

Memorandum

From: Hans Holmberg and Shanna Rucker Blount
To: Chris Bedwell and Jim Coors, COLA
 Dan Tyrolt, LCOCD
Date: April 4, 2024
Project: LCO
CC:

SUBJECT: WisCALM Assessment Update for Lac Courte Oreilles, Data through 2023

Background

The surface water quality of Lac Courte Oreilles (LCO) was assessed using the Wisconsin Department of Natural Resources (DNR) Consolidated Assessment and Listing Methodology (WisCALM 2024).

LCO is classified as a two-story fishery lake with both Fish and Aquatic Life (FAL) and recreational (REC) use designations. LCO must not exceed impairment thresholds for total phosphorus (TP) and chlorophyll *a*, as shown in Table 1. A new TP site-specific criterion of 10 µg/L for the protection of FAL has been established for LCO. Additional biological indicator metrics include macrophyte growth, dissolved oxygen, and cold-water habitat quantity.

Table 1: Two-story fishery criteria and thresholds currently applicable to LCO

Criteria for two-story fishery lake	Threshold	Relevant Sampling Locations
FAL TP	≥10 µg/L	LCO 2, LCO 3, LCO 4
REC TP	≥15 µg/L	
FAL chlorophyll <i>a</i>	≥8 µg/L	
REC chlorophyll <i>a</i>	≥5% of days with ≥20 µg/L	

Musky Bay, while hydrologically connected to the Major Basins of LCO, is classified by the DNR as a shallow lake with both Fish and Aquatic Life (FAL) and recreational (REC) use designations. Musky Bay must not exceed impairment thresholds for total phosphorus (TP) and chlorophyll *a*, as shown in Table 2.

Table 2: Shallow-lake criteria and thresholds currently applicable to Musky Bay

Criteria for shallow lakes	Threshold	Relevant Sampling Locations
FAL TP	≥40 µg/L	MB 1
REC TP	≥40 µg/L	
FAL chlorophyll <i>a</i>	≥27 µg/L	
REC chlorophyll <i>a</i>	≥30% of days with ≥20 µg/L	

The lake and its Major Basins and bays are shown in Figure 1.

