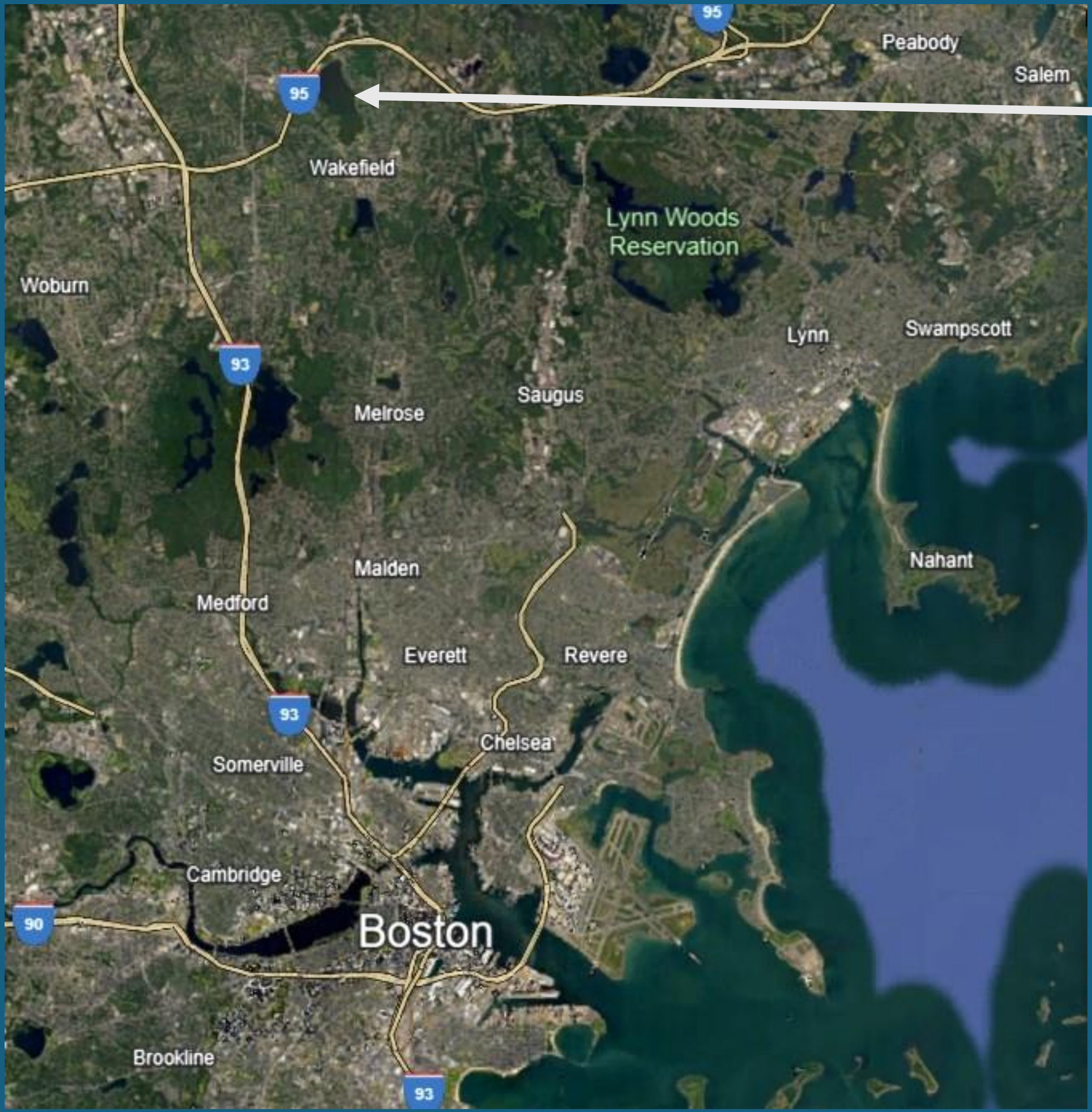
Volunteer Water Quality Testing by the Friends of Lake Quannapowitt

David D. Miller
FOLQ



Lake Quannapowitt is located 10 miles north of Boston in the town of Wakefield.

LQ is a kettle pond that was formed about 13,000 years ago.

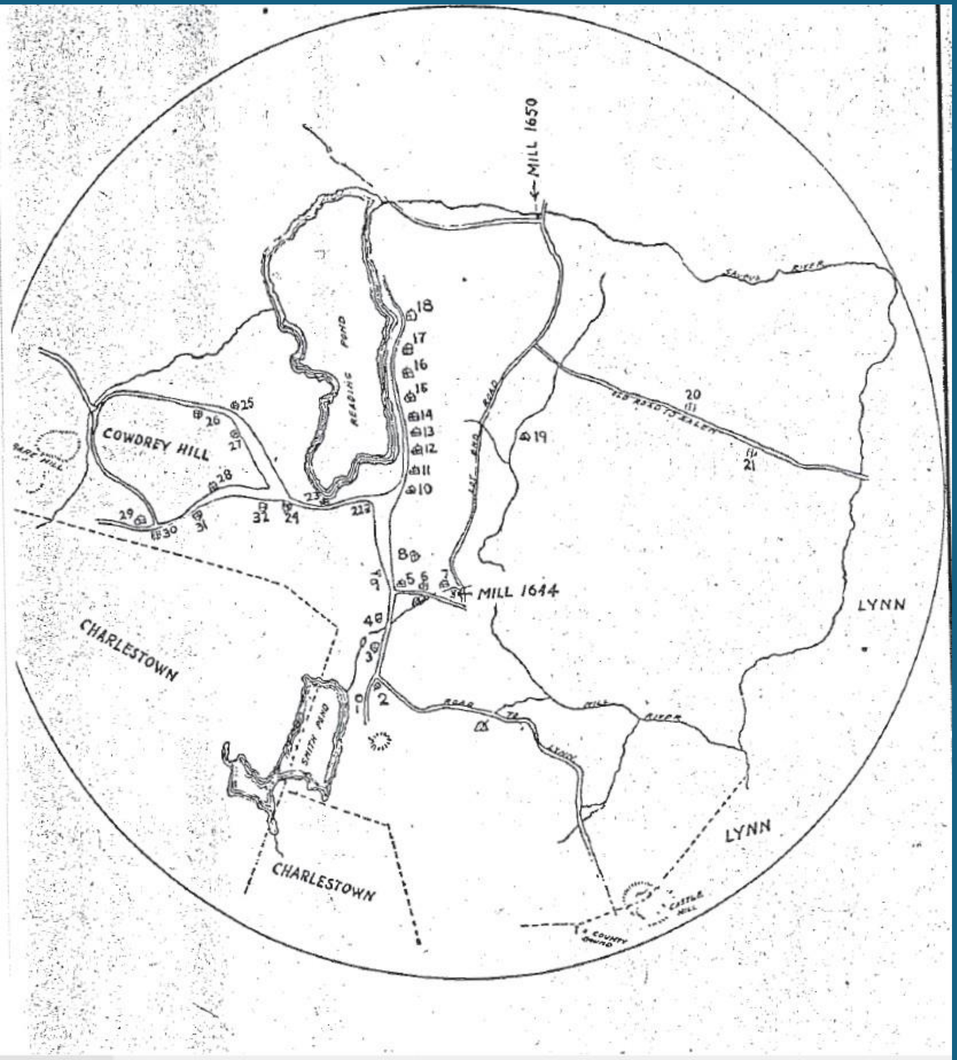
Lake characteristic	Value
Surface area	250 acres
Mean depth	6 feet
Max depth	11 feet
Watershed area	746 acres
Tributary	371 acres
Storm sewers	375 acres

Lake Quannapowitt is a medium-sized, shallow lake. It is well-mixed (polymictic), with a watershed area about 3 times the lake area. It has one tributary (<1.5 miles long) and one outlet (Saugus River).

