Yahara CLEAN Phosphorus Reduction Strategy Recommendations

Prepared for the Yahara CLEAN 3.0 Steering Team, March 2021

By Matthew Diebel[1], Kyle Minks[1], Richard Lathrop[2], Jake Vander Zanden[2], Laura Ward Good[2], Todd Stuntebeck[3], Dale Robertson[3], Greg Fries[4], Mark Riedel[5], Paul Dearlove[6]

Purpose

Reducing phosphorus (P) inputs (loading) to the Yahara lakes has the greatest potential to control algal blooms and related problems. Yahara CLEAN 2.0 recommended 14 actions that together would reduce phosphorus inputs by 50% compared to the long-term average annual input to achieve clearer lakes and significantly less algal growth. The Yahara CLEAN 3.0 Phosphorus Loading Subgroup reviewed progress on these actions and changes in understanding of the problem. This report summarizes this review and our recommendations for a revised phosphorus reduction strategy. Background information to support the recommendations is also provided.

Summary

The target phosphorus load has not changed, but the baseline P load has increased because of increased precipitation, which means the target reduction has increased. Most of the 14 actions recommended by CLEAN 2.0 are still appropriate. However, we now stress that actions that are most likely to reduce P loading during winter runoff events, increase net P export from the watershed, and retain runoff should be emphasized. Rather than promoting specific practices for broad adoption, we encourage site-specific planning to identify a management system that works for each site and meets a performance target. We also recommend focusing rural actions on areas with high runoff delivery to the lakes, implementing a pilot watershed project, and aligning progress tracking with Yahara WINS.

Recommendations

1. **The target phosphorus load has not changed, but the baseline P load has increased, which means the target reduction has increased.** The annual P load delivered to the lakes from the watershed during the late 1980's and early 2000's droughts were used by Lathrop and Carpenter (2014) to set the average annual target load of 47,600 lbs/year. In-lake P concentrations declined to a desirable 24 µg/L in lakes Mendota and Monona under these conditions. In turn, it is estimated that this reduction would result in a doubling of summer days when the lakes would be free of nuisance algal blooms. While there have been changes in the lakes since CLEAN 2.0 that might affect their response to load reduction, such as the infestation of invasive zebra mussels, no alternative load target has

[1] Dane County Land & Water Resources
[2] University of Wisconsin-Madison
[3] United States Geological Survey
[4] City of Madison Engineering
[5] Wisconsin Department of Natural Resources
[6] Clean Lakes Alliance

been established. We recommend retaining the target load of 47,600 lbs/year, with a similar distribution of this load among the lakes as in CLEAN 2.0.

The average annual load during the 1976-2008 baseline period for CLEAN 2.0 was 95,200 lbs/year. Using data from 1990-2020, the current baseline load increased to 110,100 lbs/year (Table 1). This means that the reduction needed to meet the target is now 62,500 lbs/year, or 57%, from current conditions. The increase in the baseline and the target load reduction does not mean that actions taken since CLEAN 2.0 have had no effect; instead there is a strong correlation between recent wetter weather and increased runoff and P loading. It is difficult to accurately estimate the P load reductions that have occurred from implemented actions. Therefore, the focus on using estimated P reductions by specific practices as a metric to message progress should be downplayed, in terms of planning action and in communicating annual progress to the public.

Table 1. Summary of annual input P loads (lbs/year) for the Yahara lakes.

Direct Drainage P Load	Mendota	Monona	Waubesa	Kegonsa	Total
1976-2008 Average[a]	65,300	16,500	4,600	8,800	95,200
1990-2020 Average	75,500[b]	19,100[c]	5,300[c]	10,200[c]	110,100
Target[a]	32,600	8,300	2,300	4,400	47,600

a. Lathrop & Carpenter (2014)
b. Sum of measured tributary loads plus estimates of ungauged areas (14%)
c. 1976-2008 average multiplied by ratio of 1990-2020 to 1976-2008 averages for Mendota

2. **Implement cost-effective urban actions and promote policies where urban areas fund additional rural practices.** Reducing P loading from established urban areas is relatively expensive (per pound of P) compared with rural areas. Agreements such as Yahara WINS, which allow urban areas to fund rural practices that reduce P loading, should be supported because they are potentially much more cost-effective. Urban actions recommended by CLEAN 2.0 should continue to be implemented. In particular, leaf management has the potential to greatly reduce urban P loading (including dissolved P), but further work is needed on operational feasibility.

