GRACE LAKE
BATHTUB MODELING PROJECT

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GRACE LAKE MODELING RESULTS

PROJECT PURPOSE AND GOALS

DATA REVIEW AND USE IN THE MODEL

WATER QUALITY CONDITIONS

LAND USE AND SOURCES OF PHOSPHORUS

RESULTS

SUGGESTED NEXT STEPS

MODELING PROJECT BACKGROUND

- Grace Lake water quality and management has been the subject of several reports, but only one that is publicly available that specifically relates to water quality; the 2017 lake screening report that Beltrami County Soil and Water Conservation District sponsored. This report contained some key findings such as:
    1. The lake is currently eutrophic.
    2. One inlet is from a large wetland that conveys runoff from a significant drainage area.
    3. The lake has some signature indications of internal loading.

GRACE LAKE CHARACTERISTICS

- Surface Area: 860 acres
- Littoral area (0-15 ft): 340 acres
- % littoral area: 41%
- Maximum depth: 42 feet
- Inlets: 2
- Outlets: 1 (but not always running)
- Public Accesses: 1
- Lake data availability: TP, Chl-a, and Secchi – good
- Inlet/Outlet: no data
- Lake mixing: polymictic (well mixed)

MODELING PROJECT PURPOSE AND GOALS

- Need to understand if external or internal phosphorus is driving water quality changes.
- We use Bathtub to:
  - Diagnose current condition
  - Evaluate existing information and get a better sense of information gaps
  - Conduct a rapid/rough assessment
  - Establish baseline information
  - Identify problem sources
  - Evaluate potential for correction/management

DATA REVIEW AND USE IN THE MODEL

BATHTUB MODEL

- Bathtub model software was developed by Dr. William W. Walker for the US Army Corps of Engineers. Version 6.1 was used for this project.
- Widely used in MN for ~ 30 years for lakes and reservoirs (Gold Standard)
- Extensively peer reviewed and used for effluent limits, basin management.
- Withstood legal challenges.
- Satisfies vast majority of lake/reservoir management issues encountered in MN (e.g. phosphorus management).

DATA USED IN THE MODEL

- Physical characteristics of the lake (morphometry)
- Literature Values
  - Atmospheric deposition of phosphorus
- Calculated Estimates
  - Septic system loading
- Monitoring information
  - Total Phosphorus (TP)
  - Chlorophyll *a* (Chl-*a*)
  - Secchi Disk Transparency
- Inputs from the Hydrological Simulation Program – Fortran (HSPF) watershed model
  - Lakeshed loading
  - Internal loading (from lake sediment)

