2020 Water Quality Report

U.S. Army Corps of Engineers
Saint Louis District

Rend Lake Water Quality Conditions: 1972-2020

June 2021

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Prepared for

United States Army Corps of Engineers
Saint Louis District
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EXECUTIVE SUMMARY

The United States Army Corps of Engineers (USACE) commitment to environmental compliance and protection of estuaries, rivers, lakes, and navigable waters arises from the national policy and directives expressed in Federal Statutes, Executive Orders, and internal regulations. These regulations were designed to minimize pollution, maximize recreation, protect aesthetics, preserve natural resources, and promote the comprehensive planning and use of water bodies to enhance the public interest rather than private gain; therefore, USACE, in the design, construction, management, operation, and maintenance of its facilities, will exert leadership within existing authorities and appropriations in the nationwide effort to protect, enhance, and sustain the quality of the nation's resources. It is USACEs policy to comply with requirements of the Clean Water Act and not to degrade existing water quality conditions to the maximum extent that is practicable, consistent with project authorities, Federal legal and regulatory requirements, the public interest, and water control manuals.

The United States Army Corps of Engineers, Saint Louis District (CEMVS), implemented a water quality monitoring program during the 1970s to evaluate how its civil projects may be affecting water resources. Data collected from this effort serves as an invaluable tool for evaluating the significance of annual water quality measurements and tracking long-term trends. Water quality data is provided to the Missouri Department of Natural Resources and the Illinois Environmental Protection Agency to be used as a screening mechanism for the Missouri and Illinois Water Quality Report which is required every two years by the Clean Water Act Sections 303(d) and 305(b).

The National Water Quality Inventory Report to Congress (305(b) report) is the primary vehicle for informing law makers and the public about general water quality conditions in the United States. This document characterizes our water quality, identifies widespread water quality problems of national significance and describes various programs implemented to restore and protect our waters. Currently the Illinois Environmental Protection Agency (IEPA, 2018) has listed Rend Lake as impaired for aesthetic quality and fish consumption caused by total suspended solids and mercury, respectively. The Big Muddy River upstream of Rend Lake is impaired for aquatic life and fish consumption with the sources listed as dissolved oxygen, pH, total phosphorus, sedimentation/siltation and mercury. The other main tributary, Casey Fork, is impaired for fish consumption and aquatic life. The sources are listed as polychlorinated biphenyls, chloride, iron, dissolved oxygen, pH, and total suspended solids. The smaller tributaries Gun Creek and Atchison Creek aquatic life is impaired by dissolved oxygen. Immediately downstream of Rend Lake, the Big Muddy River is impaired for aquatic life and fish consumption caused by sedimentation/siltation, mercury, and polychlorinated biphenyls.

Water quality sampling in 2020 revealed the following concerns at Rend Lake: dissolved oxygen, Atrazine, chlorophyll, manganese, and phosphorus.

TABLE OF CONTENTS

INTRODUCTION

The Big Muddy River Watershed is located in Southern Illinois and encompasses a drainage area of approximately 2,390 square miles within the following counties: Franklin, Jackson, Jefferson, Marion, Perry, Union Washington, and Williamson. The Big Muddy River originates in Jefferson County, southeast of Centralia, Illinois and flows southward for approximately 156 miles, where it joins the Mississippi River, just south of Grand Tower, Illinois in Jackson County. Major tributaries of the Big Muddy River include: Beaucoup Creek, Little Muddy River, Casey Creek, Middle Fork of the Big Muddy, and Crab Orchard Creek. Lakes and reservoirs within the Big Muddy River Watershed include: Kinkaid Lake, Rend Lake, Crab Orchard Lake, Devil's Kitchen Lake, Little Grassy Lake, and Cedar Lake.

The Rend Lake Watershed is located in south-central Illinois. It flows generally in a southerly direction and drains approximately 311,000 acres, located in the following four counties: Jefferson, Franklin, Washington, and Marion. Elevation within the watershed ranges from 642.0 feet NGVD (National Geodetic Vertical Datum) in the northern portion of the watershed to 396.0 feet NGVD at the outfall of the Rend Lake dam at the southern extent of the watershed. Approximately 37,400 people reside within the Rend Lake Watershed and the average precipitation is approximately 41.1 inches per year. Land cover data for the watershed indicate the largest percentage of area is used for crop production (35%). Approximately 27% of the watershed area is forest and 20% of the watershed is pasture.

Rend Lake is located in Franklin and Jefferson counties, about three miles northwest of Benton, Illinois. The dam is located on the Big Muddy River, 103.7 miles upstream from its confluence with the Mississippi River. The Rend Lake project is comprised of 40,840 acres of land and water. The lake has a water surface area of 20,633 acres at the normal operating pool elevation of 405.0 feet NGVD. At this pool elevation the lake shoreline is approximately 162 miles; and extends upstream from the dam approximately 13 miles. Roughly 10 miles above the main dam are two sub-impoundment dams: one on the Big Muddy River and the other on the Casey Fork River. These sub-impoundments are used for regulating water levels for fish and wildlife management activities. The lake width varies from 1.5 to 3 miles. The depth is fairly shallow, with a maximum depth of about 35 feet near the main dam, when the pool elevation is at 405.0 feet NGVD. The Rend Lake project contains 53 recreation areas, with 756 campsites, 104 picnic sites, 30 boat ramps, 235 marina slips and over 34 miles of trails. Each year, on average, over two-million people visit the lake, which annually generates nearly $35 million in visitor spending within 30-miles of the project.

There is virtually no municipal or industrial use of groundwater in the area because of the abundant water supply provided by Rend Lake, which serves as the major municipal water supply for approximately 300,000 residents of Southern Illinois. This water supply system is managed by the Rend Lake Conservancy District (RLCD), which is the largest public water supply system (1,800 square miles) in the State of Illinois and draws nearly

13 million gallons of water per day from Rend Lake. Also, the lake provides industrial water supply for a coal mine in the area, which is managed by Adena Resources.

Rend Lake is managed and operated by the CEMVS for the authorized purposes of flood risk management, water supply, water quality, fish and wildlife conservation, recreation, and area redevelopment. The lake serves as a heavy recreational usage lake. The land surrounding the lake is used predominately for agriculture. Agricultural runoff and municipal wastewater treatment facilities are the primary potential source of pollution into the Rend Lake watershed. Additional sources are marinas, recreational watercraft discharges and wildlife fecal material runoff.

Water quality is of paramount importance for sustaining ecological integrity and services provided by the Big Muddy River and Rend Lake. Water quality is influenced by a range of both point and nonpoint pollution sources, which may include natural processes, industrial and municipal effluents, and surface runoff from agricultural arenas.

The Saint Louis District (CEMVS) of United States Army Corps of Engineers (USACE) has implemented a Water Quality Management Plan (WQMP) as part of the operation and maintenance activities associated with managing USACEs' civil works projects throughout the District which includes, among other reservoirs and rivers, the Big Muddy River and Rend Lake. The WQMP addresses surface water quality management issues and adheres to the guidance and requirements specified by Clean Water Act (CWA), as well as the self-imposed Engineering Regulation (ER) 1110-2-8154, "Water Quality and Environmental Management for USACE Civil Works Projects" (USACE, 2018). Water quality monitoring is implemented to fulfill five primary objectives that drive the CEMVS WQMP:

1) Establish baseline conditions, identify significant water quality trends, and document problems and accomplishments.
2) Ensure that surface water quality, as affected by CEMVS projects, is suitable for project purposes, existing water uses, public health and safety, and in compliance with applicable state and federal water quality standards.
3) Provide support to water control, project operations, and navigation for regulations and modifications.
4) Investigate special problems, design and implement modifications, and improve water management procedures
5) Establish and maintain strong working partnerships and collaborations with appropriate entities within and outside USACE regarding water quality.

This report is intended to document and assess water quality conditions occurring at Rend Lake. The report describes conditions observed in 2020, as well as baseline data collected from 1972-2019. Additional historical data are available upon request.

REND LAKE WQMP COVERAGE

The WQMP for Rend Lake includes water samples taken at the following locations: major tributaries (REN-7 and REN-5), main body of the lake (REN-2, REN-3, REN-4, REN-8, and Rend Marina), and just downstream of the dam (REN-1). See figures 1 and 2, and Table 1 for a site map and site coordinates.

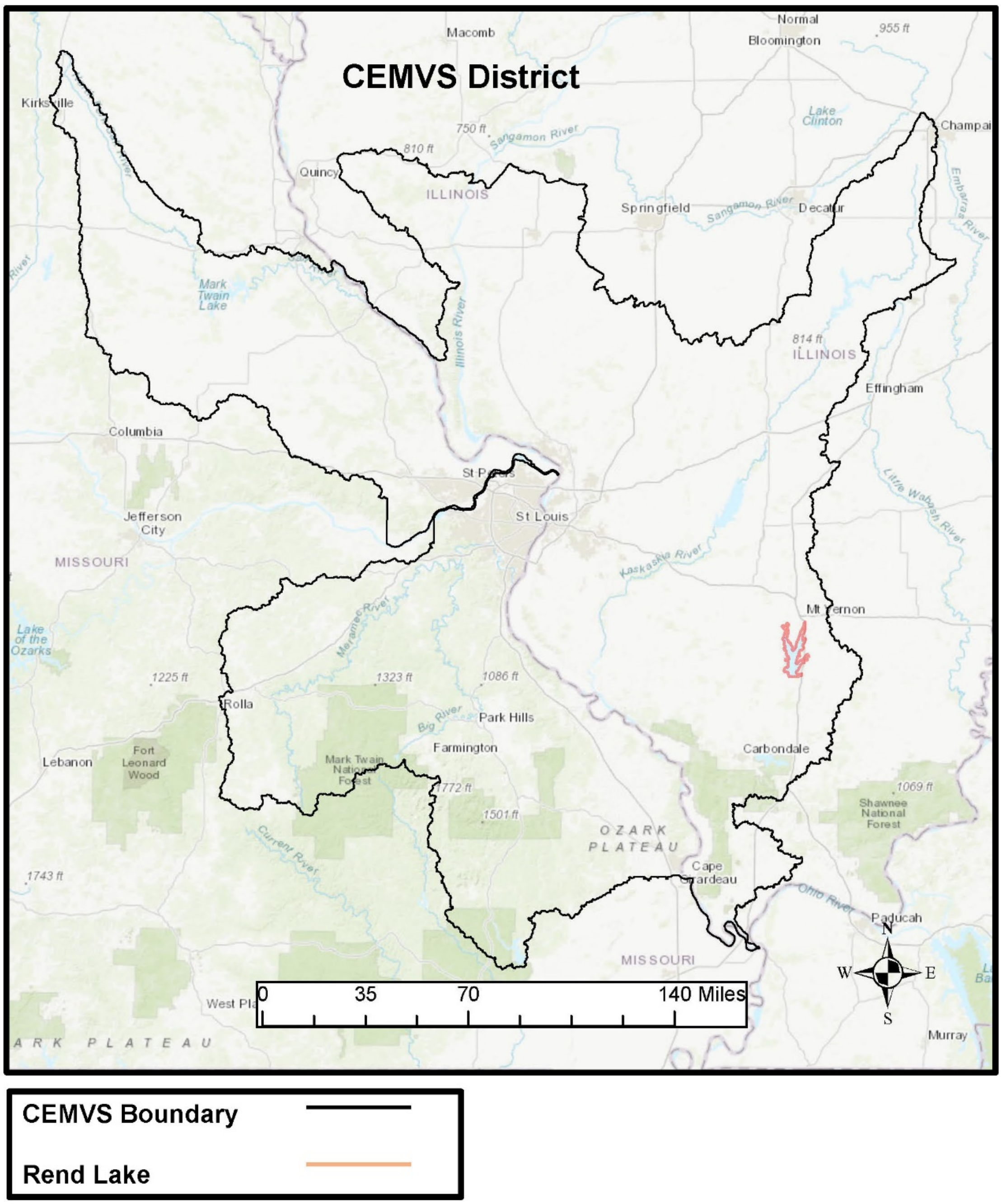


Figure 1. CEMVS District and Rend Lake

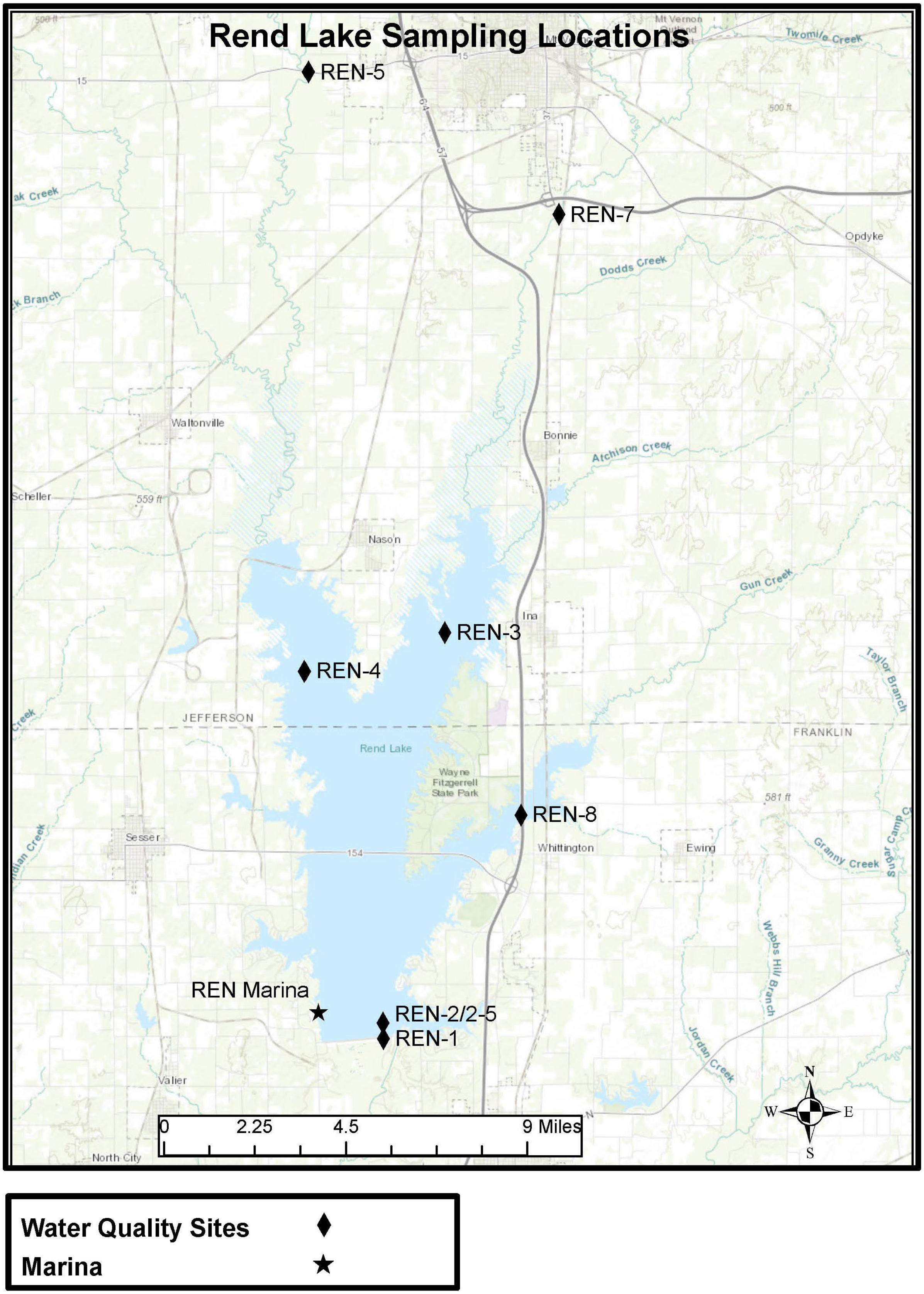


Figure 2. Water Quality (WQ) Sampling Locations at Rend Lake

Sample Location Summary Table

Table 1: Sample Location Summary and Geographic Location (NAD 1983)

