Summary of ENSR Report Findings & Recommendations

Robert P. Hart, January 18, 2007

Presentation Contents

- Overall ENSR Program 2001 to 2005
- 2001/2002 Study Year/Report
- 2002/2003 Study Year/Report
- 2003/2004 Study Year/Report
- 2004/2005 Study Year/Report
- 2005/2006 Study Year/Presentation

Overall ENSR Program 2001 to 2005

- **Study Years (measurements): 2001 – 2005**
- **Analysis of Prior Studies, Data Included for Comparison – 1991-2000**
- **Measurements Performed Primarily Apr.-Nov.**
  - In-lake (LP-1 Markham's Bay, LP-2 Oakwood, LP-15 South Area)
  - Watershed tributaries, near lake only (LP-3 to LP-14)
- **Reports Issued in Spring of Following Year**
  - Include tests, findings, recommendations for solutions
  - Main (largest) report on 2001 data issued in 2002.


LP-6
LP-8
LP-12
LP-5
LP-7
LP-2
LP-1
LP-14
LP-4
LP-13
LP-9
LP-15
LP-10
LP-3
LP-11
Lake Pocotopaug
Pocotopaug Lake
Twin Islands
Loos Pond
Strong Pond
Hutchinson Pond
East Hampton

Presentation Contents

- Overall ENSR Program 2001 to 2005
- **2001/2002 Study Year/Report**
- 2002/2003 Study Year/Report
- 2003/2004 Study Year/Report
- 2004/2005 Study Year/Report
- 2005/2006 Study Year/Presentation

2001 Study Year Prior Studies

- **Analysis of Prior Studies**
  - Frink and Norvell (1984) – Covers 1973-74, 1979-80
    - Total Phosphorous (**TP**) – **21 µg/L** (73-74), **25 µg/L** (79-80)
    - Secchi Disk Transparency (**SDT**) – **12 feet**
  - Fugro-McClelland (1993) – Covers 1977, 1987-93
    - 1977 – Mild Anabaena bloom and small fish kill (~50 perch)
    - 1987-89 – Baker Hill Condo Dev lake pollution
    - 1988 – Diatom algae bloom (reported as “oil slick”)
    - 1990 – Severe Anabaena algae bloom late summer

2001 Study Year Prior Studies

- **Analysis of Prior Studies, continued…**
  - Fugro-McClelland (1993) – continued…
    - 1992-93 Study – Ext. **P**-Loading **1263 lbs**, Internal **1099 lbs**
    - Recommend Algacide, Alum, Aeration, Biomanipulation, Watershed Management as set forth by AHLAC
  - WMC Consulting Engineers (1995)
    - Stormwater Renovation and Management Study - $3M+ drainage systems renovations, 76 specific improvements

2001 Study Year Prior Studies

- **Analysis of Prior Studies, continued…**
  - Ad Hoc Lake Advisory Committee (AHLAC) (1995)
    - 3 Reports
    - "Land Use and Phosphorous Input to Lake Pocotopaug"
      - Models transparency from P-loading and trends from changing land use, suggests land use changes
      - External **P**-Loading **1289 lbs/yr**; Watershed 791 lbs/yr (61%); atmosphere & waterfowl 498 lbs/yr (39%)
    - "Taxes and Water Quality"
      - Town tax policy encourages development; recommend watershed tax relief policy change

2001 Study Year Prior Studies

- **Analysis of Prior Studies, continued…**
  - Ad Hoc Lake Advisory Committee (AHLAC) (1995), continued…
    - "Lake Pocotopaug Management Recommendations"
      - Establish a permanent Lake Advisory Committee
      - Reduce external nutrient and sediment inputs from watershed; reduce internal nutrient recycling
      - Implement land use controls to reduce inputs

2001 Study Year Major Event History

- **Major Events**
  - December 1999 – Fish Kill, unknown cause
  - June 2000 - Alum Treatment, 22 of 177 acres/Fish Kill
    - Probable cause: too much sodium aluminate (for pH control), reduce mix with alum (aluminum sulfate)
  - April 2001 – ENSR Study and Publication
    - "Analysis of Phosphorus Inactivation Issues at Lake Poc."
  - June 2001 – Alum Treatment, 150 acres
    - Change ratio from 1.4 to 2.0; used ½ the application rate
    - No problems; reports of clear water until August bloom

2001 Study Year Major Event History

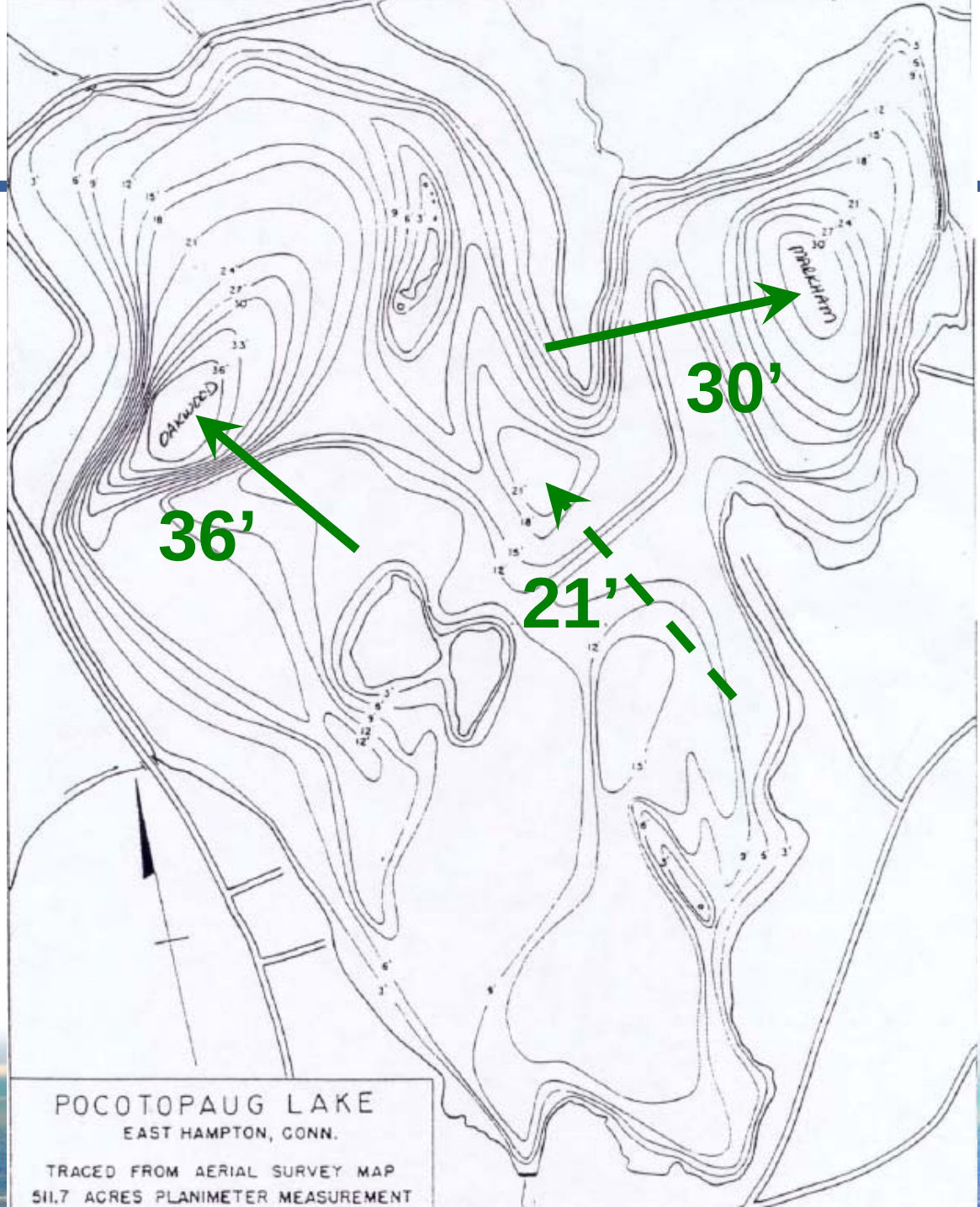
- **Major Events, continued…**
  - January 2002 – Fish Schooling
    - White & yellow perch in thousands in Christopher and Hales Brooks, shortly after ice formed; fish did not appear stressed
    - Water sample tests (Jan. 3, 2002) showed no water problems

