Nutrient Loading in the Owasco Watershed

Federation of Lake Associations Annual Conference – Lake George

April 30, 2022

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Hobart & William Smith Colleges

Owasco Lake looking South

2017, Owasco Outlet, Emerson Park, Owasco Lake

2017, NE Corner, Owasco Lake

Background: 2005 Water Quality & Its Protection

Finger Lake Water Quality

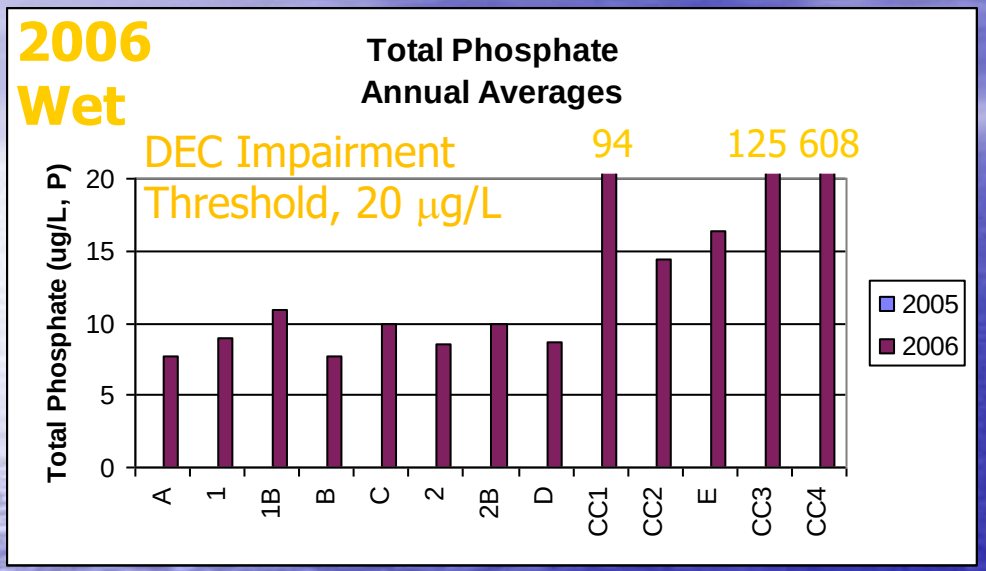
Water Quality Protection Legislation
Worst
Best
Bacteria (Total Coliform & E. coli)
Algae (Chlorophyll-a)
Nutrients (Phosphates, Nitrates)
Suspended Sediments (TSS)
Water Clarity (Secchi disk)
Best
Water Quality
Worst

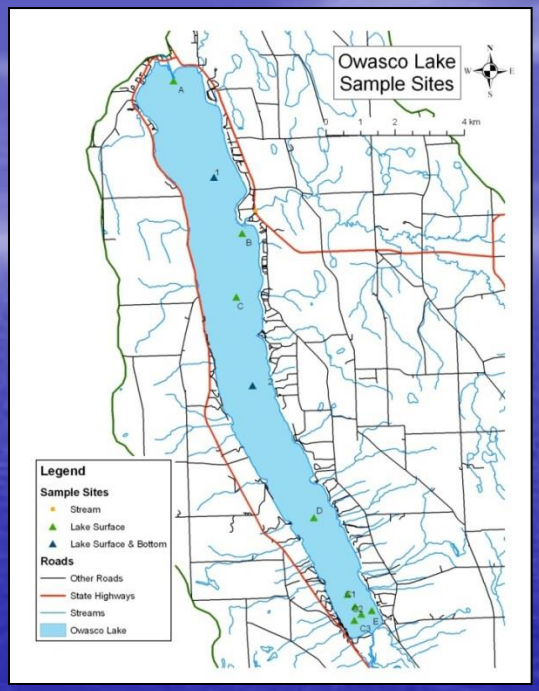
- Honeoye
- Canandaigua
- Keuka
- Seneca
- Cayuga
- Owasco
- Skaneateles

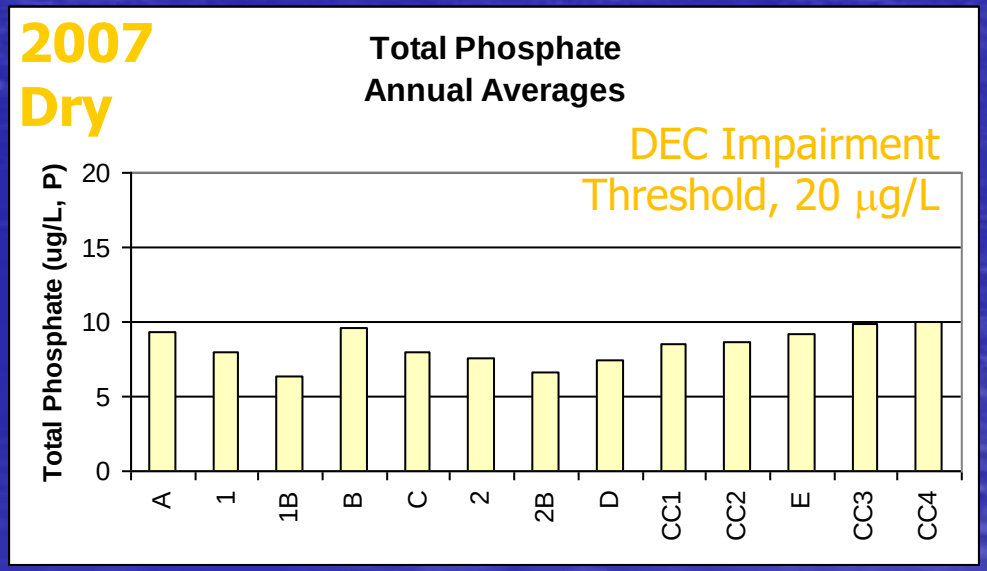
Bush, 2006, Undergraduate Honors Thesis

Owasco Lake Total Phosphates

2006 Fred L. Emerson Foundation Funds
2007 NYS Funds – Senator Nozzolio







Impact?

Nutrient Cycle

Streams, Rain

Figure 21–4 Selected phytoplankton. (1) cyanobacterium cluster: *Anabaena flos-aquae*, (2) dinoflagellate: *Ceratium hirundinella*, (3) cyanobacterium colony: *Microcystis flos-aquae*, (4) green algae colony: *Scenedesmus quadricauda*, (5) dinoflagellate: *Gymnodinium helveticum*, (6) diatom: *Asterionella formosa*, (7) chrysophyte: *Chrysococcus rufescens*, (8) filamentous diatom: *Aulacoseira islandica*, (9) chrysophyte *ivergens*, (10) cryptomonad: *Cryptomonas* alga (desmid): *Pediastrum boryanum*, (12) *nonas caudata*. Not to scale.

