Results from Water Quality Monitoring Conducted during Project AWARE 2007 – Middle Raccoon, North Raccoon, and Raccoon River Watersheds

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Abstract: From June 16-23, 2007, 400 volunteers participated in Project AWARE 2007 (A Watershed Awareness River Expedition), a weeklong river cleanup on the Middle Raccoon, North Raccoon, and Raccoon rivers in west-central Iowa. Project AWARE is a 7-day, 7-night float trip down an Iowa river that allows volunteers to participate in a river cleanup, water quality monitoring, and evening educational programs. An estimated 26 tons of trash were removed from the 102 miles of the Middle Raccoon River in Guthrie County, the North Raccoon River in Greene and Dallas counties, and the Raccoon River in Dallas and Polk counties. A total of 85% of the trash was recycled. Project AWARE is an initiative of the Iowa Department of Natural Resources IOWATER, Water Trails, and Keepers of the Land programs, and 2007 represented the fifth year of the event.

In addition to trash removal, 36 stream sites along the canoe route were monitored for a variety of water quality parameters using a combination of IOWATER methods, field meters, and lab analyses. Lab analyses were performed by Des Moines Water Works. Monitoring occurred during below normal stream flow conditions. For many of the parameters, concentrations were similar to those measured in streams statewide. Results from the Project AWARE sites showed that nitrate-N, chloride, specific conductivity, and dissolved oxygen levels were higher for the Project AWARE sites than for streams statewide. All dissolved oxygen results were greater than the 5 mg/L water quality standard. Sulfate concentrations were higher in main stem sites versus tributary sites. Three of the sites monitored were located near industrial and municipal wastewater treatment facilities. Results from these three sites showed the impact of point sources, as some of the highest levels for chloride, sulfate, fluoride, specific conductance, and orthophosphorus occurred at these sites. *E. coli* bacteria levels exceeded 235 MPN/100 ml at 14 of the sites. The highest *E. coli* bacteria levels occurred at three tributary sites sampled on Friday June 22, the day after a rain event. It is unclear what impact the rainfall had on bacteria levels at these locations. Bacteria results for the four sites sampled in the Middle Raccoon River watershed all exceeded 235 MPN/100 ml.

This report summarizes the water quality results for sites monitored during Project AWARE 2007. For more information on Project AWARE, go to *www.iowaprojectaware.com*.

Introduction

Project AWARE, which stands for A Watershed Awareness River Expedition, is the Iowa DNR's weeklong volunteer river cleanup event during which hundreds of Iowans spend anywhere from a day to an entire week improving Iowa's waterways by removing trash. In addition to trash removal, participants on Project AWARE learn about water quality, wildlife conservation, recycling, and other topics related to Iowa's natural resources. Project AWARE 2007 represents the 5th year of this annual event, with the previous four years of Project AWARE paddling the Maquoketa River in northeast Iowa, Des Moines River in north-central, Little Sioux River in northwest, and the Iowa and English rivers in southeast Iowa.

On Day 1 of Project AWARE 2007, participants paddled 15 miles on the Middle Raccoon River, beginning at Whiterock Conservancy near Coon Rapids in Guthrie County and continued south to Springbrook State Park (Figure 1). For the remainder of the week, Project AWARE traversed the North Raccoon River, beginning at McMahon Access just west of Jefferson in Greene County and ended at Walnut Woods State Park near Des Moines in Polk County. A large thunderstorm the evening of June 22 caused the discharge or flow in the Raccoon River to increase dramatically overnight, preventing Project AWARE participants from paddling on June 23 to the trip's original destination, Des Moines Waterworks Park. On Saturday June 23, participants spent the morning cleaning up storm damage in Walnut Woods State Park, therefore no water samples were collected on June 23.

For each day of Project AWARE, a minimum of two people were identified to do water testing. At least one of the two people was IOWATER trained. Before beginning monitoring for the day, those individuals were trained in the sampling procedures, use of the hand-held GPS unit, and proper collection and storage of samples for lab analyses. Prior to the event, the author identified potential monitoring sites. Sites were selected based on starting, half-way, and take-out points for each day of Project AWARE; the location of monitoring sites associated with the Agriculture's Clean Water Alliance water monitoring project in the Raccoon River watershed; location of IOWATER snapshot sites as part of the North Raccoon River snapshot event; location of major tributaries entering the Middle Raccoon or North Raccoon rivers; and other locations of interest (e.g., sites near known point sources or proximity to National Pollutant Discharge Elimination System permitted facilities; locations near unsewered communities). A total of 36 sites were sampled (Figure 1), including 20 on the main channel, 14 tributaries, and 2 sites that represented the outfalls from municipal wastewater treatment facilities (Jefferson and Perry). One of the tributary sites receives wastewater from an industrial treatment facility at Perry. All three wastewater treatment facilities are activated sludge facilities.

For all sites sampled on the Middle Raccoon, North Raccoon, and Raccoon rivers during Project AWARE 2007, volunteers collected data using IOWATER field methods. In addition, field meters were also used to measure dissolved oxygen, pH, water temperature, specific conductivity, and turbidity. Field data were recorded both on waterproof paper field sheets and in a hand-held GPS with customized software to store the water quality information and record the UTM coordinates for each site monitored. Water samples were collected from each site and stored in a cooler on ice until they could be delivered to Des Moines Water Works for the following lab analyses: bromide, chloride, total coliform bacteria, *E. coli* bacteria, fluoride, nitrite-N, nitrate-N, orthophosphorus, sulfate, and turbidity. This report summarizes the water quality from the Project AWARE 2007 sampling of 36 sites along the Middle Raccoon (4 sites) and North Raccoon and Raccoon rivers (32 sites) at main stem, tile line, and tributary locations (Figure 1), and includes chemical and physical results (Table 1).

Where possible, water quality results from Project AWARE were compared to a network of 75 to 83 streams statewide that are monitored on a monthly basis as part of the Iowa Department of Natural Resources (DNR) Watershed Monitoring and Assessment Program. Data from this network have been collected since 2000 and provide perspective on what are typical stream concentrations statewide for the various parameters. In this report, this network will be referred to as the DNR statewide stream network. The June 2007 results from this network were also compared to Project AWARE results to determine relative concentrations for the same time period.

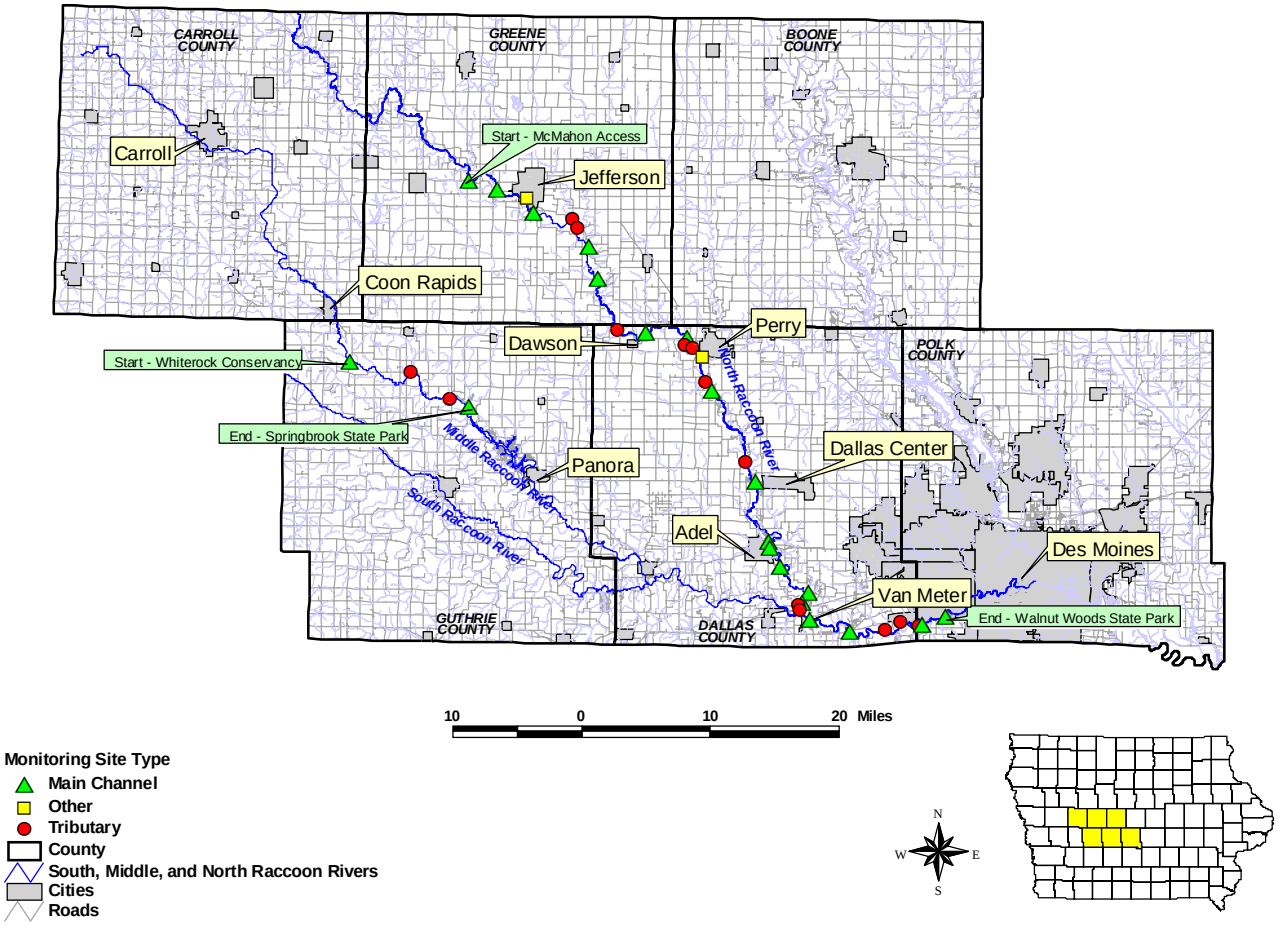

Figure 1. Location of sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Precipitation and Stream Flow Conditions

Precipitation and stream flow conditions can directly affect water quality results. Two rainstorms occurred during the week of Project AWARE: the first was Thursday June 21 in Van Meter and the second on Friday June 22 at Walnut Woods State Park in Des Moines. According to the Iowa Climate Review (Iowa Department of Agriculture and Land Stewardship, 2007), the Des Moines Airport received 0.77 inches of rain on June 21 and 1.59 inches of rain on June 22. During the week of Project AWARE, stream flow conditions for the Middle Raccoon, North Raccoon, and Raccoon rivers were below the long-term normal for most of the week. On Sunday, June 17, participants paddled the Middle Raccoon River from Whiterock Conservancy southeast of Coon Rapids to Springbrook State Park north of Guthrie Center. Discharge was 265 cubic feet per second (cfs) based on data from the U.S. Geological Survey (USGS) gaging station on the Middle Raccoon River near Bayard (37-year record; Figure 2). This discharge was 33% of the long-term normal. From June 18 through June 21, volunteers paddled the North Raccoon River. Stream flow on the North Raccoon during those days varied from 1,070 to 1,400 cfs and was 49 to 61% of the long-term normal (based on data from the USGS gaging station on the North Raccoon River at Jefferson – 67-year record; Figure 2). Most of Project AWARE's route for Friday June 22 was on the Raccoon River. Discharge on Friday was 2,310 cfs or 70% of the long-term normal for the USGS gaging station on the Raccoon River at Van Meter (92-year record). Stream levels on the Raccoon River rose significantly from Friday to Saturday in response to the rainfall from the previous two days. Water levels increased from 2,310 cfs on Friday

June 22 to 6,100 cfs on Saturday June 23, an increase from 70% to 185% of the long-term normal river level. High river levels on Saturday presented safety concerns, and participants were kept off the river. No water samples were collected on Saturday.

Table 1. Monitoring results from Project AWARE 2007.

	Unit	Method	# of samples	Min Value	Percentiles			Max Value
					25th	50th	75th	
Air Temperature	degrees F	Thermometer - Field	36	70	78	83	87	94
pH	pH units	IOWATER test strip	36	7	9	9	9	9
Dissolved Oxygen	mg/L	IOWATER field kit	35	6	6	8	8	10
Orthophosphorus	mg/L	IOWATER field kit	35	0	0	0	0	10
Nitrite-N	mg/L	IOWATER test strip	36	0	0	0	0	0.3
Nitrate-N	mg/L	IOWATER test strip	36	0	5	5	10	10
Chloride	mg/L	IOWATER test strip	36	<30	30	30	30	570
Ammonia-N	mg/L	CHEMetrics field kit	35	0	0	0	0	0
Transparency	centimeters	IOWATER transparency tube	36	6	19	29	45	60
Specific Conductivity	µS/cm	Field meter	36	400	686	731	748	3,074
Turbidity	NTU	Field meter	35	4	11	26	42	207
pH	pH units	Field meter	34	7.2	8.1	8.2	8.3	8.7
Dissolved Oxygen	mg/L	Field meter	36	6.4	9.1	9.7	10.7	12.1
Water Temperature	Degrees F	Field meter	36	61	73	75	77	86
Bromide	mg/L	DMWW Lab Analysis	35	<0.1	<0.1	<0.1	<0.1	0.39
Chloride	mg/L	DMWW Lab Analysis	35	9.6	21.1	25.9	27.9	772
Total Coliform Bacteria	MNP/100 ml	DMWW Lab Analysis	35	300	2965	4611	9780	770,000
E. coli Bacteria	MNP/100 ml	DMWW Lab Analysis	35	<100	100	200	465	5,570
Fluoride	mg/L	DMWW Lab Analysis	35	0.22	0.42	0.49	0.52	1.22
Nitrite-N	mg/L	DMWW Lab Analysis	35	<0.1	<0.1	<0.1	<0.1	0.71
Nitrate-N	mg/L	DMWW Lab Analysis	35	0.1	13.2	15.8	16.3	21.9
Orthophosporus	mg/L	DMWW Lab Analysis	35	<0.1	<0.1	<0.1	<0.1	11.79
Sulfate	mg/L	DMWW Lab Analysis	35	8.9	20.5	30.1	33.4	581
Turbidity	NTU	DMWW Lab Meter	35	1.92	16.6	31.7	44.5	165

mg/L = milligrams per liter (or parts per million - ppm)
MPN/100 ml = Most Probable Number per 100 milliliters of water
µS/cm = microsiemens per centimeter
NTU = Nephelometric Turbidity Units
DMWW = Des Moines Water Works

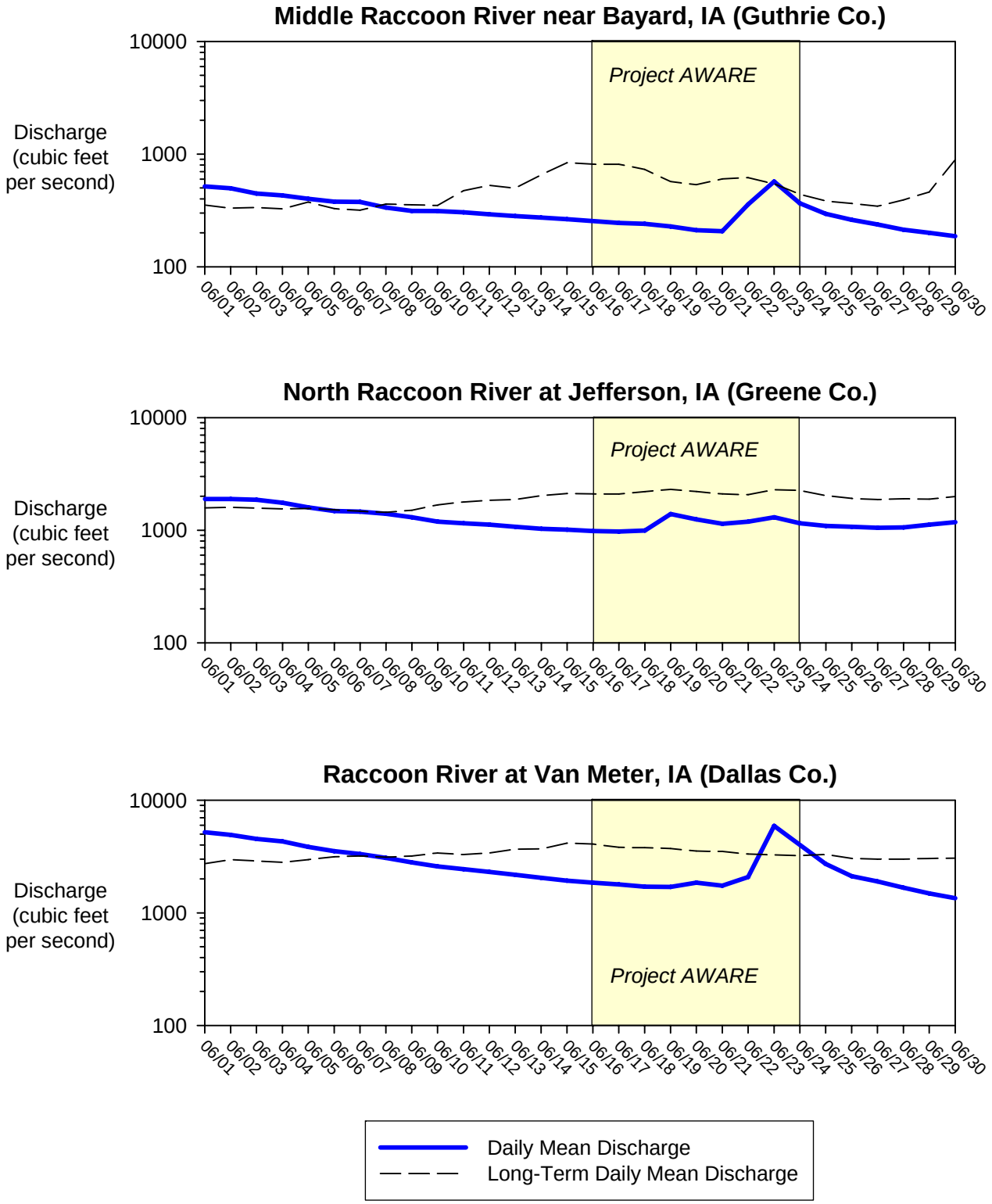

Figure 2. Discharge for the Middle Raccoon, North Raccoon, and Raccoon rivers for June 2007. Shaded area represents the week of Project AWARE. Data from http://ia.water.usgs.gov.

