Lake Jessamine
Sediment Inactivation Project

Final Results
June 5, 2014

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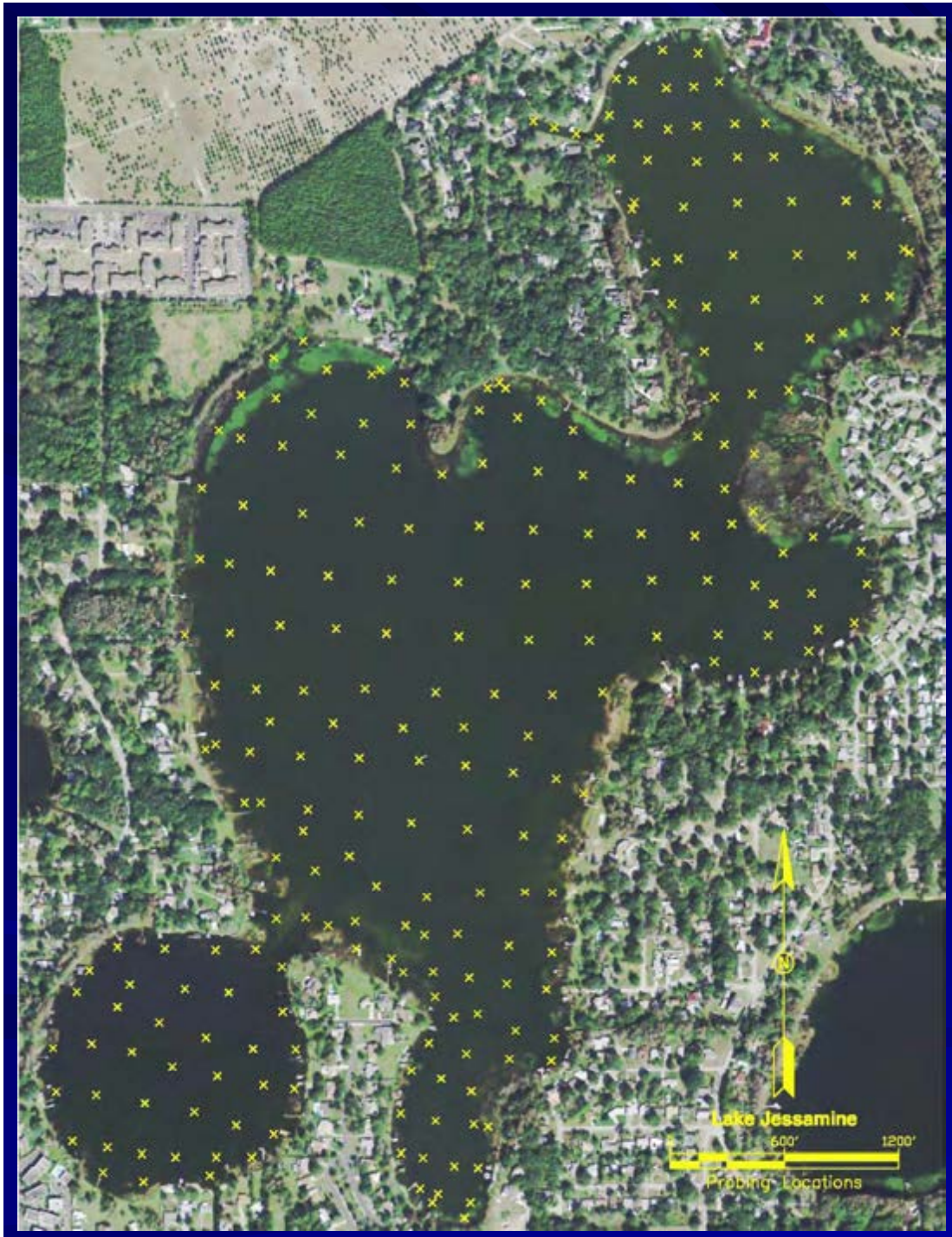
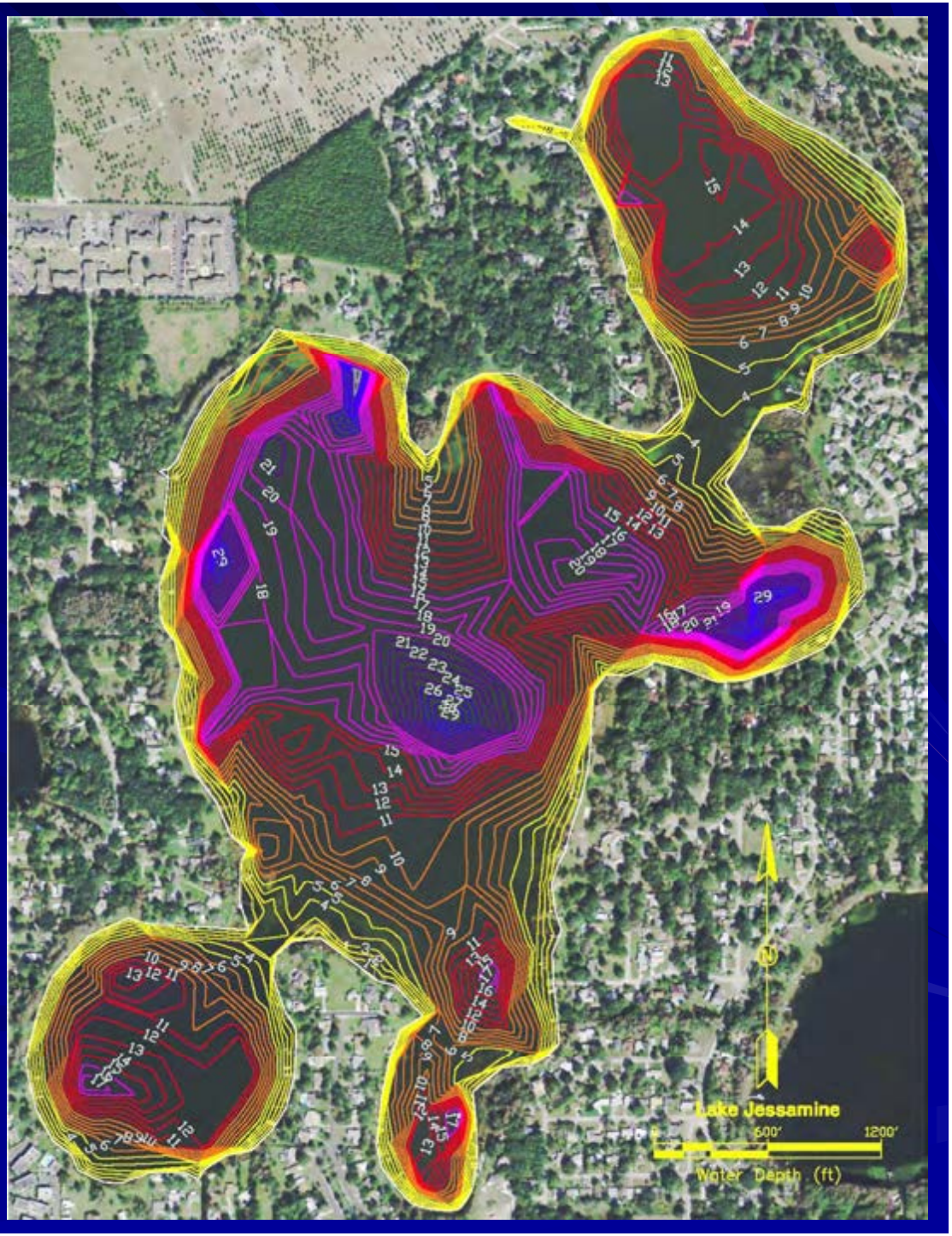
General Overview of Lake Jessamine



Probing Locations for Water and Muck Depths in Lake Jessamine (March 29, 2011)

Water Depth Contours (ft) for Lake Jessamine on March 29, 2011

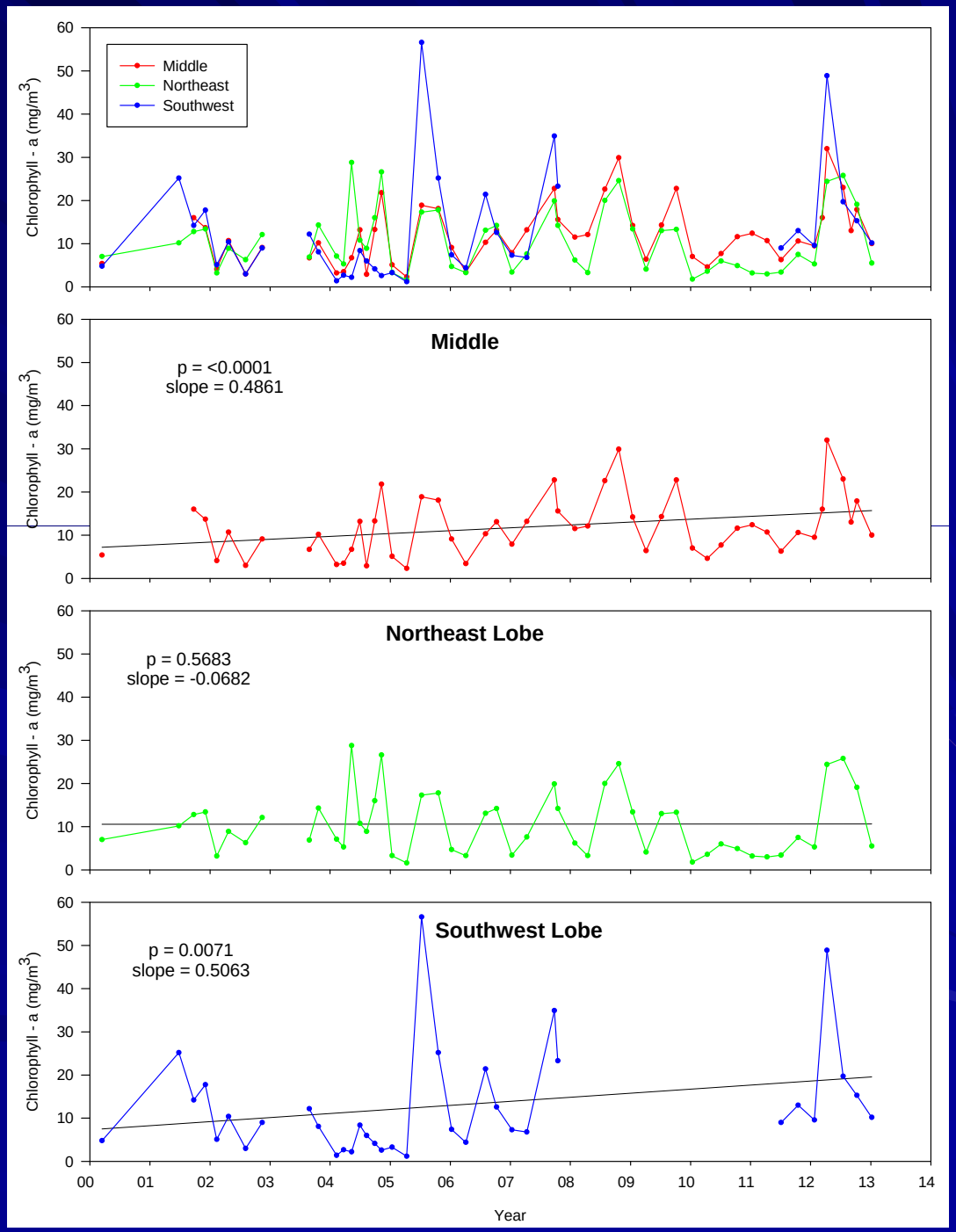


Muck Depth Contours (ft) in Lake Jessamine on March 29, 2011

Trends in Chlorophyll-a Concentrations in Lake Jessamine from 2000-2013

- chlorophyll-a is a photosynthetic pigment

- indicator of algal biomass



Lake Trophic State Classifications

Oligotrophic Lake

- Low in nutrients
- Few algae grow
- No algal blooms
- Water is very clear
- Support very few plants and fish
- About 12% of Florida lakes
- Water clarity > 12 feet
- Chlorophyll < 3 micrograms/liter
- Total P < 15 micrograms/liter

Mesotrophic Lake

- Moderate in nutrients
- Moderate algal production
- Periodic algal blooms
- Slightly green water
- Support moderate amounts of plants and fish
- About 31% of Florida lakes
- Water clarity 8 – 12 feet
- Chlorophyll 3 - 7 micrograms/liter
-Total P 15 to 25 micrograms/liter

Lake Trophic State Classifications – cont.