Dissolved Nutrients

Plankton

Outlet

Fish (Lake Trout)
&
Other Organisms

Bacterial Decomposition

Dead Organic Matter

Sediments

Human Impact: Nutrient Cycle

Agricultural Fertilizers
Animal Feedlots
Wastewater Nutrients
On-Site Systems

Streams, Rain

Dissolved Nutrients

Plankton

Algae Scum
Macrophytes
Cyanobacteria

Outlet

Eutrophication
Anoxia?
Rotten Egg Smell

Bacterial Decomposition

Zebra/Quagga Mussel Impact

Fish (Lake Trout) & Other Organisms

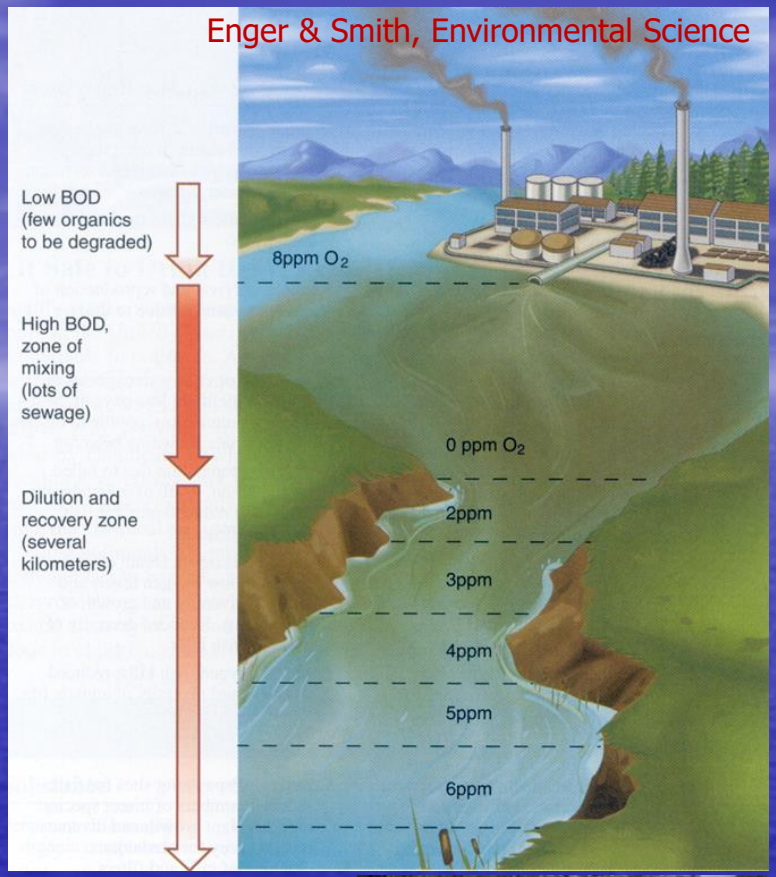
Dead Organic Matter

CAFO, Human & Soil Particulate Organic Matter

Sediments

Nutrient Loading: Hunt for Sources

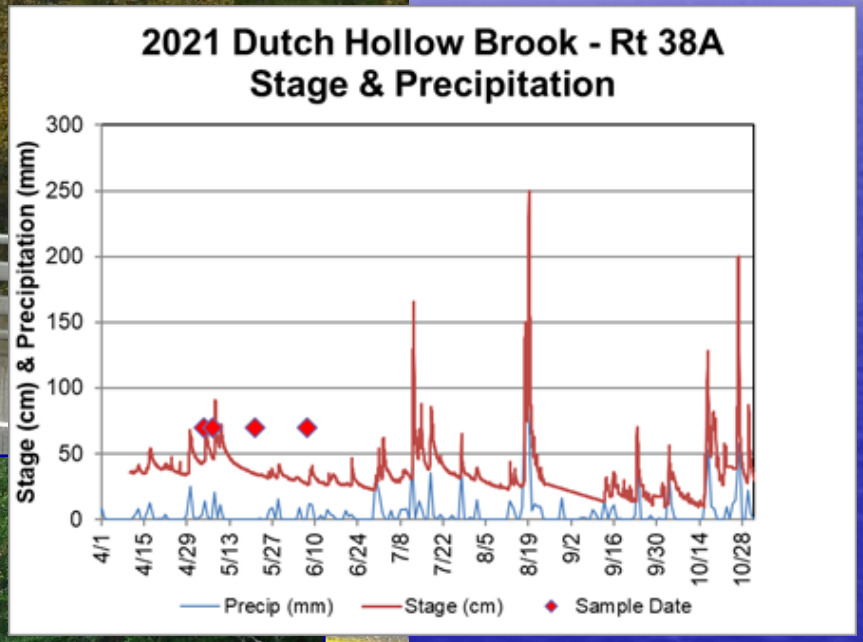
- Source: Spatial Variability
  - Multiple Sites / Same Day
    - Along Individual Streams
    - Grab Samples & Discharge
  - Major Increase in Load
  - Point Sources
- Source: Temporal Variability
  - Multiple Samples, Same Site
    - 3 – 24 hours
    - Downstream Site
    - Autosampler
    - Stage & Rating Curve
  - Event vs Baseflow Loads
  - Non Point Sources



HOBO Data Logger
Measure Stage

Event vs. Base Flow

Dutch Hollow Brook
Rainfall Event

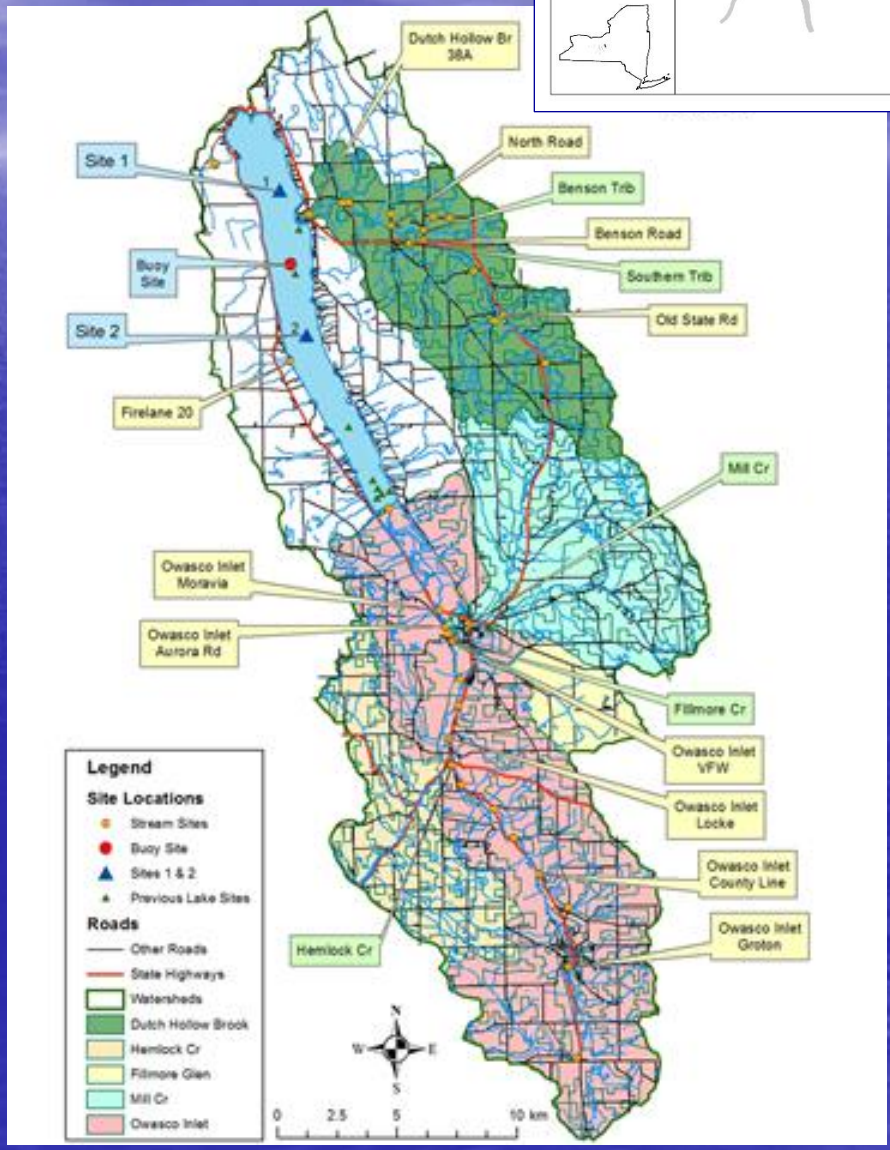


Dutch Hollow Brook
Base Flow

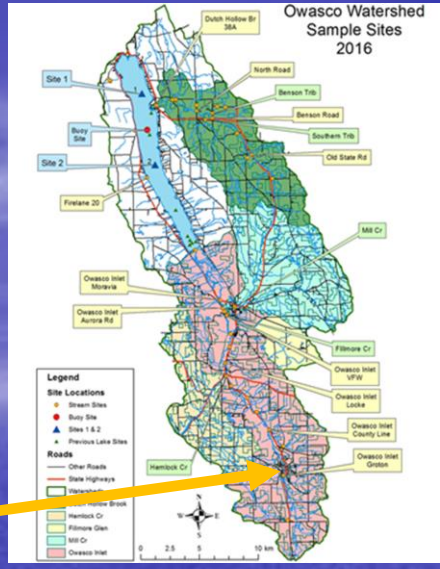
HOBO Data Logger

Owasco Lake

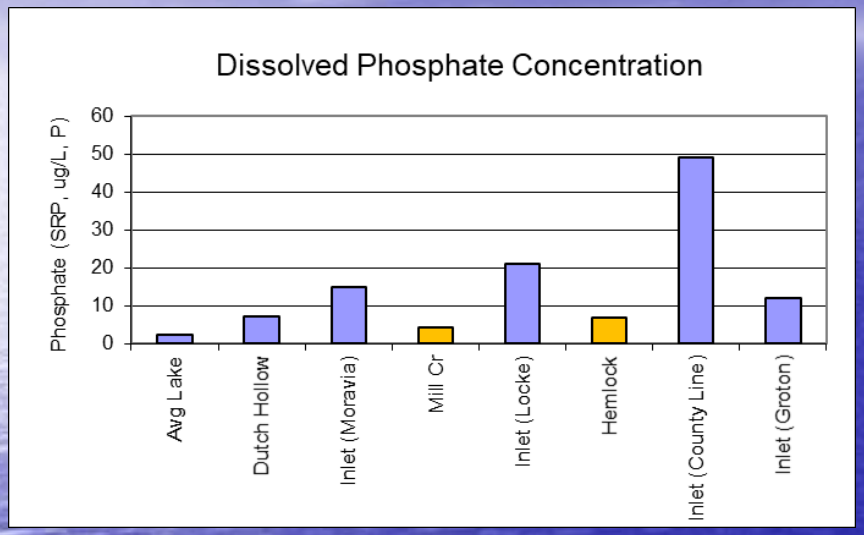
- Oligotrophic/Mesotrophic
  - 2 to 6 m Secchi Depths
  - 0.5 to 9 μg/L Chlorophyll-a
  - 4.8 to 21 μg/L T Phosphate
  - Phosphorus Limited
- Dimensions – "Middle" FL
  - 18 km long
  - 2.1 km max width
  - 0.78 km^3
  - 51 m max depth
  - 17:1 Drainage/Lake Area
    - Largest of 11 Finger Lakes
- Largest Tributaries
  - Dutch Hollow Brook (15%)
  - Owasco Inlet (57%)

