Goose Lake

Alum treatment and best available science recommendations

We request that the Board make a recommendation for their preference in restrictions and timeframe on Goose Lake. We also request that the Board formally offer this recommendation, along with the PPT/ recorded presentation from VLAWMO, to the City of White Bear Lake, taking into consideration best available science and input from resident stakeholders. We also request authorization to submit our proposal for grant funding to BWSR in August.

We offered 4 options toward the goal of extending the life of an in-lake treatment for East Goose Lake:

1) No motorized boating,
2) No large speed boats (over a certain horsepower),
3) A 200-ft no-wake zone near shore; this would include increased monitoring following treatment so that rules could change quickly if nutrient levels increase. In the year following alum treatment on East Goose, no high-powered boats would be allowed,
4) No boating after a fall treatment until June of the following year and a no-wake zone of 200 ft. If increased monitoring shows a significant increase in phosphorus in the water, immediate restrictions would follow.

What is an alum treatment?

"Aluminum sulfate, called alum, when added to lake water removes phosphates through precipitation, forming a heavier than water particulate known as a floc. This floc then settles to the lake bottom to create a barrier that retards sediment phosphorus release."

-North American Lake Management Society

Photo from alum treatment on Bald Eagle Lake, Rice Creek Watershed District, Spring of 2014 and 2016

Alum treatment process

- Dosing concerns are the biggest issue with alum treatments in shallow lakes
  - Dose calculated based on volume of lake and concentration of P measured in sediment
  - Need to prevent pH fluctuations; maintain 6-8 pH
  - Otherwise, could lead to the release of free and toxic Al compounds (toxic to fish and other aquatic life)

    (Source: Egemose *et al.* 2009)

  - In shallow lakes, this means that the dose is usually staggered over a couple of years with a year in-between to allow the sediment to stabilize.

    E.g., ½ dose alum treatment in year 1, no treatment in year 2/minimize sediment disruption, remaining ½ dose alum treatment in year 3, no treatment in year 4/minimize sediment disruption, consider continued minor periodic retreatments as needed and determined by increased monitoring

  - In shallow lakes, the number one reason for failure of treatment is insufficient applied dose

    (Source: Huser *et al.* 2016)

NALMS Positions

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.

Photo from alum treatment on Bald Eagle Lake, Rice Creek Watershed District, Spring of 2014 and 2016

Minor periodic treatments

- Example: Lake Ketchum, small lake in WA state
  - Agricultural inputs
  - Most hypereutrophic lake in county
  - Chronic, toxic cyanobacteria blooms
  - Posted for toxic blooms 19 weeks per year
  - External inputs from a legacy agricultural source meant could not reduce external loading optimally

  - Treated in 2014: 51,042 L of alum + 28,069 L of sodium aluminate (buffer)
  - Treated in 2015: 49,210 L of alum + 30,730 L of sodium aluminate
  - Annual maintenance treatment applied: 10,978 L of alum + 6,454 L of sodium aluminate

  - Maintenance doses is approximately 1/10 of the treatment dose
  - 100,252 L vs. 10,978 L of alum

(Source: Brattebo *et al.* 2017)

Alum treatment process

- Alum-treated sediment becomes more stable with age
- Initially precipitates as a fluffy layer of light colloid-dissolved Al amorphous floc with high inorganic P adsorption properties
- Al hydroxides (in contrast to iron compounds) are redox-insensitive during anoxia (bottom sediments when P is otherwise released)
- That fluffy floc is mobile and prone to resuspension
- Changes over time to a more crystalline form, also settling and becoming buried

- A biofilm (of mineral particles, detritus, algae, and bacteria) forms over the top of the crystalline settled floc that makes it less likely to be disturbed
- Takes 2-4 months in optimal conditions (warm temperatures during growing season)

(Source: Egemose *et al.* 2009)

Ferric Chloride coagulant effectiveness

Alum treatment process

- Recommendation from Egemose *et al.*:

Al-treated sediment becomes more stable with age,
but P release is still possible with sediment disturbance

"Al application to shallow lakes prone to resuspension and with a high production must be done in periods with less resuspension risk to allow 2-4 months time for floc stabilization. Otherwise, possible resuspension and high(er) pH may lead to elevated concentrations of dissolved Al in the water column."

