Great Herring Pond and Little Herring Pond

Management Plan and Diagnostic Assessment

Town of Plymouth
Department of Marine and Environmental Affairs
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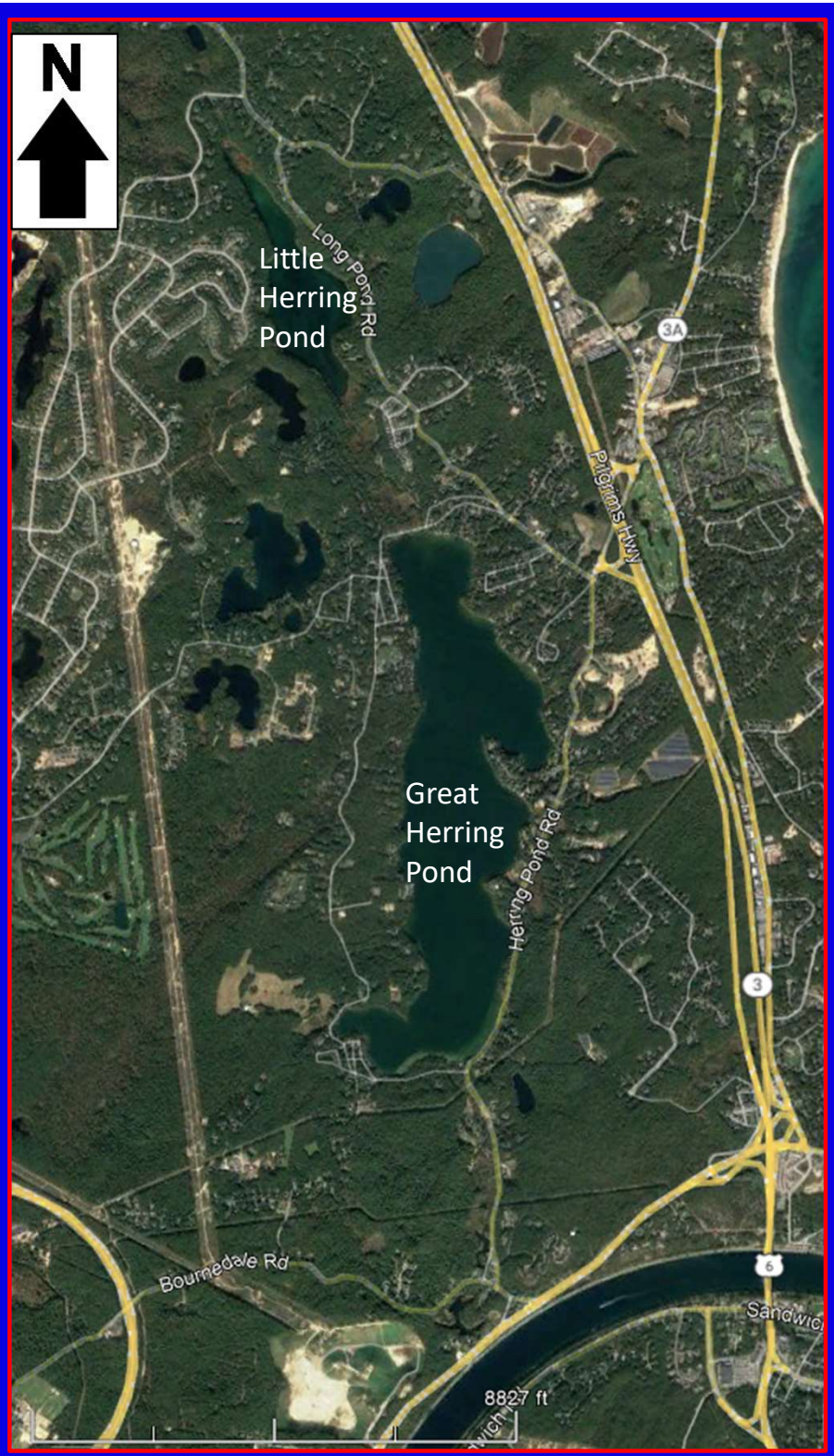
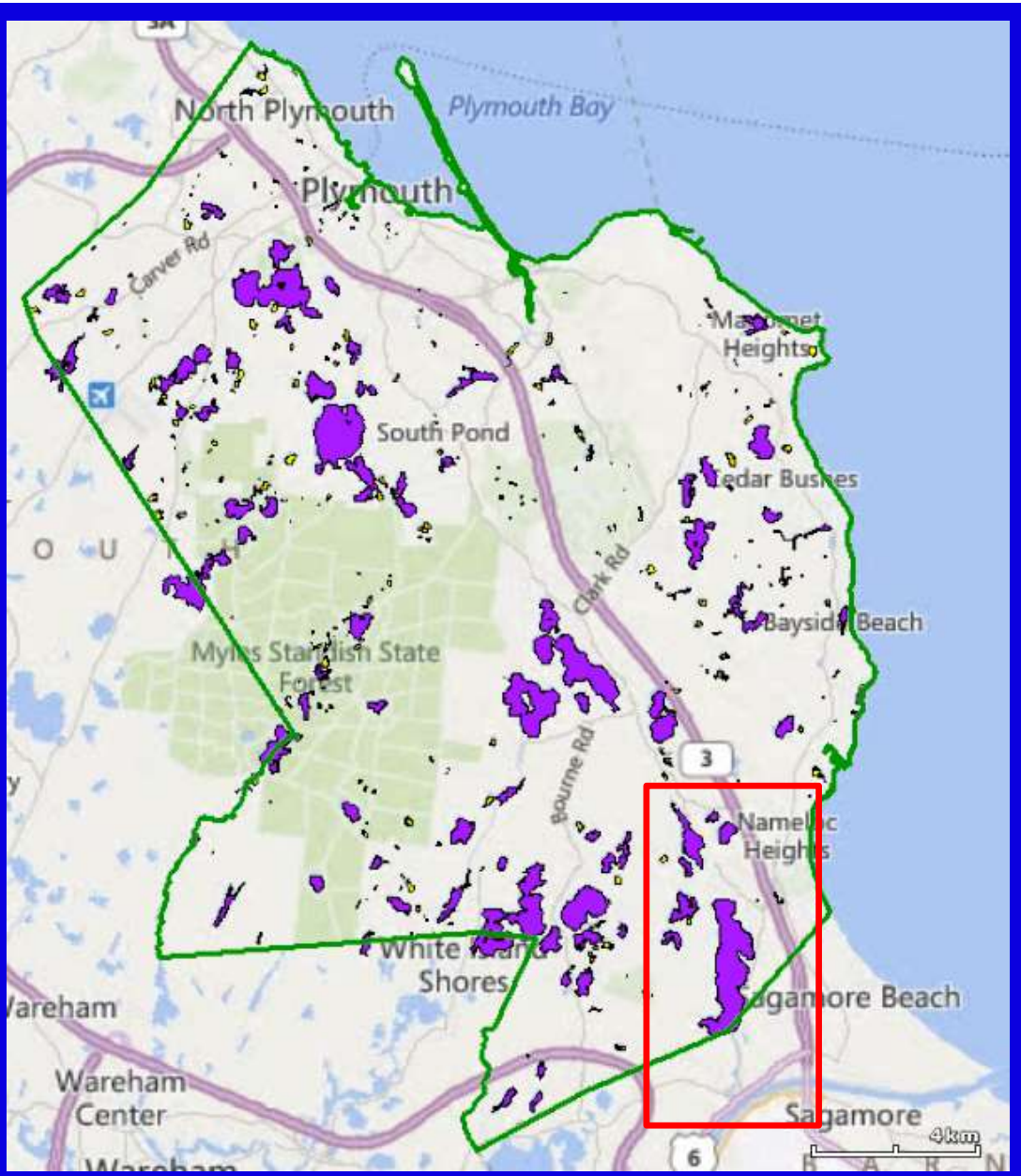
Ed Eichner
Principal/Water Scientist, TMDL Solutions
Adjunct Professor, Coastal Systems Program
School for Marine Science And Technology
University of Massachusetts Dartmouth