WATER QUALITY CONDITIONS

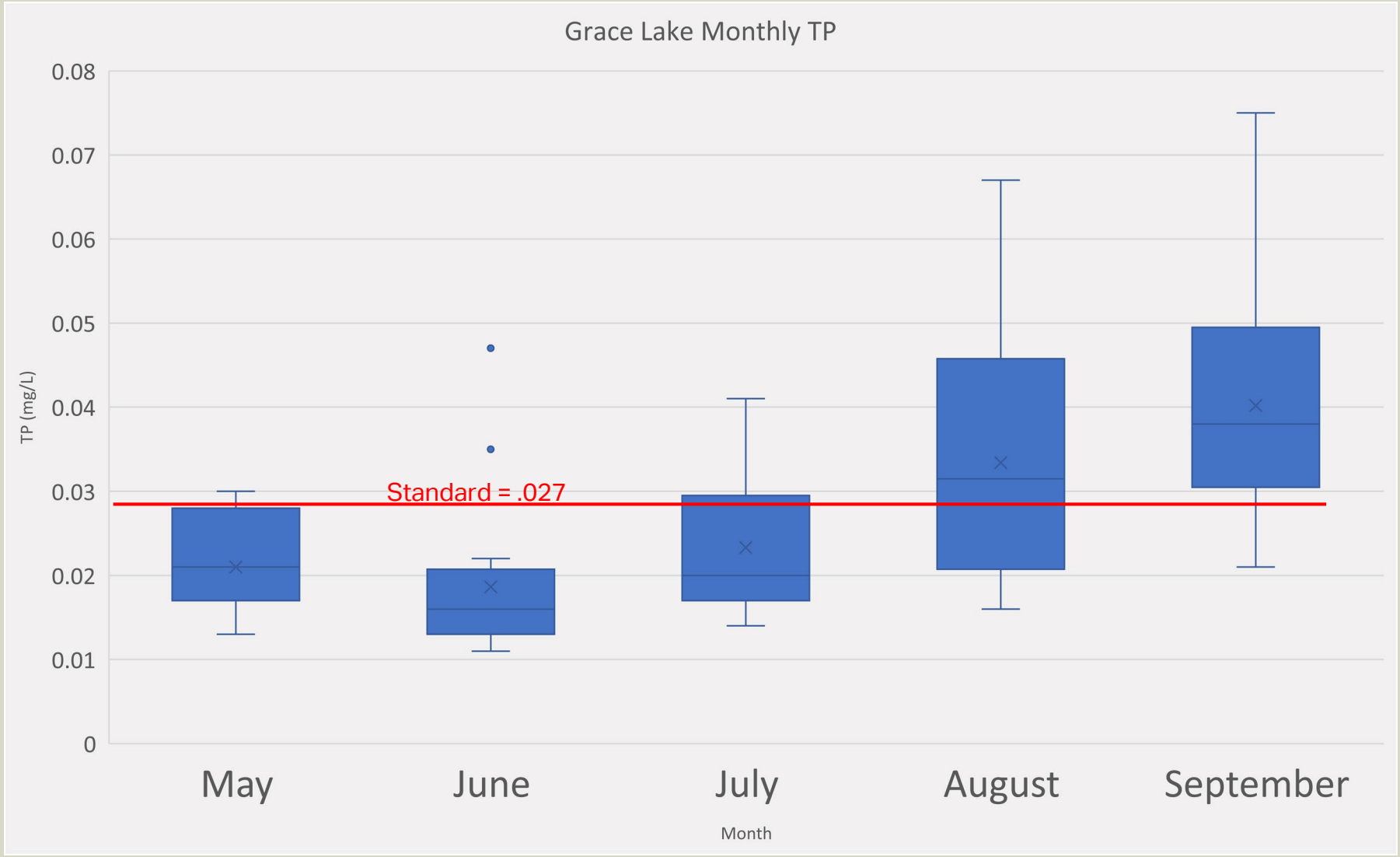
ECOREGION WATER QUALITY

Parameter	**Northern Lakes and Forests**	North Central Hardwood Forests	Western Corn Belt Plains	Northern Glaciated Plains
Total Phosphorus (ug/l or ppb)	**14 - 27**	23 - 50	65 -150	130 -250
Chlorophyll a mean (ug/l or ppb)	**4 -10**	5 - 22	30 - 80	30 - 55
Chlorophyll max (ug/l or ppb)	**< 15**	7 - 37	60 -140	40 - 90
Secchi Disk f m	**8 -15** **2.4 - 4.6**	4.9 - 10.5 1.5 – 3.2	1.6 – 3.3 0.5 – 1.0	1.0 – 3.3 0.3 – 1.0