Chemical and Physical Parameters

Water Temperature

Water temperature affects many of the biological, chemical, and physical processes in a stream, including the amount of oxygen gas that can dissolve in water, the rate of photosynthesis by algae and plants, as well as the metabolic rate of aquatic animals.

Water temperature was measured at 36 sites during Project AWARE 2007 and varied from 61 to 86 degrees Fahrenheit (Table 1; Figure 3). Temperatures of the main channel sites ranged from 70 to 80 degrees, with cooler temperatures in the morning and warmer temperatures mid afternoon. Two of the cooler water temperatures (61 and 64 degrees) were recorded at the outfalls associated with the two municipal wastewater treatment facilities (Jefferson and Perry) that were sampled. The warmest water temperature (86 degrees) occurred at a tributary site that enters the North Raccoon River upstream of the boat ramp just north of Highway 141. This tributary stream receives outflow from an industrial wastewater treatment facility in Perry.

Figure 4 compares the results of selected parameters from Project AWARE to the DNR statewide stream network. Water temperatures for sites monitored on Project AWARE were higher than streams statewide and exhibited a greater range.

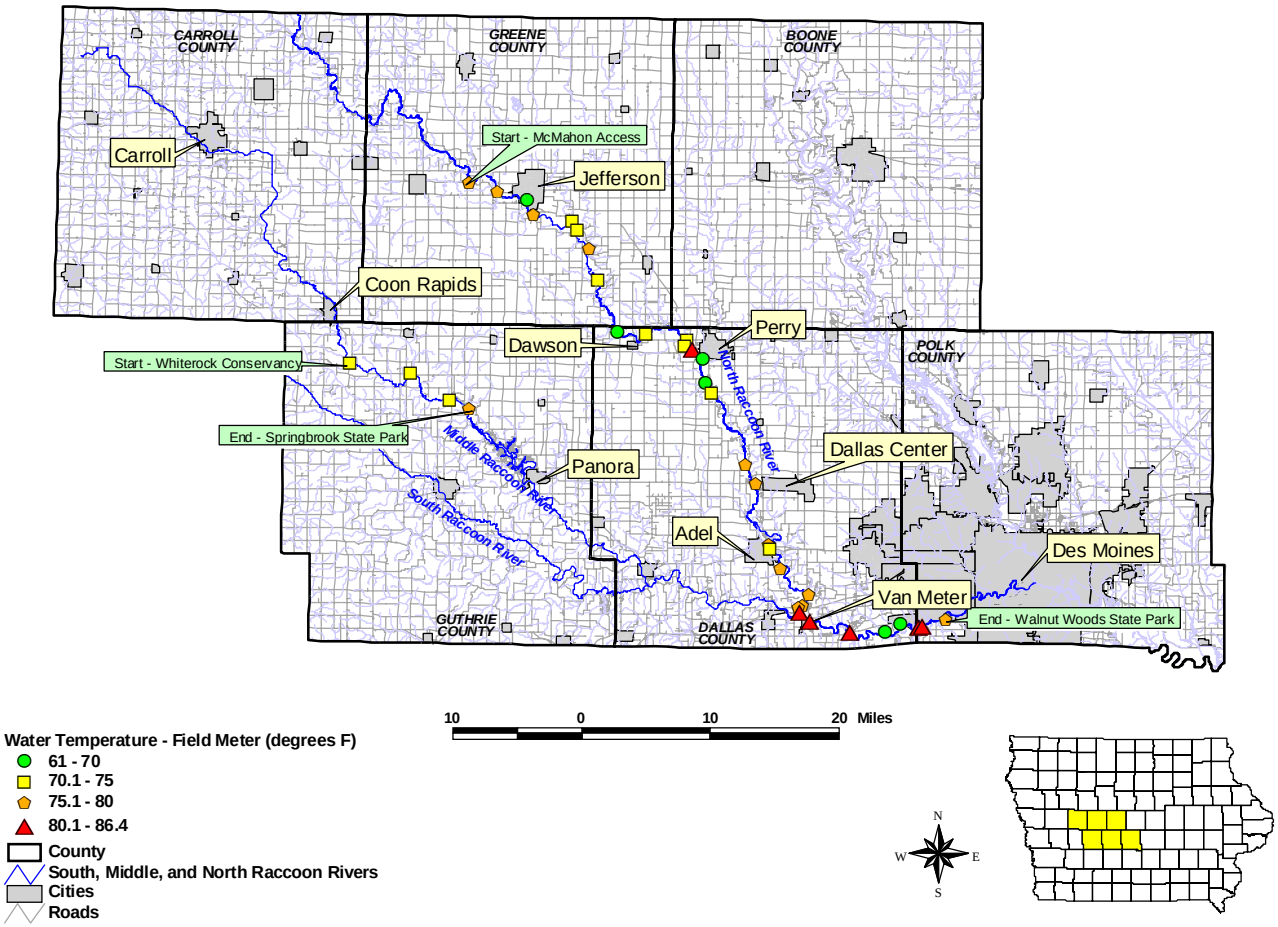

Figure 3. Water temperature (field meter) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

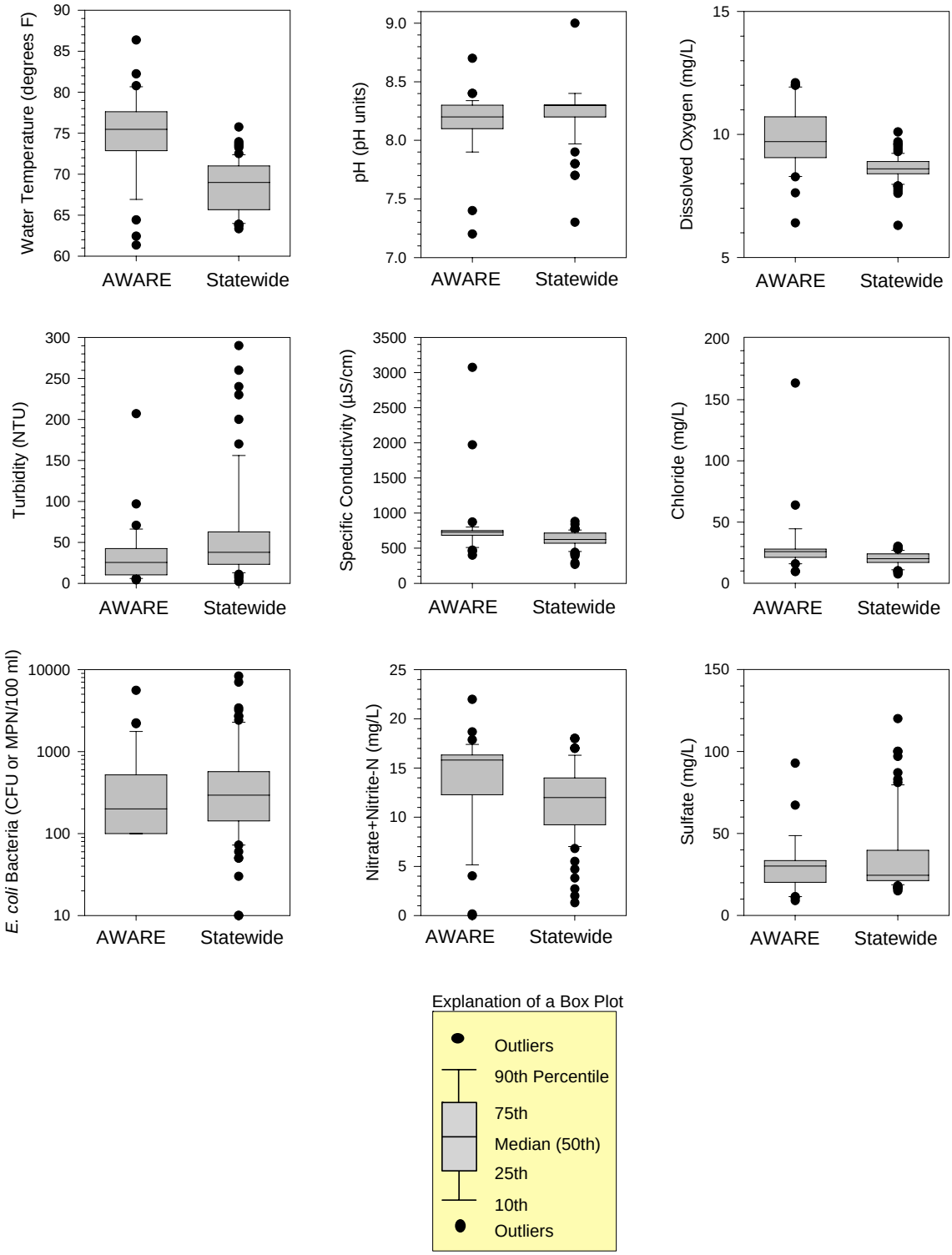

Figure 4. Box plots comparing water quality results for sites sampled during Project AWARE to the DNR statewide stream network for June 2007 (Note: the following results from Project AWARE sites are not displayed – sulfate value of 581 mg/L and chloride value of 772 mg/L.)

pH

pH is a measure of water's acid/base content. Changes in pH can be caused by atmospheric deposition of acid rain, the types of soils and bedrock that the water comes in contact with, wastewater discharges, and acid mine drainage. A pH of 7 is neutral; pH values greater than 7 are alkaline or basic, while a pH less than 7 is acidic.

pH levels ranged from 7 to 9 using the IOWATER test strip and ranged from 7.2 to 8.7 using the pH field meter (Table 1; Figures 5 and 6). These levels are similar to those typically measured in streams statewide and were similar to those reported in June 2007 for the DNR statewide stream network (Figure 4). The two lowest pH values from Project AWARE were 7.2 and 7.4, and both were measured near the two wastewater facilities at Perry.

