# Environmental and Human Health Risks at Georgica Pond; Working Towards a Sustainable Plan for Remediation

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# Outline of presentation

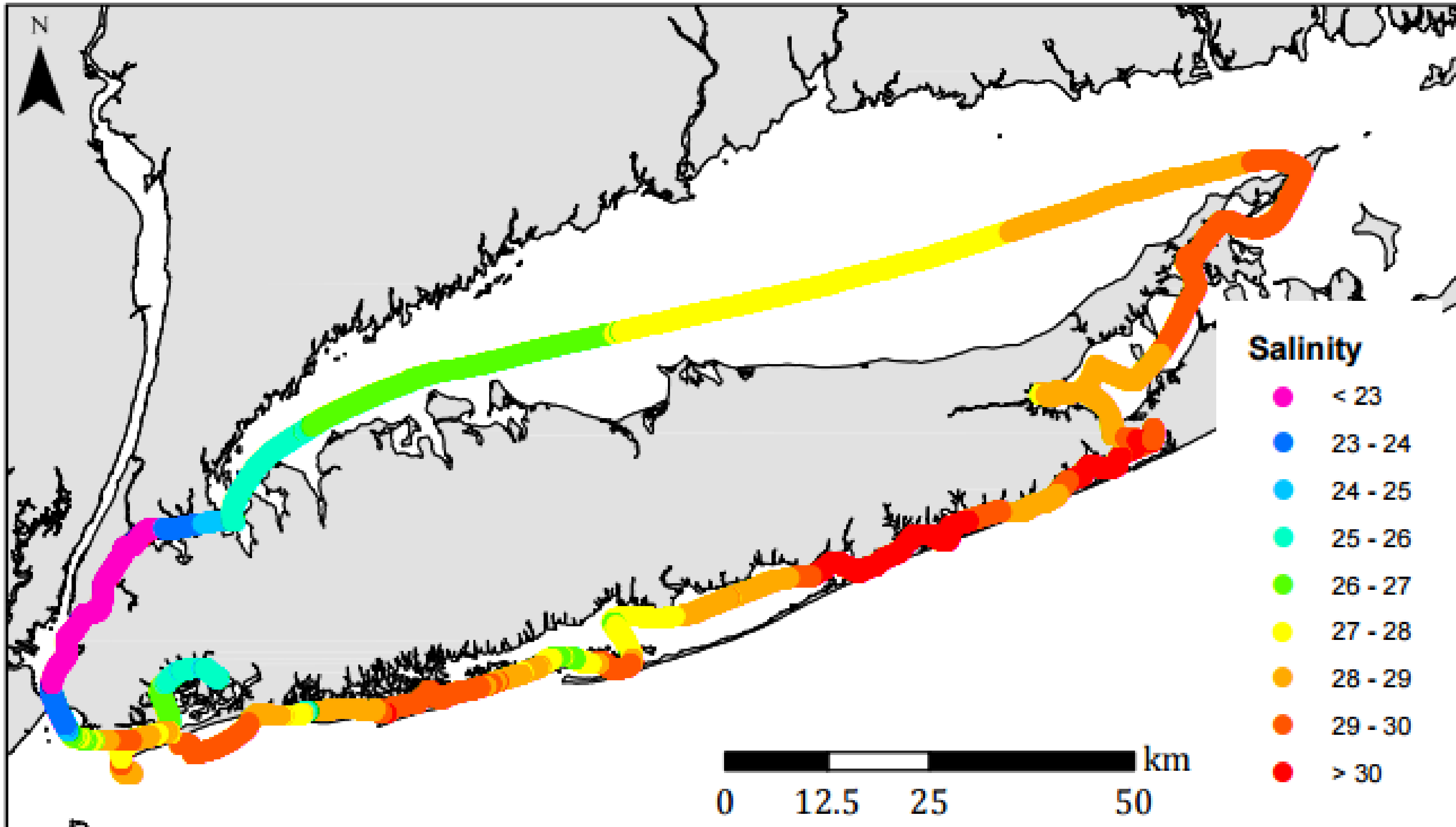
- Background on Georgica Pond
- Study objectives
- 2015 status and trends
- Identification of algae and toxins
- Factors promoting algae and toxins
- Sources and delivery of nitrogen and phosphorus
- Options for improving the conditions in Georgica Pond

# The beauty of Georgica Pond

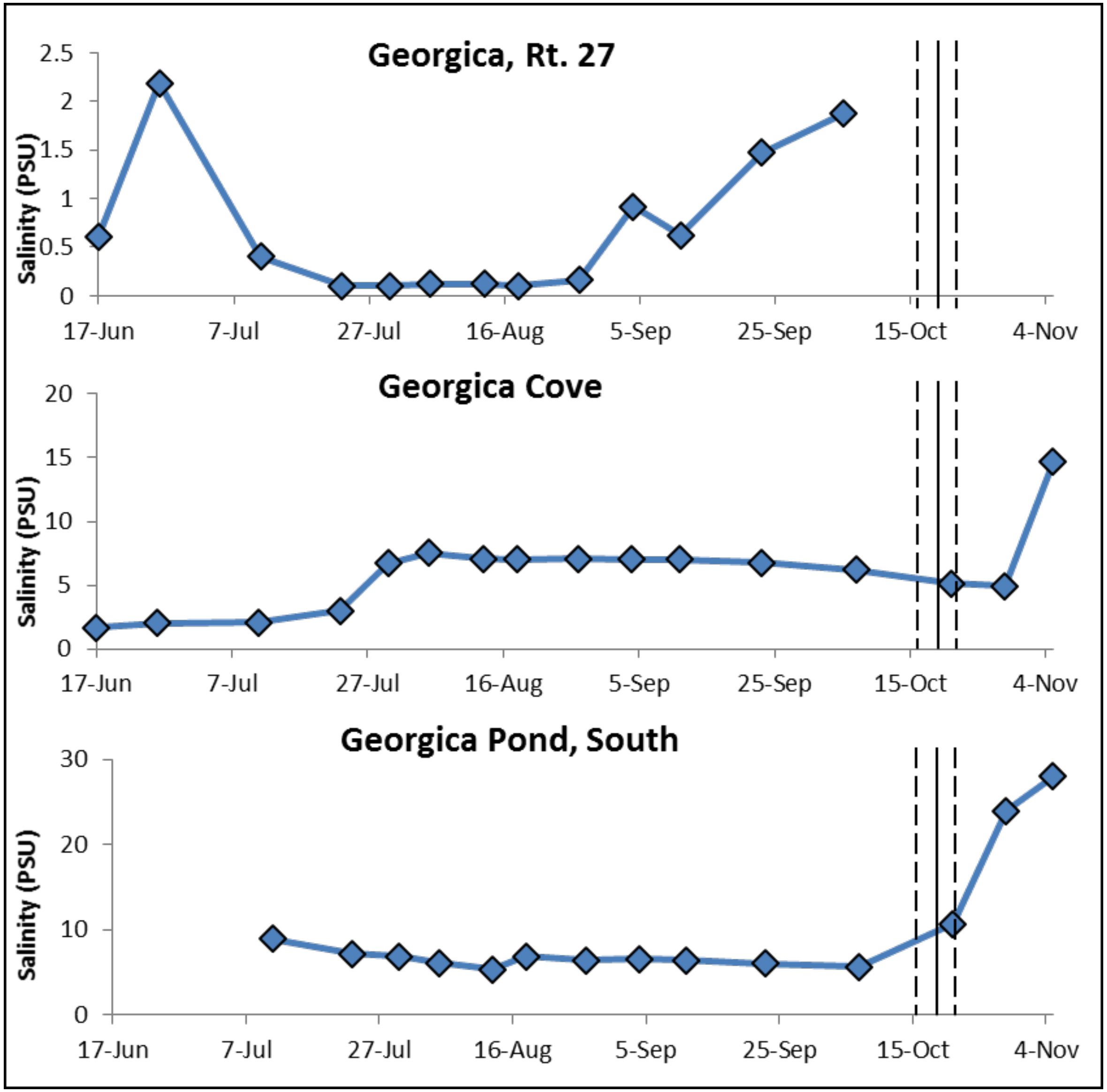
# The beauty of Georgica Pond

# The ocean inlet makes Georgica Pond regionally unique

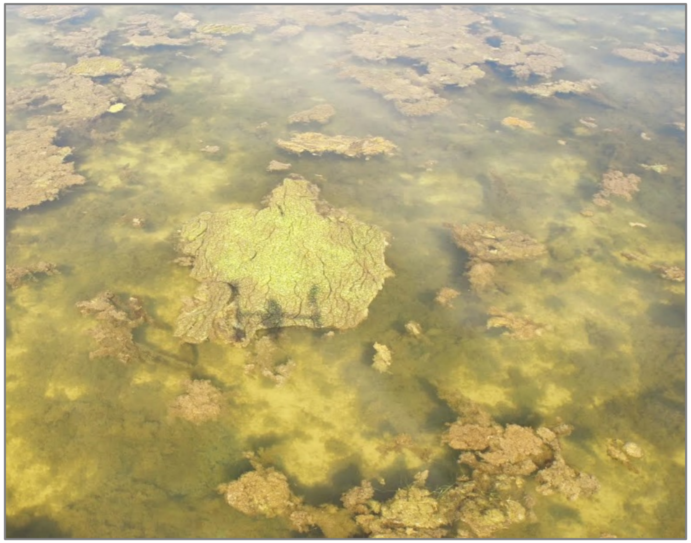
# Salinity in all of Long Island's coastal waters, <u>23 – 30 g per kg</u>

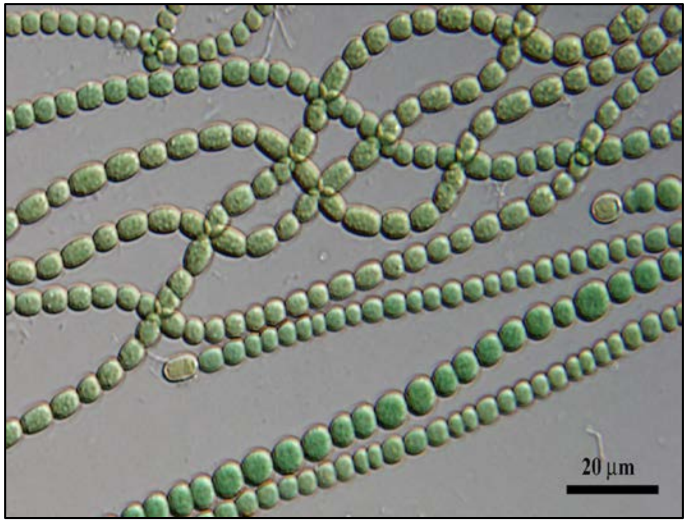


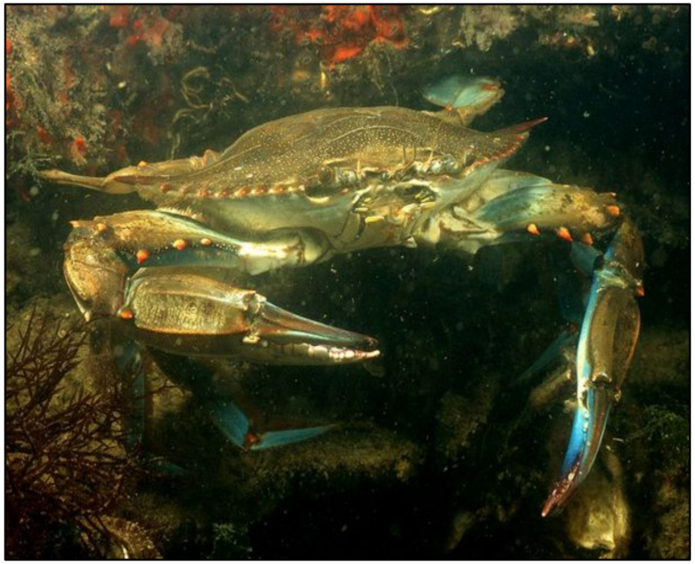
# Salinity in Georgica Pond, <u>0 – 30 g</u> per kg



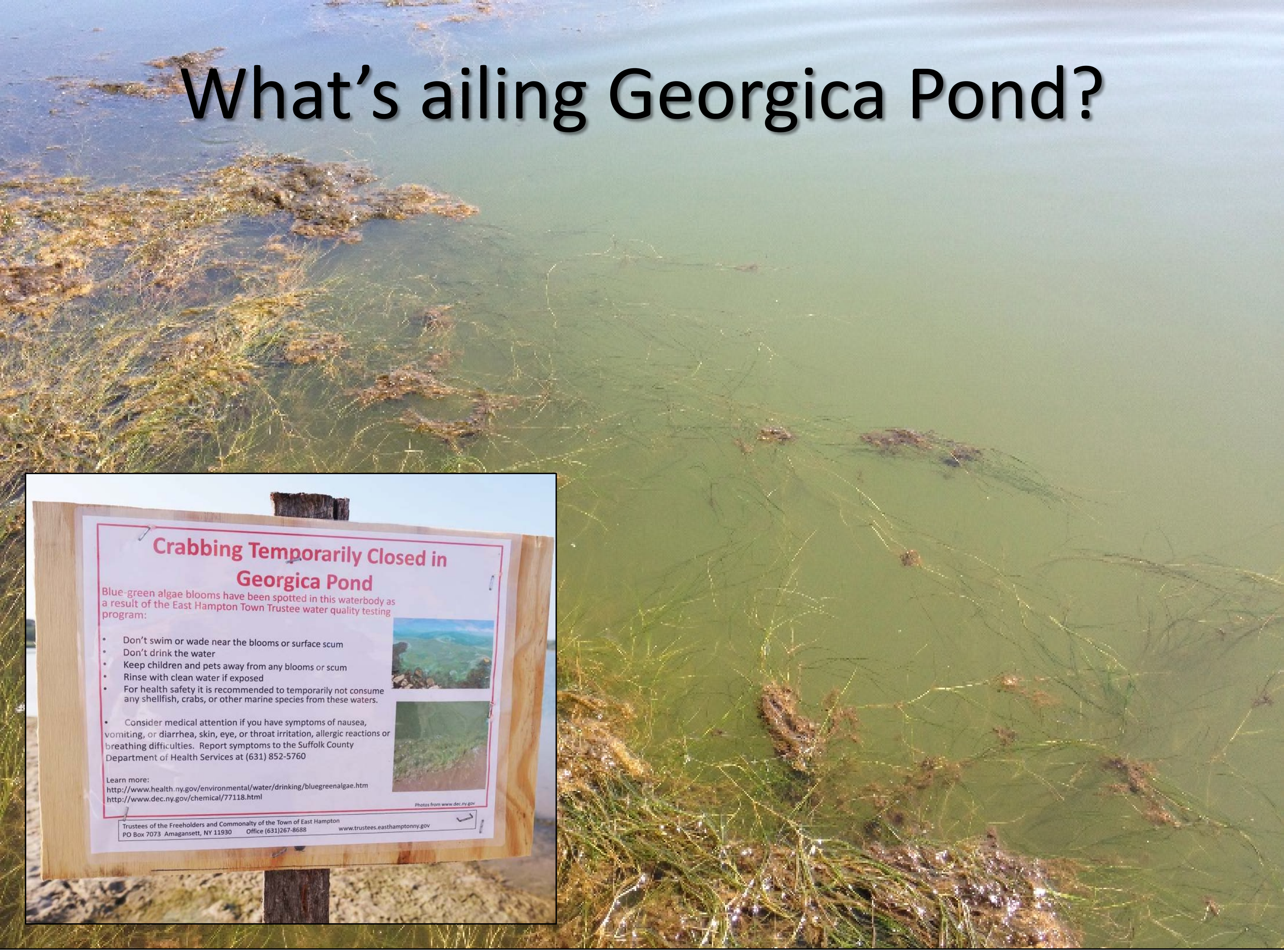
# Some uncommon inhabitants of Georgica Pond