Summer average based on 25-75 percentile reference lakes

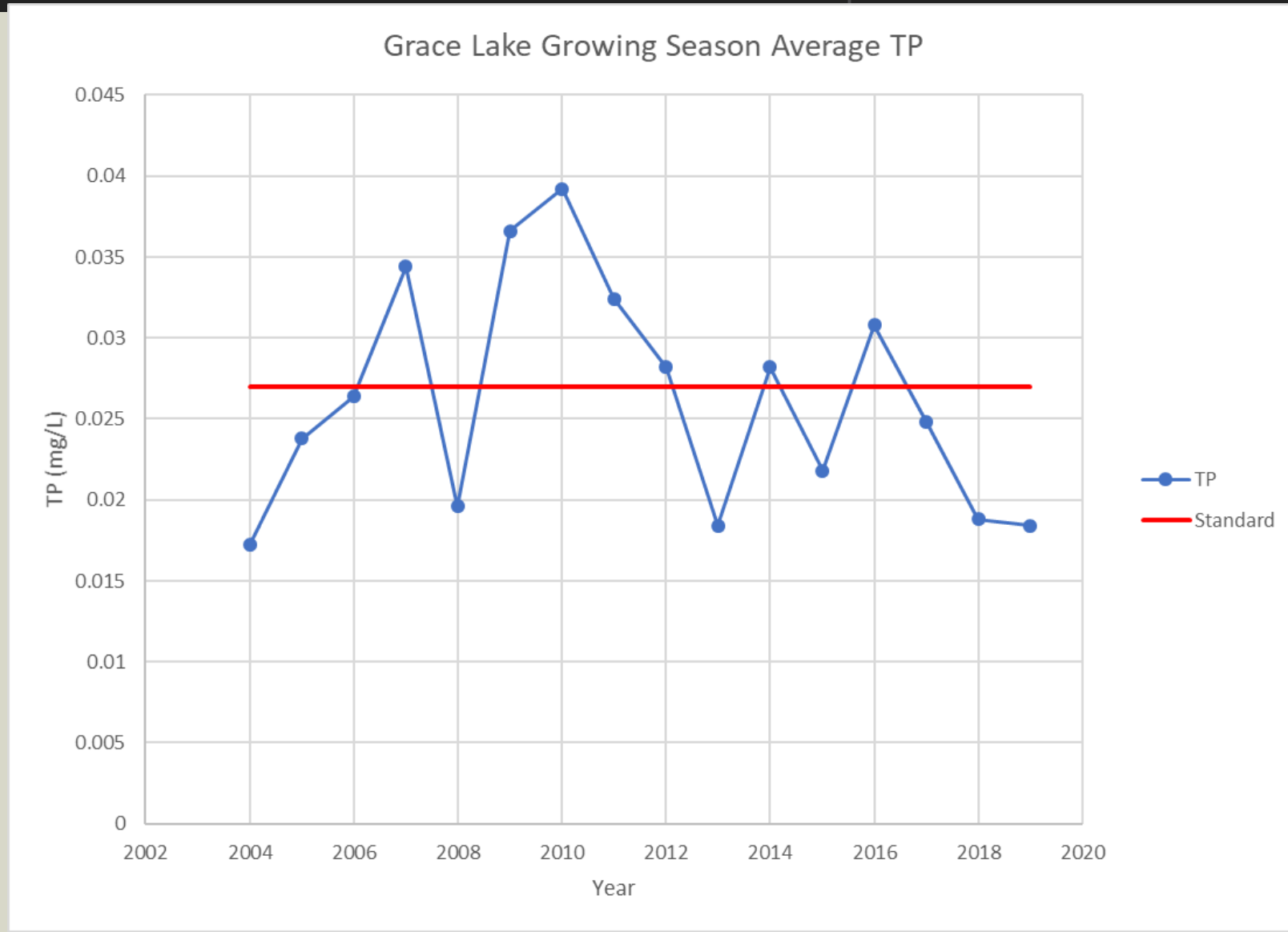
MONTHLY AVERAGE TOTAL PHOSPHORUS DURING GROWING SEASON

- Exceedances of the WQ standards for TP typically occur in August and September.