Lake usage

Development around the lake

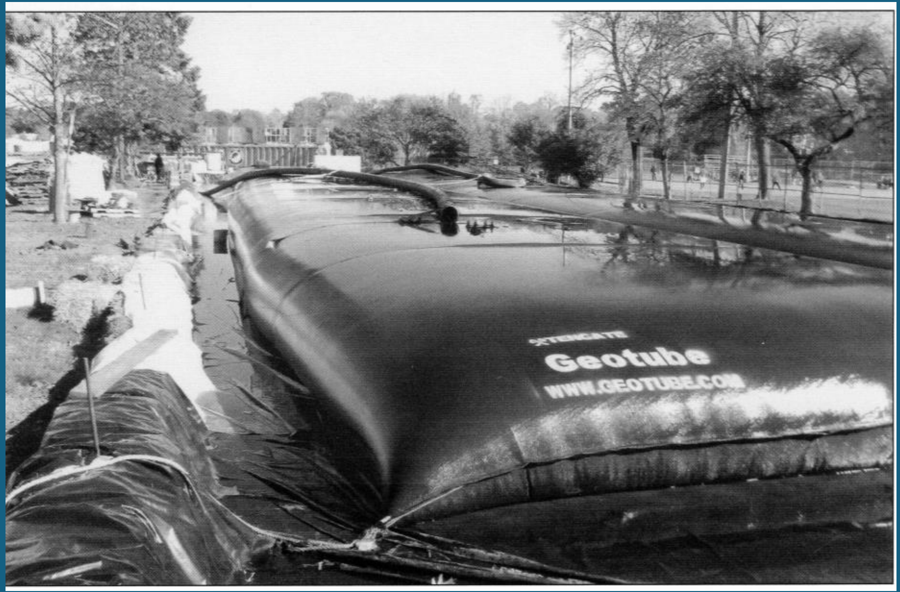
1600s



1938

Today

Chemical pollutants



Coal tar from a gas plant drained into lake until 1924. It was removed by dredging in 2008.

Copper Sulfate and Arsenic were added to the lake for many years to control algae and weeds.

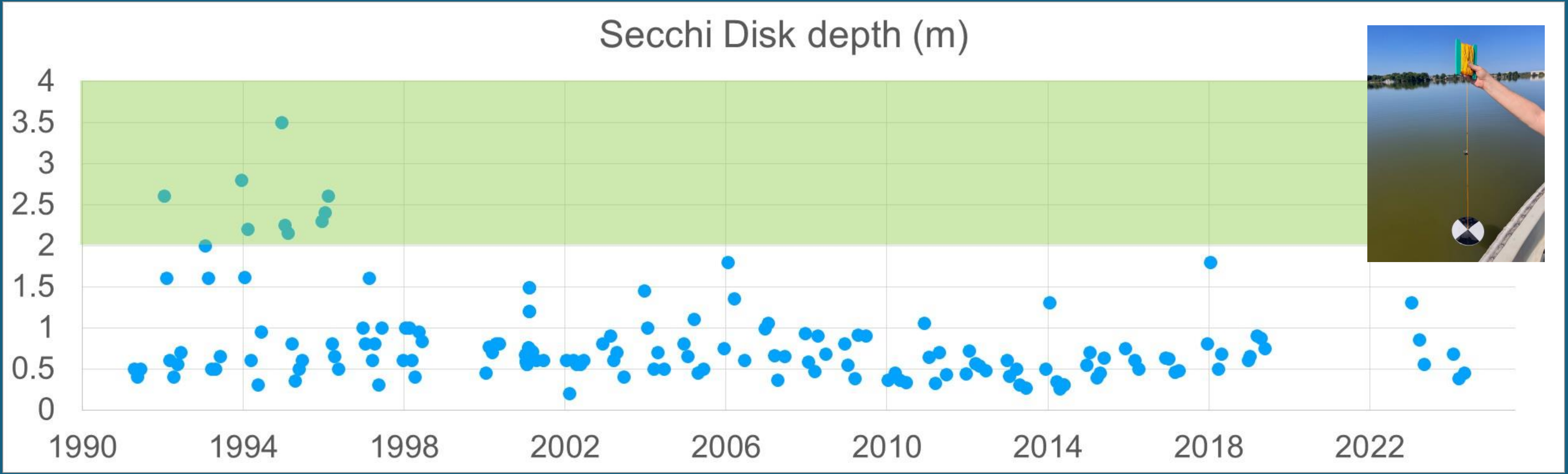
Friends of Lake Quannapowitt



FOLQ was founded as a non-profit in 1991 to "promote public awareness and provide long-term protection and enhancement of Lake Quannapowitt and its surrounding public lands.".



Lake Transparency



Secchi disk testing has been performed by FOLQ since its founding.

Lake transparency is poor ("murky").

The cause of poor lake transparency is mostly algae (predominantly cyanobacteria). Also contributing are churned-up sediments from wind and fish and suspended solids from runoff.

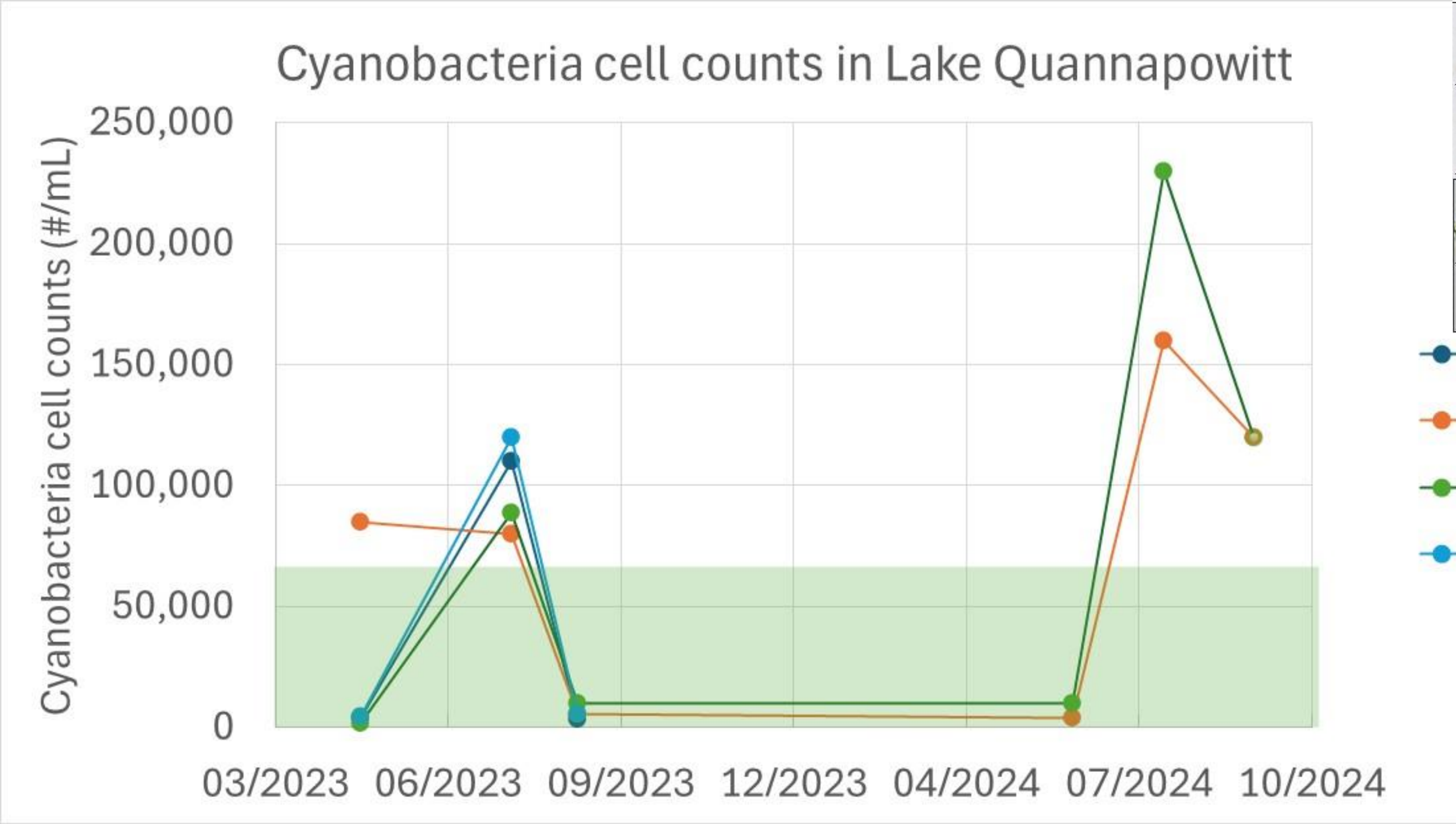
The lake is eutrophic to hyper-eutrophic.

