10 Years of IOWATER Chemical/Physical Monitoring
What the Data Tell Us

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IOWATER, Iowa's volunteer water quality monitoring program, aims to protect and improve Iowa's water quality by raising citizen awareness about Iowa's watersheds, supporting and encouraging the growth and networking of Iowa's volunteer water monitoring communities, and promoting water monitoring activities as a means of assessing and understanding Iowa's aquatic resources. Since 2000, IOWATER has conducted Level 1 workshops to train volunteers to analyze water samples for chemical, physical, biological, and habitat parameters. This report summarizes chemical and physical data submitted to the IOWATER database for stream sites from 2000 through 2009. A report summarizing the IOWATER biological data is available at http://www.iowater.net/Publications/StatusReports.htm (IOWATER, 2009).

IOWATER Materials and Methods

Upon completion of an IOWATER Level 1 workshop, all volunteers are given a complete set of the equipment necessary to do the chemical/physical assessment. This includes a thermometer, Hach® pH test strips, Hach® nitrate-N/nitrite-N test strips, a Chemetrics® dissolved oxygen test kit, a Chemetrics® phosphate test kit, Hach® chloride titrators, transparency tube, an open reel tape measure, a meter stick, and a tennis ball with a 1-meter string attached.

All of the chemical kits have an expiration date located either on the bottom of the test strip vial or on the color comparators. The chemical/physical assessment sheet includes a reminder to check the expiration date before using the equipment.

Volunteers determine where they want to monitor and then register a site by providing the Universal Transverse Mercator (UTM) coordinates to IOWATER staff. The site is then assigned a unique site number, after which the volunteer can begin to submit data to the online IOWATER database. If a volunteer wishes to monitor a site that already exists in the IOWATER database, the site can be shared, allowing more than one person to submit data for the same site.

The frequency of assessments is determined by the individual volunteers; however, IOWATER provides recommended frequencies for each assessment. Volunteers are encouraged to conduct chemical and physical assessments at least once per month from ice-out to freeze-over.

Parameters Monitored

Figure 1 shows the number of field parameters for which data records have been submitted to the IOWATER database. The field parameters, from most frequent to least frequent, are pH, dissolved oxygen, water temperature, transparency, nitrate-N, nitrite-N, chloride, phosphate, and stream flow. Some of the reasons why chloride and phosphate numbers are lower relative to the other parameters may have to do with the method and when they were included as part of the IOWATER workshops.

In 2000, only Level 1 workshops were conducted during which volunteers were trained in the sample methods for pH, dissolved oxygen, water temperature, transparency, nitrate-N, nitrite-N, phosphate, and stream flow. In 2000, the IOWATER program used a HACH test strip for phosphate. After the first year, it was determined that the test strip was not providing good data for concentrations typical for Iowa's waters, so use of the phosphate test strip was discontinued, and the phosphate data from 2000 was removed from the database. After evaluating other field kits, the Chemetrics® phosphate kit was selected and then included as part of Level 1 workshops. For those IOWATER volunteers trained in 2000, a Chemetrics® phosphate kit was provided to them and replaced the HACH phosphate test strip they initially received.

During 2001 and 2002, IOWATER also conducted Level 2 workshops which included training for the HACH chloride test strips. Therefore, there was no chloride data for 2000 submitted to the IOWATER database. In 2003, IOWATER Level 2 workshops were discontinued and chloride was added as a Level 1 parameter. From 2003 to present, all IOWATER volunteers received training and equipment to measure the parameters listed in Figure 1.

Stream flow is the least reported of the IOWATER parameters and may reflect the greater time involved to collect the parameters needed for stream flow to be calculated. IOWATER volunteers need to measure stream width, as well as depth and velocity at 1-meter intervals along the stream transect in order for flow to be calculated.

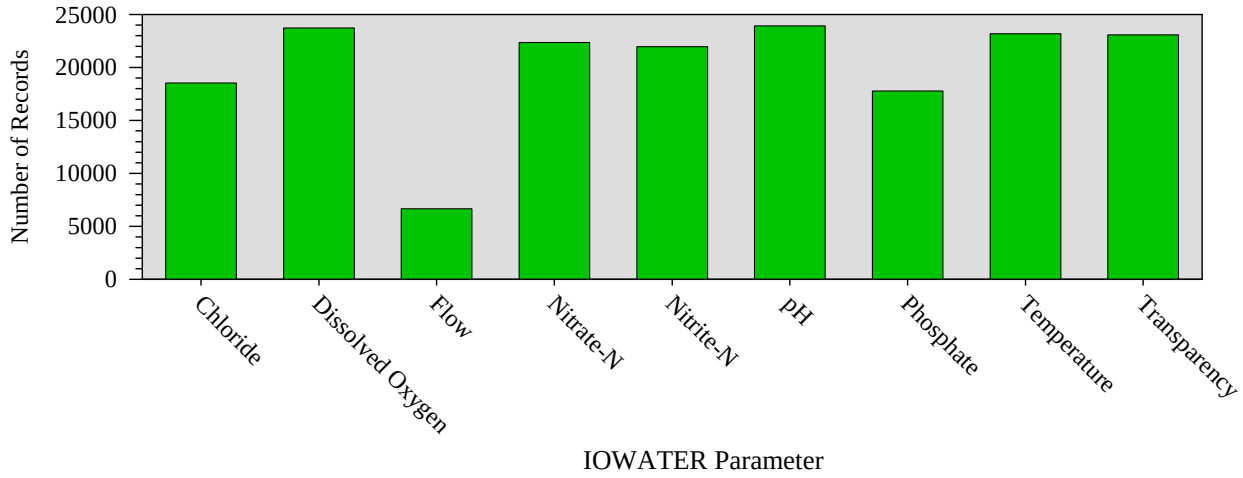

Figure 1. Number of records submitted to the IOWATER database from 2000 through 2009 that included each of the IOWATER parameters.

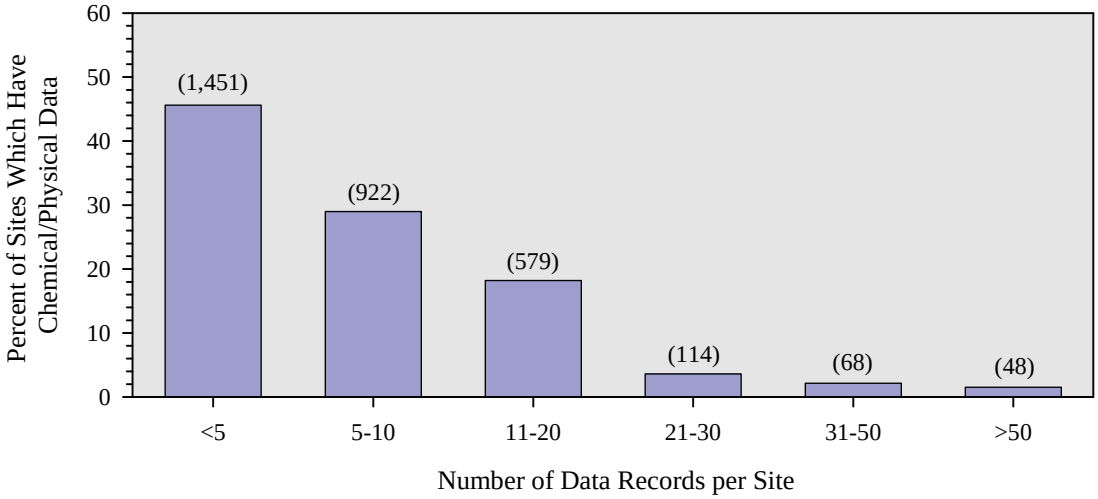

Figure 2. For sites with chemical/physical data, the percent of those sites that correspond to the number of data records per site. Number in parentheses represents the number of data records.

Figure 2 shows the number of data records submitted per site and the percent of those sites that fall into each of the categories. In general, most IOWATER sites which have chemical/physical data have less than 5 data records submitted. Seventy-five percent of the sites have 10 or less data records submitted to the IOWATER database, while 3.5% of the sites had 31 or more data records. For those sites with 31 or more data records, 63 IOWATER volunteers were responsible for collecting these longer-term data sets.

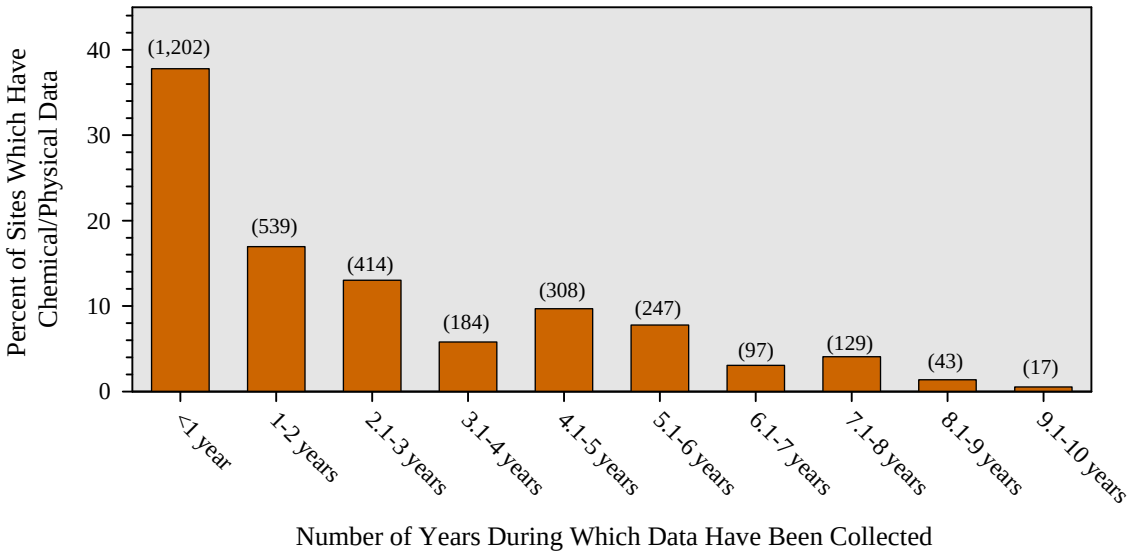

Figure 3. For sites with chemical/physical data, the percent of those sites that correspond to the number of years during which data have been collected. Number in parentheses represents the number of sites.

Figure 3 shows the number of years during which data have been collected and the percent of those sites that fall into each of the categories. For 38% of the sites, data was collected for less than a year, while 45% of the sites were sampled from 1-5 years.

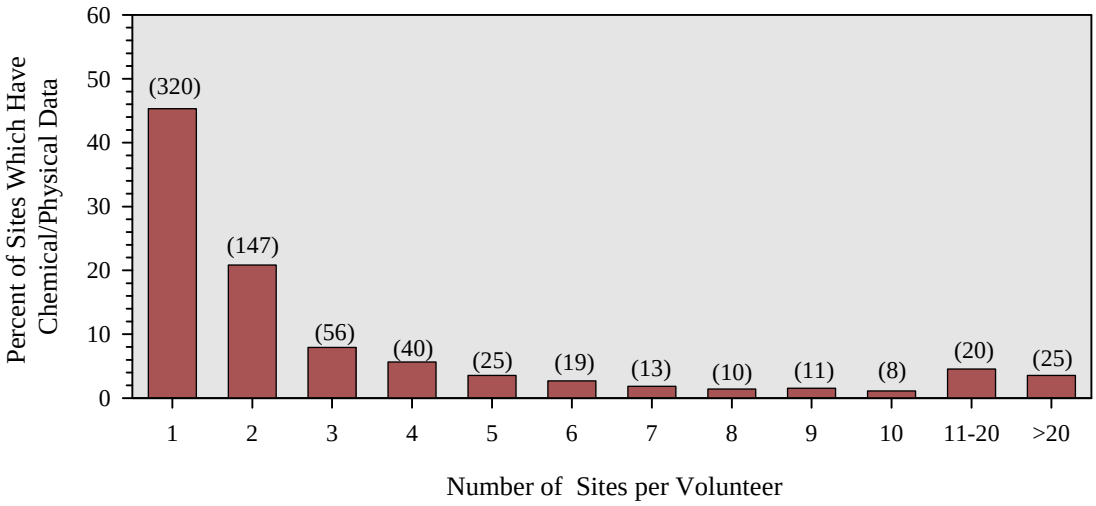

Figure 4. For sites with chemical/physical data, the percent of those sites that correspond to the number of sites per volunteer. Number in parentheses represents the number of data records

Figure 4 shows the number of sites per volunteer and the percent of those sites that fall into each of the categories. Forty-five percent of the sites represent the only sites being sampled by a volunteer, while 21% of the sites were registered by an IOWATER volunteer who also has a second site registered. Eight percent of the sites represent sites registered by IOWATER volunteers who have registered 11 or more IOWATER sites. Many of these IOWATER volunteers represent either snapshot events (a snapshot is a sampling event organized at the watershed or county scale where multiple sites are sampled within a couple of hours on the same day) or volunteers involved in watershed efforts, both of which would explain having so many sites registered to a single IOWATER ID. The large number of sites registered by single individuals does not necessarily translate into large quantities of data.

Data Submitted by Month and Year

Figure 5 shows by month the number of chemical/physical data assessments submitted to the IOWATER database from 2000 through 2009. The winter months of January, February, and December had the fewest data submittals, while May and October had the greatest. The high number of data submittals during May and October is likely caused by several factors. IOWATER sponsored watershed and countywide snapshot events tend to occur most often during these months, often times with 50-100 sites being sampled per event. May and October are the months during which the spring and fall IOWATER statewide snapshot events occur. For middle and high school groups, May and October tend to be popular months to conduct water sampling as part of classroom activities.

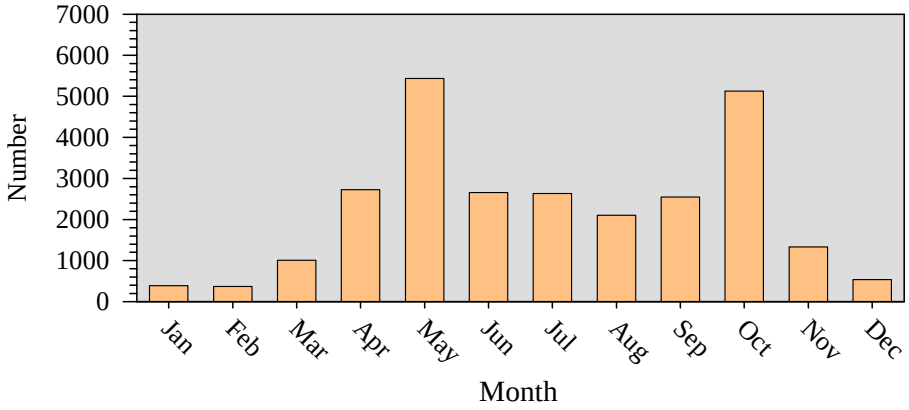

Figure 5. Number of chemical/physical data assessments by month submitted to the IOWATER database for data collected from 2000 through 2009. Number in parentheses represents the number of records.

Figure 6 shows by year the number of chemical/physical data assessments submitted to the IOWATER database. The number of data records submitted increased from 2000 through 2004, with the greatest number of records submitted in 2004, followed by a decline through 2008, including a decline of ~1,200 records from 2008 to 2009. The increase in records in 2004 corresponds to an increase in the number of countywide and watershed snapshot events that were conducted. In 2004, 24 snapshots were held, and 37% of the data records were associated with these snapshots. From 2003-2008, from 37 to 56% of the IOWATER data submitted were collected as part of snapshot events. In 2007 when the greatest number of snapshot events occurred (31), 56% of the IOWATER data were associated with snapshots. The decline in data submitted in 2009 corresponds to both a decline in IOWATER volunteers submitting data, as well as fewer snapshots being conducted. For 2009, snapshots only comprised 25% of the data submitted to the IOWATER database.

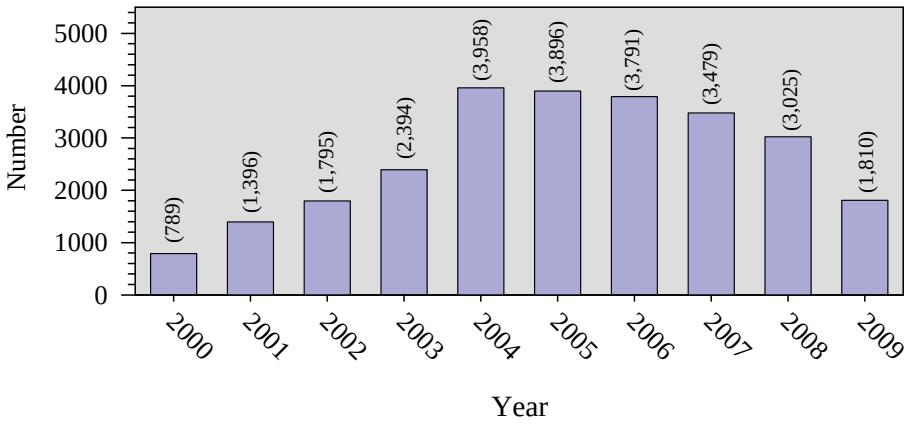

Figure 6. Number of chemical/physical data assessments by year submitted to the IOWATER database for data collected from 2000 through 2009. Number in parentheses represents the number of records.

Water Odor

As part of the IOWATER Chemical/Physical assessment, water odor can be evaluated to provide an idea of potential problems in a stream. Water odor is indicated by selecting one or more of the following categories: none, sewage/manure, rotten egg, petroleum, and/or musky. The water odor category musky

was added to the IOWATER chemical/physical assessment form in 2006. A total of 23,957 records in the IOWATER database reported water odor, of which 23,907 (99%) had a single response to the possible categories while the remainder had two or more categories recorded. For records that indicated a single water odor category, none was reported 96% of the time, sewage/manure 2%, rotten eggs <1%, petroleum <1%, and musky 2% (Figure 7). For data records where two or more categories were indicated, sewage/manure and rotten eggs was the most frequent combination.

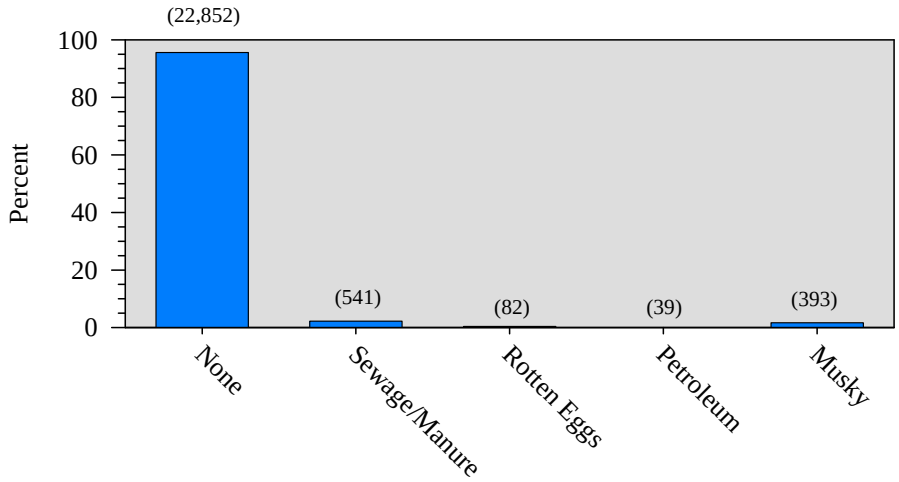

Figure 7. Percent of IOWATER data records for which a single water odor category was selected. Number in parentheses represents the number of records.