2001 Study Year Major Event History

- **Major Events, continued…**
  - 1992-2001 – Volunteer Lake Study Group Publications
    - Annual in-lake water sampling 1991-2000
      - Minimum **S**ecchi **D**isk **T**ransparencies – **1.3 to 5.6 feet**
      - Average **S**ecchi **D**isk **T**ransparencies - **3.9 to 9.0 feet**
      - Max. Surface **P**hosphorus – **18 to 36 µg/L**
      - Late Summer Bloom Duration – 4 to 13 weeks

2001 Study Year System Features

- **Watershed & Lake Features**
  - Watershed Area – 2381 acres; Lake Area – 512 acres
    - 4.7 to 1 ratio (low)
    - Approx. 172 acres experience summer thermal stratification
  - Lake Water Volume – 7.1 Million cubic meters
    - Avg Input (all sources) – 9 Mil m^3, yields 1.3/yr flushing rate
  - Depth Average – 11 feet
    - Deep Spots: LP1 - Markham's Bay (30 ft); LP2 - Oakwood (36 ft)


30’
36’
21’
POCOTOPAUG LAKE
EAST HAMPTON, CONN.
TRACED FROM AERIAL SURVEY MAP
511.7 ACRES PLANIMETER MEASUREMENT

2001 Study Year Findings

- **Primary 2001 Findings**
  - In-Lake Water Quality (see graphs)

"Lake Pocotopaug exhibits lower SDT than predicted based on TP concentrations. Either SDT is limited by non-algal turbidity and/or phytoplankton are present in moderate to high densities even with limited phosphorus availability."

  - Lower **SDT** (water clarity) than predicted from **TP** levels.
  - Either due to non-algal turbidity or unusually low nutrient requirement by algae.

Figure 14. 2001 Surface Water Phosphorus vs. Secchi Disk Transparency

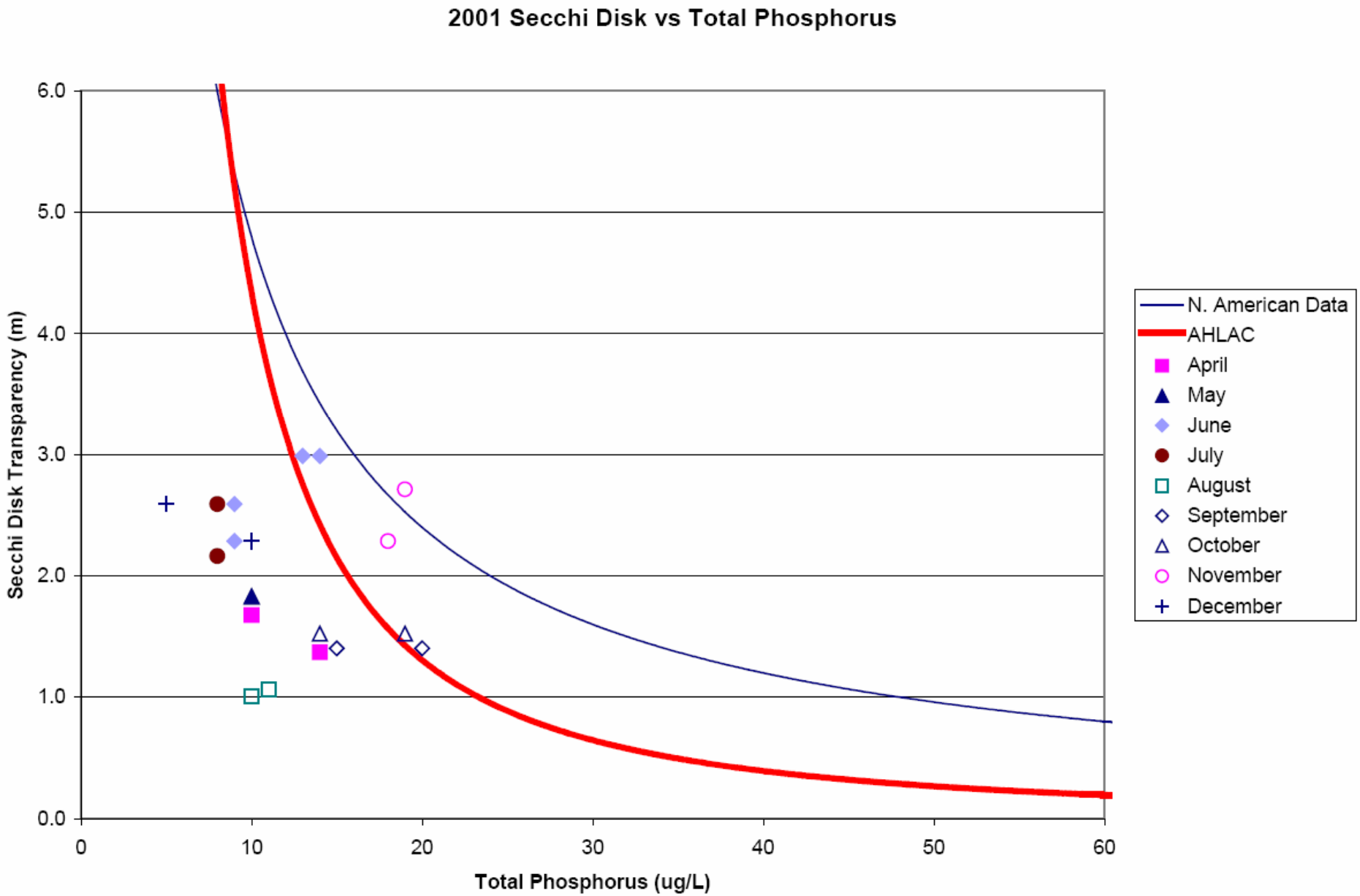
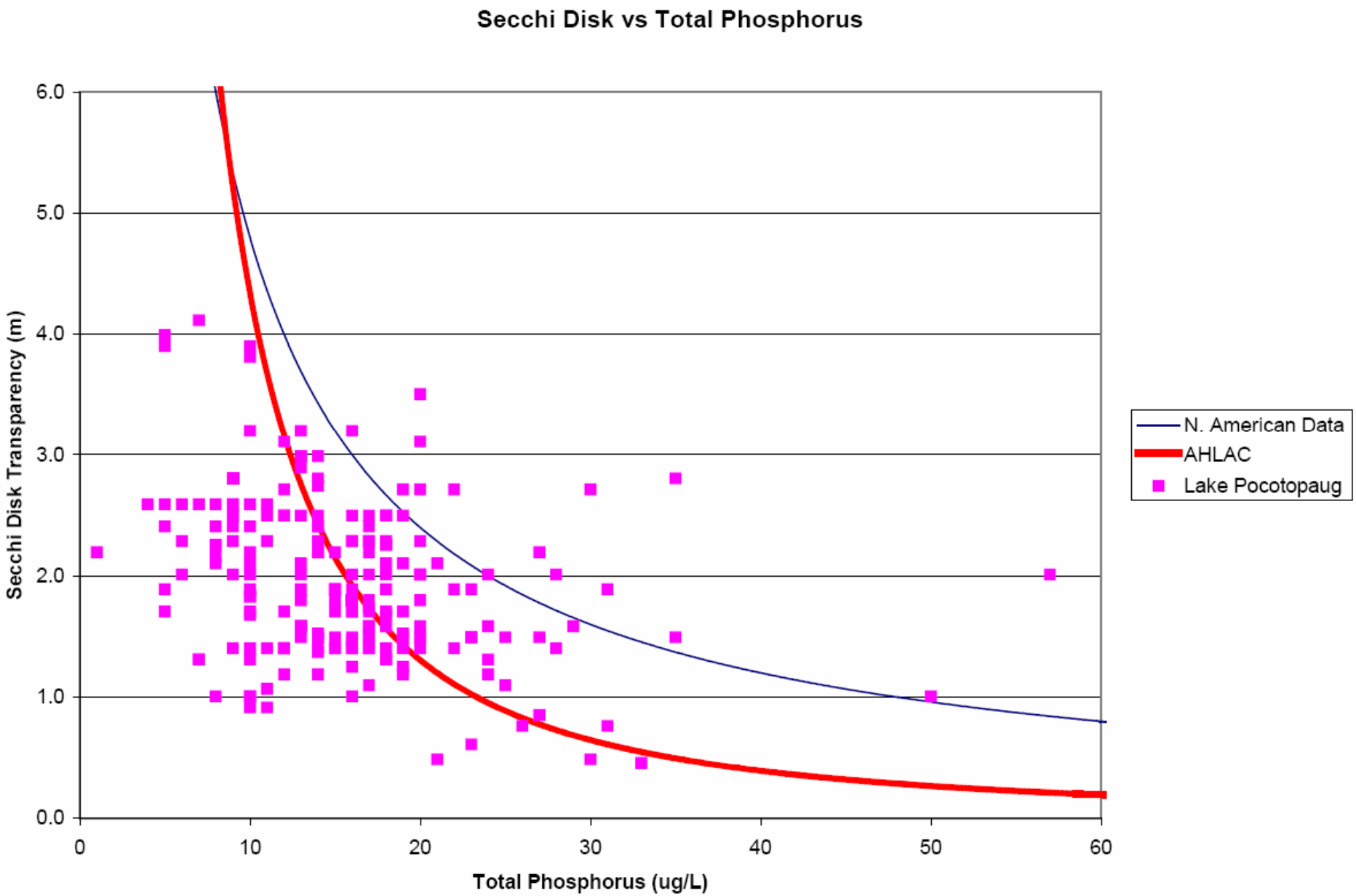
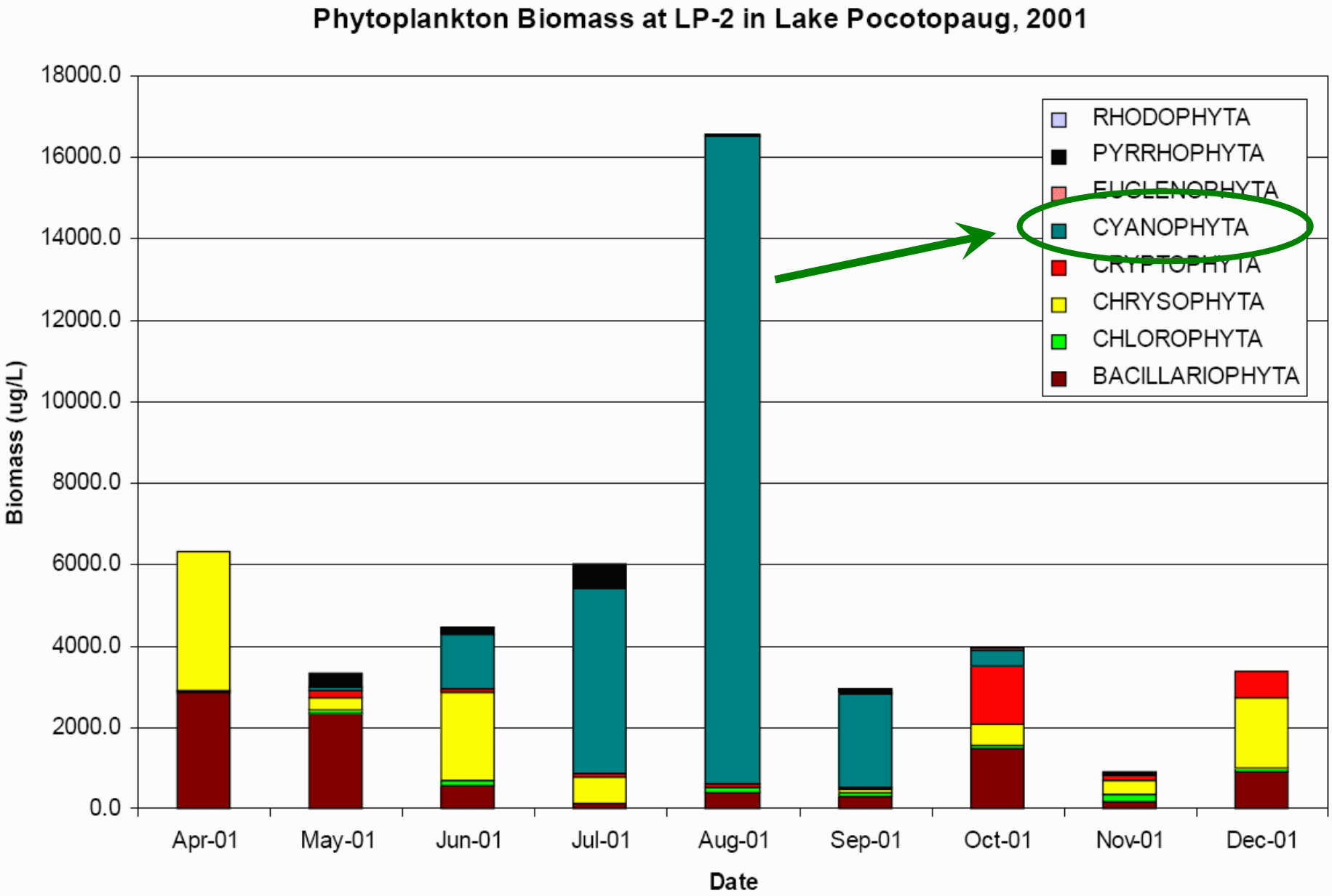


