# 2021 Water Quality Report

U.S. Army Corps of Engineers
Saint Louis District

## Wappapello Lake Water Quality Conditions: 1983-2021

December 2022

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Prepared for

United States Army Corps of Engineers
Saint Louis District
1222 Spruce Street
Saint Louis, MO 63103-2833

Prepared by:

Ben Greeling
Environmental Specialist

## 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 USACE 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. The 2020 water quality report compiled by the Missouri Department of Natural Resources (MDNR) has Wappapello Lake listed as impaired for Chlorophyll-a caused by non-point sources.

Water quality sampling in 2021 revealed the following concerns at Wappapello Lake: dissolved oxygen, chlorophyll-a, manganese, and total phosphorus.

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# INTRODUCTION

Wappapello Lake is located on the upper St. Francis River in southeastern Missouri and is primarily utilized as a recreational lake. The dam site lies 22 miles southeast of Greenville, one mile southwest of Wappapello and 16 miles northeast of Poplar Bluff. Lake Wappapello is an 8,400 acre reservoir located in Wayne County, with the southern arms reaching into Butler County. Construction of this lake began in September 1938 and was completed in June 1941. Approximately 71% of Lake Wappapello's 1,310 square mile watershed is forested and 21% is covered by grassland. The surrounding lands are residential with little agricultural use due to the steep terrain.

The St. Francis River begins its journey in Iron County, Missouri in an area that separates the Black, Big, and St. Francis River drainages. The river flows northeasterly then winds south through the Ozark foothills to Wappapello Lake and continues its course through southeastern Missouri and Arkansas, emptying into the Mississippi River north of Helena, Arkansas. Of the 225 miles of the river in Missouri, most runs through hilly terrain. The lower river then winds through the lowlands of the Bootheel and on through Arkansas.

Nestled in the foothills of the Ozark Mountains, Wappapello Lake offers activities for all walks of life. Over 44,000 acres of public lands and water welcome hunting, fishing, swimming, boating, camping, and picnicking. Interpretation of the natural resources through trails, visitor center exhibits, and various programs highlight the natural beauty found in Southeast Missouri.

Wappapello Lake's authorized purposes are to provide flood risk reduction management for the St. Francis River and its tributaries and to provide and manage recreation and fish and wildlife conservation on project lands and waters. The area around the lake has camping sites and nature trails. Wappapello Lake is managed by the St. Louis District but is an integral part of the Memphis District's St. Francis Basin Project, which manages the St. Francis and Little St. Francis Rivers through a combination of a reservoir, levees, a pumping station, channel improvements and interior drainage. Although flood risk reduction management is the primary authorized purpose, the lake has become a major regional recreation resource. Lands have also been out granted to the MDNR for operation of Lake Wappapello State Park. The Missouri Department of Conservation (MDC) leases additional lands to manage for a third authorized purpose, fish and wildlife conservation.

Water quality is of paramount importance for sustaining ecological integrity and services provided by Wappapello 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 water quality management program for the reservoir includes monitoring baseline parameters and ecological trends as well as investigating problem areas to ensure that federal and state regulations are met.

The Saint Louis District of the United States Army Corps of Engineers has implemented a Water Quality Management Plan (WQMP) as part of the operation and maintenance activities associated with managing USACE civil works projects throughout the District which includes, among other reservoirs and rivers, the Wappapello Lake and watershed. 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 Wappapello Lake. The report describes conditions observed in 2021, as well as baseline data collected from 1983-2020. Additional historical data are available upon request.

## WAPPAPELLO LAKE WQMP COVERAGE

The WQMP for Wappapello Lake includes water samples taken at the following locations: major tributary (WAP-7), main body of the lake (WAP-6, WAP-5, WAP-2, Chaonia Landing Marina, Lost Creek Marina, Sundowner Marina, and Lakeside/Barretts Marina), and just downstream of the dam (WAP-1). See figures 1 and 2, and Table 1 for a site map and site coordinates.

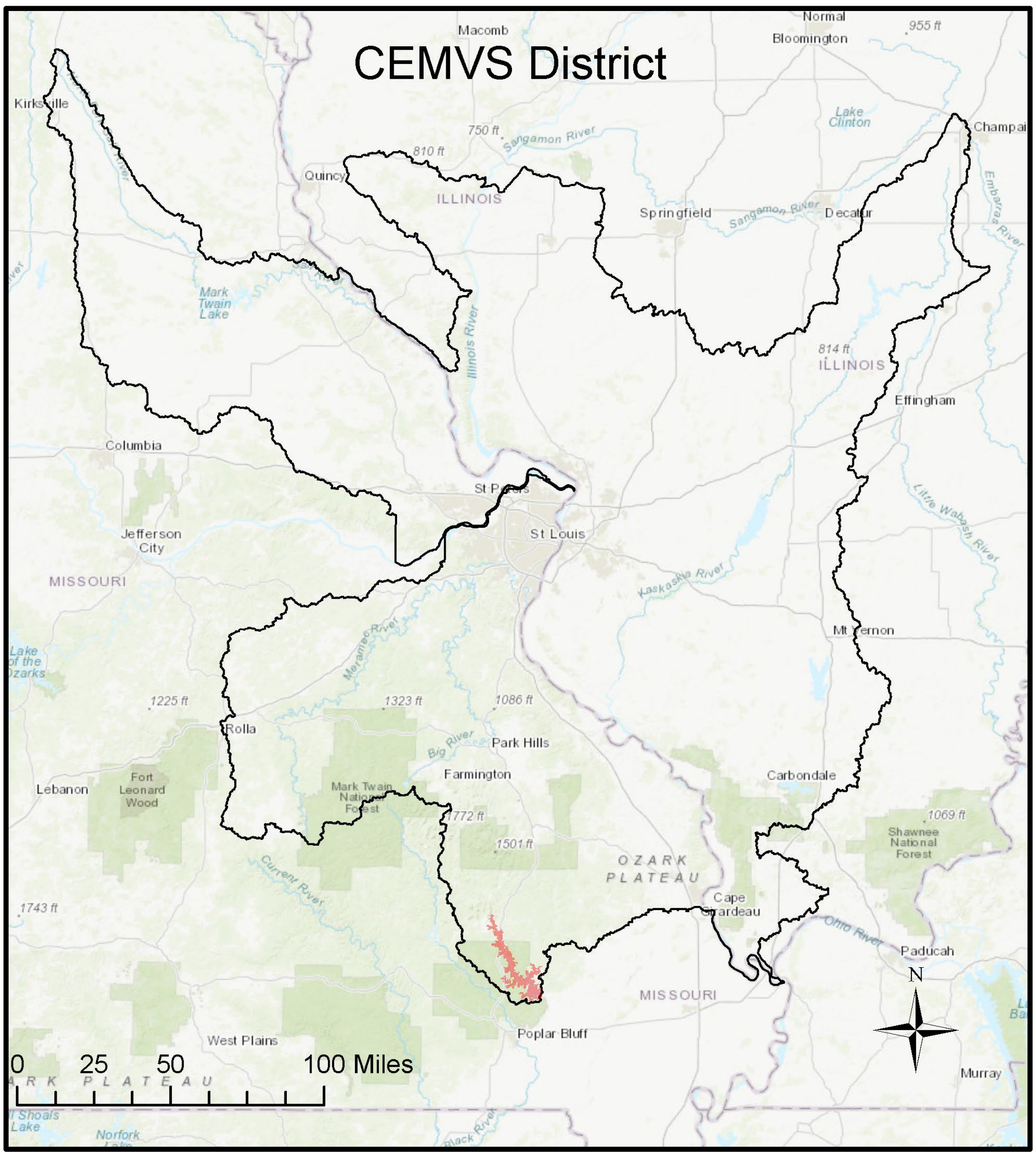



**Figure 1. CEMVS District and Wappapello Lake**

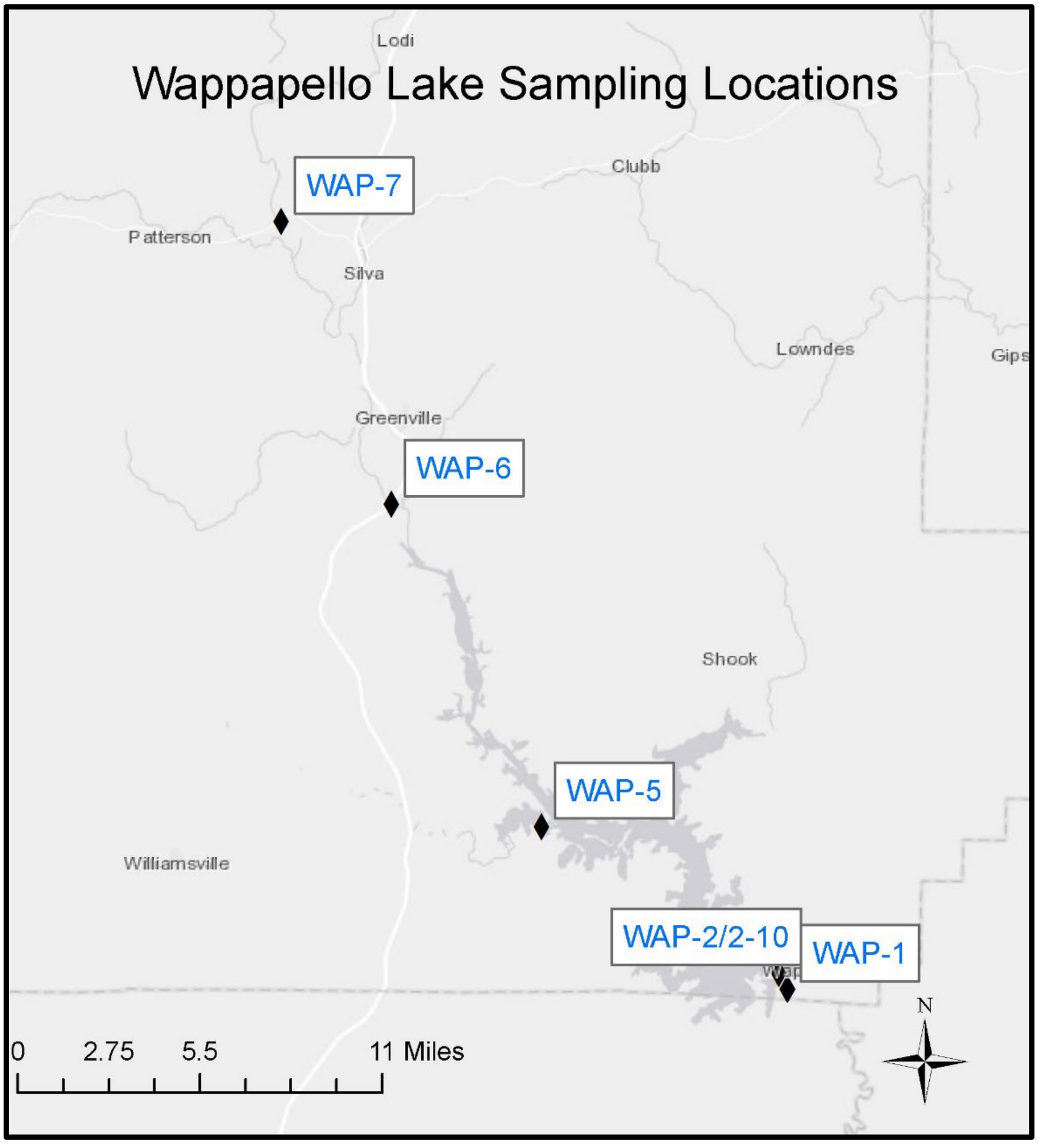



**Figure 2. Water Quality (WQ) Sampling Locations in 2021 at Wappapello Lake**

## 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 | WAP-7 | 37.194363 | -90.502689 |
| Main Reservoir Surface | RS | WAP-6 | 37.095997 | -90.454627 |
| | RS | WAP-5 | 36.983761 | -90.389062 |
| | RS | WAP-2 | 36.932670 | -90.285493 |
| | RS | WAP-BAR | 36.925789 | -90.290833 |
| | RS | WAP-CL | 36.973408 | -90.358743 |
| | RS | WAP-LC | 36.999247 | -90.337950 |
| | RS | WAP-SUN | 36.942487 | -90.276351 |
| Reservoir Benthic | RB | WAP-2-10 | 36.932670 | -90.285493 |
| Tail Race (below main dam) | TR | WAP-1 | 36.927171 | -90.281812 |

Samples at Marinas are not always taken in the exact same location. WAP-BAR Marina was renamed Lakeside Marina in 2021.

