Notes from PPT presentation:

Process:

Aluminum sulfate is added to lake water to remove phosphate through precipitation, forming a heavier particulate (called floc) that settles to the lake bottom. This creates a barrier that retards sediment phosphorus release. The floc initially is "fluffy" and becomes more crystalline over time. A biofilm layer will also form over the floc layer and protect it from disruption.

Dosing is the biggest challenge and, along with sediment disruption, is most likely reason for failure in shallow lakes. To add enough alum to correctly dose the lake, the treatment is usually split into 2 installments and added over a couple of years, usually with a "rest" year in-between. The entire dose can't be added at once because the pH needs to remain between 6-8 to prevent the release of free and toxic Al compounds.

According to the North American Lake Management Society:

1) Alum is a safe and effective lake management tool.
2) Alum applications should be designed and controlled to avoid concerns with toxicity to aquatic life.
3) Watershed management is an essential element of protecting and managing lakes. In cases where watershed phosphorus reductions are neither adequate nor timely, alum is an appropriate tool to accomplish meaningful water quality objectives.

Minor periodic treatments may be needed after the first full dose has been added to the lake. According to one study with high continuing external load, the maintenance dose was ~1/10 the original dose.

Timing: Spring treatments are most effective and recommended. Plant material can prevent an even layer of alum settling into the lake. Patchy coverage would allow phosphorus sediment release from areas that were missed by the alum. However, Goose Lake has high algae and very little plant coverage. Therefore, engineering has recommended that an initial fall treatment would be acceptable. A fall treatment would slow down development of the biofilm layer because cold temperatures will limit growth. In the event of a fall treatment, ideally no motorboat activity would be allowed for at least the following year.

History:

Many lakes have been effectively treated with alum, including many shallow lakes. A minimum of 24 Minnesota lakes are included in the literature. Many treated lakes are not represented in the literature because they were not part of a published scientific study. The Midwest has been a pioneering location for lake alum treatments. The first ones were done in WI, in the early 1970s. Mean longevity of treatments is 11 years, regularly up to 15 years. In shallow lakes, the mean longevity is 5.7 years up to 14 years.

Stratified lakes are more successful with alum treatments. Increasing mixing (from wind and boat disturbance) increases the likelihood of P-release from resuspended sediment.

Minneapolis treated 4 lakes including Lake of the Isles (a shallow lake that was historically a small lake combined with a marsh system). They do not allow gas motors on their lakes; only electric. Gas motors have to be out of the water. This was done to protect lake water quality, shoreline stability, and allowed an increase in nonmotorized recreational use.

Mixing of the sediment can also happen as a result of benthic feeding fish (e.g., carp most often analyzed in the literature; bullhead are also benthic feeders). Carp are not present in Goose Lake. Commercial fishing removal, hired by VLAWMO, reduced bullhead abundance by 75%, in preparation for the alum treatment).

The most similar lake and case study we have found involves Half Moon Lake, Eau Claire, WI. Half Moon had a ski team with shows, invasive Curly-leaf pondweed, and high internal loading. Research directly focused on the impact of the ski team, although researchers acknowledged that boat activity was the hardest to measure and least predictable. They found that water was fully mixed at the jump site, and sediment remained anoxic at other areas. Mixing reduces stratification of the lake, and anoxic sediments release phosphorus. Turbidity and phosphorus were increased in the water column following boating activity.

The ski team was moved to another lake in 2007. Alum treatments were done in 2011 and 2017. The recommended interval of treatment for this lake is 3-5 years. Only electric motors are allowed on the lake because "Motor boat activity has been determined to disrupt the layer of alum on lake sediments, and encouraging the release of phosphorus."

Boat horsepower and mixing depth:

Horsepower	Mixing Depth (m) and (ft)	
10	1.8 m	5.9 ft
28	3.0 m	9.8 ft
50	4.6 m	15.1 ft

Goose Lake is 7.4 feet deep (maximum). Boating effects (e.g., shoreline erosion, increased turbidity, increased phosphorus release, disturbance of wildlife) are most pronounced on shallow lakes.

Some residents have asked why we don't just leave the lake alone. Toxic algae blooms are becoming more common especially in high nutrient impacted lakes, in urban heat islands, and areas that are warming overall as a result of climate change. Goose Lake has had toxic algae blooms in the past. Size and frequency of potentially harmful algal blooms are likely to increase without intervention to improve water quality.

Toxic algae blooms are dangerous to wildlife, pets, and humans. High algae and lake eutrophication are also expensive. $2.4 billion annually was calculated for U.S. annual value of losses in recreational water usage and waterfront real estate (2009). Greatest losses were attributed to lakefront property values.

What do residents want?

VLAWMO sent a letter to 47 residents living immediately adjacent to the lake, including all lake shore owners. We received responses from 9 individuals.

Residents' preferences for lake restrictions