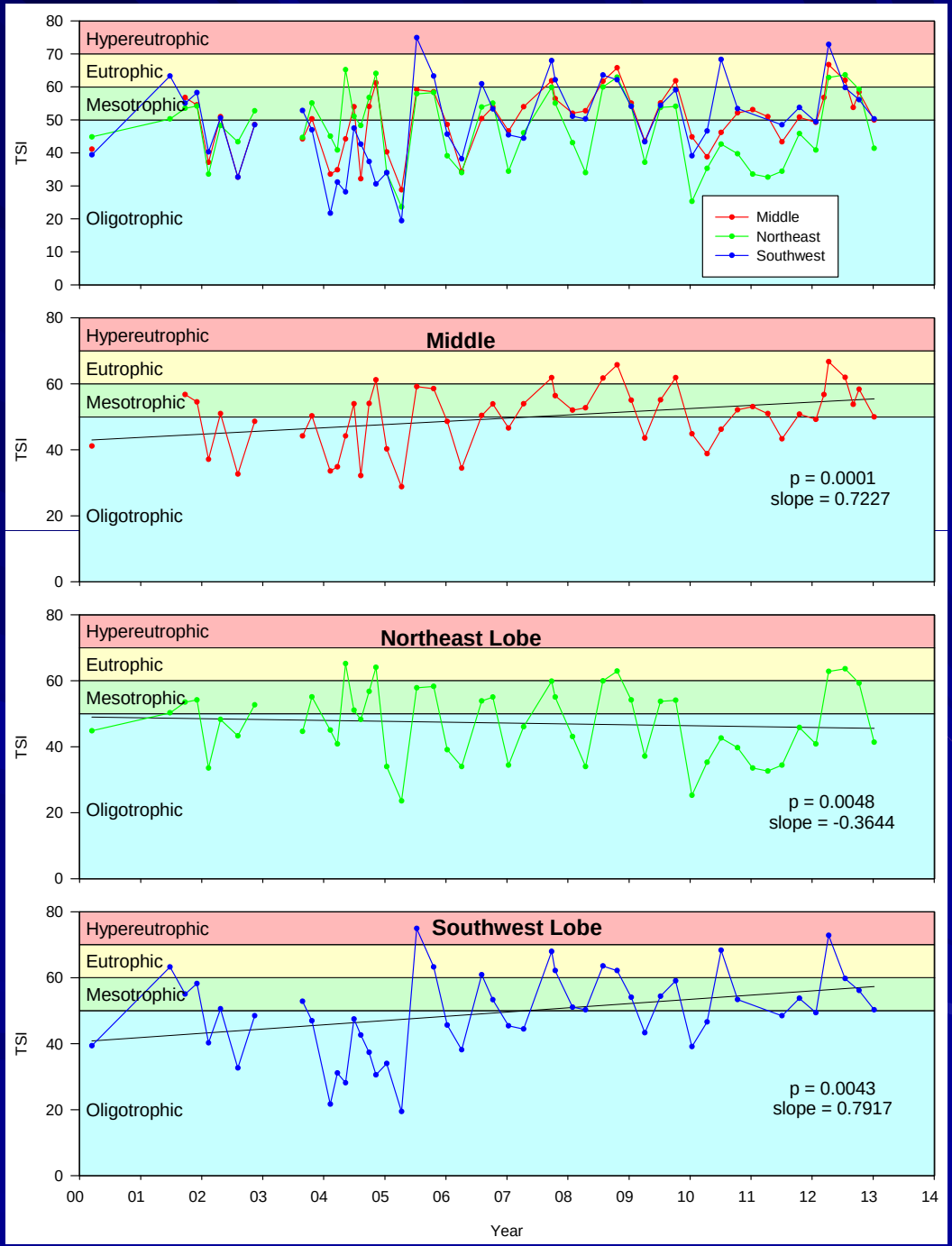
Eutrophic Lake

- High in nutrients
- High level of algal production
- Frequent algal blooms
- Green water with poor visibility
- May have large amount of plants
- About 41% of Florida lakes
- Water clarity 3 - 8 feet
- Chlorophyll 7 to 40 micrograms/liter
- Total P 25 to 100 micrograms/liter

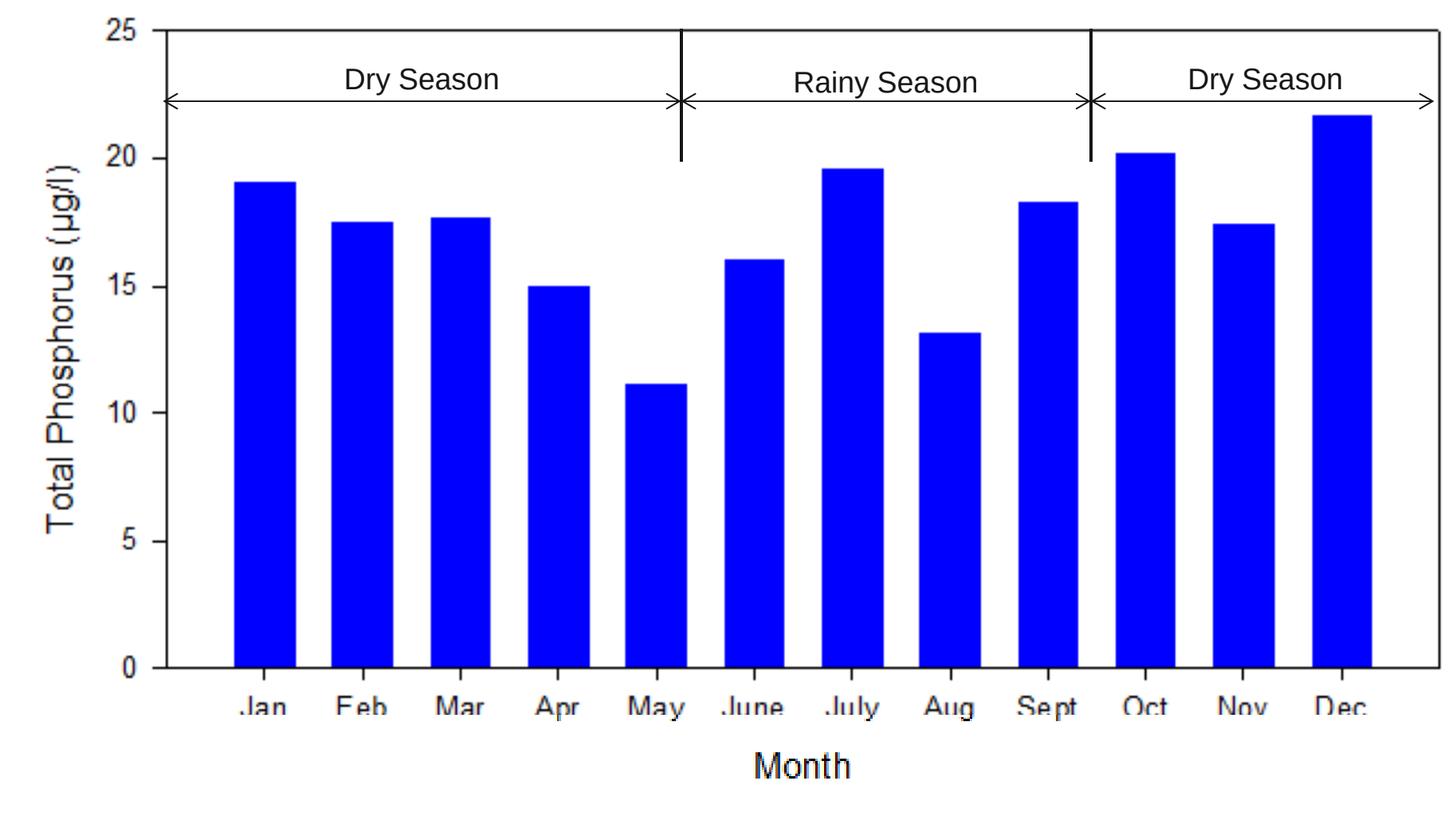
Hyper-eutrophic Lake

- Very high in nutrients
- Extremely high algal production
- Virtually constant algal blooms
- Most biologically productive lakes
- Support large amounts of plants and fish
- About 16% of Florida lakes
- Water clarity < 3 feet
- Chlorophyll > 40 micrograms/liter
- Total P > 100 micrograms/liter