# What’s ailing Georgica Pond?



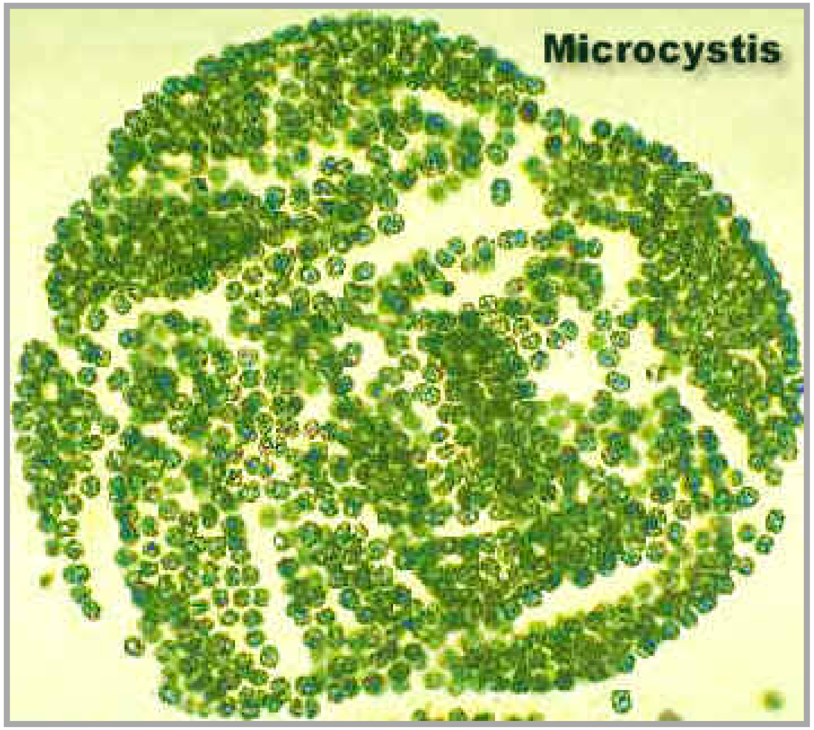
# Macroalgal, blooms in Georgica Pond

# The emergence of macroalgal, *Cladophora* blooms in Georgica Pond

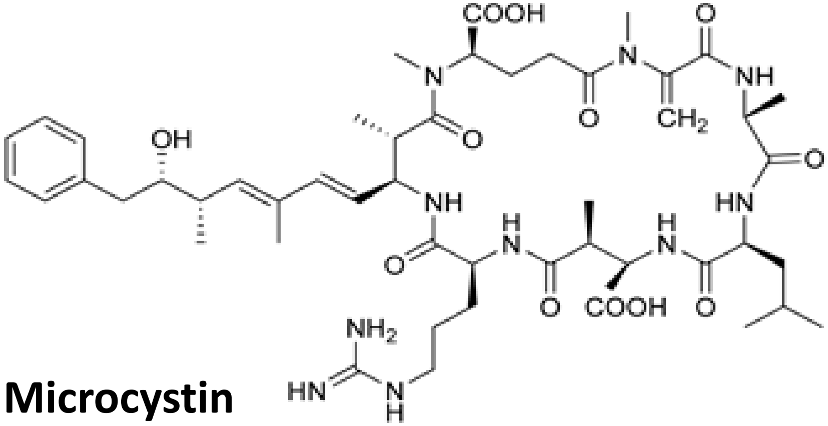
# The macroalage as seen by satellite


# Georgica Pond, summer 2014

# Freshwater, blue green algae and their toxins



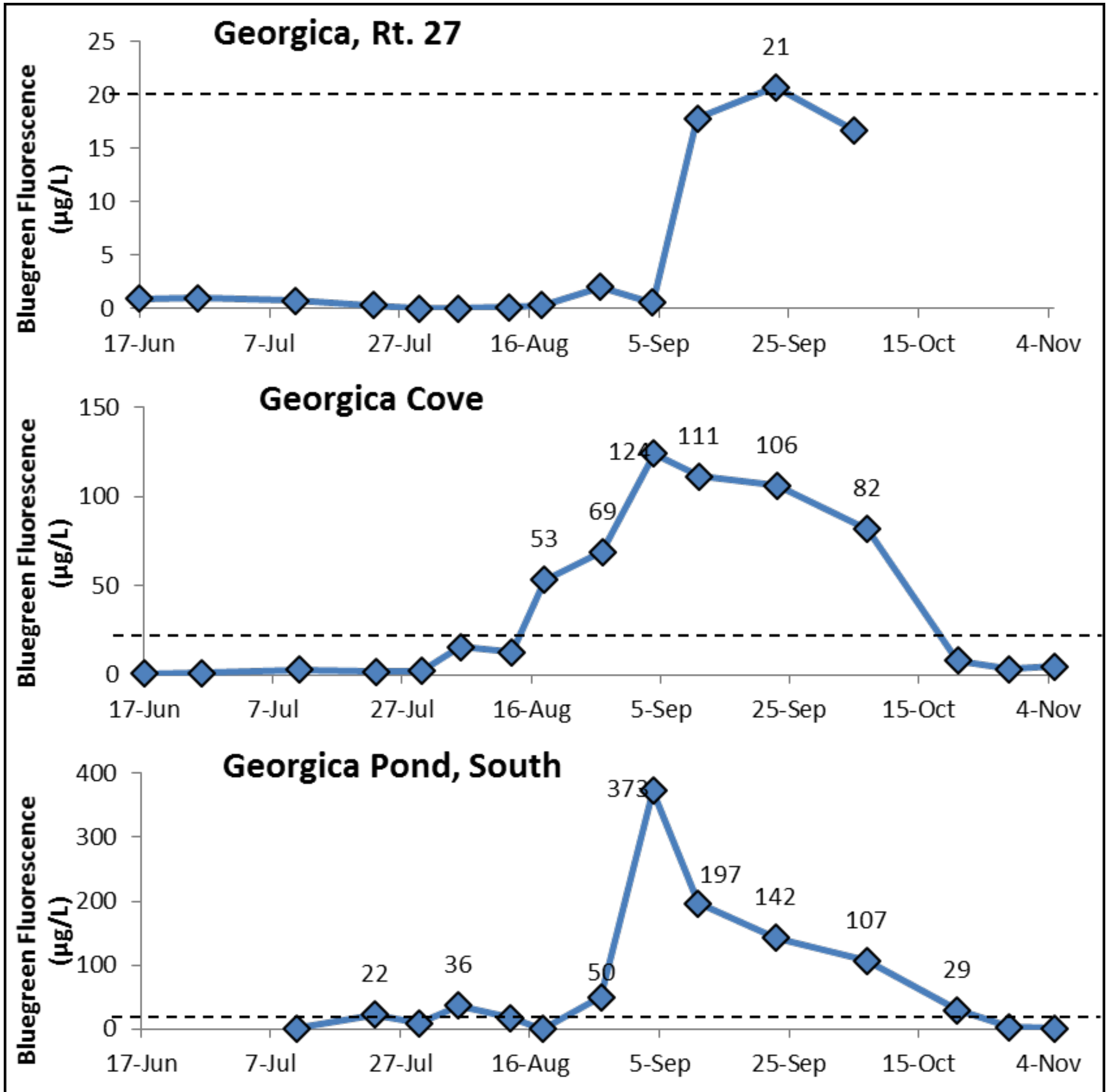





Microcystin

# Mid-summer blue green algal bloom

# Temporal, spatial dynamics of total blue green algae

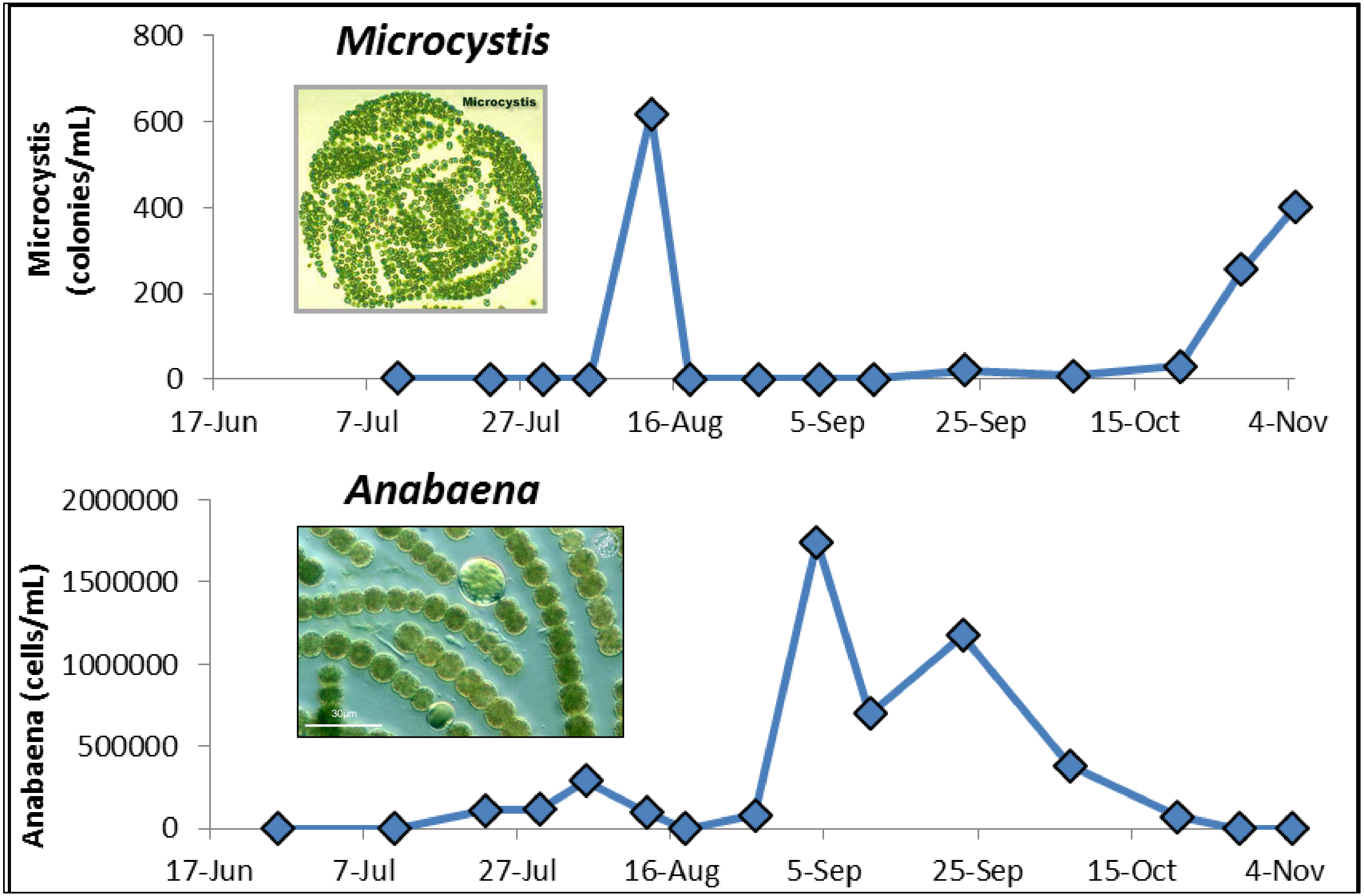



NYSDEC standard

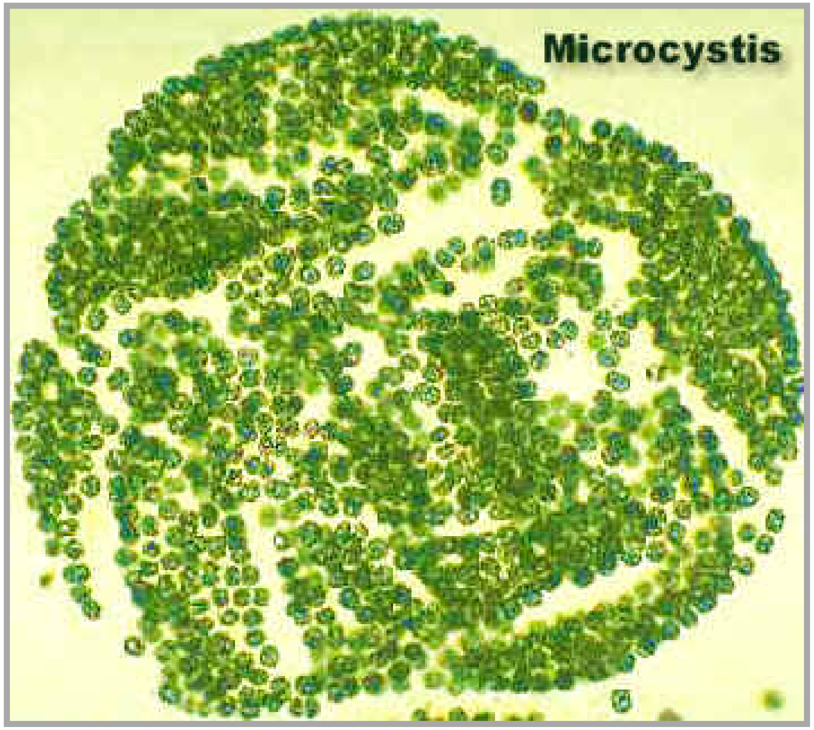
NYSDEC standard

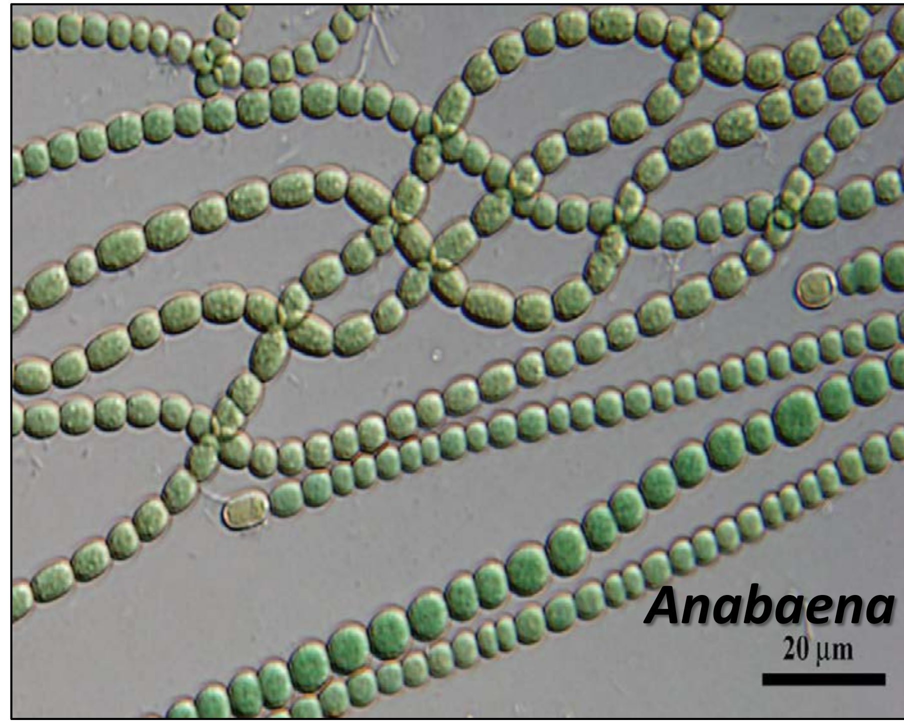
NYSDEC standard

# Temporal dynamics of *Microcystis*, *Anabaena*, microcystin

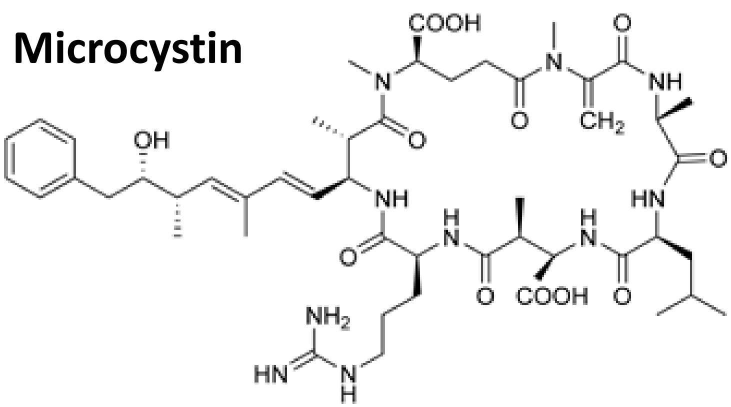


# Dangers of cyanotoxins

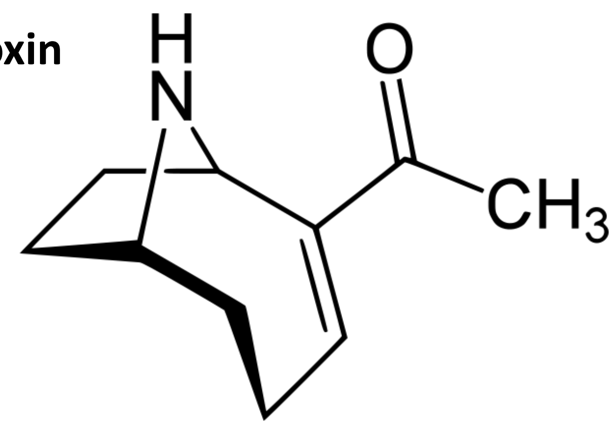



**Microcystin**

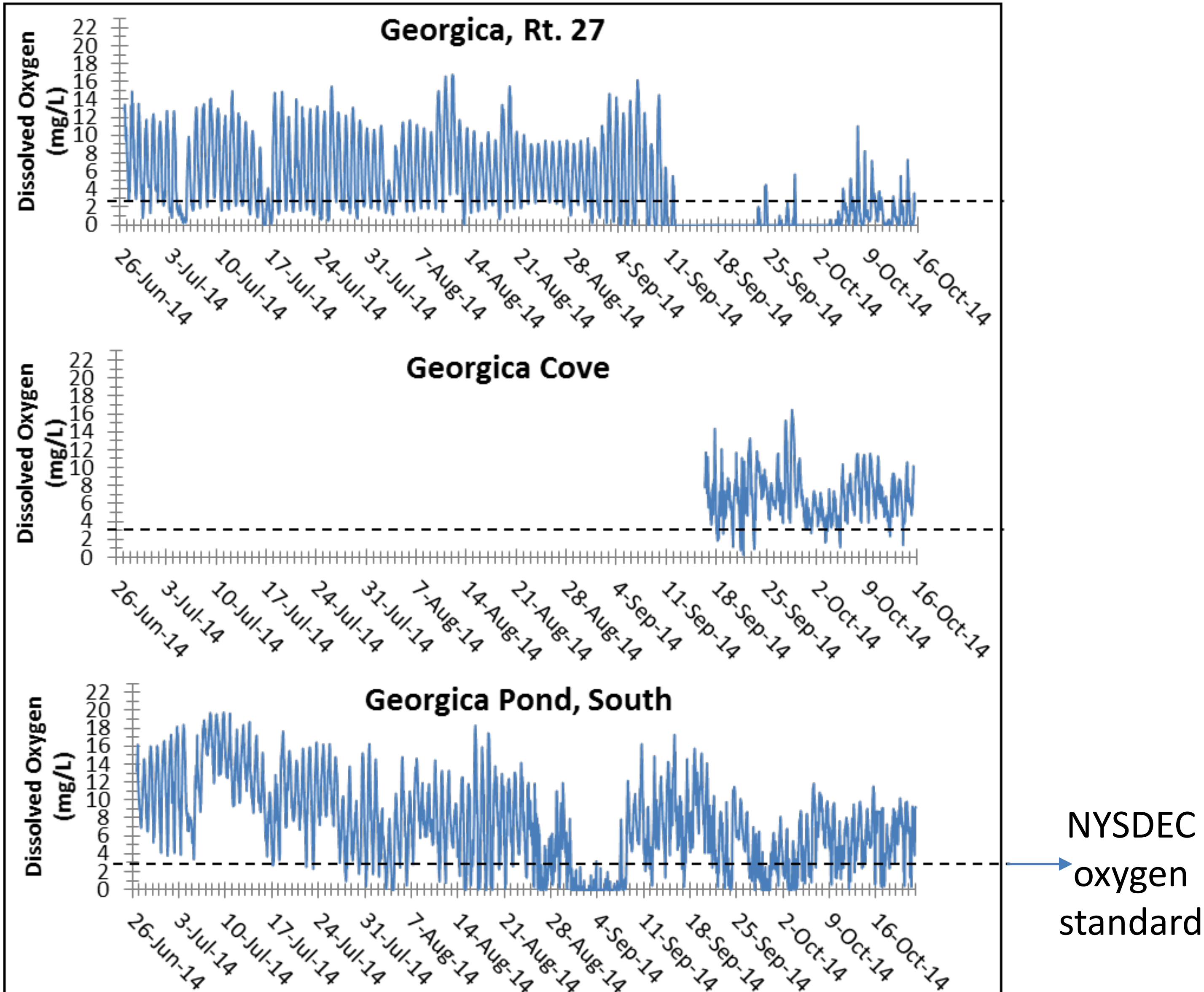



**Anatoxin**



# Danger of cyanotoxins

# Continuous dissolved oxygen, Georgica Pond, 2014

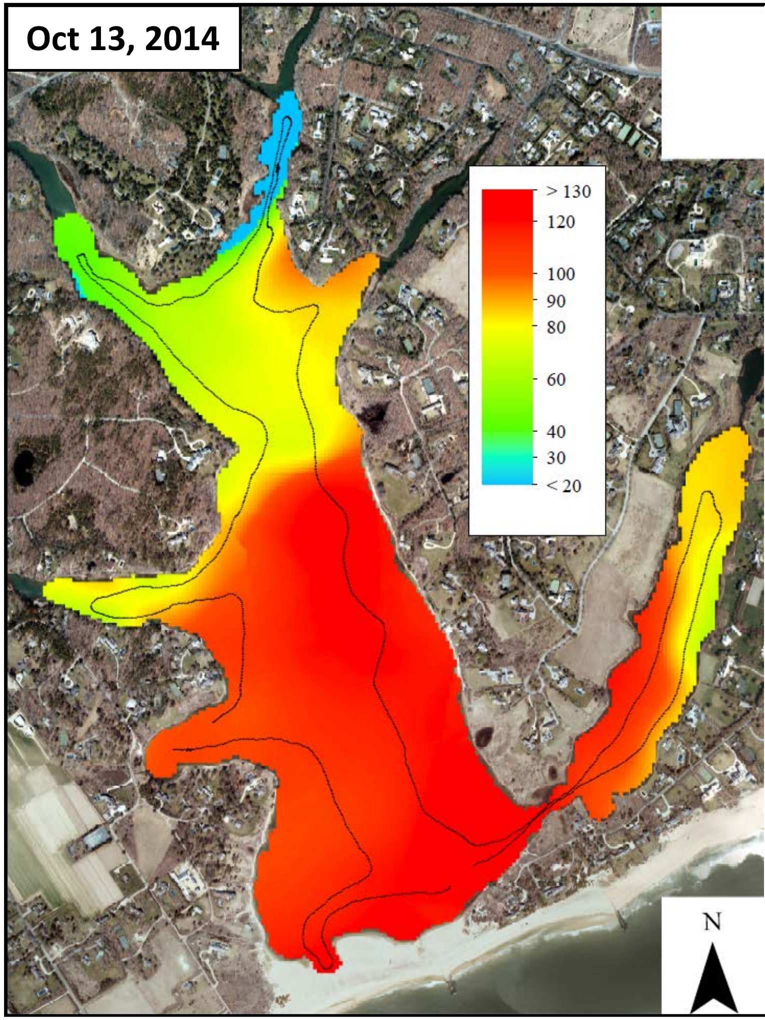


# Opening of the ocean inlet or ‘Cut’ in 2014

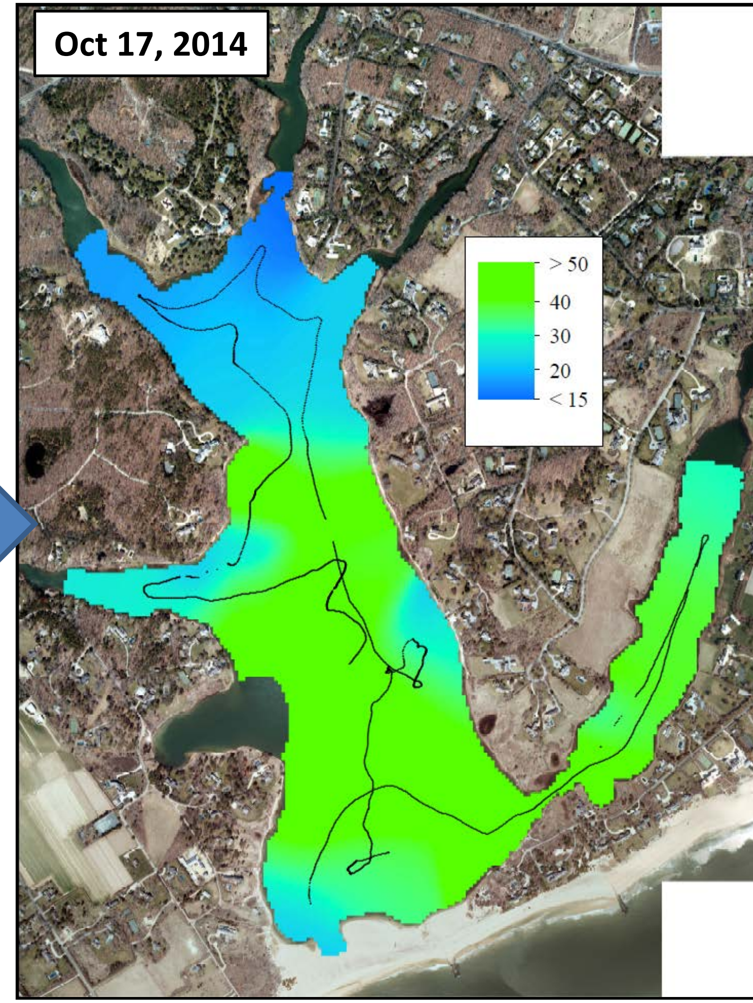

Inlet open

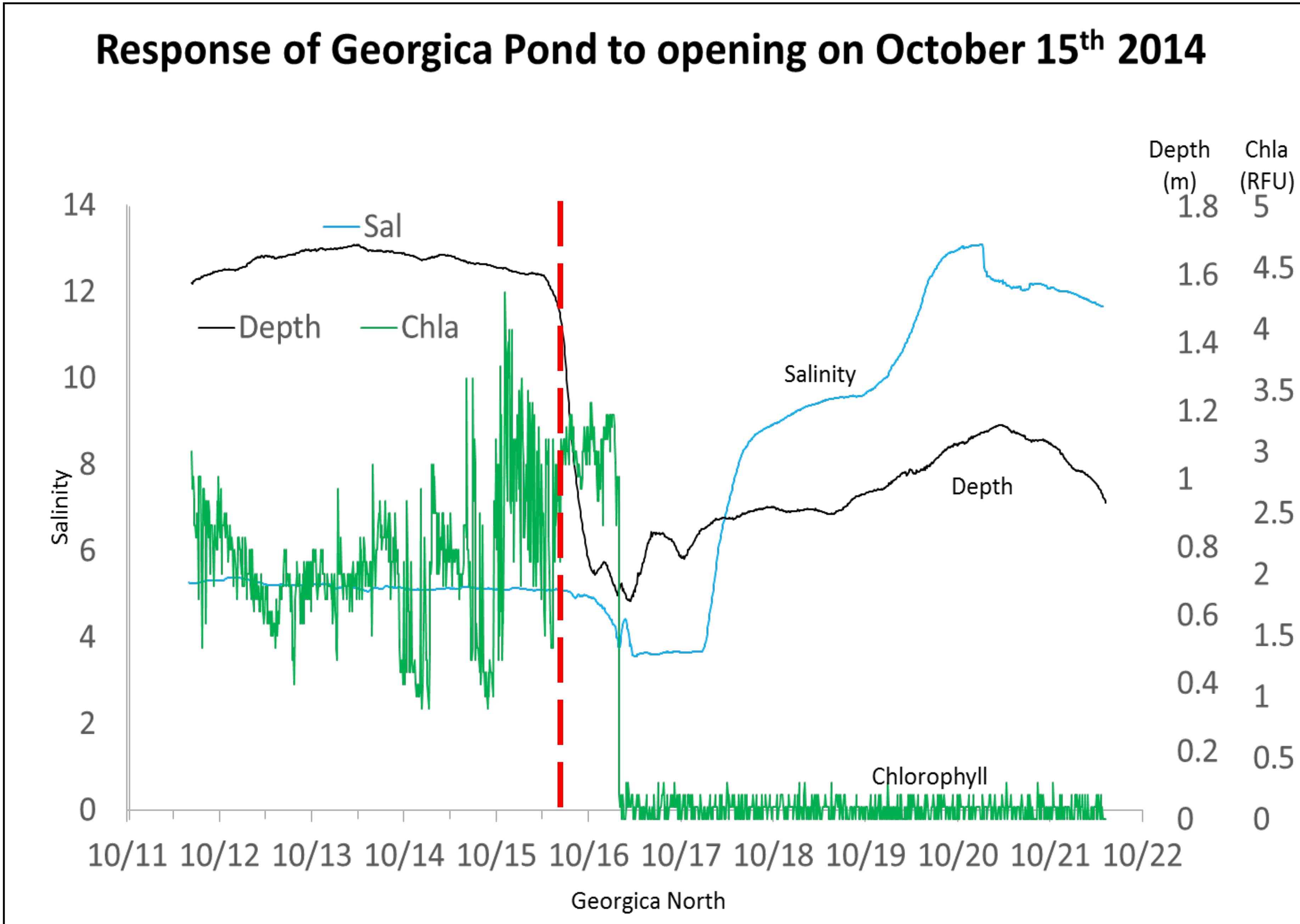
Inlet closed

# Opening the Georgica ocean inlet, change in blue green algae

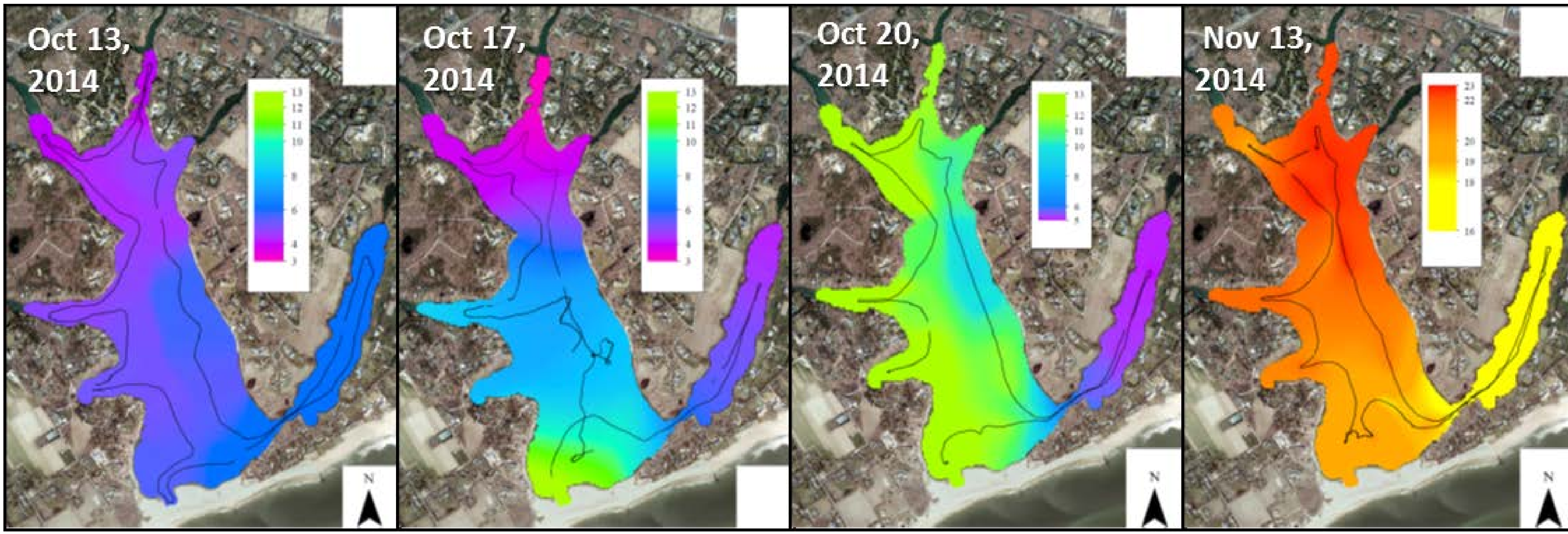



October 15, inlet open




Response of Georgica Pond to opening on October 15th 2014
Sal
Depth
Chla
Salinity
Depth
Chlorophyll
Depth (m)
Chla (RFU)
Georgica North
10/11 10/12 10/13 10/14 10/15 10/16 10/17 10/18 10/19 10/20 10/21 10/22
0 2 4 6 8 10 12 14
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

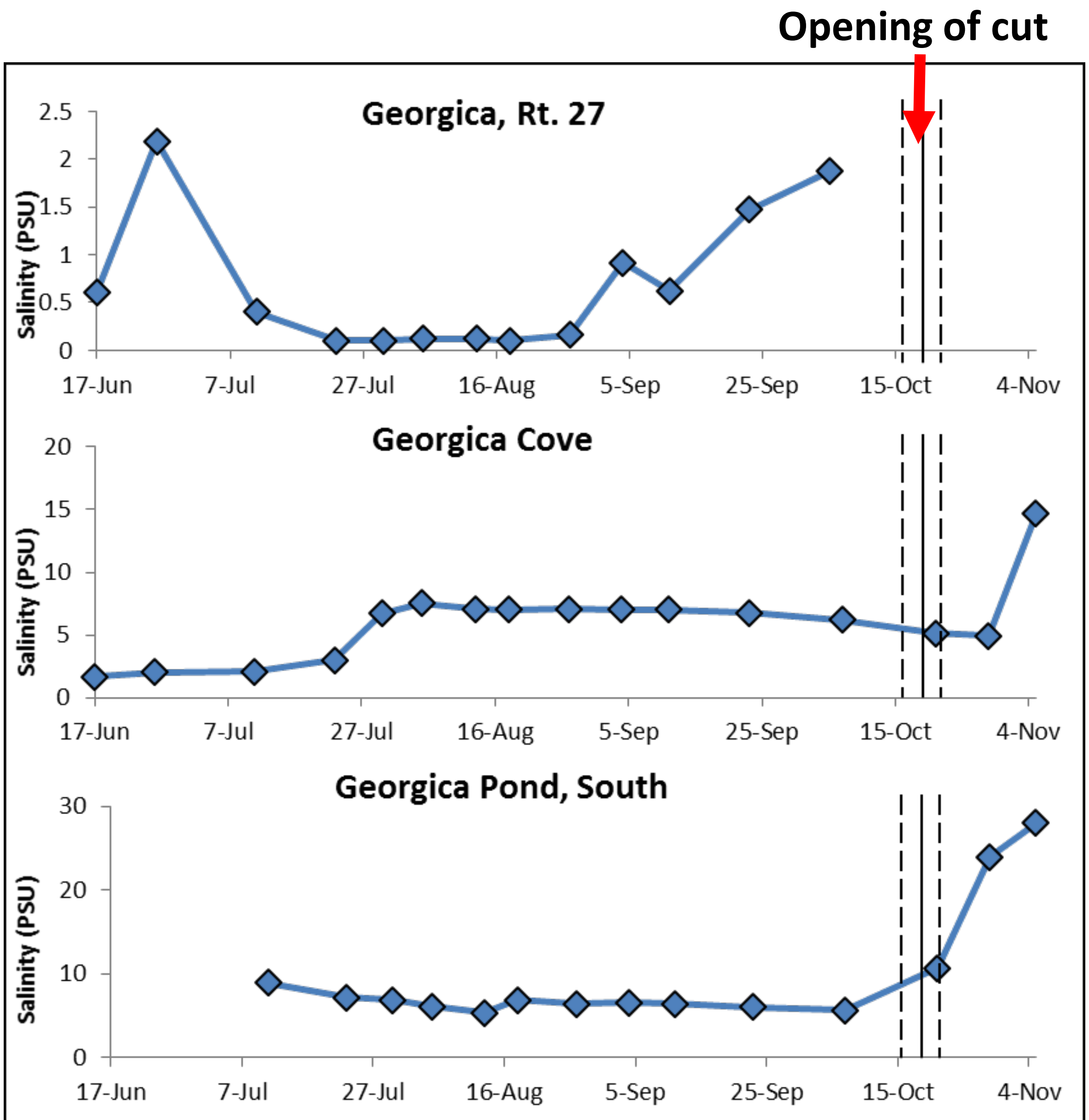
# Change in salinity following the opening of the cut




**< 5 g per kg**

**Pond >20 g per kg**
**Cove > 15 g per kg**

# Temporal, spatial dynamics of salinity




**Delayed, small response of Cove**

**Immediate response of Pond**

# Georgica cut opening

Inlet open, ocean water intrudes

Salinity rises, Pond flushed

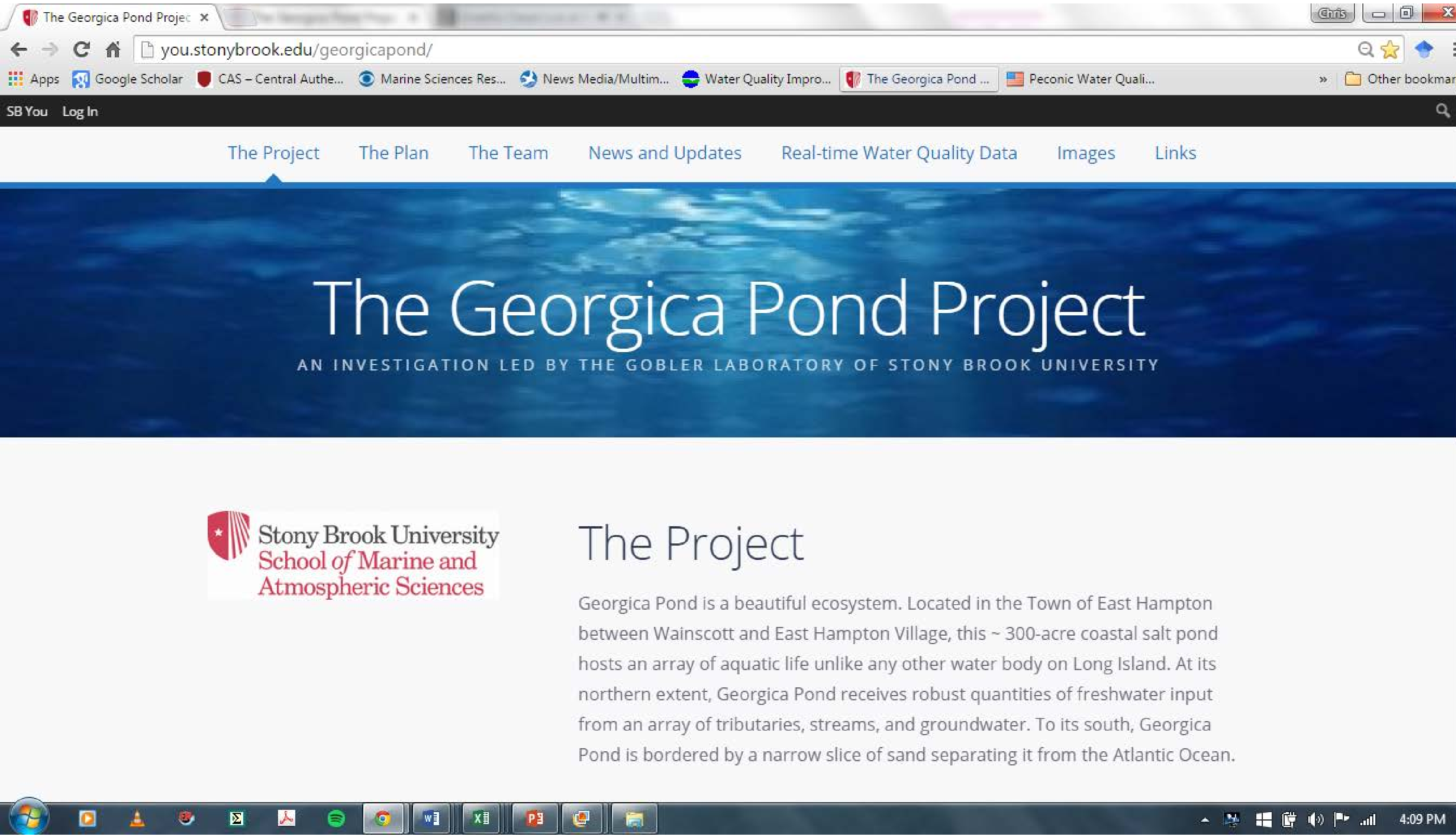
Algal blooms decline

Dissolved oxygen rises

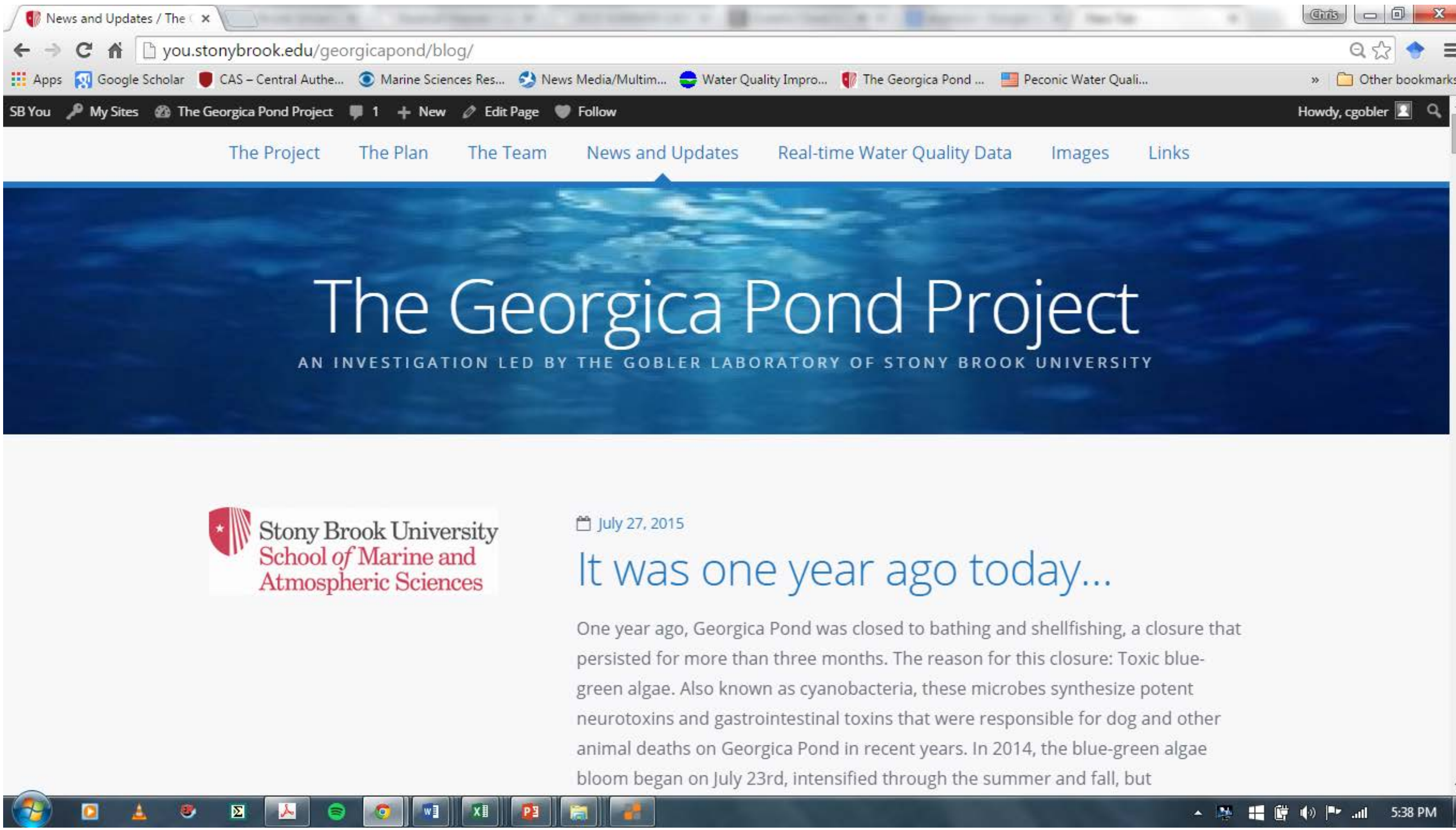
# 2015 study objectives:

1. **Support for Georgica Pond stewards.**
2. **Establish a continuous water quality monitoring station with telemetry.**
3. **Perform genetic and toxin analysis of algae in Georgica Pond.**
4. **Evaluate and quantify nutrient sources to Georgica Pond.**

# you.stonybrook.edu/georgicapond

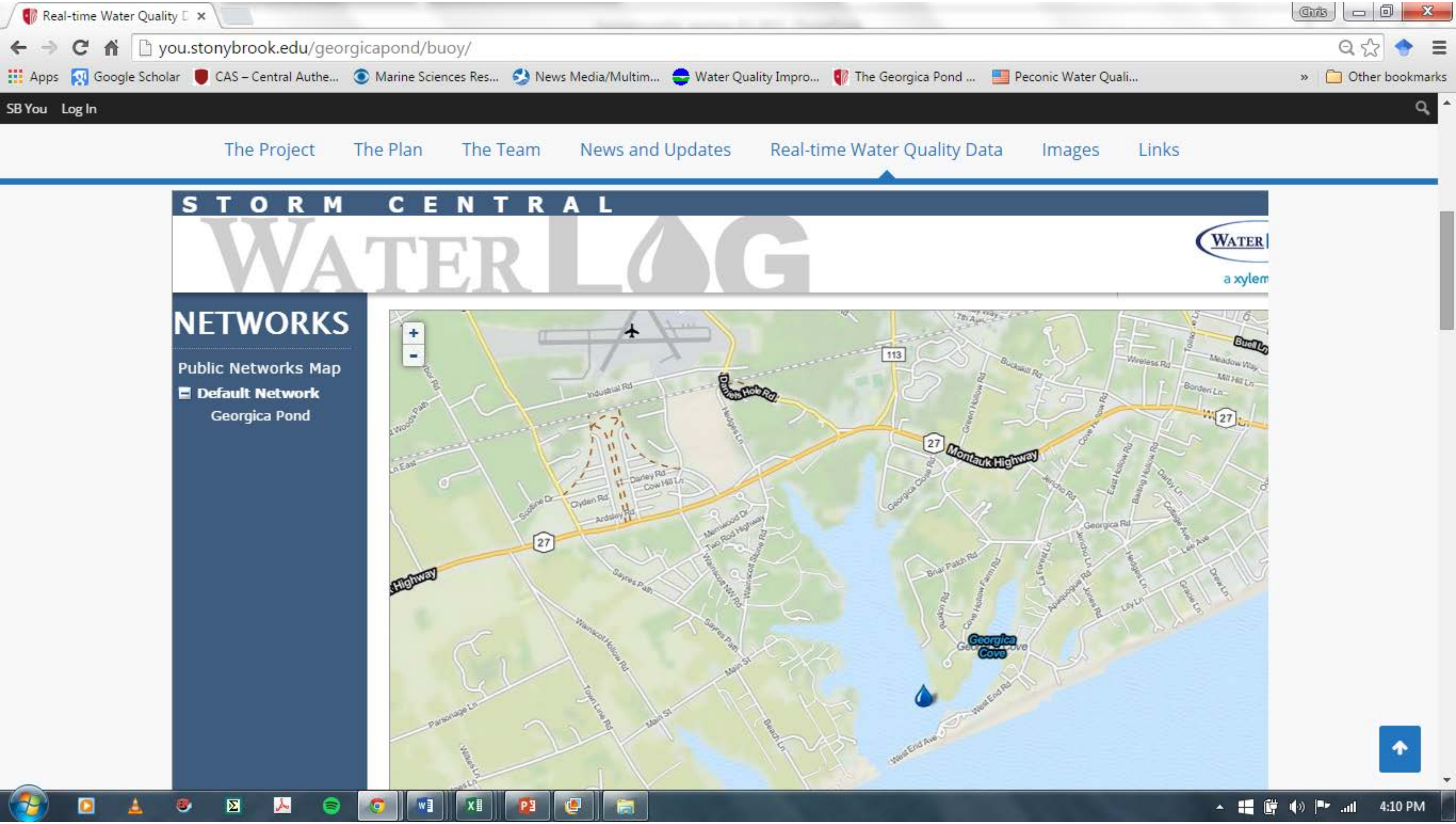


# you.stonybrook.edu/georgicapond/blog

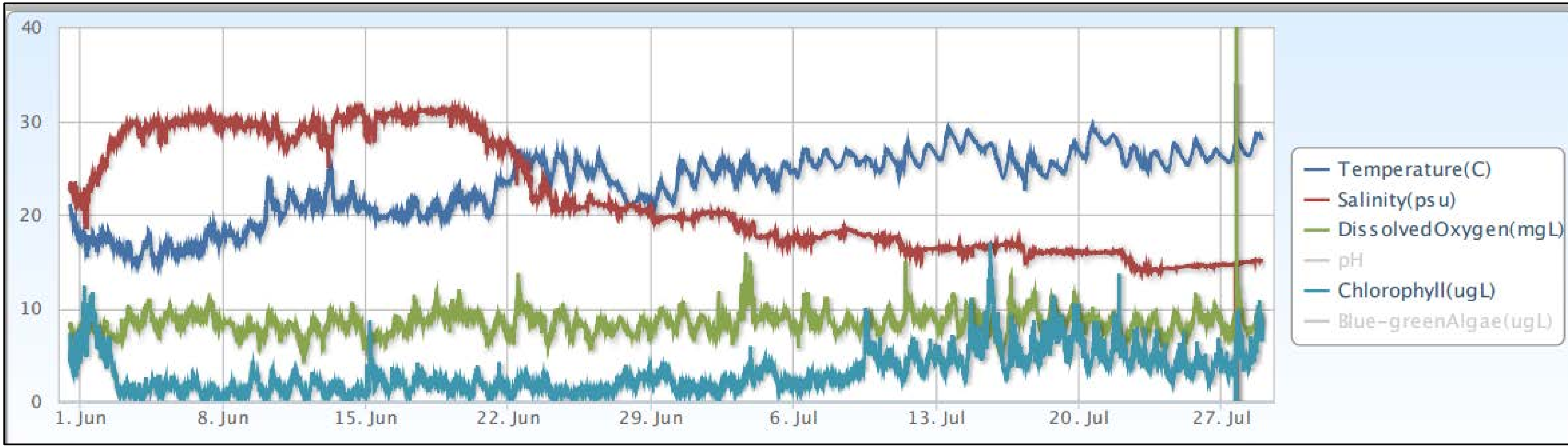


# Buoy deployment, May 2015

# you.stonybrook.edu/georgicapond/buoy

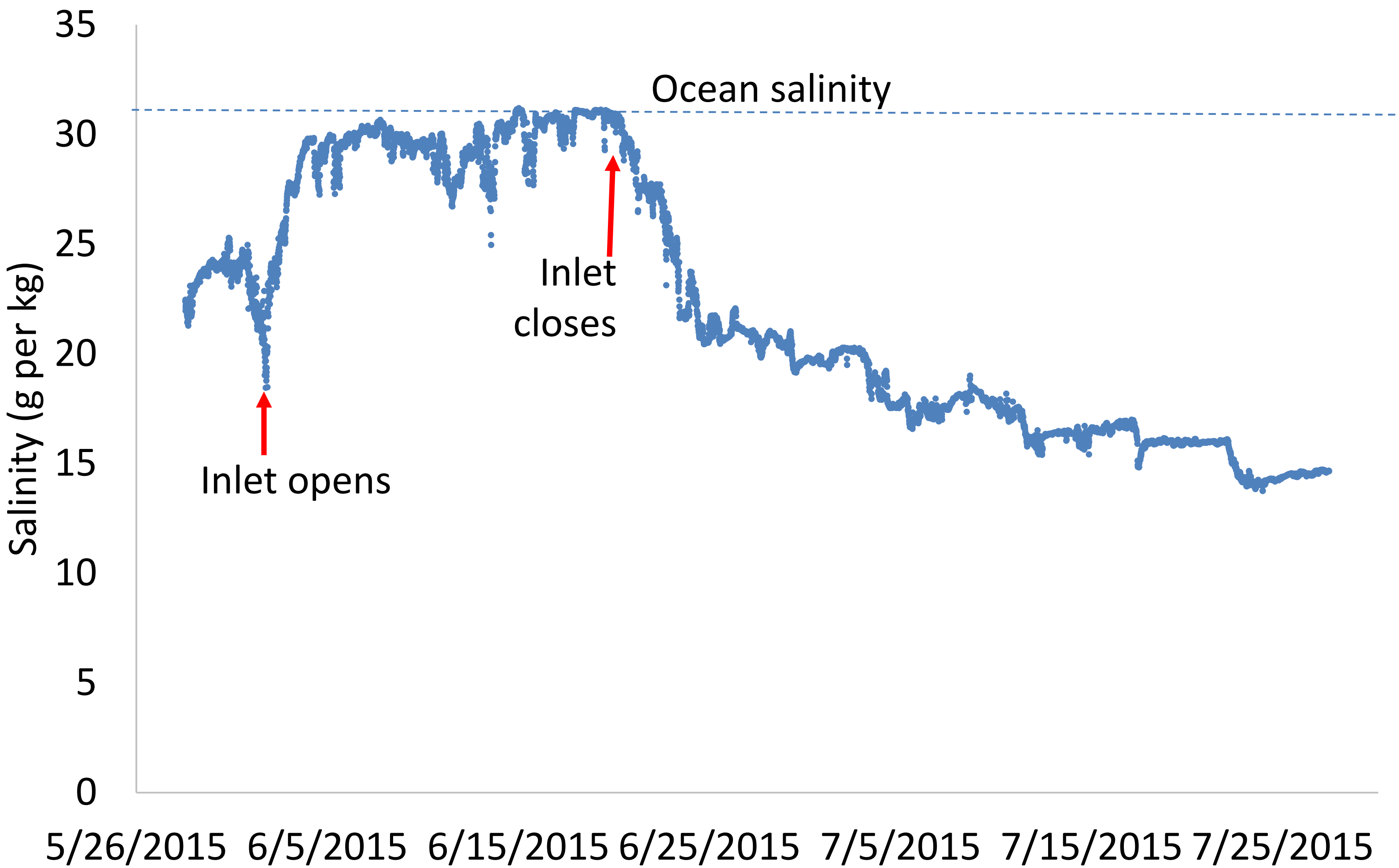


# Continuous, real-time data

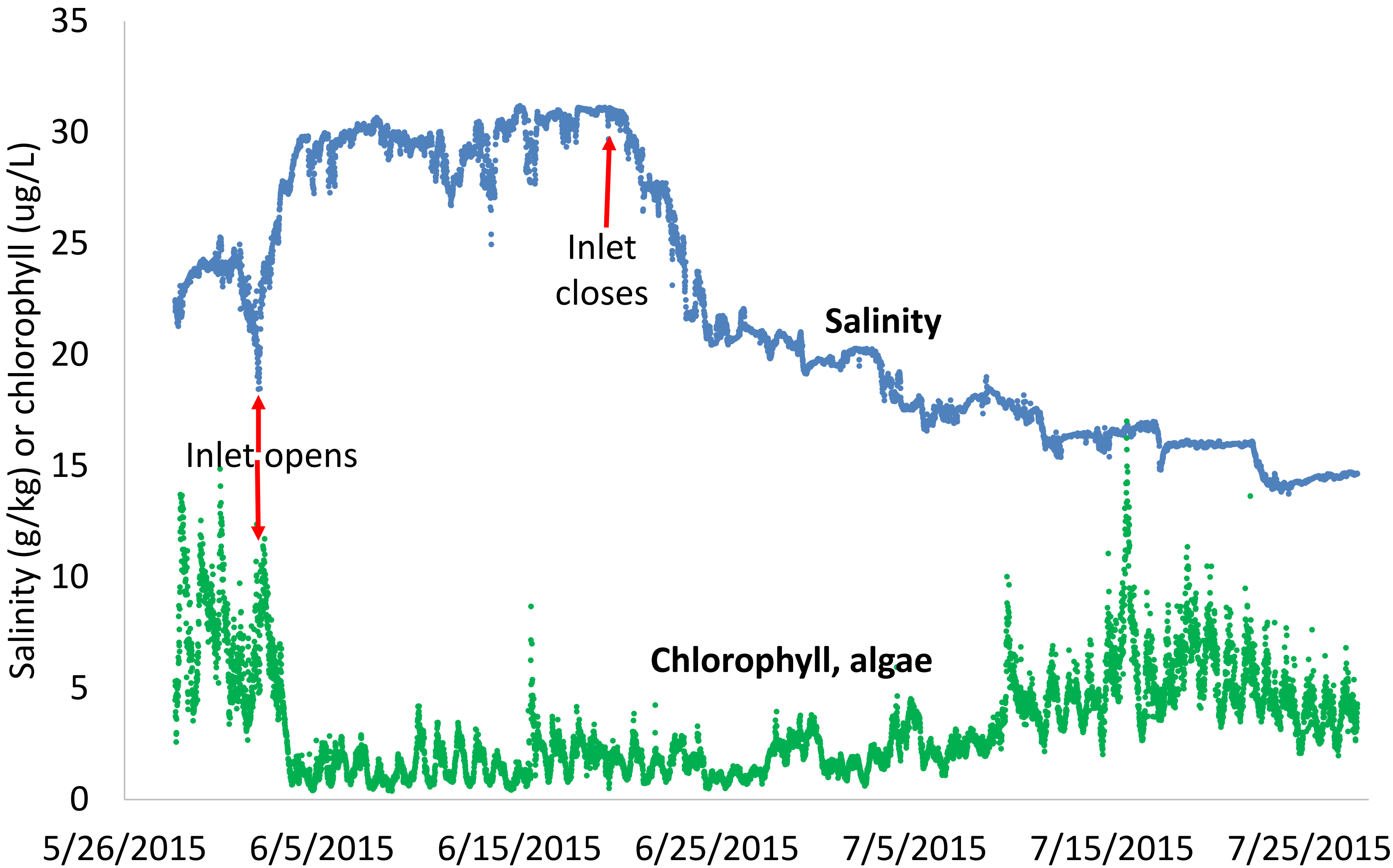


# 2015: A year like no other?

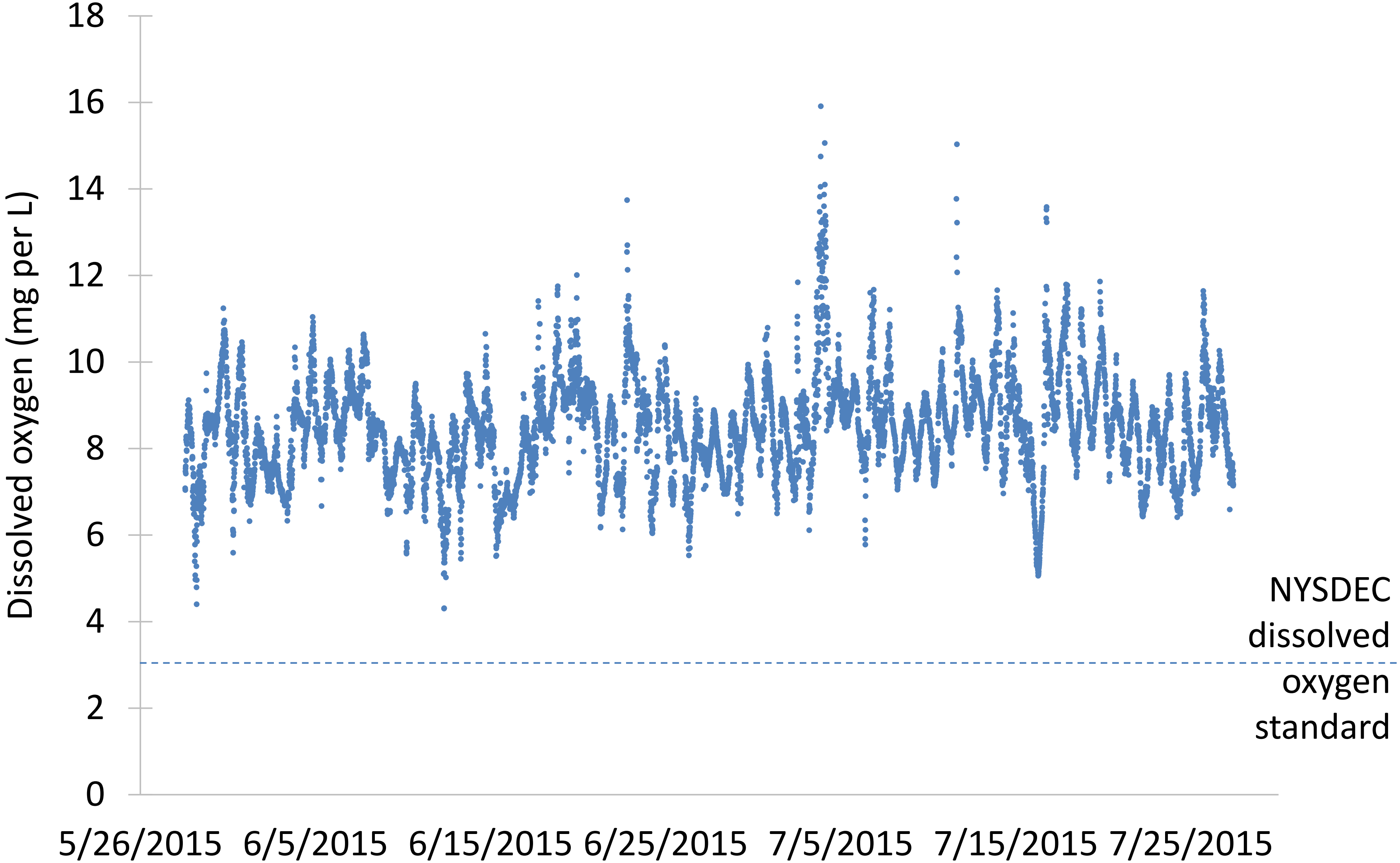
*Cut was mostly for the first half of 2015*



