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Memorandum

To: Big Roche-A-Cri Lake District
From: Barr Engineering Co. (Barr)
Subject: Data Gaps Analysis
Date: November 11, 2019

This memorandum summarizes an analysis that Barr performed to identify data gaps that must be filled prior to beginning a 9 Key Elements Plan and/or other future lake management planning efforts for Big Roche-A-Cri Lake. The following sections describe Barr's evaluation of existing watershed plans, lake management plans, historical monitoring data and surveys to determine the gaps that should be addressed to support future lake planning efforts. The data and information we reviewed and evaluated include the following:

- Wisconsin Department of Natural Resources (WiDNR) critical habitat designated areas
- WDNR fisheries surveys and their interpretation of the lake's fishery
- In-lake water quality data from Citizen Based Monitoring of Big Roche-A-Cri Lake
- WDNR water quality and biota/habitat data from WDNR monitoring of Big Roche-A-Cri Creek and its tributaries
- USGS flow monitoring data (no data available)
- Big Roche-A-Cri Lake Management Plan
- Big Roche-A-Cri Creek Watershed, 2011 Water Quality Management Plan Update
- Designation of Critical Habitat in Big Roche-A-Cri Lake, Adams County.
- Literature regarding potential stressors on the lake's ecology, given what we already knew about the current condition

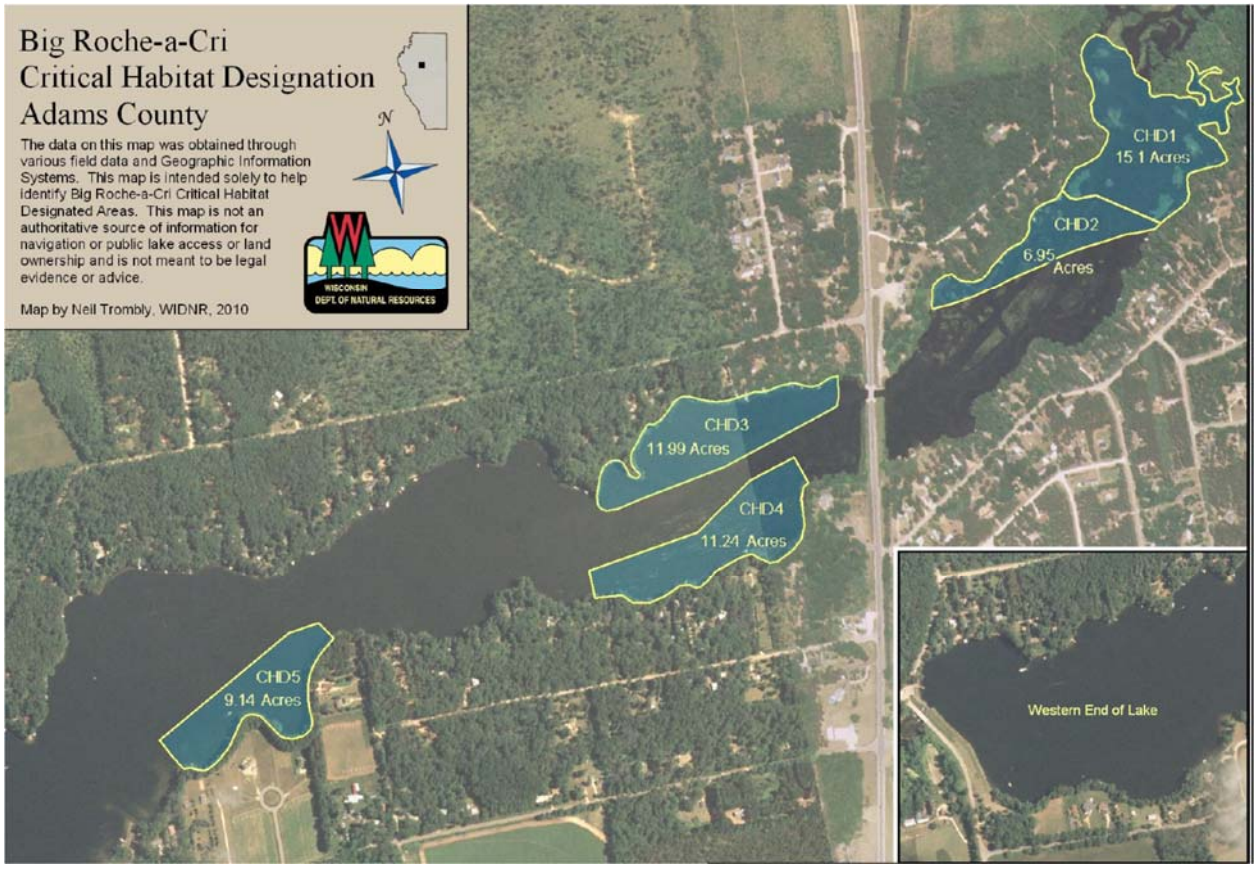
Electronic records of supporting information and data referenced in this memo are available upon request.