# METHODS AND ANALYSIS: WATER QUALITY

## Data Collection and Historical Reference Data

During 2021, water quality samples were collected and analyzed for 10 locations during two separate sampling events (n=20; Table 1). One duplicate sample was collected during the second sampling event for quality control purposes. 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 previous years ranging as far back as 1983 (parameter dependent). Historical reference data are intended to represent the current condition of Wappapello Lake.

## Statistical Summary and Comparison to Applicable Water Quality Standards

Statistical analyses were performed on water quality monitoring data collected for 10 locations, and classified as TRIB (n= 1), RS (n=7), RB (n=1), and TR (n=1). Descriptive statistics were calculated to describe central tendencies and boxplots created to illustrate comparisons between groups. 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.

Internal checks are also used for field sampling. This includes 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 $20^oC$. The temperature standard in Missouri is less than a rise of 2.77°C above normal seasonal temperature or less than 32.22°C.

**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.

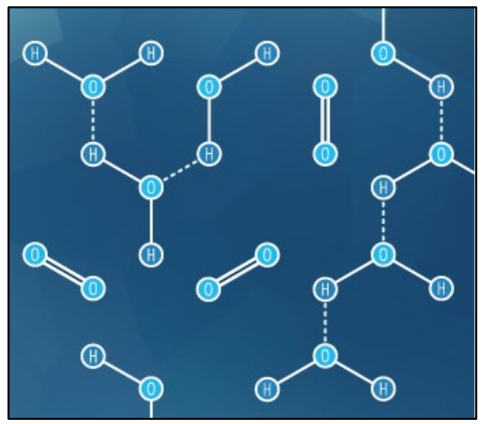


***Figure 1: Dissolved oxygen ($O_2$) vs oxygen bonded in water ($H_2O$).***

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 Missouri 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 acid 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 Missouri 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 (microsiemens per centimeter) 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. Missouri does not currently have a standard criterion for 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.

**Pesticides** 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, are 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.

**Nitrogen** 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. Missouri has set the standard 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.

**Total Ammonia Nitrogen (TAN)** 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 regard 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).

**Total Phosphorus (TP)** 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 (algae 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:

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

*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 |
| 40-60 | Mesotrophic |
| 60-70 | Eutrophic |
| 70-100 | Hypereutrophic |

## Laboratory Methods and Water Quality Criteria Summary Table

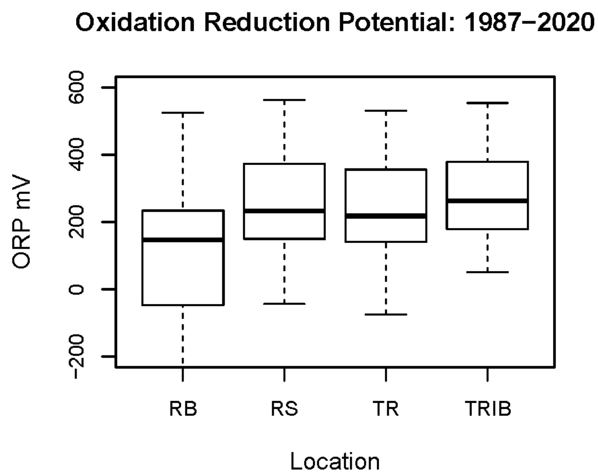
**Table 2: Metrics, Methods, and Water Quality Criteria Used for Evaluating Water Quality**

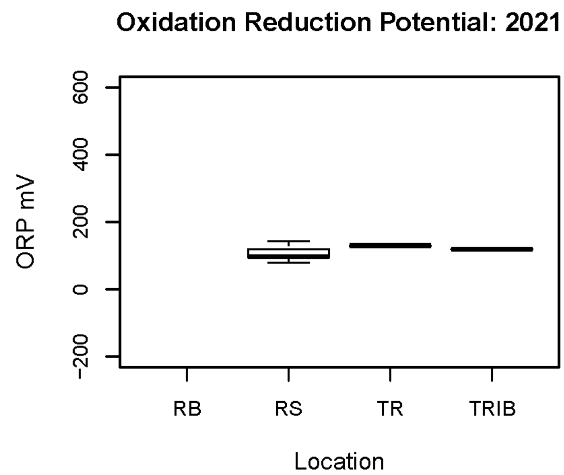
| Metric | Abbreviation | Analysis Method | Water Quality Criteria | Source |
|---|---|---|---|---|
| Alachlor | | EPA Method 8270C | < 2ug/L DWS | Missouri DNR |
| Ammonia Nitrogen | $NH_3$ | EPA Method 350.1 | pH & temp dependent | Missouri DNR |
| Atrazine | Atrazine | EPA Method 8270C | 3 ug/L DWS | Missouri DNR |
| Bacteria: E. Coliform | E Col | EPA Method 1604 | WBC-A: 126, WBC-B: 206, SCR: <1,134 cfu/100mL, DSB: 190 mpn/100ml (geometric mean) | Missouri DNR |
| Chlorophyll a (1) | Chl_a | SM Method 10200H | Criteria: <15 ug/L, or screening value: <6 ug/L with any other eutrophication impacts | Missouri DNR |
| Chlorophyll a (2) | Chl_a | SM Method 10200H | < 25mg/cm³ (Eutrophic Upper Limit) | Carlson 1977 |
| Chlorpyrifos | | EPA Method 8270C | < .041 ug/L: chronic or 0.083: acute aquatic life, 20 ug/L DWS | Missouri DNR |
| | | | | |
| Depth | Depth | Multiparameter Meter | Measurements reported at ~1 meter | ----- |
| Dissolved Oxygen | DO | Multiparameter Meter | Greater than 5.0mg/L | Missouri DNR |
| Metolachlor | | EPA Method 8270C | 70 ug/L DWS | Missouri DNR |
| Metribuzin | | EPA Method 8270C | 100 ug/L DWS | Missouri DNR |
| Nitrate as Nitrogen | $NO_3$ | Green Method | < 10 mg/L | Missouri DNR |
| Non-Volatile Suspended Solids | NVSS | TSS - VSS | ----- | ----- |
| Orthophosphate | Ortho | EPA Method 365.2 | ----- | ----- |
| Pheophytin a | Phpy_a | SM Method 10200H | ----- | ----- |
| Potential of Hydrogen | pH | Multiparameter Meter | Range: 6.5 – 9.0pH 4-day average | Missouri DNR |
| Secchi Disk | SD | ----- | 1.093 meters | USEPA* |
| Specific Conductivity | SpCond | Multiparameter Meter | 500 uS/cm | ----- |
| Temperature | Temp | Multiparameter Meter | Less than rise of 2.77…°C above normal seasonal temp. or above 32.22…°C | Missouri DNR |
| Total Dissolved Solids | TDS | Multiparameter Meter | <250 mg/L | USEPA* |

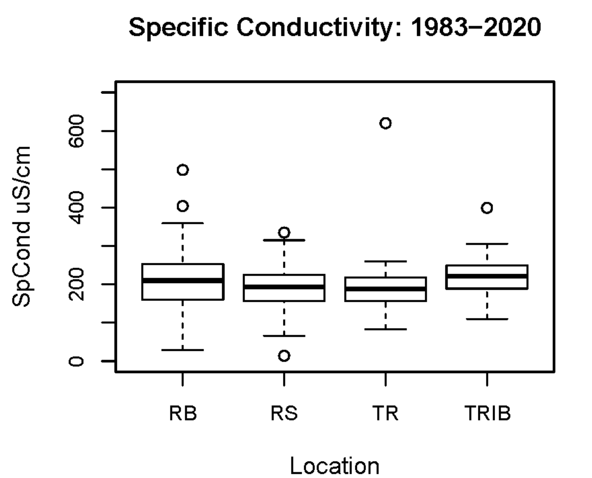
| Metric | Abbreviation | Analysis Method | Water Quality Criteria | Source |
|---|---|---|---|---|
| Total Manganese | TMn | EPA Method 6010C | < 0.05 mg/L | Missouri DNR |
| Total Organic Carbon | TOC | EPA Method 415.1 | ----- | ----- |
| Total Iron | TFe | EPA Method 6010C | < 1 mg/L | Missouri DNR |
| Total Phosphorus | TP | EPA Method 365.2 | Screening value: <0.016 mg/L, with any other eutrophication impacts | Missouri DNR |
| Trifluralin | | EPA Method 8270C | < 5 ug/L: DWS | Missouri DNR |
| Turbidity | Turb | Multiparameter Meter | ----- | ----- |
| Volatile Suspended Solids | VSS | EPA Method 160.4 | ----- | ----- |

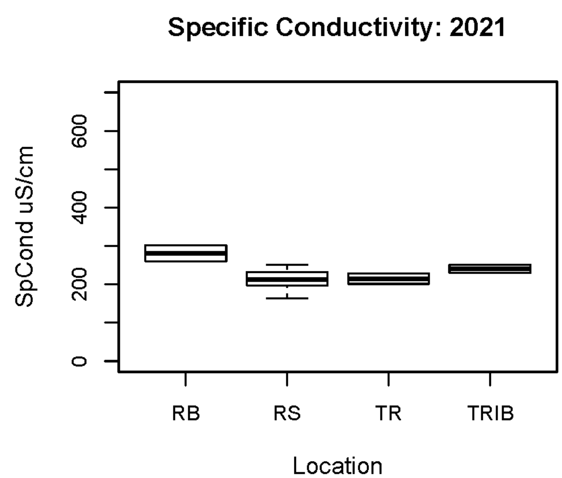
**1 mg/L is equivalent to 1 drop in two bathtubs and 1 ug/L is equivalent to 1 drop in an Olympic size swimming pool. PWS is public water supply. DWS is drinking water standard. WBC is whole body contact recreation (WBC-A is designated swimming, WBC-B recreation). SCR is secondary contact recreation. DSB is designated swimming beach. The DSB advisory of 190 MPN/100 mL is the level MDNR will post signs notifying visitors that swimming is not recommended. USEPA* refers to the Federal EPA reference nutrient conditions for level III ecoregion 72 lakes and rivers.*

# RESULTS AND SUMMARY STATISTICS:  WATER QUALITY



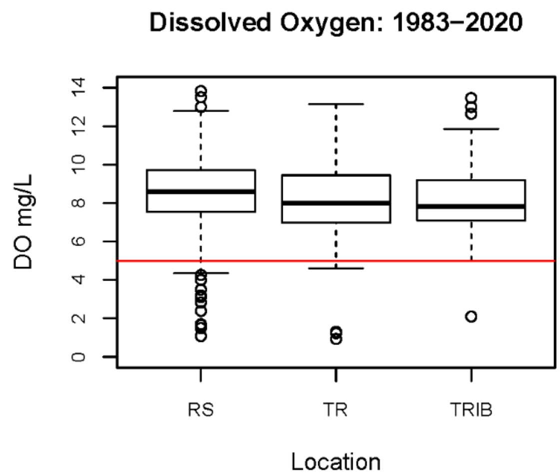



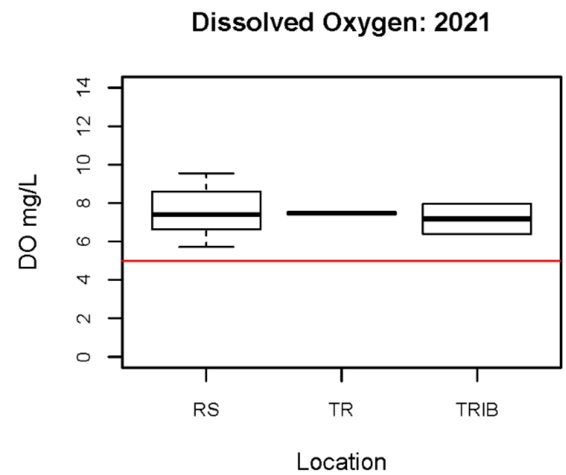



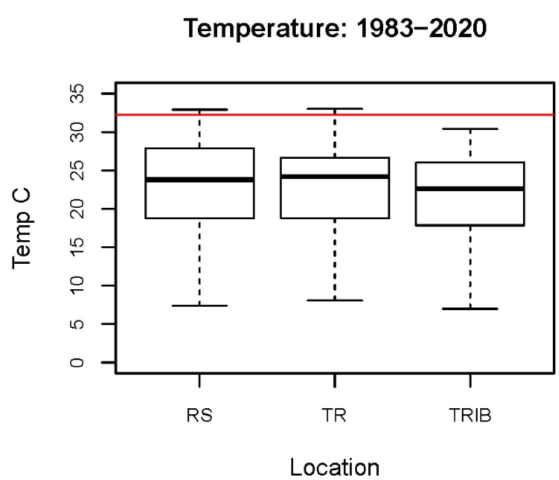



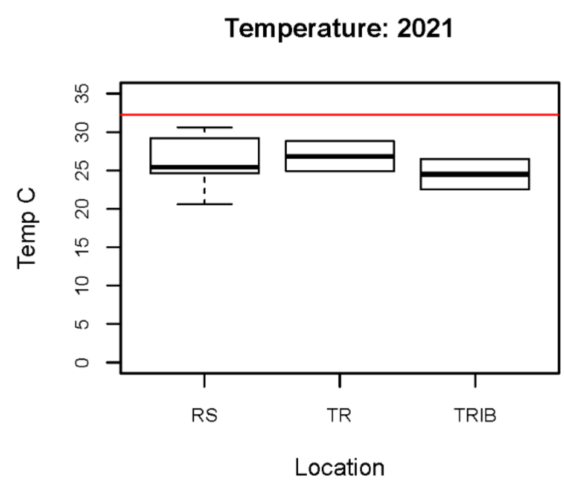

| | Historical Reference 1983-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| ORP | RB | 108.1 | 146.5 | 156 | ---- | ---- | 1 |
| | RS | 256.1 | 233.0 | 399 | 106.3 | 96.5 | 7 |
| | TR | 246.0 | 218.0 | 108 | ---- | ---- | 1 |
| | TRIB | 284.3 | 263.0 | 108 | ---- | ---- | 1 |
| SpCond | RB | 211.7 | 210.0 | 207 | 281.5 | 281.5 | 2 |
| | RS | 189.7 | 193.0 | 481 | 212.9 | 213.2 | 14 |
| | TR | 186.1 | 188.0 | 125 | 214.5 | 214.5 | 2 |
| | TRIB | 218.8 | 221.8 | 125 | 240.4 | 240.4 | 2 |

