# *IIHR 2015 Water Monitoring Report*


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# Executive Summary

Situated on the Iowa River on the University of Iowa campus in Iowa City, Iowa, IIHR Hydroscience and Engineering seeks to be a research leader in hydraulics, hydrology, water quantity and water quality, and to educate students to be future leaders in these areas. The education IIHR provides, combined with hands-on engineering practice, attracts a vibrant international mix of students with a rich variety of interests.

Recent leaders of the institute have encouraged IIHR's further development, incorporating the strengths of the past into an expanding and complex mix of research, education, and public service. Today's blend of applied and theoretical studies, both of which have been enriched by computerized collection and analysis of data and by numerical modeling techniques, has set the stage for a great diversity of projects ranging from model studies of specific hydraulic structures to computational fluid dynamics investigations of complex flow mechanisms.

The floods of 2008, which hit the University of Iowa campus hard, brought about the creation of IIHR's Iowa Flood Center, the nation's first academic center devoted to the study and research of floods. State appropriations, in combination with various grants and contracts, support IFC's efforts to improve flood monitoring and prediction capabilities in Iowa.

In 2012 the Flood Center extended efforts beyond water quantity issues into the pressing issue of Iowa water quality. A modest equipment purchase began the creation of what may be the largest real-time, continuous water quality monitoring network in the U.S. The timing was fortuitous, because around this time a coalition of Iowa stakeholders developed the Iowa Nutrient Reduction Strategy (INRS), a science and technology-based approach to assess and reduce nutrients delivered to Iowa waterways. The Iowa Nutrient Research Center (INRC) supports this effort with research and science-based information. Iowa's strategy was one of the first, and other states have looked to it as a guide for their own efforts.

The INRC has created a very productive collaborative team, with overlapping and complementary sets of knowledge. The IIHR continuous monitoring network, quadrupling in size since 2012, is the backbone of the University's effort to support INRS. The state-of-the-art remote sensors provide near real-time data, which are relayed back to the center every 15 minutes. The sensors measure nitrate, dissolved oxygen, temperature, specific conductance, turbidity and pH.

Researchers at IIHR have also developed an easy-to-use web platform, the Iowa Water-Quality Information System (IWQIS), to disseminate the sensor data, similar to the Iowa Flood Center's Iowa Flood Information System. IWQIS displays near real-time data on nitrate and other water quality variables from in-stream sensors across Iowa in a user-friendly, Google Maps interface. This new information makes it possible for all interested Iowans to use a science-based approach when making decisions that affect water quality. Water quality data from several USGS monitoring sites is collected by IIHR and also displayed in IWQIS. All archived IIHR water quality is made available to interested persons upon request.

This report is a summary of data collected from 2012 to 2015, with a special focus on 2015 nitrate data. The report is the first in what is intended to be recurring annual reports, issued for public consumption in the first quarter of each year.

Larry Weber, Ph.D.
Director
March 1, 2016

# Part One:

## The IIHR Water Monitoring Network

# I. Overview

## A. Iowa Water Quality History

Prior to European settlement in the 19th century, Iowa was covered with prairies, oak savannahs, wetlands and forests. Much of the landscape was internally drained, meaning that rainfall and snowmelt drained to small depressional areas, rather than streams. Groundwater-fed streams meandered across the landscape and likely ran shallow and clear, carrying low levels of sediment and nutrients. Rivers easily spilled out into the flood plain after heavy rains, and river banks re-vegetated during drought, reducing streambank erosion.

Over several decades, the native prairie was broken and cultivated for corn, oats and alfalfa, and a few other minor crops. Soil erosion was intense in the first years following a field's cultivation.

From the period of 1880 to 1920, many of Iowa's wettest areas were drained using pervious clay pipes. This was most common in the recently-glaciated area of north-central Iowa known as the Des Moines Lobe. Many new streams were constructed in ditches to drain water externally to the river network. Many existing streams were straightened to facilitate crop production.

The post-World War II era brought new developments to agriculture. The emergence of chemical fertilizers, soybeans, and continued drainage of the landscape with plastic drainage tiles helped Iowa become a world leader in crop and livestock production.

The loss of the native ecosystems, stream straightening and incision, artificial drainage, and discharges from industries and municipalities degraded water quality. Although the decline in water quality probably subsided in the early 1980s, Iowa's streams still carry more nutrients and sediment than most people find acceptable.

## B. Iowa Landforms

To the untrained eye, Iowa's landscape may look uniform. The homogeneity of the corn and soybean landscape masks significant landscape differences that exist across the state. There are seven major landforms in Iowa, all shaped by glacial, wind, river and marine environments of the geologic past.

Stream water quality is greatly affected by the landform. For example, the streams flowing through the shallow limestone rock layers of northeast Iowa can be quite clear and cold. Rivers and streams of the artificially drained area of north central Iowa contain high levels of nutrients. Southern Iowa streams are muddier as the Loess soils of this area are easily eroded. Descriptions of Iowa Landforms follow, along with a map showing their location.

In western Iowa's **Loess Hills**, thick deposits of wind-blown silt (loess) form a unique landscape feature. The Loess was carried around by Missouri River floods and ground down by glaciers, especially from about 28,000 to 12,000 years ago. The formation is only about 15 miles wide, but runs about 200 miles north to south. The soil is fertile but easily erodible.

The **Des Moines Lobe** was formed during a brief period of glaciation in Iowa, from 15,000 to 12,000 years ago. The melted glacier left behind a poorly drained landscape of wetlands and potholes, with abundant clay and peat soils. Curved bands of ridges and knobby hills contribute to a gently rolling landscape. The Des Moines Lobe is part of the Prairie Pothole Region that extends from the city of Des Moines north and west to into Alberta. Most of the potholes have been drained with ditching and underground tile lines to make way for agriculture. Agriculture also created many streams here that did not exist prior to European settlement.

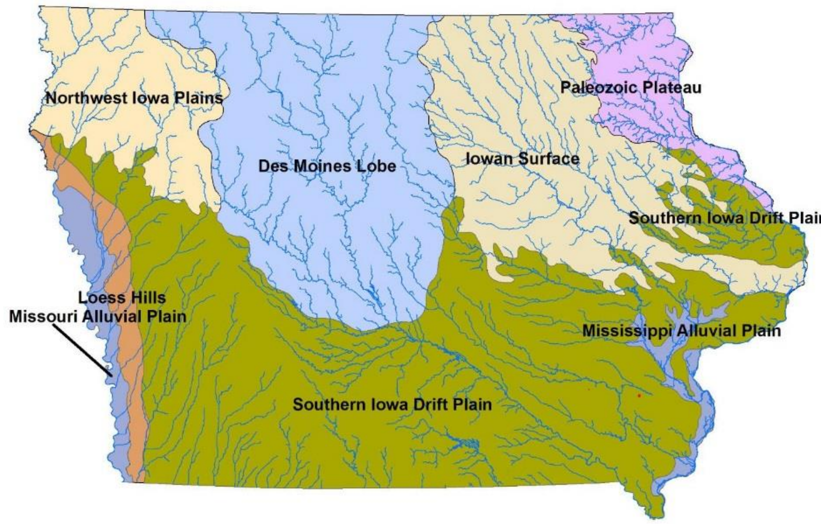


*Figure 1: Iowa Landforms*

The **Southern Iowa Drift Plain** (SIDP) was formed by glaciers that extended south to the Missouri River 500,000 years ago. Nature has had a lot of time to erode and carve away at the Loess soils here, a process that was sped up by early settlers. The hilly landscape is fertile but easily eroded.

Long, gently rolling slopes and low relief characterize the **Iowan Surface** of Northeast Iowa. This area was a prehistoric tundra when the Wisconsin glacier covered the Des Moines Lobe area 15,000 years ago. Drainage is well developed but slow because of the low relief. Thus, many of the farmed fields are artificially drained with tile to enhance crop production. A mantle of silt and sand dominates, likely deposited by persistent northwesterly winds blowing off the Wisconsin glacier. Some soils may have formed under forest, rather than prairie.

The **Northwest Iowa Plains** are similar to the Iowan Surface, but unlike the Iowan Surface, this area probably never had trees. Loess soils dominate because of its proximity to the Missouri and Big Sioux Rivers. This is the highest and driest area of Iowa, but still wet enough to require artificial drainage in many areas to enhance crop production.

The **Paleozoic Plateau** of Northeast Iowa is easily recognizable as “different”, even to the most untrained of eyes. This region is part of the four-state (IA, MN, IL, WI) Driftless Area, where glaciers never tread. Narrow valleys are carved into the sedimentary rock of the Paleozoic Age. Dissolving limestone helped create a landscape of caves, springs, and sinkholes. Groundwater wells in this area are easily contaminated by surface activities.

The Mississippi and Missouri River **Alluvial Plains** seem disproportionately wide relative to the river itself. This is because they were originally formed by the huge floods that resulted from melting glaciers. Sloughs and oxbow lakes mark disconnected sections of the river channel. Levees and artificial drainage enable crop production, although the sandy soils can sometimes require irrigation during drier years. Smaller versions of these alluvial plains can be found along some interior rivers.

### C. Iowa Nutrient Reduction Strategy

In response to the public's desire for improved water quality, a coalition of Iowa stakeholders developed the Iowa Nutrient Reduction Strategy (INRS) in 2011, a science and technology-based approach to assess and reduce nutrients delivered to Iowa waterways. The Iowa Nutrient Research Center (INRC) supports this effort with research and science-based information. Iowa's strategy was one of the first, and other states have looked to it as a guide for their own efforts.

The INRC provides science-based information on water quality for Iowans. INRC research evaluates the performance of current and emerging nutrient management practices, and provides recommendations on how to best implement these practices. This information benefits all Iowans, from farmers to urban dwellers, who depend on water for life and livelihood.

The INRC has created a very productive collaborative team, with overlapping and complementary sets of knowledge. For example, Iowa State University has more than 150 years of experience and credibility in farming practices and agricultural science. IIHR— Hydroscience & Engineering (IIHR) at the University of Iowa has been an acknowledged worldwide leader in hydrology and fluids-related research for nearly a century. The combination sets up a powerful force for progress.

### D. IIHR Water Quality Monitoring

In support of the Iowa Nutrient Reduction Strategy, and the backbone of the water-quality research at IIHR, is a network of 28 water-quality monitoring sites throughout Iowa. The state-of-the-art remote sensors provide near real-time data, which are relayed back to the center every 15 minutes. The sensors measure nitrate, dissolved oxygen, temperature, specific conductance, and pH.

Researchers at IIHR have also developed an easy-to-use web platform, the Iowa Water-Quality Information System (IWQIS), to disseminate the sensor data, similar to the Iowa Flood Center's Iowa Flood Information System. IWQIS displays near real-time data on nitrate and other water quality variables from in-stream sensors across Iowa in a user-friendly, Google Maps interface. This new information makes it possible for all interested Iowans to use a science-based approach when making decisions that affect water quality. Water quality data from several USGS monitoring sites is collected by IIHR and also displayed in IWQIS. All archived IIHR water quality is made available to interested persons upon request.

Real-time monitoring by IIHR predates the INRC. The monitoring program was an off-shoot of the Lucille A. Carver Mississippi River Environmental Research Station (LACMRERS). LACMRERS was a dream of its founding director, Tatsuaki Nakato, and IIHR's former director, V.C. Patel. They obtained a generous grant of $1.2 million from the Roy J. Carver Charitable Trust, which represented the bulk of the building costs. LACMRERS opened in 2002.

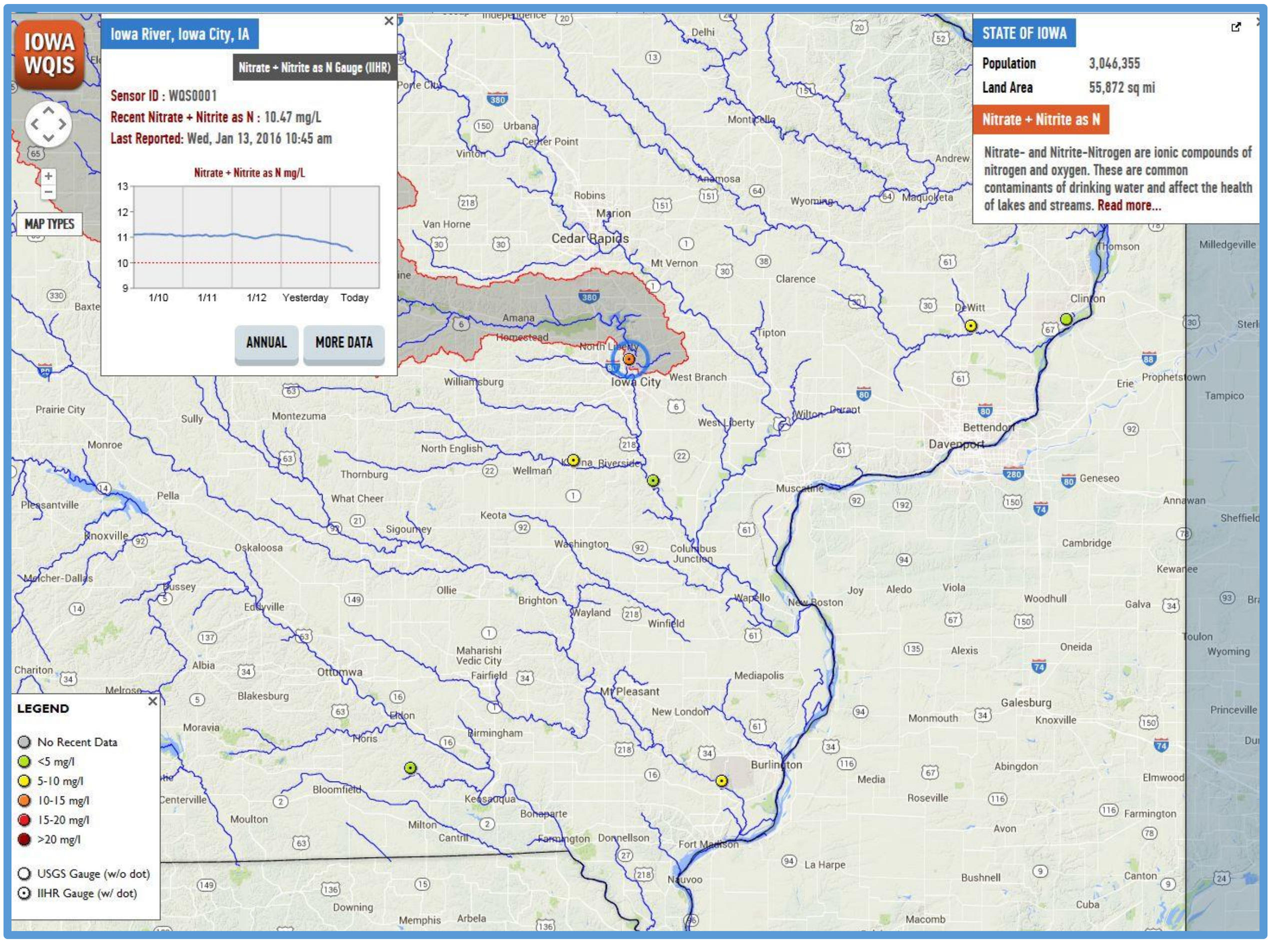


*Figure 2: Screenshot from the IWQIS website illustrating nitrate concentration in the Iowa River at Iowa City*

In 2008, a second major contribution from the Carver Trust brought its support of LACMRERS to a total of more than $2 million, allowing IIHR to equip the laboratory with a multi-beam echo sounder, state-of-the art water quality sensors and data loggers, sediment laboratory equipment, and other equipment for large-river research. From this second contribution, a few nitrate sensors were deployed along and in the Mississippi River, in Clear Creek in Johnson County, and for short-term research projects. Four sites were monitored in Lake Odessa (SE Iowa) in 2011-2012 to assess nitrogen processing.

The current program of real-time stream monitoring of interior streams began in 2012. That year seven nitrate sensors were deployed at sites in the Lower Iowa River Watershed. In 2013, three additional stream sites were added. Also in 2013, equipment was purchased with funding from the Housing and Urban Development (HUD) (one sensor deployed on Otter Creek in NE Iowa) and additional devices were funded by IIHR to monitor a constructed wetland in NE Iowa and the Skunk River at Augusta.

Twelve stream sites were added in 2014 with funding from HUD and INRC. This enlarged the network to 22. This expanded to 28 sites in 2015 with funding from HUD, INRC, the City of Dubuque, and Iowa Department of Natural Resources (IDNR).

The objectives of IIHR water quality monitoring are three-fold:

- Inform the water quality discussion in Iowa with credible data.
- Quantify nitrogen loads transported from Iowa watersheds. This will help track progress toward water quality objectives outlined in the INRS.
- Use accumulated data to conduct original research on water quality, hydrology, and land use effects on Iowa streams.

### E. Staff

The monitoring network and IWQIS are operated and maintained by several IIHR scientific staff members. These include:

- Thomas Stouffler, Research Assistant: thomas-stoeffler@uiowa.edu
- Brandon Barquist, Shop Manager: brandon-barquist@uiowa.edu
- Samuel Debionne, Engineer: samuel-debionne@uiowa.edu
- Ibrahim Demir, Ph.D. Assistant Research Engineer: ibrahim-demir@uiowa.edu
- Caroline Davis, Ph.D., Assistant Research Scientist: caroline-davis@uiowa.edu
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- Larry Weber, Ph.D., Professor and IIHR Director: larry-weber@uiowa.edu

## II. Monitored Parameters

A. **Nitrate- and Nitrite-Nitrogen ($NO_x$)** are ionic compounds of nitrogen and oxygen. These are common contaminants of drinking water and affect the health of lakes and streams. Many nitrogen compounds naturally exist in lakes, streams and groundwater, including nitrate and nitrite. Nitrate is a negative ion consisting of one nitrogen atom and three oxygen atoms. It is an essential plant nutrient. Because it is a relatively stable form of nitrogen, and because it is very water soluble, it is the most common form of nitrogen entering the stream network from farmed fields. It is also present in municipal wastewater discharge, leakage from septic tanks, and runoff from manure. Nitrate and nitrite (one nitrogen with two oxygen atoms) in drinking water pose an acute health risk for infants less than 6 months of age. The infant's digestive system has not developed a mature assemblage of microorganisms, and as a result, nitrate and nitrite compete with hemoglobin for oxygen in the bloodstream. This condition is known as methemoglobinemia (blue baby syndrome). Very few methemoglobinemia cases caused by contaminated drinking water have been reported in the United States since 1960. Incidence was higher prior then. Drinking water nitrate and nitrite are measured "as nitrogen" in the U.S., with a limit set at 10 parts per million (mg/L) for nitrate-nitrogen and 1 mg/L for nitrite-nitrogen.

Elevated $NO_x$ in streams and lakes can upset the natural balance, leading to harmful algae blooms and poor diversity of organisms. Prior to European settlement, $NO_x$ levels in Iowa streams were likely less than 2 mg/L. Nitrite usually is not stable in the environment, especially in streams, where it is quickly converted to nitrate. In Iowa, about 80-90% of $NO_x$ originates from non-point sources (mostly row crop and animal agriculture) with the balance coming from wastewater treatment discharges, septic tanks, and natural sources.

Nitrate-nitrite nitrogen ($NO_x$-N) is measured using the Nitratax Plus SC Sensor (Hach Co.) with a 2 mm path length. The device works on the principle of ultraviolet (UV) light absorption. Both forms of $NO_x$-N absorb UV. As the concentration increases, absorption of UV also increases. A built-in photometer measures the primary beam, while a second beam of UV light provides a reference standard and corrects for interference caused by turbidity (cloudiness) and dissolved organic material. The optic windows of the device are automatically cleaned at a defined interval using a wiper, operating much like the windshield wiper of automobile. $NO_x$-N is quantified in the range of 0.1-26 mg/L in 0.1 mg/L increments. Figure 3 illustrates the Nitratax sensor.

*Figure 3: Nitratax Plus SC*

**B. Turbidity**. Soil particles obstruct the transmittance of light through water and impart a property known as turbidity. Turbid water is cloudy water. Turbidity is measured in Nephelometric Turbidity Units (NTUs). Clear water like drinking water has a turbidity less than 1 NTU. Muddy floodwaters can have turbidity greater than 1000 NTU. A few rivers are naturally muddy. The Missouri River, for example, was very muddy prior to dam construction and channelization, and its aquatic life was adapted to that condition. Most Iowa streams, however, likely ran clear (less than 10 NTU) before the prairie was broken. Excess cloudiness reduces diversity of fish and other organisms in our lakes and streams.

*Figure 4: DTS-12 Turbidimeter*

Turbidity is measured using a DTS-12 Turbidimeter (Figure 4) provided by Stevens Water Monitoring Systems. A continuous beam of light is transmitted through the water being measured. Suspended (not dissolved) solid particles “scatter” the light beam. The scattered light is measured at a 90 degree angle to the transmitted beam. The scattered light is then converted to standardized NTU. The DTS-12 also measures temperature. It can measure turbidity in the range of 0-1600 nephelometric turbidity units (NTUs) at an accuracy of +2% + 0.2 NTU at <400 NTU and +4% at >400 NTU. Precision is 0.01 NTU.

**C. Temperature.** Extremes of temperature, especially excess heat, are harmful to aquatic life and can lead to fish kills and other negative consequences. Because natural vegetation along the stream bank (riparian area) has been altered, many Iowa streams do not have shady areas and suffer from heat stress.

Temperature is measured using an electronic thermometer contained within the Hydrolab HL4 multiparameter water quality sensor (OTT Hydromet). Multiple measurement probes are contained with the sonde (Figure 5). Temperature is measured from -5 to 50C at an accuracy of

+ 0.10 and precision of 0.01C with an electronic thermometer. Conversions between Celsius and Fahrenheit scale are shown in Table 1 below.

| Degrees Celsius | Degrees Fahrenheit |
|---|---|
| 0 | 32 |
| 10 | 50 |
| 20 | 68 |
| 30 | 86 |

***Table 1: Celsius-Fahrenheit conversions***

**D. Specific Conductance (SC)** is created by the positive and negative ions of dissolved salts. Ions enable water to conduct electricity. Water with high SC is salty and harmful to freshwater organisms. SC greater than about 1000 microsiemens (µS) would likely be stressful to aquatic life. Excess SC can be caused by stormwater runoff (road salts), wastewater discharges, and manure runoff.

High-conductivity (high levels of salts or ions) water transmits electricity much better than water without ions. To measure conductivity, a current is induced across two electrodes. The amount of electricity that is conducted from one electrode to the other is converted to conductivity. An SC probe is contained within the Hydrolab HL4 and is measured inside a temperature range of -5 to 50C with temperature compensation. Range of SC measurement is 0-100 milliSiemens per centimeter (mS/cm) with an accuracy of ±0.5% of reading + 0.001 mS/cm and a precision of 0.001 mS/cm.

**E. pH** is the measure of acidity or alkalinity in the water. A pH of 7 is exactly neutral; lower than 7 is acid, higher than 7 is basic (alkaline). Most Iowa waters are slightly to moderately alkaline (7.5-8.5) in their natural condition. pH tends to be slightly higher in the summer. In a lake or stream plagued by algae, pH levels can vary greatly between daytime and nighttime. This stresses the other organisms.

pH is measured using an ion-selective electrode contained within the Hydrolab HL4 at an accuracy of ±0.2 and precision of 0.01 unit. pH is a logarithmic conversion of hydrogen ion concentration. The electrode allows passage of hydrogen ions, and only hydrogen ions, from the measured water to the electrode itself, where a voltage is measured and converted to the pH scale.

**F. Dissolved oxygen (DO)** is needed by fish and other aquatic life. Decomposition of organic material from wastewater discharges or manure consumes DO. Ammonia and nitrite-nitrogen also consume oxygen. Algae blooms affect DO levels by giving off oxygen in the day but consuming it at night. When DO drops below 4-5 parts per million, fish begin to die. Fish like carp and bullhead can tolerate much lower DO levels than desirable species like smallmouth bass and walleye.

Dissolved oxygen (DO) is measured using the principle of luminescence quenching by oxygen in a probe contained within the Hydrolab HL4. Measurement range is 0-60


***Figure 5: Hydrolab HL4***

mg/L, although natural waters rarely exceed 10 mg/L. Accuracy is +0.1 mg/L at DO < 8, +0.2 mg/L at DO > 8. Precision is 0.01 mg/L.

## III. IIHR Water Monitoring Network Sites

### A. Equipment Deployment

Nearly all monitoring sites are interior streams. Equipment is deployed such that sensors are immersed in flowing water. Care is taken to deploy the sensors in spots where the risk of damage due to river debris and vandalism is low. Most sensors are removed in late fall to prevent ice damage. IIHR scientists and technicians have developed an easy-to-install package system for instrument power, control, and data transmission that facilitates simple and rapid deployment of equipment.

The sensors themselves reside within PVC pipe, perforated so that the flowing stream can continuously bathe the sensor with fresh water. Solar panels, deep cycle batteries, and data loggers are situated on the adjacent stream bank. Data is conveyed back to IIHR in Iowa City via cell phone signals. Figure 6 illustrates a typical deployment.

*Figure 6: Typical deployment of sensor equipment at IIHR monitoring site*

### B. Site Selection

Sites are selected based on a number of factors:

- Some sensing equipment is/was funded specifically for a research proposal or project in a selected watershed.
- Major interior river sites are selected based on their strategic importance for nutrient load estimations.