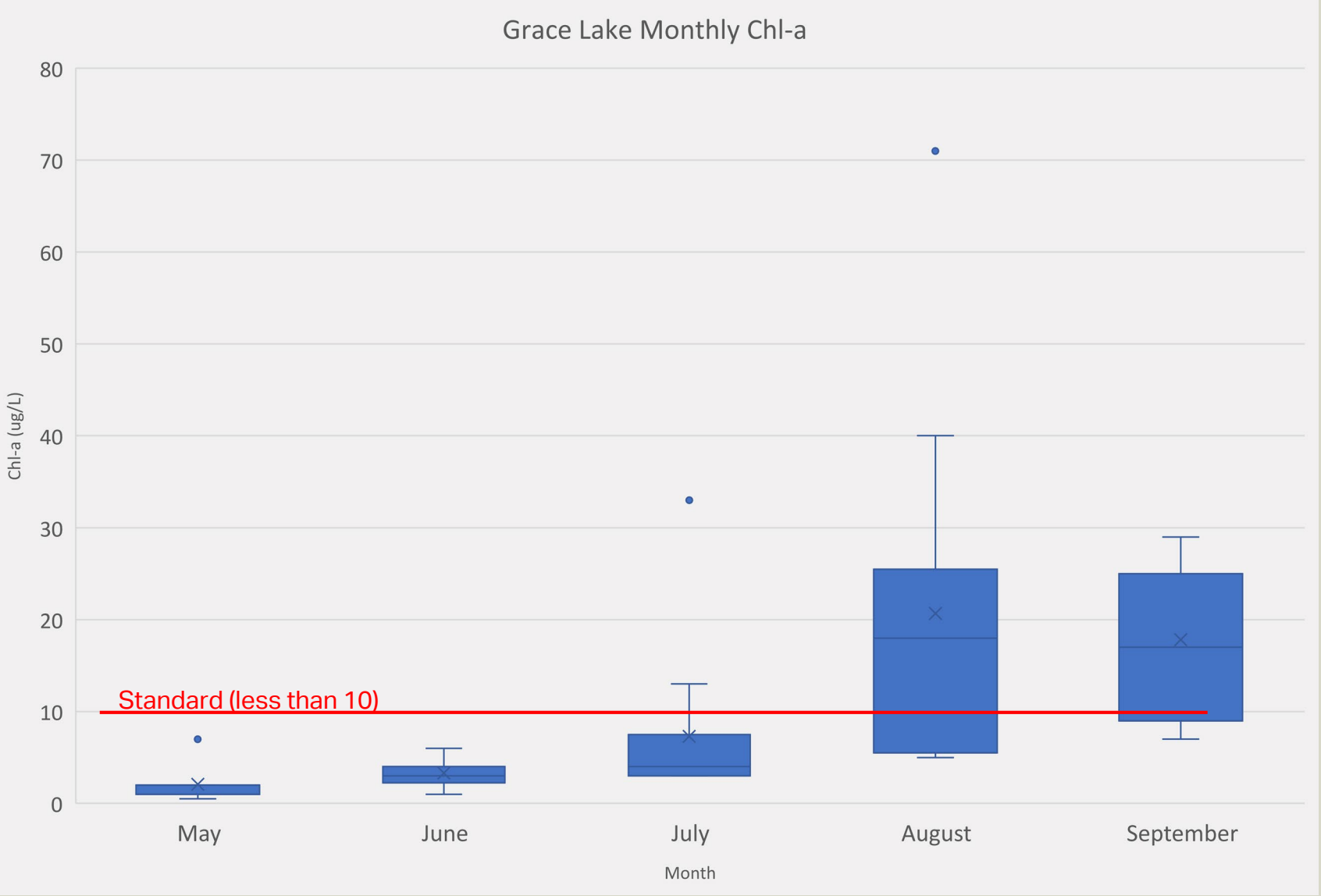
GROWING SEASON AVERAGE TP 2004-2019

- Average TP during growing season exceeded TP standards in 7 of 15 years.