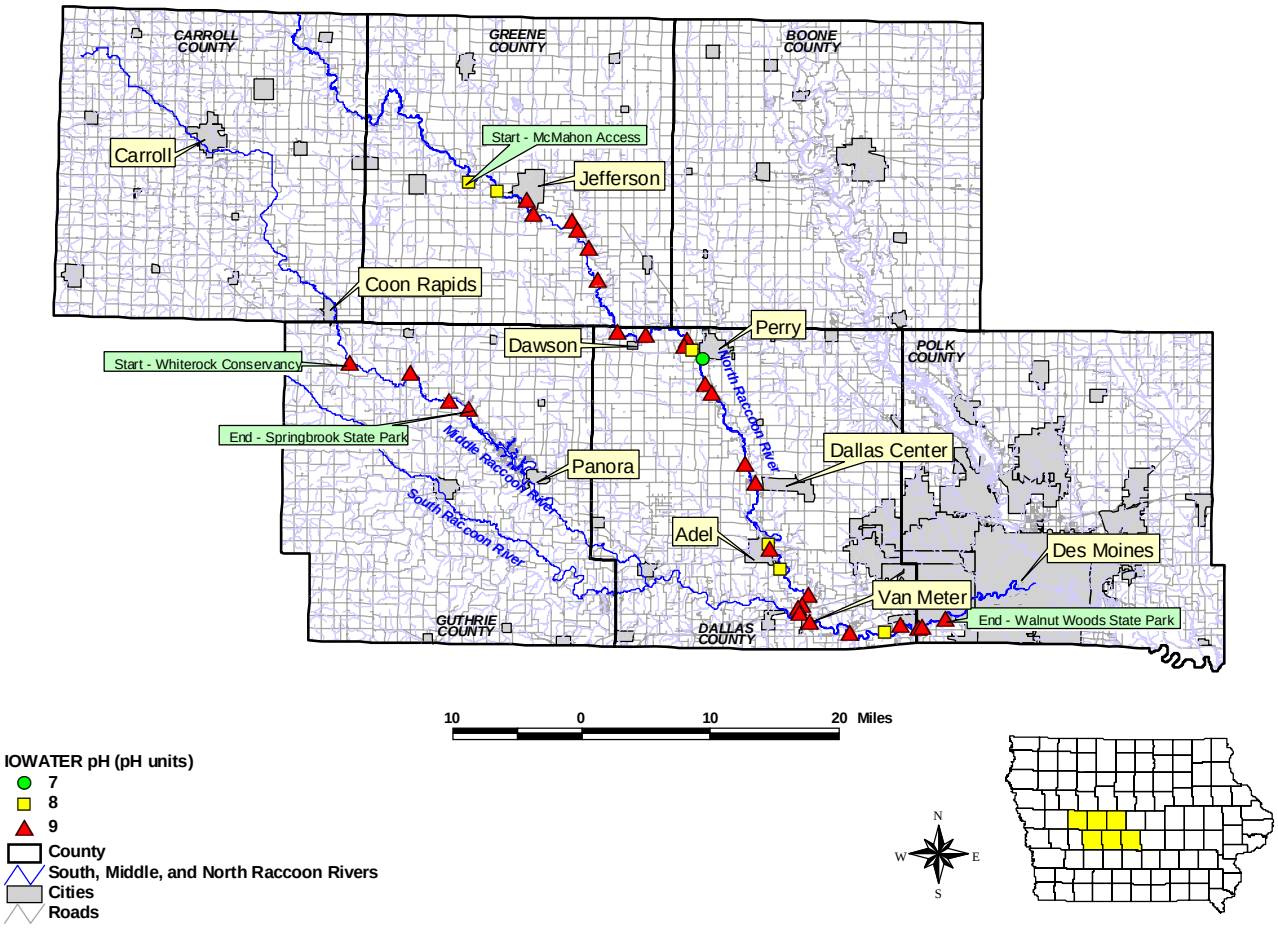

Figure 5. pH (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

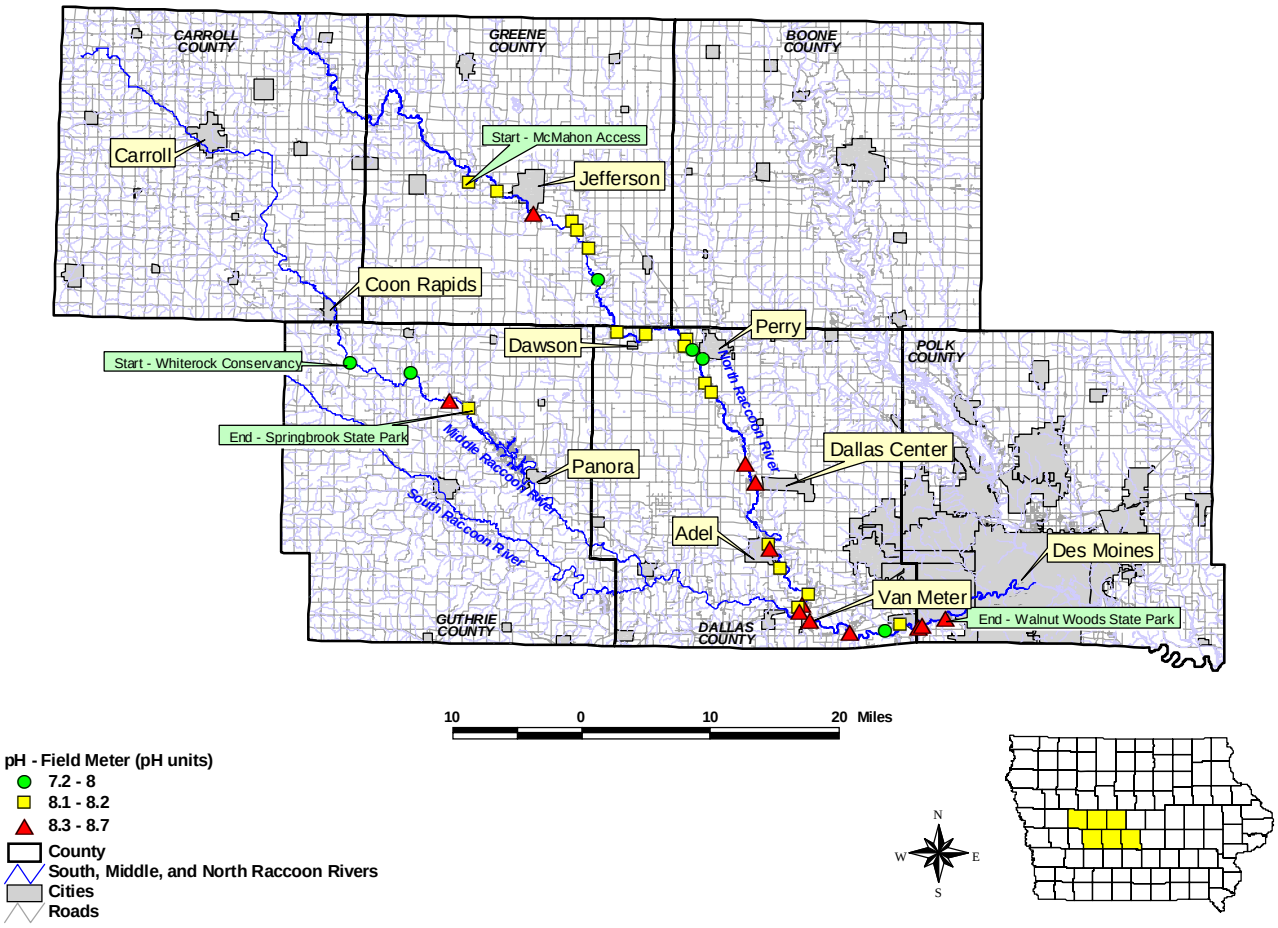

Figure 6. pH (field meter) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

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 include soil, algae, plankton, and microbes. Transparency ranged from 6 to 60 centimeters (cm) for all Project AWARE sites (Table 1; Figure 7). Transparency varied from 15 to 45 cm for sites on the main stem and ranged from 6 to 60 cm for tributary sites. All three sites associated with the wastewater treatment facilities had transparency of 60 cm. Sites on the main stem of the Middle Raccoon River had low transparency levels, with all three sites less than 20 cm. Transparency was higher in the upper part of the North Raccoon watershed compared to the lower part. Overall, some of the lowest transparency levels were from tributary sites as were some of the highest levels.

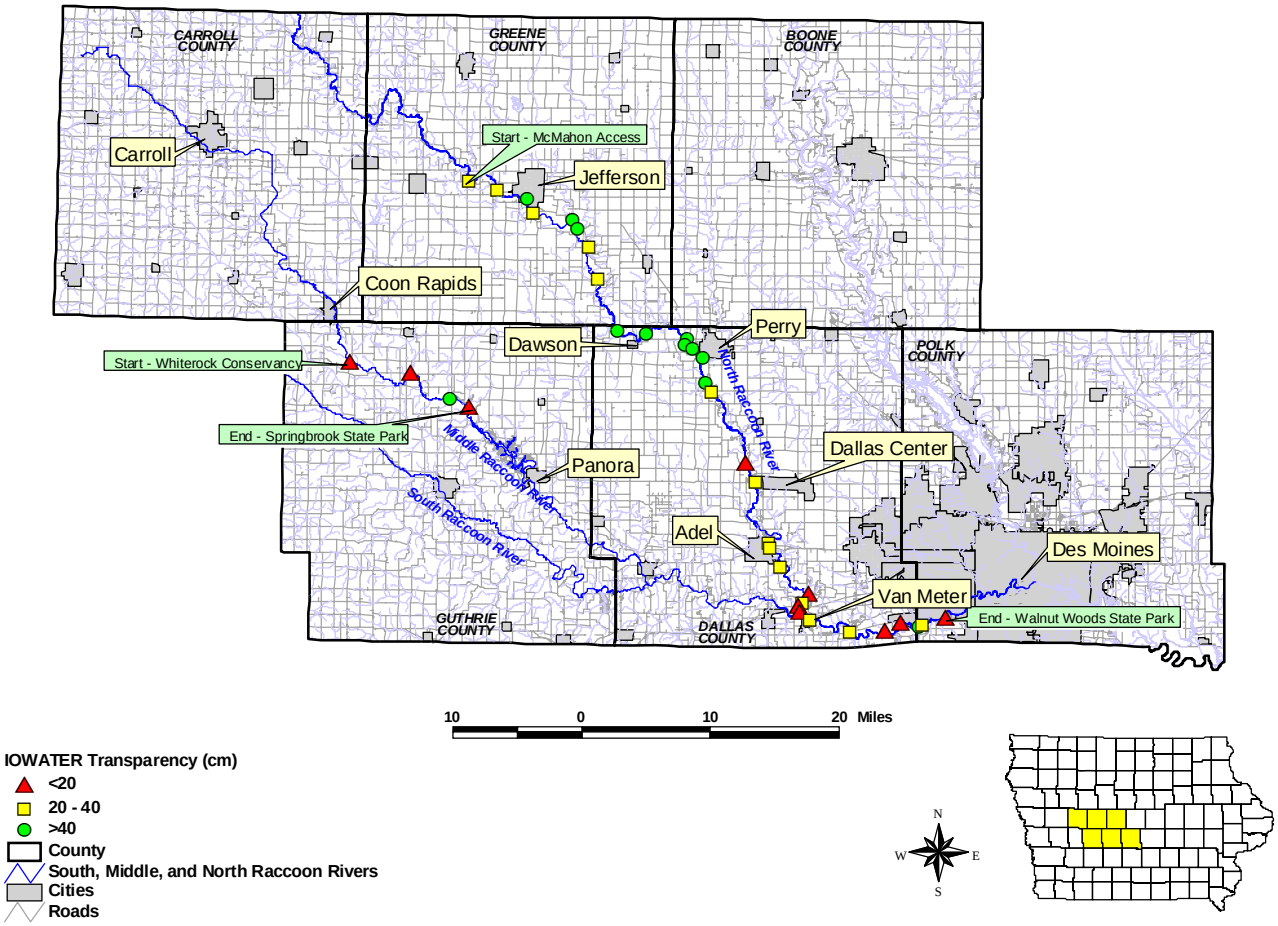

Figure 7. Water transparency (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

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. Oxygen enters a stream through diffusion from the surrounding air and as a product of photosynthesis from aquatic plants. Oxygen in a stream can be consumed through respiration by aquatic plants and animals, and by the decomposition of organic matter. Iowa has a water quality standard minimum of 5 mg/L of dissolved oxygen for warm water streams.

For Project AWARE sites, dissolved oxygen ranged from 6 to 10 mg/L using the IOWATER method and ranged from 6.4 to 12.1 mg/L using the field meter (Table 1; Figures 8 and 9). Some of the lower dissolved oxygen concentrations (6.4 and 7.62 mg/L) were associated with the wastewater treatment facility sites (Figure 9). Higher concentrations occurred in the lower part of the North Raccoon River watershed relative to the upper part. All dissolved oxygen concentrations measured met the water quality standard minimum of 5 mg/L for warm water streams. Dissolved oxygen concentrations were slightly higher than levels measured in streams statewide in June 2007 (Figure 4).

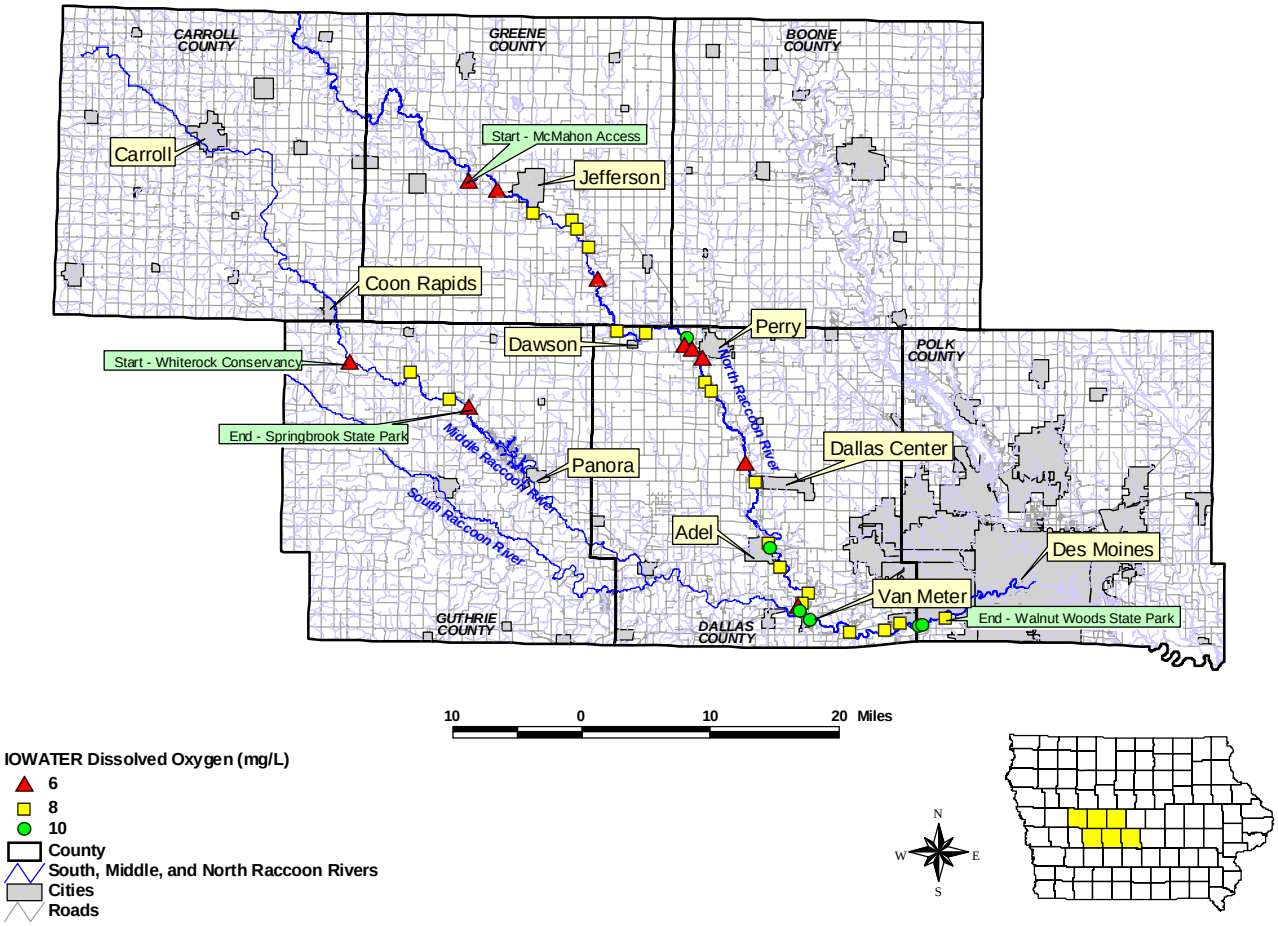

Figure 8. Dissolved oxygen (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

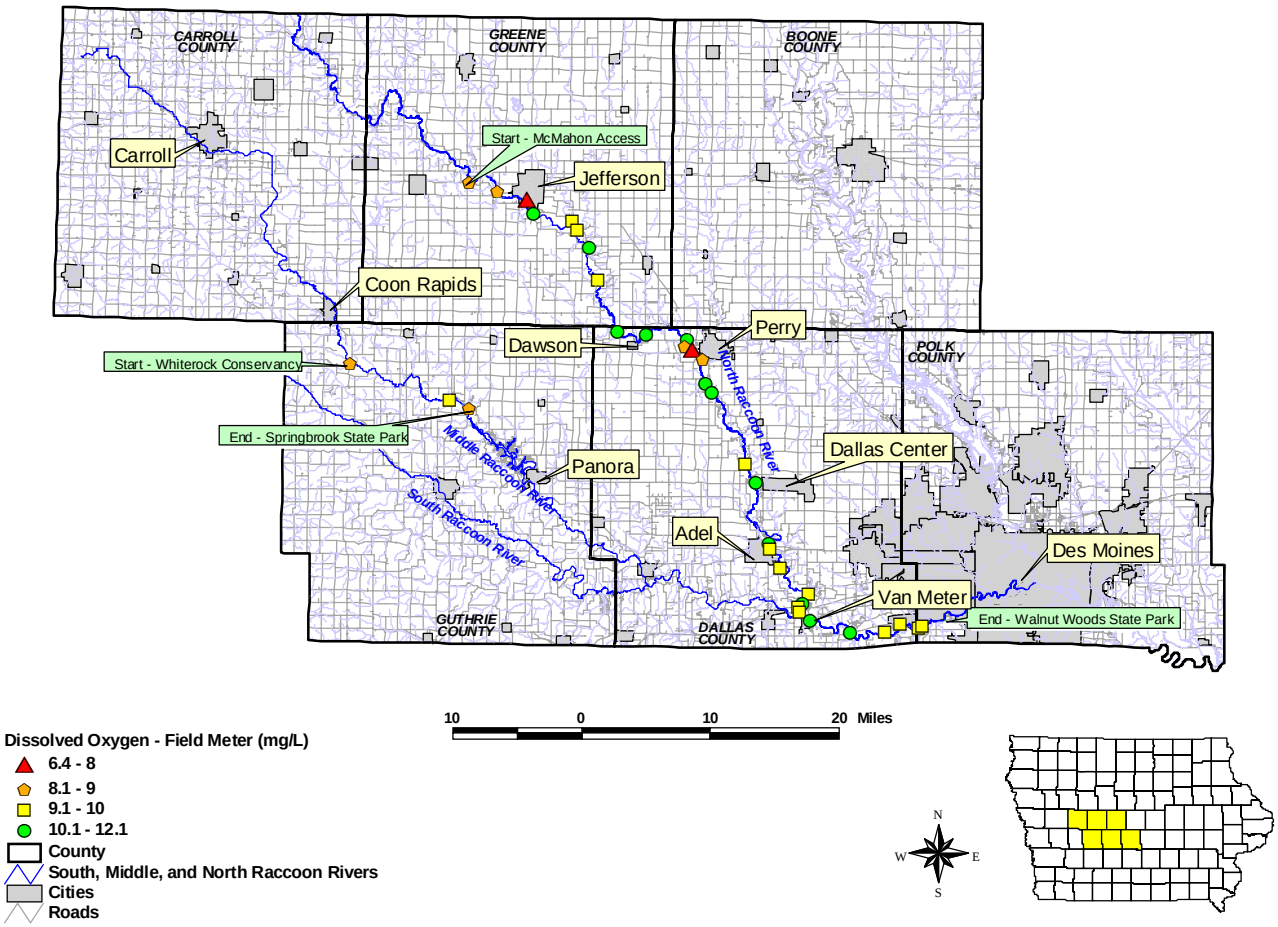

Figure 9. Dissolved oxygen (field meter) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Nitrite-N and Nitrate-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. Typical nitrate+nitrite-N concentrations for Iowa streams range from 2.9 to 8.7 mg/L, with higher concentrations generally occurring in the late spring/early summer. Nitrite-N and nitrate-N are not measured separately as part of the DNR statewide stream network, rather it is measured as nitrate+nitrite-N.