- Significance of the stream for recreation, municipal water supply, or other designated uses.
- Suitability of the site for sensor equipment, i.e. security, water depth, etc.
- Requests from outside stakeholders.

The number and location of IIHR monitoring sites can vary from week to week depending upon research needs, equipment maintenance, and other factors. Table 2 below and the map shown in Figure 7 illustrate sites monitored in 2015. Water quality data along with additional information about each site can be found later in this report.

| Code | Name | Years Monitored |
|---|---|---|
| WQS0001 | Iowa River at Iowa City | 2012-2015 |
| WQS0002 | Clear Creek at Coralville | 2012-2015 |
| WQS0003 | Clear Creek near Oxford | 2012-2015 |
| WQS0004 | Unnamed Clear Creek tributary near Homestead | 2012-2014 |
| WQS0005 | English River near Kalona | 2012-2015 |
| WQS0006 | Iowa River near Lone Tree | 2012-2015 |
| WQS0007 | Cedar River near Conesville | 2012-2015 |
| WQS0008 | Slough Creek CREP Wetland outlet near Orchard | 2013-2015 |
| WQS0009 | Otter Creek at Elgin | 2013-2015 |
| WQS0010 | Skunk River at Augusta | 2013-2015 |
| WQS0011 | Clear Creek near Homestead | 2014-2015 |
| WQS0012 | Slough Creek CREP Wetland inlet near Orchard | 2014-2015 |
| WQS0013 | Beaver Creek near Bassett | 2014-2015 |
| WQS0014 | Beaver Creek near Colwell | 2014-2015 |
| WQS0015 | Otter Creek near Elgin | 2014-2015 |
| WQS0016 | Otter Creek near West Union | 2014-2015 |
| WQS0017 | Brockcamp Creek near Ft. Atkinson | 2014-2015 |
| WQS0019 | S. Chequest Creek near Douds | 2014-2015 |
| WQS0020 | Mississippi River near Fairport | 2014-2015 |
| WQS0021 | Rapid Creek near Iowa City | 2014-2015 |
| WQS0022 | Rapid Creek tributary near Iowa City | 2014-2015 |
| WQS0023 | Wapsipinicon River near DeWitt | 2015 |
| WQS0024 | South Fork of the Iowa River near New Providence | 2015 |
| WQS0025 | South Fork of Catfish Creek near Dubuque | 2015 |
| WQS0026 | Middle Fork of Catfish Creek at Dubuque | 2015 |
| WQS0027 | Lime Creek near Brandon | 2015 |
| WQS0028 | Des Moines River near Boone | 2015 |
| WQS0029 | Alluvial Well near WQS00028 | 2015 |
| WQS0030 | Spring at Manchester Fish Hatchery near Manchester | 2015 |
| WQS0031 | Big Spring near Elkader | 2015 |

***Table 2: 2015 monitoring sites.***

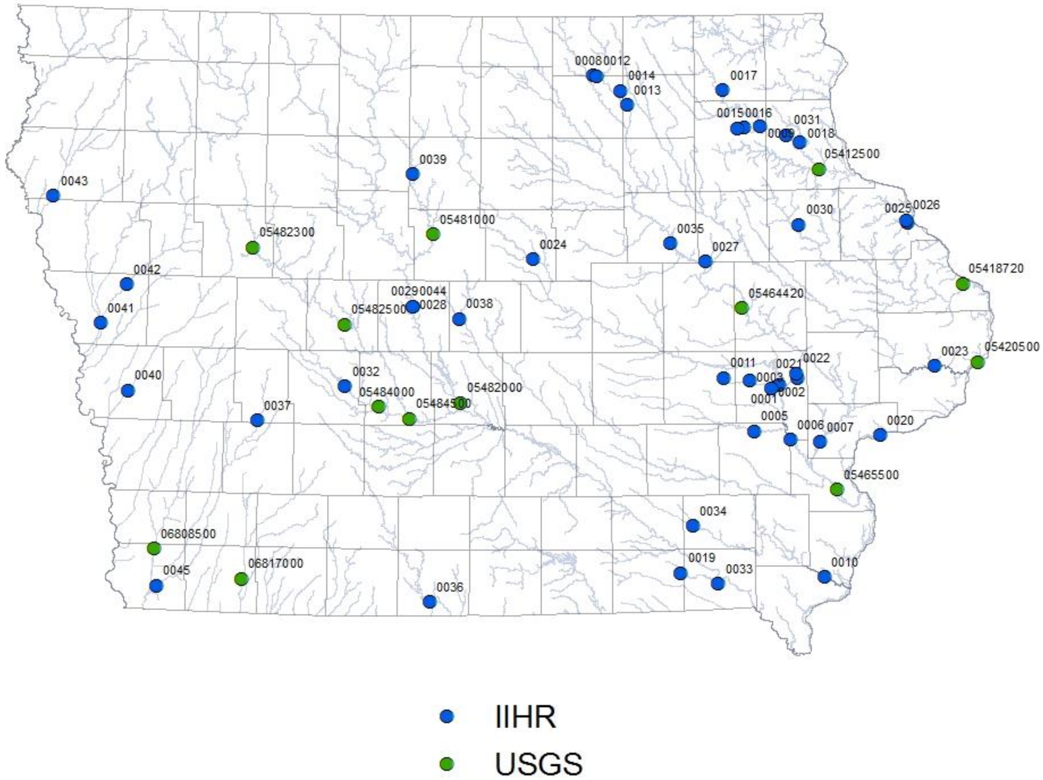



**Figure 7: Iowa Continuous Monitoring Sites. Sites with numbers greater than 0031 are future deployments planned for 2016.**

## IV. Maintenance and Quality Control

Sensor output is monitored daily via IWQIS at the University of Iowa's Oakdale campus. When non-sensical data or obvious malfunction is indicated, staff visit the site. Many times the problem can be resolved on site. If not, the equipment is retrieved and returned to Oakdale, where repairs are made if possible. If IIHR staff are unable to make repairs, the device is sent to the manufacturer for repairs. It is important to recognize that this equipment is exposed to harsh conditions very much unlike traditional measurement conditions found in a laboratory. Thus, equipment does malfunction from time to time, and at a higher frequency than lab measurement equipment. Downtime creates gaps in data during the monitoring season. Service contracts are maintained with the manufacturers for the most critical equipment, so that data gaps are kept to a minimum.

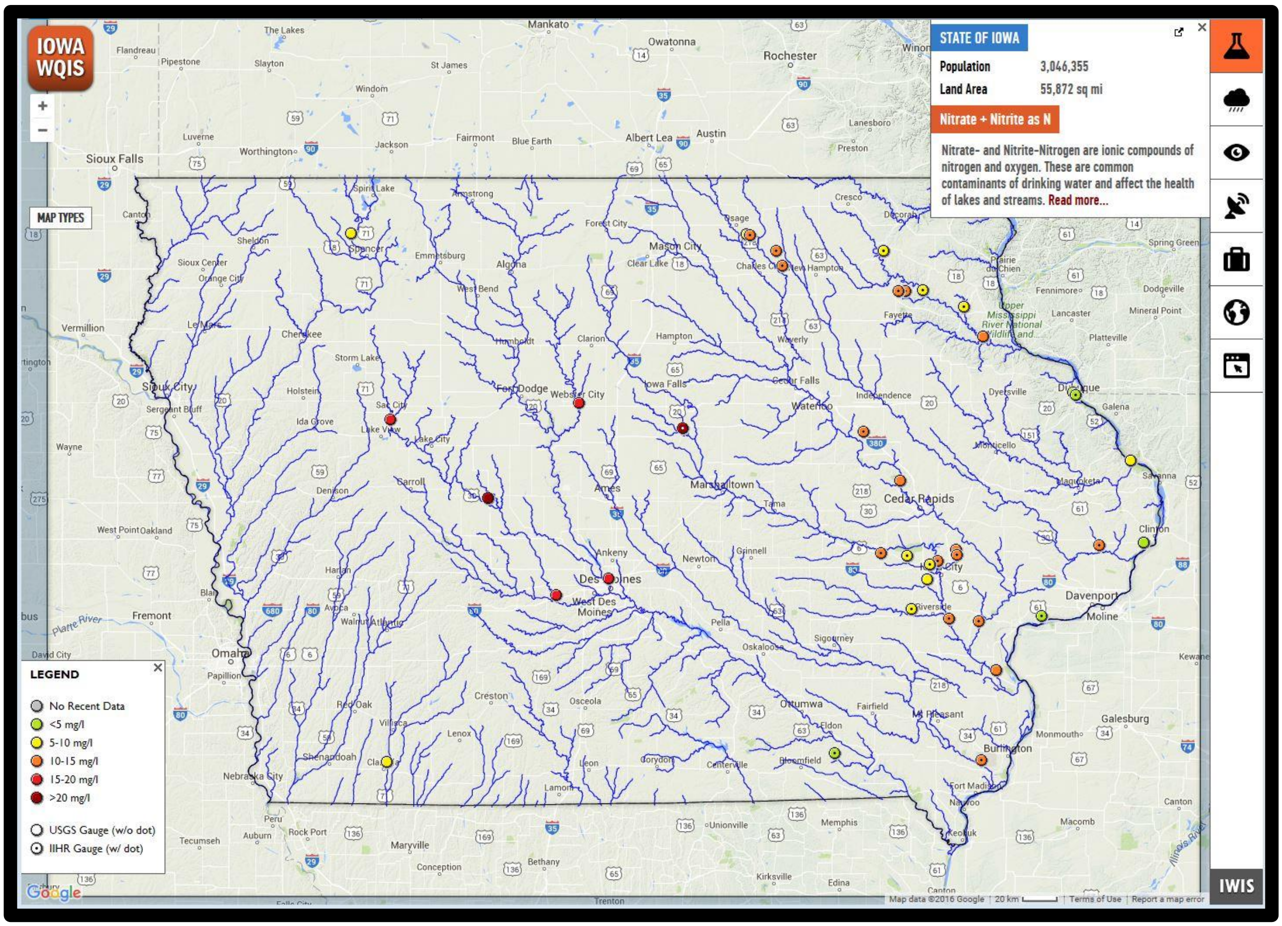
All equipment is checked, calibrated, and maintained according to the manufacturers' recommendations. Equipment is checked with known concentration solutions at the Oakdale facility. Because of keen interest from the public, and because many research projects focus on it, special attention is given to the Nitratax units and $NO_x$ measurements. Each nitratax site is visited at least once every six weeks. Instrument components are checked at each visit, and a grab water sample is collected from the stream, with the date and time noted. This sample is then analyzed by the State Hygienic Laboratory and the result compared to the Nitratax result at the time of sampling. If problems are indicated, the Nitratax unit is calibrated and/or serviced. These comparative results are archived and accessed when necessary.

Other notes on data:

- Although the monitoring season can vary from year to year and site to site based on weather and maintenance considerations, the monitoring “season” is considered to April through October. Some data is reported outside this window. Quality Control examination of all data was conducted from March deployment (variable date from year to year) through October 31 for monitoring years 2012-2015 using all available data/information for each site, including IIHR field site notes, discharge and gage height, weather/precipitation conditions, system health variables (e.g., battery voltage), and acceptable limits/thresholds for each measured parameter.
- Temporal plots in the appendix figures show both approved data (red color) and raw or omitted data (gray color). Omitted data was not otherwise used in this report for calculations or for monthly statistics.
- Data was filtered to a 15 minute data interval, and matched to USGS discharge data where available.
- Missing data or gaps in the record for nitrate concentration and/or discharge were estimated using linear interpolation. A data success or interpolation percentage is available upon request for each month/year combination monitored. For example, for site WQS0002 during September 2012, 6.7% of the N concentration data and 7.5% of the Q data was estimated by linear interpolation.
- The full dataset, consisting of measured and estimated (or interpolated) values, was used to calculate the monthly statistics for each site. This includes site data presented on the individual site pages, the Nitrate summary tables, and the box plots included in the appendix figures.
- N Load and Yield calculations were carried out using an integral of the 15 minute data (N concentration and Q) for each month.

# Part Two:

## Water and Climate Data



## V. Climate

### A. Overview.

Land use has dramatically changed Iowa stream hydrology and water quality over the past 175 years. Urbanization, along with conversion of the native prairies, wetlands and savannahs to agricultural land has increased loads of nutrients, sediment, and synthetic chemicals in Iowa waterways. However, large-scale conversion of uncropped land to cropped land mostly ended in the 1970s. Since that time, land use change in Iowa has been minimal. The exception to this is around urban centers like Des Moines-Ames and Cedar Rapids-Iowa City where agricultural land has been developed for housing and commercial uses.

Thus most of Iowa has seen a relatively stable land use condition over the past 25 years, especially in the most intensely farmed areas like the Des Moines Lobe. The amount of land idled in the USDA's Conservation Reserve Program (CRP) does change from year to year, but these acres have always been a relatively small percentage of the total.

Because the total amount of cropped area has changed relatively little in recent decades, land use effects on water quality have been relatively static. Even so, water quality can change dramatically from year to year, this because of Iowa's dynamic weather. This is not to say weather "causes" water quality to be good or bad, only that year-to-year variations are mostly driven by it in a largely unchanging landscape.

Iowa has an extreme and dynamic climate characteristic of a mid-continental location. In fact, Iowa (especially the northern half) has some of the most extreme climate on earth. Precipitation especially can be highly variable from year to year. Pollutant loadings tend to be higher in wet years, although high river flows can dilute the concentrations of contaminants. Movement of contaminants such as nitrate into the stream network tends to be far lower in dry years. However, the warm, stagnant water resulting from a drought may be favorable for nuisance and harmful algae blooms.

The narrative that follows summarizes Iowa climate from 2012-2015, the period of record here for IIHR monitoring data.

### B. 2012

This year finished as one of the most extreme years in the Iowa climate record. Statewide, it was the second warmest year ever next to 1931, with many locations, including Des Moines, experiencing their hottest year. Warmth in March was especially remarkable, with the statewide average temperature almost 17 degrees (F) above normal. In terms of deviation from average, March 2012 was the second most abnormal month ever in the record (a frigid February 1936 is first). Perhaps even more remarkable, March was warmer than April in some locations.

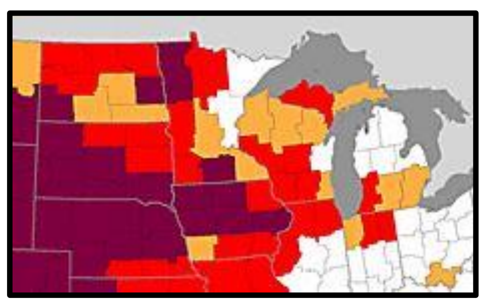


*Figure 8: Map showing extreme drought conditions (darkest red) in September 2012*

The warm spring of 2012 was followed by one of the worst droughts in Iowa history. Statewide annual precipitation was more than 8 inches below normal. This coupled with extreme July heat and low soil moisture conditions carrying over from 2011 to produce severe drought nearly statewide.

**C. 2013**

More extreme weather followed the 2012 drought. A statewide average of 13.6 inches of rain fell during April and May, more than double the average and two inches more than the previous record for the two months combined. Many Iowa farmers were unable to plant crops because of wet fields. Nitrate levels in many Iowa streams were higher than had ever been measured. Following a normal June, the weather turned extreme again. Less rain fell from July to December than fell in April and May. Average temperatures for the year ended up about 2 degrees F below normal, with December being the most abnormal month (six degrees colder than normal).

**D. 2014**

Weather in 2014 was most notable for the severe winter (Dec 2013-Feb 2014). Statewide the winter was the 4th-coldest after 1936, 1979, and 1978. The eastern 1/3 of Iowa was especially cold, reflecting the persistent "polar vortex" that affected the entire eastern U.S.

The year was wet, nearly eight inches above normal for precipitation. June was especially wet with a statewide average rainfall exceeding 10 inches. Historic floods hit Northwest Iowa during this time.

**E. 2015**

The big weather story in 2015 was precipitation. The first three months were extremely dry, especially March. After a normal April, the skies opened and rainfall from May through September was far above average. A few stations, especially in the west and south, experienced their wettest year ever. Bedford, IA near the Missouri border received an amazing 63 inches of rain in 2015. Many cities near the Missouri-Mississippi divide saw rainfall exceeding 50 inches.

Statewide annual temperatures were 1.1 degrees above normal, but extreme heat was rare. The year was the second consecutive without a 100 degree day anywhere in the state.

The graphs that follow illustrate temperature and precipitation in each of Iowa's nine climate zones. The water quality narrative that follows will refer to these zones when discussing weather effects on water quality data.


***Figure 9: Iowa's climate zones correspond to crop district designations.***

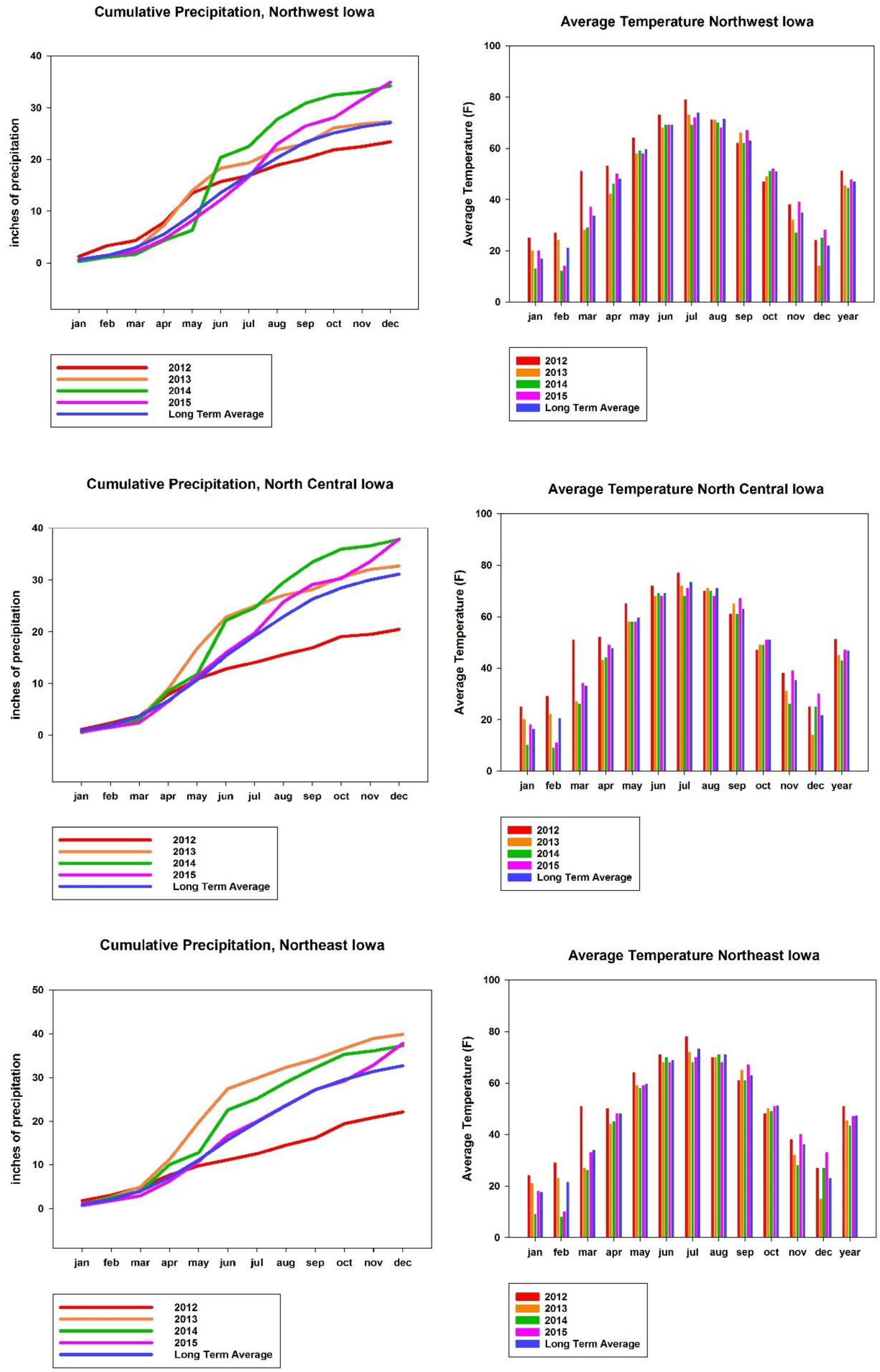



*Figure 10: Precipitation and Temperature for Northern Iowa Regions, 2012-2015*

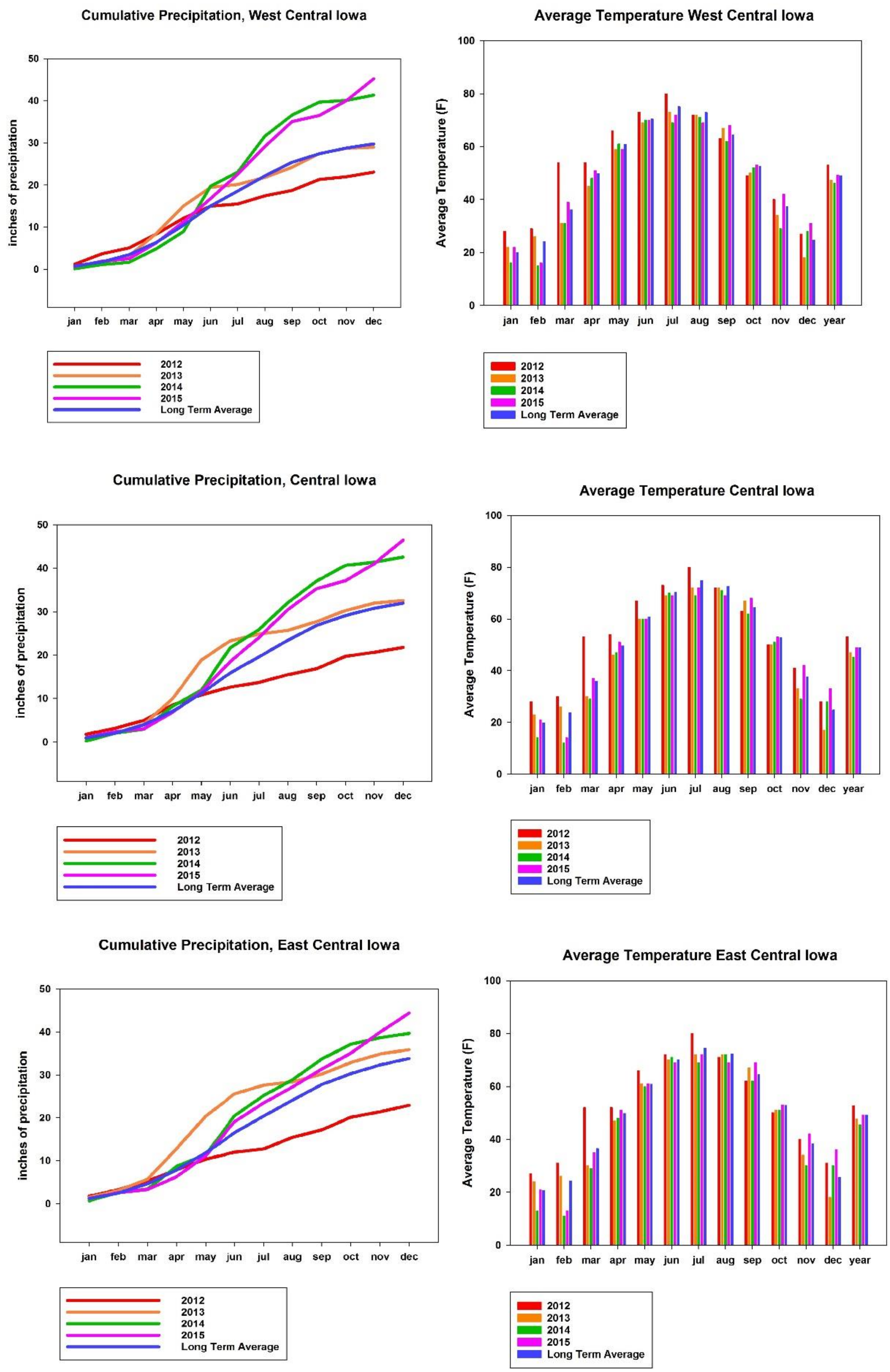
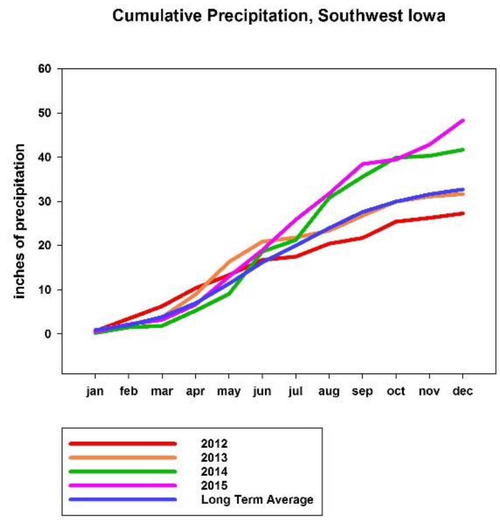
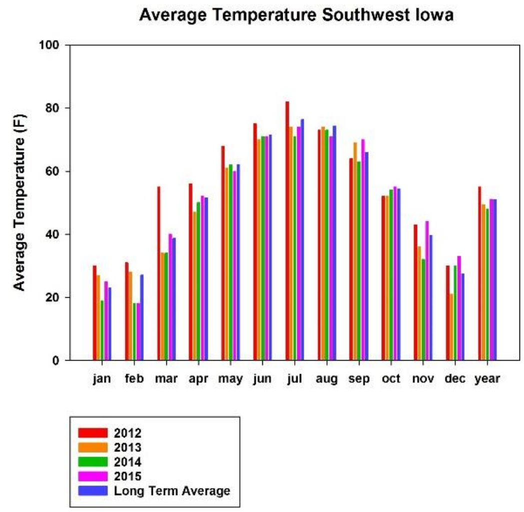
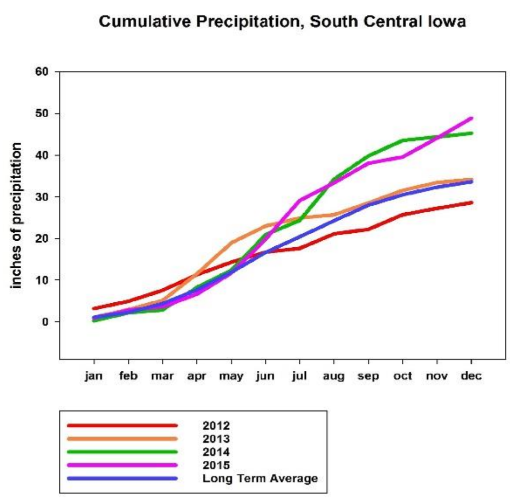
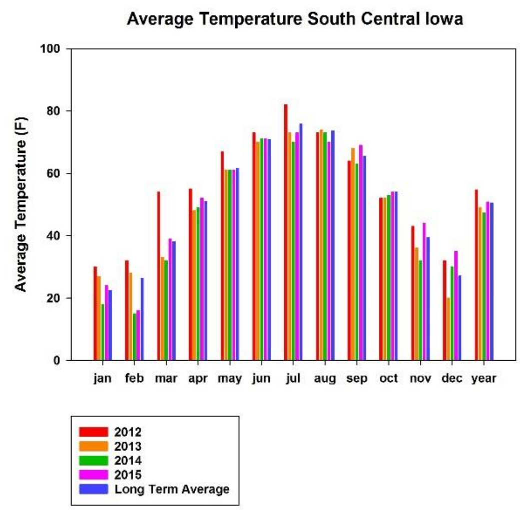