Timing of treatment

- Spring alum treatment is most effective
- High plant biomass can hamper alum treatment effectiveness
  - Prevents an even layer of alum settling onto the bottom

  (Source: James, W.F. *et al.* 2001)

- Previous plant surveys in the lake showed low plant biomass
- Recent survey (June 13, 2019) included 94 points and also supported previous findings
  - All points were devoid of plants, although Canada waterweed was observed
  - Lake already has high amounts of algae
  - West Goose had high Curly-leaf pondweed and other plants
- Recommendation from Barr Engineering: a fall alum treatment is viable in Goose Lake because of the sparse vegetation; spring is still optimal

Alum treatment process

- Recommendation from Barr Engineering:
  If fall treatment is applied, ideally there would be no water skiing the following year to allow the alum floc to settle, become crystalline, and for the biofilm to form during the growing season

Cost

- Budgeting $170,000 for alum treatment (See VLAWMO Budget and Water Plan)
- Alum is 50 times more effective in P removed per dollar spent than catchment BMP measures in urban lakes (Soure: Brattebo *et al.* 2017)
- Algae blooms come with health risks, unfavorable appearance, unpleasant odors, and affect property values:
- Annual value losses in recreational water usage and waterfront real estate were approximately $2.2 billion annually as a result of eutrophication in U.S. freshwaters…in 2009. "Greatest economic losses were attributed to lakefront property values ($0.3-$2.8 billion per year) and recreational use ($0.37-$1.16 billion)" (Source: Zamparas & Zacharias, 2014)

History

- At least 250 alum treatments worldwide;
  first in U.S. were Horseshoe and Snake Lakes in WI in the early 1970s
  - Commonly used and effective in-lake technique to improve water quality in eutrophic lakes
    (Source: Brattebo *et al.* 2017)

- 114 treated lakes were examined (dataset is global, including 24 MN lakes)
  - Dosing #1 issue in effectiveness
  - Presence of carp (and also benthic feeding fish) #2
  - Mean treatment last = 11 years and regularly up to 15 years
  - Shallow, polymictic (regularly mixing instead of stratified) lakes mean = 5.7 years
    - Range = 0-14 years with a maximum estimated of 16 years

    (Source: Huser *et al. 2016)*

- Earlier review paper predicted 5 years for effectiveness in shallow lakes
  and stated “alum [is] a highly cost-effective, in-lake treatment for shallow lakes”
  (with caveats, esp. veg.)

    (Source: Welch & Schrieve 1994)

History

- Minneapolis Chain of Lakes: Harriet, Calhoun, Cedar (deep lakes), and Lake of the Isles (shallow lake/was historically a small lake and marsh system that was dredged)

- Lake of the Isles: 109 acres, maximum depth 31 feet

  treatment lasted 5 years
  with positive effects still evidenced 9 years out

- City of Minneapolis does not allow gas motors; only electric

- Protection of alum treatments and allowing high-recreational nonmotorized use, and maintaining shoreline stability

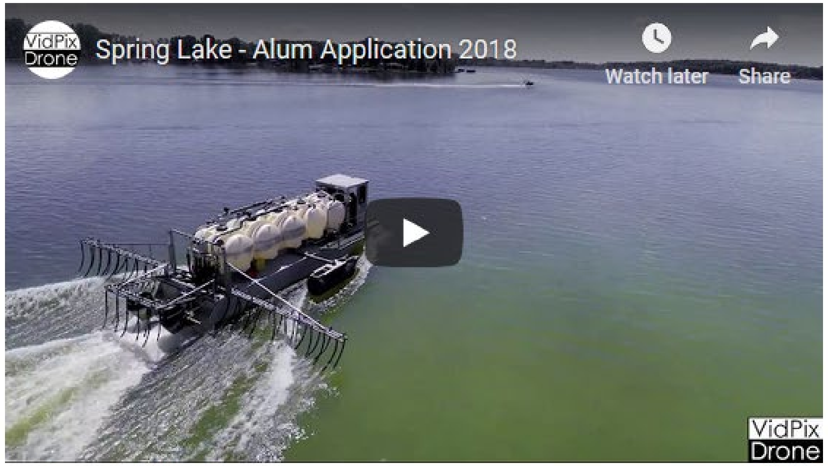
(Source: Huser *et al.* 2011)

Recent History

Spring Lake Alum Treatment

Spring Lake Alum Treatment Complete!

Posted by PLSLWD Staff - June 5, 2018 - News, Spring Lake, Spring Lake Alum Treatment



The Spring Lake Alum Treatment was completed on May 26, 2018. Mike Thibault of Prior Lake, with VidPixDrone, provided excellent footage of the treatment overlaid with some facts about the treatment itself! In case you weren't able to see the alum treatment in action, click here to view a short video capturing the barge and alum floc (learn what floc is in the video!). Fun fact: Mike's daughter wrote and recorded the music!