Figure 13. 1991-2001 Surface Water Phosphorus vs. Secchi Disk Transparency



2001 Study Year Findings

- **Primary 2001 Findings**
  - In-Lake Biology - Zooplankton
    - Feed on algae; eaten by small fish
    - Levels best in spring, very low in summer
    - Sizes too small to eat large filamentous algae (Anabaena)
  - In-Lake Biology – Phytoplankton (see graph)


Phytoplankton Biomass at LP-2 in Lake Pocotopaug, 2001
Biomass (ug/L)
18000.0
16000.0
14000.0
12000.0
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Date
RHODOPHYTA
PYRRHOPHYTA
EUGLENOPHYTA
CYANOPHYTA
CRYPTOPHYTA
CHRYSOPHYTA
CHLOROPHYTA
BACILLARIOPHYTA

2001 Study Year Findings

- **Primary 2001 Findings**
  - Tributary and Storm Drain Water Quality
    - Some test locations show very high phosphorus levels, mostly under wet weather conditions (see tables)
      - LP-6 Candlewood Brook
      - LP-9 Storm drains, end of Hawthorne and Emerson Rd.
      - LP-10 O'Neil's Brook
      - LP-12 Storm drain bottom of Mohican, Wangonk Trail
      - LP-13 Storm drainage swale, end of Park Street

Table 12 continued. 2001 Dry and Wet Weather Tributary and Storm Drain Data.