Water Color

Similar to water odor, water color can also provide an idea of potential problems in a stream. Water color is indicated by selecting one or more of the following categories: clear, brown, green, oily sheen, reddish, blackish, milky, and/or gray. The water color categories milky and gray were added to the IOWATER chemical/physical assessment form in 2006; the other water color categories have been part of the IOWATER assessment form since 2000.

A total of 24,315 records in the IOWATER database reported water color, of which 21,119 (87%) had a single response to the possible categories while the remainder had two or more categories selected. For single response records, clear was reported 62% of the time, brown 33%, green 3%, and the remaining categories each <1% (Figure 8).

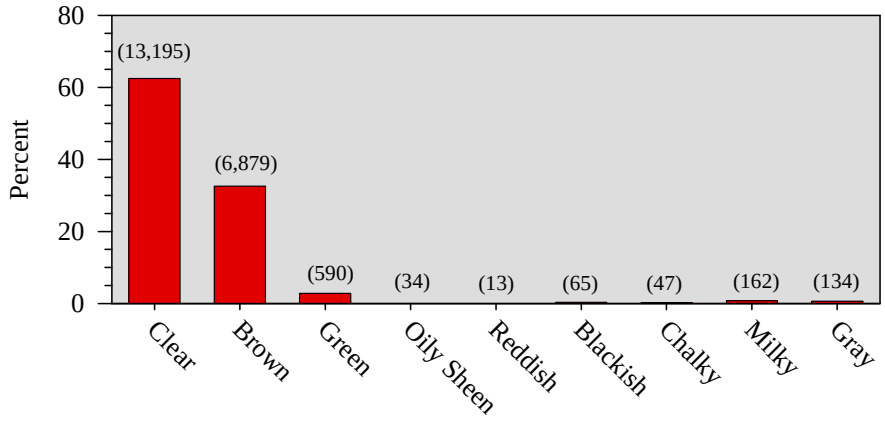

Figure 8. Percent of IOWATER data records for which a single water color category was selected. Number in parentheses represents the number of records.

Two categories were reported for 2,868 records. For those records, a combination of clear and brown was most common, followed by a combination of clear and green. A total of 293 records had 3 colors indicated, with the most common combination being clear, brown, and green. Thirty-five records reported 4 or more color categories.

Figure 9 shows the transparency result associated with the records where a single water color category was selected. For records where "clear" was recorded for water color, more than 75% of the transparency results were between 51 and 60 centimeters (cm). For the other water color categories, transparency results were more variable. Note, the numbers corresponding to the water color categories in Figures 8 and 9 do not agree, as not all records with a single water color category had a corresponding transparency.

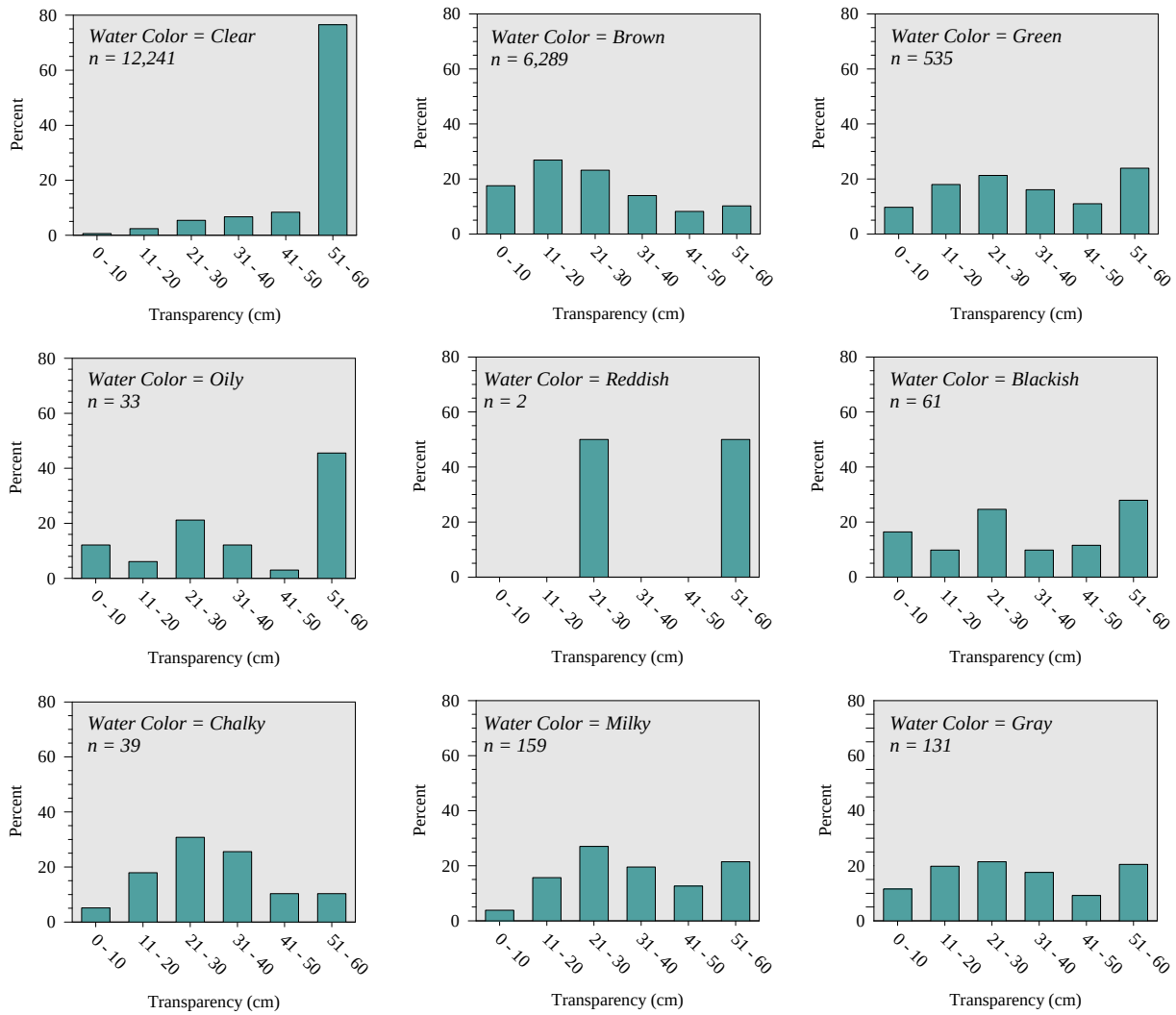

Figure 9. Distribution of transparency associated with various water color categories identified for data collected from 2000 through 2009. Data records for which two or more color categories were identified were not included. A single water color category was identified for 87% of the data records, while the remaining 13% of the records had a water color response of two or more categories indicated.

Transparency

Transparency is a measure of water clarity and is affected by the amount of material suspended in water. As more material is suspended in water, less light can pass through the water, making it less transparent (or more turbid). These materials can include soil, algae, plankton, and microbes. Transparency is measured using a transparency tube that ranges from 0 to 60 centimeters. The higher the transparency, the clearer the water is and the easier it is to see through.

Figure 10 shows the distribution of transparency results. Fifty percent of the results were between 51 and 60 centimeters (for this report, values recorded as 60+ were considered to be 60). The remaining results were fairly evenly divided among the other categories.

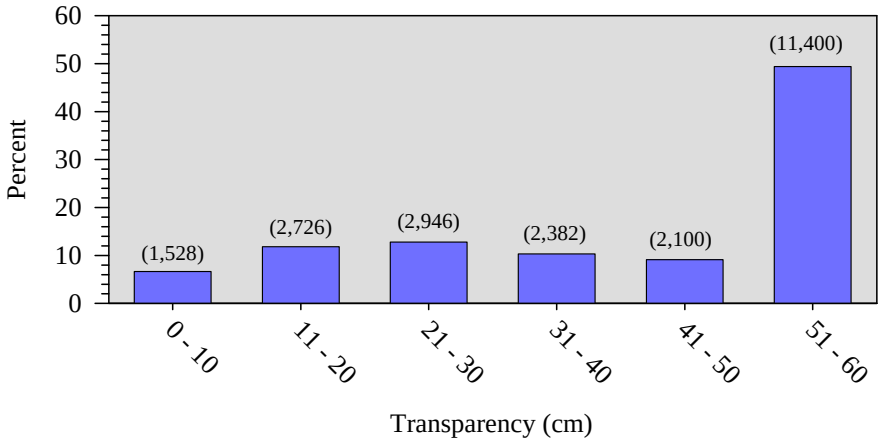

Figure 10. Distribution of IOWATER transparency data. Number in parentheses represents the number of records.

Figure 11 shows the transparency results by month. Higher transparency tended to occur during the winter months when less runoff and rainfall occurred. January had the lowest variability in results, likely due to the time of year and the fewer data sets collected during this month. Transparency was the most variable and had the lowest median level during June.

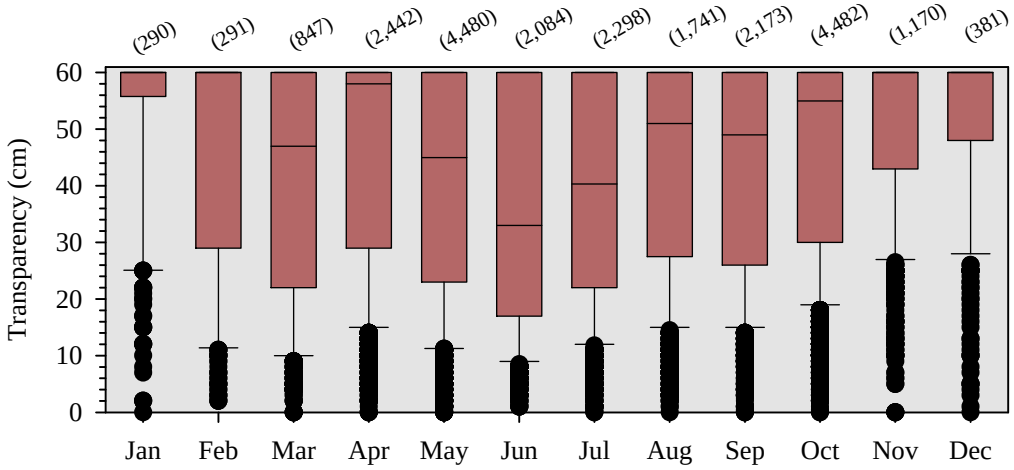

Figure 11. Box plots of IOWATER transparency by month. Number in parentheses represents the number of records.

Figure 12 shows the median transparency by month from May 2000 through December 2009. The lowest median transparency each year generally occurs in May or June, and for some years, a second low occurs during March. Median transparency by month was generally high, with it being 50 cm or higher for 61% of the months and 60 cm for 45% of the months.

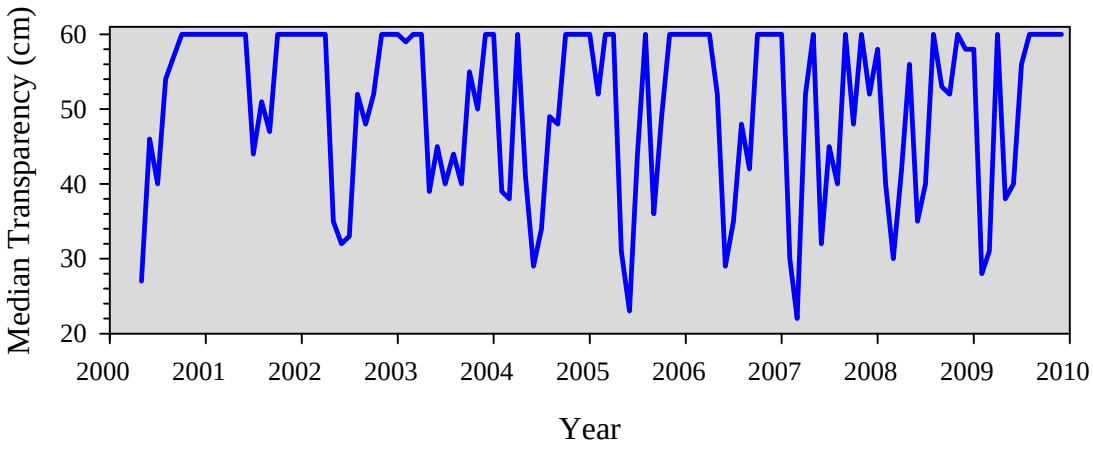

Figure 12. Time series graph of the median transparency from May 2000 through December 2009.

Water Temperature

Many of the chemical, physical, and biological characteristics of a stream are directly affected by water temperature. Water temperatures fluctuate seasonally, daily, and even hourly. Temperature impacts the amount of oxygen dissolved in water, the rate of photosynthesis by algae and aquatic plants, the metabolic rates of aquatic animals, and the sensitivity of organisms to diseases, parasites, and toxic wastes. The temperature of some streams is normally higher than others, depending on groundwater flow into the stream, weather, shading by riparian vegetation, and other factors.

The majority of the water temperatures reported were between 40 and 70 degrees Fahrenheit (F) (Figure 32). As shown in Figure 14, the majority of samples were collected between May and October, so temperatures between 40 and 70 degrees reflect typical temperatures for that time of year.

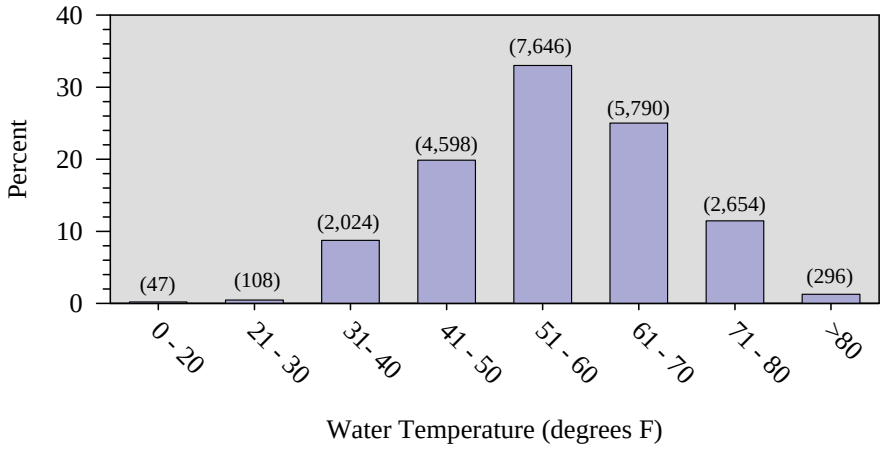

Figure 13. Distribution of IOWATER water temperature data. Number in parentheses represents the number of records.

Water temperatures showed a seasonal trend, with lower temperatures in the winter and higher during the summer (Figure 14). Statewide stream monitoring by the Iowa Department of Natural Resources (DNR) shows lower temperatures during the winter months. The difference may have to do with the fact that the Iowa DNR does consistent monthly monitoring even during the winter months, whereas fewer IOWATER volunteers are collecting samples during the winter months (see Figure 14).

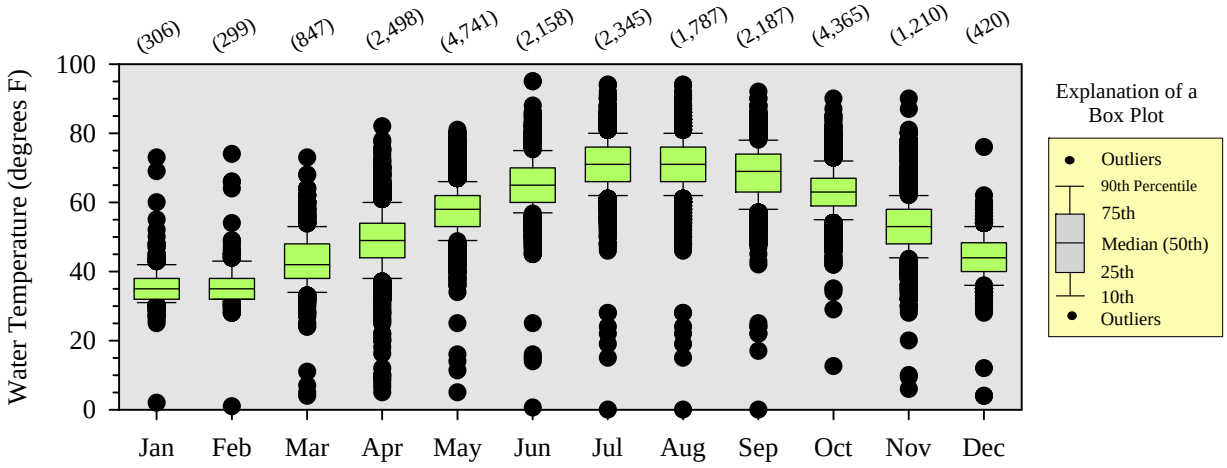

Figure 15. Box plots of IOWATER water temperature data by month. Number in parentheses represents the number of records.

pH

pH is a measure of a water's acid/base content and is measured in pH units on a scale of zero to 14. A pH of seven is neutral (distilled water), while a pH greater than seven is basic/alkaline and a pH less than seven is acidic. The pH level of stream water is influenced by the concentration of acids in rain and the types of soils and bedrock in the state. Low pH levels (acidic) can have a harmful impact on the health of aquatic communities. Very acidic water or acid rain can allow toxic substances, such as ammonia and heavy metals, to leach from our soils and possibly be taken up by aquatic plants and animals (bioaccumulation). High pH can also be detrimental to aquatic organisms.

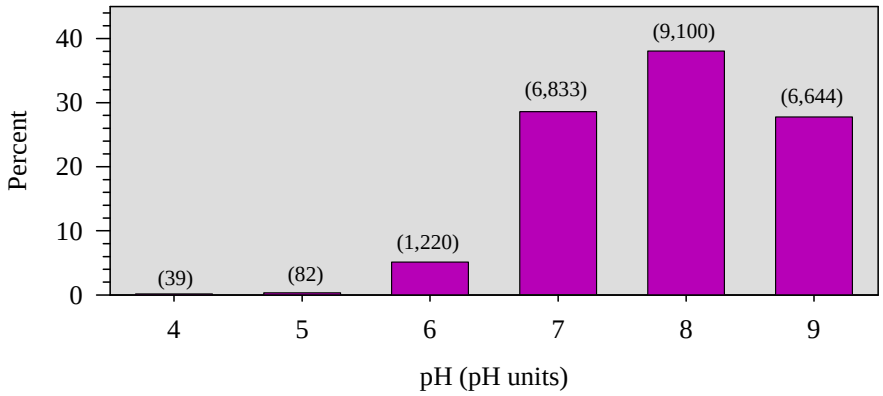

Figure 15. Distribution of IOWATER pH data. Number in parentheses represents the number of records. Number in parentheses represents the number of records.

The majority of sites reported pH values of 7, 8, or 9 (Figure 15). Based on a network of streams statewide that have been professionally monitored on a monthly basis since 2000, the average pH is 8.0 to 8.4. For sites that reported pH values of 4 or 5, those low results overall were not common. No site had consistently low pH values.