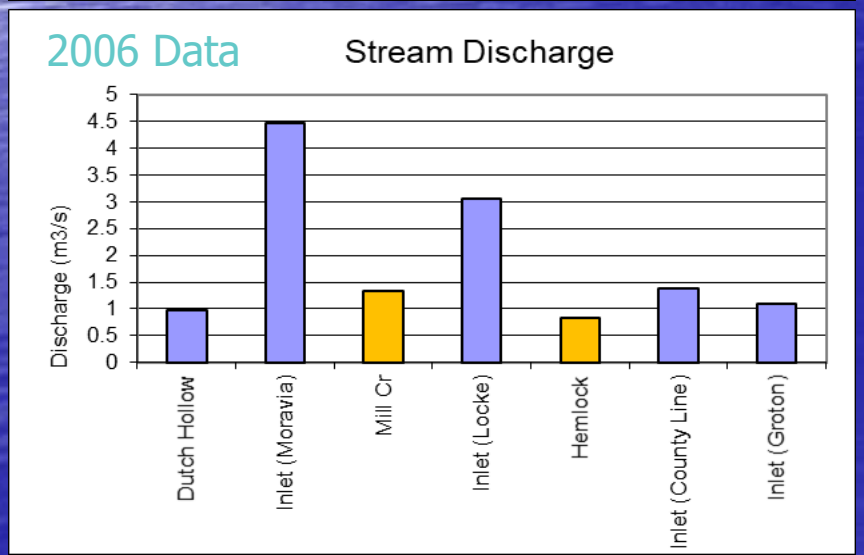


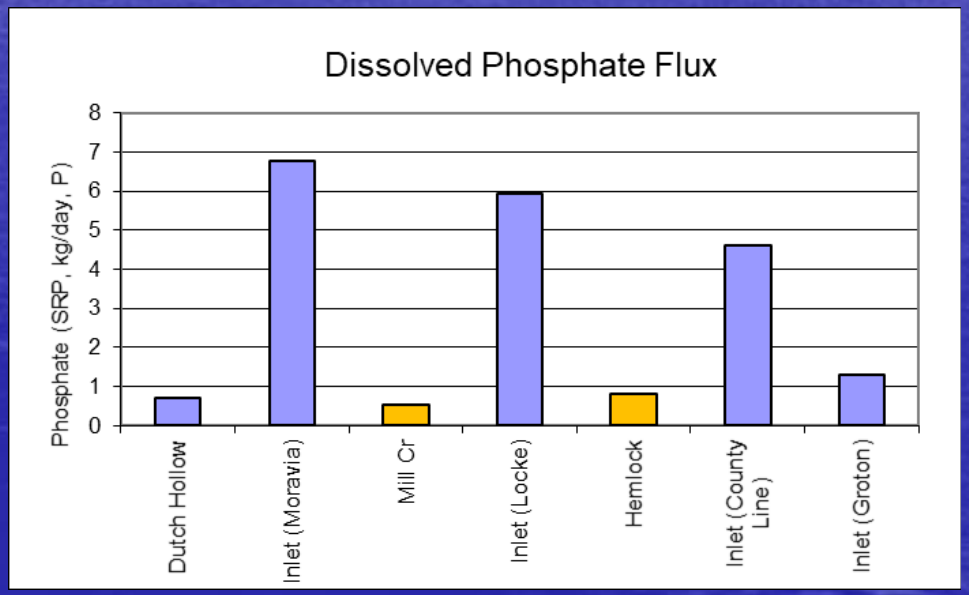
Stream Segment Analysis:
Owasco Inlet



Groton MWWTF





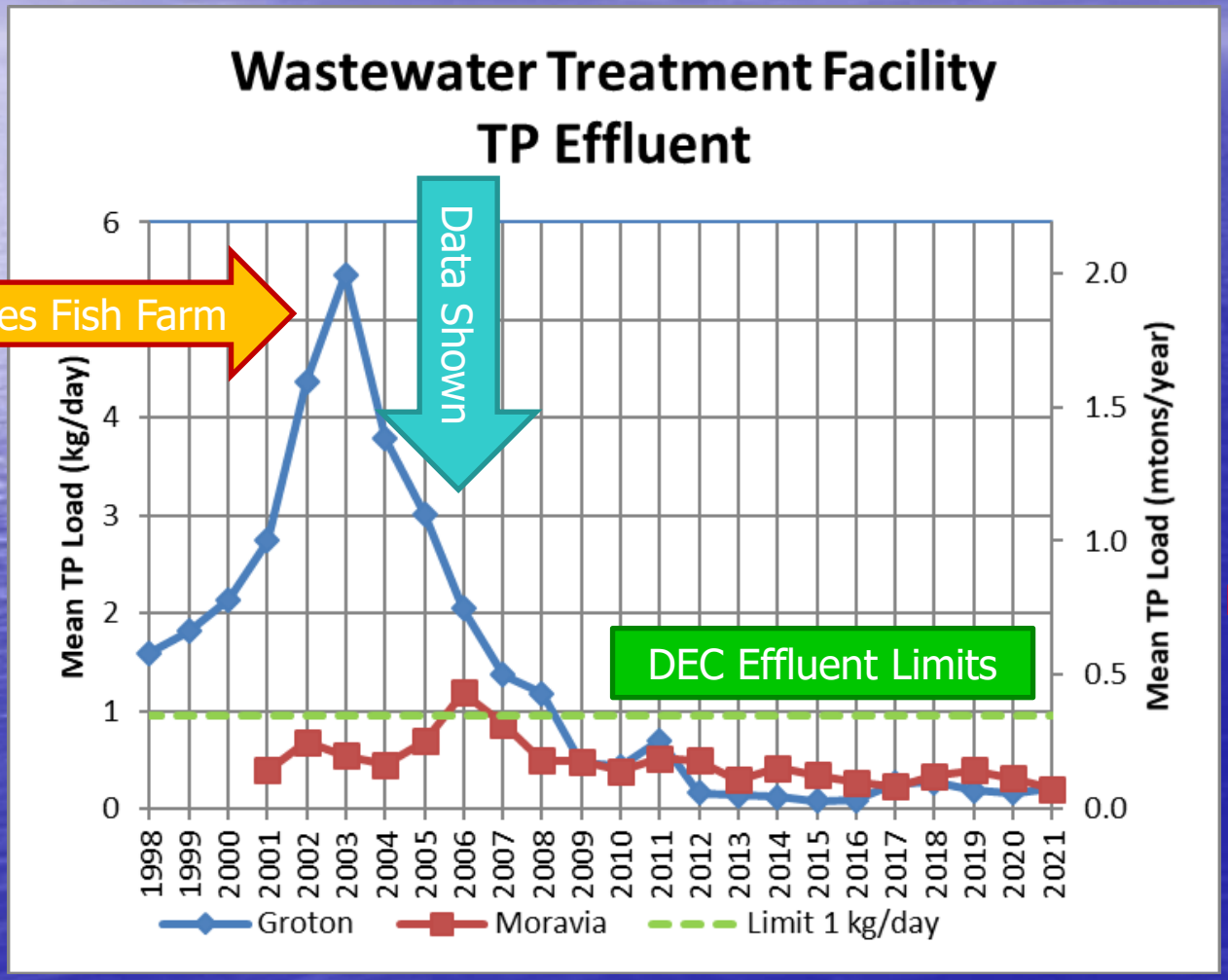


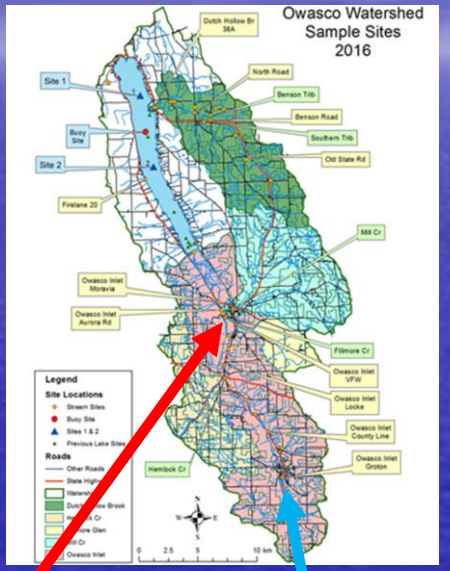
Flux = Concentration x Discharge

mass/time = mass/volume x volume/time

Flux Required for Loads

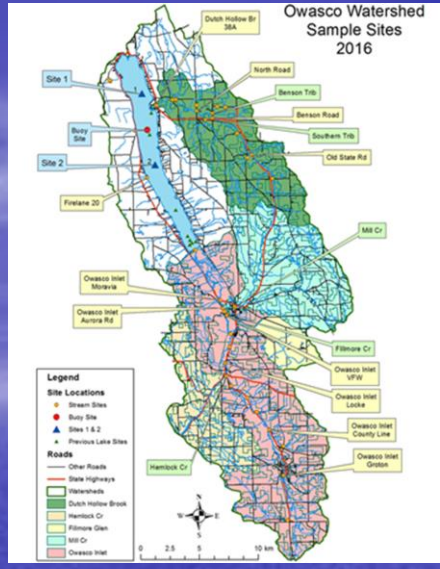
Point Source – Groton MWWTF

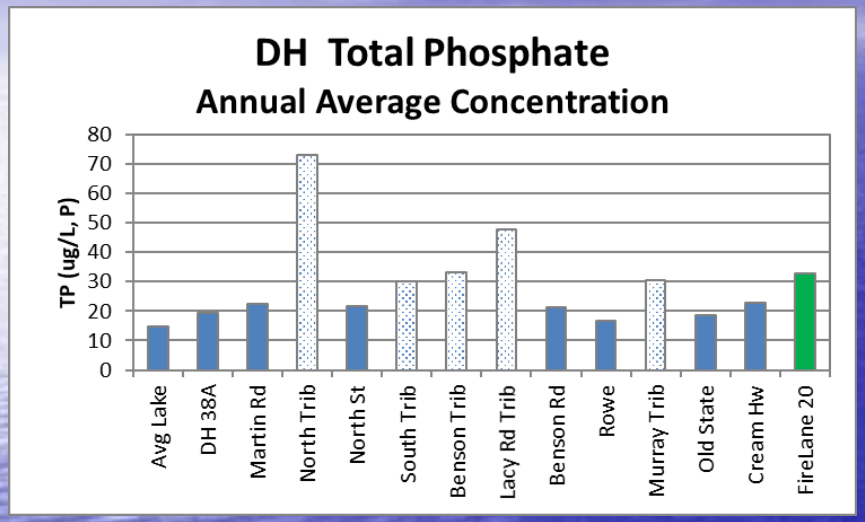


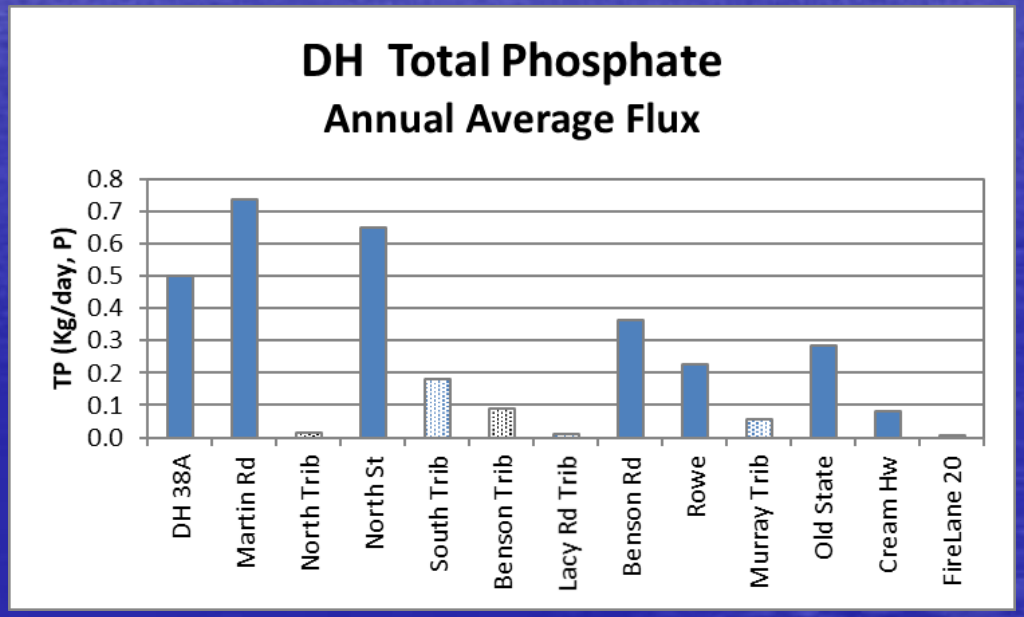


Annual MWWTF Loads from EPA Web Site: http://cfpub.epa.gov/dmr/facility_search.cfm