Sample Location Type	Abbreviation	Site Name	Latitude	Longitude
Major Tributary	TRIB	REN-5	38.309795	-88.988575
	TRIB	REN-7	38.2695630	-88.8987040
Main Reservoir Surface	RS	REN-2	38.039294	-88.961891
	RS	REN-3	38.1517450	-88.9395220
	RS	REN-4	38.1407880	-88.9899850
	RS	REN-8	38.1002570	-88.9123030
	RS	REN-MAR	38.044727	-88.985267
Reservoir Benthic	RB	REN-2-5	38.039294	-88.961891
Tail Race (below dam)	TR	REN-1	38.0369550	-88.9615650

Samples at Marinas are not always taken in the exact same location.

METHODS AND ANALYSIS: WATER QUALITY

Data Collection and Historical Reference Data

During 2020, water quality samples were collected and analyzed for 9 locations during four separate sampling events (n=36; Table 1). One duplicate sample was also collected during each sampling event for quality control purposes. With the exception of the benthic sample location REN 2-5 in front of the dam, samples were collected from the upper one meter of the water column, preserved, and transported to the Applied Research and Development Laboratory (ARDL) in Mount Vernon, Illinois for analysis.

For the purpose of this report, historical reference data refers to water quality data collected during the previous years ranging as far back as 1972 (parameter dependent) at Rend Lake. Historical reference data are intended to represent the current condition of Rend Lake.

Statistical Summary and Comparison to Applicable Water Quality Standards

Statistical analyses for 2020 data were performed on water quality monitoring data collected for 9 locations, and classified as TRIB (n= 2), RS (n=5), RB (n=1), and TR (n=1). For comparison, statistical analyses were also performed on historical water quality monitoring data and, although some sampling locations have been removed, they were classified in the same manner. Descriptive statistics were calculated to describe central tendencies and corresponding 95% confidence levels for the mean. Monitoring results were compared to applicable water quality standard criteria established by the appropriate state agencies pursuant to the Federal Clean Water Act. If a state water quality standard criteria was not available, recommended criteria from the literature were considered.

Seasonal data are classified as: Winter (December 01 - March 14), Spring (March 15 – May 31), Summer (June 1 – September 15), Fall (September 16 – November 30).

Quality Assurance

The United States Army Corps of Engineers, Saint Louis District quality assurance procedures considers two primary focus areas: (1) those that involve laboratory analysis of samples, and (2) those concerning the collection and processing of the water samples in the field.

Since 2012, ARDL has analyzed water quality samples for CEMVS. Their quality assurance program includes the use of quality control charts, check standards, field and in-house matrix spikes, laboratory blanks and performance evaluation samples. In addition, one blind duplicate sample is submitted for at least every 20 samples, or, in this case, every sampling event (one event/day at Rend Lake has 9 samples and one duplicate).

Internal checks are also used for field sampling. These include adherence to operating procedures for data collection and periodic evaluation of sampling personnel. Field sampling equipment and multimeters are calibrated/serviced in accordance with factory recommendations.

Water Quality Parameters and Criteria

Parameters used to characterize water quality have been generally accepted criteria for assessing aquatic life and human health include:

Temperature (Temp) is important because it controls several aspects of water quality. Colder water holds more dissolved oxygen which is required by aquatic organisms. Plants grow more rapidly and use more oxygen in warmer water. Decomposition of organic matter which uses oxygen is accelerated in warmer water. Temperature can also determine the availability of toxic compounds such as ammonia. Since aquatic organisms are cold blooded, water temperature regulates their metabolism and ability to survive. The number and kinds of organisms that are found in streams or lakes is directly related to temperature. Certain organisms require a specific temperature range, such as Salmonids, which require water temperatures below $20^{o}C$. Water temperature criteria for warm water bodies in Illinois is within $2.8^{o}C$ of the seasonal norm.

Dissolved Oxygen (DO) refers to the measurement of free oxygen molecules (O_2) that are not bonded to any other elements; thus, oxygen bonded in water (H_2O) would not be considered in a measurement of dissolved oxygen. Oxygen is dissolved in surface waters through interactions with the atmosphere and as a waste product of photosynthesis ($CO_2 + H_2O = (CH_2O) + O_2$) from phytoplankton and aquatic vegetation. Additional factors influencing DO include temperature, pressure, and salinity.

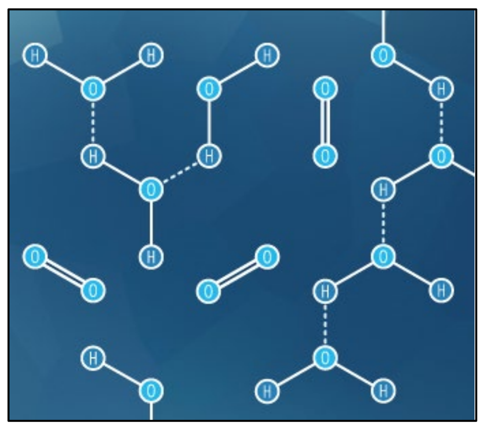


Figure 1: Dissolved oxygen (O_2) vs oxygen bonded in water (H_2O).

Dissolved oxygen is required for most aquatic life including fish, invertebrates, bacteria, and plants. Fish and invertebrates utilize DO for respiration through gills and cutaneous breathing, and plants require dissolved oxygen for respiration when photosynthesis is not possible. Smaller microbes and bacteria utilize DO for decomposition of organic materials, a process essential for nutrient cycling. Bottom feeders such as worms and mussels can persist when DO is $\geq$1mg/L, while most inland fish species require a minimum DO of 4mg/L. The DO water quality criteria for Illinois is $\geq$5mg/L.

Potential of Hydrogen (pH) is a measure of how acidic or basic water is. Potential of Hydrogen is reported on a logarithmic scale ranging from 0 – 14, with 7.0 being neutral. As pH increases from 7.0, water increases in alkalinity, whereas a decrease from 7.0 indicates an increase in acidity. Since pH is measured on a logarithmic scale, every one-unit change in pH indicates a 10-fold change in acidity; thus, a pH of 6.0 is ten times more acidic than a pH of 7.0 and a pH of 4.0 would be one-thousand times more than a pH of 7.0.

The pH of water varies considerably beyond the local level. Natural variation in bedrock and soil composition through which water moves has been reported as one of the most influential factors. Additional factors include decomposition of organic materials, acidity of local precipitation, discharge of effluents and chemicals, and mining operations.

Most freshwater streams and rivers have a natural pH ranging from 6 to 8. As pH approaches 5 (acidic), less tolerant fish and aquatic invertebrate assemblages may be extirpated, and a pH below 4.5 would be without most desired aquatic life. Conversely, when pH exceeds 9.5 (alkaline), aquatic fish and invertebrates begin to rapidly decrease and beyond 10, fish become extirpated. The pH water quality criteria for Illinois ranges from 6.5 – 9.0.

Conductivity is a measure of water's ability to conduct electrical current. In its purist form, water has a *near* neutral charge, indicating that it is an inefficient conductor of electrical current. Thus the ability to carry electrical current is driven by water soluble ions (atoms and molecules with a charge) such as salts and other inorganic materials. Conductivity is also influenced by water temperature; as temperature increases, conductivity increases. For this reason, conductivity is commonly reported as Specific Conductivity (SpCond), which is the measurement of conductivity at 25 degrees Celsius.

Conductivity in streams and rivers is affected by the geology of the area. Streams running through granite tend to have lower conductivity due to granite being composed of inert material; materials that do not ionize or dissolve into ionic compounds in water. Conversely, streams that run through areas of limestone or clay soils tend to have higher conductivity readings because of the presence of materials that ionize. Conductivity is useful as a general measure of water quality. A stream tends to have a relatively constant range of conductivity that, once established, can be used as a baseline. Significant changes, either increases or decreases, might indicate a source of pollution has been introduced into the water. The pollution source could be a treatment plant, which raises the conductivity, or an oil spill, which would lower the conductivity. In general, there are no water quality criteria for SpCond. The District threshold of 500 µS/cm is a rule of thumb value that is often associated with some form of biological impairment.

Oxidation Reduction Potential (ORP) is a measurement of the net status of all the oxidation and reduction reactions in a given water sample. Oxidation involves an exchange of electrons between 2 atoms. The atom that loses an electron is oxidized and the one that gains an electron is reduced. Oxidation reduction potential sensors measure the electrochemical potential between the solution and a reference electrode. Readings are expressed in millivolts. Positive readings indicate increased oxidizing potential and negative readings increased reduction. Oxidation reduction potential values are used much like pH values to determine water quality. While pH readings characterize the state of a system relative to the receiving or donating hydrogen ions (base or acid), ORP readings characterize the relative state of losing or gaining electrons. Generally ORP readings above 400mV are harmful to aquatic life; however, ORP is a non-specific measurement, which is a reflection of a combination of effects of all the dissolved materials in the water. Therefore, the measurement of ORP in relatively clean water has only limited utility unless a predominant redox-active material is known to be present.

Total Suspended Solids (TSS) concentrations, which cause the photosynthetic activity to be reduced by more than 10% from the seasonably established norm, can have a detrimental effect on aquatic life. Soil particles, organic material, and other debris comprise suspended solids in the water column. **Turbidity (FNU)** measurements are inverse to suspended solid measurements. As TSS increases, the FNU or water transparency decreases. Total suspended solids can be an important indicator of the type and degree of FNU. Total Suspended Solids measurements represent a combination of **Volatile Suspended Solids (VSS)**, which consist of organic material, and **Nonvolatile Suspended Solids (NVSS)**, which is comprised of inorganic mineral particles in the water. In order to more accurately determine the types and amounts of suspended solids, VSS are analyzed. Volatile suspended solid concentration represents the organic portion of the total suspended solids. Organic material often includes plankton, and additional plant and animal debris present in water. Total VSS indicates the presence of organics in suspension; and, therefore, show additional demand levels of oxygen. Illinois does not currently have a standard criteria for TSS, NVSS or VSS.

Total Organic Carbon (TOC) is a measure of the amount of organic carbon in a water body. In addition to natural organic substances, TOC includes insecticides and herbicides, as well as domestic and industrial waste. Industrial waste effluent may include carbon-containing compounds with various toxicity levels. Further, a high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen supplies.

Currently, there are no state or federal water quality standard criteria set for TOC. Because carbon occurs naturally, its concentration varies based on physical and chemical attributes in a watershed; thus, this study relies on historical reference conditions to identify unfavorable conditions.

Metals Iron (TFe) and Manganese (TMn) (T=total) are nutrients for both plants and animals. Living organisms require trace amounts of metals. However, excessive amounts can be harmful to the organism. Heavy metals exist in surface waters in three forms, colloidal, particulate, and dissolved. Water chemistry determines the rate of adsorption and desorption of metals to and from sediment. Metals are desorbed from the sediment if the water experiences increases in salinity, decreases in redox potential, or decreases in pH. Metals in surface waters can be from natural or human sources. Metal levels in surface water may pose a health risk to humans and the environment.

<u>Pesticides</u> are commonly used throughout much of the agricultural landscape that the Big Muddy River flows. This study considers one insecticide and seven herbicides. Atrazine and Alachlor herbicides are commonly used agricultural chemicals which can be readily transported by rainfall runoff. Both compounds are suspected of causing cancer; and therefore, were monitored for the protection of human and aquatic health. Herbicides which are pesticides used to kill vegetation are the most widely used and sampled. Two of the most widely used herbicides are Atrazine and Alachlor. Atrazine is a preemergence or postemergence herbicide use to control broadleaf weeds and annual grasses. Atrazine is most commonly detected in ground and surface water due to its wide use, and its ability to persist in soil and move in water. Alachlor is a Restricted Use Pesticide (RUP) due to the potential to contaminate groundwater. The water quality standards for the pesticides sampled are located in Table 2.

<u>Nitrogen</u> occurs naturally in water through several forms including nitrogen (N2), nitrite (NO2-N), nitrate (NO3-N), ammonia (NH3), and ammonium (NH4). Nitrates are the most commonly reported form of nitrogen, and may have a meaningful influence on a water body's trophic status. Algae and other plants use NO3-N as a food source, thus excess levels of NO3-N can promote increases in algae production and hypereutrophic conditions.

In general, NO3-N does not have a *direct* effect on fish or aquatic insects. Illinois has set criteria standards for NO3-N to 10 mg/L to accommodate safe drinking waters for human and livestock; however, this threshold likely exceeds the concentration that is appropriate for assessing ecosystem health.

<u>Total Ammonia Nitrogen (TAN)</u> includes NH3 and NH4. Total ammonia nitrogen is a colorless gas with a strong pungent odor. Ammonia occurs naturally and is a biological requirement for aquatic life, however elevated concentrations can be toxic to freshwater organisms. Unnatural sources of ammonia include, accidental releases of ammonia rich fertilizer, effluent from sewage treatment plants, improper disposal of ammonia products, and livestock waste.