Nitrite-N was measured at Project AWARE sites using both the IOWATER method and lab analysis (Table 1; Figures 10 and 11). Six of the 36 sites had measurable levels of nitrite-N of 0.15 or 0.30 mg/L using the IOWATER method, while five of those six sites had detectable levels reported through lab analysis. The two highest lab nitrite-N concentrations were 0.71 (near Jefferson) and 0.29 mg/L (near Perry), both associated with sites near wastewater treatment facilities.

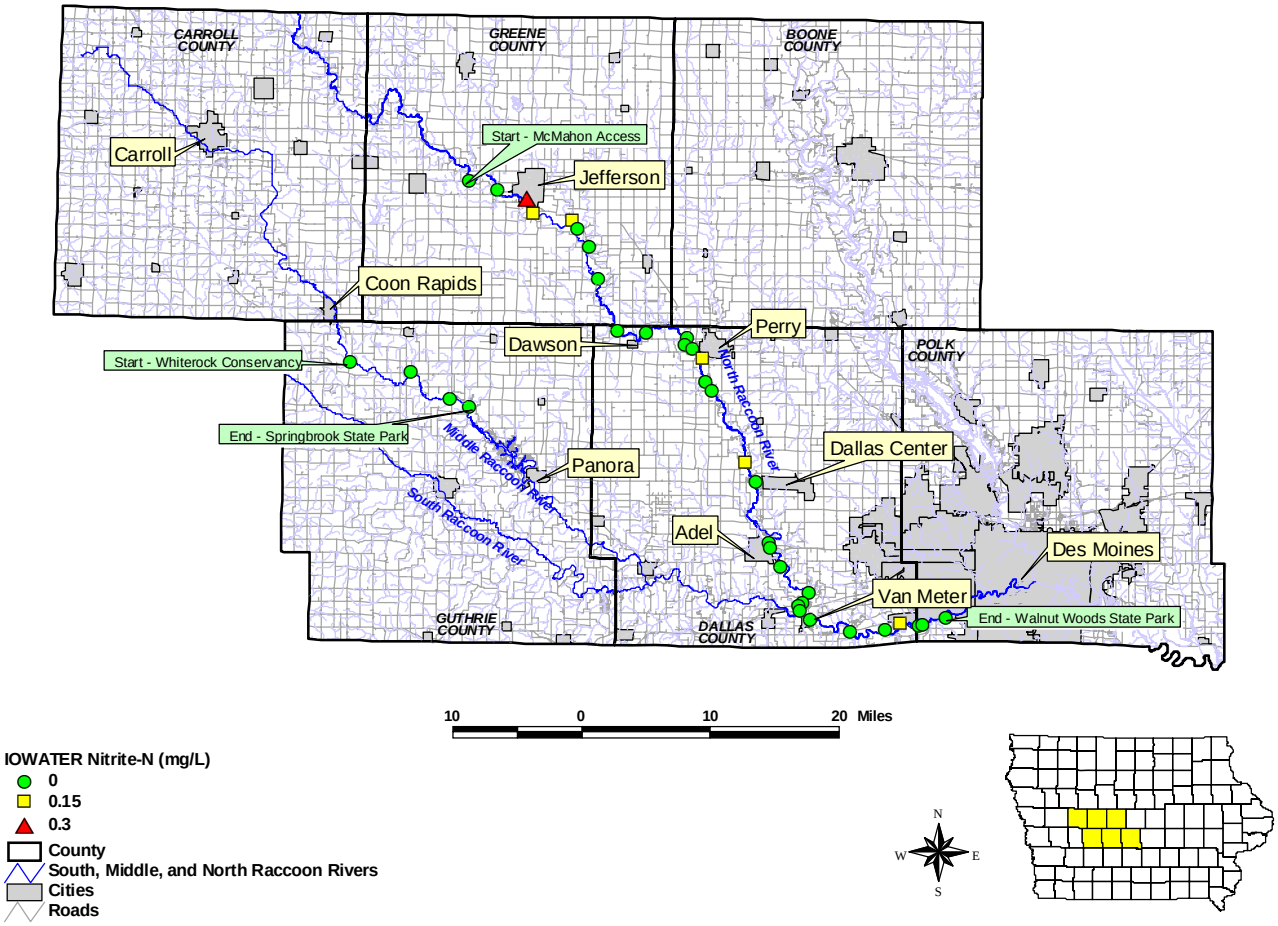

Figure 10. Nitrite-N (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

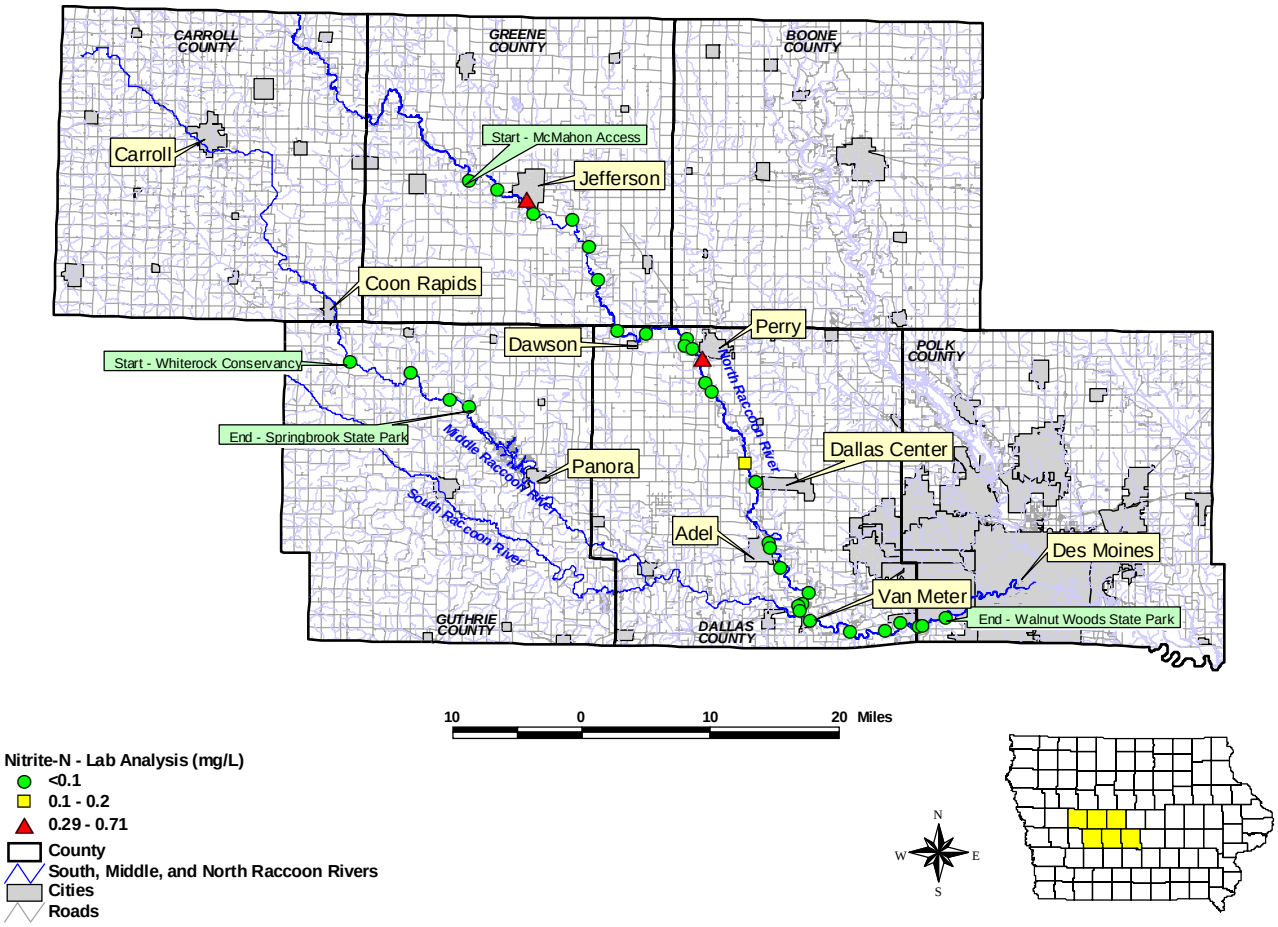

Figure 11. Nitrite-N (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Nitrate-N was measured at Project AWARE sites using both the IOWATER method and lab analysis (Table 1; Figures 12 and 13). Nitrate-N ranged from 0 to 10 mg/L (median of 5 mg/L) using the IOWATER method and ranged from 0.1 to 21.9 mg/L based on lab analysis (median 15.8 mg/L). The lowest nitrate-N concentration was 0.10 mg/L and occurred at an unnamed tributary to the Raccoon River in southwest Polk County. The highest concentration was 21.92 mg/L and occurred at the site that receives discharge from the industrial wasteawater treatment facility near Perry.

Nitrate-N concentrations ranged from 16 to 18 mg/L on the main stem of the Middle Raccoon River, 15 to 17 mg/L on the North Raccoon River, and 13 to 15 mg/L on the Raccoon River.

Nitrate-N concentrations from Project AWARE sites were higher relative to the DNR network of streams statewide and showed a greater range in values (Figure 4). The median nitrate-N concentration for Project AWARE sites was 15.8 mg/L (Table 1) whereas the median concentration in streams statewide for June 2007 was 12 mg/L.

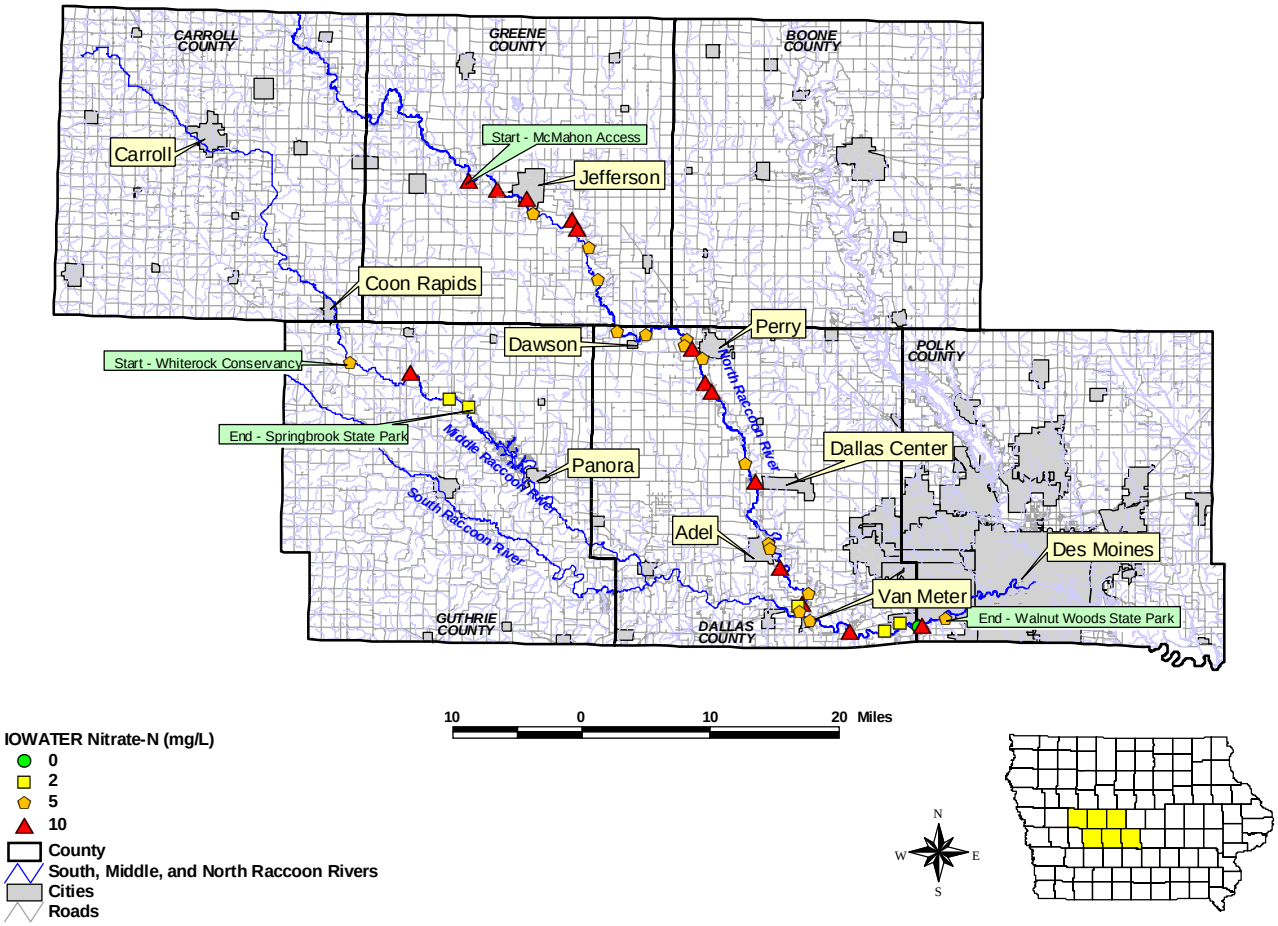

Figure 12. Nitrate-N (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

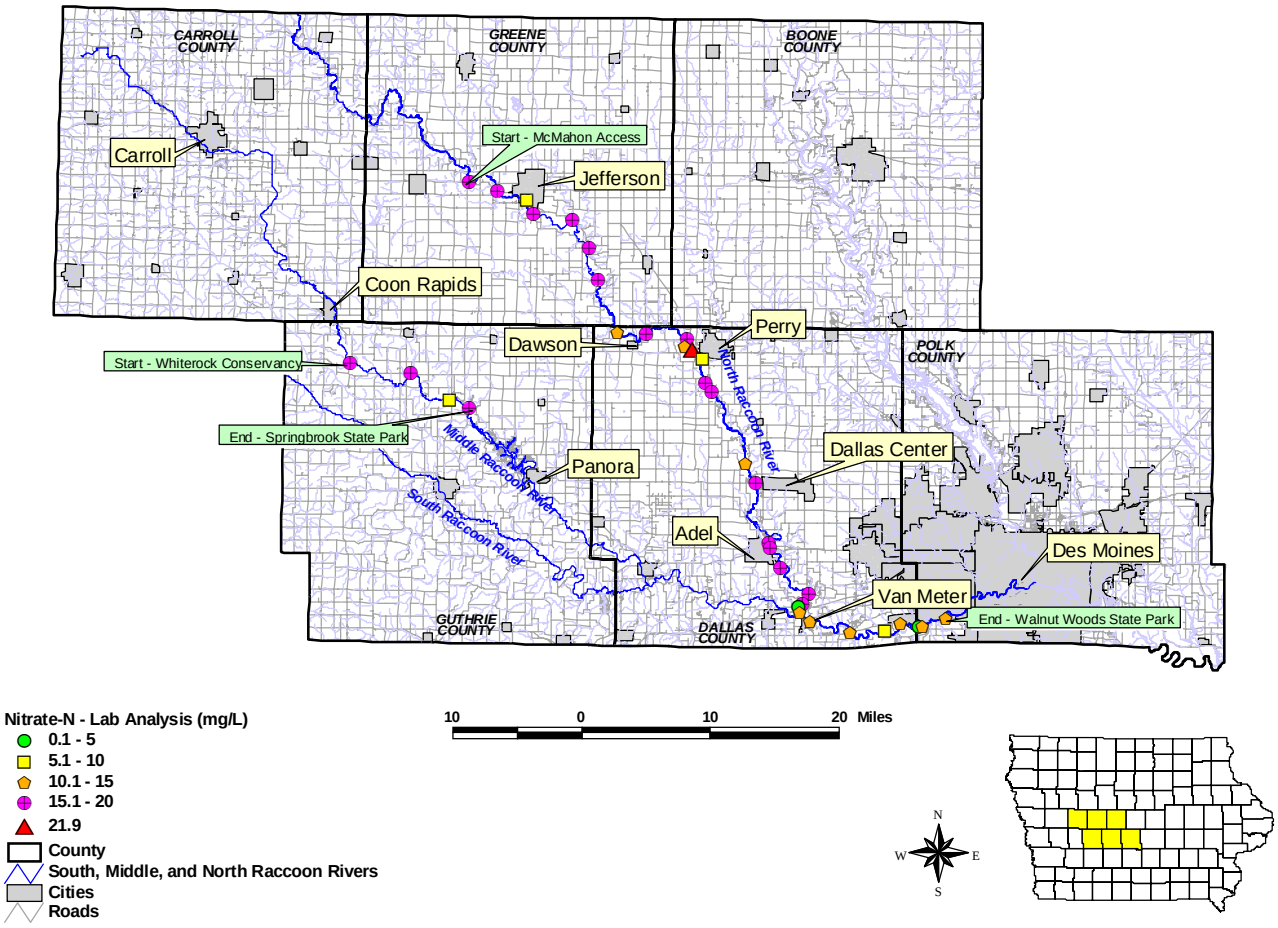

Figure 13. Nitrate-N (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Ammonia-N

Ammonia-N is another form of nitrogen that can be present in water. It represents the concentration of ionized and unionized ammonia in water, both products of the decomposition of organic matter. Typical concentrations in Iowa streams are <0.1 to 0.6 mg/L.

