Elm Creek Watershed Restoration and Protection Plan (WRAPP)

Elm Creek Watershed Lakes – Part I

Elm Creek Watershed Management Commission Technical Advisory Committee Meeting
December 11, 2013

Outline of Presentation

- Focus on Fish Lake, Weaver Lake, and Rice Lake
- Current conditions, watershed/lake characteristics
- Modeling approach, results for Fish and Rice Lake
- Preliminary loading capacities and allocations for Fish and Rice Lake
- Weaver Lake conditions, watershed/lake characteristics, and protection strategy elements

TMDL – A Number

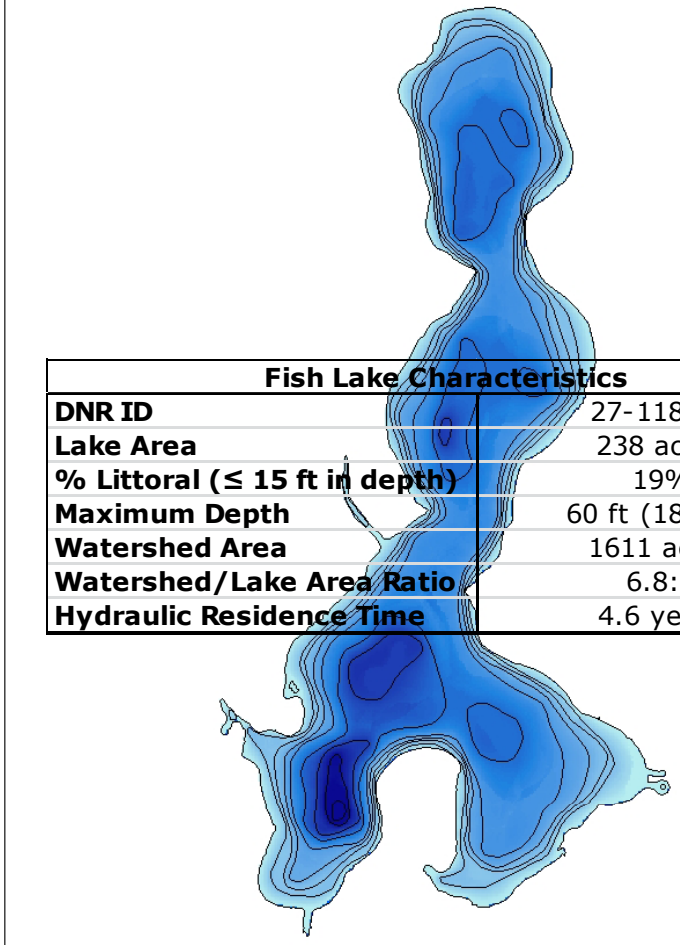
$$TMDL = \sum WLAs + \sum LAs + MOS + RC$$

- **WLA** = Wasteload Allocation (attributed to existing or future permitted sources)
- **LA** – Load Allocation (attributed to existing or future non-permitted sources)
- **MOS** – Margin of Safety (Potential scientific error)
- **RC** – Reserve Capacity (Future Capacity)

TMDL Modeling Approach

- Estimate the watershed, internal, and atmospheric loading to the lake.
- Input sources of loading to an in-lake response model (i.e. BATHTUB model).
- Calibrate the in-lake response model to observed water quality conditions.
- In-lake response simulations to estimate the load reduction necessary to meet water quality standards.

Fish Lake



Fish Lake Characteristics	
DNR ID	27-118-00
Lake Area	238 acres
% Littoral (≤ 15 ft in depth)	19%
Maximum Depth	60 ft (18.3 m)
Watershed Area	1611 acres
Watershed/Lake Area Ratio	6.8:1
Hydraulic Residence Time	4.6 years

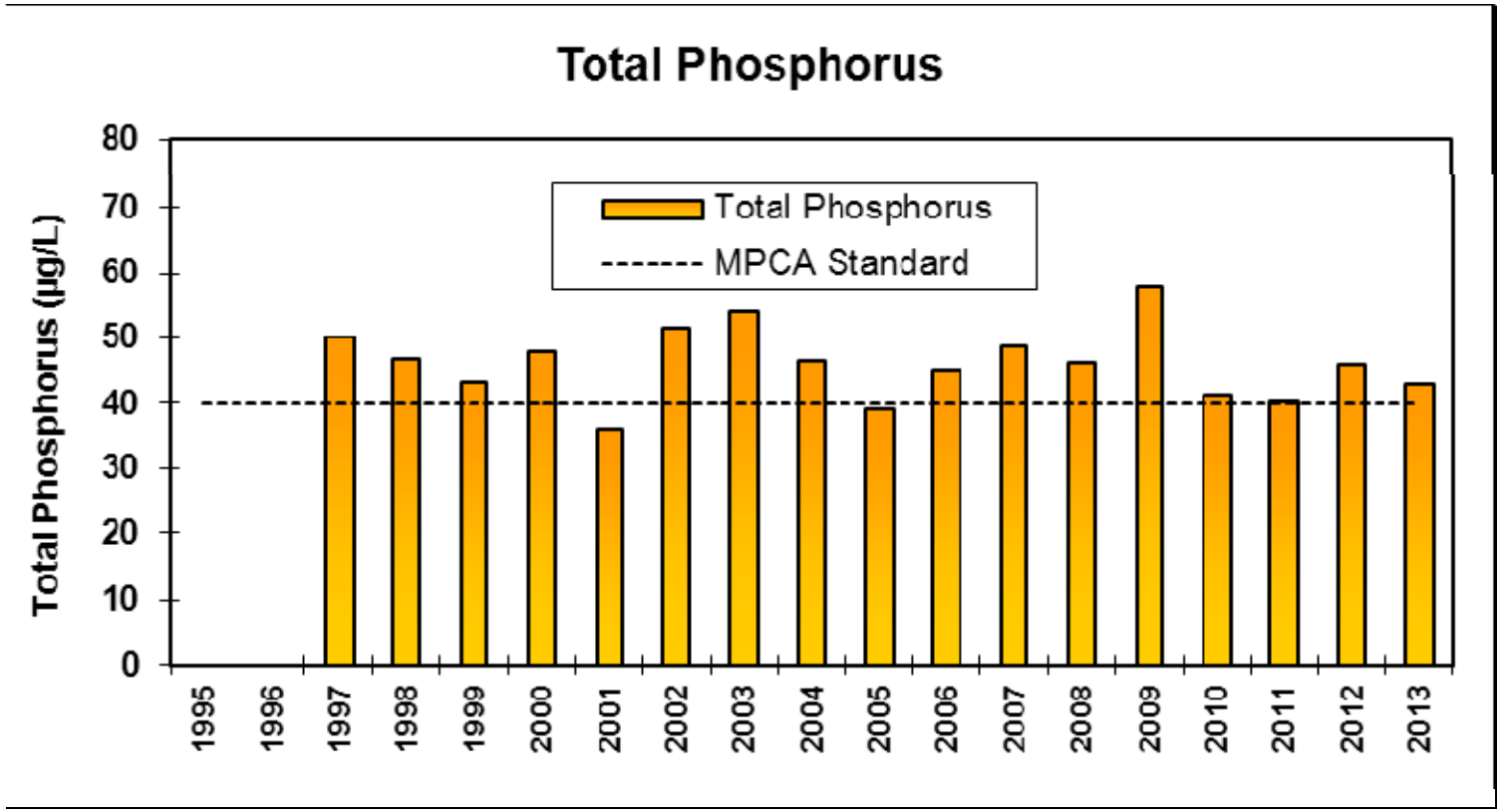
Fish Lake Bathymetry
Contours
Depth_m
High : 19.0
Low : 0.0

Fish Lake
Bathymetric Map
Water Resources Department
Created by: BV
Map Created: 12/05/2013