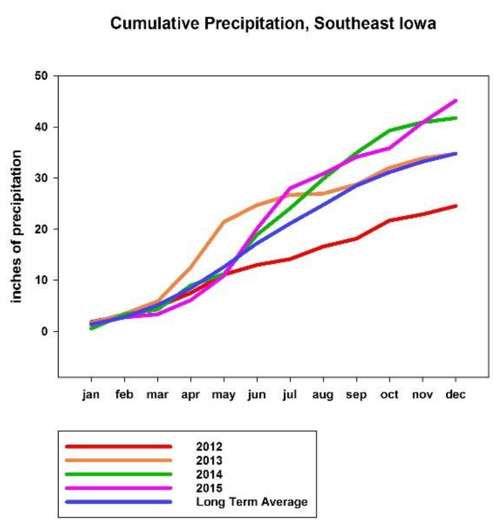

*Figure 11: Precipitation and Temperature for Central Iowa Regions, 2012-15*



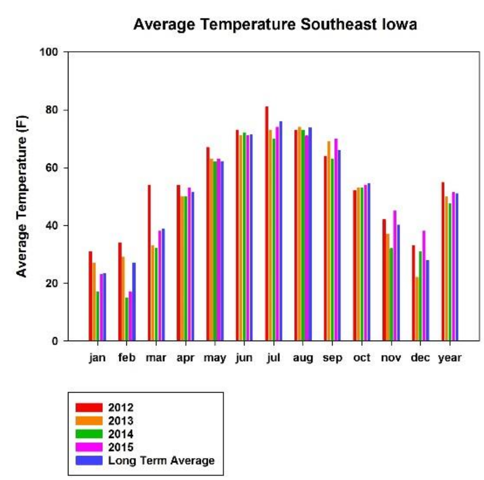




***Figure 12: Precipitation and Temperature for Southern Iowa Regions, 2012-15***

## VI. Water Quality

### A. Data reported

The pages that follow illustrate nitrate data collected at each IIHR monitoring site from 2012 (or when data collection began) through 2015. Data for other parameters, including turbidity, specific conductance, temperature, dissolved oxygen, and pH is also available in an appendix for some sites, but is not presented in this narrative report. People may request the nitrate and other data in Excel format by contacting:

Christopher S. Jones
332 Trowbridge Hall, University of Iowa
Iowa City, IA 52242
319-335-0589
Christopher-s-jones@uiowa.edu

### B. Definitions

Some important water quality definitions for interpreting the data include:

1. **Concentration**, measured in milligrams per liter (mg/L), which is equivalent to parts per million. Concentration is the mass of a contaminant per unit volume of water. Nitrate and nitrite are reported "as nitrogen". Nitrate and nitrite ions contain both nitrogen and oxygen atoms. It is common to convert their concentration to nitrogen as a way to standardize reporting. The maximum amount of nitrogen in the nitrate-nitrite form allowed in municipal drinking water is 10 mg/L.
2. **Load.** Load is the total mass of a contaminant that passes a given point on a stream within a defined period of time. For the purposes of this report, the point on the stream is the location of the nitrate sensor. The period of time is usually the total amount measured April through October, unless otherwise noted. Load is a product of concentration and river discharge. Usually the river discharge used is that measured by the nearby USGS discharge gauge, unless otherwise noted. Discharge and load data is available for only a few sites. Load is reported in pounds of nitrogen present in the form of nitrate and nitrite. Comparing load from year to year is illustrative of climatic and other factors that cause variability in water quality.
3. **Yield.** Yield is the amount of nitrogen transported in the river, per unit area of watershed draining to the measurement site. Yield is reported here as pounds nitrogen per acre. Yield is especially useful for comparing nitrogen loss between different watersheds. It is calculated by dividing the load by the total land area upstream of the sensor.

### C. Figures and Graphs

Data is collected every 15 minutes for each nitrate sensor. Space limits how this immense amount of data can be presented. Here we present data for the individual sites in four formats:

1. **Temporal line graph of nitrate concentration**. This tracks nitrate concentration throughout the measurement year. If there are multiple years of monitoring data, they are

superimposed on one another in the same graph. The reader may notice sudden drops in nitrate concentrations in this graph, as illustrated in the graph from Clear Creek, a small tributary of the Iowa River, in Figure 13 below. These drops are caused by rain events. Since rain and overland runoff contain low levels of nitrate, compared to tile water and groundwater, stream nitrate drops during and immediately after rainstorms. These changes tend to be more dramatic and of a shorter duration in small streams. For comparison, see Figure 14 of the much larger Iowa River.

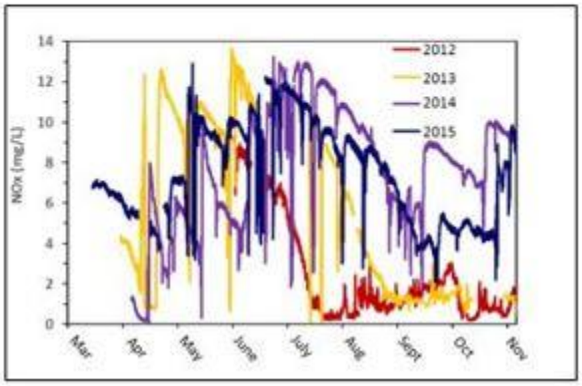



***Figure 13*****: Clear Creek nitrate sensor data, showing rapid and dramatic changes in nitrate in response to rain.**

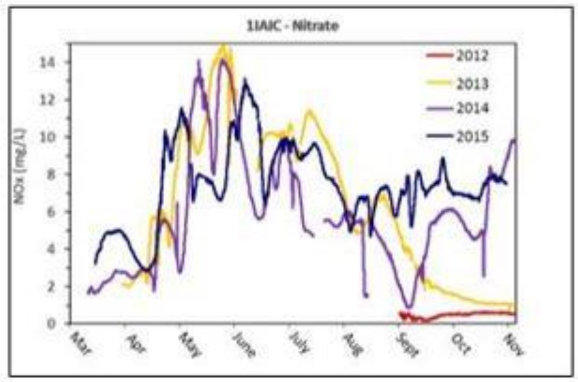



***Figure 14*****: Iowa River nitrate, showing less dramatic changes to rain events.**

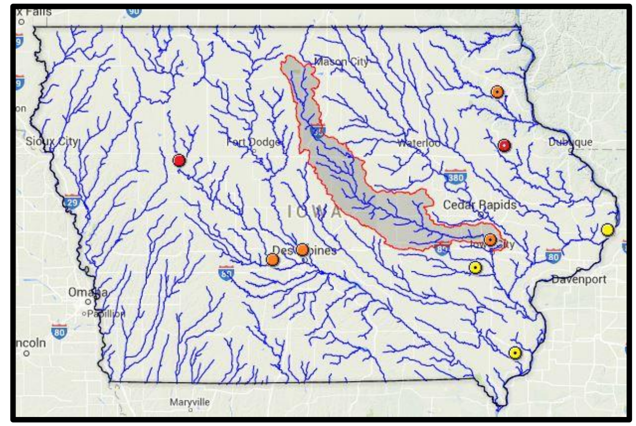
2. **Monthly bar chart**. This illustrates the load of nitrogen transported by the stream each month. If there are multiple years of monitoring data, they are superimposed on one another in the same graph. This graph is especially useful when evaluating nitrate because about 70% the annual load usually occurs in the months from April through July.
3. **Summary table of concentration, discharge (water flow), load, and yield**. Included in this data are averages (mean), standard deviation, minimum (min) and maximum (max) values for concentration and discharge. The standard deviation is an indicator of the data variability and is useful for comparisons between sites, i.e. a higher standard deviation means more variability.

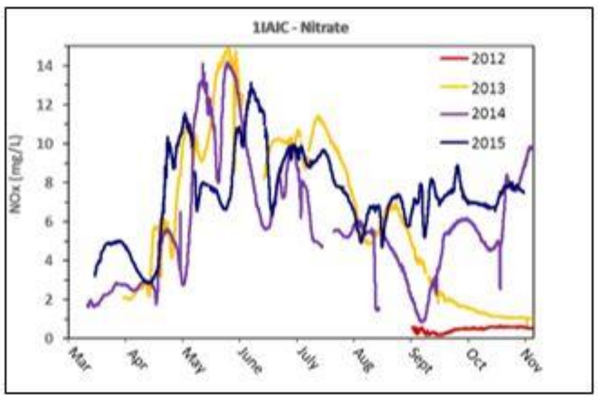
**D. Overall Summaries**

Following the individual report summaries, site and year comparisons are made and data presented in summary tables. The report ends with sections summarizing limitations of and future plans for the monitoring network.

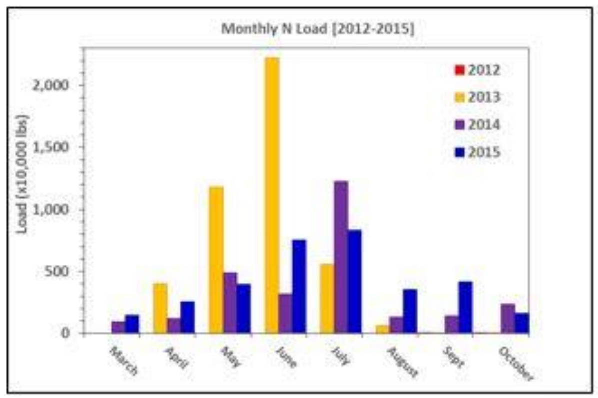
## 1. Site WQS0001 Iowa River at Iowa City

| Site No. | WQS0001 |
|---|---|
| Name | **Iowa River near Iowa City, Iowa** |
| Location | Left bank of Iowa River, 210 ft downstream of Dubuque Street bridge (41.6938, -91.5481) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | August 2012 – December 2015 |
| Drainage Area | 3147 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | 2.6 mi downstream from USGS 05453520 (stage, discharge)<br>260 ft downstream of DNR Ambient Monitoring Site (Storet ID 10520002) |
| Purpose & Significance | This site provides nitrogen-N load estimations for the drainage area above Coralville Dam, including the Coralville Reservoir; contributing in part to statewide N-loading estimates related to the Iowa Nutrient Reduction Strategy. Data from this site is used to inform decisions at the Iowa City water treatment plant regarding water-supply use. Discharge at this site is dominantly controlled by US Army Corps of Engineers regulation of Coralville Lake levels and associated flow from the dam. |
| | |




Temporal nitrate concentration.




Monthly N load 2012-2015.

Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.

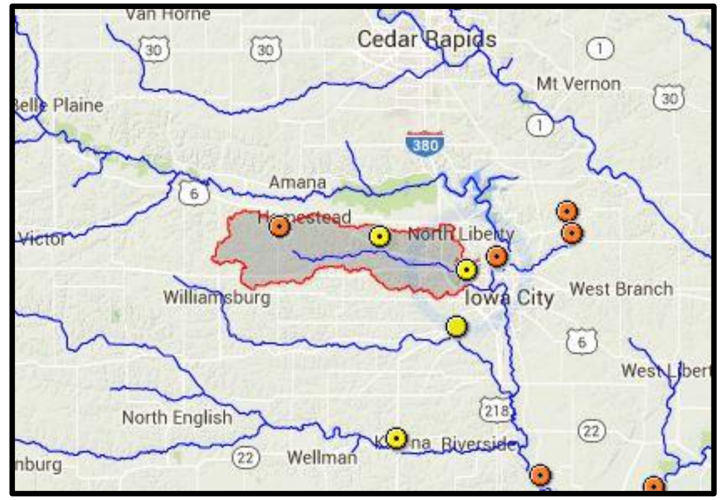
| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 7.7 | 1.3 | 13.0 | 2.8 | 3423 | 1142 | 6620 | 790 | 31,721,795 | 15.8 |
| 2014 | 6.1 | 1.7 | 14.2 | 0.8 | 3756 | 1700 | 18500 | 150 | 26,639,062 | 13.2 |
| 2013 | 6.5 | 1.2 | 14.9 | 0.7 | 4043 | 1973 | 19400 | 102 | 44,345,044 | 22.0 |

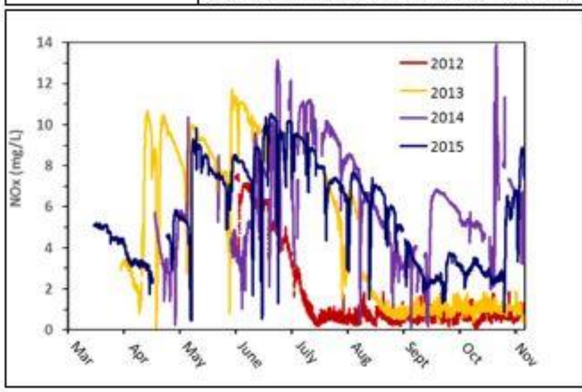
**Discussion:** This site receives water primarily from the Des Moines Lobe and the Southern Iowa Drift Plain, with very small areas of the Iowan Surface also contributing. The headwaters of the Iowa River are drained extensively by field tiles and county tile mains. This contributes to a large load and yield of nitrate delivered by the stream. High nitrate concentrations along with discharges characteristic of a large river make the Iowa one of the biggest contributors to Mississippi River Basin nitrate loads.

Like weather statewide, weather in this watershed was very dry during 2012 and wet in 2014 and ’15. Overall 2013 was about normal but April and May were very wet and the summer dry. Large N loads were observed in Apr-May of 2013, as the repressed crop yields of the 2012 drought left abundant N on landscape. The wettest year of 2015 had the largest overall N load and the highest individual N measurement (14.9 mg/L). Nitrate levels likely decline 1-2 mg/L in the upstream Coralville reservoir as algae and bacteria have time to process this nutrient and remove it from the water column.

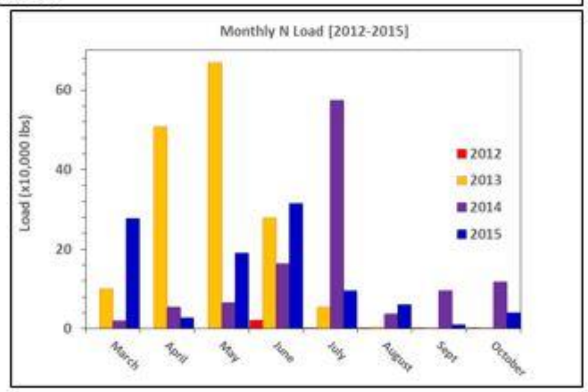
## 2. Site WQS0002 Clear Creek at Coralville

| Site No. | WQS0002 |
|---|---|
| Name | Clear Creek at Coralville, Iowa |
| Location | Left bank of Clear Creek, 16 ft upstream of Camp Cardinal Blvd bridge (41.6765, -91.5983) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen, chlorophyll-a |
| Period of Record | May 2012 - present |
| Drainage Area | 98 sq mi |
| Funding Sources | IIHR, INRC, EPSCoR |
| Co-located Measurement | USGS 05454300 (stage, discharge)<br>CZO/EPSCoR project-related YSI EXO sonde deployed at site (parameters: fluorescent dissolved organic matter, oxidation-reduction potential, turbidity, total algae, chloride, ammonia), and water sampling of storm events by isco water sampler. |
| Purpose & Significance | The Clear Creek watershed is a small (HUC10) tributary of the Lower Iowa river watershed that is highly utilized by U of I researchers due to its close proximity to the U of I campus. Current research projects, including funding from the Critical Zone Observatory Intensively Managed Landscapes (CZO-IML) grant and EPSCoR, provide additional water quality data sampling and resources for WQS data integration and analysis. The WQS0002 site is the most downstream USGS gage station on Clear Creek, prior to Clear Creek entering the Iowa River. This site is one of three sites within the nested Clear Creek watershed. |




Temporal nitrate concentration.




Monthly N load 2012-2015.

**Discussion:** An interesting feature of the Clear Creek data is the 2015 load, which is the smallest of the three complete years (2013-15). This contrasts with the Iowa River (that receives flow from Clear Creek) which had its largest loading year in 2015. These differences may be linked to the idea that Clear Creek water quality is driven by local weather, while Iowa River water quality is driven by weather on a regional scale. The other possibility is that artificially-drained area the Clear Creek watershed is proportionately smaller when compared to the Iowa River watershed upstream from their confluence.

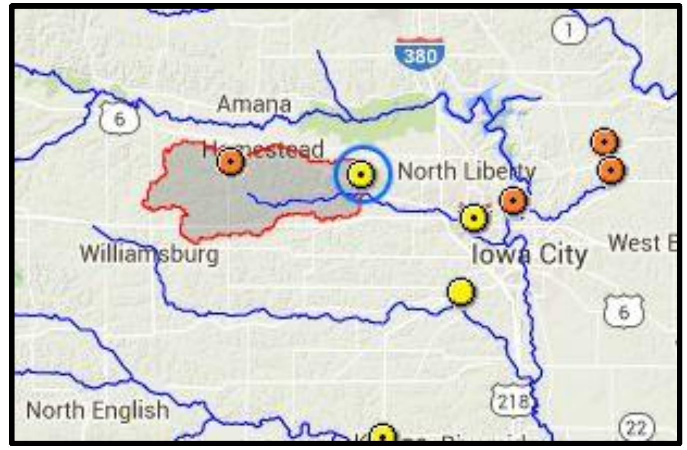
This Clear Creek site (vs the other two) is interesting in that it has a large urban component. The nitrate concentration in streams such as this typically drops as it flows through the urban area, while specific conductance increases due to street and storm sewer runoff (road salts).

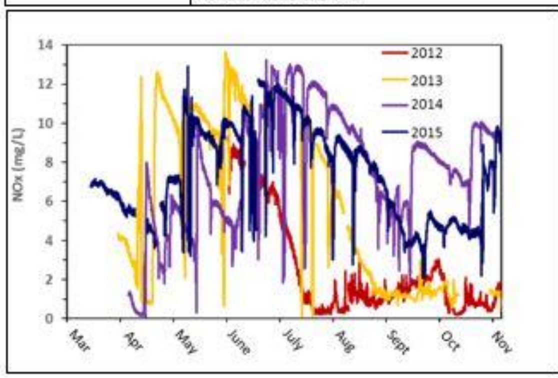
Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 5.7 | 1.3 | 10.5 | 0.4 | 96 | 97 | 2120 | 11 | 737,778 | 11.8 |
| 2014 | 6.2 | 1.7 | 13.8 | 0.4 | 152 | 239 | 5010 | 29 | 1,106,409 | 17.6 |
| 2013 | 5.1 | 1.4 | 11.7 | 0.3 | 175 | 205 | 1840 | 3 | 1,518,478 | 24.2 |

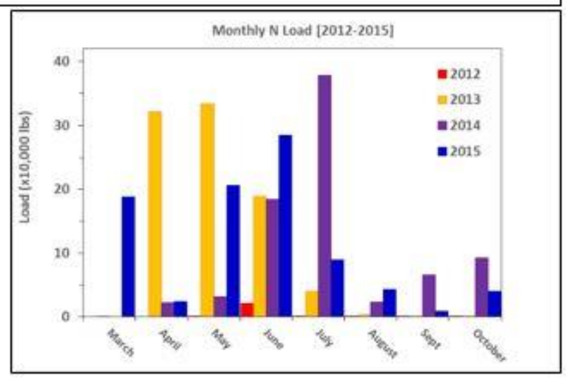
## 3. Site WQS0003 Clear Creek near Oxford

| Site No. | WQS0003 |
|---|---|
| Name | Clear Creek near Oxford, Iowa |
| Location | Left bank of Clear Creek, 10 ft upstream of Eagle Ave NW bridge (41.7182, -91.7403) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | May 2012 - present |
| Drainage Area | 61 sq mi |
| Funding Sources | IIHR, INRC, EPSCoR |
| Co-located Measurement | USGS 05454300 (stage, discharge)<br>CZO/EPSCoR project-related YSI EXO sonde deployed at site (parameters: fluorescent dissolved organic matter, oxidation-reduction potential, turbidity, total algae, chloride, ammonia), and water sampling of storm events by isco water sampler. |
| Purpose & Significance | The Clear Creek watershed is a small (HUC10) tributary of the Lower Iowa river watershed that is highly utilized by UofI researchers due to it's close proximity to the UofI campus. Current research projects, including funding from the Critical Zone Observatory Intensively Managed Landscapes (CZO-IML) grant and EPSCoR, provide additional water quality data sampling and resources for WQS data integration and analysis. The WQS0003 site is the most upstream USGS gage station on Clear Creek, above the Coralville station. This site is one of three sites within the nested Clear Creek watershed. |




Temporal nitrate concentration.




Monthly N load 2012-2015.

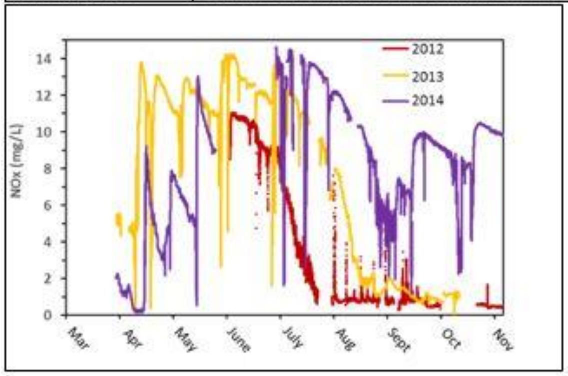
**Discussion:** An interesting feature of the Clear Creek data is the 2015 load, which is the smallest of the three complete years (2013-15). This contrasts with the Iowa River (that receives flow from Clear Creek) which had its largest loading year in 2015. These differences may be linked to the idea that Clear Creek water quality is driven by local weather, while Iowa River water quality is driven by weather on a regional scale. The other possibility is that Iowa River nitrate is driven much more by tile nitrate compared to Clear Creek. Clear Creek lies within the Southern Iowa Drift Plain landform, which is does not have the extensive tile network of the Des Moines Lobe that feeds the Iowa River.

Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 7.4 | 1.3 | 12.9 | 2.1 | 73 | 95 | 2740 | 6 | 696,780 | 17.8 |
| 2014 | 7.5 | 1.9 | 13.2 | 0.1 | 90 | 160 | 4630 | 5 | 798,031 | 20.4 |
| 2013 | 5.7 | 1.6 | 13.7 | 0 | 100 | 170 | 6000 | 1 | 888,593 | 22.8 |

## 4. Site WQS0004 Unnamed Clear Creek tributary near Homestead

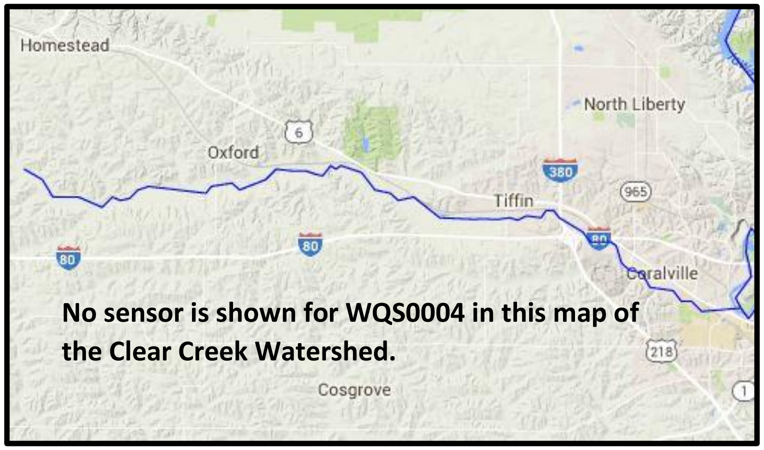
| Site No. | WQS0004 |
|---|---|
| Name | Clear Creek near Homestead, Iowa |
| Location | Left bank of Clear Creek, 5 ft upstream of 210th St bridge (41.7012, -91.8573) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | May 2012 – November 2014 |
| Drainage Area | 8 sq mi |
| Funding Sources | IIHR, INRC, EPSCoR |
| Co-located Measurement | IFC CLRCRKS01 (stage) |
| Purpose & Significance | This site was discontinued in 2014 in favor of continuing measurement at the South Amana catchment location, currently WQS0011. |




Temporal nitrate concentration.