Aquatic plant survey and critical habitat information

Barr completed a summary report of the 2019 Big Roche-A-Cri Lake aquatic plant surveys in September, 2019, which documented the diversity and high quality of the lake's plant community. Wild celery, a native species, dominated the plant community, occurring at two thirds of littoral sample sites and often impaired navigation. Changes since the only other plant survey (from 2008) were also noted, with the results showing increased overall plant frequency, increased number of native species, a decreased tolerance of the plant community to degradation, increased quality of the plant community, and increased plant density.

A total of 3 aquatic invasive species (AIS) were also observed in 2019 (curly-leaf pondweed, Eurasian watermilfoil, and narrow-leaved cattail). A comparison of 2008 and 2019 data indicate (1) the frequency of Eurasian watermilfoil significantly declined in 2019; (2) the frequency of curly-leaf pondweed collected on the rake in summer did not change significantly; and (3) the frequency of visual observations of curly-leaf pondweed (CLP) near sample locations in summer significantly increased in 2019. The summer surveys in 2008 and 2019 occurred after the natural senescence (die-back) of CLP.

The plant survey report figures were compared with the following map of the critical habitat designated areas (WDNR, 2011) and used to confirm that curly-leaf pondweed is present in CHD2 and CHD5, while Eurasian watermilfoil is present in CHD4.