This was the 2nd of 3 treatments planned for Spring Lake. The first treatment was done in 2013 and the third treatment will be done in three years or so, depending on the how the water quality in Spring Lake responds.

Everything went smoothly and we have already heard great feedback from lakeshore residents. "Water quality is amazing. We were swimming this weekend and I couldn't believe how good it looked. With the heat wave last weekend [Memorial Day weekend], we should have seen more algae and didn't" said Jeff Will, a lakeshore resident of Spring Lake.

News & Events

- Ongoing Projects
  - Fish Point Park Retrofits
  - Highway 13 Ferric Chloride
  - Monitoring
  - CR 12/17 Wetland Restoration
  - Carp Management
  - Flood Study
  - Indian Ridge Park Water Quality Project
  - Spring Lake Shoreline Restoration
- Completed Projects
  - Arctic Lake Subwatershed Analysis
  - Lower Prior Diagnostic Study
  - Spring Lake Alum Treatment
- News
- Flooding Updates
- Prior Lake
- Spring Lake

News Archives

News Archives Select Month

Spring Lake is 587 acres

History and lessons learned

- Effectiveness of alum treatments depends upon:
  - Lake morphometry
  - Dose
  - Bioturbation
  - Macrophyte cover
  - Water column pH

(Source: Steinman *et al.* 2018)

Spring Lake, 2013 & 2018

Benthic feeding fish

- Bullheads
  - In 2015, 16,000 pounds of bullhead were removed from Goose Lake
  - Bullhead numbers were reduced based on 2017 follow-up fish survey results
    - In 2012, 80 Black bullhead per net
    - In 2017, 22 Black bullhead per net
    - 75% reduction
    - Conclusion in report:
      - Evidence of food web changes following harvest
      - Black bullhead numbers remained low
      - Largemouth bass, perch, and sunfish spp. lower
      - Black crappies dramatically higher.

Water skiing in Half Moon Lake, Eau Claire, WI

- Our closest example with striking similarity to Goose Lake
  - Size: HM = 132 acres   Goose = 120 acres
  - Dept: HM = 9 feet   Goose = 7.4 feet
  - Hypereutrophic
  - Internal load from historical sources
  - Curly-leaf pondweed infestation
  - Water ski team (Ski Sprites)
    - Practice and shows

  - Research studied directly impact of skiing on sediment disruption

  - Pre alum treatment: summer P budget measured
  - Sources were: 42% internal load from sediment, 20% decomposition of Curly-leaf, and 17% motor boat activity
  - Boat activity was hardest to measure and least predictable

Water skiing in Half Moon Lake, Eau Claire, WI

- But researchers didn't give up
- Measured motor boat results at the ski jump and at varying distances from high ski activity areas
- Found that water was fully mixed only at the jump site
- At all other sites, sediment remained anoxic
- DO was not increased in the water column; it was mixed (higher at sediment and lower at surface) post skiing
- Weaker stratification increased P suspension, weaker stratification = mixed
- Turbidity and P increased more widely following motor boat activity across the lake though increases were not uniform
- Anoxic sediment conditions allow release of P from sediment
- Alum treatments are more effective when lakes remain stratified

Water skiing in Half Moon Lake, Eau Claire, WI

- P resuspended from motor boat activity did not result in increases in Soluble Reactive Phosphorus (most bioavailable)
- Did result in increases in Particulate Phosphorus
  - Not as bioavailable, but has been shown to be used by algae for growth
  - Does stimulate algae growth
- Alum treatments were done in 2011, 2017, and recommendation is for retreatment on 3-5 year intervals

Sources: James *et al.* 2001, James 2017, Townsend 2018

Water skiing in Half Moon Lake, Eau Claire, WI

- Ski team was relocated to Lake Altoona in 2007

“Motor boat activity has been determined to disrupt the layer of alum on lake sediments, and encouraging the release of phosphorus. No internal combustion engines are allowed on Half Moon Lake, unless associated with research/studies.”