Toxic concentrations for freshwater organisms range from 0.53 – 22.8 mg/L, and are strongly dependent on both pH and temperature. In general, an increase in pH and/or temperature corresponds with an increase in toxicity. Additional information in regards to the relationship between pH, temperature, and ammonia, as it relates to toxicity, can be reviewed in Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater (USEPA 2013).

<u>Total Phosphorus (TP)</u> is analyzed as phosphorus and has been monitored due to the potential for uptake by nuisance algae. Levels of phosphate can indicate the potential for rapid growth of algae (algal bloom) which can cause serious oxygen depletion during the algae decay process. Phosphorous is typically the limiting nutrient in a water body; therefore, any addition of phosphorous to the ecosystem stimulates the growth of plants and algae. Phosphorous is delivered to lakes and streams by way of runoff from agricultural fields and urban environments. Other sources of phosphorous are anaerobic decomposition of organic matter, leaking sewer systems, and point source pollution. The general standard for phosphorous in lake water is 0.05 mg/L. Dissolved phosphorous, also called **Orthophosphate (PO_4-P)** is generally found in much smaller concentrations than total phosphorous, and is readily available for algal uptake. Orthophosphate concentrations in a water body vary widely over short periods of time as plants take it up and release it.

Chlorophyll a (CHL_a) is a measure of the amount of algae growing in a waterbody, and therefore can be used to classify trophic status. Although algae are a natural part of freshwater ecosystems, too much algae can cause aesthetic problems such as green scums and bad odors, and can result in decreased levels of DO.

Pheophytin a (PHEO a) is a natural degradation product or digestion of CHL_a. The ratio of PHEO_a to CHL_a can provide an indication of the decline or growth in eukaryotic algae and cyanobacteria populations.

Trophic Status is determined using a modified **Trophic State Index (TSI)**, as described by Carlson (1977). Trophic State Index is calculated from secchi-depth transparency, total phosphorus, and chlorophyll-a measurements. Values for these three parameters are converted to an index number ranging from 0-100 according to the following equations:

$$TSI\ (Seechi\ Depth) = 10(6 - (\ln SD/\ln 2))$$
$$TSI\ (Chlorophyll\text{-}a) = TSI(Chl) = 10(6 - ((2.04 - 0.68 \ln Chl)/\ln 2))$$
$$TSI\ (Total\ Phosphorus) = TSI(TP) = 10(6 - (\ln (48/TP)/\ln 2))$$

where ln indicates the Natural Logarithm

A TSI average value, calculated as the average of the three individually determined TSI metrics, is used as an overall indicator of a water body's trophic state. The relationship between TSI and trophic condition is defined as follows:

TSI	Trophic Condition
0-40	Oligotrophic
40-50	Mesotrophic
50-70	Eutrophic
70-100	Hypereutrophic

Laboratory Methods and Water Quality Criteria Summary Table

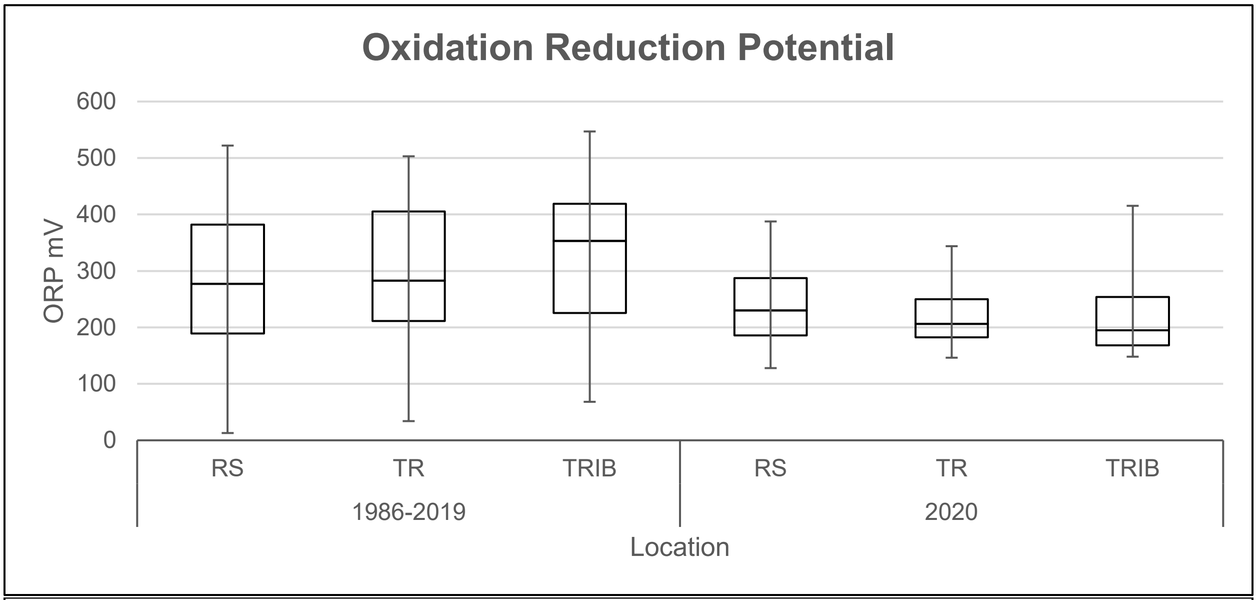
Table 2: Metrics, Methods, and Water Quality Criteria Used for Evaluating Water Quality

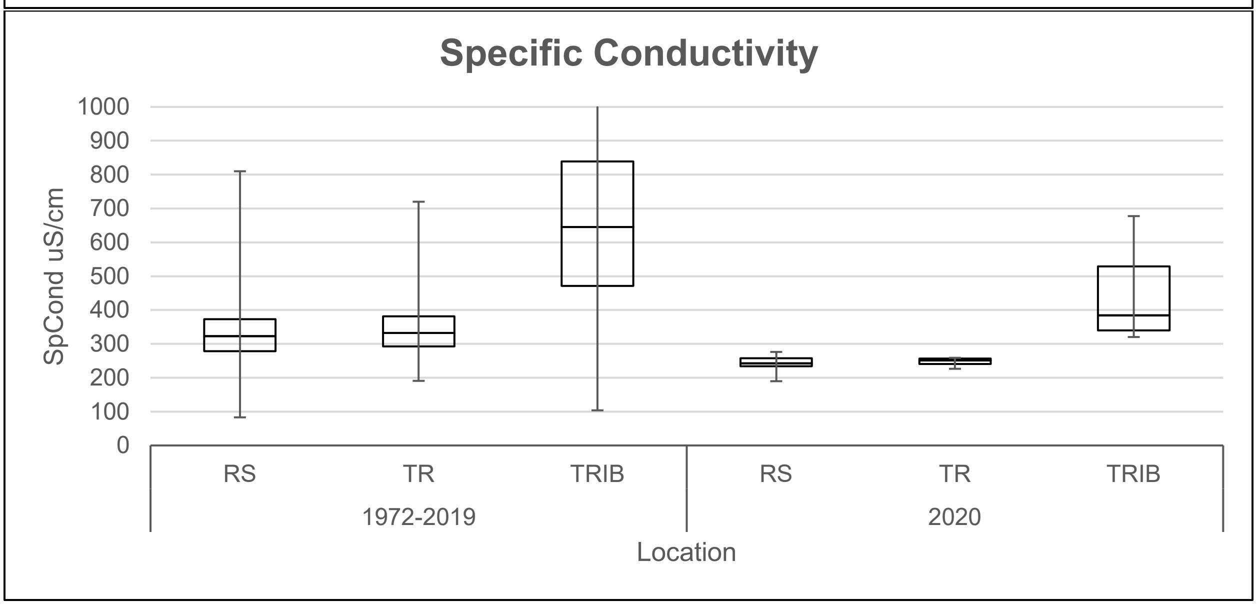
Metric	Abbreviation	Analysis Method	Water Quality Criteria	Source
Alachlor		EPA Method 8270C	< 2µg/L PWS or <1100 µg/L: aquatic life	Illinois EPA
Ammonia Nitrogen	NH_3	EPA Method 350.1	<15 mg/L	United States EPA
Atrazine	Atrazine	EPA Method 8270C	9 µg/L: Chronic or 82 µg/L: Acute or 3 µg/L DWS	Illinois EPA
Bacteria: E. Coliform	E Col	EPA Method 1604	< 235 E. Col per 100/mL for single sample	Illinois EPA
Chlorophyll a	Chl_a	SM Method 10200H	< 25mg/cm^3 (Eutrophic Upper Limit)	Carlson 1977
Chlorpyrifos		EPA Method 8270C	< 0.11 µg/L: aquatic life	Illinois EPA
Cyanazine		EPA Method 8270C	< 30 µg/L: chronic or < 370 µg/L acute (aquatic life)	Illinois EPA
Depth	Depth	Multiparameter Meter	Measurements reported at ~1 meter	-----
Dissolved Oxygen	DO	Multiparameter Meter	Greater than 5.0mg/L	Illinois EPA
Metolachlor		EPA Method 8270C	30.4 µg/L: Chronic or 380 µg/L: Acute	Illinois EPA
Metribuzin		EPA Method 8270C	8.4 mg/L: aquatic life or 8.3 mg/L: human health	Illinois EPA
Nitrate as Nitrogen	NO_3	Green Method	< 10 mg/L	Illinois EPA
Non-Volatile Suspended Solids	NVSS	TSS - VSS	-----	-----
Orthophosphate	Ortho	EPA Method 365.2	-----	-----
Pendmethalin		EPA Method 8270C	< 30 µg/L: chronic or < 350 µg/L acute (aquatic life)	Illinois EPA
Pheophytin a	Phpy_a	SM Method 10200H	-----	-----
Potential of Hydrogen	pH	Multiparameter Meter	Range: 6.5 – 9.0pH	Illinois EPA
Specific Conductivity	SpCond	Multiparameter Meter	500 µS/cm	-----
Temperature	Temp	Multiparameter Meter	Less than rise of 2.8°C above normal seasonal temperature	Illinois EPA
Total Dissolved Solids	TDS	Multiparameter Meter	< 500 mg/L	Illinois EPA
Total Manganese	TMn	EPA Method 6010C	< 1 mg/L	Illinois EPA

Metric	Abbreviation	Analysis Method	Water Quality Criteria	Source
Total Organic Carbon	TOC	EPA Method 415.1	-----	-----
Total Iron	TFe	EPA Method 6010C	< 1 mg/L	Illinois EPA
Total Phosphorus	TP	EPA Method 365.2	Less than 0.05 mg/L	Illinois EPA
Total Suspended Solids	TSS	EPA Method 160.2	-----	-----
Trifluralin		EPA Method 8270C	< 1.1 µg/L: chronic or < 26 µg/L acute (aquatic life)	Illinois EPA
Turbidity	Turb	Multiparameter Meter	-----	-----
Volatile Suspended Solids	VSS	EPA Method 160.4	-----	-----

**1 mg/L is equivalent to 1 drop in two bathtubs and 1 ug/L is equivalent to 1 drop in an Olympic size swimming pool. PWS is public water supply. DWS is drinking water standard.*

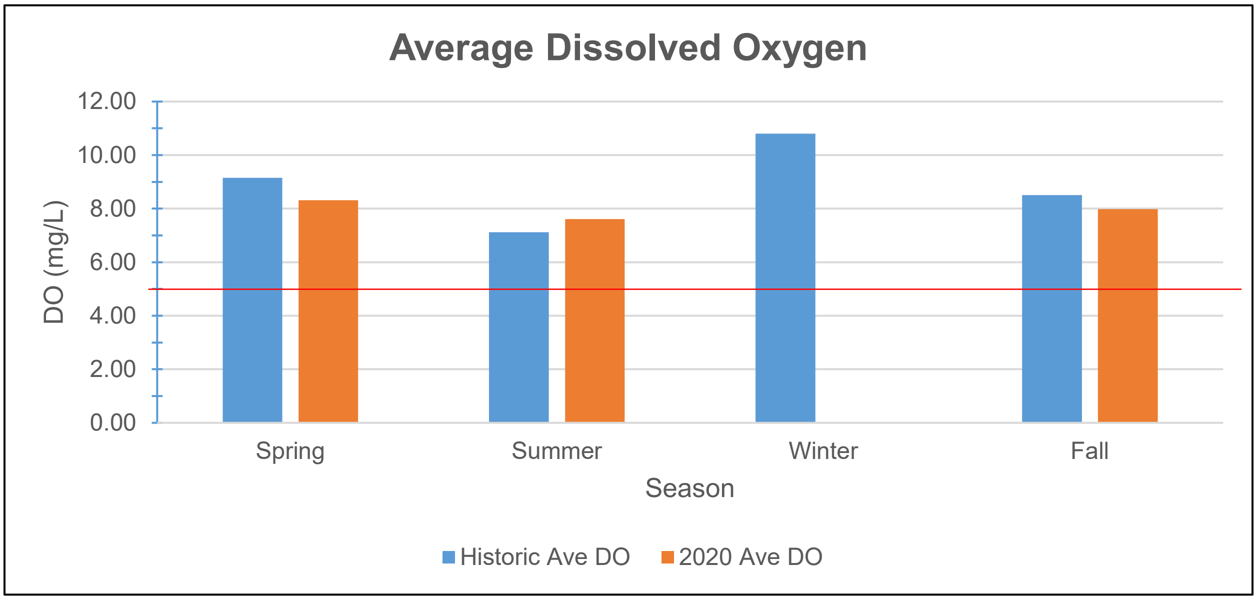
RESULTS AND SUMMARY STATISTICS: WATER QUALITY





	Historical Reference 1973-2019					**2020**			
	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
SpCond	RS	328.95	323.00	750	5.30	243.47	242.95	20	8.88
	TR	341.27	332.50	226	8.96	246.63	250.60	4	23.38
	TRIB	702.39	645.00	369	38.04	438.66	384.05	8	108.81
ORP	RS	282.78	277.00	406	10.71	239.28	229.80	20	34.67
	TR	309.96	323.50	110	21.94	225.70	206.35	4	134.07
	TRIB	327.82	353.00	179	17.31	229.81	194.90	8	79.92

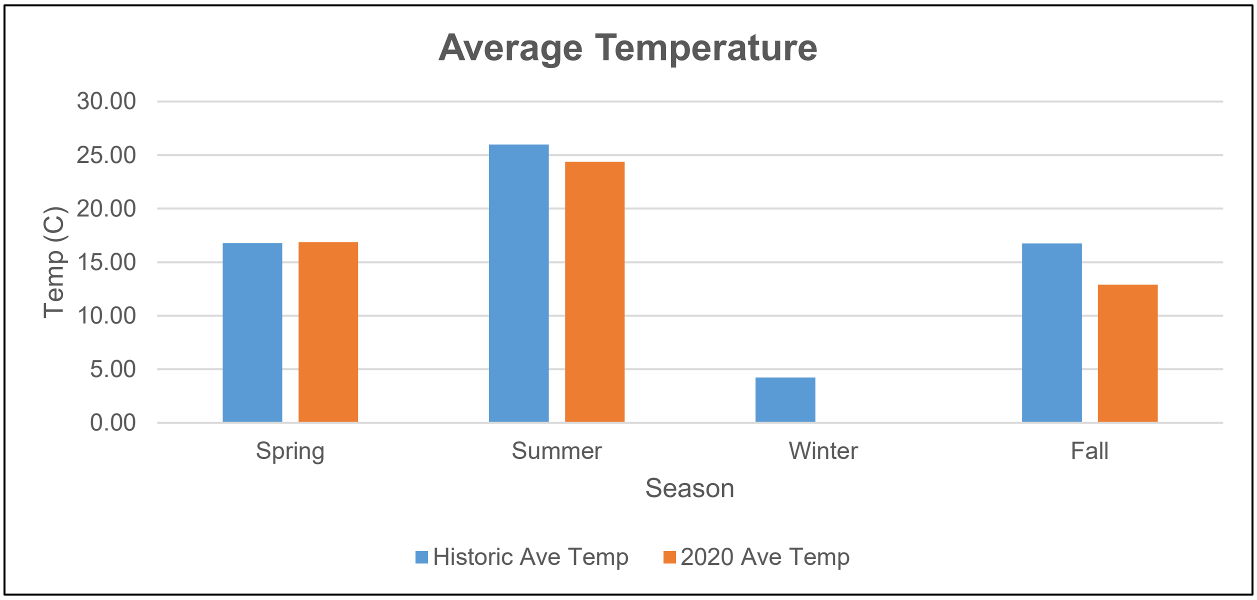
**This report does not acknowledge a water quality criteria for SpCond or ORP.*



Red line placed at the 5 mg/L level.