N

ThreeRivers
PARK DISTRICT

Fish Lake


Total Phosphorus
Total Phosphorus (µg/L)
80
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Total Phosphorus
MPCA Standard
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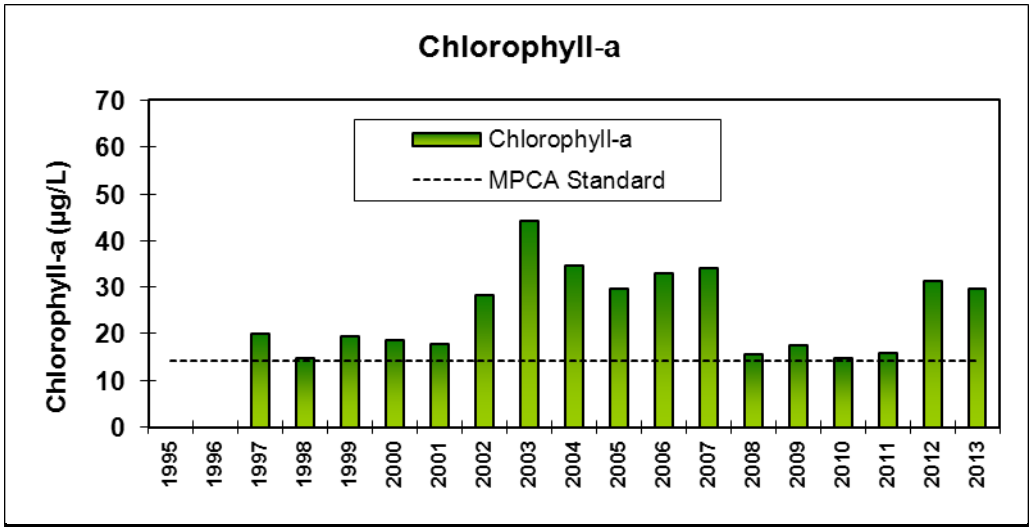
Fish Lake


Chlorophyll-a
Chlorophyll-a (µg/L)
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Chlorophyll-a
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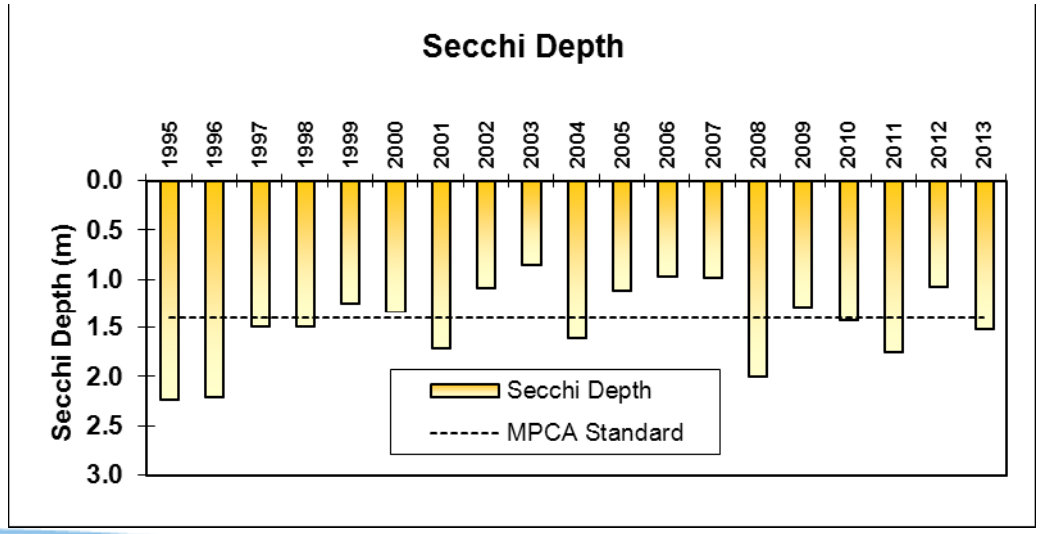
Secchi Depth
Secchi Depth (m)
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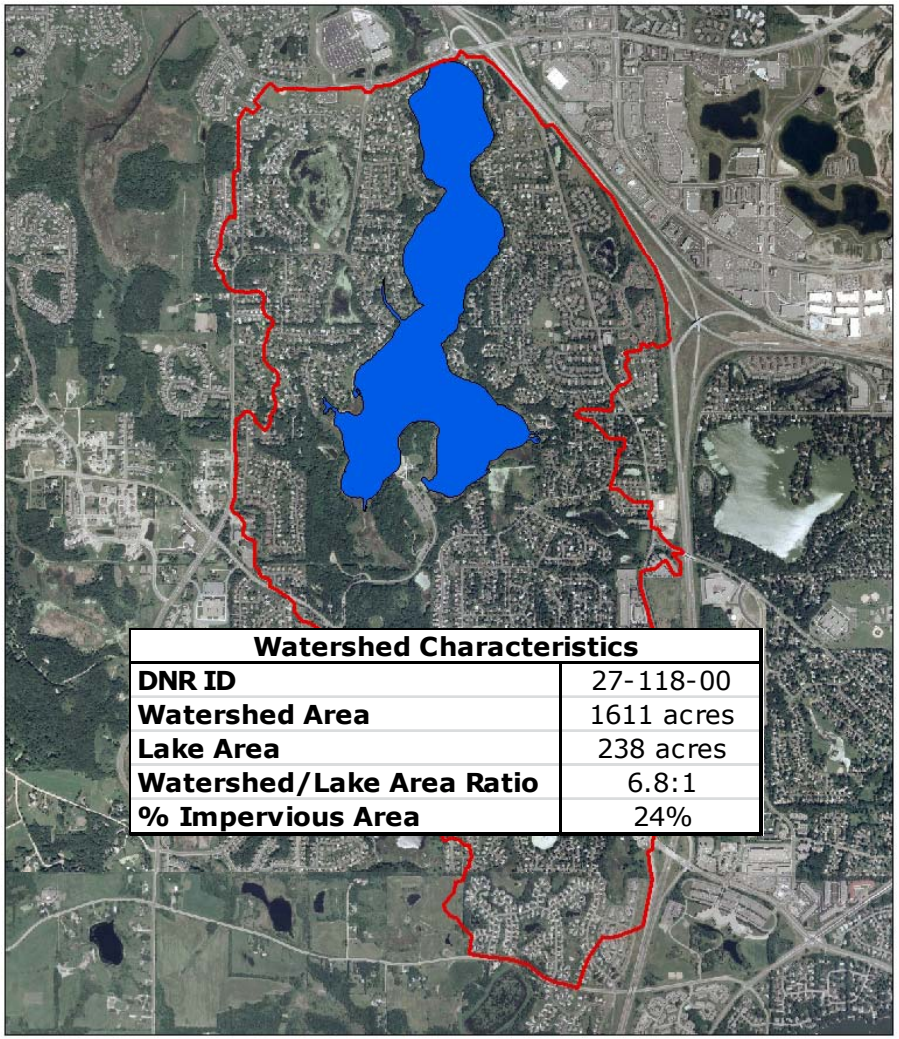
Secchi Depth
MPCA Standard

Fish Lake Watershed



Watershed Characteristics	
DNR ID	27-118-00
Watershed Area	1611 acres
Lake Area	238 acres
Watershed/Lake Area Ratio	6.8:1
% Impervious Area	24%

Fish Lake
Watershed Boundary

Fish Lake
Watershed Boundary
Water Resources Department
Created by: BV
Map Created: 12/05/2013