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



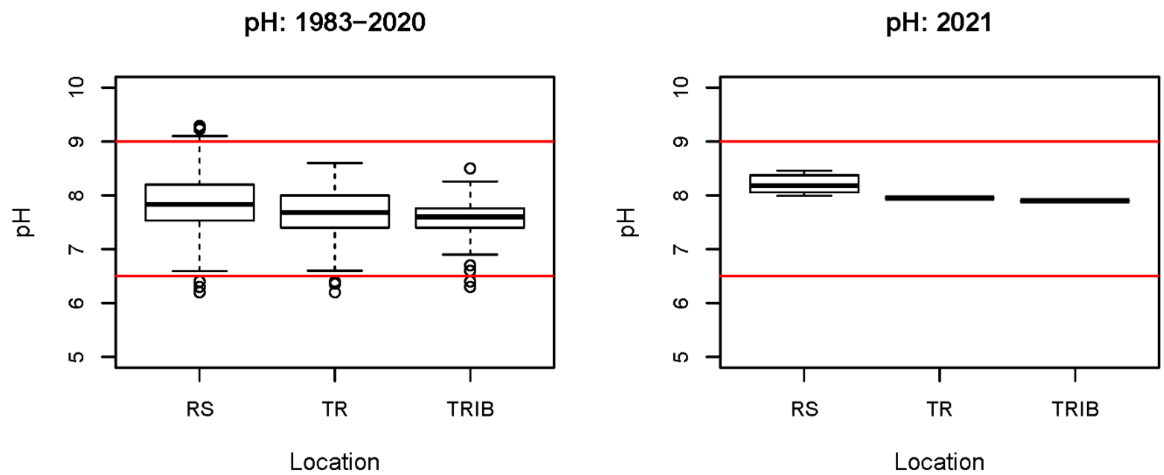




*Red line placed at the 5 mg/L level for DO and 32.22 C for temperature.*

| | Historical Reference 1983-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| DO | RS | 8.5 | 8.6 | 466 | 7.6 | 7.4 | 14 |
| | TR | 8.2 | 8.0 | 123 | 7.5 | 7.5 | 2 |
| | TRIB | 8.2 | 7.8 | 121 | 7.2 | 7.2 | 2 |
| Temp | RS | 22.8 | 23.8 | 482 | 26.5 | 25.5 | 14 |
| | TR | 22.3 | 24.2 | 128 | 26.9 | 26.9 | 2 |
| | TRIB | 21.3 | 22.6 | 127 | 24.5 | 24.5 | 2 |

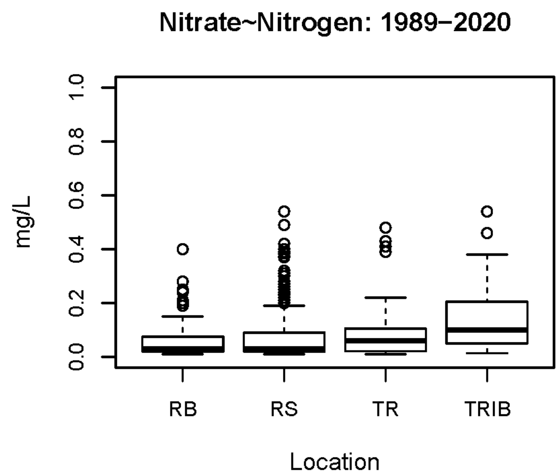
** Neither DO or temperature standard was exceeded in 2021.*

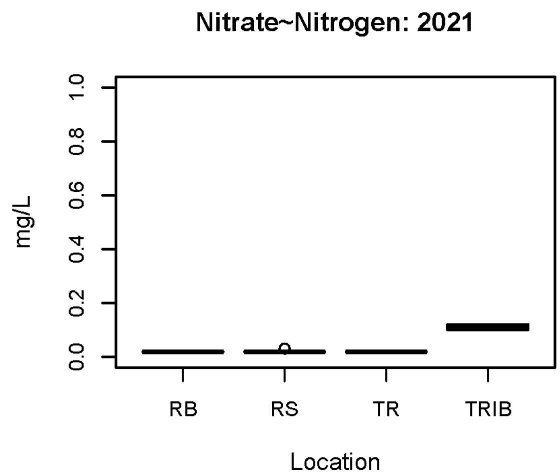


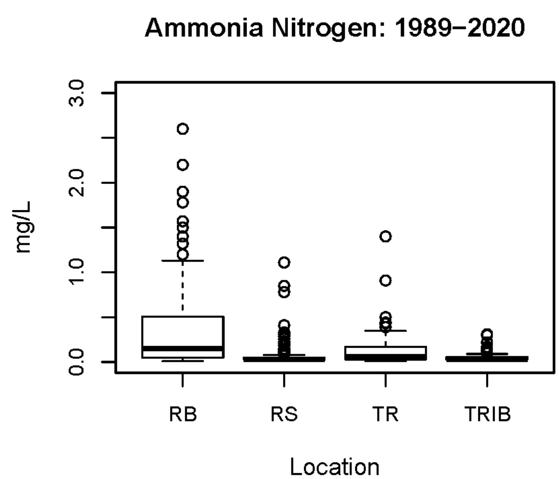

**Red lines indicate the upper and lower water quality criteria standards (between 6.5 and 9).*

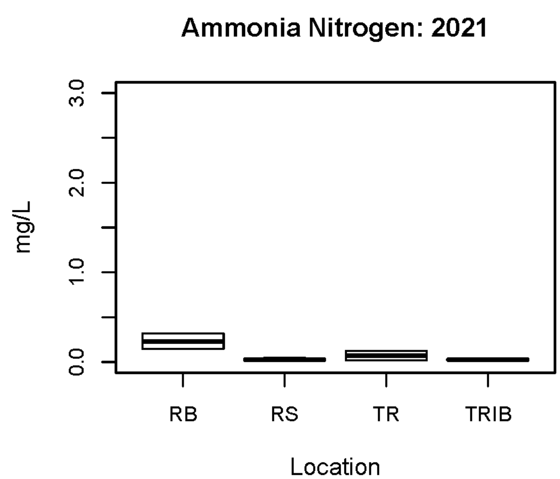
| | **Historical Reference 1984-2020** | | | | **2021** | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| pH | RS | 7.9 | 7.8 | 478 | 8.2 | 8.2 | 7 |
| | TR | 7.6 | 7.7 | 126 | ---- | ---- | 1 |
| | TRIB | 7.6 | 7.6 | 125 | ---- | ---- | 1 |

**All pH readings were within the water quality standard during 2021.*



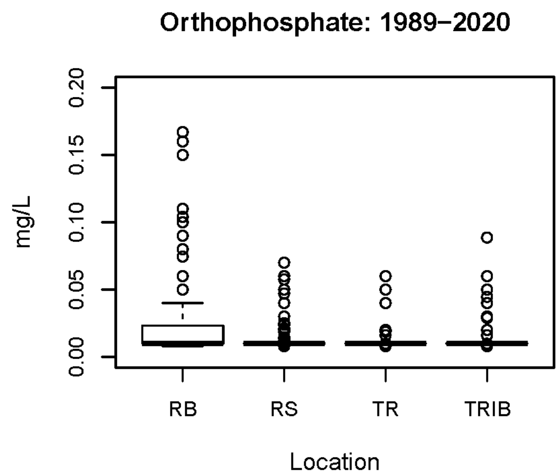



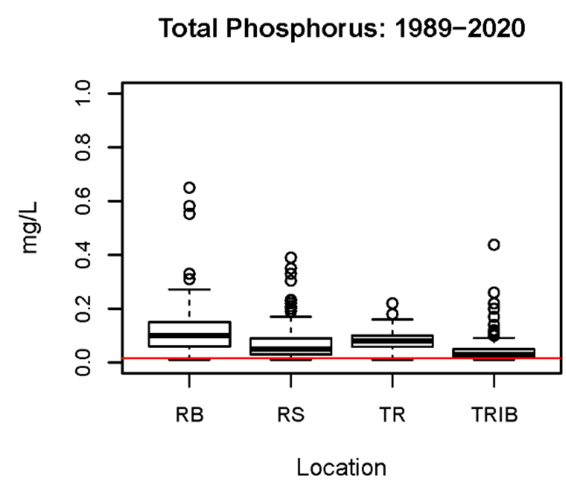



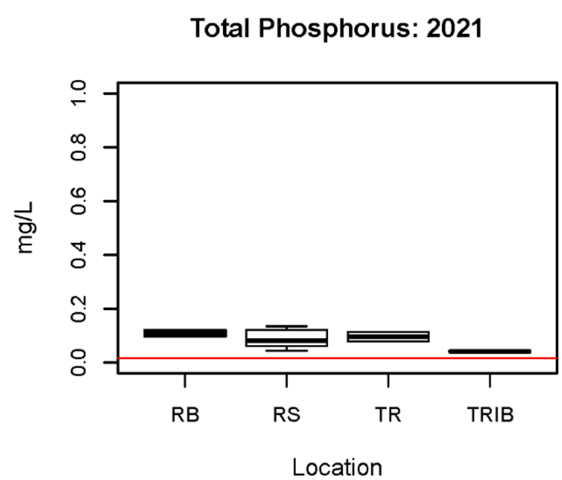




| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| NO3-N | RB | 0.06 | 0.03 | 103 | 0.02 | 0.02 | 2 |
| | RS | 0.08 | 0.03 | 319 | 0.02 | 0.02 | 6 |
| | TR | 0.08 | 0.06 | 108 | 0.02 | 0.02 | 2 |
| | TRIB | 0.14 | 0.10 | 108 | 0.11 | 0.11 | 2 |
| NH3N | RB | 0.41 | 0.15 | 107 | 0.23 | 0.23 | 2 |
| | RS | 0.06 | 0.03 | 313 | 0.03 | 0.03 | 6 |
| | TR | 0.13 | 0.06 | 108 | 0.07 | 0.07 | 2 |
| | TRIB | 0.05 | 0.03 | 105 | 0.03 | 0.03 | 2 |