Dissolved Oxygen

Dissolved oxygen levels in a stream can be affected by a number of variables, including water temperature, season of the year, time of day, stream flow, presence of aquatic plants, dissolved or suspended solids, and human impacts. Iowa has a water quality standard of 5 mg/L of dissolved oxygen for warm water streams and 7 mg/L for cold water streams to support aquatic life.

Figure 16 shows the percent occurrence of dissolved oxygen concentrations. Seventy percent of the records had a median dissolved oxygen of 8 mg/L or greater, while 4% of the records (n = 966) reported <5 mg/L. For those sites with low dissolved oxygen, they tended to have multiple results, and the low dissolved oxygen tended to be rare. Low dissolved oxygen (<5 mg/L) tended to occur most frequently from July through October when stream flow is low and water temperatures at their highest. Warm water holds less dissolved oxygen than cold water. About one-third of the 966 sites were associated with snapshot sampling events. Most of those sites had multiple data records. For those sites, low dissolved oxygen was not typical. When it did occur, it almost always was associated with fall rather than spring snapshots.

For sites that reported a dissolved oxygen of <5 mg/L, all of the data for those sites were evaluated to see if the low dissolved oxygen concentrations correlated to certain levels of transparency, chloride, and/or phosphate. Some patterns were apparent. For results when dissolved oxygen was <5 mg/L, chloride tended to be slightly higher, transparency somewhat lower, and phosphate concentrations higher.

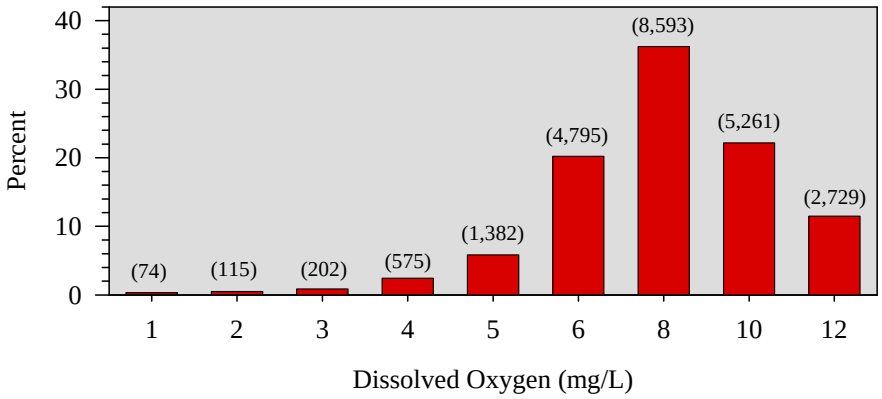

Figure 16. Percent occurrence of IOWATER dissolved oxygen concentrations. Number in parentheses represents the number of records.

Figure 17 shows the dissolved oxygen concentrations by month. In spite of fewer samples being collected during the winter months, the graph shows a pattern typical for dissolved oxygen in streams in Iowa, with lower levels during the summer months and higher during the winter. Dissolved oxygen tended to be lowest during June, July, and August, the time of year when water temperatures are also the highest.

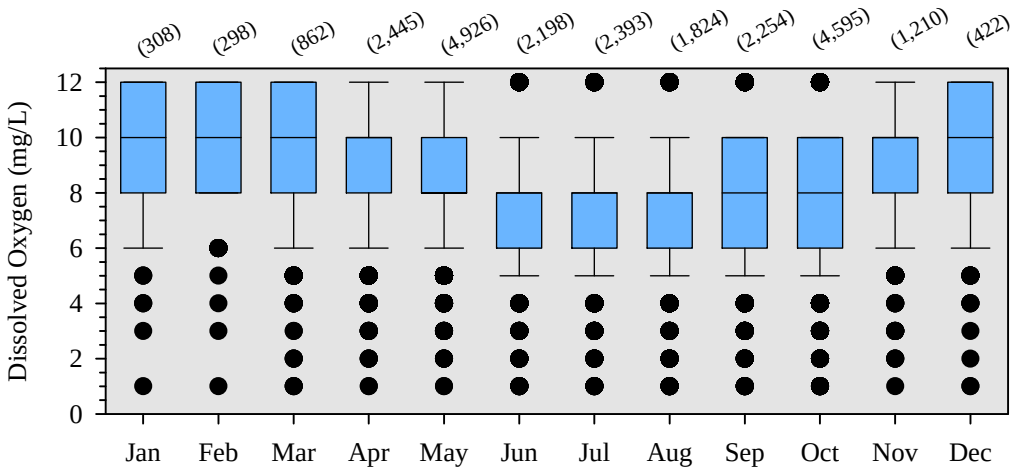

Figure 17. Box plots of IOWATER dissolved oxygen concentrations by month. Number in parentheses represents the number of records.

Figure 18 shows the water temperature associated with the dissolved oxygen results. The lower dissolved oxygen tended to occur with slightly higher water temperatures. The higher dissolved oxygen occurred over a greater range in water temperature, likely in part because there were more results for the higher concentrations of dissolved oxygen.

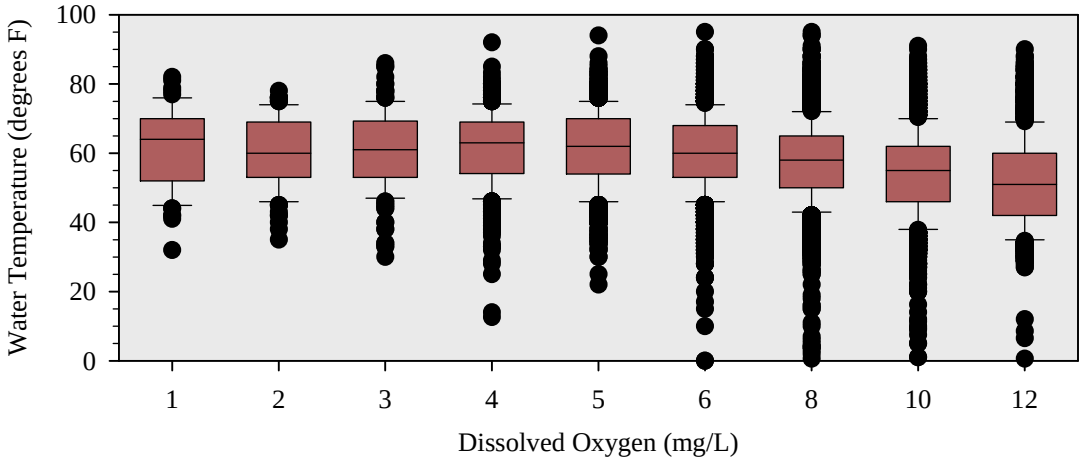

Figure 18. Box plots of water temperature relative to dissolved oxygen concentrations.

Chloride

Chloride is a component of salt and is a measure of human or animal waste inputs to a stream. Potential sources of chloride to a stream include direct input from livestock, septic system inputs, and/or discharge from municipal wastewater facilities. During winter months, elevated chloride levels in streams may occur as a result of road salt runoff to nearby streams. Typical concentrations of chloride in Iowa streams range from 20 to 30 milligrams per liter (mg/L). Higher concentrations tend to occur during winter months or under lower flow stream conditions.

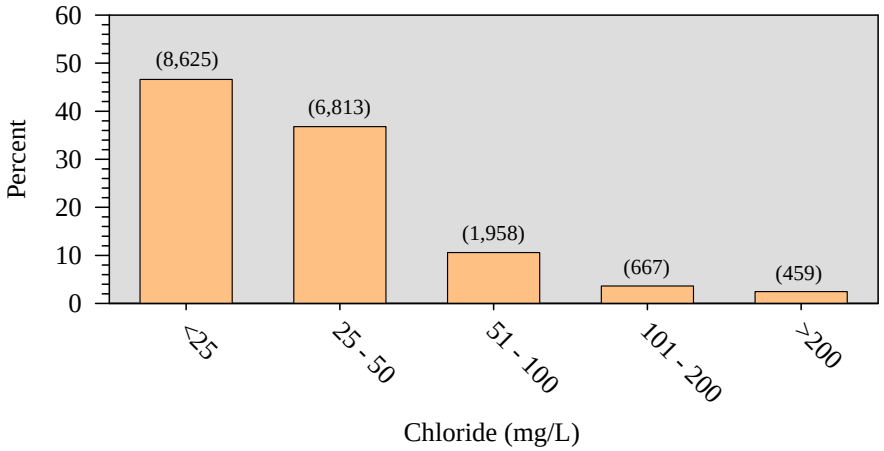

Figure 19. Distribution of IOWATER chloride concentrations. Number in parentheses represents the number of records.

The majority of chloride concentrations reported for IOWATER sites were below 50 mg/L (Figure 19). Forty-seven percent of the chloride results were below the detection limit of 25 mg/L, while 37% were between 25 to 50 mg/L. Chloride concentrations greater than 100 mg/L tend to suggest that potential point sources may be impacting the site.

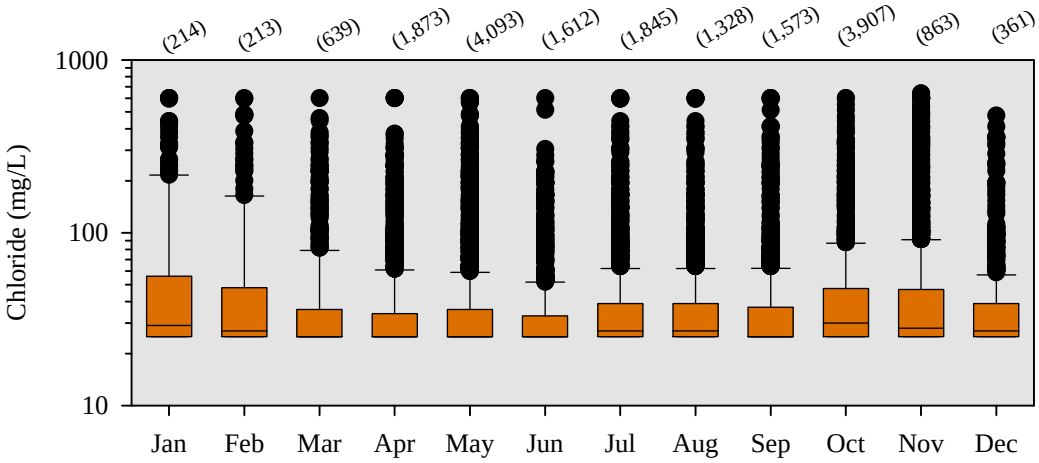

Figure 20. Box plots of IOWATER chloride concentrations by month. Number in parentheses at the top of the graph represents the number of records per month.

Figure 20 shows the distribution of chloride concentrations by month. Chloride levels tended to be lower during the late spring/early summer when stream flows were higher, and levels were highest during the month of October and the winter months.

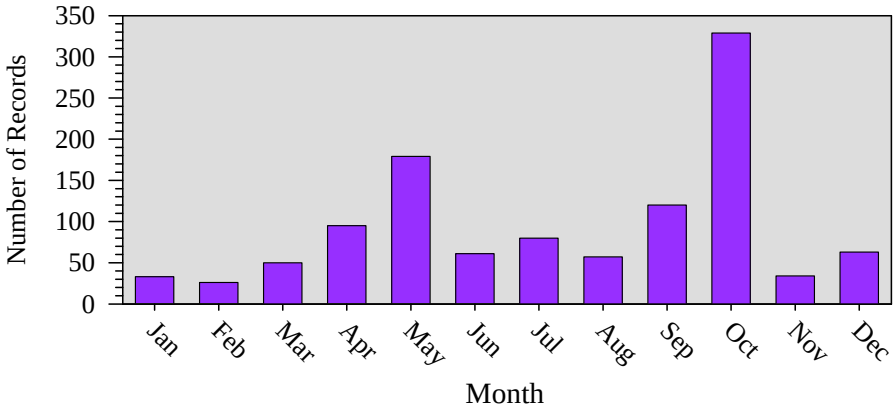

Figure 21. Distribution by month of IOWATER chloride concentrations greater than 100 mg/L.

Figure 21 shows the month when the chloride concentrations >100 mg/L occurred. A total of 1,127 data records had chloride greater than 100 mg/L. The greatest number of these data records occurred during October, followed by May, September, and April. It's not surprising that the greatest number occurred in October, as that is when many of the snapshot events occurred and is also a low-flow time of the year when point source inputs would be most apparent. Of the 1,127 records >100 mg/L, 51% were associated with county or watershed snapshot sampling events. Of these 51%, 61% were for sites sampled as part of the Johnson and Iowa County Watershed and Scott County snapshots. There tends to be a few sites sampled as part of these snapshots which account for most of the high chloride results. For many of these sites, known or suspected point source inputs exist nearby.

For sites which had a chloride concentration greater than 100 mg/L, the data were evaluated to determine if elevated chloride was typical for the site. In most instances, the result greater than 100 mg/L was the highest value reported for the site. Most of the other results for those sites were low. For sites where chloride was elevated part of the time, the higher chloride concentrations generally occurred in the fall when flows were lower. There were exceptions to this, however. For nearly 25 of the sites, elevated chloride concentrations were frequently reported. Many of these 25 sites were either located in urban areas (such as Ames, Bettendorf, Davenport, Dubuque, Fairfield), located downstream of community wastewater facilities (North Liberty, Orange City, Osceola), or affected by the storage or application of road salt.

Given that elevated chloride can indicate point source inputs, one would expect elevated levels to be associated with lower rather than higher rainfall amounts. The chloride and rainfall data displayed in Figure 22 tend to support that expectation. Keep in mind, however, 84% of the reported chloride results were <50 mg/L, so the slightly higher rainfall associated with the low chloride concentrations is probably more a factor of more chloride data being reported which included a greater range in rainfall amounts.

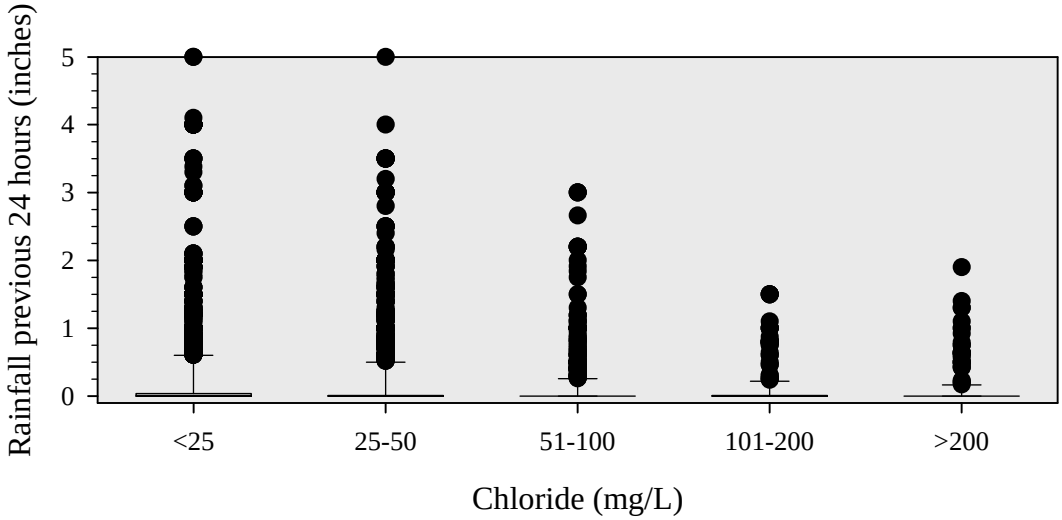

Figure 22. Box plot of IOWATER chloride concentrations relative to reported rainfall amount for the 24 hours prior to sampling.

Chloride from Snapshot Events

The Polk County snapshot, which has been occurring on a bi-annual basis since June 2004, has included two sets of chloride results: one is collected in the field using the IOWATER test strip while the other is measured using a lab procedure by Des Moines Water Works, a partner in the Polk County snapshot. Figure 23 shows the chloride data from the 12 Polk County snapshots (data points = 700+). Data below the IOWATER method detection limit were plotted as 25 mg/L. Data from this snapshot provide an opportunity to evaluate how accurate the IOWATER method is to the lab data. The data show a strong relationship between the lab procedure versus the IOWATER field method for a range in chloride concentrations and under varying flow conditions.

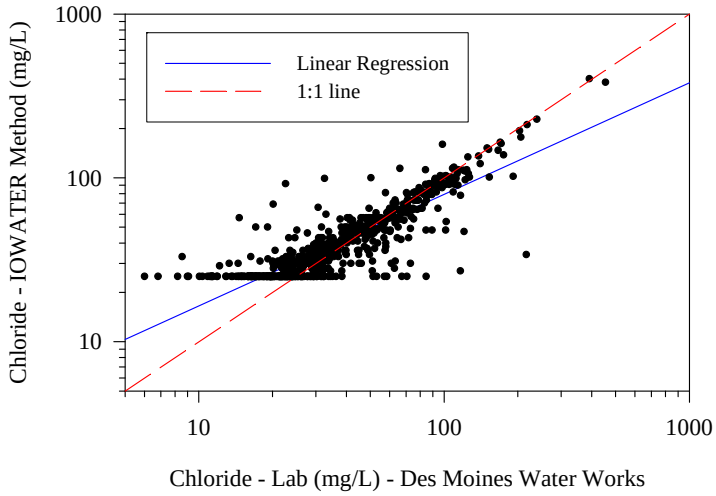

Figure 23. Scatter plot of chloride data collected during Polk County snapshot events from June 2004 through October 2009. Data represents chloride results using both the IOWATER test strip and lab analyses performed by Des Moines Water Works.

Phosphorus

Phosphorus is an essential nutrient for plants and animals and is usually present in natural waters attached to sediment. Plant growth in surface waters is generally limited by the amount of dissolved orthophosphate present. It is the simplest form of phosphorus found in natural waters and is most available for plants to use. The test kit IOWATER uses measures orthophosphate, which will be referred to as simply "phosphate."

There are natural sources of phosphorus, such as certain soils and rocks, but most elevated levels of phosphorus are caused by human activities. These include human, animal, and industrial wastes, as well as runoff from fertilized lawns and cropland. Excess phosphorus in water speeds up plant growth, causes algal blooms. When these plants and algae die and decompose, the process can result in low dissolved oxygen, or hypoxic, conditions that can lead to the death of certain fish, invertebrates, and other aquatic animals.

Phosphate concentrations for the IOWATER sites were relatively low, with 20% of the sites reporting 0 mg/L and 65% of the samples having 0.2 mg/L or less (Figure 24).

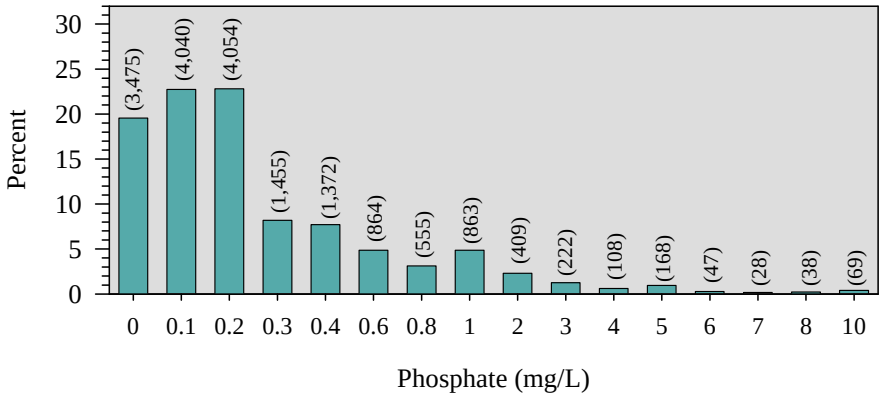

Figure 24. Distribution of IOWATER phosphate concentrations. Number in parentheses represents the number of records.