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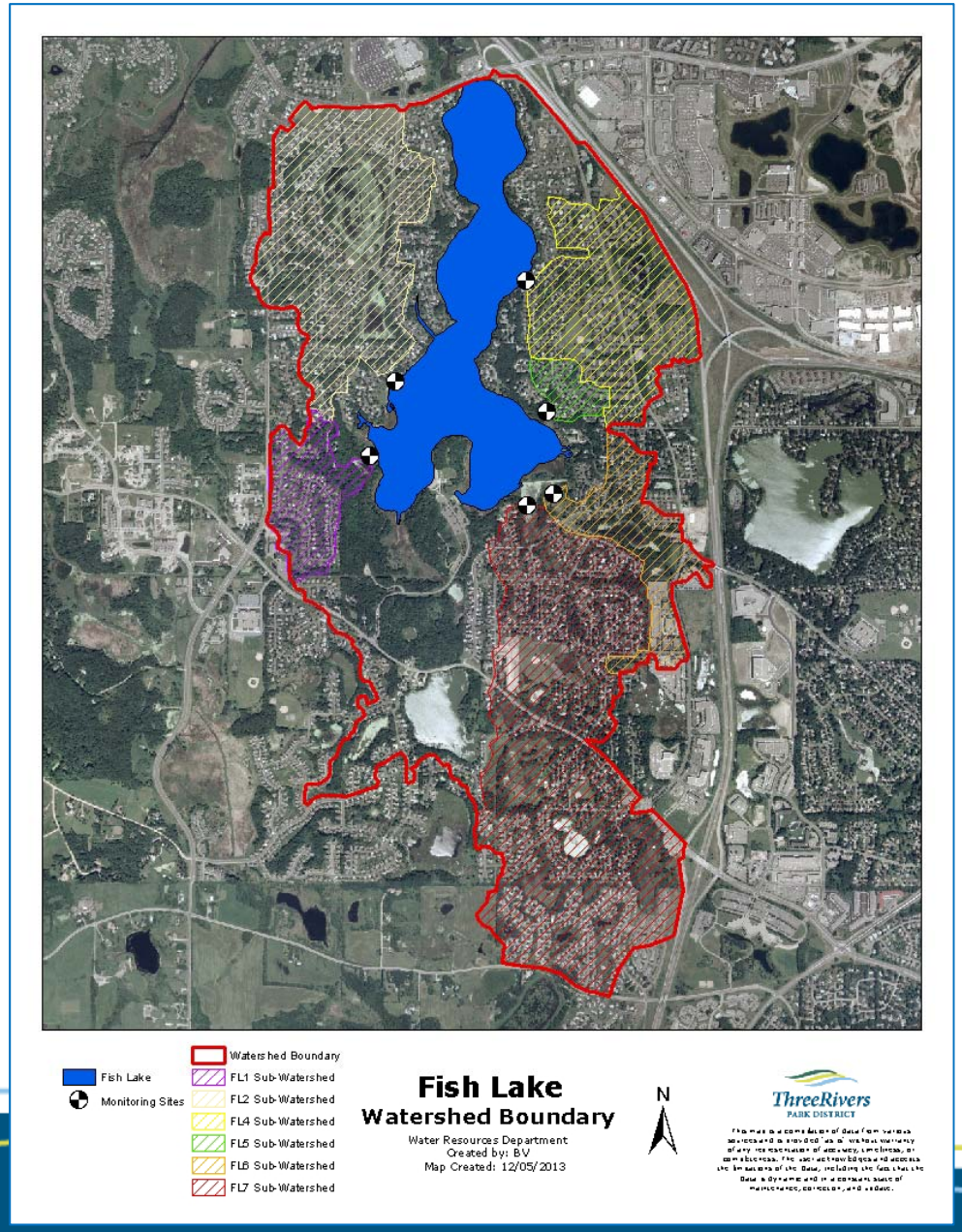
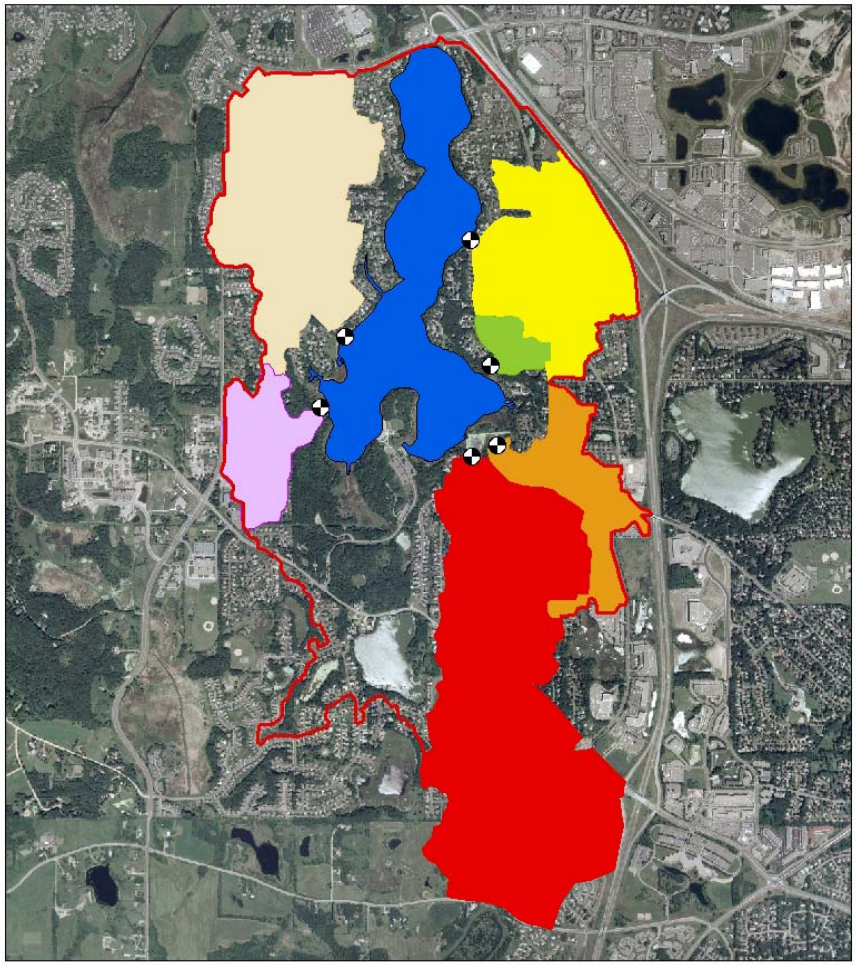
PARK DISTRICT

Fish Lake Monitored Watershed



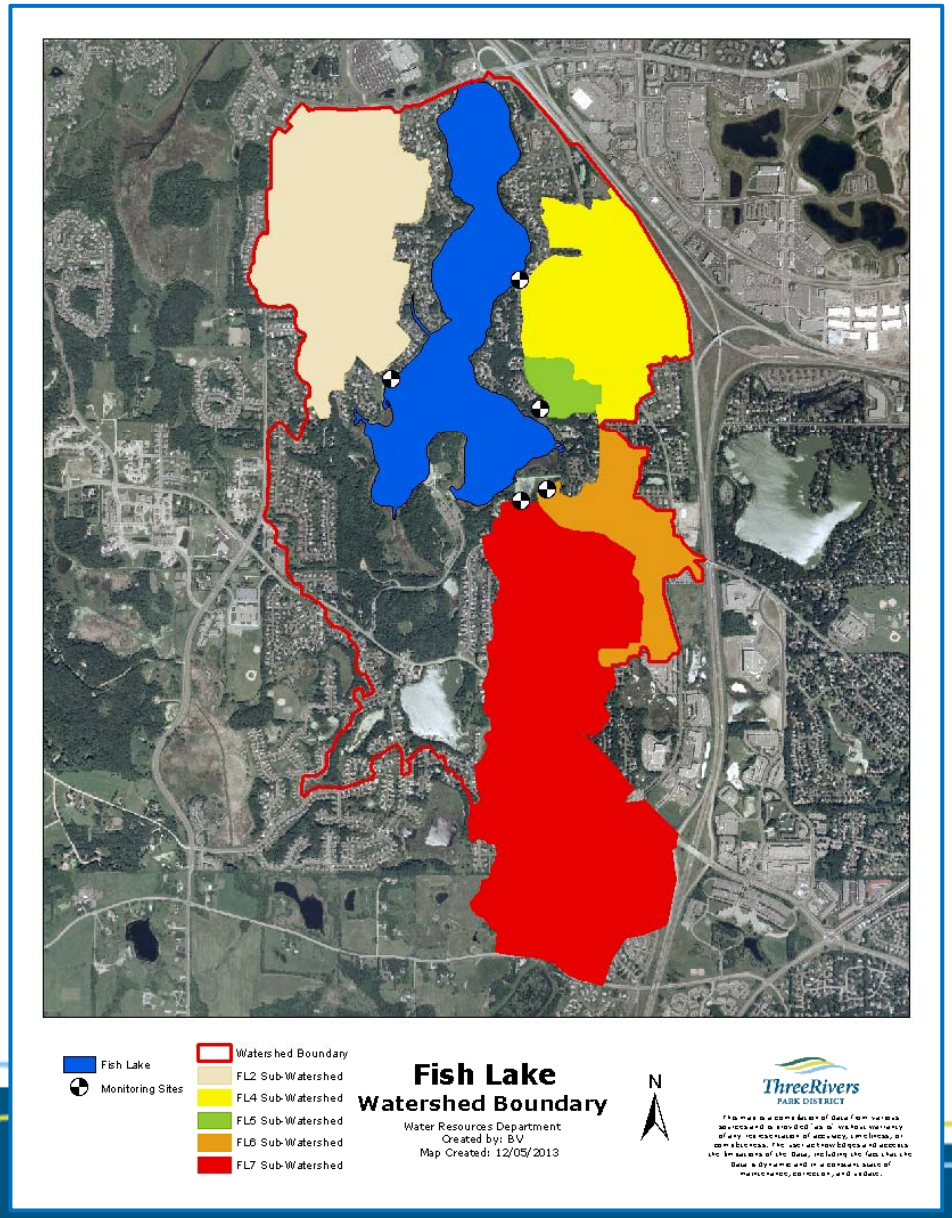
Fish Lake Watershed
62% Monitored



P8 Modeling Approach for TMDL

- P8 model will be developed for the Fish Lake Watershed to estimate loading.
- P8 model will be calibrated to the monitored watershed data.
- The watershed loading estimates will be input into the BATHTUB in-lake response model.
- The modeling results will also be used and incorporated into the urban portions of the SWAT Model.