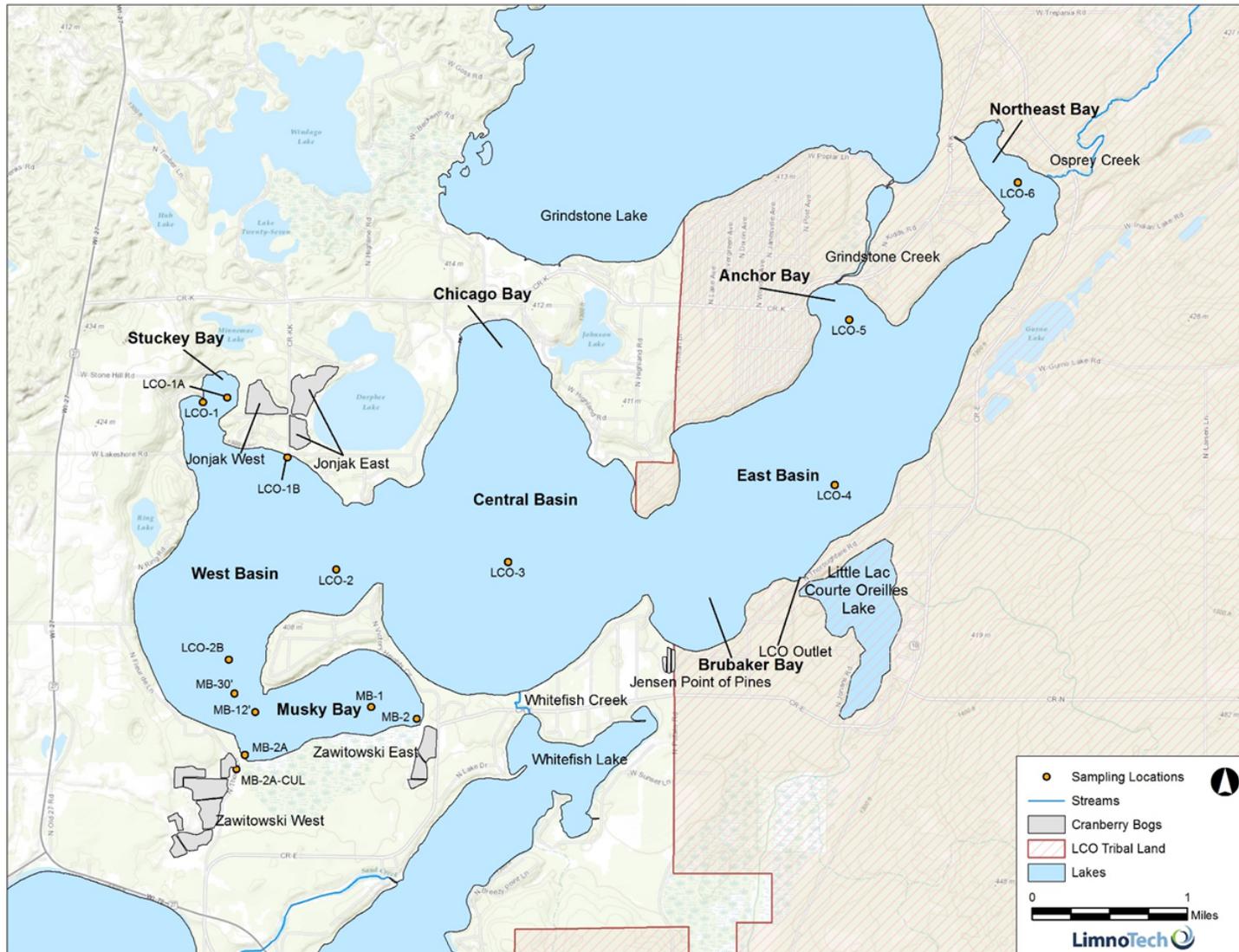


Figure 1: LCO map showing major basins and bays, sampling stations, and cranberry bog locations.

Compiled LCO Data

There are eight LCO locations that are sampled routinely throughout the ice-off season by the LCO Conservation Department (LCOCD). These locations are presented in Table 3 and Figure 1. During the most recent five years, between 2019 and 2023, samples were collected weekly or biweekly at these locations. Analysis of surficial TP and surficial chlorophyll *a* were made on each sample collected.

Table 3: LCO Sampling Characteristics (2019-2023)

Location Name	Station Code	Sampling Frequency	# of TP Samples ¹	# of Chlorophyll <i>a</i> Samples ²	# of Qualifying Years
Musky Bay	MB 1	weekly-biweekly	40	23	5
Stuckey Bay	LCO 1	weekly-biweekly	34	22	5
West Basin near Musky Bay	LCO 2B	weekly-biweekly	35	20	5
West Basin	LCO 2	weekly-biweekly	34	22	5
Central Basin	LCO 3	weekly-biweekly	35	22	5
East Basin	LCO 4	weekly-biweekly	36	22	5
Anchor Bay	LCO 5	weekly-biweekly	33	22	5
Northeast Bay	LCO 6	weekly-biweekly	33	22	5
		Total	280	175	-

¹ samples counted during the target date range of June 1st – September 15th

² samples counted during the target date range of July 15th – September 15th (also includes 7/14/21 and 7/13/22 samples collected within one week of the sample season)

TP Assessment

Fish and Aquatic Life and Recreational Usage

WisCALM assessment: The TP impairment threshold for two-story fishery lakes in Wisconsin is 10 µg/L for the fish and aquatic life (FAL) and 15 µg/L for the recreational (REC) use designations. The more protective threshold of 10 µg/L is used in the assessment. The TP impairment threshold for shallow lakes is 40 µg/L for both FAL and REC use designations. WisCALM states that if the lower bound of the 80% two-sided confidence interval of the mean concentration between June 1st and September 15th exceeds this threshold, there is an exceedance; and if it exceeds 1.5 times the threshold there is an overwhelming exceedance.

Of the three deep sampling locations in the Major Basins (LCO 2, LCO 3, and LCO 4), all three have a 5-year mean greater than the 10 µg/L standard (15.6, 14.3, and 13.7 µg/L, respectively). Additionally, the lower confidence intervals for the three locations also exceed 10 µg/L. Therefore, they are considered to be clearly exceeding the standard. See Figure 3 for mean concentrations and confidence limits.