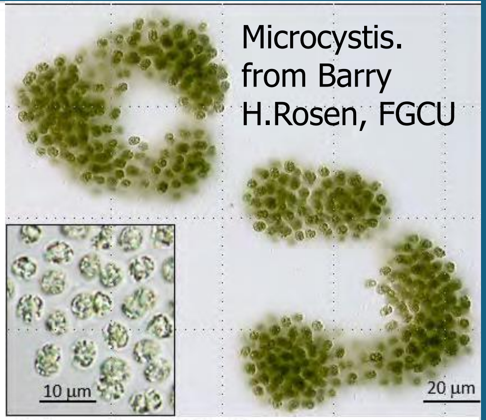
Lake Quannapowitt

Harmful Algae Bloom (HAB) at lake outlet

July 2020

Cyanobacteria

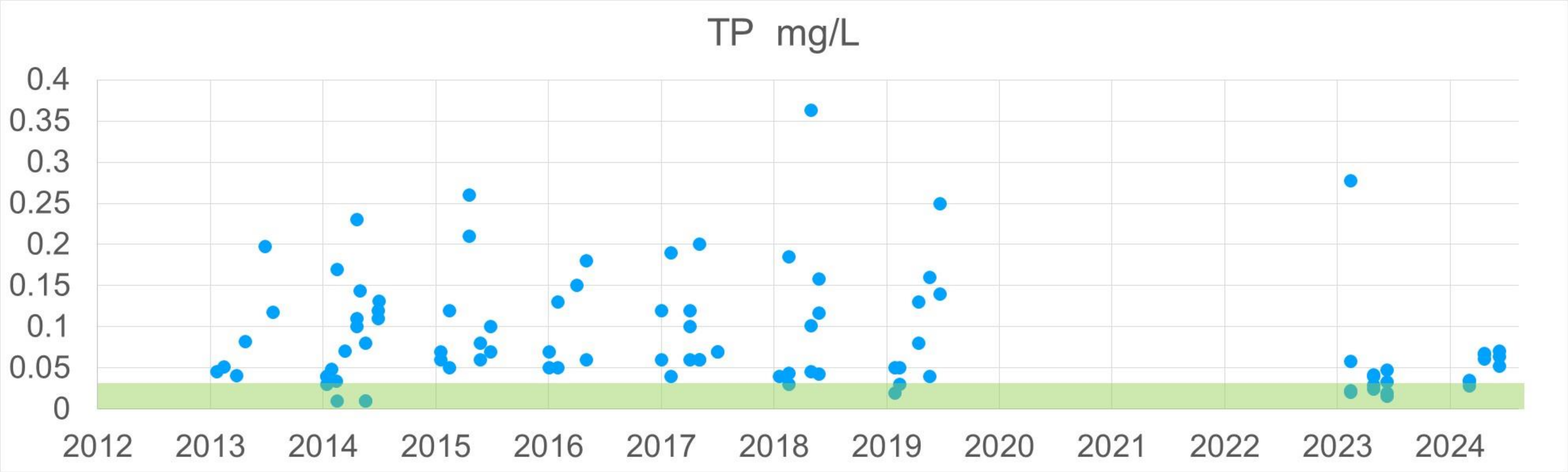




Cyanobacteria cell counts (and toxin levels) peak in summer.

<u>What is the explanation for high cyanobacteria counts?</u>

Total Phosphorus (in-lake)



Total phosphorus levels are higher than desirable and typically well above our target level of 0.03 mg/L (30 ug/L). Total phosphorus typically increases in late spring and early summer.

<u>What is the origin of all this phosphorus?</u>

External sources of phosphorus

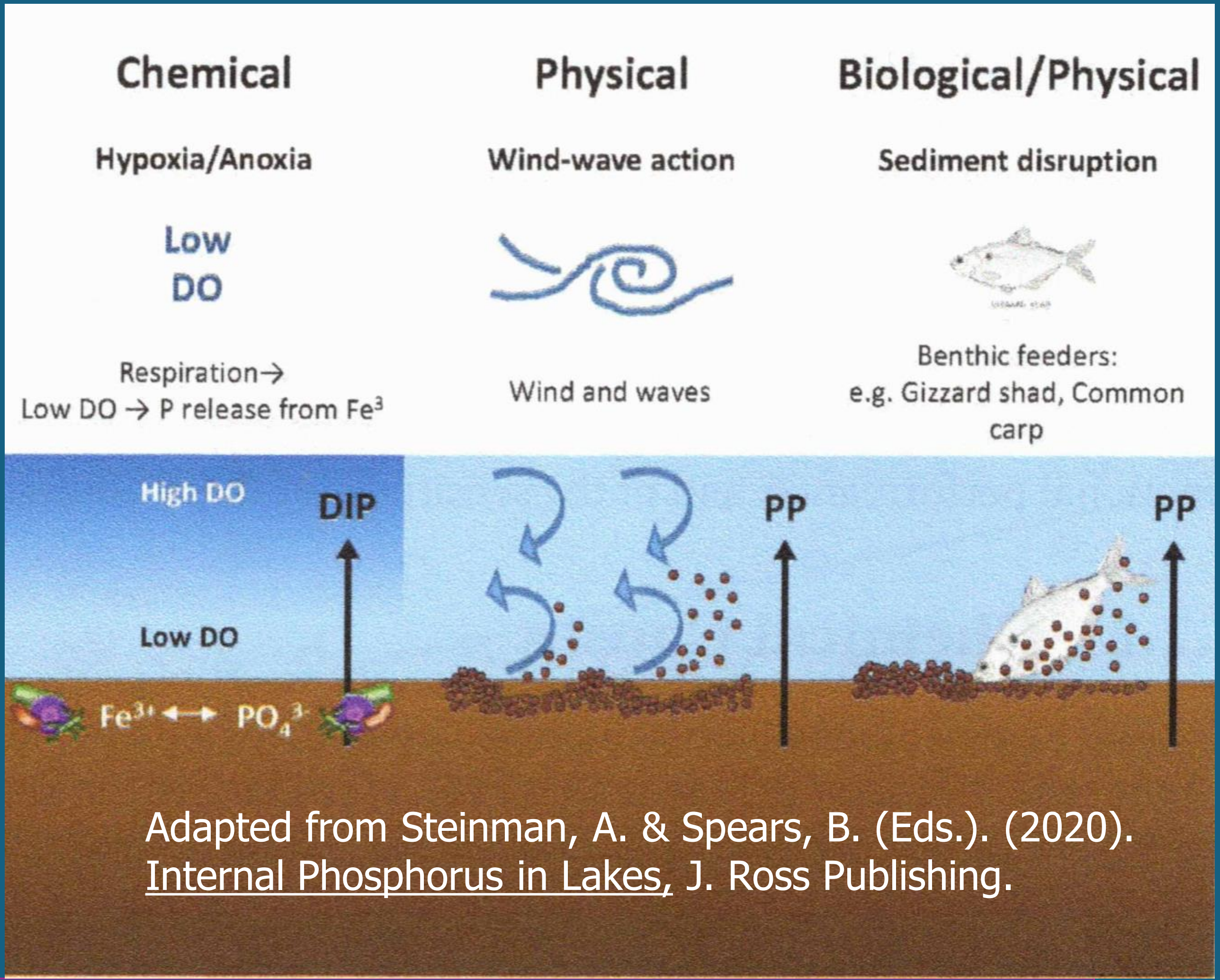
=> and some methods for mitigation advanced by FOLQ