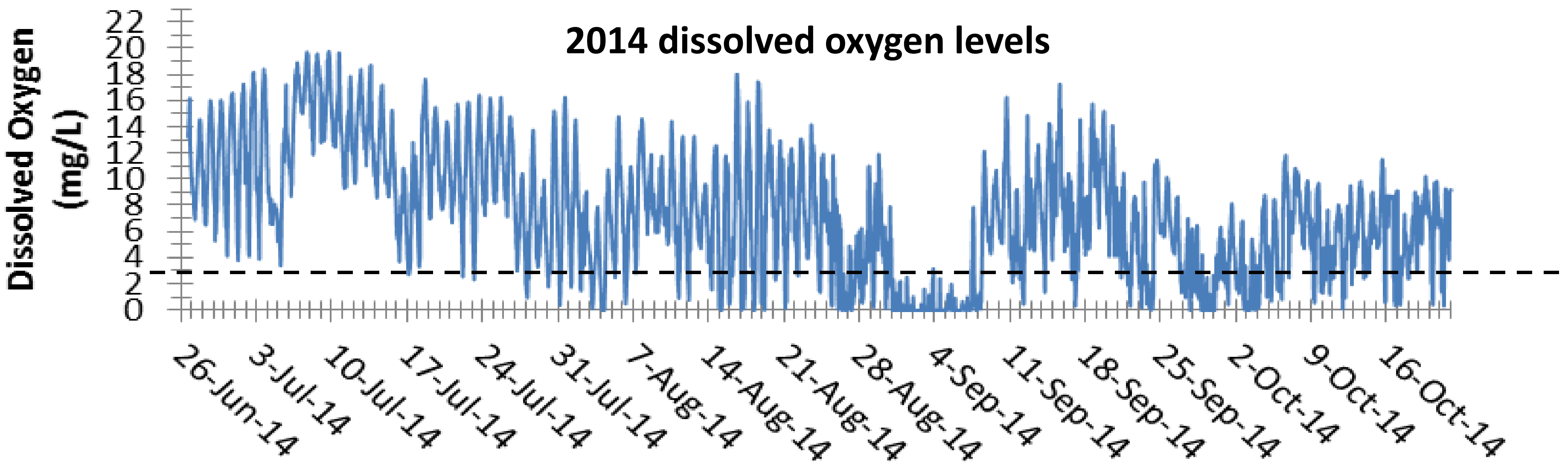
# Salinity and chlorophyll, 2015

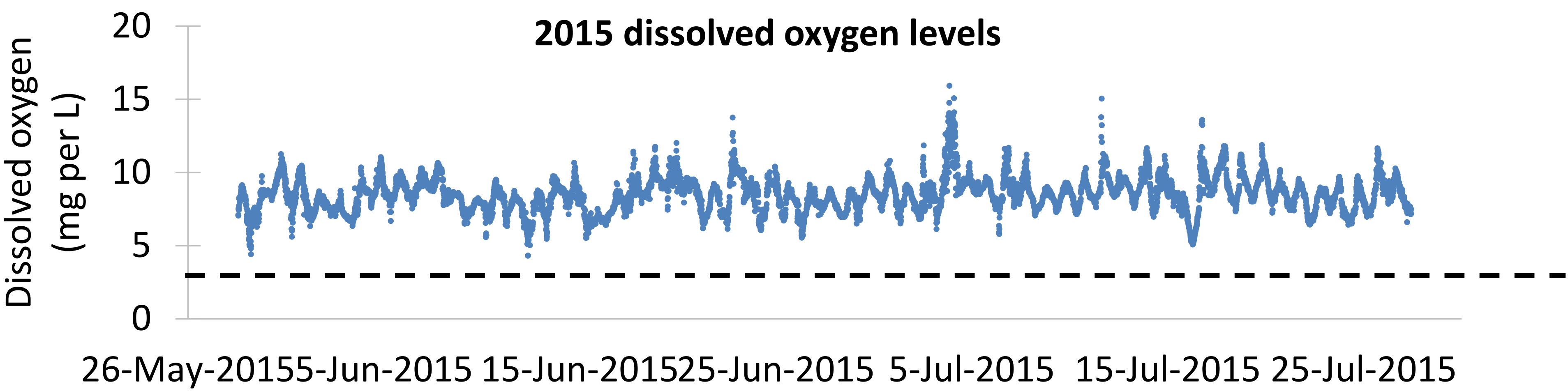


# Dissolved oxygen, spring - summer 2015



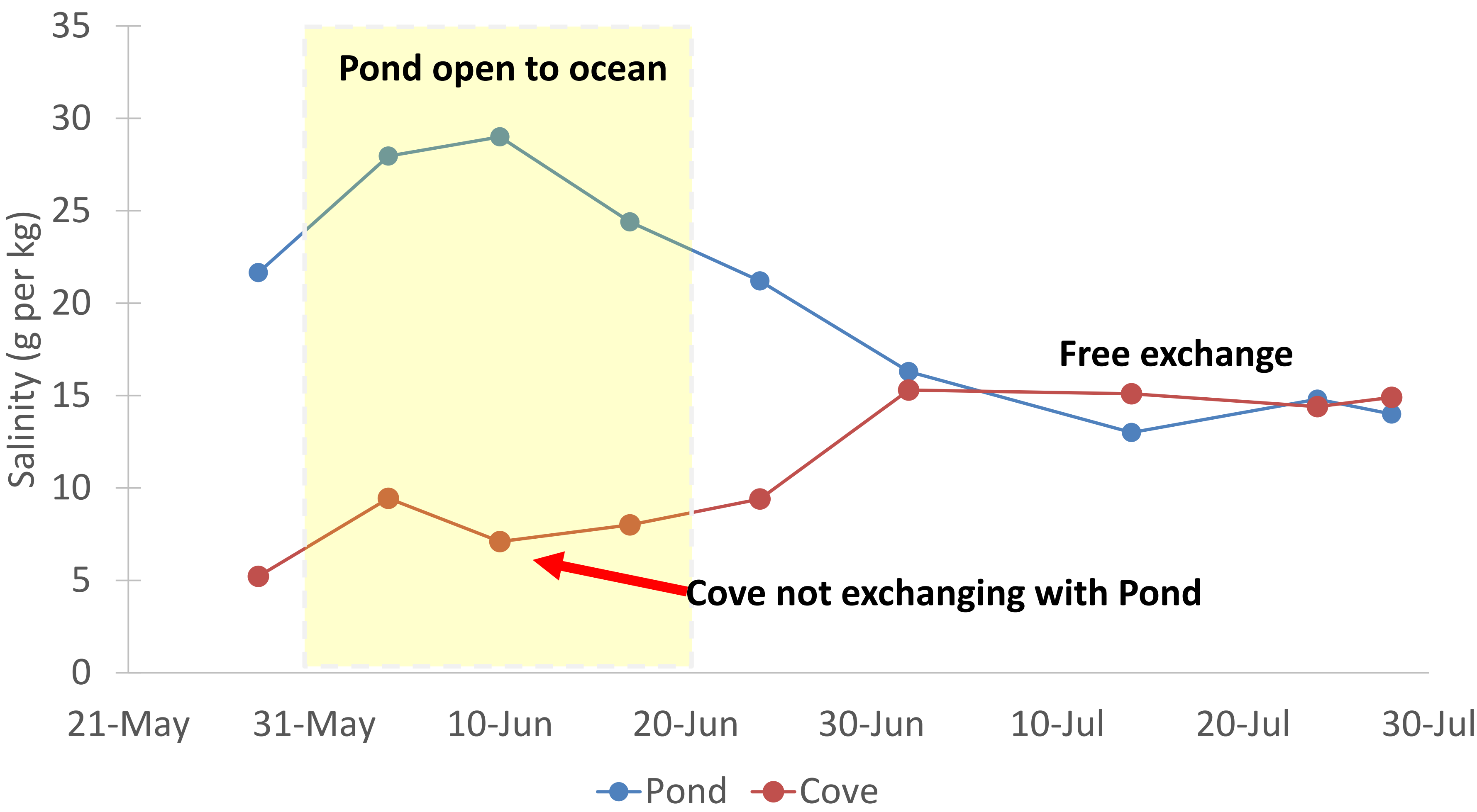
# 2014 v 2015 comparison



# Pond & Cove salinity this spring, summer

*Cove is cut-off from Pond when open*

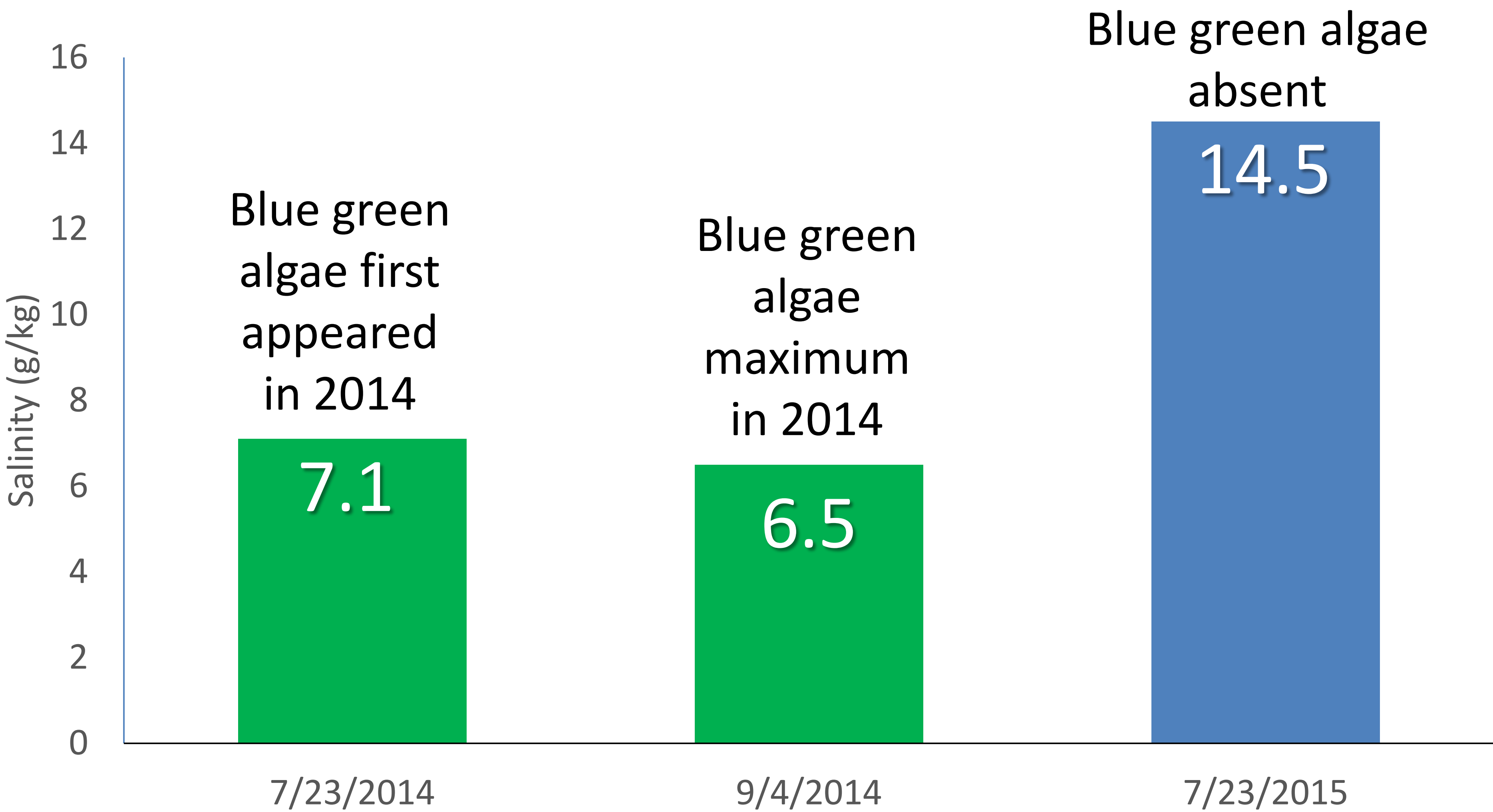


# Georgica Pond, summer 2014

# *Current* blue-green algae outbreaks

# Ocean protection from blue-green algae

*Blue-green can bloom only in low salinity water*

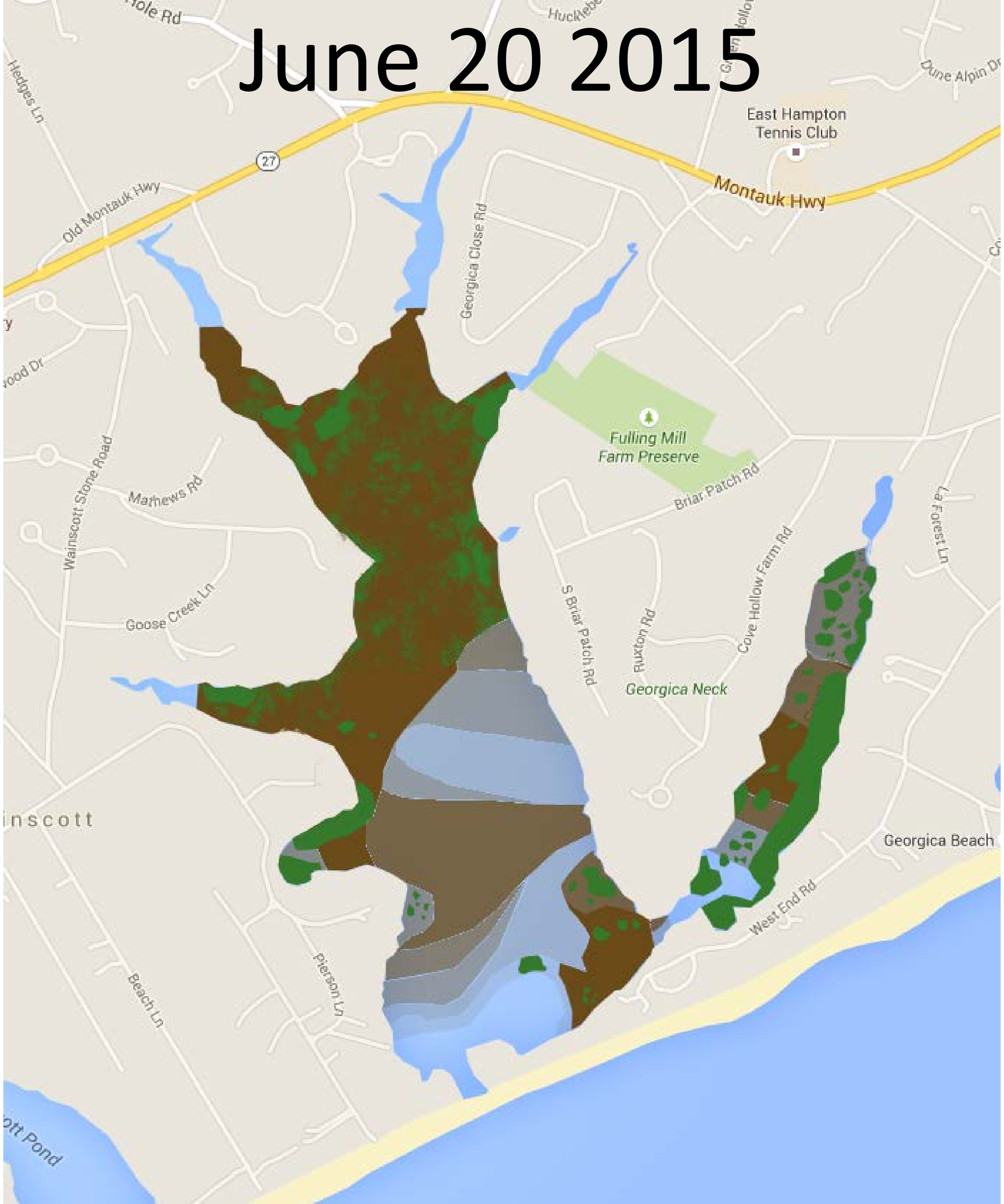


# Macroalgae bloom, 2015

# Macroalgae bloom, 2015

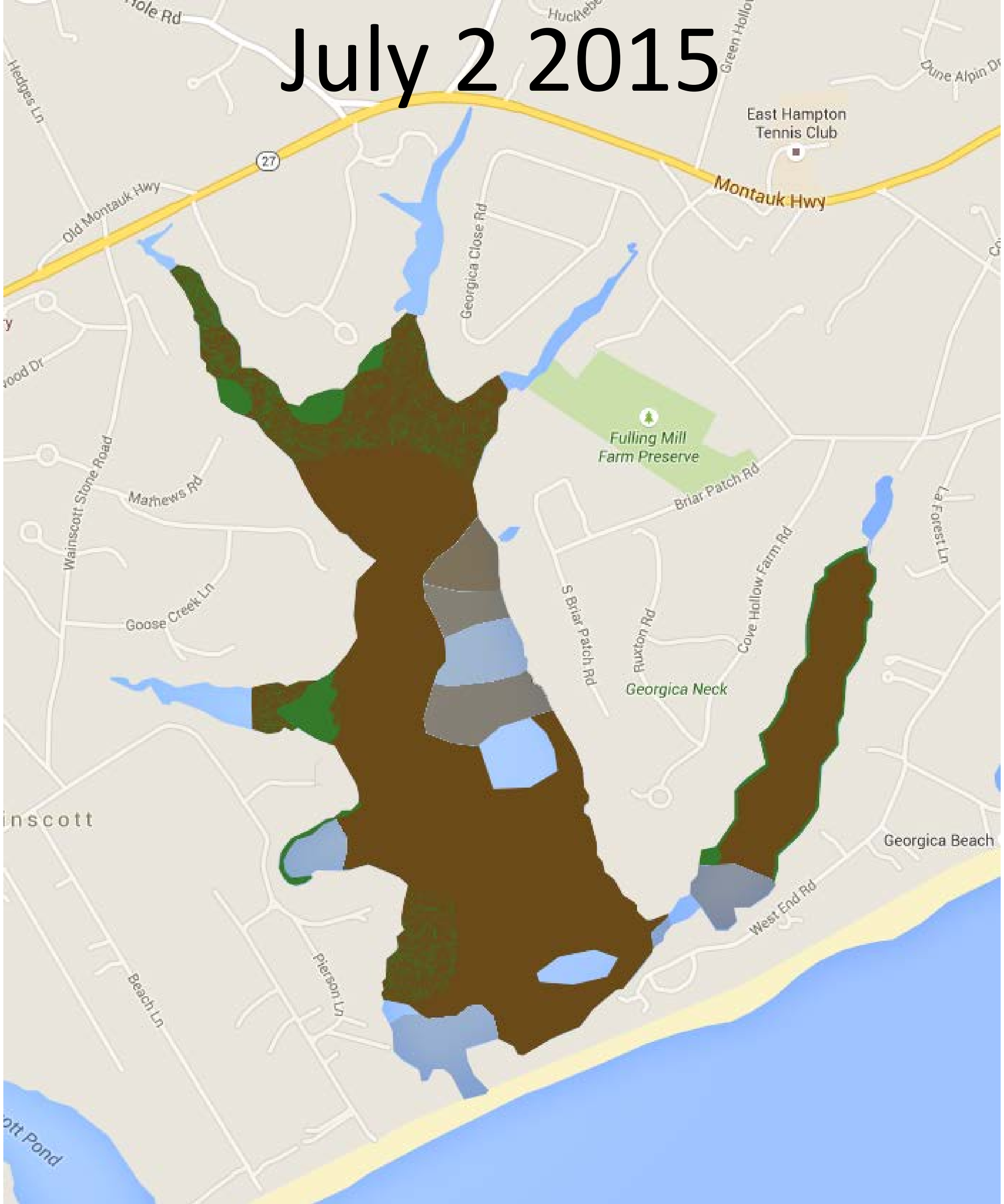
# The macroalgae

# June 20 2015



Montauk Hwy
27
Old Montauk Hwy
East Hampton
Tennis Club
Georgica Close Rd
Hedges Ln
Fulling Mill
Farm Preserve
Briar Patch Rd
Mathews Rd
Wainscott Stone Road
Goose Creek Ln
S Briar Patch Rd
Ruxton Rd
Cove Hollow Farm Rd
La Forest Ln
Georgica Neck
Georgica Beach
West End Rd
Beach Ln
Pierson Ln
Dune Alpin Dr

# July 2 2015



Hedges Ln
27
Old Montauk Hwy
Georgica Close Rd
Green Hollow
Dune Alpin Dr
East Hampton
Tennis Club
Montauk Hwy
Fulling Mill
Farm Preserve
Briar Patch Rd
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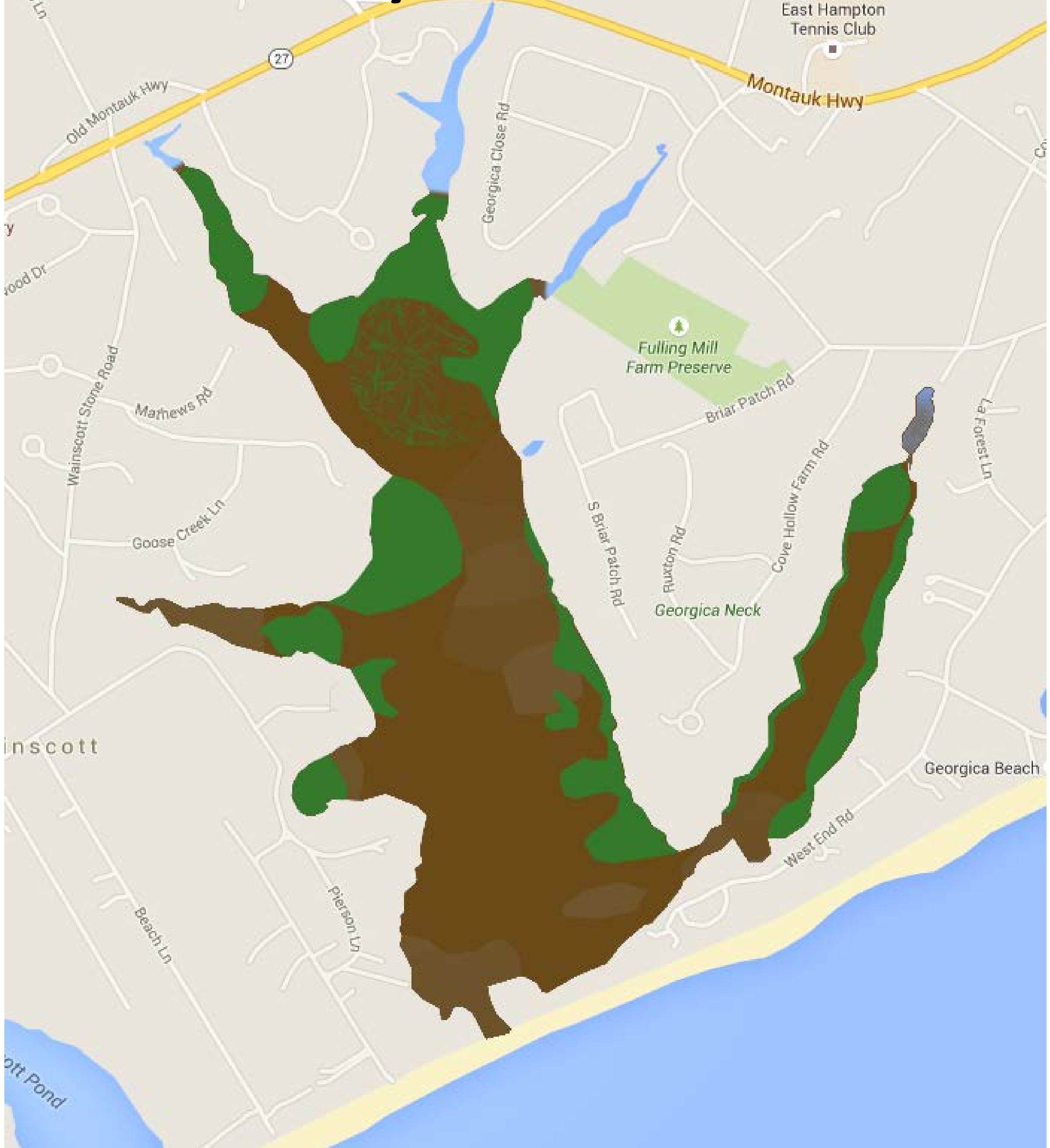
Mathews Rd
Goose Creek Ln
S Briar Patch Rd
Ruxton Rd
Cove Hollow Farm Rd
La Forest Ln
Georgica Neck
Georgica Beach
West End Rd
Pierson Ln
Beach Ln

# July 15 2015



Hedges Ln
27
Old Montauk Hwy
Montauk Hwy
East Hampton
Tennis Club
Dune Alpin Dr
Georgica Close Rd
Fulling Mill
Farm Preserve
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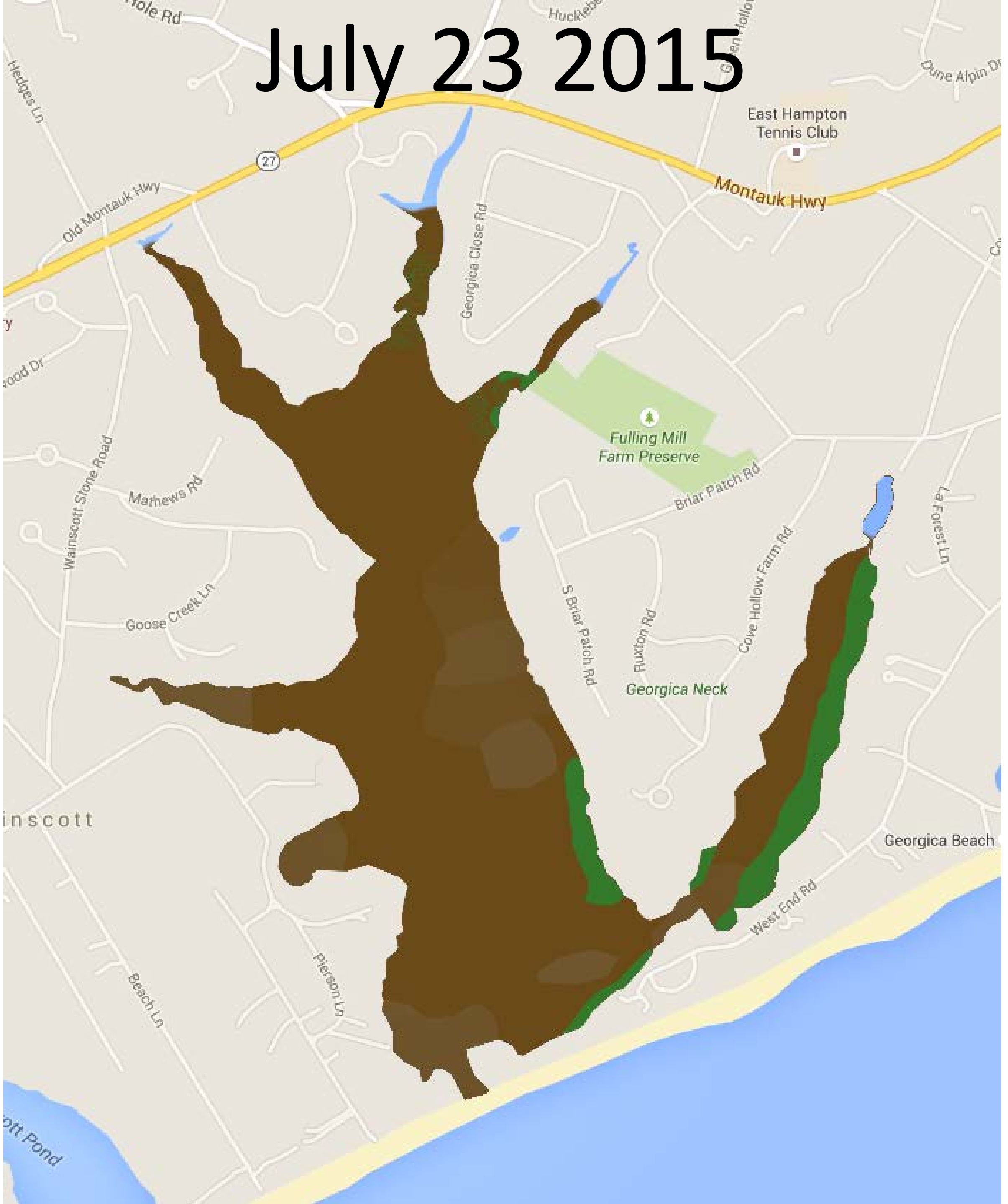
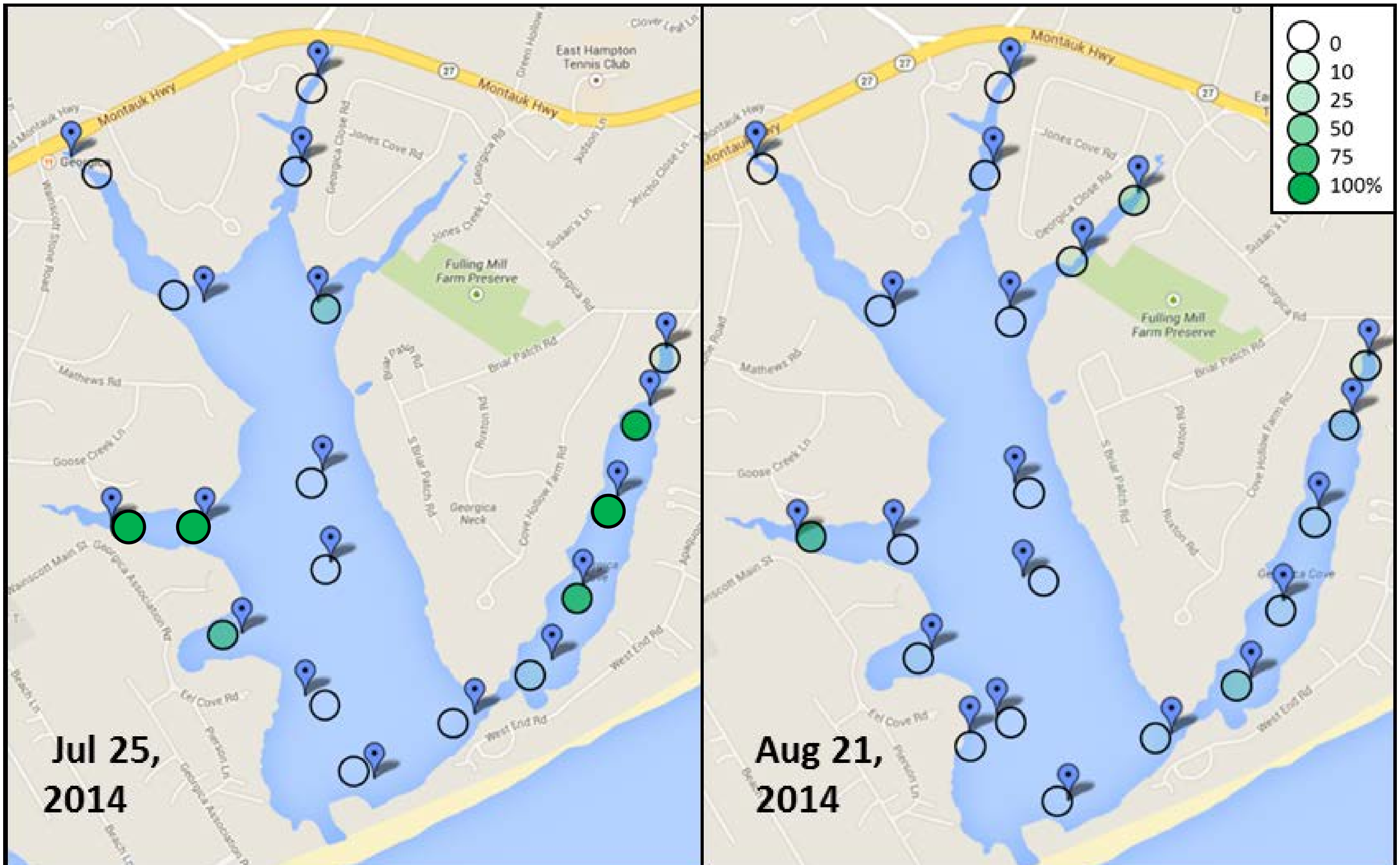
Goose Creek Ln
S Briar Patch Rd
Ruxton Rd
Cove Hollow Farm Rd
Georgica Neck
La Forest Ln
Georgica Beach
West End Rd
Pierson Ln
Beach Ln

# July 23 2015



Hole Rd
Hedges Ln
East Hampton
Tennis Club
Dune Alpin Dr
Old Montauk Hwy
27
Montauk Hwy
Georgica Close Rd
Fulling Mill
Farm Preserve
Briar Patch Rd
Mathews Rd
Wainscott Stone Road
Goose Creek Ln
S Briar Patch Rd
Ruxton Rd
Cove Hollow Farm Rd
La Forest Ln
Georgica Neck
inscott
Georgica Beach
West End Rd
Beach Ln
Pierson Ln
ott Pond