Fish Lake Watershed
62% Monitored



FL5 Sub-Watershed

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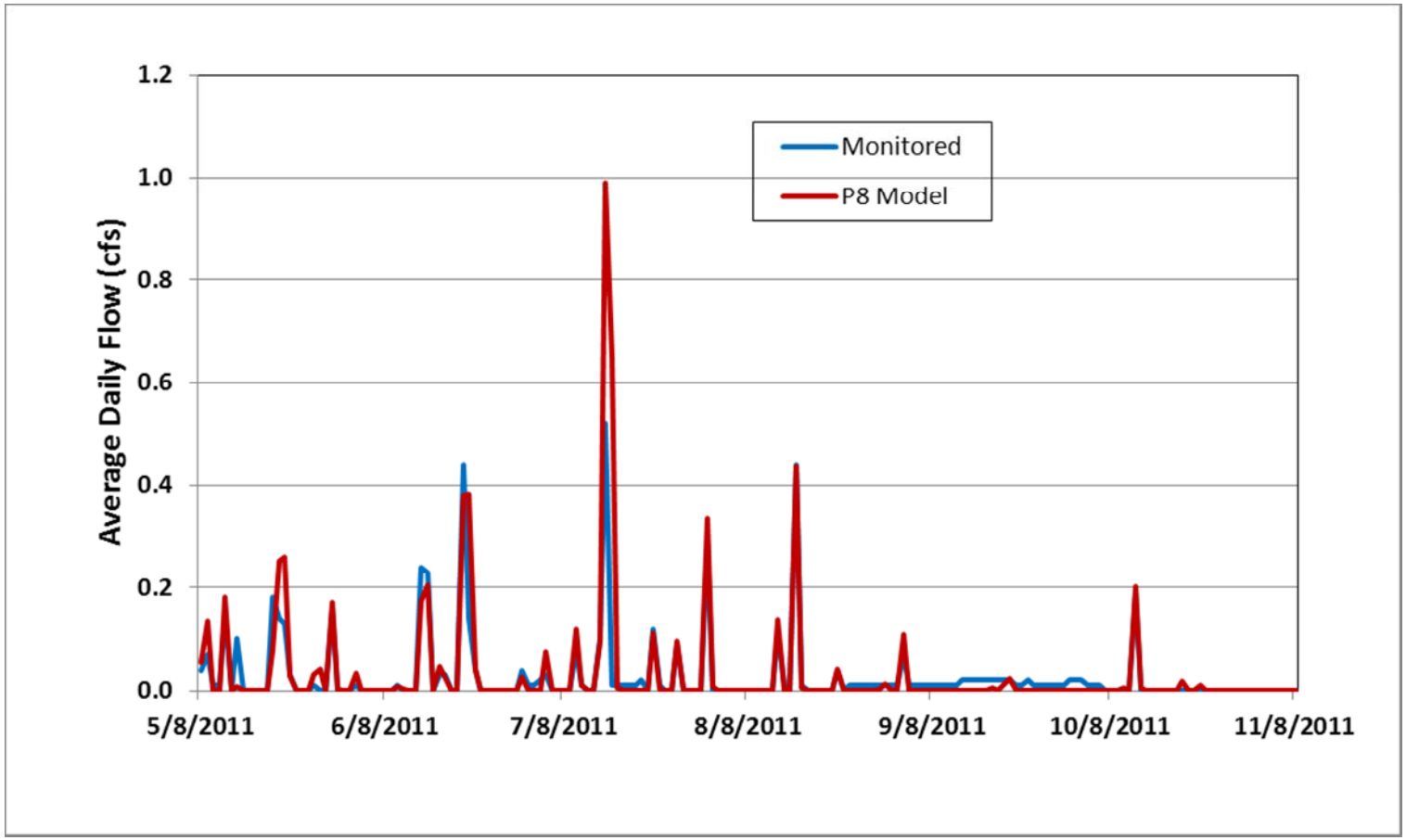
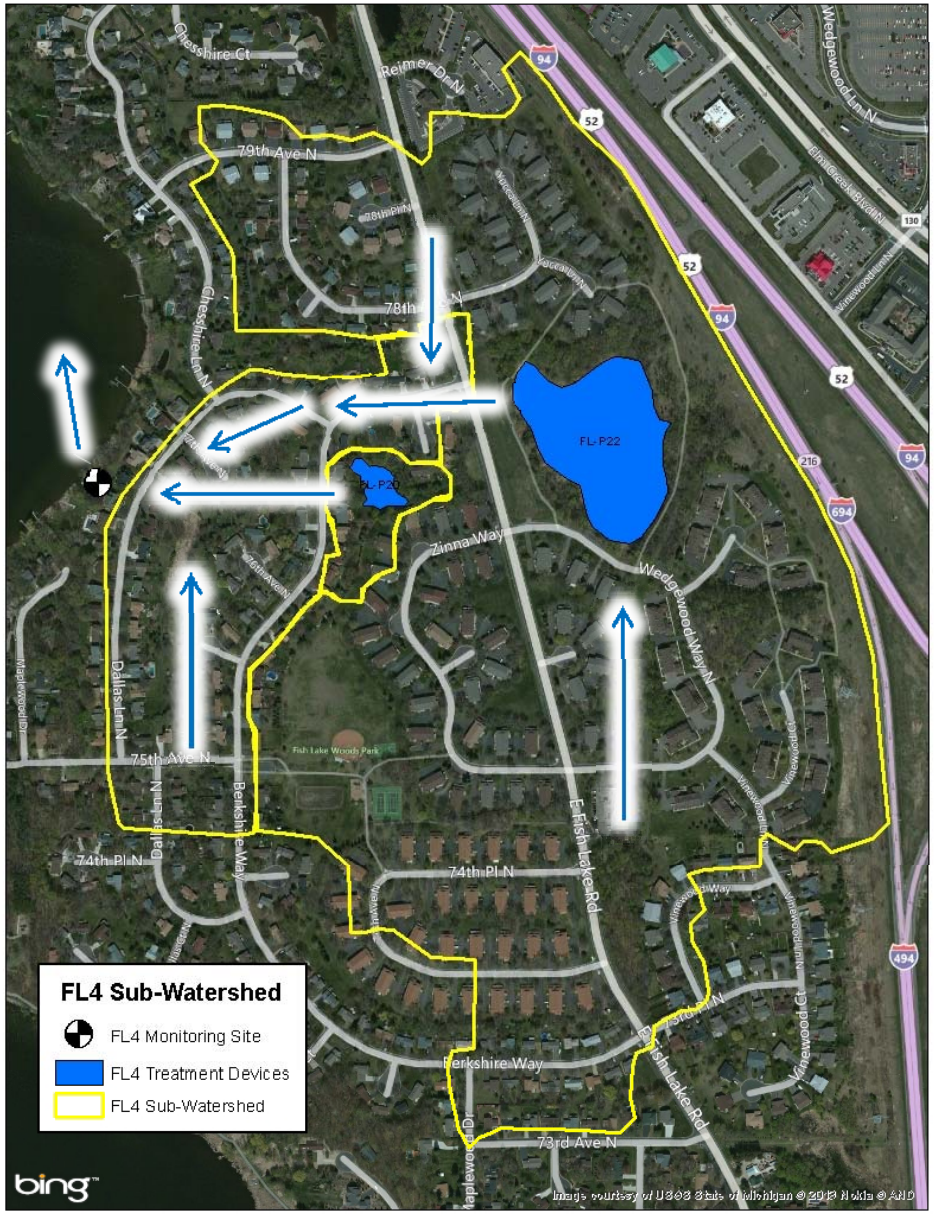
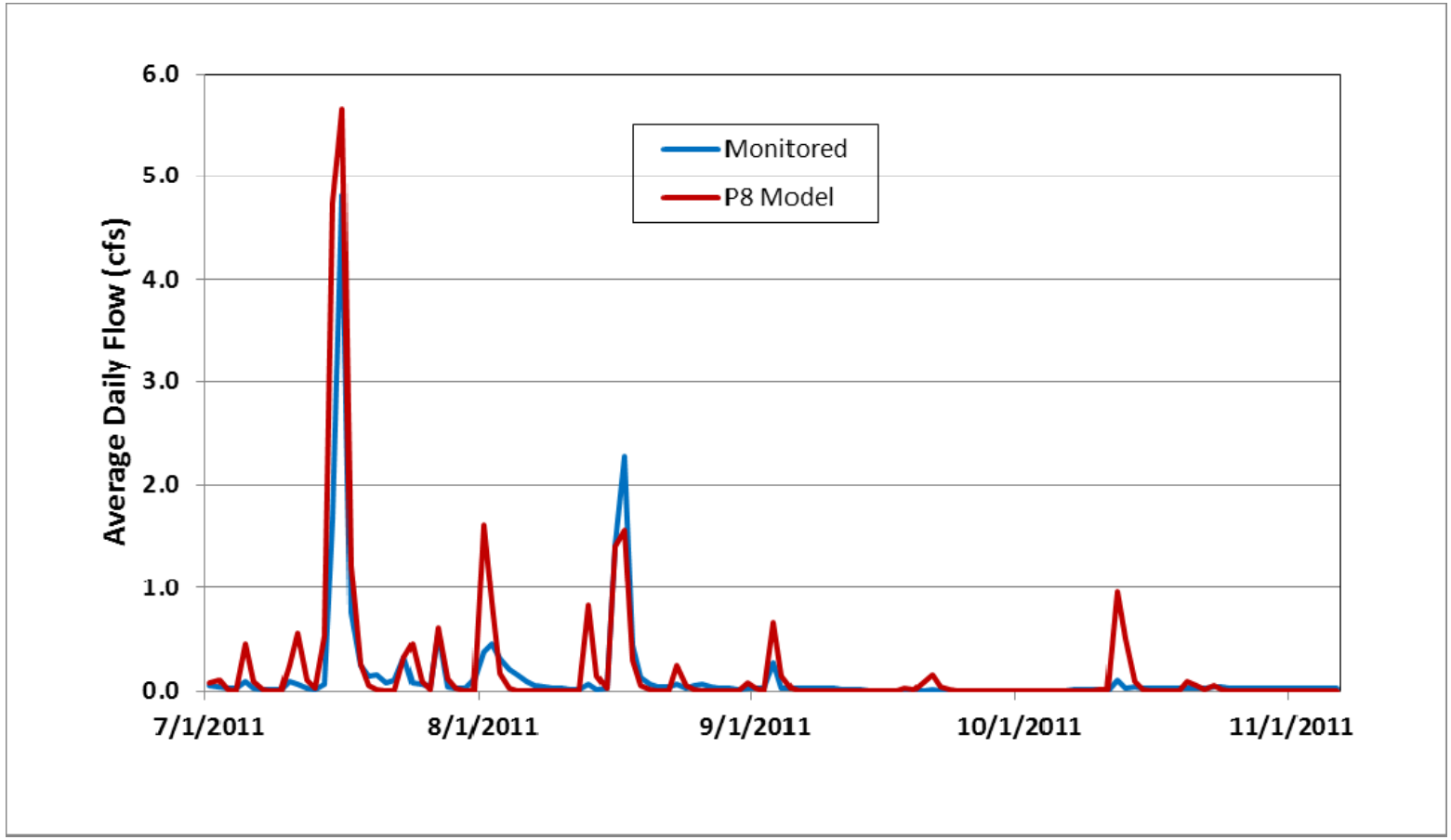