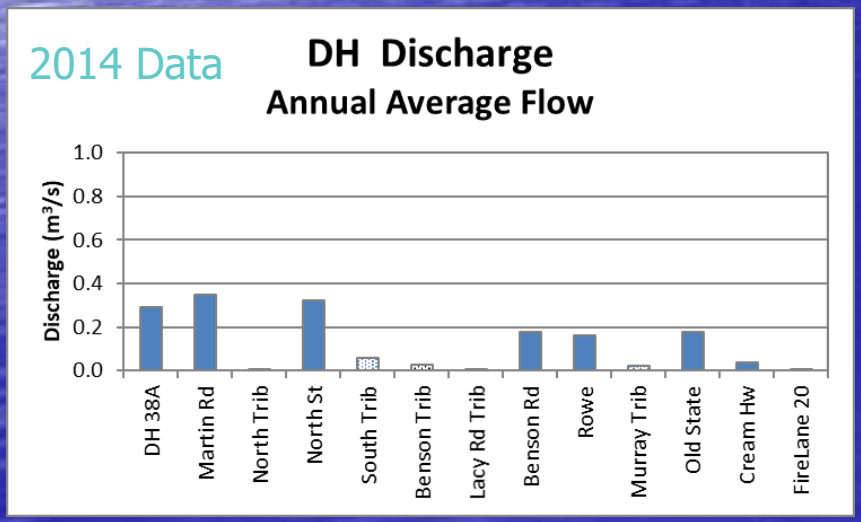
Stream Segment Analysis:
Dutch Hollow Brook



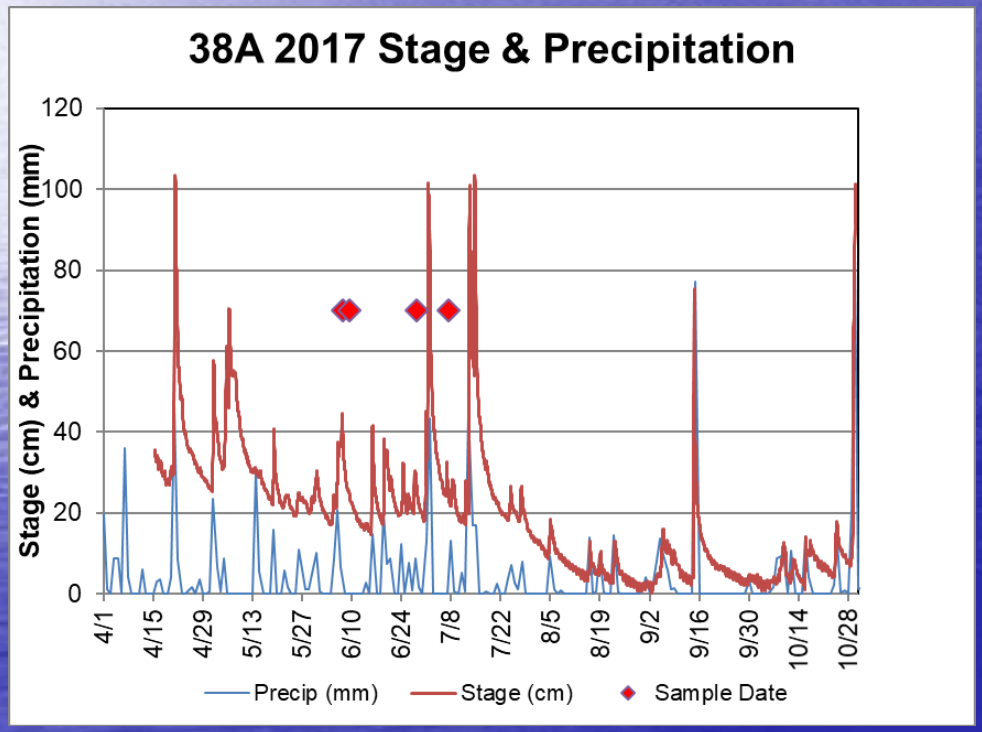




2014 Data



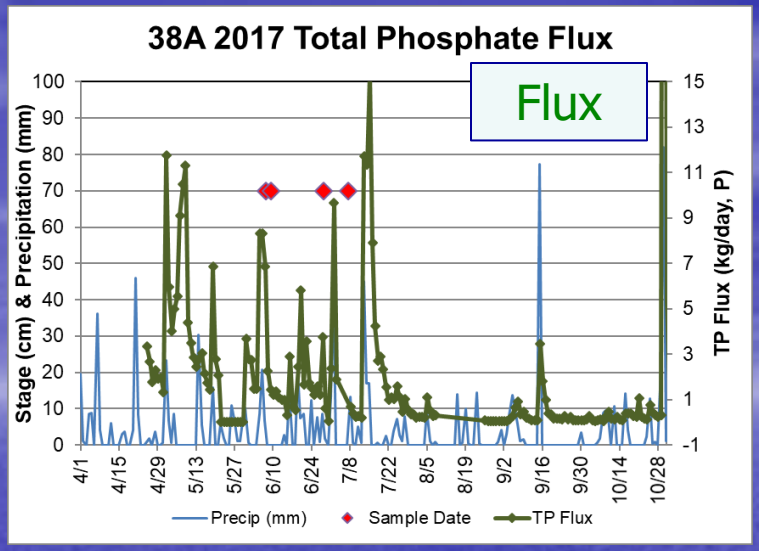
Precipitation Events

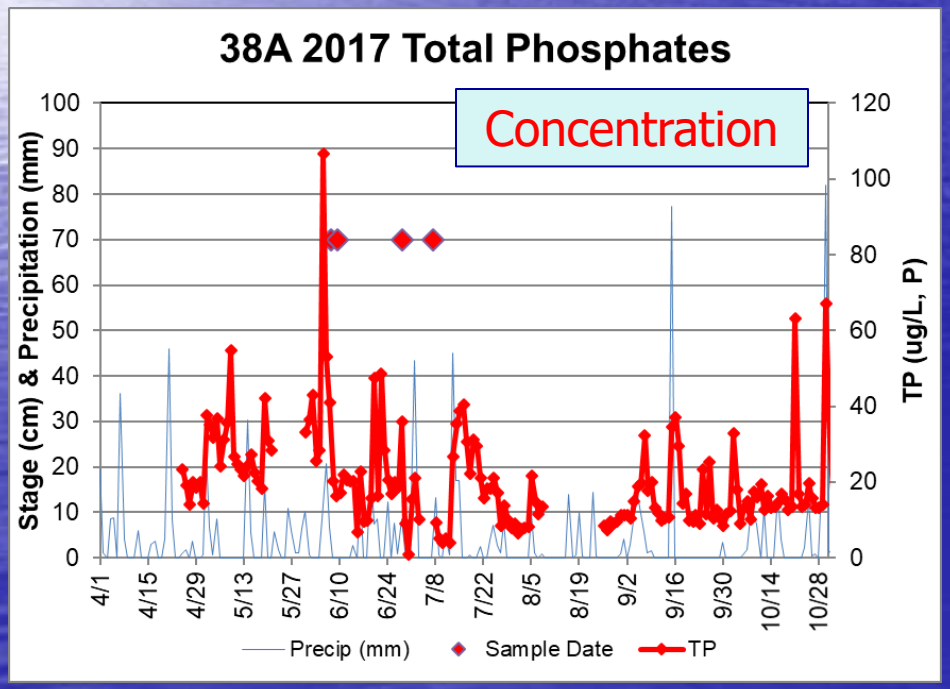


Rainfall Induced Events

- Sharp Rise in Stage (~1 m)
- More Gradual Decline
- Increase in
  - Discharge
  - Nutrients, esp. TP & SRP
    - Nitrates
      - Event & Groundwater Sources
  - Suspended Sediments
  - Flux (Discharge x Nutrient Conc.)
- Proportional Change
  - Season
  - Saturation
  - Duration
  - Intensity
- Event Lasts a Few Days