# Mid-summer macroalgal bloom



# What are that macroalgae?

**Sago Pondweed?**

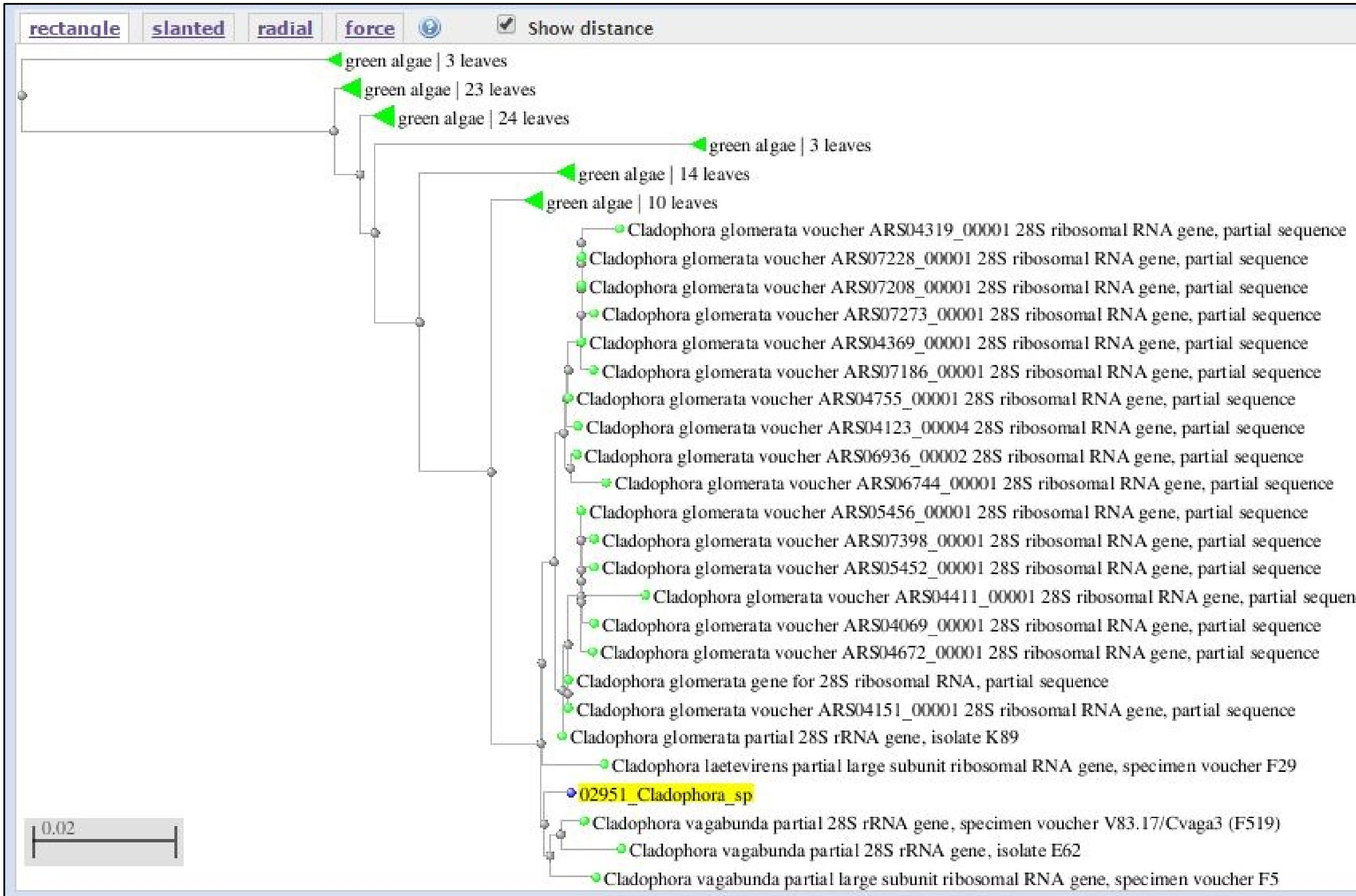
***Cladophora*?**

# DNA does not lie

## *Cladophora vagabunda*

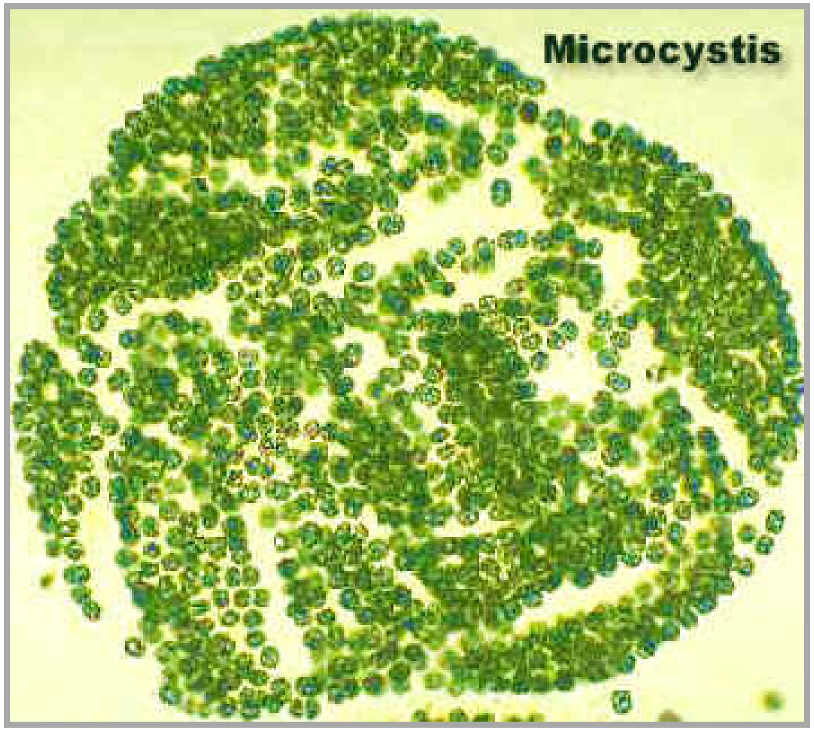
| Description | Max score | Total score | Query cover | E value | Ident | Accession |
|---|---|---|---|---|---|---|
| Cladophora vagabunda partial 28S rRNA gene, specimen voucher V83.17/Cvaga3 (F519) | 1033 | 1033 | 95% | 0.0 | 99% | AM503481.1 |
| Cladophora glomerata voucher ARS07208_00001 28S ribosomal RNA gene, partial sequence | 1016 | 1016 | 96% | 0.0 | 99% | KM676859.1 |
| Cladophora glomerata voucher ARS07228_00001 28S ribosomal RNA gene, partial sequence | 1014 | 1014 | 95% | 0.0 | 99% | KM676860.1 |
| Cladophora glomerata voucher ARS04755_00001 28S ribosomal RNA gene, partial sequence | 1014 | 1014 | 94% | 0.0 | 99% | KM676834.1 |
| Cladophora glomerata voucher ARS04151_00001 28S ribosomal RNA gene, partial sequence | 1014 | 1014 | 94% | 0.0 | 99% | KM676829.1 |
| Cladophora glomerata gene for 28S ribosomal RNA, partial sequence | 1013 | 1013 | 94% | 0.0 | 99% | AB807613.1 |
| Cladophora glomerata voucher ARS04123_00004 28S ribosomal RNA gene, partial sequence | 1011 | 1011 | 94% | 0.0 | 99% | KM676854.1 |
| Cladophora glomerata voucher ARS06936_00002 28S ribosomal RNA gene, partial sequence | 1009 | 1009 | 94% | 0.0 | 99% | KM676876.1 |
| Cladophora glomerata voucher ARS04369_00001 28S ribosomal RNA gene, partial sequence | 1009 | 1009 | 94% | 0.0 | 99% | KM676842.1 |

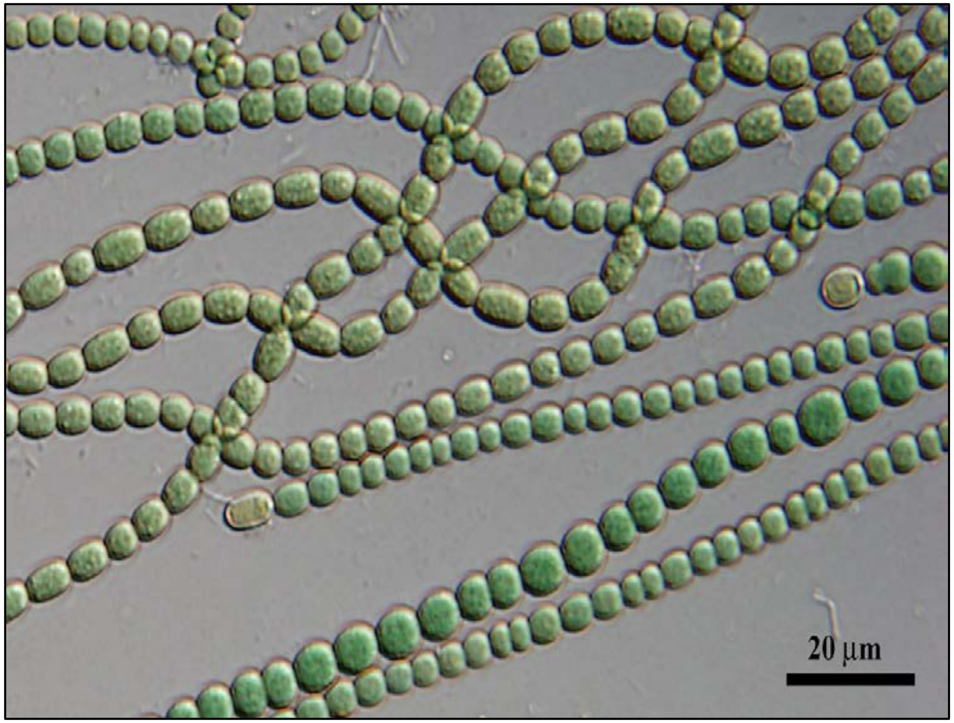
# Phylogentic analysis of *Cladaphora*



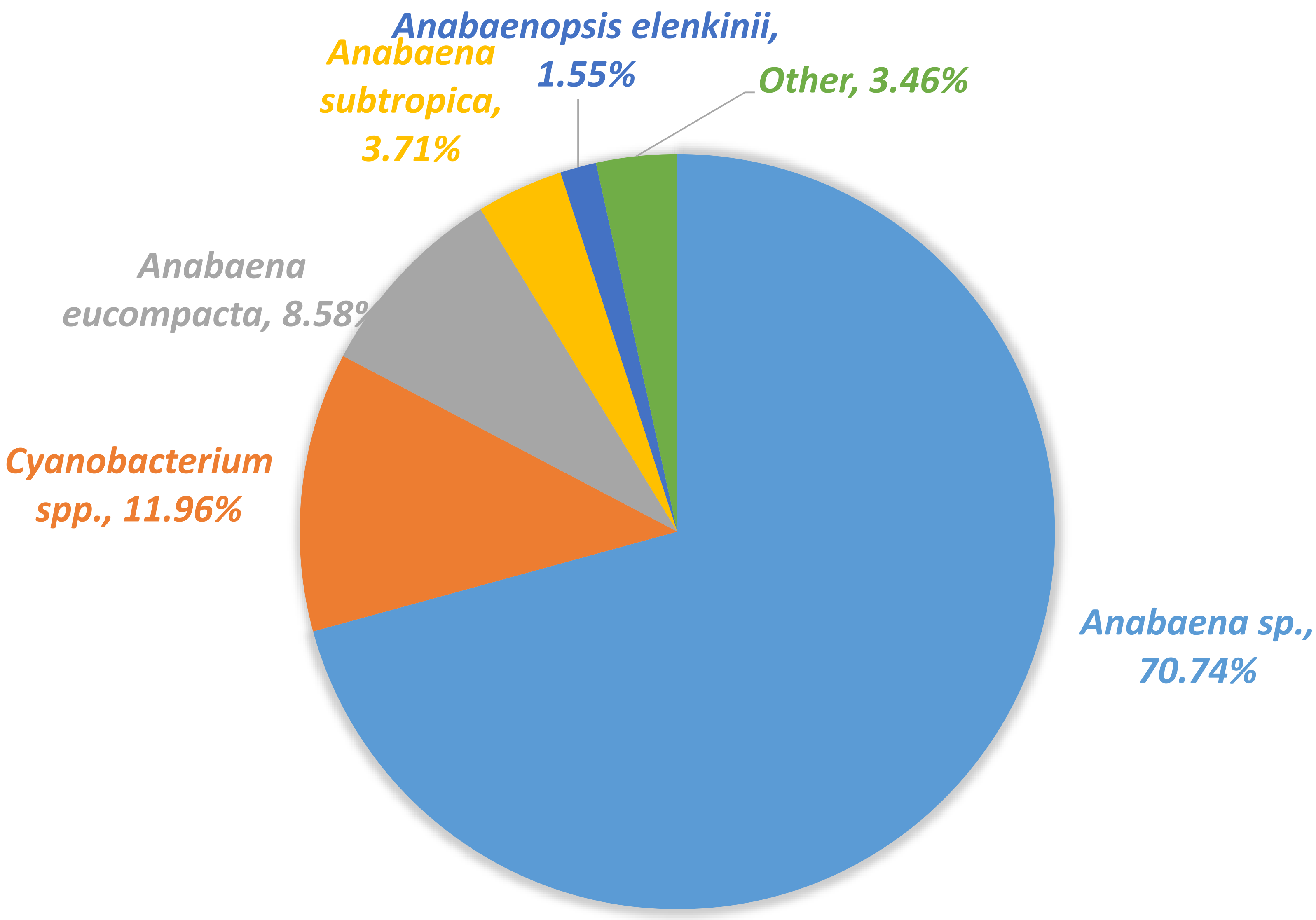
# Second, green, branching algae

# *What blue-green algae reside in Georgica Pond? What toxins do they synthesize?*

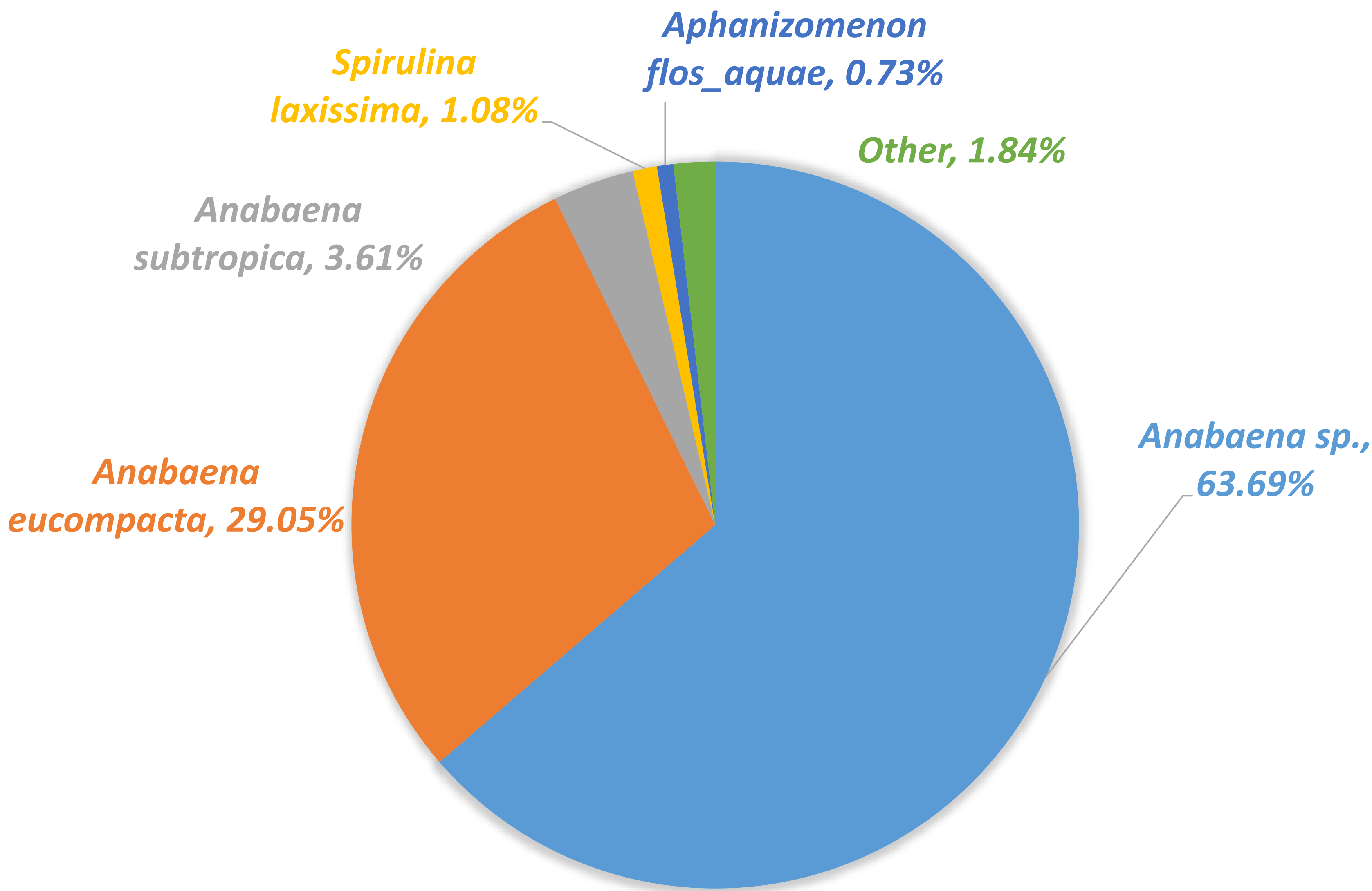


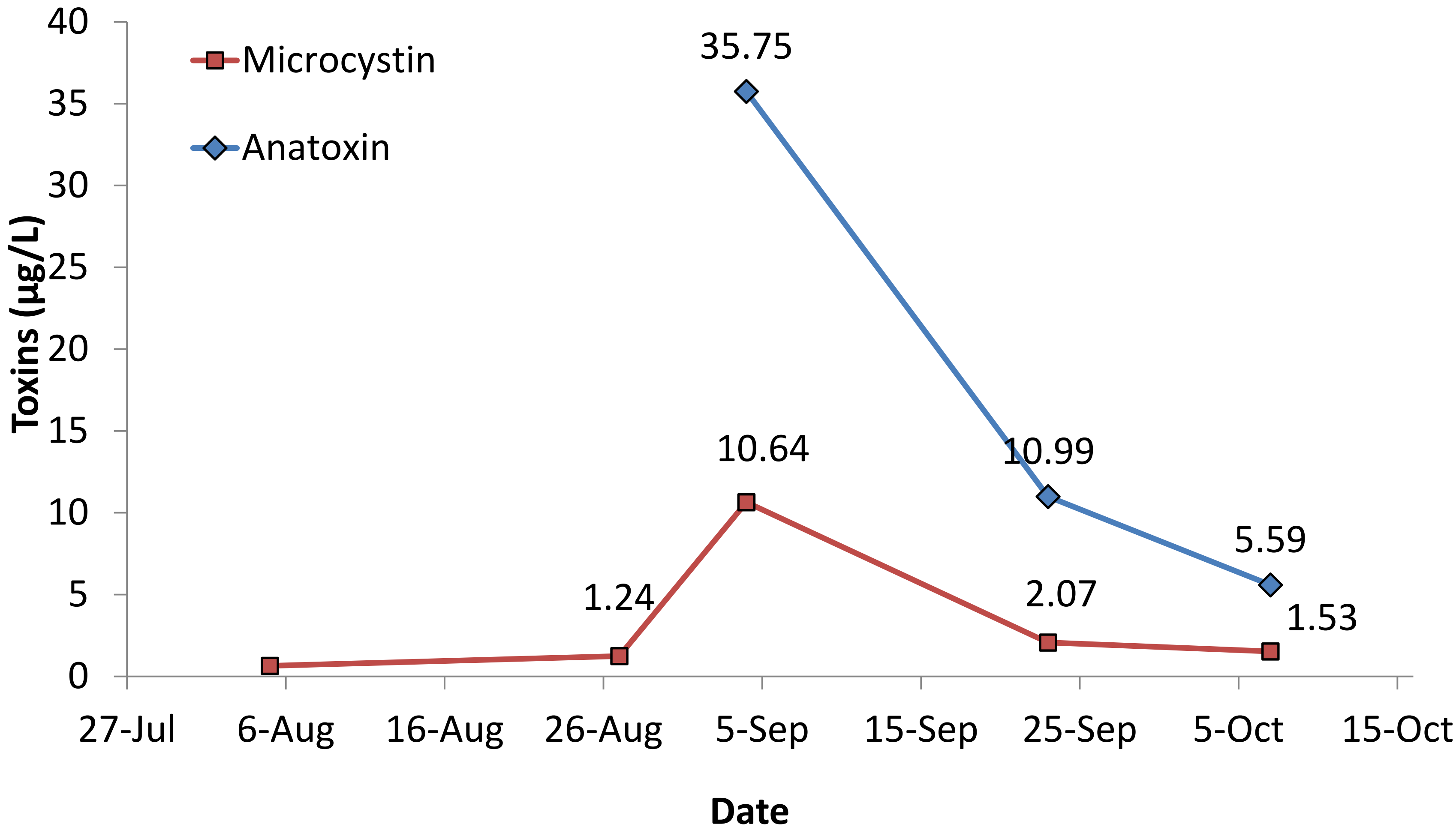
# August cyanobacterial diversity, metagenomic sequencing



# October cyanobacterial diversity, metagenomic sequencing



# Cyanotoxins in Georgica Pond, 2014



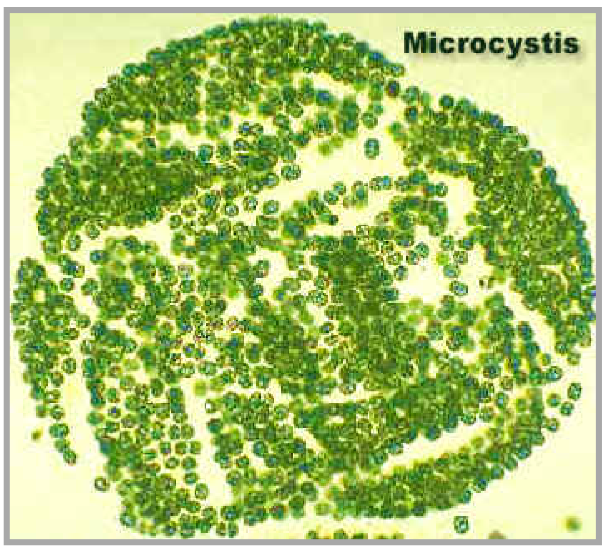
# Toxins producers identified via metagenomic sequencing

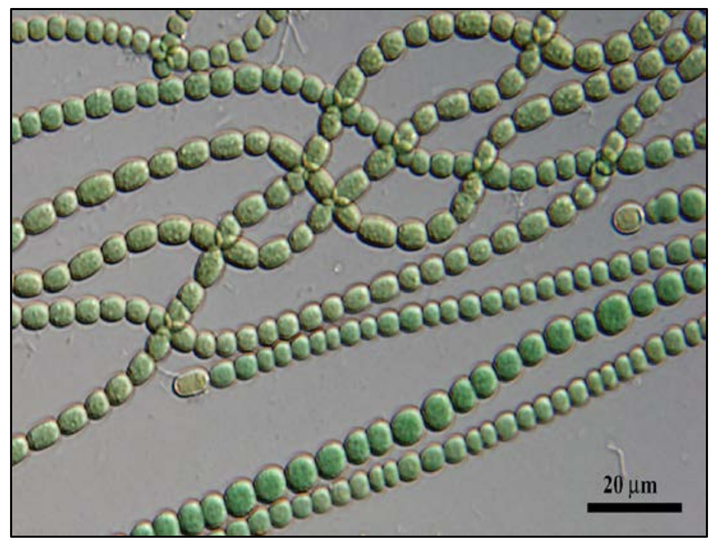
**Microcystin synthesis genes**

- *Microcystis aeruginosa* FCY-26
- *Anabaena* clone BaT 10-14

**Anatoxin synthesis genes**

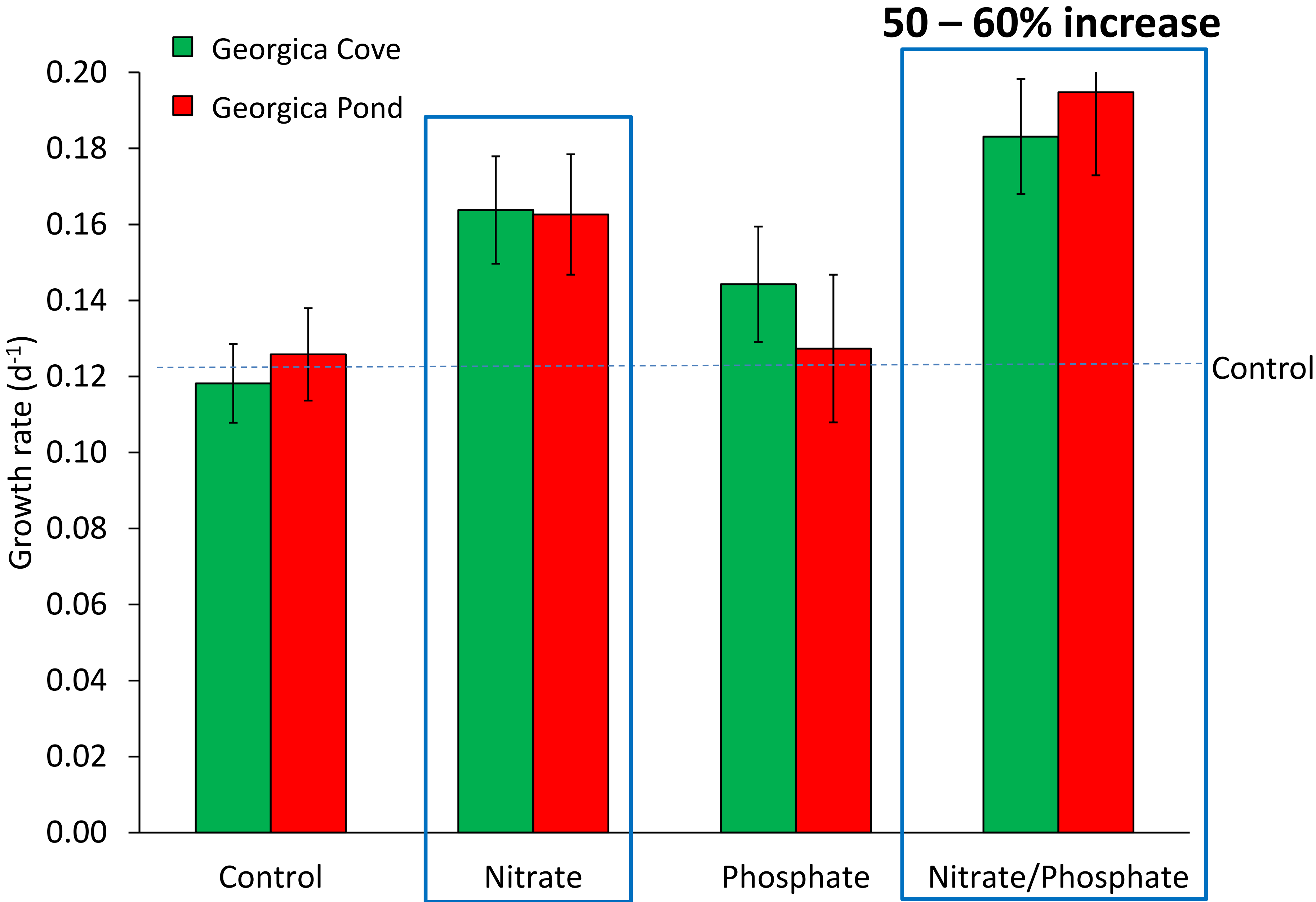
- *Anabaena azollae*
- *Anabaena issatschenkoi*



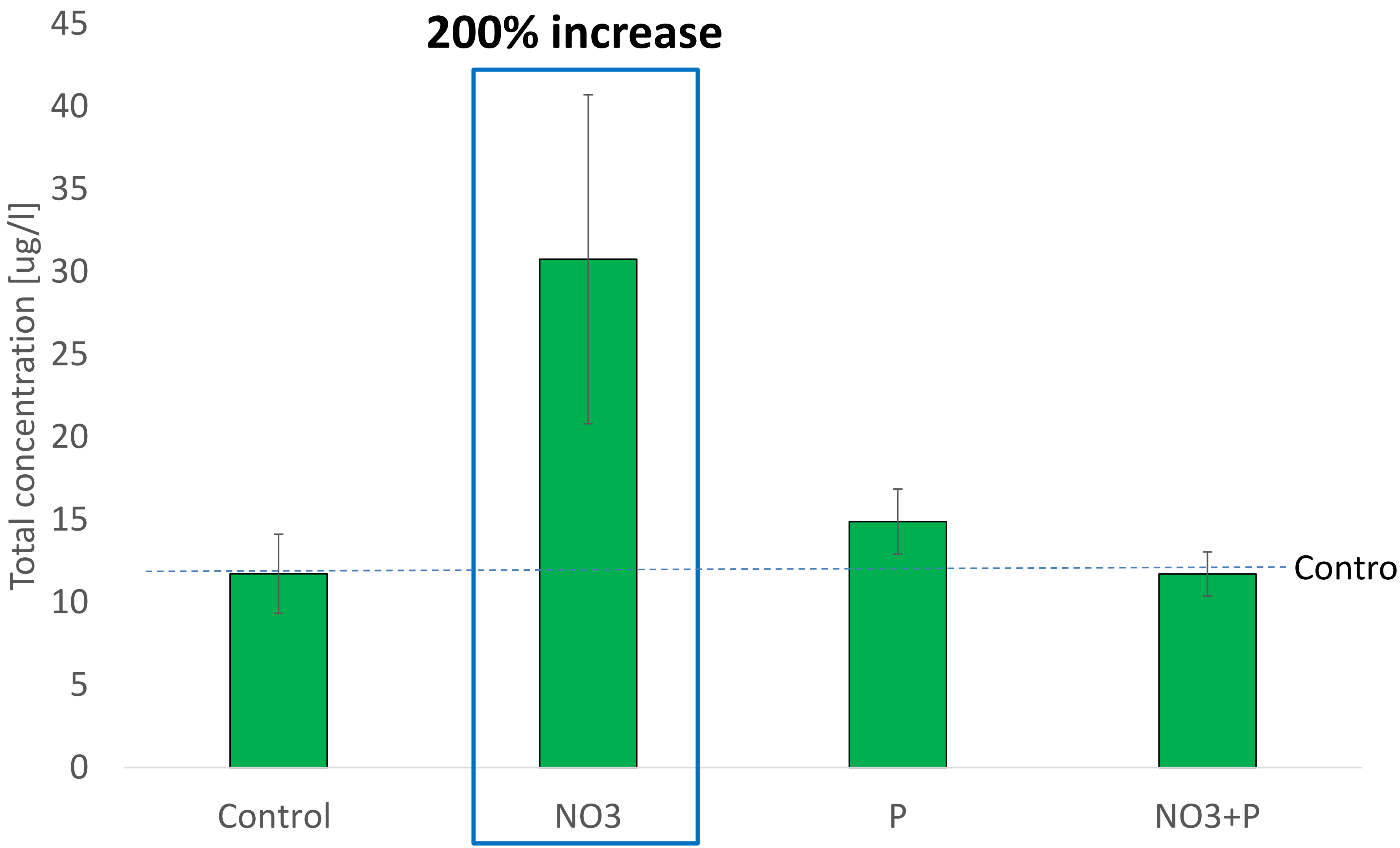



# *What is promoting (micro- and macro) algal blooms in Georgica Pond?*

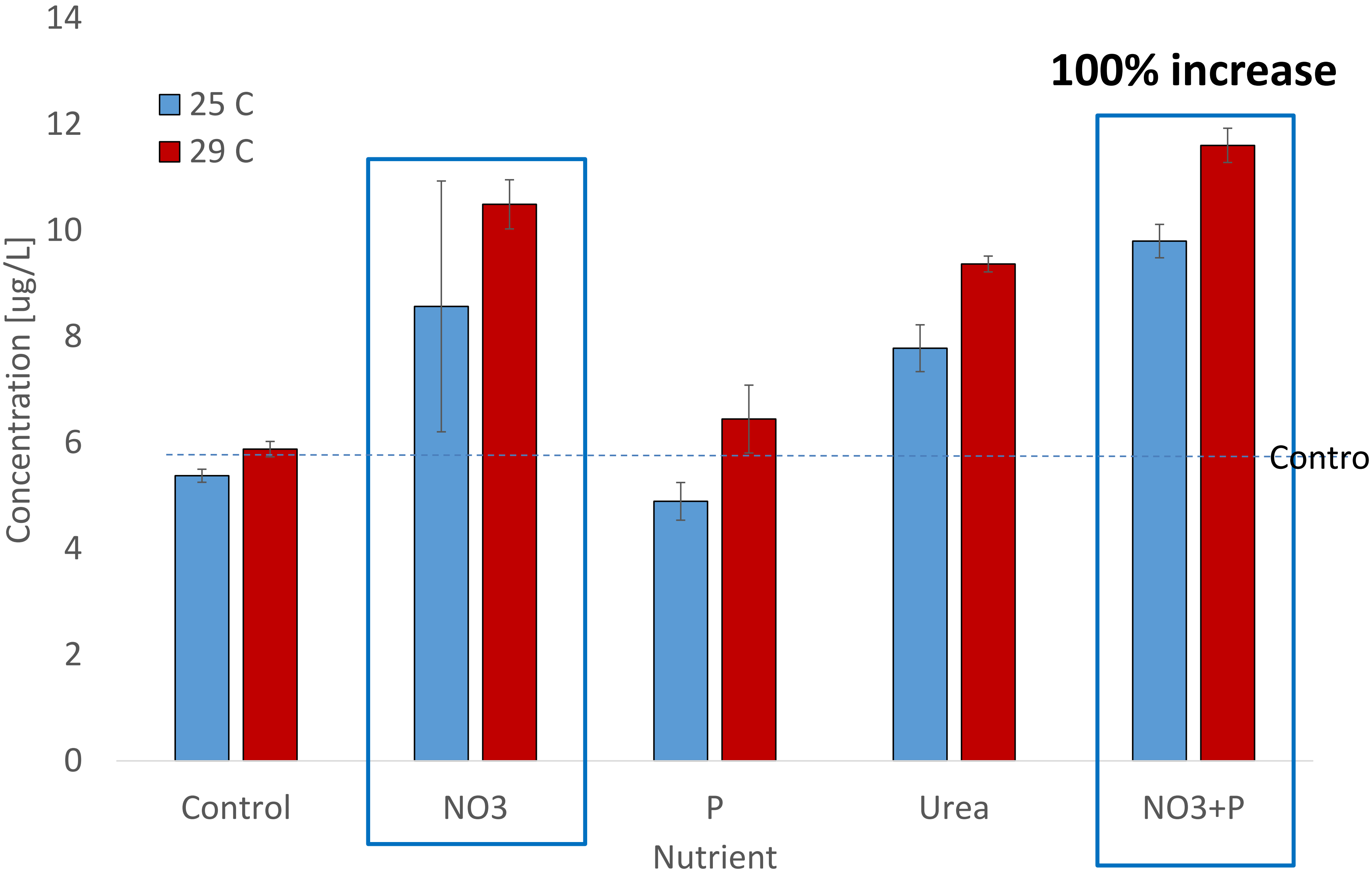
# Nutrients controlling *Cladophora*, 2015



# Nutrients controlling microalgae, 2015



# Nutrients controlling toxic blue-green algae



# <u>Nitrogen and phosphorus</u> are promoting algal blooms.

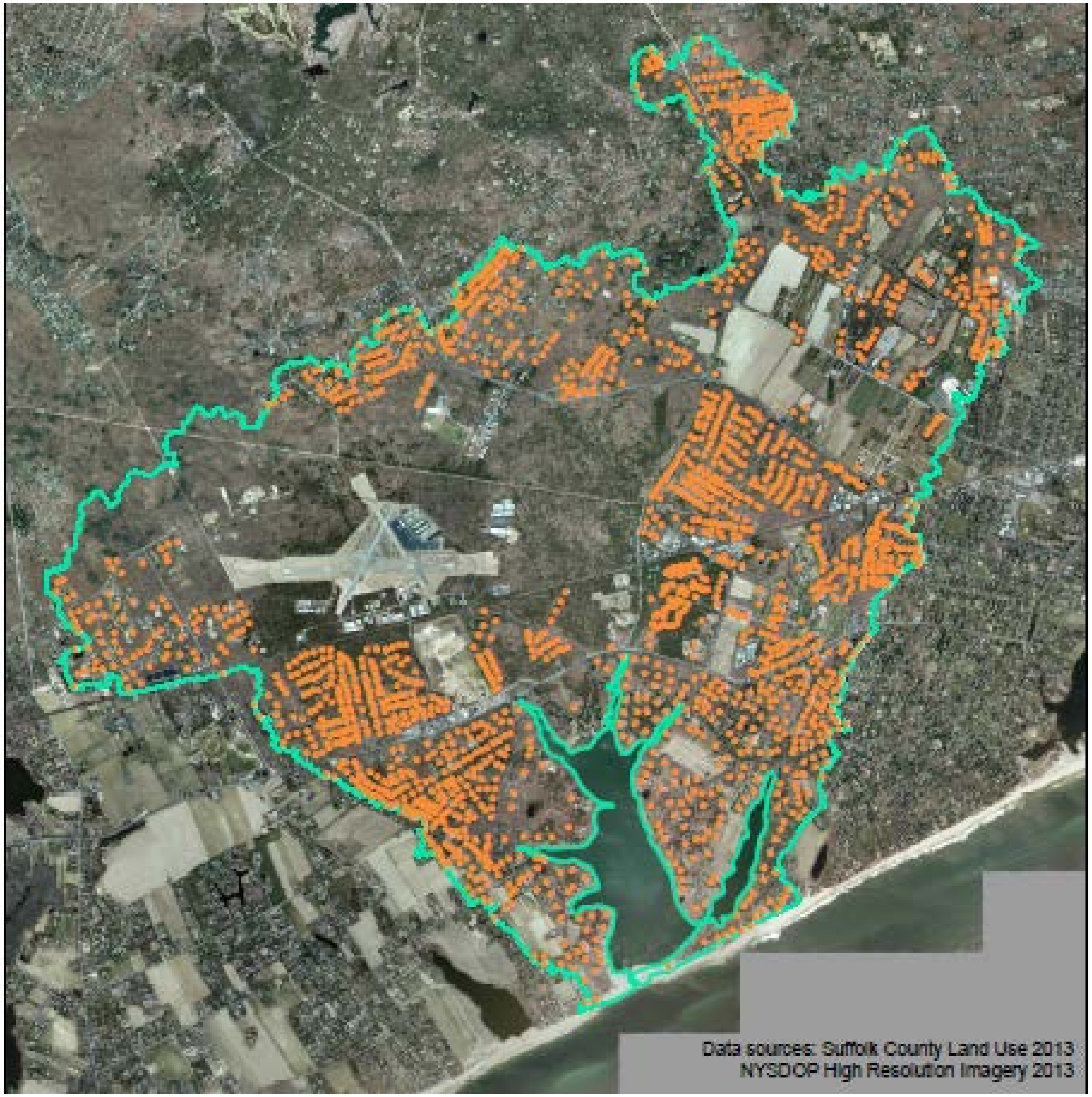
*How much nitrogen and phosphorus is entering Georgica Pond?*

*Where is it coming from?*

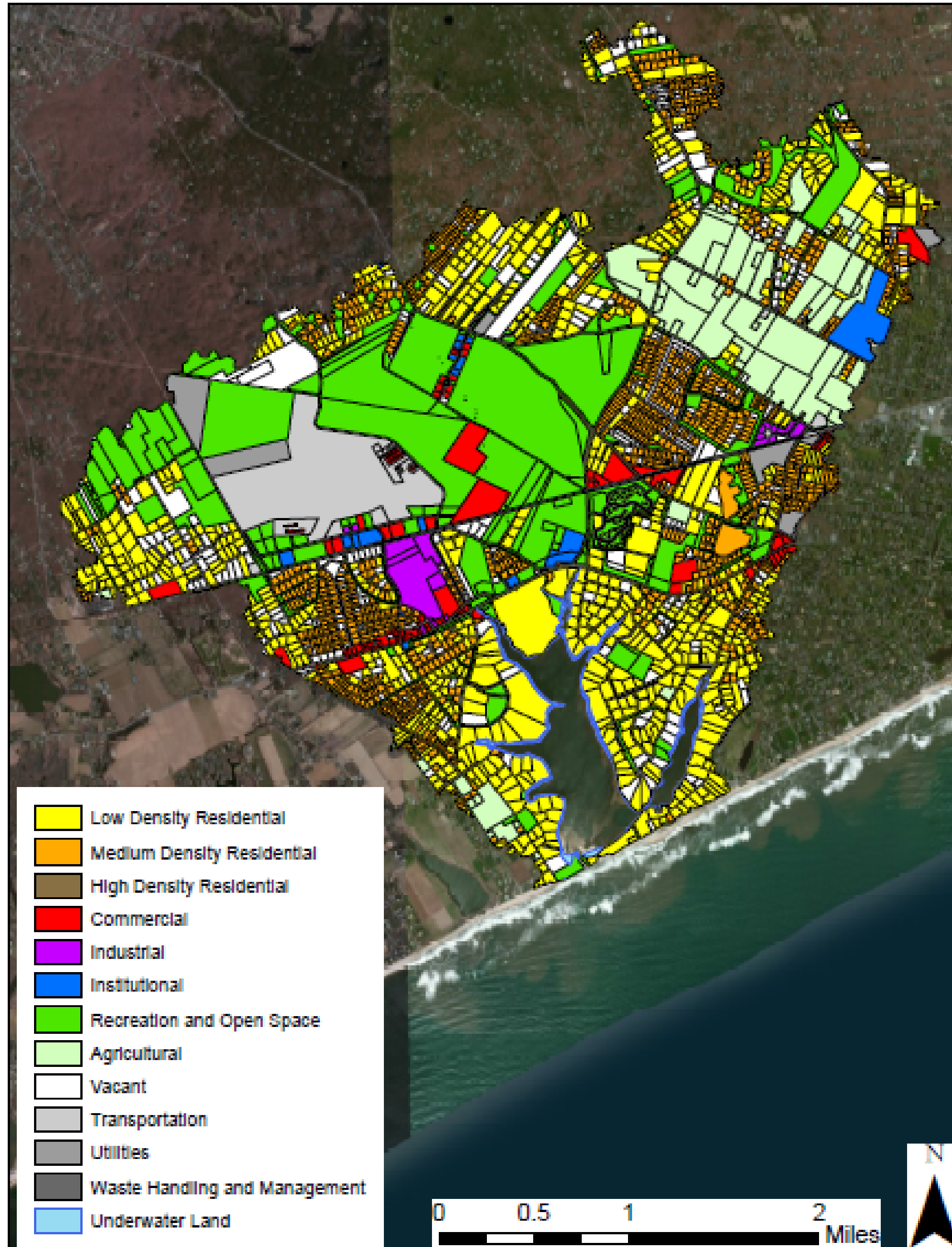
# Nutrient loading analysis approach

- **Seven (7)** independent models designed and executed to determine the loading of nitrogen (4) and phosphorus (3) to Georgica Pond.
- Multiple models and approaches strengthen the convictions on conclusions.
- Models are based on measurements within the watershed and water as well as theoretical calculations based on precise land use data.
- Models were made for the eastern and western sides of Georgica Pond as well as Georgica Cove and the southwest corner of the Pond.
- Models were peer-reviewed by the NYSDEC and The Nature Conservancy.
- Tons of data! Summarized at the end.