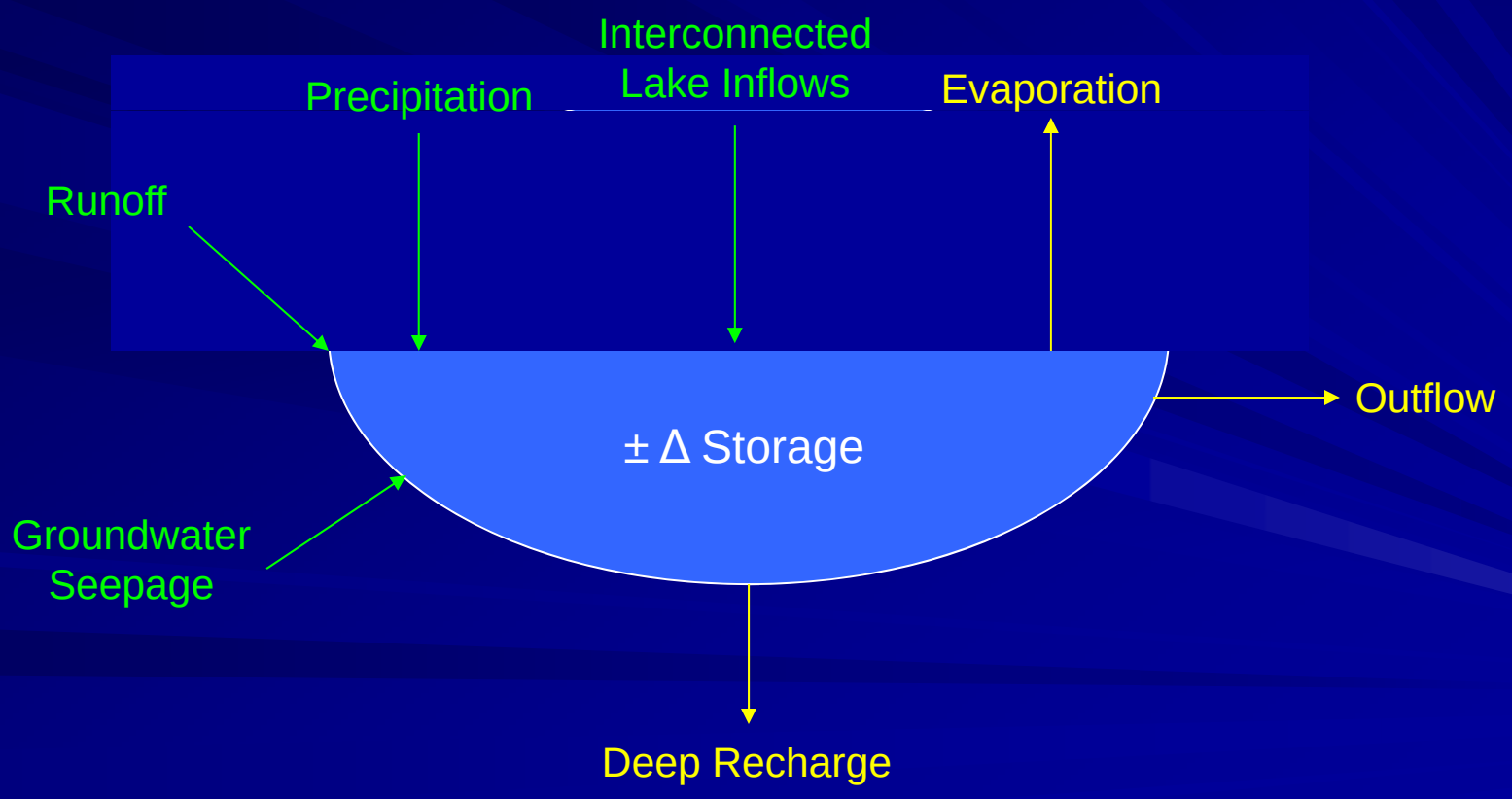
Trends in TSI Values in Lake Jessamine from 2000-2013



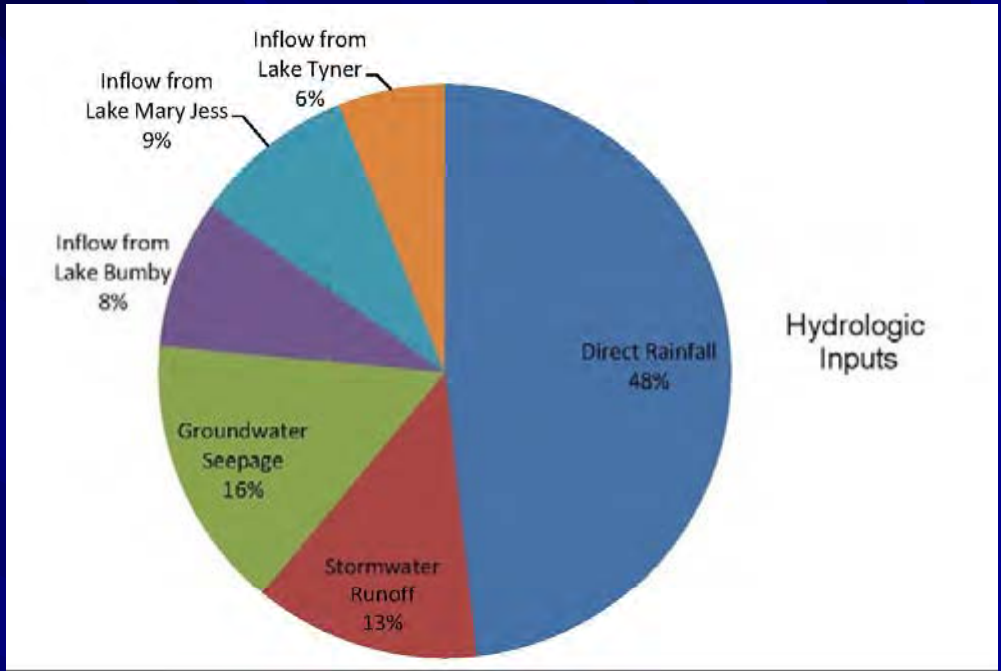
Mean Monthly Concentrations of Total Phosphorus in Lake Jessamine from 1989-2009