- Storm runoff and stream inflow
  - Vegetative barriers and retention ponds
  - Fertilizer reduction
- Wildlife and waterfowl (geese!)
  - Goose control
- Atmosphere (dry and wet)
- Point sources – none for LQ
- Groundwater – small for LQ

Internal sources of phosphorus

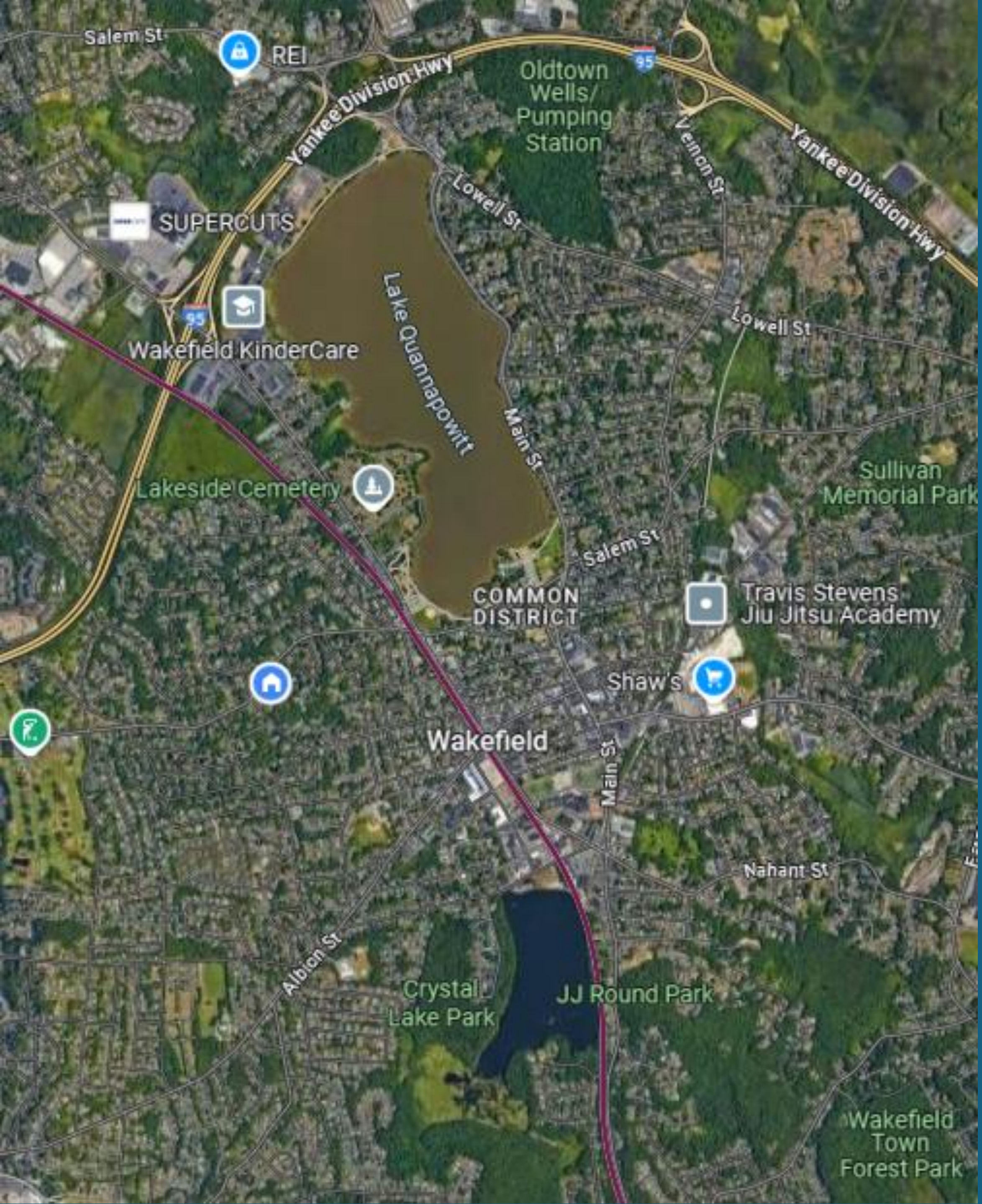
=> and some methods for mitigation

- Chemical (redox)
  - Alum
- Physical
  - Aquatic plants
  - Fish removal
- Biological (mineralization and fecal)
  - Dredging



Adapted from Steinman, A. & Spears, B. (Eds.). (2020). Internal Phosphorus in Lakes, J. Ross Publishing.