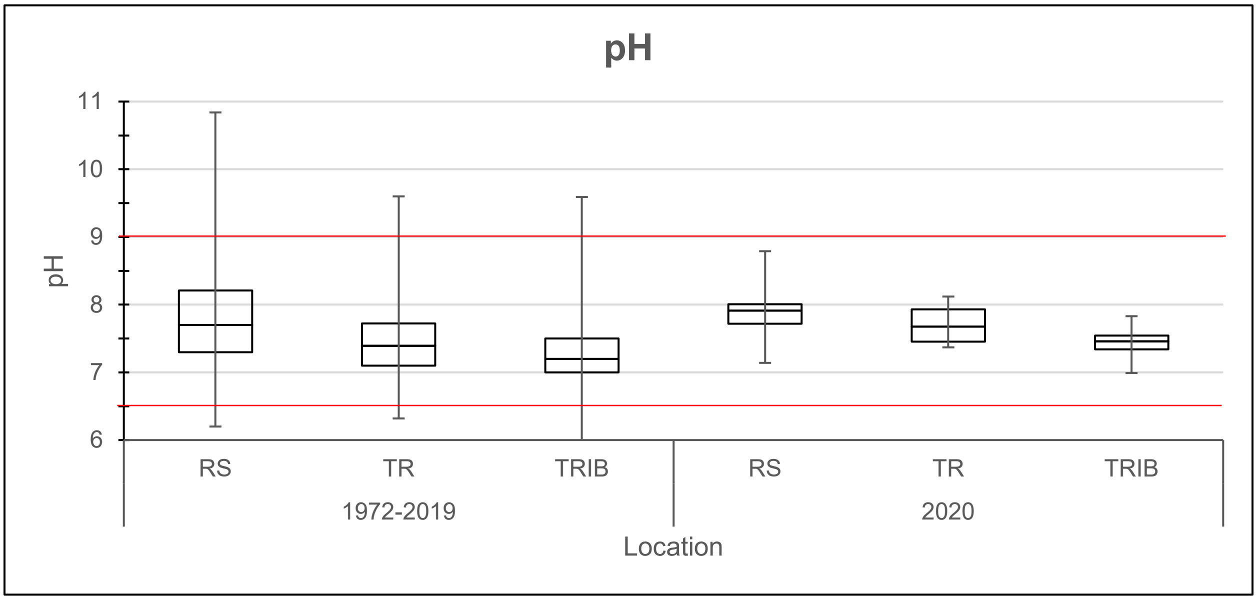
		Historical Reference 1973-2019				2020			
Season	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
Spring	RS	10.03	10.00	215	0.27	9.24	8.71	10	1.17
	TR	8.92	9.10	74	0.59	6.96	6.96	2	42.63
	TRIB	7.75	7.90	123	0.38	8.27	8.43	4	3.64
Summer	RS	7.91	7.80	326	0.23	8.24	7.17	5	1.90
	TR	6.33	6.80	95	0.42	8.01	8.01	1	
	TRIB	5.66	5.62	125	0.38	5.82	5.82	2	5.02
Fall	RS	9.30	9.40	139	0.35	9.40	9.52	5	0.65
	TR	9.03	9.25	40	0.54	9.99	9.99	1	
	TRIB	5.73	5.88	47	0.51	3.43	3.43	2	21.28
Winter	RS	11.27	11.90	71	0.63				
	TR	12.00	12.30	24	0.97				
	TRIB	9.89	10.80	68	0.67				

** DO was recorded below the standard at REN-1 in May and at REN-5 in November 2020. All other observations met the Illinois state standard.*



		Historical Reference 1973-2019				2020			
Season	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
Spring	RS	16.94	16.45	220	0.72	15.96	15.13	10	4.45
	TR	15.85	16.05	74	1.06	13.52	13.52	2	58.17
	TRIB	17.04	17.91	128	0.71	15.62	15.83	4	10.96
Summer	RS	26.91	27.00	325	0.28	25.44	25.30	5	0.52
	TR	25.41	25.85	94	0.45	25.70	25.70	1	
	TRIB	24.02	24.00	128	0.60	21.05	21.05	2	13.34
Fall	RS	17.46	18.00	142	0.82	13.56	13.20	5	0.91
	TR	17.35	18.00	40	1.49	12.90	12.90	1	
	TRIB	14.25	14.00	49	1.33	11.20	11.20	2	20.33
Winter	RS	4.47	5.00	71	0.73				
	TR	3.71	4.00	24	1.15				
	TRIB	4.17	3.00	67	0.91				

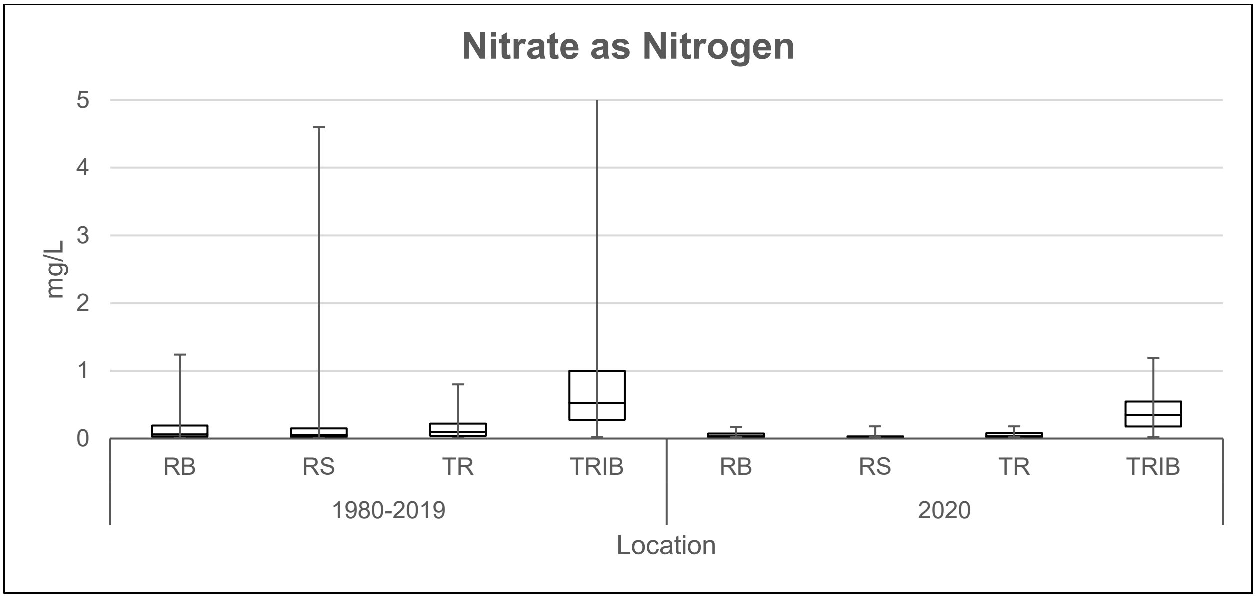
** All temperatures were within acceptable range of water quality criteria during 2020.*

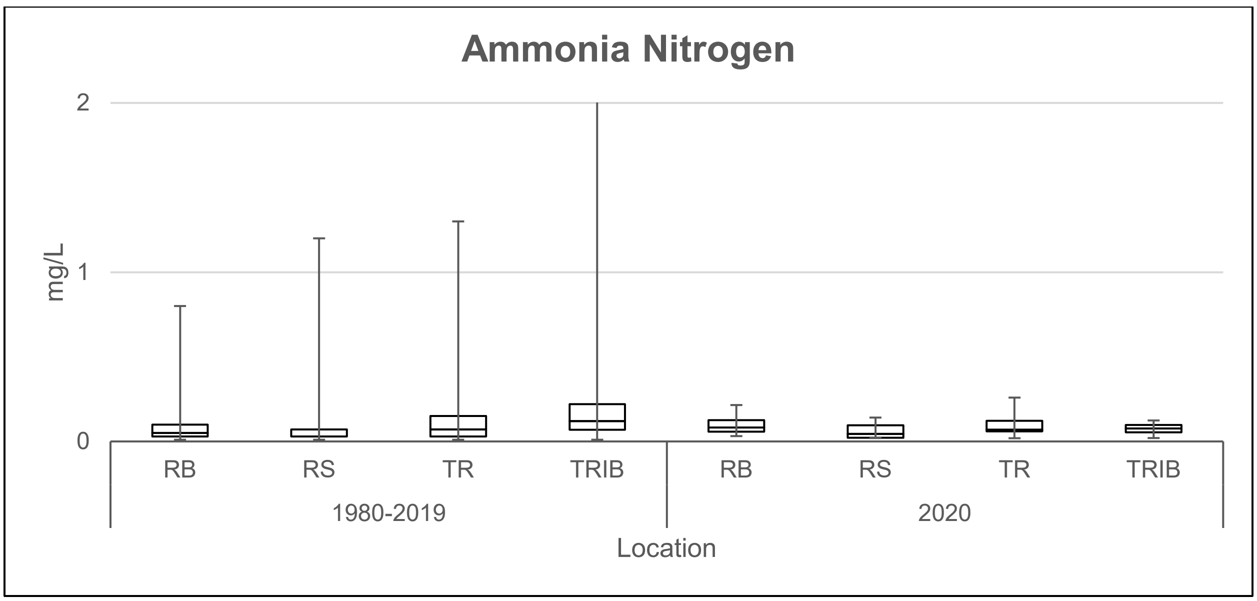


**Red lines indicate the upper and lower water quality criteria standards (between 6.5 and 9).*

		Historical Reference 1972-2019				2020			
	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
pH	RS	7.81	7.70	748	0.05	7.88	7.91	20	0.18
	TR	7.41	7.39	230	0.06	7.71	7.68	4	0.55
	TRIB	7.27	7.20	359	0.05	7.43	7.46	8	0.22

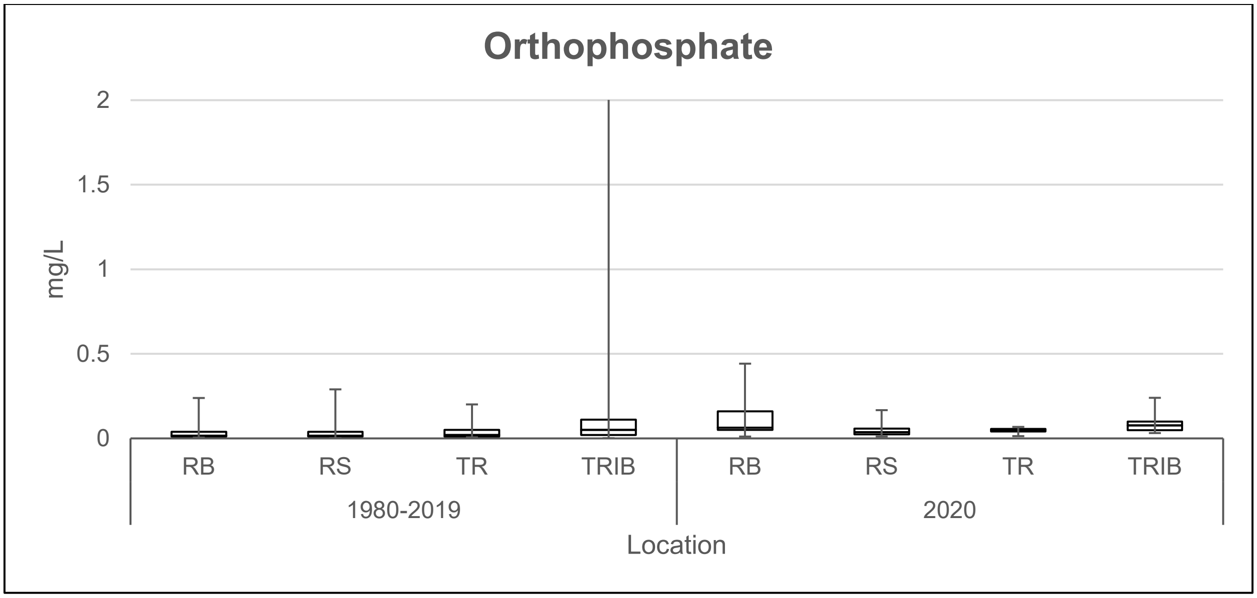
**All pH readings were within water quality standards during 2020.*