Figure 25 shows the phosphorus concentration relative to the amount of rainfall that had occurred during the 24 hours prior to sampling. While it may appear that higher phosphate concentrations were associated with higher rainfall amounts, this may be due to fewer data records reporting phosphate concentrations of 1 mg/L or more, which likely translated to less variability in rainfall.

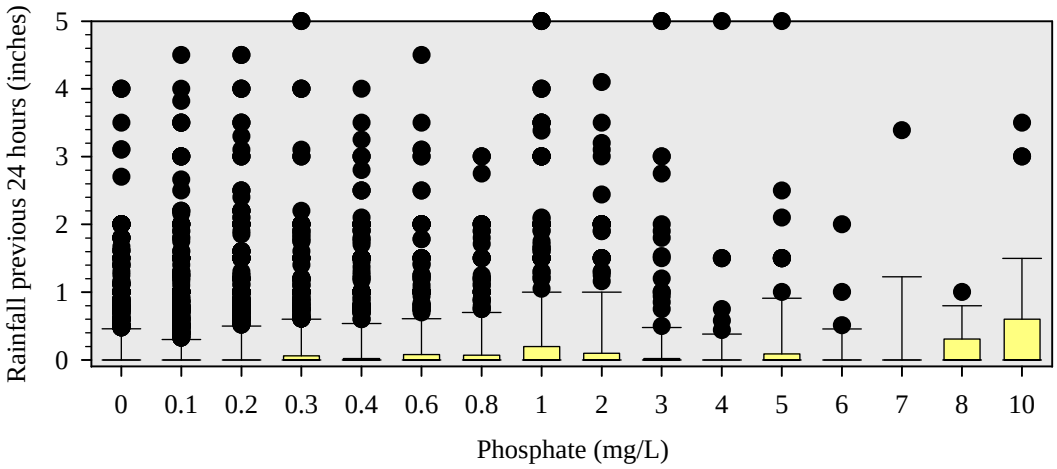

Figure 25. Box plots of rainfall for the previous 24 hours relative to the various phosphate concentrations.

Figure 26 shows the transparency associated with the phosphate concentrations. As phosphate increased from 0 to 1 mg/L, transparency tended to decrease. It is unclear what effect sediment or algae in the water may have had on the ability of IOWATER volunteers to read the phosphate ampoule. IOWATER Program staff know that sediment and algae can cause a change in the shade of color in the ampoule, thus making it more difficult to accurately match to the color comparators in the phosphate kit. From 1 to 10 mg/L, there is no trend relative to transparency. This may be due to fewer sample results for these concentrations.

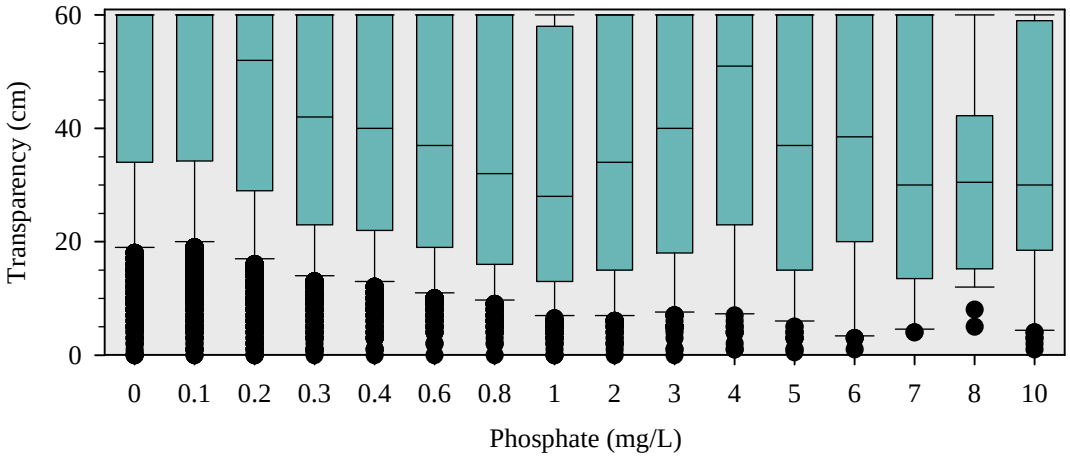

Figure 26. Box plots of transparency for the various phosphate concentrations.

Figure 27 shows the chloride versus phosphate concentrations. For phosphate results from 0 to 1 mg/L, chloride concentrations showed a slight increase as phosphate increased. For phosphate concentrations from 1 to 10 mg/L, chloride was higher overall than for phosphate concentrations less than 1 mg/L. For sites where phosphate was 1 mg/L or higher and chloride was 100 mg/L or more, these sites tended to be associated with known point source inputs from human or animal waste or be sites located downstream of a wastewater treatment facility.

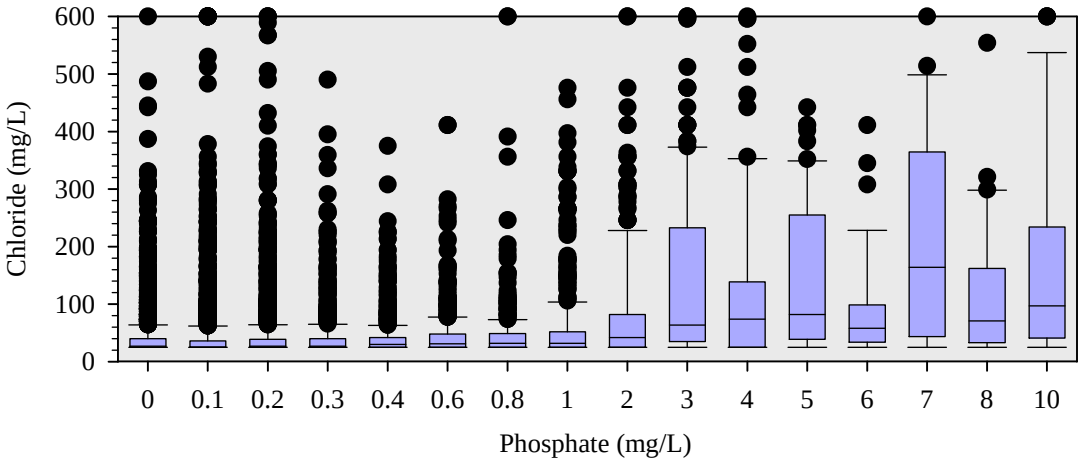

Figure 27. Box plots of chloride concentrations relative to phosphate concentrations.

Nitrite-N

Nitrogen is a necessary nutrient for plant growth, and includes both nitrite- and nitrate-nitrogen. Too much nitrogen in surface waters, however, can cause nutrient enrichment, increasing aquatic plant growth and changing the types of plants and animals that live in a stream. Sources of nitrogen include soils; human and animal wastes; decomposing plants; and fertilizer runoff from golf courses, lawns, and cropland.

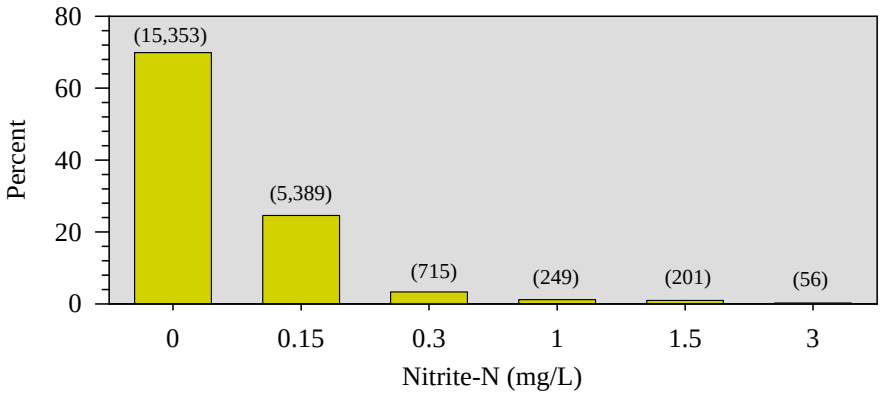

Figure 28. Distribution of IOWATER nitrite-N concentrations. Number in parentheses represents the number of records.

IOWATER nitrite-N concentrations overall were low, with 70% of the results reported as 0 mg/L and 25% as 0.15 mg/L (Figure 28). For sites with nitrite-N concentrations of 1 mg/L or higher, those high values were generally unusual for those sites. In some instances, a few sites did have recurring high nitrite-N results. For those sites when high nitrite-N occurred, phosphate levels tended to be elevated and for some, chloride was high. Many of these sites tended to be impacted by known nearby sources of human or animal wastes.

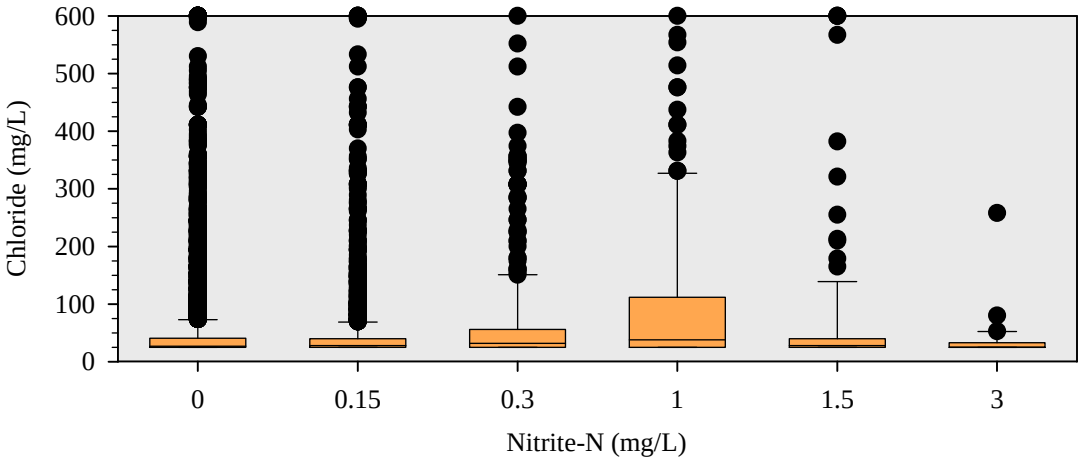

Figure 29. Box plots of chloride concentrations relative to nitrite-N concentrations.

For sites where nitrite-N concentrations were 0.3 or 1.0 mg/L, chloride tended to be higher relative to chloride concentrations associated with the other nitrite-N levels (Figure 29).

Nitrate-N

Nitrate-N concentrations were generally 5 mg/L or less (Figure 30). Only 2% of samples reported nitrate-N concentrations of 20 or 50 mg/L. For those sites with elevated levels (20 or 50 mg/L), those occurred mostly during the months of May, June, and July.

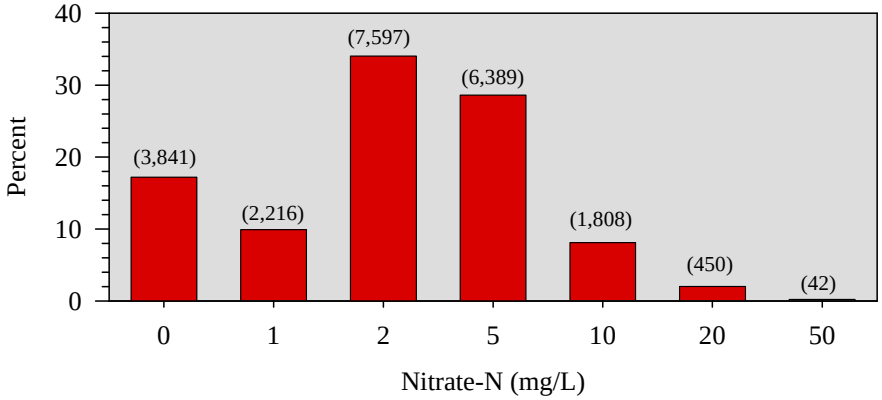

Figure 30. Distribution of IOWATER nitrate-N concentrations. Number in parentheses represents the number of records.

Figure 31 shows the nitrate-N concentrations by month. Slightly higher nitrate-N levels occurred during May, June, and July, and lower levels during fall and winter. Based on a network of streams statewide that have been professionally monitored on a monthly basis since 2000, nitrate+nitrite-N concentrations show a similar trend although more distinct. The IOWATER data may not show a more apparent trend due to the intervals associated with the nitrate-N test strip which are 0, 1, 2, 5, 10, 20, and 50 mg/L.

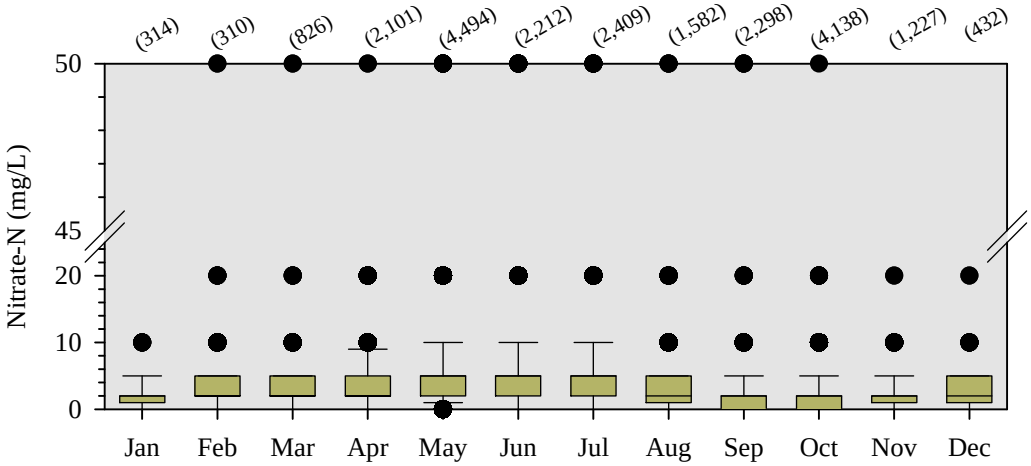

Figure 31. Box plots of IOWATER nitrate-N by month. Number in parentheses represents the number of records.

Figure 32 shows the chloride concentrations associated with the nitrate-N results. Chloride concentrations tended to have the greatest variability at nitrate-N levels of 0 mg/L. As nitrate-N levels increased from 1 to 10 mg/L, chloride concentrations tended to decrease overall. At nitrate-N concentrations of 20 and 50 mg/L, chloride concentrations increased.

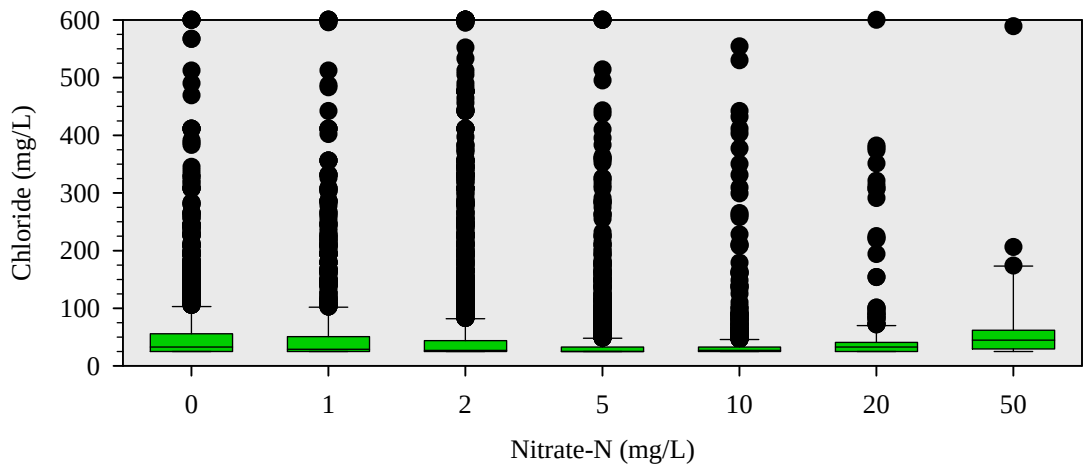

Figure 32. Box plots of chloride concentrations relative to nitrate-N concentrations

Higher nitrate-N concentrations tended to be associated with higher rainfall amounts (Figure 33). This also had to do with the time of year, as many of these higher rainfall events occurred during the late spring, early fall. Nitrate-N is water soluble and can be transported to nearby waterways at times of rainfall.

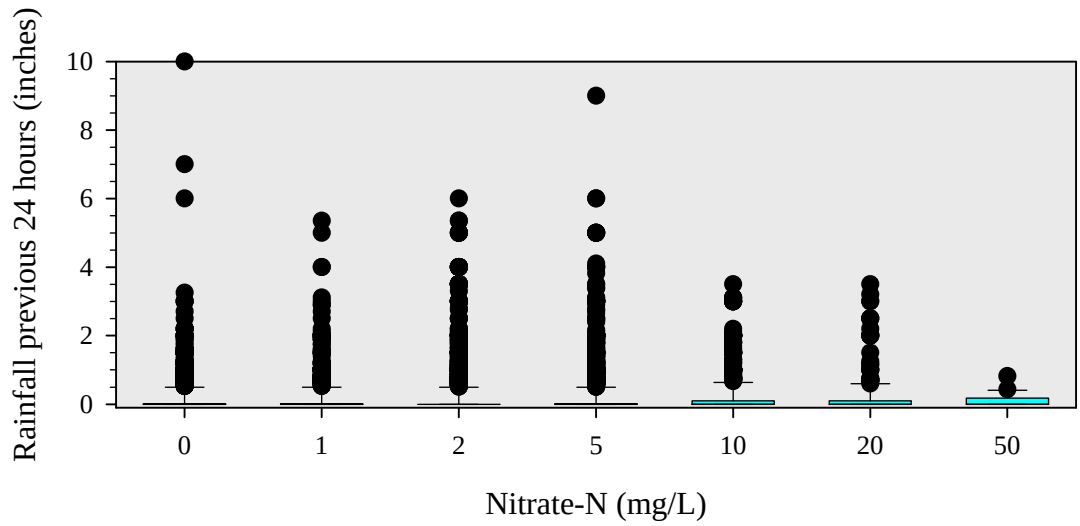

Figure 33. Box plots of rainfall for the previous 24 hours for the various nitrate-N results

Flow

Of the chemical/physical records in the IOWATER database, 25% of the records had flow. Of the volunteers who submitted data to the database, 25% submitted flow for their site(s), 27% did not, and 48% reported flow for some but not all of their sites.

Beginning in 2005, a qualitative measure of stream flow (or flow category) was included as part of the chemical/physical assessment. The IOWATER volunteer is now able to describe the stream flow as "high," "normal," "low," or "not sure." For IOWATER sites registered after 7/1/2005 for which data had

been submitted to the IOWATER database (n = 1,029), 21% of the data records reported a flow category and manual measurement; 3% reported just a manual measurement and no flow category; 56% had neither a flow category or manual measurement; and 20% reported just a flow category and no manual measurement (Figure 34). A reason why many data records didn't report a flow category may be related to the large number of snapshot sites included in this group. About 40% of the sites registered after July 1, 2005, were snapshot sites, and manual flow measurements and selection of a flow category were not included as part of the snapshots.