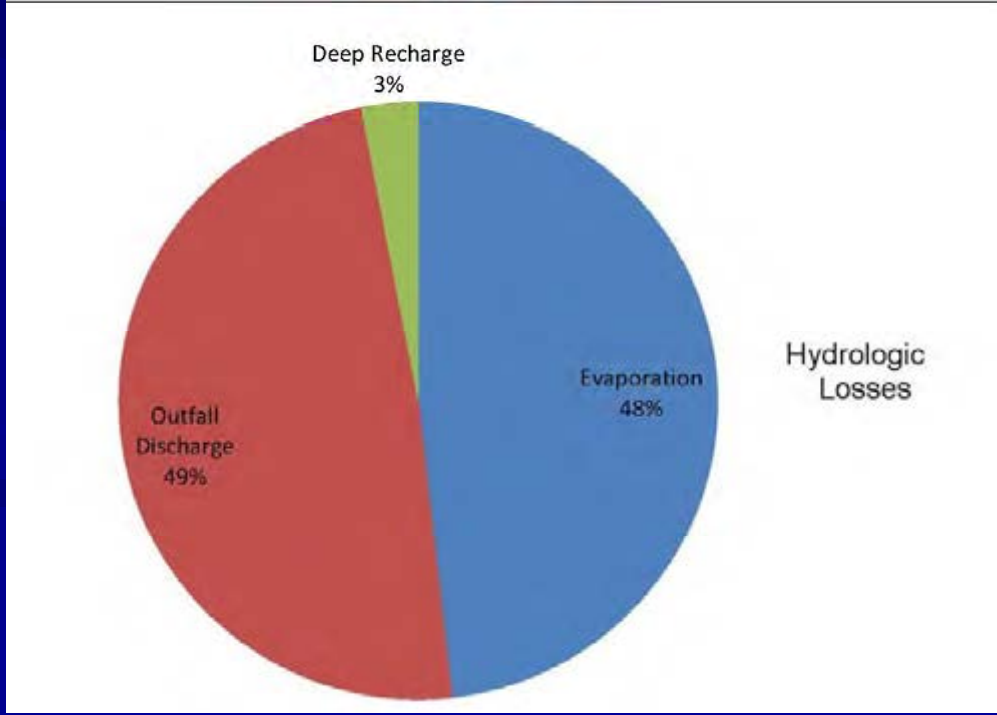


Hydrologic Budget Components

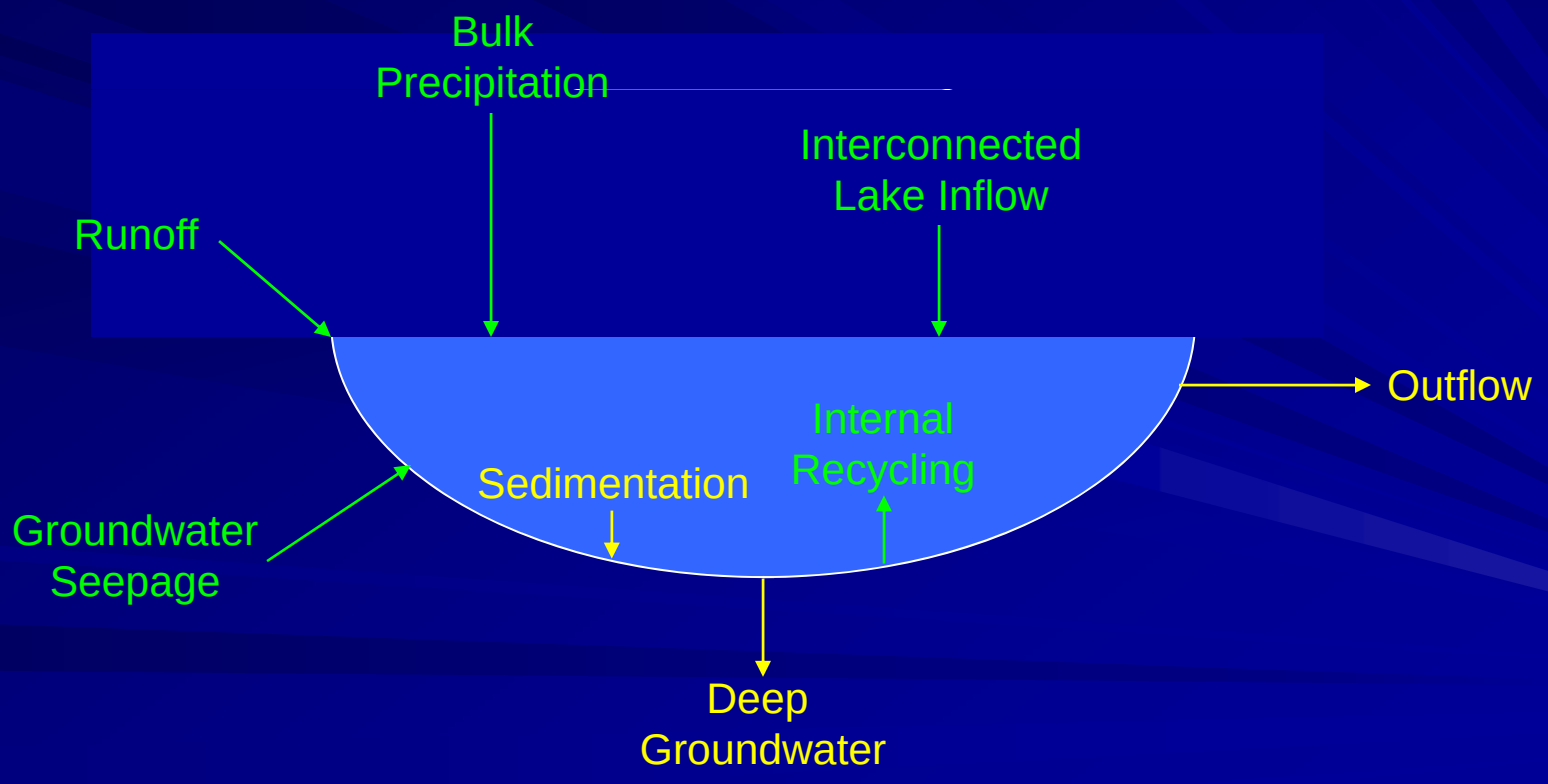


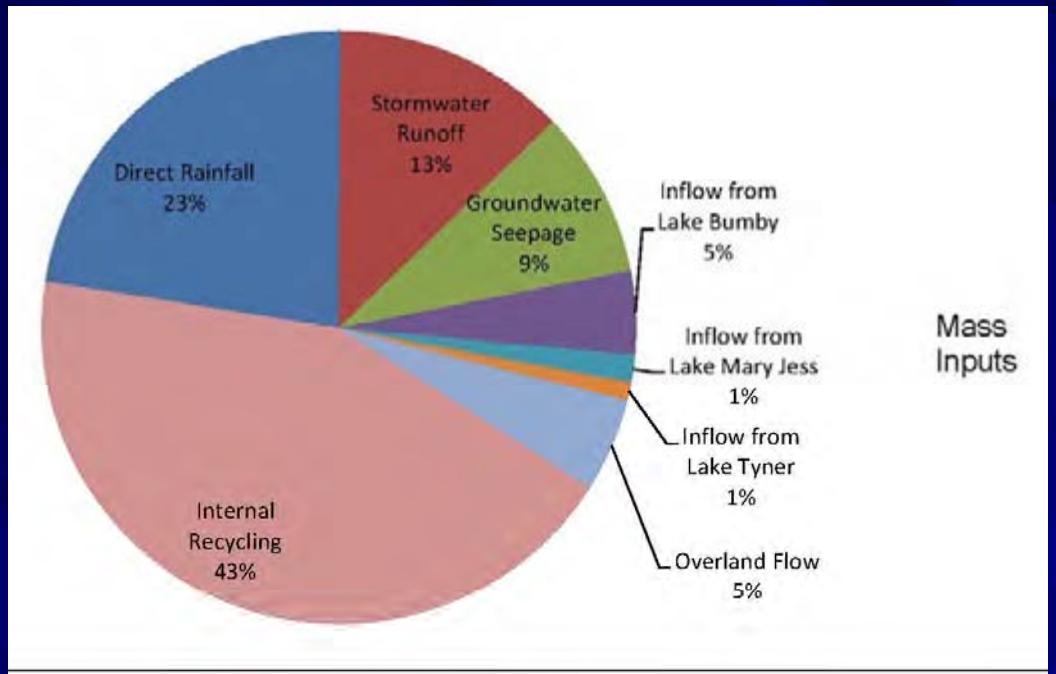
Summary of Mean Annual Hydrologic Inputs and Losses to Lake Jessamine

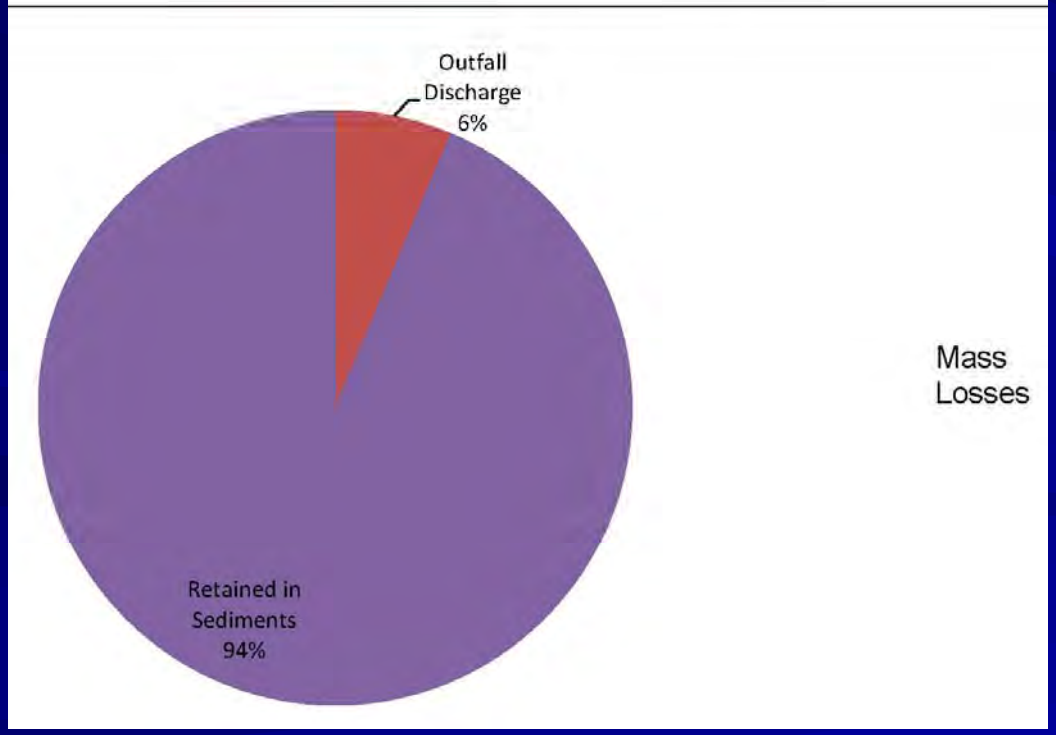




Nutrient Budget Components







Summary of Mean Annual Mass Inputs and Losses of Total Phosphorus to Lake Jessamine

- Lake Jessamine is a P limited lake

- P inputs must be controlled to improve water quality

Locations of Sediment Monitoring Sites in Lake Jessamine

Photographs of Typical Sandy Sediments Collected in Lake Jessamine During December 2010

Thick light brown sand over brown sand

Dark brown sand

Brown sand with detritus layer

Thick light brown sand

Photographs of Typical Sandy and Organic Muck Sediments Collected in Lake Jessamine During December 2010

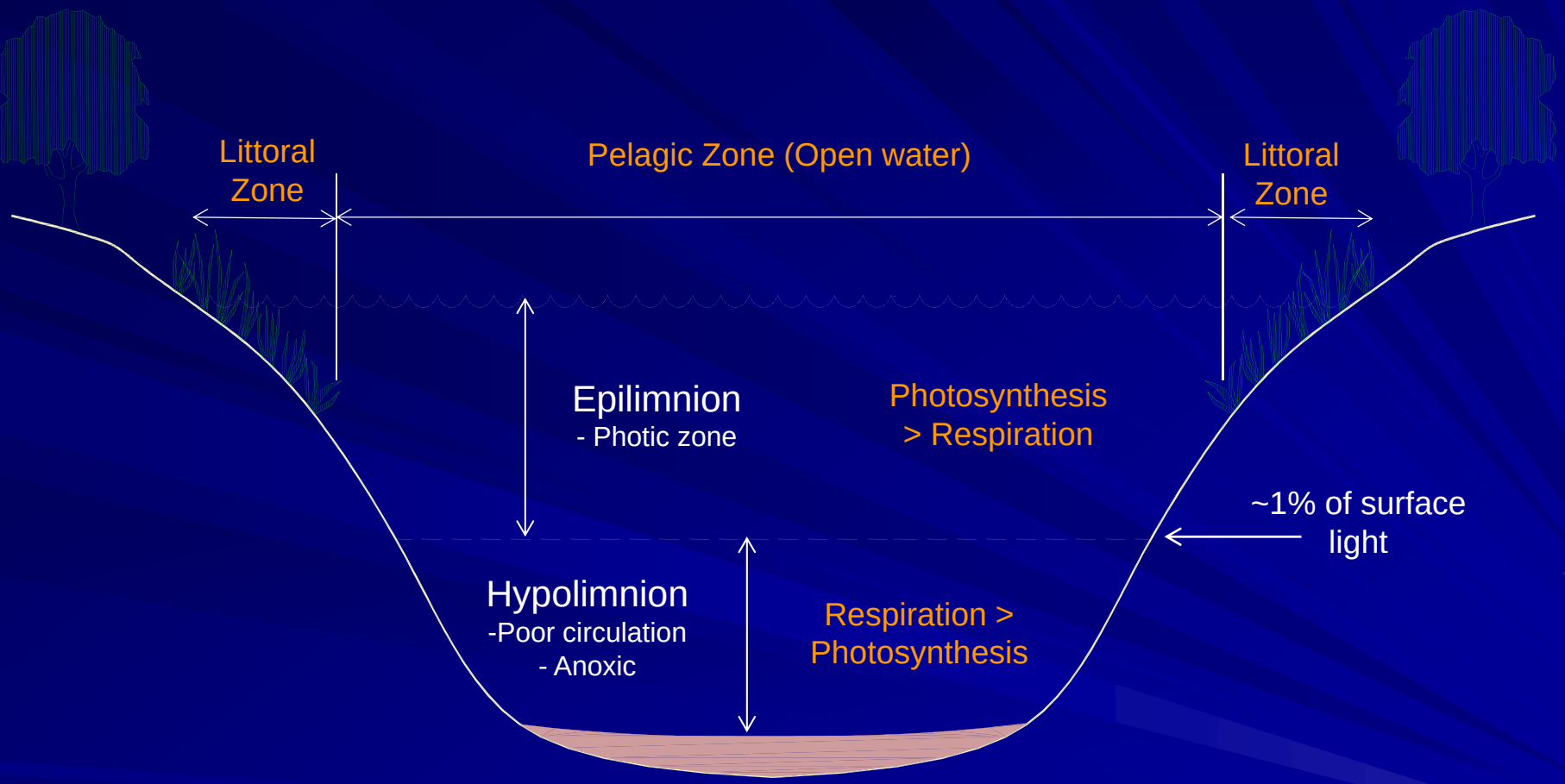
Thick unconsolidated organic muck

Unconsolidated organic muck over brown sand

Thin layer of unconsolidated organic muck over sand

Thin layer of unconsolidated organic muck over sand

Typical Zonation in a Lake



- Lakes are sinks for nutrients

- Organic matter accumulates in the bottom of lakes and undergoes decomposition
  - Nutrients are released during the decomposition

Phosphorus Bonding in Sediments

- P in lake sediments is generally bound in associations with:
  - Saloid
    - Consists of soluble P in pore water and easily exchangeable P
  - Iron and manganese
    - Direct inorganic precipitates (ex. $FePO_4$) and adsorption onto Fe/Mn oxides
    - Stability depends on redox potential
      - Bond with P is strong under oxidized conditions
      - Bond breaks apart under reduced conditions
  - Calcium
    - Primarily as inorganic precipitates
    - Becomes more significant at higher pH
    - Stability depends on pH
  - Aluminum
    - Direct inorganic precipitates (ex. AlPO4) and adsorption onto metal oxides
    - Stability depends on pH
  - Organic matter
    - Fresh matter – decomposes relatively quickly
    - Recalcitrant matter – decomposes very slowly
- Significance depends on geology of the watershed and lake

P Fractionation of Sediments

- Saloid – soluble + easily exchangeable P
- Fe Bound – sediment P bound with Fe

- Available for release
- Σ(Saloid + Fe Bound) is referred to as "Total available P"

- Al Bound – sediment P bound with Al
- Ca Bound – sediment P bound with Ca
- Organic Bound – P associated with organic matter

