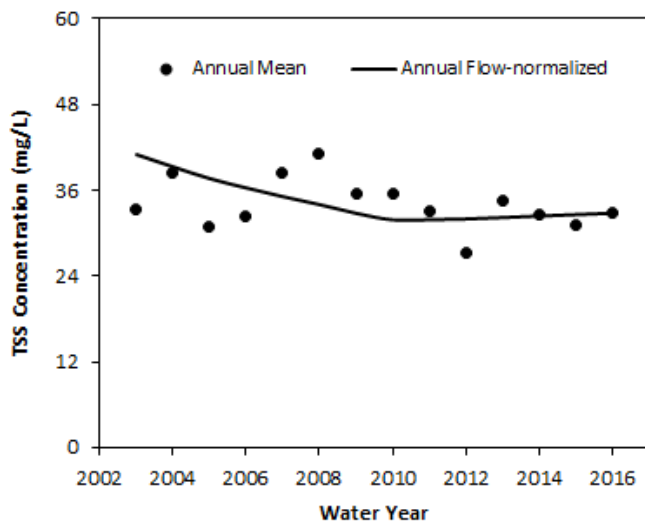
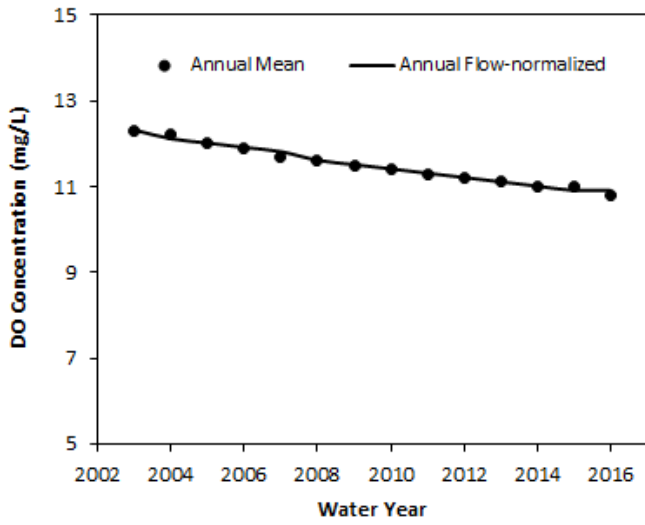


Figure D.5 Annual trends of DO, TSS and CHL-A concentrations and fluxes for Fox River at Montgomery

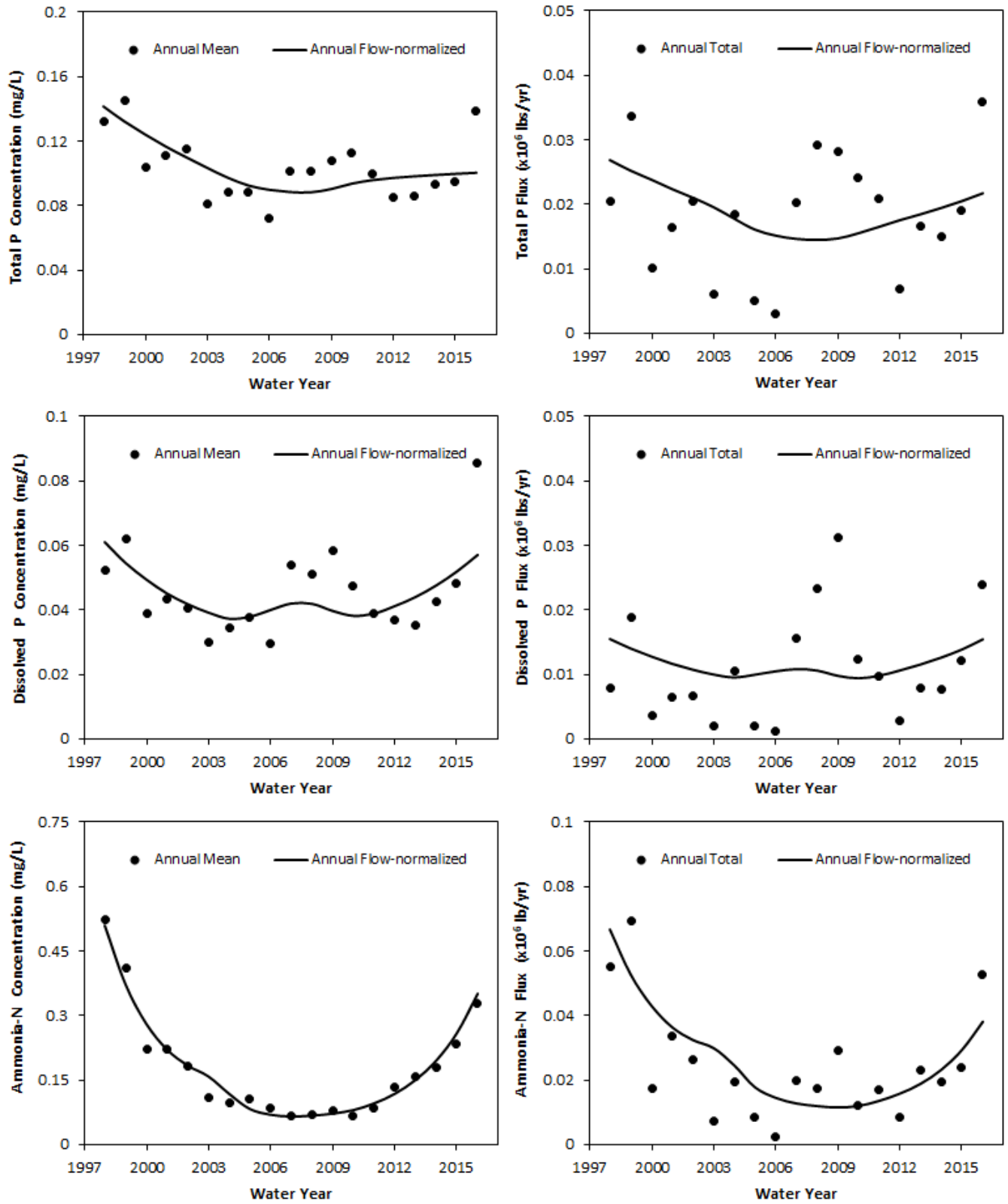


Figure D.6 Annual trends of TP, DP, and NH₃-N concentrations and fluxes for Blackberry Cr at Rt 47

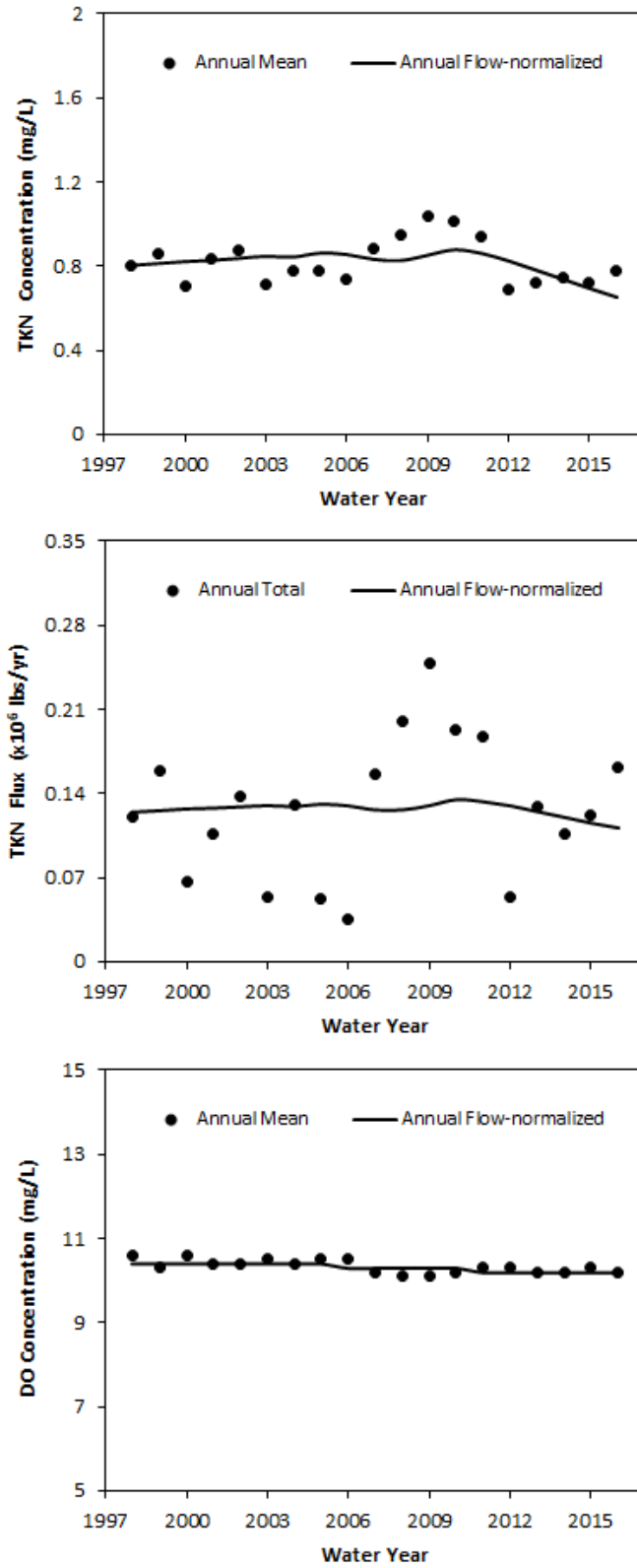


Figure D.7 Annual trends of TKN and DO concentrations and fluxes for Blackberry Cr at Rt 47

Winter Trends

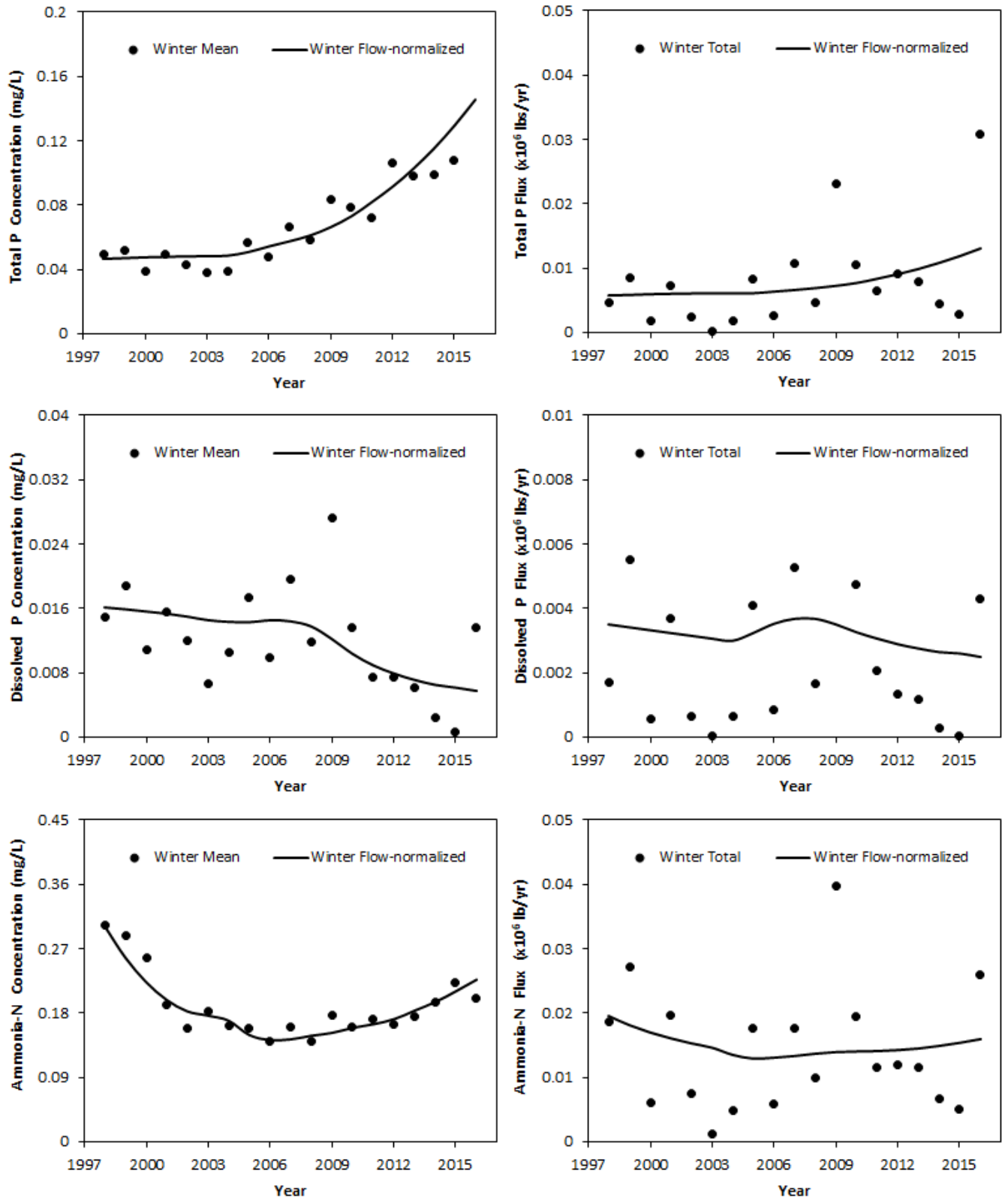


Figure D.8 Winter trends of TP, DP, and NH₃-N concentrations and fluxes for Poplar Cr near Mouth-Elgin

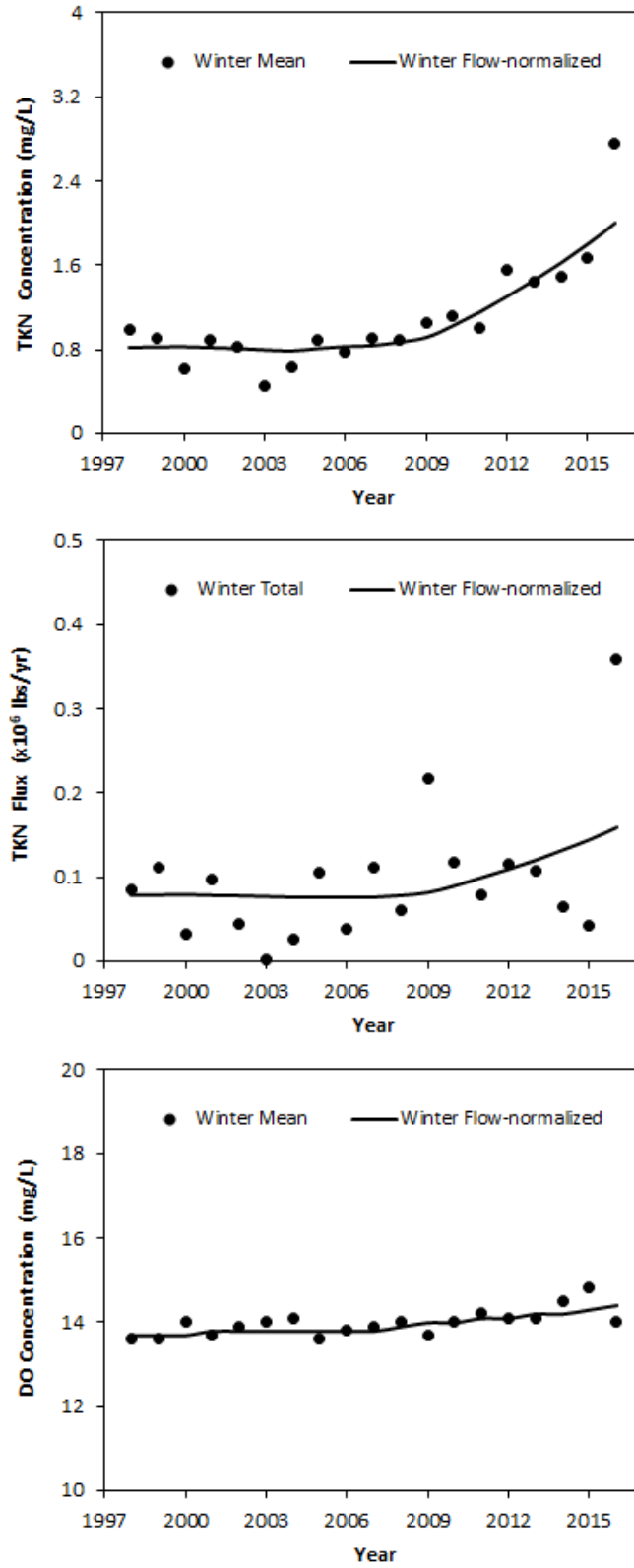


Figure D.9 Winter trends of TKN and DO concentrations and fluxes for Poplar Cr near Mouth-Elgin