**All observations of nitrate and ammonia nitrogen were within the water quality standard during 2021.*



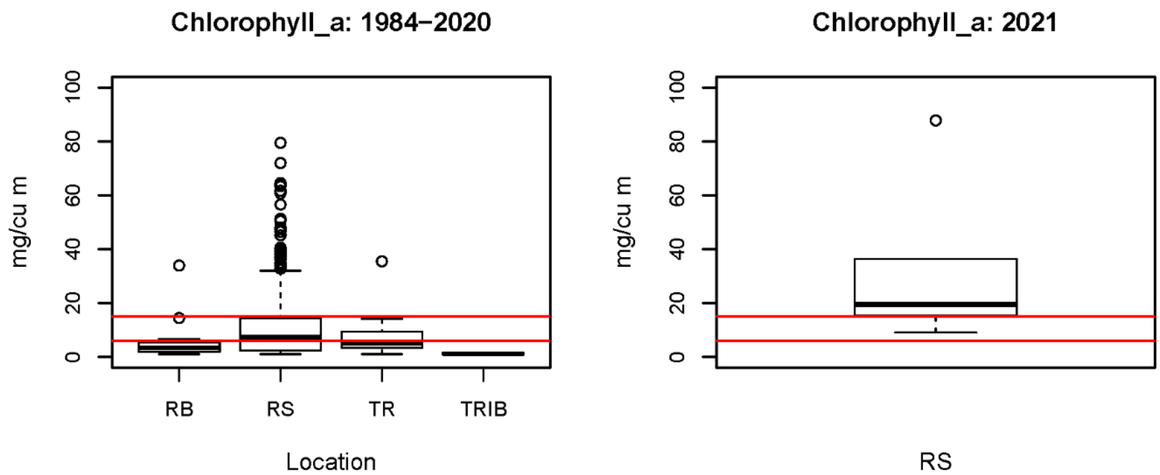




**Red line indicates the TP water quality screening value of 0.016 mg/L.*

| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| PO4 | RB | 0.03 | 0.01 | 107 | ---- | ---- | ---- |
| | RS | 0.01 | 0.01 | 312 | ---- | ---- | ---- |
| | TR | 0.01 | 0.01 | 106 | ---- | ---- | ---- |
| | TRIB | 0.02 | 0.01 | 104 | ---- | ---- | ---- |
| TP | RB | 0.13 | 0.10 | 108 | 0.11 | 0.11 | 2 |
| | RS | 0.07 | 0.05 | 322 | 0.09 | 0.08 | 6 |
| | TR | 0.08 | 0.08 | 111 | 0.10 | 0.10 | 2 |
| | TRIB | 0.05 | 0.03 | 109 | 0.04 | 0.04 | 2 |

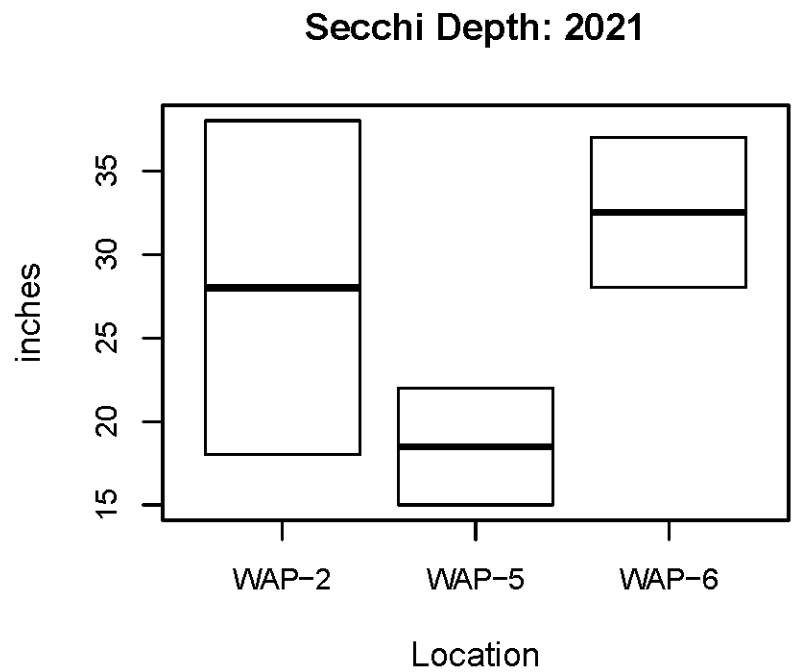
**TP exceeded the screening value of 0.016 mg/L at all locations. On the historical TP plot one outlier (1.5 mg/L) is not visible. This study does not acknowledge a water quality standard for PO4. PO4 was not sampled in 2021.*

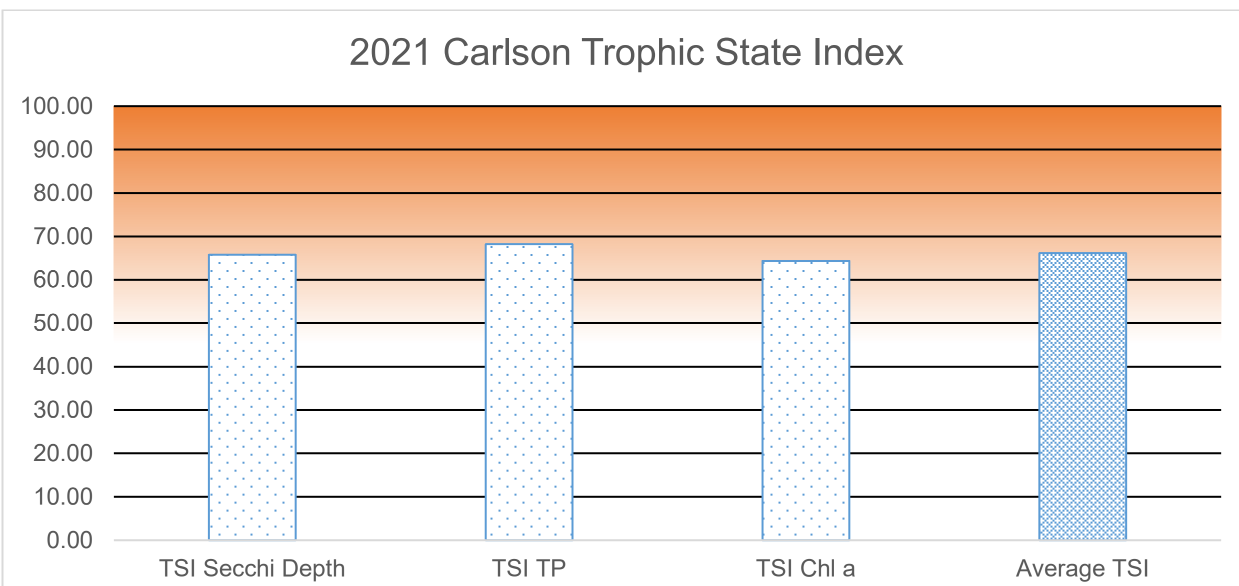



**Red lines indicate the screening value of 6 and criterion of 15 mg/cu m.*

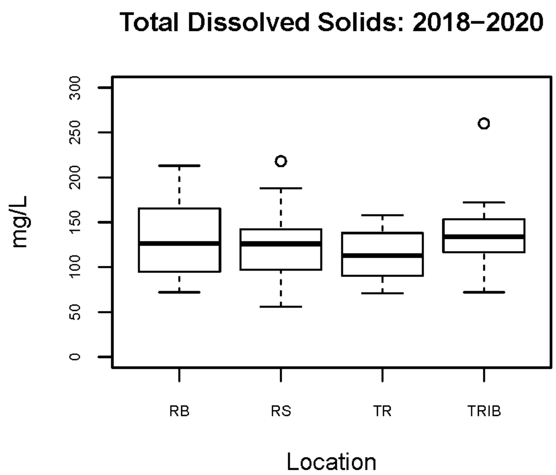
| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| Chl_a | RB | 6.77 | 3.30 | 11 | ---- | ---- | ---- |
| | RS | 11.39 | 7.30 | 381 | 31.27 | 19.50 | 6 |
| | TR | 8.86 | 5.25 | 10 | ---- | ---- | ---- |
| | TRIB | 1.25 | 1.15 | 4 | ---- | ---- | ---- |

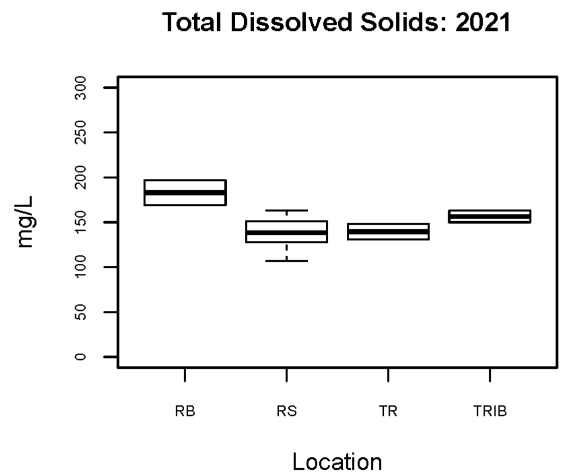
**The CHL_a criterion (15 mg/cu m) was exceeded for all observations except one in 2021 while the screening value (6 mg/cu m) was exceeded for all observations. Since 2014, chlorophyll-a samples have only been taken from the lake surface.*

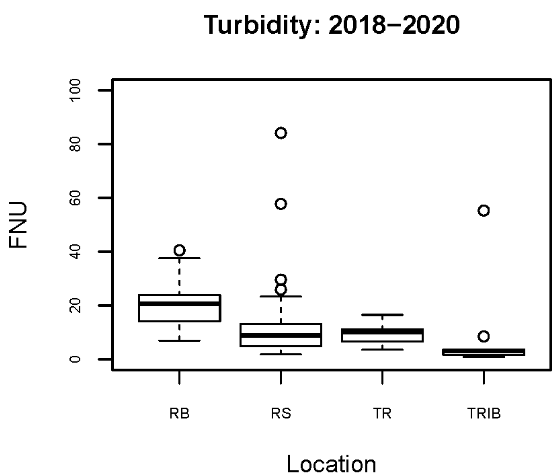


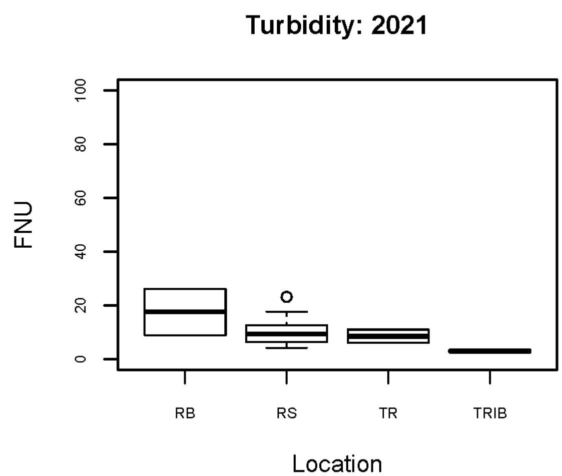




*<40 = Oligotrophic __ 40-60 = Mesotrophic __ 60-70 = Eutrophic __ >70 Hypereutrophic*



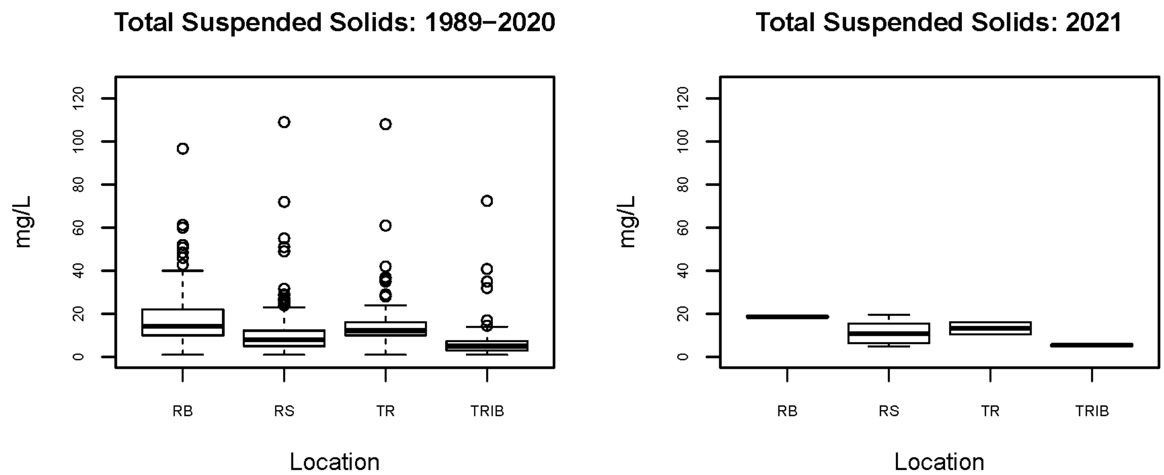



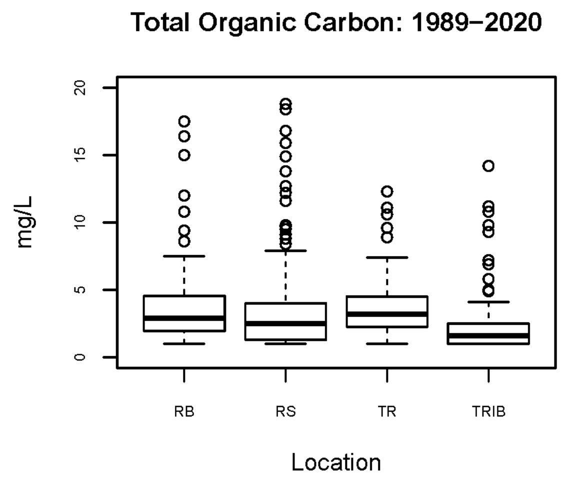

| | **Historical Reference 2018-2020** | | | | **2021** | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| TDS | RB | 133.17 | 126.50 | 12 | 183.00 | 183.00 | 2 |
| | RS | 122.11 | 126.00 | 74 | 138.29 | 138.50 | 14 |
| | TR | 114.75 | 113.00 | 12 | 139.50 | 139.50 | 2 |
| | TRIB | 141.08 | 134.00 | 12 | 156.50 | 156.50 | 2 |
| FNU | RB | 20.88 | 20.58 | 12 | 17.54 | 17.54 | 2 |
| | RS | 11.38 | 8.95 | 73 | 10.26 | 9.30 | 14 |
| | TR | 9.40 | 10.22 | 12 | 8.53 | 8.53 | 2 |
| | TRIB | 7.39 | 3.17 | 12 | 3.03 | 3.03 | 2 |