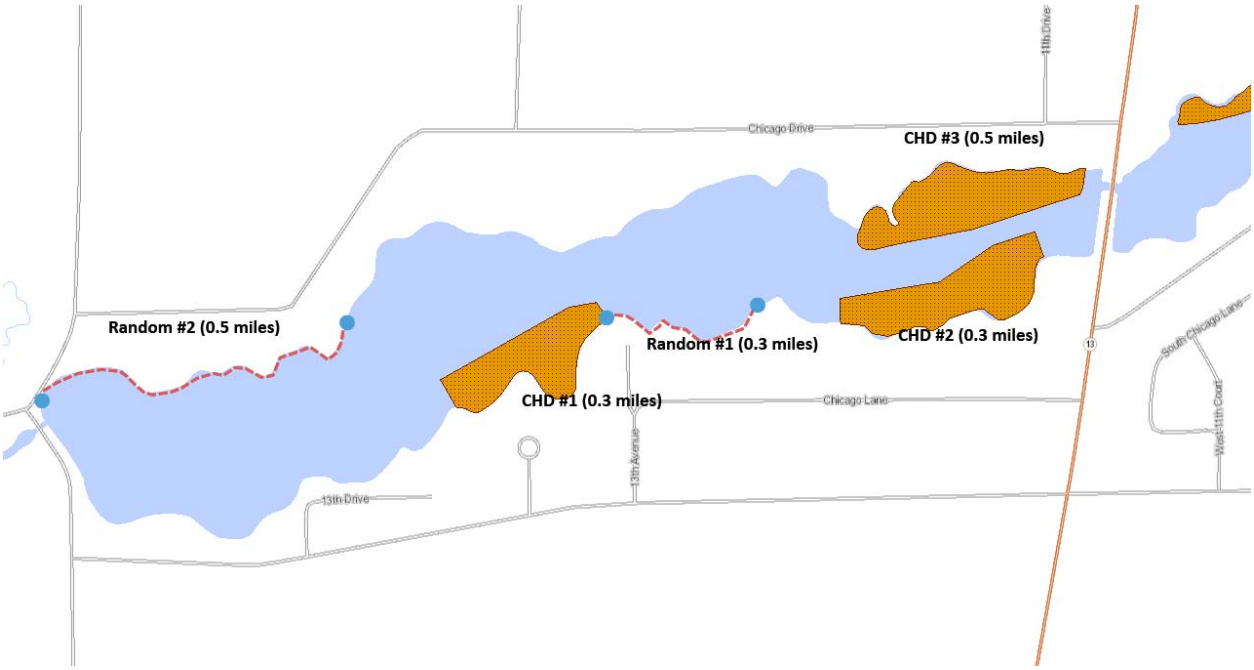


If there is a concern that high flow or lake levels affected the representativeness of the 2019 aquatic plant surveys, additional plant surveys may be warranted. Unfortunately, lake stage data was not available for 2008 or 2019, so it is not immediately clear whether the 2008 plant surveys were representative of past conditions on Big Roche-A-Cri Lake. Also, the 2008 data was obtained after several years of unrestricted harvesting. Since 2009, harvesting has been conducted as per the plan. There were several expansions of harvested areas from 2009, however, it was considerably less than the 2008 (and prior) harvesting operations, which would most certainly affect the aquatic plant community.

Fisheries survey and interpretation

For this portion of the evaluation, Barr compiled the following information about the Big Roche-A-Cri Lake fishery, as provided by WDNR staff:

- WDNR performed spring electrofishing surveys in 2009 and 2018. The data collected during the electrofishing surveys were used to assess the largemouth bass and bluegill populations. Big Roche-A-Cri Lake is a warm clear lake with a relatively simple fish community (bass, panfish, and northern pike). With electrofishing surveys, the northern pike population cannot be assessed—this would require a netting survey, if there are concerns.
- Fall electrofishing surveys occurred in 2014, 2015, 2016 and 2018 to assess walleye stocking as a part of the Wisconsin Walleye Initiative. No walleyes age-0 or age-1+ (≤12") were caught during these surveys. The walleye population in the lake would not persist if the lake was not stocked with extended growth fingerlings and at numbers that would establish a fishery.
- In the fall of 2018, WDNR looked at the fish in the areas designated for aquatic plant protections (see following figure). Overall, they observed that the Critical Habit Designation (CHD) areas had more fish and a higher diversity of species, including young of the year bluegill, young of the year largemouth bass, shiners, etc. dominating CHD #1 and CHD#3 that they could not effectively net due to aquatic plants. The only place they saw walleye for the entire survey was in CHD #1 and CHD #2. Random Site #1 had some nice largemouth bass and bluegill and there were small pockets of plants that held shiners and smaller fish. Random Site #1 appeared be cut by the aquatic plant harvester, so they could more effectively dip fish than the CHD areas. The WDNR saw very few fish on Random Site #2, which netted 2 bluegills, and they missed a bass or two, but they didn't see many fish.