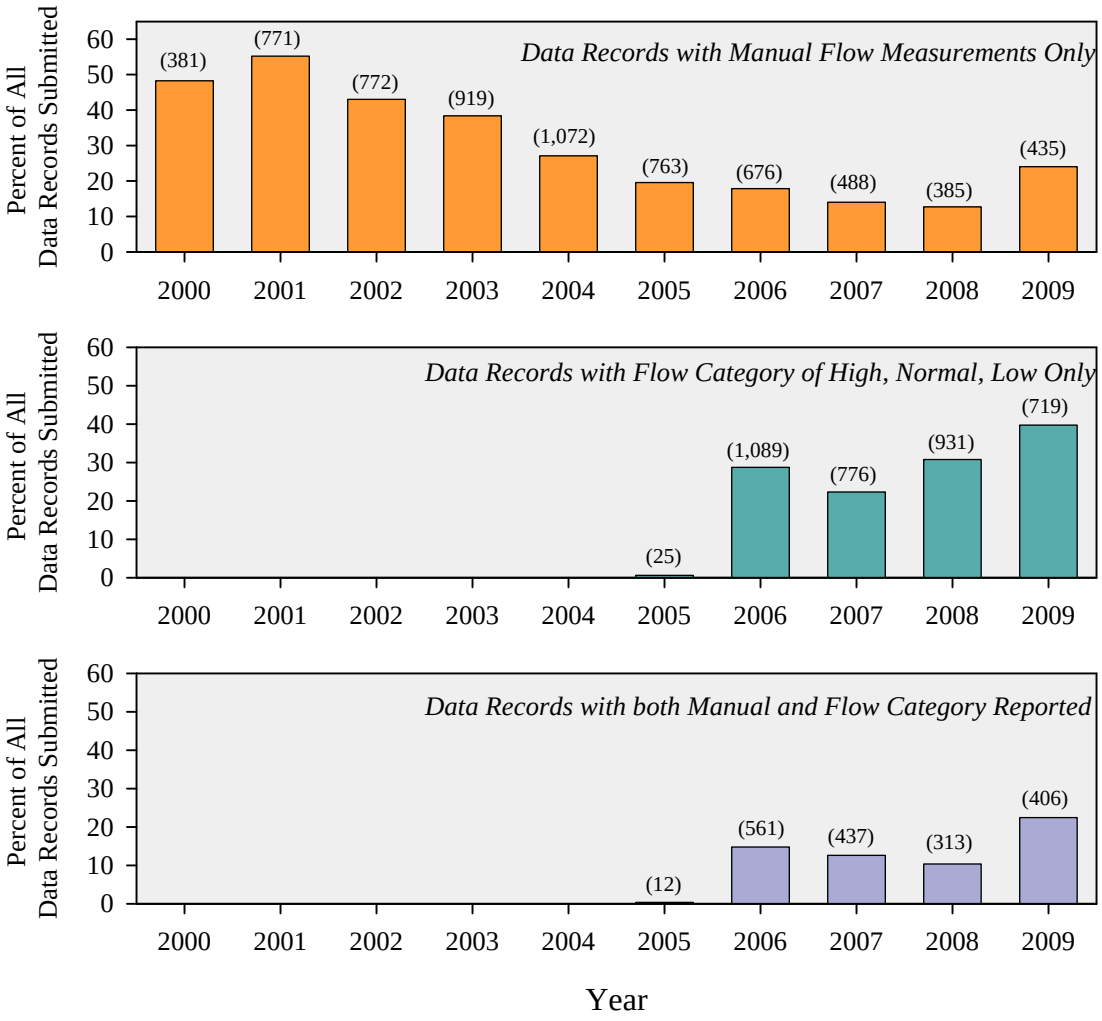

Figure 34. Percent of IOWATER data that have just manual flow reported, just the flow category reported, or both the manual flow and a flow category reported. Not until 2005 was the flow category was added to the Chemical/Physical field assessment form. Number in parentheses represents the number of records.

In general, for the longer term chemical/physical data sets, if the volunteer had started to collect manual flow measurements, he/she, tended to continue to do so for the entire time they monitored. For the sites with shorter data records (i.e., 10 or less records), the IOWATER volunteer may have done flow the first few times but then discontinued collecting flow data..

For those IOWATER volunteers with long-term data sets that were started prior to 2005, the majority have either been measuring flow throughout and added the flow category option when it became

available, or they never have measured flow and did not add the flow category option when it became available.

Ecoregions and Major Basins

Ecological regions (ecoregions) are areas of general similarity, both ecologically and geographically, based on perceived patterns of land use, landforms, vegetation, and soils. Ecoregions were initially delineated in the late 1980s (Omernik 1987) to provide a geographic framework for more efficient management of ecosystems and their components. Ecoregions can be recognized and defined at different scales to suit a variety of purposes (Omernik 1995). In 1993, the U.S. Environmental Protection Agency (EPA) and Iowa DNR completed an ecoregion refinement project to facilitate biocriteria development (Griffith et al., 1994). This project used Omernick's (1987) initial 4 ecoregions defined for Iowa and further refined the ecoregions into 10 ecoregions or subecoregions for Iowa (Figure 35; Table 1).

For the IOWATER chemical/physical data, sites were located in all ten ecoregions, however only 5 data records were available for the Missouri Alluvial Plain (47d). Given how few data records were available for this ecoregion, the Missouri Alluvial Plain was not included in any ecoregion analyses of the IOWATER data.

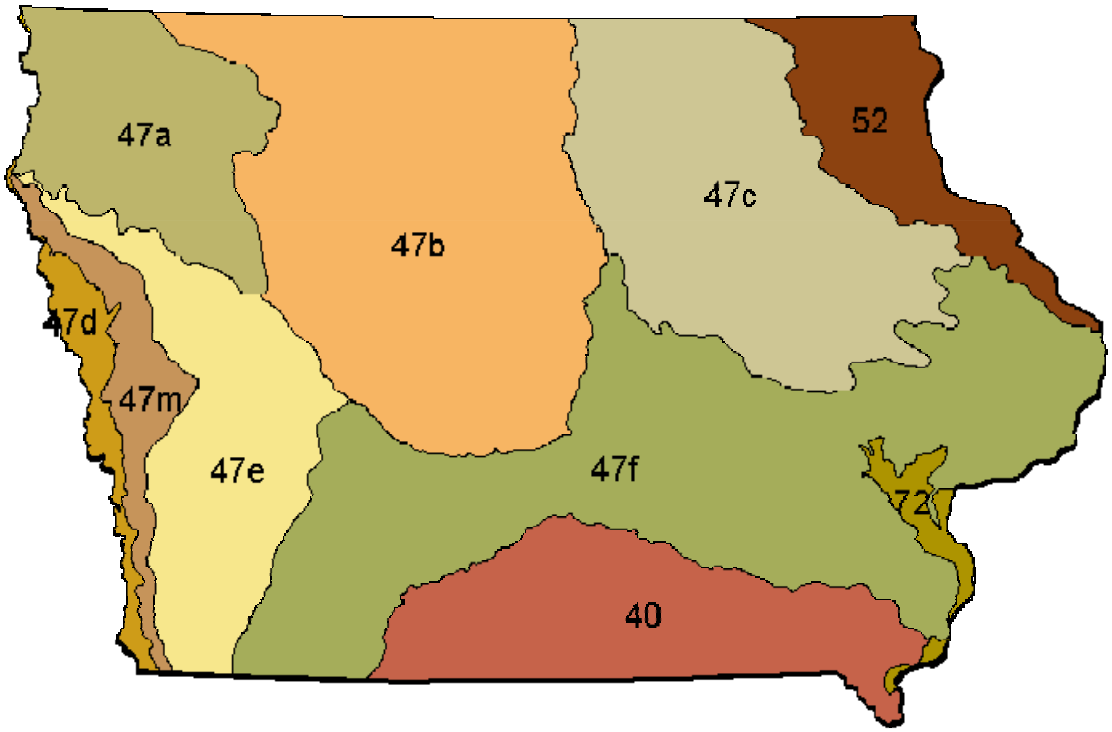

Figure 35. Ecoregions and subregions of Iowa. (Modified from Griffith, et. al 1994.)

Table 1. Level IV ecoregions or subecoregions for Iowa based on Griffith and others (1994) and displayed in Figure 35.

Ecoregion Code	Ecoregion Name	Ecoregion Code	Ecoregion Name
40	Central Irregular Plains	47e	Loess Hills and Rolling Prairies
47a	Northwest Iowa Loess Prairies	47f	Southern Iowa Rolling Loess Prairies
47b	Des Moines Lobe	47m	Loess Hills
47c	Iowan Surface	52	Paleozoic Plateau
47d	Missouri Alluvial Plain	72	Interior River Lowland

Another way to evaluate the IOWATER data is by major basins or watersheds. Figure 36 illustrates the seven major basins in Iowa. While ecoregions represent areas where features such as bedrock geology, topography, soil type, vegetation, land use, and human impacts are similar, the major basins are based on watersheds and the land draining those areas. In many instances, a major basin may include more than one ecoregion within its drainage area.

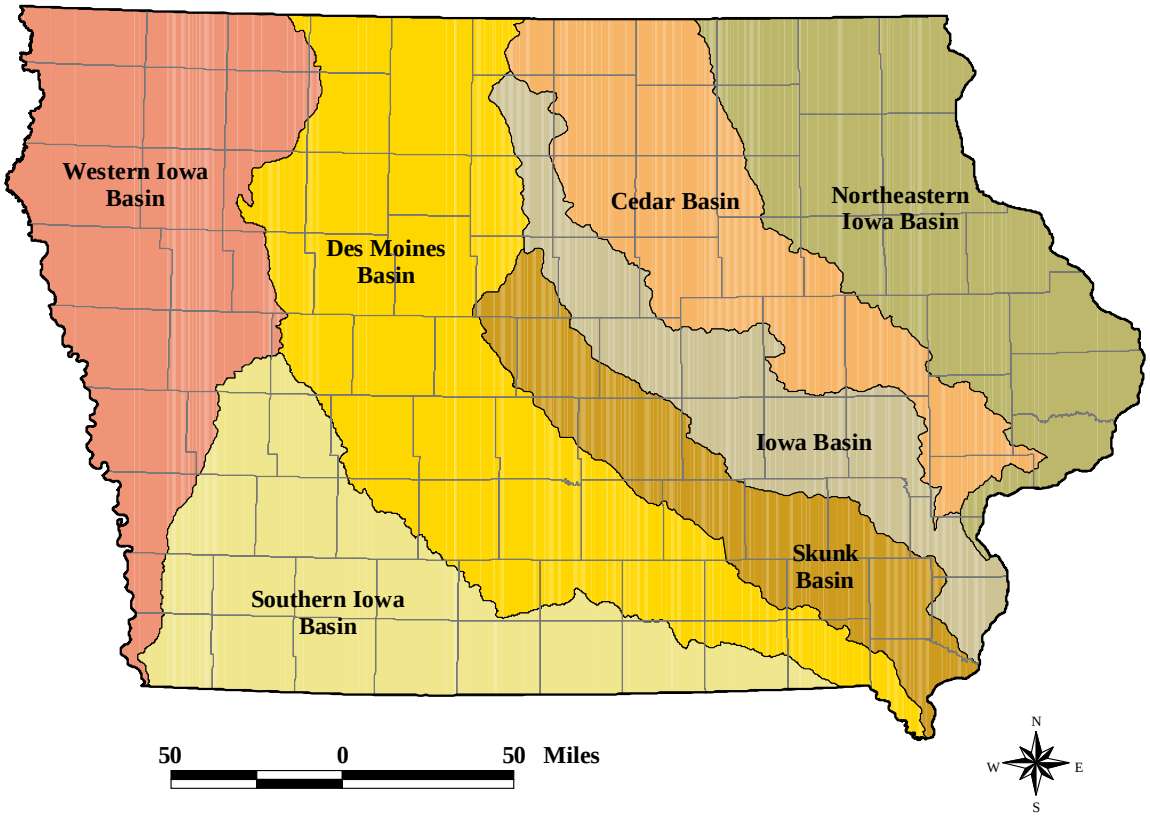

Figure 36. Major river basins or watersheds of Iowa.

The lowest median temperature occurred in the Northwest Iowa Loess Plains (47a), while the highest occurred in the Interior River Lowland (72) (Figure 37). Based on data that occurred between the 25th and 75th percentile for each ecoregion, the Loess Hills (47m) showed the greatest range in concentrations while the Southern Iowa Rolling Loess Prairies (47f) and Paleozoic Plateau (52) showed the narrowest range.

As for the basins, the Western Iowa basin had the lowest median temperature while the Des Moines and Southern Iowa basins had the highest. Based on data that occurred between the 25th and 75th percentile for each basin, the Western Iowa basin showed the greatest range in concentrations while the Northeastern Iowa showed the narrowest range. The small range in temperature is due to the strong influence of groundwater in this region that moderates the temperature.

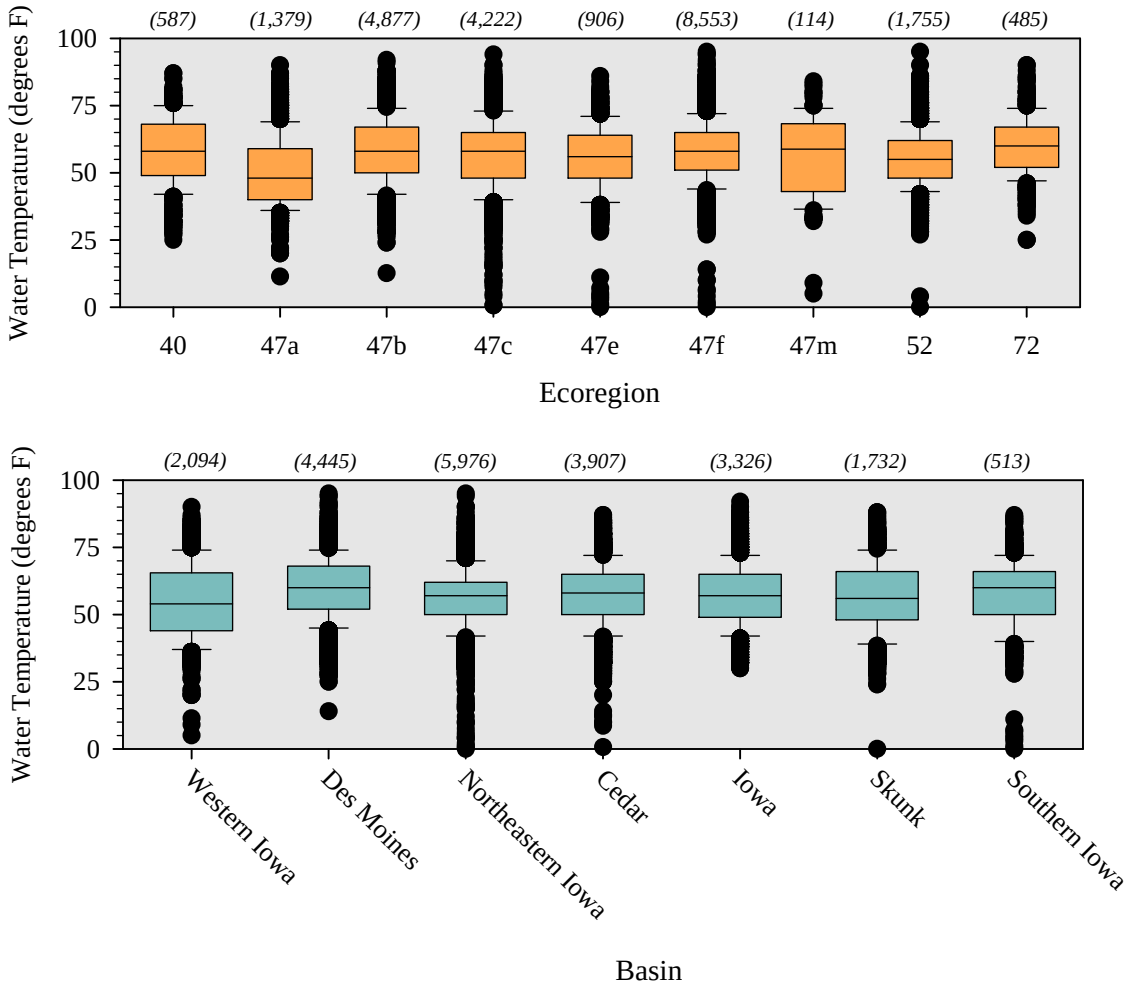

Figure 37. Box plots of IOWATER temperature data by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

The lowest median transparency (24 cm) occurred in the Loess Hills and Rolling Prairies (47e) ecoregion while the highest median transparency (60 cm) occurred in the Paleozoic Plateau (52) ecoregion (Figure 38). Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range occurred in the Loess Hills (47m) and the smallest range occurred in the Paleozoic Plateau (52). The landscape of the Loess Hills (the combination of highly erodible loess soils and relief) is more susceptible to erosion than the other ecoregions, likely resulting in the lower transparencies. While the Paleozoic Plateau has quite a bit of relief, more of the landscape is in pasture and other land uses that are not as susceptible to erosion, hence resulting in higher transparencies.

The Southern Iowa basin had the lowest median transparency (21 cm) while the Skunk River basin had the highest (60 cm). Based on data that occurred between the 25th and 75th percentile, the Des Moines Lobe showed the greatest range while the Southern Iowa basin showed the narrowest range.