Nitrate-N values for monitoring years 2013-2014.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | -- | -- | -- | -- |
| 2014 | 8.9 | 2.1 | 14.6 | 0.1 |
| 2013 | 6.9 | 1.5 | 14.2 | 0.0 |



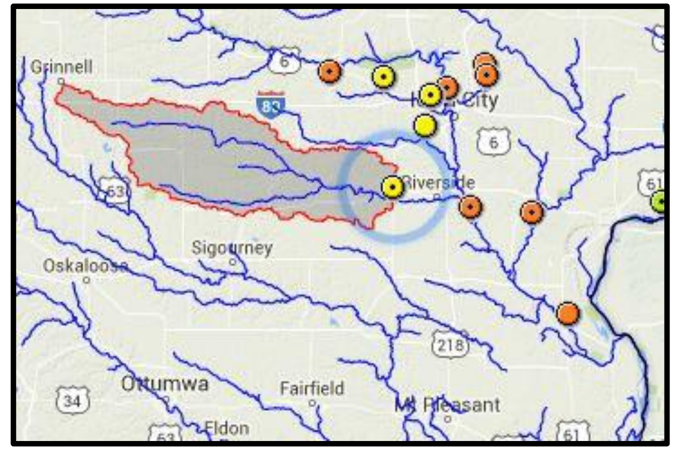

**Discussion:** Upstream a few miles upstream from WQS0003. This site was not monitored in 2015 and there are no plans to monitor this site in 2016. There are no discharge measurements here. As a result, load calculations have not been performed

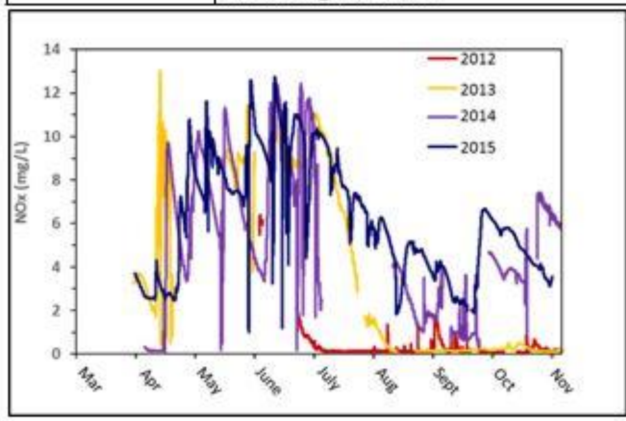
This site did have the high nitrate concentrations consistent with its headwater location. This site likely has a high percentage of tiled land draining to its sensor.

One peer-reviewed paper has been generated with data from this location (Davis et al. 2014) that examined antecedent soil moisture conditions and their effect on nitrate concentrations.

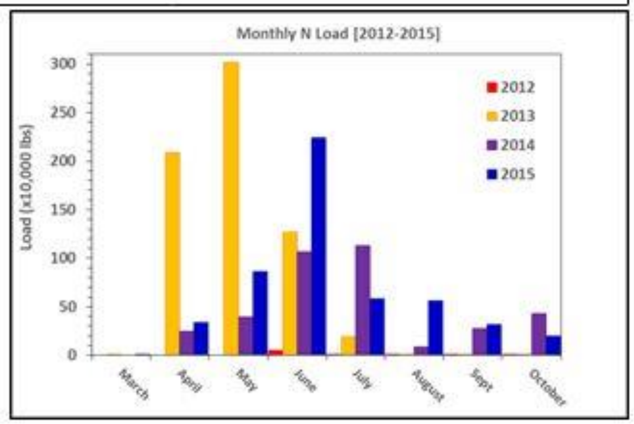
## 5. Site WQS0005 English River near Kalona

| Site No. | WQS0005 |
|---|---|
| Name | English River near Kalona, Iowa |
| Location | Left bank of English River, 5 ft downstream of Hwy 1 bridge (41.4694, -91.7144) |
| WQ Parameters | Nitrate + nitrite as N, temperature, turbidity |
| Period of Record | May 2012 - present |
| Drainage Area | 576 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | USGS 05455500 (stage, discharge)<br>11 mi upstream of DNR Ambient Monitoring Site (Storet ID 10920001) |
| Purpose & Significance | The English River is a large tributary of the Iowa River, characteristic of an agricultural watershed in the Southern Iowa Drift Plain. This site is an important location for IFC flood research and reporting, and is part of ongoing research activities at IIHR. As of the 2016 monitoring season, this site will be a Water Quality Initiative (WQI) project area funded through the Iowa Nutrient Reduction Strategy. In addition, nitrate measurements at this site contribute in part to statewide N-loading estimates. |




Temporal nitrate concentration.




Monthly N load 2012-2015.

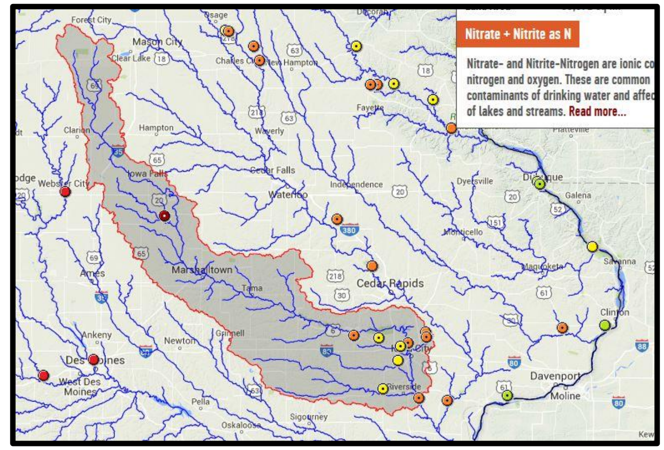
**Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.**

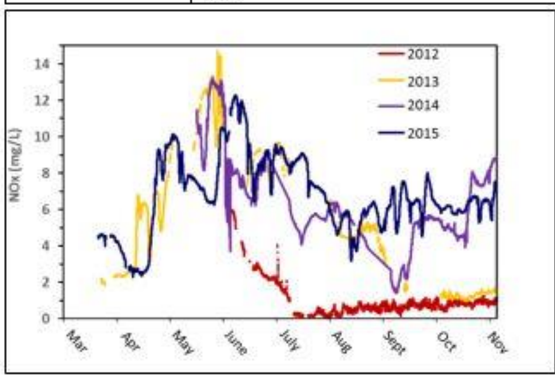
| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 6.2 | 1.6 | 12.8 | 1 | 686 | 781 | 10100 | 120 | 5,106,900 | 13.9 |
| 2014 | 4.6 | 1.9 | 12.5 | 0.1 | 848 | 1387 | 22400 | 66 | 3,619,822 | 9.8 |
| 2013 | 4.1 | 1.1 | 13.0 | 0.1 | 883 | 1301 | 27200 | 6 | 6,566,589 | 17.8 |

**Discussion:** The English River is the second largest tributary of the Iowa River (the Cedar River is the largest). The watershed of the English River, however, yields a significantly smaller amount of nitrogen on a per acre basis. Again this is a reflection of landform, so important when discussing Iowa water quality. The English River watershed lies entirely within the Southern Iowa Drift Plain. There is less artificial drainage here, and the soils have smaller amounts of nitrogen-containing organic matter. This is manifested in lower stream nitrate levels when compared to Des Moines Lobe and Iowan Surface streams. That said, the English River can still have remarkably high nitrate levels at times. The stream is very flashy, with the standard deviation of the discharge greater than the average flow for 2013-2015. Heavy flows and N loads in April and May of 2013 on the heels of the 2012 drought, resulted in 2013 being the largest loading year for nitrate-N.

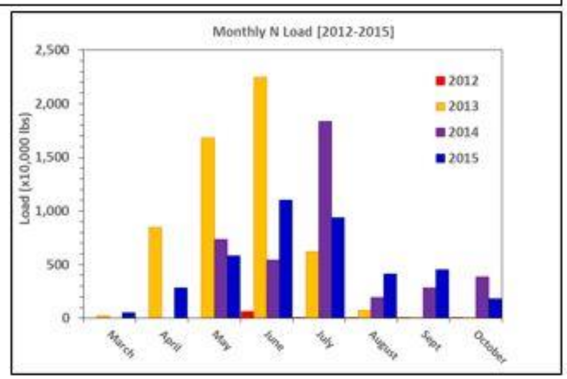
## 6. WQS0006 Iowa River near Lone Tree

| Site No. | WQS0006 |
|---|---|
| Name | Iowa River near Lone Tree, Iowa |
| Location | Left bank of Iowa River, 17 ft downstream of Tri-County Bridge Rd bridge (41.4238, -91.4787) |
| WQ Parameters | Nitrate + nitrite as N, temperature, turbidity |
| Period of Record | June 2012 - present |
| Drainage Area | 4293 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | USGS 05455700 (stage, discharge)<br>DNR Ambient Monitoring Site (Storet ID 10580002) |
| Purpose & Significance | The Iowa River near Lone Tree WQS site is a significant location for strategic load calculation to quantify the Iowa River watershed's contribution of N-loading to the Mississippi River. This site is located immediately upstream of the confluence with the Cedar River. In conjunction with WQS0001 (Iowa River, Iowa City), the N load contribution of the Lower Iowa River watershed can be quantified directly, in addition to the summation of the N load estimates from Clear Creek, Old Mans Creek, and the English River watersheds that drain in to the Iowa River above the Lone Tree site. |




Temporal nitrate concentration.




Monthly N load 2012-2015.

**Discussion:** This is the last gauging station on the Iowa upstream from the Cedar River confluence. Nitrate concentrations and yields are slightly lower here than the Iowa River-Iowa City location. This illustrates a dilution effect resulting from the English River, which has lower nitrate levels characteristic of the Southern Iowa Drift Plain.

This site will be strategically important in the coming years as scientists quantify N loads from Iowa's major watersheds. Comparing the Iowa River watershed with the adjacent Skunk and Cedar River Watersheds will inform the discussion about farming practices and potential conservation practices. Concentration and per acre yields seem to be higher in the Cedar and lower in the Skunk, when compared to the Iowa River.

The data here shows highest levels of N loading in 2013. A perfect storm of a very wet April and May that year, following on the heels of the 2012 drought, resulted in historically high nitrate concentrations here and in many other Iowa streams.

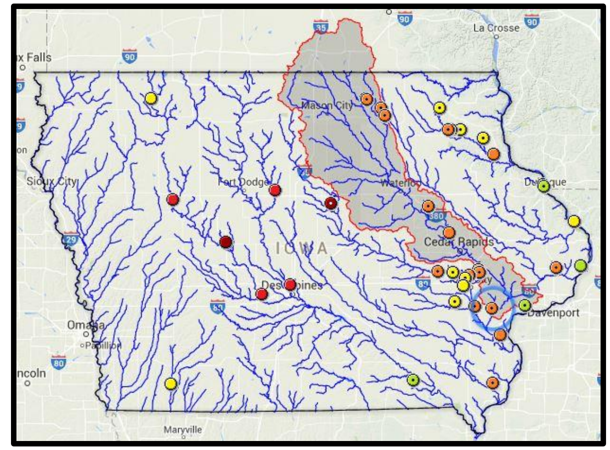
Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.

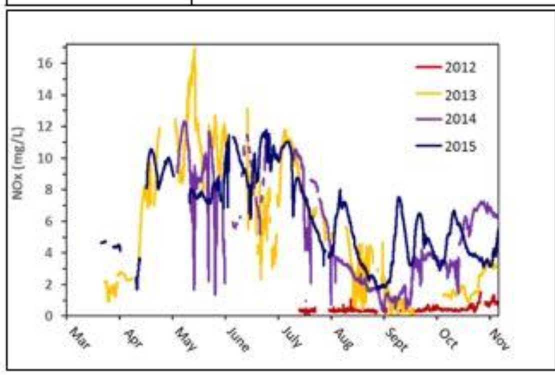
| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 6.9 | 1.2 | 12.3 | 2.4 | 4655 | 1753 | 14300 | 1200 | 36,657,047 | 13.3 |
| 2014* | 6.6 | 1.2 | 13.2 | 1.4 | 6202 | 3453 | 46600 | 915 | 39,726,137 | 14.5 |
| 2013 | 5.7 | 0.9 | 14.7 | 1.0 | 5847 | 3105 | 45600 | 182 | 46,401,181 | 16.9 |

*May-Oct

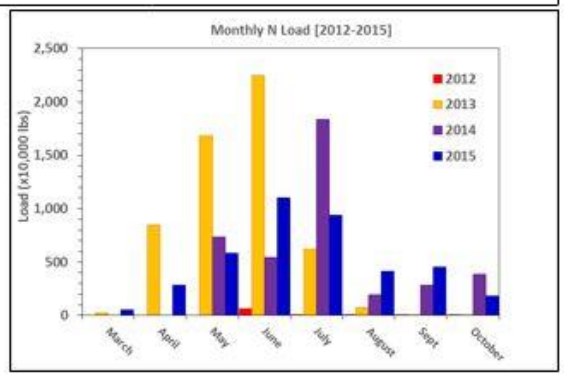
## 7. WQS0007 Cedar River at Conesville

| Site No. | WQS0007 |
|---|---|
| Name | Cedar River near Conesville, Iowa |
| Location | Right bank of Cedar River, 15 ft upstream of 231st St bridge (41.4097, 91.2904) |
| WQ Parameters | Nitrate + nitrite as N, temperature, turbidity |
| Period of Record | June 2012 - present |
| Drainage Area | 7787 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | USGS 05465000 (stage, discharge)<br>DNR Ambient Monitoring Site (Storet ID 10700001) |
| Purpose & Significance | This site is a significant location for strategic load calculation to quantify the Cedar River watershed's contribution of N-loading to the Mississippi River. This site is located immediately upstream of the confluence with the Iowa River. In conjunction with nitrate concentration measurements at the USGS gage (Cedar River, Palo), the N load contribution of the Middle and Lower Cedar River watersheds can be estimated. |




Temporal nitrate concentration.




Monthly N load 2012-2015.

**Discussion:** Receiving water from both Minnesota and Iowa, the Cedar River watershed is Iowa's second largest (Des Moines River watershed is the biggest). At almost 8000 square miles, it is bigger than a few states. Although it is bigger than the receiving Iowa River, it is considered an Iowa River tributary due to the hydrology and geomorphology of the confluence. The Cedar drains primarily the Iowan Surface, with small parts of the Southern Iowa Driftplain and the Mississippi Alluvial Plain contributing.

This site is unique among the seven sites where load/N yield values are available for 2013-'15. It was the only site where load and N yield was highest during 2014. It is not apparent from the climate data (Figures 9, 10, and 11) why this should be so.

Many recent conservation efforts have focused on the Cedar River. Its importance as municipal water supply for Cedar Rapids and its large N contributions to the Mississippi Basin merit this attention.

This site will be particularly important in the coming years as scientists estimate N loads from Iowa's largest watersheds, and how this relates to the state's Nutrient Reduction Strategy.

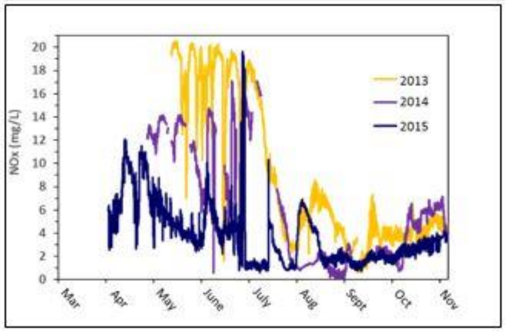
**Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.**

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 6.4 | 1.7 | 11.8 | 1.7 | 7469 | 2857 | 23900 | 2360 | 65,718,219 | 13.2 |
| 2014* | 5.8 | 1.8 | 12.3 | 0.4 | 10482 | 6724 | 77700 | 2400 | 86,029,683 | 17.3 |
| 2013 | 5.4 | 1.7 | 17.0 | 0.1 | 12678 | 5526 | 61300 | 1420 | 78,186,981 | 15.7 |

*May-Oct

## 8. WQS0008 and WQS0012 Slough Creek CREP Wetland Outlet near Orchard

| Site No. | WQS0008 |
|---|---|
| Name | Slough Creek CREP wetland near Orchard, Iowa |
| Location | Left bank of Slough Creek, 240 ft downstream of CREP wetland weir (43.2100, -92.7502) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen, chlorophyll-a |
| Period of Record | May 2013 - present |
| Drainage Area | 6 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | 550 ft upstream of DNR Ambient Monitoring Site (Storet ID 15340015) |
| Purpose & Significance | This site monitors the outflow of water from the weir of the CREP wetland on Slough Creek. The CREP wetland sites are important for demonstrating the effectiveness of constructed wetlands for the purpose of reducing nitrate loads to the Cedar and Mississippi Rivers, which is a key intent of the Iowa Nutrient Reduction Strategy. |



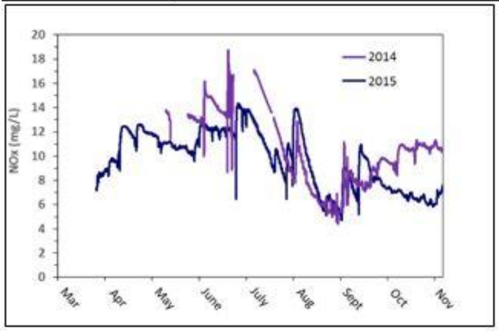

Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 3.9 | 1.6 | 19.6 | 0.6 |
| 2014 | 7.6 | 1.9 | 17.1 | 0.1 |
| 2013 | 9.4 | 2.4 | 20.5 | 0.6 |

*2013 N Concentration values = May through Oct only

**Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.**

| Site No. | WQS0012 |
|---|---|
| Name | Slough Creek near Orchard, Iowa |
| Location | Right bank of Slough Creek, 5 ft upstream of Hwy 218 bridge (43.2063, -92.7322) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen, chlorophyll-a |
| Period of Record | May 2014 - present |
| Drainage Area | 5 sq mi |
| Funding Sources | INRC |
| Co-located Measurement | DNR Ambient Monitoring Site (Storet ID 15340014) |
| Purpose & Significance | This site monitors the inflow of water to the CREP wetland on Slough Creek. The CREP wetland sites are important for demonstrating the effectiveness of constructed wetlands for the purpose of reducing nitrate loads to the Cedar and Mississippi Rivers. |

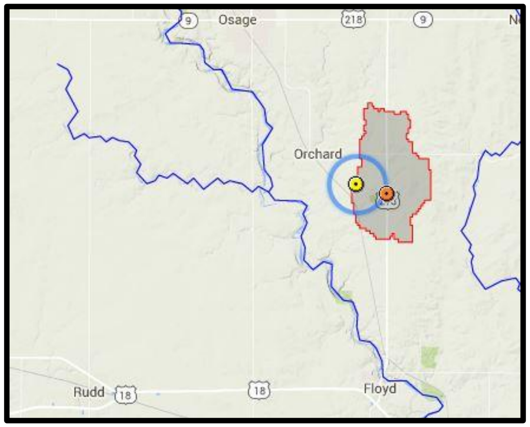



Temporal nitrate concentration

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 9.8 | 1.2 | 14.4 | 4.7 |
| 2014 | 11.2 | 1.4 | 18.7 | 4.4 |

**2014 N Concentration values = May-Oct only

**Nitrate-N concentration measured for monitoring years 2014-2015.**




**Discussion:** A 24-acre constructed wetland was completed at this site in 2012. The wetland is positioned along Slough Creek which drains to a Cedar River tributary, Spring Creek. Lowering nitrate levels in the Cedar is critical because of the downstream municipal water supply in Cedar Rapids.

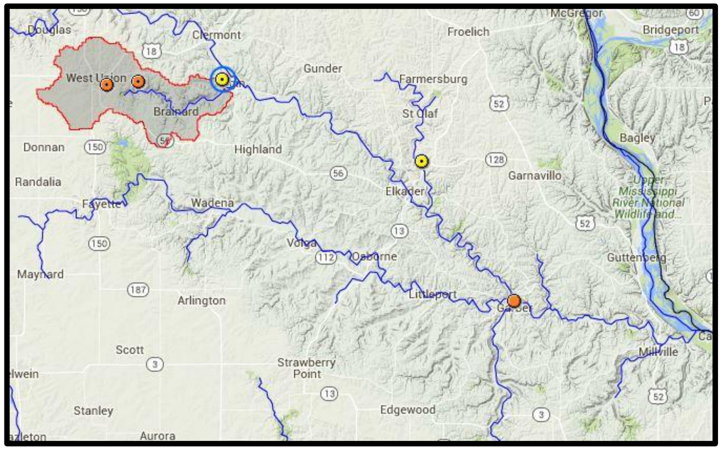
Researchers at IIHR have been studying water quality and nutrient processing in the wetland since 2013. Work has shown modest declines in the nitrate traveling through the wetland, especially after about June 1. Monitoring nitrate levels at the wetland over the past two years have shown the increasing capacity of developing aquatic vegetation to process nitrate.

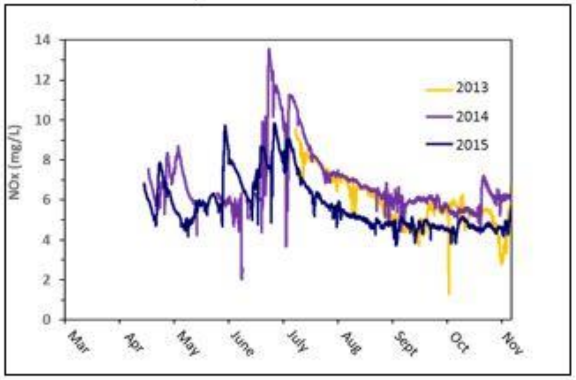
Nitrate in the water entering the wetland can exceed 20 parts per million (ppm), more than twice the safe limit for drinking water. As the water warms in late spring, however, this aquatic vegetation and other life in the wetland begins to process nitrate and sequester it as organic material, or convert it to harmless nitrogen gas which is released to the atmosphere. By the end of the summer, nitrate levels in the water leaving the wetland are less than 2 ppm.

The wetland also provides critical habitat for birds, reptiles, amphibians, and certain fishes. Birds present include pelicans and trumpeter swans.

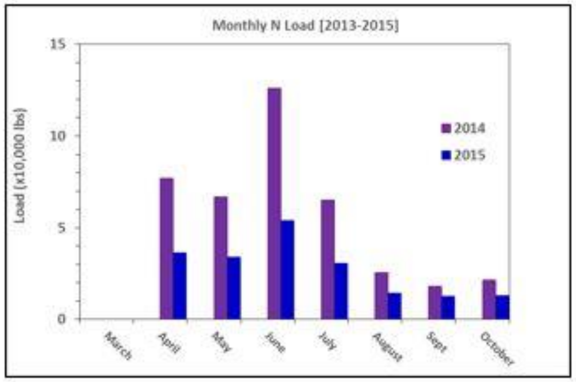
## 9. WQS0009 Otter Creek at Elgin

| | |
|---|---|
| Site No. | WQS0009 |
| Name | Otter Creek at Elgin, Iowa |
| Location | Right bank of Otter Creek, 5 ft upstream of Cedar Rd bridge (42.9500, -91.7538) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | June 2013 - present |
| Drainage Area | 46 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | USGS 05411900 (stage, discharge) |
| Purpose & Significance | Otter Creek is a tributary of the Turkey River in NE Iowa. This site is one of three nested sites within the Otter Creek watershed that are currently being operated by IIHR and are funded by HUD through the Iowa Watersheds Project. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |




Temporal nitrate concentration.




Monthly N load 2013-2015.

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 5.8 | 0.7 | 9.8 | 3.7 | 27 | 12 | 430 | 14 | 194,642 | 6.6 |
| 2014 | 6.8 | 1.0 | 13.6 | 2 | 49 | 83 | 1860 | 14 | 399,939 | 13.6 |
| 2013* | 6.0 | 0.7 | 9.6 | 1.3 | | | | | | |

*May-Oct

Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.

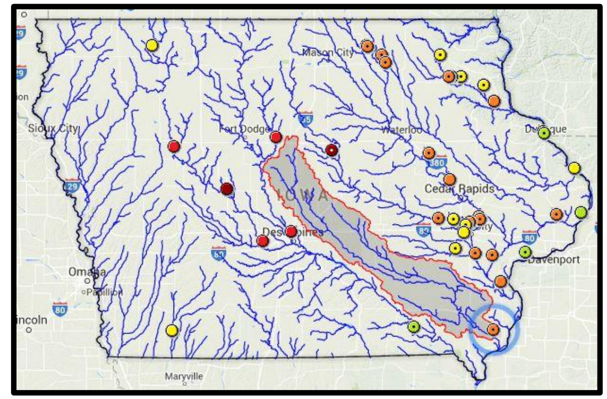
**Discussion:** Currently IIHR researchers are developing a hydrograph separation model that uses nitrate concentrations from three Otter Creek sites to examine the contributions of tile drainage, groundwater and surface/storm flow to the stream. Otter Creek is a tributary of the Turkey River, and major Iowa interior stream.