		Ammonium-N (mg/L)		Nitrate-N (mg/L)		TKN (mg/L)		Total Phosphorus (mg/L)		Dissolved Phosphorus (mg/L)	
Station		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
LP-3	Mar	0.050	0.050	0.50	0.30	0.10	0.10	0.010	0.030	0.005	0.005
	May	0.042	0.010	0.34	0.11	0.22	2.29	0.008	0.196	0.004	0.007
	Jun	0.023		0.15		0.45		0.010		0.004	
	Aug	0.050	0.102	0.13	0.13	0.30	0.38	0.021	0.027	0.014	0.012
	Sept		0.010		0.26		1.16		0.108		0.012
LP-4	Mar		0.050		2.00		0.20		0.100		0.070
	May										
	Jun										
	Aug		0.093		0.33		1.38		0.210		0.104
	Sept		0.098		0.01		0.83		0.196		0.022
LP-5	Mar	0.050	0.050	0.20	0.10	0.10	0.10	0.005	0.300	0.005	0.070
	May	0.005	0.023	0.15	0.05	0.12	0.89	0.008	0.084	0.003	0.006
	Jun	0.025	0.005	0.07	0.01	0.20	0.88	0.009	0.098	0.004	0.006
	Aug	0.010	0.013	0.22	0.29	0.21	0.25	0.008	0.011	0.001	0.001
	Sept	0.014	0.045	0.26	0.24	0.18	0.36	0.003	0.019	0.002	0.011
LP-6	Mar	0.050	0.050	0.30	0.30	0.10	0.20	0.450	0.100	0.005	0.080
	May	0.030	0.023	0.05	0.07	0.25	4.80	0.021	0.590	0.009	0.013
	Jun	0.010	0.010	0.08	0.23	0.36	0.88	0.021	0.255	0.005	0.019
	Aug	0.013		0.07		0.20		0.017		0.005	
	Sept		0.045		0.24		0.54		0.053		0.050
LP-7	Mar	0.050	0.050	0.10	0.05	0.10	0.10	0.080	0.300	0.020	0.060
	May	0.060	0.010	0.03	0.01	0.44	3.05	0.036	0.335	0.010	0.027
	Jun	0.033		0.01		0.39		0.015		0.006	
	Aug										
	Sept		0.170		0.23		0.59		0.047		0.020

Table 12 continued. 2001 Dry and Wet Weather Tributary and Storm Drain Data.

		Ammonium-N (mg/L)		Nitrate-N (mg/L)		TKN (mg/L)		Total Phosphorus (mg/L)		Dissolved Phosphorus (mg/L)	
Station		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
LP-8	Mar	0.050	0.050	0.50	0.50	0.10	0.10	0.030	0.200	0.020	0.070
	May	0.015	0.010	0.01	0.16	0.21	1.77	0.026	0.137	0.002	0.007
	Jun	0.010	0.011	0.01	0.10	0.28	1.77	0.012	0.203	0.001	0.012
	Aug										
	Sept		0.026		0.63		0.84		0.112		0.027
LP-9	Mar										
	May	0.021	0.113	2.75	0.01	0.18	5.08	0.234	0.770	0.185	0.135
	Jun		0.034		0.26		4.76		1.245		0.028
	Aug		0.039		1.29		0.38		0.063		0.011
	Sept		0.026		0.76		0.22		0.034		0.030
LP-10	Mar	0.050	0.050	0.30	0.05	0.10	0.40	0.260	0.070	0.005	0.005
	May	0.206	0.034	0.29	0.20	0.44	7.80	0.026	1.210	0.007	0.014
	Jun	0.117	0.025	0.15	0.33	0.70	2.96	0.058	1.070	0.016	0.029
	Aug		0.143		0.96		3.66		0.706		0.024
	Sept		0.091		0.61		0.85		0.075		0.070
LP-11	Mar	0.050	0.050	0.05	1.30	0.10	0.50	0.010	0.040	0.005	0.030
	May	0.063	0.091	0.01	0.09	0.56	1.35	0.012	0.084	0.008	0.017
	Jun	0.049	0.011	0.01	0.01	0.79	1.70	0.022	0.196	0.008	0.015
	Aug										
	Sept		0.032		0.40		0.90		0.206		0.040
LP-12	Mar	0.050	0.050	2.10	1.90	0.10	0.40	0.060	0.080	0.030	0.050
	May		0.113		0.01		9.08		0.925		0.031
	Jun	0.049		1.27		0.32		0.013		0.001	
	Aug		0.132		0.51		1.30		0.162		0.095
	Sept		0.072		0.01		0.87		0.079		0.060

Table 12 continued. 2001 Dry and Wet Weather Tributary and Storm Drain Data.

		Ammonium-N (mg/L)		Nitrate-N (mg/L)		TKN (mg/L)		Total Phosphorus (mg/L)		Dissolved Phosphorus (mg/L)	
Station		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
LP-13	Mar										
	May		0.113		0.01		22.95		3.010		0.012
	Jun	0.035		0.33		0.38		0.007		0.006	
	Aug		0.032		0.12		1.74		0.124		0.014
	Sept										
LP-14	Mar										
	May										
	Jun										
	Aug		0.110		0.40		1.73		0.198		0.041
	Sept		0.032		0.01		0.60		0.120		0.082
28	Mar	0.050	0.050	3.20	0.40	0.10	0.60	0.020	0.090	0.005	0.030
	May										
	Jun										
	Aug										
	Sept										

2001 Study Year Findings

- **Primary 2001 Findings**
  - Attempt to relate precipitation levels to problems
    - No significant relationship between precipitation and all measured parameters, including phosphorus and water clarity, except for chlorophyll-a during summer only.

2001 Study Year Findings

- **Primary 2001 Findings**
  - **P**hosphorus Loading Summary
    - Varies with weather from **620** to **1900 lbs/yr**
    - Watershed: 50 to 73%
    - Ground water & precipitation: 9 to 17%
    - Waterfowl: 6 to 11%
    - Internal loading: 12 to 22%

2001 Study Year Findings

- **Primary 2001 Findings**
  - Diagnostic Summary

"Nutrient levels are generally low, and are typically below the level below at which algal blooms are generally found. However, Lake Pocotopaug is unusual in this regard. Algal blooms are present even under this relatively low phosphorus condition. Reducing the surface water phosphorus concentration by 60%, about the maximum it is reasonable to expect, is predicted to result in phosphorus concentrations between 7 – 11 ug/L (as opposed to the current 10-22 ug/L), a level at which blooms may still occur in Lake Pocotopaug."

  - Low nutrient levels, less than normally cause blooms - Lake Pocotopaug unusual in this regard
  - A 60% reduction of **TP** from **10-22** to **7-11 ug/L** is still likely to allow blooms

2001 Study Year Findings

- **Primary 2001 Findings**
  - Diagnostic Summary, continued…

    "There is no "smoking gun" in the watershed. Excessive nutrient concentrations are found in all tributaries and storm drains, although runoff from developed areas tends to provide the highest values. …the major tributaries are suspect due to the higher portion of the load they contribute."

    - "There is no "smoking gun" in the watershed."
    - Most nutrients from developed area tributaries and storm drains, especially major tributaries

2001 Study Year Findings

- **Primary 2001 Findings**
  - Diagnostic Summary, continued…

    "Disturbance of sediments in the shallow basin could influence whole lake water clarity, could provide nutrients to support algal growth, and should be investigated as a potential source."

    - Investigate shallow basin sediment disturbance as potential nutrient source

2002 Report Recommendations

- **ENSR 2002 Recommendations**

  "Watershed management is the crux of controlling incoming sediment and nutrients. This should include both source controls and transport mitigation techniques, with the objective of reducing inputs to the maximum degree possible. In-lake techniques may be necessary to abate past inputs, as with the 2001 alum treatment. Additional in-lake measures may aid achievement of the desired conditions, including additional alum treatment (if warranted by further investigation) and adjusting the fish community to foster larger and more zooplankton to more effectively graze available algae."

  - Watershed management to reduce incoming sediment and nutrients using both source controls and transport mitigation
  - In-Lake techniques needed to abate past inputs
    - Additional alum treatment
    - Walleye stocking

2002 Report Recommendations

- **ENSR 2002 Recommendations**
  - Management Options For Control Of Algae
    - 18 suggested control techniques are described (but not necessarily recommended)
      - Physical Controls (8)
      - Chemical Controls (6)
      - Biological Controls (4)

2002 Report Recommendations

- **ENSR 2002 Recommendations**
  - Source Controls
    - Education of residents followed by…
      - Septic tank maintenance
      - Low-impact landscaping and lawn maintenance
    - No-Phosphorus Fertilizer Ordinance
      - Lawn fertilizer demonstrated in many studies to be the most major contributor of phosphorus from residential areas.