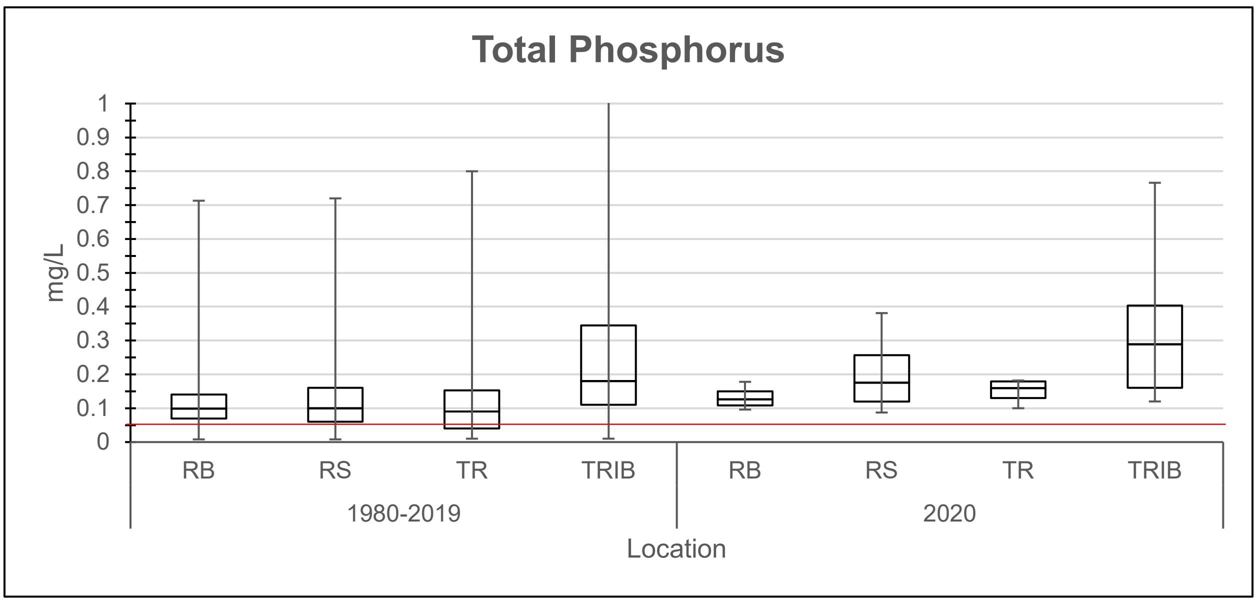




		Historical Reference 1980-2019				**2020**			
	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
NO3N	RB	0.14	0.06	176	0.03	0.06	0.03	4	0.12
	RS	0.13	0.05	746	0.02	0.04	0.02	16	0.03
	TR	0.16	0.10	234	0.02	0.07	0.03	4	0.12
	TRIB	0.88	0.53	367	0.12	0.43	0.35	8	0.33
NH3N	RB	0.08	0.05	172	0.01	0.10	0.08	4	0.13
	RS	0.06	0.03	679	0.01	0.06	0.04	16	0.02
	TR	0.12	0.07	202	0.02	0.11	0.07	4	0.16
	TRIB	0.62	0.12	303	0.21	0.07	0.08	8	0.03

**All observations of nitrate and ammonia nitrogen were within the water quality standard.*

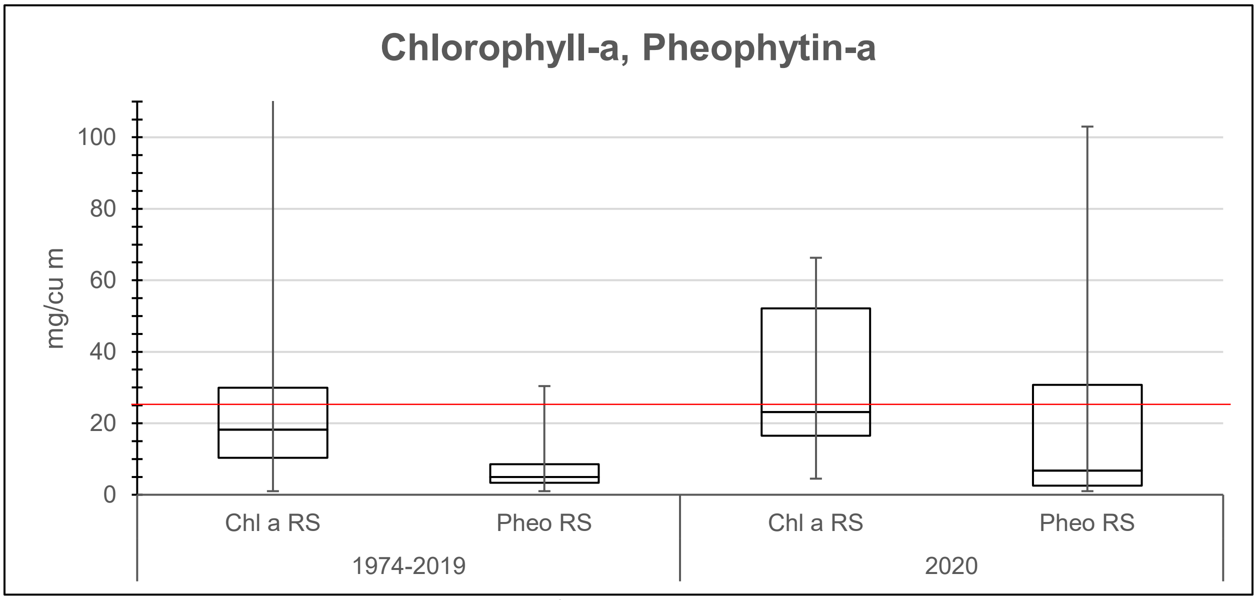




**Red line indicates the water quality standard of 0.05 mg/L.*

		Historical Reference 1980-2019				**2020**			
	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
Ortho	RB	0.03	0.02	175	0.01	0.15	0.06	4	0.32
	RS	0.03	0.02	727	0.00	0.05	0.04	16	0.02
	TR	0.04	0.02	217	0.01	0.05	0.05	4	0.04
	TRIB	0.34	0.05	366	0.10	0.09	0.08	8	0.06
TP	RB	0.12	0.10	186	0.01	0.13	0.13	4	0.06
	RS	0.13	0.10	782	0.01	0.19	0.18	16	0.05
	TR	0.11	0.09	238	0.01	0.15	0.16	4	0.06
	TRIB	0.54	0.18	379	0.11	0.33	0.29	8	0.18

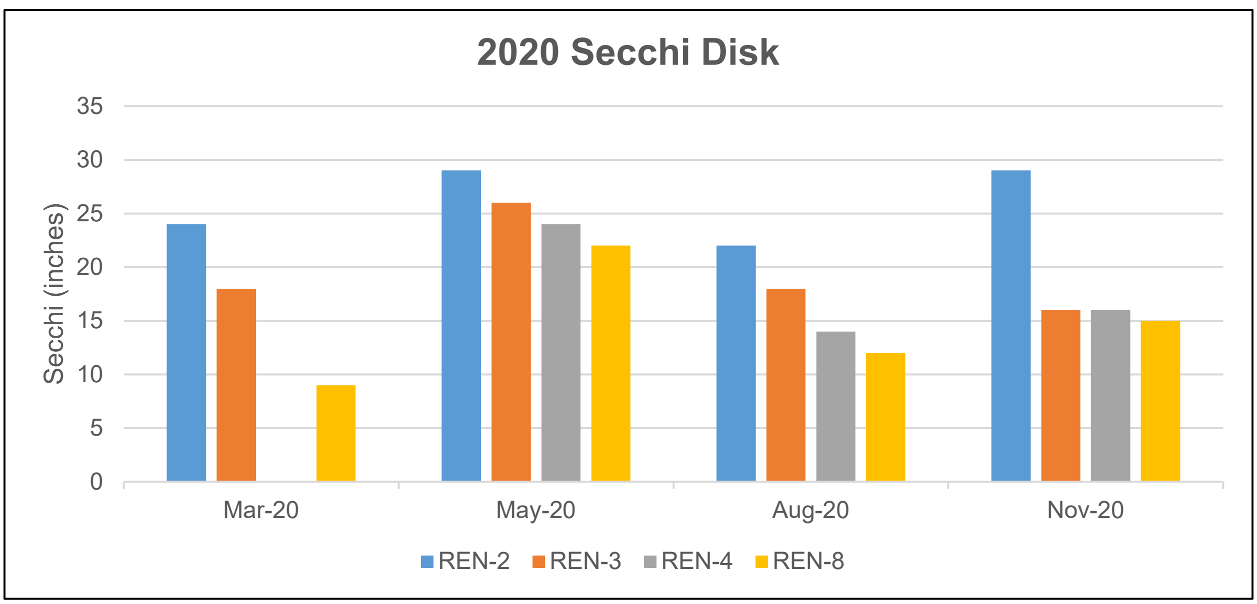
**Total phosphorus exceeded the proposed criteria of 0.05 mg/L for all locations. This study does not acknowledge a water quality criteria for orthophosphate.*

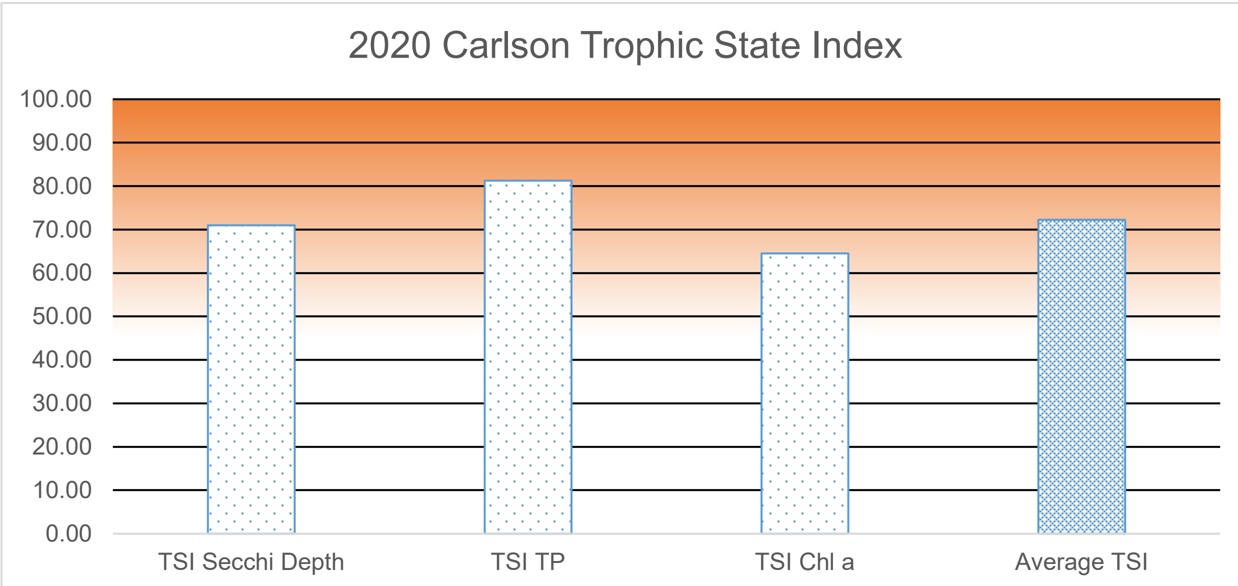


**Red line indicates the water quality standard of 25 mg/cm³. See Carlson 1977.*

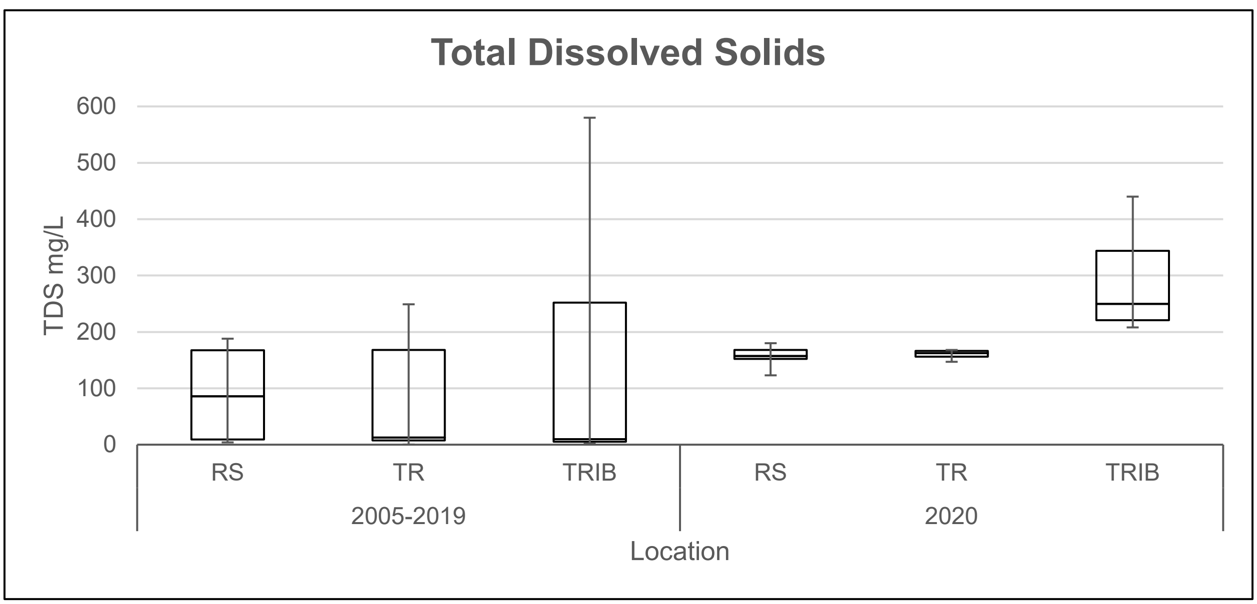
		Historical Reference 1974-2019				2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
Chl a	RS	23.64	18.20	503	1.77	31.72	23.15	16	11.37
Pheo a	RS	7.02	5.00	463	0.48	21.97	6.75	16	16.08