Ammonia-N was measured with a CHEMetrics field kit (Table 1; Figure 14). This field kit is being evaluated by the IOWATER staff for possible future use with IOWATER volunteers. There were no detectable concentrations of ammonia-N measured at any of the sites.

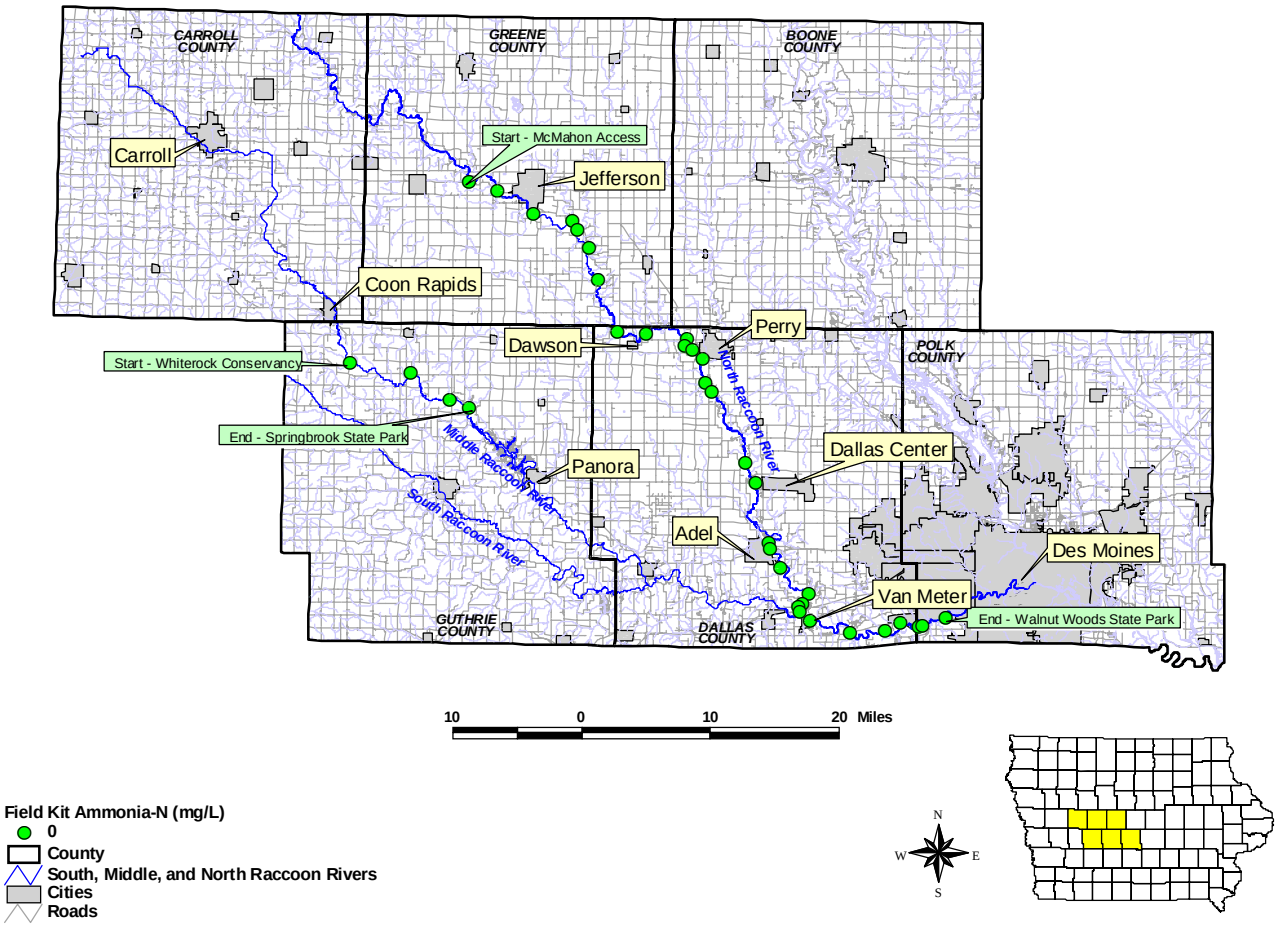

Figure 14. Ammonia-N (field kit) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Orthophosphorus

Phosphorus is a necessary nutrient for plant growth. Too much phosphorus 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 phosphorus include certain soils and bedrock; human and animal wastes; detergents; decomposing plants; and runoff from fertilized lawns and cropland. Orthophosphorus is the form of phosphorus most available for plants to use. Typical concentrations of orthophosphorus in streams statewide vary from <0.1 to 0.15 mg/L, with a median of <0.10 mg/L.

For Project AWARE, orthophosphorus was measured using both the IOWATER method and was analyzed in the lab. IOWATER orthophosphorus results ranged from 0 to 10 mg/L, with a median of 0 mg/L, whereas lab results ranged from <0.1 to 11.79 mg/L, with a median of <0.1 mg/L (Table 1; Figures 15 and 16). The three highest orthophosphorus values were associated with the three wastewater treatment facility sites. The site associated with the industrial wastewater facility near Perry had a lab orthophosphorus value of 11.79 mg/L and an IOWATER result of 10 mg/L, the maximum that can be measured. Lab results for the other two sites associated with the municipal wastewater treatment facilities were 0.55 and 1.53 mg/L. Aside from any sites associated with point source inputs, orthophosphorus concentrations were similar for the main channel versus tributary sites. Orthophosphorus concentrations measured at Project AWARE sites were similar to concentrations typical of streams statewide.

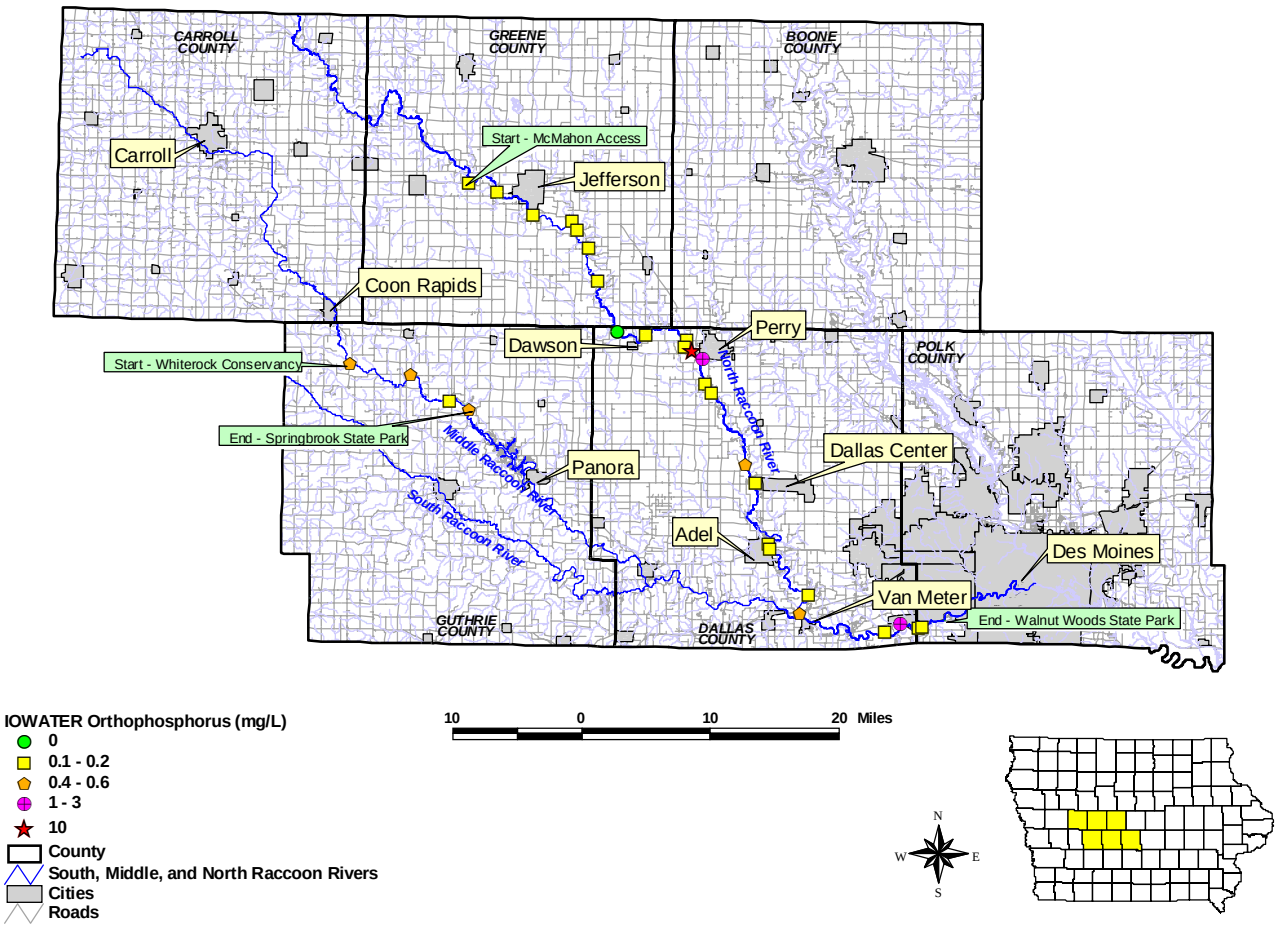

Figure 15. Orthophosphorus (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

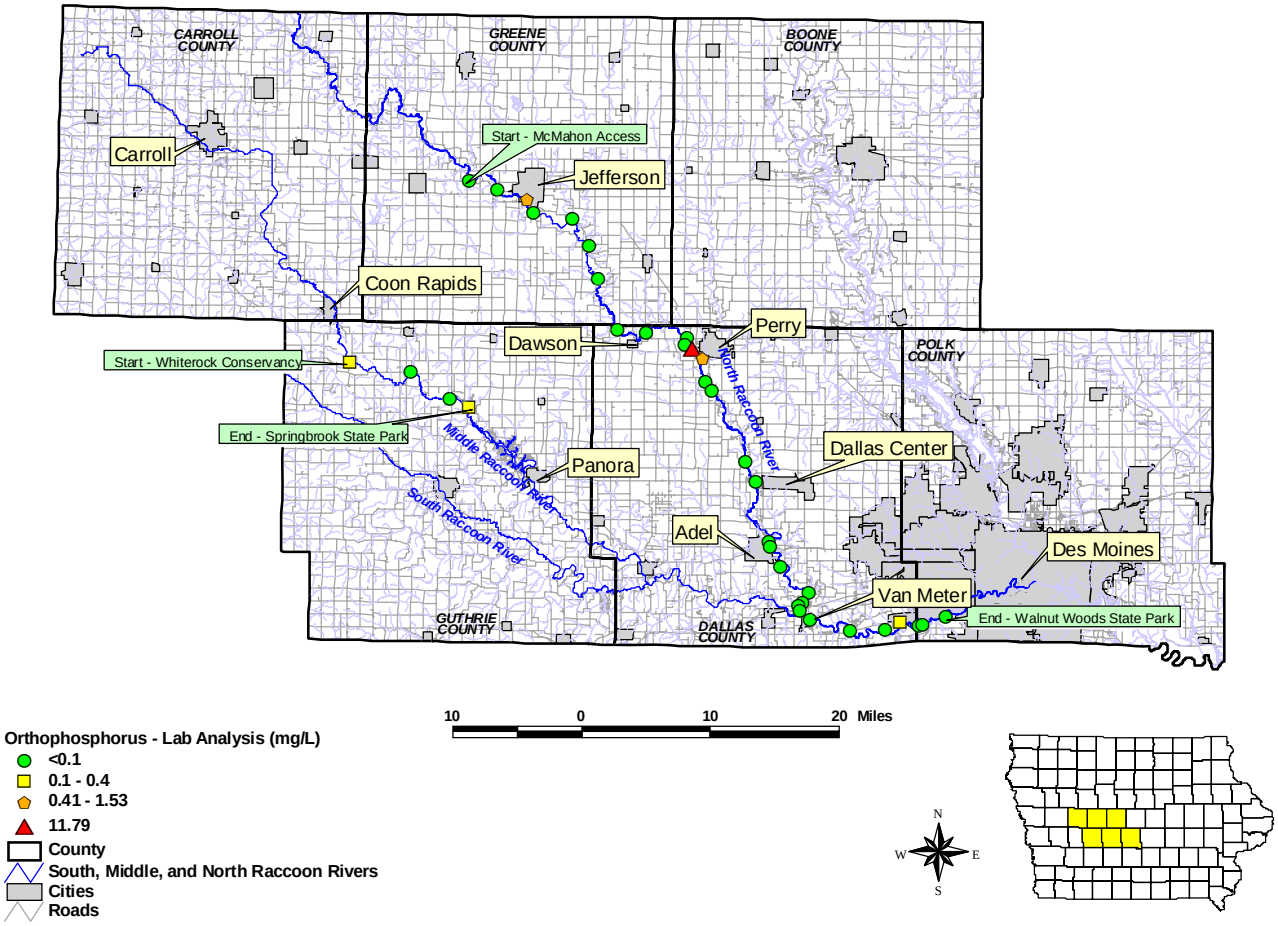

Figure 16. Orthophosphorus (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

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 17 to 30 mg/L, with a median of 23 mg/L, with higher concentrations during winter months.

For Project AWARE sites, IOWATER chloride concentrations ranged from <30 to 570 mg/L, with a median of 30 mg/L, whereas lab results varied from 9.6 to 772 mg/L, with a median of 26 mg/L (Table 1; Figures 17 and 18). Chloride concentrations tended to be higher at sites on the North Raccoon and Raccoon rivers relative to the Middle Raccoon River. The highest chloride concentrations (64, 163, and 772 mg/L) occurred at the three sites associated with wastewater treatment facilities. If results from these three sites were excluded from calculations, the median chloride for the remaining sites would be 23 mg/L, which is the same for streams statewide.

Chloride results from sites sampled on Project AWARE were slightly higher than levels in streams statewide for June 2007 (Figure 4).