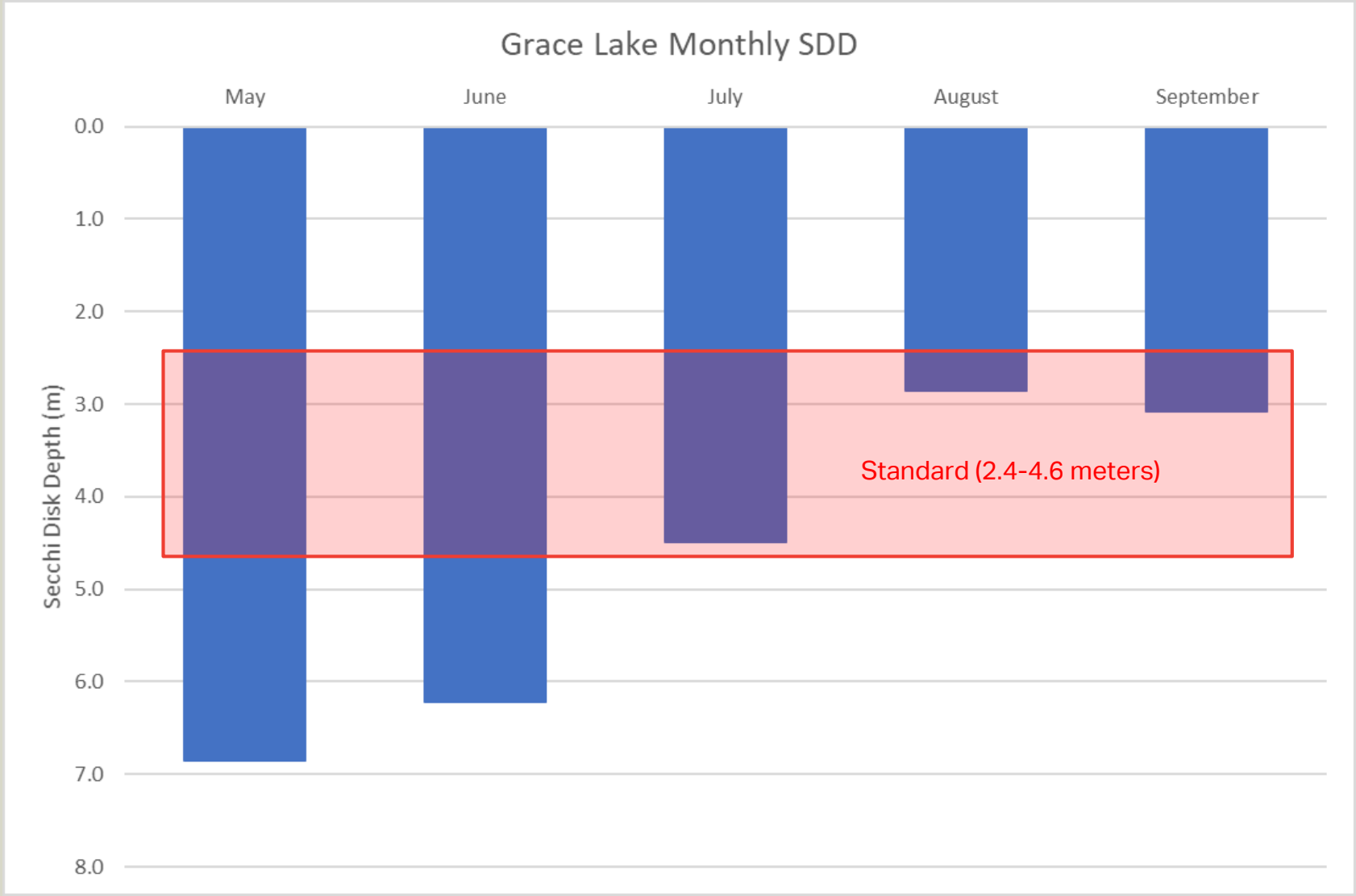
MONTHLY AVERAGE CHLOROPHYLL A DURING GROWING SEASON

- Exceedances of WQ standards for Chlorophyll *a* typically occur in August and September.