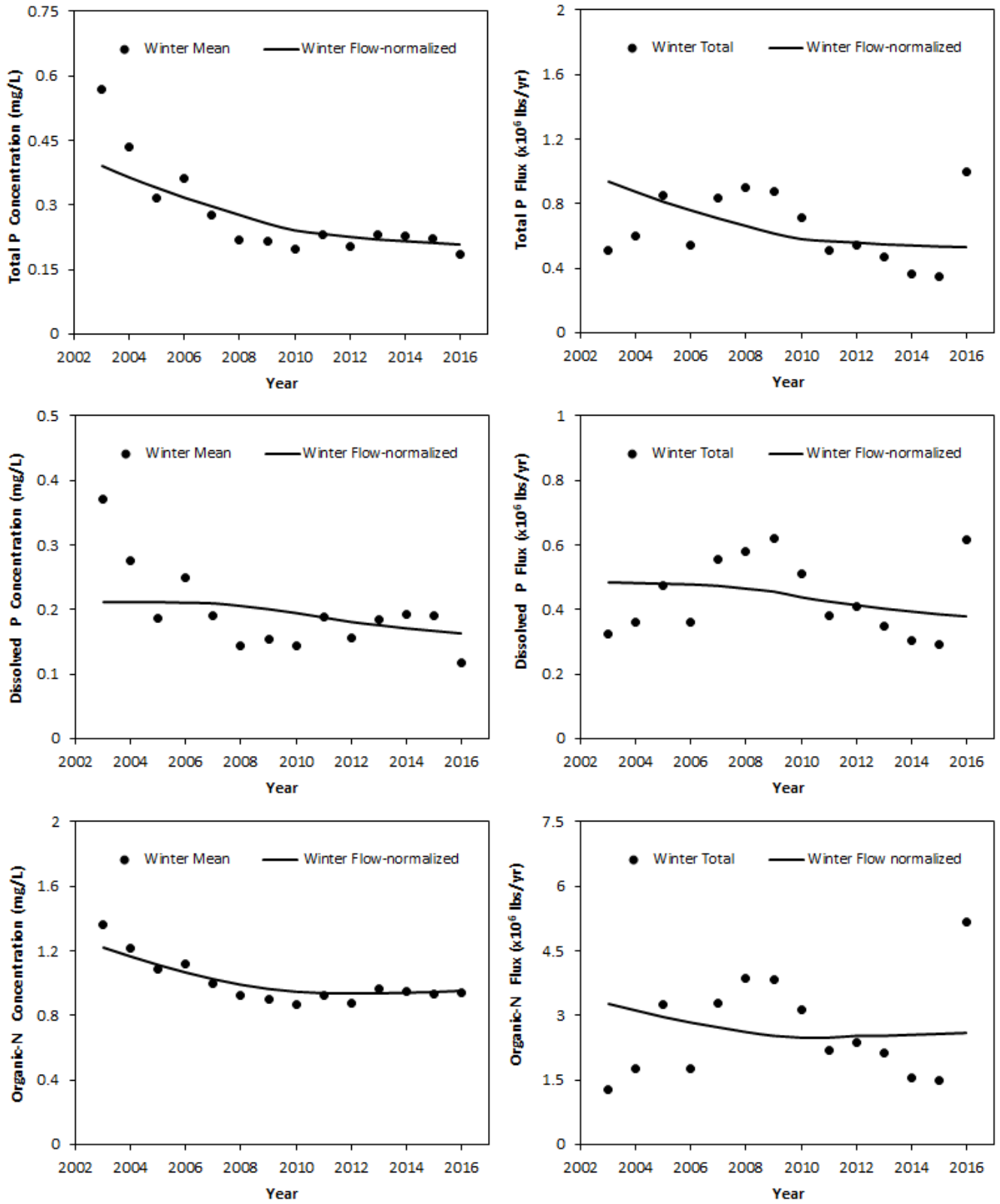


Figure D.10 Winter trends of TP, DP, and Org-N concentrations and fluxes for Fox River at Montgomery

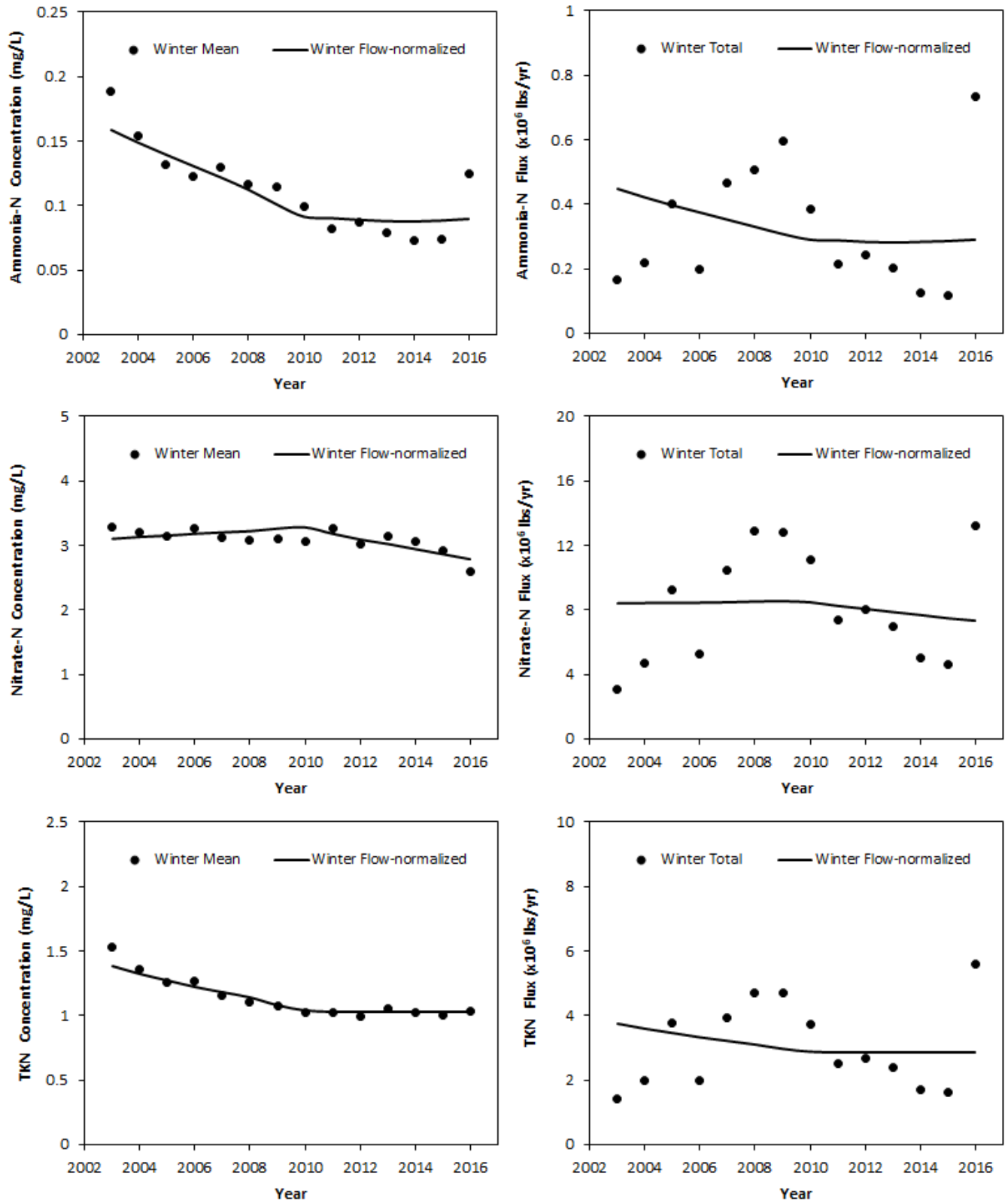


Figure D.11 Winter trends of NH₃-N, NO₃-N and TKN concentrations and fluxes for Fox River at Montgomery

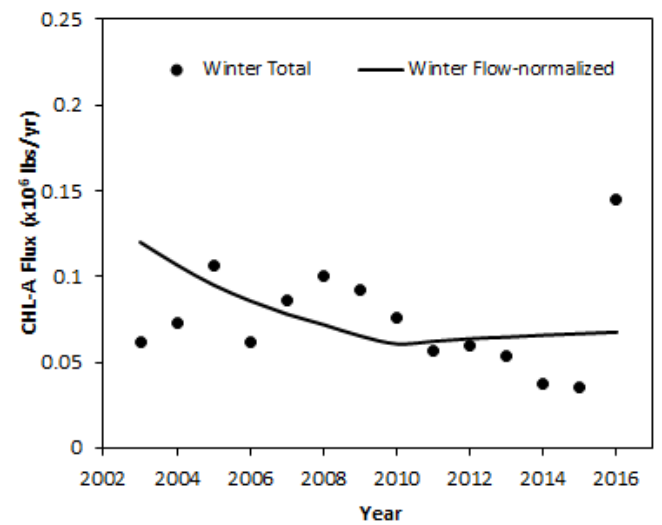
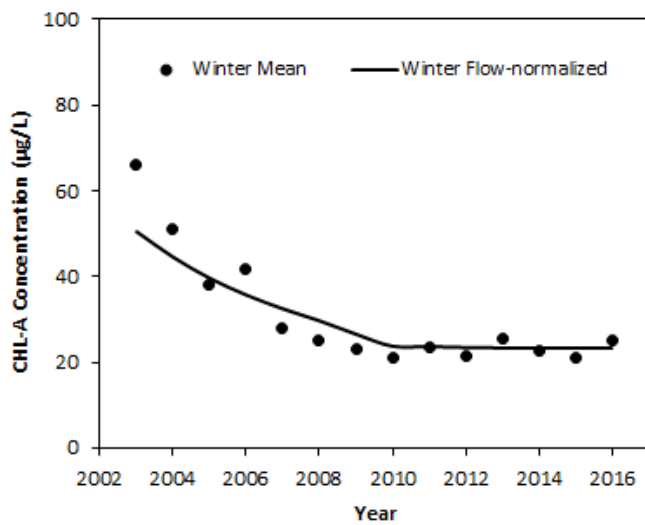
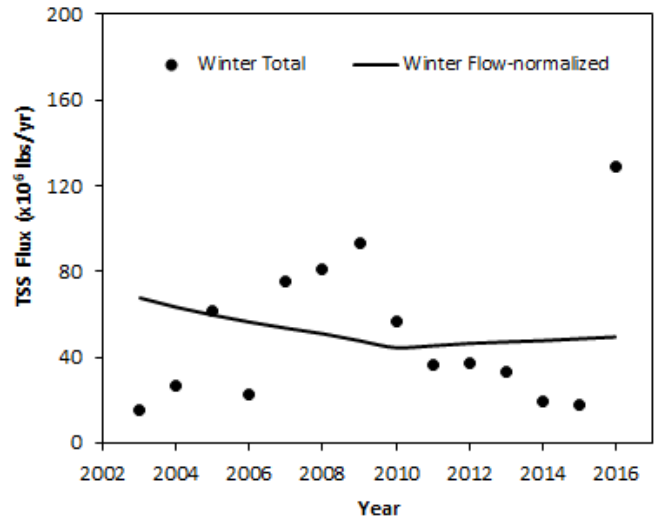
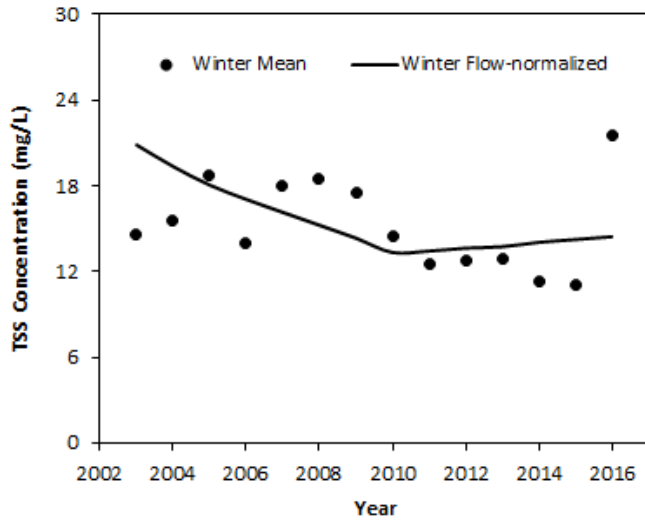
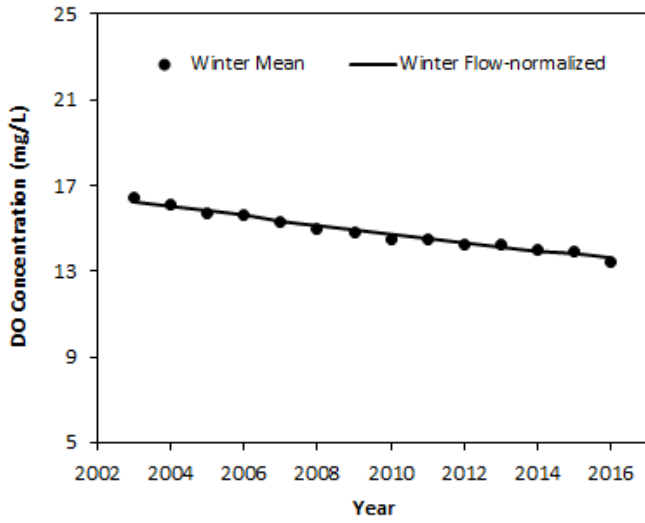


Figure D.12 Winter trends of DO, TSS and CHL-A concentrations and fluxes for Fox River at Montgomery