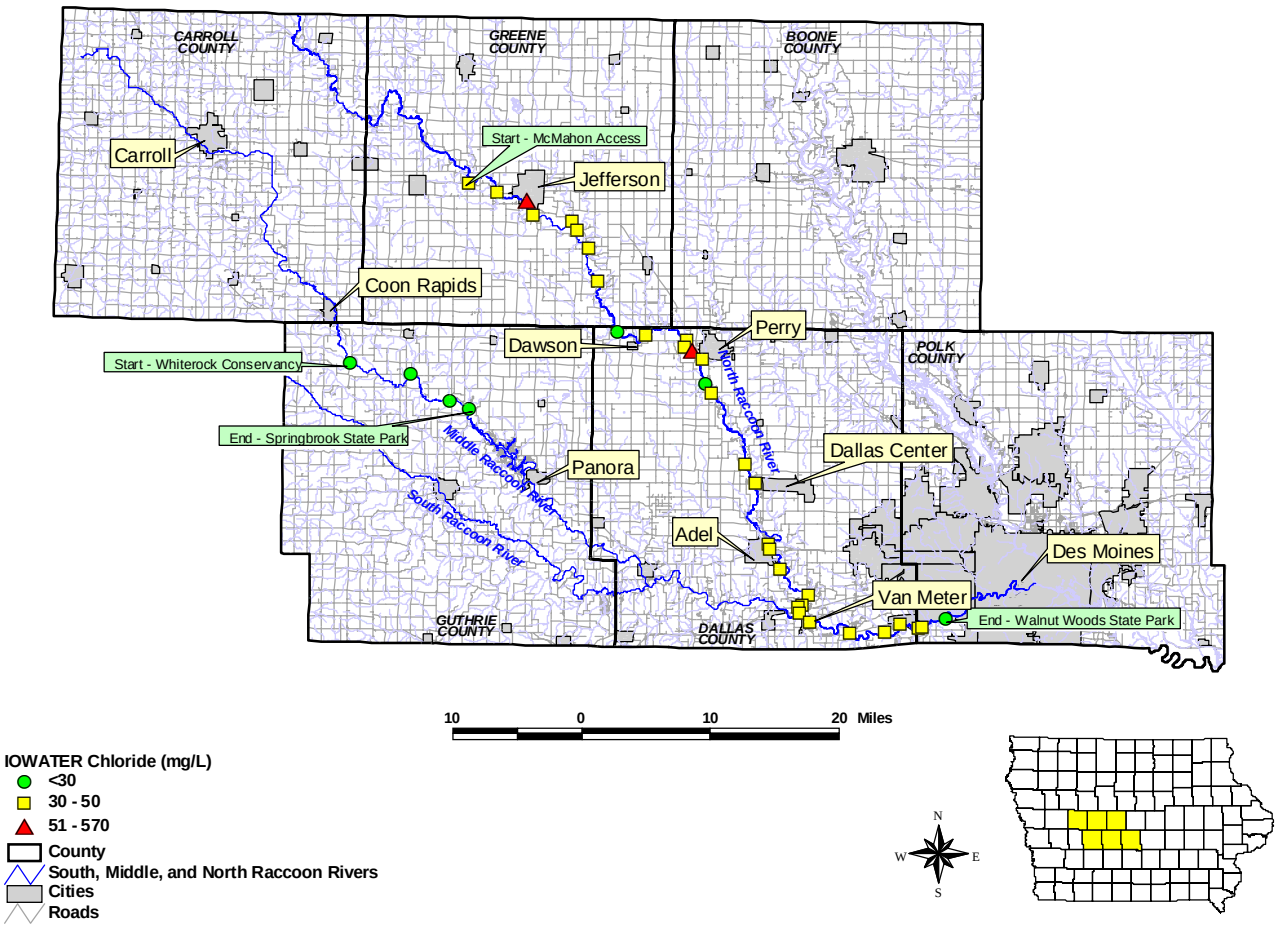

Figure 17. Chloride (IOWATER method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

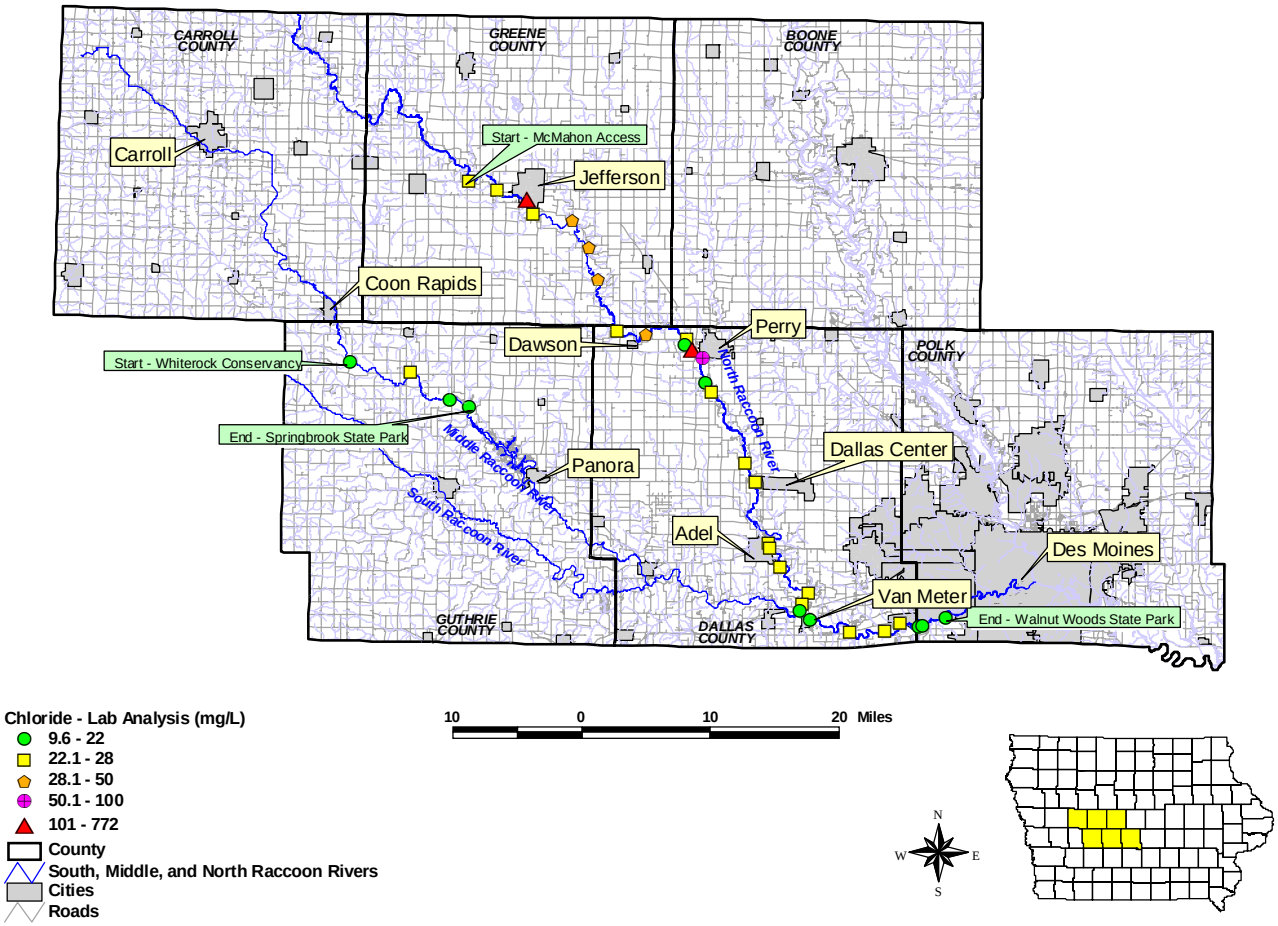

Figure 18. Chloride (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Specific Conductivity

Specific conductivity is a measure of how well water can conduct an electrical current. Conductivity increases with the increasing amount and mobility of ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, specific conductance is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution. Typical specific conductivity levels for streams statewide vary from 510 to 720 µS/cm, with a median of 620. Higher levels tend to occur in northwest Iowa relative to the rest of the state.

On Project AWARE, specific conductivity was measured using a field meter. Specific conductivity levels at these sites ranged from 400 to 3,074 µS/cm, with most results between 686 and 748 (Table 1; Figure 19). The three highest conductivity measurements were 872, 1,970, and 3,072 µS/cm, and all occurred at the sites associated with wastewater treatment facilities. The elevated conductivity readings are not surprising, given that many of the ions that were measured were also high for these three sites. If results for these three sites were excluded, the median conductivity would be 723 µS/cm, higher than the median for streams statewide.

Specific conductivity for the mainstem sites on the Middle Raccoon River versus the North Raccoon River were similar, averaging 740 µS/cm, compared to 680 µS/cm for the main stem sites on the Raccoon River.

Specific conductivity levels for sites sampled as part of Project AWARE were higher than levels in streams statewide for June 2007 (Figure 4). The median specific conductivity was 731 µS/cm for Project AWARE sites and was 625 µS/cm for streams statewide.

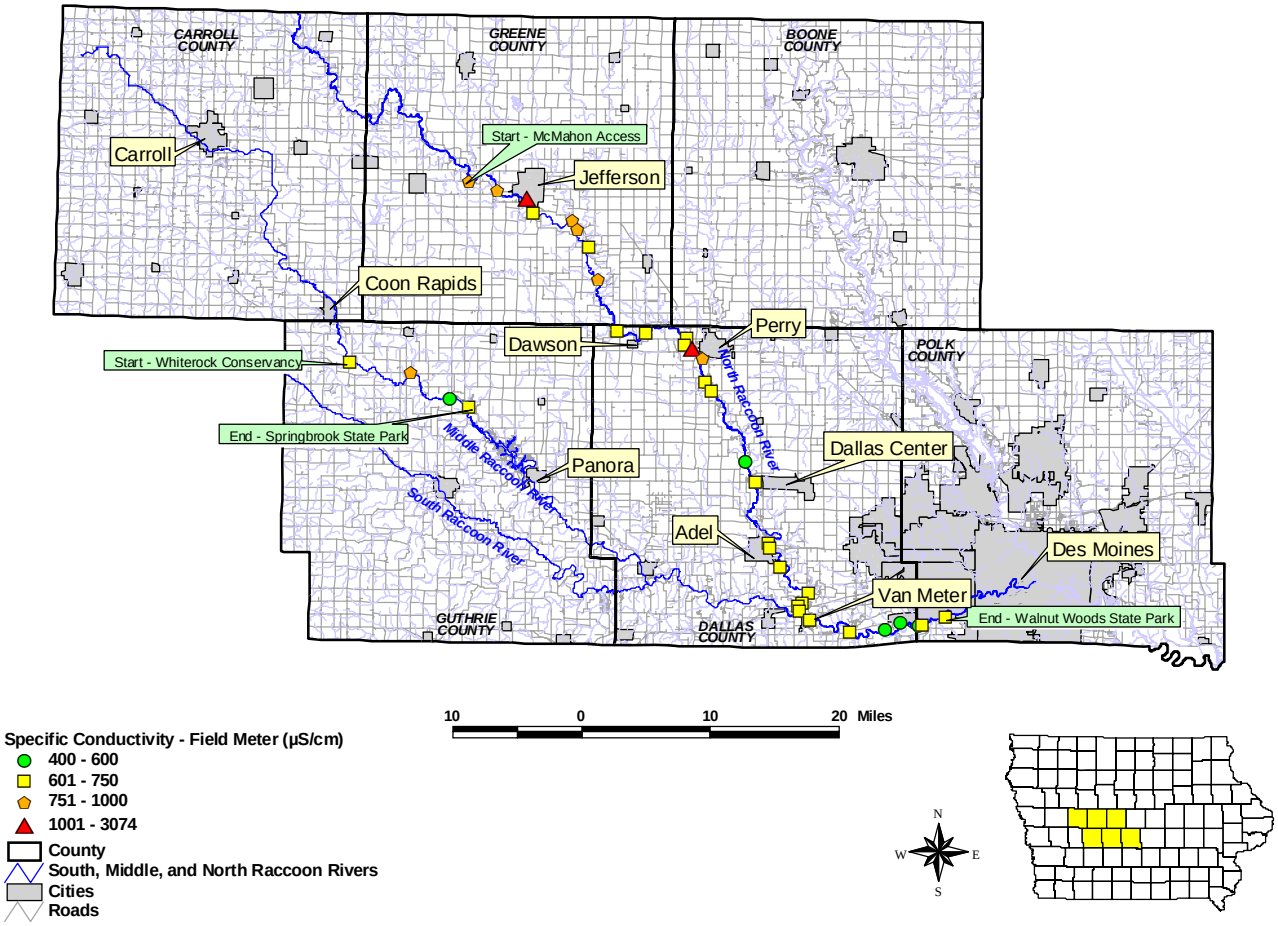

Figure 19. Specific conductivity (field meter) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Turbidity

Turbidity refers to how turbid or dirty the water is. The greater the amount of total suspended solids or algae in the water, the murkier it appears and the higher the measured turbidity. A major source of turbidity in rivers is typically from overland runoff flows, stream bank erosion, re-suspension of bottom sediments, and organic detritus from stream and/or wastewater discharges. Dredging operations, channelization, increased flow rates, floods, or even too many bottom-feeding fish (such as carp) may stir up bottom sediments and increase the cloudiness of the water. Typical turbidity levels in Iowa streams statewide range from 6 to 43 Nephelometric Turbidity Units (NTU) with a median of 17 NTU.

Turbidity was measured using both a field meter and measured in the lab. Turbidity from the field meter ranged from 4 to 207 NTU, with a median of 26, and from 2 to 165 NTU in the lab, with a median of 32 (Table 1; Figures 20 and 21). Turbidity tended to be lower in the upper versus the lower part of the North Raccoon watershed. Johnson Creek in the southeast part of Dallas County had the highest turbidity reading of 207 NTU. It is unknown if the rainfall the previous day caused this elevated result. As would be expected, sites with high turbidity levels had low transparency readings, and vice versa.

Figure 4 compares the turbidity results from Project AWARE to results from the DNR statewide stream network for June 2007 (Figure 4). Project AWARE turbidity levels were lower than levels statewide.

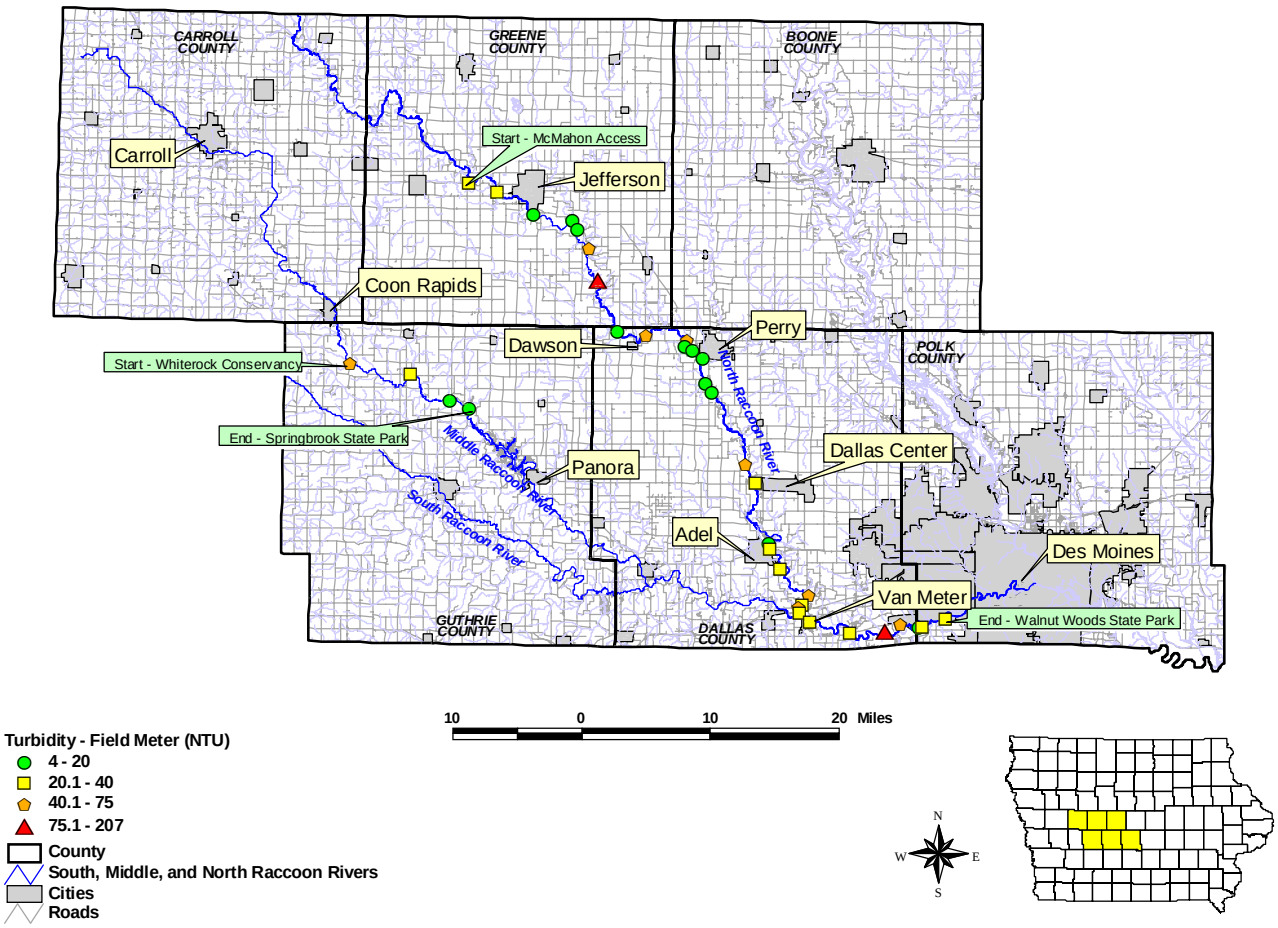

Figure 20. Turbidity (field meter) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