Additional analyses: Although WisCALM compares only the deep spots of the three main basins to the criteria, COLA also finds it informative to evaluate the bay concentrations and to calculate an area-weighted lake-wide average that includes both basins and bays. The average TP concentration in Musky Bay over the 2019-2023 period (27.1 µg/L) did not exceed the shallow lake TP criterion (40 µg/L). See Figure 3 for mean concentrations and confidence limits for the other individual locations.

The area-weighted lake-wide average during the 2019-2023 period was 15.1 µg/L, a 1.4% decrease as compared to the 2018-2022 period of 15.3 µg/L.

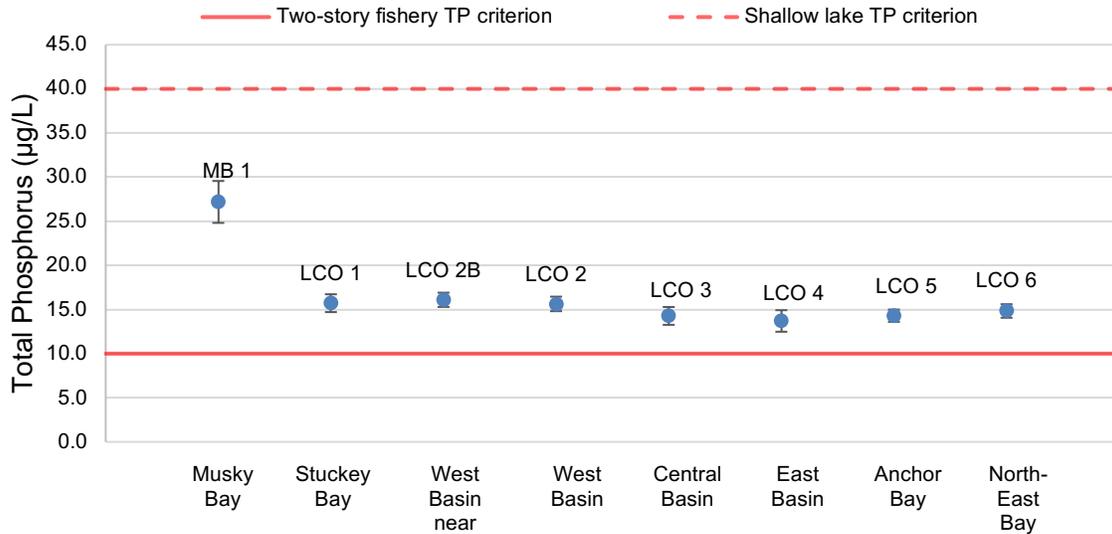


Figure 3: Monthly mean TP concentrations in LCO, 2019-2023. Error bars represent 80% confidence interval of the mean.

The recreational season mean TP concentrations for the Major Basins and Musky Bay were analyzed for temporal trends from 2002 to 2023. The Mann-Kendall Test was used to identify statistically significant trends. Statistically significant temporal trends ($p < 0.05$) were identified at the major basins (increasing TP, $p = 0.011$) and Musky Bay (decreasing TP, $p = 0.009$) using the annual area-weighted average concentration across the recreation season. The significant trends are shown in Figure 4.