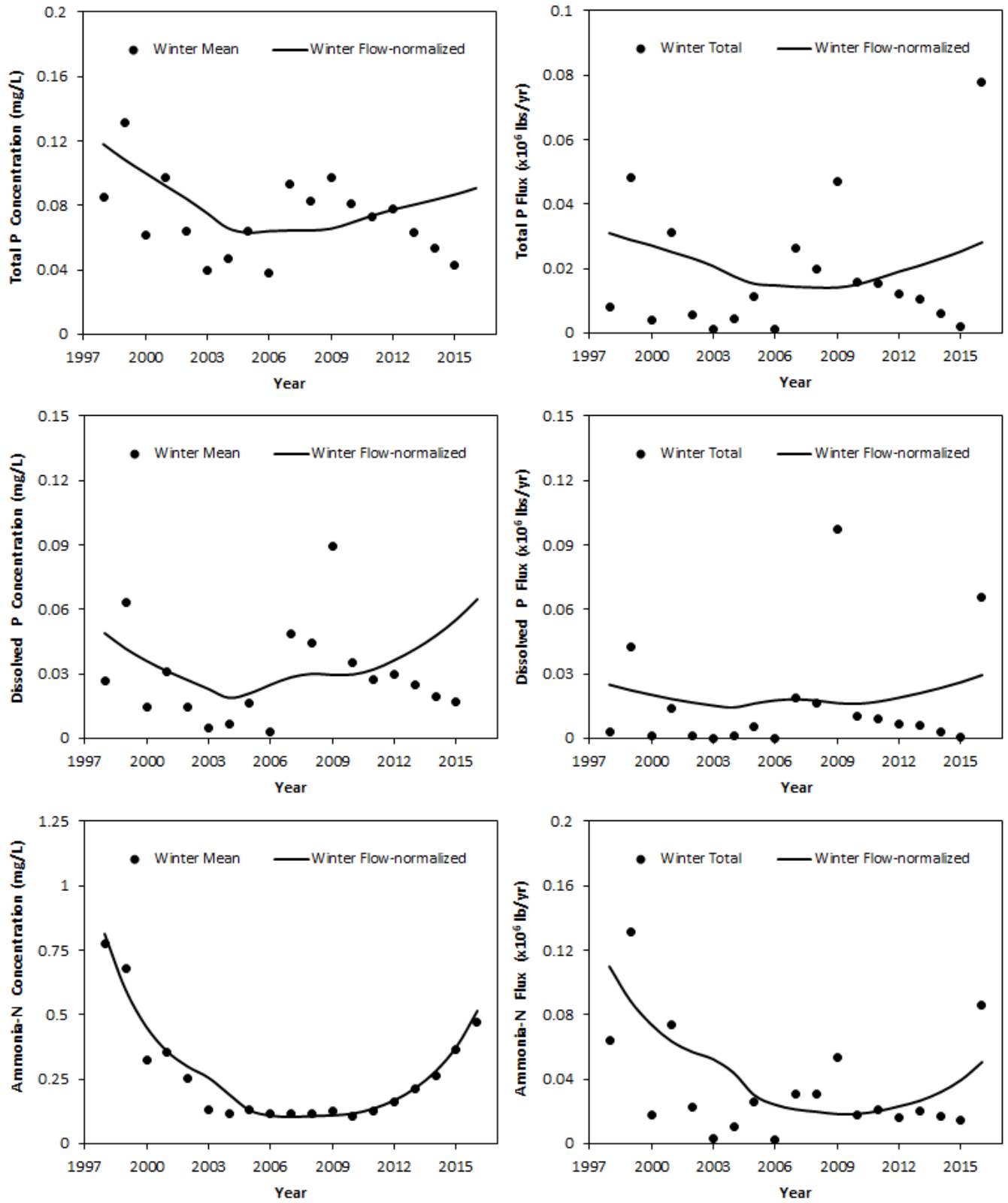


Figure D.13 Winter trends of TP, DP, and NH₃-N concentrations and fluxes for Blackberry Cr at Rt 47

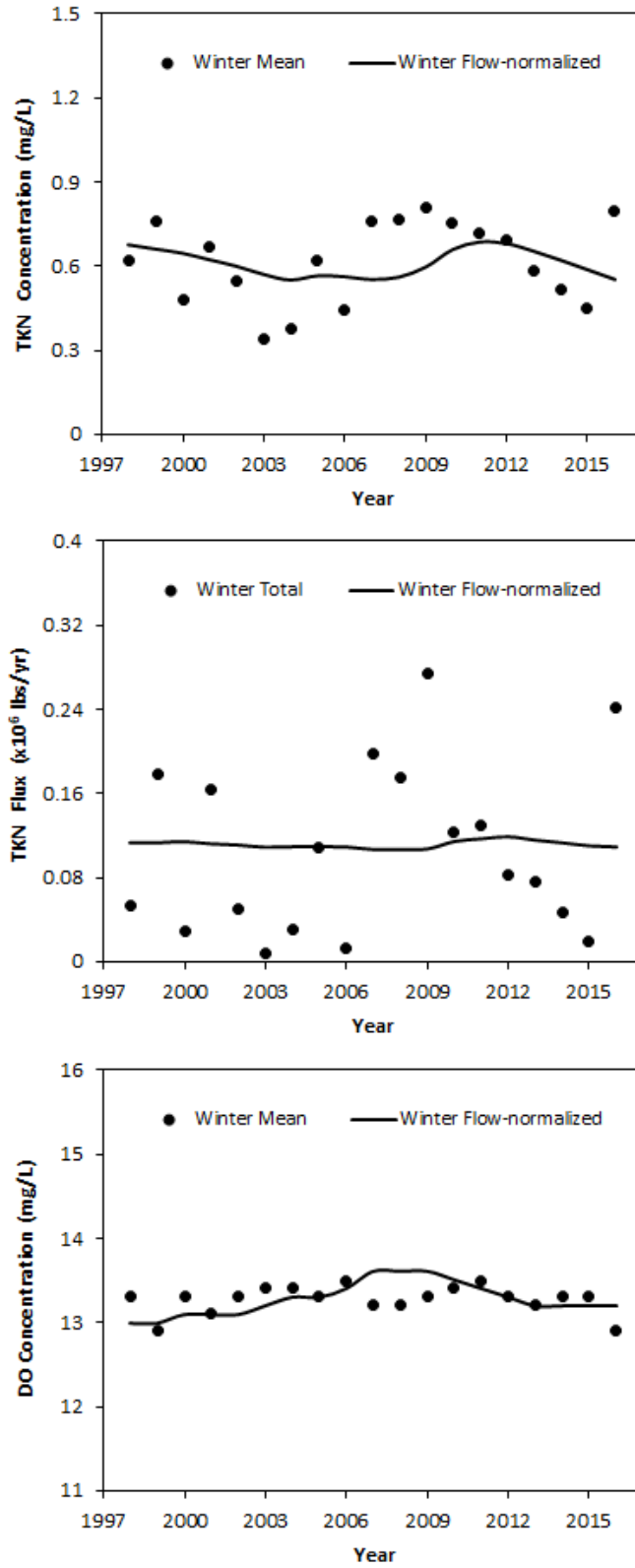


Figure D.14 Winter trends of TKN and DO concentrations and fluxes for Blackberry Cr at Rt 47

Spring Trends

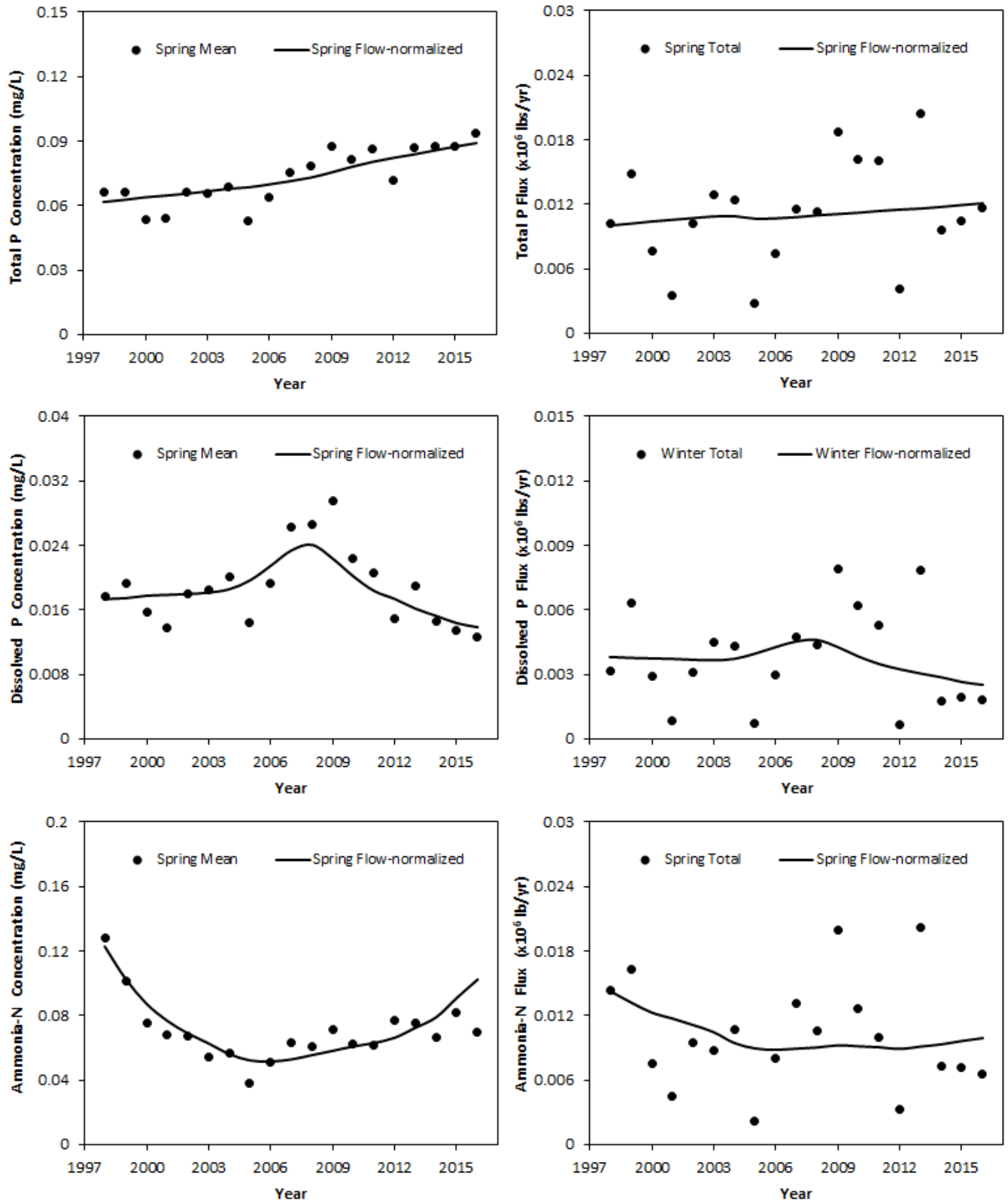


Figure D.15 Spring trends of TP, DP, and NH₃-N concentrations and fluxes for Poplar Cr near Mouth-Elgin

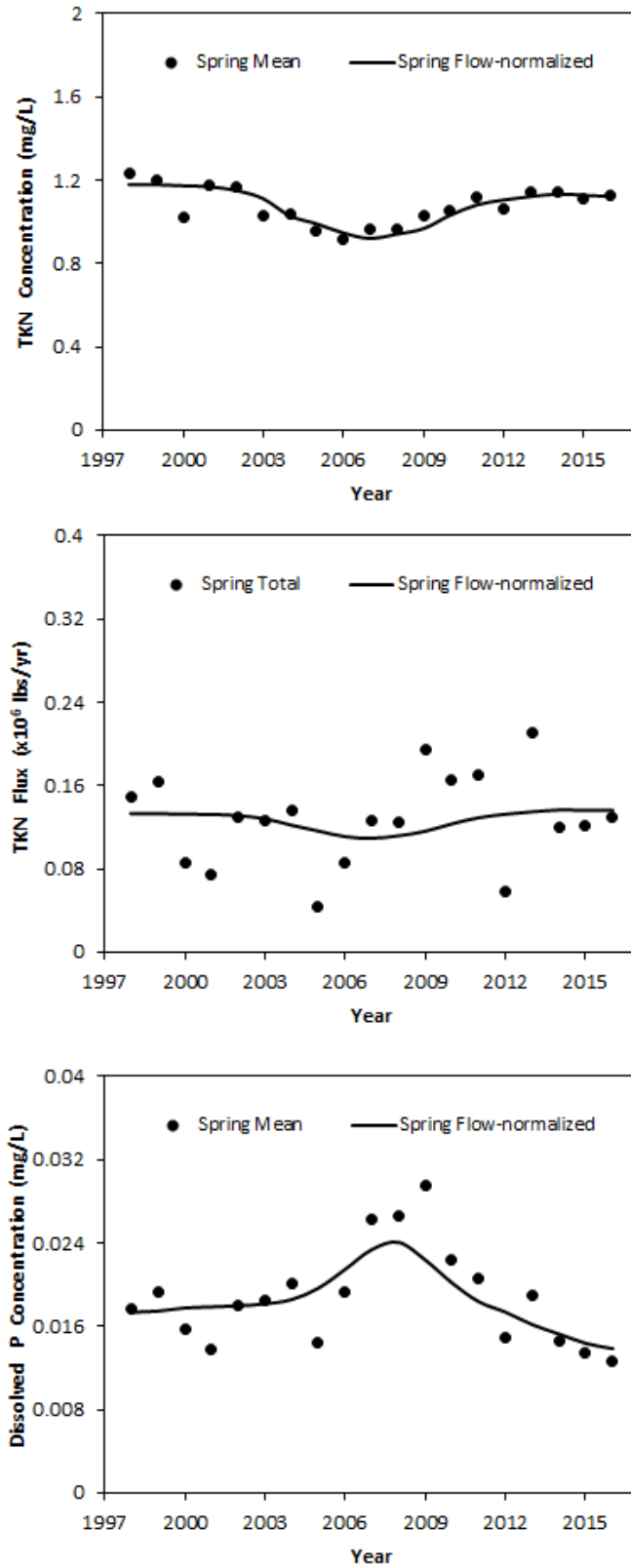


Figure D.16 Spring trends of TKN and DO concentrations and fluxes for Poplar Cr near Mouth-Elgin