- Verified by Parks Division Manager
  for the City of Eau Claire, June 18, 2019

Sediment disruption with motor boat activity: Case study comparing 2 shallow lakes, 1 with motor boat activity and 1 without

- Motor boat activity creates enough disturbance on the bottom sediment to release the stored P into the overlying water

- On boating lake: turbidity increased, algae cover was significant, odor was detected, P concentrations increased significantly. Lake is susceptible to wind disturbance, but major cause of mixing is the direct result of motor boat activity
- On nonboating lake: ~2 feet of submerged veg, little surface algae, no odor detected, turbidity decreased (settling from spring snowmelt), P concentrations decreased (result of stratification possible). “With limited mixing, stratification prevents these nutrients from re-entering the water column through resuspension.”

(Source: Nedohin & Elefsiniotis, 1997)

Sediment disruption with motor boat activity: Case study comparing 2 shallow lakes, 1 with motor boat activity and 1 without

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

(Source: Nedohin & Elefsiniotis, 1997)

Sediment disruption with motor boat activity: Case study comparing 2 shallow lakes, 1 with motor boat activity and 1 without

"It was determined that motor boat activity had sufficient impacts on Brereton [boating lake] Lake to disrupt the bottom sediment and release phosphorus and other nutrients into the overlying water."

(Source: Nedohin & Elefsiniotis, 1997)

Summary of boating impacts on WI lakes

- Boat wakes cause shoreline erosion
- Increase turbidity; release nutrients from bottom sediments; physically disturb aquatic plants, fish, and wildlife
- Propellers from outboard engines create turbulence and wake that can impinge upon bottom sediments at depths down to 10 feet
- Declines in water quality are most pronounced on shallow lakes

- Sediment resuspension by boats at 3 ft depth was equivalent to the amount of disturbance generated by a 20 mph wind, but boat pass frequency was much higher than frequency of winds of that magnitude

(Source: Asplund, 1997)

Summary of boating impacts on WI lakes

- Turbulence (prop wash) of most recreational watercraft extends about 4-6 feet below the propeller or discharge point; can extend up to 10 feet in some cases
- Shallow areas of less than 10 feet deep are most susceptible to stirring and resuspension of sediments
- Vegetation in shallow areas may be impacted
- Boats can spread invasive species (like Curly-leaf)

(Source: Asplund, 2009-2010)

Toxic algae blooms, urban centers and climate change

- Why don't we just leave this lake alone and move on to something else?

- Phosphorus management is key to reducing harmful algal blooms
- Often P mgmt alone will allow a potentially abrupt switch to a healthy state (clear water with plants)
- Goose Lake is our most impaired lake; climate change and urban heat island effects compound to make Goose Lake a place that is likely to increase in frequency and intensity of algal blooms without intervention

Toxic algae blooms, urban centers and climate change

- Recreational use: cyanobacterial scums pose risks of illness and mortality
  - Illness and mortality of pets and cattle widely reported worldwide
  - Human incidents have rarely been reported
  - But human exposure to HABs should be avoided

- Drinking water: potential toxin production makes cyanobacteria in drinking water reserves undesirable and requires extra purification to remove (ozone, chlorination, peroxide, and/or UV treatment)

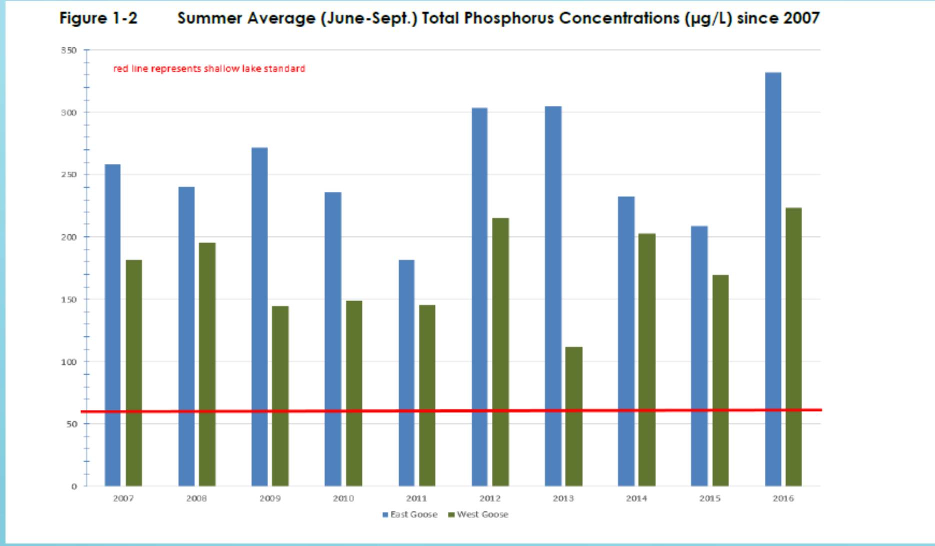
- Ecology: reduction in biodiversity (plants); shallow lakes in our area should have clear water with high native plant biomass