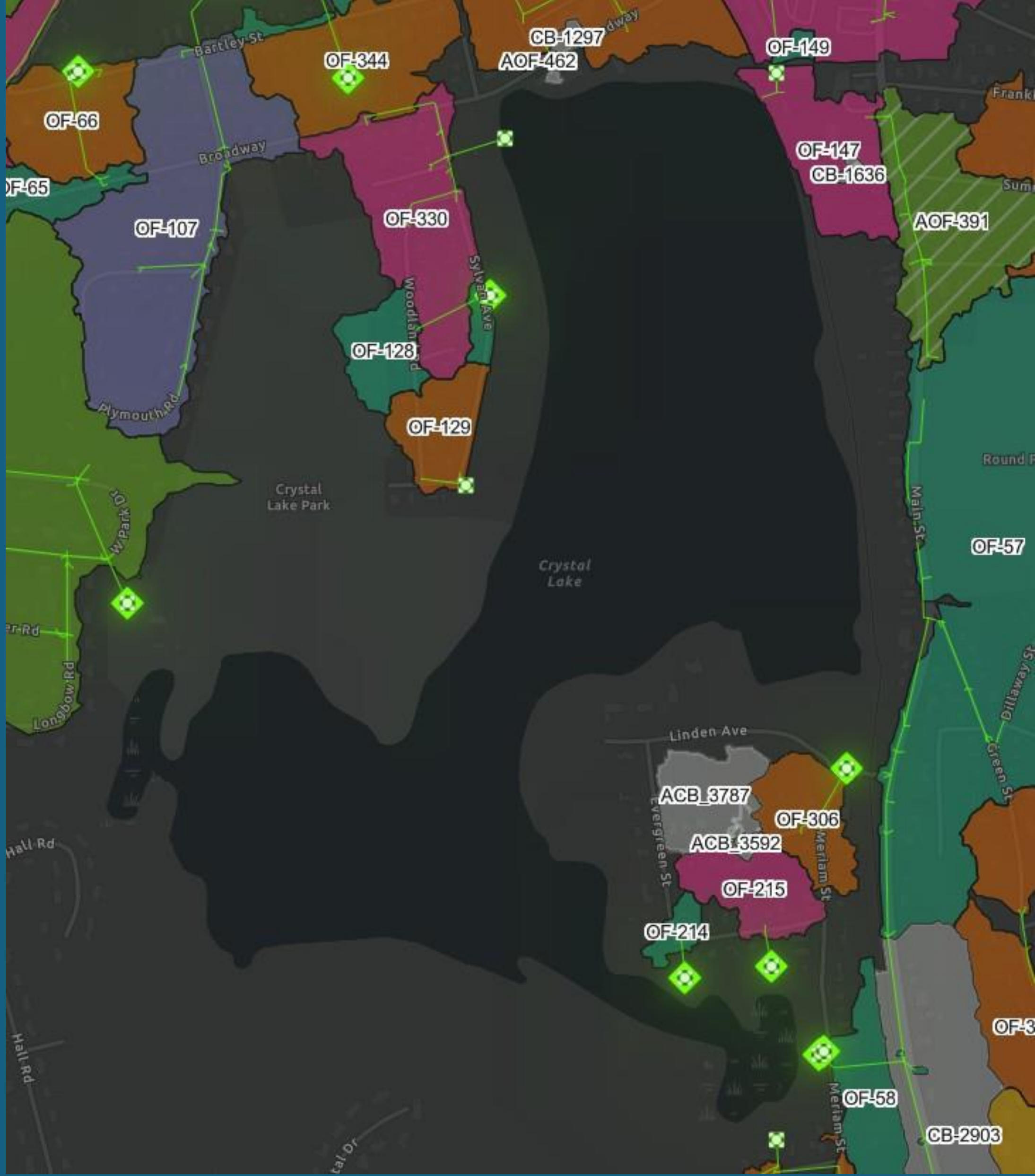
A successful phosphorus reduction plan requires an understanding of the relative importance of each of these sources.



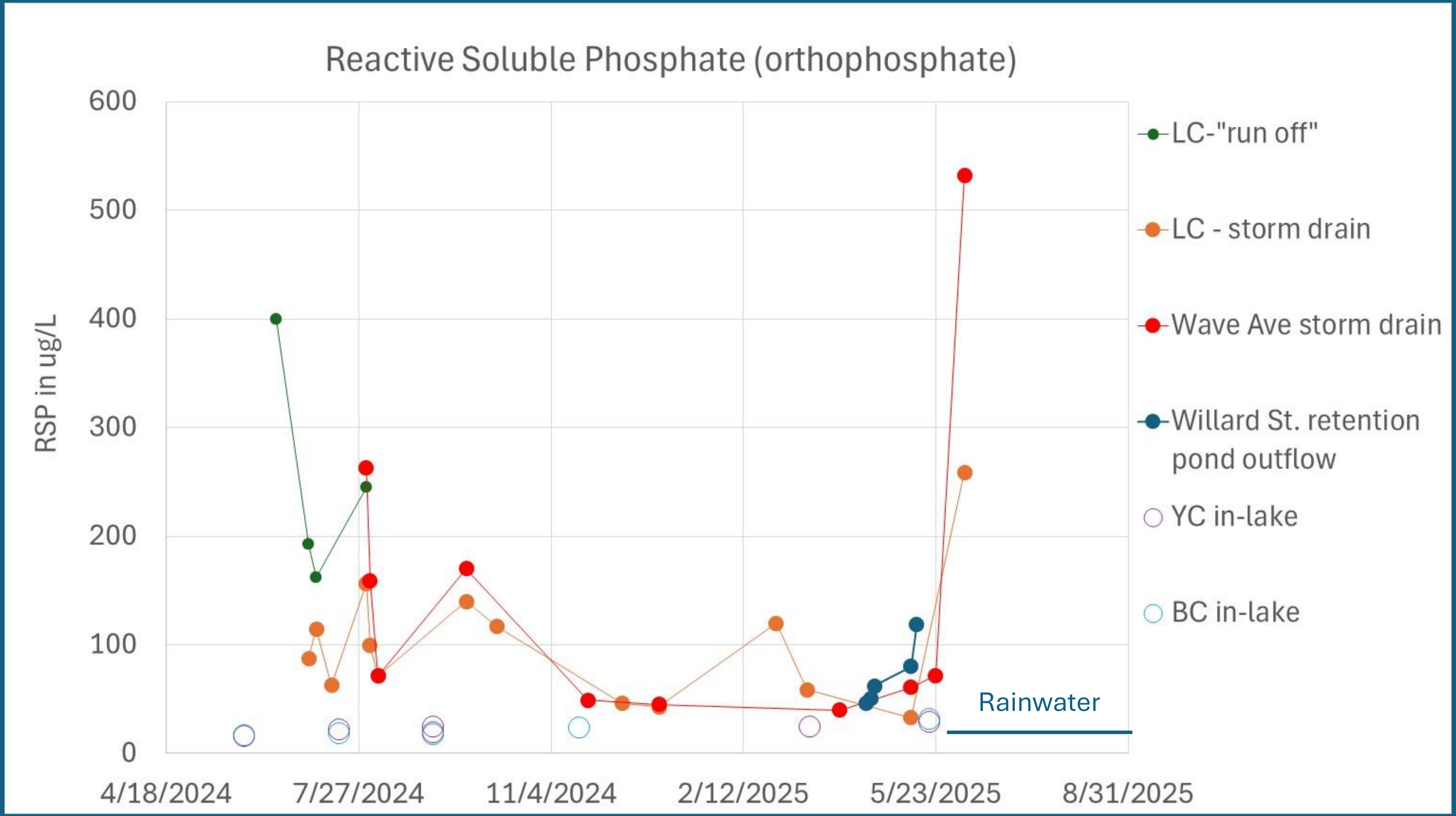
Note the difference in appearance between the two lakes in Wakefield: Lake Quannapowitt and Crystal Lake.

<u>What accounts for this?</u>

30 storm drains and one stream feed into Lake Quannapowitt



Less than 10 storm drains flow into Crystal Lake, a backup water supply for the town