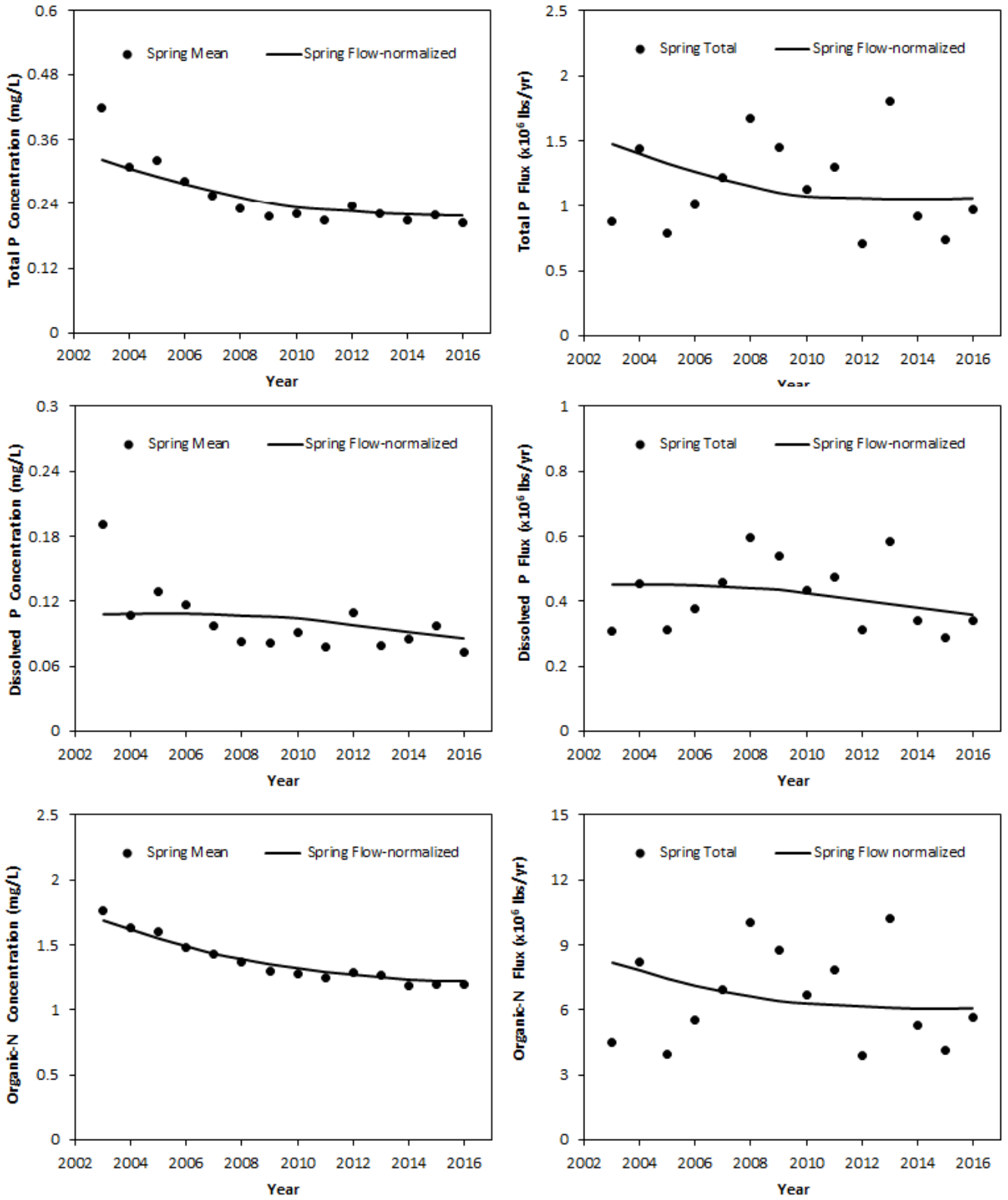


Figure D.17 Spring trends of TP, DP, and Org-N concentrations and fluxes for Fox River at Montgomery

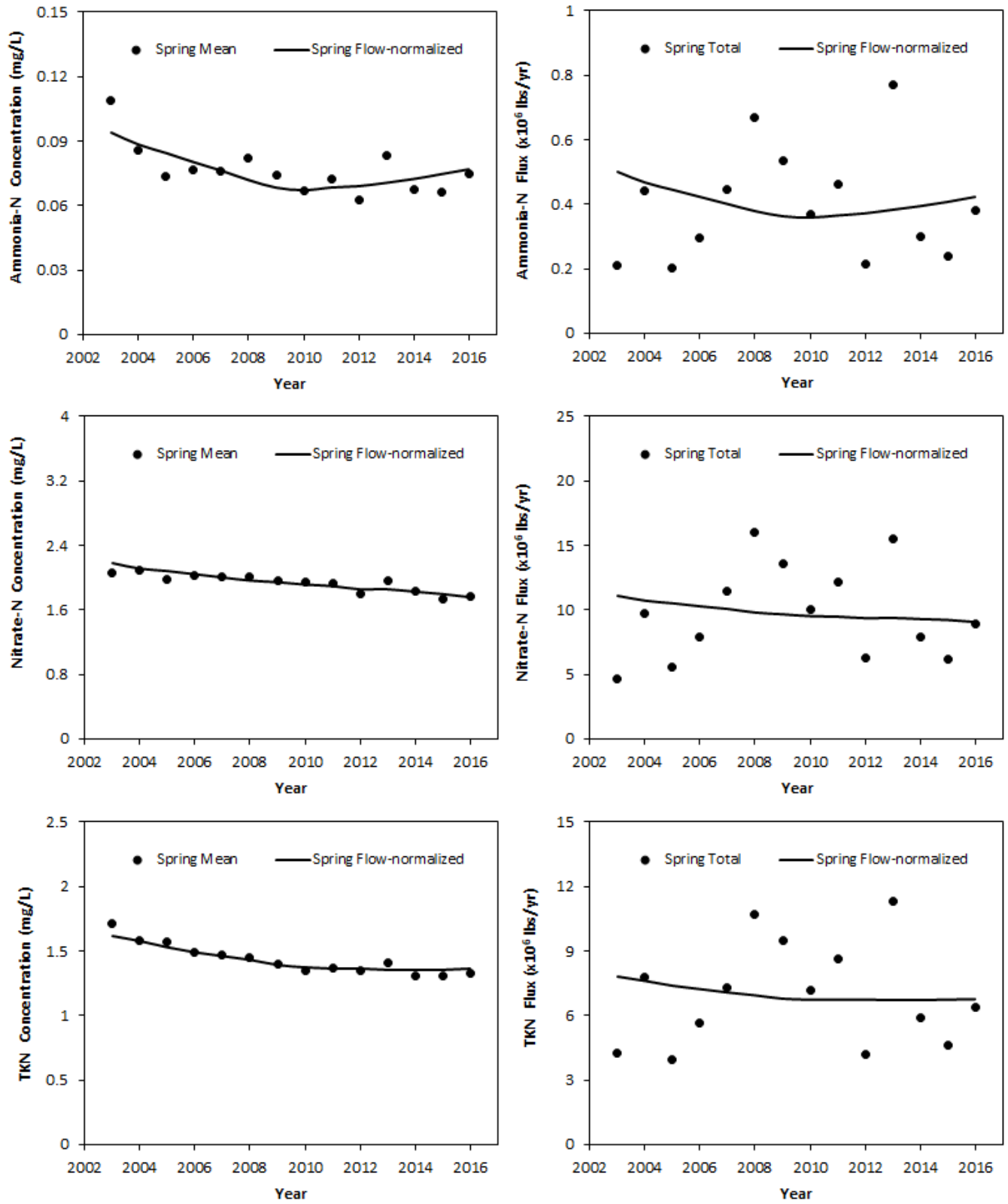


Figure D.18 Spring trends of $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$ and TKN concentrations and fluxes for Fox River at Montgomery

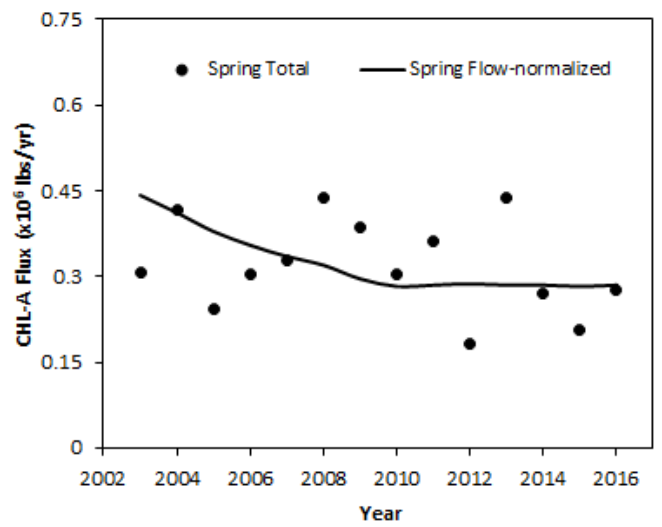
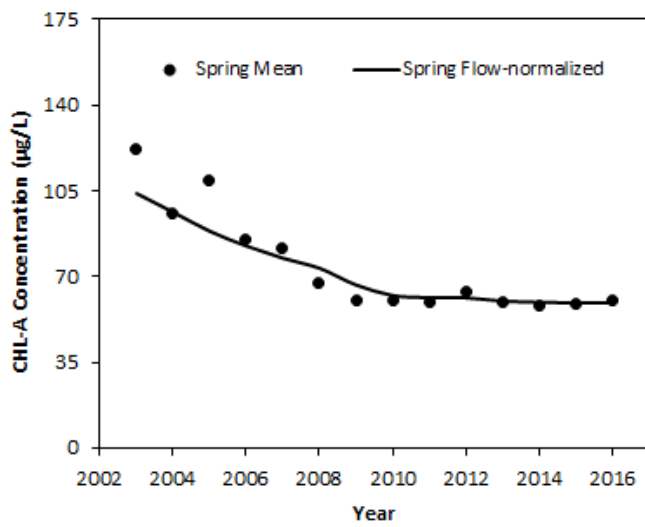
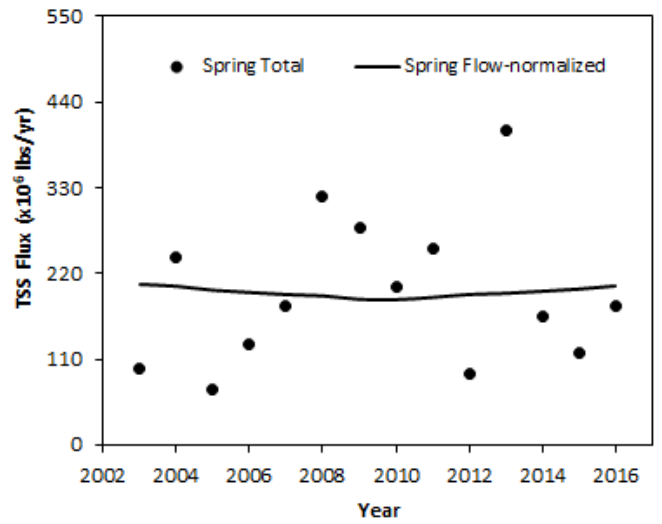
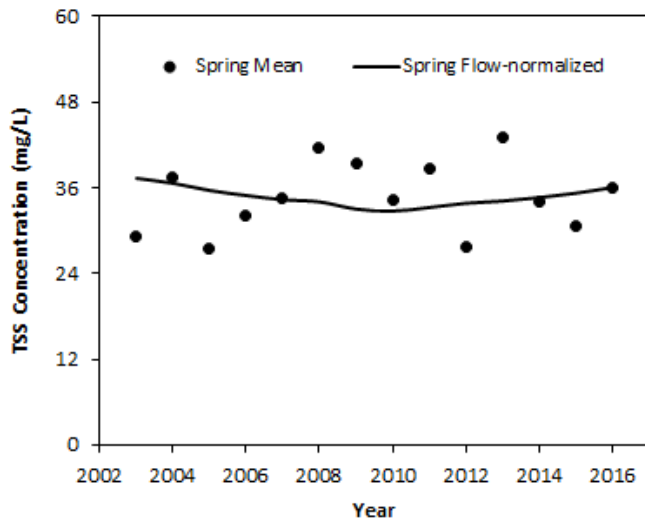
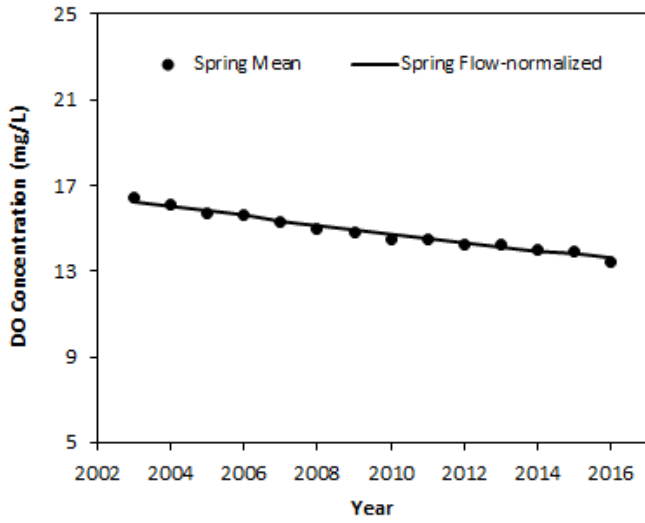


Figure D.19 Spring trends of DO, TSS and CHL-A concentrations and fluxes for Fox River at Montgomery

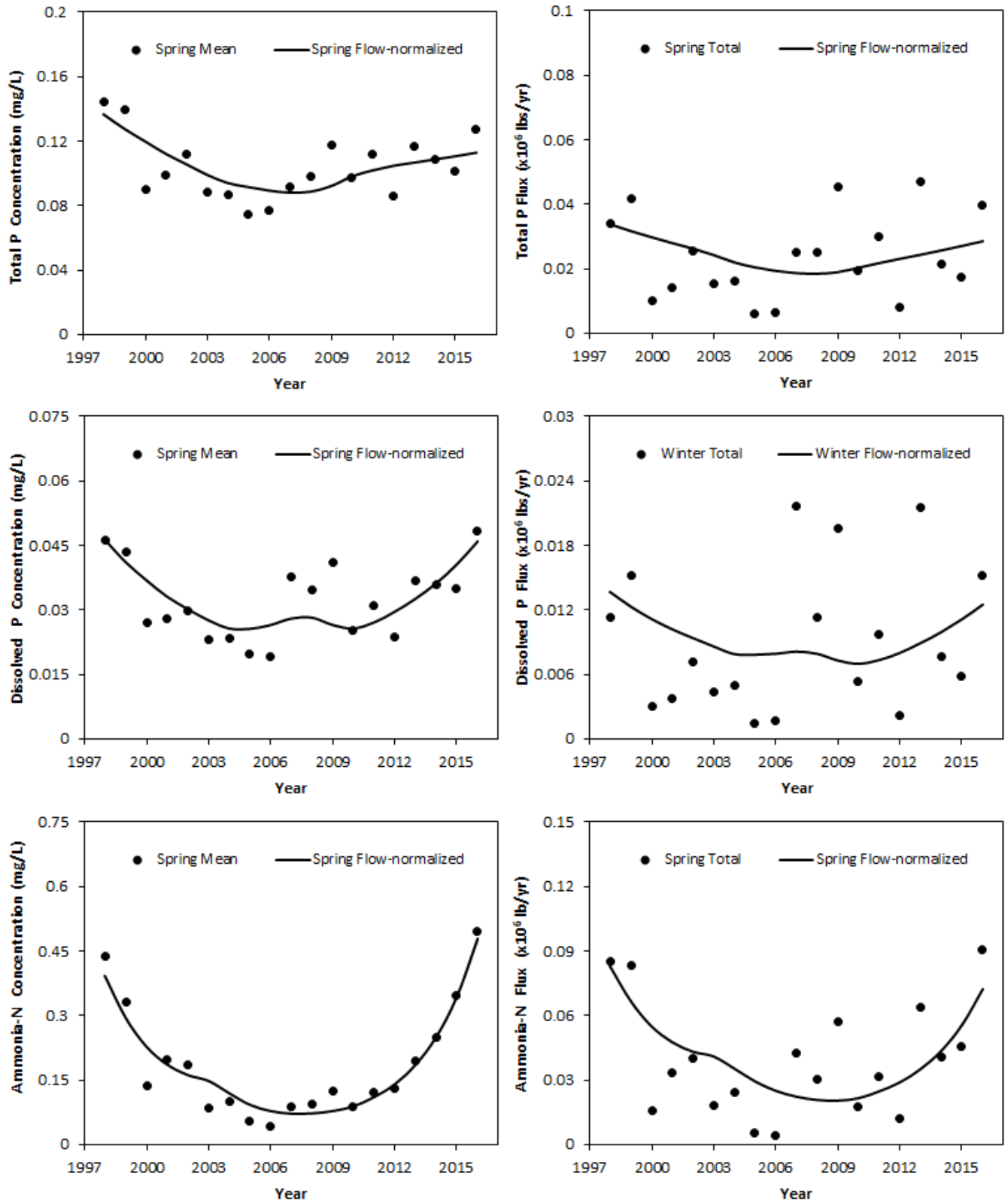


Figure D.20 Spring trends of TP, DP, and NH₃-N concentrations and fluxes for Blackberry Cr at Rt 47