Precipitation Events: Total Phosphorus Conc. & Flux





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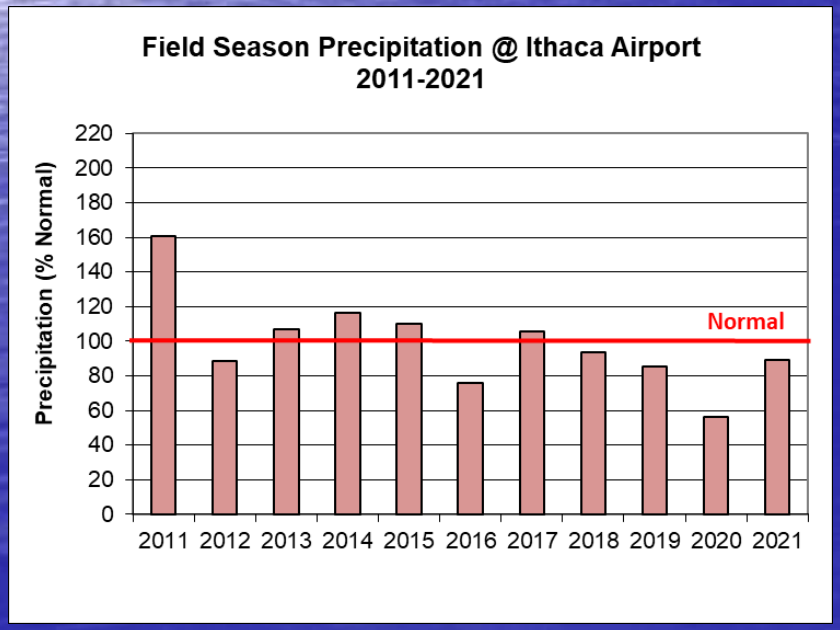
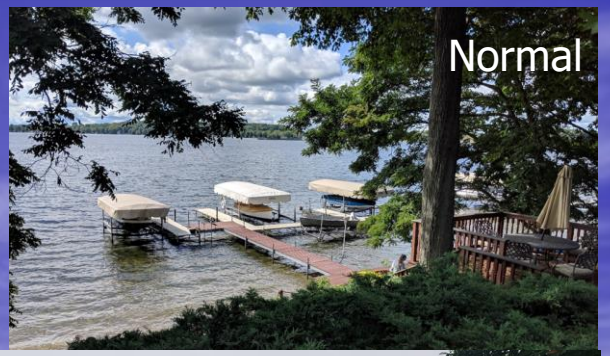
Nutrient & Sediment Loads

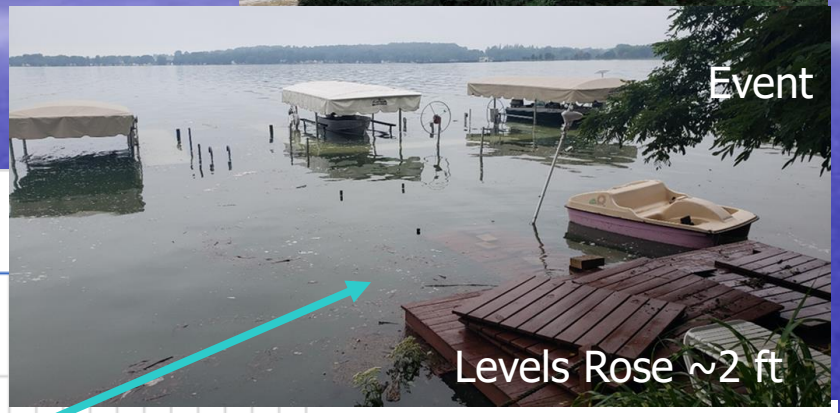
- Events
  - > 90 % Loads
- Baseflow
  - Remainder
- Precipitation Variable
  - Loads to Lake Proportional

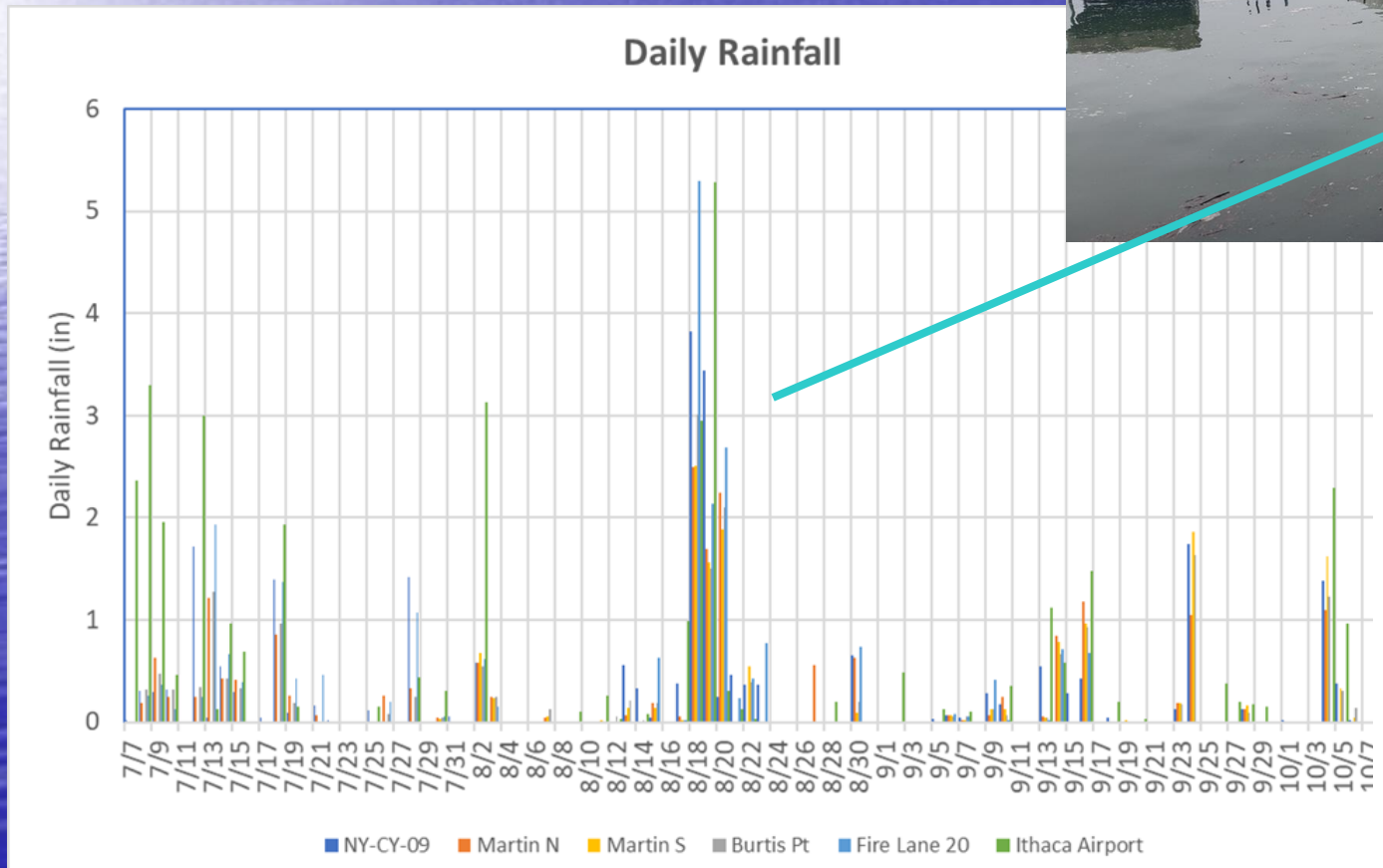


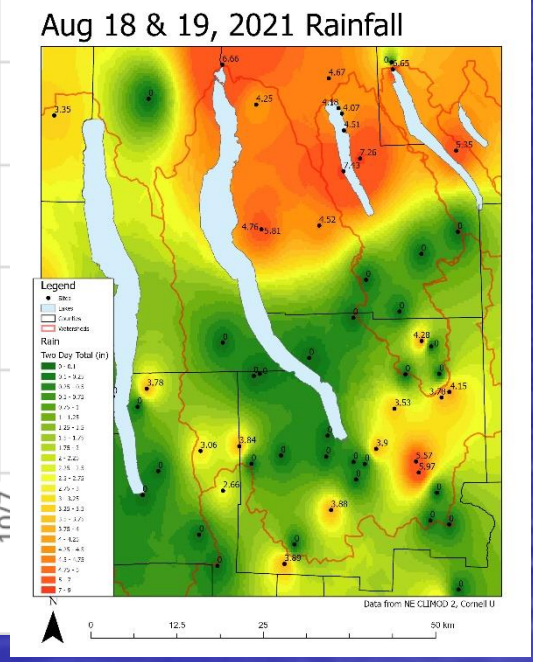
Year	TSS kg/day (Event %)	TP kg/day (Event %)
2011	8,730 (99)	2.7 (90)
2012	2,410 (95)	1.9 (59)
2013	7,550 (98)	4.4 (90)
2014	14,600 (99)	3.5 (74)
2015	36,600 (99)	3.7 (99)
2016	7,500 (99)	1.4 (97)
2017	14,800 (99)	2.2 (92)
2018	3,300 (97)	2.1 (91)
2019	25,000 (99)	2.4 (97)
2020	8,500 (99)	1.0 (93)
2021	27,700 (99)	4.7 (95)