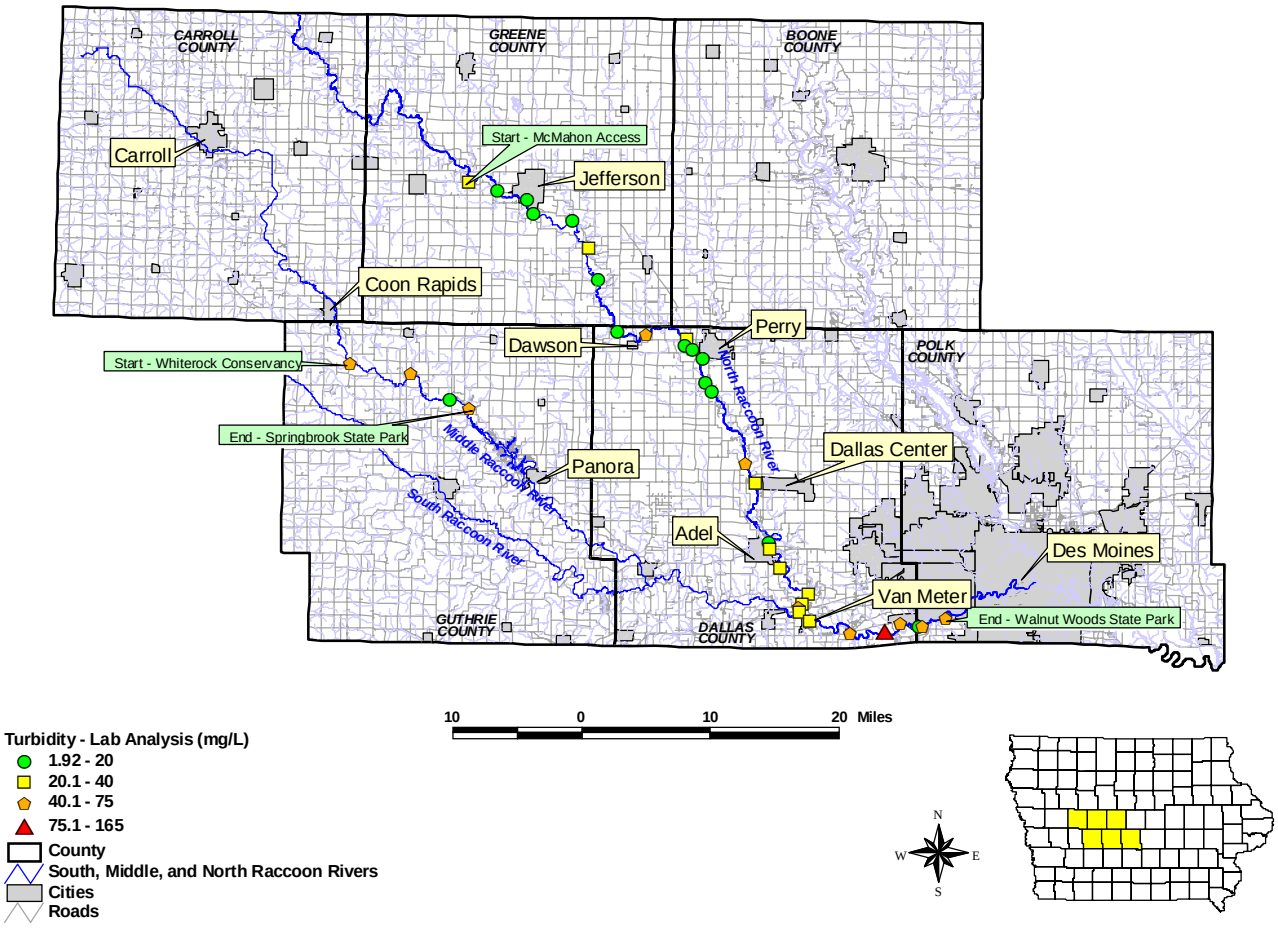

Figure 21. Turbidity (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Total Coliform and Escherichia coli *Bacteria*

Total coliforms is a group of bacteria that includes fecal coliforms and other nonfecal bacteria that are widespread in the environment. Total coliform is the standard test used for drinking water while *E. coli* bacteria are used as the indicator of health risk for recreational contact. *E. coli* bacteria are a type of bacteria present in the gastrointestinal tract of warm-blooded animals. These bacteria are called "indicator bacteria" because by themselves, they do not cause illness, but their presence suggests that disease-causing organisms or pathogens may be present. As the number of indicator bacteria rises in water, so does the likelihood that pathogens are present. The most frequent sources of pathogens are sewage overflows, malfunctioning septic systems, animal waste, polluted storm-water runoff, and boating wastes. The presence of these bacteria suggests that a pathway exists for a relatively fresh source of human or animal waste to enter the stream. Bacteria levels are reported as Most Probable Number per 100 milliliters (MPN/100 ml).

Iowa's water quality standard for *E. coli* bacteria applies to Class A water bodies. All of the stretches of the Middle Raccoon, North Raccoon, and Raccoon rivers that were canoed as part of Project AWARE 2007 are designated Class A1, primary contact recreational use. The one-time maximum *E. coli* bacteria standard for Class A1 water bodies is 235 CFU/100 (CFU = Colony Forming Units per 100 milliliters of water). The bacteria results for the Project AWARE sites are reported as Most Probable Number per 100 milliliters (MPN/100 ml; Table 1). MPN/100 ml is a statistical calculation of the number of colonies of bacteria whereas CFU is a direct count of the number of colonies.

Total coliform bacteria levels ranged from 300 to 770,000 MPN/100 ml, while *E. coli* ranged from <100 to 5,570 MPN/100 ml (Table 1; Figures 22 and 23). Fourteen of the 35 sites sampled had *E. coli* bacteria levels greater than

235 MPN/100 ml. All four sites in the Middle Raccoon watershed exceeded 235, with levels ranging from 630 to 1,480 MPN/100 ml. Most of the sites in the North Raccoon watershed were less than 235. Three tributary sites were sampled on Friday June 22, the day after the first storm, and those three sites had the highest *E. coli* levels of all sites sampled during the week. *E. coli* was 5,570 MPN/100 ml for Johnson Creek and 2,230 for Sugar Creek, both in Dallas County, and an unnamed tributary in Polk County had an *E. coli* of 2,180 MPN/100 ml. The three sites associated with the wastewater treatment facilities had *E. coli* levels of 100 and 200 MPN/100 ml.

E. coli results from Project AWARE were similar to levels seen from the DNR statewide stream network for June 2007 (Figure 4).

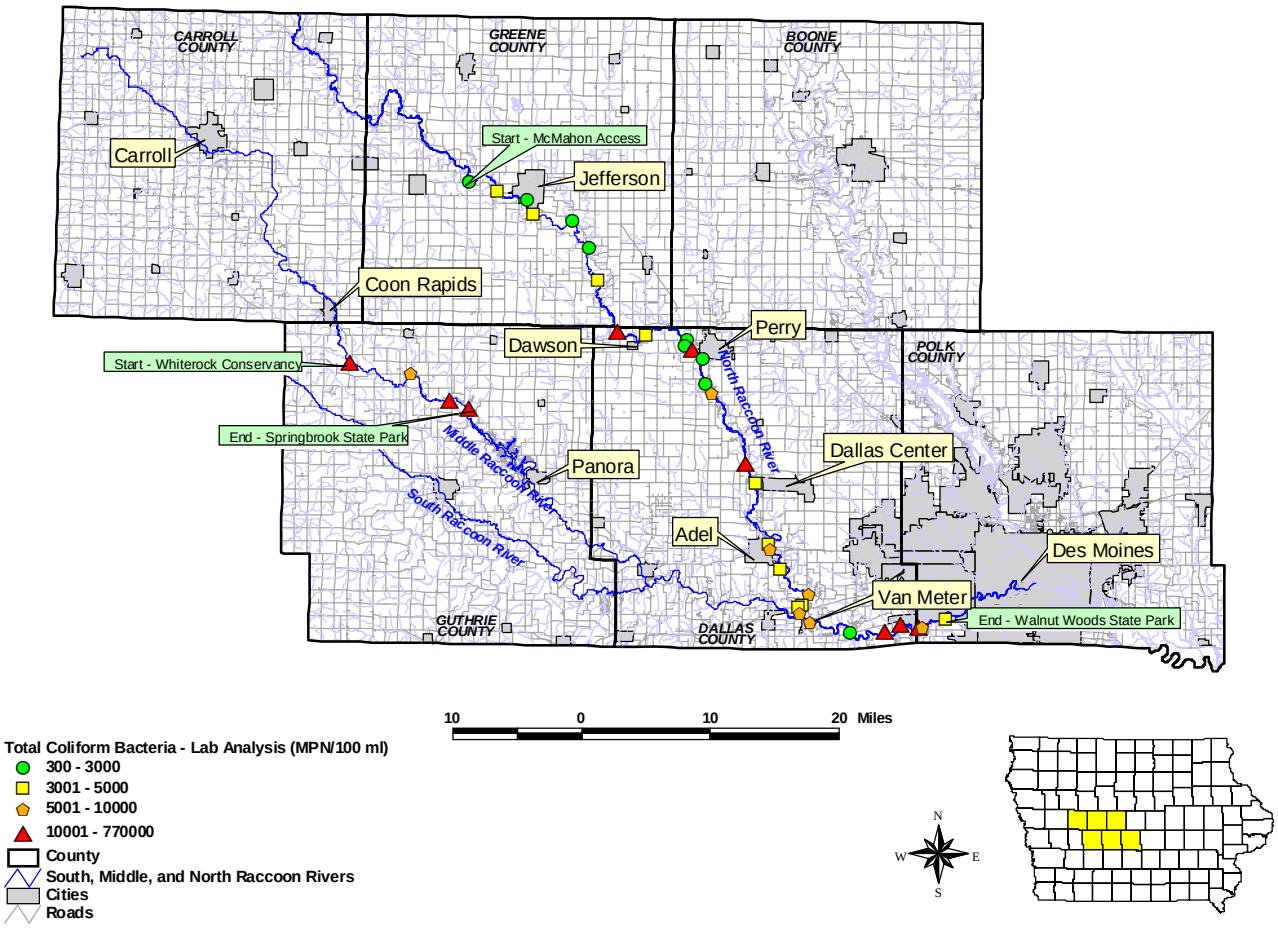

Figure 22. Total coliform bacteria (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

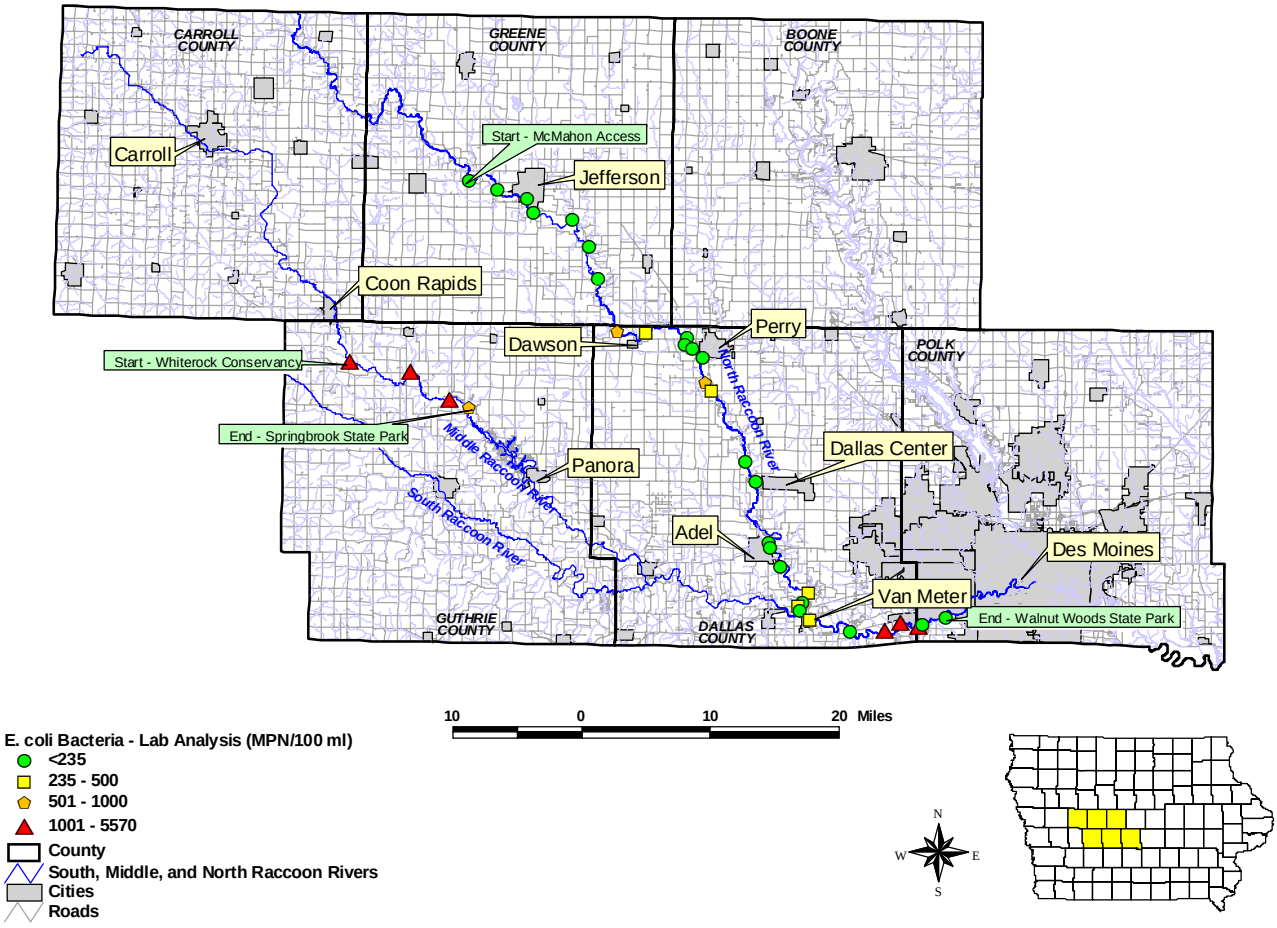

Figure 23. *E. coli* bacteria (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Sulfate

Sulfate in streams is generally related to the types of minerals in the soils and bedrock, as dissolved sulfate in streams is generally derived from the dissolution of gypsum and other sulfide minerals. Ingestion of water containing high levels of sulfate may cause a laxative effect. Average sulfate concentrations in Iowa streams are 26 to 61 mg/L, with a median of 37 mg/L. Higher sulfate concentrations tend to occur in streams in the northwest part of Iowa.

Sulfate concentrations for Project AWARE sites ranged from 8.9 to 581 mg/L, with a median of 30 mg/L (Table 1; Figure 24). The lowest sulfate concentration occurred at Battle Creek, a tributary to the Middle Raccoon River. The highest levels (67, 93, and 581 mg/L) occurred at the three sites associated with the wastewater treatment facilities. Tributary sites had lower sulfate (ranged from 8.9 to 25 mg/L) compared to main stem sites (ranged from 26 to 36 mg/L), while levels were higher for the North Raccoon River relative to the Middle Raccoon River.