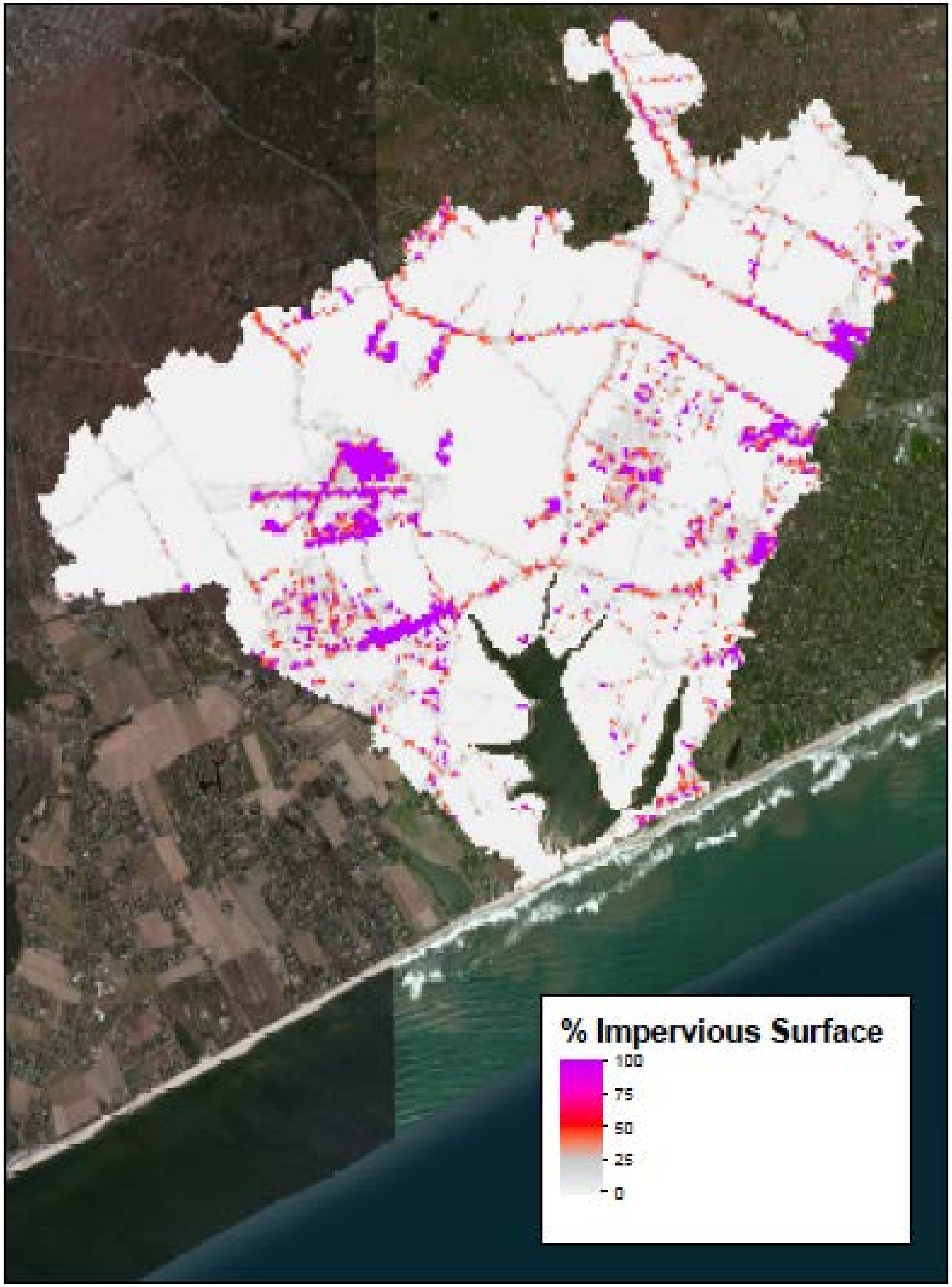
# Homes (>2,000) within the Georgica Pond watershed



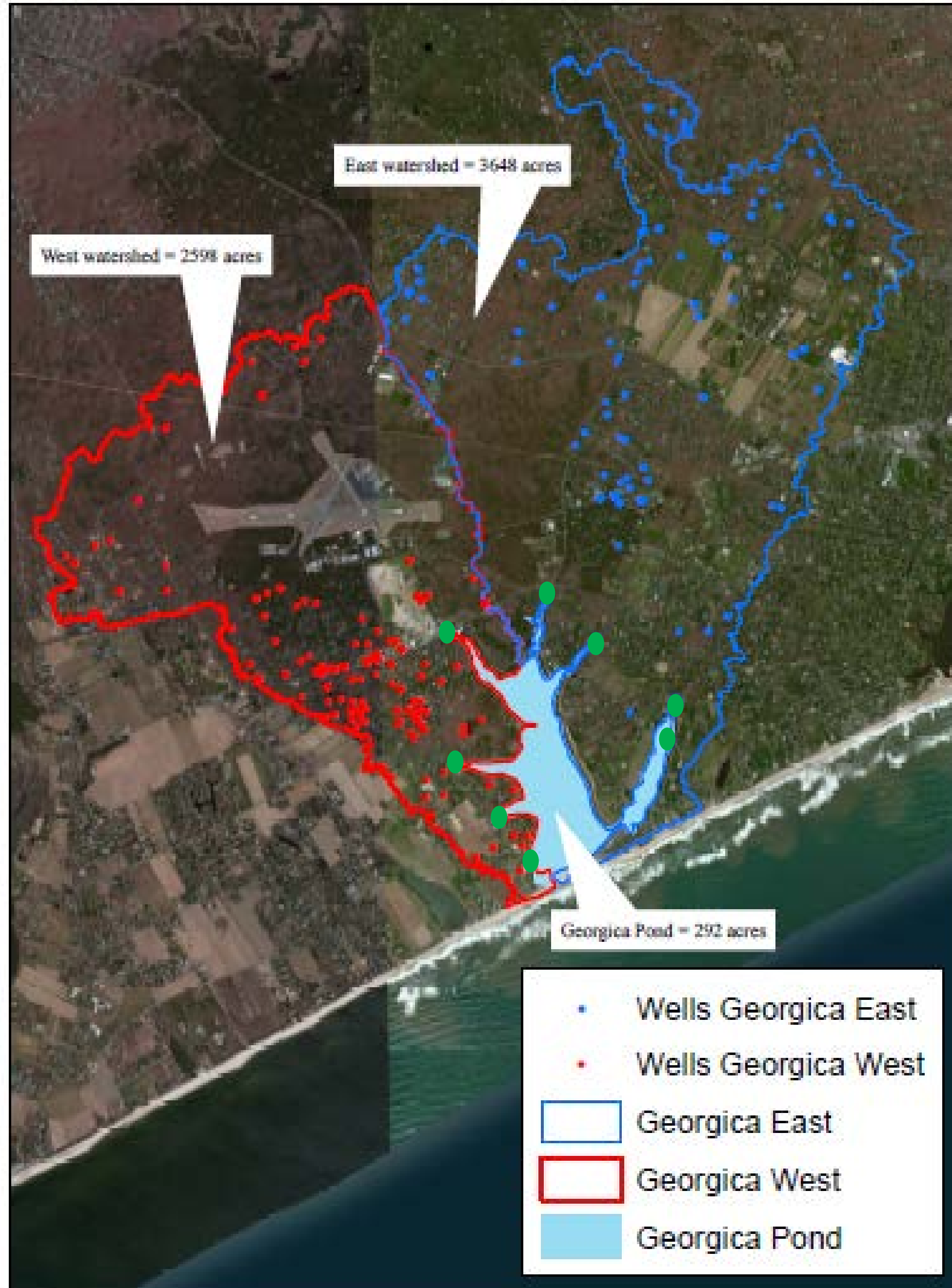
# Land use patterns across the Georgica Pond watershed



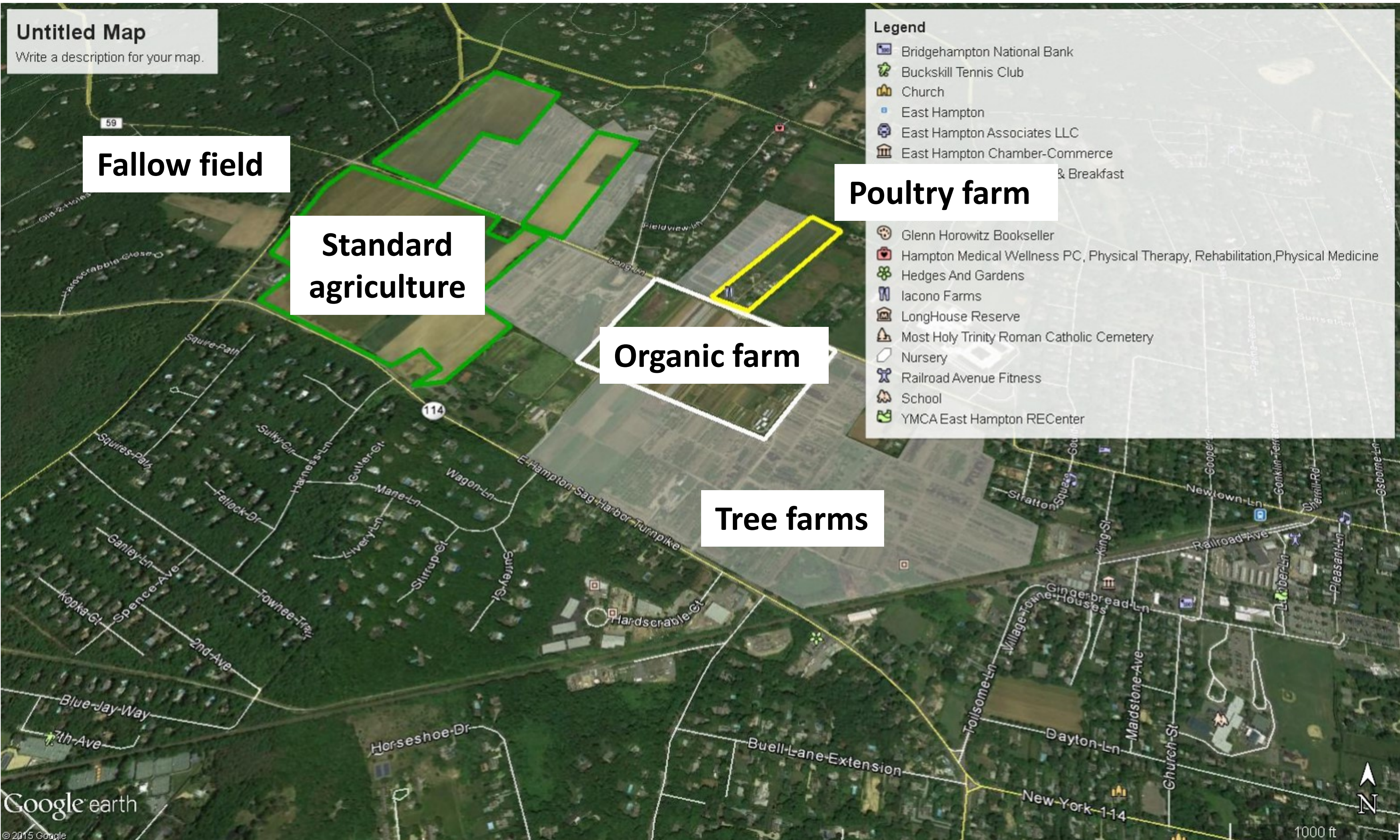
# Impervious surfaces across the Georgica Pond watershed



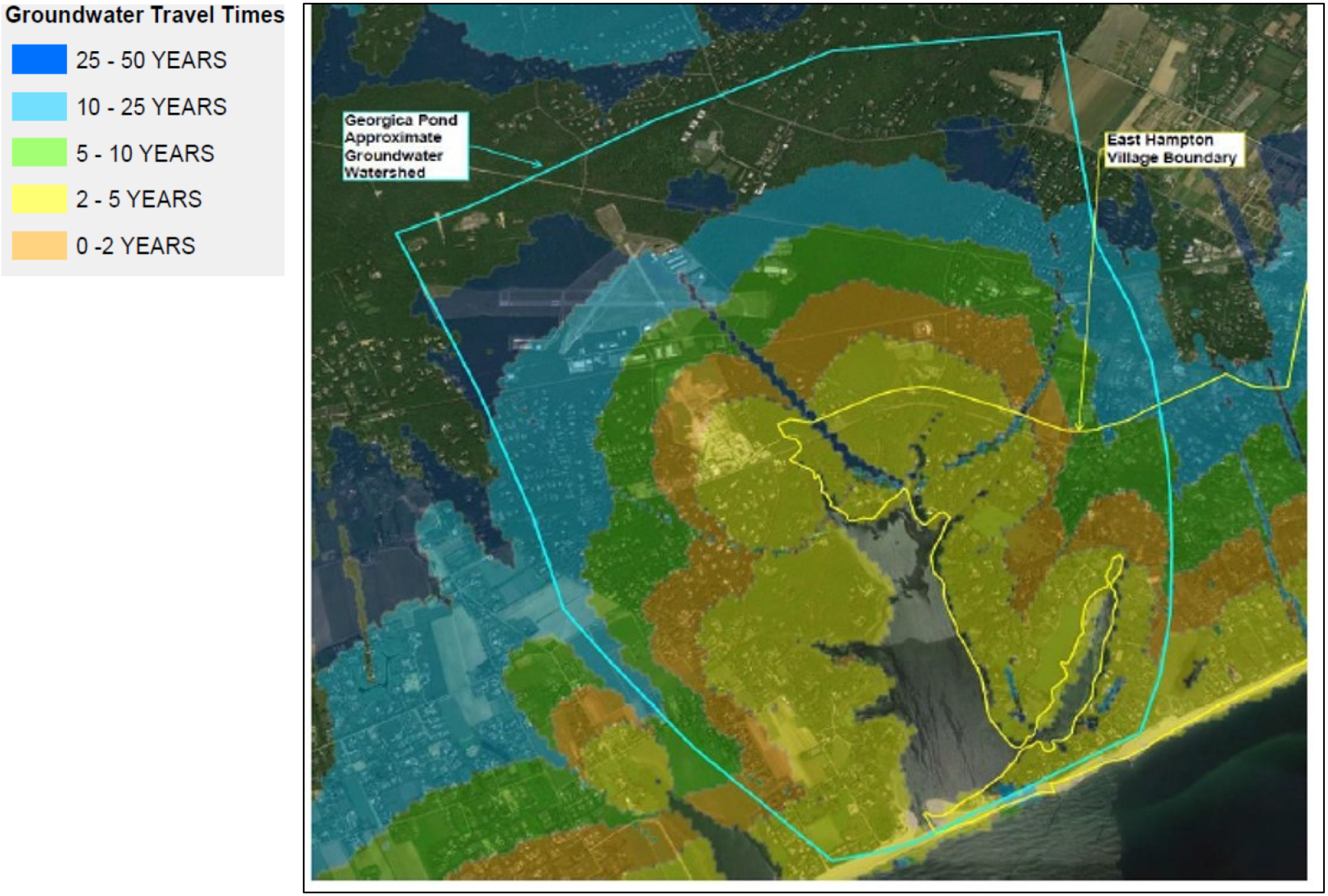
# Nitrogen and phosphorus data from hundreds of groundwater wells in the watershed examined



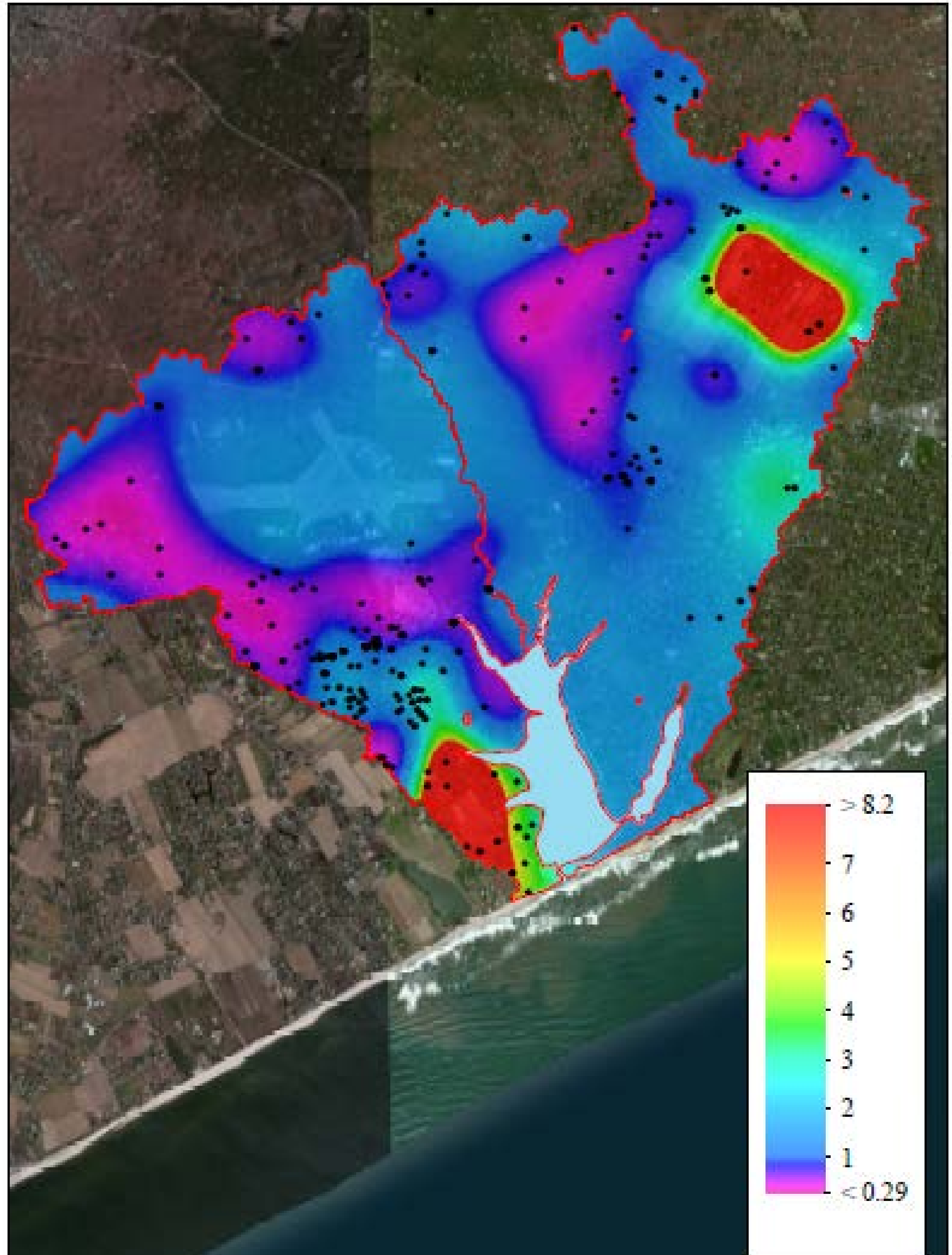
# Detailed data on agriculture within eastern watershed of Georgica Pond obtained from Cornell University



# Groundwater travel times



# Nitrate levels in groundwater across Georgica Pond watershed



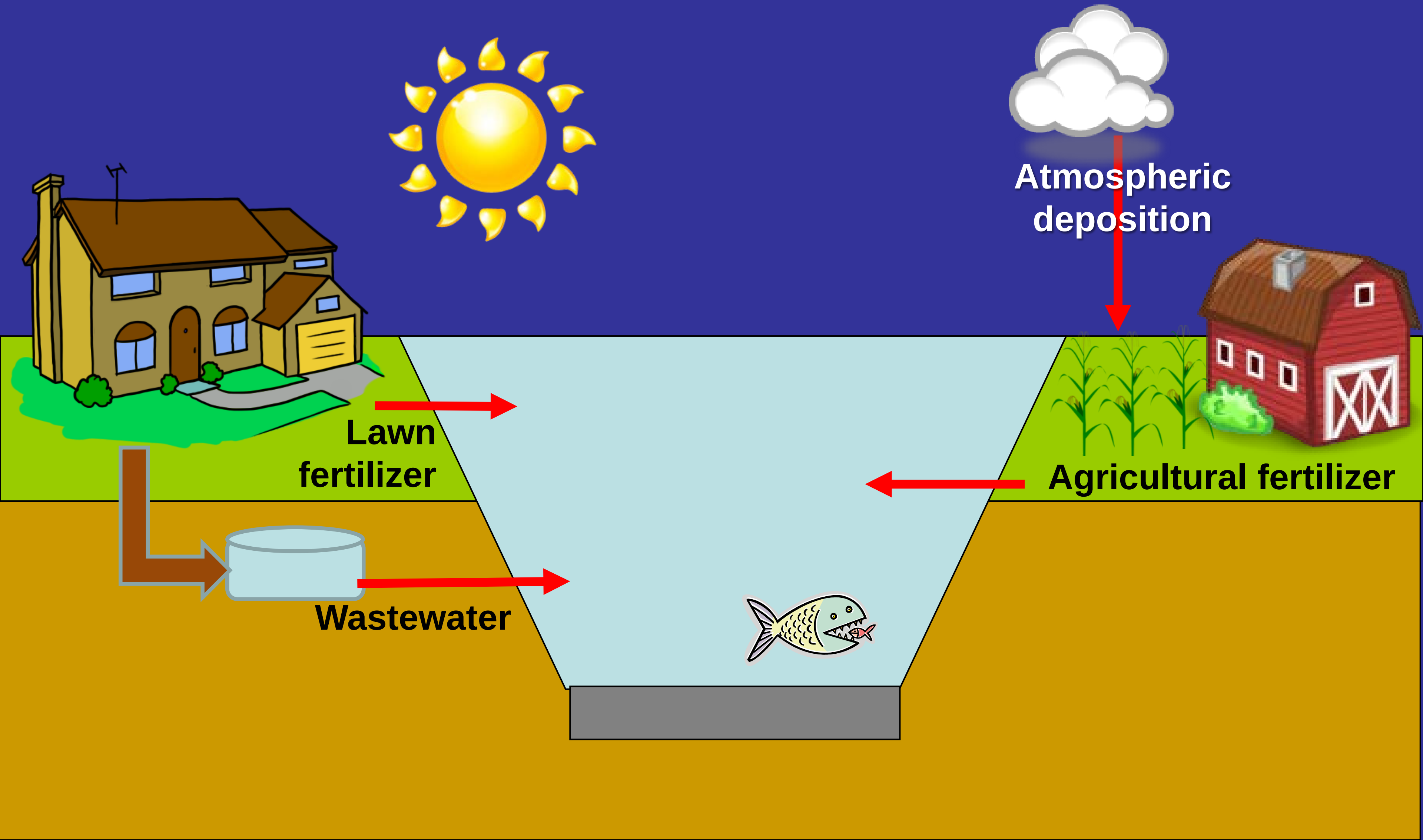
# Isotopic signature of nitrogen in groundwater and streams entering Georgica Pond, N-15:N-14 ratios

< 5 = Fertilizer

**>8 = Wastewater**

# Nitrogen loading model

*Describes movement of N* ***from land to sea***



# Data behind the Nitrogen Loading model

| Constants and Calculations | West | East | Total | |
|---|---|---|---|---|
| Average occupancy rate per house | 2.380935553 | 2.300980816 | 2.336091447 | *people per house* |
| Average lawn size | 0.05 | 0.05 | 0.05 | *ha* |
| Percent of buildings with fertilized lawns | 0.5 | 0.5 | 0.5 | *percent* |
| Area of driveway per building | 0.01254 | 0.01254 | 0.01254 | *ha* |
| N inputs from wet and dry deposition | 16.87506667 | 16.87506667 | 16.87506667 | *kg per ha per yr* |
| Forest N uptake | 0.65 | 0.65 | 0.65 | *percent of deposition retained* |
| Forest N release | 0.35 | 0.35 | 0.35 | *percent od deposition released* |
| Vadose N uptake | 0.61 | 0.61 | 0.61 | *percent of deposition retained* |
| Vadose N release | 0.39 | 0.39 | 0.39 | *percent of deposition released* |
| Turf N uptake | 0.62 | 0.62 | 0.62 | *percent of deposition retained* |
| Turf N release | 0.38 | 0.38 | 0.38 | *percent of deposition released* |
| N throughput from freshwater ponds to aquifer | 0.44 | 0.44 | 0.44 | *percent of inputs* |
| N throughput from wetlands to aquifer | 0.22 | 0.22 | 0.22 | *percent of inputs* |
| N released per person per year | 4.82 | 4.82 | 4.82 | *kg per cap per yr* |
| Percent of N inputs released from septic tanks | 0.94 | 0.94 | 0.94 | *percent of added N released* |
| Leaching field effluent | 0.95 | 0.95 | 0.95 | *percent of added N released* |
| N released from the plume of the septic system | 0.66 | 0.66 | 0.66 | *percent of added N released* |
| Fertilizer applied to lawns | 122 | 122 | 122 | *kg per ha per yr* |
| Fertilizer applied to golf courses | 146 | 146 | 146 | *kg per ha per yr* |
| Gaseous loss of fertilizer | 0.385 | 0.385 | 0.385 | *percent fertilizer applied* |
| Gaseous loss of fertilizer | 0.615 | 0.615 | 0.615 | *Percent fertilizer transported* |
| Fertilizer application to agriculture | 136 | 109.4207237 | 111.5792118 | *kg per ha per yr* |
| Denitrification in aquifer | 0.15 | 0.15 | 0.15 | *percent of N entering the aquifer that is lost* |
| Denitrification in aquifer | 0.85 | 0.85 | 0.85 | *percent of N entering the aquifer that is released* |

| Inputs | West | East | Total | |
|---|---|---|---|---|
| Number of buildings | 744 | 1416 | 2153 | |
| Watershed area | 1051.8484 | 1477.5842 | 2529.4326 | ha |
| Area of wetlands (freshwater) | 11.01759615 | 26.66158867 | 37.67918482 | ha |
| Area of agriculture | 12.4417 | 140.7634 | 153.2051 | ha |
| Area of golf courses | 0 | 0.9157 | 0.9157 | ha |
| Area of parks and athletic fields | 5.3121 | 11.7312 | 17.0433 | ha |
| Impervious surfaces total | 84.59830172 | 99.48105275 | 184.0793545 | ha |
| Area of freshwater ponds | 0.3366 | 0.5721 | 0.9087 | ha |
| Buildings within 200m of shore | 57 | 106 | 162 | |
| Percent of buildings with cesspools | 0.5 | 0.5 | 0.5 | |
| Percent of buildings with septic systems | 0.5 | 0.5 | 0.5 | |
| Area of roof per building | 0.03337224973 | 0.03036664273 | 0.03150400367 | ha |
| % Road Area of Watershed | 0.04110921393 | 0.04825276042 | 0.04847207525 | |
| Fertilizer: Parks & Athletic Fields | 146 | 146 | 146 | kg/ha/yr |
| Area of road | 43.24 | 71.30 | 122.61 | ha |
| Area of driveway | 9.33 | 17.76 | 27.00 | ha |
| Area of roof | 24.83 | 43.00 | 67.83 | ha |
| Area of lawn | 37.2 | 70.8 | 107.65 | ha |
| | | | | |
| **Calculations** | | | | |
| **Atmospheric Deposition** | West | East | Total | |
| Natural Vegetation | 4,864 | 5,874 | 10,693 | [Watershed area - (wetlands+ponds+agriculture+impervious+parks&athl.+road+driveway+roof+golf+lawn)]*atm depo*forest release |
| Turf | 239 | 460 | 696 | (lawn area+golf)*atm depo*turf release |
| Agriculture | 80 | 903 | 982 | (agriculture)*atm depo*turf release |
| Impervious Surfaces | 1,428 | 1,679 | 3,106 | impervious surfaces*atm depo |
| Ponds | 2 | 4 | 7 | Ponds*atm depo*%pond recharge |
| Wetlands | 41 | 99 | 140 | wetlands*atm depo*%wetland recharge |
| Roads | 730 | 1,203 | 2,069 | road*atm depo |
| Driveways | 60 | 114 | 173 | driveway*atm depo*turf release |
| Roof | 159 | 276 | 435 | roof*atm depo*turf release |
| **Subtotal** | 7,602 | 10,612 | 18,302 | |
| **Total with transport loss** | **2,520** | **3,518** | **6,067** | **subtotal*vadose release*denitrification** |
| | | | | |
| **Fertilizer** | | | | |
| Agriculture | 1,041 | 9,472 | 10,513 | agriculture*ag application rate*gaseous loss |
| Lawns | 1,396 | 2,656 | 4,038 | (#buildings*lawn size*% fertilized)*lawn application rate*gaseous loss |
| Golf | 0 | 82 | 82 | golf*golf application rate*gaseous loss |
| Parks +Athletic fields | 477 | 1,053 | 1,530 | parks and ath.*parks application rate*gaseous loss |
| **Subtototal** | 2,913 | 13,264 | 16,164 | |
| **Total with transport loss** | **966** | **4,397** | **5,358** | **subtotal*vadose release*denitrification** |
| | | | | |
| **Wastewater** | | | | |
| Cesspools | 2,079 | 3,831 | 5,911 | (#buildings-buildings200m)*%buildingsWcess pools*occupancy*N release pp*septic plume release*denitrification* septic tank release |
| Septic systems | 1,975 | 3,639 | 5,616 | (#buildings-buildings200m)*%buildingsWseptic systems*occupancy*N release pp*septic plume release*denitrification*septic tank release*leach field release |
| 200m of shore (cess)* | 203 | 365 | 566 | buildings200m*%buildingsWcess pools*occupancy*N release pp*septic plume release*septic tank release |
| 200m of shore (septic) | 193 | 346 | 538 | buildings200m*%buildingsWseptic systems*occupancy*N release pp*septic plume release*septic tank release*leach field release |
| **Total** | **4,449** | **8,181** | **12,630** | |
| | | | | |
| **Total Nload (kg/yr)** | **7,935** | **16,096** | **24,056** | |
| **Total Nload (kg/ha/yr)** | **7.544009865** | **10.89348982** | **9.510276747** | |
| | | | | |
| **% atmospheric** | **0.32** | **0.22** | **0.25** | |
| **% fertilizer** | **0.12** | **0.27** | **0.22** | |
| %agriculture | 0.04 | 0.20 | 0.14 | |
| %lawns&other | 0.08 | 0.08 | 0.08 | |
| **% waste water** | **0.56** | **0.51** | **0.53** | |

| | Ground Water N (kgN/yr) | Watershed Area (m^2) | Precipitation (m/yr) | Recharge % | Stream Flow Volume (m^3/yr) | Runoff Volume (m^3/yr) | Groundwater Nitrate (kgN/m^3) |
|---|---|---|---|---|---|---|---|
| **Total** | 33533.81179 | 25294326 | 1.1266 | | | | 0.002410906979 |
| **West** | 12119.47438 | 10518484 | 1.1266 | 0.5 | 197762.256 | 193910.6958 | 0.002115377419 |
| **East** | 21414.3374 | 14775842 | 1.1266 | 0.5 | 61903.416 | 245755.6868 | 0.002621285714 |
| | | *From map. | *From CASTNET | *From Chris | *From below calc. | *From below calc. | *From County. Sites averaged. |

| | Runoff N (kgN/yr) | <200m Watershed (m^2) | Precipitation | %Impervious | Runoff Volume (m^3/yr) | Runoff N (kgN/m^3) |
|---|---|---|---|---|---|---|
| **Total** | 553.9796421 | 2648540 | 1.1266 | 0.1473489268 | | |
| **West** | 244.3274767 | 1061557 | 1.1266 | **0.1621394515** | 193910.6958 | 0.00126 |
| **East** | 309.6521654 | 1586983 | 1.1266 | **0.1374553205** | 245755.6868 | 0.00126 |
| | | *From map. | *From CASTNET | *From Ryan. Adjusted for 200m. Issy says 14%. | | *From Stinette thesis. |

| | Stream N (kgN/yr) | Stream Flow Vol. (m^3/yr) | Avg. Stream N (kgN/m^3) |
|---|---|---|---|
| **Total** | 57.66315139 | | |
| **West** | 53.48974082 | 197762.256 | 0.004435654144 |
| **East** | 4.173410575 | 61903.416 | 0.00009900675784 |
| | *From Measurements | *From Measurements | *From Measurements |

| | Atmospheric N Dep. (kgN/yr) | Pond Area (m^2) | Wet N Dep. (kgN/m^2/yr) | Dry N Dep. (kgN/m^2/yr) | Wet NH4 Dep. | Wet NO3 Dep. | Wet Inorg. N |
|---|---|---|---|---|---|---|---|
| **Total** | 2030.487334 | 1203247 | 0.0011754 | 0.0005121066667 | 0.0001618 | 0.0007242 | 0.0002894 |
| **kgN/ha/yr** | 16.87506667 | *From map. | | | *From NADP | *From NADP | *From NADP |

| | Benthic N Flux (kgN/yr) | Pond Area (m^2) | Mill Pond Area (m^2) | Mill Pond Flux (kg/yr) | (kgN/m^2/yr) |
|---|---|---|---|---|---|
| **Total** | 9515.210409 | 1203247 | 393219 | 10365.18 | 0.02635981476 |

| WHOLE | kgN/yr | kgN/ha/yr | |
|---|---|---|---|
| **Ground Water N (kgN/yr)** | 33533.81179 | 13.25744429 | 0.7339259764 |
| **Runoff N (kgN/yr)** | 553.9796421 | 0.2190134033 | 0.01212448058 |
| **Stream N (kgN/yr)** | 57.66315139 | 0.02279687207 | 0.00126202428 |
| **Atmospheric N Dep. (kgN/yr)** | 2030.487334 | 0.8027441942 | 0.04443954683 |
| **Benthic N Flux (kgN/yr)** | 9515.210409 | | 0.2082513057 |
| **Total sans Atm & Benthic** | **34,145.45** | **13.49925457** | |
| **TOTAL** | 45691.15232 | | |
| **WEST** | | | |
| **Ground Water N (kgN/yr)** | 12119.47438 | 11.52207331 | |
| **Runoff N (kgN/yr)** | 244.3274767 | 0.2322839268 | |
| **Stream N (kgN/yr)** | 53.48974082 | 0.05085308949 | |
| **Total** | **12,417.29** | **11.80521033** | |

| | **Ground Water P (kgN/yr)** | Watershed Area (m^2) | Precipitation (m/yr) | Recharge % | Stream Flow Volume (m^3/yr) | Runoff Volume (m^3/yr) | Groundwater Phosphorus (kgP/m^3) |
|---|---|---|---|---|---|---|---|
| **Total** | 299.4482361 | 25294326 | 1.1266 | | | | 0.00002155918781 |
| **West** | 136.4512821 | 10518484 | 1.1266 | 0.5 | 197762.256 | 193910.6958 | 0.00002381670623 |
| **East** | 162.996954 | 14775842 | 1.1266 | 0.5 | 61903.416 | 245755.6868 | 0.00001995212734 |
| | | *From map. | *From CASTNET | *From Chris | *From below calc. | *From below calc. | *From our GW |

| | **Runoff P (kgP/yr)** | <200m Watershed (m^2) | Precipitation | %Impervious | Runoff Volume (m^3/yr) | Runoff P (kgP/m^3) | |
|---|---|---|---|---|---|---|---|
| **Total** | 114.3132595 | 2648540 | 1.1266 | | | | |
| **West** | 50.41678091 | 1061557 | 1.1266 | **0.1621394515** | 193910.6958 | 0.00026 | 8.387096774 |
| **East** | 63.89647857 | 1586983 | 1.1266 | **0.1374553205** | 245755.6868 | 0.00026 | 8.387096774 |
| | | *From map. | *From CASTNET | *From Ryan. Adjusted for 200m. Issy says 14%. | | *From Hook Report | |