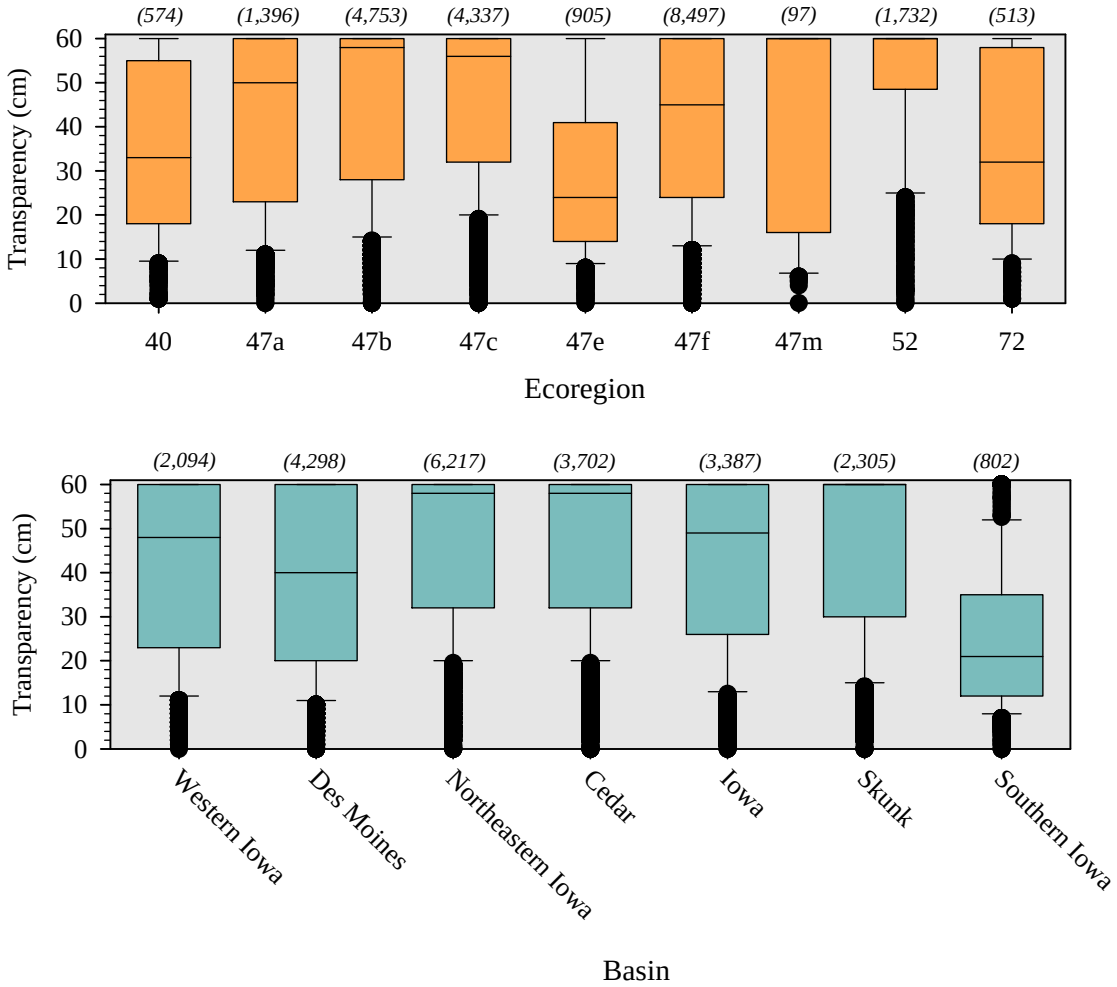

Figure 38. Box plots of IOWATER transparency data by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

pH showed little variability among the ecorgions, as the median was 8 for all ecorgions and variability between the 25th and 75th percentile differed by 1 to 2 pH units (Figure 39). The same was true for pH based on basins.

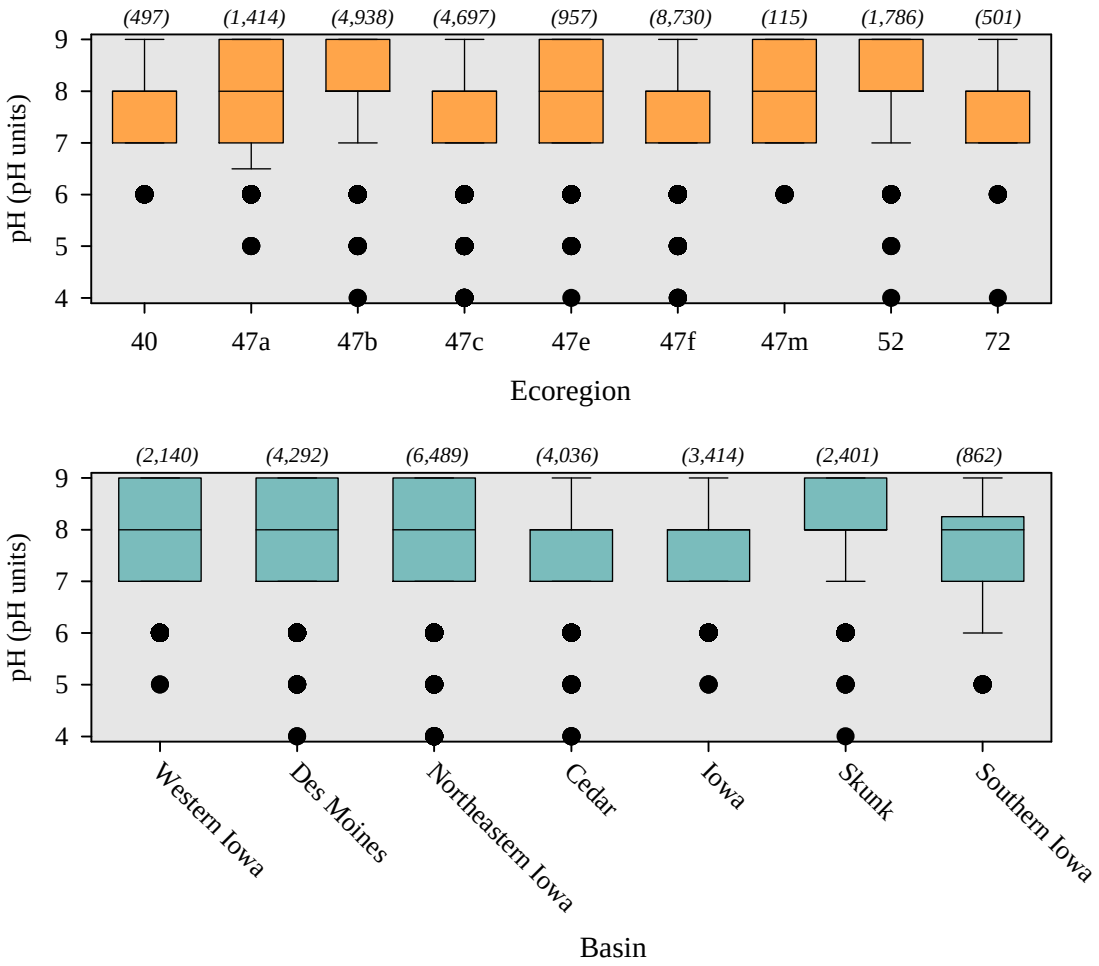

Figure 39. Box plots of IOWATER pH data by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

There was not much variability in dissolved oxygen concentrations, as the median for all ecoregions was 8 mg/L (Figure 40). Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range in dissolved oxygen occurred in the Central Irregular Plains (40), Des Moines Lobe (47b), Iowan Surface (47c), Southern Iowa Rolling Loess Prairies (47f), and the Interior River Lowland (72). The smallest range occurred in the Northwest Iowa Loess Prairies (47a), Loess Hills and Rolling Prairies (47e), Loess Hills (47m), and the Paleozoic Plateau (52).

Dissolved oxygen in the basins showed little variability, too, as the median dissolved oxygen concentration was 8 mg/L for all of the basins. Based on data that occurred between the 25th and 75th percentile for each basin, all of the basins showed the same variability.

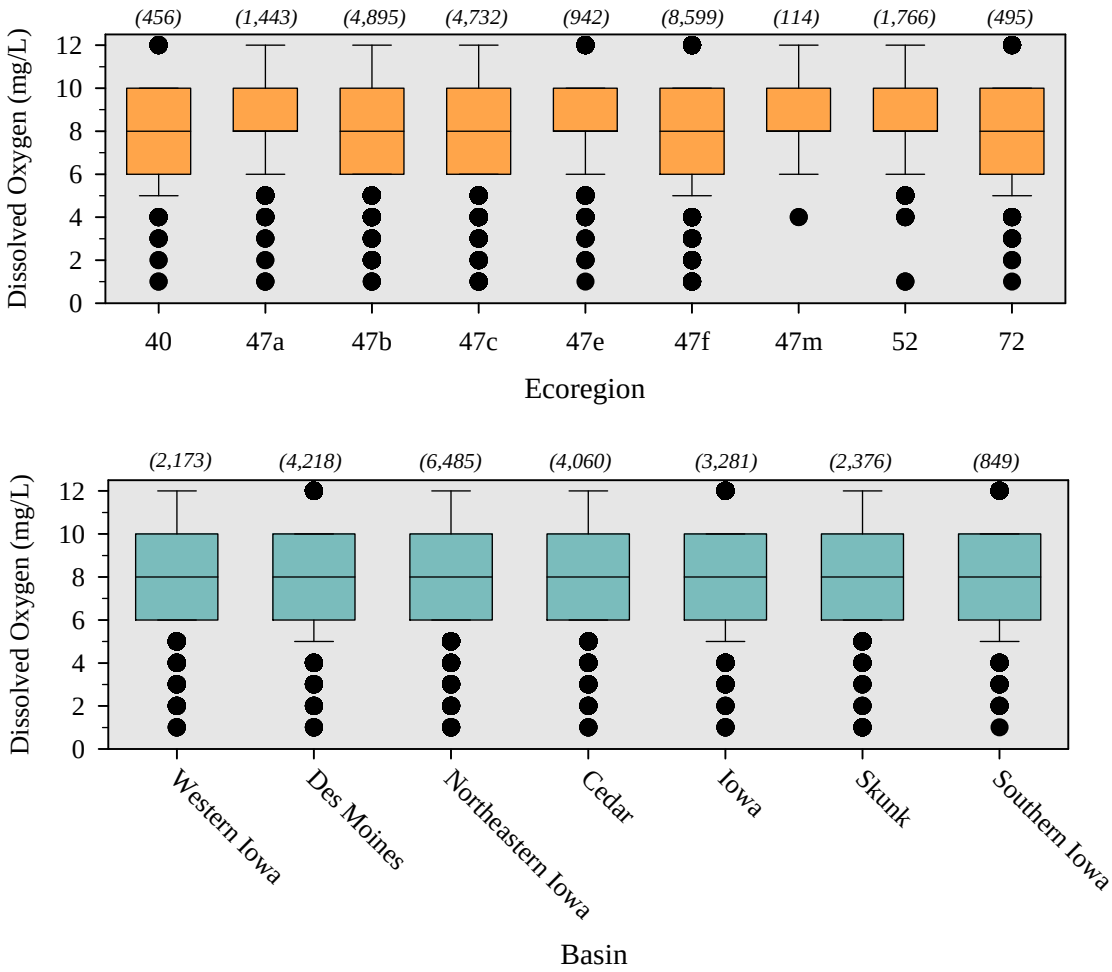

Figure 40. Box plots of IOWATER dissolved oxygen concentrations by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

The lowest median chloride was at the detection limit of 25 mg/L and occurred in the Iowan Surface (47c), Loess Hills and Rolling Prairies (47e), Southern Iowa Rolling Loess Prairies (47f), Loess Hills (47b), and the Paleozoic Plateau (52) ecoregions (Figure 41). The highest median chloride (31 mg/L) occurred in the Des Moines Lobe (47b) ecoregion. It is unclear what is causes these difference, whether its due to differences in inputs applied to the land surface and/or differences in density of tile lines and the more efficient delivery of chloride to surface waters. Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range in chloride occurred in the Paleozoic Plateau (52) and the smallest range occurred in the Loess Hills (47m).

In terms of the basins, the Northeastern Iowa, Cedar, and Southern Iowa basins had the lowest median chloride (25 mg/L) while the Skunk River basin had the highest (30 mg/L). Based on data that occurred between the 25th and 75th percentile for each basin, the Iowa basin showed the greatest range in concentrations while the Cedar Basin showed the narrowest range.

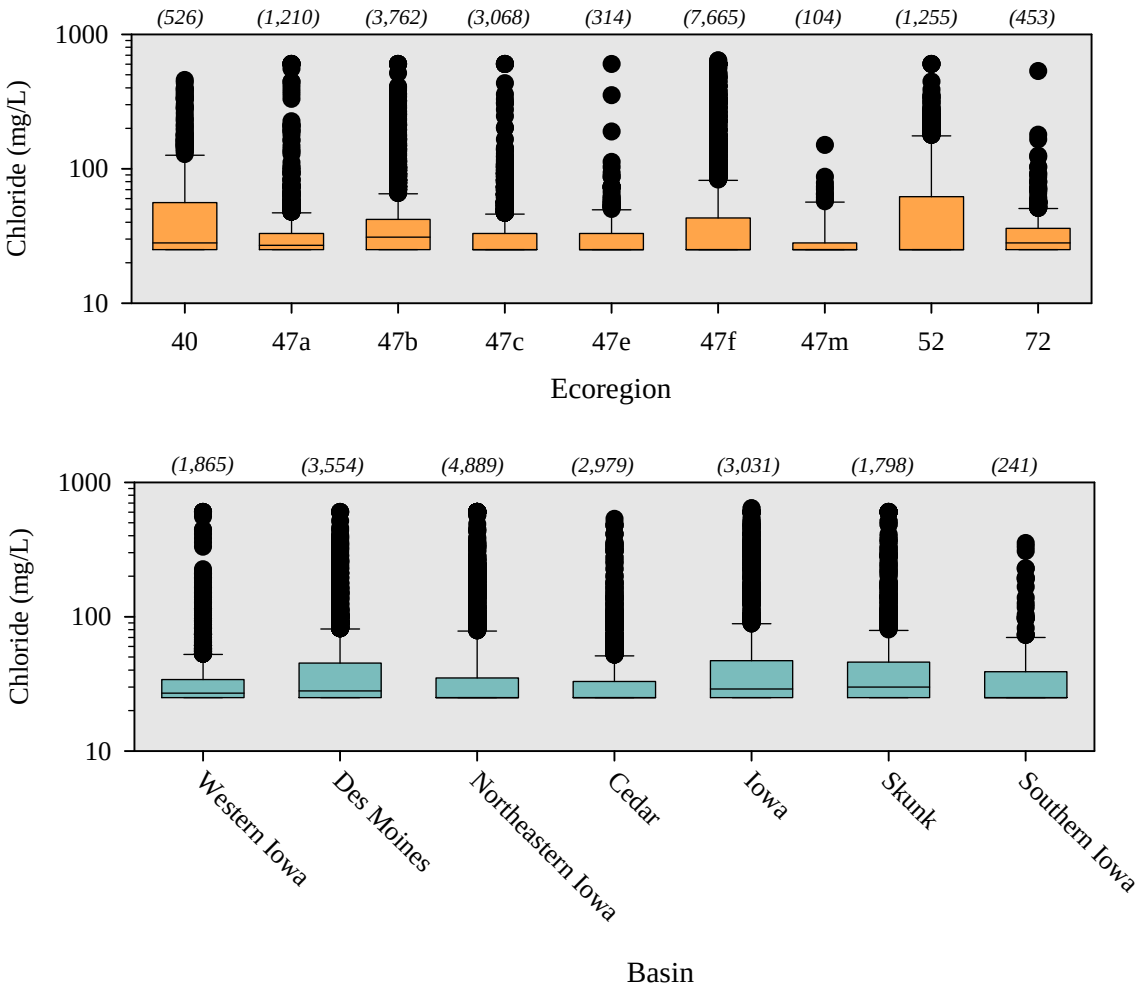

Figure 41. Box plots of IOWATER chloride concentrations by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

The lowest median phosphorus concentration was 0.1 mg/L and occurred in the Northwest Iowa Loess Prairies (47a), Iowan Surface (47c), and Paleozoic Plateau (52) ecoregions (Figure 42). The highest median phosphorus (0.4 mg/L) occurred in the Interior River Lowland (72) ecoregion. Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range in phosphorus occurred in the Interior River Lowland (72) ecoregion and the smallest range occurred in the Paleozoic Plateau (52).

In terms of the basins, the Cedar River basin had the lowest median phosphorus (0.1 mg/L) while the Southern Iowa basin had the highest (0.3 mg/L). Based on data that occurred between the 25th and 75th percentile for each basin, the Southern Iowa basin showed the greatest range in concentrations while the Northeastern Iowa showed the narrowest range.

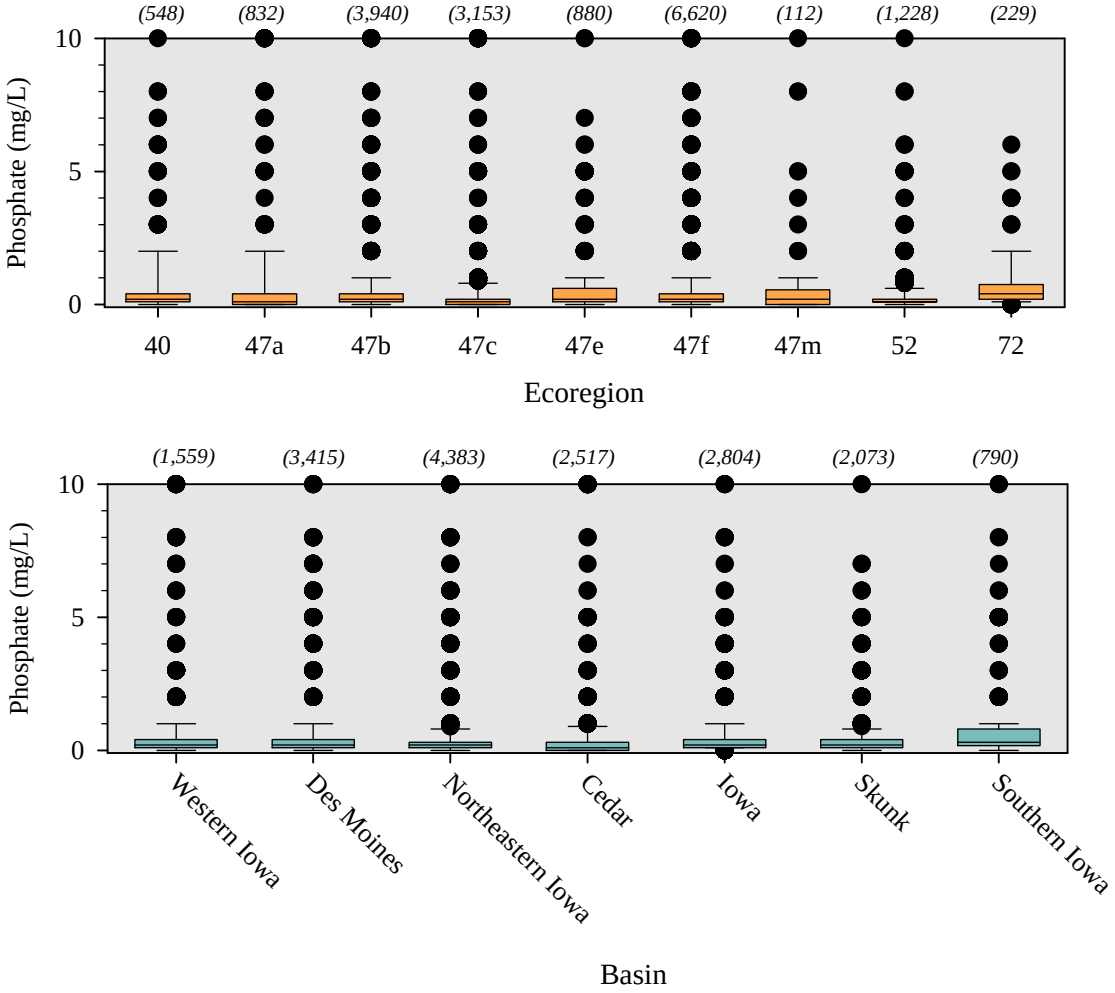

Figure 42. Box plots of IOWATER phosphorus concentrations by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

There was not much variability in nitrite-N concentrations, as the median for all ecoregions was 0 mg/L (Figure 43). Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range in nitrite-N occurred in the Northwest Iowa Loess Prairies (47a), Des Moines Lobe (47b), Iowan Surface (47c), Loess Hills and Rolling Prairies (47e), Southern Iowa Rolling Loess Prairies (47f), Loess Hills (47m), and the Interior River Lowland (72), while the smallest occurred in the Central Irregular Plains (40) and Paleozoic Plateau (52).