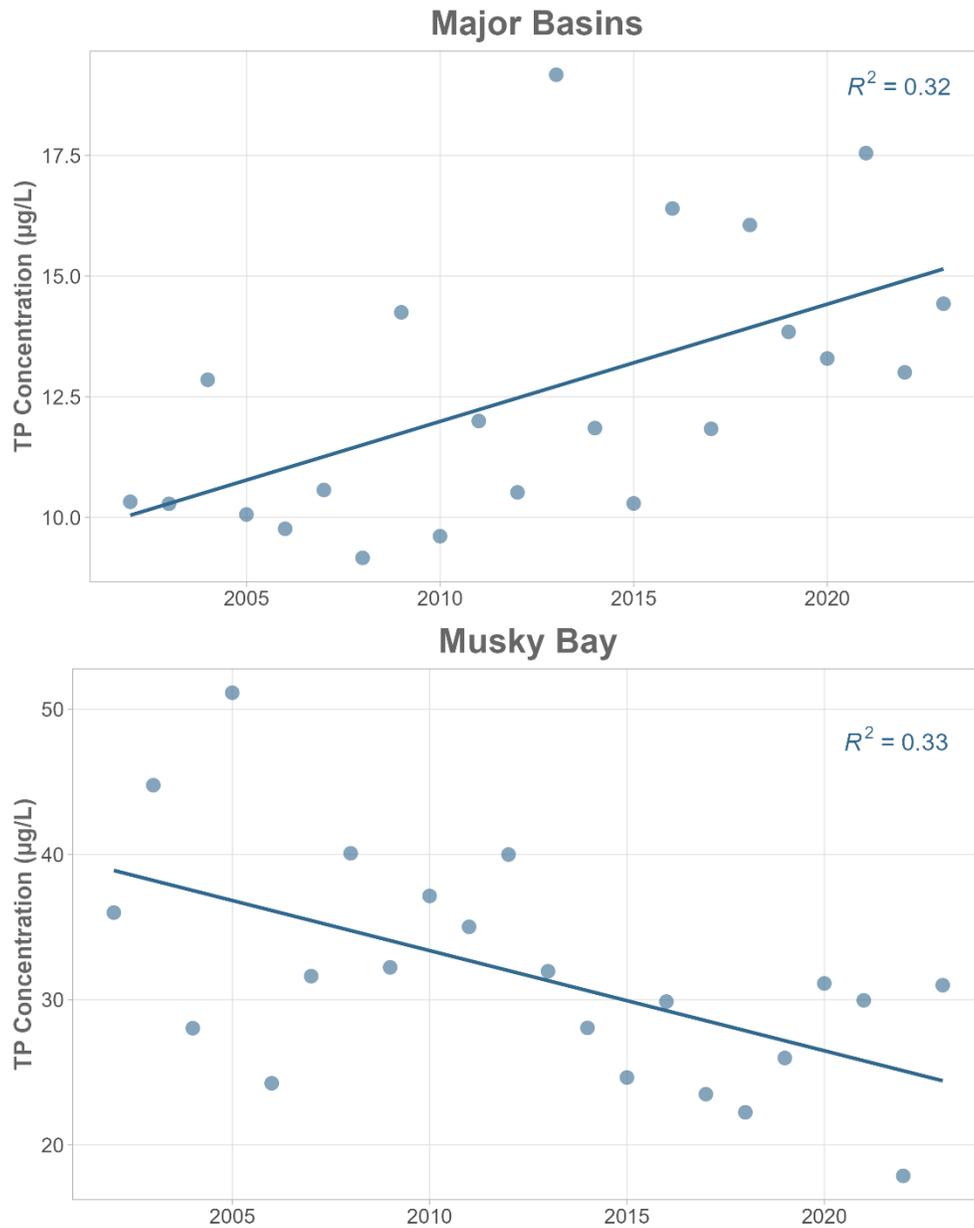


Figure 4. Statistically significant trends in recreational season mean total phosphorus concentration in LCO and Musky Bay.

The area-weighted lake-wide average TP concentration in 2023 (15.5 µg/L) was 2.3% higher than the overall weighted average during the entire 2019-2023 assessment period (15.1 µg/L).

Musky Bay average concentrations for TP did not exceed the shallow lake criterion of 40 µg/L in 2023. The 2023 average concentration was greater than the concentrations from both 2021 and 2022. Despite the increase in TP concentrations, the long term trend of Musky Bay TP concentrations is decreasing, as previously observed in recent years. All Major Basin sampling locations had average TP concentrations above the current two-story fishery criterion of 10 µg/L in 2023 (Figure 5).