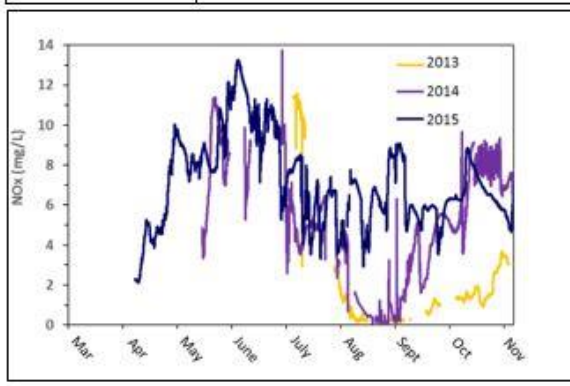
This site is near the confluence of the Turkey. Being the furthest-downstream site of the three Otter Cr sensors, it has the lowest nitrate concentration, which is typical, as high nitrate water from the headwaters (tile drainage) is diluted by lower nitrate groundwater throughout the stream course.

This site is the only one of the three with a flow gauge and load calculations. N yield (lbs/acre) is modest for an Iowa stream.

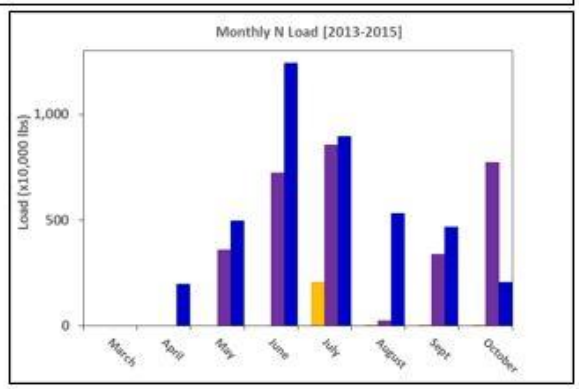
## 10. WQS0010 Skunk River at Augusta

| Site No. | WQS0010 |
|---|---|
| Name | Skunk River at Augusta, Iowa |
| Location | Right bank of Skunk River, upstream of Perkins Rd bridge (40.7530, -91.2754) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature |
| Period of Record | July 2013 - present |
| Drainage Area | 4312 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | USGS 05474000 (stage, discharge) |
| Purpose & Significance | This site is located near the mouth of the Skunk River before its confluence with the Mississippi River, and is a crucial load calculation site for the Iowa Nutrient Reduction Strategy. There are several Water Quality Initiative projects funded through the Iowa Nutrient Reduction Strategy upstream of this site, along with several medium-large point source discharges. |






Temporal nitrate concentration.




Monthly N load 2013-2015.

**Nitrate-N, discharge, and N load and yield calculated for monitoring years 2013-2015.**

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 7 | 1.5 | 13.3 | 2.1 | 5036 | 2309 | 24900 | 1070 | 40,388,335 | 14.6 |
| 2014 | 5.6 | 1.6 | 13.7 | 0.1 | 4851 | 3900 | 25300 | 250 | 30,720,060 | 11.1 |
| 2013* | 2.4 | 1.2 | 11.6 | 0.1 | 5628 | 4872 | 56775 | 92 | | |
| *May-Oct | | | | | | | | | | |
| **Jul-Oct | | | | | | | | | | |

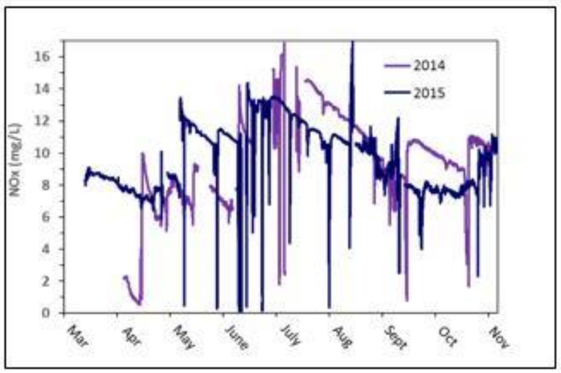
**Discussion:** The Skunk River is a major interior stream and its watershed occupies about 8% of Iowa's area. The two major branches (South and North) are independent, parallel rivers until they combine southeast of Sigourney.

The Skunk River is a study in contrasts. The Des Moines Lobe headwaters, despite very high nitrate concentrations, offer an excellent cool water fishery for smallmouth bass. Between Ames and Colfax, the stream has been straightened and loses most of its biological integrity. Downstream of Colfax, it is characteristic of turbid, Southern Iowa Drift Plain Streams.

Nitrate concentrations can approach 14 mg/L at the mouth, quite high for a watershed of this size. The Skunk River is also interesting in that it is one of the few major rivers in Iowa where water quality is quite dependent on point-source pollution, at least during certain times of the year. This site near the Mississippi confluence will be important when assessing load reductions that may result from Iowa's Nutrient Reduction Strategy.

## 11. WQS0011 Clear Creek near Homestead

| Site No. | WQS0011 |
|---|---|
| Name | **Clear Creek near Homestead, Iowa** |
| Location | Right bank of Clear Creek, downstream of 190th St bridge (41.7305, -91.9071) |
| WQ Parameters | Nitrate + nitrite as N, temperature, specific conductance, pH, dissolved oxygen, chlorophyll-a |
| Period of Record | April 2014 - present |
| Drainage Area | 10 sq mi |
| Funding Sources | INRC, EPSCoR |
| Co-located Measurement | IFC CLRCRK03 (stage)<br>CZO/EPSCoR project-related YSI EXO sonde deployed at site (parameters: fluorescent dissolved organic matter, oxidation-reduction potential, turbidity, total algae, chloride, ammonia), and water sampling of storm events by isco water sampler. |
| Purpose & Significance | The Clear Creek watershed is a small (HUC10) tributary of the Lower Iowa river watershed that is highly utilized by U of I researchers due to its close proximity to the U of I campus. Current research projects, including funding from the Critical Zone Observatory Intensively Managed Landscapes (CZO-IML) grant and EPSCoR, provide additional water quality data sampling and resources for WQS data integration and analysis. The WQS0011 site is the most upstream site on Clear Creek, above the Oxford station. This site is one of three sites within the nested Clear Creek watershed. |

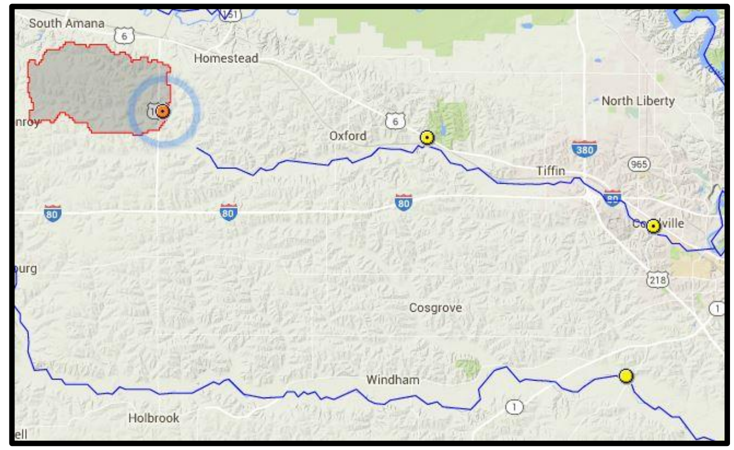



**Temporal nitrate concentration.**

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 9.7 | 1.4 | 16.8 | 0.1 |
| 2014 | 9.4 | 2.0 | 16.9 | 0.5 |

**Nitrate-N concentration measured for monitoring years 2014-2015.**

**Note on Clear Creek:** This watershed is one of seven selected for targeted practice implementation in a recent $97 million grant from the U.S. Housing and Urban Development. IIHR will be working with stakeholders in the watershed to implement practices that will reduce flooding and improve water quality.



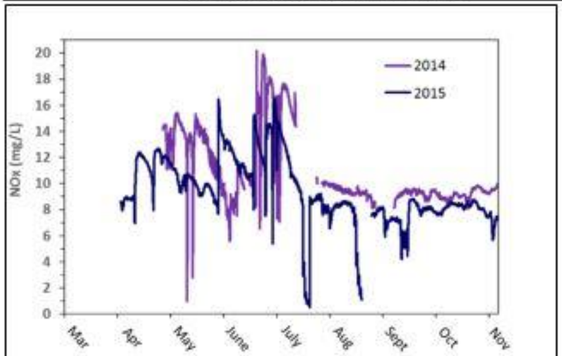

**Discussion:** Clear Creek is studied closely by IIHR researchers because of its proximity to Iowa City, it is an important tributary of the Iowa River, and it has both an urban and rural component. The headwaters are intensely cropped with corn and soybeans and the lower sections are highly developed within the city of Coralville.

This site has the highest nitrate concentrations of the three the Clear Creek nitrate sensors, with values at times exceeding 16 mg/L.

During 2014-'15, nitrate concentrations averaged 6.0 mg/L at the mouth of Clear Creek, 7.5 mg/L at the approximate midway point at Oxford, and 9.6 mg/L at this headwater location. This illustrates the differences in landuse, hydrology, and also effects of dilution and in-stream processing of nitrate in this small watershed.

## 12. WQS0013 Beaver Creek near Bassett

| Site No. | WQS0013 |
|---|---|
| Name | Beaver Creek near Bassett, Iowa |
| Location | Right bank of Beaver Creek, upstream of Hwy 18 bridge (43.0668, -92.5283) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2014 - present |
| Drainage Area | 17 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | IFC BEAVER01 (stage) |
| Purpose & Significance | Beaver Creek is a tributary of the Little Cedar and Cedar River in northeast Iowa. This site is one of two water quality monitoring sites within the Beaver Creek watershed that are currently being operated by IIHR and are funded by HUD through the Iowa Watersheds Project. This site is part of a dense network of monitoring equipment that has been deployed to track watershed conditions associated with the construction of small-scale flood mitigation projects. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |

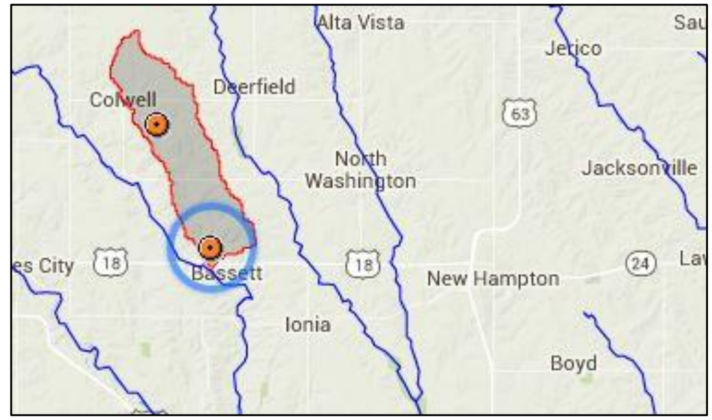



| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 9.3 | 1.7 | 16.5 | 0.5 |
| 2014 | 11.2 | 1.6 | 20.2 | 1.0 |

**Nitrate-N concentration measured for monitoring years 2014-2015.**

**Iowan Surface:** Cedar Creek is an Iowan Surface stream. The Iowan Surface is a vast plain with elliptical-shaped hills oriented in NW-SE direction, indicative of persistent winds that blew during past ice ages. This wind was likely generated by a persistent anti-cyclonic movement of air over the continental ice sheet during the last Wisconsinin ice age, which left the Iowan surface uncovered tundra.

Relief here is low, and as a result water moves slowly from the landscape to the streams. This requires artificial drainage (tile) of most farmed fields. As the primary mechanism for nitrate transport, tile increases stream nitrate levels in this region of Iowa.




**Discussion:** Beaver Creek is a small tributary of the Cedar River. The watershed is the site of multiple IIHR research projects associated with both water quality and flooding. The data from the Beaver Creek nitrate sensors are interesting in that the downstream site has a higher nitrate concentration than the upstream site, which is atypical of Iowa watersheds. Intriguingly, there is a constructed CREP wetland upstream of the Colwell site (WQS0014) that may be producing this effect by lowering nitrate concentrations in the headwaters.

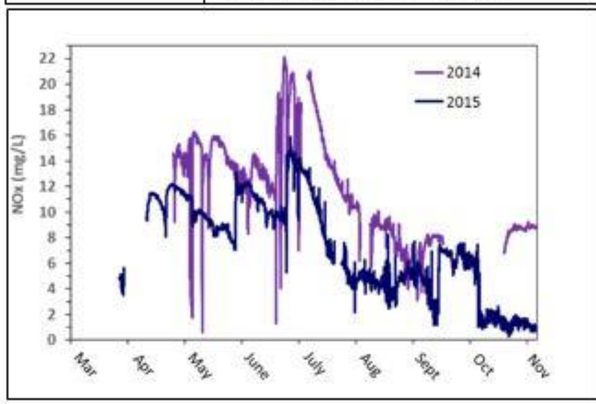
Six more CREP wetlands are planned for the watershed in the coming years which potentially could lower nitrate concentrations further.

There are no significant point source inputs in the Beaver Creek watershed.

Reducing nitrate concentrations in Cedar River tributaries is important because of the downstream municipal water supply at Cedar Rapids.

## 13. WQS0014 Beaver Creek near Colwell

| Site No. | WQS0014 |
|---|---|
| Name | Beaver Creek near Colwell, Iowa |
| Location | Left bank of Beaver Creek, upstream of 155th St bridge (43.1341, -92.5675) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2014 - present |
| Drainage Area | 7 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | IFC BEAVER03 (stage) |
| Purpose & Significance | Beaver Creek is a tributary of the Little Cedar and Cedar River in northeast Iowa. This site is one of two water quality monitoring sites within the Beaver Creek watershed that are currently being operated by IIHR and are funded by HUD through the Iowa Watersheds Project. This site is part of a dense network of monitoring equipment that has been deployed to track watershed conditions associated with the construction of small-scale flood mitigation projects. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 7.2 | 1.5 | 15.8 | 0.3 |
| 2014 | 11.5 | 1.9 | 22.1 | 0.6 |

**Nitrate-N concentration measured for monitoring years 2014-2015.**

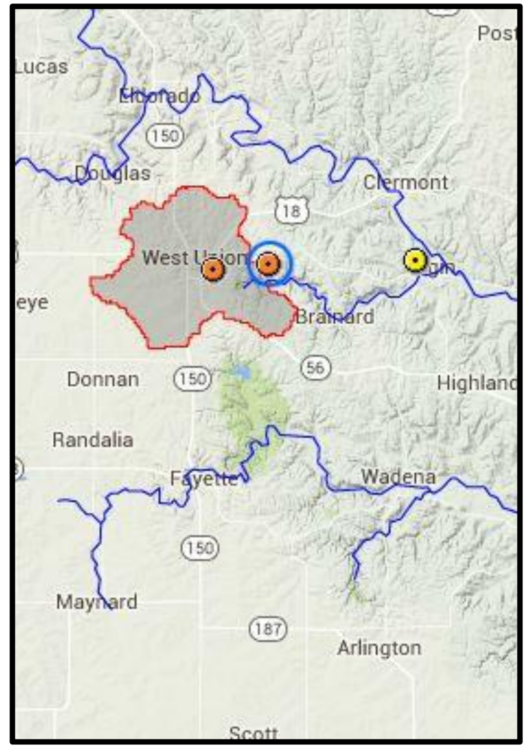

**Discussion:** Beaver Creek is a small tributary of the Cedar River. The watershed is the site of multiple IIHR research projects associated with both water quality and flooding. The data from the Beaver Creek nitrate sensors is interesting in that the upstream (Colwell) site has a lower nitrate concentration than the downstream site, which is atypical of Iowa watersheds. Intriguingly, there is a constructed CREP wetland upstream of the Colwell site (WQS0014) that may be producing this effect by lowering nitrate concentrations in the headwaters.

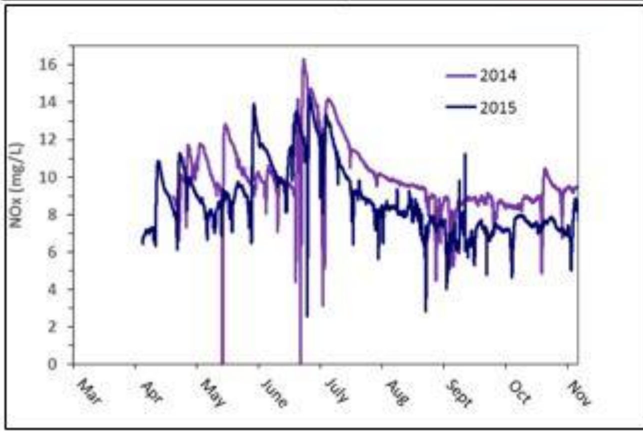
Six more CREP wetlands are planned for the watershed in the coming years which potentially could lower nitrate concentrations further.

**CREP Wetlands:** The Conservation Reserve Enhancement Program (CREP) is a major state/federal initiative to develop wetlands which are strategically located using advanced computer technology and designed to remove nitrate from tile-drainage water from cropland areas. Removal of nitrate from these waters helps protect drinking water supplies and reduce hypoxia in the Gulf of Mexico. The program is implemented in cooperation with the USDA Farm Service Agency (FSA) and is available in 37 Soil and Water Conservation Districts (SWCD) in the tile-drained region of Northern Iowa.

## 14. WQS0015 Otter Creek near Hornet Rd Elgin

| | |
|---|---|
| **Site No.** | **WQS0015** |
| **Name** | **Otter Creek at Hornet Rd near Elgin, Iowa** |
| **Location** | Left bank of Otter Creek, 30 ft downstream of Hornet Rd bridge (42.9500, -91.7538) |
| **WQ Parameters** | Nitrate + nitrite as N, turbidity, temperature |
| **Period of Record** | April 2014 - present |
| **Drainage Area** | 26 sq mi |
| **Funding Sources** | HUD |
| **Co-located Measurement** | IFC OTTRCRK03 (stage) |
| **Purpose & Significance** | Otter Creek is a tributary of the Turkey River in NE Iowa. This site is one of three nested sites within the Otter Creek watershed that are currently being operated by IIHR and are funded by HUD through the Iowa Watersheds Project. This site is part of a dense network of monitoring equipment that has been deployed to track watershed conditions associated with the construction of small-scale flood mitigation projects. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |




**Temporal nitrate concentration.**

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 8.7 | 1.2 | 14.3 | 2.9 |
| 2014 | 9.9 | 1.2 | 16.3 | 0.0 |

**Nitrate-N concentration measured for monitoring years 2014-2015.**

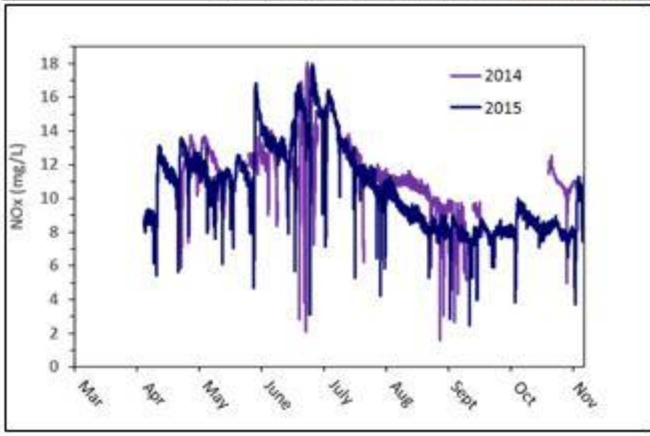
**Discussion:** Currently IIHR researchers are developing a hydrograph separation model that uses nitrate concentrations from three Otter Creek sites to examine the contributions of tile drainage, groundwater and surface/storm flow to the stream. Otter Creek is a tributary of the Turkey River, a major Iowa interior stream.

This site is about midway between the headwaters and the stream's confluence with the Turkey. There is no flow gauge.

Nitrate concentrations follow a typical pattern of decline from the headwaters downstream. Nitrate levels here are midway between those at the upstream site and those downstream at the mouth. This likely reflects dilution of headwater tile flow with lower nitrate groundwater as the stream progresses downstream.

## 15. WQS0016 Otter Creek at West Union

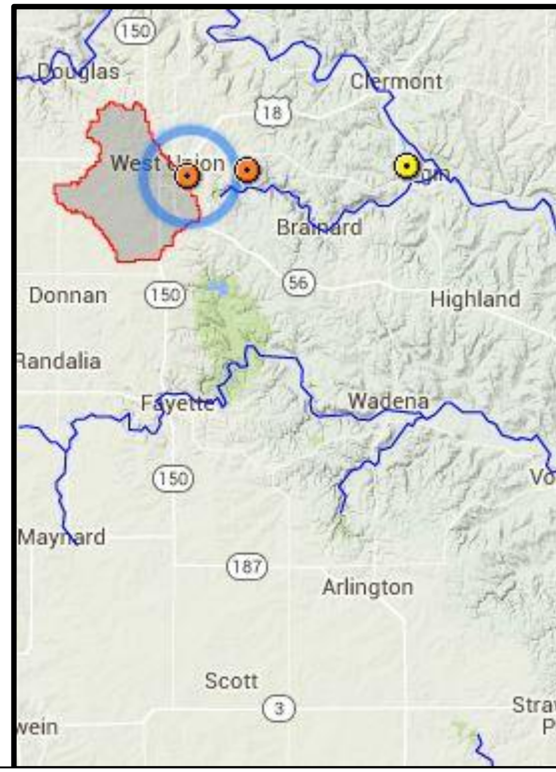
| Site No. | WQS0016 |
|---|---|
| Name | Otter Creek near West Union, Iowa |
| Location | Left bank of Otter Creek, 10 ft upstream of Echo Valley Rd bridge (42.9472, -91.7950) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2014 - present |
| Drainage Area | 15 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | IFC OTTRCRK04 (stage) |
| Purpose & Significance | Otter Creek is a tributary of the Turkey River in NE Iowa. This site is one of three nested sites within the Otter Creek watershed that are currently being operated by IIHR and are funded by HUD through the Iowa Watersheds Project. This site is part of a dense network of monitoring equipment that has been deployed to track watershed conditions associated with the construction of small-scale flood mitigation projects. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 10.5 | 1.4 | 18.0 | 2.5 |
| 2014 | 11.0 | 1.2 | 18.0 | 1.6 |

Nitrate-N concentration measured for monitoring years 2014-2015.



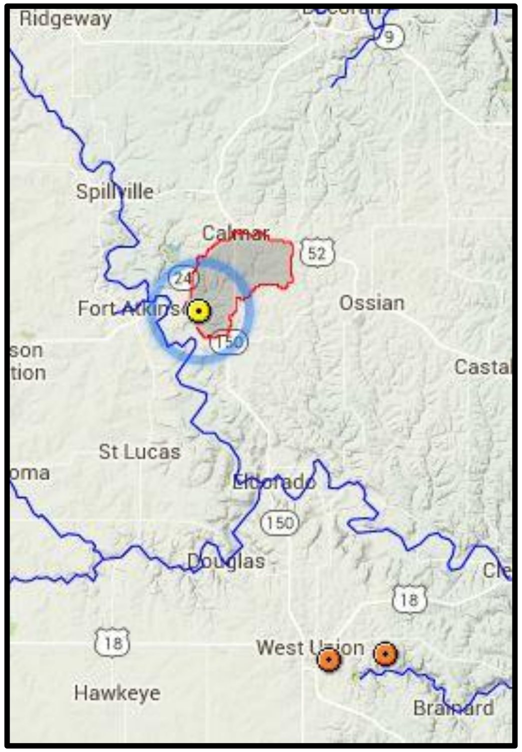

**Discussion:** Currently IIHR researchers are developing a hydrograph separation model that uses nitrate concentrations from three Otter Creek sites to examine the contributions of tile drainage, groundwater and surface/storm flow to the stream. Otter Creek is a tributary of the Turkey River, and major Iowa interior stream.

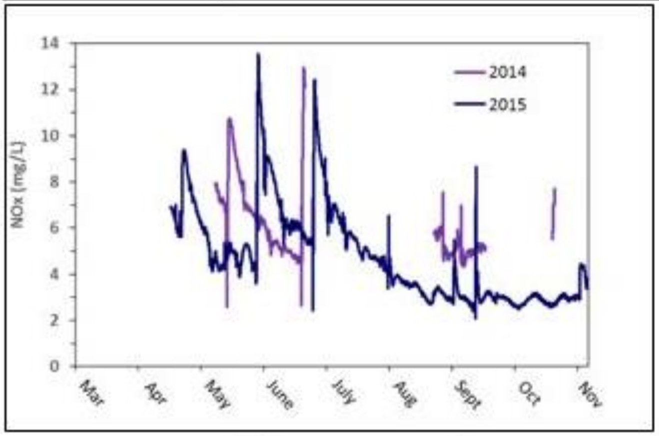
This site is near the headwaters and the city of West Union, which may provide an urban component to the water quality observed in this stream.

Nitrate concentrations follow a typical pattern of decline from the headwaters downstream. Nitrate levels here are higher than either of the two downstream sites. This likely reflects dilution of headwater tile flow with lower nitrate groundwater as the stream progresses downstream.