MONTHLY AVERAGE SECCHI DISK DEPTH (SDD - TRANSPARENCY) DURING THE GROWING SEASON

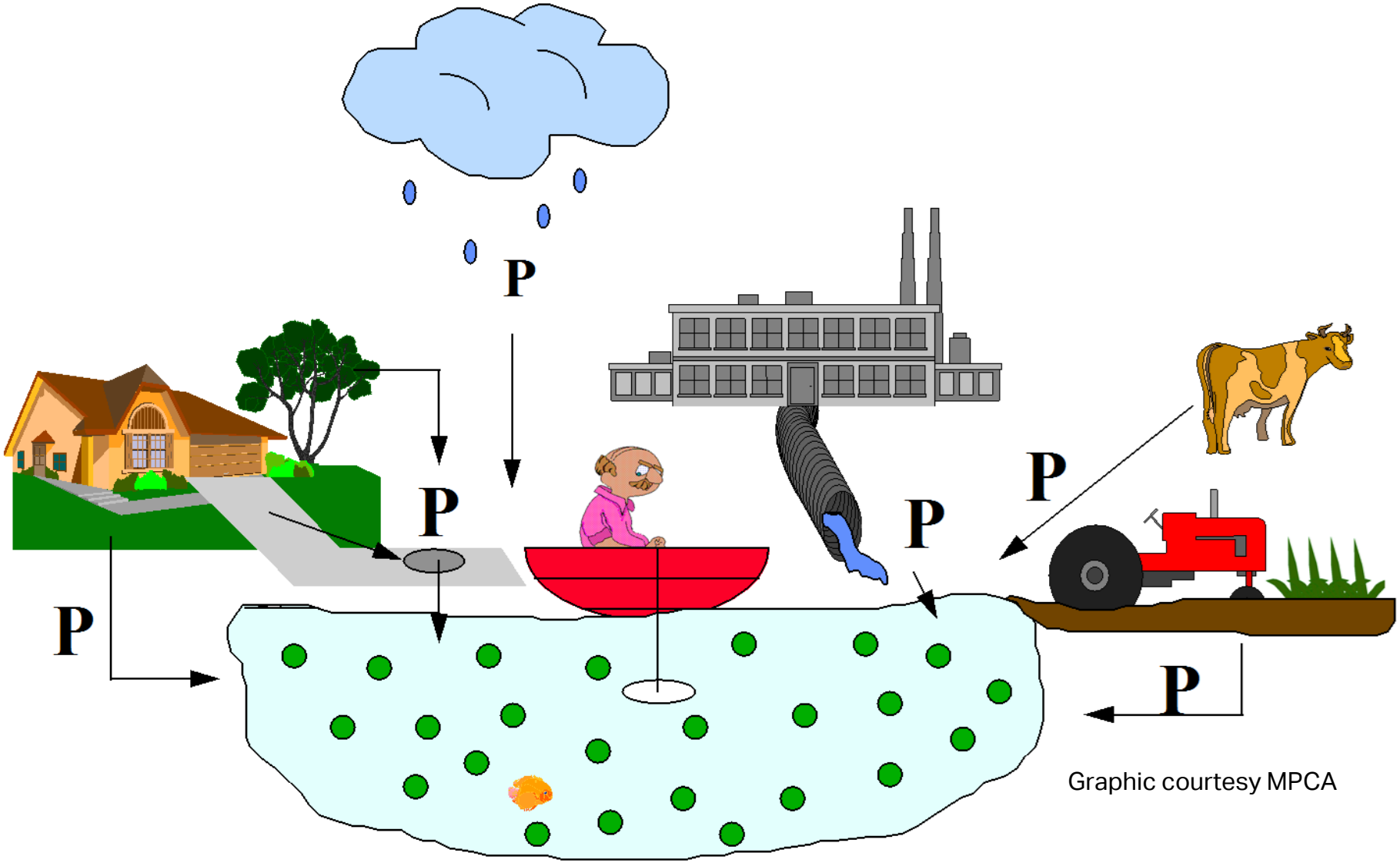
- On average, Secchi transparency has remained within standard.