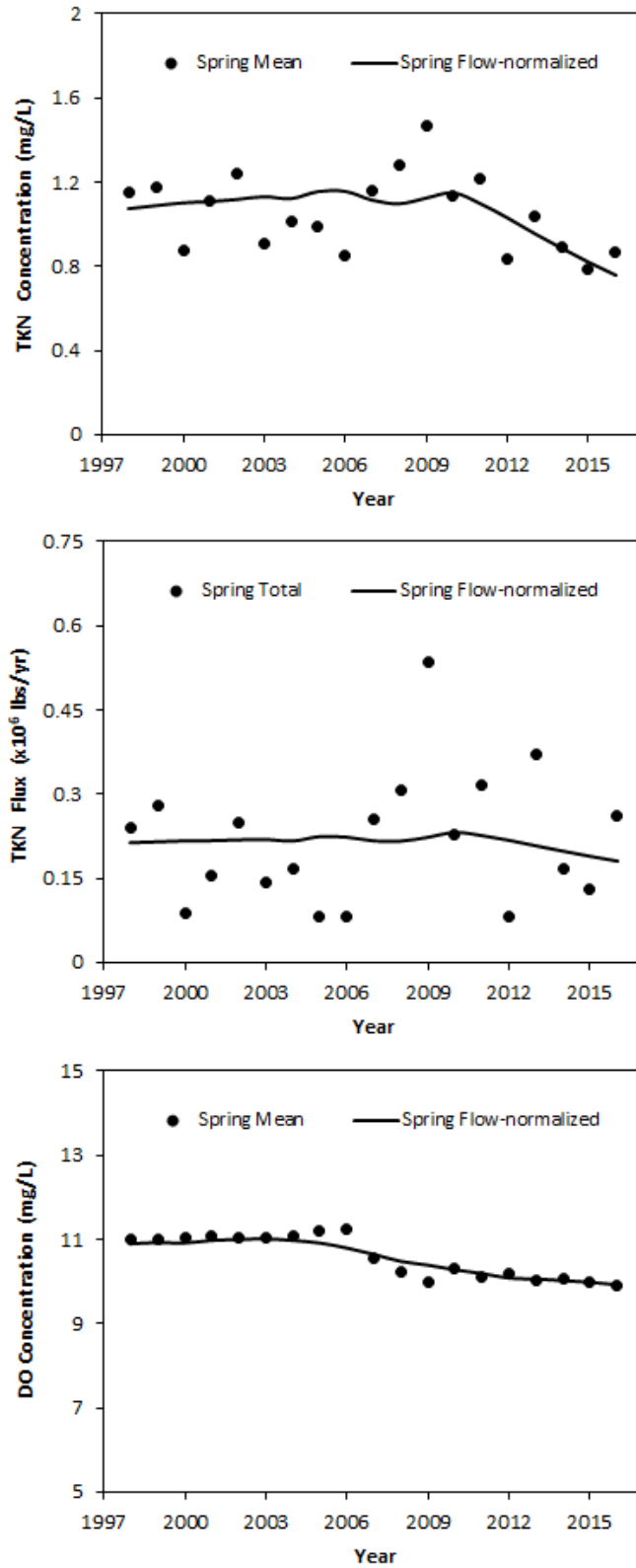


Figure D.21 Spring trends of TKN and DO concentrations and fluxes for Blackberry Cr at Rt 47

Summer Trends

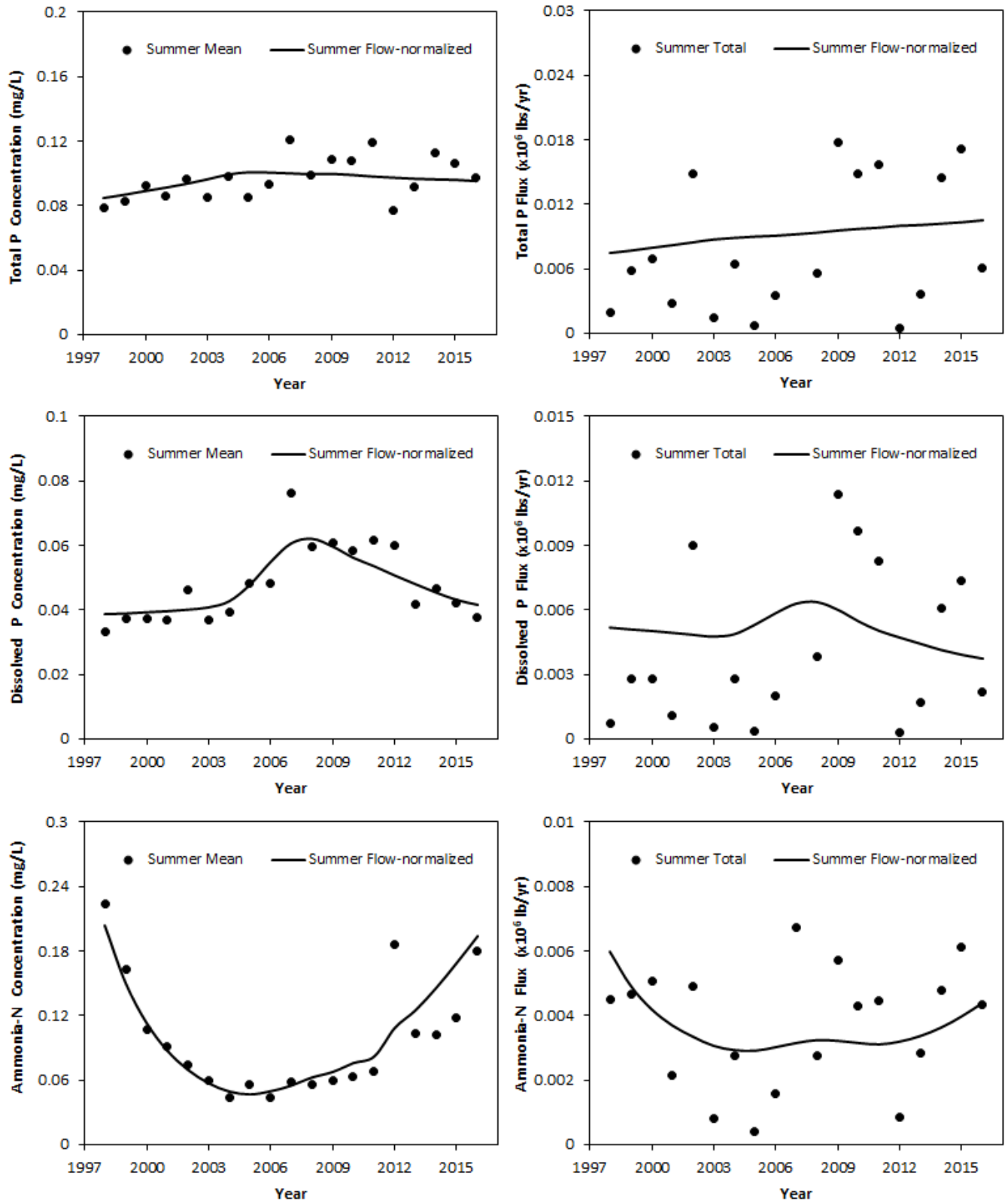


Figure D.22 Summer trends of TP, DP, and NH₃-N concentrations and fluxes for Poplar Cr near Mouth-Elgin

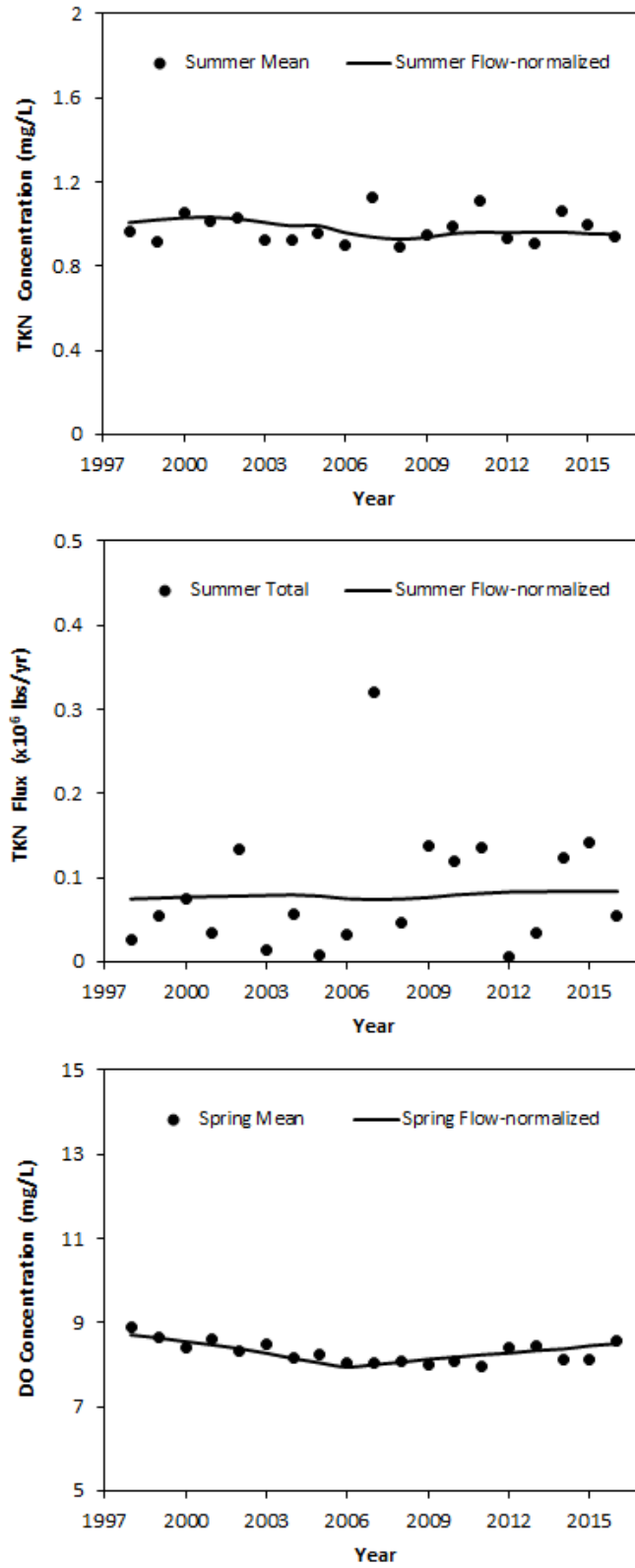


Figure D.23 Summer trends of TKN and DO concentrations and fluxes for Poplar Cr near Mouth-Elgin

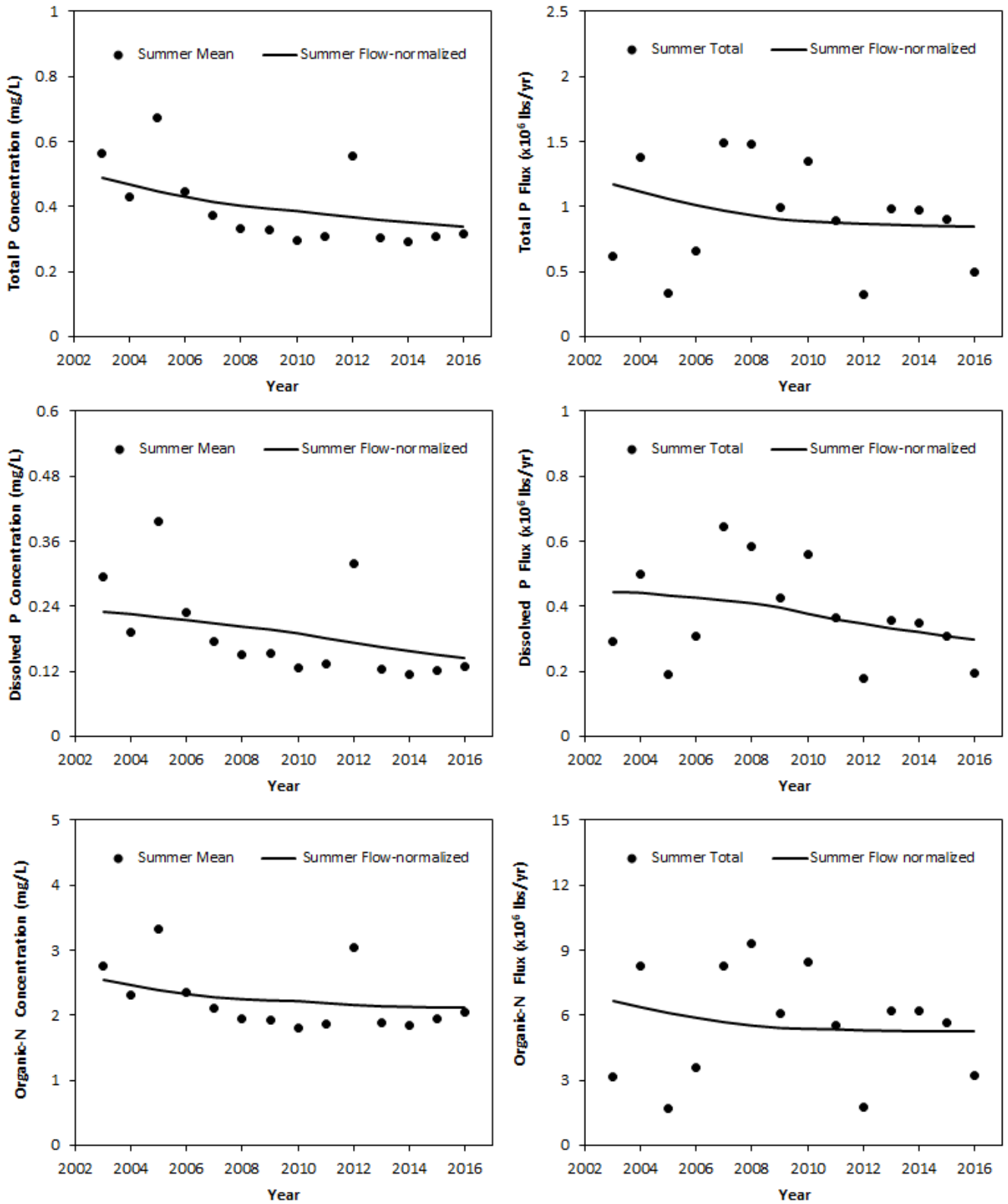


Figure D.24 Summer trends of TP, DP, and Org-N concentrations and fluxes for Fox River at Montgomery