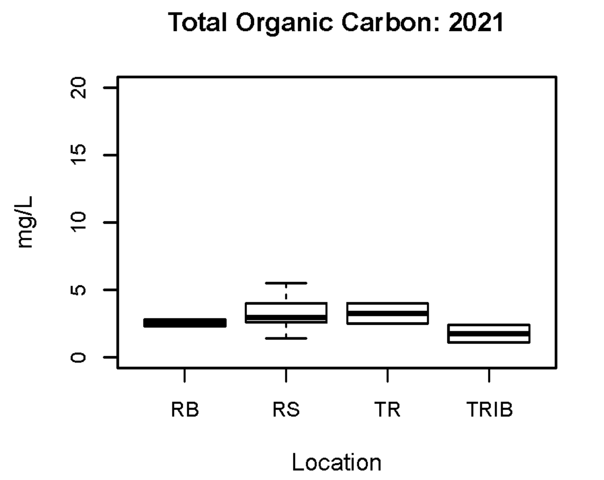
* *All TDS observations were below the reference standard in 2021. This study does not recognize a standard for turbidity.*




| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| TSS | RB | 21.66 | 14.20 | 101 | 18.60 | 18.60 | 2 |
| | RS | 10.67 | 8.00 | 322 | 11.35 | 10.85 | 6 |
| | TR | 14.84 | 12.15 | 110 | 13.20 | 13.20 | 2 |
| | TRIB | 6.78 | 5.00 | 106 | 5.40 | 5.40 | 2 |

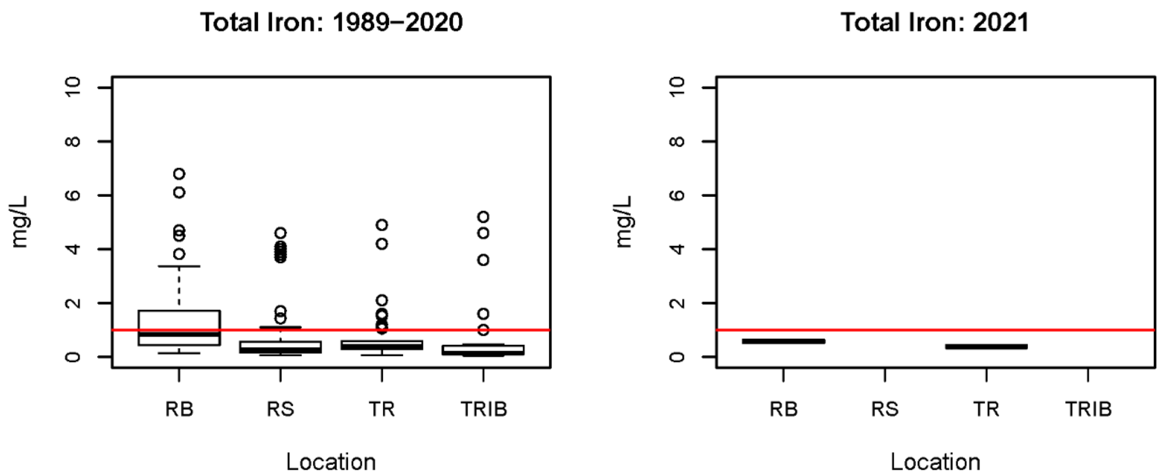
** This study does not recognize a standard for TSS.*



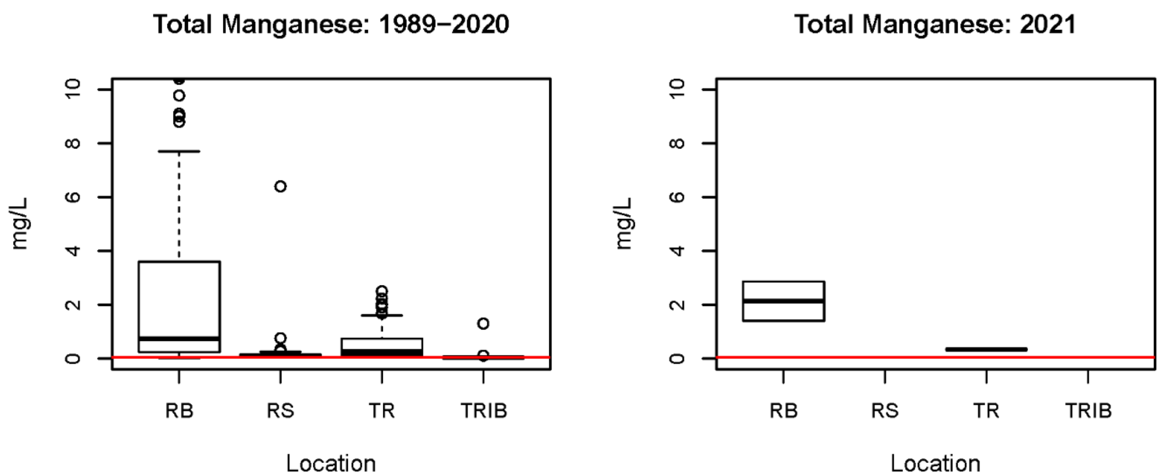




| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| TOC | RB | 3.65 | 2.90 | 108 | 2.55 | 2.55 | 2 |
| | RS | 3.23 | 2.50 | 322 | 3.23 | 2.95 | 6 |
| | TR | 3.62 | 3.20 | 111 | 3.25 | 3.25 | 2 |
| | TRIB | 2.37 | 1.60 | 109 | 1.75 | 1.75 | 2 |

**This study does not recognize a standard for TOC.*



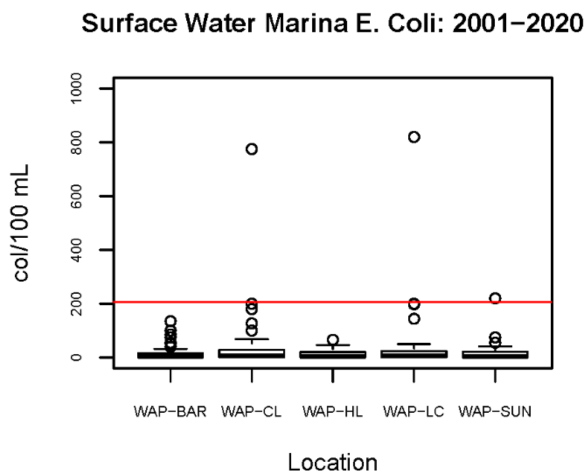

*Red line indicates the water quality standard of  1 mg/L.*

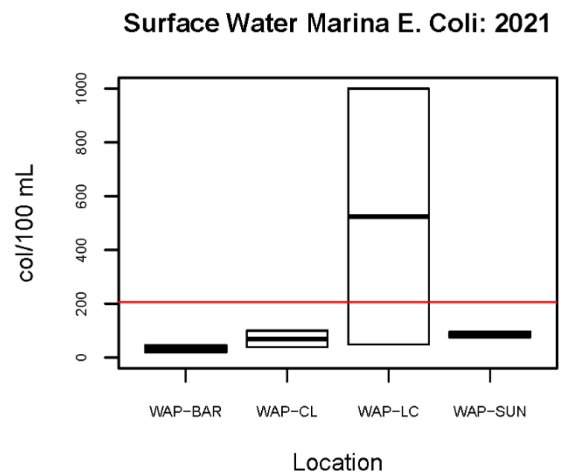



*Red line indicates the standard for manganese of 0.05 mg/L.*

| | Historical Reference 1984-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| TFe | RB | 1.31 | 0.84 | 106 | 0.57 | 0.57 | 2 |
| | RS | 0.63 | 0.27 | 119 | ---- | ---- | ---- |
| | TR | 0.56 | 0.39 | 110 | 0.38 | 0.38 | 2 |
| | TRIB | 0.54 | 0.14 | 42 | ---- | ---- | ---- |
| TMn | RB | 2.36 | 0.73 | 106 | 2.14 | 2.14 | 2 |
| | RS | 0.17 | 0.10 | 108 | ---- | ---- | ---- |
| | TR | 0.50 | 0.26 | 107 | 0.33 | 0.33 | 2 |
| | TRIB | 0.07 | 0.03 | 39 | ---- | ---- | ---- |

*In 2021 the Fe standard was not exceeded while Manganese exceeded the standard of 0.05 mg/L at every sampling event in front of the dam and in the discharge.*




**Whole body contact recreation standard is geometric mean of <206 cfu/100mL. Secondary body contact recreation standard is geometric mean of <1,134 cfu/100mL.*

| | Historical Reference 2001-2020 | | | | 2021 | | |
|---|---|---|---|---|---|---|---|
| | Location | Mean | Median | n | Mean | Median | n |
| E col | WAP-BAR | 15.87 | 4.00 | 53 | 32.50 | 32.50 | 2 |
| | WAP-CL | 39.31 | 6.50 | 52 | 69.50 | 69.50 | 2 |
| | WAP-HL | 13.22 | 4.00 | 18 | ---- | ---- | |
| | WAP-LC | 35.75 | 6.00 | 53 | 524.00 | 524.00 | 2 |
| | WAP-SUN | 15.83 | 4.00 | 52 | 85.50 | 85.50 | 2 |

**One single sample at LC Marina (1000 cfu/100mL) was greater than WBC 206 cfu/10mL, but the SCR standard was not exceeded. All other Marina bacteria levels did not exceed the water quality standard in 2021.*

**2021 Wappapello Lake Swimming Beach Bacteria Levels (E. Coli CFU/ 100 mL)**

| Date | Rockwood | Redman | Peoples |
|---|---|---|---|
| 4/18/2021 | <1 | N/A | 2 |
| 4/19/2021 | N/A | <1 | N/A |
| 4/26/2021 | 1 | 21.6 | 1 |
| 5/3/2021 | 2 | N/A | N/A |
| 5/17/2021 | 1 | 1 | 1 |
| 5/24/2021 | <1 | <1 | <1 |
| 6/1/2021 | 4.1 | 2 | <1 |
| 6/7/2021 | <1 | 4.1 | 6.3 |
| 6/14/2021 | <1 | 1 | 2 |
| 6/21/2021 | 1 | 2 | 1 |
| 6/28/2021 | <1 | 1 | <1 |
| 7/6/2021 | 2 | 3 | 3 |
| 7/12/2021 | 3 | 3.1 | <1 |
| 7/19/2021 | 18.5 | 18.9 | 16 |
| 7/26/2021 | <1 | <1 | <1 |
| 8/2/2021 | 6.3 | 5.2 | 5.2 |
| 8/9/2021 | 7.5 | 10.8 | 13.2 |
| 8/16/2021 | <1 | <1 | 2 |
| 8/23/2021 | 9.7 | 8.6 | 12 |
| 8/30/2021 | 2 | <1 | 4.1 |
| 9/7/2021 | 17.1 | 6.3 | 18.7 |
| 9/13/2021 | 1 | 3 | <1 |
| 9/20/2021 | 13.5 | 10.9 | 12 |

**Beach bacteria levels did not exceed the swimming advisory or standards during 2021.*

# 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 2021 did not deviate far from conditions observed during the reference period (1983-2020); nevertheless, concerns regarding DO, Mn, CHL-a, and TP were evident. In addition, estimated TSI levels were indicative of a eutrophic system.

During the two sampling events in 2021, DO was recorded below 1 mg/L one time in June at site WAP-5 located in the Otter Creek arm. At a shallower depth of 0.04 meters the DO was recorded at 6.17 mg/L. All other surface water observations for DO were above 5 mg/L. A review of historical DO data at WAP-5 revealed that 7.1% of measurements were less than the standard of 5 mg/L. The historical DO at the other two lake sites WAP-6 and WAP-2 had fewer observations below the standard (0.82% and 1.5% respectively). WAP-5 is located in a narrow back water shallow area that is sheltered by a ridge to the southwest. During the warmer months it is not abnormal for the epilimnion layer to be very shallow in these locations as there is not much wind-induced mixing.