2002 Report Recommendations

- **ENSR 2002 Recommendations**
  - Transport Mitigation
    - Installation of deeper, larger catch basins as roads are re-worked
    - Maintenance of all coarse sediment and debris traps
    - Expansion of existing and new detention systems
    - Use of wetland features, establishment of infiltration chambers
    - Increasing frequency of street sweeping and catch basin cleaning, emphasis on early spring cleaning

2002 Report Recommendations

- **ENSR 2002 Recommendations**
  - In-Lake Actions
    - Further alum treatment, if other untreated areas turn out to be significant sources of phosphorus
    - Monitor zooplankton and walleye populations and sizes and if needed, continue walleye stocking
    - Continued Monitoring Program
      - In-lake and watershed water quality
      - Algal and fish monitoring and assays
      - Associated analysis and reporting

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2002 Study Year Tests

- **Test Types Performed**
  - In-Lake – June to September
    - LP2 (Oakwood), LP15 (South area)
    - Nutrients, SDT, etc.
    - Temperature & D.O. profiles
    - Phytoplankton
      - Attempt to find onset of bloom for copper treatment
    - Zooplankton
  - Laboratory Algal Assay

2002 Study Year Findings

- **Primary 2002 Findings**
  - In-Lake
    - D.O. (dissolved oxygen) and temperature profiles track and show mild thermal stratification
    - Nitrogen nutrients low to medium, minor differences from prior years
    - **TP 20 ug/L**, higher than 2001, **13 ug/L**
    - **SDT** from **3.0** to **6.5 ft**, compares to 2001 min **3.3 ft**

2002 Study Year Findings

- **Primary 2002 Findings**
  - In-Lake, continued…
    - Phytoplankton – see 2003 findings (similar)
    - Zooplankton – see 2003 findings (similar)

2002 Study Year Study Findings

- **Primary 2002 Findings**
  - Laboratory Algal Assay
    - Algal assay with Lake Pocotopaug water to determine if algal growth could be minimized by reducing phosphorus concentrations through dilution
    - Total of 40 tests – 2 water types x 5 mixtures x 4 replicates
    - Surface waters promoted algal (Anabaena) growth unless diluted by very large amount (>10 to 1)
    - Bottom waters did not support algal growth, regardless of dilution

2003 Report Recommendations

- **ENSR 2003 Recommendations**
  - **“Alternatives are limited at this time.”**
    - Alum treatment to further inactivate P in sediment - highly speculative, expensive
    - Aeration of the bottom waters, very expensive
    - Continuing biomanipulation using walleye to control panfish, encourage zooplankton
      - Not likely to provide consistent and strong control of this algal species
    - **“The copper treatment is therefore recommended.”**

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2003 Study Year Tests

- **Test Types Performed**
  - In-Lake – April to September
    - LP2 Only (Oakwood)
    - Nutrients, SDT, etc.
    - Temperature & D.O. profiles
    - Phytoplankton
      - Attempt to find onset of bloom for copper treatment
    - Zooplankton

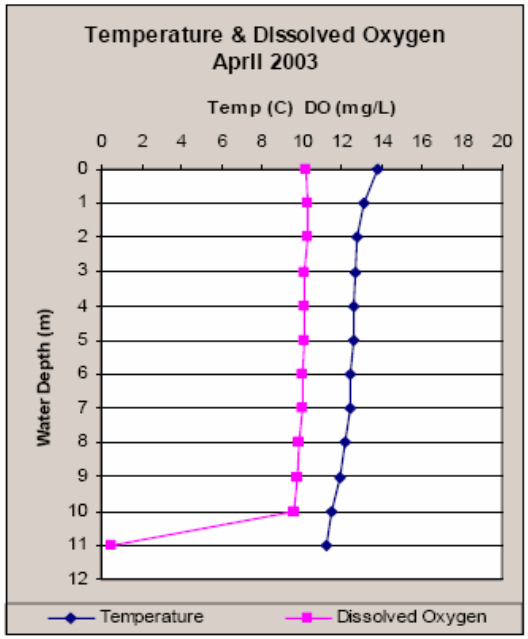
2003 Study Year Tests

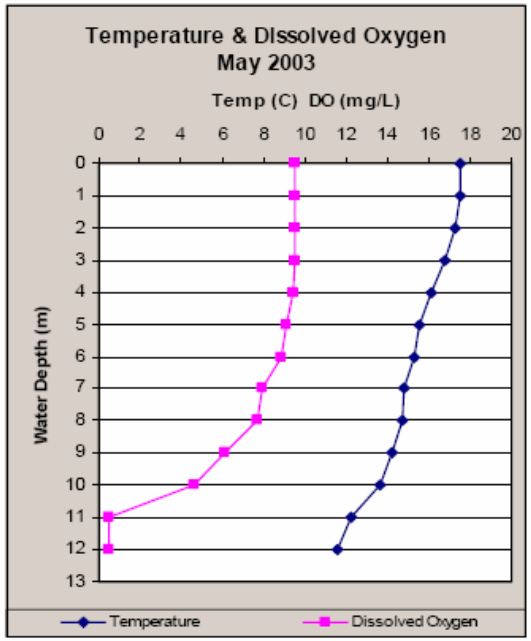
- **Test Types Performed, continued…**
  - Watershed Tributaries – September
    - Dry weather nutrients - LP-3, 5, 10
    - Wet (first flush) weather nutrients - LP-3, 4, 5, 10
    - Post-wet weather nutrients - LP-3, 5, 7, 10, 11
    - Efficacy of new Stormceptors® (2)
      - Lake Drive, bottom of Clark Hill & Ola Ave.

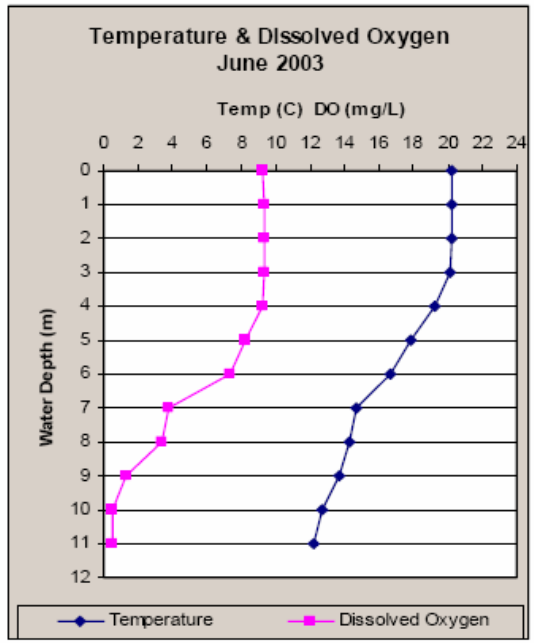
2003 Study Year Findings

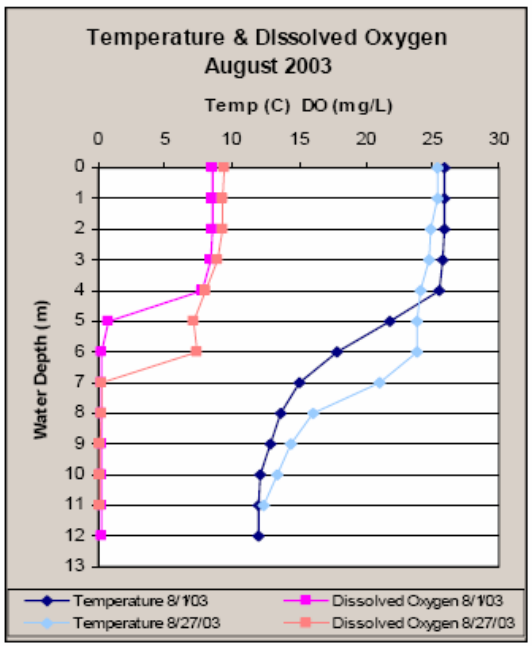
- **Primary 2003 Findings**
  - In-Lake
    - D.O. (dissolved oxygen) and temperature profiles track as expected (see graph)
    - Nitrogen nutrients low to medium (not high)
    - **TP 24 ug/L**, similar to 2002, **22 ug/L**, higher than prior years (see graph)
    - **SDT** from **2.8** to **8.0 ft**, compares to 2002 min **3.0 ft** (see graph)

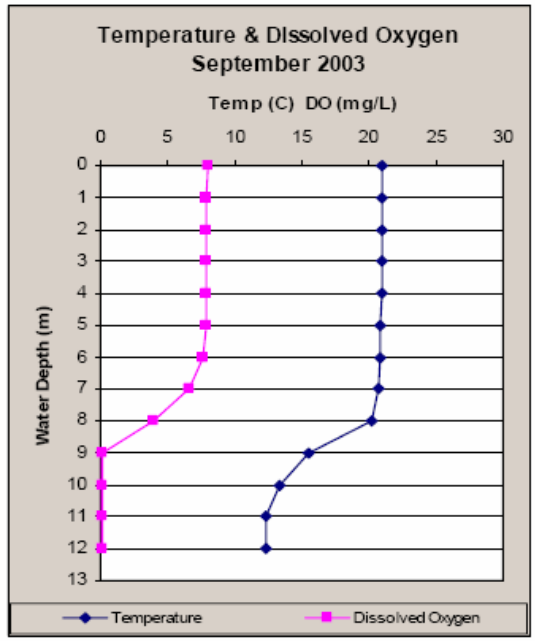
Figure 2. Lake Pocotopaug Temperature and Dissolved Oxygen Profiles 2003.