## 16. WQS0017 Brockcamp Creek near Ft. Atkinson

| Site No. | WQS0017 |
|---|---|
| Name | Brockcamp Creek near Fort Atkinson, Iowa |
| Location | Right bank of Bohemian Creek, 50 ft downstream of CR-B32 bridge (43.1335, -91.8893) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature |
| Period of Record | May 2014 – November 2015 |
| Drainage Area | 8 sq mi |
| Funding Sources | INRC |
| Co-located Measurement | IFC BRCKCMP01 (stage) |
| Purpose & Significance | Brockcamp (Bohemian) Creek is a tributary of the Turkey River in NE Iowa. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 4.9 | 0.9 | 13.6 | 2.1 |
| 2014 | 7.1 | 1.2 | 13.0 | 2.6 |

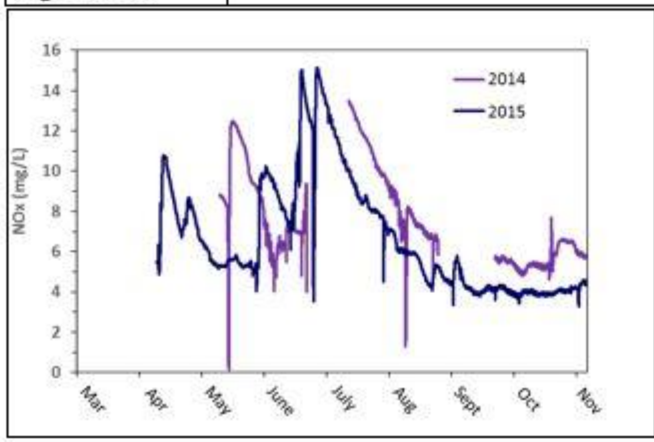
*** 2014 N Concentration values May-June & Aug-Oct only*

**Nitrate-N concentration measured for monitoring years 2014-2015.**

**Discussion:** This Winnishiek County stream is one of the few IIHR sites located within the Paleozoic Plateau (Driftless) Region of Iowa. Artificial drainage is usually not as necessary here as in other farmed areas of Iowa, and nitrate levels can be lower as a result. Still, concentrations here exceed 13 mg/L, far higher than most water quality objectives for Iowa waters.

## 17. WQS0018 Roberts Creek near Elkader

| Site No. | WQS0018 |
|---|---|
| Name | Roberts Creek near Elkader, Iowa |
| Location | Right bank of Roberts Creek, downstream of Hwy 13 bridge (42.8742, -91.3826) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature |
| Period of Record | May 2014 – November 2015 |
| Drainage Area | 116 sq mi |
| Funding Sources | INRC |
| Co-located Measurement | IFC RBRTSCR01 (stage) |
| Purpose & Significance | Roberts Creek is a tributary of the Turkey River in NE Iowa. This stream will not be monitored in 2016. |

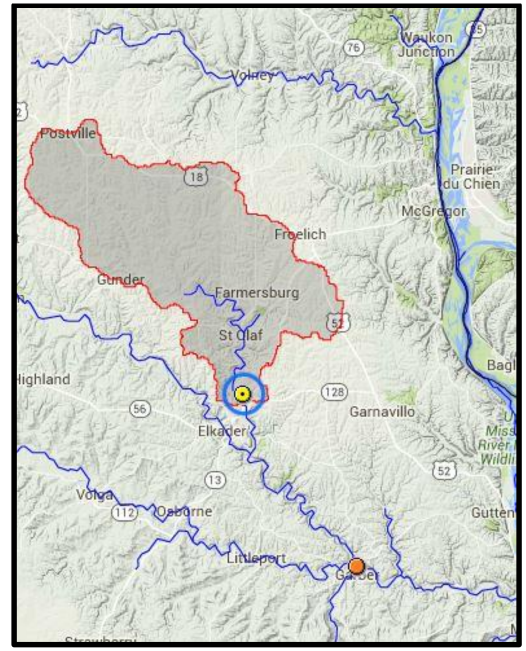



Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 6.7 | 1.2 | 15.1 | 3.3 |
| 2014 | 7.7 | 1.0 | 13.5 | 0.1 |

***2014 N Concentration values = May - Oct only*

**Nitrate-N concentration measured for monitoring years 2014-2015.**



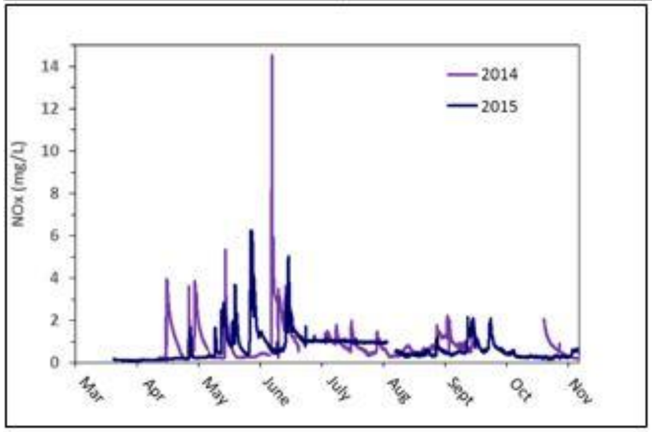

**Discussion:** Like WQS0017, this is another stream located within the Paleozoic Plateau (Driftless) Region of Iowa and the Turkey River Watershed. The Turkey Basin has been the focus of several IIHR research projects. Much of stream nitrate in this area originates from groundwater, and not necessarily tile water. The porous Karst materials found in the subsurface allow nitrate to infiltrate rapidly to shallow aquifers in the area.

**Karst** topography is a landscape formed from the dissolution of soluble rocks such as limestone, dolomite, and gypsum. It is characterized by underground drainage systems with sinkholes and caves. Karst is common in the Paleozoic Plateau (Driftless) Region of Northeast Iowa. Groundwater in this area is very vulnerable to contamination from surface activities. Rock outcroppings, deep and narrow valleys, and cool water streams are all characteristic of this Iowa region, the most unique geographic region in the state.

## 18. WQS0019 South Chequest Creek near Douds

| Site No. | WQS0019 |
|---|---|
| Name | South Chequest Creek near Douds, Iowa |
| Location | Left bank of S Chequest Creek, downstream of Yak Blvd bridge (40.7828, -92.1978) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2014 - present |
| Drainage Area | 31 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | IFC SCHQSTCR01 (stage) |
| Purpose & Significance | South Chequest creek is a tributary of the Des Moines River in SE Iowa. This site is currently being operated by IIHR and is funded by HUD through the Iowa Watersheds Project. This site is part of a dense network of monitoring equipment that has been deployed to track watershed conditions associated with the construction of small-scale flood mitigation projects. Research evaluates the use of water quality measurements to deduce groundwater, stormwater, and tile water contributions to the stream. |

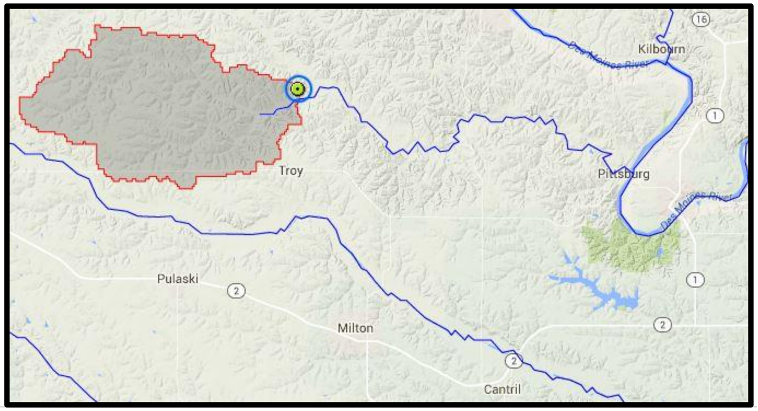
**Discussion:** The watershed of this small lower Des Moines River tributary is the site of numerous IIHR research efforts focusing on flooding. Nitrate concentrations are typically low relative to the rest of Iowa, although a reading of 14.5 mg/L was registered in 2014. This does not appear to have been an anomalous result and may have been the result of a release of some form into creek. Monitoring will continue into 2016. This stream is fairly characteristic of Southern Iowa Drift Plain streams.




**Temporal nitrate concentration.**

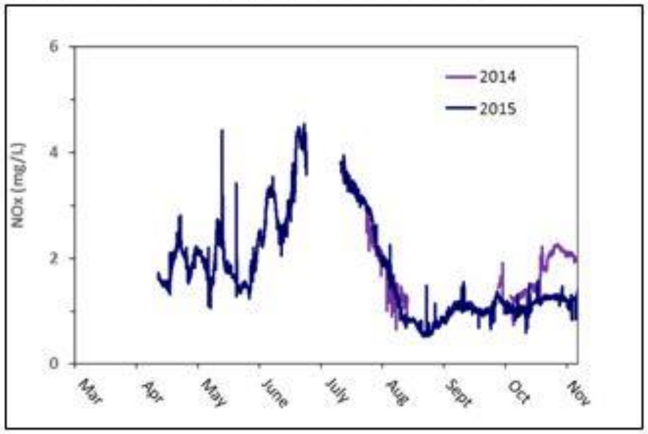
| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 0.7 | 0.4 | 6.3 | 0.1 |
| 2014 | 1.0 | 0.6 | 14.5 | 0.2 |

**Nitrate-N concentration measured for monitoring years 2014-2015.**



## 19. WQS0020 Mississippi River Pool 16 at Fairport

| Site No. | WQS0020 |
|---|---|
| Name | Mississippi River Pool 16 near Fairport, Iowa |
| Location | Right bank of Mississippi River, at Iowa DNR Fairport Fish Hatchery (41.4362, -90.8978) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | July 2014 - present |
| Drainage Area | 99300 sq mi |
| Funding Sources | IIHR, INRC |
| Co-located Measurement | 19.3mi downstream of Lock & Dam 15, US Army Corps of Engineers (Rock Island District) |
| Purpose & Significance | This site is located along Pool 16 of the Mississippi River near the Lucille A. Carver Mississippi Riverside Environmental Research Station operated by IIHR. |




**Temporal nitrate concentration.**

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 1.9 | 0.3 | 4.5 | 0.5 |
| 2014 | 1.8 | 0.2 | 3.0 | 0.6 |

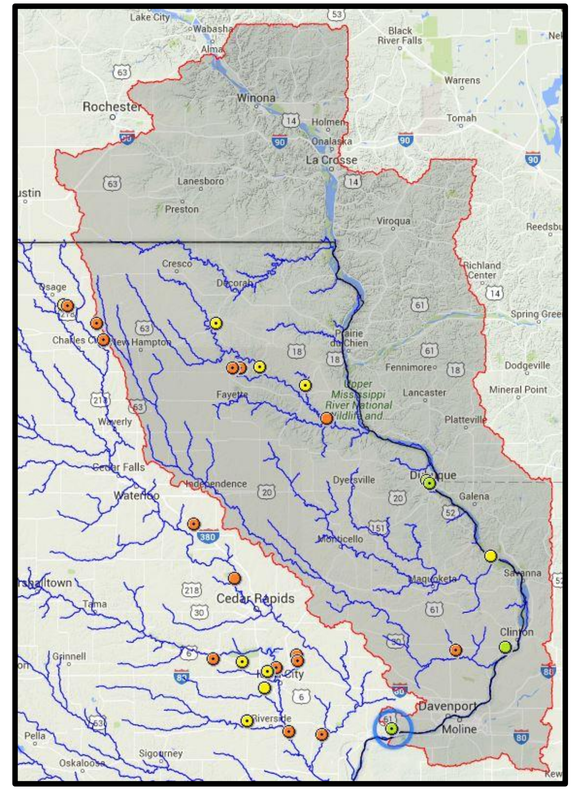
***2014 N Concentration values = July-Oct only*

**Nitrate-N concentration measured for monitoring years 2014-2015.**

**Discussion:** This is the only IIHR "Big River" water quality monitoring location. The nitrate sensor is located at the Lucille A. Carver Environmental Research Station near Muscatine.

Water quality in the two big rivers (Mississippi and Missouri) tends to be substantially different than interior streams. Because of the enormous upstream watershed area, water quality changes much more slowly. The area upstream of this sensor (not completely shown in the map) is almost twice Iowa's size.

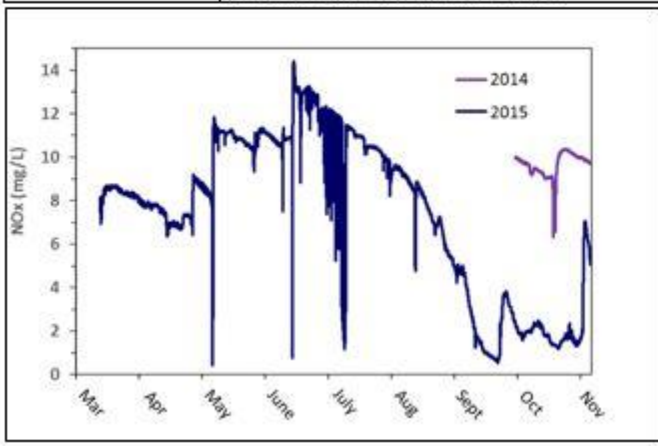
Nitrate concentrations are far lower than interior streams. This is because the high nitrate from streams like the Skunk and Turkey River is diluted by groundwater and lower nitrate concentrations from streams to the north of Iowa.




The lock and dam system on the Mississippi, and the huge reservoir dams on the Missouri, both affect water quality, mainly by settling solid materials. This has contributed to wetland erosion along the Louisiana coast. Levees on both rivers divorce the river from its flood plain. This removes the ability of backwater areas to process nutrients, effectively increasing nitrate and phosphorous concentrations in the river. Managing these rivers for navigation, flood control, water quality, and biodiversity is an enormous and challenging task for the country.

## 20. WQS0021 Rapid Creek near Iowa City

| Site No. | WQS0021 |
|---|---|
| Name | **Rapid Creek near Iowa City, Iowa** |
| Location | Left bank of Rapid Creek, 20ft downstream of Rapid Creek Rd NE bridge (41.7217, -91.4262) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | September 2014 - present |
| Drainage Area | 6 sq mi |
| Funding Sources | INRC-Rapid Creek |
| Co-located Measurement | IFC RAPIDCR01 (stage) |
| Purpose & Significance | Rapid Creek is a tributary of the Iowa River north of Iowa City. This site is located on the East Branch of Rapid Creek and is part of a paired watershed study of stacked best management practices funded by the INRC. |


Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 7.4 | 1.2 | 14.4 | 0.4 |
| 2014 | 9.7 | 0.3 | 10.4 | 6.4 |

**2014 values only part Sept - Oct*

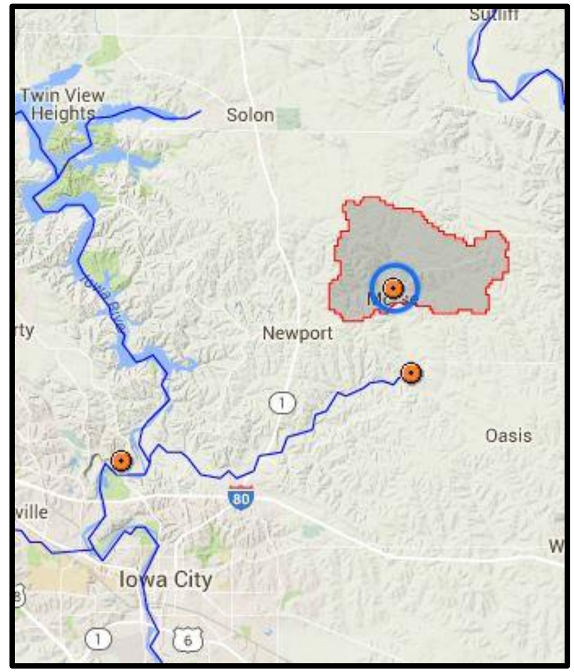
**Nitrate-N concentration measured for monitoring years 2014-2015.**

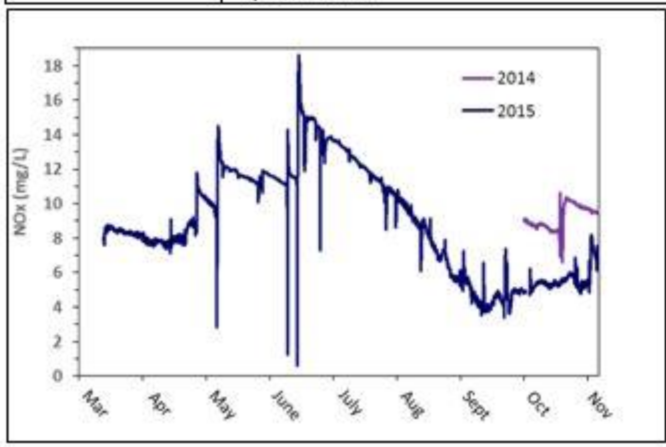
**Discussion:** This small watershed on the outskirts of Iowa City is the site of a paired watershed study. In this type of study, two or more similar watershed are studied for a period of time to assess how conservation practices manifest themselves in stream water quality. Presumably weather is affecting all the basins nearly equally.

Practices are not implemented in a "control" watershed, while practices are implemented in one or more "treatment" watersheds. Such practices might include cover crops, buffers, reduced tillage and others. This watershed is the control watershed of the study; WQS0022 is the treatment watershed. The study is ongoing, but thus far it appears the nitrate concentration has declined more in the control watershed.

## 21. WQS0022 Rapid Creek tributary near Iowa City

| | |
|---|---|
| Site No. | WQS0022 |
| Name | **Rapid Creek tributary near Iowa City, Iowa** |
| Location | Left bank of Rapid Creek, 10ft upstream of Putnam St NE bridge (41.7483, -91.4338) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH |
| Period of Record | September 2014 - present |
| Drainage Area | 3 sq mi |
| Funding Sources | INRC-Rapid Creek |
| Co-located Measurement | IFC RAPIDTRB01 (stage) |
| Purpose & Significance | Rapid Creek is a tributary of the Iowa River north of Iowa City. This site is located on a tributary of Rapid Creek and is part of a paired watershed study of stacked best management practices funded by the INRC. |




**Temporal nitrate concentration.**

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 8.9 | 1.1 | 18.6 | 0.6 |
| 2014 | 9.1 | 0.4 | 10.5 | 6.6 |

**2014 values only part Sept - Oct*

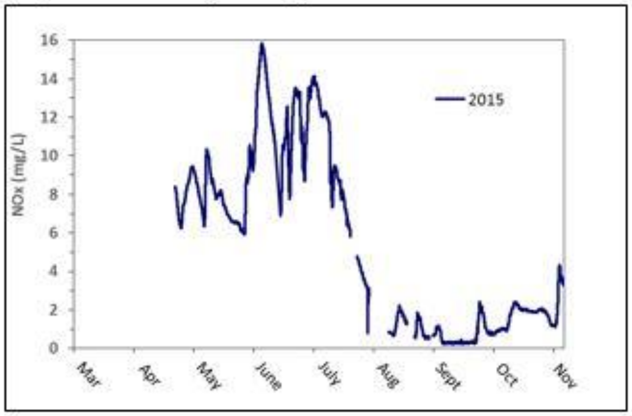
**Nitrate-N concentration measured for monitoring years 2014-2015.**

**Discussion:** This small watershed on the outskirts of Iowa City is the site of a paired watershed study. In this type of study, two or more similar watersheds are studied for a period of time to assess how conservation practices manifest themselves in stream water quality. Presumably weather is affecting all the basins nearly equally.

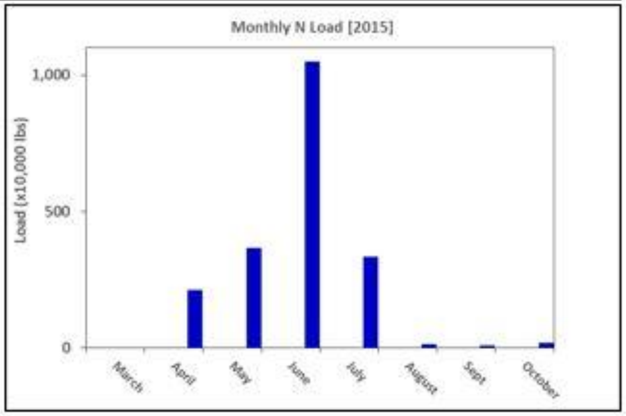
Practices are not implemented in a "control" watershed, while practices are implemented in one or more "treatment" watersheds. Such practices might include cover crops, buffers, reduced tillage and others. This watershed is the treatment watershed of the study; WQS0021 is the control watershed. The study is ongoing, but thus far it appears the nitrate concentration has declined more in the control watershed.

## 22. WQS0023 Wapsipinicon River near DeWitt

| Site No. | WQS0023 |
|---|---|
| Name | Wapsipinicon River near De Witt, Iowa |
| Location | Right bank of Wapsipinicon River, 80ft upstream of Scott Park Rd bridge (41.7668, -90.5349) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2015 - present |
| Drainage Area | 2336 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | USGS 05422000 (stage, discharge)<br>DNR Ambient Monitoring Site (Storet ID 10820001) |
| Purpose & Significance | The Wapsi River is a crucial site for N load estimations associated with the Iowa Nutrient Reduction Strategy. |




Temporal nitrate concentration.



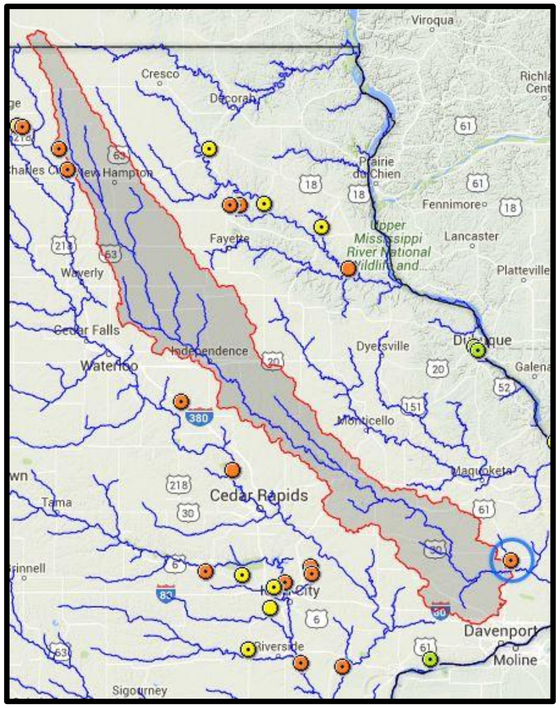

Monthly N load 2015.

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 5.5 | 1.4 | 15.8 | 0.2 | 1982 | 869 | 13100 | 398 | 20,015,334 | 13.4 |

Nitrate-N measured for monitoring year 2015.

Wapsipinicon facts:

- 291 miles long, headwaters are in Minnesota
- Drains the Iowan Surface; watershed is boundary between Iowan surface and Driftless Area

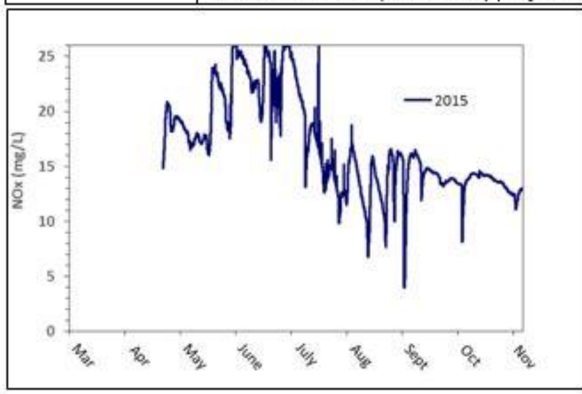



**Discussion:** The “Wapsi” is one of Iowa’s premier rivers for angling, offering an excellent cool and warm water fishery for walleye, northern pike and smallmouth bass and catfish. It can also have very high nitrate concentrations and loads, as illustrated by the 2015 data. Of the ten 2015 IIHR sites with load/N yield data, it ranked 7th highest in terms of N yield. Most of its course flows through the Iowan Surface Landform.

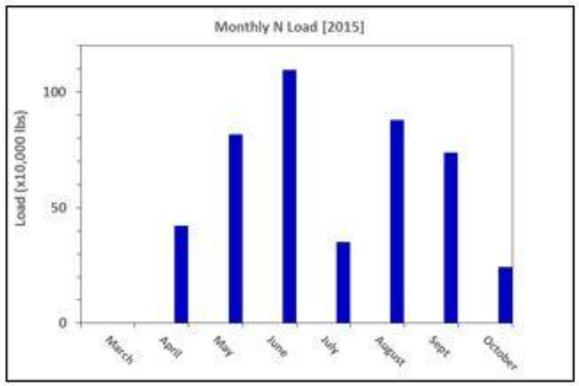
This will be a strategically important site in 2016 for load estimation associated with the Iowa Nutrient Reduction Strategy.