- Other: fishery, odor

(Source: Stroom & Kardinaal, 2016)

Goose Lake specifically

- The most impaired lake in our watershed
- It is highly visible in WBL even though it doesn't have public water access
- It is a priority in our Comprehensive Water Plan
- 6 years of extensive study, drainage area work, and a bullhead harvest have brought us to this best practice: An alum treatment with continued monitoring, vegetation restoration, and adaptive mgmt



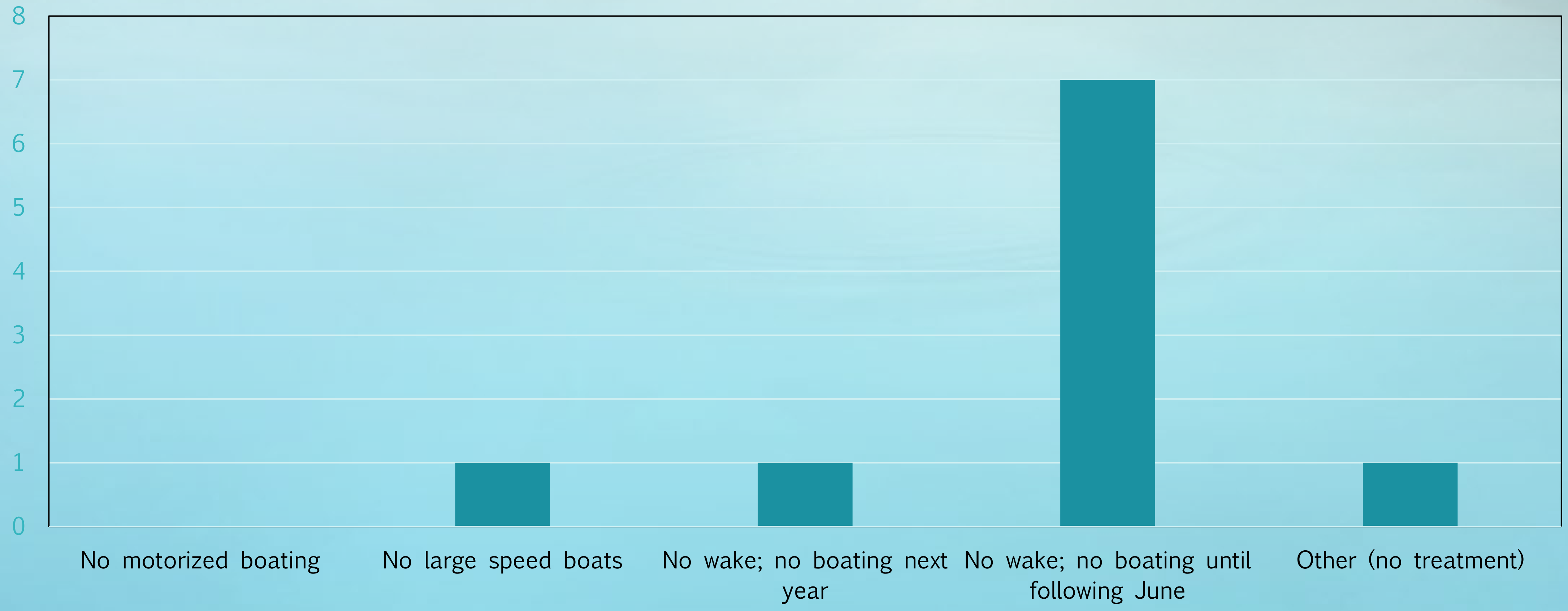
Key to successful restoration

- Chemical lake restoration methods are not a panacea
- Management requires targeted approach
  - Reduction of external loads
  - Adaptive and increased monitoring are essential
- P release from sediment into lake water may be so intense & persistent that it prevents any improvement of water quality for a considerable period after loading reductions
- Internal loading enhances eutrophication and decreases lakes response-time to external decrease in P-load by a decade or longer

(Source: Zamparas & Zacharias, 2014)

What do residents want?

- Letter sent to 47 residents on lake shore and immediately adjacent
- 9 individuals responded; 1 voted for 2 (both no wake options)



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Literature

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