3. **Group rural actions that relate to agricultural operations as a P Index performance target.** The majority of the rural actions in the CLEAN 2.0 plan are related to agricultural operations. While that plan categorizes these actions, they are all strongly inter-related parts of agricultural management systems, including the actions related to manure digesters. As such, we recommend grouping these actions as "Reduce phosphorus loss to surface waters from agricultural operations." Because the effects of individual practices are difficult to isolate from the overall performance of the management system, the integrative Wisconsin P Index appears to be the best way to track progress by agricultural operations.

   For example, the average P Index in the Lake Mendota watershed in 2019 was 3.0. To meet the target P load, a 57% reduction, means the average P Index target should be 1.3. This doesn't mean that all fields, or even all farm averages, need to be at 1.3, but that the average P Index, weighted by runoff delivery should be 1.3. In 2019, 22% of Mendota

watershed fields had P Index values less than 1.3. If all fields that currently have a PI > 3 were to decrease to 3, the watershed average would decrease by 30% to 2.1. This would be a good interim goal.

4. **Group other rural actions as "Practices to reduce P transport through the drainage network."** The existing drainage network of the Yahara watershed efficiently transports P, including both current and legacy sources, to the lakes. There are several practices that can slow or stop P transport, including dredging legacy sediment from streams and ditches, stabilizing eroding stream banks, restoring wetlands, and constructing basins. This family of practices can play an important role in the overall P reduction plan, but because the choice of practice is site-specific, they should be considered as a group for planning purposes.

5. **Emphasize rural actions that are most likely to reduce P loading during winter runoff events, increase net P export from the watershed, and retain runoff.**

    a. **Winter runoff**: The largest fraction of annual P loading occurs during winter (Jan-Mar) when rain and snowmelt occur on frozen ground with little vegetation to slow runoff. Actions that have the potential to reduce winter P runoff include reducing P sources (soil P and soluble P on the soil surface), retaining runoff in constructed basins or natural depressions, and converting cropland to perennial vegetation. Other practices, such as cover crops, can also be effective in some situations.

    b. **Net phosphorus export:** Actions that increase net P export out of the Yahara watershed have the greatest potential to result in lasting improvements in the lakes. The most promising methods include transporting manure (usually digested or composted solids) outside of the watershed, transporting manure within the watershed to replace commercial P fertilizer for non-livestock farms, and reducing imports of P-containing fertilizers and feed supplements.

    c. **Retain runoff:** The terrain of the Yahara watershed was very good at retaining runoff, but land drainage in ditches, drain tiles, and storm sewers has reduced this retention capacity. Retention of runoff reduces both P loading and flooding. Actions that could help retain more runoff include preventing additional land drainage (i.e., creating culverts and other drainage outlets into topographic depressions that currently hold water), improving soil infiltration capacity by reducing tillage and increasing organic matter, and constructing basins in strategic locations to retain runoff.

6. **Focus rural actions on areas with high runoff delivery to the lakes.** It has been known for a long time that parts of the Yahara watershed are topographic depressions, which are also called internally drained areas. These areas collect runoff from their watersheds, and it either infiltrates into the ground, is taken up by vegetation, or evaporates. For the most part, the land that drains to these depressions has a relatively minor effect on the lakes. Until recently, about 15% of the Yahara watershed was mapped as internally drained, and P-reducing actions in these areas have been excluded from progress tracking. New terrain data derived from LiDAR, plus new GIS tools, have made it possible to refine this map. Now, we estimate that about 41% of the Yahara watershed is internally drained. This means that future actions should be targeted to the other 59% of the watershed where runoff is delivered directly to the lakes.

7. **Implement a pilot watershed project.** In large, complex systems like the Yahara watershed, when actions do not achieve predicted outcomes, it can be hard to isolate the reason; possibilities include lag times in the movement of P through the watershed, inaccurate estimates of the effectiveness of actions, unaccounted-for land use changes, and weather variation. To help understand these factors with the goal of making better decisions in the future, we recommend implementing a pilot watershed project on a relatively small sub-watershed within the larger Yahara watershed. The Dorn Creek watershed would be a good option for this approach because it is the smallest area and has the highest P yield (lbs/acre/year) of the gauged tributaries. With this approach, extra P reduction efforts are focused on the pilot watershed to determine how much is needed to reach the target P yield (load per watershed area), that if achieved over the entire watershed, would meet the lake water quality goal. Additional water quality monitoring in the pilot watershed would help determine which specific P-reducing actions were most effective. Actions would continue concurrently in the rest of the watershed, but at a lesser intensity. Findings from the pilot watershed would be reviewed periodically and used to revise the watershed-wide strategy.
8. **Refine public messaging on progress and align with Yahara WINS.** Progress toward water quality goals is currently tracked in three main areas: land management, tributary P loading, and in-lake water quality. It is challenging to synthesize sometimes conflicting information into a coherent public message.