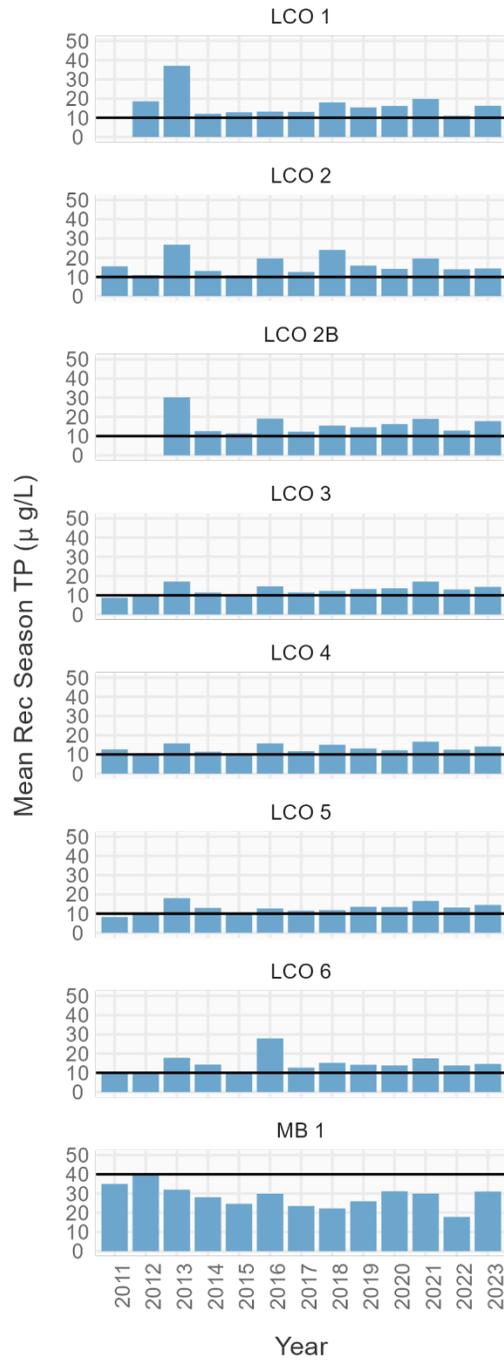


Figure 5: Annual average of monthly mean TP concentrations for identification of non-compliance with applicable standards, 2011-2023. Applicable standards are shown in black lines.

Chlorophyll *a* Assessment

Fish and Aquatic Life

The 2024 WisCALM updates the chlorophyll *a* impairment threshold for two-story fishery lakes in Wisconsin to 8 µg/L for the FAL use designations. The impairment threshold for shallow lakes (that is applied to Musky Bay) remains at 27 µg/L. WisCALM states that if the lower bound of the 80% two-sided confidence interval of the mean concentration between July 15th and September 15th exceeds this threshold, there is an impairment.

The available chlorophyll *a* data do not demonstrate an impairment at LCO sampling locations using the WisCALM thresholds for fish and aquatic life use. The concentrations of the three main basins clearly meet the criteria of 8 µg/L, and Musky Bay clearly meets the criterion of 27 µg/L (Figure 6). Other bays sampled also show low chlorophyll *a* concentrations.