The basins showed little variability in nitrite-N concentrations, as all of the basins had a median nitrite-N concentration of 0 mg/L Based on data that occurred between the 25th and 75th percentile for each basin, the Iowa basin showed the narrowest range in concentrations while the remaining basins were very similar.

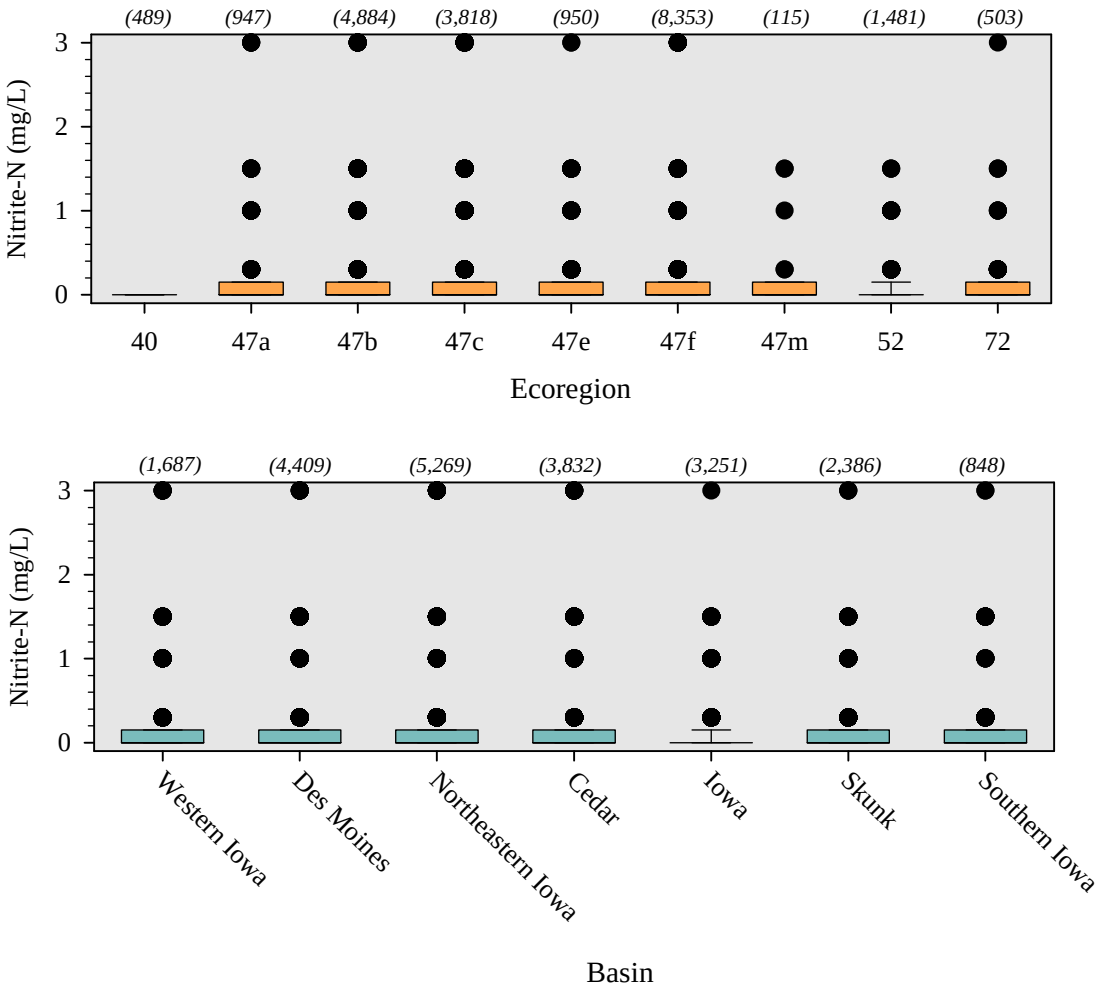

Figure 43. Box plots of IOWATER nitrite-N concentrations by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

The lowest median nitrate-N concentration was 1 mg/L and occurred in the Central Irregular Plains (40) and the Loess Hills (47m) ecoregion (Figure 44). The highest median nitrate-N (5 mg/L) occurred in the Northwest Iowa Loess Prairies (47a) ecoregion. Based on data that occurred between the 25th and 75th percentile for each ecoregion, the greatest range in nitrate-N occurred in the Southern Iowa Rolling Loess Prairies (47f) ecoregion while the smallest range occurred in the Paleozoic Plateau (52) and Interior River Lowland (72).

The basins showed little variability in nitrate-N concentrations, as all had a median of 2.0 mg/L Based on data that occurred between the 25th and 75th percentile for each basin, the Cedar basin showed the narrowest range in concentrations while the remaining basins were very similar.

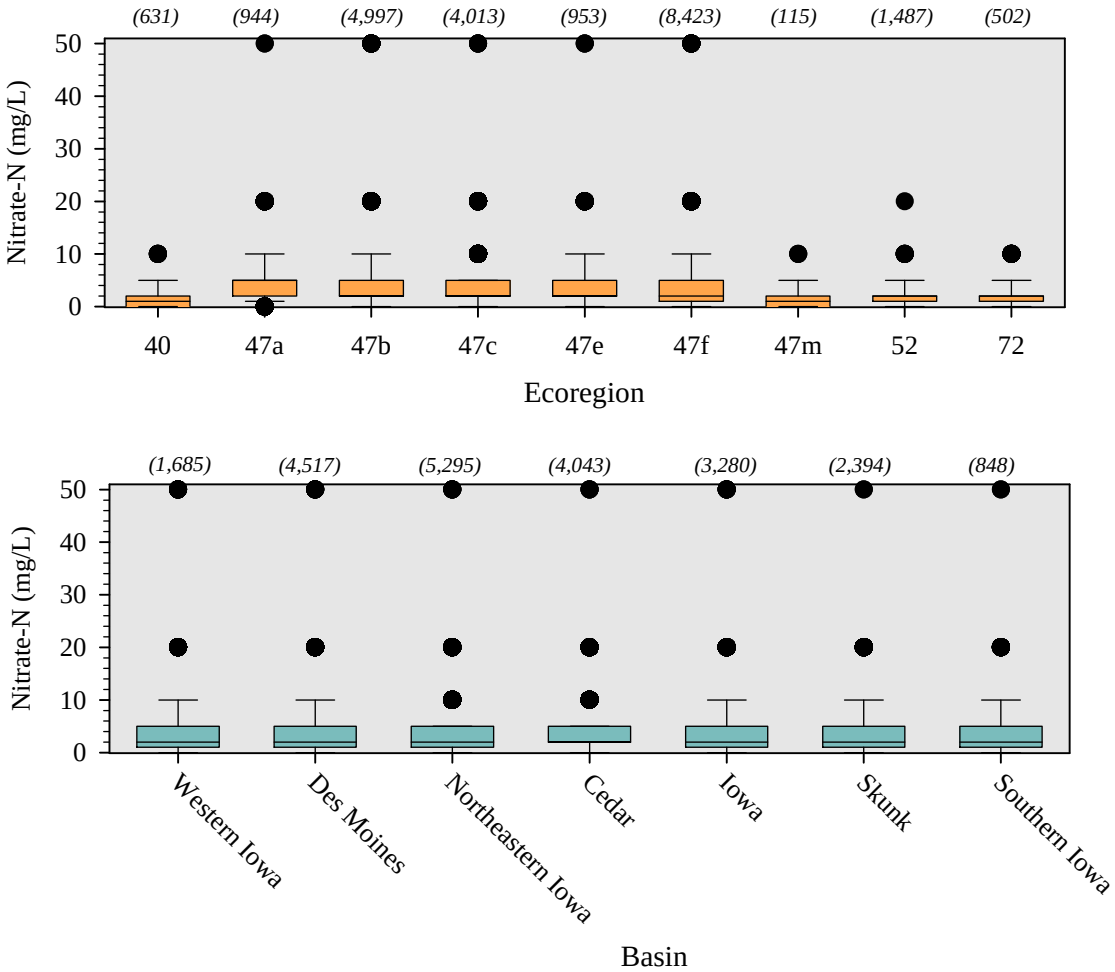

Figure 44. Box plots of IOWATER nitrate-N concentrations by ecoregion (top graph) and major river basin (bottom graph). Number in parentheses represents the number of records.

Spatial Trends in IOWATER Data

In order to evaluate the spatial variability of IOWATER parameters, IOWATER sites with five or more data records submitted from 2000 through 2009 were used to calculate median values for each site and each parameter. Figures 45 through 52 show the median values for the various parameters. Keep in mind that the time of year, frequency of monitoring, and the years during which each site has been monitored varies. There are, however, some general observations that can be made based on the data.

Figure 45 shows the median water temperatures. The median water temperatures for sites in O'Brien County (northwest Iowa) were very similar, as most represent sites sampled as part of the O'Brien County snapshot which occurs in March or April. A total of 55% of the IOWATER sites overall had a median water temperature between 51-60 degrees Fahrenheit. Sites where water temperatures were between 71 to 86 degrees were sampled primarily during the summer months when water temperatures were warmer. For sites where the median water temperatures were between 18 to 40 degrees, sampling occurred primarily during the non-summer months.

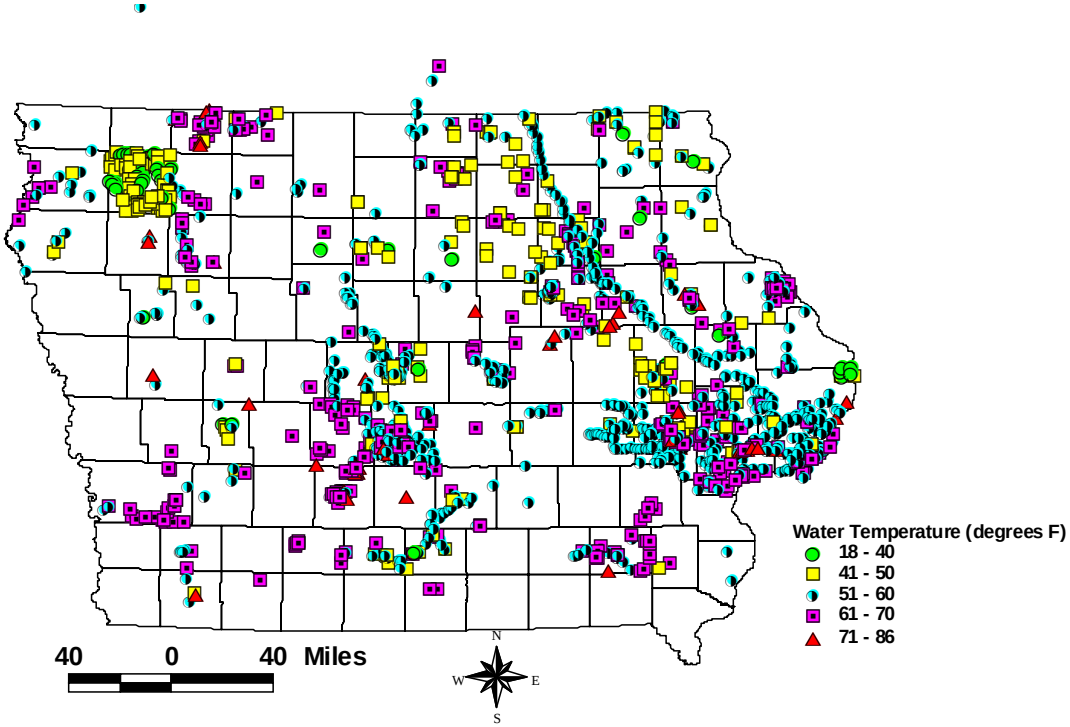

Figure 45. Median water temperature for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 46 shows the median transparency for the IOWATER sites. A total of 48% of the sites had a transparency between 51 and 60 cm. Lower transparancies tended to occur in the west and southwest parts of Iowa.

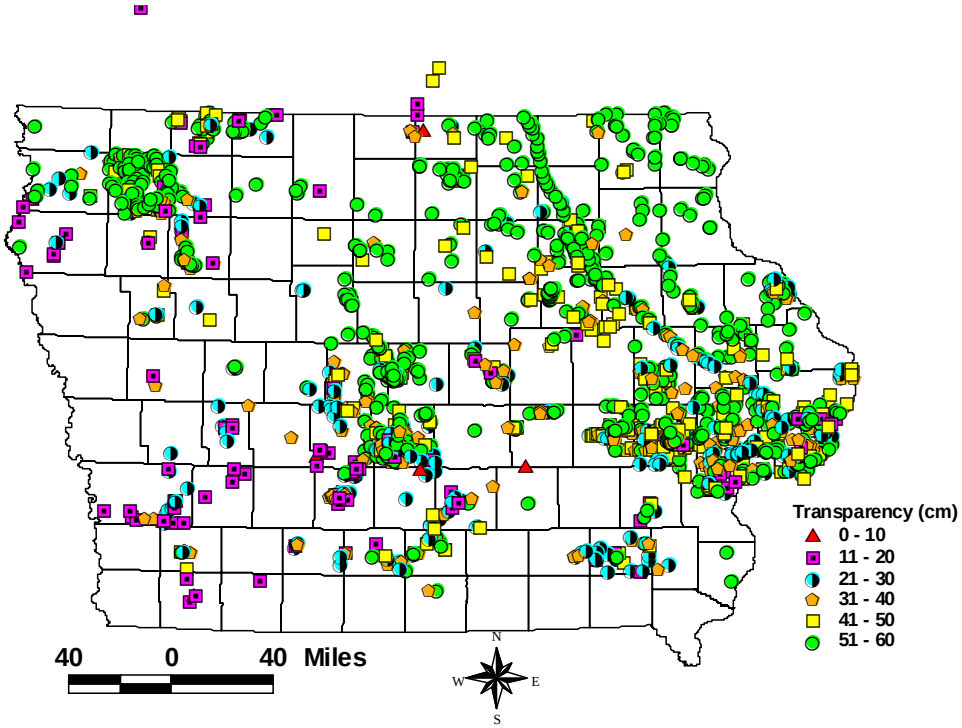

Figure 46. Median transparency for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 47 shows the median pH for the IOWATER sites. The vast majority of sites had pH values of 7, 8, or 9. There was no apparent spatial trend to the pH data.

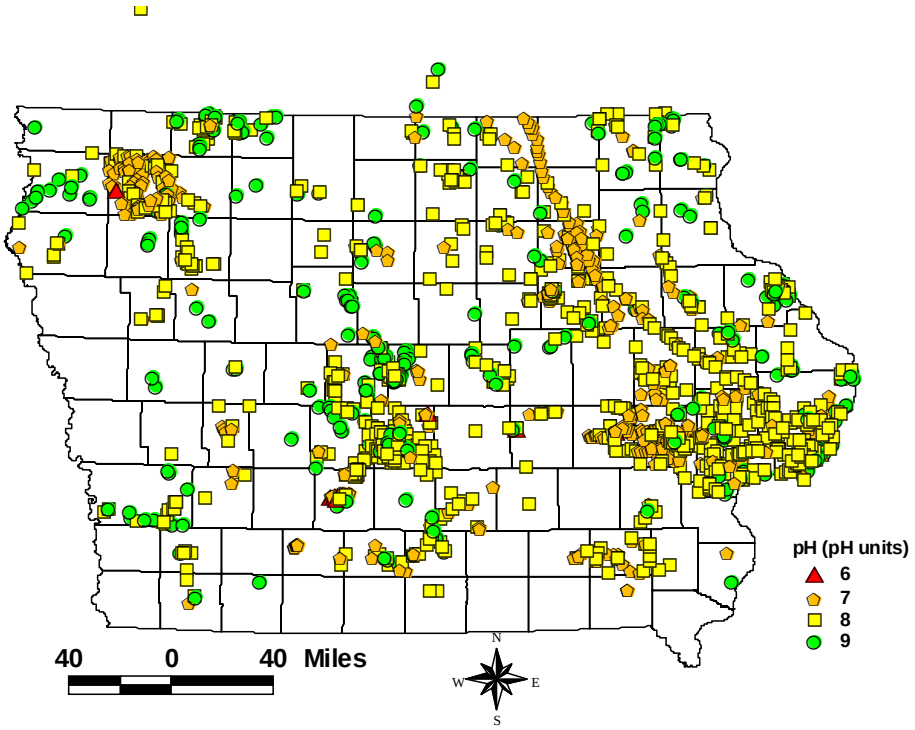

Figure 47. Median pH for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 48 shows the median dissolved oxygen concentrations statewide. As with pH, dissolved oxygen did not show a pattern spatially. A total of 79% of the sites had a median dissolved oxygen concentration of 8 or 10 mg/L while <1% were less than 5 mg/L.

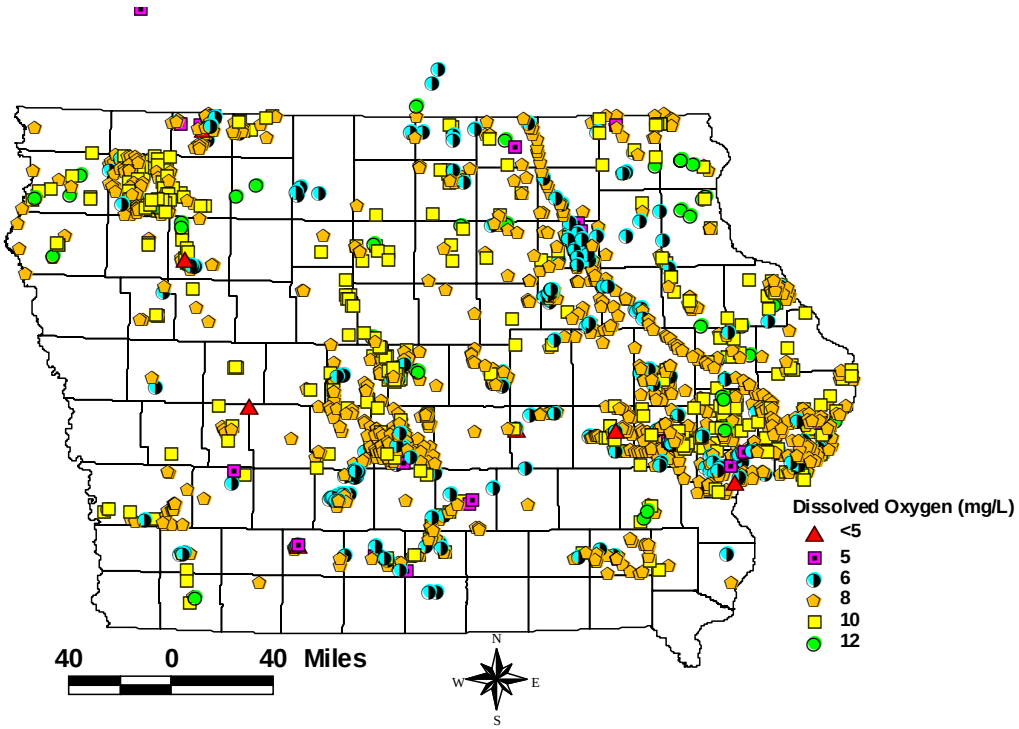

Figure 48. Median dissolved oxygen concentration for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 49 shows the median chloride concentrations. Overall, the majority of median chloride concentrations were <25 mg/L (49% of the sites). The higher chloride concentrations tended to be sites sampled as part of the Johnson and Iowa County Watershed and Scott County snapshots or sites in urban areas such as Ames, Bettendorf, Davenport, Des Moines, Dubuque, and North Liberty.