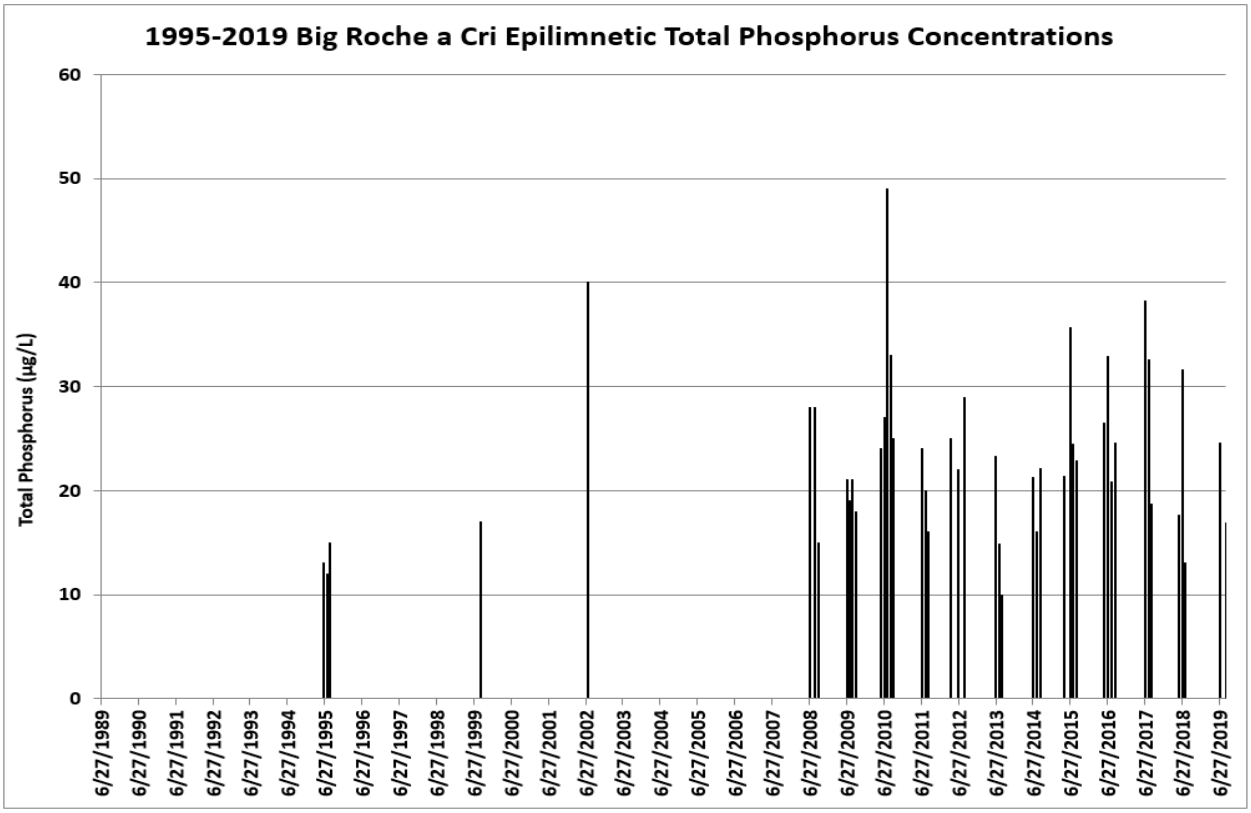


- Compared to other warm clear lakes, like Big Roche-A-Cri Lake, the observed 30.5 bass/mile is in the normal range (18.5-38.3, median of 26.0). Size structure indexed by RSD14 (relative stock density, percentage of stock length fish that are 14" or greater) in 2009 could not be calculated due to too small of a sample size. In 2018, RSD14 was 36.1%, meaning 36.1% of all the bass greater than or equal to 8" were 14" or greater. Compared to other warm clear lakes, the bass size structure is considered in the high range (25-45%) and above average. Bluegill relative abundance was 79/mile in 2009 and 69/mile in 2018, both catch rates are typically observed in other lakes. Size structure of bluegill appears to have gotten worse, but sample size was too small in 2018 to calculate a RSD value because not many fish over 6" were caught. Mean length of bluegill decreased from 5.1" to 4.6". Maximum length was 7" in both years, so bluegill can still grow to larger sizes.
- There are 94 lakes in the state that have special panfish regulations with the objective to improve size structure by reducing harvest of panfish. These lakes were determined to have bluegill populations with good growth (not stunted). With the poor size structure in Big Roche-A-Cri Lake, the populations are not reaching their size structure potential likely due to size selectivity and high harvest by anglers. Research has shown that to improve bluegill size structure in these situations, the harvest must be reduced. Big Roche-A-Cri Lake was picked as a reference lake for the study. The WDNR will be surveying the lake again in an upcoming spring for the evaluation of special regulations for the panfish project. More information for the panfish project can be found on the WDNR's webpage: https://dnr.wi.gov/topic/fishing/outreach/panfishplan.html.