Large Events in 2021
Late Summer & Fall
One Huge Flood
8/18 - 8/20









Atmospheric Rivers Provide Moisture Source – Climate Δ

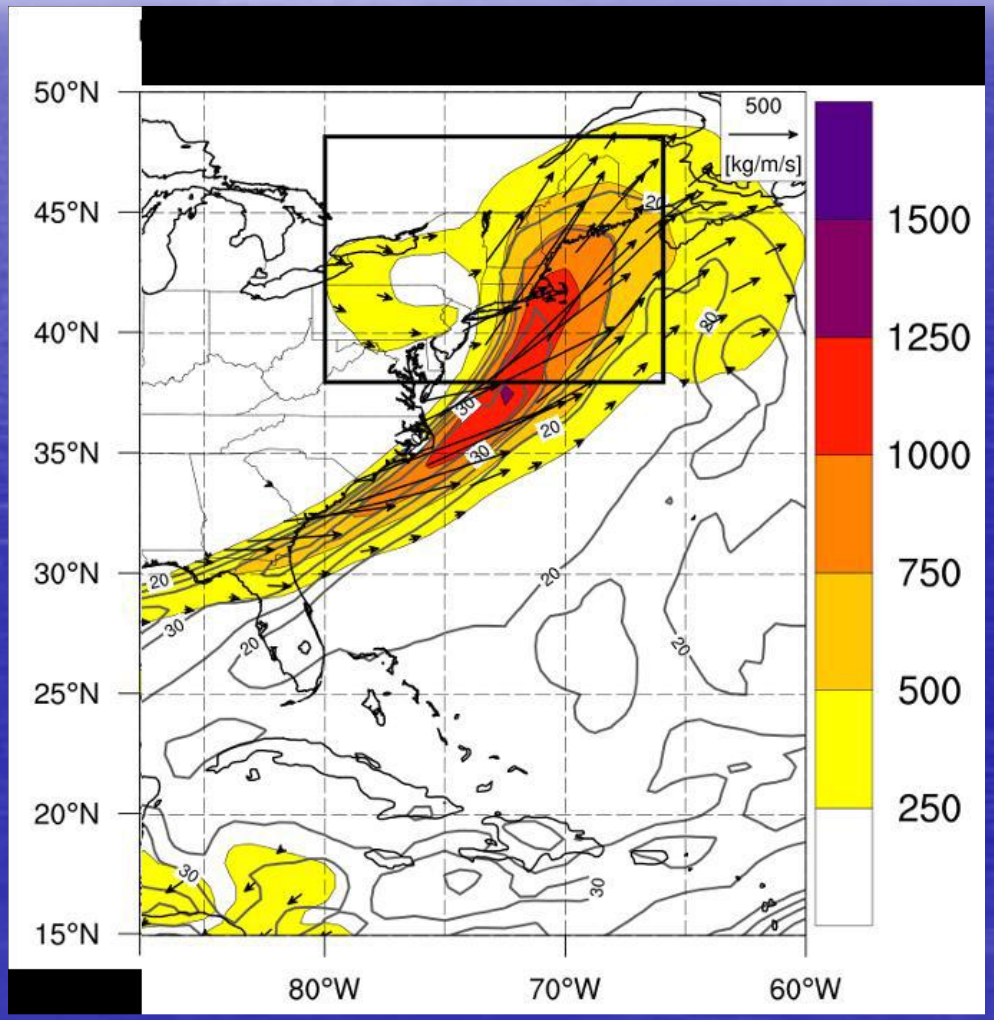
See Tim Jones Poster

Colors of Integrative Vapor Transport (IVT) show Atmospheric River

Moisture From Gulf & Atlantic to Northeast

Global Warming?

Metz, et al., in press.



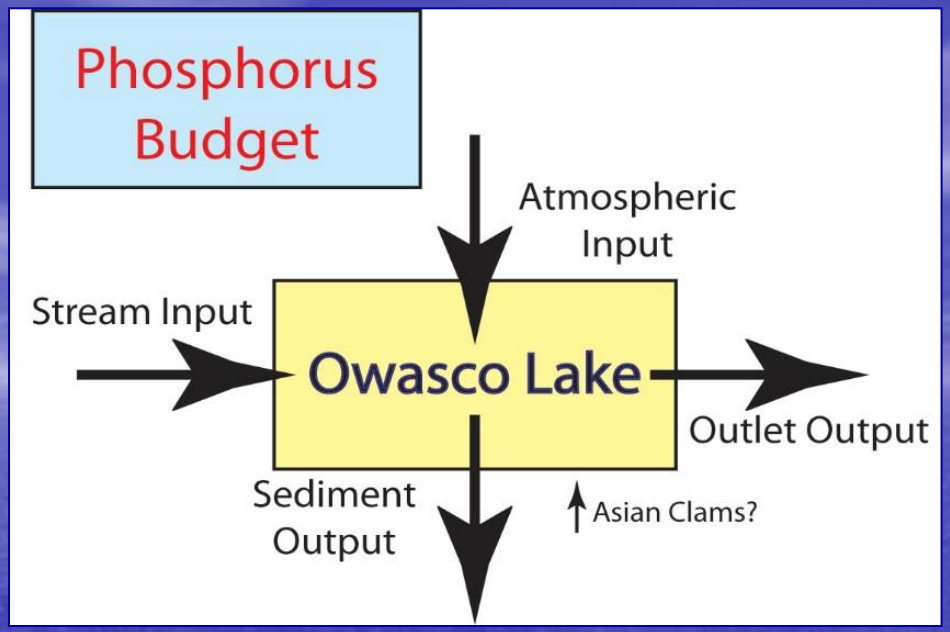
Impact on Cyanobacteria Blooms, e.g., HAB Events

See JoAnna Shaw's Poster

Lots Blooms after Heaviest Rain

Delivered Nutrients for HABs Events?

Phosphorus Budget
Past 11 Years



Before 2016

Inputs >> Outputs

2016 - 2020

Inputs ~ Outputs

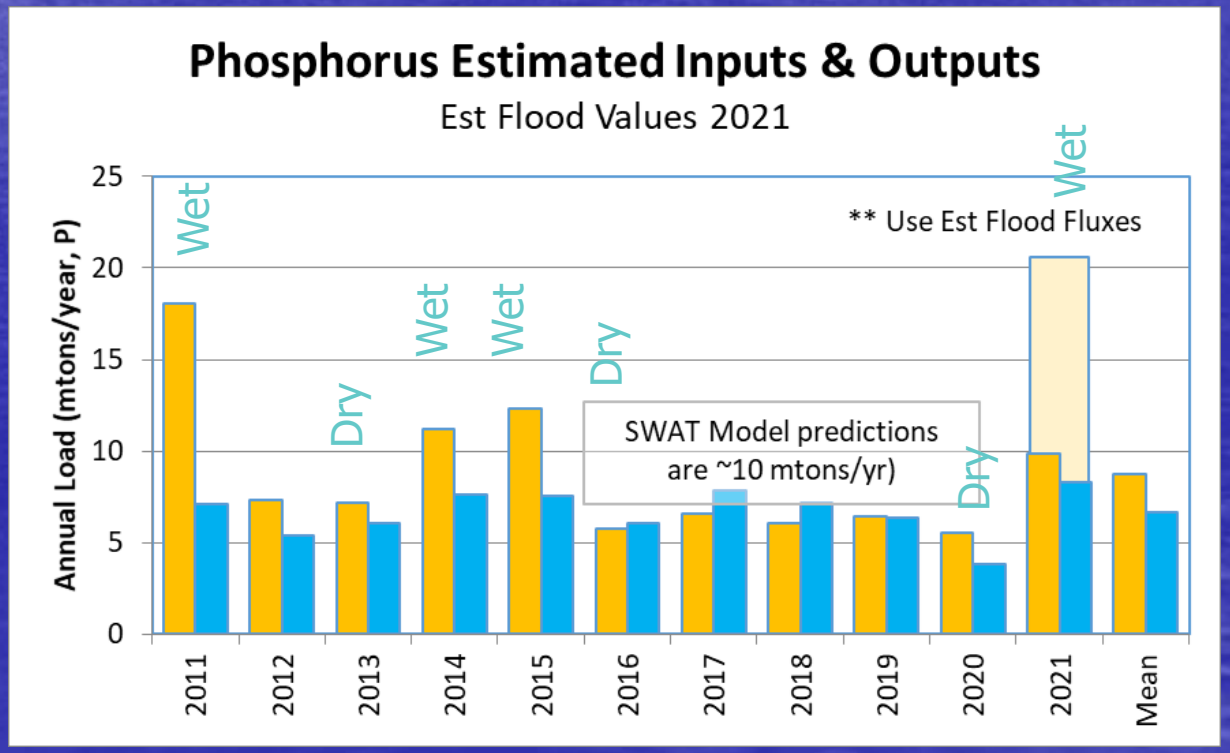
Were Remediation Efforts Working?

HOWEVER, Water Quality in Lake LACKED Improvement!

2021

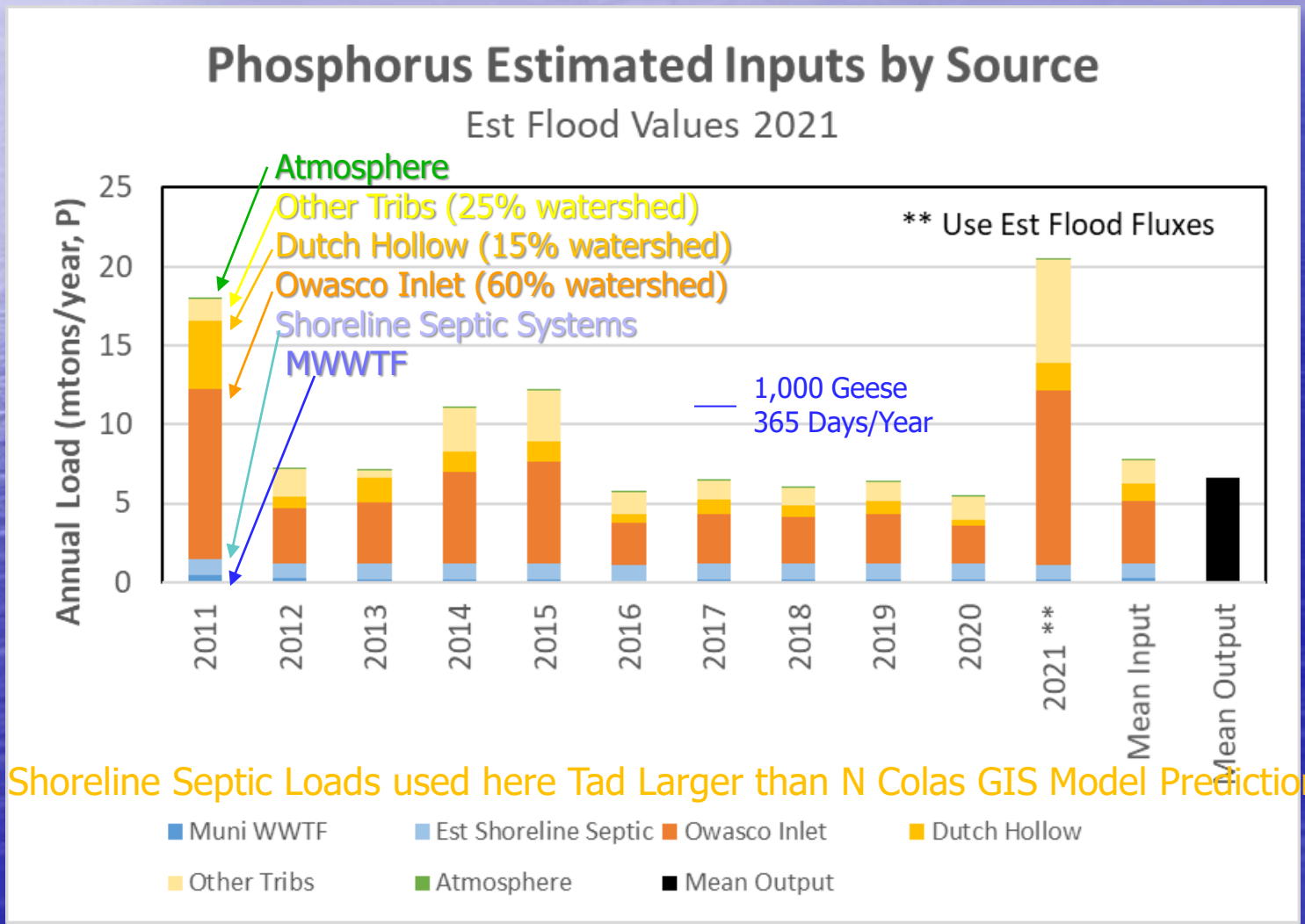
Inputs >> Outputs

8/18 Event > 50% Load!