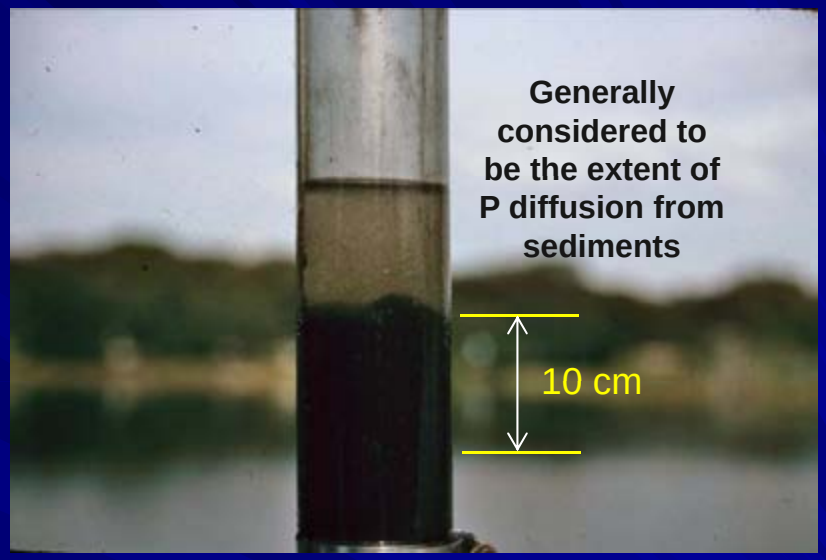
Unavailable for release

Inactivant Dose Determination

- Based on available P in sediments
- The 0-10 cm layer of the sediments is sectioned off and speciated for available P using a modification of the Chang and Jackson technique
- Sufficient inactivant is added to bind all available P in the top 10 cm
- Alum dose determined by:

Alum dose = total available P x Al:P ratio

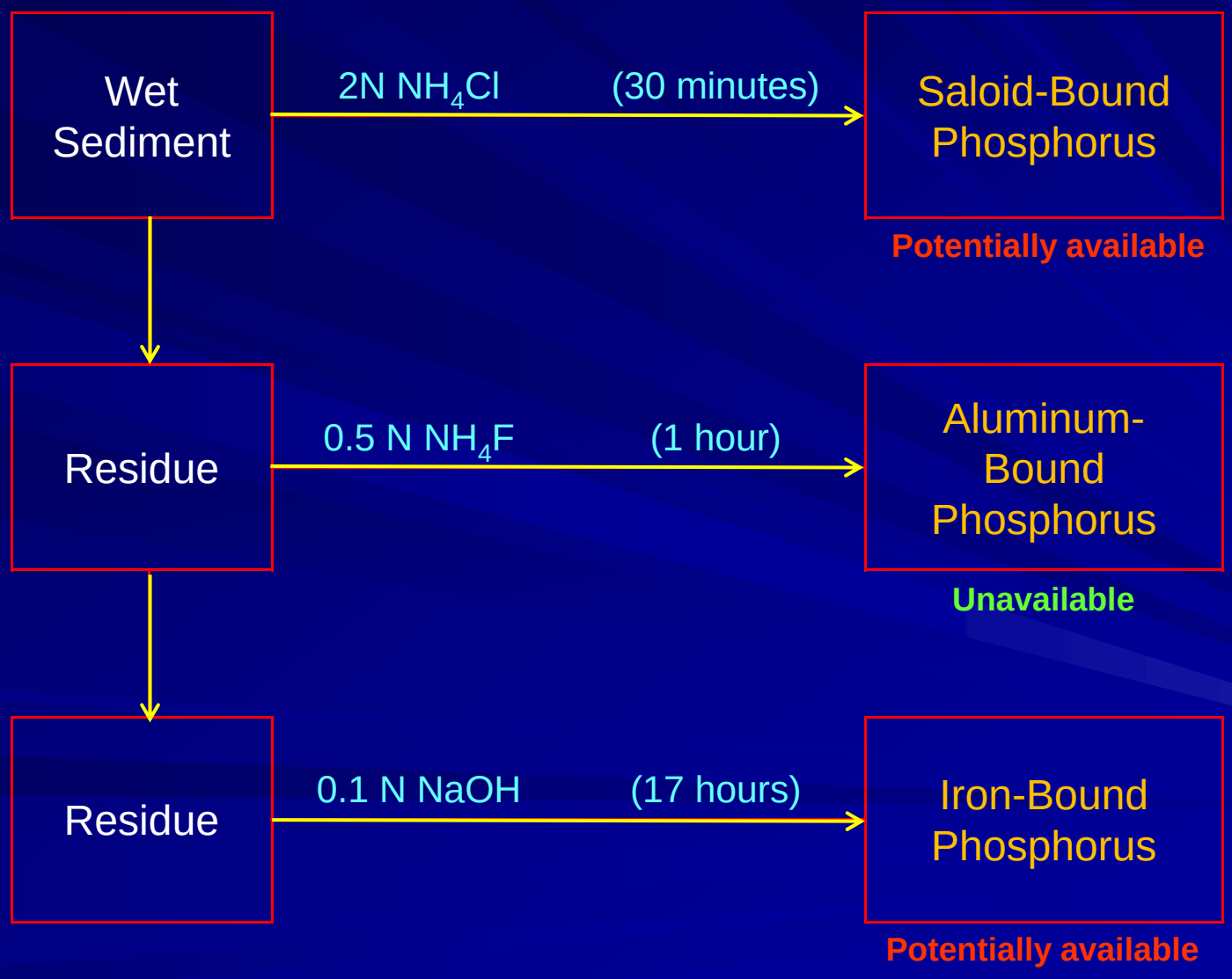
- Al:P ratio usually between 5-10



Thick, flocculent, organic sediments

Element	Electronegativity (Pauling Scale)
Fe	1.8
Al	1.6
Ca	1.3
La	1.1

Modified Chang and Jackson Speciation Procedure for Evaluating Sediment P Bonding



Isopleths of Total Available Phosphorus in the Top 10 cm of Sediments in Lake Jessamine