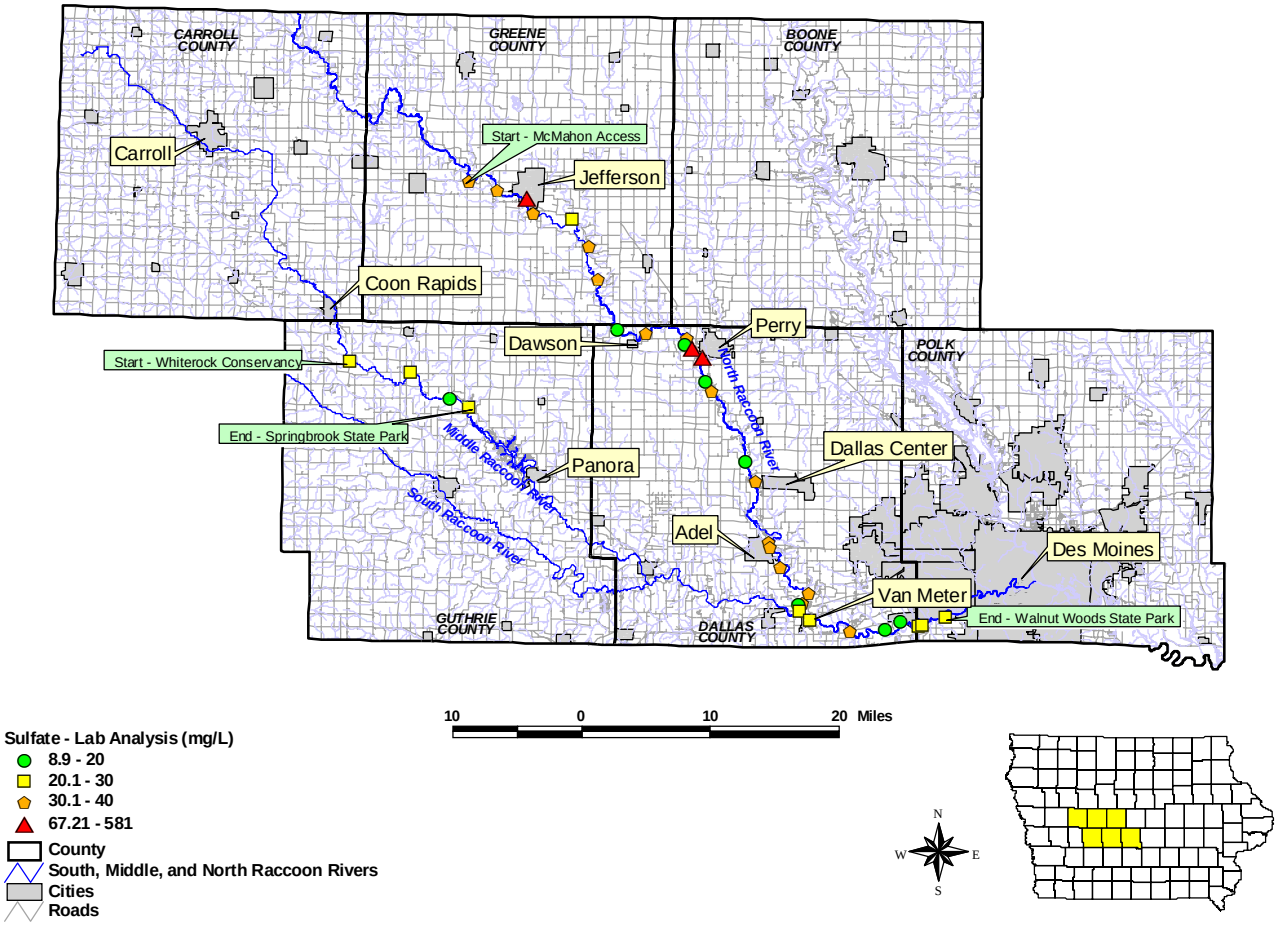

Figure 24. Sulfate (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Fluoride

Fluoride ions may be present in streams either naturally or artificially. Fluoride can occur in soils and rocks in some areas. Other sources of fluoride include releases from wastewater treatment facilities, since some public water supplies add fluoride to their drinking water.

Fluoride concentrations for the Project AWARE sites ranged from 0.22 to 1.22 mg/L, and the highest concentration occurred at the site associated with the industrial wastewater treatment facility near Perry (Table 1; Figure 25). The second highest fluoride concentration, 0.60 mg/L, occurred at the site near the City of Perry wastewater treatment facility. The lowest concentration, 0.22 mg/L, occurred at the site near the City of Jefferson wastewater treatment facility. Fluoridation is part of the drinking water treatment process for both the City of Jefferson and the City of Perry.

The DNR network of streams statewide does not monitor for fluoride, so typical fluoride concentrations for streams statewide is unknown. There are stream sites throughout the Cedar River watershed in eastern Iowa that have been monitored on several occasions during the past seven years for fluoride, and concentrations from these sites typically range from 0.04 to 0.5 mg/L.

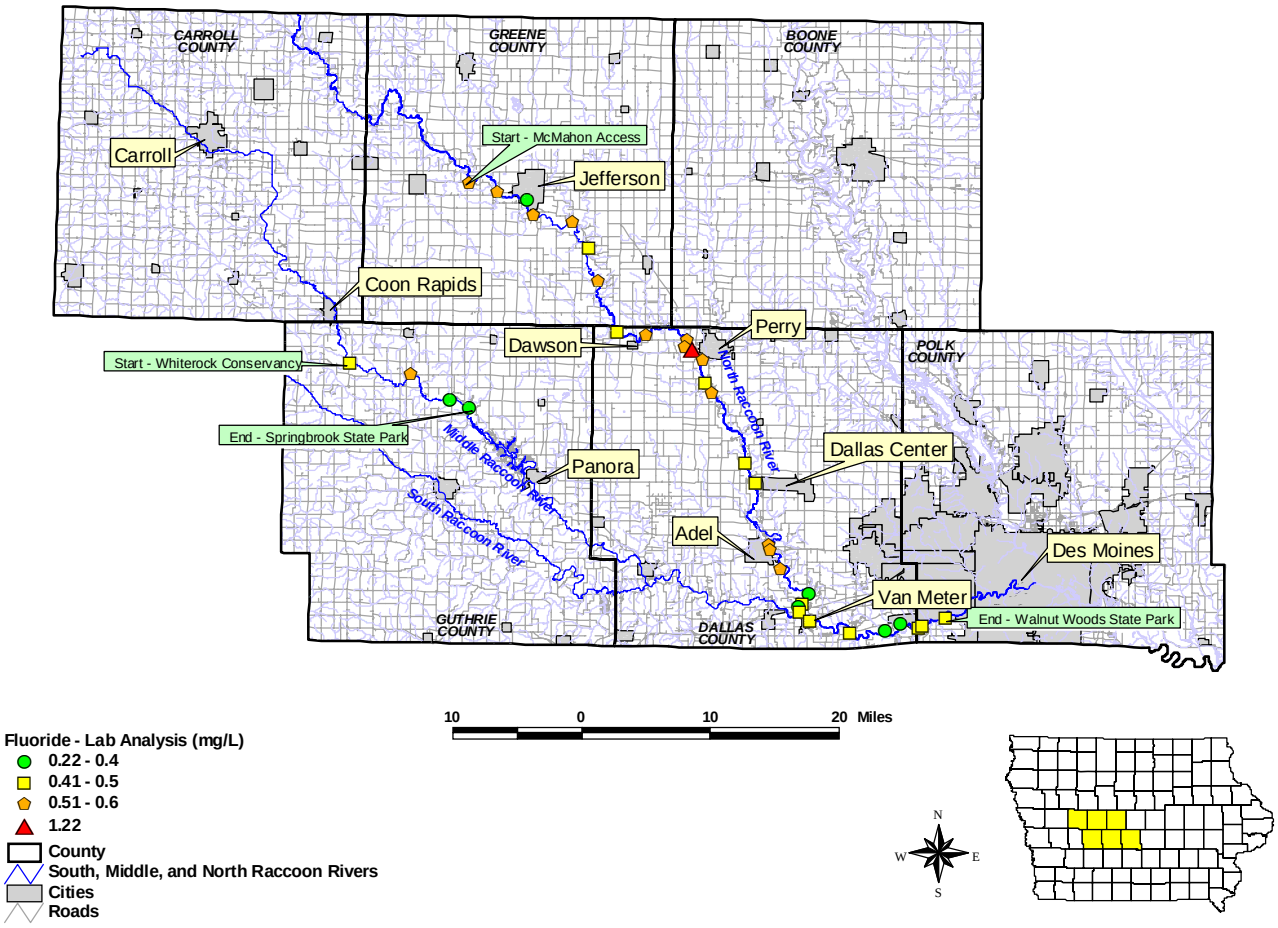

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Figure 25. Fluoride (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Bromide

Bromide occurs naturally in some surface water and groundwater, particularly in areas of salt intrusion. Bromide can also be present due to industrial and agricultural activity. For Project AWARE, bromide was detected at one site at a concentration of 0.39 mg/L (Table 1; Figure 26). This site was associated with the industrial wastewater treatment facility near Perry. The DNR network of streams statewide does not monitor for bromide, so typical bromide concentrations for streams statewide is unknown.

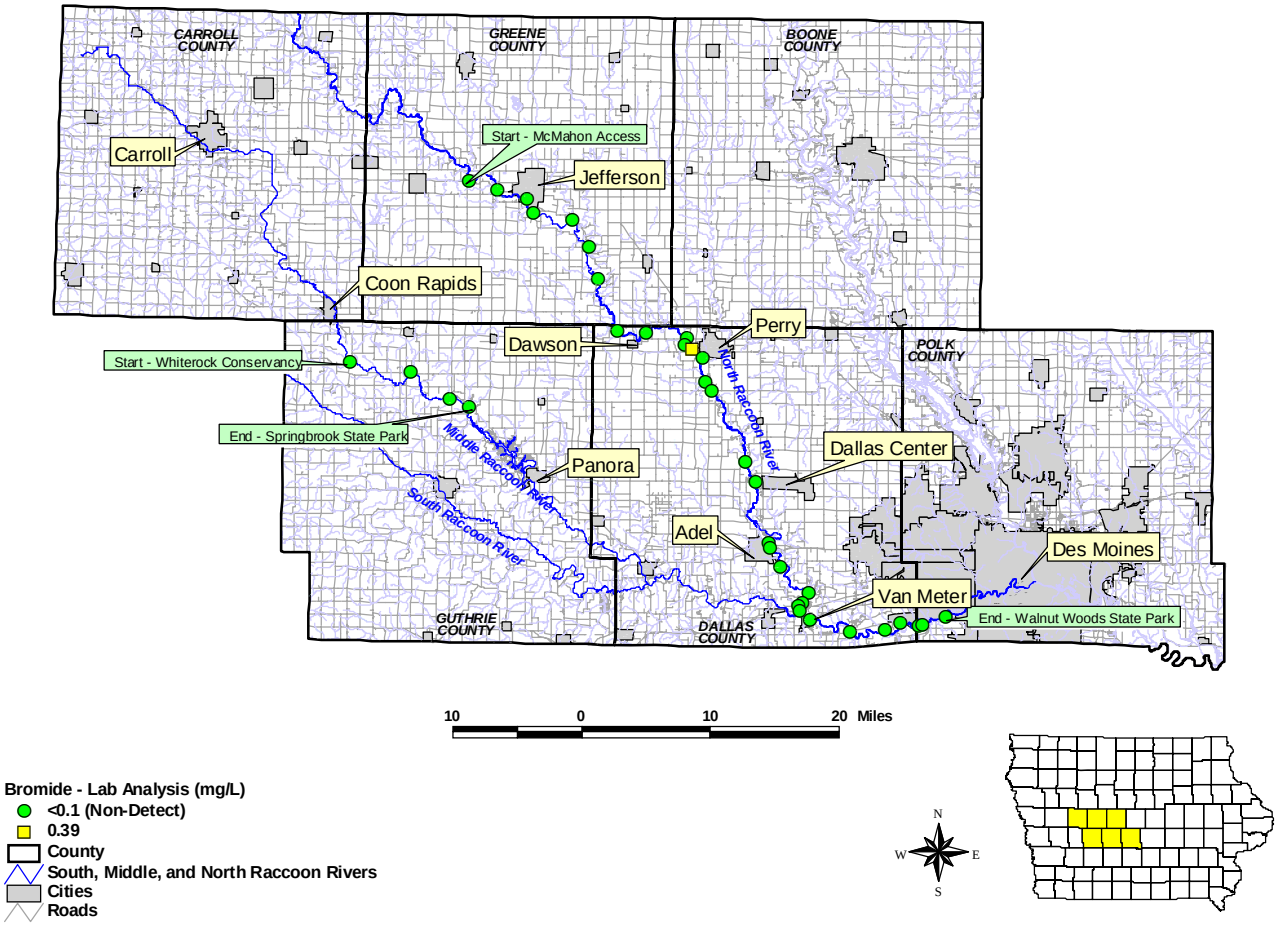

Figure 26. Bromide (lab method) for sites sampled as part of Project AWARE 2007 on the Middle Raccoon, North Raccoon, and Raccoon rivers.

Summary

In addition to 26 tons of trash removed during Project AWARE 2007, a total of 36 sites were monitored for a variety of field and lab parameters.

Below are some observations from the data.

- Project AWARE occurred during below normal stream flow conditions for the Middle Raccoon, North Raccoon, and Raccoon rivers for all but the last day of the trip. Rain on both Thursday June 21 and Friday June 22 caused water levels on the Raccoon River to increase from 2,310 to 6,100 cfs. Given the high water levels, the last stretch of the Project AWARE route from Walnut Woods State Park to Des Moines Waterworks Park was not completed and no stream monitoring was done that day.

- Dissolved oxygen concentrations ranged from 6.4 to 12.1 mg/L; all concentrations met the water quality standard minimum of 5 mg/L for warm water streams. Dissolved oxygen levels for Project AWARE sites were slightly higher than levels statewide.

- In general, water quality for the three sites near the one industrial and two municipal wastewater treatment facilities reflected the impact from point sources, as these sites had elevated chloride, sulfate, fluoride, specific conductance, orthophosphorus, transparency, and detectable levels of nitrite-N. Of the 36 sites monitored, the site near the industrial wastewater treatment facility had the highest nitrate-N (21.92 mg/L), orthophosphorus (11.79 mg/L lab result; 10 mg/L IOWATER method), sulfate (581 mg/L), and fluoride

(1.22 mg/L); the only detection of bromide (0.39 mg/L); the lowest dissolved oxygen (6.4 mg/L); and the second lowest pH (7.4).

- Nitrate-N concentrations for Project AWARE sites ranged from 0.1 to 21.9 mg/L and overall were higher than levels in streams statewide during June 2007.

- Orthophosphorus was elevated for sites associated with wastewater treatment facilities. If those sites were excluded, there were no differences in concentrations between sites on the main channel versus tributary sites. Concentrations at Project AWARE sites were similar to those for streams statewide.

- Higher chloride concentrations occurred at sites on the North Raccoon and Raccoon rivers relative to the Middle Raccoon River. The highest chloride concentrations were associated with point sources or wastewater treatment facilities. Chloride at Project AWARE sites tended to be higher than concentrations in streams statewide.

- Specific conductivity levels were higher for Project AWARE sites compared to streams statewide, but that was not surprising given that many of the ion concentrations were also higher for Project AWARE sites relative to streams statewide.

- At 14 of the 35 sites, *E. coli* bacteria levels exceeded 235 MPN/100 ml. The highest levels were measured at three tributary sites that were sampled on Friday June 22. It is unknown what effect the previous day's rainfall had on the bacteria levels or whether these three tributaries tend to have elevated bacteria relative to other sites. Overall, *E. coli* bacteria levels for Project AWARE sites were similar to levels measured as part of the DNR statewide stream network.

- For Project AWARE, sulfate concentrations were higher at tributary sites compared to sites on the main stem. Concentrations were also higher for the North Raccoon River relative to the Middle Raccoon River.

Acknowledgements

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