Loads by Source

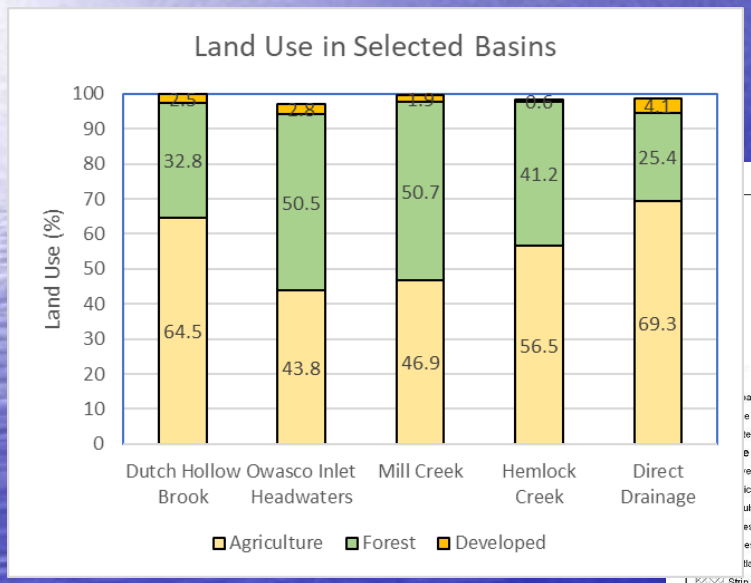
Majority From Rain Events
Rainfall Varried from Year to Year



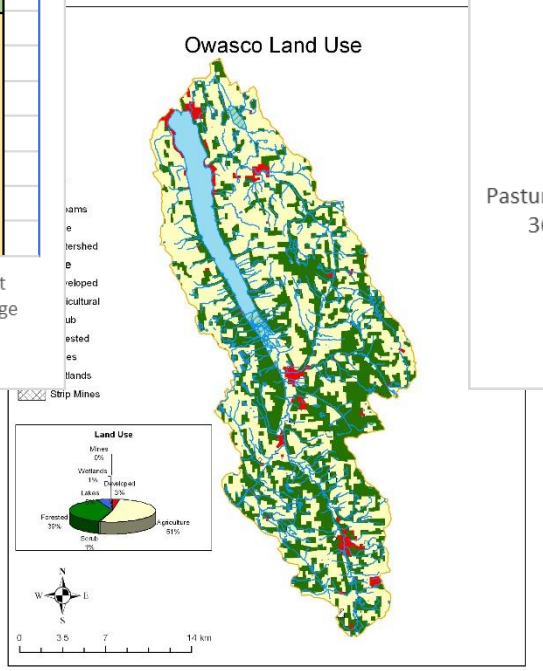
SWAT Model (Soil & Water Assessment Tool)

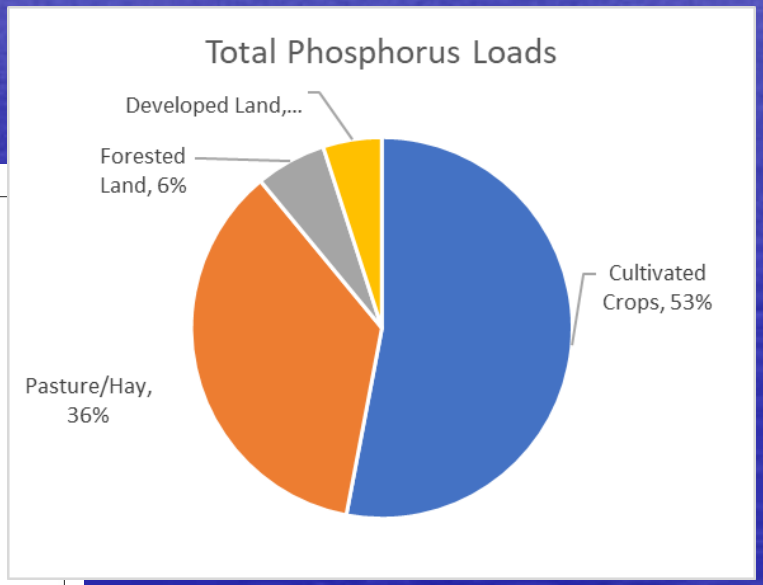
Landscape:
50-50 Agricultural & Forested Land!

TP Loads:
~90% Agricultural Land!



Land Use Map

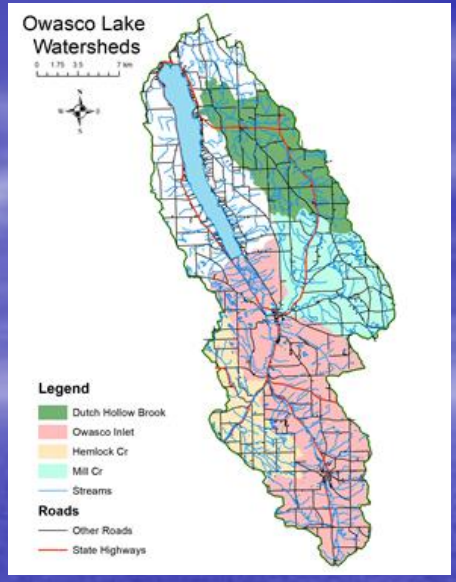


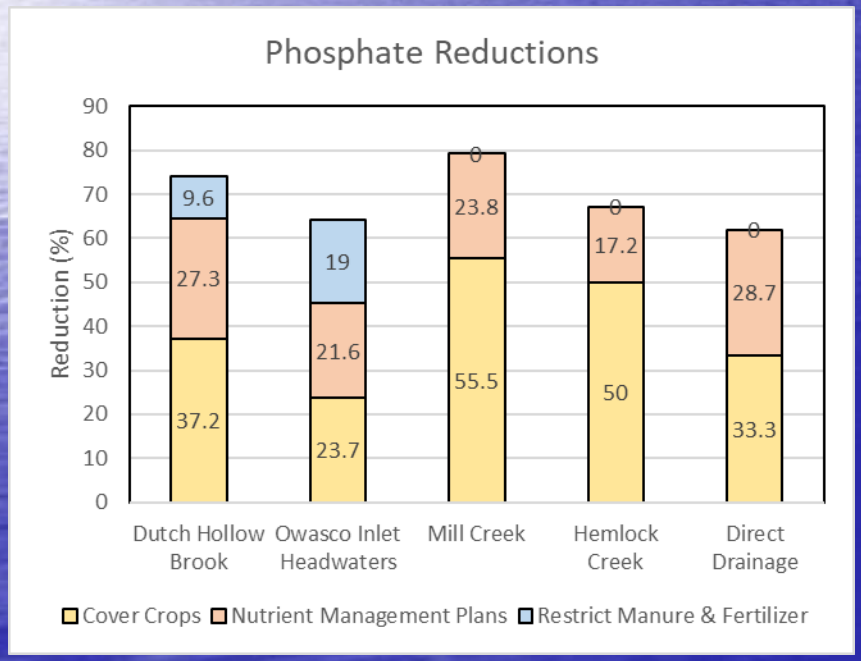


Watershed-Scale model used to simulate the quantity and quality of water, and predict impact of land use, land management practices & climate. Soil erosion control.

TP Loads On Per Acre Basis:
Agricultural Land >> Forests

SWAT Model
TP Reduction Strategies





Remediation Strategies:

- Winter Cover Crops
- Nutrient Management Plans
- Restrict Manure & Fertilizer Use

If followed:

~70% P Reductions

How to Curtail Degradation?