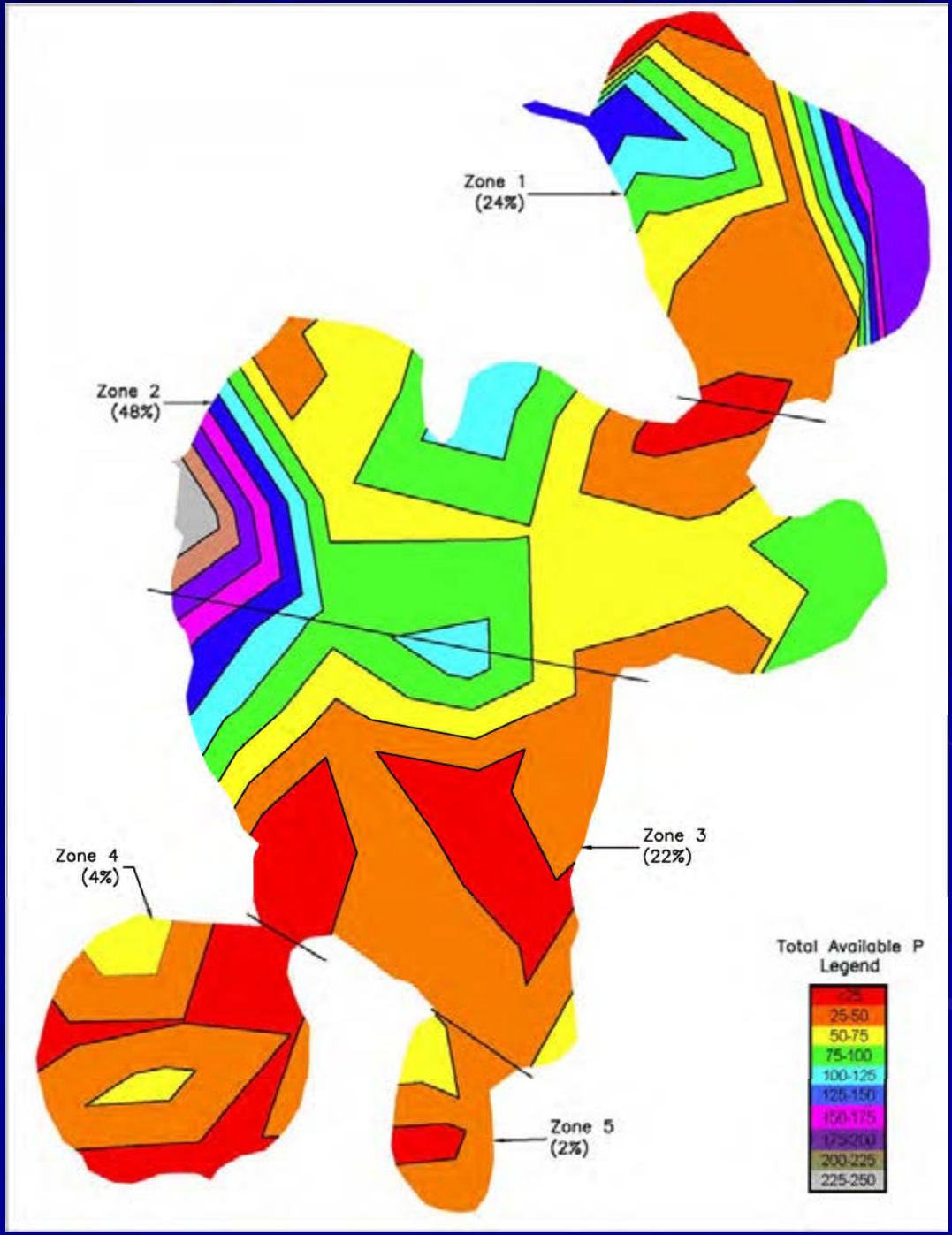
- sum of saloid + iron bound P

Internal Recycling = 139 kg total P/yr
= 43% of total inputs

Groundwater Seepage = 36 kg total P/yr
= 10% of total inputs

Combined inputs = 49%

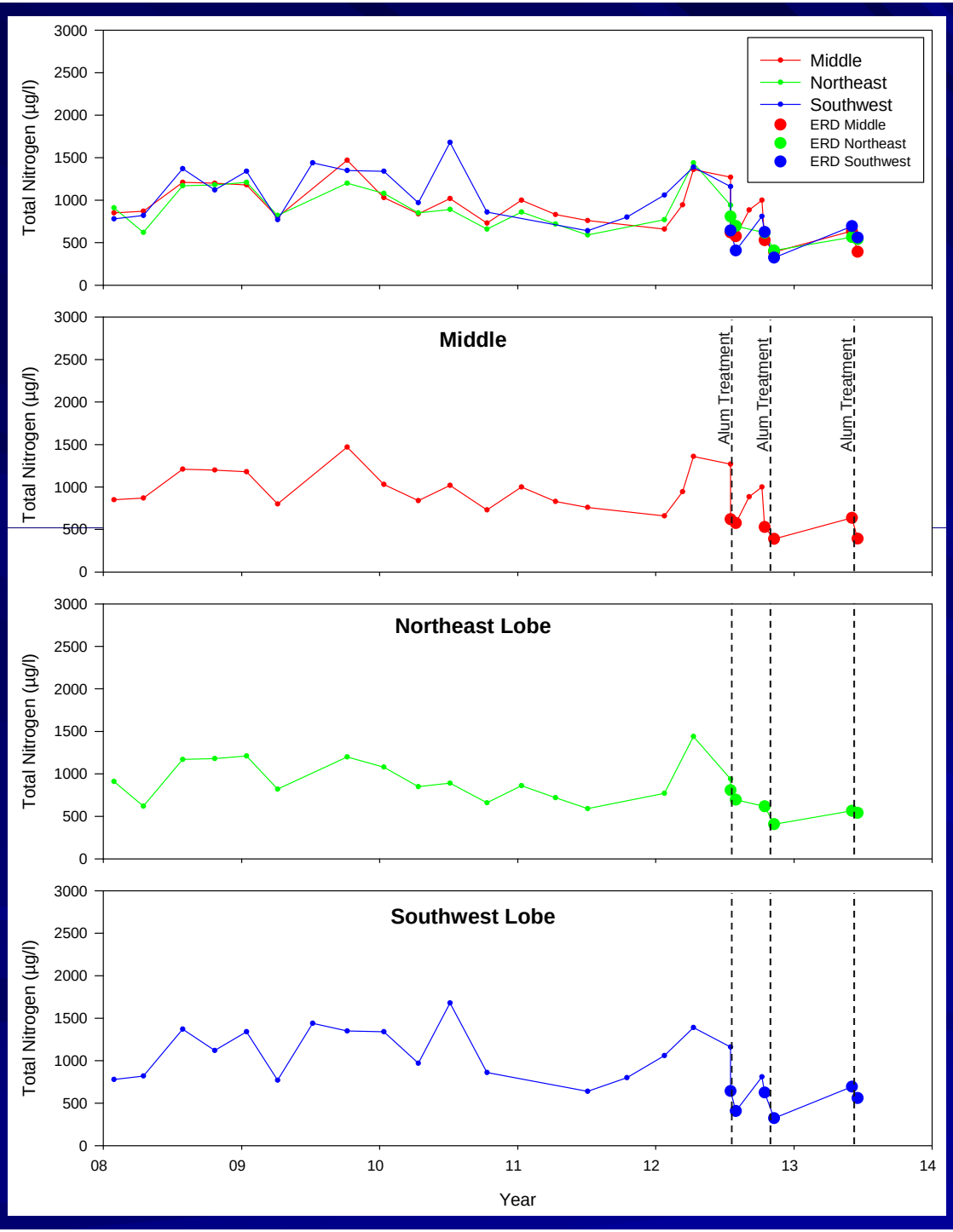
Application Map Indicating the Fraction of Total Alum to be Applied to the Identified Zones



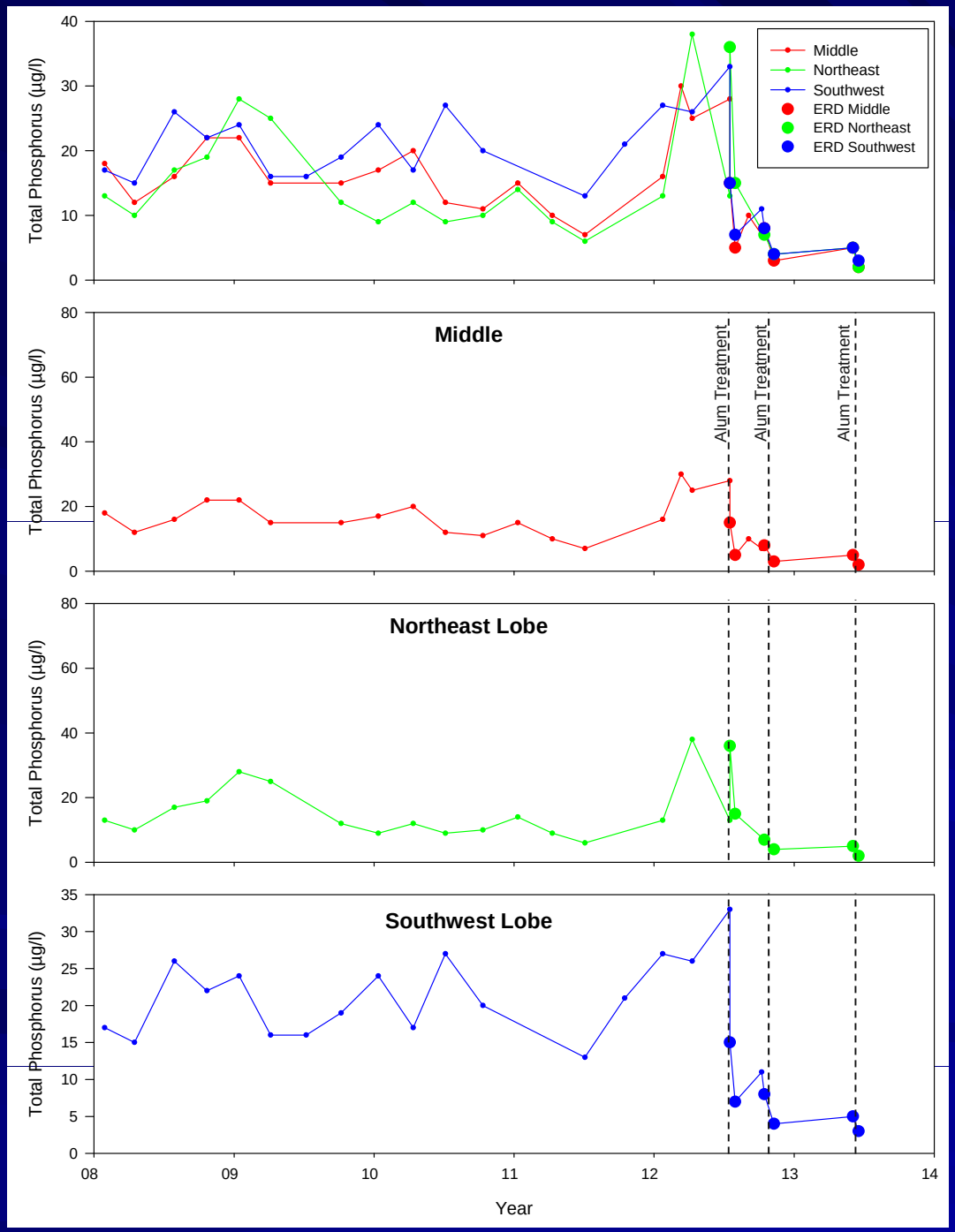
Applied Chemical Quantities for Lake Jessamine Sediment Inactivation

Zone	Fraction of Total	Alum (gallons)	Sodium Aluminate (gallons)	Gallons per Application	
				Alum	Sodium Aluminate
1	0.24	45,027	11,436	15,009	3,812
2	0.48	91,280	23,182	30,427	7,727
3	0.22	41,545	10,551	13,848	3,517
4	0.04	6,993	1,776	2,331	592
5	0.02	4,155	1,055	1,385	352
	TOTAL:	189,000	48,000	63,000	16,000

Application Boat and Tanker Barge Used for Alum Application in Lake Jessamine



Comparison of Pre- and Post-Treatment Concentrations of Total Nitrogen in Lake Jessamine



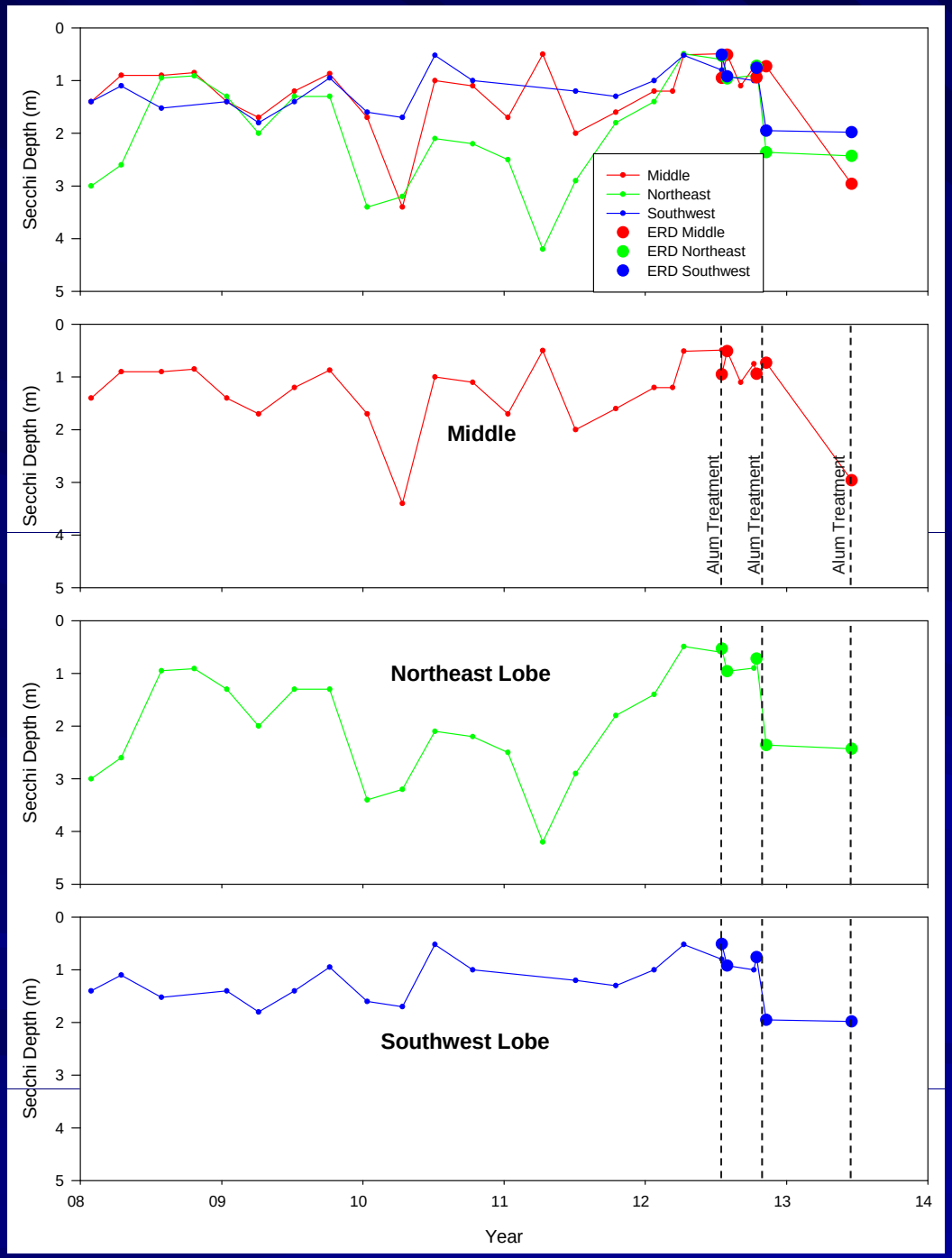
Comparison of Pre- and Post-Treatment Concentrations of Total Phosphorus in Lake Jessamine