FL4 Sub-Watershed

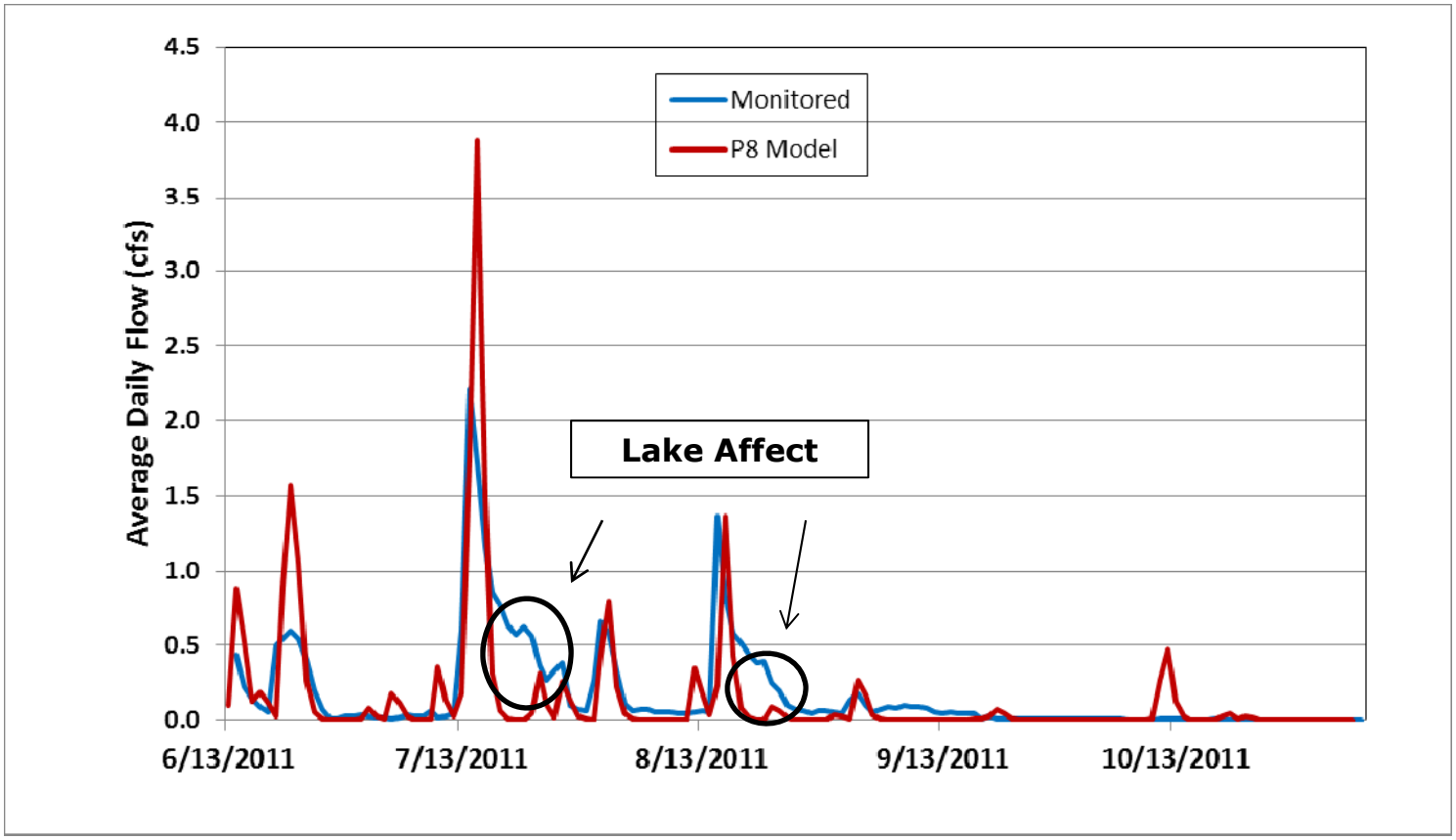


FL4 Sub-Watershed

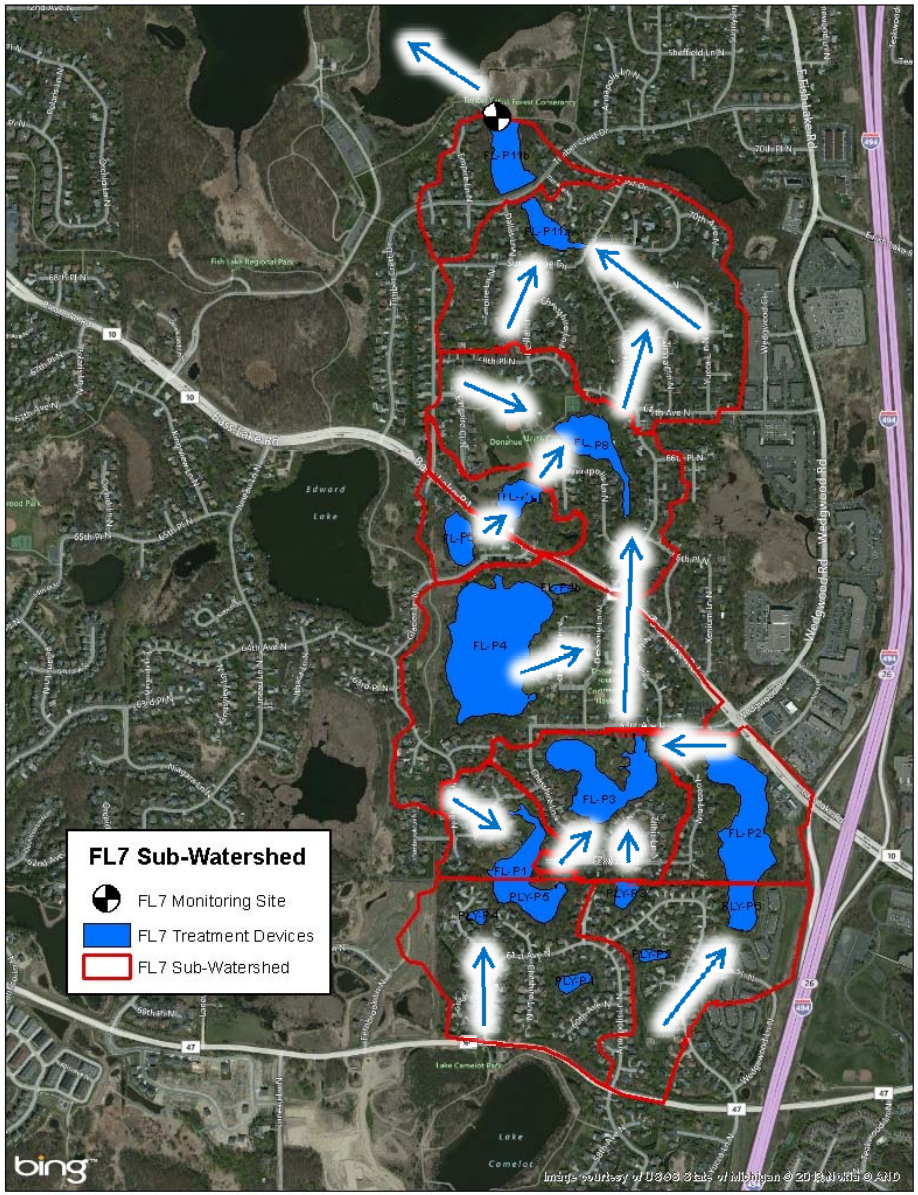


FL6 Sub-Watershed