Both are Great Ponds:
Great Herring: 419 acres
Little Herring: 81 acres

Great Herring and Little Herring Ponds Background

State Classifications

1991 - Area of Critical Environmental Concern designation includes both ponds

Natural Heritage and Endangered Species Program (NHESP)

- GHP: Priority Habitat for Rare Species and Estimated Habitat of Rare Wildlife
- LHP: not listed

Current Integrated List of Waters (2021):

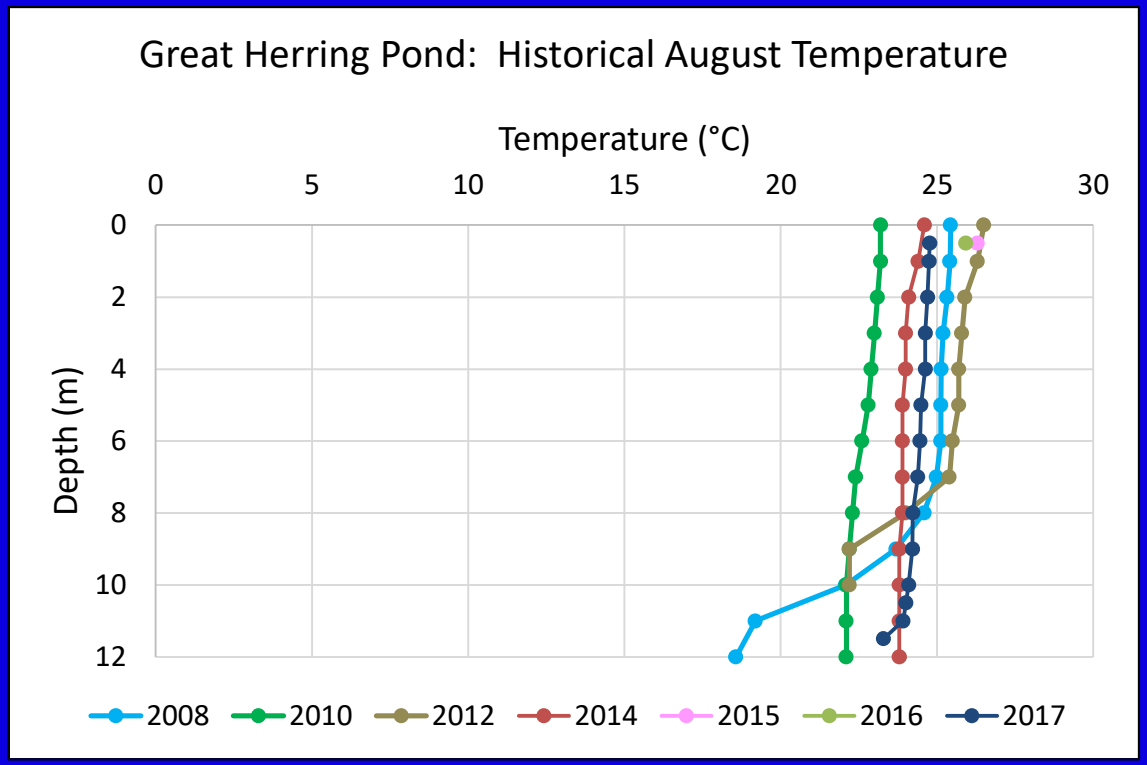
- GHP: Impaired due to low dissolved oxygen (Cat. 5)
- LHP: Attaining some uses; other uses not assessed (Cat. 2)

Cat. 5 require a TMDL

Class B waters and warm water fisheries under 314 CMR 4

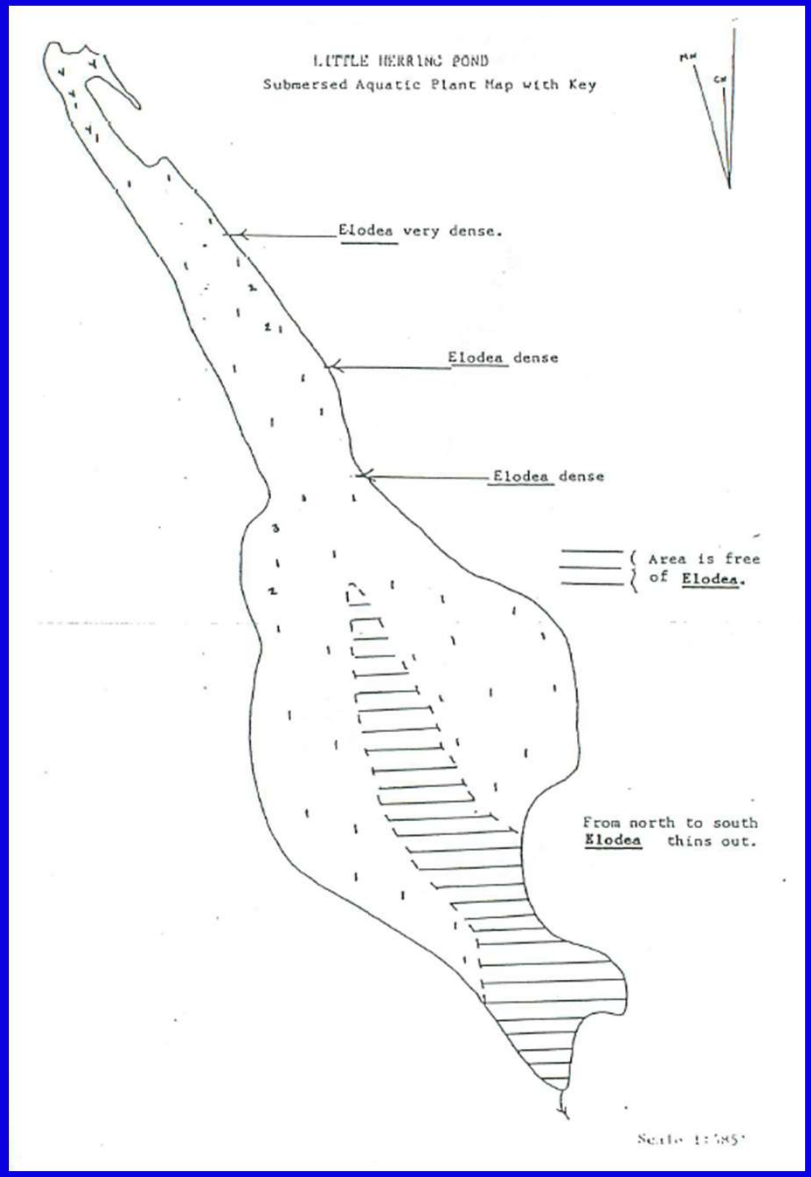
GHP Historical Data (after 2008)

- Well-mixed water column (49 ft/15 m total depth); surprising for such a deep pond
- Inconsistent deep anoxia: measured in June & August (but not all profiles); none in September (10 of 26 had anoxia; 8 – 11 m depth)
- Seasonal loss of clarity (5.1 m in April/May, 2.6 m Aug/Sept); no apparent trend
- P control of water quality conditions