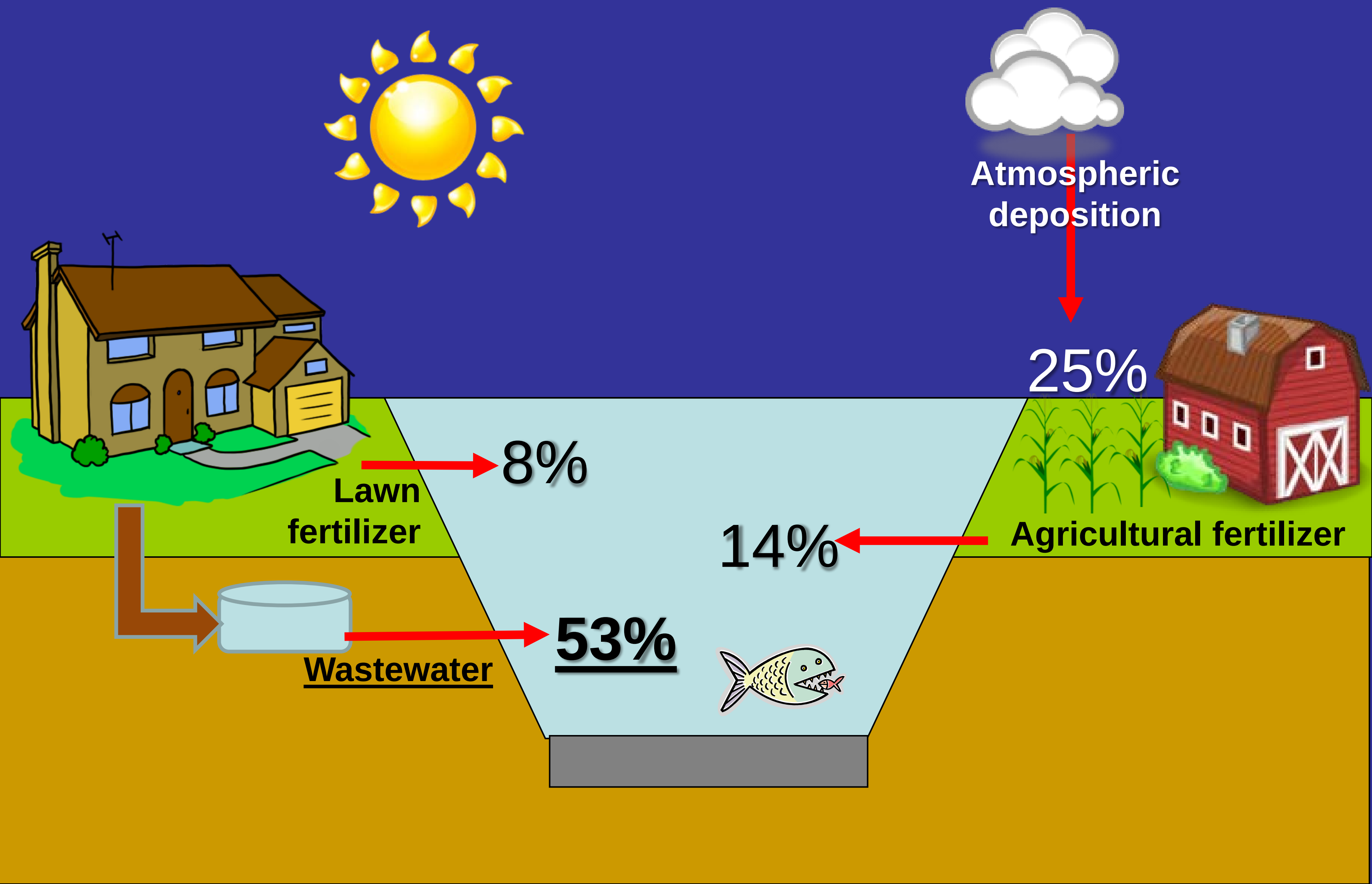
| | **Stream P (kgP/yr)** | Stream Flow Vol. (m^3/yr) | Avg. Stream P (kgP/m^3) | |
|---|---|---|---|---|
| **Total** | 2.614969619 | | | |
| **West** | 1.593149275 | 197762.256 | 0.000009508361316 | 0.3067213328 |
| **East** | 1.021820344 | 61903.416 | 0.00001907125288 | 0.6152017056 |
| | *From Measurements | *From Measurements | *From Measurements | |

| | **Atmospheric P Dep. (kgP/yr)** | Pond Area (m^2) | Total P Dep. (kgP/m^2/yr) | (kgP/ha/yr) |
|---|---|---|---|---|
| **Total** | 6.8585079 | 1203247 | 0.0000057 | 0.057 |
| **kgP/ha/yr** | 0.057 | *From map. | | *From Hook Report |

| | **Benthic P Flux (kgP/yr)** | Pond Area (m^2) | Mill Pond Area (m^2) | Mill Pond Flux (kg/yr) | (kgP/m^2/yr) |
|---|---|---|---|---|---|
| **Total** | 466.3149347 | 1203247 | 393219 | 507.969664 | 0.001291823803 |

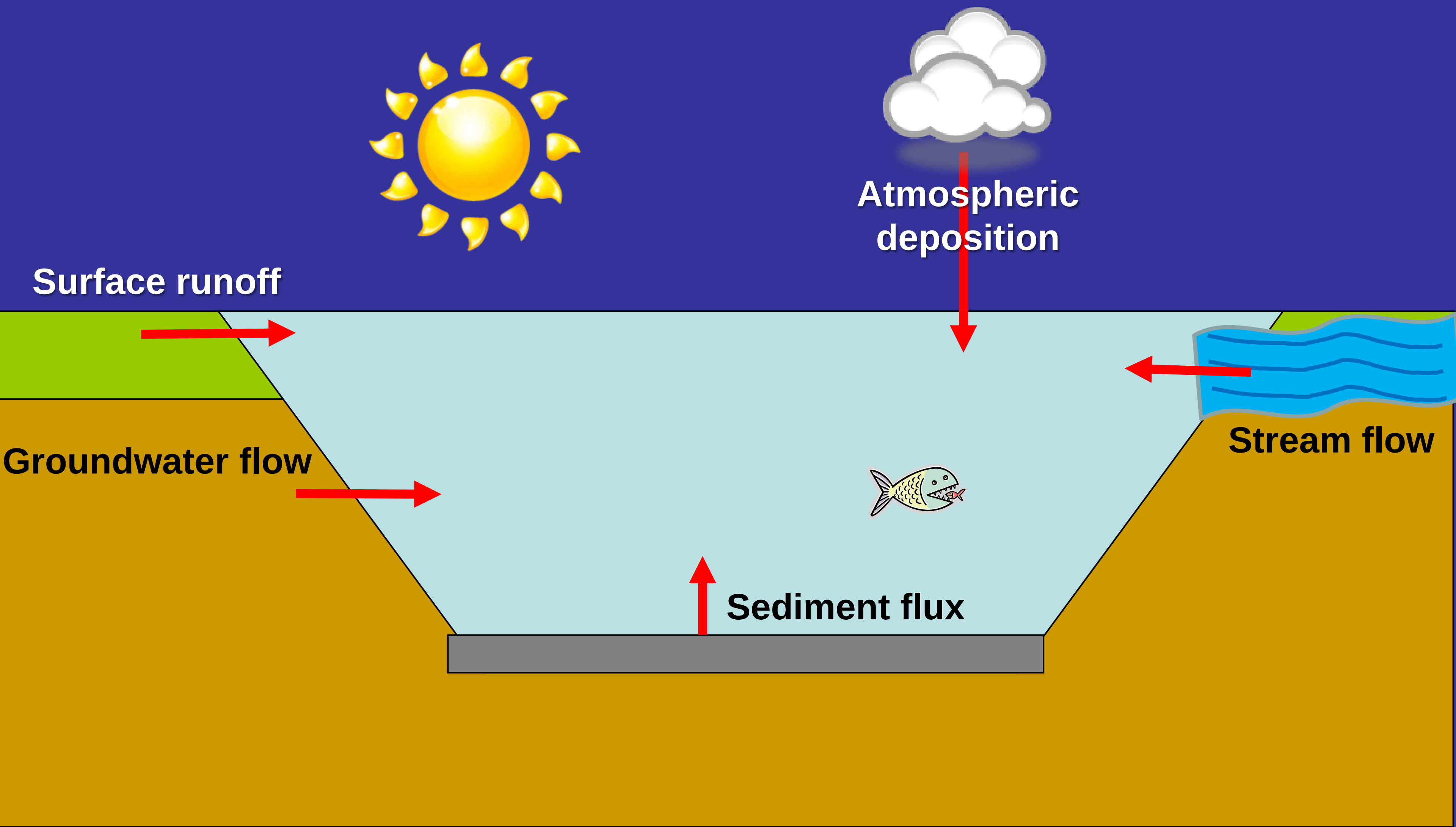
| **WHOLE** | **kgP/yr** | **kgP/ha/yr** | **Fraction of total** |
|---|---|---|---|
| **Ground Water N (kgN/yr)** | 299.4482361 | 0.1183855368 | 0.3364586922 |
| **Runoff N (kgN/yr)** | 114.3132595 | 0.04519324195 | 0.1284418646 |
| **Stream N (kgN/yr)** | 2.614969619 | 0.001033816682 | 0.002938168111 |
| **Atmospheric N Dep. (kgN/yr)** | 6.8585079 | 0.002711480788 | 0.007706188652 |
| **Benthic N Flux (kgN/yr)** | 466.3149347 | | 0.5239493648 |
| **Total sans Atm & Benthic** | **416.38** | **0.1646125954** | 0.9994942784 |
| **TOTAL** | 889.5499078 | | |
| **WEST** | | | |
| **Ground Water N (kgN/yr)** | 136.4512821 | 0.1297252362 | |
| **Runoff N (kgN/yr)** | 50.41678091 | 0.04793160394 | |
| **Stream N (kgN/yr)** | 1.593149275 | 0.001514618718 | |
| **Total** | **188.46** | **0.1791714589** | |

# Nitrogen loading model

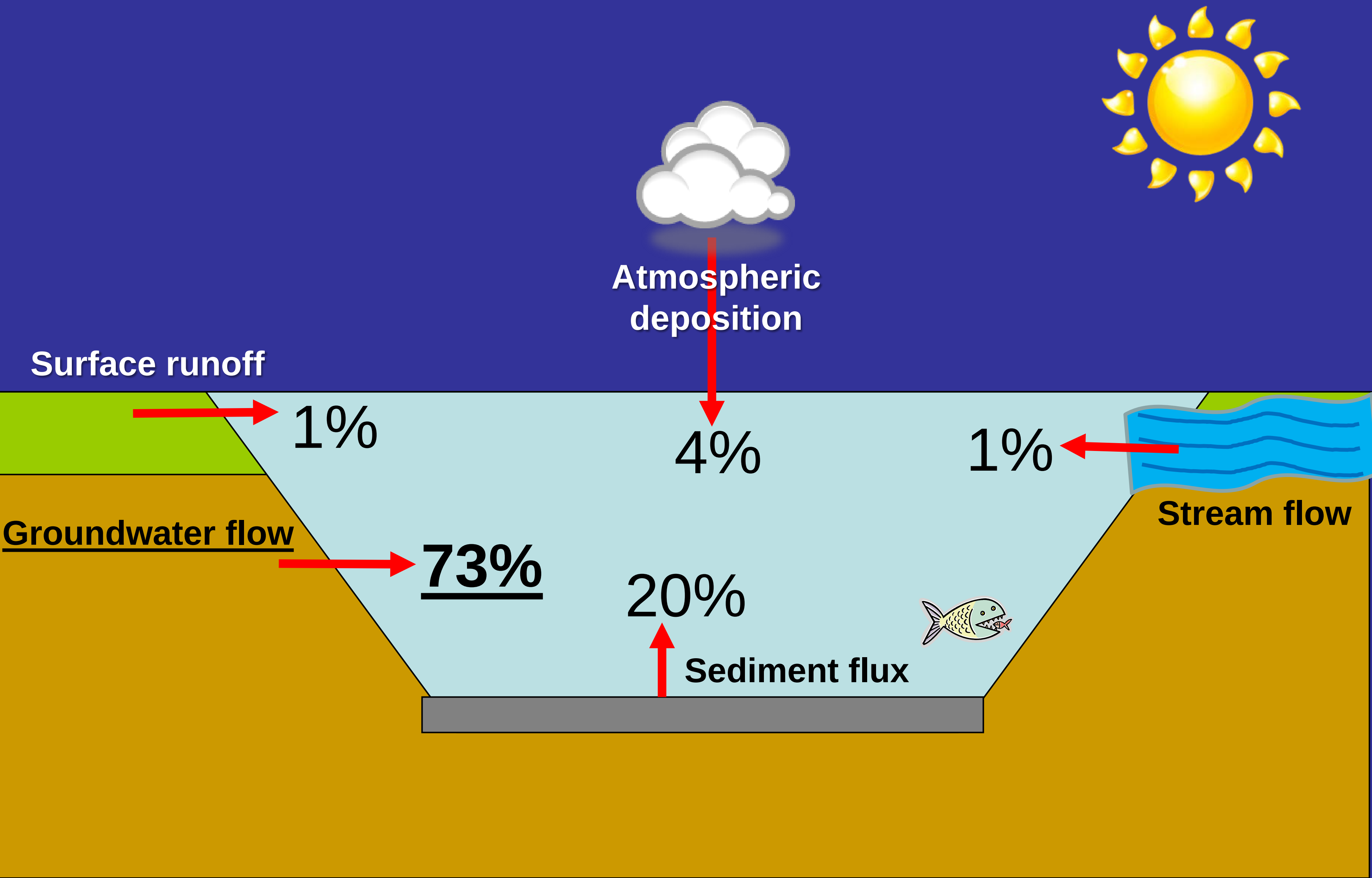


# Volumetric flux model

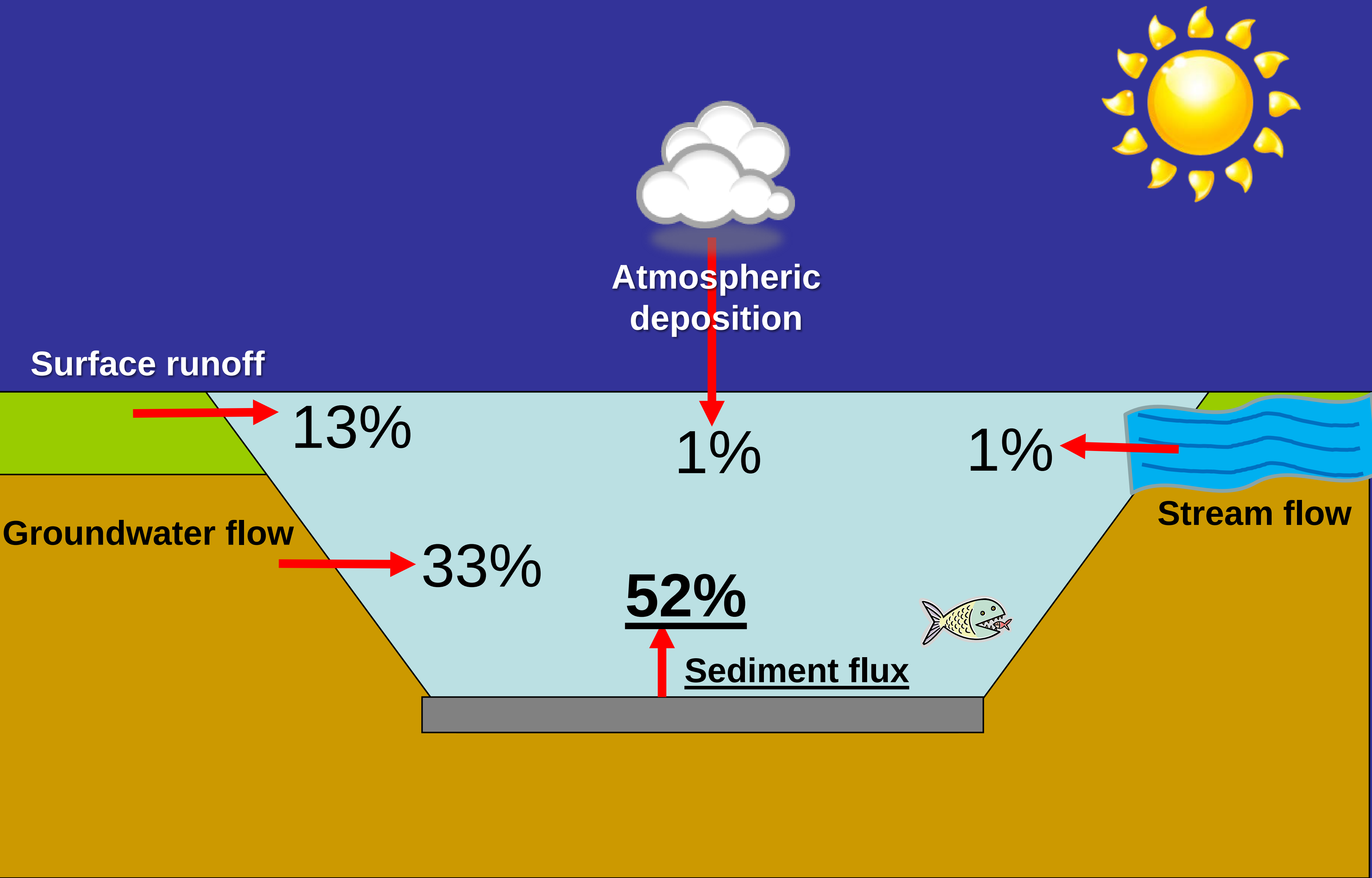
*Quantifies the* ***route of delivery for nutrients***



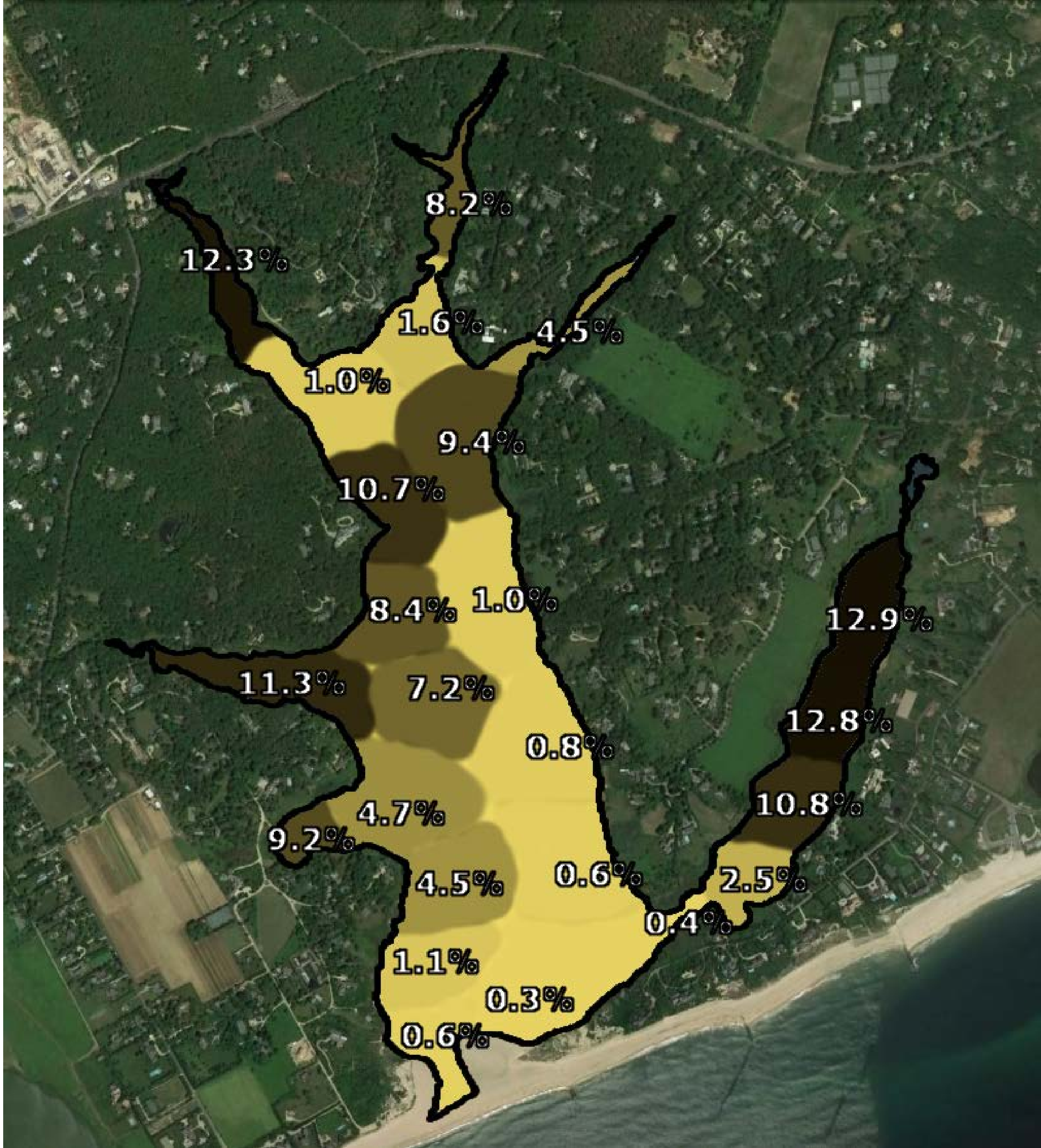
# Volumetric flux model, **nitrogen**



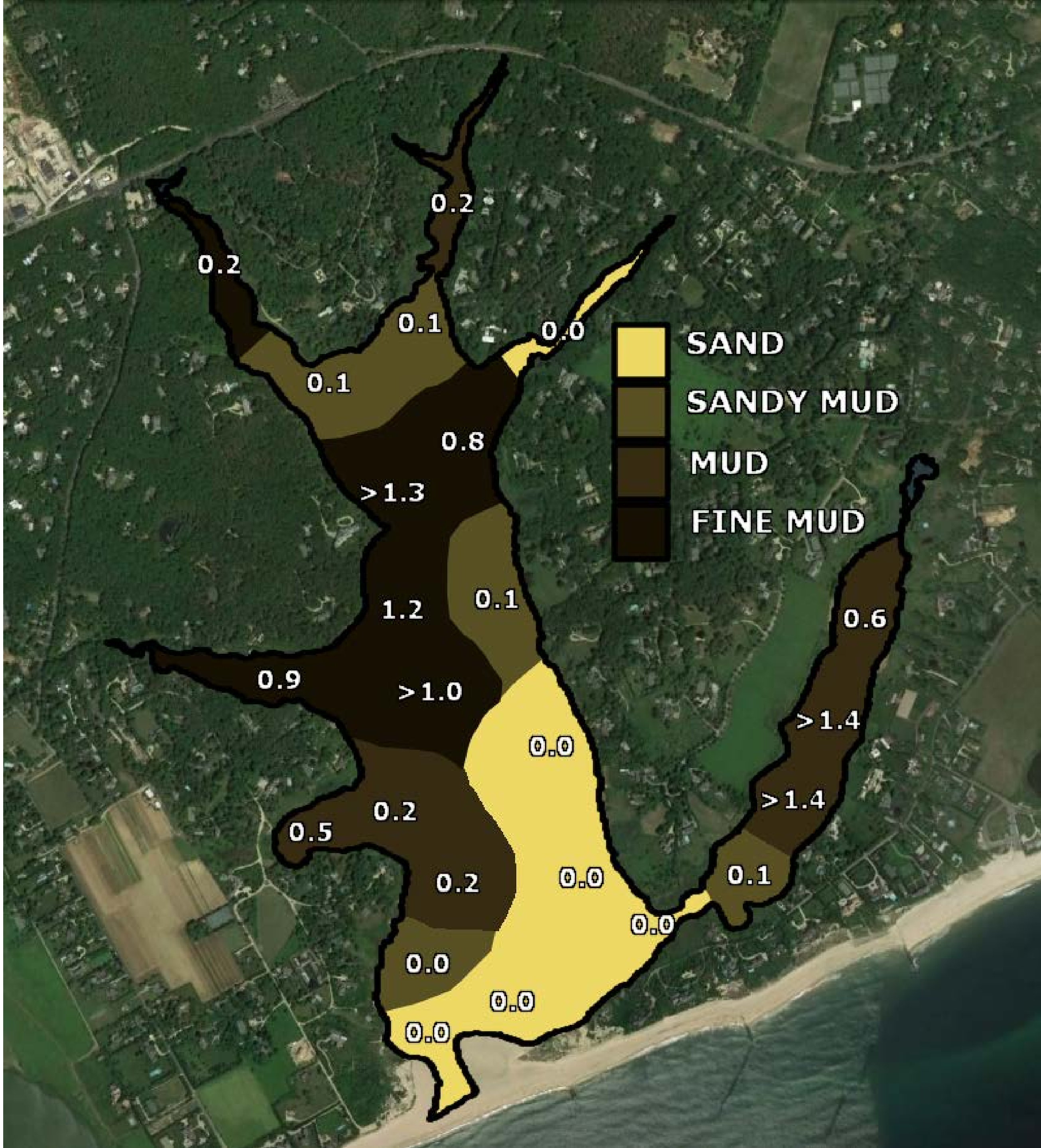
# Volumetric flux model, **phosphorus**



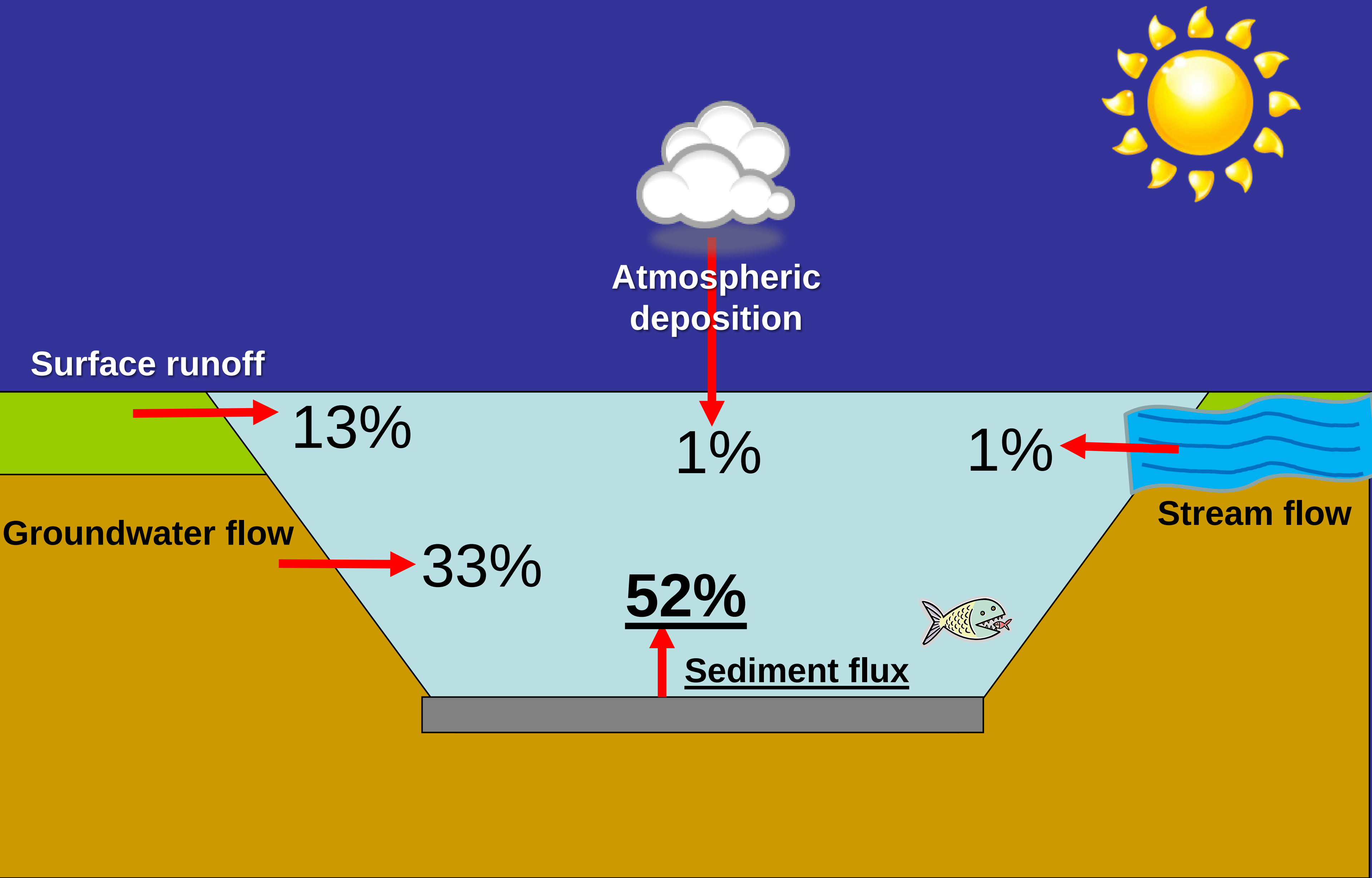
# Organic matter content of sediments, Georgica Pond



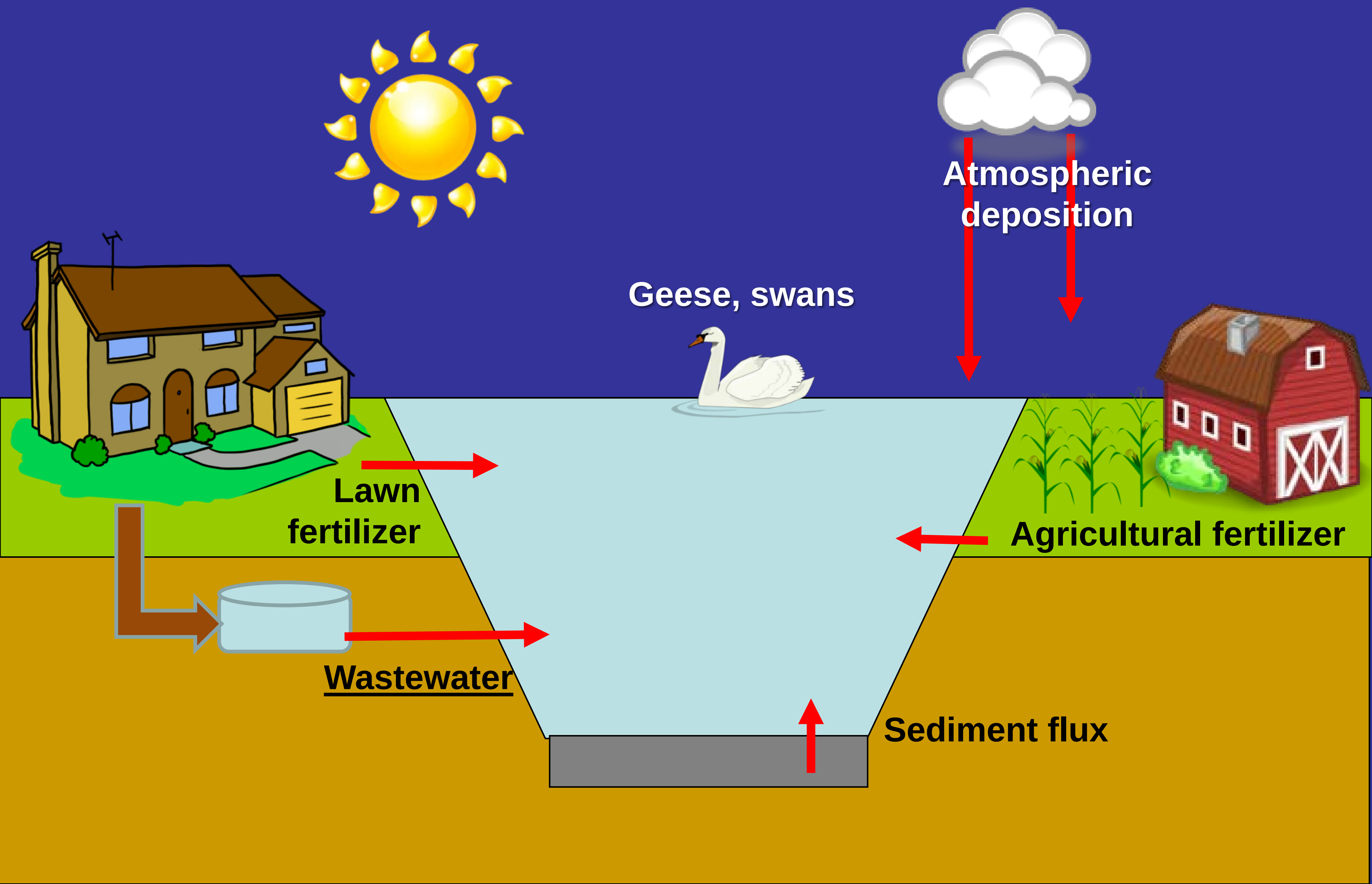
# Sediment type and depth of mud in meters, Georgica Pond