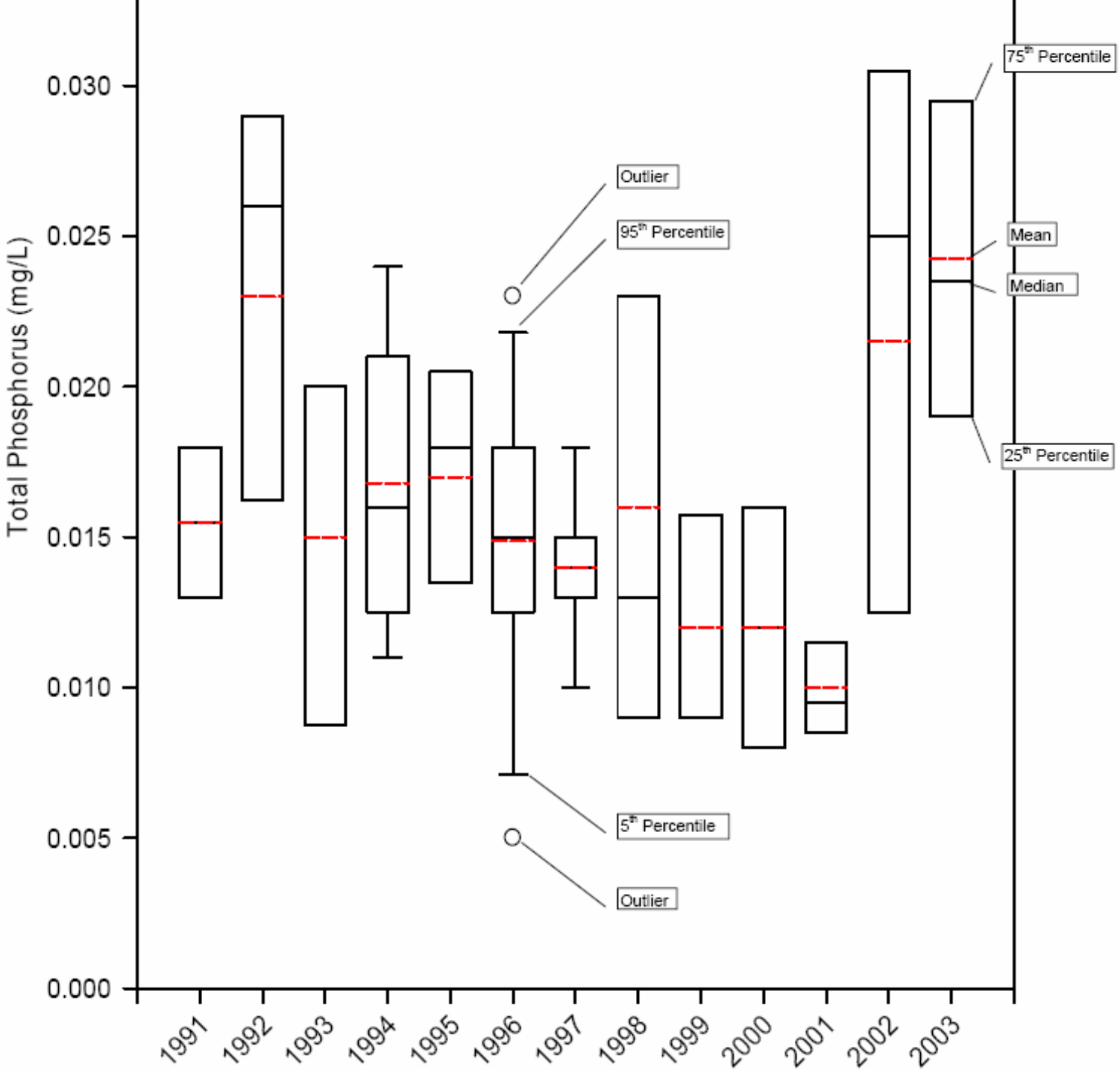
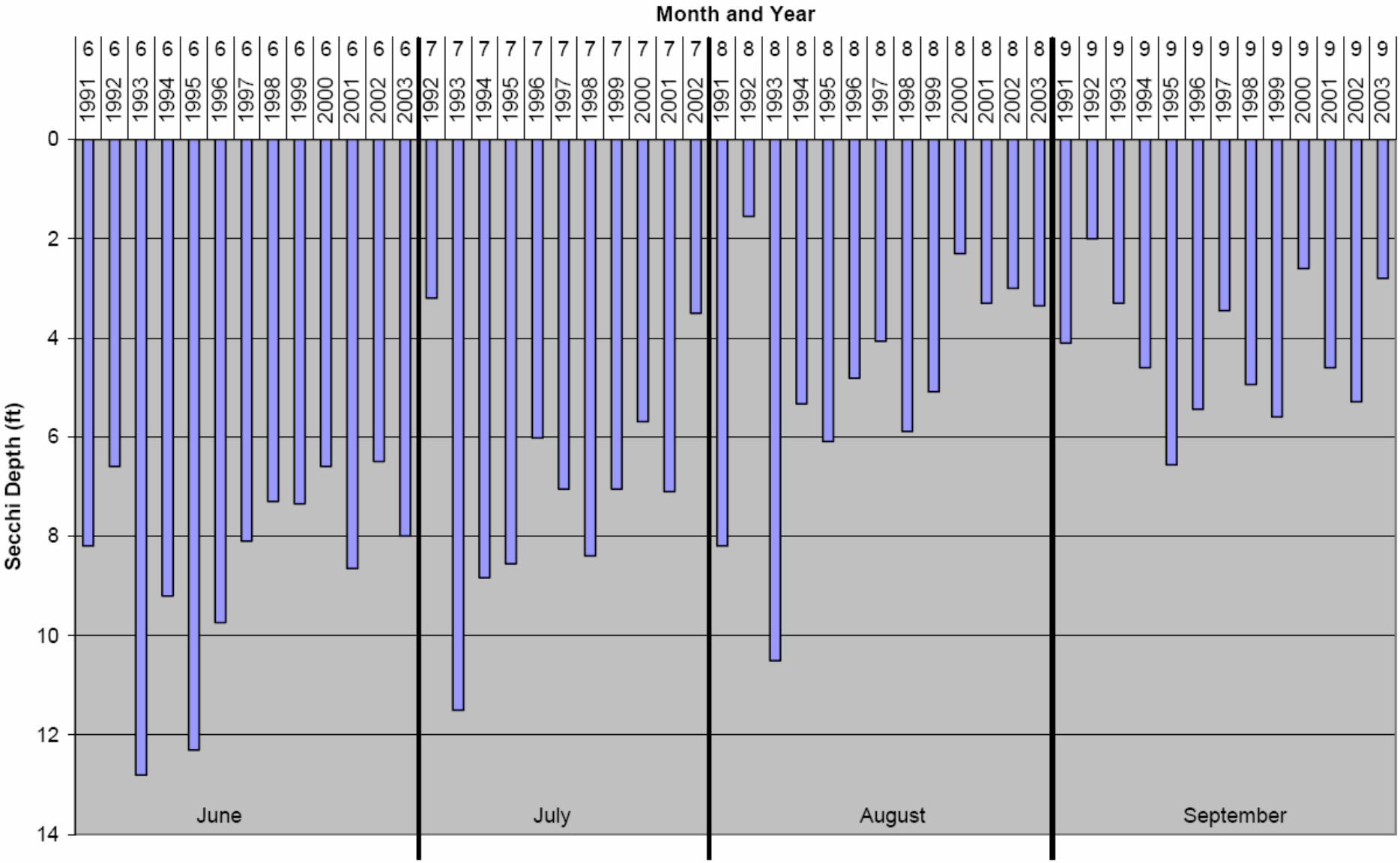