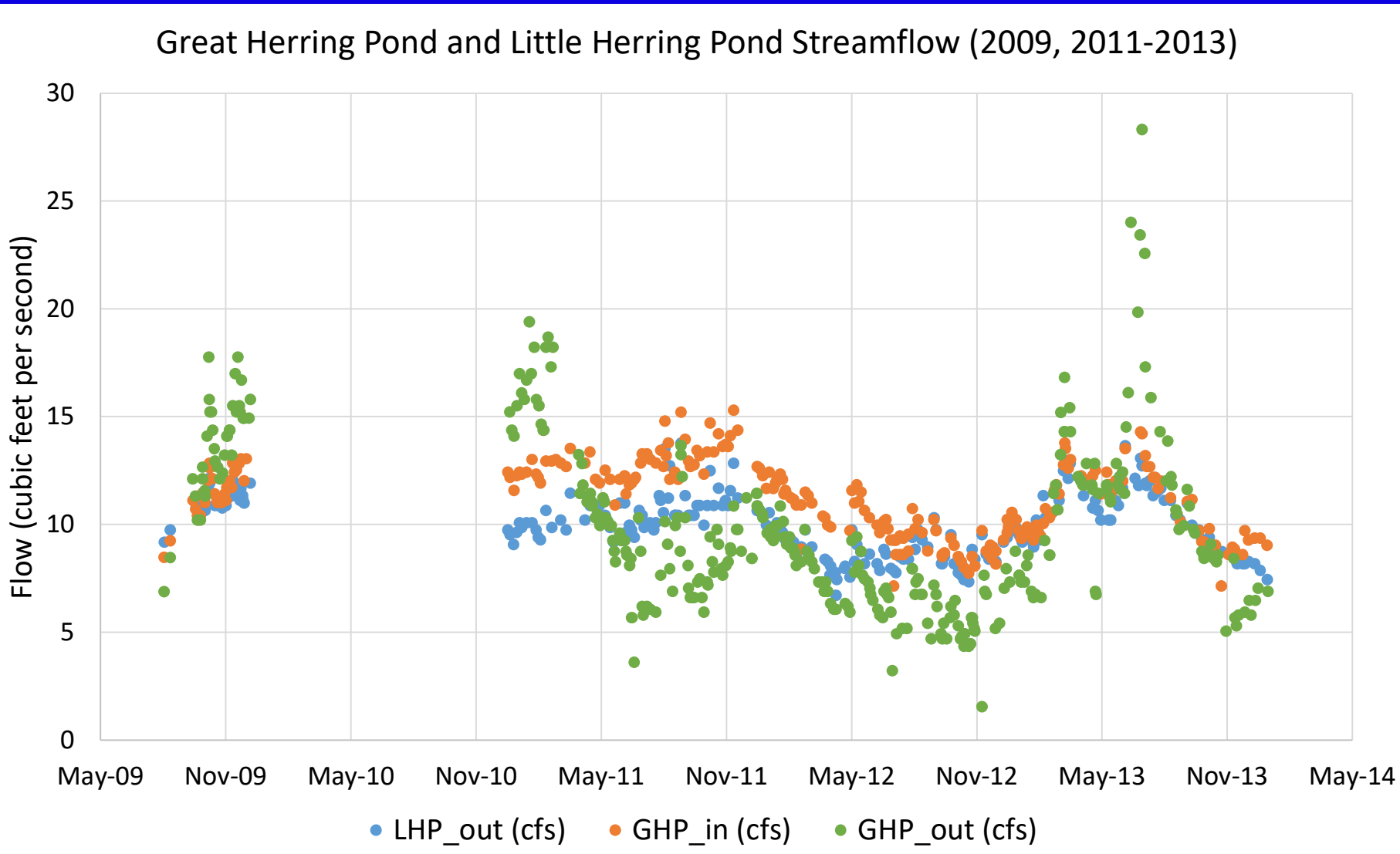


LHP Historical Data (detailed 1976, then after 2008)

- Well-mixed water column (81 acres, but only 1.5 m deep)
- Well-oxygenated (no readings below MassDEP minimum)
- High nutrient levels
- Clarity: usually see Secchi on bottom
- 1976: bottom mostly covered by *elodea* (waterweed)
- P control of water quality conditions



Great Herring and Little Herring Ponds Background



Data from Herring Ponds Watershed Association

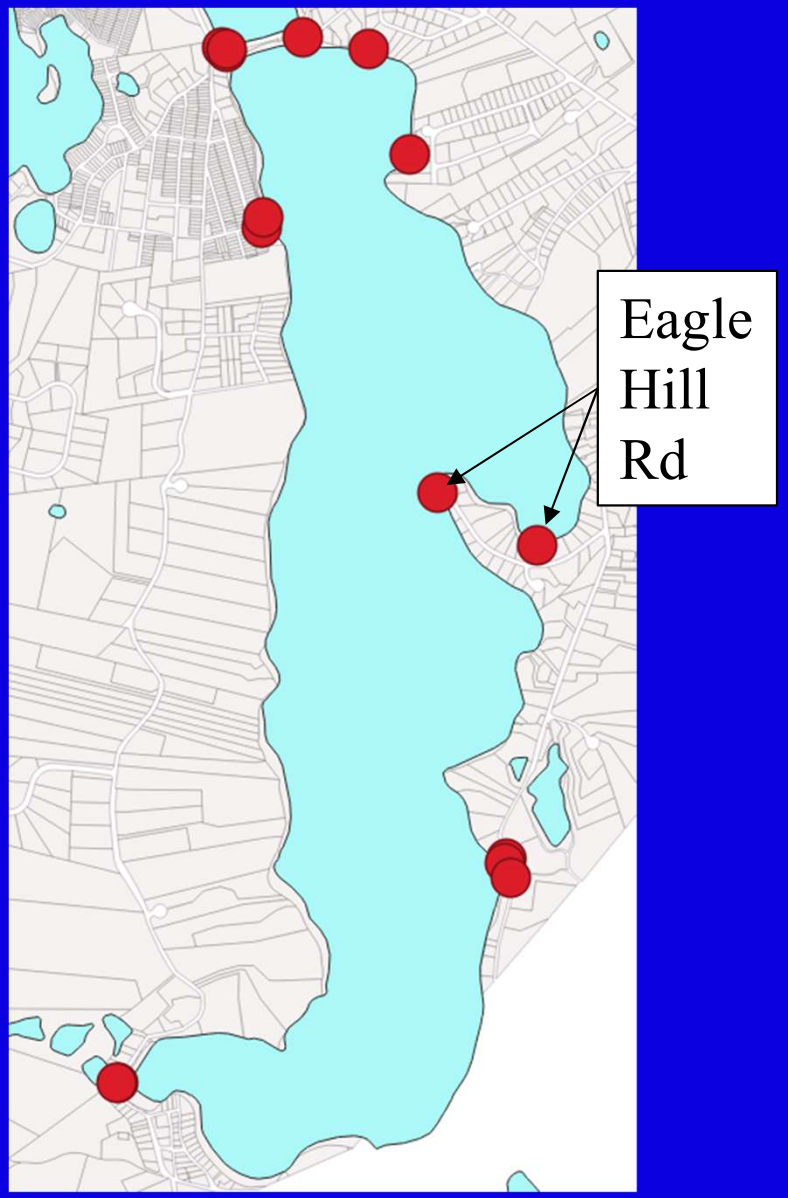
Great Herring and Little Herring Ponds Background

2015 – CSP/SMAST stormwater measurement at GHP

- 6 of 13 runoff discharge sites
- Three storms
- Eagle Hill Road sites had greatest impact
- Estimated annual loads at all 13 sites:

  5.6 kg TP
  45 kg TN
  1,800 kg TSS

2019 Three storms at Eagle Hill Rd
=> measurements largely confirmed



2021 GHP and LHP Data Gaps

Water Column Measurements: 10X between April and October 2021

Temperature and dissolved oxygen profiles
Secchi clarity
Water quality samples:

- LHP: 0.15 m, 0.5 m, and 1 m
- GHP: 0.5 m, 1 m, 2 m, 3 m, 8 m, 9 m, 10 m, 11 m, and 12 m

Monthly phytoplankton samples: species, cell counts, biomass

Stream Flow and Water Quality: monthly April through October 2021
LHP and GHP outflows

Bathymetric, rooted plant and freshwater mussel surveys

Sediment cores and measurement of P regeneration under aerobic and anaerobic conditions: LHP: 3 cores, GHP: 13 cores

LHP 2021 Summary

- Well-mixed water column:
  - Temp, DO, TP, TN, pigments similar throughout water column
  - P determines WQ conditions
- All Secchi readings: light on bottom
- All DO above MassDEP minimum, although many profiles had DO saturation levels >110% (*i.e.*, active phytoplankton)
- Sediments removing TP from water column (rates >GHP)
- Aquatic plants covering almost whole bottom (video review suggests same plant as 1976 and greater coverage)
- Freshwater mussels around most of shallow margin
- Limited cyanobacteria, green phytoplankton dominant until September, biomass concentration greater than GHP (highest in May)