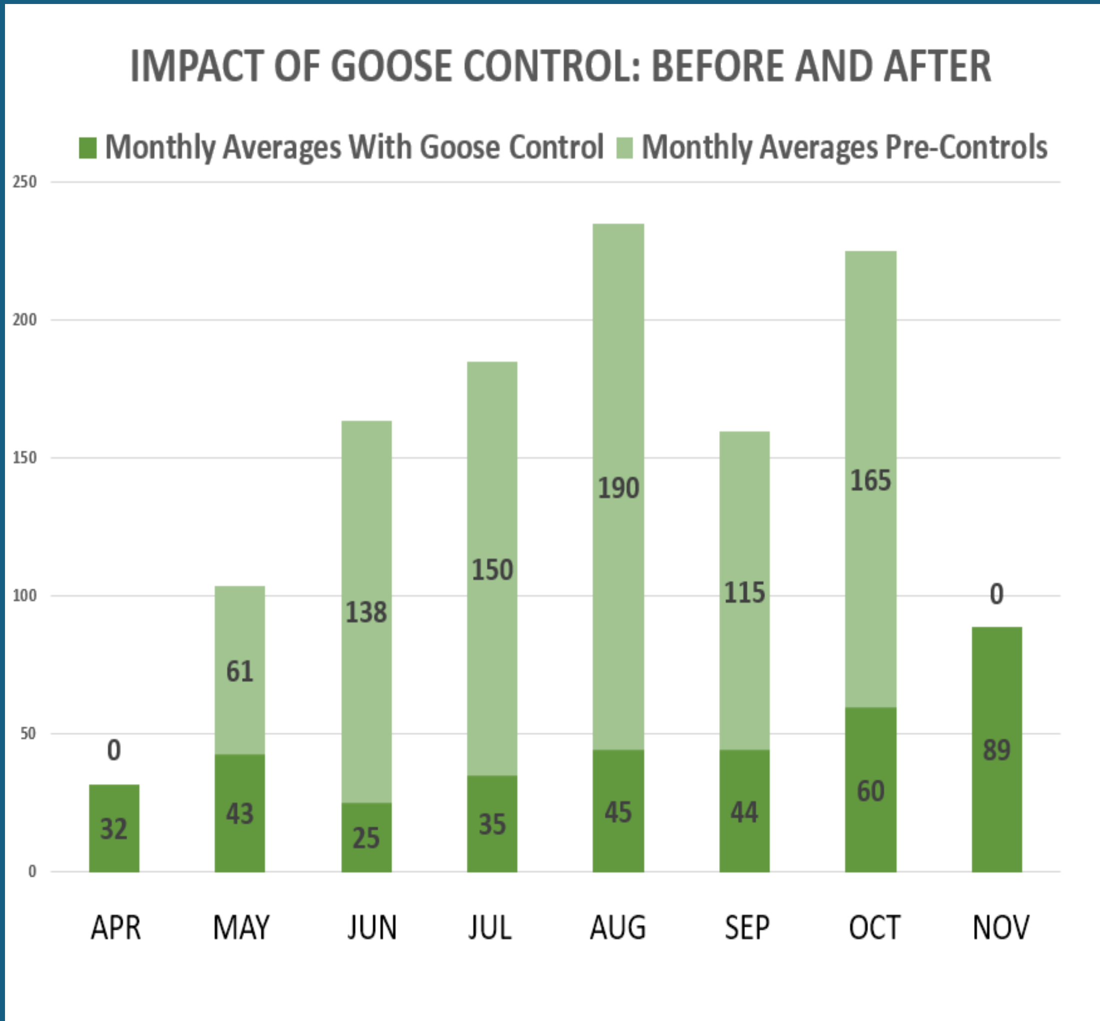
Reactive soluble phosphorus (RSP) is one of the major components of total phosphorus. It is relatively easy and inexpensive to measure.

From limited data, we estimate TP to be roughly bounded between 2x and 3x the level of RSP.

Soluble phosphorus concentrations from the lake tributary and storm runoff are consistently higher than in-lake values, and thus external flow adds significant amounts phosphorus to the lake.

The amount of phosphorus can be estimated from precipitation records and assumptions of runoff (% of precipitation that is not retained by watershed).

Geese

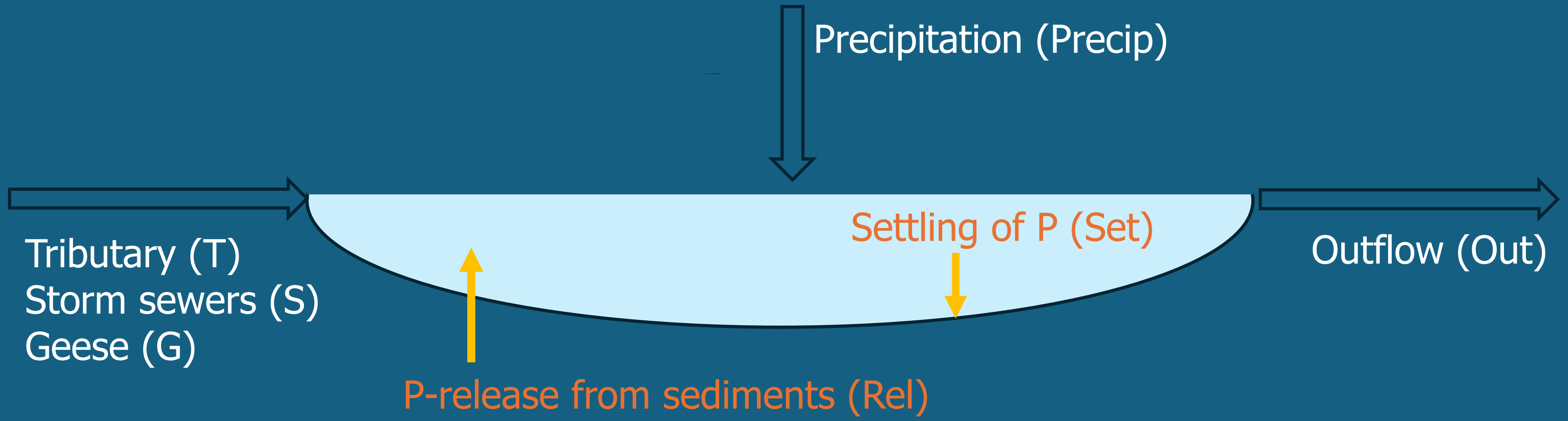


One goose can produce a quarter pound of phosphorus over the course of a summer.

FOLQ initiated efforts to control geese that have since been taken over by the town.

Quantifying sources of key nutrient phosphorus:

Accumulation of P in lake =
T+S+G+Precip+(Rel-Set)-Out = T+S+G+Precip+Inet-Out



The difference between P release and settling is the net internal flux (Inet).

The gross amount of P-release (Rel) can be calculated using model predictions of P-settling (approximate and model dependent), or direct measurements of P-release from sediment samples (more accurate but expensive).

Quantifying sources of key nutrient phosphorus:

Example: May 29, 2024 to July 17, 2024:
In-lake TP increases from 32.3 mg/m3 to 65.3 mg/m3

Source	TP conc mg/m^3	Precip mm*	Runoff coeff**	Flow m^3	P kg
Net change in lake P					**63.33**
Tributary	191	105.5	65.80%	1.04E+05	19.84
Storm drains	425	105.5	45.10%	7.23E+04	30.70
Precipitation	30	105.5	100%	1.07E+05	3.20
Geese					1.55
Total external load					**55.29**
Evaporation**				1.01E+05	0
Outflow	48.8		100%	1.82E+05	8.90
Net internal flux					**16.94**

* From NOAA website
** Calculated from 1999 data in consultant report to Town of Wakefield