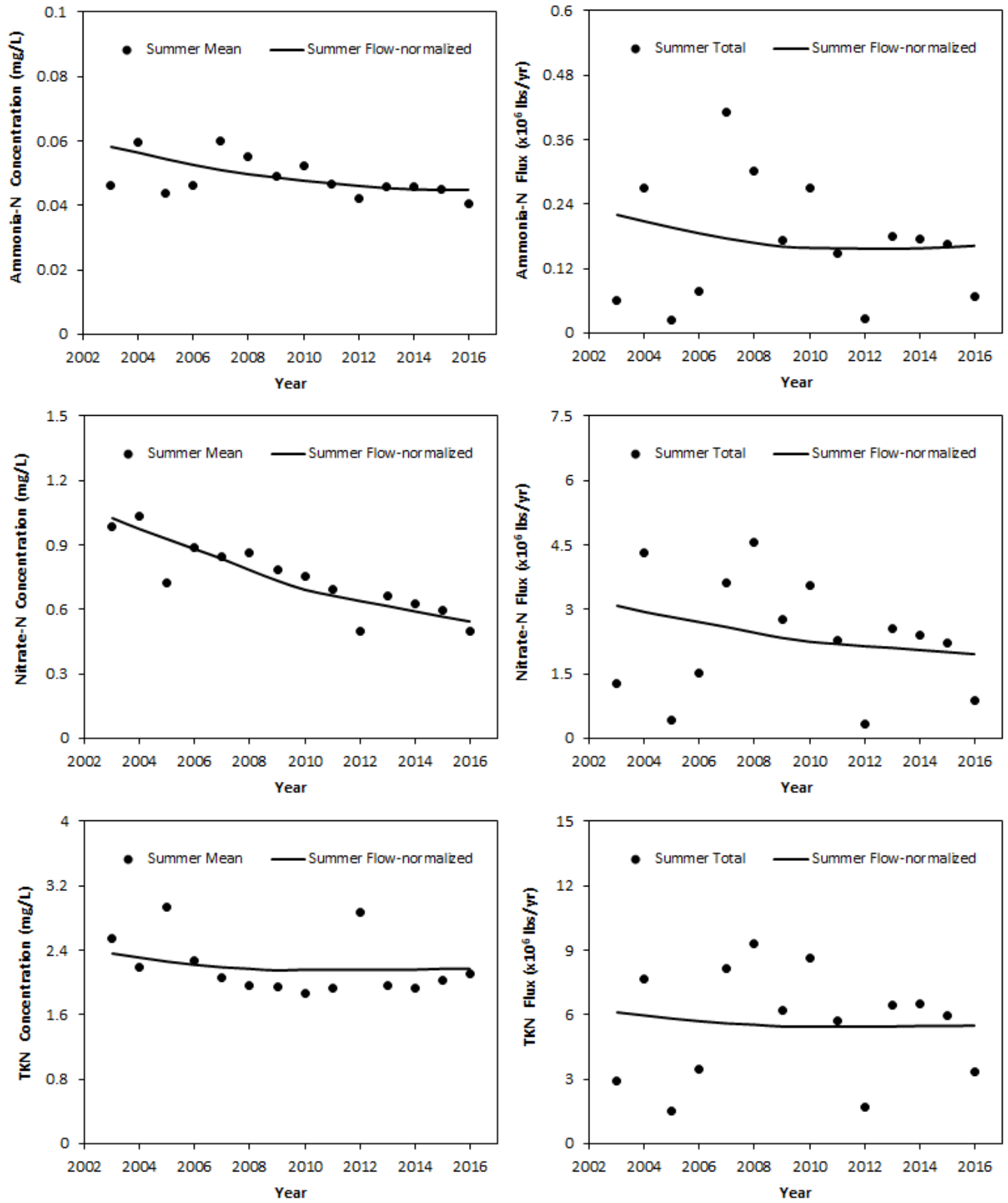


Figure D.25 Summer trends of $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$ and TKN concentrations and fluxes for Fox River at Montgomery

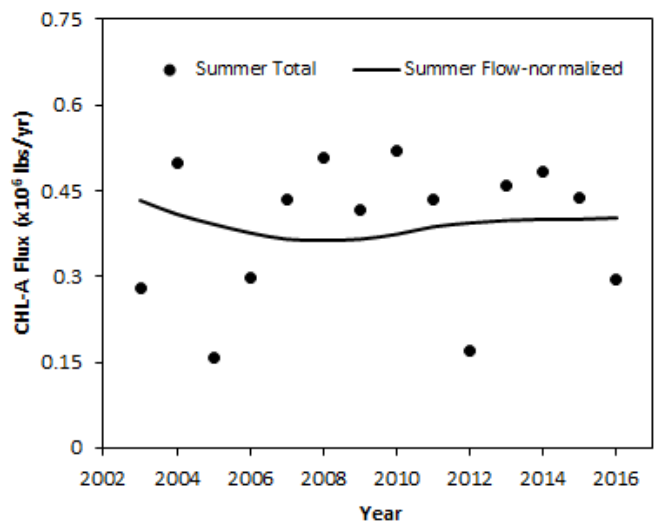
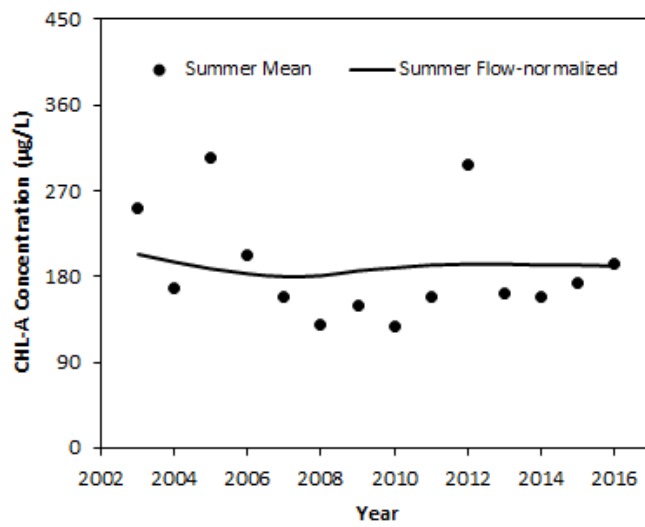
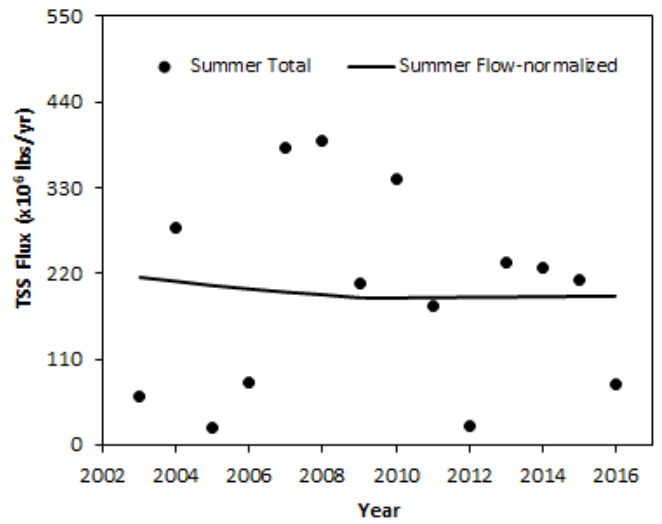
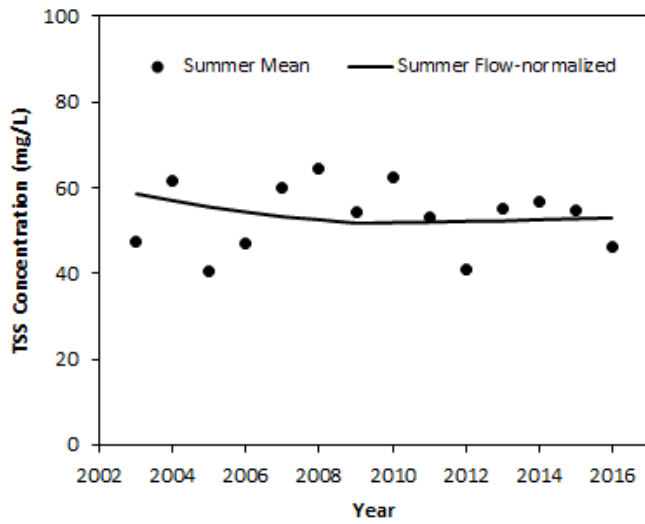
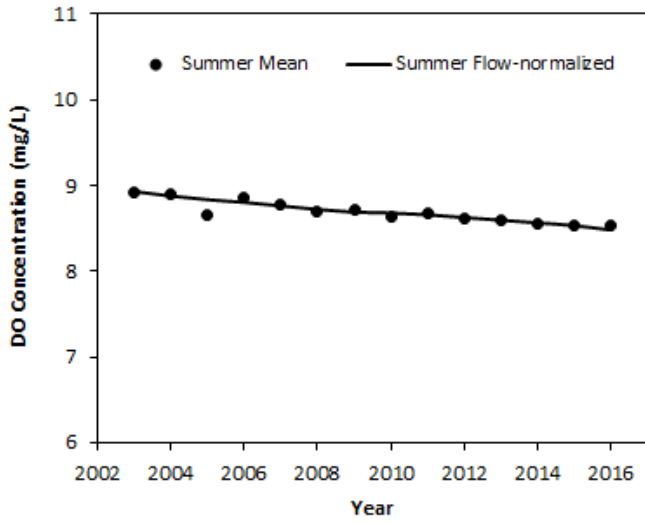


Figure D.26 Summer trends of DO, TSS and CHL-A concentrations and fluxes for Fox River at Montgomery

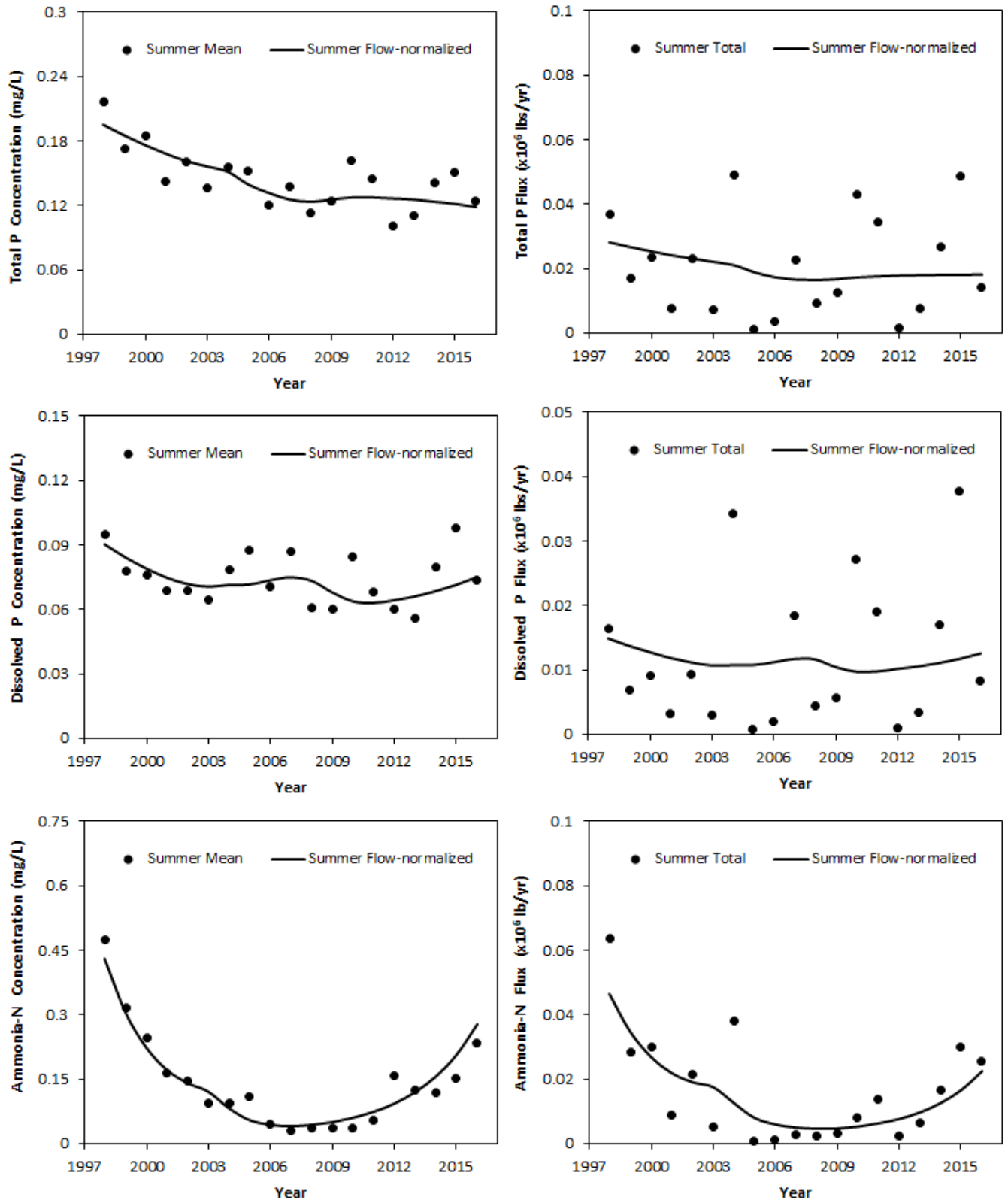


Figure D.27 Summer trends of TP, DP, and NH₃-N concentrations and fluxes for Blackberry Cr at Rt 47