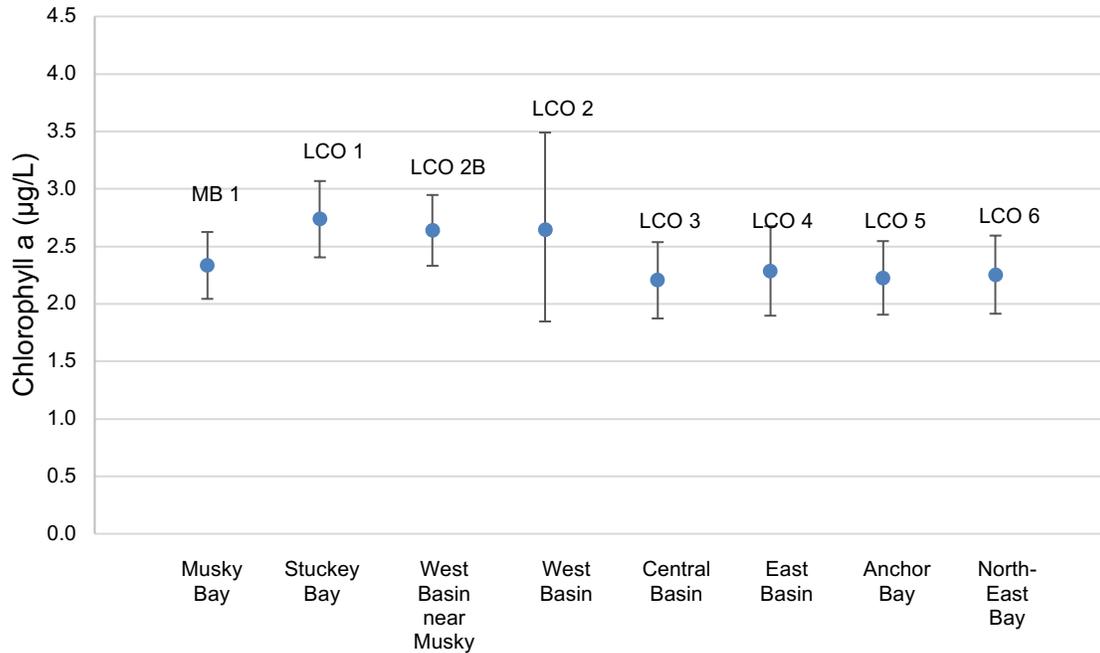


Figure 6: Monthly mean chlorophyll *a* concentrations in LCO, 2019-2023. Error bars represent 80% two-sided confidence interval of the mean.

Recreational Usage

The chlorophyll *a* impairment threshold for two-story fishery lakes in Wisconsin is no more than 5% of days with “nuisance algal blooms.” The impairment threshold for shallow lakes (which applies to Musky Bay) is no more than 30% days with “nuisance algal blooms.” WisCALM states that “nuisance algal blooms” are defined as days exceeding 20 µg/L chlorophyll *a* during the period between July 15th and September 15th. If more than 5% of days exceed this criterion, the waterbody is impaired.

During this assessment period (2019-2023), there were no observed chlorophyll *a* concentrations greater than 20 µg/L.

Dissolved Oxygen and Cold-Water Habitat

Cisco, lake whitefish and other cold-water fishes need a band of water that has both cold enough temperatures and high enough oxygen for them to survive. Therefore, measures that represent the presence and overall quantity of suitable habitat by combining both dissolved oxygen (DO) and temperature are needed for assessing support of the two-story fishery.

Habitat Quantity

An assessment of LCO temperature and DO profile data was performed to evaluate the habitat quantity available for cisco and lake whitefish in LCO. The critical habitat, or the minimum habitat quantity over the course of a year, was quantified for the years 2019-2023. Suitable habitat was quantified as maintaining a depth of at least 1 meter above a DO concentration of 6 mg/L and below a temperature of 66°F to support sustainable cisco and lake whitefish populations in LCO. Available temperature and DO profiles were assessed at the three deep sampling locations in the Major Basins: LCO 2 in the West Basin; LCO 3 in the Central Basin; and LCO 4 in the East Basin. For the years 2019-2023, a desirable habitat was not maintained throughout each year, indicating the absence of a suitable season-long habitat for cold-water species.

Suitable habitat for whitefish was absent from the Major Basins on at least one profiling day in each of the last five years. The duration of stress, or suboptimal habitat, was also assessed at each location in 2023 (Figures 7-9). The duration helps quantify the amount of stress that a certain species may face in a given year due to habitat depletion. In 2023, suitable habitat with a depth of at least 1 meter was absent for 20-34 days in the West Basin, for 25-55 days in the Central Basin, and for 0-14 days in the East Basin.