Review of historical water quality and quantity monitoring data

For this portion of the review, Barr used the WDNR Surface Water Data Viewer and accessed the SWIMS database to review and evaluate the following:

- There is a long history (going back to 1989) of Citizen Based Monitoring, with water quality data available for up to three locations (west end-deep hole, lake center and east end) in Big Roche-A-Cri Lake that typically includes sample results for Secchi disc transparency, chlorophyll-a, total phosphorus, weather, appearance/perception and profile measurements for water temperature and dissolved oxygen. Occasionally, these datasets have included some staff gauge measurements of lake stage. The following graphs summarize the historical monitoring data for total phosphorus, chlorophyll-a and Secchi disc transparency:


1995-2019 Big Roche a Cri Epilimnetic Total Phosphorus Concentrations
Total Phosphorus (µg/L)
0
10
20
30
40
50
60
6/27/1989
6/27/1990
6/27/1991
6/27/1992
6/27/1993
6/27/1994
6/27/1995
6/27/1996
6/27/1997
6/27/1998
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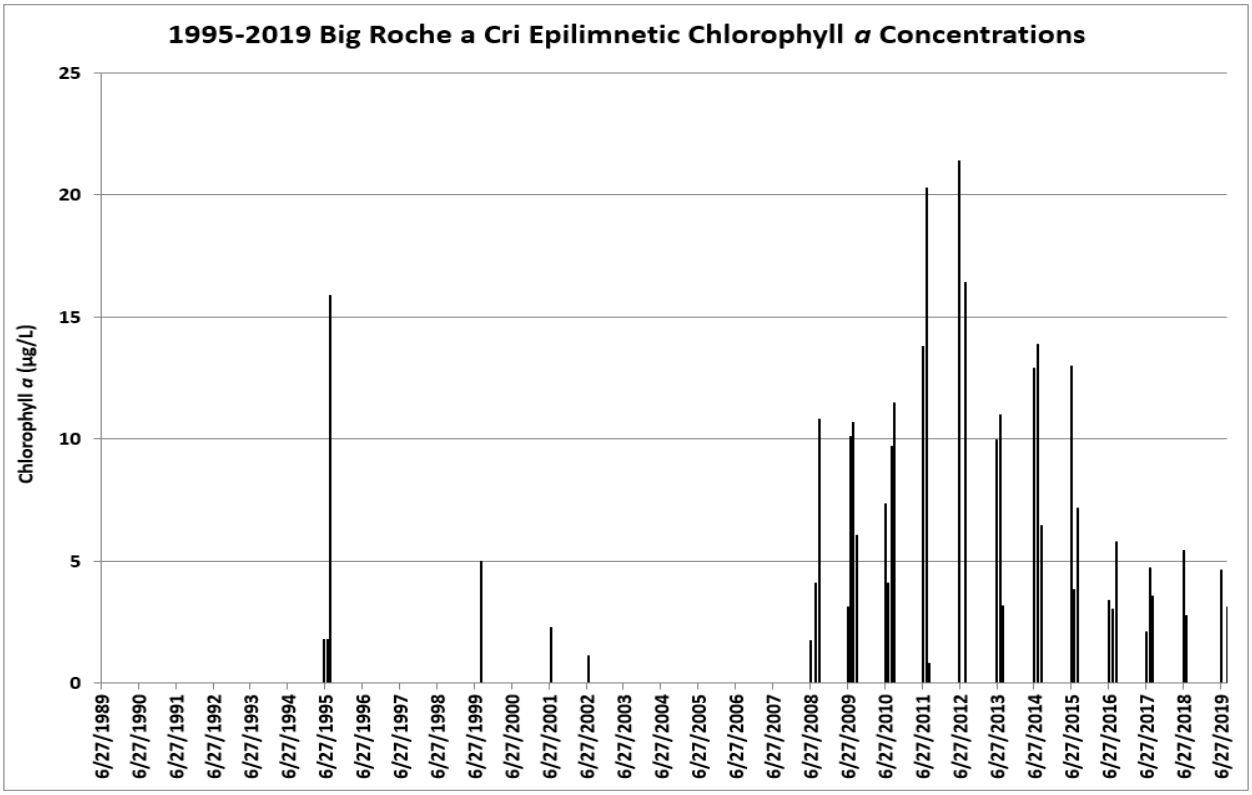
1995-2019 Big Roche a Cri Epilimnetic Chlorophyll *a* Concentrations
Chlorophyll *a* (µg/L)
0
5
10
15
20
25
6/27/1989
6/27/1990
6/27/1991
6/27/1992
6/27/1993
6/27/1994
6/27/1995
6/27/1996
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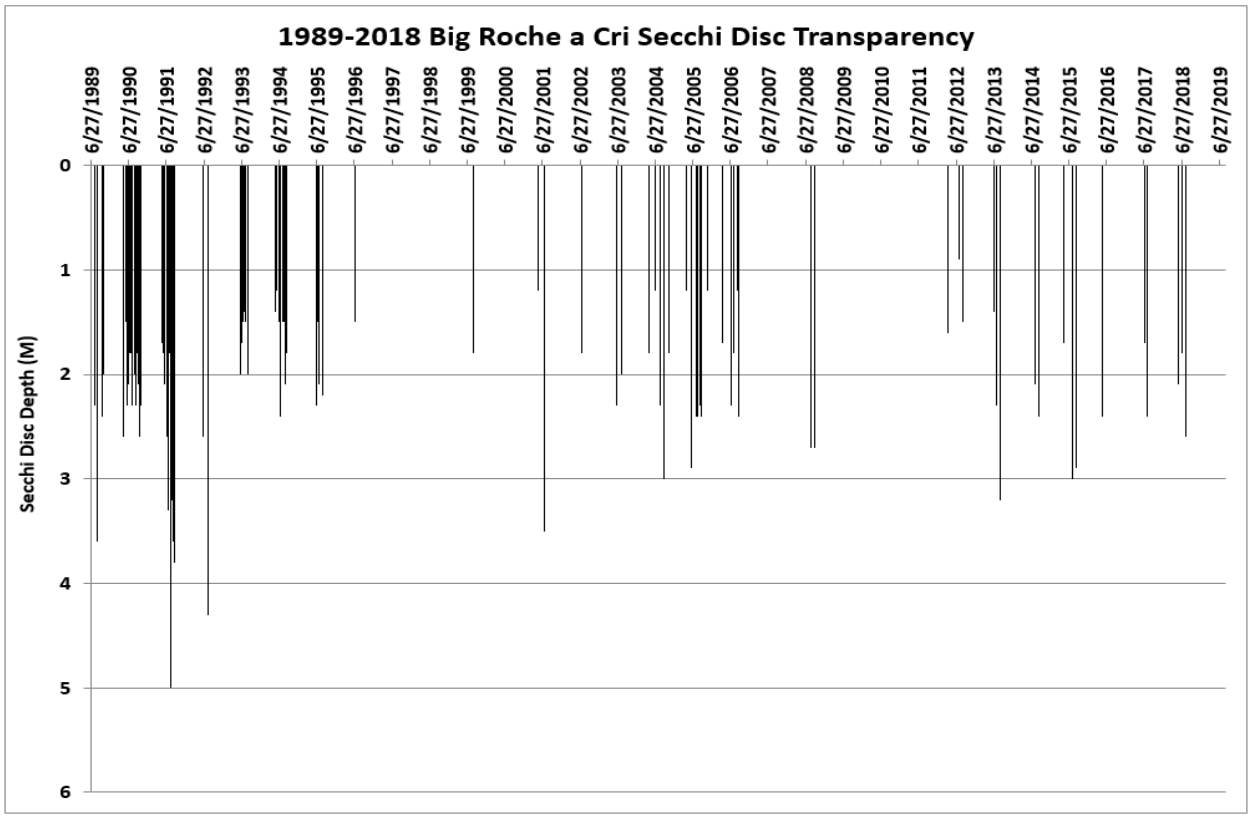