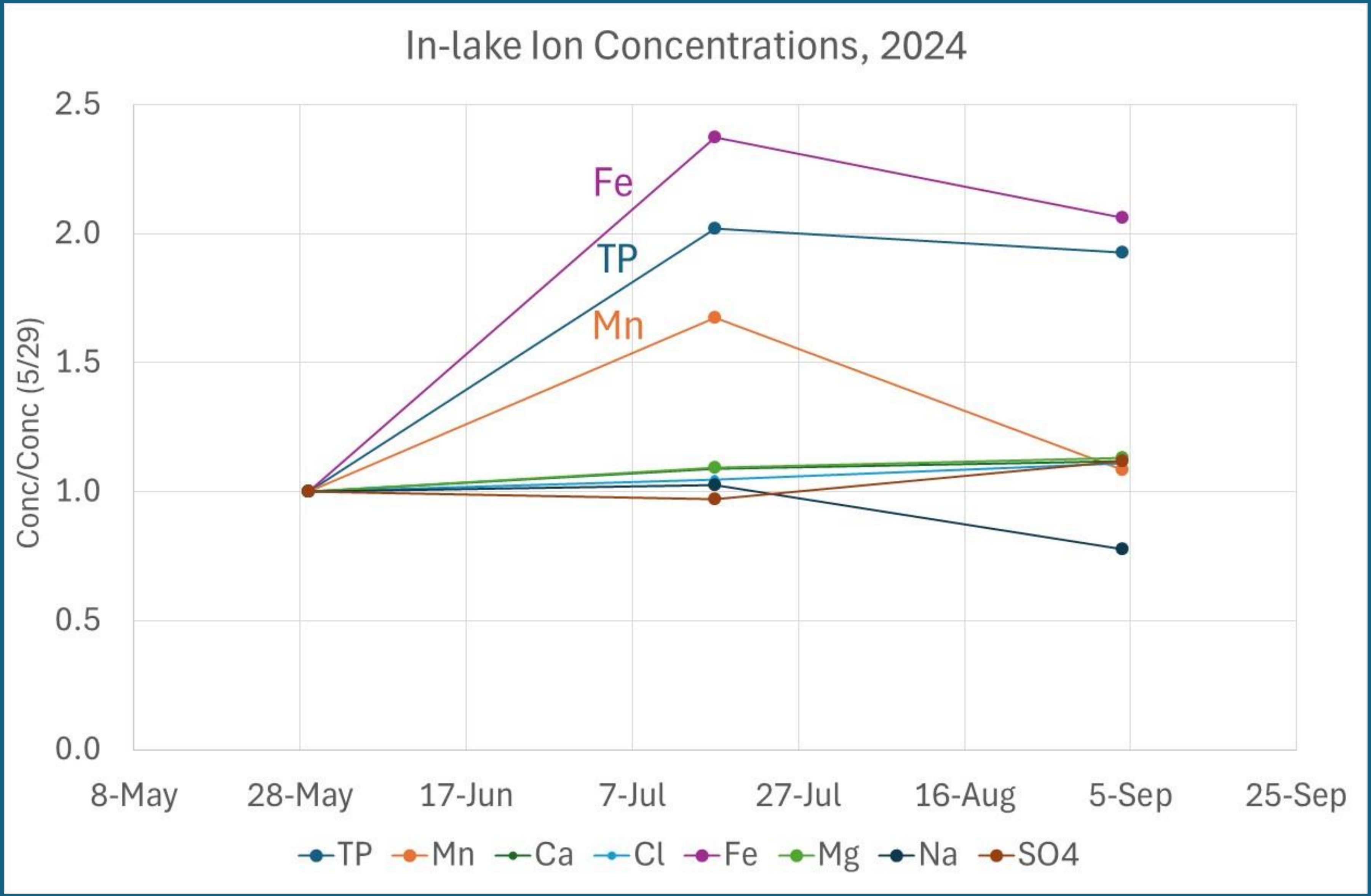
Assuming TP is 2.5 x RSP, the net amount of P flowing into the lake from external sources is 55 kg.

By mass balance, estimates of net internal flux are thus 17 kg, or 23% of the total input phosphorus.

A 25-year-old study provided an estimate of 15% internal recycling (annual, by mass balance).

External loading, and especially storm water, provides much of the phosphorus to the lake.

Redox chemistry



TP increase from May to July is accompanied by increase in redox-active ions Fe and Mn.

This is consistent with a redox mechanism of internal release of P from sediments.

Sedimentation disruption by carp and wind is also probable.

Conclusions

- Storm water supplies much of the phosphorus to the lake.
  - There is evidence for release of phosphorus from lake sediments as well.

- The relative amount of external versus internal loading of phosphorus can be estimated using a mass balance approach.

Future Directions

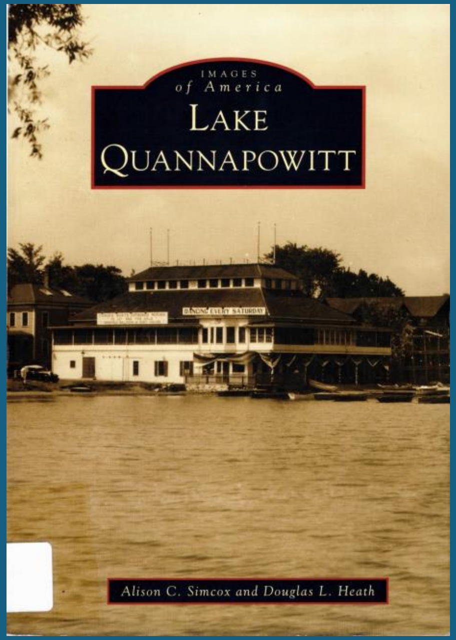
- Our estimates of external versus internal loading are sensitive to assumptions on the conversion of RSP concentrations to TP concentrations.
- Future measurements will focus on obtaining data to better correlate TP to RSP.
- Note: Lab measurement of P-release from lake sediments is a more direct, but expensive, way of measuring internal load.

Acknowledgements

- FOLQ
  - Bill Conley
  - Carol Dennison
  - Lee Danielson
  - Brie Weiler Reynolds
  - Rob Wettach
  - John Sofia

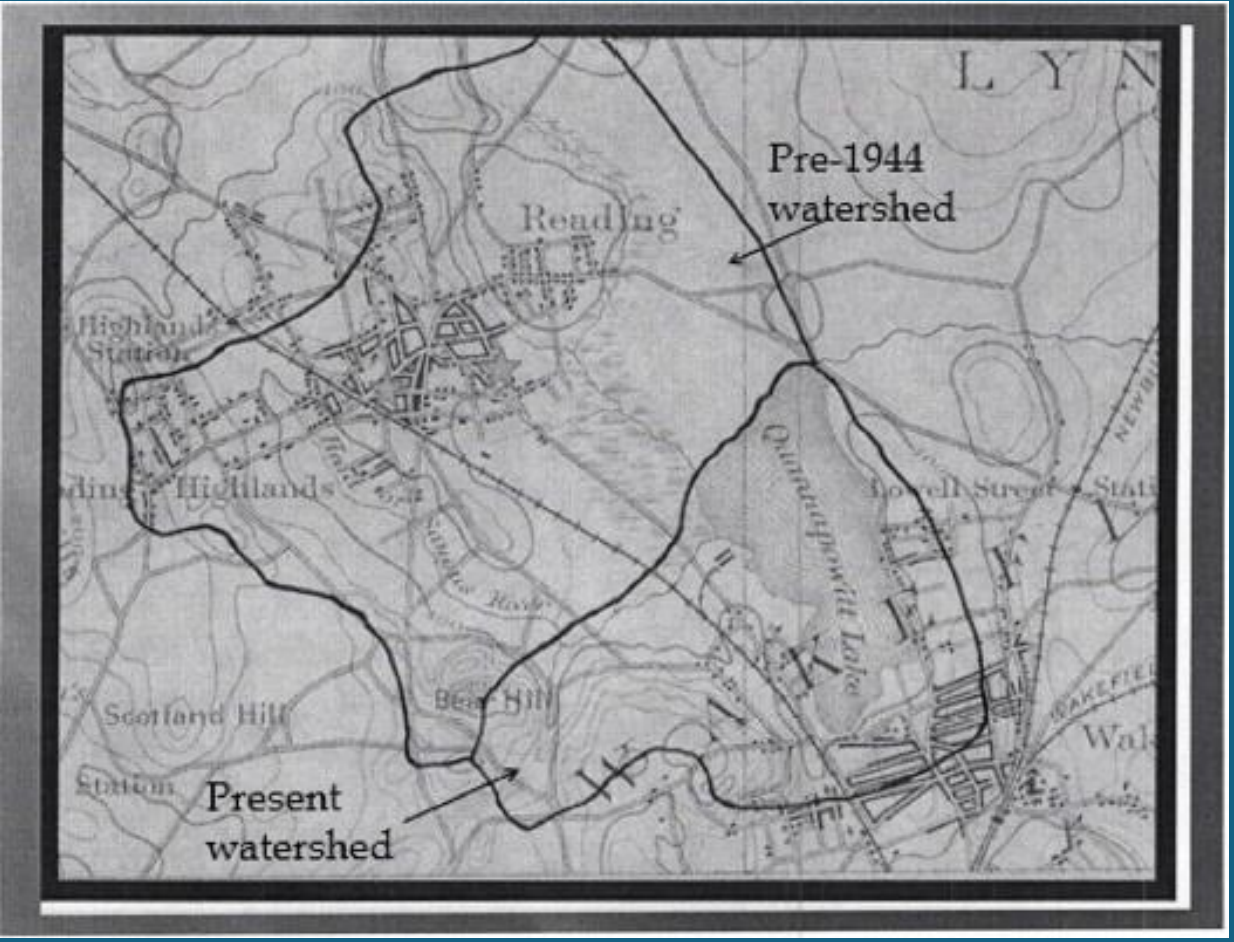
- Environmental Scientists
  - Doug Heath
  - Barry Rosen