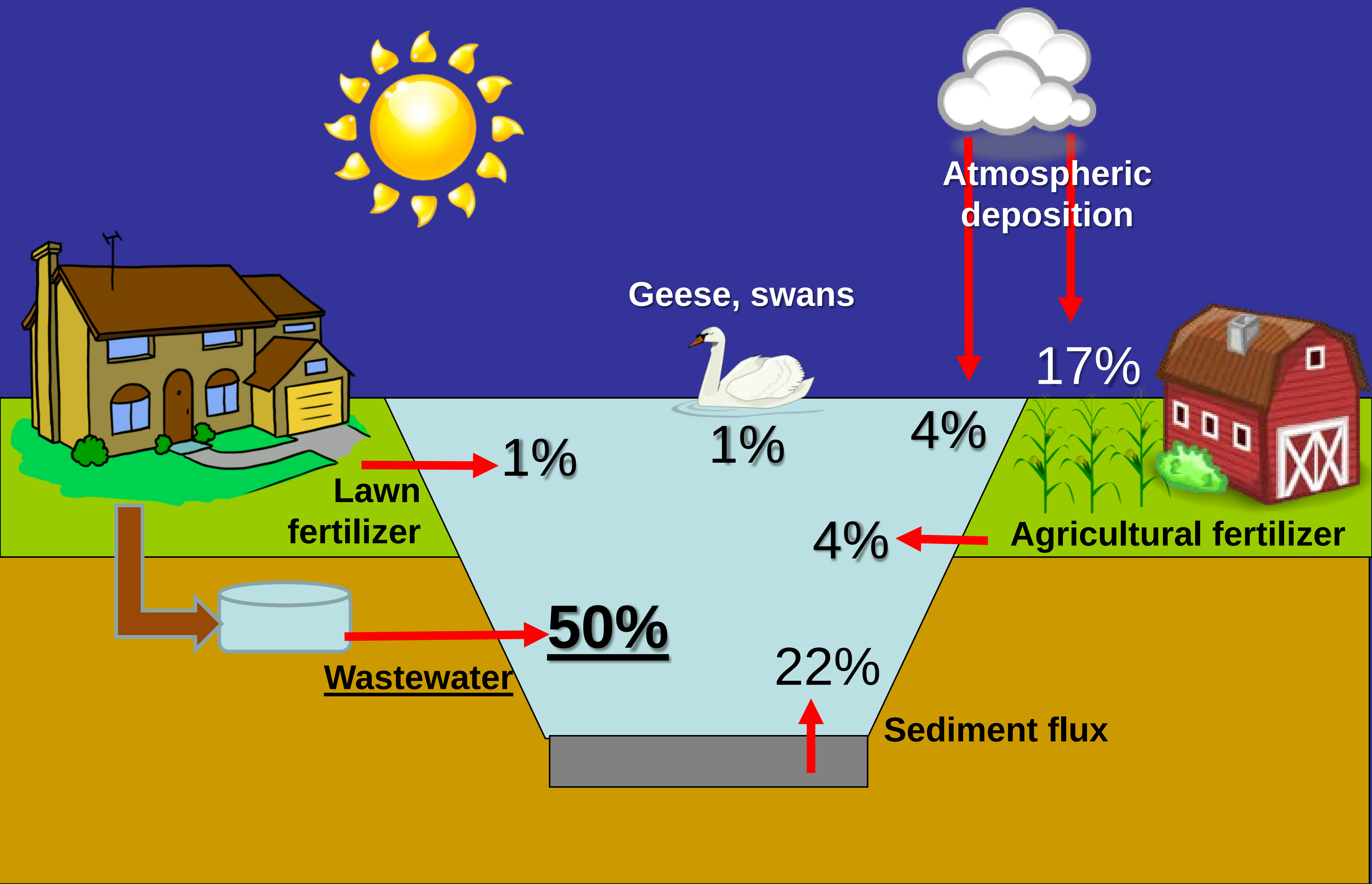
# Volumetric flux model, **phosphorus**



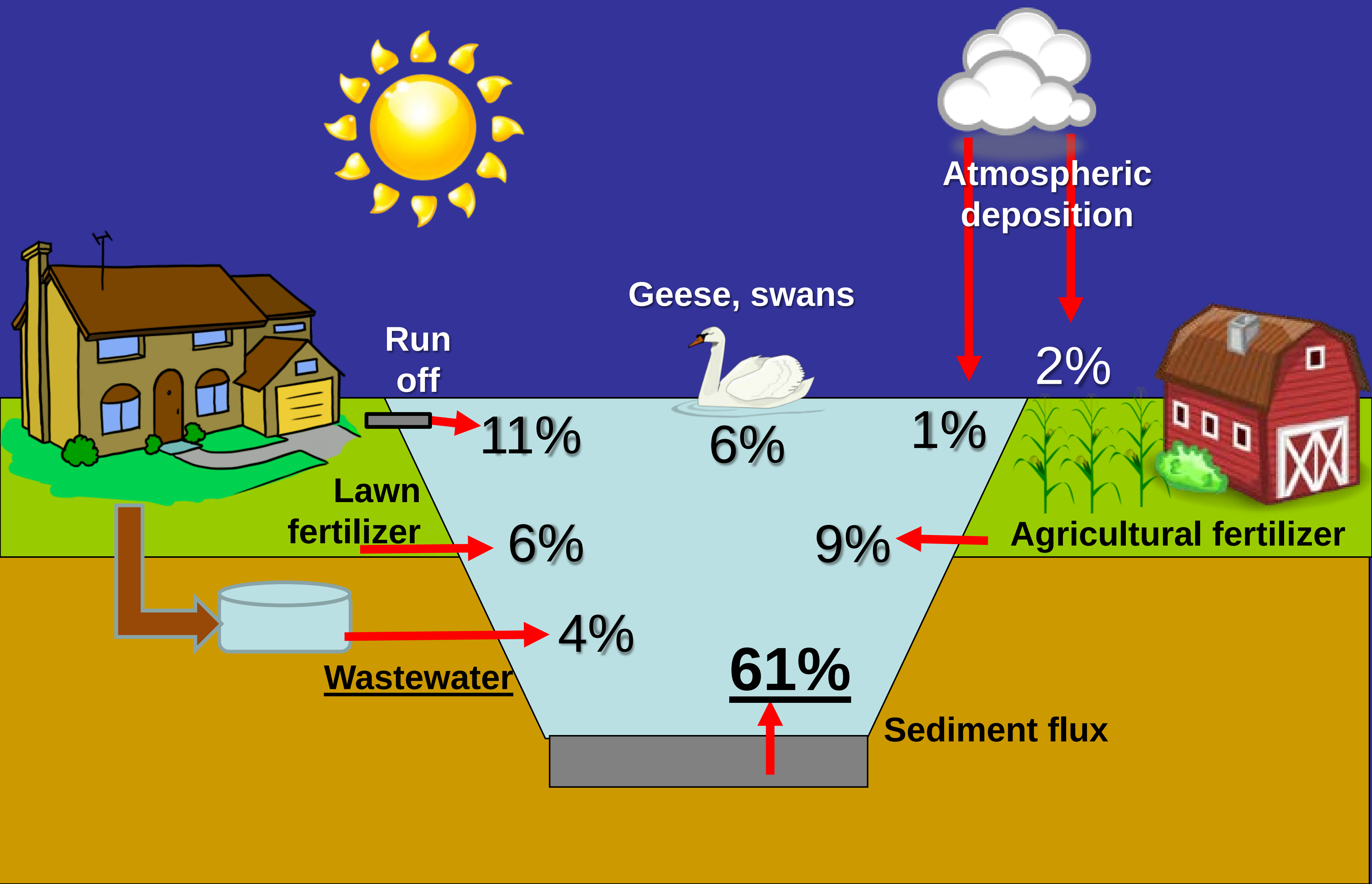
# Independent, hybrid **nitrogen** loading model



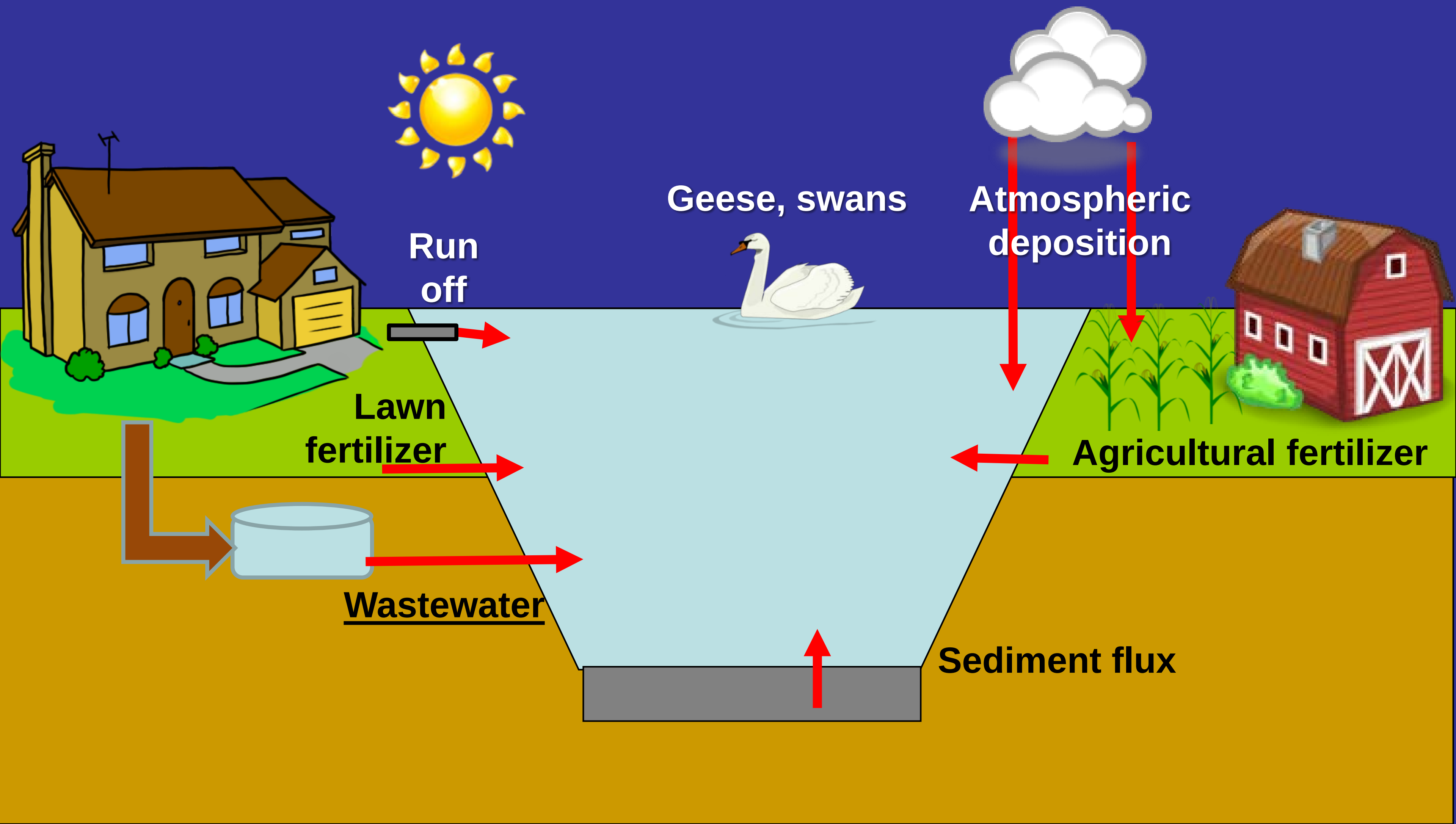
# Independent, hybrid **nitrogen** loading model



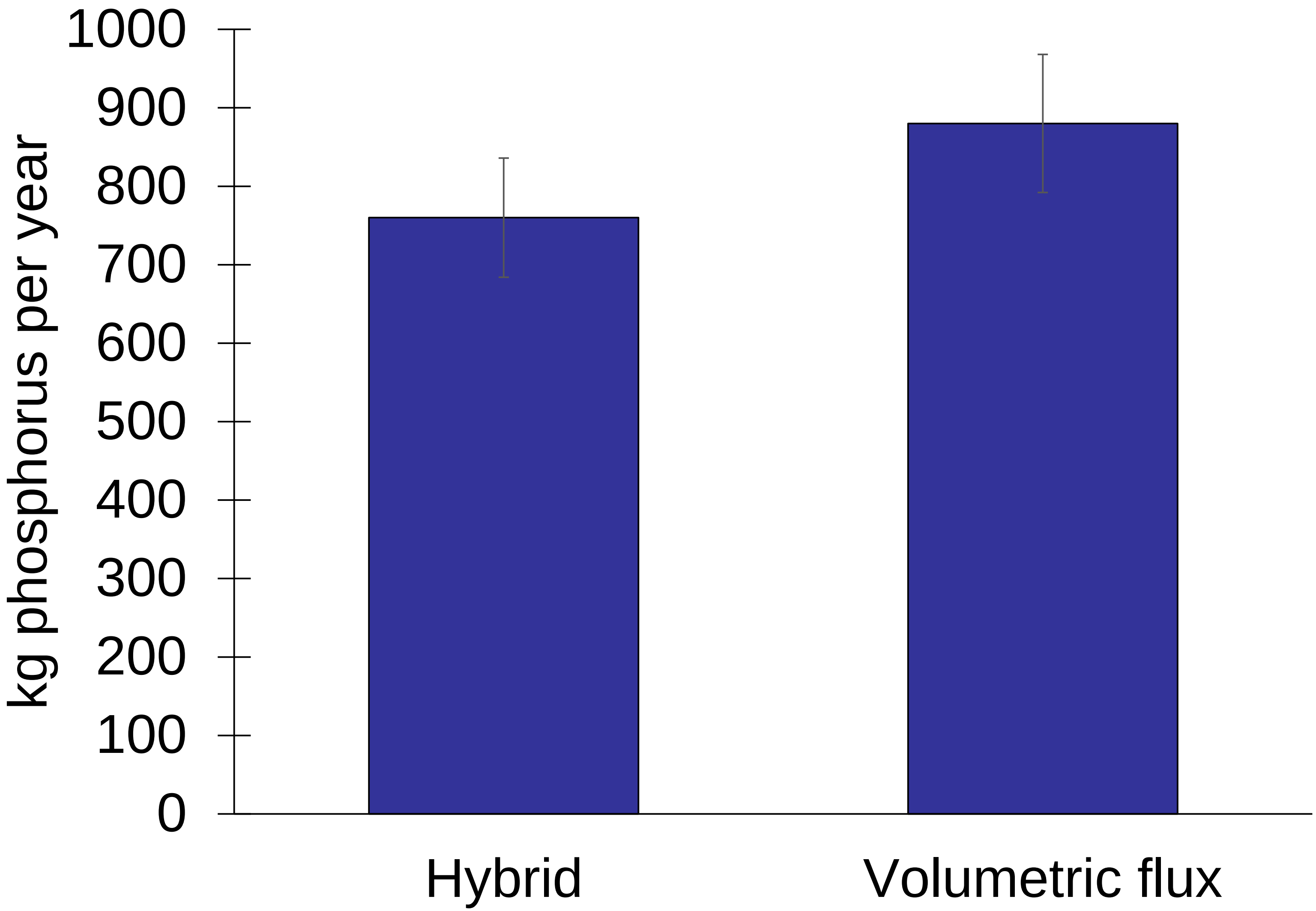
# Independent, hybrid **phosphorus** loading model



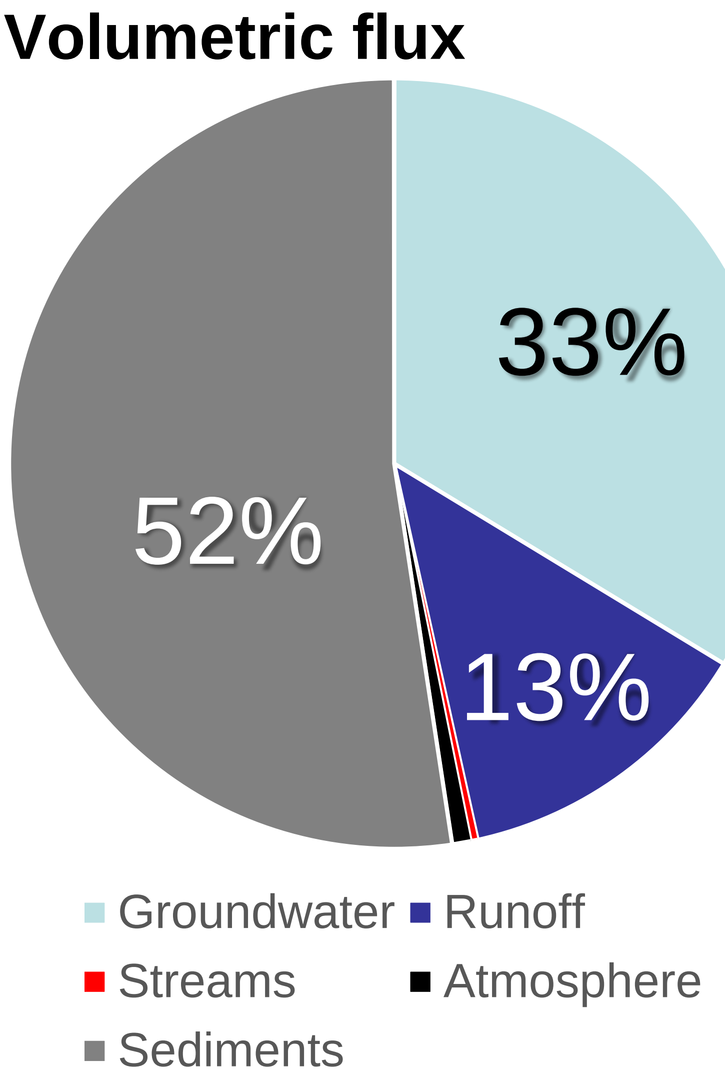
# *How do these independent models compare?*

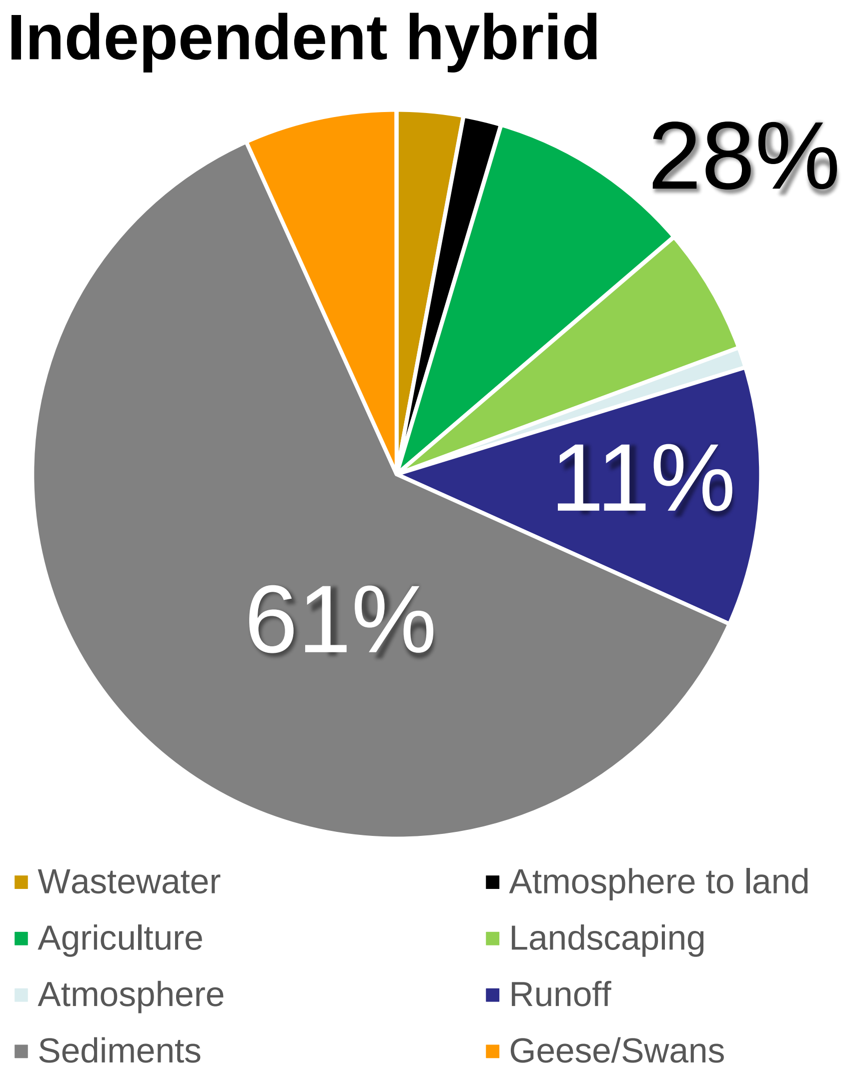


# Phosphorus model comparisons

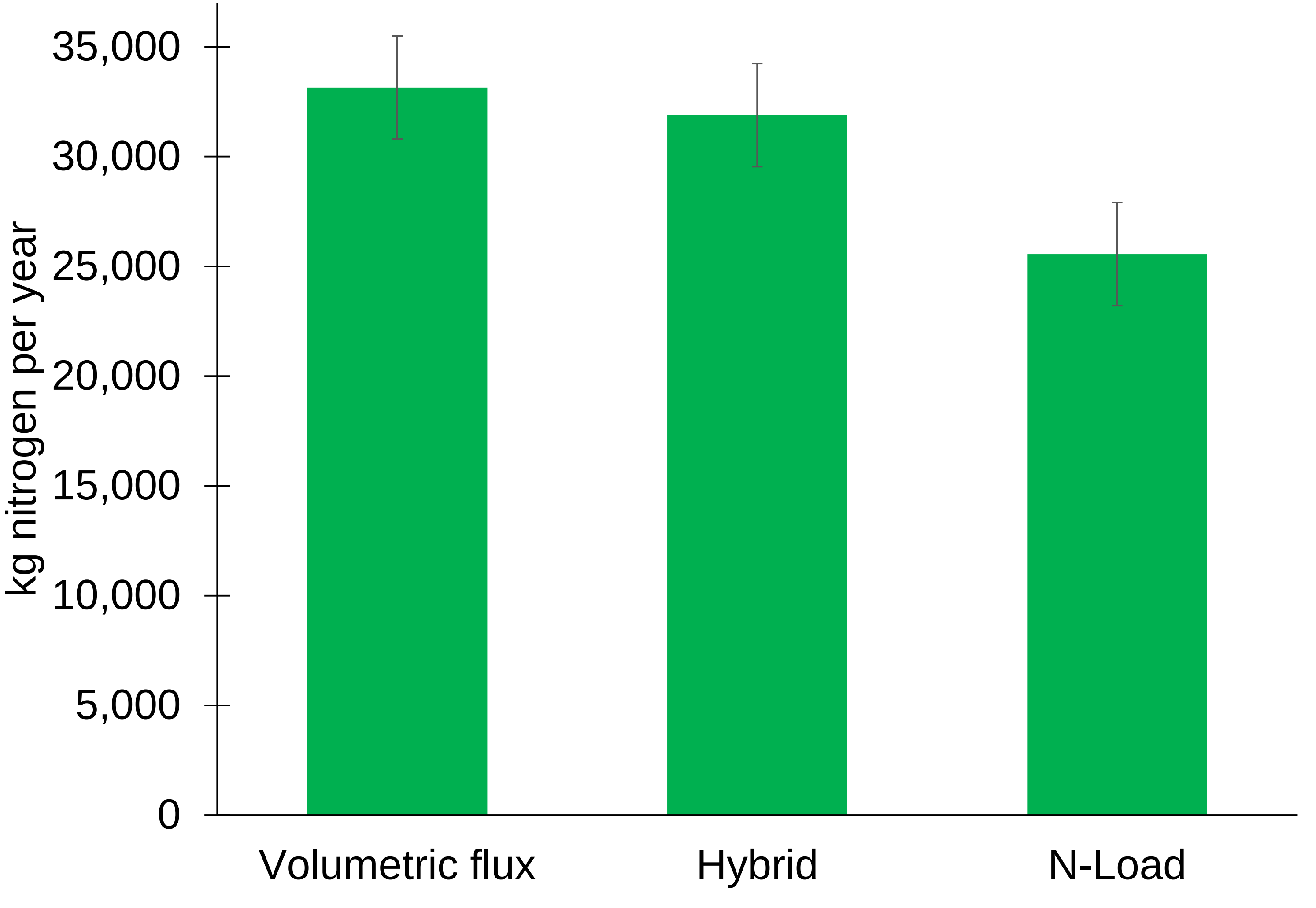


# Phosphorus model comparisons



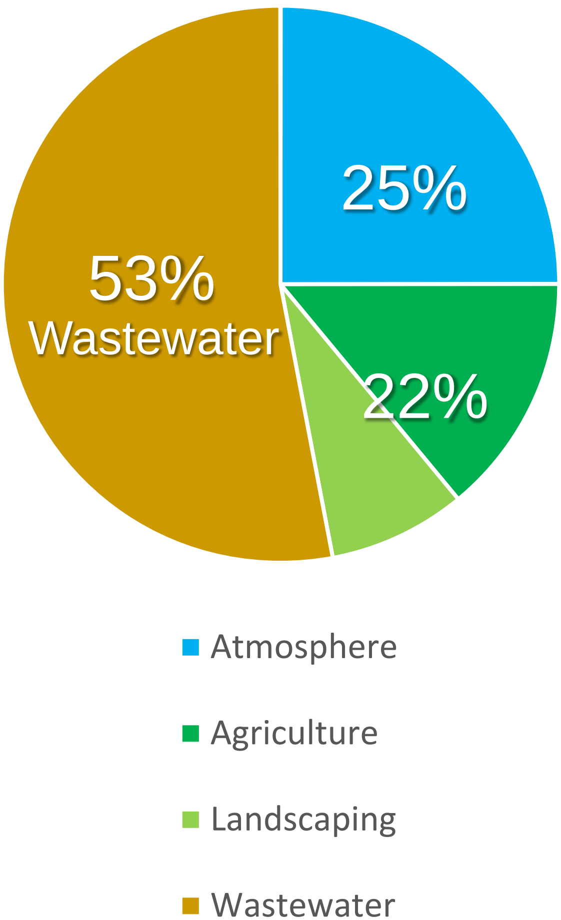
# Nitrogen model comparisons



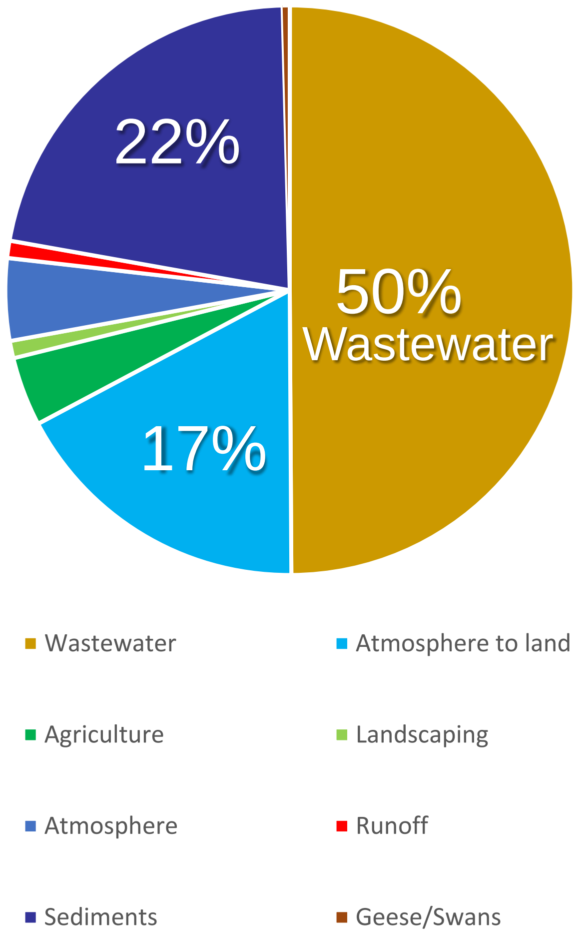
# Comparison of nitrogen models

## *- recall N isotope data says mainly wastewater too*

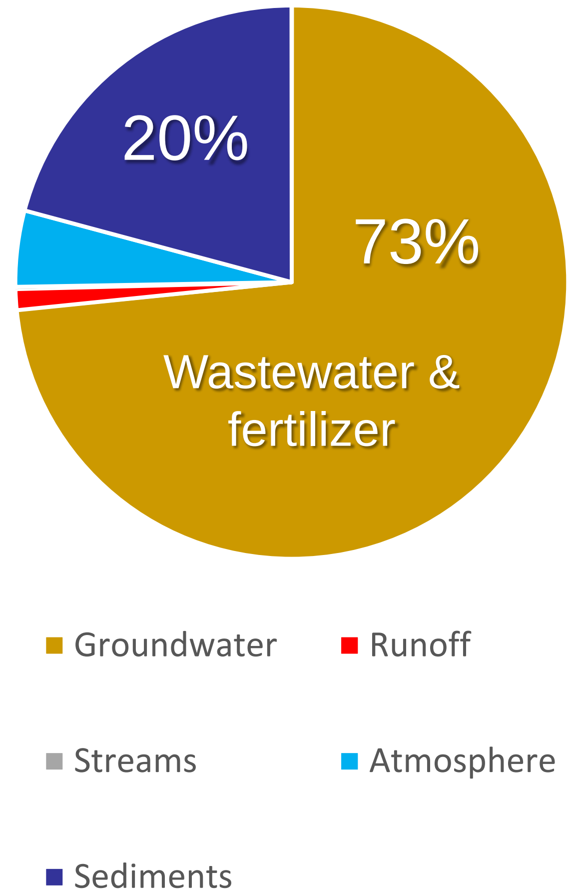
### N-Load model




### Independent hybrid




### Volumetric flux



***We know where the nitrogen and phosphorus is coming from.***

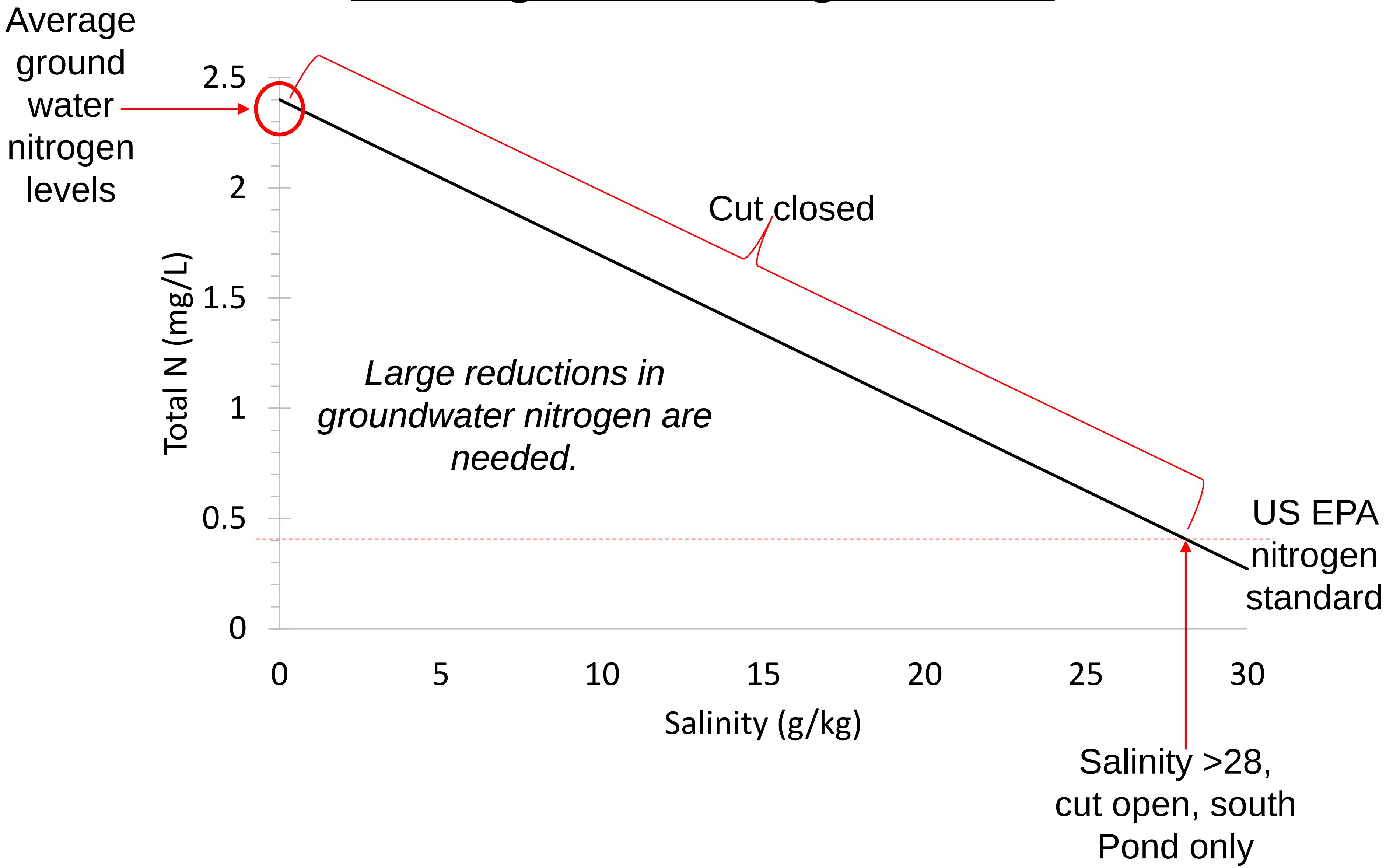
***How much should levels be reduced?***