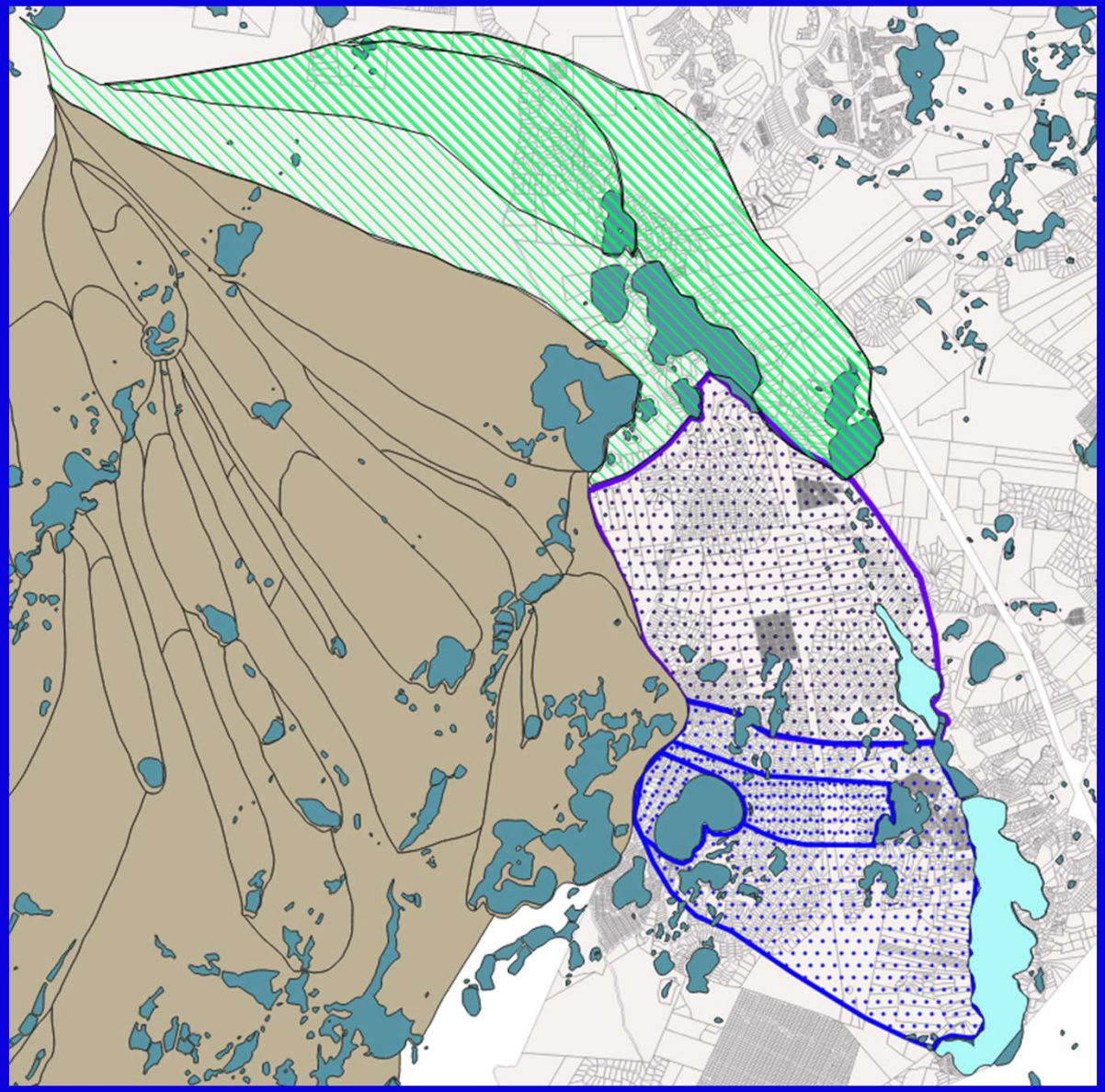
GHP 2021 Summary

- Temperature: mostly well-mixed water column:
  June 25 stratification at 8 m, July 14 stratification at 12.6 m
- Dissolved oxygen: hypoxia in Jun-Sept, anoxia in Jul, Aug, Sept
  June 25 DO <MassDEP min ≥8 m, but no anoxia
  July 14 DO <MassDEP min ≥9 m, anoxia ≥12 m
  Aug 18 DO <MassDEP min ≥8 m, anoxia ≥9 m (shallow DO 106-110% saturation)
  Sept 15 DO <MassDEP min and anoxia ≥12.5 m
- Secchi readings: generally consistent with historical readings: loss of 5 m of clarity between Apr and Oct (biggest loss Apr to May)
- P determines WQ conditions
- Shallow TP increased from ~ 10 ppb in Apr/May to 20/22 ppb in Jul-Oct

GHP 2021 Summary (cont'd)

- Pigments
  April: all depths ≤ Ecoregion threshold
  Shallow concentrations did not exceed threshold until June
  Increased during summer at all depths, peaked at >10X threshold
- Sediments
  Aerobic: removing TP from water column; no notable difference with depth
  Anaerobic: 7 day delay to initiate P release; total P release depends on depth and duration of anoxia
- Aquatic plants sparse; phytoplankton dominant pond
- Freshwater mussels around most of shallow margin (≤8 m depth)
- Phytoplankton biomass low until October; cyano generally present, but not dominant; highest cyano cell count in October (3% of MassDPH 70,000 cells/ml criterion)

Combined LHP GHP: Water Budget and Streamflow



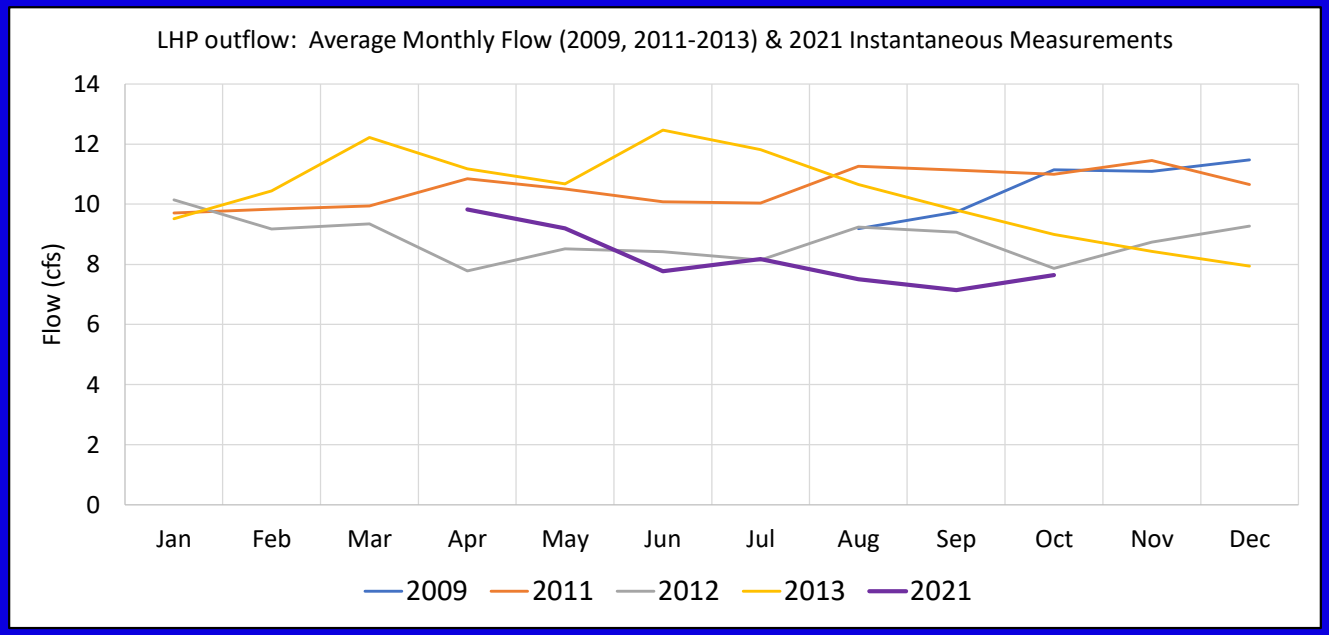
GW input vs. Pond Volume
= water residence time:
LHP: 13 days
GHP: 7.2 months