Total Phosphorus (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Outlier
95th Percentile
5th Percentile
Outlier
75th Percentile
Mean
Median
25th Percentile

Figure 6. Average Secchi Disk Transparency 1991-2003 at Oakwood Basin (LP-2)



2003 Study Year Findings

- **Primary 2003 Findings**
  - In-Lake, continued…
    - Attempt at finding onset of Anabaena bloom for copper treatment failed

2003 Study Year Findings

- **Primary 2003 Findings**
  - In-Lake, continued…
    - Phytoplankton
      - Summer transition from a diatom-dominated community (good algae) to one with abundant *Anabaena aphanizomenoides* (bad blue-green algae)
    - Zooplankton
      - Tested in April, May, June only.
      - Present but not abundant, declined by June.
      - Small to medium sized, no large forms
      - Walleye having no effect yet (only 2 years)

2003 Study Year Findings

- **Primary 2003 Findings**
  - Watershed Tributaries
    - High levels of wet-weather nutrients
    - Clark Hill storm drain worst

2004 Report Recommendations

- **ENSR 2004 Recommendations**
  - "2004 phytoplankton sampling of the lake should proceed in an effort to determine the onset of an algal bloom." (for copper treatment)
    - Lengthy discussion on copper sulfate treatment in report: why, how, good effects, adverse effects, etc.

2004 Report Recommendations

- **ENSR 2004 Recommendations**
  - "Alternatives are limited at this time."
    - Alum treatment to further inactivate P in sediment - highly speculative, expensive
    - Aeration of the bottom waters, very expensive
    - Continuing biomanipulation using walleye to control panfish, encourage zooplankton
      - Not likely to provide consistent and strong control of this algal species
    - **"The copper treatment is therefore recommended."**

2004 Report Recommendations

- **ENSR 2004 Recommendations**
  - "…more attention should be paid to watershed inputs."
    - Modified "first flush" effect
      - Most external phosphorus loading occurs during peak storm periods and is likely from near-lake developed areas
      - Very wet 2003 summer could explain lake nutrient increase
      - Need to address multiple small sources entering lake to reduce earliest runoff
      - Stormceptors® may help, but may have inadequate capacity at two current locations

2004 Report Recommendations

- **ENSR 2004 Recommendations**

  "The improvement related to alum treatment is evident, but so is the gradual rise of phosphorus levels since that treatment. As the treatment only addressed about a third of the bottom of the lake, some influence from the remaining two thirds is possible, but the available data suggest longer term influences from the watershed. Again, the need for more watershed management is stressed, while in-lake approaches are used to seek interim relief."

  - Alum worked, but effect fading
    - Only used on 1/3 of lake, remaining 2/3 may be a problem
  - Long term watershed influence indicated
  - Watershed management needed
  - In-Lake approaches for interim relief

Presentation Contents

- Overall ENSR Program 2001 to 2005
- 2001/2002 Study Year/Report
- 2002/2003 Study Year/Report
- 2003/2004 Study Year/Report
- **2004/2005 Study Year/Report**
- 2005/2006 Study Year/Presentation

2004 Study Year Tests

- **Test Types Performed**
  - Similar to 2003

2004 Study Year Findings

- **Primary 2004 Findings**
  - In-Lake – Similar to 2003
    - D.O. (dissolved oxygen) and temperature profiles track as expected
    - Nitrogen nutrients low to medium (not high)
    - **TP 24 ug/L**, same as 2003, similar to 2002, **22 ug/L**, higher than prior years (see graph)
    - **SDT** from **2.5** to **9.5 ft**, compares to 2003 min **2.8 ft** (see graph)

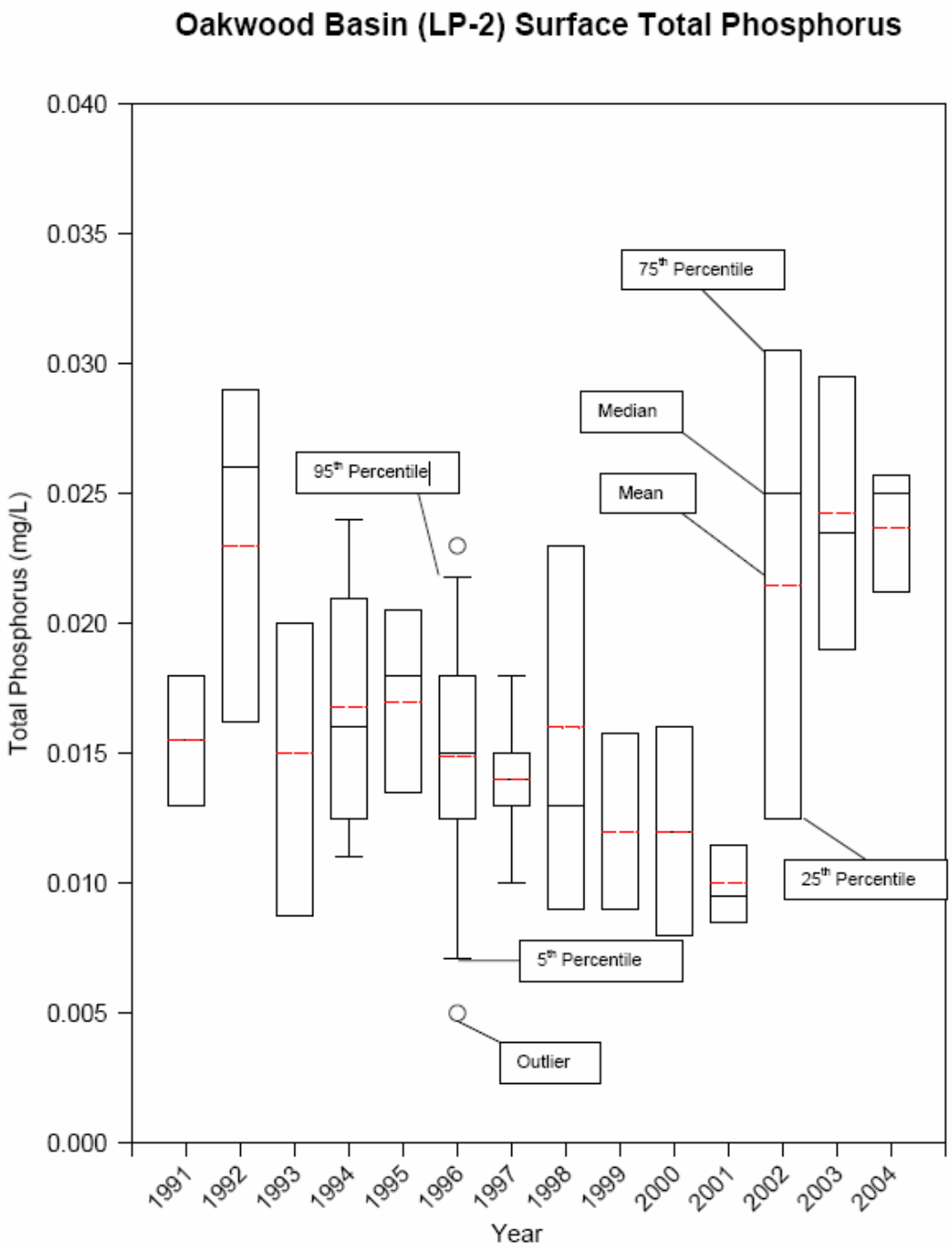
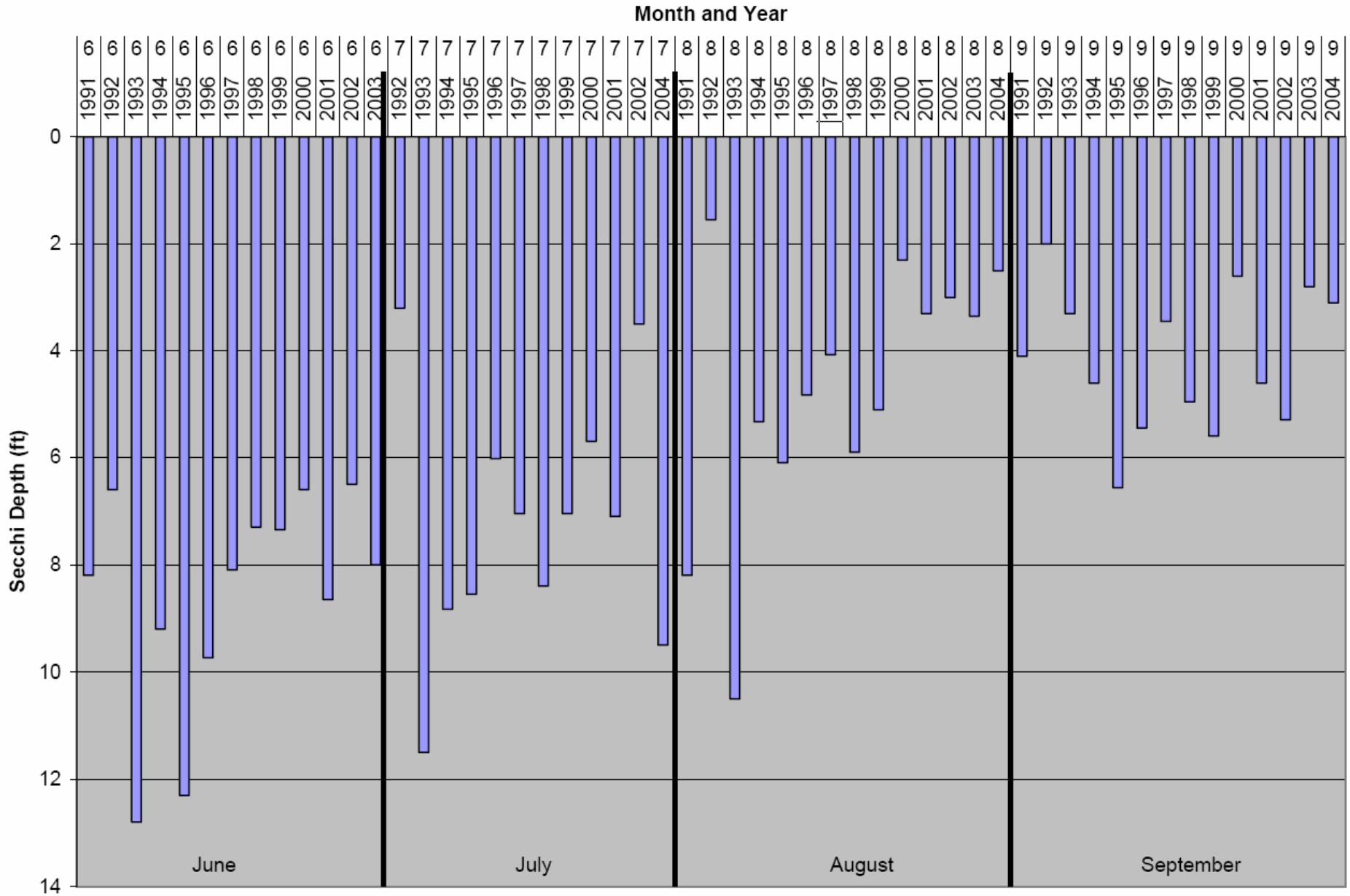