***<u>Target concentrations (USEPA):</u>***

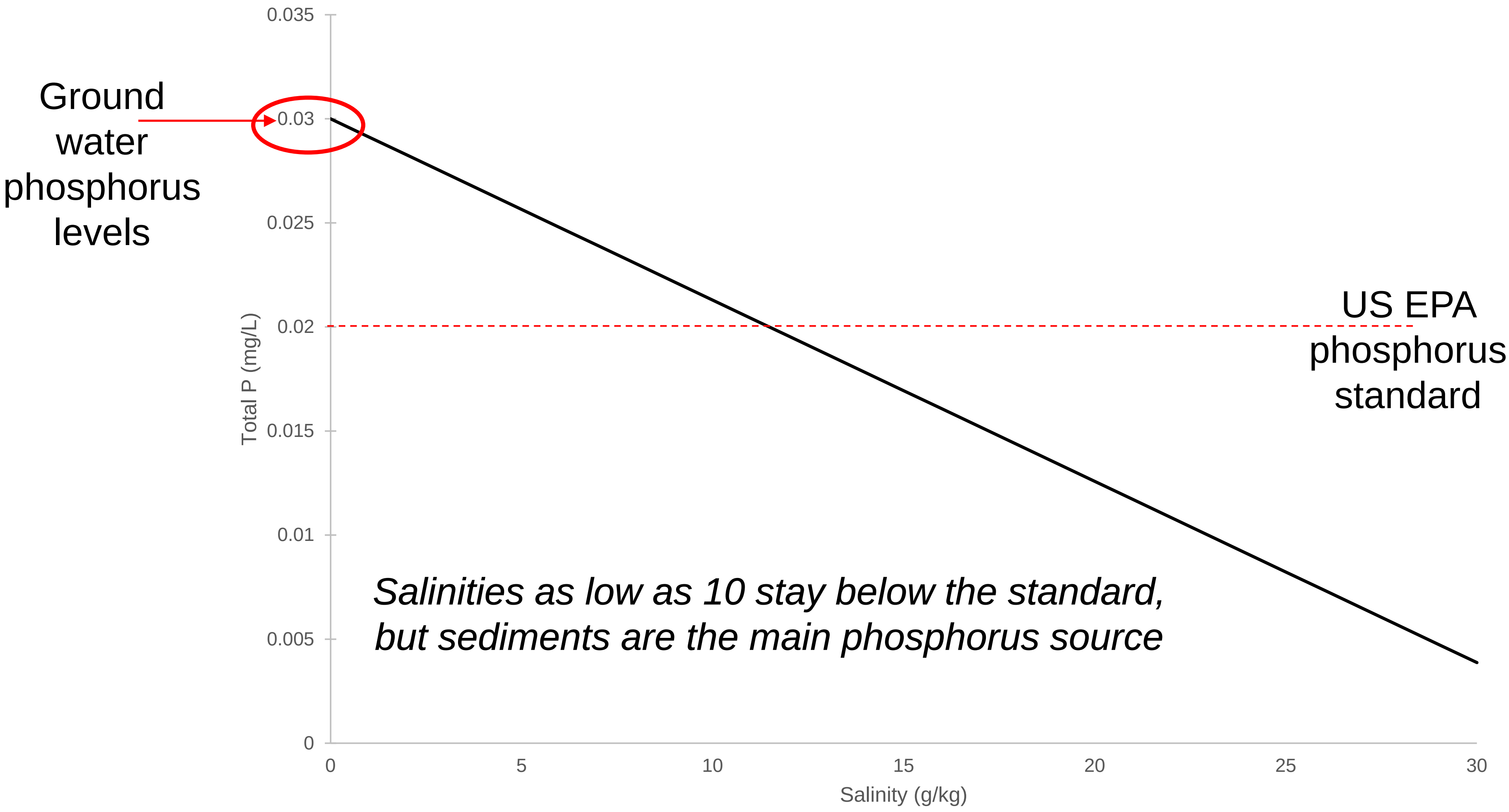
***Total nitrogen = 0.45 mg $L^{-1}$***

***Total phosphorus= 0.02mg $L^{-1}$***

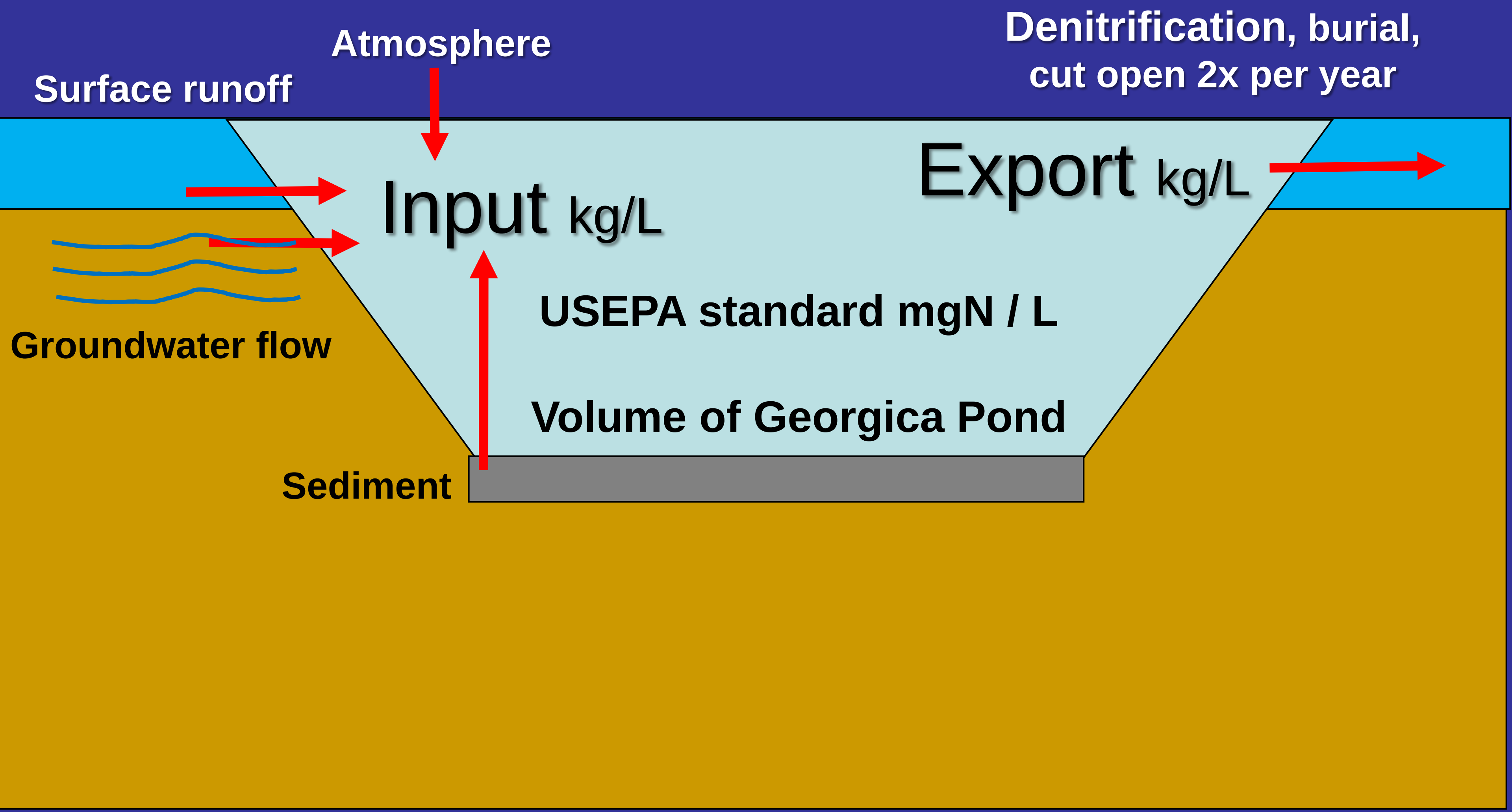
# Nitrogen mixing model



# Phosphorus mixing model



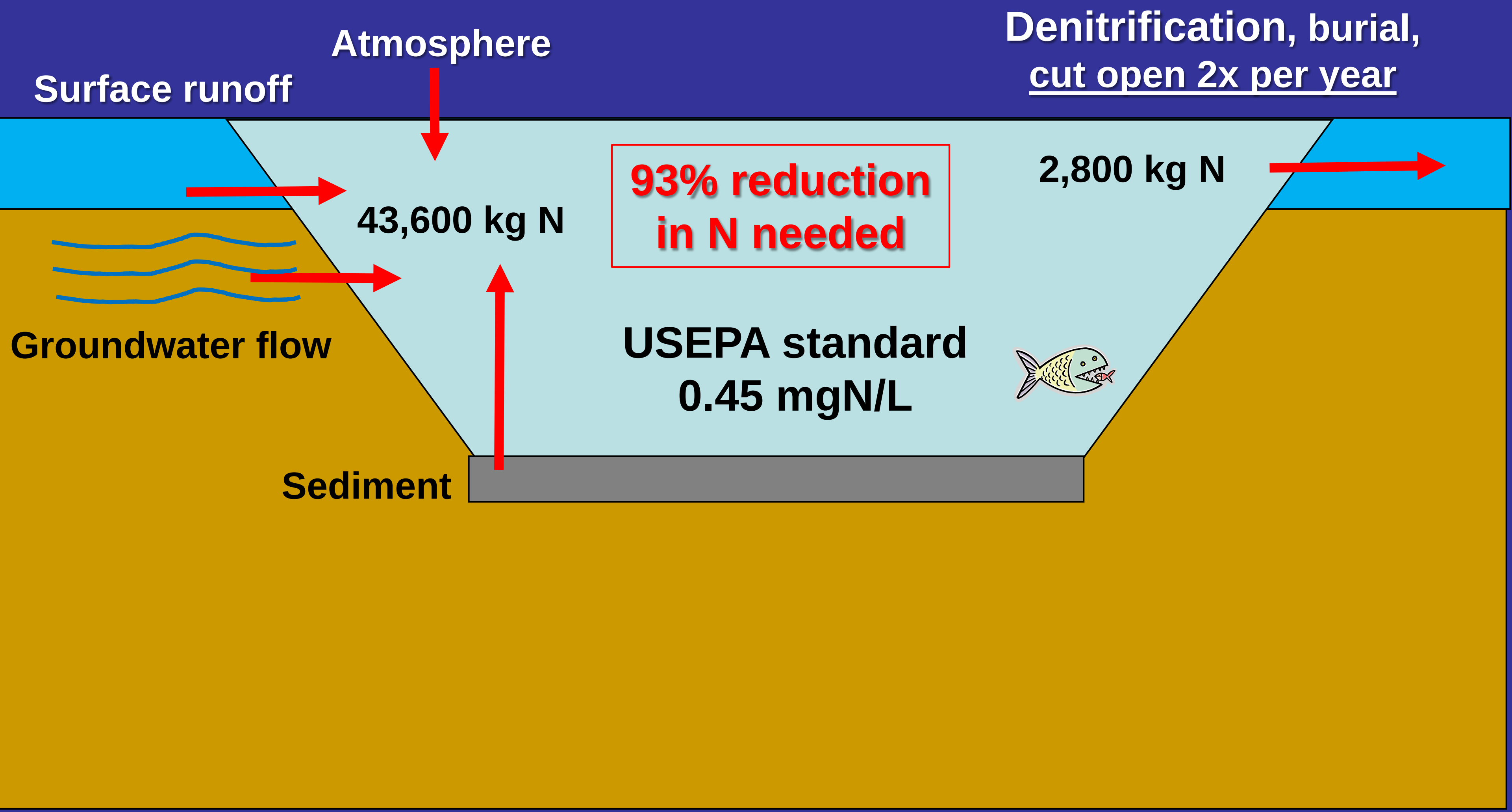
# Total maximum daily load determinations



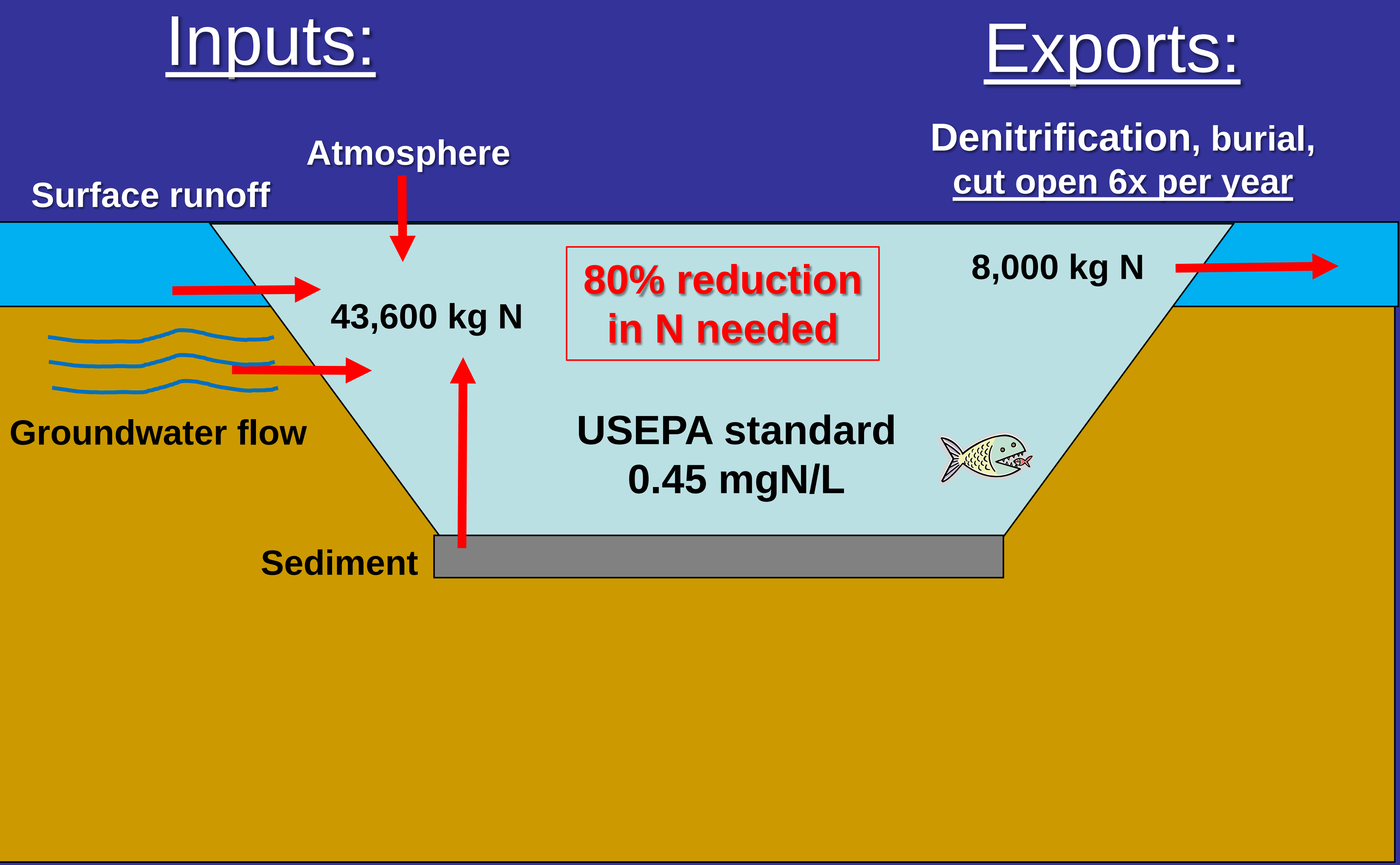
# Total maximum daily load, nitrogen

## Inputs:

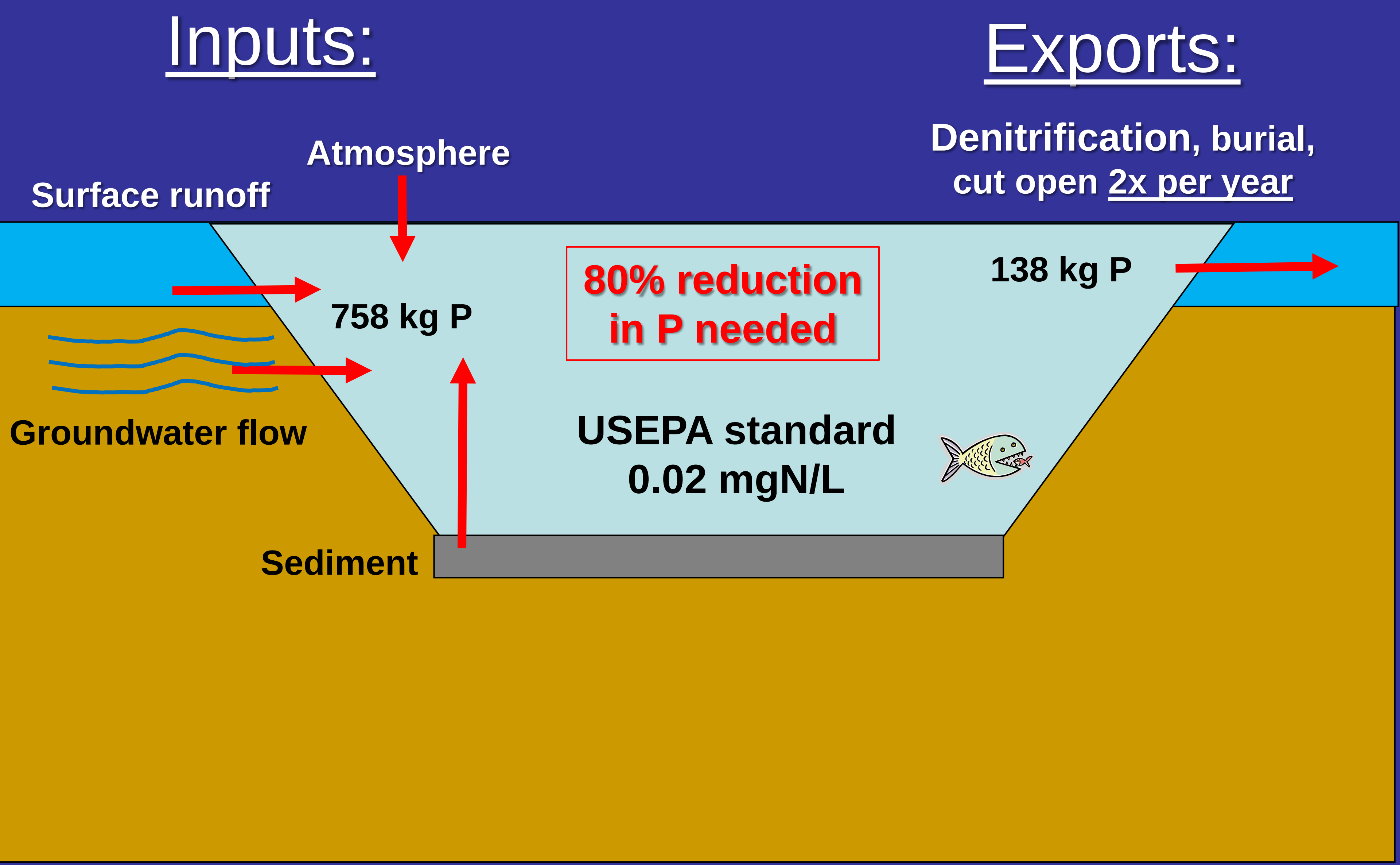
## Exports:



# Total maximum daily load, nitrogen



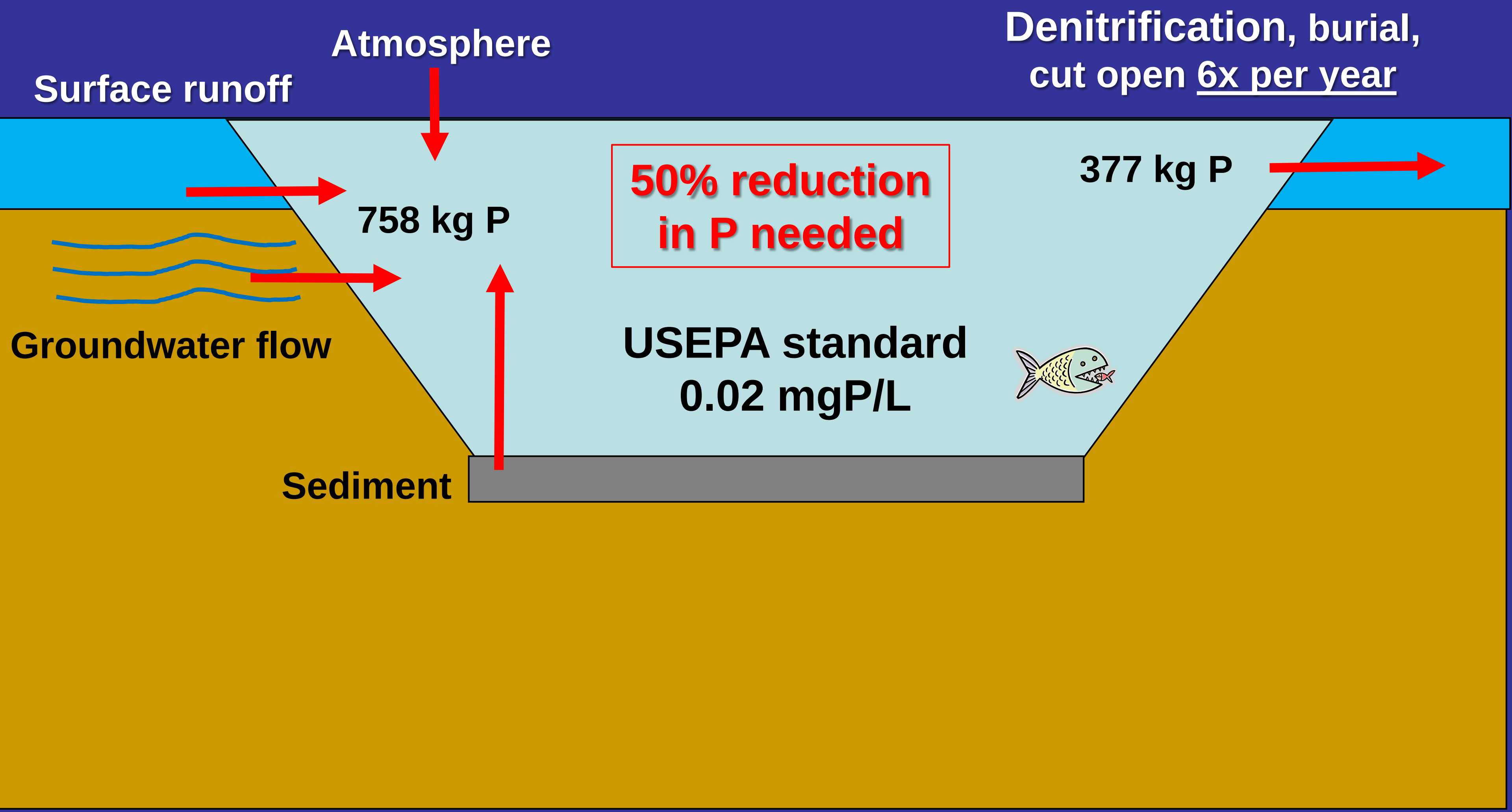
# Total maximum daily load, phosphorus



# Total maximum daily load, phosphorus

## Inputs:

## Exports:



# Nutrient loading summary:

- Sediments are the primary source of phosphorus followed by groundwater and run-off.

- Wastewater delivered via groundwater is the primary source of nitrogen followed by sediments.

- At least 50% and 80% reductions in phosphorus and nitrogen delivery, respectively, are required to reach federal water quality standards.

# Management options

*What can be done to reduce nutrient delivery and mitigate algal blooms in Georgica Pond?*

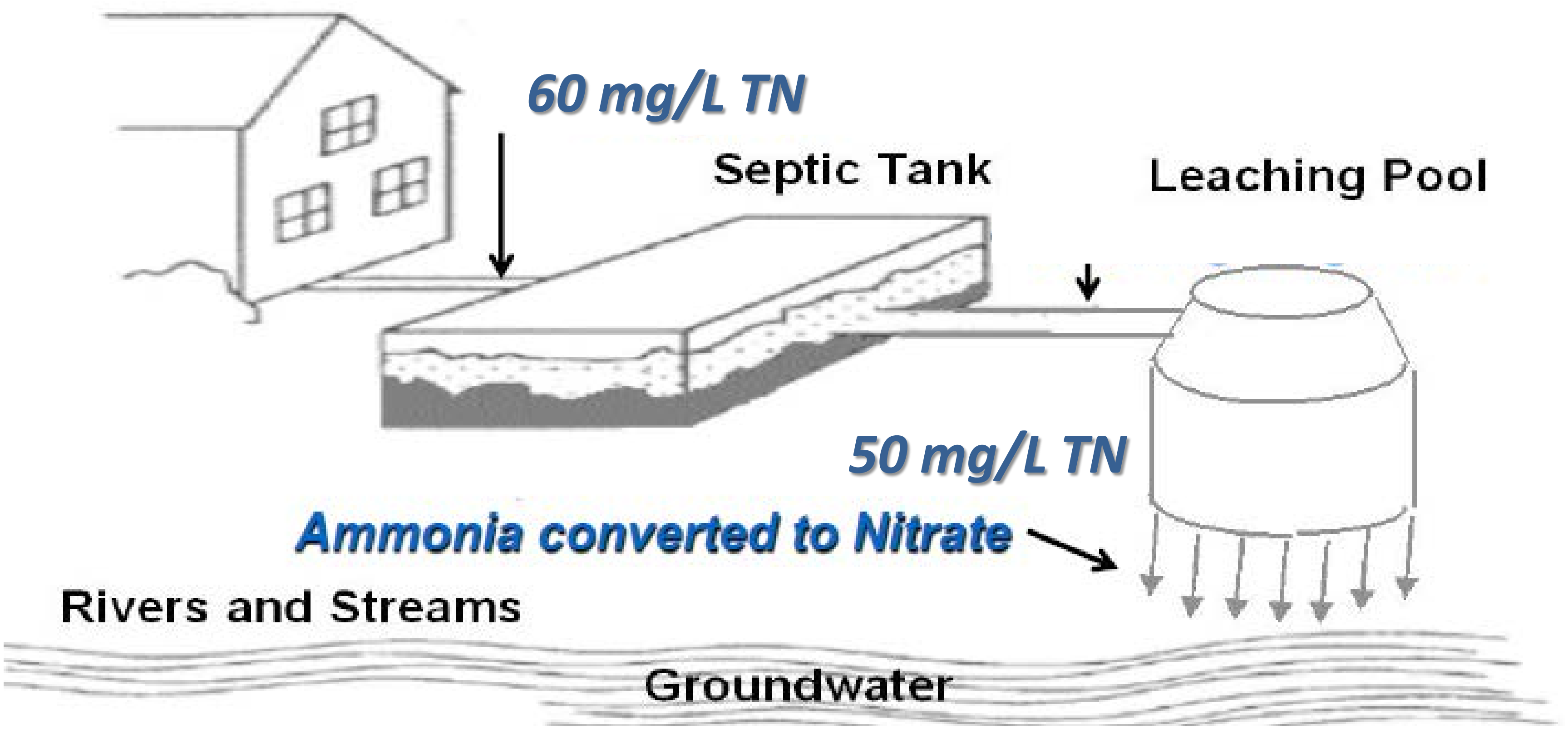
# First step recommendations

- Upgrade septic systems to maximize the removal of nitrogen.
- Minimize fertilizer use; switch to organic fertilizers.
- Create and expand the growth of local and natural vegetation adjacent to Georgica Pond to create buffers that are not fertilized and intercept land runoff.

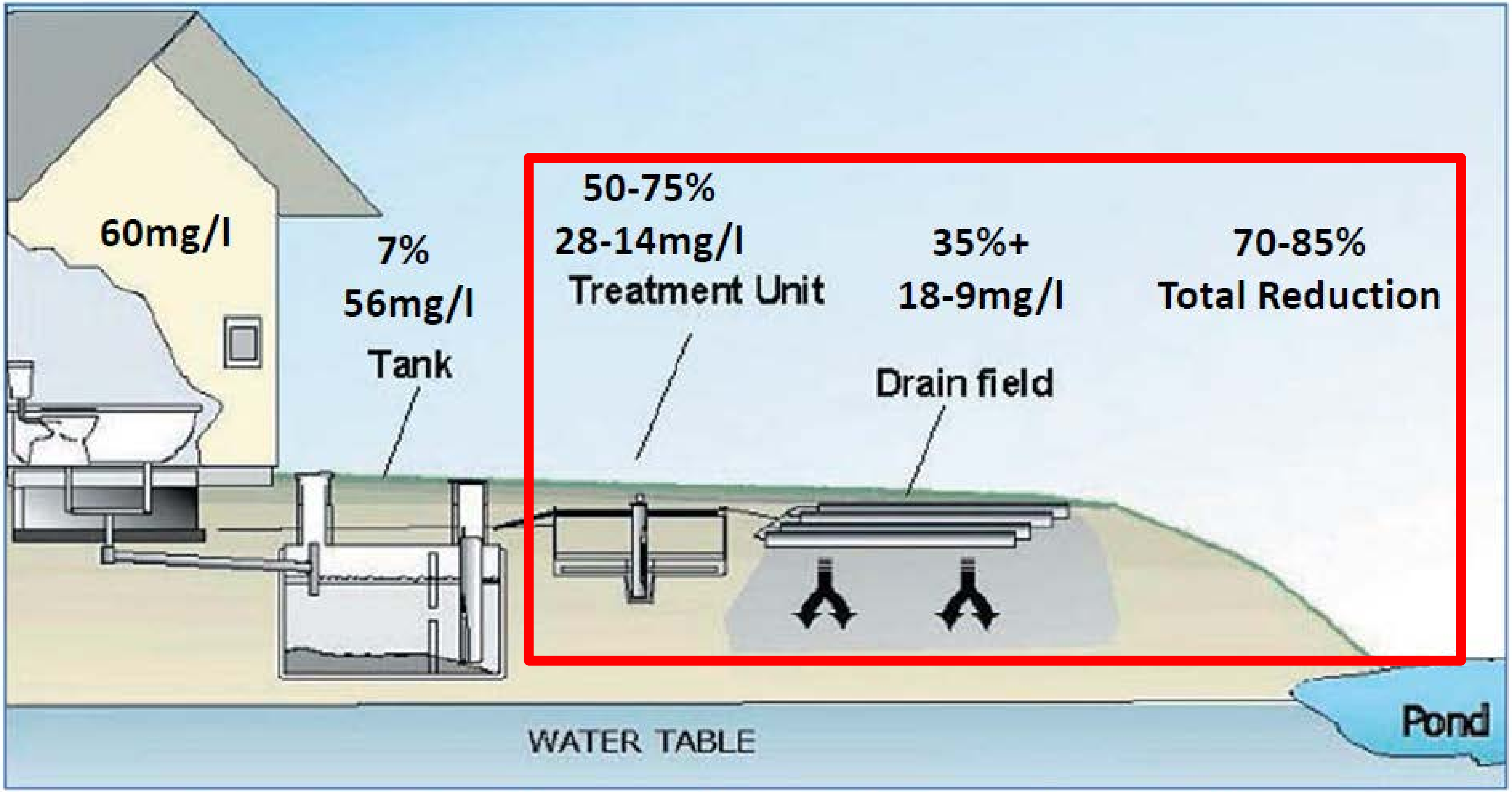
# NYS fertilizer laws

- Application of fertilizer prohibited between December 1st and April 1st .
- Use of phosphorus fertilizer on lawns or non-agricultural turf is restricted to a level of < 0.67.
- Application of any fertilizer on lawns or non-agricultural turf within 20 feet of a water body or on paved surfaces is restricted.

# Standard septic tank and leaching pools



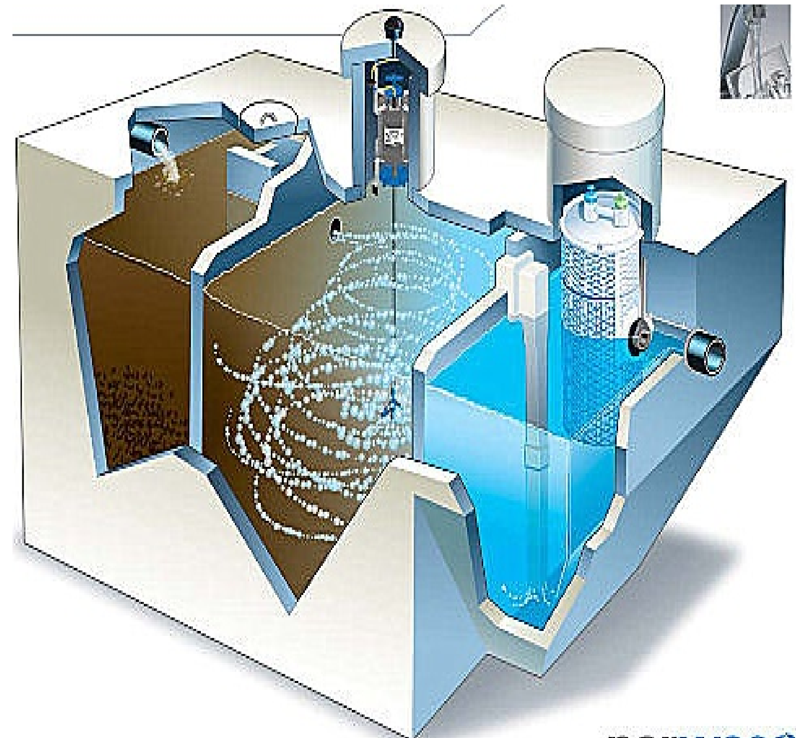
# Alternative waste treatment systems




*Alternative and innovative systems add a component between the septic tank and drainfield.*

# Advanced and innovative on-site septic systems

- Currently available for intermediate flow rates only, not individual homes; should change in 2016.
- Town of Brookhaven, Carmans River law: Intermediate-size sanitary systems can discharge no more than an annual average 3 parts per million of effluent = advanced treatment.
- Addressing wastewater flows are a **critical long-term solution**.



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# Opening the cut on a regular basis

Opening the cut:

- Flushes out nutrients and algal blooms.
- Keeps salinity too high for blue-green algae.
- Restricts the regions covered by macroalgae

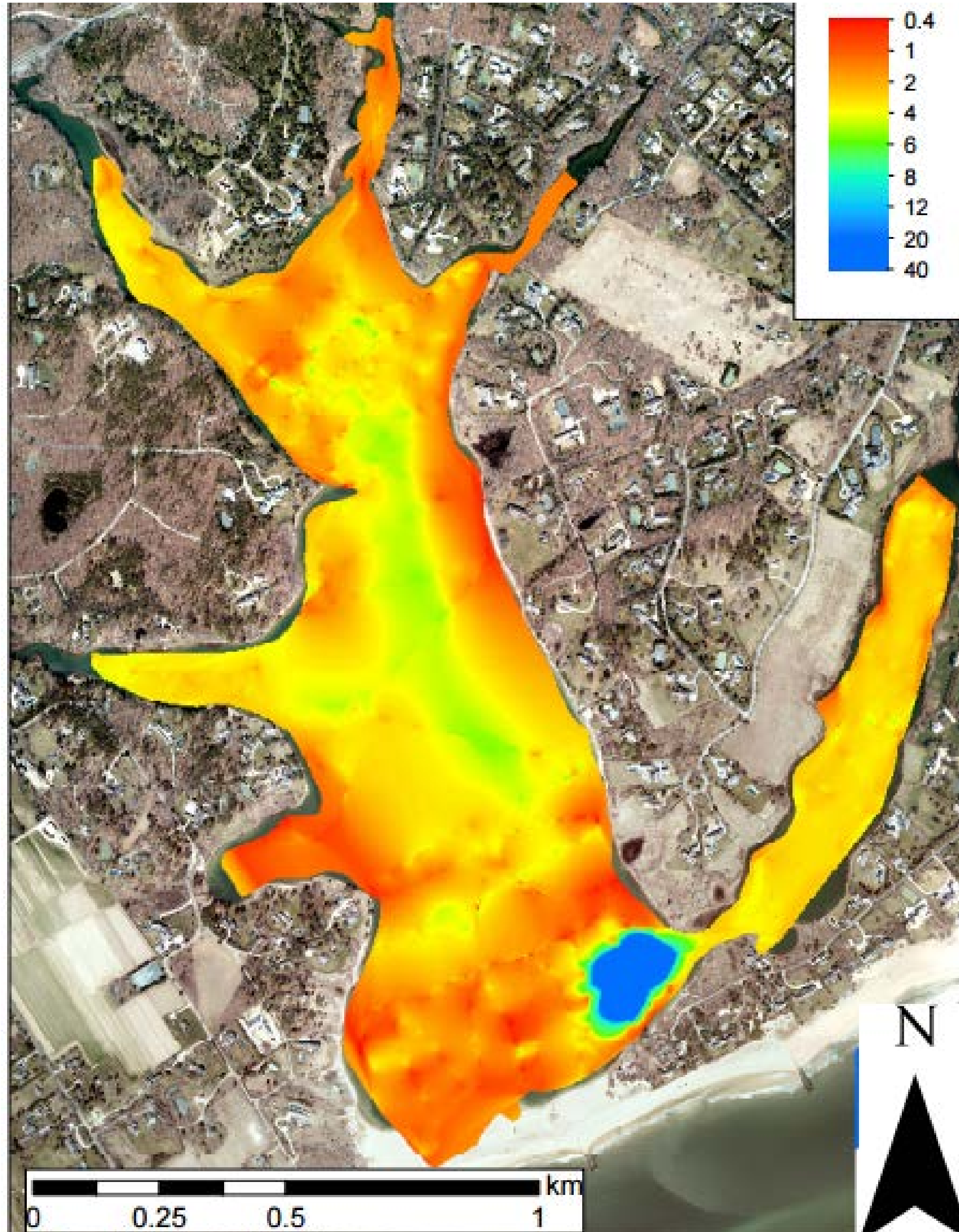
- Being open for > six months reduces the accumulation of nitrogen and phosphorus and reduces the need for other reductions.

# Dredging Georgica Pond

- Removal of the thick layer of mud across parts of the Pond could eliminate 50% of the phosphorus and 20% of the nitrogen fueling algal blooms.
- A greater depth within the Pond would provide more dilution of nutrients and could lower water temperatures.

- Deepening the passage from Georgica Cove to the Pond will allow the Cove to exchange with the Pond.
- Dredging the bar along the north end of the pond will permit better exchange to the south.

# Bathymetry or water depth of Georgica Pond

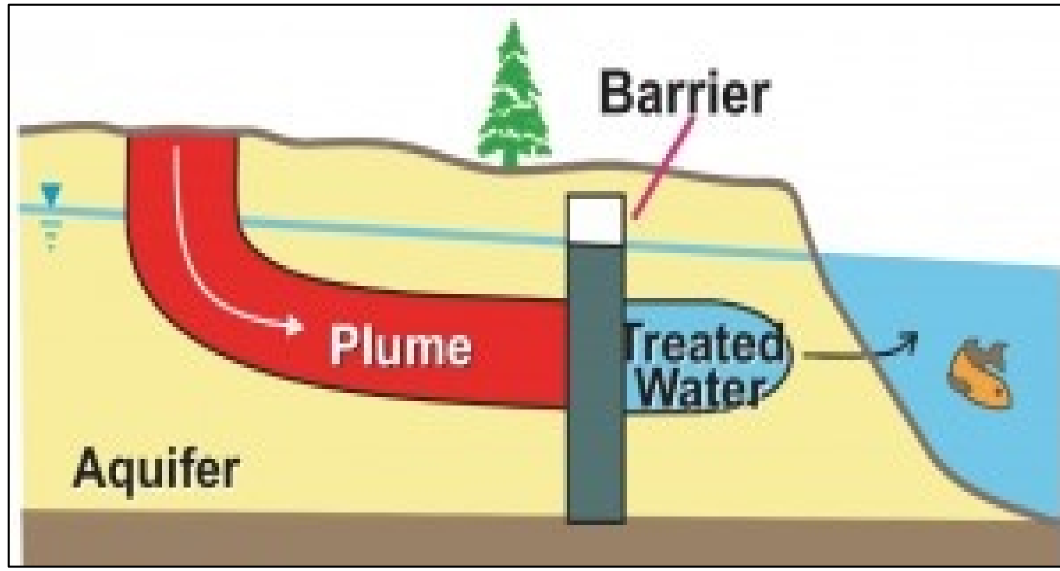


# Harvesting macroalgae to mitigate nitrogen and phosphorus

- Preliminary analyses indicate macroalgae contain **3%** nitrogen and **0.2%** phosphorus.
- Algae re-grow weekly (good).
- Weekly removal of macroalgae during summer months would represent a significant removal of nutrients.
- Preliminary discussions with NYSDEC Marine Habitat Section Head have been positive; a path forward for 2016 has been established.

# Permeable reactive barriers (PRB) to remove nitrogen, phosphorus

- PBR can remove N (and perhaps P) from groundwater before it enters Georgica Pond.
- Targeted placement of PBR could alleviate serve nitrogen loading in region with heavy loads, poor flushing, or both.




- May be most effective at the headwaters of streams and/or coves where groundwater discharge is concentrated.
- Georgica Cove is small, but receives 16% of the total nitrogen delivery to the Pond and thus may be a good PBR candidate.

# Storm drain, Georgica Cove

- The storm drain within Georgica Cove was cited in a prior NYSDEC study as a strong source of pathogens.
- The drain is not a large source of phosphorus and nitrogen.

- A constructed wetland could intercept pathogens and slightly reduce the delivery of nutrients.

# East Hampton Town Comprehensive Wastewater Management Plan recommendations for Georgica Pond:

1. Enforce NYS law regarding fertilizer applications near water bodies **(Covered)**. ✓
2. Groundwater modeling and sampling to determine groundwater flow patterns and existing groundwater quality **(THIS STUDY).** ✓
3. Demonstration project of the use of the Permeable Reactive Barrier for nitrogen and phosphorus removal **(Covered)**. ✓

# Conclusions:

- Georgica Pond suffers from algal blooms, blue-green algae, low oxygen, and fish kills.
- These events are promoted by excessive nitrogen and phosphorus.
- Most of the nitrogen (N) entering Georgica Pond comes from wastewater and sediments.
- Most of the phosphorus (P) Georgica Pond comes from sediments.
- 80% and 90% reductions in P and N are needed to achieve federal water quality standards; 50 and 80% if the Cut is opened for much of the year.
- Frequent opening of the cut also mitigates microalgae blooms and prevents blue-green algal blooms.
- Harvesting macroalgae will remove significant amounts of N and P while improving aesthetics during summer.
- Dredging muds will remove nutrients and improve water circulation in the Pond.
- Permeable reactive barriers can help mitigate point sources high nitrogen groundwater before it enters the Pond in targeted locations.
- Responsible fertilizer use is required by farms and homeowners.
- Improving the removal of nitrogen and phosphorus from wastewater is the central long term solution.

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Thank you for your attention.

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