LAND USE AND SOURCES OF PHOSPHORUS

RESPEC

SOURCES OF LAKE PHOSPHORUS LOADING

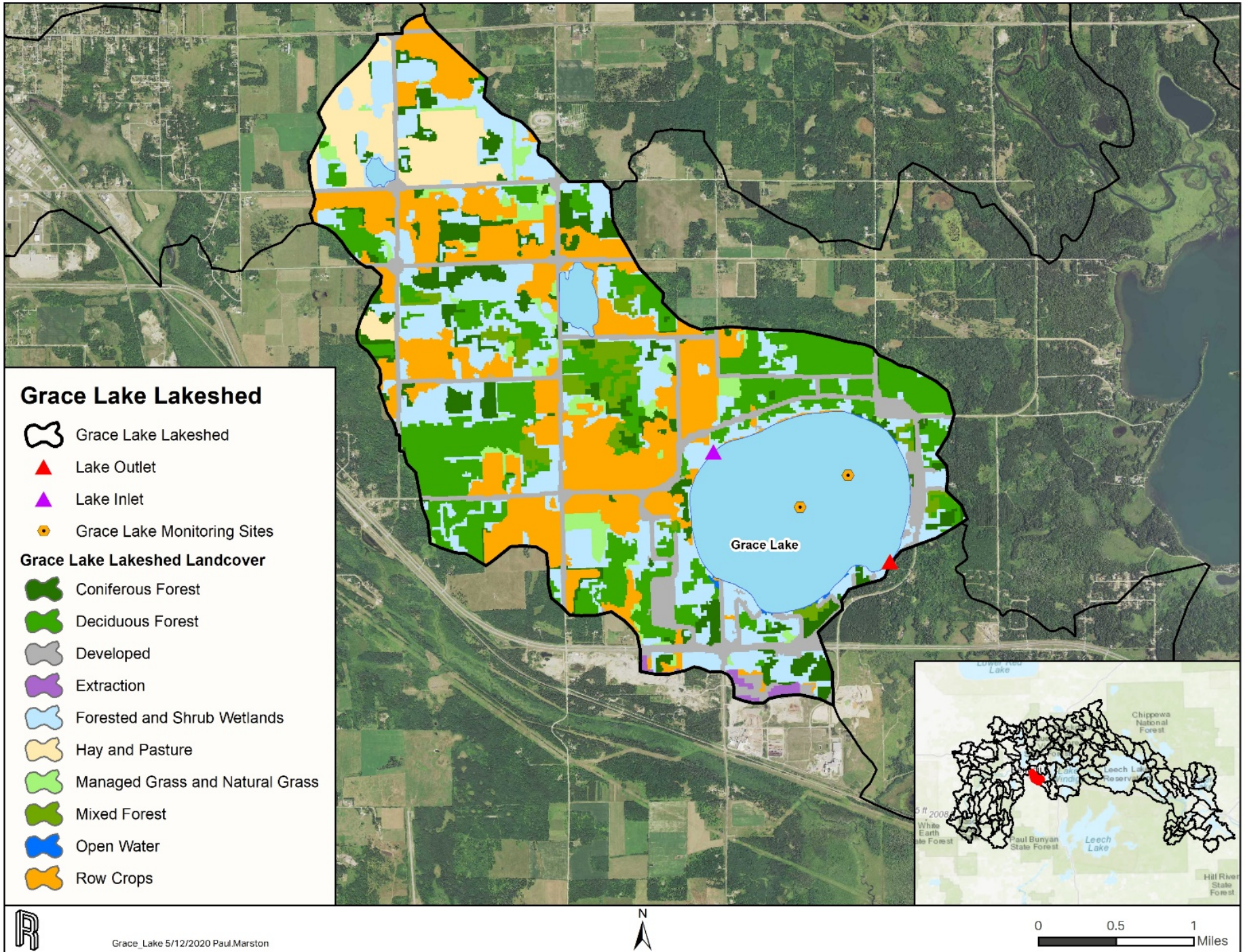


Graphic courtesy MPCA

LAND USE

- 4,957 acre watershed
- Forest: 31%
- Agriculture: 24%
- Wetlands: 24%
- Developed: 12%
- Pasture/Hay/Grass land: 8%
- Feedlots: 1%

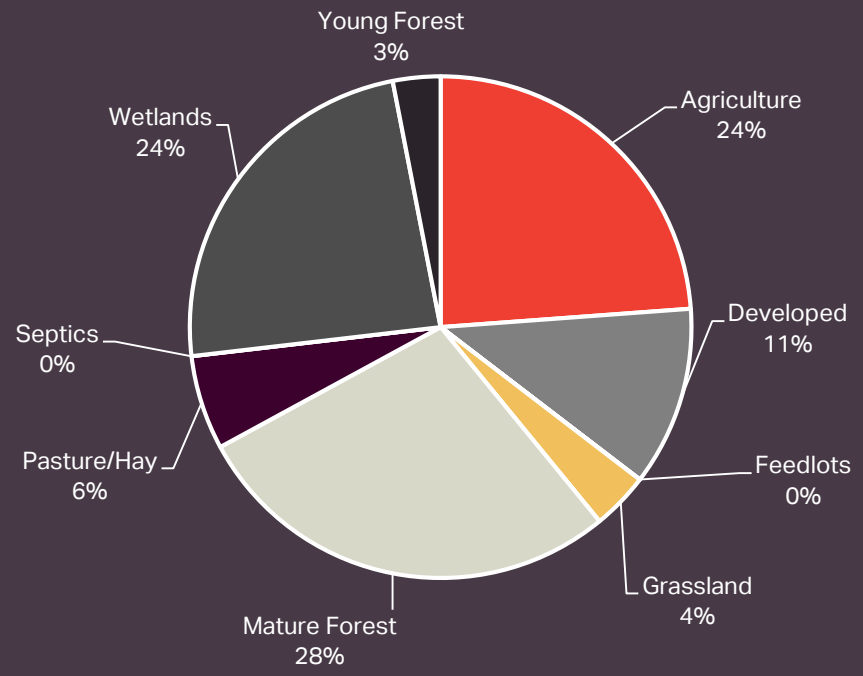
Note: there are minor discrepancies with pie chart on next slide due to rounding.