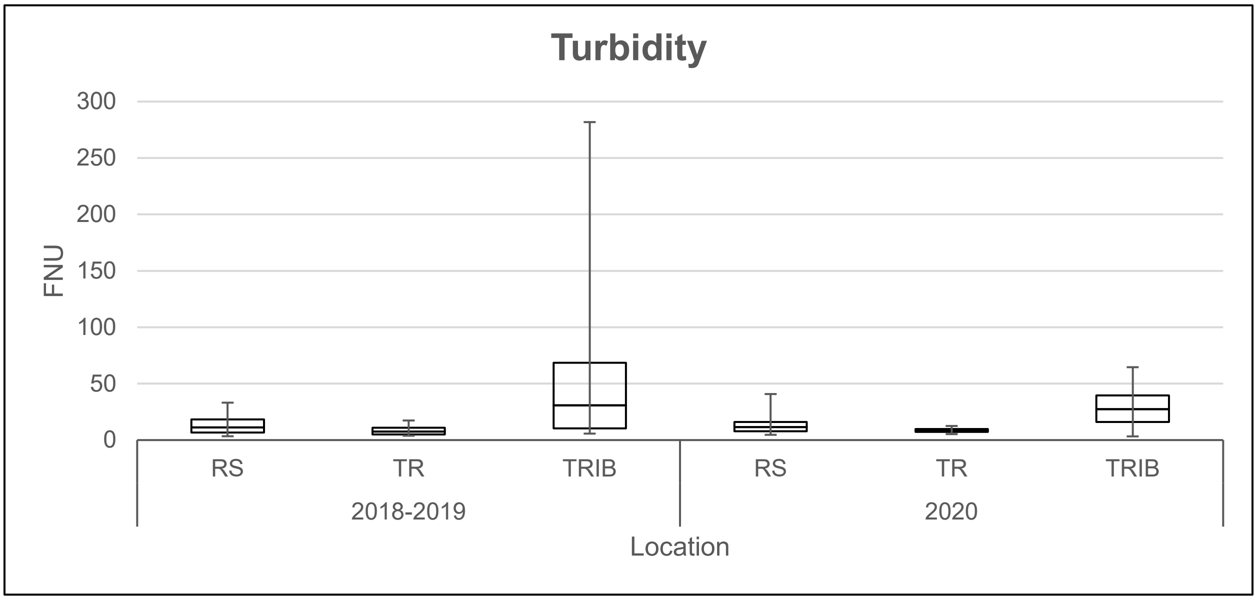
**The proposed criteria for chlorophyll-a of 25mg/cm³ was exceeded at all the lake sites at least one time in 2020. This study does not acknowledge a criteria for pheophytin.*





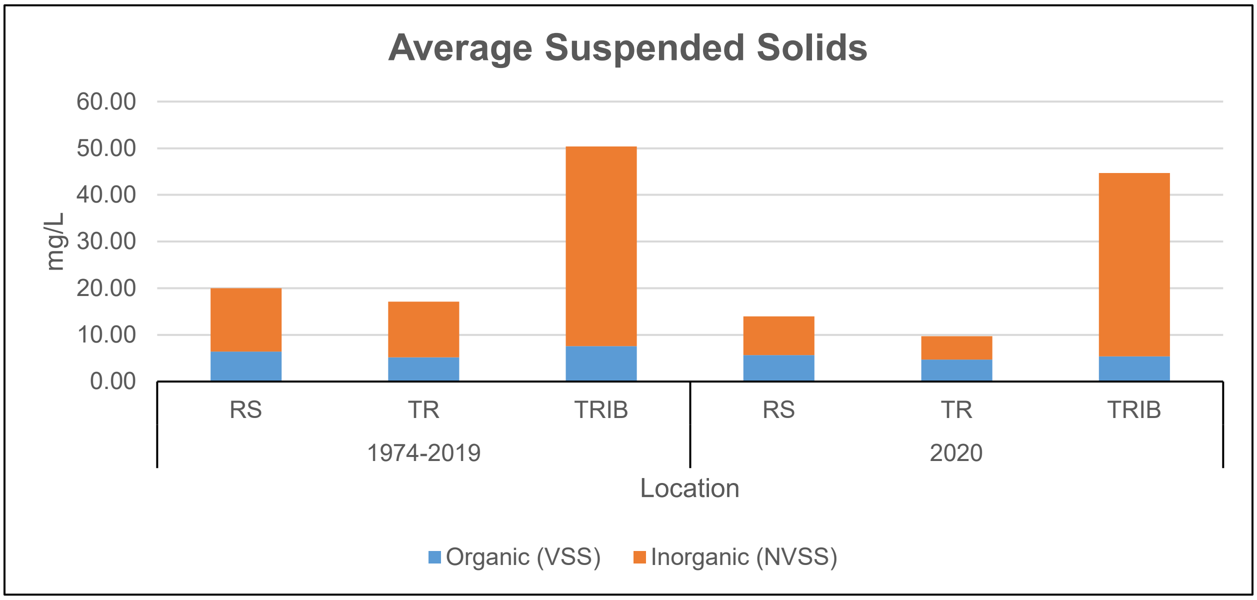
<40 = Oligotrophic __ 40-50 = Mesotrophic __ 50-70 = Eutrophic __ >70 Hypereutrophic





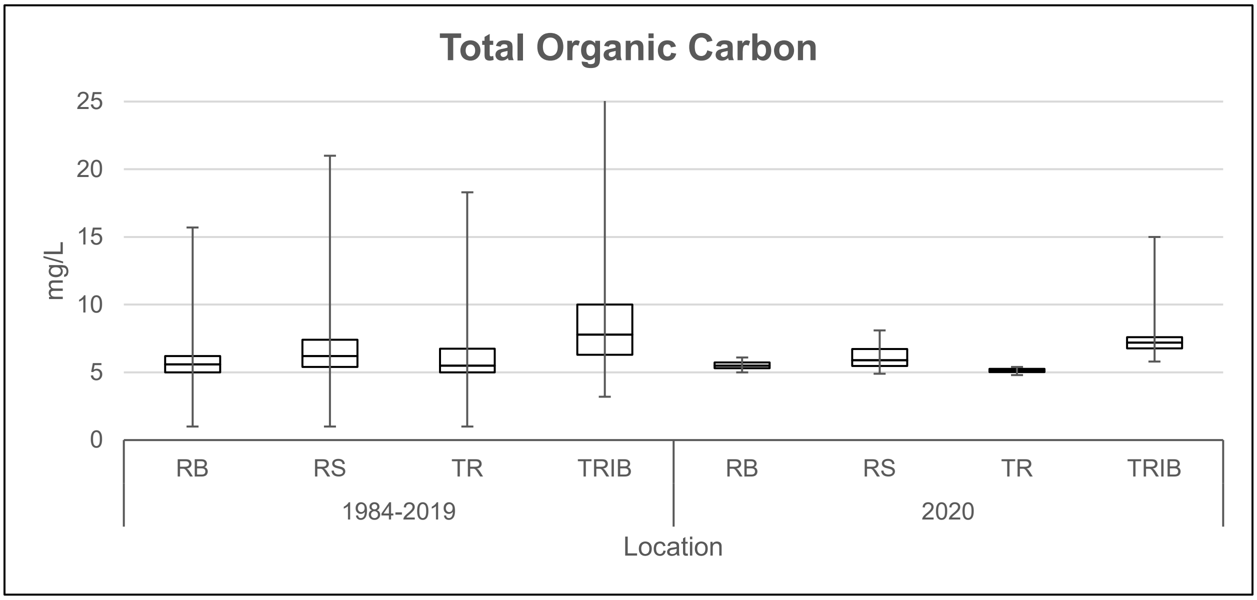
		Historical Reference 2005-2019				2020			
	Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
FNU	RS	13.06	11.26	38	2.59	14.46	11.58	20	4.56
	TR	8.78	7.66	8	4.05	8.73	8.57	4	4.75
	TRIB	57.55	30.66	16	39.24	29.08	27.31	8	17.01
TDS	RS	85.80	86.00	75	17.83	158.10	157.00	20	5.82
	TR	87.12	12.58	17	45.89	160.00	162.50	4	15.10
	TRIB	128.17	9.54	36	57.74	285.13	249.50	8	70.70

* *All observations of TDS were within the referenced water quality standard during 2020.*



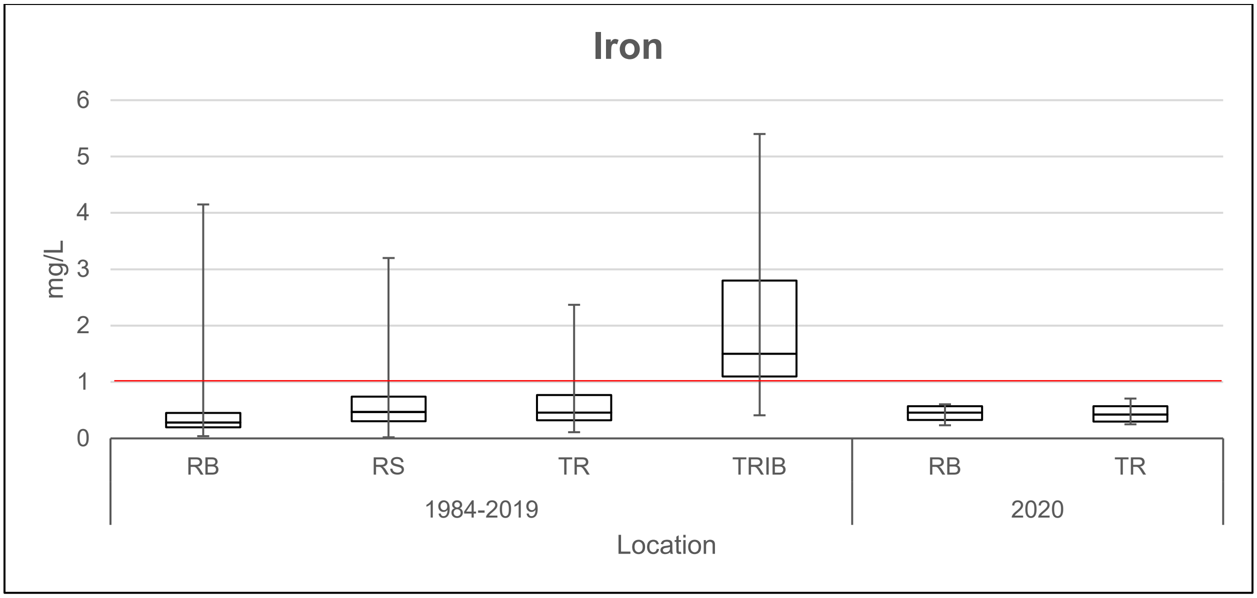
		Historical Reference 1974-2019				2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
TSS	RS	19.92	15.75	726	1.57	13.99	12.80	16	3.78
	TR	17.04	13.00	219	2.03	9.70	9.40	4	2.67
	TRIB	50.33	30.55	328	7.11	44.70	29.40	8	47.93
VSS	RS	6.44	6.00	717	0.27	5.66	4.60	16	1.28
	TR	5.20	5.00	215	0.43	4.70	4.00	4	2.23
	TRIB	7.56	5.00	325	0.81	5.38	4.20	8	2.65
NVSS	RS	13.56	9.20	726	1.42	8.33	7.60	16	3.17
	TR	11.93	8.30	219	1.77	5.00	5.20	4	1.10
	TRIB	42.84	24.90	328	6.46	39.32	25.20	8	45.44

**The solids data measured in 2020 were comparable to the historical data..*

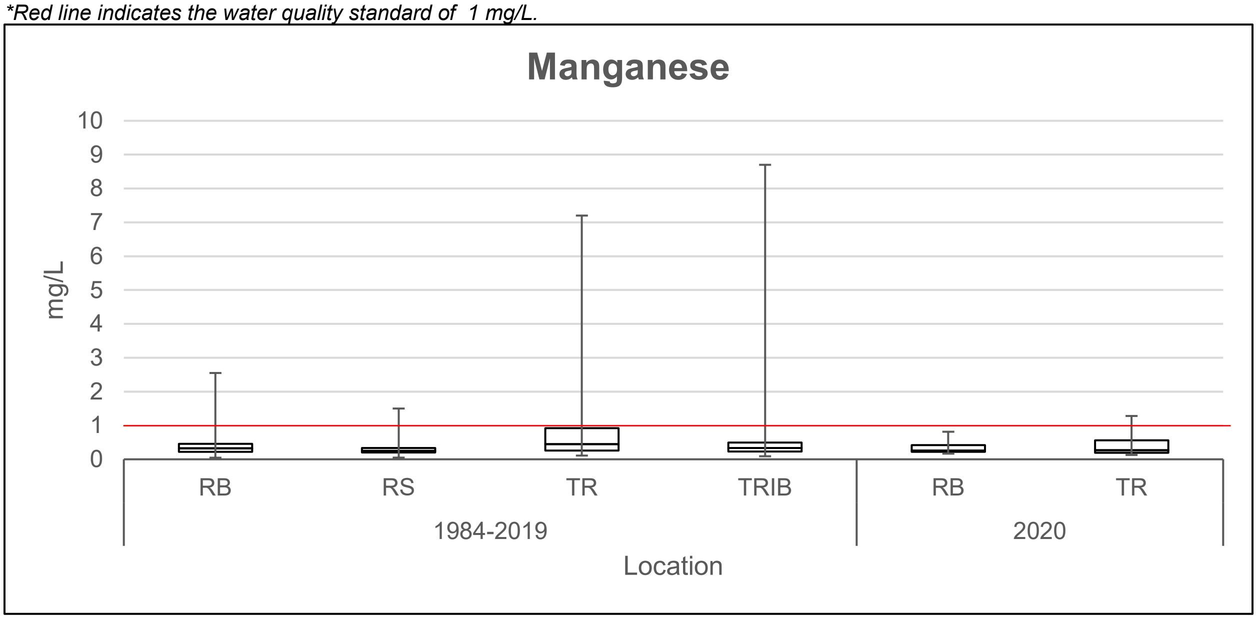


	Historical Reference 1984-2019				2020			
Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
RB	5.86	5.60	148	0.29	5.53	5.50	4	0.73
RS	6.77	6.20	525	0.20	6.13	5.90	16	0.48
TR	6.35	5.50	150	0.41	5.13	5.15	4	0.40
TRIB	8.79	7.80	201	0.63	7.99	7.20	8	2.43

**This study does not recognize a water quality criteria for TOC.*



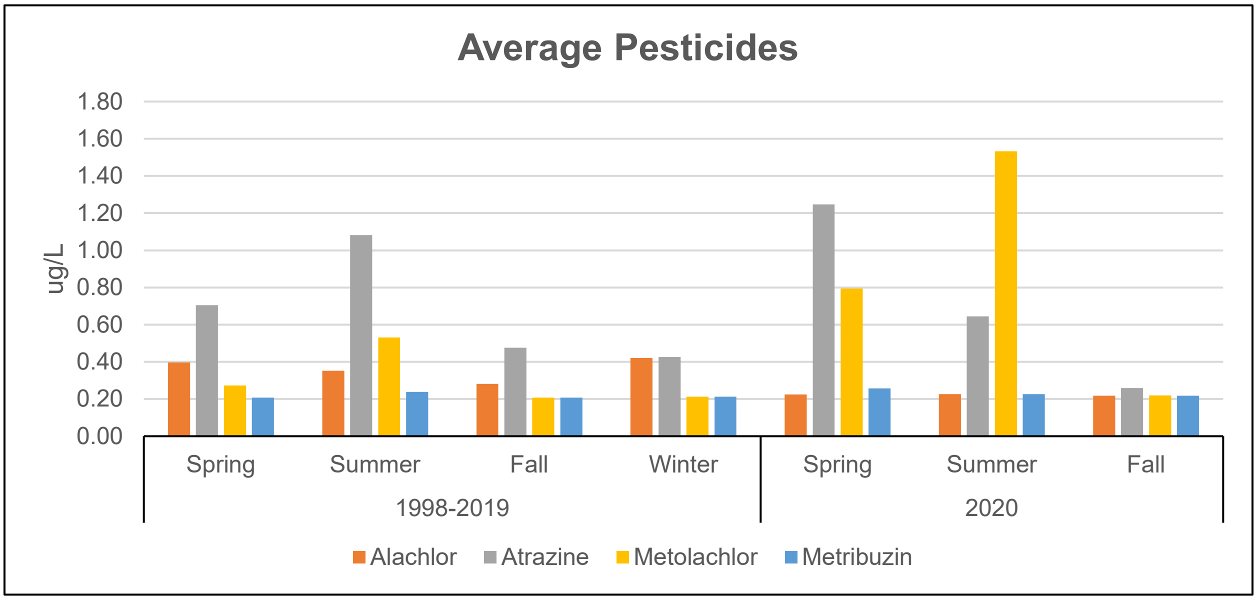
Red line indicates the water quality standard of 1 mg/L.