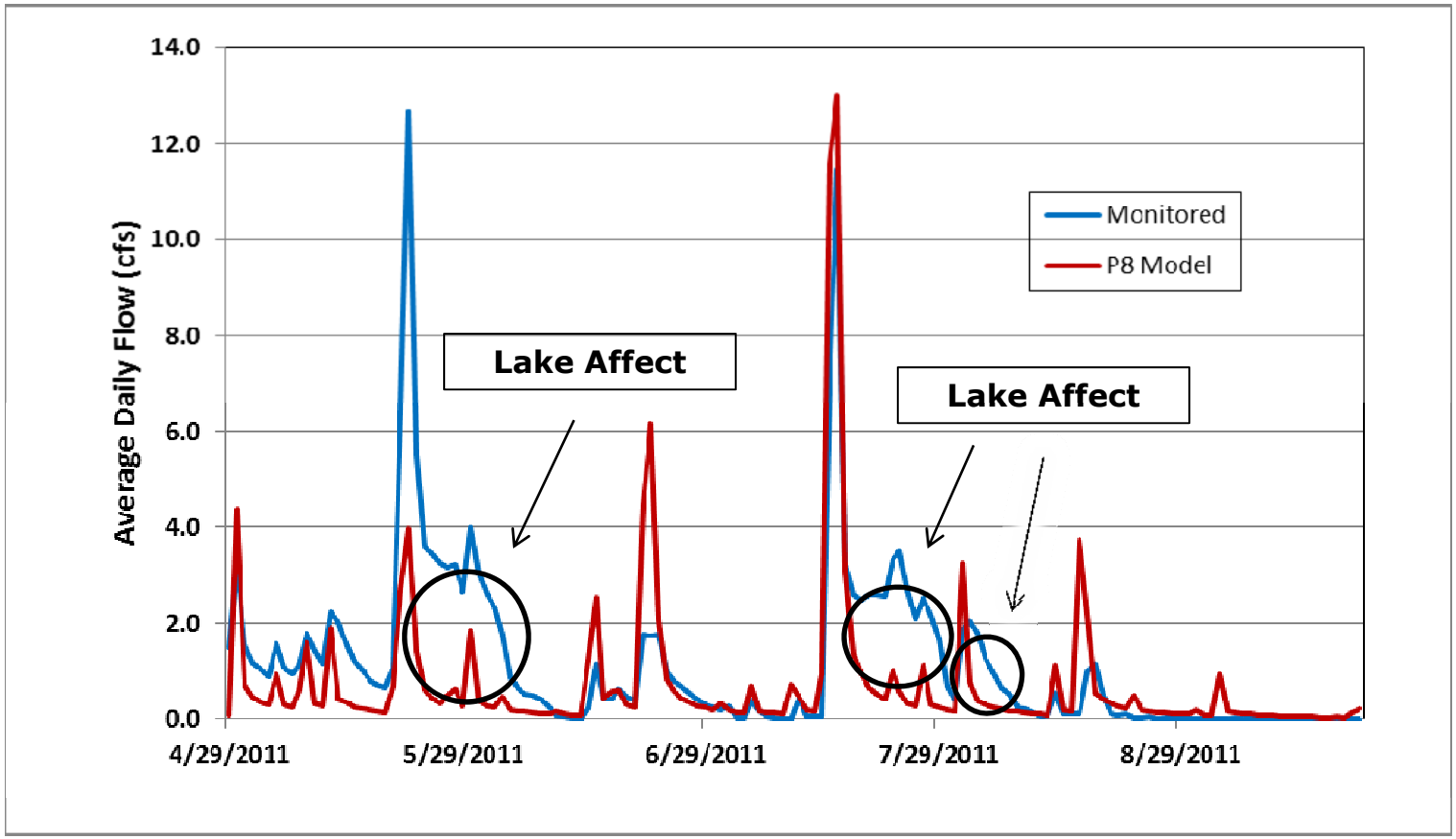
FL6 Sub-Watershed



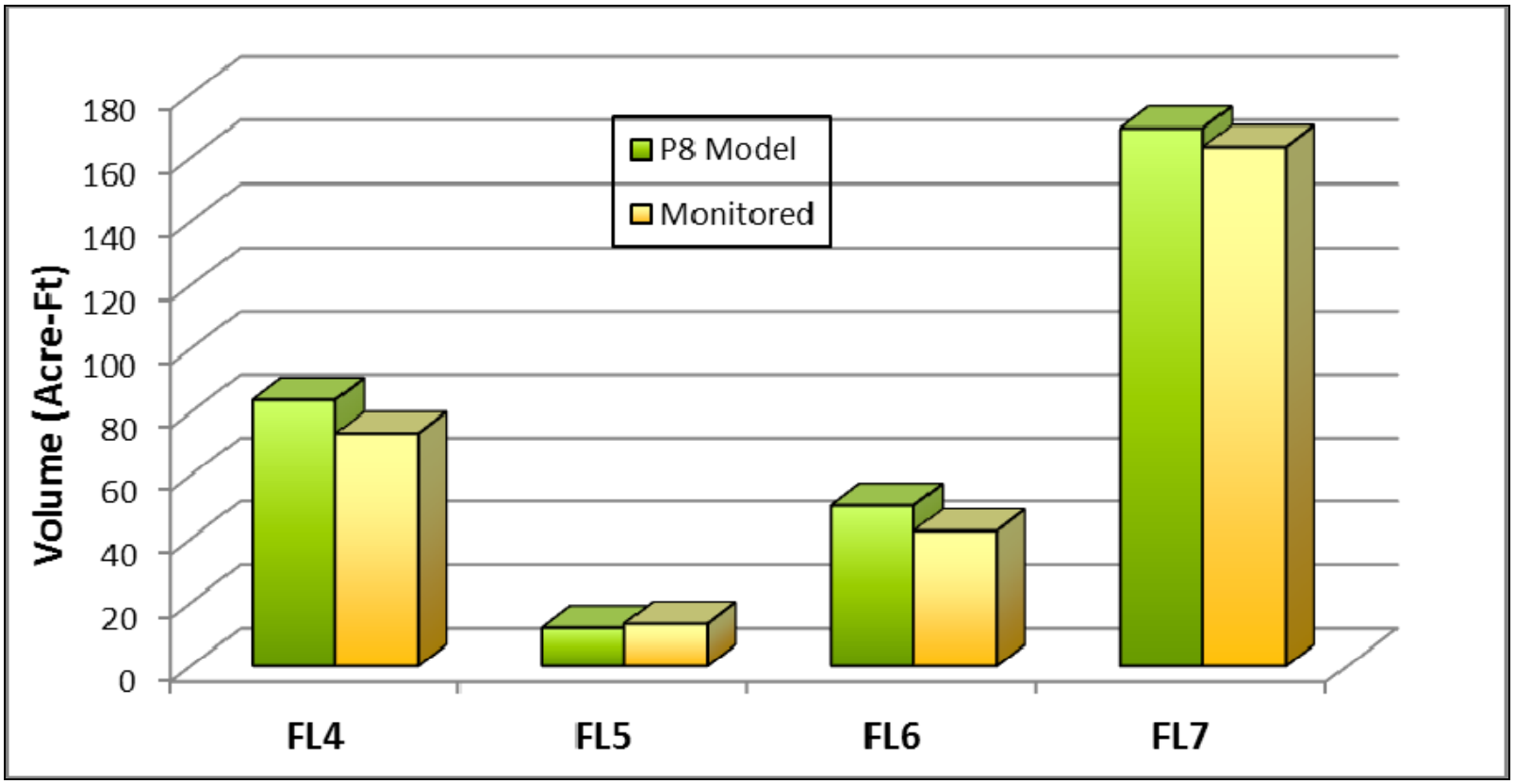
FL7 Sub-Watershed