Oakwood Basin (LP-2) Surface Total Phosphorus
Total Phosphorus (mg/L)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year
75th Percentile
Median
Mean
95th Percentile
25th Percentile
5th Percentile
Outlier

Figure 6. Average Secchi Disk Transparency 1991-2004 at Oakwood Basin (LP-2)



2004 Study Year Findings

- **Primary 2004 Findings**
  - In-Lake – Similar to 2003
    - Phytoplankton
      - Similar slow transition from diatoms to cyanophytes during summer
      - Again, could not identify start of Anabaena bloom for application of copper treatment
    - Zooplankton
      - Generally low levels, small size for a New England lake, but some larger sizes were present compared to 2003
        - Walleye, getting larger, may be having an effect

2004 Study Year Findings

- **Primary 2004 Findings**
  - In-Lake, continued…
    - Stable, relatively low nitrogen levels; phosphorus limits algal growth
      - Favors nitrogen-fixing cyanophytes like Anabaena
    - No long term water clarity trend, except possibly in August, getting worse from 1990's to early 2000's

"Internal loading of phosphorus was strongly curtailed by the 2001 alum treatment, but has increased back to pre-treatment levels since (although the 2004 values were among the lowest observed)."

- 2001 alum treatment worked, now back to pre-treat **P** levels
  - However, 2004 **P** levels among lowest observed!?

2004 Study Year Findings

- **Primary 2004 Findings**
  - Watershed Tributaries – Similar to 2003
    - High levels of wet-weather nutrients
      - Loading due primarily to nearby lawn fertilizer, impervious surface pollutants
    - Clark Hill storm drain worst but all tributaries contribute to loading
    - Weather dependent - inputs low during dry years

2005 Report Recommendations

- **ENSR 2005 Recommendations**
  - Similar to 2004 – Pay attention to the nearby watershed inputs, lawn fertilizer, etc.
    - Reduce first flush nutrient loading by 50%
  - Concern that alum effect is wearing off in bottom sediments of deep areas

2005 Report Recommendations

- **ENSR 2005 Recommendations**
  - Interim in-lake measures are needed
    - Alum treatment - costly
    - Increasing oxygen levels in the bottom waters of deep areas (172 acres)
    - Mixing of surface waters – whole lake surface
      - Recommends limited SolarBee trial
    - Use of algaecides
      - GreenClean alternative to copper – expensive (10x)

2005 Report Recommendations

- **ENSR 2005 Recommendations**
  - Continued Testing

Presentation Contents

- Overall ENSR Program 2001 to 2005
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- 2002/2003 Study Year/Report
- 2003/2004 Study Year/Report
- 2004/2005 Study Year/Report
- **2005/2006 Study Year/Presentation**

2005 Tests & Studies

- **Slide Presentation Only (no report)**
- **Tests**
  - Upstream/downstream storm water assessment
    - Detailed results not shown
- **Database**
  - Assimilation of historical data into database
- **Analytical**
  - External loading estimations…

2005 Studies

- **External P Loading Estimations, Various Methods**
  - Empirical Model — **495 to 1382 lbs/yr, avg. 911**
  - Measurements — **907 to 1041 lbs/yr**
  - Older Estimates — **616 to 1890 lbs/yr**
  - Sources — **784 to 1379 lbs/yr total**
    - Watershed — 577 lbs/yr (791 older data)
    - Atmosphere — 164 lbs/yr (454 older data)
    - Waterfowl/Wildlife — 0 to 43 lbs/yr
    - Internal loading — 0 to 35 lbs/yr
    - Groundwater — 0 to 26 lbs/yr

2006 Recommendations

- **ENSR 2006 Recommendations**
  - Recommend **10 ug/L TP** In-Lake Surface Waters Concentration
    - Best possible target
    - But…level at which blooms have occurred in the past and may still occur in the future.
  - To Reach Target, Models Say External **P** Loading Must Be Reduced as Follows…

2006 Recommendations

- **ENSR 2005 Recommendations**
  - Best Guess Current **P** Load — **1000 lbs/yr**
    - Watershed — **750 lbs/yr**
    - Other Sources — **250 lbs/yr**
  - Recommended Target — **455 lbs/yr**
    - Uncontrollable Sources — 207 lbs/yr
    - Forested Watershed — 119 to 238 lbs/yr
    - Additional Sources — 129 to 10 lbs/yr
    - Reduction Required — **-545 lbs/yr**
      - Development Related % — -86% to -106%

End