Living organisms require trace amounts of metals, but excessive levels can be harmful. TMn in 2021 exceeded the standard of 0.05 mg/L above and below the dam. Mean 2021 TMn levels were comparable to historical levels. Historically, Mn has exceeded the standard in 84.7% of observations. 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. Future monitoring is imperative to document potential trends.

In December of 2018 MDNR published revised numeric criteria for CHL_a as well as screening values for TN and TP for four ecoregions (10 CSR 20-7.031(5)(N)). Wappapello Lake falls in the Ozark Highland ecoregion. Prior to 2018 the old standard of 0.05 mg/L for TP was exceeded often (33.3% of observations). The new screening value for TP at Wappapello Lake of 0.016 mg/L was exceeded in 62.5% of observations during the period 2019-2021. In 2021, the TP screening value was exceeded at all sites with a mean across all sites of 0.084 mg/L. The historical mean across all sites is 0.078 mg/L. With respect to the TP historical mean comparisons across the sample locations, RB was the greatest, followed by TR, then RS and TRIB. The 2021 data displayed similar distribution. TN was not analyzed for or calculated in 2021. 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.

The CHL_a screening value of 6 ug/L was exceeded at all sites while the criterion of 15 ug/L was exceeded at all lakes sites at least once. The 2021 surface mean CHL_a level (31.27 ug/L) was significantly greater than the historical surface mean (11.39 ug/L). The 2021 samples were taken in June and September which would bias the Chl_a levels somewhat high in comparison due to more algal activity in the warmer seasons. The historical data includes a significant number of samples being taken in the fall and winter months. However, MDNR nutrient screening threshold criteria apply to the period of May through September. Therefore, the 2021 observations are relevant. Chl_a is an indicator of the abundance of phytoplankton. Any water environment with a level recorded above 25 ug/L is considered to be eutrophic (nutrient enrichment increases algal and plant growth and negative effects). The 2021 TSI level, an average of the individual trophic state indexes for secchi depth, CHL_a, and TP, for Wappapello Lake was 66.11. Wappapello Lake is considered 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 over time.

Given the 2020 listing of Wappapello Lake as impaired for CHL_a (MDNR, 2020), USACE conducted a thorough investigation in early 2021 using annual water quality monitoring data collected from 1990 – 2019. The primary objectives for the investigation were to 1) Verify the MDNR 303d listing for Wappapello Lake using data collected by CEMVS, 2) Determine the current trophic status of Wappapello Lake, 3) Identify trends or patterns to determine if trophic conditions are stable or escalating, 4) identify management implications that may evolve, and 5) Develop recommendations for improving conditions at Wappapello Lake. The conclusions of that study were as follows. The listing of Wappapello Lake as an impaired waterbody was appropriate. Water quality data collected by USACE indicated that ~50% of observations made near the reservoir outflow (WAP-2) exceeded the state criteria during summer and fall. Further, CHL-a levels are trending upward at locations throughout the lake. Prior to 2010 no measurement of CHL_a had exceeded the current criteria near the inflow site (WAP-6), however from 2010-2019, 22% of measurements exceeded the criteria. Phosphorus levels were historically excessive for all sites and exceeded Missouri’s OHR screening levels in more than 85% of observations. The results of this assessment indicates that Wappapello Lake is currently a eutrophic system which is atypical for the region. TSS and TP are trending upward near the reservoir’s tributaries. If these trends continue, there is increased potential for the reservoirs trophic status to shift to Hypereutrophic. In general, pH values observed in this study were within the bounds of the state standard. However, pH values appear to be on the rise, which may also be linked to the reservoirs increasing CHL_a concentrations (Schepker, 2021).

# MONITORING PROGRAM RECOMMENDATIONS

The 2020 water quality report compiled by the Missouri Department of Natural Resources (MDNR) has listed Wappapello Lake impaired for chlorophyll-a caused by non-point sources. In addition to the routine water quality monitoring program, the following are recommended.

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 Wappapello 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 eutrophic status of Wappapello Lake it is recommended that Total Nitrogen (TN) be added to the sampling program, which is a strong indicator of trophic status and is used by the state of Missouri to capture all lakes trophic status included in the 305(b) report. 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.

According to the Missouri State Code of Regulations 10CSR20-7.031, the parameters TP, TN, and CHL_a must be sampled a minimum of four times per year in order to calculate a geometric mean to be compared to the state's ecoregion criteria thresholds. Thus, given the eutrophic status of Wappapello Lake, it is imperative that sampling remain at a minimum of four events per year during the months of May through September.

Based on the findings of the Trophic study above, there is an immediate need for an in-depth watershed analysis to identify impactful nutrient sources in the reservoir's watershed. This would include review of updated land-use and land-cover data, active NPDES permits, aerial imagery, annual water budgets, additional nutrient monitoring in tributaries, and development of Total Maximum Daily Loads. This effort would take years to complete, however would be critical to guiding upland restoration efforts if ever pursued (Schepker, 2021).

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USACE. (1987). Engineering and Design: Reservoir Water Quality Analysis. USACE ER 1110-2-1201. Washington D.C.

Schepker, T.J. (2021). Trophic Status and Long-Term Trend Analysis Wappapello Lake: 1990-2019. USACE St. Louis District, Environmental Quality Section.

Dept. of Natural Resources, Rules of Department of Natural Resources: Division 20, Clean Water Commission: Chapter 7, Water Quality (1981). Jefferson City, MO.

# APPENDIX A:  FIELD DATA

| Date | Site | Depth (m) | DO (mg/L) | pH | ORP (mV) | Temp (C) | Sp Cond (µS/cm) | TDS (mg/L) | Turbidity (FNU) | Secchi (in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/10/2021 | MTL-1 | 0.5 | 5.35 | NA | NA | 17.1 | 193.5 | 126 | 37.3 | |
| 6/10/2021 | MTL-11 | 0.4 | 8.30 | NA | NA | 27.3 | 493.7 | 321 | 16.7 | |
| 6/10/2021 | MTL-12 | 0.7 | 8.07 | NA | NA | 18.1 | 211.3 | 137 | 36.7 | |
| 6/10/2021 | MTL-13 | 0.4 | 9.90 | NA | NA | 28.1 | 508.1 | 330 | 3.8 | |
| 6/10/2021 | MTL-22 | 1.1 | 11.51 | NA | NA | 25.5 | 195.1 | 127 | 21.9 | 24 |
| 6/10/2021 | MTL-22 | 2.2 | 7.75 | NA | NA | 23.8 | 198.0 | 129 | 23.7 | |
| 6/10/2021 | MTL-22 | 3.0 | 6.33 | NA | NA | 21.9 | 196.6 | 128 | 27.6 | |
| 6/10/2021 | MTL-22 | 4.1 | 5.73 | NA | NA | 19.8 | 194.6 | 127 | 31.6 | |
| 6/10/2021 | MTL-22 | 5.2 | 5.47 | NA | NA | 18.8 | 196.3 | 128 | 32.3 | |
| 6/10/2021 | MTL-22 | 6.1 | 5.59 | NA | NA | 18.3 | 193.6 | 126 | 34.9 | |
| 6/10/2021 | MTL-22 | 7.1 | 5.32 | NA | NA | 17.5 | 192.3 | 125 | 40.3 | |
| 6/10/2021 | MTL-22 | 8.2 | 5.26 | NA | NA | 16.3 | 190.5 | 124 | 40.4 | |
| 6/10/2021 | MTL-22 | 9.1 | 5.20 | NA | NA | 15.6 | 188.4 | 122 | 42.1 | |
| 6/10/2021 | MTL-22 | 10.1 | 4.99 | NA | NA | 15.1 | 188.1 | 122 | 42.4 | |
| 6/10/2021 | MTL-22 | 11.2 | 4.61 | NA | NA | 14.2 | 188.8 | 123 | 44.9 | |
| 6/10/2021 | MTL-22 | 12.1 | 4.35 | NA | NA | 13.4 | 191.9 | 125 | 41.0 | |
| 6/10/2021 | MTL-22 | 13.1 | 4.27 | NA | NA | 12.4 | 197.2 | 128 | 35.7 | |
| 6/10/2021 | MTL-22 | 14.2 | 4.29 | NA | NA | 11.7 | 200.9 | 131 | 31.8 | |
| 6/10/2021 | MTL-22 | 15.4 | 4.30 | NA | NA | 10.8 | 205.4 | 134 | 27.7 | |
| 6/10/2021 | MTL-22 | 16.2 | 4.27 | NA | NA | 10.5 | 207.0 | 135 | 26.7 | |
| 6/10/2021 | MTL-33 | 1.1 | 12.93 | NA | NA | 26.4 | 195.9 | 127 | 21.5 | 27 |
| 6/10/2021 | MTL-33 | 2.0 | 9.14 | NA | NA | 24.4 | 199.0 | 129 | 22.2 | |
| 6/10/2021 | MTL-33 | 3.1 | 6.70 | NA | NA | 22.6 | 199.6 | 130 | 25.5 | |
| 6/10/2021 | MTL-33 | 4.3 | 4.98 | NA | NA | 19.0 | 200.0 | 130 | 33.5 | |
| 6/10/2021 | MTL-33 | 5.3 | 4.91 | NA | NA | 18.6 | 200.0 | 130 | 34.2 | |
| 6/10/2021 | MTL-33 | 6.1 | 5.26 | NA | NA | 18.2 | 196.1 | 127 | 34.0 | |
| 6/10/2021 | MTL-33 | 7.0 | 5.23 | NA | NA | 17.7 | 194.3 | 126 | 34.9 | |
| 6/10/2021 | MTL-33 | 8.2 | 5.14 | NA | NA | 16.6 | 194.0 | 126 | 36.3 | |
| 6/10/2021 | MTL-33 | 9.2 | 5.15 | NA | NA | 15.7 | 190.1 | 124 | 40.1 | |
| 6/10/2021 | MTL-33 | 10.3 | 4.45 | NA | NA | 14.8 | 195.1 | 127 | 37.7 | |
| 6/10/2021 | MTL-33 | 11.1 | 4.50 | NA | NA | 14.2 | 192.2 | 125 | 40.0 | |
| 6/10/2021 | MTL-33 | 12.1 | 4.43 | NA | NA | 13.7 | 192.2 | 125 | 38.9 | |
| 6/10/2021 | MTL-33 | 13.1 | 4.21 | NA | NA | 12.7 | 197.2 | 128 | 37.3 | |
| 6/10/2021 | MTL-33 | 14.1 | 3.69 | NA | NA | 12.0 | 201.2 | 131 | 30.7 | |
| 6/10/2021 | MTL-33 | 15.3 | 3.57 | NA | NA | 10.8 | 207.3 | 135 | 27.1 | |
| 6/10/2021 | MTL-33 | 16.3 | 3.50 | NA | NA | 10.4 | 208.0 | 135 | 26.6 | |
| 6/10/2021 | MTL-33 | 17.0 | 3.10 | NA | NA | 9.9 | 210.2 | 137 | 25.5 | |
| 6/10/2021 | MTL-33 | 18.1 | 3.03 | NA | NA | 9.7 | 210.8 | 137 | 25.3 | |
| 6/10/2021 | MTL-5 | 1.0 | 10.22 | NA | NA | 25.7 | 384.2 | 250 | 47.7 | |
| 6/10/2021 | MTL-66 | 1.1 | 9.71 | NA | NA | 28.3 | 201.7 | 131 | 28.1 | 21 |
| 6/10/2021 | MTL-66 | 2.0 | 8.78 | NA | NA | 26.0 | 201.2 | 131 | 29.2 | |
| 6/10/2021 | MTL-66 | 3.1 | 7.75 | NA | NA | 24.4 | 202.5 | 132 | 31.1 | |