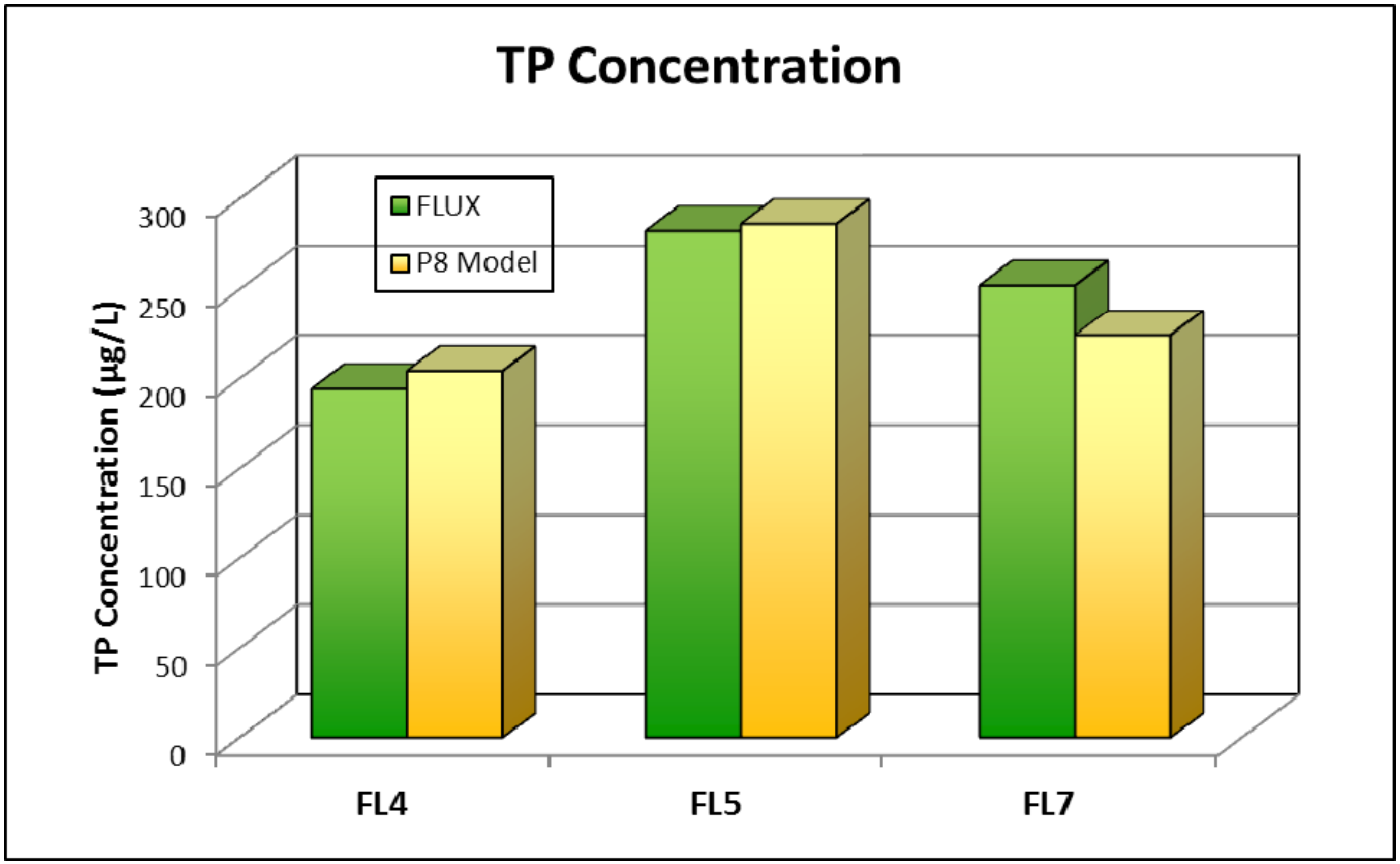
FL7 Sub-Watershed



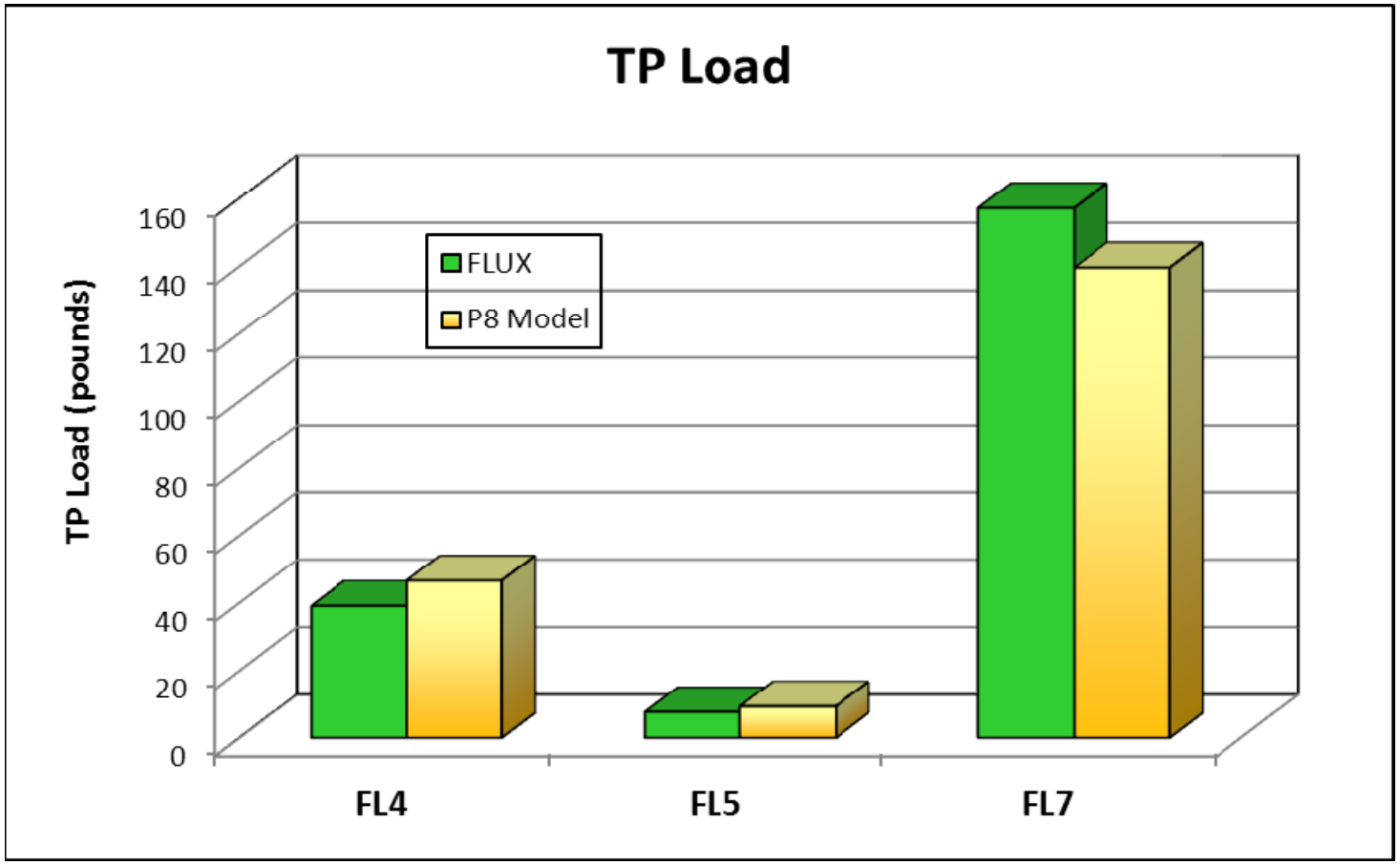
Fish Lake
Model vs Monitored
Flow Volume 2011