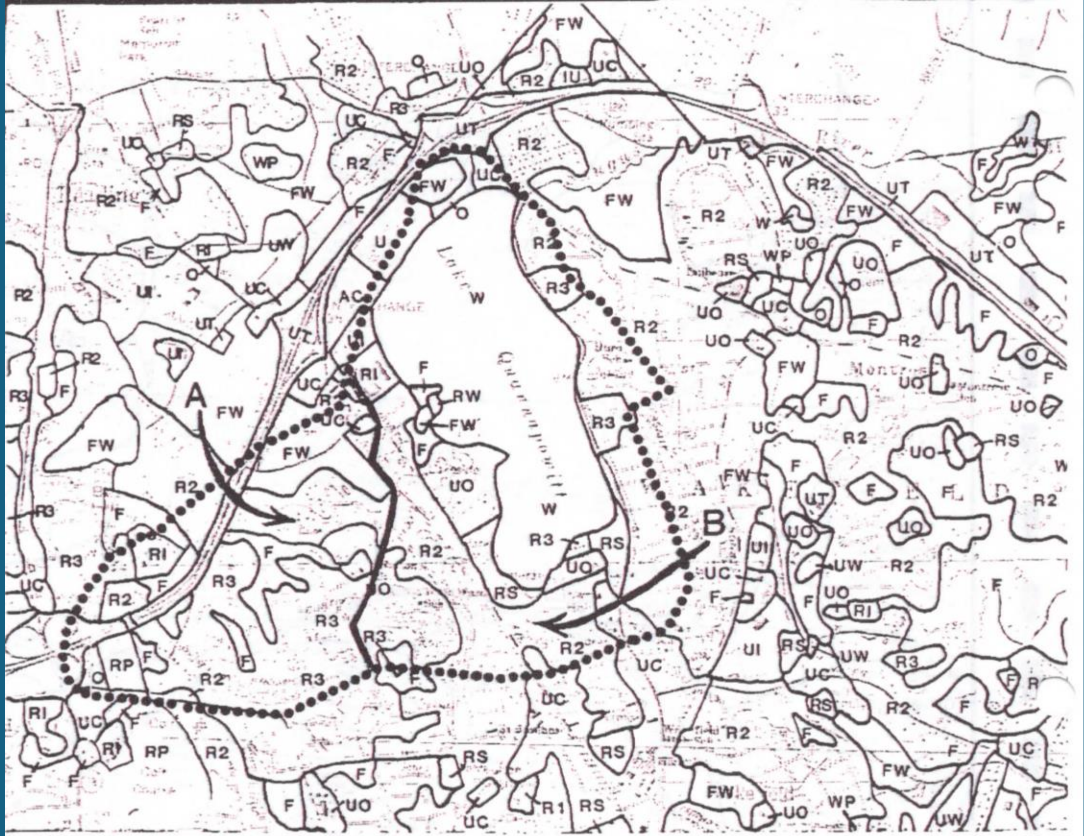
- Other VIPs
  - Bill Renault
  - Dennis Fazio
  - Amanda Haley



Black and white photos in this presentation were taken from “Lake Quannapowitt” by Alison C. Simcox and Douglas L. Heath”, 2011.

Appendix





LEGEND - 1980 LAND USE CATEGORIES

UI	Industrial	AC	Cropland
UC	Commercial	AP	Pasture
R1	Dense Residential <1/4 acre lot	WP	Woody Perennial
R2	Medium Residential 1/4 - 1/2 acre	O	Open
R3	Sparse Residential >1/2 acre	W	Water
UT	Transportation	FW	Fresh Wetland
UO	Open and Public	SW	Salt Wetland
UW	Waste Disposal	RW	Water Recreation
M	Mining	RP	Participation Recreation
F	Forest	RS	Spectator Recreation

A SUBWATERSHED DRAINED BY INLET

B SUBWATERSHED DRAINED BY STORM SEWERS

Prepared by:
DEPARTMENT of FORESTRY & WILDLIFE MANAGEMENT, REMOTE SENSING PROJECT, UNIVERSITY of MASSACHUSETTS at AMHERST SOIL CONSERVATION SERVICE
In cooperation with:
METROPOLITAN AREA PLANNING COUNCIL, MASSACHUSETTS DEPARTMENT of PUBLIC WORKS, U.S. DEPARTMENT of TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION and URBAN MASS TRANSPORTATION ADMINISTRATION

FIGURE 2
LAND USE

1000 0 1000 2000 FEET

DIAGNOSTIC/FEASIBILITY STUDY
LAKE QUANNAPOWITT
WAKEFIELD, MASSACHUSETTS

Quantifying sources of key nutrient phosphorus:

Example: May 29, 2024 to July 17, 2024:
In-lake TP increases from 32.3 mg/m3 to 65.3 mg/m3

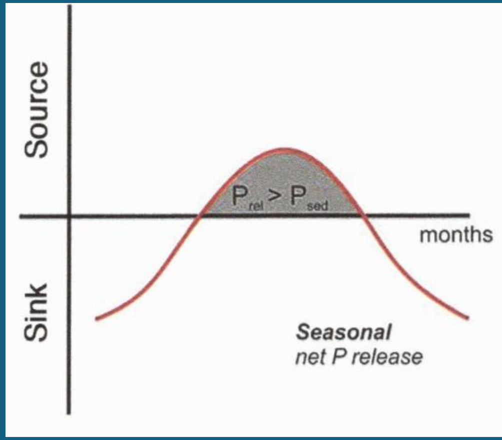
Source	TP conc mg/m^3	TP conc mg/m^3	Precip mm	Runoff coeff	Flow m3	P kg	P kg
Net change in lake P						**63.33**	**63.33**
Multiplier from RSP	2	3				2	3
Tributary	152	229	105.5	65.80%	1.04E+05	15.87	23.81
Storm drains	340	509	105.5	45.10%	7.23E+04	24.56	36.84
Precipitation	30	30	105.5	100%	1.07E+05	3.20	3.20
Geese						1.55	1.55
Total external load						**45.18**	**65.40**
Evaporation**					1.01E+05		
Outflow	48.8	48.8		100%	1.82E+05	8.90	8.90
Net internal flux						**27.05**	**6.83**

* From NOAA website
** Calculated from 1999 data in consultant report to Town of Wakefield

Depending on how we calculate TP from RSP, we obtain estimates of external load ranging from 45 to 65 kg during this 49-day period.

By mass balance, estimates of net internal load thus vary from 27 to 7 kg, or 37% to 9% of the total input phosphorus.

A 25-year-old study provided an estimate of 15% internal recycling (by mass balance).



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