| Date | Site | Depth (m) | DO (mg/L) | pH | ORP (mV) | Temp (C) | Sp Cond (µS/cm) | TDS (mg/L) | Turbidity (FNU) | Secchi (in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/10/2021 | MTL-66 | 4.1 | 6.17 | NA | NA | 21.4 | 203.7 | 132 | 33.9 | |
| 6/10/2021 | MTL-66 | 5.1 | 4.71 | NA | NA | 19.4 | 202.1 | 131 | 38.0 | |
| 6/10/2021 | MTL-66 | 6.2 | 4.09 | NA | NA | 18.3 | 200.7 | 130 | 41.4 | |
| 6/10/2021 | MTL-66 | 7.2 | 2.74 | NA | NA | 17.6 | 202.3 | 131 | 45.5 | |
| 6/10/2021 | MTL-66 | 8.3 | 1.23 | NA | NA | 16.6 | 202.3 | 131 | 48.9 | |
| 6/10/2021 | MTL-66 | 9.1 | 1.41 | NA | NA | 16.0 | 198.6 | 129 | 52.8 | |
| 6/10/2021 | MTL-66 | 10.1 | 0.82 | NA | NA | 15.3 | 197.2 | 128 | 55.7 | |
| 6/10/2021 | MTL-66 | 11.2 | 0.72 | NA | NA | 14.5 | 195.3 | 127 | 63.5 | |
| 6/10/2021 | MTL-66 | 12.3 | 0.66 | NA | NA | 14.2 | 195.2 | 127 | 64.7 | |
| 6/10/2021 | MTL-77 | 0.9 | 9.86 | NA | NA | 29.1 | 203.2 | 132 | 29.7 | 21 |
| 6/10/2021 | MTL-77 | 2.0 | 7.84 | NA | NA | 25.0 | 205.2 | 133 | 32.1 | |
| 6/10/2021 | MTL-77 | 3.1 | 6.71 | NA | NA | 23.0 | 205.4 | 134 | 34.2 | |
| 6/10/2021 | MTL-77 | 4.1 | 3.76 | NA | NA | 19.2 | 211.2 | 137 | 39.1 | |
| 6/10/2021 | MTL-77 | 5.1 | 4.35 | NA | NA | 18.1 | 201.4 | 131 | 41.2 | |
| 6/10/2021 | MTL-77 | 6.1 | 3.83 | NA | NA | 17.9 | 202.4 | 132 | 42.4 | |
| 6/10/2021 | MTL-77 | 7.0 | 3.57 | NA | NA | 17.5 | 201.4 | 131 | 44.2 | |
| 6/10/2021 | MTL-77 | 8.1 | 3.14 | NA | NA | 17.0 | 200.3 | 130 | 43.7 | |
| 6/10/2021 | MTL-77 | 9.1 | 3.09 | NA | NA | 16.8 | 199.0 | 129 | 46.4 | |
| 6/10/2021 | MTL-77 | 10.1 | 3.09 | NA | NA | 15.7 | 195.1 | 127 | 55.5 | |
| 6/10/2021 | MTL-77 | 11.1 | 1.76 | NA | NA | 15.1 | 197.4 | 128 | 55.9 | |
| 6/10/2021 | MTL-77 | 12.3 | 0.92 | NA | NA | 13.9 | 196.2 | 128 | 61.9 | |
| 6/10/2021 | MTL-77 | 13.1 | 0.46 | NA | NA | 12.9 | 197.6 | 128 | 69.9 | |
| 6/10/2021 | MTL-9 | 0.4 | 3.82 | NA | NA | 24.8 | 247.5 | 161 | 72.5 | |
| 6/10/2021 | MTL-BJ-MAR | 1.2 | 12.84 | NA | NA | 30.1 | 197.1 | 128 | 20.9 | |
| 6/10/2021 | MTL-BJ-MAR | 7.6 | 5.25 | NA | NA | 17.4 | 193.5 | 126 | 36.2 | |
| 6/10/2021 | MTL-BJ-MAR | 14.7 | 4.05 | NA | NA | 12.2 | 199.6 | 130 | 38.0 | |
| 6/10/2021 | MTL-IC MAR | 1.0 | 8.13 | NA | NA | 25.4 | 199.1 | 129 | 28.8 | |
| 6/10/2021 | MTL-IC MAR | 6.4 | 4.82 | NA | NA | 18.0 | 196.0 | 127 | 43.8 | |
| 6/10/2021 | MTL-IC MAR | 11.3 | 3.00 | NA | NA | 14.1 | 190.8 | 124 | 68.6 | |
| 9/1/2021 | MTL-1 | 1.0 | 7.97 | 7.6 | 293.2 | 25.8 | 177.8 | 116 | 5.9 | |
| 9/1/2021 | MTL-11 | 0.3 | 6.03 | 7.7 | 156.2 | 26.0 | 446.1 | 290 | 16.6 | |
| 9/1/2021 | MTL-12 | 0.5 | 5.75 | 7.6 | 356.7 | 27.4 | 180.8 | 118 | 7.4 | |
| 9/1/2021 | MTL-13 | 0.0 | 7.65 | 7.9 | 150.0 | 25.8 | 344.3 | 224 | 8.3 | |
| 9/1/2021 | MTL-22 | 1.0 | 5.75 | 8.0 | 208.6 | 27.2 | 176.0 | 114 | 2.1 | |
| 9/1/2021 | MTL-22 | 2.1 | 4.77 | 7.7 | 213.8 | 26.9 | 177.2 | 115 | 2.3 | |
| 9/1/2021 | MTL-22 | 3.0 | 2.16 | 7.3 | 226.2 | 26.5 | 178.4 | 116 | 3.5 | |
| 9/1/2021 | MTL-22 | 4.1 | 0.91 | 7.2 | 210.1 | 26.0 | 179.5 | 117 | 3.8 | |
| 9/1/2021 | MTL-22 | 5.1 | 0.64 | 7.1 | 44.6 | 25.0 | 179.5 | 117 | 6.2 | |
| 9/1/2021 | MTL-22 | 6.1 | 0.50 | 7.0 | -24.6 | 23.5 | 170.4 | 111 | 13.0 | |
| 9/1/2021 | MTL-22 | 7.1 | 0.41 | 7.0 | -55.0 | 21.1 | 169.0 | 110 | 21.9 | |
| 9/1/2021 | MTL-22 | 8.1 | 0.36 | 7.0 | -36.6 | 19.1 | 179.6 | 117 | 27.5 | |
| 9/1/2021 | MTL-22 | 9.0 | 0.33 | 7.0 | -16.6 | 16.8 | 202.9 | 132 | 30.4 | |

| Date | Site | Depth (m) | DO (mg/L) | pH | ORP (mV) | Temp (C) | Sp Cond (µS/cm) | TDS (mg/L) | Turbidity (FNU) | Secchi (in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/2021 | MTL-22 | 10.0 | 0.29 | 7.0 | -2.7 | 14.5 | 209.2 | 136 | 33.0 | |
| 9/1/2021 | MTL-22 | 11.1 | 0.27 | 7.0 | 3.8 | 13.2 | 208.9 | 136 | 31.5 | |
| 9/1/2021 | MTL-22 | 12.0 | 0.25 | 7.0 | 8.9 | 12.0 | 210.4 | 137 | 28.7 | |
| 9/1/2021 | MTL-22 | 13.0 | 0.24 | 7.0 | 15.2 | 11.2 | 212.4 | 138 | 25.5 | |
| 9/1/2021 | MTL-22 | 14.1 | 0.22 | 6.9 | 25.9 | 10.6 | 215.4 | 140 | 22.5 | |
| 9/1/2021 | MTL-22 | 15.0 | 0.21 | 6.9 | 32.8 | 10.2 | 217.8 | 142 | 21.6 | |
| 9/1/2021 | MTL-22 | 16.1 | 0.20 | 6.9 | 39.9 | 9.6 | 222.5 | 145 | 21.4 | |
| 9/1/2021 | MTL-33 | 1.1 | 6.30 | 8.0 | 109.0 | 27.5 | 179.5 | 117 | 2.4 | 30 |
| 9/1/2021 | MTL-33 | 2.3 | 5.67 | 7.9 | 114.3 | 27.2 | 178.6 | 116 | 2.4 | |
| 9/1/2021 | MTL-33 | 3.0 | 5.30 | 7.8 | 118.6 | 27.1 | 178.3 | 116 | 2.4 | |
| 9/1/2021 | MTL-33 | 5.1 | 0.74 | 7.1 | -66.9 | 24.7 | 184.8 | 120 | 10.8 | |
| 9/1/2021 | MTL-33 | 6.2 | 0.57 | 7.1 | -70.9 | 22.6 | 173.4 | 113 | 16.2 | |
| 9/1/2021 | MTL-33 | 7.0 | 0.48 | 7.0 | -74.9 | 21.6 | 174.7 | 114 | 19.4 | |
| 9/1/2021 | MTL-33 | 8.1 | 0.42 | 7.0 | -63.3 | 18.9 | 183.7 | 119 | 25.9 | |
| 9/1/2021 | MTL-33 | 9.1 | 0.39 | 7.0 | -48.7 | 16.7 | 203.2 | 132 | 28.6 | |
| 9/1/2021 | MTL-33 | 10.3 | 0.36 | 7.0 | -38.3 | 14.2 | 212.6 | 138 | 28.4 | |
| 9/1/2021 | MTL-33 | 11.2 | 0.34 | 7.0 | -33.4 | 13.3 | 212.6 | 138 | 27.0 | |
| 9/1/2021 | MTL-33 | 12.1 | 0.31 | 7.0 | -25.9 | 11.9 | 214.1 | 139 | 24.8 | |
| 9/1/2021 | MTL-33 | 13.1 | 0.30 | 7.0 | -22.7 | 11.1 | 216.4 | 141 | 22.8 | |
| 9/1/2021 | MTL-33 | 14.2 | 0.29 | 7.0 | -16.6 | 10.2 | 220.7 | 143 | 19.7 | |
| 9/1/2021 | MTL-33 | 15.2 | 0.27 | 7.0 | -11.7 | 9.6 | 224.7 | 146 | 18.8 | |
| 9/1/2021 | MTL-5 | 0.0 | 7.38 | 8.1 | 138.3 | 27.4 | 465.1 | 302 | 82.5 | |
| 9/1/2021 | MTL-66 | 1.1 | 5.94 | 7.7 | 131.6 | 27.4 | 172.7 | 112 | 3.9 | 39 |
| 9/1/2021 | MTL-66 | 2.2 | 5.38 | 7.6 | 135.5 | 27.1 | 173.0 | 112 | 3.9 | |
| 9/1/2021 | MTL-66 | 3.1 | 5.21 | 7.6 | 137.5 | 27.1 | 173.1 | 112 | 3.7 | |
| 9/1/2021 | MTL-66 | 4.1 | 5.11 | 7.5 | 139.9 | 27.1 | 173.1 | 112 | 3.6 | |
| 9/1/2021 | MTL-66 | 5.1 | 3.62 | 7.3 | 147.5 | 26.9 | 174.4 | 113 | 5.2 | |
| 9/1/2021 | MTL-66 | 6.1 | 2.32 | 7.2 | 101.9 | 26.5 | 176.6 | 115 | 9.4 | |
| 9/1/2021 | MTL-66 | 7.2 | 0.53 | 7.1 | -114.0 | 23.3 | 196.1 | 127 | 52.4 | |
| 9/1/2021 | MTL-66 | 8.1 | 0.41 | 7.0 | -125.3 | 21.7 | 203.7 | 132 | 56.4 | |
| 9/1/2021 | MTL-66 | 9.2 | 0.34 | 7.1 | -136.8 | 20.0 | 208.6 | 136 | 49.3 | |
| 9/1/2021 | MTL-66 | 10.0 | 0.29 | 7.1 | -141.6 | 16.0 | 246.9 | 160 | 22.5 | |
| 9/1/2021 | MTL-77 | 1.3 | 7.10 | 8.1 | 82.9 | 28.1 | 173.4 | 113 | 3.1 | 41 |
| 9/1/2021 | MTL-77 | 2.3 | 6.24 | 7.8 | 96.6 | 27.9 | 173.6 | 113 | 3.4 | |
| 9/1/2021 | MTL-77 | 3.2 | 5.83 | 7.7 | 104.0 | 27.8 | 173.6 | 113 | 3.7 | |
| 9/1/2021 | MTL-77 | 4.2 | 5.64 | 7.7 | 107.1 | 27.7 | 173.6 | 113 | 3.8 | |
| 9/1/2021 | MTL-77 | 5.1 | 4.20 | 7.4 | 113.9 | 27.5 | 174.0 | 113 | 5.6 | |
| 9/1/2021 | MTL-77 | 6.2 | 0.59 | 7.1 | -69.6 | 25.4 | 178.6 | 116 | 20.0 | |
| 9/1/2021 | MTL-77 | 7.1 | 0.45 | 7.0 | -105.4 | 23.2 | 182.5 | 119 | 44.1 | |
| 9/1/2021 | MTL-77 | 8.1 | 0.39 | 7.0 | -114.4 | 21.8 | 179.2 | 117 | 42.8 | |
| 9/1/2021 | MTL-77 | 9.1 | 0.36 | 7.0 | -120.2 | 19.7 | 192.5 | 125 | 49.4 | |
| 9/1/2021 | MTL-77 | 10.2 | 0.33 | 7.1 | -126.3 | 17.1 | 221.4 | 144 | 52.0 | |