## 23. WQS0024 South Fork of the Iowa River near New Providence

| Site No. | WQS0024 |
|---|---|
| Name | **South Fork Iowa River near New Providence, Iowa** |
| Location | Right bank of SF Iowa River, 40ft upstream of R Ave bridge (42.3149, -93.1524) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature |
| Period of Record | April 2015 - present |
| Drainage Area | 224 sq mi |
| Funding Sources | INRC |
| Co-located Measurement | USGS 05451210 (stage, discharge) |
| Purpose & Significance | The South Fork Iowa River is a major tributary of the Iowa River in north-central Iowa, which drains an area of intense crop and livestock production. This site is co-located with an Agricultural Research Service (USDA-ARS) project area. |




**Temporal nitrate concentration.**




**Monthly N load 2015.**

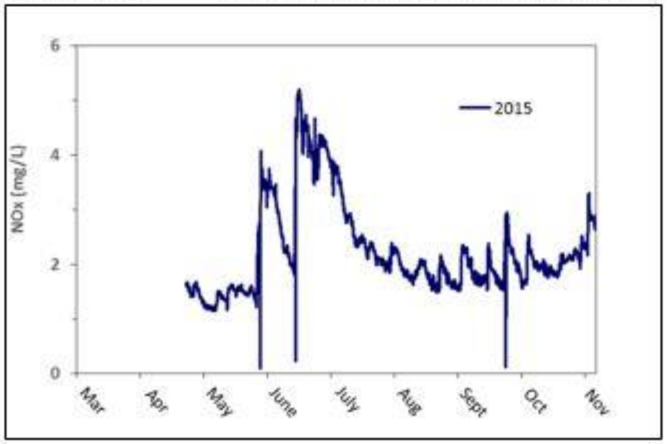

| | Nitrate-N Concentration (mg/L) | | | | Discharge (cubic feet per second-cfs) | | | | N Load (lbs) | N Yield (lbs/acre) |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Avg (Apr-Oct) | St Dev | Max | Min | Avg (Apr-Oct) | St Dev | Max | Min | Tot (Apr-Oct) | Tot (Apr-Oct) |
| 2015 | 16.7 | 2.2 | 26.0 | 4 | 237 | 236 | 3940 | 38 | 4,539,466 | 31.7 |

**Nitrate-N concentration measured for monitoring year 2015.**

**Discussion:** Of the ten 2015 IIHR monitoring sites with N yield data, this site is by far the highest. Its per acre nitrate-N loss was 32 lbs for the April to October period, almost double the next highest site. This is an area of intense crop and livestock production, and it drains the intensely-tiled Des Moines Lobe Landform, a perfect formula for high nitrate concentrations. There are about 100 confined swine-feeding operations, most of which are located in Tipton Creek and the upper South Fork. For these reasons, this site is of interest to both water quality and agronomic researchers. The Agriculture Research Service arm of USDA has studied this watershed for many years. Because of its extremely high nitrate levels, this could be a good watershed to demonstrate the effectiveness of various practices.

## 24. WQS0025 South Fork of Catfish Creek near Dubuque

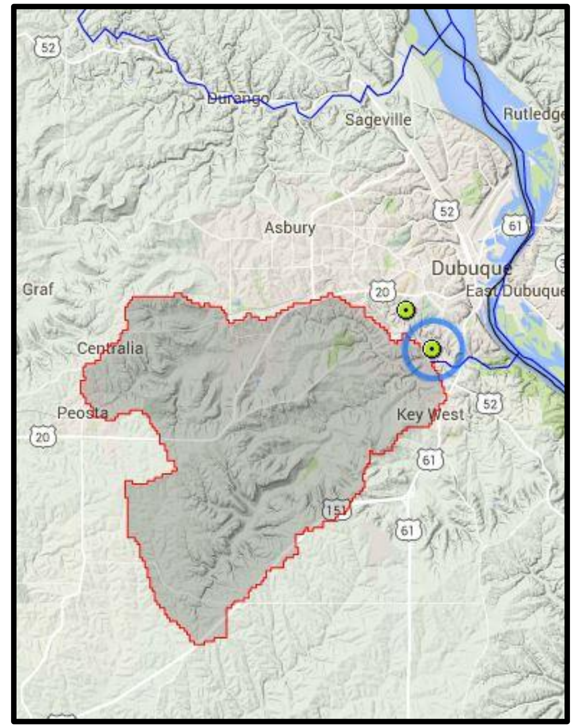
| Site No. | WQS0025 |
|---|---|
| Name | South Fork Catfish Creek at Dubuque, Iowa |
| Location | Right bank of Catfish Creek, upstream of Manson Rd bridge (42.4673, -90.6829) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2015 - present |
| Drainage Area | 41 sq mi |
| Funding Sources | INRC, City of Dubuque |
| Co-located Measurement | IFC CTFSHCR01 (stage) |
| Purpose & Significance | This site is one of two sites located on Catfish Creek related to a nutrient trading study funded by the INRC. The City of Dubuque is a partner of this site. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 2.2 | 0.5 | 5.2 | 0.1 |

Nitrate-N concentration measured for monitoring year 2015.

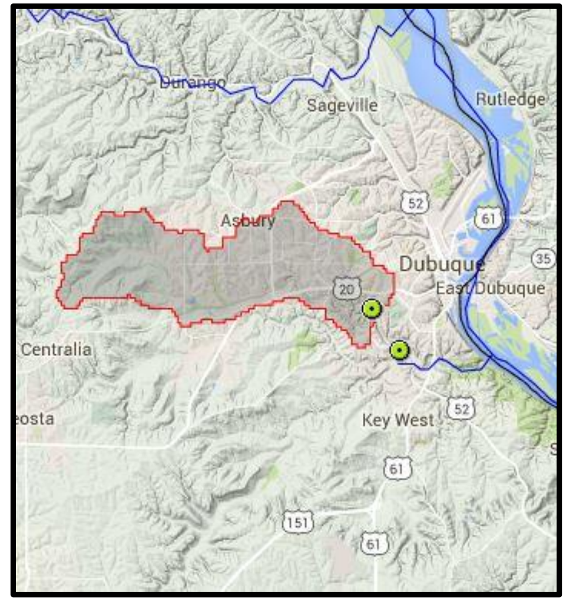


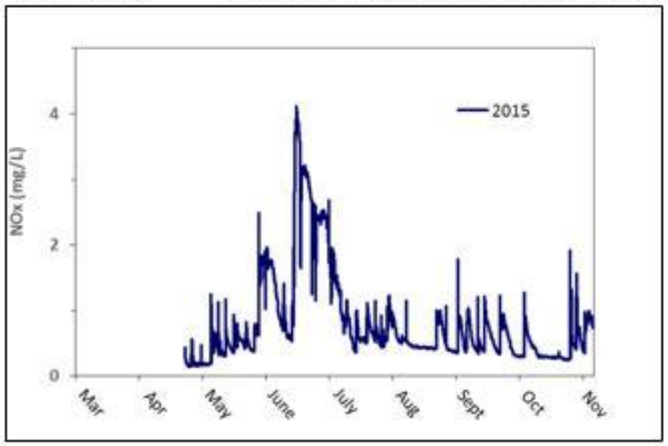

**Discussion:** Nutrient trading is an idea for improving water quality. The idea stems from the fact that costs to reduce nutrient loads from point sources may be far greater than the cost to reduce the same load amount from a non-point source. Wastewater treatment plants essentially pay upstream landowners to implement practices that will create load reduction credits for the point source discharger.

One IIHR research project focuses on the practicality of nutrient trading in this small watershed. Unlike many places in Iowa, it may actually be a good solution here because of the large point source discharge at the City of Dubuque wastewater treatment provides upstream farmers with a practical trading partner. The mostly agricultural south fork of this stream (this site) tends to have a higher nitrate level than the mostly urban middle fork.

## 25. Middle Fork of Catfish Creek near Dubuque

| Site No. | WQS0026 |
|---|---|
| Name | Middle Fork Catfish Creek at Dubuque, Iowa |
| Location | Right bank of Catfish Creek, upstream of Fremont Ave bridge (42.4812, -90.6953) |
| WQ Parameters | Nitrate + nitrite as N, turbidity, temperature, specific conductance, pH, dissolved oxygen |
| Period of Record | April 2015 - present |
| Drainage Area | 13 sq mi |
| Funding Sources | HUD |
| Co-located Measurement | None |
| Purpose & Significance | This site is one of two sites located on Catfish Creek related to a nutrient trading study funded by the INRC. The City of Dubuque is a partner of this site. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Apr-Oct) | St Dev | Max | Min |
| 2015 | 0.8 | 0.4 | 4.1 | 0.1 |

Nitrate-N concentration measured for monitoring year 2015.

**Advantages of Water Quality Trading compared to regulations:**

•allowing individual entities flexibility in choosing pollution-abatement technologies and practices (e.g., flexibility for the farmers to choose which BMPs to implement)

•providing incentives to innovate within the pollution-abatement sphere

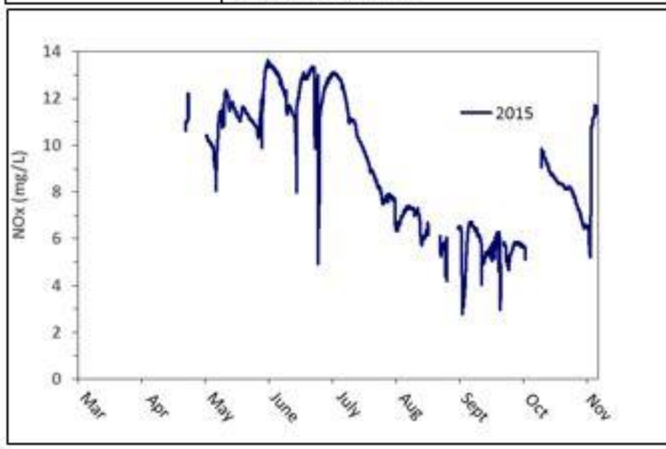
•addressing future growth in the basin while meeting water quality goals

**Discussion:** Nutrient trading is an idea for improving water quality. The idea stems from the fact that costs to reduce nutrient loads from point sources may be far greater than the cost to reduce the same load amount from a non-point source. Wastewater treatment plants essentially pay upstream landowners to implement practices that will create load reduction credits for the point source discharger.

One IIHR research project focuses on the practicality of nutrient trading in this small watershed. Unlike many places in Iowa, it may actually be a good solution here because of the large point source discharge at the City of Dubuque wastewater treatment provides upstream farmers with a practical trading partner. The mostly urban middle fork of this stream (this site) tends to have a lower nitrate level than the mostly agricultural south fork.

## 26. WQS0027 Lime Creek near Brandon

| | |
|---|---|
| **Site No.** | **WQS0027** |
| **Name** | **Lime Creek near Brandon, Iowa** |
| **Location** | Left bank of Lime Creek, 15ft downstream of Benton-Buchanan Rd bridge (42.2974, -92.0177) |
| **WQ Parameters** | Nitrate + nitrite as N |
| **Period of Record** | April 2015 - present |
| **Drainage Area** | 41 sq mi |
| **Funding Sources** | Coe College, INRC |
| **Co-located Measurement** | IFC LIMECR01 (stage) |
| **Purpose & Significance** | Lime Creek is a tributary of the Cedar River in east-central Iowa. This nitrate sensor at this site is owned and operated by Coe College, and is part of a long-term monitoring project in the Lime Creek watershed. |




**Temporal nitrate concentration.**

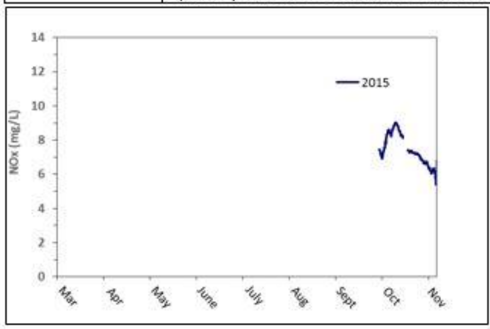
| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| **Year** | **Avg (Apr-Oct)** | **St Dev** | **Max** | **Min** |
| 2015 | 9.2 | 1.0 | 13.6 | 2.8 |

**Nitrate-N concentration measured for monitoring year 2015.**


**Discussion**: Lime Creek is a tributary of the Cedar River. Monitoring here is coordinated by Coe College, with maintenance and data management assistance provided IIHR beginning in 2015. The Cedar River and groundwater under its influence are an important source of municipal drinking water for the downstream city of Cedar Rapids. Data from this site illustrates that nitrate levels can frequently exceed the drinking water standard of 10 mg/L in the Cedar watershed.

## 27. WQS0028 and WQS0029 Des Moines River and Groundwater Well at Boone

| Site No. | WQS0028 |
|---|---|
| Name | Des Moines River near Boone, Iowa |
| Location | Left bank of Des Moines River, 0.1mi upstream of 188th Rd bridge (42.0823, -93.9385) |
| WQ Parameters | Nitrate + nitrite as N |
| Period of Record | 2015 |
| Drainage Area | |
| Funding Sources | INRC |
| Co-located Measurement | |
| Purpose & Significance | This site is one of two sites located in the Des Moines River watershed in cooperation with the City of Boone Water Work to evaluate the river-groundwater interaction at/near the Water Works intake wells. This site is located upstream of the Saylorville Reservoir and may be used to help quantify loads associated with activities upstream of the reservoir. |

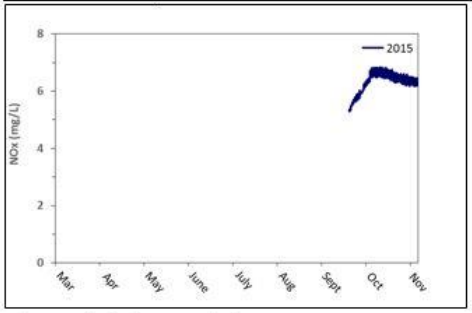



Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Sept-Oct) | St Dev | Max | Min |
| 2015 | 7.5 | 0.6 | 9.0 | 5.4 |

Nitrate-N concentration measured for monitoring year 2015.

| Site No. | WQS0029 |
|---|---|
| Name | Des Moines River alluvial well near Boone, Iowa |
| Location | 240ft south of 188th Rd, 260ft east of left bank of Des Moines River (42.0800, -93.9363) |
| WQ Parameters | Nitrate + nitrite as N |
| Period of Record | Planned September 2015 |
| Drainage Area | |
| Funding Sources | INRC |
| Co-located Measurement | |
| Purpose & Significance | This site is one of two sites located in the Des Moines River watershed in cooperation with the City of Boone Water Work to evaluate the river-groundwater interaction at/near the Water Works intake wells. This site is located upstream of the Saylorville Reservoir and may be used to help quantify loads associated with activities upstream of the reservoir. |




Temporal nitrate concentration.

| Nitrate-N Concentration (mg/L) | | | | |
|---|---|---|---|---|
| Year | Avg (Sept-Oct) | St Dev | Max | Min |
| 2015 | 6.0 | 0.3 | 6.8 | 5.3 |

Nitrate-N concentration measured for monitoring year 2015.

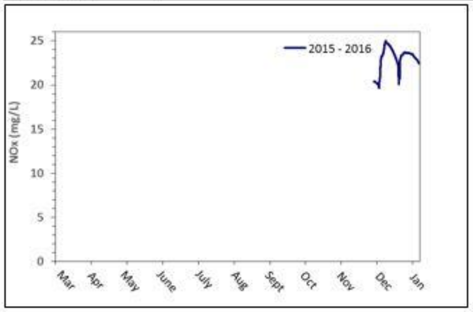

**Discussion:** these sites were installed in late 2015 as part of a pilot project with the Boone Waterworks (BWW). BWW obtains water for the City from several wells located along the east bank of the Des Moines River. Water quality in these wells, including nitrate levels, is directly affected by water quality and river stage of the adjacent Des Moines River.

The data shows nitrate levels in the well following those in the river, with the concentration in the well about 80% of that in the river. This lower level may be due to dilution from groundwater in the surrounding river valley, or due to processing of nitrate by organisms in the sands and gravels of the river bed and bank, as the water seeps into the well from the Des Moines River. These and research questions will be explored in 2016.

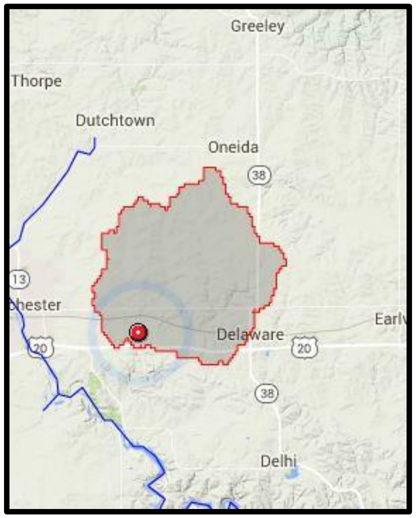
**Des Moines River:** This is the longest interior river in Iowa and the 32nd longest river in the continental U.S. It travels 525 miles from its source in Minnesota to its confluence with the Mississippi at Keokuk. Along with its major tributary the Raccoon River, its watershed covers about 14,000 square miles or about ¼ of Iowa. Along with Boone, Des Moines and Ottumwa both use the water for municipal supply. Nitrate loads from this important stream will be quantified next year with an IIHR sensor at Keosauqua.

## 28. WQS0030 Manchester Fish Hatchery and WQS0031 Big Spring Fish Hatchery

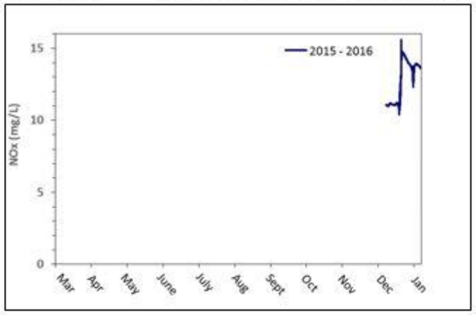
| Site No. | WQS0030 |
|---|---|
| Name | Manchester Fish Hatchery near Delaware, Iowa |
| Location | 42.4621, -91.3969 |
| WQ Parameters | Nitrate + nitrite as N |
| Period of Record | 2015 |
| Drainage Area | |
| Funding Sources | INRC |
| Co-located Measurement | |
| Purpose & Significance | This location is a groundwater monitoring site and will be operated in cooperation with Iowa DNR. |




Temporal nitrate concentration.




| Site No. | WQS0031 |
|---|---|
| Name | Big Spring Fish Hatchery near Elkader, Iowa |
| Location | 42.9201, -91.4862 |
| WQ Parameters | Nitrate + nitrite as N |
| Period of Record | 2015 |
| Drainage Area | |
| Funding Sources | DNR, INRC |
| Co-located Measurement | |
| Purpose & Significance | Big Spring is a long-term groundwater monitoring site in an area of karst formation. This research site will be operated in cooperation with Iowa DNR. |




Temporal nitrate concentration.


**Discussion**: These sensors were installed in late 2015 in collaboration with Iowa DNR. Both are measuring groundwater nitrate in DNR fish hatcheries. These sites provide a good way to constructively use the monitoring equipment in the winter months. The sites are both located in the Paleozoic Plateau region of Iowa. Karst geology makes shallow groundwater, like that emerging from these springs, very vulnerable to surface contamination. Both sites, especially the Manchester site, have quite high nitrate levels. Monitoring here will continue throughout 2016.

## 29. Summary Tables

The tables that follow summarize and aggregate data so the reader can make comparisons between sites and years.

Landform Abbreviations:

- **AP:** Mississippi Alluvial Plain
- **DML:** Des Moines Lobe
- **IS:** Iowan Surface
- **PP:** Paleozoic Plateau
- **SIDP:** Southern Iowa Drift Plain

| Site | Description | Watershed Area ($mi^2$) | Landform(s) | Climate Zone(s) | Period | Ave NO3-N Concentration (mg/L) | Concentration Rank | NO3-N Load (lbs) | NO3-N Yield (lbs/acre) | Yield Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | 3147 | DML, IS, SIDP | NC, C, EC | Sep-Oct | 0.5 | 6 of 7 | 22,431 | 0.1 | NA |
| 0002 | Clear Creek Coralville | 98 | SIDP | EC | Jun-Oct | 1.7 | 3 of 7 | 25,224 | 0.4 | 2 of 4 |
| 0003 | Clear Creek Oxford | 61 | SIDP | EC | Jun-Oct | 2.5 | 2 of 7 | 23,052 | 0.6 | 1 of 4 |
| 0004 | Clear Cr. Homestead | 8 | SIDP | EC | Jun-Oct | 2.9 | 1 of 7 | NA | NA | NA |
| 0005 | English R. Kalona | 576 | SIDP | C, EC, SE | Jun-Oct | 0.7 | 5 of 7 | 57,235 | 0.2 | 4 of 4 |
| 0006 | Iowa River Lone Tree | 4293 | DML, IS, SIDP, AP | NC, C, EC, SE | Jun-Oct | 1.2 | 4 of 7 | 762,025 | 0.3 | 3 of 4 |
| 0007 | Cedar River Conesville | 7787 | IS, SIDP, AP | NC, NE, EC, SE | Jul-Oct | 0.4 | 7 of 7 | 307,732 | 0.1 | NA |

**Table 3: 2012 Nitrate Data**

| Site | Description | Watershed Area ($mi^2$) | Landform(s) | Climate Zone(s) | Period | Ave NO3-N Concentration (mg/L) | Concentration Rank | NO3-N Load (lbs) | NO3-N Yield (lbs/acre) | Yield Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | 3147 | DML, IS, SIDP | NC, C, EC | Apr-Oct | 6.5 | 3 of 10 | 44,345,044 | 22.0 | 3 of 6 |
| 0002 | Clear Creek Coralville | 98 | SIDP | EC | Apr-Oct | 5.1 | 8 of 10 | 1,518,478 | 24.2 | 1 of 6 |
| 0003 | Clear Creek Oxford | 61 | SIDP | EC | Apr-Oct | 5.7 | 5 of 10 | 888,592 | 22.8 | 2 of 6 |
| 0004 | Clear Cr. Homestead | 8 | SIDP | EC | Apr-Oct | 6.9 | 2 of 10 | NA | NA | NA |
| 0005 | English R. Kalona | 576 | SIDP | C, EC, SE | Apr-Oct | 4.1 | 9 of 10 | 6,566,589 | 17.8 | 5 of 6 |
| 0006 | Iowa River Lone Tree | 4293 | DML, IS, SIDP | NC, C, EC, SE | Apr-Oct | 5.7 | 6 of 10 | 54,887,205 | 20.0 | 4 of 6 |
| 0007 | Cedar River Conesville | 7787 | IS, SIDP | NC, NE, EC, SE | Apr-Oct | 5.4 | 7 of 10 | 78,186,981 | 15.7 | 6 of 6 |
| 0008 | Slough Creek Wetland Outlet | 6 | IS | NE | May-Oct | 9.4 | 1 of 10 | NA | NA | NA |
| 0009 | Otter Cr. Elgin | 46 | IS | NE | July-Oct | 6.0 | 4 of 10 | NA | NA | NA |
| 0010 | Skunk River Augusta | 4312 | DML, SIDP, AP | NC, C, SE | July-Oct | 2.4 | 10 of 10 | 2,150,224 | 0.8 | NA |

**Table 4: 2013 Nitrate Data**

| Site | Description | Watershed Area ($mi^2$) | Landform(s) | Climate Zone(s) | Period | Ave NO3-N Concentration (mg/L) | Conc. Rank | NO3-N Load (lbs) | NO3-N Yield (lbs/acre) | Yield Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | 3147 | DML, IS, SIDP | NC, C, EC | Apr-Oct | 6.1 | 15 of 19 | 26,639,062 | 13.2 | 6 of 8 |
| 0002 | Clear Creek Coralville | 98 | SIDP | EC | Apr-Oct | 6.2 | 14 of 19 | 1,106,409 | 17.6 | 2 of 8 |
| 0003 | Clear Creek Oxford | 61 | SIDP | EC | Apr-Oct | 7.5 | 9 of 19 | 798,031 | 20.4 | 1 of 8 |
| 0004 | Clear Cr. Homestead | 8 | SIDP | EC | Apr-Oct | 8.9 | 7 of 19 | NA | NA | NA |
| 0005 | English R. Kalona | 576 | SIDP | C, EC, SE | Apr-Oct | 4.6 | 18 of 19 | 3,619,822 | 9.8 | 8 of 8 |
| 0006 | Iowa River Lone Tree | 4293 | DML, IS, SIDP | NC, C, EC, SE | May-Oct | 6.6 | 13 of 19 | 39,726,137 | 14.5 | 4 of 8 |
| 0007 | Cedar River Conesville | 7787 | IS, SIDP | NC, NE, EC, SE | May-Oct | 5.8 | 16 of 19 | 86,029,683 | 17.3 | 3 of 8 |
| 0008 | Slough Creek Wetland Outlet | 6 | IS | NE | May-Oct | 6.7 | 12 of 19 | NA | NA | NA |
| 0009 | Otter Cr. Elgin | 46 | PP | NE | Apr-Oct | 6.8 | 11 of 19 | 399,938 | 13.6 | 5 of 8 |
| 0010 | Skunk River Augusta | 4312 | DML, SIDP, AP | NC, C, SE | May-Oct | 5.6 | 17 of 19 | 30,720,060 | 11.1 | 7 of 8 |
| 0011 | Clear Creek South Amana | 10 | SIDP | EC | Apr-Oct | 9.4 | 6 of 19 | NA | NA | NA |
| 0012 | Slough Creek Wetland Inlet | 5 | IS | EC | May-Oct | 11.2 | 2 of 19 | NA | NA | NA |
| 0013 | Beaver Cr Bassett | 17 | IS | NE | May-Oct | 10.8 | 4 of 19 | NA | NA | NA |
| 0014 | Beaver Cr Colwell | 7 | IS | NE | Apr-Oct | 11.5 | 1 of 19 | NA | NA | NA |
| 0015 | Otter Cr Hornet Rd | 26 | PP | NE | Apr-Oct | 9.9 | 5 of 19 | NA | NA | NA |
| 0016 | Otter Cr West Union | 15 | IS | NE | Apr-Oct | 11.0 | 3 of 19 | NA | NA | NA |
| 0017 | Brockcamp Cr Ft. Atkinson | 8 | PP | NE | May-Oct | 7.1 | 10 of 19 | NA | NA | NA |
| 0018 | Roberts Cr Elkader | 116 | PP | NE | May-Oct | 7.7 | 8 of 19 | NA | NA | NA |
| 0019 | S. Chequest Cr. Douds | 31 | SIDP | SE | Apr-Oct | 1.0 | 19 of 19 | NA | NA | NA |
| 0020 | Mississippi River Fairport | 99,300 | Multiple | Multiple | July-Oct | 1.8 | NA | NA | NA | NA |
| 0021 | Rapid Cr Iowa City | 6 | SIDP | EC | Oct | 9.6 | NA | NA | NA | NA |
| 0022 | Rapid Cr tributary Iowa City | 3 | SIDP | EC | Oct | 9.3 | NA | NA | NA | NA |