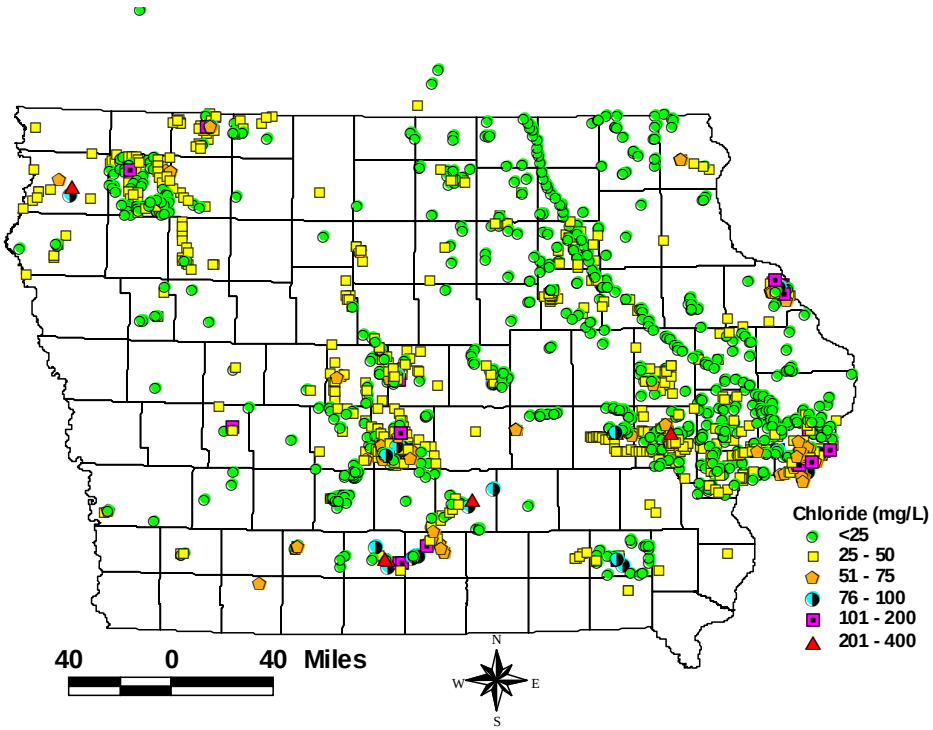

Figure 49. Median chloride concentration for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 50 shows the median phosphate concentrations. The majority of median phosphate concentrations were 0.2 mg/L or less. A total of 8% were 0 mg/L and 45% were 0.1-0.2 mg/L. The site with the highest median phosphate also had elevated chloride and nitrite-N concentration and is located immediately downstream of a wastewater facility.

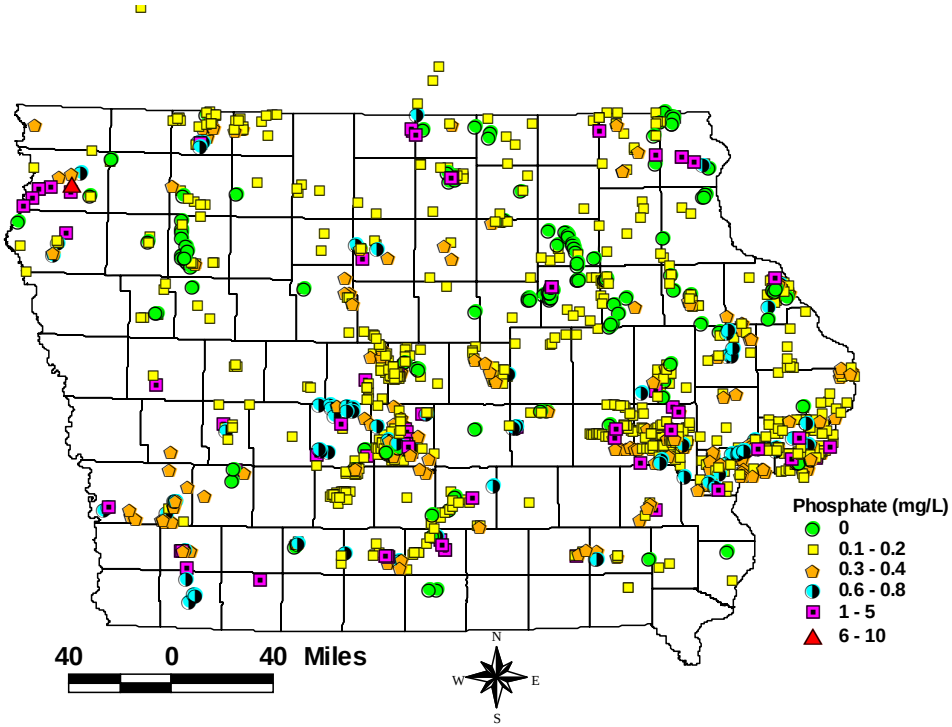

Figure 50. Median phosphate concentration for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 51 shows the median nitrite-N concentrations for the IOWATER sites. A total of 78% of the sites had median nitrite-N levels of 0 mg/L, while 21% were 0.15 mg/L. Ten sites had median concentrations of 0.3 or 1 mg/L. Some of those sites with the higher nitrite-N concentrations are located a short distance downstream of the discharge from a wastewater treatment facility.

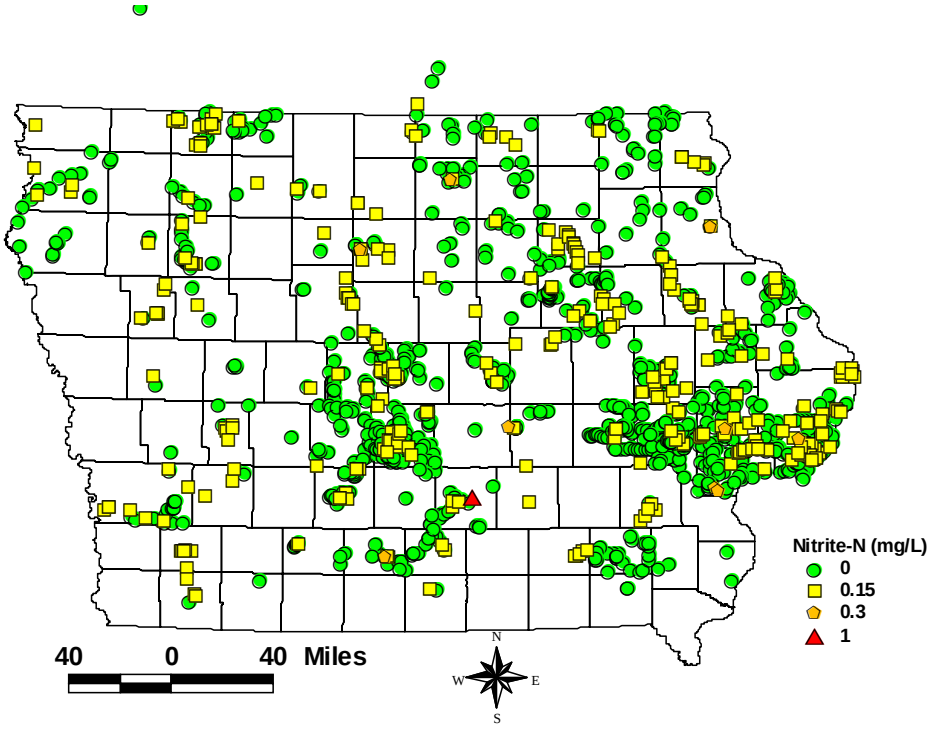

Figure 51. Median nitrite-N concentration for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

Figure 52 shows the median nitrate-N concentrations for the IOWATER sites. A total of 10% of the sites had median nitrate-N levels of 0 or 1 mg/L, while 47% were 2 mg/L. Another 30% were 5 mg/L. Lower nitrate-N concentrations tended to occur across the southern part of Iowa.

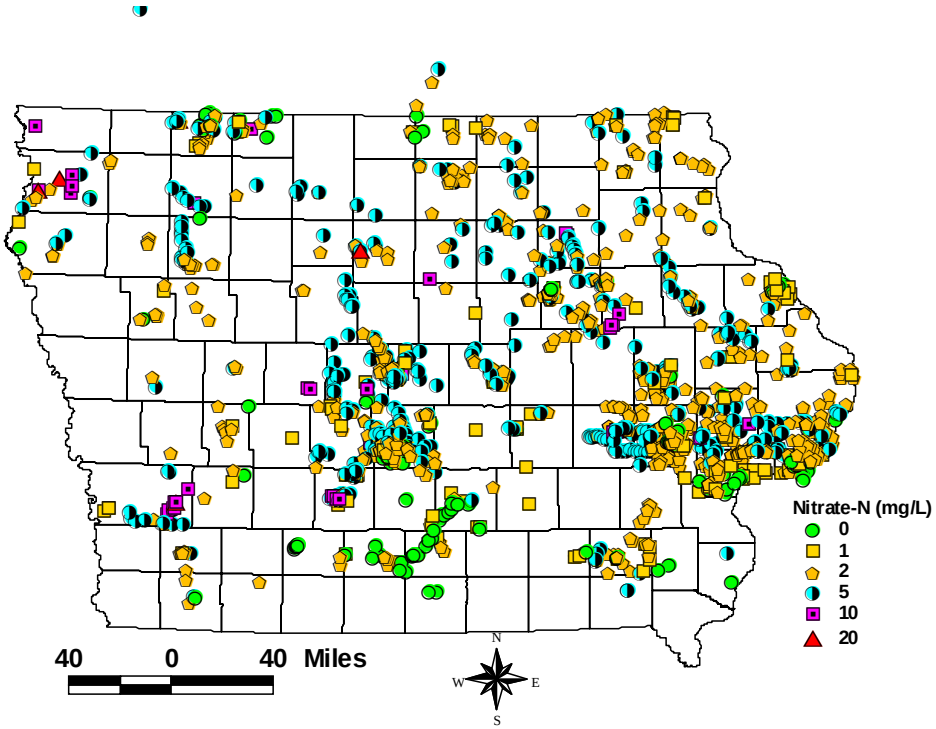

Figure 52. Median nitrate-N concentration for IOWATER sites that had five or more data records collected from 2000 through 2009. Map includes sites outside of Iowa.

IOWATER Data Compared to Ambient Stream Data Statewide

Figure 53 shows the median values for IOWATER collected data versus data from a network of streams statewide that are monitored on a monthly basis (ambient stream network). Keep in mind that the IOWATER sites sampled and their frequency of monitoring varies when compared to the ambient stream network, where the same 74 stream sites are sampled on a monthly basis throughout the year.

For the most part, as dissolved oxygen levels increased for the ambient stream network, the IOWATER data showed an increase as well. The sags in IOWATER dissolved oxygen that appear in Figure 53 occurred during the summer months and corresponded to lows associated with the ambient stream network. Overall, dissolved oxygen concentrations were higher for the ambient stream network. This reflects a difference in the methods used to measure dissolved oxygen for the two data sets. For the ambient stream network, a field meter is used which has no upper limit whereas the IOWATER kit has an upper limit of 12 mg/L.

Ambient stream pH values generally varied between 8 and 8.4, whereas the IOWATER pH was 7, 8, or 9. Again, the difference can be explained by the methods used. The IOWATER pH test strip reports pH in whole number increments so the IOWATER results show a greater range than the ambient stream data.

Water temperature tracked well between the IOWATER collected data versus the ambient stream network data. Even during the winter, a time when IOWATER volunteers tend to sample less frequently, median temperatures were very similar to those for the ambient stream network.

For nitrate-N, Figure 53 shows the limitations of the IOWATER method in measuring nitrate-N. The IOWATER test strip measure nitrate-N in increments of 0, 1, 2, 5, 10, 20, and 50 mg/L. Where increases in nitrate-N occurred in the ambient stream data, increases tended to occur in the IOWATER data as well, however not to the concentration that occurred in the ambient stream data. For the most part, the IOWATER median concentration tended to fluctuate between 2 and 5 mg/L. The IOWATER median nitrate-N remained consistent at 2 mg/L from July 2007 through December 2009 (Figure 53).

The IOWATER method used for phosphate actually measures dissolved orthophosphate. Figure 53 shows the median concentrations for phosphate using the IOWATER kit and the total phosphorus and orthophosphorus concentrations reported from the ambient stream network. Overall, the IOWATER phosphorate method tracks relatively well with the total phosphorus results for the ambient stream network. Lower levels tend to occur during the winter months and higher concentrations in the late spring/early summer.

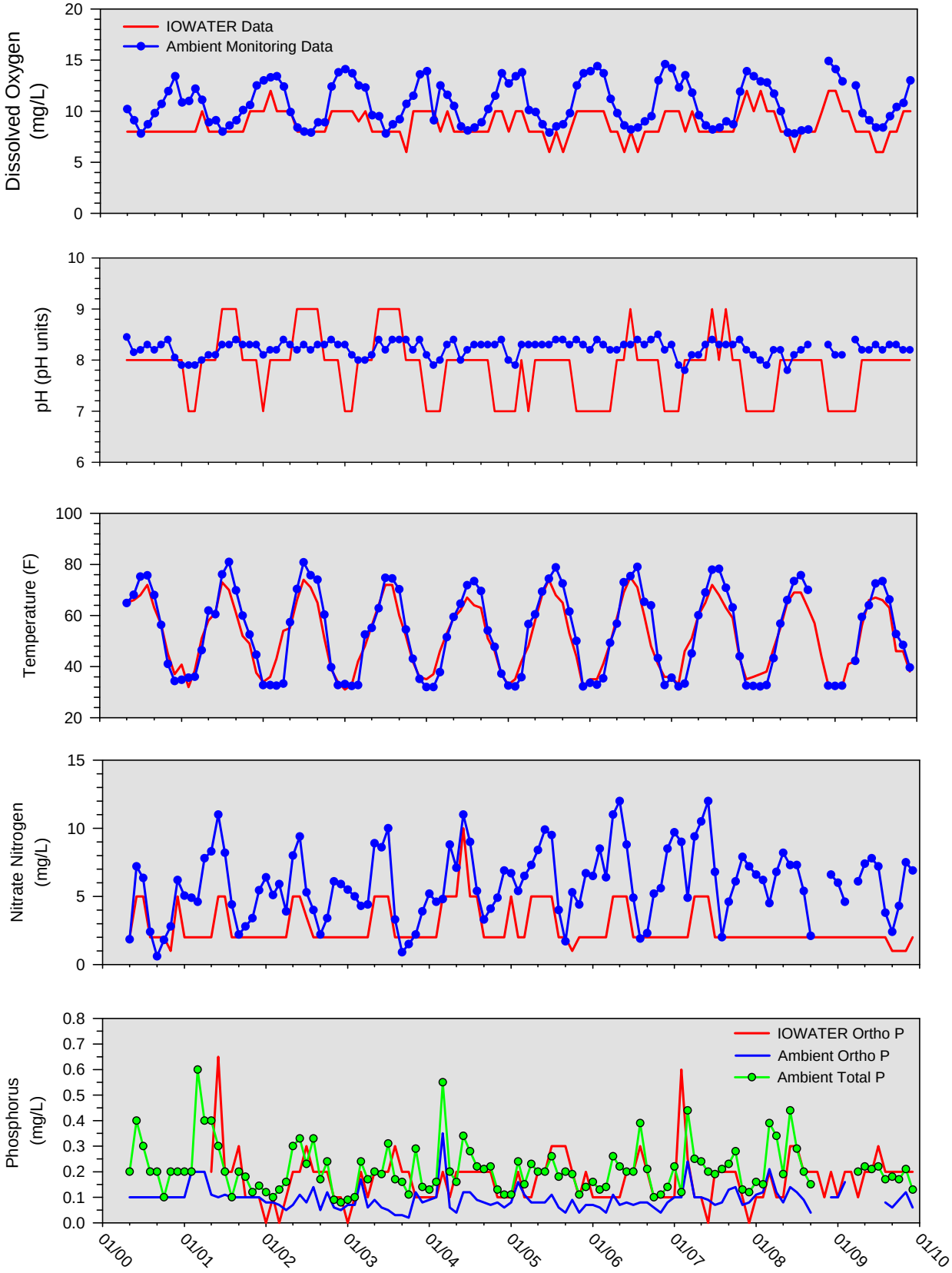
Dissolved Oxygen (mg/L)
IOWATER Data
Ambient Monitoring Data
pH (pH units)
Temperature (F)
Nitrate Nitrogen (mg/L)
Phosphorus (mg/L)
IOWATER Ortho P
Ambient Ortho P
Ambient Total P
01/00
01/01
01/02
01/03
01/04
01/05
01/06
01/07
01/08
01/09
01/10

Figure 53. Comparison of median values for IOWATER collected data versus data from a network of streams statewide that are monitored on a monthly basis (ambient stream network).

Summary

- For the chemical/physical assessment, the IOWATER field parameters that were monitored, from most frequent to least frequent, were pH, dissolved oxygen, water temperature, transparency, nitrate-N, nitrite-N, chloride, phosphate, and stream flow.
- In general, most IOWATER sites had less than 5 data records submitted. Seventy-five percent of the sites had 10 or less data records submitted to the IOWATER database, while 3.5% of the sites had 31 or more data records.
- For 38% of the IOWATER sites, chemical/physical data was collected for less than a year, while 45% of the sites were sampled for a 1 to 5 year period of time.
- IOWATER volunteers tended to sample their sites most frequently during May and October, and least frequently during January, February, and December.
- The number of chemical/physical data records submitted increased from 2000 through 2004, followed by a decline through 2009.
- The water color "clear" correlated to high transparency, as sites which had "clear" water generally had transparency of 51-60 centimeters.
- The vast majority of IOWATER data (99%) reported a water odor of "none."
- Fifty percent of the transparency results were between 51 and 60 centimeters. Higher transparency tended to occur during the winter months when less runoff and rainfall occurred. Transparency was the most variable and had the lowest median level during June.
- For 70% of the IOWATER data reported, dissolved oxygen concentrations were 8 mg/L or greater, while only 4% were <5 mg/L. For sites with low dissolved oxygen of 5 mg/L or less, low dissolved oxygen tended to be a rare occurrence and occurred most frequently from July through October when stream flow was low and water temperatures were at their highest.
- The majority of chloride concentrations were <50 mg/L (81% of the samples). For chloride concentrations >100 mg/L, most occurred during the month of October when flow is generally low and point source inputs are most apparent.
- For ~25 IOWATER sites, elevated chloride concentrations were frequently reported. Many of these sites were either located in urban areas, located downstream of community wastewater facilities, or affected by the storage or application of road salt.
- Phosphate concentrations were relatively low, as 85% of the samples were at or below 0.2 mg/L. As phosphate levels increased from 0 to 1 mg/L, so did chloride. For phosphate concentrations from 1 to 10 mg/L, chloride levels were generally high.
- Nitrate and nitrite nitrogen concentrations were variable. Nitrate-N was 0 mg/L for 17% of the data and 2 or 5 mg/L for 63% of the results. Nitrite-N was low, as 70% of the data reported 0 mg/L and 25% were 0.15 mg/L.

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