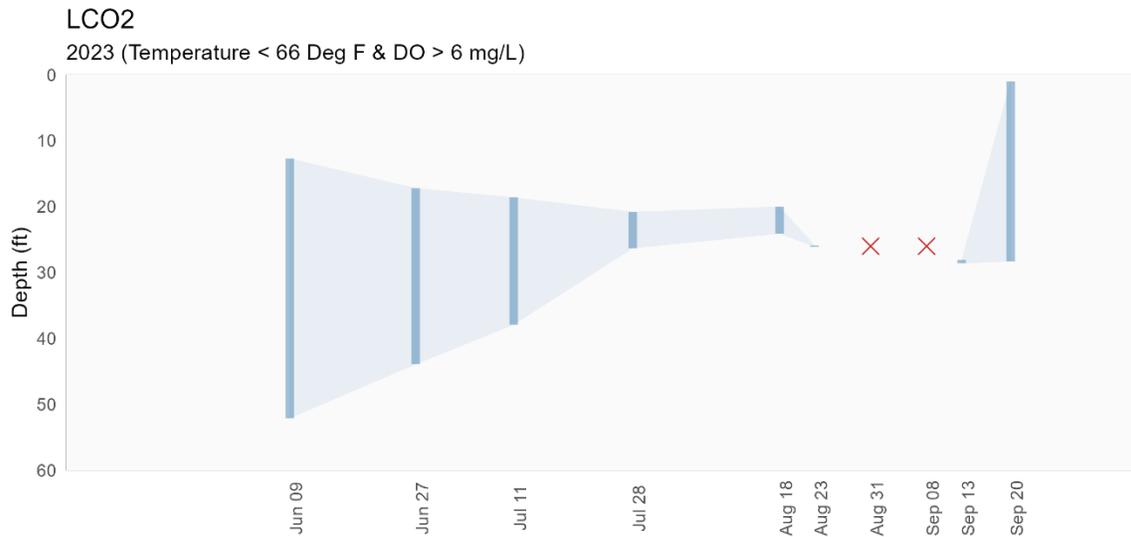


Figure 7: Depth of suitable habitat (blue) for whitefish in the West Basin. Days with profiles are shown on the x-axis. Solid lines show the range of suitable habitat from a profile. Red 'x'

marks are placed where profiles were taken but no suitable habitat was measured. The habitat ranges filled in with light blue were interpolated between profiling dates.

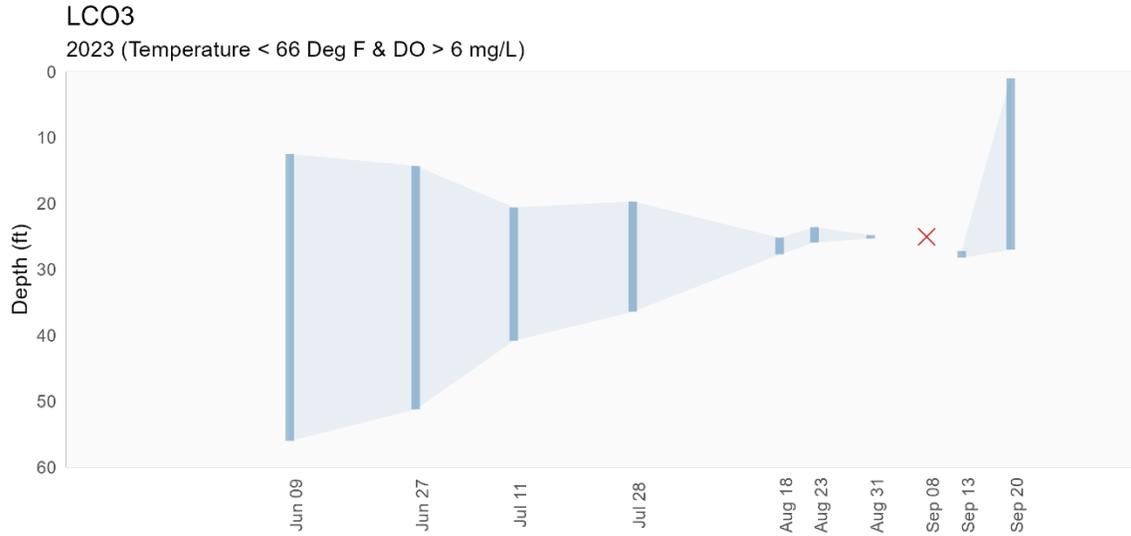


Figure 8: Depth of suitable habitat (blue) for whitefish in the Central Basin. Days with profiles are shown on the x-axis. Solid lines show the range of suitable habitat from a profile. Red ‘x’ marks are placed where profiles were taken but no suitable habitat was measured. The habitat ranges filled in with light blue were interpolated between profiling dates.