**Table 5: 2014 Nitrate Data**

| Site | Description | Watershed Area ($mi^2$) | Landform(s) | Climate Zone(s) | Period | Ave NO3-N Concentration (mg/L) | Conc. Rank | NO3-N Load (lbs) | NO3-N Yield (lbs/acre) | Yield Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | 3147 | DML, IS, SIDP | NC, C, EC | Apr-Oct | 7.7 | 9 of 26 | 31,721,795 | 15.8 | 3 of 10 |
| 0002 | Clear Creek Coralville | 98 | SIDP | EC | Apr-Oct | 5.7 | 19 of 26 | 737,778 | 11.8 | 9 of 10 |
| 0003 | Clear Creek Oxford | 61 | SIDP | EC | Apr-Oct | 7.4 | 10 of 26 | 696,780 | 17.8 | 2 of 10 |
| 0005 | English R. Kalona | 576 | SIDP | C, EC, SE | Apr-Oct | 6.2 | 17 of 26 | 5,106,900 | 13.9 | 6 of 10 |
| 0006 | Iowa River Lone Tree | 4293 | DML, IS, SIDP | NC, C, EC, SE | Apr-Oct | 6.9 | 14 of 26 | 39,515,982 | 14.4 | 5 of 10 |
| 0007 | Cedar River Conesville | 7787 | IS, SIDP | NC, NE, EC, SE | Apr-Oct | 6.4 | 16 of 26 | 65,718,219 | 13.2 | 8 of 10 |
| 0008 | Slough Creek Wetland Outlet | 6 | IS | NE | Apr-Oct | 3.9 | 22 of 26 | NA | NA | NA |
| 0009 | Otter Cr. Elgin | 46 | PP | NE | Apr-Oct | 5.8 | 18 of 26 | 194,642 | 6.6 | |
| 0010 | Skunk River Augusta | 4312 | DML, SIDP, AP | NC, C, SE | Apr-Oct | 7.0 | 13 of 26 | 40,388,335 | 14.6 | 4 of 10 |
| 0011 | Clear Creek South Amana | 10 | SIDP | EC | Apr-Oct | 9.7 | 4 of 26 | NA | NA | NA |
| 0012 | Slough Creek Wetland Inlet | 5 | IS | EC | Apr-Oct | 9.8 | 3 of 26 | NA | NA | NA |
| 0013 | Beaver Cr Bassett | 17 | IS | NE | Apr-Oct | 9.3 | 5 of 26 | NA | NA | NA |
| 0014 | Beaver Cr Colwell | 7 | IS | NE | Apr-Oct | 7.2 | 12 of 26 | NA | NA | NA |
| 0015 | Otter Cr Hornet Rd | 26 | PP | NE | Apr-Oct | 8.7 | 8 of 26 | NA | NA | NA |
| 0016 | Otter Cr West Union | 15 | IS | NE | Apr-Oct | 10.5 | 2 of 26 | NA | NA | NA |
| 0017 | Brockcamp Cr Ft. Atkinson | 8 | PP | NE | Apr-Oct | 4.9 | 21 of 26 | NA | NA | NA |
| 0018 | Roberts Cr Elkader | 116 | PP | NE | Apr-Oct | 6.7 | 15 of 26 | NA | NA | NA |
| 0019 | S. Chequest Cr. Douds | 31 | SIDP | SE | Apr-Oct | 0.7 | 26 of 26 | NA | NA | NA |
| 0020 | Mississippi River Fairport | 99,300 | Multiple | Multiple | Apr-Oct | 1.9 | 24 of 26 | NA | NA | NA |
| 0021 | Rapid Cr Iowa City | 6 | SIDP | EC | Apr-Oct | 7.4 | 11 of 26 | NA | NA | NA |
| 0022 | Rapid Cr tributary Iowa City | 3 | SIDP | EC | Apr-Oct | 8.9 | 7 of 26 | NA | NA | NA |
| 0023 | Wapsipinicon R. at De Witt | 2336 | IS, SIDP | NE, EC | Apr-Oct | 5.5 | 20 of 26 | 20,015,334 | 13.4 | 7 of 10 |
| 0024 | S. Fork of Iowa R. at New Providence | 224 | DML | C | Apr-Oct | 16.7 | 1 of 26 | 4,539,466 | 31.7 | 1 of 10 |
| 0025 | S. Fork Catfish Cr Dubuque | 41 | PP | NE | Apr-Oct | 2.2 | 23 of 26 | NA | NA | NA |
| 0026 | Middle Fork Catfish Cr Dubuque | 13 | PP | NE | Apr-Oct | 0.8 | 25 of 26 | NA | NA | NA |
| 0027 | Lime Creek Brandon | 41 | IS | EC | Sept-Oct | 9.2 | 6 of 26 | NA | NA | NA |
| 0028 | Des Moines River Boone | 5452 | DML | NC, C | Sept-Oct | 7.5 | NA | NA | NA | NA |
| 0029 | Alluvial Well Boone | 5452 | DML | NC, C | Apr-Oct | 6.0 | NA | NA | NA | NA |

**Table 6: 2015 Nitrate Data**

| Site | Description | Watershed Area ($mi^2$) | Landform(s) | Climate Zone(s) | Concentration (mg/L) | | | | Yield (lbs/acre) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2012 | 2013 | 2014 | 2015 | 2012 | 2013 | 2014 | 2015 |
| 0001 | Iowa River Iowa City | 3147 | DML, IS, SIDP | NC, C, EC | 0.5 | 6.5 | 6.1 | 7.7 | 0.1 | 22.0 | 13.2 | 15.8 |
| 0002 | Clear Creek Coralville | 98 | SIDP | EC | 1.7 | 5.1 | 6.2 | 5.7 | 0.4 | 24.2 | 17.6 | 11.8 |
| 0003 | Clear Creek Oxford | 61 | SIDP | EC | 2.5 | 5.7 | 7.5 | 7.4 | 0.6 | 22.8 | 20.4 | 17.8 |
| 0004 | Clear Cr. Homestead | 8 | SIDP | EC | 2.9 | 6.9 | 8.9 | | | | | |
| 0005 | English R. Kalona | 576 | SIDP | C, EC, SE | 0.7 | 4.1 | 4.6 | 6.2 | 0.2 | 17.8 | 9.8 | 13.9 |
| 0006 | Iowa River Lone Tree | 4293 | DML, IS, SIDP | NC, C, EC, SE | 1.2 | 5.7 | 6.6 | 6.9 | 0.3 | 20.0 | 14.5 | 14.4 |
| 0007 | Cedar River Conesville | 7787 | IS, SIDP | NC, NE, EC, SE | 0.4 | 5.4 | 5.8 | 6.4 | 0.1 | 15.7 | 17.3 | 13.2 |
| 0008 | Slough Creek Wetland Outlet | 6 | IS | NE | | 9.4 | 6.7 | 3.9 | | | | |
| 0009 | Otter Cr. Elgin | 46 | PP | NE | | 6.0 | 6.8 | 5.8 | | | 13.6 | 6.6 |
| 0010 | Skunk River Augusta | 4312 | DML, SIDP, AP | NC, C, SE | | 2.4 | 5.6 | 7.0 | | 0.8 | 11.1 | 14.6 |
| 0011 | Clear Creek South Amana | 10 | SIDP | EC | | | 9.4 | 9.7 | | | | |
| 0012 | Slough Creek Wetland Inlet | 5 | IS | EC | | | 11.2 | 9.8 | | | | |
| 0013 | Beaver Cr Bassett | 17 | IS | NE | | | 10.8 | 9.3 | | | | |
| 0014 | Beaver Cr Colwell | 7 | IS | NE | | | 11.5 | 7.2 | | | | |
| 0015 | Otter Cr Hornet Rd | 26 | PP | NE | | | 9.9 | 8.7 | | | | |
| 0016 | Otter Cr West Union | 15 | IS | NE | | | 11.0 | 10.5 | | | | |
| 0017 | Brockcamp Cr Ft. Atkinson | 8 | PP | NE | | | 7.1 | 4.9 | | | | |
| 0018 | Roberts Cr Elkader | 116 | PP | NE | | | 7.7 | 6.7 | | | | |
| 0019 | S. Chequest Cr. Douds | 31 | SIDP | SE | | | 1.0 | 0.7 | | | | |
| 0020 | Mississippi River Fairport | 99,300 | Multiple | Multiple | | | 1.8 | 1.9 | | | | |
| 0021 | Rapid Cr Iowa City | 6 | SIDP | EC | | | 9.6 | 7.4 | | | | |
| 0022 | Rapid Cr tributary Iowa City | 3 | SIDP | EC | | | 9.3 | 8.9 | | | | |
| 0023 | Wapsipinicon R. at De Witt | 2336 | IS, SIDP | NE, EC | | | | 5.5 | | | | 13.4 |
| 0024 | S. Fork of Iowa R. at New Providence | 224 | DML | C | | | | 16.7 | | | | 31.7 |
| 0025 | S. Fork Catfish Cr Dubuque | 41 | PP | NE | | | | 2.2 | | | | |
| 0026 | Middle Fork Catfish Cr Dubuque | 13 | PP | NE | | | | 0.8 | | | | |
| 0027 | Lime Creek Brandon | 41 | IS | EC | | | | 9.2 | | | | |
| 0028 | Des Moines River Boone | 5452 | DML | NC, C | | | | 7.5 | | | | |
| 0029 | Alluvial Well Boone | 5452 | DML | NC, C | | | | 6.0 | | | | |

**Table 7: Year-to-Year Nitrate Comparisons**

## 30. Other Data

The narrative and data reporting thus far has focused on nitrate-nitrite nitrogen, the parameter of most interest in the IIHR monitoring program. However, much more data exists at several sites. This data is illustrated in graphic form in the Appendix. All data is available in electronic form (tables, graphs, etc.) by request. Individuals interested in this data should contact Chris Jones (christopher-s-jones@uiowa.edu) or Carrie Davis (caroline-davis@uiowa.edu) to request the data. The table below illustrates what data is available.

### Abbreviations

**NOx**: Nitrate-nitrite nitrogen
**Turb**: Turbidity
**Temp**: Temperature
**SC**: Specific Conductance (Conductivity)
**pH**: pH
**DO**: Dissolved Oxygen
**Q**: Discharge

| Site | Description | NOx | Turb | Temp | SC | pH | DO | Q |
|---|---|---|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | X | X | X | X | X | X | X |
| 0002 | Clear Creek Coralville | X | X | X | X | X | X | X |
| 0003 | Clear Creek Oxford | X | X | X | X | X | X | X |
| 0004 | Clear Cr. Homestead | X | | | | | | |
| 0005 | English R. Kalona | X | X | X | | | | X |
| 0006 | Iowa River Lone Tree | X | X | X | | | | X |
| 0007 | Cedar River Conesville | X | X | X | | | | X |
| 0008 | Slough Creek Wetland Outlet | X | X | X | X | X | X | |
| 0009 | Otter Cr. Elgin | X | X | X | X | X | X | X |
| 0010 | Skunk River Augusta | X | X | X | | | | X |
| 0011 | Clear Creek South Amana | X | X | X | X | X | X | |
| 0012 | Slough Creek Wetland Inlet | X | X | X | X | X | X | |
| 0013 | Beaver Cr Bassett | X | X | X | X | X | X | |
| 0014 | Beaver Cr Colwell | X | X | X | X | X | X | |
| 0015 | Otter Cr Hornet Rd | X | X | X | | | | |
| 0016 | Otter Cr West Union | X | X | X | X | X | X | |
| 0017 | Brockcamp Cr Ft. Atkinson | X | X | X | | | | |
| 0018 | Roberts Cr Elkader | X | X | X | | | | |
| 0019 | S. Chequest Cr. Douds | X | X | X | X | X | X | |
| 0020 | Mississippi River Fairport | X | X | X | X | X | X | |
| 0021 | Rapid Cr Iowa City | X | X | X | X | X | X | |
| 0022 | Rapid Cr tributary Iowa City | X | X | X | X | X | X | |
| 0023 | Wapsipinicon R. De Witt | X | X | X | X | X | X | X |
| 0024 | S. Fork of Iowa R. New Providence | X | X | X | | | | X |
| 0025 | S. Fork Catfish Cr Dubuque | X | X | X | X | X | X | |
| 0026 | Middle Fork Catfish Cr Dubuque | X | X | X | X | X | X | |
| 0027 | Lime Creek Brandon | X | | | | | | |
| 0028 | Des Moines River Boone | X | | | | | | |
| 0029 | Alluvial Well Boone | X | | | | | | |
| 0030 | Manchester Hatchery Spring | X | | | | | | |
| 0031 | Big Spring Hatchery Spring | X | | | | | | |

**Table 8: Available Water Quality by Request**

## VII. Monitoring Year 2016

Monitoring will continue with redeployment of equipment in March. The IIHR network will be expanded to 45 sites. Data from these sites, along with USGS nitrate monitoring locations will be available through IWQIS.

IIHR sites fall into one of three basic categories: 1) strategic site for N load estimations related to the Iowa Nutrient Reduction Strategy (INRS); 2) monitoring for INRS Water Quality Initiative (WQI) projects; 3) IIHR Research Projects. In the table below, USGS sites are designated as category 4. Many of the USGS will be similar in purpose to the IIHR load estimation sites.

| Site | Description | Type | Site | Description | Type |
|---|---|---|---|---|---|
| 0001 | Iowa River Iowa City | 1 | 0031 | Big Spring Fish Hatchery Spring | 3 |
| 0002 | Clear Creek Coralville | 3 | 0032 | Middle Raccoon River Panora | 1 |
| 0003 | Clear Creek Oxford | 3 | 0033 | Des Moines River Keosauqua | 1 |
| 0005 | English River Kalona | 1,2,3 | 0034 | Cedar Creek Batavia | 2 |
| 0006 | Iowa River Lone Tree | 1 | 0035 | Miller Creek LaPorte City | 2 |
| 0007 | Cedar River Conesville | 1 | 0036 | Thompson River Davis City | 1 |
| 0008 | Slough Creek Wetland Outlet | 3 | 0037 | East Nishnabotna River Brayton | 2 |
| 0009 | Otter Creek Elgin | 3 | 0038 | Squaw Creek Ames | 2 |
| 0010 | Skunk River Augusta | 1 | 0039 | Boone River Goldfield | 2 |
| 0011 | Clear Creek Homestead | 3 | 0040 | Boyer River Logan | 1 |
| 0012 | Sough Creek Wetland Inlet | 3 | 0041 | Little Sioux River Turin | 1 |
| 0013 | Beaver Creek Bassett | 3 | 0042 | Maple River Mapleton | 1 |
| 0014 | Beaver Creek Colwell | 3 | 0043 | Floyd River James | 1 |
| 0015 | Otter Creek Hornet Road | 3 | 0044 | Des Moines River Stratford* | 1,3 |
| 0016 | Otter Creek West Union | 3 | 0045 | East Nishnabotna River Riverton | 1 |
| 0017 | Brockcamp Creek Ft. Atkinson | 2 | USGS | North Raccoon River Sac City | 4 |
| 0018 | Roberts Creek Elkader | 2 | USGS | North Raccoon River Jefferson | 4 |
| 0019 | S. Chequest Creek Douds | 2 | USGS | South Raccoon River Redfield | 4 |
| 0020 | Mississippi River Pool 16 Fairport | 1,3 | USGS | Raccoon River Van Meter | 4 |
| 0021 | Rapid Creek Iowa City | 3 | USGS | Des Moines River Des Moines 2nd Ave. | 4 |
| 0022 | Rapid Creek tributary Iowa City | 3 | USGS | Boone River Webster City | 4 |
| 0023 | Wapsipinicon River De Witt | 1 | USGS | Nodaway River Clarinda | 4 |
| 0024 | S. Fork Iowa River New Providence | 1,3 | USGS | Maquoketa River Green Island | 4 |
| 0025 | S. Fork Catfish Creek Dubuque | 3 | USGS | Turkey River Garber | 4 |
| 0026 | Middle Fork Catfish Creek Dubuque | 3 | USGS | Iowa River Wapello | 4 |
| 0027 | Lime Creek Brandon | 3 | USGS | Cedar River Palo | 4 |
| 0028 | Des Moines River Boone | 1,3 | USGS | Mississippi River Comanche | 4 |
| 0029 | Alluvial Well, Boone | 3 | USGS | West Nishnabotna at Randolph | 4 |
| 0030 | Manchester Fish Hatchery Spring | 3 | | | |

*Beginning in July, moved from 0028 or 0029.

**Table 9: Summary of 2016 IIHR and USGS Iowa Real-time Water Quality Monitoring Sites**

The map that follows on the next page illustrates the 2016 sites shown above.

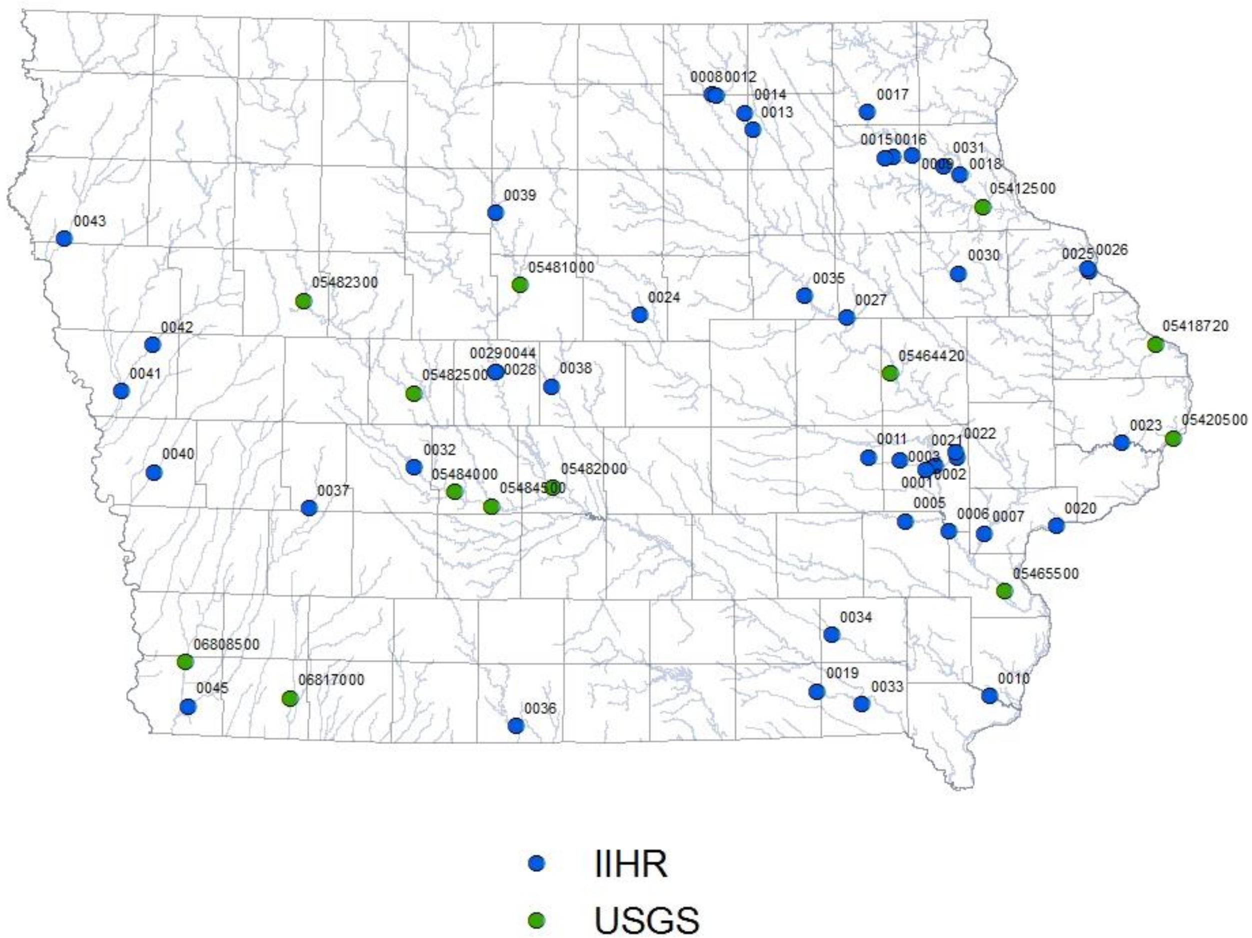



**Figure 15: 2016 IIHR and USGS Real Time Continuous Monitoring Sites**

# Appendix: Additional Water Quality Data

**Appendix**

The data graphs that follow illustrate real time data collected for pH, dissolved oxygen, turbidity, temperature and specific conductance where available, and nitrate data. The table below serves as a key for the graphs. Complete data sets txt. Files or other formats may be requested by contacting Chris Jones (christopher-s-jones@uiowa.edu) or Carrie Davis (caroline-davis@uiowa.edu) at IIHR.

| IWQIS ID | ID | Name | Appendix Figure # | Page |
|---|---|---|---|---|
| WQS0001 | 1IAIC | Iowa River, Iowa City | A1.1 - A1.5 | 1 - 5 |
| WQS0002 | 2CCC | Clear Creek, Coralville | A2.1 - A2.5 | 6 - 10 |
| WQS0003 | 3CCO | Clear Creek, Oxford | A3.1 - A3.5 | 11 - 15 |
| WQS0004 | 4CCH | Clear Creek, Homestead | A4.1 - A4.4 | 16 - 19 |
| WQS0005 | 5ENGK | English River, Kalona | A5.1 - A5.5 | 20 - 24 |
| WQS0006 | 6IALT | Iowa River, Lone Tree | A6.1 - A6.5 | 25 - 29 |
| WQS0007 | 7CRC | Cedar River, Conesville | A7.1 - A7.5 | 30 – 34 |
| WQS0008 | 8SCCREP | Slough Creek CREP, Orchard | A8.1 - A8.4 | 35 - 38 |
| WQS0009 | 9OCE | Otter Creek, Elgin | A9.1 - A9.4 | 39 - 42 |
| WQS0010 | 10SRA | Skunk River, Augusta | A10.1 - A10.4 | 43 - 46 |
| WQS0011 | 11CCSAC | Clear Creek SAC, Homestead | A11.1 - A11.3 | 47 - 49 |
| WQS0012 | 12SCO | Slough Creek, Orchard | A12.1 - A12.3 | 50 - 52 |
| WQS0013 | 13BCB | Beaver Creek, Bassett | A13.1 - A13.3 | 53 - 55 |
| WQS0014 | 14BCC | Beaver Creek, Colwell | A14.1 - A14.3 | 56 - 58 |
| WQS0015 | 15OCEH | Otter Creek (Hornet Rd), Elgin | A15.1 - A15.3 | 59 - 60 |
| WQS0016 | 16OCWU | Otter Creek, West Union | A16.1 - A16.3 | 61 - 63 |
| WQS0017 | 17BCFA | Brockcamp Creek, Fort Atkinson | A17.1 - A17.3 | 64 - 66 |
| WQS0018 | 18RCE | Roberts Creek, Elkader | A18.1 - A18.3 | 67 - 69 |
| WQS0019 | 19SCCD | S Chequest Creek, Douds | A19.1 - A19.3 | 70 - 72 |
| WQS0020 | 20MRF | MS River Pool 16, Fairport | A20.1 - A20.3 | 73 - 75 |
| WQS0021 | 21RCIC1 | Rapid Creek, Iowa City (1) | A21.1 - A21.3 | 76 - 78 |
| WQS0022 | 22RCIC2 | Rapid Creek, Iowa City (2) | A22.1 - A22.3 | 79 - 81 |
| WQS0023 | 23WRDW | Wapsipinicon River, De Witt | A23.1 - A23.2 | 82 - 83 |
| WQS0024 | 24SFINP | SF Iowa River, New Providence | A24.1 - A24.2 | 84 - 85 |
| WQS0025 | 25CFCD1 | Catfish Creek, Dubuque (1) | A25.1 - A25.2 | 86 - 87 |
| WQS0026 | 26CFCD2 | Catfish Creek, Dubuque (2) | A26.1 - A26.2 | 88 - 89 |
| WQS0027 | 27LCB | Lime Creek, Brandon | A27.1 - A27.2 | 90 |
| WQS0028 | 28DMRB | Des Moines River, Boone | A28.1 - A28.2 | 91 |
| WQS0029 | 29gwDMRB | Des Moines River, Alluvial Well, Boone | A29.1 - A29.2 | 92 |
| WQS0030 | 30gwMFH | Manchester Fish Hatchery near Manchester, IA | A30.1 | 93 |
| WQS0031 | 31gwBSFH | Big Spring Fish Hatchery near Elkader, IA | A31.1 | 93 |