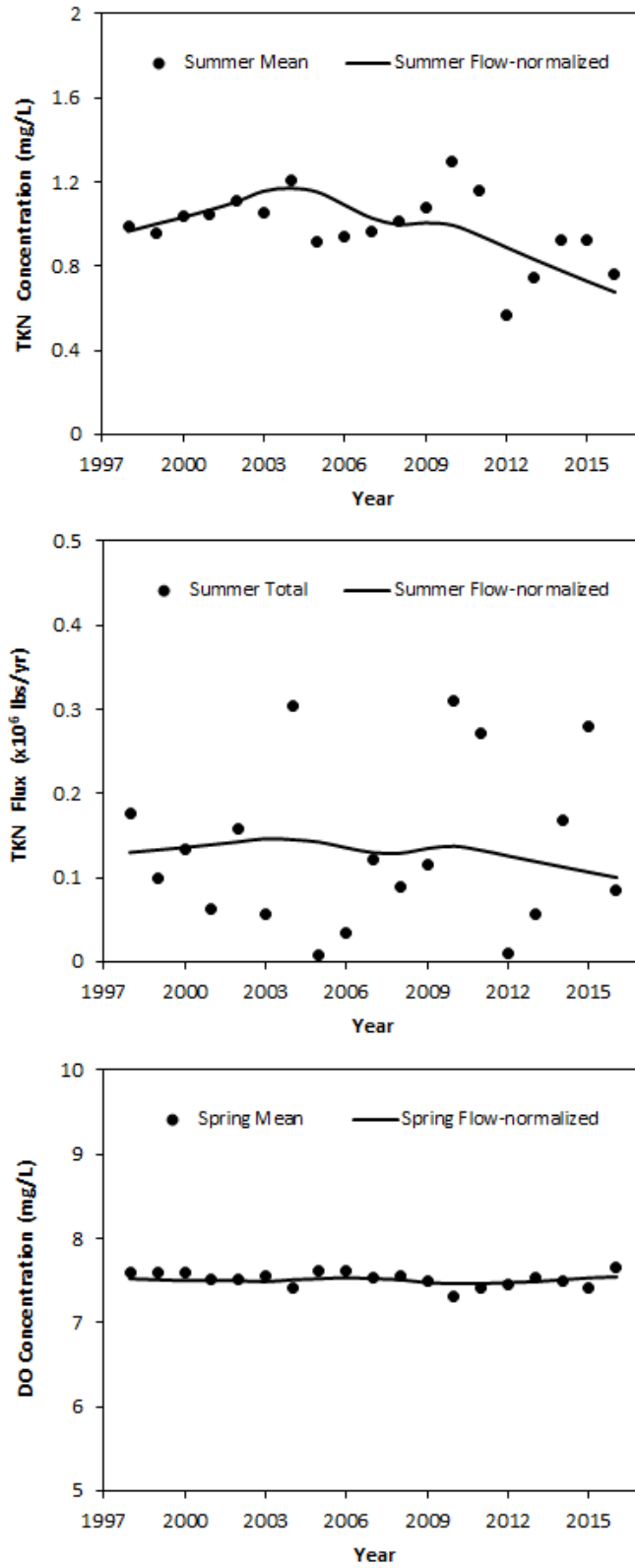


Figure D.28 Summer trends of TKN and DO concentrations and fluxes for Blackberry Cr at Rt 47

Fall Trends

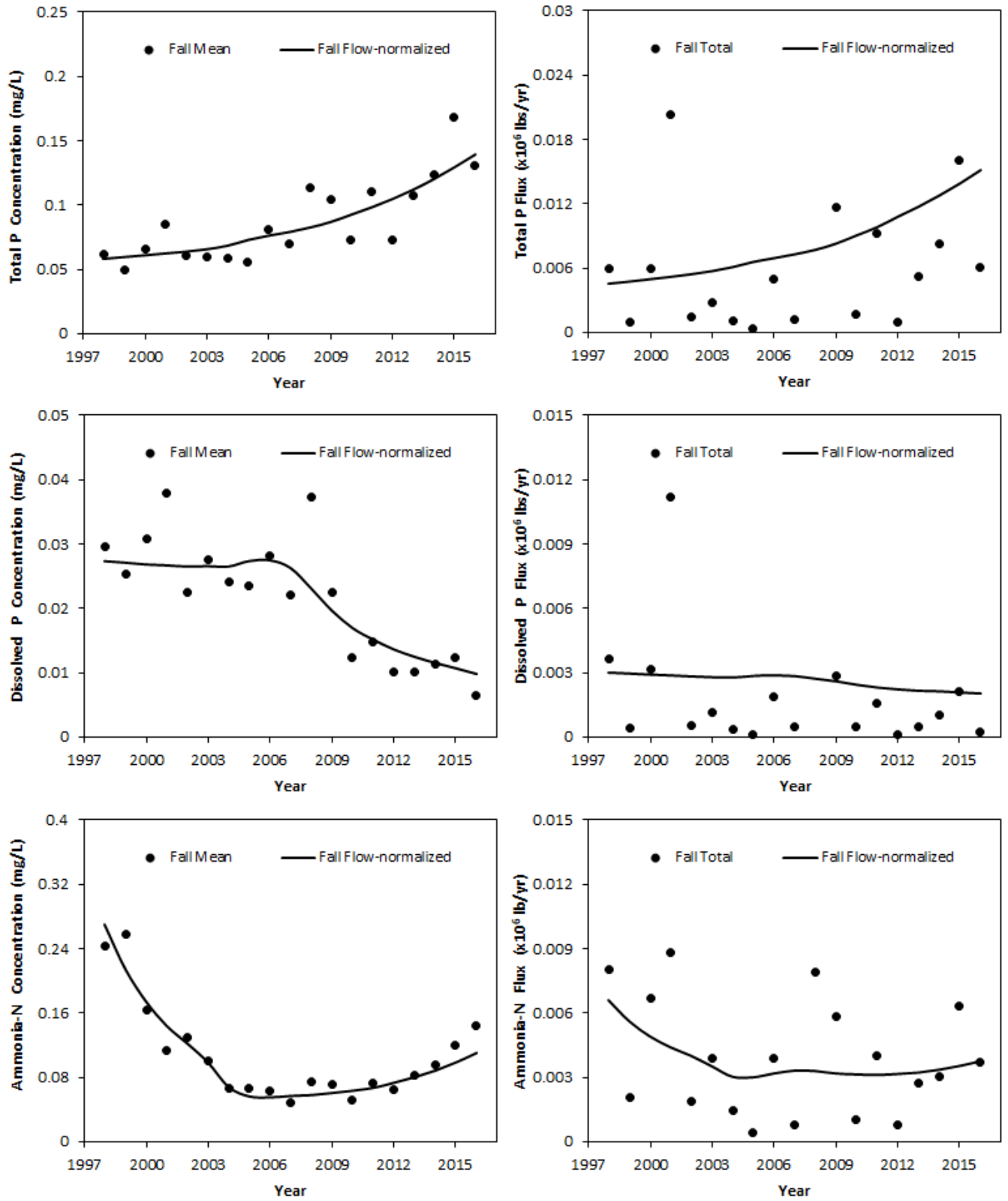


Figure D.29 Fall trends of TP, DP, and NH₃-N concentrations and fluxes for Poplar Cr near Mouth-Elgin

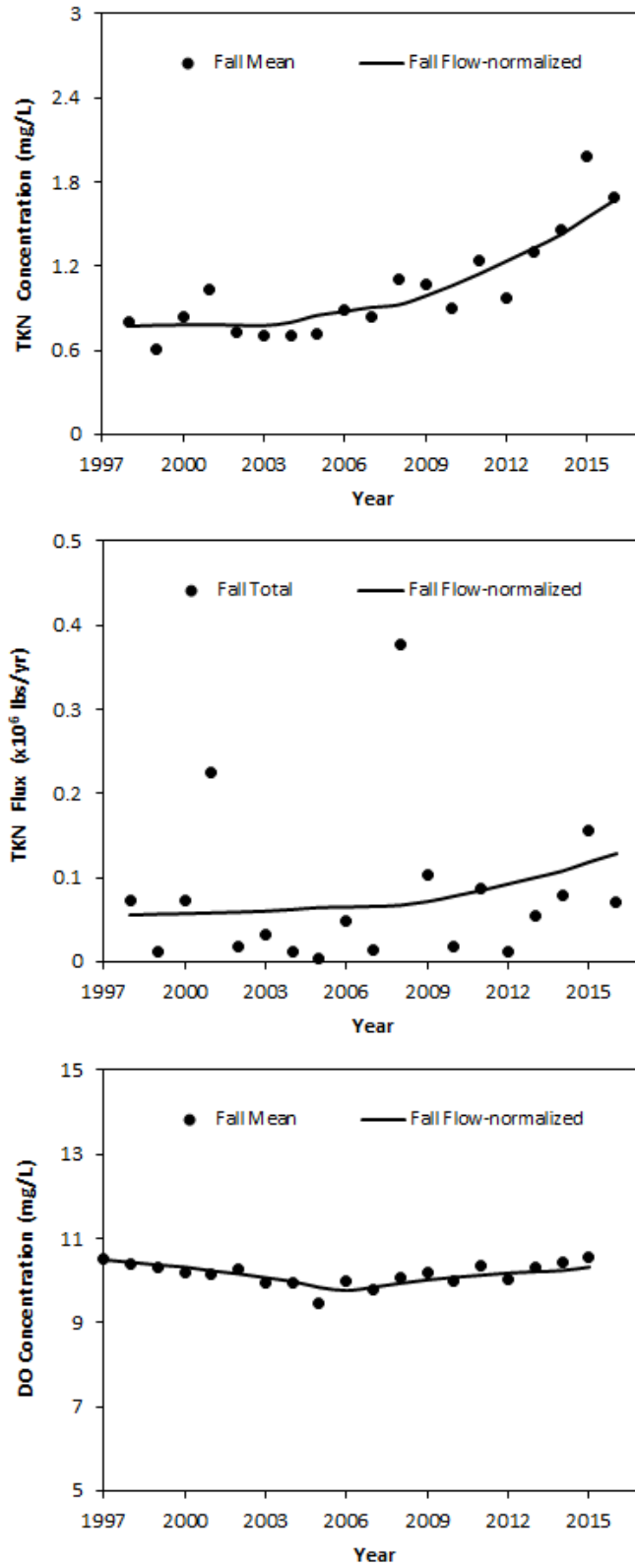


Figure D.30 Fall trends of TKN and DO concentrations and fluxes for Poplar Cr near Mouth-Elgin

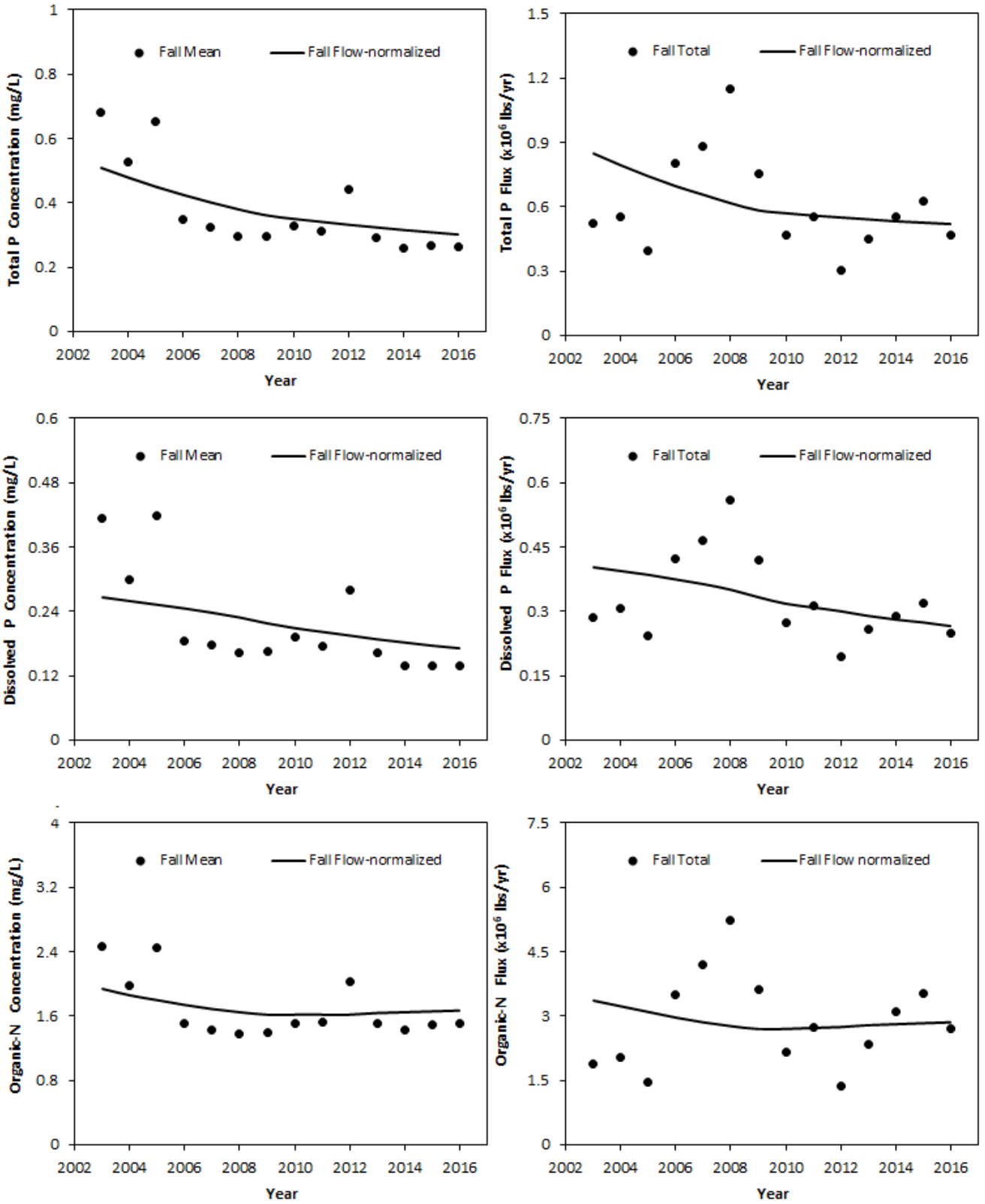


Figure D.31 Fall trends of TP, DP, and Org-N concentrations and fluxes for Fox River at Montgomery