Secchi Disk

- Secchi Disk
  - The depth at which a 20 cm disk can be viewed
    - A measure of water column transparency
    - An estimate of algal biomass in the water
    - Depth of the photic zone

Standard 20 cm Disk

Father Pietro Secchi
Scientific advisor to the Pope
(1818-1878)



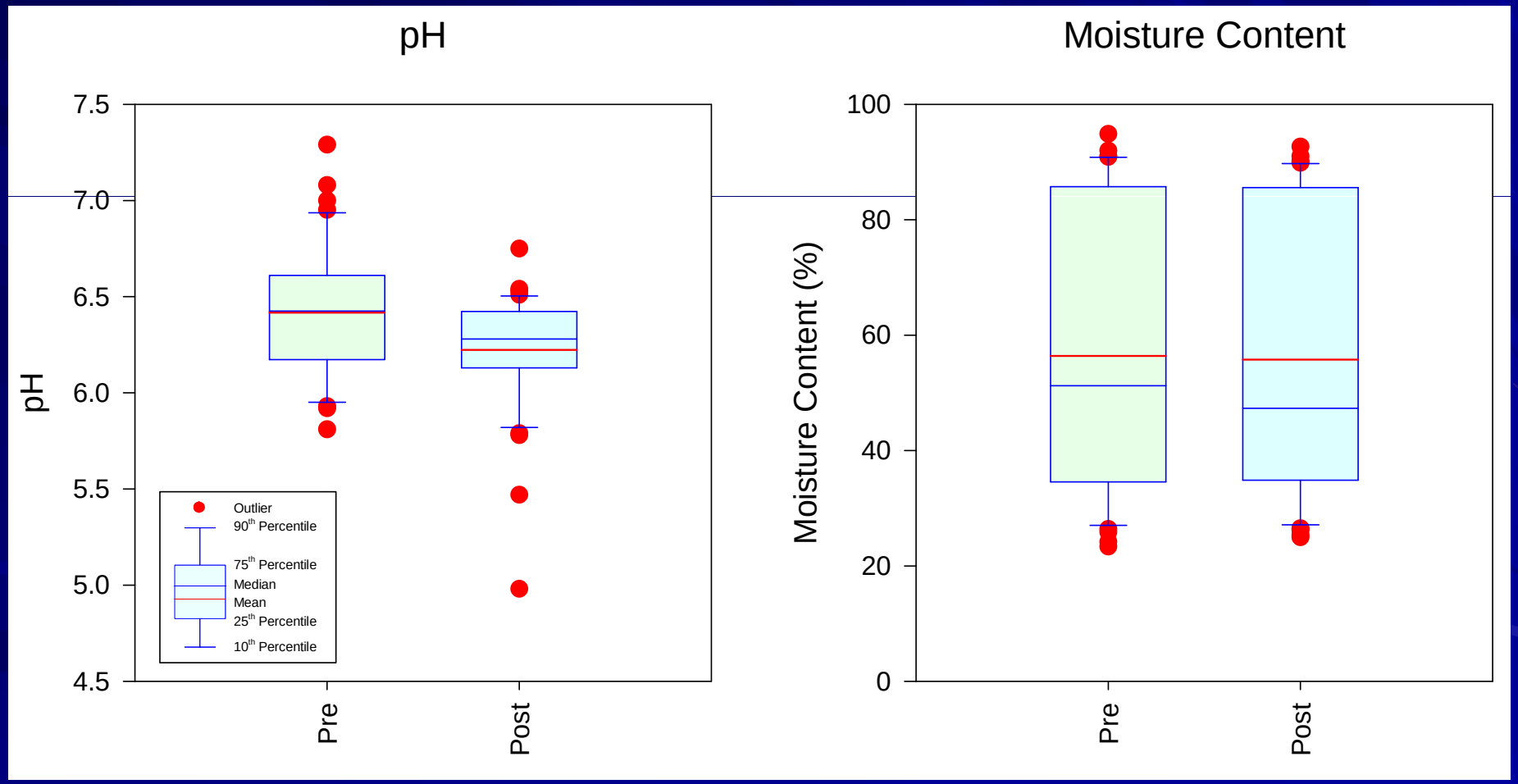
Comparison of Pre- and Post-Treatment Secchi Disk Depths in Lake Jessamine

Summary of Mean General Characteristics of Pre- and Post-Treatment Sediment Core Samples Collected in Lake Jessamine During December 2010 and September 2013

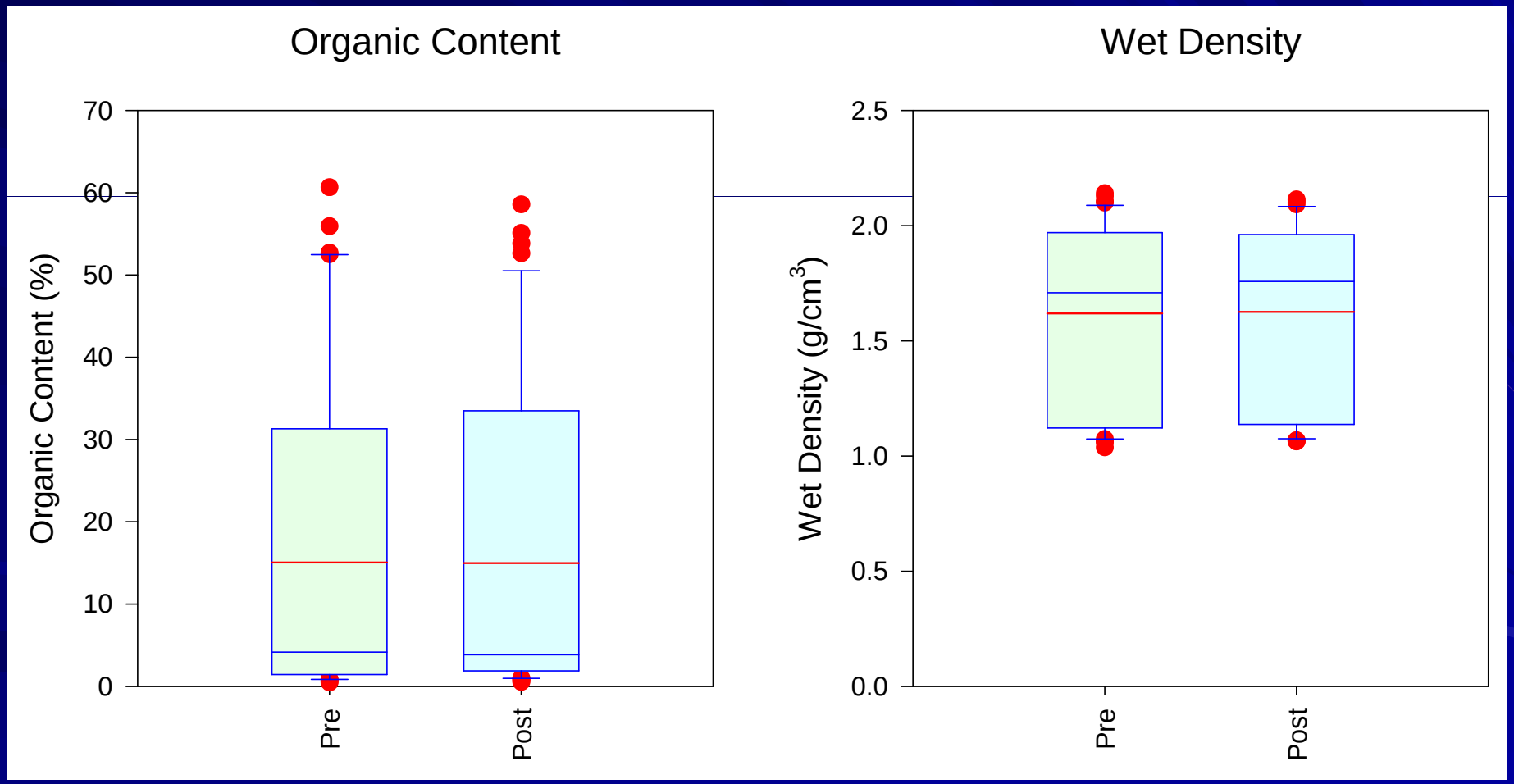
Parameter	Units	Mean Value By Sediment Collection Date[1]	
		December 2010	September 2013
pH	s.u.	6.41	6.21
Moisture Content	%	51.2	50.8
Organic Content	%	5.4	5.6
Density (wet)	g/cm^3	1.57	1.58
Total Nitrogen	$\mu g/cm^3$	1,653	1,522
Total Phosphorus	$\mu g/cm^3$	119	111

1. Reflects geometric mean values

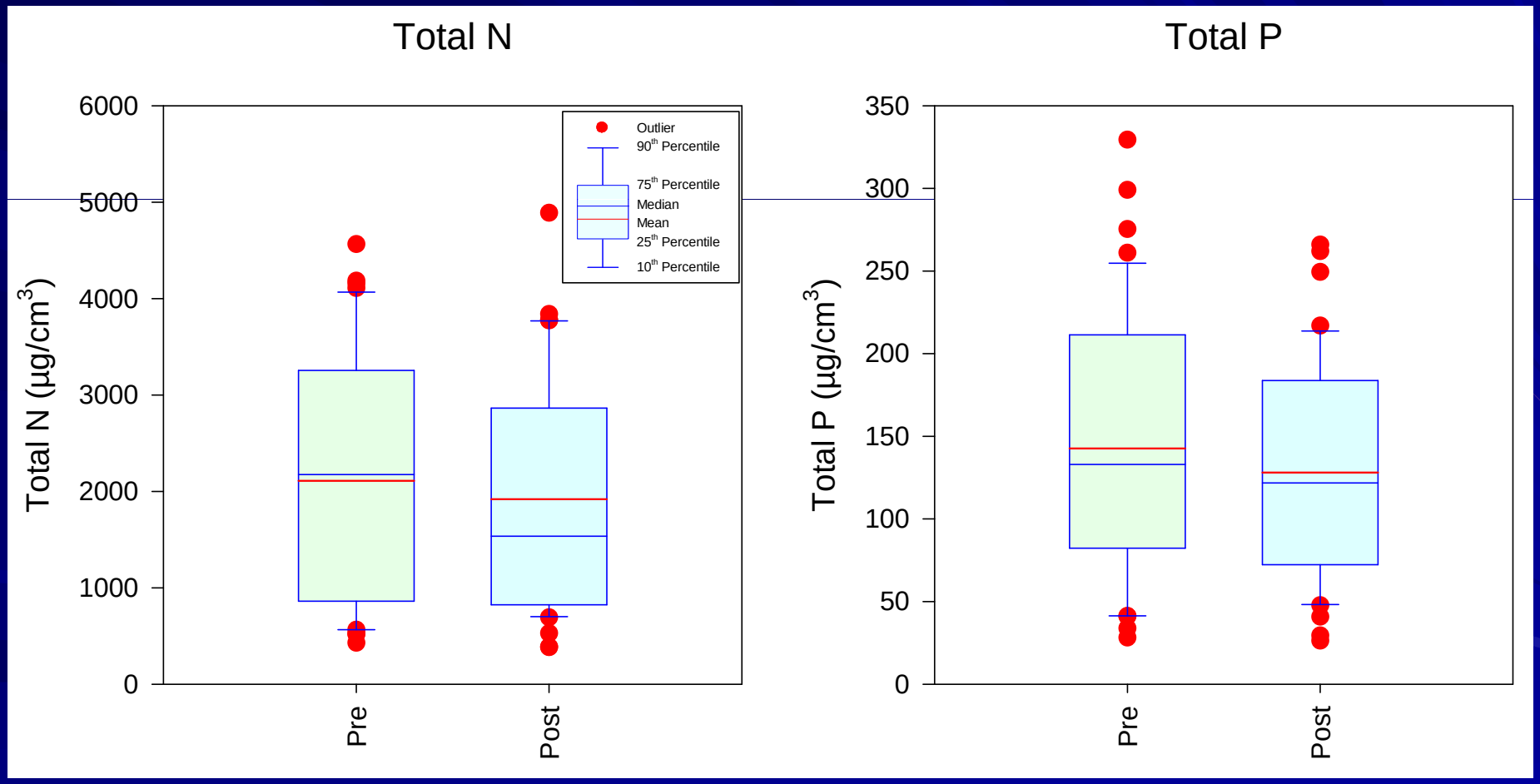
Statistical Summary of Pre- and Post-Treatment Values of pH, and Moisture Content in the Top 10 cm of Lake Jessamine Sediments