- Reduce Sources
  - Agricultural
    - BMPs to Curtail Impact Runoff Events
    - More Responsible Manure Spreading
      - Perhaps Waste Water Treatment?
      - Remove P from Animal Wastes before Spreading
  - Roadside Ditches & Drainage Tile
    - Especially Farm Field Drain Tiles
      - Source SRP
  - Stream Bank Erosion
- Bioreactors
  - Removes & Recovers P
- Complete 9E (Watershed) Plan
  - Critical for Remediation Funding

Owasco Inlet Turbidity Plume

Veness Bk Turbidity

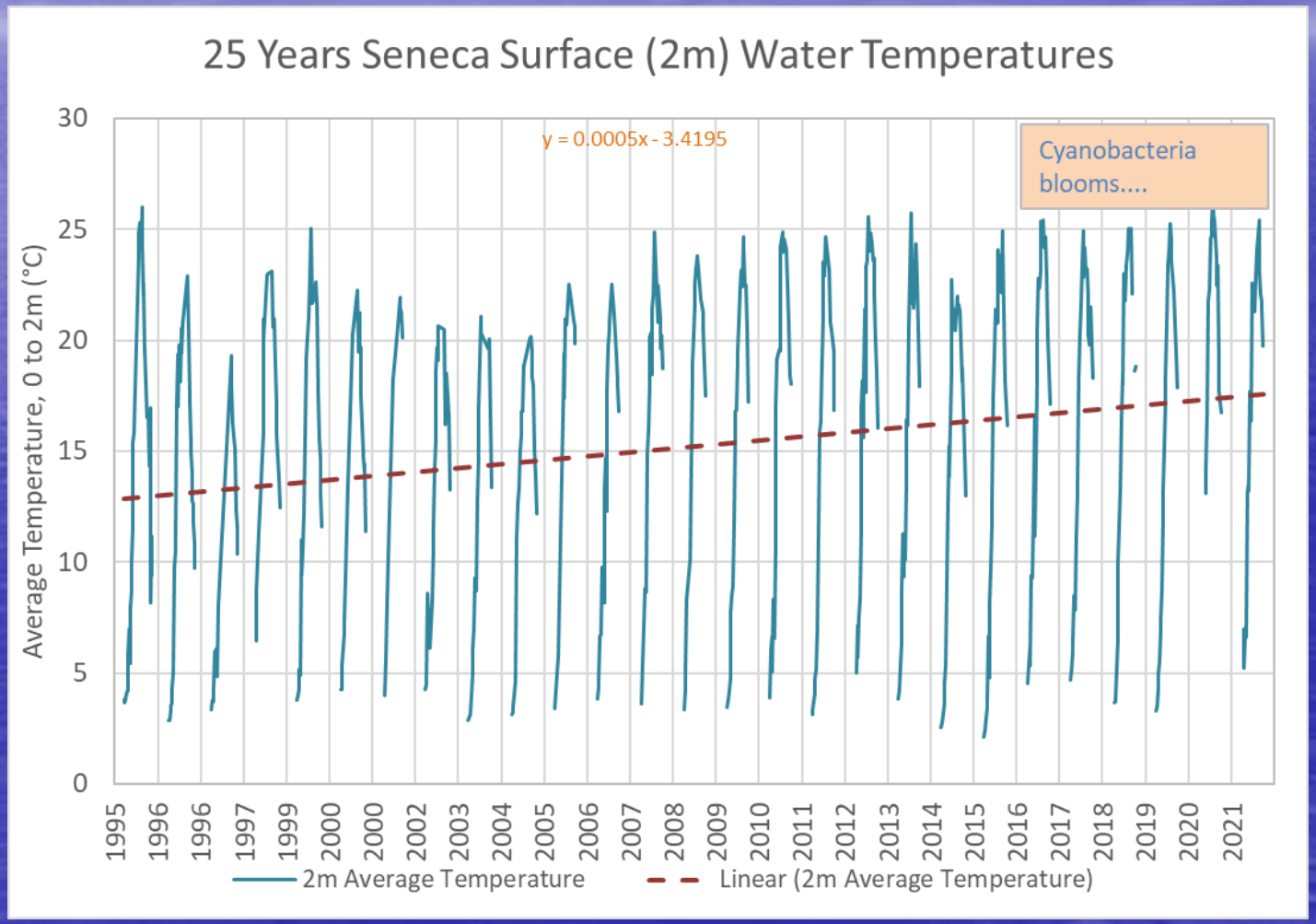
Joe Leonardi, by permission

Other Long Term Datasets
Surface Water Temperatures

See
Janne Knieke's
Poster

Increasing Surface
Water Temperatures

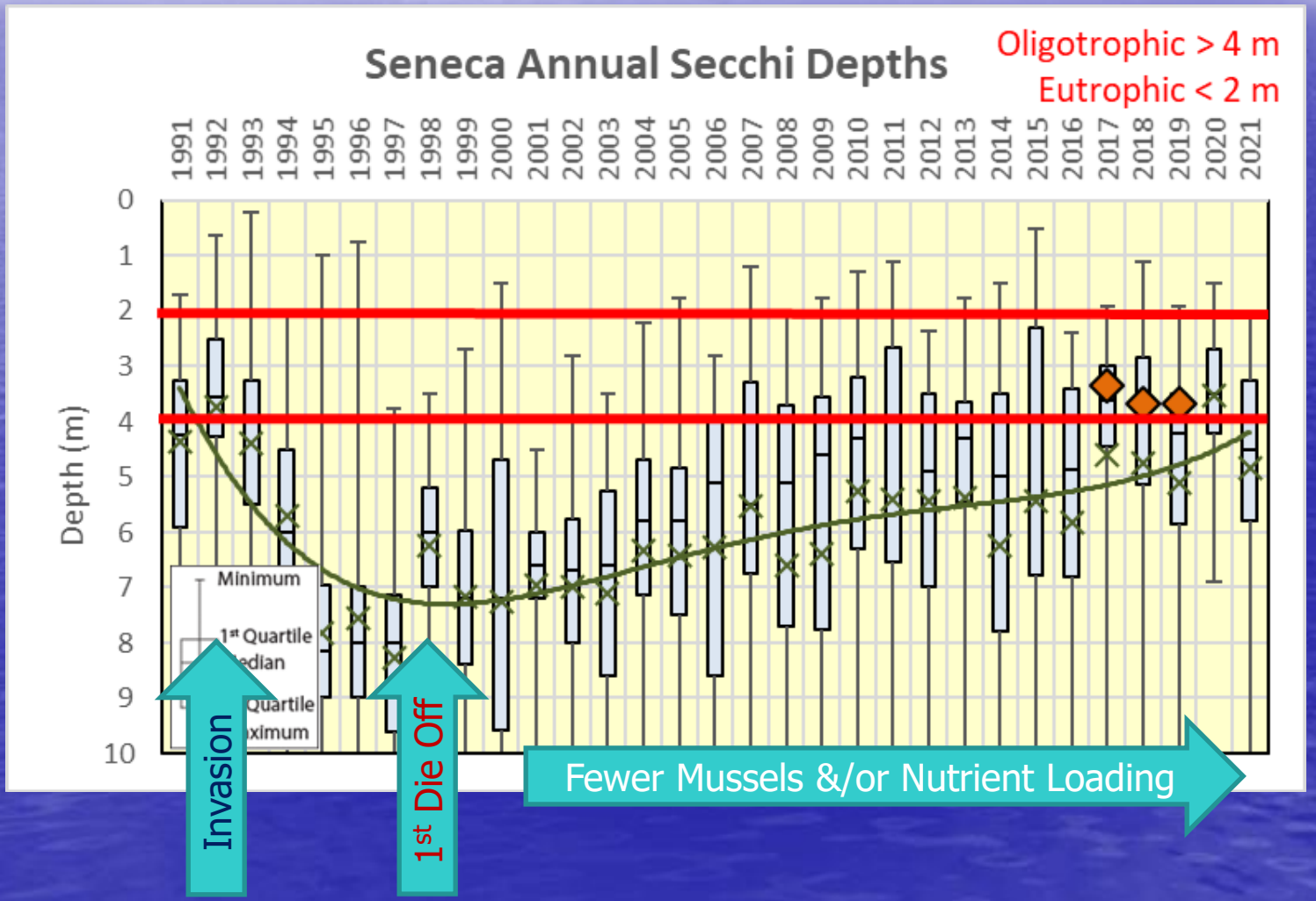
Spark for HABs?
Global Warming?



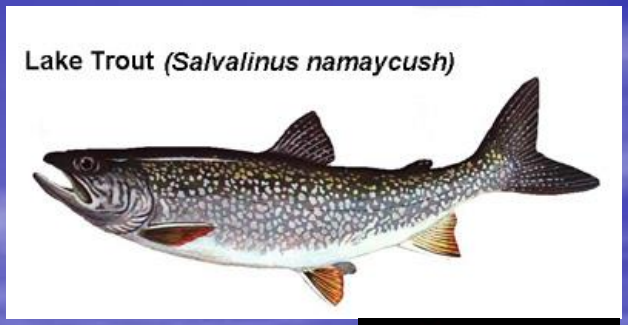
Other Long Term Datasets
Secchi Disk Depths

See Stephanie Stone's Poster

Changing Water Clarity due to change in Zebra & Quagga Mussels? Nutrient Loading?



Initial Zebra Mussel Impact



Plankton

Dissolved Nutrients

Former Pathway

Zebra & Quaggas

Bacterial Decomposition

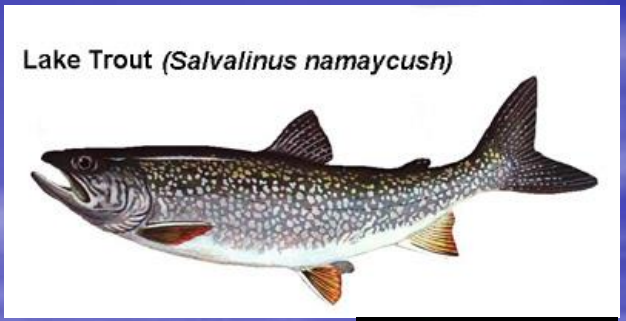
Fish (Lake Trout) & Other Organisms

Former Pathway

Dead Organic Matter

Concentrates Nutrients in Mussel Biomass!

After 1st Die Off



Plankton

Dissolved Nutrients

Nearshore Shunt

Former Pathway

Zebra & Quaggas

Bacterial Decomposition

Fish (Lake Trout) & Other Organisms

Nearshore Shunt

Former Pathway

Dead Organic Matter

Concentrates Organics/Nutrients to Nearshore Regions!
Macrophytes & HABs along Shoreline

Final Thought…

HABs Positive Feedback Loop?

Plankton

Dissolved Nutrients

Former Pathways

HABs Diversion

Bacterial Decomposition

HABs Macrophytes

Zebra & Quaggas

Fish (Lake Trout) & Other Organisms

HABs Diversion

Former Pathways

Dead Organic Matter

Concentrates Even More Organics/Nutrients to Nearshore Regions!

More HABs Events along Shoreline

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email: halfman@hws.edu

Questions