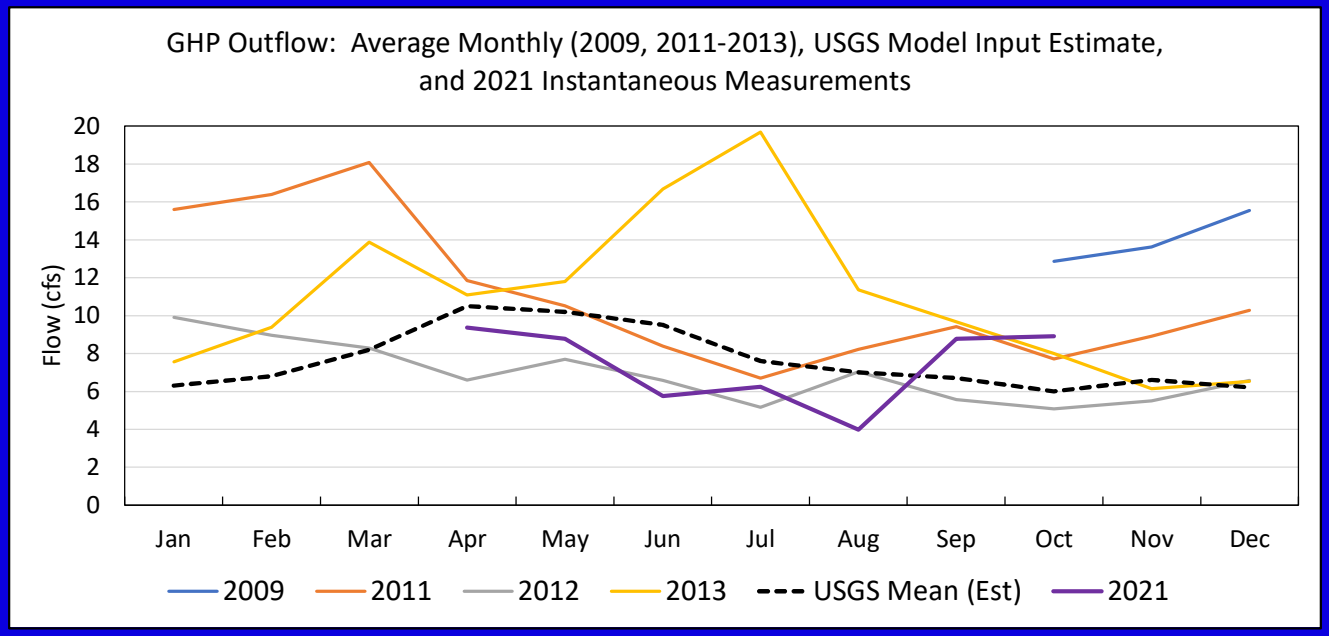
Variables:

- Groundwater
- Precipitation
- Surface Evaporation

Combined shed input:
LHP: 9.8 cfs
(matches 2012/13 avg)
GHP: 19.9 cfs
(>>8.8 cfs 2012/13 avg)

Streamflow Readings





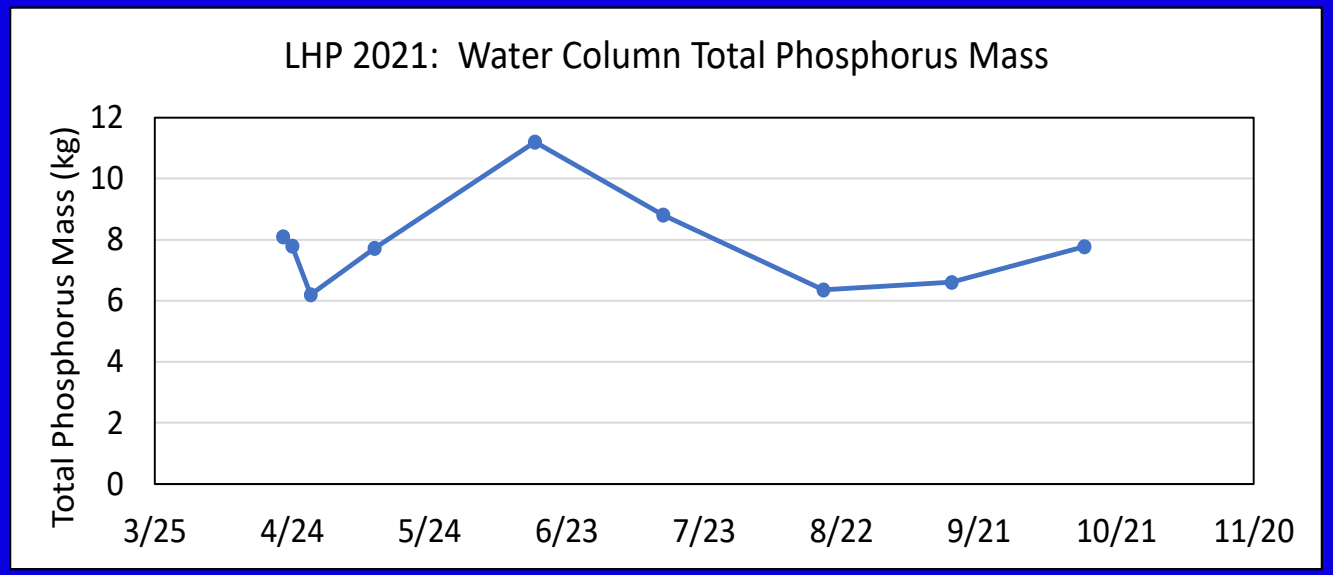
2021 flows low at both outflows, but generally consistent with past ranges

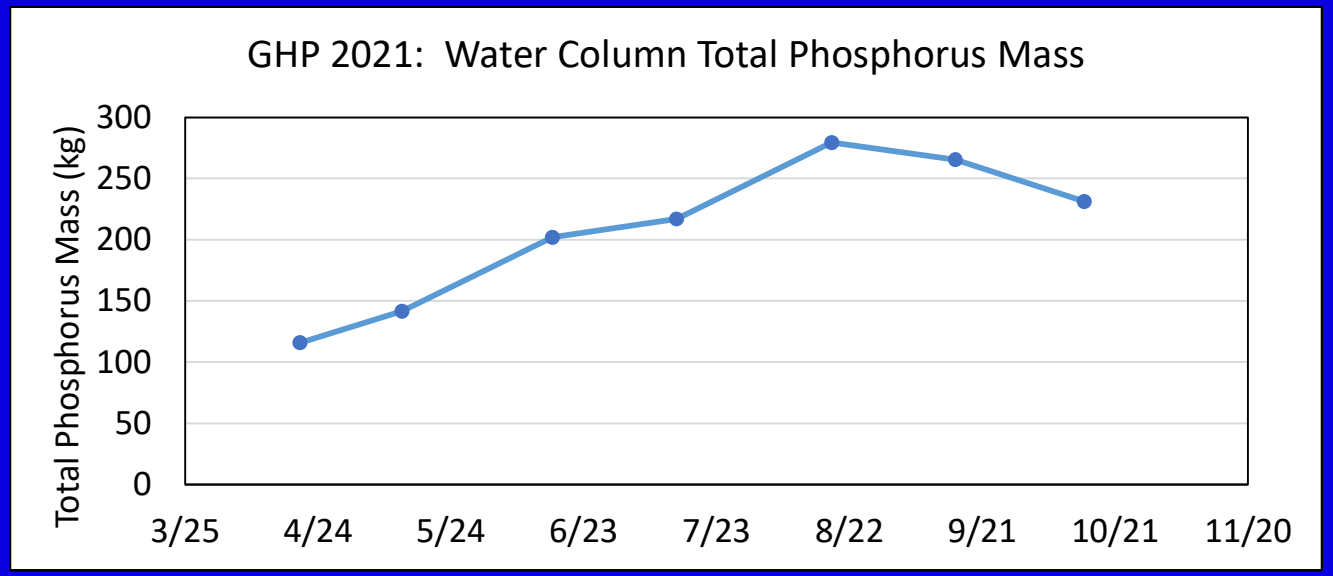
Low flows consistent with below avg GW levels in 2021