LAND USE COMPARED TO THE SOURCES OF PHOSPHORUS

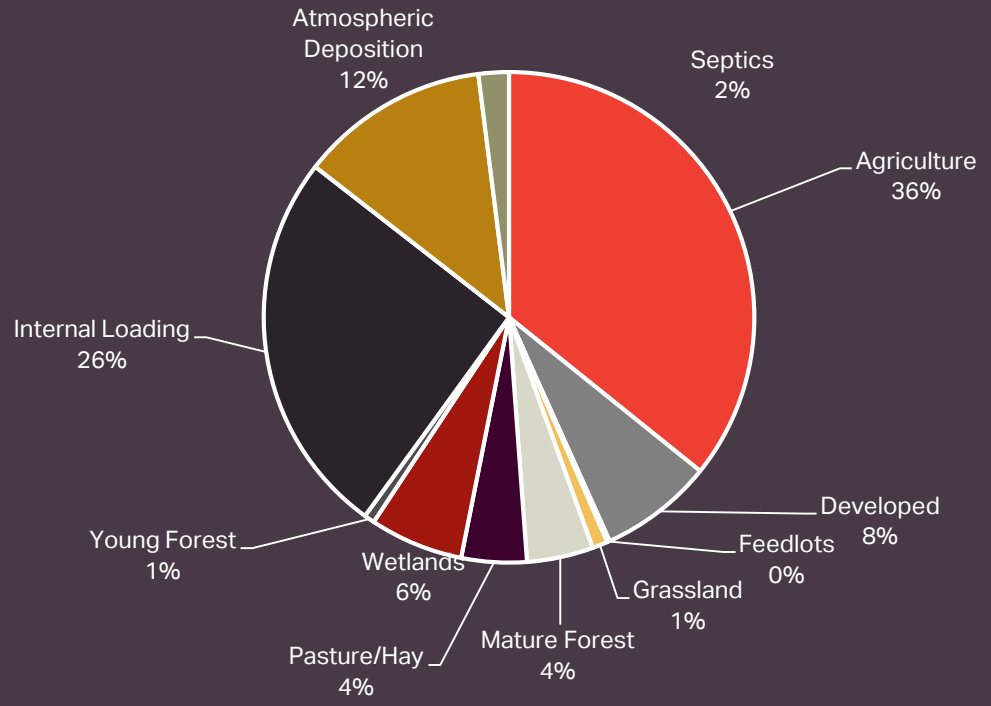
RESPEC

Grace Lake Lakeshed Area Land Use



Land use in the Grace Lake watershed.

Grace Lake Total Phosphorus Loading by Source



Sources of phosphorus loading to Grace Lake.

ECOREGION WATER QUALITY

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RESULTS

GRACE LAKE BATHTUB TOTAL PHOSPHORUS LOADING RESULTS

- External load
  - 60% from the lakeshed/watershed
  - 2% from septic systems
  - 12% from the atmosphere
- Internal load accounts for 26% of the source of phosphorus in the lake.
- Controlling external loading is critical to:
  - Prevent algal blooms
  - Decrease the likelihood of increased internal loading, which is more difficult to manage and reduce.

	Grace Lake Bathtub Model Results	TP (lbs/yr)	TP (lbs/day)	Percent of Total TP Load (%)
Load	Lakeshed/watershed	986.3	2.70	60
	SSTS	32.9	0.09	2
	Internal Loading	420.3	1.15	26
	Atmospheric Deposition	205.6	0.56	12
	TOTAL LOAD	**1,645.2**	**4.51**	**100**

lbs/yr = pounds per year
lbs/day = pounds per day
SSTS = Subsurface Sewage Treatment System.

SUGGESTED NEXT STEPS

FUTURE CONSIDERATIONS

- Watershed loading
  - According to the model results, agriculture accounts for 36% of the TP load to Grace Lake and wetlands account for 6% of the TP loading to Grace Lake.
  - The functionality of the wetland that is located at the inlet should be evaluated further. Wetlands can be a large source of TP loading if they do not have stable water levels and experience anoxic conditions (a lack of oxygen throughout the water column). In theory the wetland should be filtering out the high phosphorus loads coming from the watershed, but that should be verified by monitoring the water coming into the wetland and out of the wetland for one entire season.
- Reduce erosion and sediment resuspension by keeping shorelines and especially aquatic vegetation intact.
- Use phosphorus free fertilizer only as necessary.

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