| Date | Site | Depth (m) | DO (mg/L) | pH | ORP (mV) | Temp (C) | Sp Cond (µS/cm) | TDS (mg/L) | Turbidity (FNU) | Secchi (in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/1/2021 | MTL-77 | 11.1 | 0.32 | 7.1 | -129.8 | 14.2 | 244.2 | 159 | 52.4 | |
| 9/1/2021 | MTL-77 | 12.0 | 0.29 | 7.1 | -131.5 | 13.3 | 247.7 | 161 | 52.7 | |
| 9/1/2021 | MTL-9 | 0.0 | 5.76 | 7.8 | 143.0 | 25.6 | 380.6 | 247 | 12.9 | |
| 9/1/2021 | MTL-BJ-MAR | 1.1 | 6.00 | 8.3 | -39.2 | 28.0 | 177.6 | 115 | 2.6 | |
| 9/1/2021 | MTL-BJ-MAR | 6.1 | 0.76 | 7.1 | -64.0 | 22.7 | 175.7 | 114 | 20.6 | |
| 9/1/2021 | MTL-BJ-MAR | 11.5 | 1.13 | 7.2 | -45.9 | 12.9 | 213.6 | 139 | 32.2 | |
| 9/1/2021 | MTL-IC MAR | 0.8 | 5.50 | 7.8 | 50.5 | 27.5 | 172.1 | 112 | 3.5 | |
| 9/1/2021 | MTL-IC MAR | 4.1 | 3.22 | 7.4 | 25.4 | 26.6 | 172.0 | 112 | 8.7 | |
| 9/1/2021 | MTL-IC MAR | 8.2 | 1.03 | 7.1 | -94.5 | 21.5 | 170.9 | 111 | 31.5 | |
| 9/29/2021 | MTL-1 | 0.6 | 8.84 | 8.1 | 352.8 | 23.4 | 185.6 | 121 | 2.2 | |
| 9/29/2021 | MTL-11 | 0.3 | 8.48 | 7.8 | 207.3 | 23.3 | 441.5 | 287 | 11.0 | |
| 9/29/2021 | MTL-12 | 0.1 | 8.20 | 7.6 | 200.3 | 24.3 | 183.5 | 119 | 4.1 | |
| 9/29/2021 | MTL-13 | 0.6 | 7.10 | 7.8 | 181.8 | 20.1 | 399.9 | 260 | 6.6 | |
| 9/29/2021 | MTL-22 | 1.0 | 9.25 | 8.1 | 225.8 | 22.5 | 179.0 | 116 | 2.1 | 44 |
| 9/29/2021 | MTL-22 | 2.0 | 8.67 | 8.0 | 223.9 | 22.1 | 179.1 | 116 | 2.0 | |
| 9/29/2021 | MTL-22 | 3.0 | 8.22 | 7.9 | 225.2 | 22.0 | 179.2 | 116 | 2.0 | |
| 9/29/2021 | MTL-22 | 4.1 | 7.73 | 7.7 | 226.9 | 21.9 | 179.0 | 116 | 2.1 | |
| 9/29/2021 | MTL-22 | 5.0 | 7.76 | 7.7 | 227.1 | 21.9 | 179.7 | 117 | 2.0 | |
| 9/29/2021 | MTL-22 | 6.0 | 7.15 | 7.6 | 224.4 | 21.8 | 180.2 | 117 | 3.4 | |
| 9/29/2021 | MTL-22 | 7.0 | 6.14 | 7.6 | 224.3 | 21.4 | 180.9 | 118 | 3.8 | |
| 9/29/2021 | MTL-22 | 8.0 | 5.15 | 7.4 | 225.2 | 20.8 | 183.3 | 119 | 5.3 | |
| 9/29/2021 | MTL-22 | 9.0 | 2.60 | 7.3 | 226.1 | 19.5 | 190.2 | 124 | 10.2 | |
| 9/29/2021 | MTL-22 | 10.0 | 1.00 | 7.2 | 231.0 | 13.9 | 213.8 | 139 | 27.4 | |
| 9/29/2021 | MTL-22 | 11.0 | 0.69 | 7.1 | 231.4 | 12.2 | 216.1 | 140 | 28.5 | |
| 9/29/2021 | MTL-22 | 12.0 | 0.59 | 7.1 | 230.4 | 11.3 | 219.1 | 142 | 27.0 | |
| 9/29/2021 | MTL-22 | 13.0 | 0.53 | 7.1 | 229.4 | 10.8 | 221.2 | 144 | 27.3 | |
| 9/29/2021 | MTL-22 | 14.0 | 0.49 | 7.0 | 228.3 | 10.1 | 225.9 | 147 | 33.2 | |
| 9/29/2021 | MTL-22 | 15.0 | 0.46 | 7.0 | 223.5 | 9.8 | 229.5 | 149 | 37.9 | |
| 9/29/2021 | MTL-22 | 16.0 | 0.38 | 7.0 | -48.4 | 9.5 | 234.3 | 152 | 54.7 | |
| 9/29/2021 | MTL-22 | 16.0 | 0.44 | 7.0 | 217.6 | 9.6 | 232.1 | 151 | 53.2 | |
| 9/29/2021 | MTL-33 | 1.1 | 8.30 | 7.8 | 199.7 | 22.5 | 180.9 | 118 | 2.0 | 55 |
| 9/29/2021 | MTL-33 | 2.2 | 6.82 | 7.6 | 193.5 | 21.9 | 181.2 | 118 | 2.0 | |
| 9/29/2021 | MTL-33 | 3.1 | 6.65 | 7.5 | 191.7 | 21.9 | 181.6 | 118 | 2.1 | |
| 9/29/2021 | MTL-33 | 4.0 | 6.52 | 7.5 | 182.2 | 21.8 | 181.7 | 118 | 2.3 | |
| 9/29/2021 | MTL-33 | 5.1 | 6.47 | 7.5 | 179.5 | 21.8 | 181.7 | 118 | 2.4 | |
| 9/29/2021 | MTL-33 | 6.1 | 6.19 | 7.5 | 176.5 | 21.8 | 182.7 | 119 | 2.4 | |
| 9/29/2021 | MTL-33 | 7.2 | 5.05 | 7.4 | 172.8 | 21.2 | 184.3 | 120 | 3.9 | |
| 9/29/2021 | MTL-33 | 8.1 | 2.98 | 7.3 | 171.0 | 20.6 | 188.5 | 122 | 5.9 | |
| 9/29/2021 | MTL-33 | 9.1 | 0.67 | 7.1 | 171.3 | 18.8 | 195.9 | 127 | 11.9 | |
| 9/29/2021 | MTL-33 | 10.0 | 0.52 | 7.1 | 172.5 | 14.1 | 216.1 | 140 | 28.1 | |
| 9/29/2021 | MTL-33 | 11.1 | 0.47 | 7.0 | 171.9 | 11.7 | 218.8 | 142 | 27.5 | |
| 9/29/2021 | MTL-33 | 12.3 | 0.43 | 7.0 | 170.4 | 10.9 | 221.7 | 144 | 27.6 | |

| Date | Site | Depth (m) | DO (mg/L) | pH | ORP (mV) | Temp (C) | Sp Cond (µS/cm) | TDS (mg/L) | Turbidity (FNU) | Secchi (in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/29/2021 | MTL-33 | 13.1 | 0.41 | 7.0 | 169.8 | 10.5 | 226.7 | 147 | 29.5 | |
| 9/29/2021 | MTL-33 | 14.3 | 0.36 | 6.9 | 169.2 | 9.7 | 232.9 | 151 | 33.3 | |
| 9/29/2021 | MTL-33 | 15.2 | 0.35 | 6.9 | 168.3 | 9.6 | 234.8 | 153 | 36.0 | |
| 9/29/2021 | MTL-33 | 16.2 | 0.35 | 6.9 | 168.3 | 9.4 | 237.3 | 154 | 38.7 | |
| 9/29/2021 | MTL-5 | 0.8 | 5.97 | 7.7 | 364.1 | 20.1 | 384.4 | 250 | 44.5 | |
| 9/29/2021 | MTL-66 | 1.1 | 6.59 | 7.5 | 338.8 | 21.7 | 184.1 | 120 | 3.8 | 36 |
| 9/29/2021 | MTL-66 | 2.2 | 5.94 | 7.4 | 327.4 | 21.5 | 183.2 | 119 | 3.3 | |
| 9/29/2021 | MTL-66 | 3.2 | 5.37 | 7.4 | 316.4 | 21.4 | 184.3 | 120 | 5.1 | |
| 9/29/2021 | MTL-66 | 4.2 | 4.65 | 7.3 | 311.4 | 21.4 | 188.4 | 122 | 5.9 | |
| 9/29/2021 | MTL-66 | 5.1 | 4.40 | 7.3 | 304.4 | 21.4 | 189.3 | 123 | 5.9 | |
| 9/29/2021 | MTL-66 | 5.1 | 4.35 | 7.3 | 299.0 | 21.4 | 189.2 | 123 | 5.8 | |
| 9/29/2021 | MTL-66 | 6.1 | 4.16 | 7.3 | 291.7 | 21.3 | 190.3 | 124 | 6.0 | |
| 9/29/2021 | MTL-66 | 7.2 | 3.61 | 7.2 | 288.0 | 21.1 | 191.7 | 125 | 8.2 | |
| 9/29/2021 | MTL-66 | 7.2 | 3.56 | 7.2 | 286.4 | 21.1 | 191.8 | 125 | 8.2 | |
| 9/29/2021 | MTL-66 | 8.3 | 1.64 | 7.2 | 281.9 | 20.6 | 195.2 | 127 | 11.2 | |
| 9/29/2021 | MTL-66 | 9.2 | 0.53 | 7.0 | -48.4 | 16.7 | 236.7 | 154 | 46.2 | |
| 9/29/2021 | MTL-66 | 10.1 | 0.43 | 7.0 | -91.4 | 13.4 | 262.8 | 171 | 46.2 | |
| 9/29/2021 | MTL-77 | 1.0 | 9.63 | 8.1 | 137.4 | 22.5 | 180.9 | 118 | 2.9 | 44 |
| 9/29/2021 | MTL-77 | 2.0 | 8.17 | 7.8 | 144.6 | 22.0 | 181.8 | 118 | 2.8 | |
| 9/29/2021 | MTL-77 | 3.1 | 6.31 | 7.5 | 147.3 | 21.5 | 182.2 | 118 | 3.0 | |
| 9/29/2021 | MTL-77 | 4.1 | 5.89 | 7.4 | 146.9 | 21.3 | 184.8 | 120 | 4.1 | |
| 9/29/2021 | MTL-77 | 4.4 | 5.85 | 7.4 | 146.6 | 21.3 | 184.5 | 120 | 4.0 | |
| 9/29/2021 | MTL-77 | 5.1 | 5.70 | 7.3 | 147.5 | 21.3 | 185.3 | 120 | 4.3 | |
| 9/29/2021 | MTL-77 | 6.1 | 5.62 | 7.4 | 145.6 | 21.2 | 185.6 | 121 | 4.8 | |
| 9/29/2021 | MTL-77 | 7.2 | 5.21 | 7.3 | 145.9 | 21.1 | 187.4 | 122 | 5.7 | |
| 9/29/2021 | MTL-77 | 8.2 | 4.53 | 7.3 | 146.2 | 21.0 | 189.0 | 123 | 6.4 | |
| 9/29/2021 | MTL-77 | 9.1 | 0.70 | 7.0 | 4.2 | 18.6 | 209.6 | 136 | 22.6 | |
| 9/29/2021 | MTL-77 | 10.0 | 0.51 | 7.0 | -69.0 | 14.8 | 253.1 | 165 | 56.1 | |
| 9/29/2021 | MTL-77 | 11.1 | 0.46 | 7.0 | -88.5 | 13.0 | 263.1 | 171 | 71.6 | |
| 9/29/2021 | MTL-9 | 0.7 | 8.07 | 7.8 | 203.6 | 21.5 | 493.1 | 321 | 8.5 | |
| 9/29/2021 | MTL-BJ-MAR | 1.1 | 8.55 | 7.8 | 152.9 | 22.6 | 180.4 | 117 | 2.2 | |
| 9/29/2021 | MTL-BJ-MAR | 4.1 | 5.97 | 7.3 | 16.5 | 21.9 | 180.7 | 117 | 4.9 | |
| 9/29/2021 | MTL-BJ-MAR | 9.4 | 1.14 | 7.2 | -38.0 | 15.3 | 213.4 | 139 | 38.2 | |
| 9/29/2021 | MTL-IC MAR | 1.1 | 8.57 | 7.9 | 421.8 | 22.4 | 179.5 | 117 | 3.2 | |
| 9/29/2021 | MTL-IC MAR | 4.1 | 6.15 | 7.4 | 84.9 | 21.6 | 179.6 | 117 | 4.9 | |
| 9/29/2021 | MTL-IC MAR | 8.2 | 4.37 | 7.4 | 40.8 | 20.6 | 184.0 | 120 | 13.1 | |

# APPENDIX B:  LABORATORY DATA