- WDNR has monitored Big Roche-A-Cri Creek and its tributaries (including Dry Creek, Buckner Creek and Unnamed Creek) for water quality, macro-invertebrates and fish habitat. A portion of the creek is designated as an Outstanding Resource Water and is intended to support trout. Some of the stream monitoring sites included sample results for phosphorus, but there was no consistent or continuous series of water quality samples associated with stream flows. Only one sample result for nitrate (6.42 mg/L on 10/13/11) from Buckner Creek, and six discrete sampling events were sampled for nitrogen parameters (nitrate, TKN and ammonia) from Big Roche-A-Cri Creek at CTH W in 2011, were available from the database for all of the watershed stream monitoring sites. None of the available nitrogen data was paired with flow monitoring.

- No USGS or other flow monitoring stations were identified in the Big Roche-A-Cri Lake watershed. Some of the stream monitoring sites included paired flow and temperature monitoring.

- No sediment monitoring data was found for Big Roche-A-Cri Lake.

- Overall, the available watershed monitoring data does not allow for the determination of stream nutrient (both phosphorus and nitrogen) loadings delivered to Big Roche-A-Cri Lake.

Big Roche-A-Cri Lake Management Plan

The Big Roche-A-Cri Lake Management Plan (Big Roche-A-Cri Lake Management Plan Advisory Group, 2015) consists of goals and action items intended to address natural resource issues and activities for a five-year period. The report also documented lake and watershed characteristics, prior studies of the lake and watershed, and an inventory to survey the lake property owners for management issues and goals.

Summary of data gaps to be filled for future planning efforts

For decades, research has documented that nitrogen and phosphorus are the nutrients of primary concern for aquatic plants and these are the nutrients that determine aquatic plant abundance (Nichols et al. 1988, Vollenweider 1968, Sawyer 1947, Stewart and Rolich 1967, Barker et al. 2008). Shultz and Maleug (1973) demonstrated that rooted plants will remove nutrients from both the water and sediment media. Gerloff (1969) found that plants will not only remove the amount of nutrients they require, but will also remove nutrients in excess of their needs – luxury consumption. Chapman et al. (1968) described the ability of aquatic plants to concentrate elements from their environment. These excess nutrients could be used at times when the plant undergoes nutrient stress. Barker et al. (2008) confirmed reductions in species richness of aquatic plant communities in shallow lakes as winter nitrate concentrations rise above 1 to 2 mg/L. Potential habitats of Eurasian watermilfoil were linked with chlorophyll-a, nitrate, suspended solids, water temperature, water depth and velocity (Son et al., 2017). Nutrient management is integral to successful protection of lake water quality and management of aquatic plants and fisheries.

The largest gaps in our understanding of the factors that are impacting Big Roche-A-Cri Lake water quality and biological integrity include the following:

- The available watershed (inflow) monitoring data does not allow for the determination of stream nutrient (both phosphorus and nitrogen) loadings delivered to Big Roche-A-Cri Lake, nor does it allow us to differentiate/quantify the individual sources.
- Citizen lake water quality monitoring does not include data for nitrogen forms that may affect aquatic plant growth and/or diversity.
- There is not a concerted effort to log lake levels and/or flow through the Big Roche-A-Cri Lake system. As a result, it is not clear if the aquatic plant surveys from 2008 or 2019 were representative of typical hydrologic (climatic) or water quality conditions.
- More fisheries survey data, paired with the aforementioned parameters, will be necessary to fully evaluate the potential stressors on the biologic integrity of Big Roche-A-Cri Lake.

Recommendations

Given the aforementioned data gaps, it is recommended that state and local water resource professionals collect the following monitoring data and complete the suggested planning:

- Collect watershed (inflow) monitoring data for two years, including continuous flow and stream phosphorus and nitrogen concentrations, and use the monitoring data to calculate nutrient loadings.
- Gauge the lake outflow so that lake stage elevation data can be collected and matched up with an outflow/spillway rating curve and the hydraulic residence time of the lake can be calculated.
- Repeat fisheries and aquatic plant surveys during one of the two years of recommended inflow monitoring, consistent with the monitoring performed in 2019; this data can be used to identify potential stressors for biologic integrity.
- Update the monitoring database
- Evaluate potential stressors for biologic integrity
- Develop a 9 Key Elements Plan or an updated Lake Management Plan

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Water Quality Data and Reports from Citizen Based Monitoring for 1989-2019. https://dnr.wi.gov/lakes/CLMN/Station.aspx?id=013007

WDNR. WDNR Surface Water Data Viewer to access the SWIMS database. https://dnr.wi.gov/topic/surfacewater/swdv/