GHP outflow fell 31% from Apr to July, then another 58% in Aug

GHP outflow historically more variable than LHP outflow

Combined LHP GHP: Water Column Mass





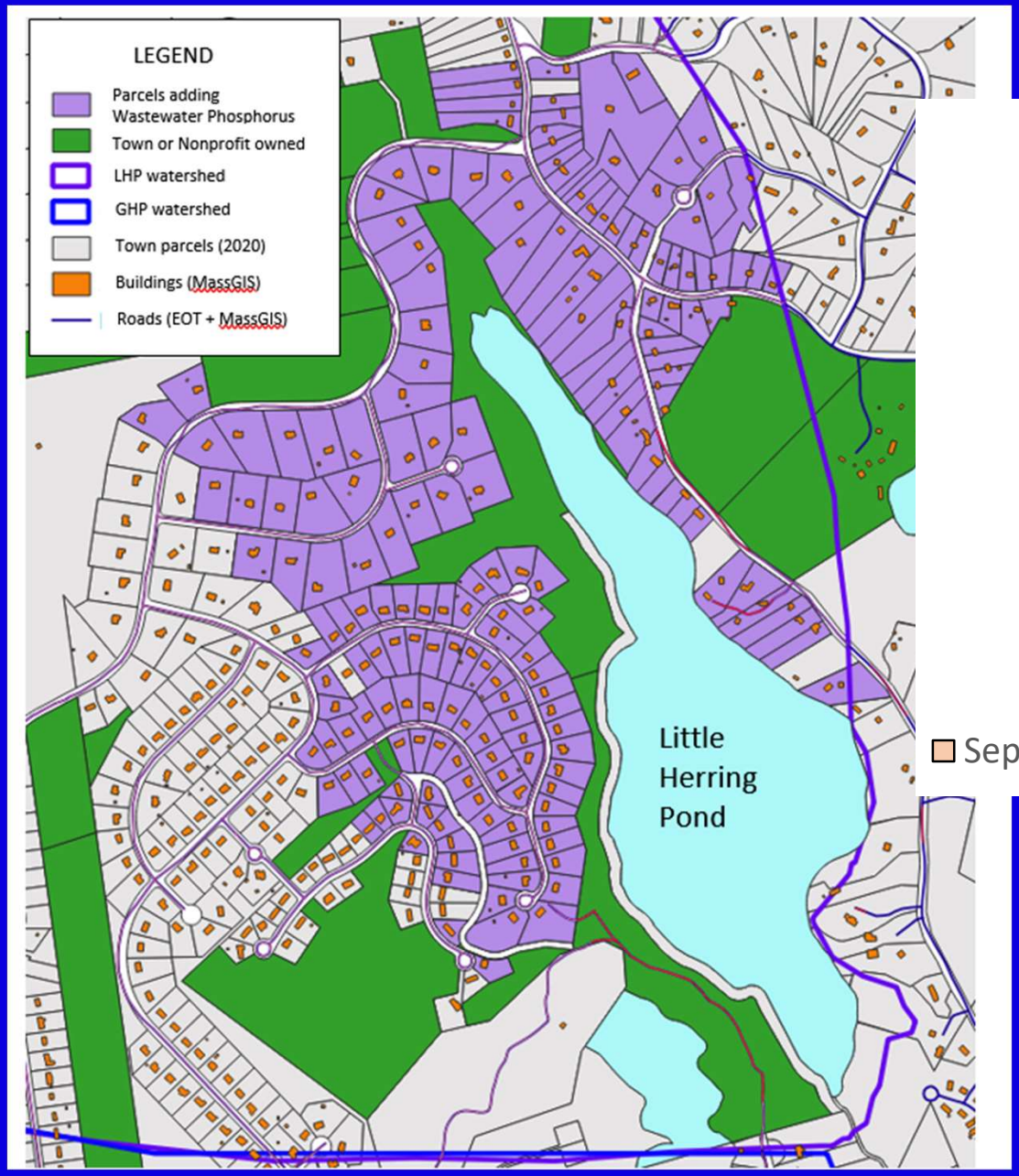
LHP:

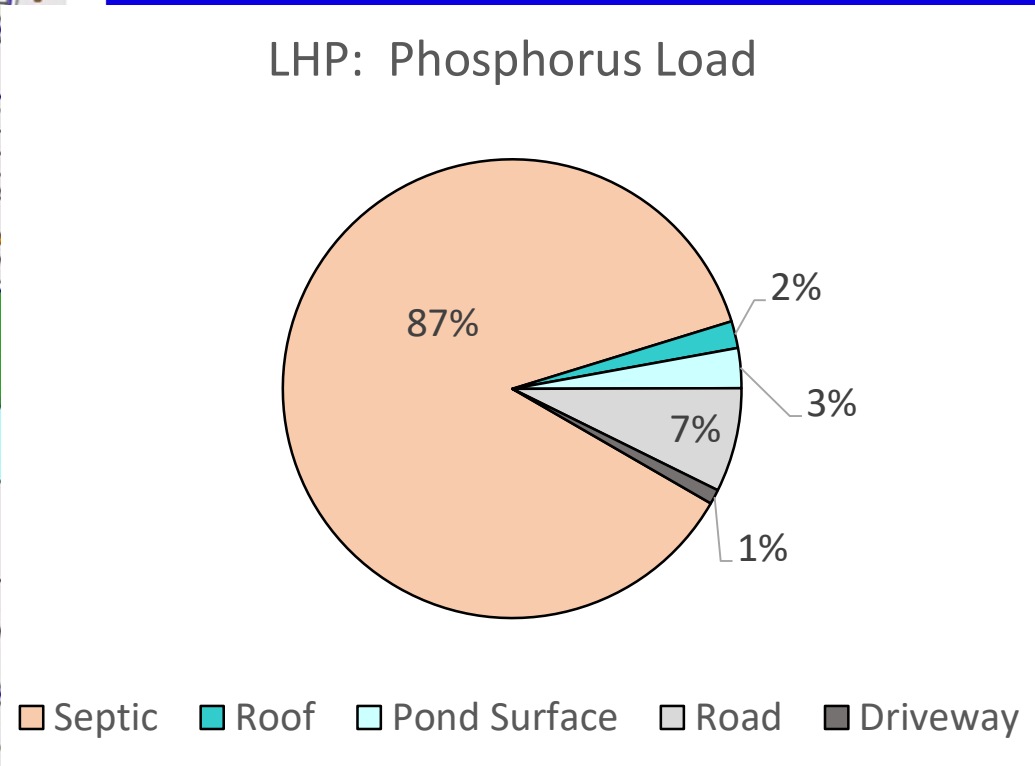
- Relatively stable
- 8 kg avg TP month
- 6.2 to 11.2 kg range

GHP:

- Increased from Apr-Aug
- 116 kg in Apr
- 279 kg in Aug

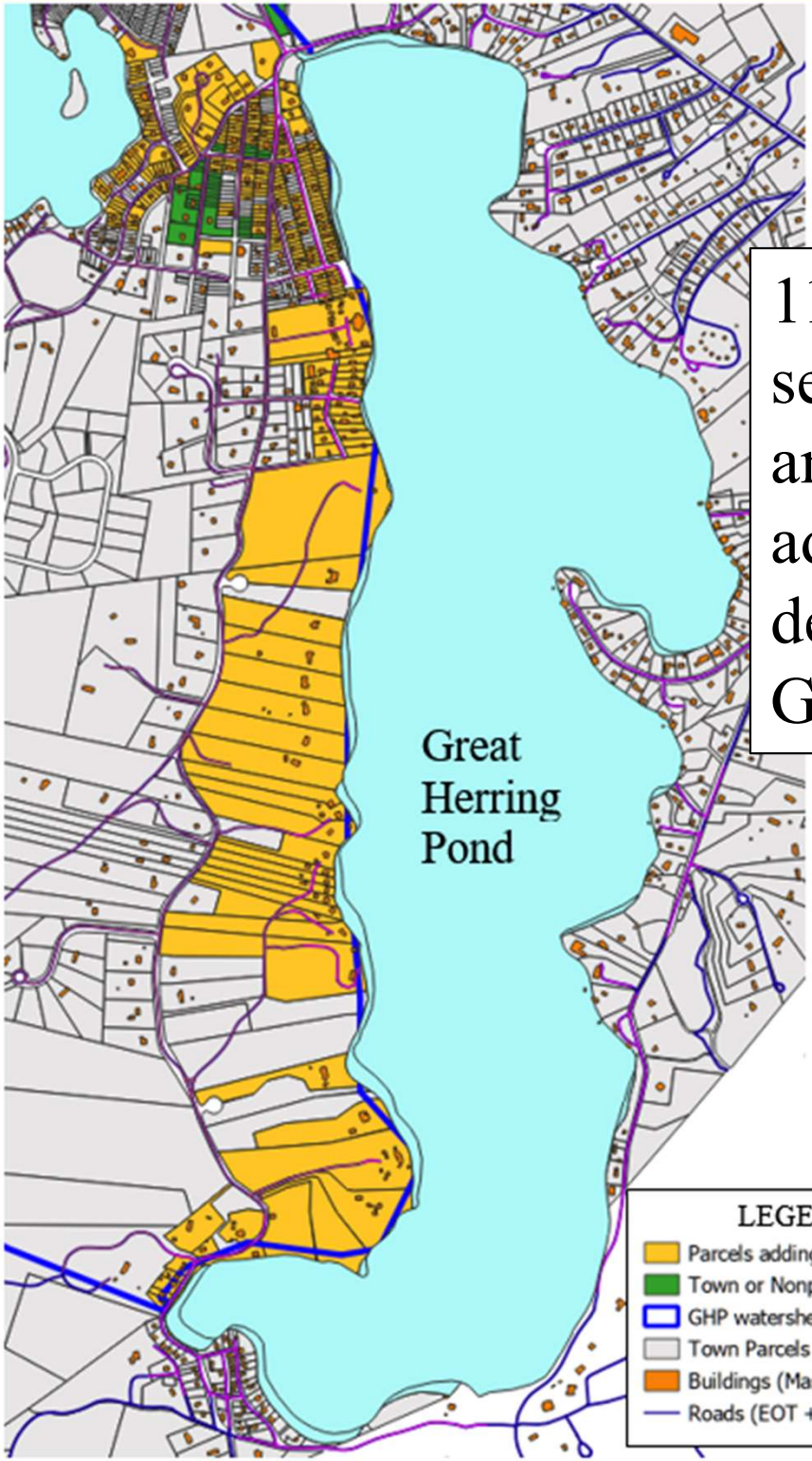
LHP Phosphorus Budget





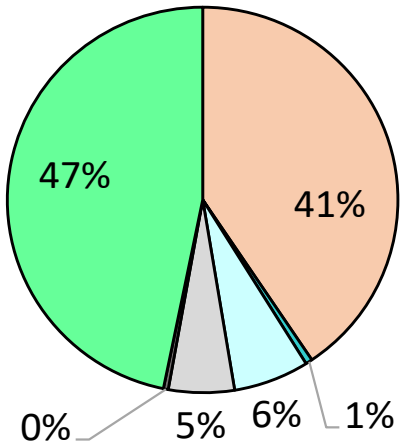
128 to 178 septic systems and houses adding P depending on GW flow rate

GHP Phosphorus Budget

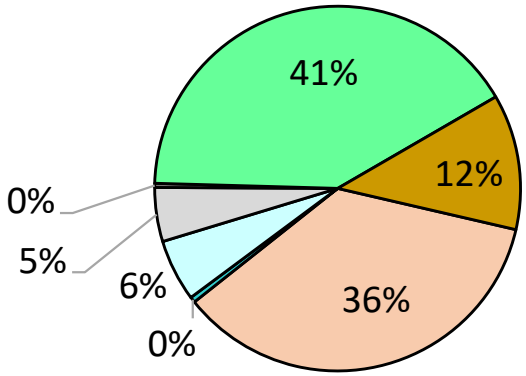


116 to 158 septic systems and houses adding P depending on GW flow rate

GHP: Steady State Phosphorus Load



GHP: Summer Anoxia Phosphorus Load



Septic
Roof
Pond Surface
Road
Driveway
Stream inflow
Sediments

Diagnostic Conclusions

- Great Herring Pond is impaired
  - regular deep water dissolved oxygen concentrations less than the Massachusetts regulatory minimum,
  - regular deep hypoxia and anoxia in deep portions of the water column sufficient to prompt sediment release of phosphorus,
  - shallow water phosphorus and chlorophyll concentrations greater than Ecoregion thresholds, and
  - loss of water clarity during the summer (~5 m in 2021)

- Little Herring Pond is not impaired (but will require regular check-ins)

- Management/Remediation of GHP will require management of LHP phosphorus inputs, as well as management of GHP phosphorus inputs

Water Quality Management Goals

- Phosphorus controls Great Herring Pond water quality

- April had acceptable water quality in GHP
  - high clarity,
  - all DO conc's above the MassDEP minimum and
  - low TP concentrations

- Water column TP mass in April = 116 kg
  - 116 kg TP in GHP volume = concentration of 11 µg/L
  - Ecoregion threshold 10 µg/L TP

WQ Management Goals/Options

Attaining 116 kg TP in August with 2021 outflow would require a water column mass of 50 kg TP in April (selected as an initial planning threshold)

~90 kg added from GHP watershed
(77% is wastewater)
~100 kg added by LHP stream inflow
(87% is wastewater)
~30 kg added by GHP sediments
(only occurs in summer)
~6 kg added by GHP stormwater outfalls

Areas of potential reduction

WQ Management Goals/Options

LONG TERM:
Watershed Wastewater Options/Primary P source

- Removing all LHP watershed wastewater P and 60 to 70 residences in GHP watershed would meet GHP threshold

Issues:

- Nearest municipal sewer is ~7.5 miles away
- Planning and building new wastewater infrastructure will take years
- P-reducing septic systems are experimental (limited by MassDEP to 15 installations per technology) and would require more extensive use in GHP watershed; if MassDEP limit overcome, estimated cost $5.4 to $7.4 million