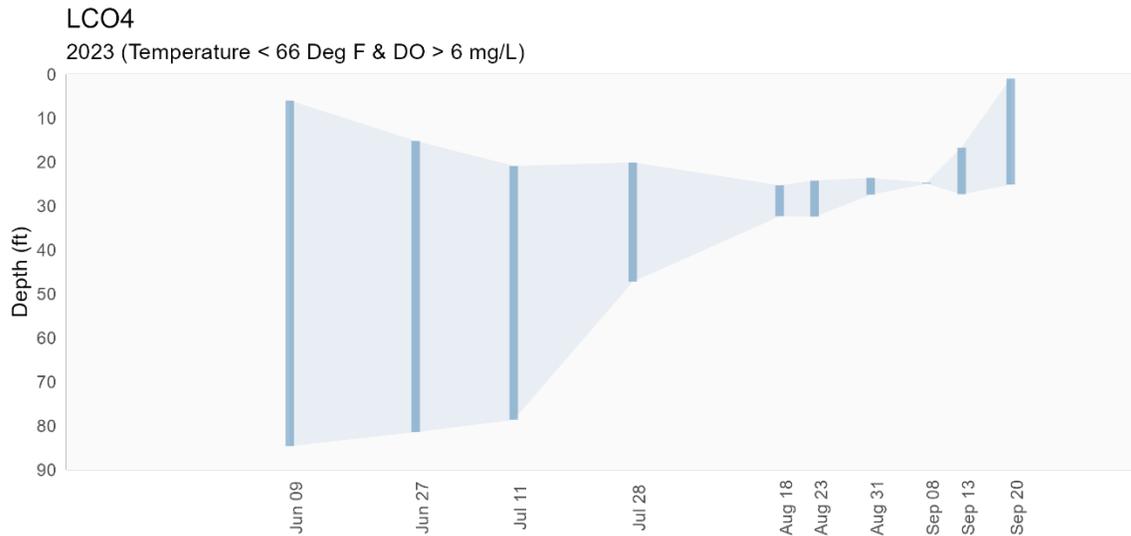


Figure 9: Depth of suitable habitat (blue) for whitefish in the East Basin. Days with profiles are shown on the x-axis. Solid lines show the range of suitable habitat from a profile. Red ‘x’ marks are placed where profiles were taken but no suitable habitat was measured. The habitat ranges filled in with light blue were interpolated between profiling dates.

Conclusions

The update of the WisCALM assessment for LCO, using data for the most recent five years (2019-2023), continues to confirm impairment of the two-story cold-water fishery habitat for cisco and lake whitefish. The measures of TP above the site-specific criterion of 10 µg/L and the oxythermal habitat band dropping below 1m demonstrate the impairment of this designated use.

Additionally, a statistically significant increasing trend in total phosphorus concentration was identified at the major basins suggesting a degradation in water quality.

This update demonstrates that conclusions from previous assessments remain the same, as listed below.

- Continued data collection in LCO is critically important;
- Understanding and addressing the drivers of the impaired oxythermal habitat for cisco and lake whitefish is high priority. The habitat for cold-water species has been found to be insufficient (< 1 m) every year since at least 2013;
- Results of TP and Chlorophyll *a* sampling and analysis generally indicate higher levels in the western end of LCO. This includes the West Basin and both Musky Bay and Stuckey Bay. Cranberry bogs discharge to Musky Bay and Stuckey Bay;
- The 2024 WisCALM requires the Lower Confidence Level (LCL) of the TP data to exceed the applicable criterion to list phosphorus as the cause of impairment. The calculation of the LCL for 2019-2023 data indicates that all LCLs for the major basin monitoring stations clearly exceed the currently applicable criterion of 10 µg/L. Therefore, DNR should list LCO as impaired for TP.

Consistent with last year's assessment, LimnoTech recommends an updated survey of overall fish community structure in Lac Courte Oreilles take place. Methods could follow DNR fyke and electrofishing protocols, as previously conducted. The goals of the survey should consider characterizing and evaluating:

1. Cold-water community abundance and richness
2. Overall fish community abundance and richness
3. Age distribution of existing cold-water populations
4. Cold-water species movements during periods of oxythermal stress

Routine data collection demonstrates that there are insufficient oxythermal conditions for cold-water species, but little is known about the status of the cold-water species populations. No fish kills have been reported in the past several years, however, there are not enough data to describe how the fish populations are responding to impaired conditions.

The 2012 DNR fyke netting and creel surveys noted a pike fyke net capture rate of 8 per net-night indicating a population "greater than desired".¹ This high population is affirmed by the most recent (2016) fyke netting and creel surveys which reported a pike catch rate of 35 per net-night.² These reports suggest possible food web pressure on the fish community, but community structure assessments have not been reported since 2016. The current status of the fish community is uncertain.

¹ <https://dnr.wi.gov/topic/fishing/documents/north/2012LacCourtOreillesSawyerFykeNet.pdf>

² <https://dnr.wi.gov/topic/fishing/documents/north/SawyerLCOSEN12016.pdf>