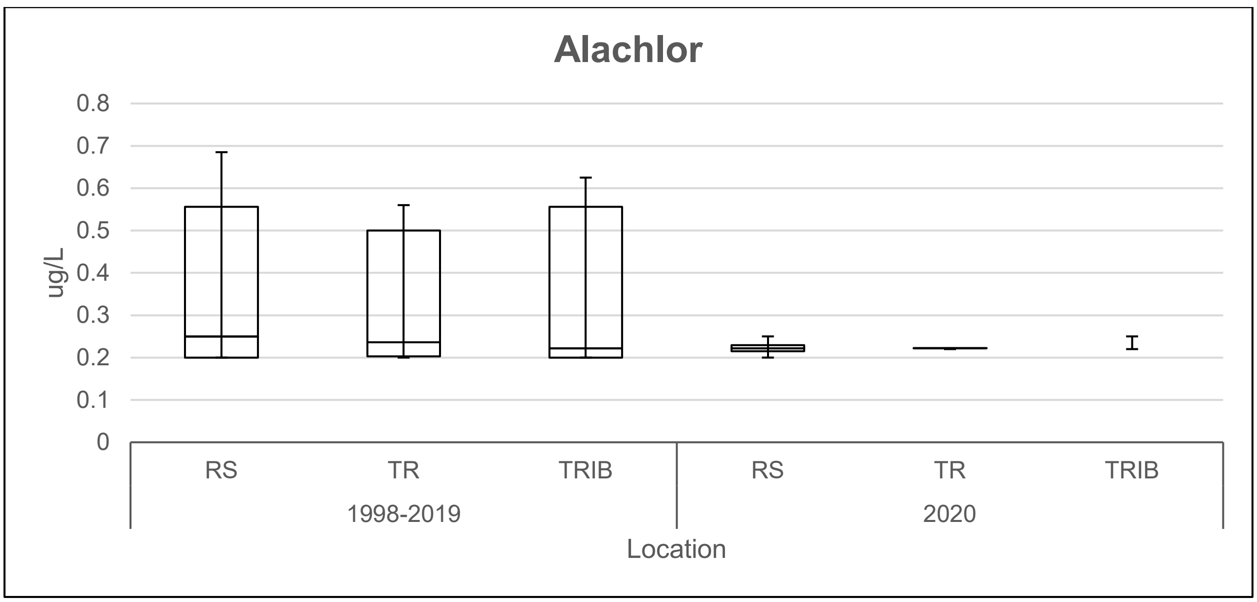
Red line indicates the water quality standard of 1 mg/L.

		Historical Reference 1984-2019				2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
Iron	RB	0.44	0.28	147	0.08	0.44	0.46	4	0.28
	RS	0.59	0.47	234	0.06				
	TR	0.58	0.46	145	0.06	0.45	0.42	4	0.33
	TRIB	2.06	1.50	65	0.34				
Mang	RB	0.41	0.32	147	0.05	0.38	0.26	4	0.47
	RS	0.28	0.25	234	0.02				
	TR	0.77	0.45	145	0.16	0.49	0.27	4	0.85
	TRIB	0.65	0.33	65	0.31				

**In 2020 manganese exceeded the standard of 1 mg/L at REN-1 once in May. All other measurements for manganese and iron were within the state standards.*

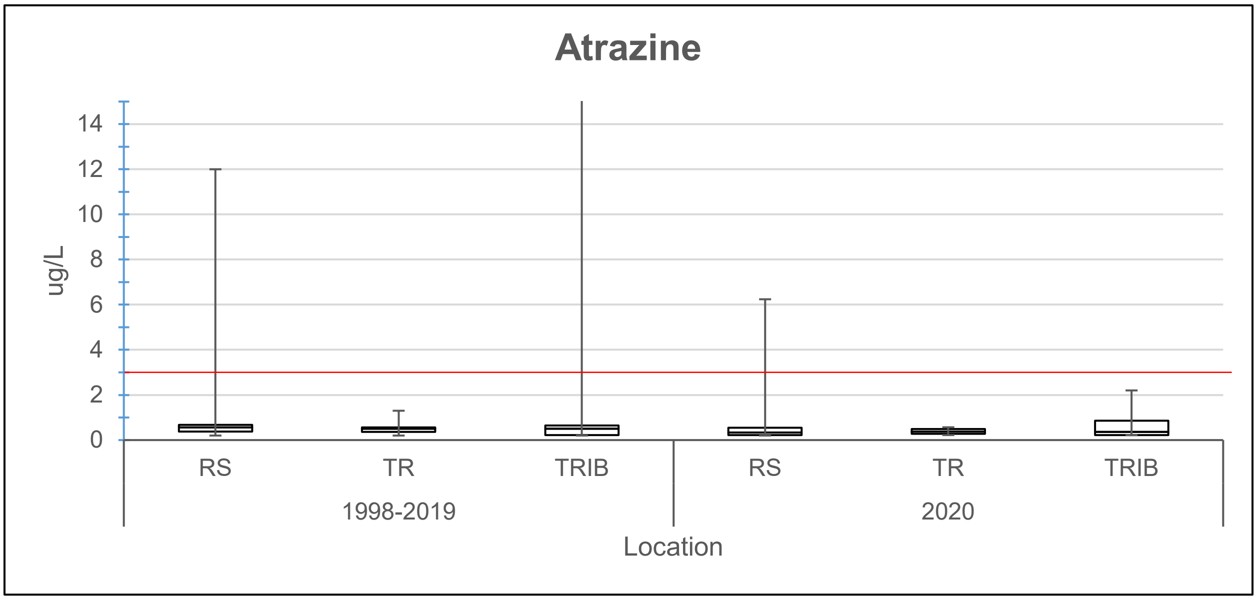


**Of the eight pesticides tested, only the above four were reported above detection levels for the period 1998-2020.*



		Historical Reference 1998-2019				2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
Alachlor	RS	0.37	0.25	231	0.02	0.22	0.22	16	0.01
	TR	0.36	0.24	58	0.04	0.22	0.22	4	0.00
	TRIB	0.37	0.22	111	0.03	0.23	0.22	8	0.01

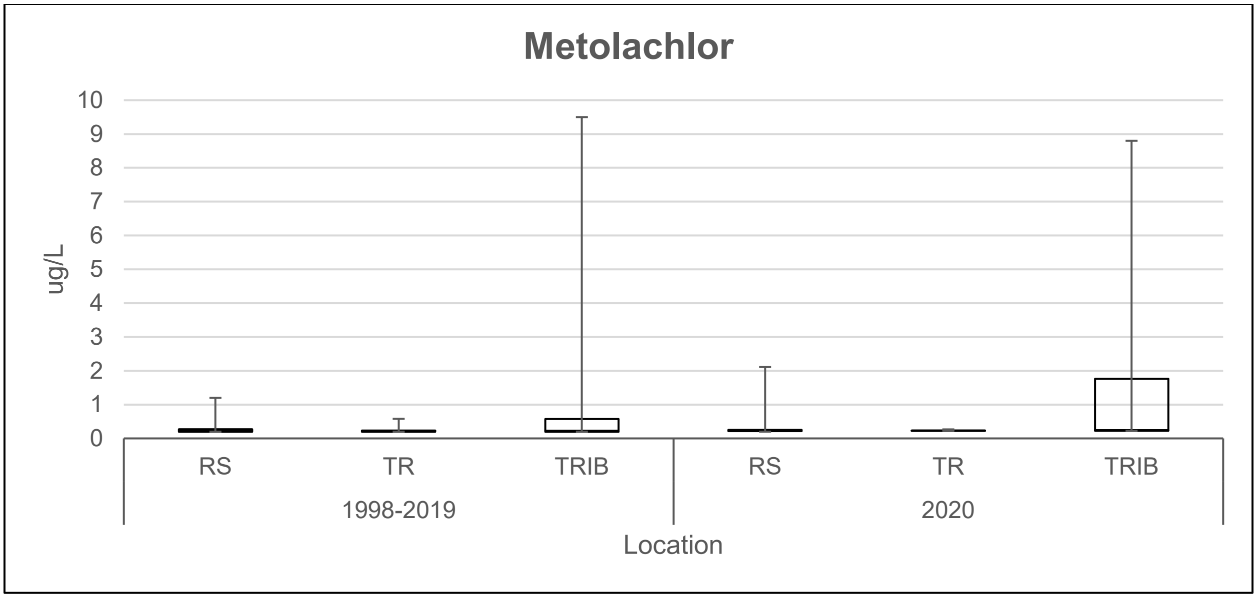
**All measurements of Alachlor were within the water quality criteria in 2020.*



Red line indicates the water quality standard of 3 ug/L DWS.

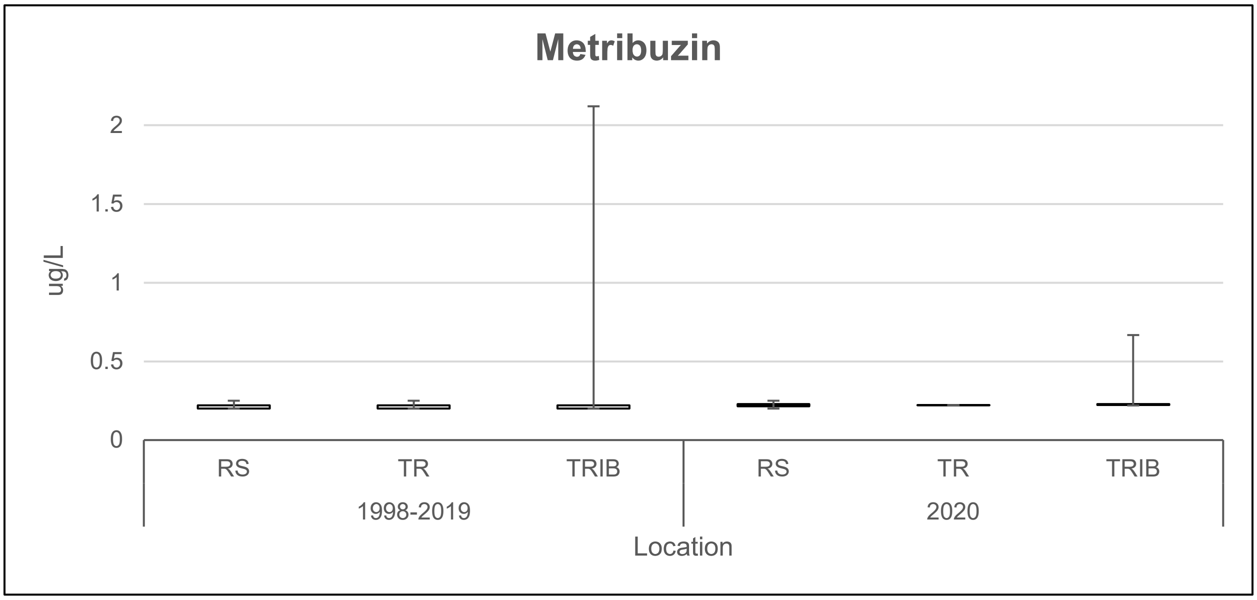
	Historical Reference 1998-2019					2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
Atrazine	RS	0.76	0.56	232	0.15	1.02	0.33	16	0.88
	TR	0.51	0.50	58	0.06	0.39	0.38	4	0.25
	TRIB	1.29	0.50	111	0.68	0.74	0.36	8	0.66

Atrazine exceeded the water quality criteria twice in May 2020.