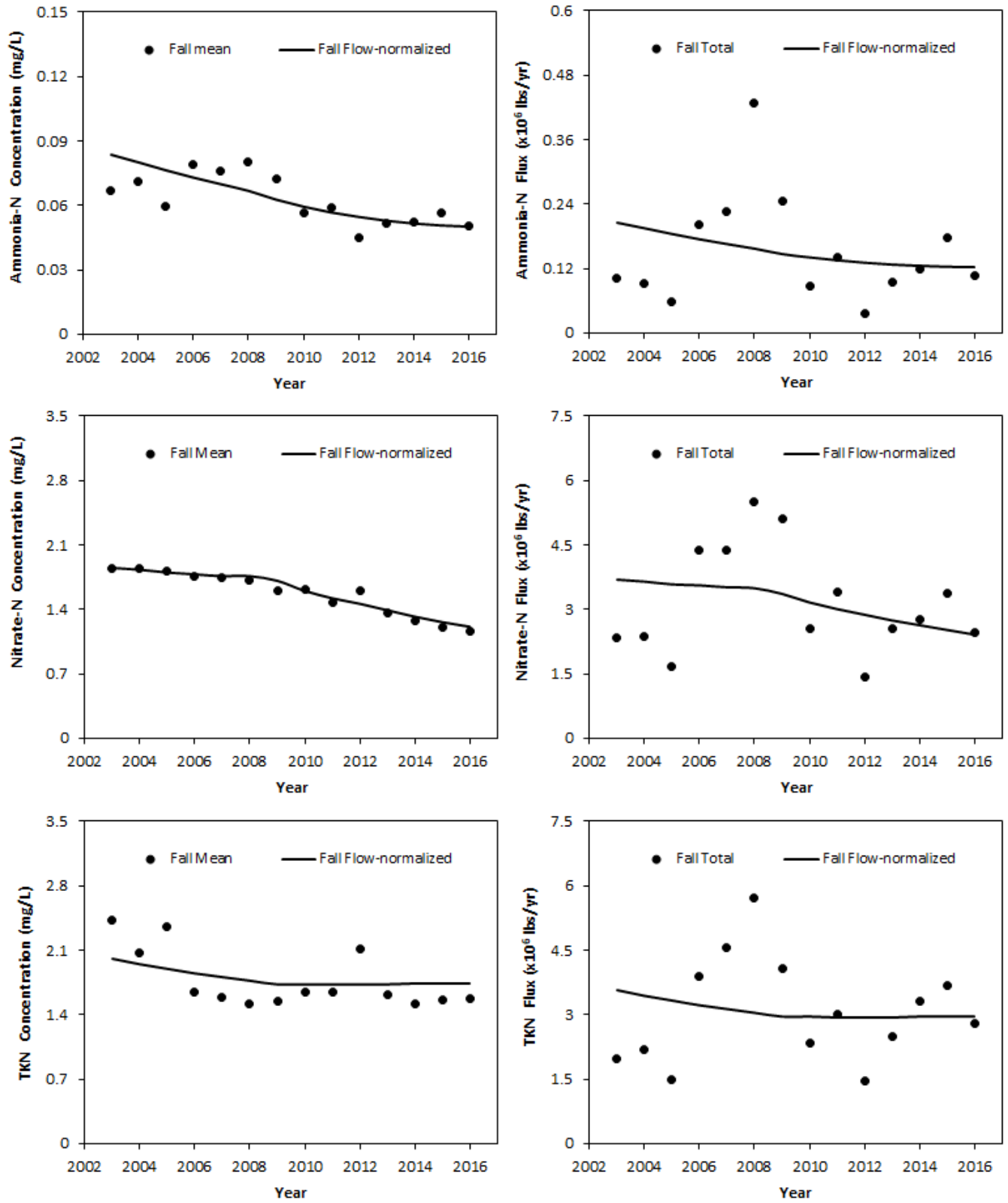


Figure D.32 Fall trends of $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$ and TKN concentrations and fluxes for Fox River at Montgomery

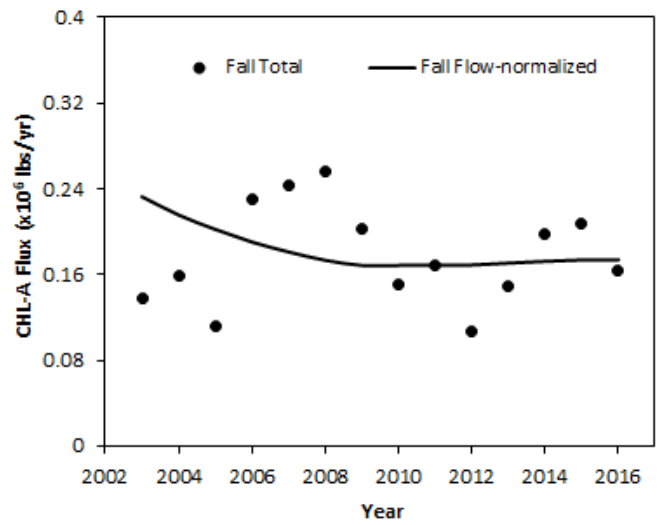
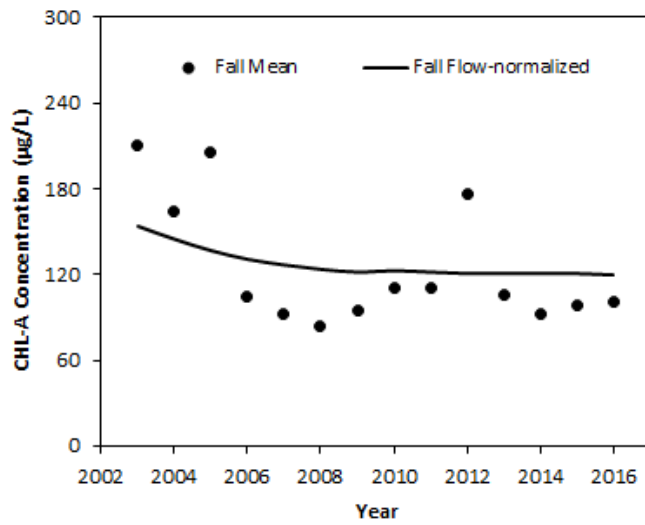
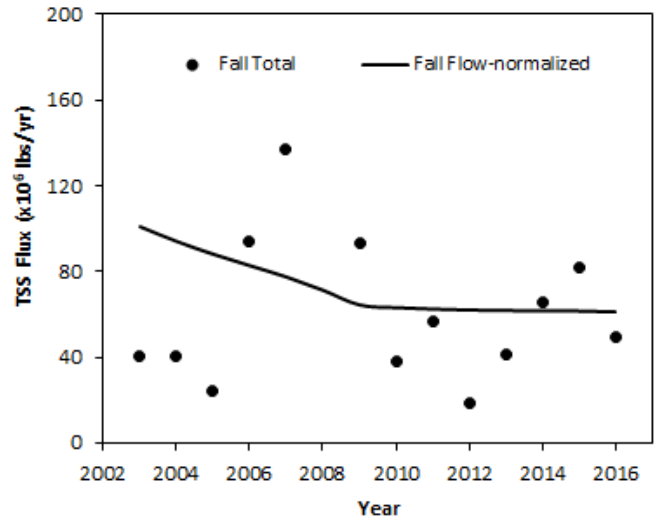
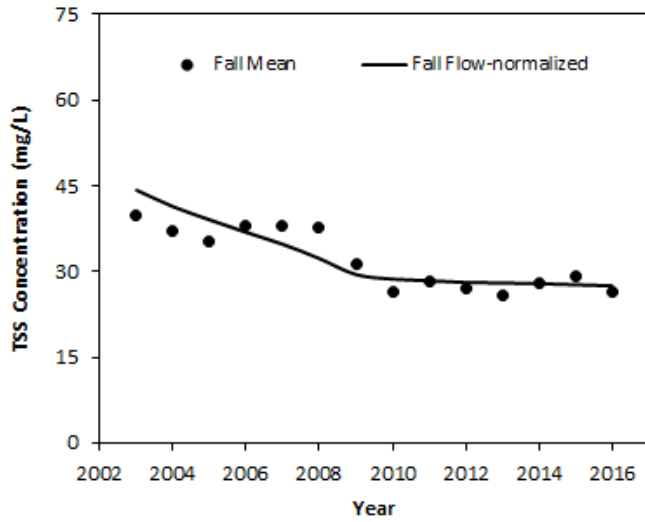
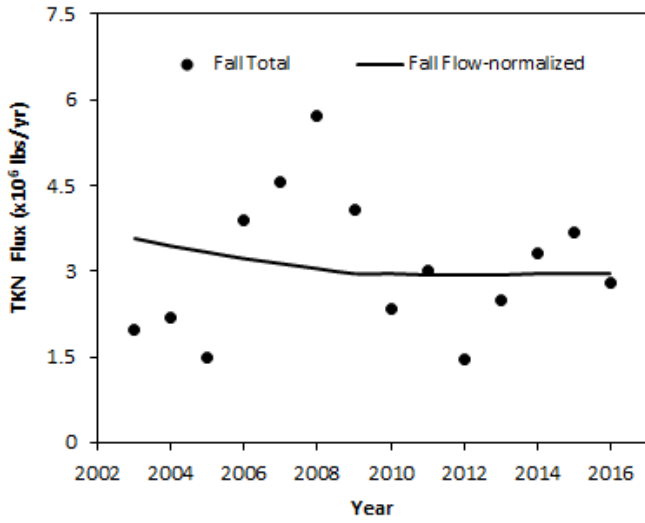


Figure D.33 Fall trends of DO, TSS and CHL-A concentrations and fluxes for Fox River at Montgomery

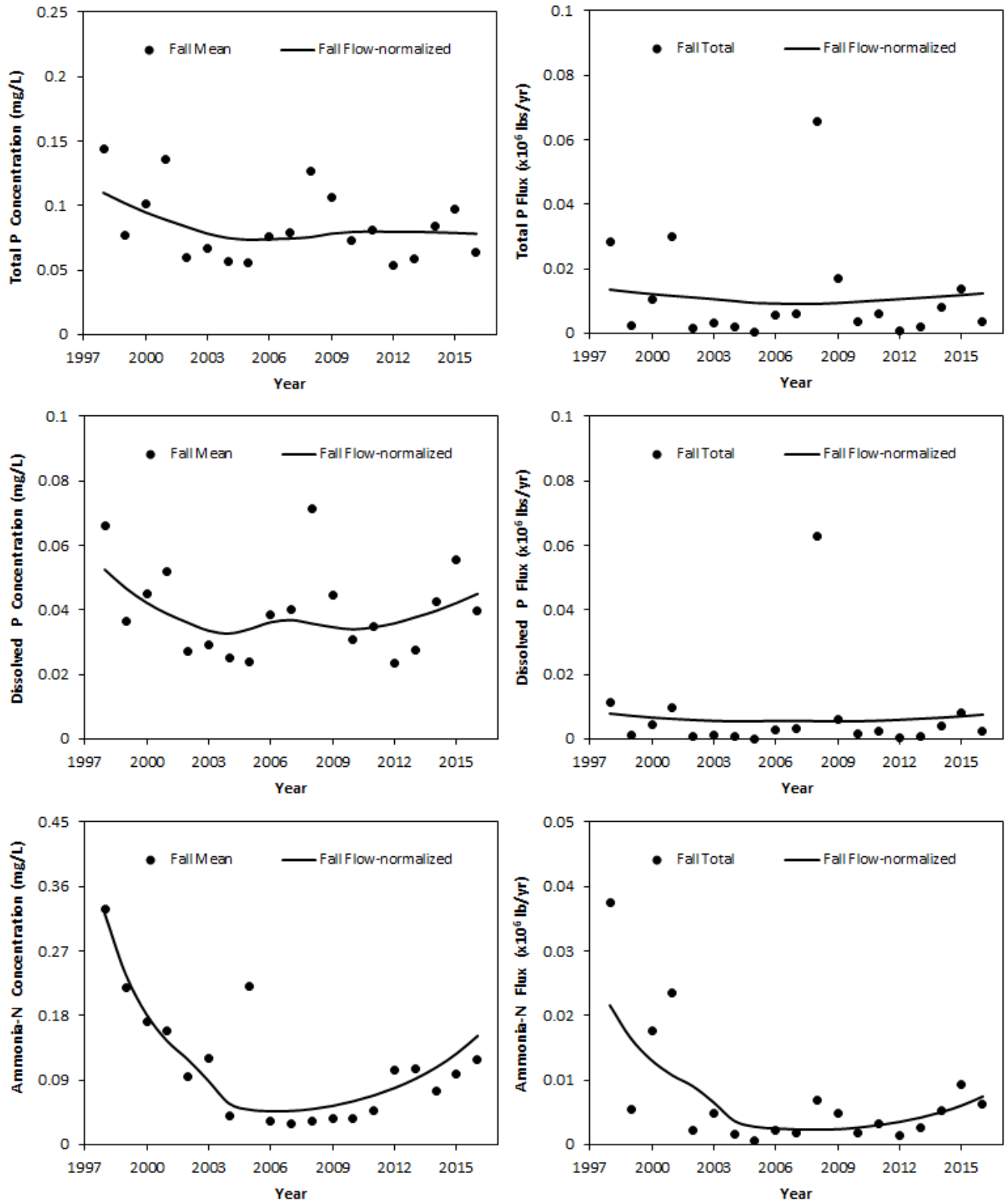


Figure D.34 Fall trends of TP, DP, and NH₃-N concentrations and fluxes for Blackberry Cr at Rt 47

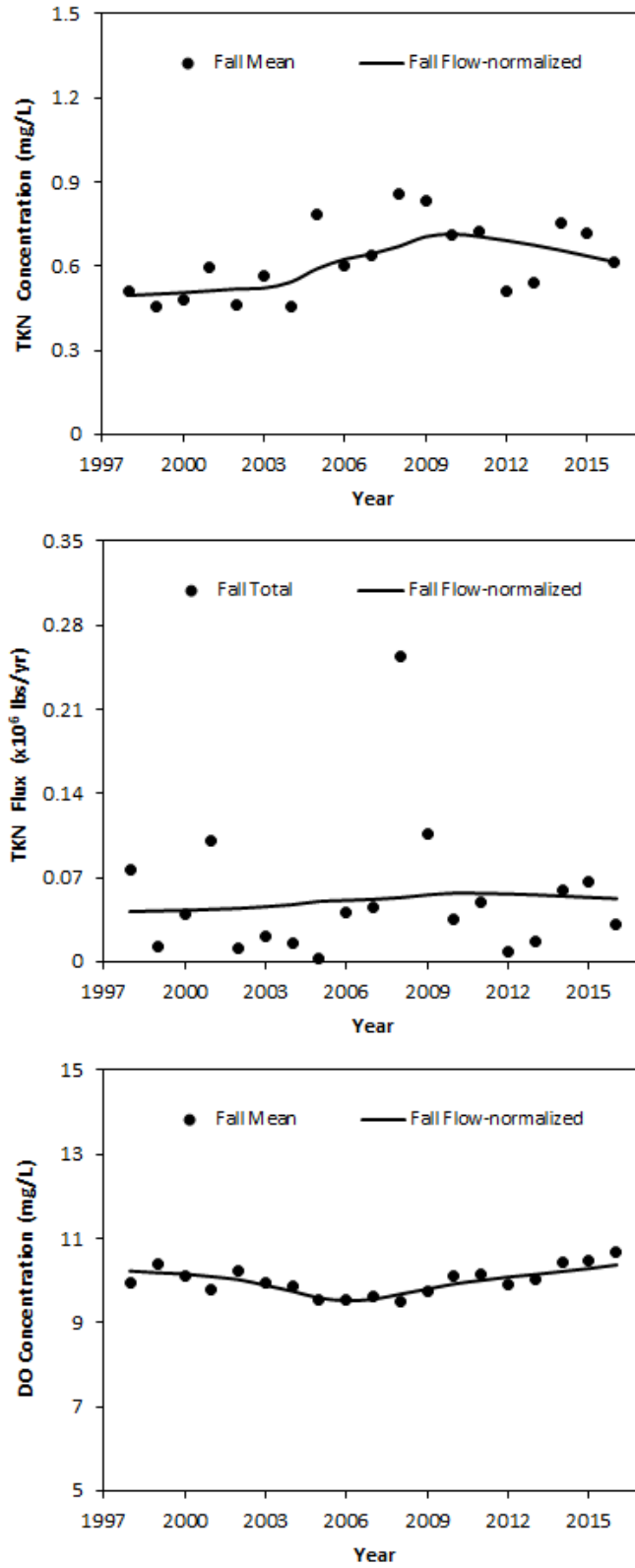


Figure D.35 Fall trends of TKN and DO concentrations and fluxes for Blackberry Cr at Rt 47