WQ Management Goals/Options

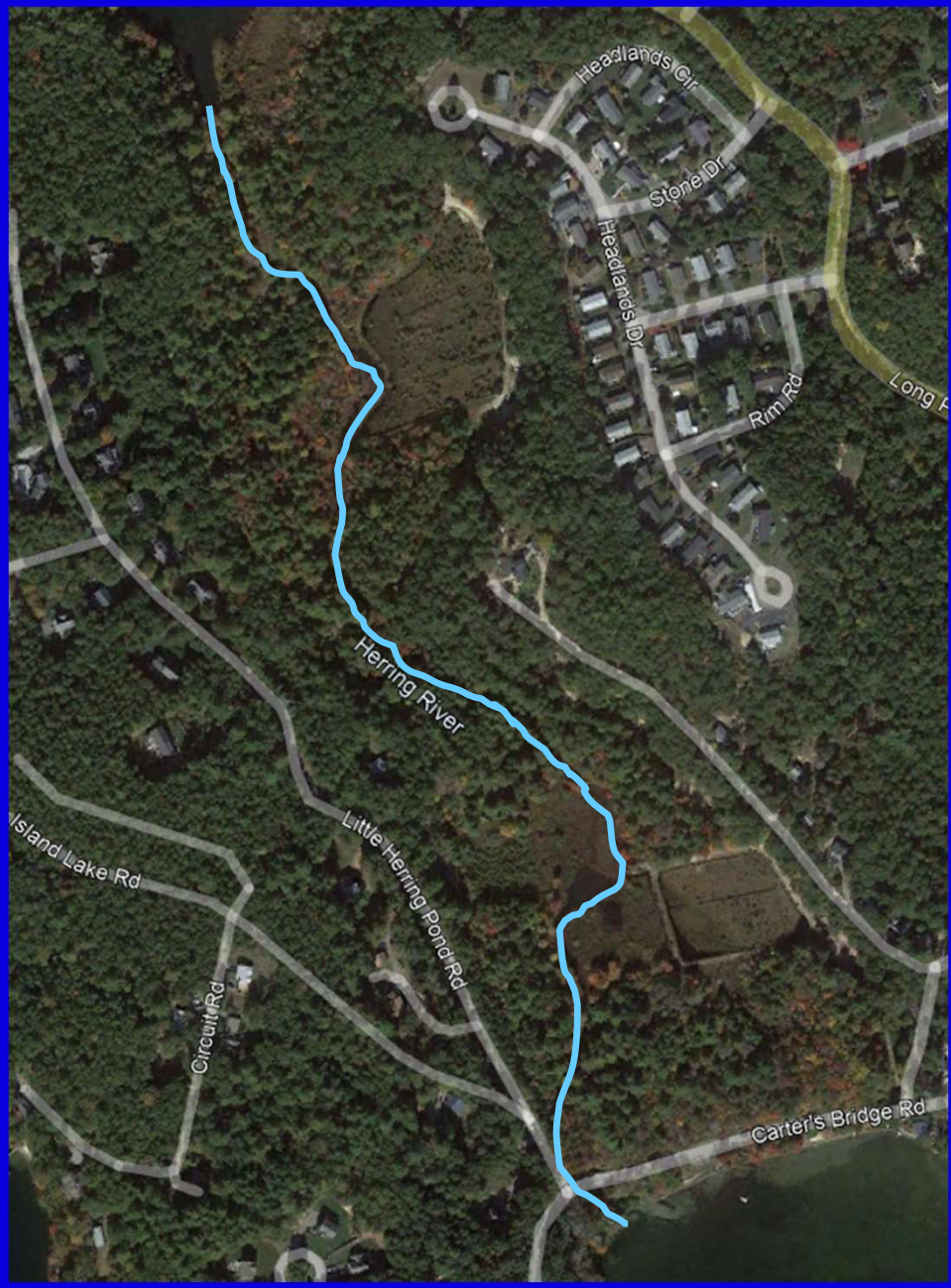
INTERIM
In-pond P reductions

- Sediment Treatment: alum treatment, dredging, or aeration (only 12% of summer P)
- Alum treatment to try to strip out some portion of water column P
- Experimental (all will require monitoring and permitting)
  - Temporary or permanent Permeable Reactive Barriers along shoreline (temporary less expensive and easier to permit)
  - Floating wetlands (successful in high ortho-P settings; highly experimental in natural lake settings)

WQ Management Goals/Options

INTERIM
Treat P in stream between ponds

- Construct enhanced wetlands to slow flow and increase residence time (Town has experience in wetland reconstruction)
- Install in-stream PRB (highly experimental)

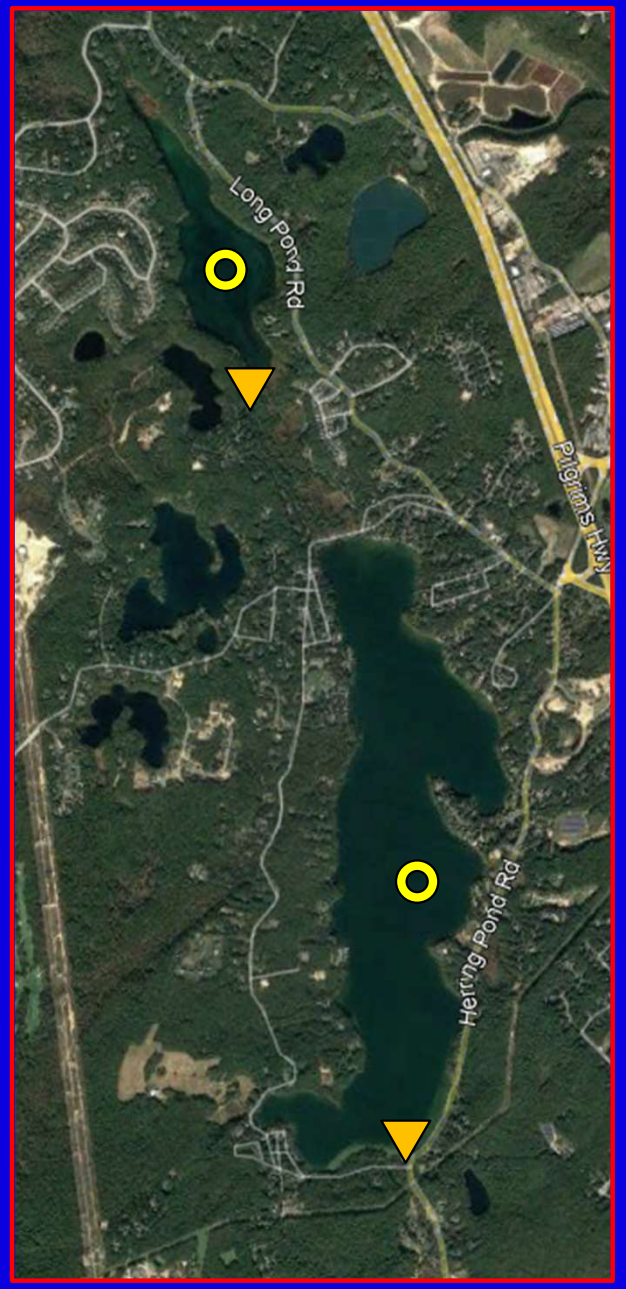


WQ Management Goals/Options

SHORT TERM
Develop Monitoring Plan

- Deep Spot Water Quality Sampling:
  - GHP (monthly: April – October
  - LHP (annual: August/September)
- Stream Flow and Water Quality Measurements at LHP and GHP outflows
- Annual Review of Data

- *Optional*
- Continuous Monitoring in GHP Deep Spot
- Stage-Discharge Curves at LHP and GHP outflows



WQ Management Goals/Options

Current Strategy Summary

LONG TERM MANAGEMENT GOALS

- Sewer Little Herring Pond and portion of the Great Herring Pond watershed

INTERIM MANAGEMENT GOALS

Explore temporary interim P reduction options

- In Stream Phosphorus Removal - Carters River
  - ✓ Restoration of the wetlands between LHP and GHP
  - ✓ Instream Permeable Reactive Barrier
- Permeable Reactive Barriers
- Floating Wetlands – LHP and/or GHP
- Spot Alum Treatment – GHP
- Evaluate direct discharge stormwater improvement options - GHP

SHORT TERM MANAGEMENT GOALS

- Develop and implement a Monitoring Plan
- Use 50 kg TP mass within the GHP water column as a preliminary threshold, but avoid TMDL designation until attainment of satisfactory water quality

Coastal Systems Program
University of Massachusetts Dartmouth

Science for Management

Questions & Discussion

Coastal Systems Program:

Brian Howes
Ed Eichner
Roland Samimy
David Schlezinger
David White
Dale Toner
Sara Sampieri
Jen Benson
Michie Labrie

Contact:
Ed Eichner
TMDL Solutions LLC
eichner@tmdlsolutions.net
Cell: 508-737-5991