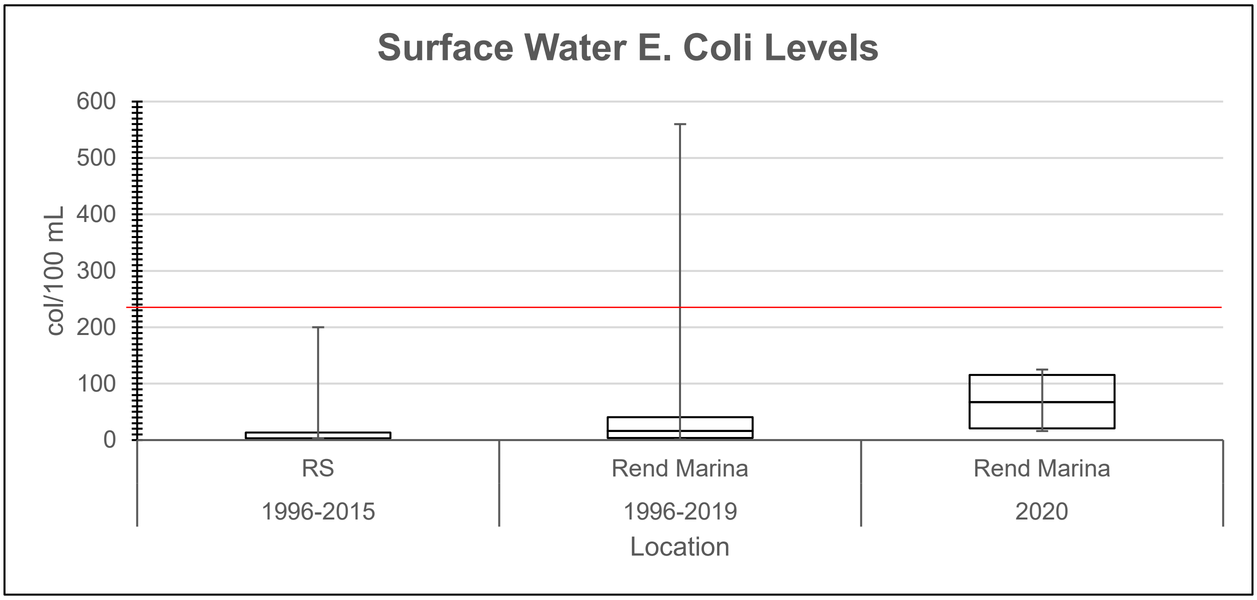
	Historical Reference 1998-2019					2020			
	Location	Mean	Median	Count	CL(95.0 %)	Mean	Median	Count	CL(95.0 %)
Metolachlor	RS	0.30	0.22	120	0.03	0.43	0.22	16	0.27
	TR	0.26	0.22	30	0.04	0.23	0.22	4	0.04
	TRIB	0.73	0.22	58	0.38	1.95	0.24	8	2.69

**Metolachlor did not exceed water quality criteria in 2020.*



	Historical Reference 1998-2019					2020			
	Location	Mean	Median	Count	CL(95.0%)	Mean	Median	Count	CL(95.0%)
Metribuzin	RS	0.21	0.20	128	0.00	0.22	0.22	16	0.01
	TR	0.21	0.20	32	0.00	0.22	0.22	4	0.00
	TRIB	0.26	0.20	62	0.07	0.28	0.22	8	0.13

**Metribuzin did not exceed water quality criteria in 2020.*



Red line indicates the water quality standard of 235 col per 100 mL.

	Historical Reference 1996-2019				2020			
Marina Location	Mean	Median	Count	CL (95.0%)	Mean	Median	Count	CL (95.0%)
Rend Marina	45.84	16.00	44	28.63	68.75	67.00	4	91.88
RS	16.81	3.00	48	11.03				

Marina bacteria levels did not exceed the water quality standard in 2020.

2020 Swimming Beach Bacteria Levels (E. Coli / 100mL)	Dale Miller		North Marcum		Sandusky	
	Shallow	Deep	Shallow	Deep	Shallow	Deep
6/3/2020	6.3	1	307.6	1	55.6	9.7
6/16/2020	1	3.1	1	1	261.3	10.8
6/17/2020	n/a	n/a	n/a	n/a	6.3	1
6/29/2020	15.8	16.1	14.6	24.6	66.3	45.7
7/14/2020	1	1	1	2	4.1	6.3
7/27/2020	1	1	3.1	4.1	17.1	4.1
8/10/2020	93.3	105	37.9	13.4	38.8	9.7
8/24/2020	3.1	5.2	2	1	2	2

Beach bacteria levels exceeded the reference water quality criterion twice in 2020.

DISCUSSION: WATER QUALITY

Water quality metrics assessed by CEMVS can be sporadic and highly variable from year to year, thus long-term data collection using consistent and comparable methodology is critical to identify trends or patterns. In general, conditions observed during 2020 did not deviate far from conditions observed during the reference period (2014-2018); nevertheless, concerns regarding DO, Atrazine, Mn, and TP were evident. In addition, CHL_a and subsequent TSI levels were indicative of a hyper eutrophic system.

With a few exceptions, all DO levels recorded in 2020 were above the 5 mg/L standard. On May 26 2020 DO was recorded at 3.6 mg/L at REN-1. At the time of this sampling the sluice gate was closed, allowing no flow. Similar readings have been observed at REN-1 in previous years. On November 12 2020 DO was recorded at 1.8 mg/L at REN-5 during a time of very low flow. There have been 46 events since 1972 that DO was recorded below the standard at REN-5 compared with 21 events at the other main tributary, REN-7, and 23 events at REN-1, the controlled discharge. Given that both main tributaries are impaired for DO, and the historical data, these few low readings in 2020 are not out of the ordinary. All other parameters measured at that time (pH, ORP, SpCond, Temp, TDS, & Turb) were within the normal ranges. The historic average DO level (8.9 mg/L) is similar to the 2020 average DO levels (7.97 mg/L).

Pesticides are commonly used throughout much of the agricultural landscape that the Big Muddy River flows. Of the eight pesticides tested, only Alachlor, Atrazine, Metolachlor, and Metribuzin were detected between 1998 and 2020. Of those four, only Atrazine was found to exceed the criteria in 2020. The Atrazine drinking water standard (3 ug/L) was exceeded on May 26 2020 at REN-4 and REN-8 with a level of 3.31 ug/L and 6.24 ug/L respectively. Atrazine levels were recorded over the standard multiple times in the tributaries historically. The 2020 Atrazine average (0.849 ug/L) is comparable to the historic Atrazine average (0.87 ug/L). Atrazine and Alachlor herbicides are commonly used agricultural chemicals which can be readily transported by rainfall runoff. Both compounds are suspected of causing cancer; and therefore, were monitored for the protection of human and aquatic health. Atrazine is most commonly detected in ground and surface water due to its wide use, and its ability to persist in soil and move in water. Only low levels of pesticides have been observed in the tailrace.

Total suspended solids can affect water quality by increasing temperature through the absorption of sunlight by suspended particles in the water column, and consequently reduce DO. TSS are also strongly correlated with water clarity and the presence of Macrophytes. Given that Rend lake and its tributaries are impaired by TSS it is imperative to continue monitoring TSS trends. The historic mean and median TSS data are greater than 2020 data. Thus, the 2020 TSS data indicate normal levels in comparison to the historical range.

Living organisms require trace amounts of metals, but excessive levels can be harmful. TFe did not exceed the criterion of 1 mg/L in 2020. The mean TFe concentrations in

2020 were similar to the historical data. Iron cycling is a function of oxidation-reduction processes. Elevated levels of iron near the bottom of a lake is not immediately detrimental to the overall lake system. Iron oxidizes relatively rapidly (minutes to hours); therefore, any iron released through the discharge should be oxidized in a short period of time. TFe levels in the tailrace in 2020 were found to be less than the criterion and similar to the levels in front of the dam. TMn in 2020 exceeded the criterion once in the tailrace in May. Historically, TMn has exceeded the criterion multiple times in the tailrace and once in front of the dam. The mean concentrations of TMn in 2020 were less than the historical values.

TP levels have surpassed the 0.05 mg/L criterion for several years. In 2020 the TP criterion was exceeded at all locations with a mean concentration across all sites of 0.21 mg/L compared to the historical mean of 0.22 mg/L. Phosphorus is a limiting nutrient for primary producers (algae and plants) due to its relatively low amount in the environment. Higher inputs of TP and NO3-N into the lake contribute to a highly productive environment which stimulates algal growth that can lead to blooms that deplete the oxygen levels during die off. In addition, blooms can sometimes contain toxins which may be harmful to humans and wildlife.

Although there is not a state criterion for CHL_a the proposed standard of 25 mg/cm^3 was exceeded at all the lake sampling locations at least once in 2020. The 2020 mean CHL_a concentration (31.72 mg/cm^3) was greater than the historical mean (23.64 mg/cm^3). CHL_a is an indicator of the abundance of phytoplankton. Any water environment with a level recorded above 25 mg/cm^3 is considered to be eutrophic (nutrient enrichment increases algal and plant growth and negative effects). The 2020 TSI level, an average of the individual trophic state indexes for secchi depth, CHL_a, and TP, for Rend Lake was 72.25. Rend Lake is considered hyper-eutrophic based on this TSI level. This does not necessarily mean the water quality is poor, but that its trophic level indicates nutrient levels are abundant, which can support an abundance of plants and algae. Long term monitoring and analyses are important to assess changes in trophic levels over time.

Swimming beach bacteria levels exceeded the criterion twice in 2020 in June at North Marcum and Sandusky beaches, but the samples immediately following were low. All remaining parameters evaluated during the 2020 water quality monitoring effort were within designated criteria or within historical reference norms.

MONITORING PROGRAM RECOMMENDATIONS

The Illinois Environmental Protection Agency (IEPA, 2018) has listed Rend Lake and its tributaries with multiple water quality impairments. In order to better understand the causes of these impairments the following additional monitoring is recommended: chemical and in-situ data collected downstream of the spillway (previously unsampled), include mercury for site REN-1, augment current sampling suite at REN-7 (Casey Fork) to include chloride, iron, mercury, and augment the current sampling suite at site REN-5 (Big Muddy River) as well as all the lake sites to include mercury.

In accordance with EM-1110-2-1201, benthic sediment samples should be taken to monitor and assess potential impacts to aquatic and human health. Sediment sampling and analyses occurred at Rend Lake in 2018, and prior to that in 2007. During these last analyses multiple exceedances over the recommended criteria were observed. Identifying trends over time is much more achievable with more consistent data. Contaminated sediments may have negative impacts on ecological processes. It is recommended, if possible, to sample and analyze for sediment metals and nutrients, as well as grain size analyses yearly or every two years.

Given the hypereutrophic status of Rend Lake it is recommended that Nitrite (NO_2) and Total Khejdahl Nitrogen (TKN) be added to the monitoring program. Doing so would allow CEMVS to evaluate Total Nitrogen (TN), which is a strong indicator of trophic status. Similarly, it would strengthen the monitoring program to add CHL_a to every sample site. Currently CHL_a is only sampled at the lake sites and not the tributaries or lake discharge. This would allow for a trophic status comparison between the tributaries, lake, and discharge.

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APPENDIX A: FIELD DATA

Date	Location	Depth (m)	Temp (°C)	ORP (mV)	Sp Cond (µS/cm)	pH	ODO (% Sat)	ODO (mg/L)	TDS (mg/L)	Turbidity (FNU)	Secchi (in)
3/26/2020	REN-1	0.5	8.9	194.2	226.4	7.5	89.2	10.3	147	8.1	
3/26/2020	REN-2	1.1	9.1	219.2	224.1	7.4	93.3	10.8	146	7.7	24
3/26/2020	REN-2-5	7.0	8.8	228.1	225.3	7.2	88.1	10.2	146	9.1	
3/26/2020	REN-3	1.0	10.4	187.4	231.5	7.6	102.1	11.4	150	13.2	18
3/26/2020	REN-4	0.9	10.2	217.8	233.4	7.2	81.3	9.1	152	40.8	
3/26/2020	REN-5	0.9	8.8	199.5	397.5	7.2	88.5	10.3	258	64.6	
3/26/2020	REN-7	1.1	10.6	226.8	326.1	7.0	91.9	10.2	212	45.1	
3/26/2020	REN-8	1.0	11.1	220.2	189.8	7.1	90.6	10.0	123	38.6	9
3/26/2020	REN-MAR	1.1	10.1	189.8	223.6	7.9	104.8	11.8	145	7.0	
5/26/2020	REN-1	1.2	18.1	146.3	245.3	7.4	38.0	3.6	159	12.5	
5/26/2020	REN-2	1.0	19.2	160.1	234.6	7.7	76.5	7.1	153	7.6	29
5/26/2020	REN-2-5	5.0	18.0	184.4	237.5	7.4	52.6	5.0	154	9.7	
5/26/2020	REN-3	1.2	22.8	145.4	240.8	7.8	94.6	8.1	156	11.2	26
5/26/2020	REN-4	1.1	22.4	127.9	243.8	7.8	92.8	8.1	158	11.9	24
5/26/2020	REN-5	0.8	21.1	173.8	552.0	7.6	67.3	6.0	359	34.8	
5/26/2020	REN-7	0.9	22.0	150.3	521.0	7.8	76.0	6.6	339	18.4	
5/26/2020	REN-8	1.1	23.1	182.0	243.8	7.7	91.7	7.8	156	10.6	22
5/26/2020	REN-MAR	1.0	21.3	150.0	233.6	8.0	93.3	8.3	152	7.3	
8/5/2020	REN-1	0.3	25.7	343.8	255.9	8.1	98.2	8.0	166	9.1	
8/5/2020	REN-2	1.0	26.1	357.6	253.5	8.8	125.5	10.2	165	8.5	22
8/5/2020	REN-2-5	4.9	25.7	343.0	254.9	8.3	93.9	7.7	166	8.8	
8/5/2020	REN-3	1.1	25.1	318.8	262.5	8.0	86.2	7.1	171	15.7	18
8/5/2020	REN-4	1.1	25.1	338.7	276.3	8.6	117.1	9.7	180	20.2	14
8/5/2020	REN-5	0.5	20.0	415.3	370.6	7.4	59.7	5.4	241	19.8	
8/5/2020	REN-7	0.0	22.1	334.4	320.3	7.5	71.3	6.2	208	37.7	
8/5/2020	REN-8	1.0	25.6	387.6	241.6	7.9	87.8	7.2	157	20.3	12
8/5/2020	REN-MAR	1.2	25.3	306.7	255.0	8.1	86.8	7.1	166	8.4	
11/12/2020	REN-1	1.0	12.9	218.5	258.9	7.9	94.7	10.0	168	5.3	

Date	Location	Depth (m)	Temp (°C)	ORP (mV)	Sp Cond (µS/cm)	pH	ODO (% Sat)	ODO (mg/L)	TDS (mg/L)	Turbidity (FNU)	Secchi (in)
11/12/2020	REN-2	0.9	13.0	259.4	257.8	7.9	91.3	9.6	168	4.7	29
11/12/2020	REN-2-5	6.2	12.7	278.1	258.0	7.8	89.7	9.5	168	5.2	
11/12/2020	REN-3	1.1	14.2	239.4	260.6	8.0	92.9	9.5	169	15.7	16
11/12/2020	REN-4	1.1	13.2	253.5	262.0	8.1	96.3	10.1	170	17.6	16
11/12/2020	REN-5	0.9	9.6	190.3	677.5	7.5	15.4	1.8	440	8.9	
11/12/2020	REN-7	0.3	12.8	148.1	344.3	7.4	48.3	5.1	224	3.3	
11/12/2020	REN-8	1.1	14.5	242.9	242.1	8.0	87.2	8.9	157	14.9	15
11/12/2020	REN-MAR	1.1	12.9	281.2	259.0	7.9	84.1	8.9	168	7.4	

APPENDIX B: LABORATORY DATA