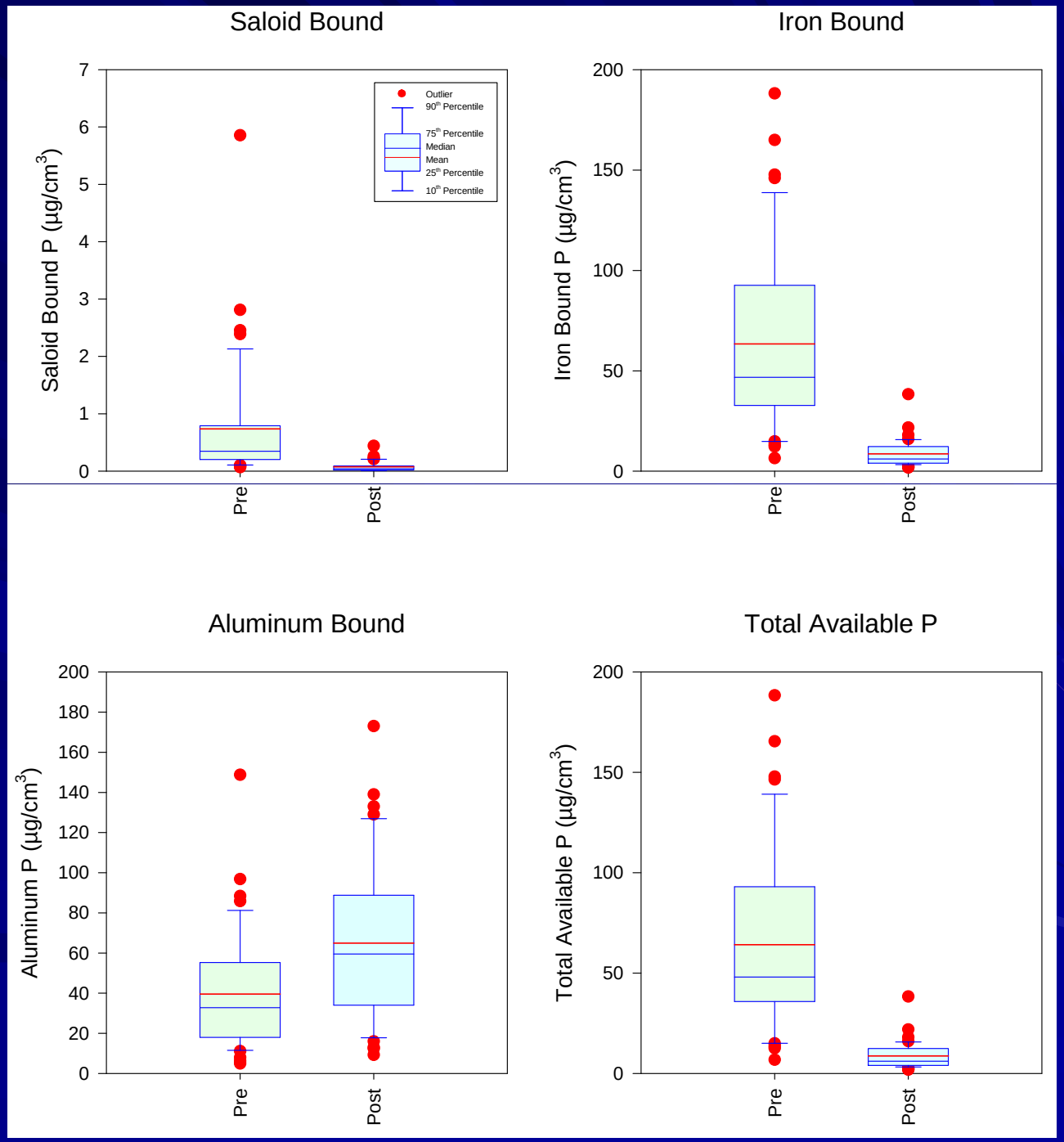
Statistical Summary of Pre- and Post-Treatment Values of Organic Content and Wet Density in the Top 10 cm of Lake Jessamine Sediments



Statistical Summary of Pre- and Post-Treatment Values of Total Nitrogen and Total Phosphorus in the Top 10 cm of Lake Jessamine Sediments



Statistical Summary of Pre- and Post-Treatment Values of Sediment Phosphorus Speciation in Lake Jessamine Sediments

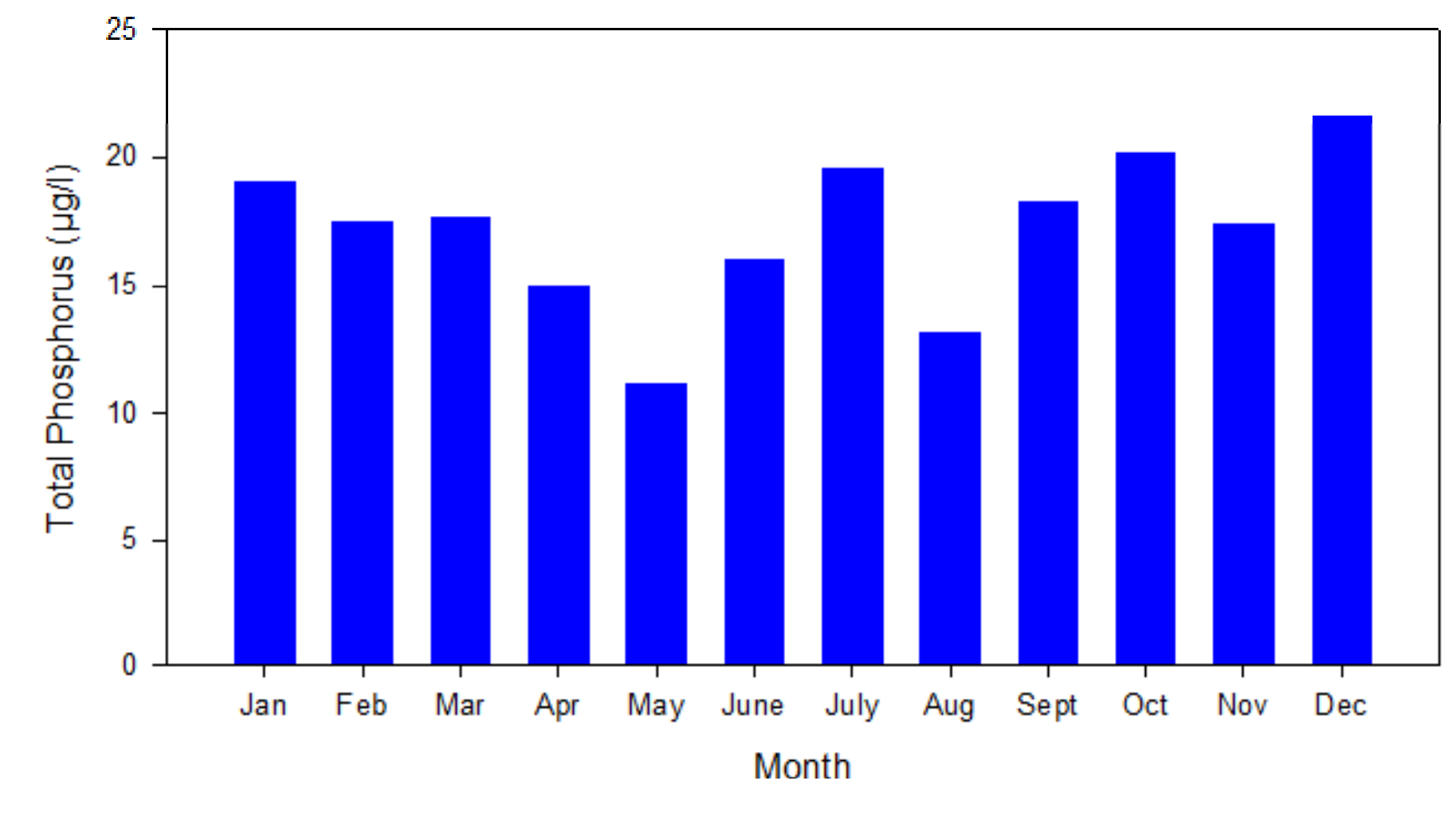


Summary of Mean Pre- and Post-Treatment Phosphorus Speciation in Sediment Core Samples Collected in Lake Jessamine

Parameter	Units	Mean Value by Sediment Collection Date[1]		Change in Concentration (%)
		Pre- (12/10)	Post- (9/13)	
Saloid-Bound P	$\mu g/cm^3$	0.41	0.05	-89
Fe-Bound P	$\mu g/cm^3$	49	7	-86
Total Available P	$\mu g/cm^3$	50	7	-86
% of Total Sediment P	%	42	6	-85
Al-Bound P	$\mu g/cm^3$	31	53	74

1. Reflects geometric mean values

Mean Monthly Concentrations of Total Phosphorus in Lake Jessamine from 1989-2009



The alum treatment will reduce P concentrations the most during dry season conditions

Summary

- Lake Jessamine is a phosphorus limited lake
  - Largest P loading is contributed by internal recycling (43% of total)
- Sediment inactivation conducted in Lake Jessamine in 3 separate applications
  - 189,000 gallons of alum
  - 48,000 gallons of sodium aluminate
- Treatment was successful in reducing available P in Lake Jessamine while increasing unavailable P bonding
  - Available P reduced by 86%
  - Aluminum bound P increased by 74%

Questions?