Fish Lake
Model vs Monitored
Total Phosphorus Concentration 2011



Fish Lake
Model vs Monitored
Total Phosphorus Load 2011



Fish Lake BATHTUB Model Loading Input

- P8 Model was run for years with average precipitation conditions (2010-2012).
  - Medina (Met Council Data) 2000-2012 = 28.5 inches
  - MSP Airport 1970-2012 = 29.41 inches
- The flow volume and nutrient concentration from the P8 model simulation was averaged for 2010-2012 and was input into the BATHTUB model.

P8 Model Estimates 2010-2012		
Watershed	**Volume (Acre-ft)**	**TP Concentration (µg/L)**
FL1	45.93	226.5
FL2	157.60	240.8
FL4	122.38	197.1
FL5	16.58	262.4
FL6	73.63	166.1
FL7	292.46	210.3
Edward Lake (FL-A13)	14.82	273.6
Edward Lake	40.76	114.9
Direct (FL-A34)	241.30	266.5
Direct (FL-A15)	27.63	182.8

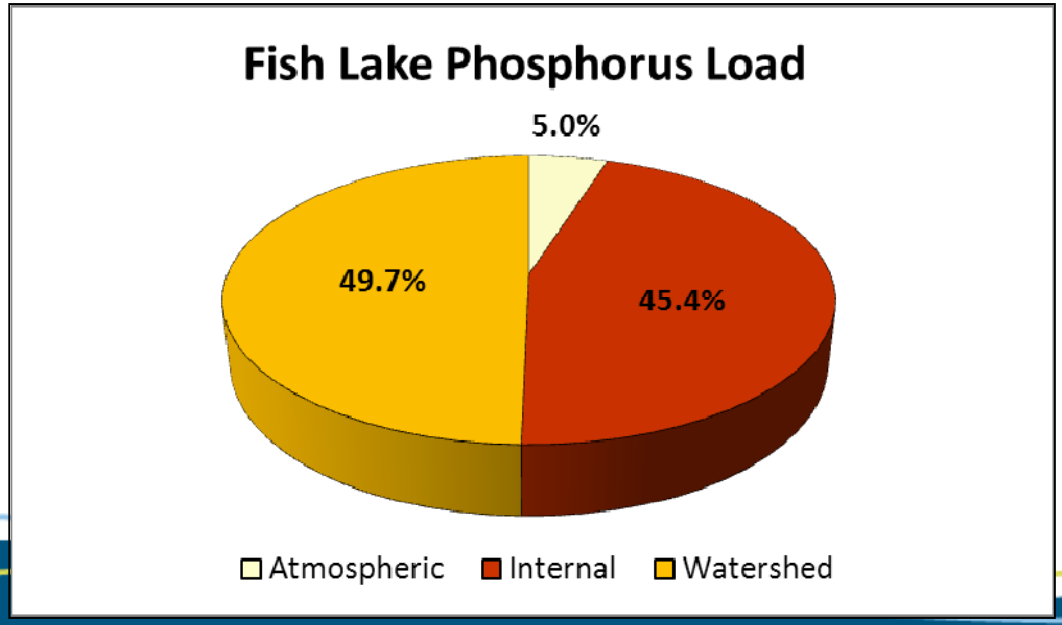
BATHTUB Model Loading Input

- Sediment cores were collected in 2012 to estimate sediment phosphorus release rates for Fish Lake.
- William James from University of Wisconsin STOUT laboratory analyzed sediment cores.
- Nürenberg equation (1988) was used to estimate internal loading of Fish Lake.
  - TP Sediment Release Rate = 7.6 mg/m^2/day
  - TP Internal Load = approximately 590 pounds
- TP internal load input into the BATHTUB model for calibration was 568 pounds.

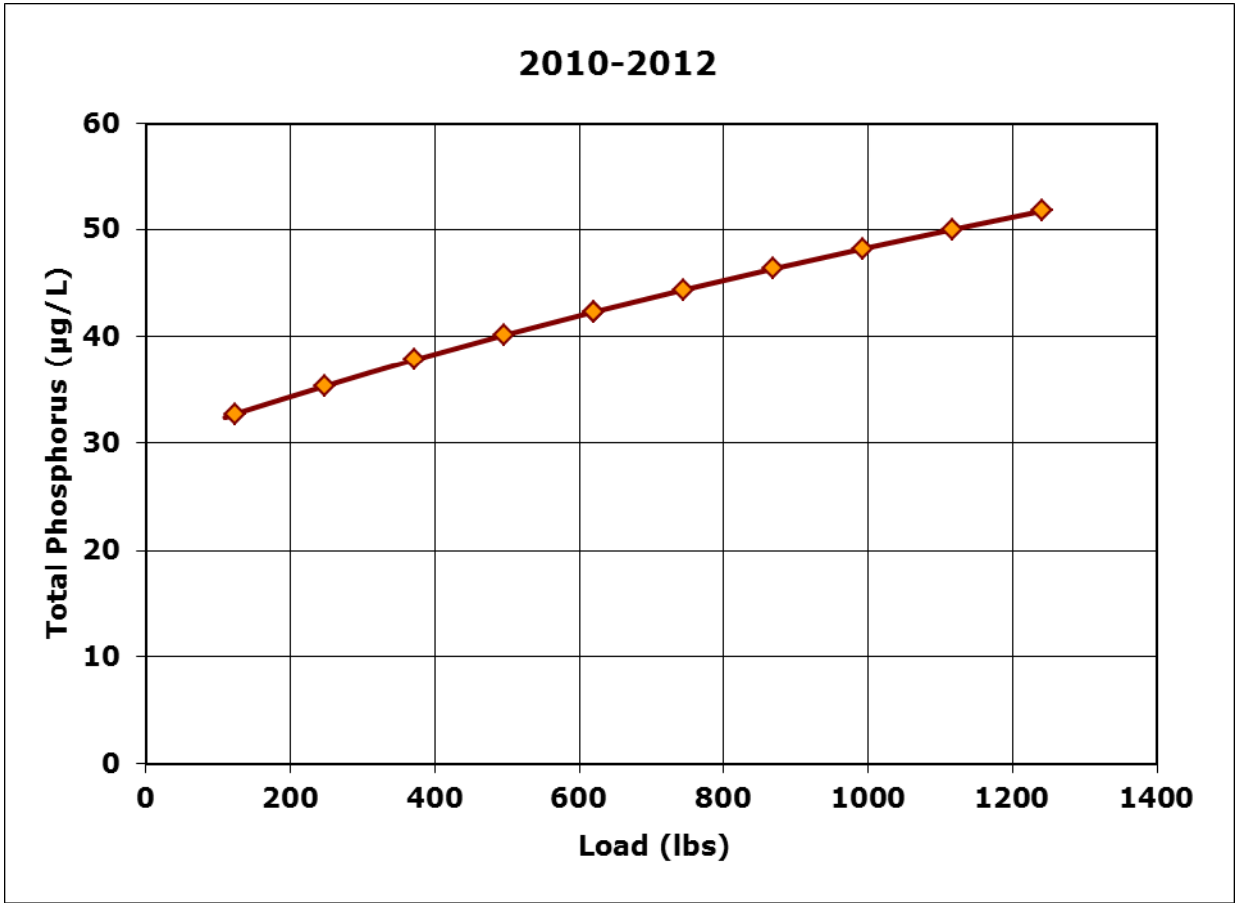
Fish Lake BATHTUB Model Output

Fish Lake BATHTUB Model Estimates			
Variable	**Predicted**	**Observed**	**Model**
Total Phosphorus (µg/L)	42.3	42.0	Canfield and Bachman, General
Chlorophyll-a (µg/L)	21.6	21.0	P,Light,T
Secchi (m)	1.4	1.4	Transparency vs Chl-a & Turbidity

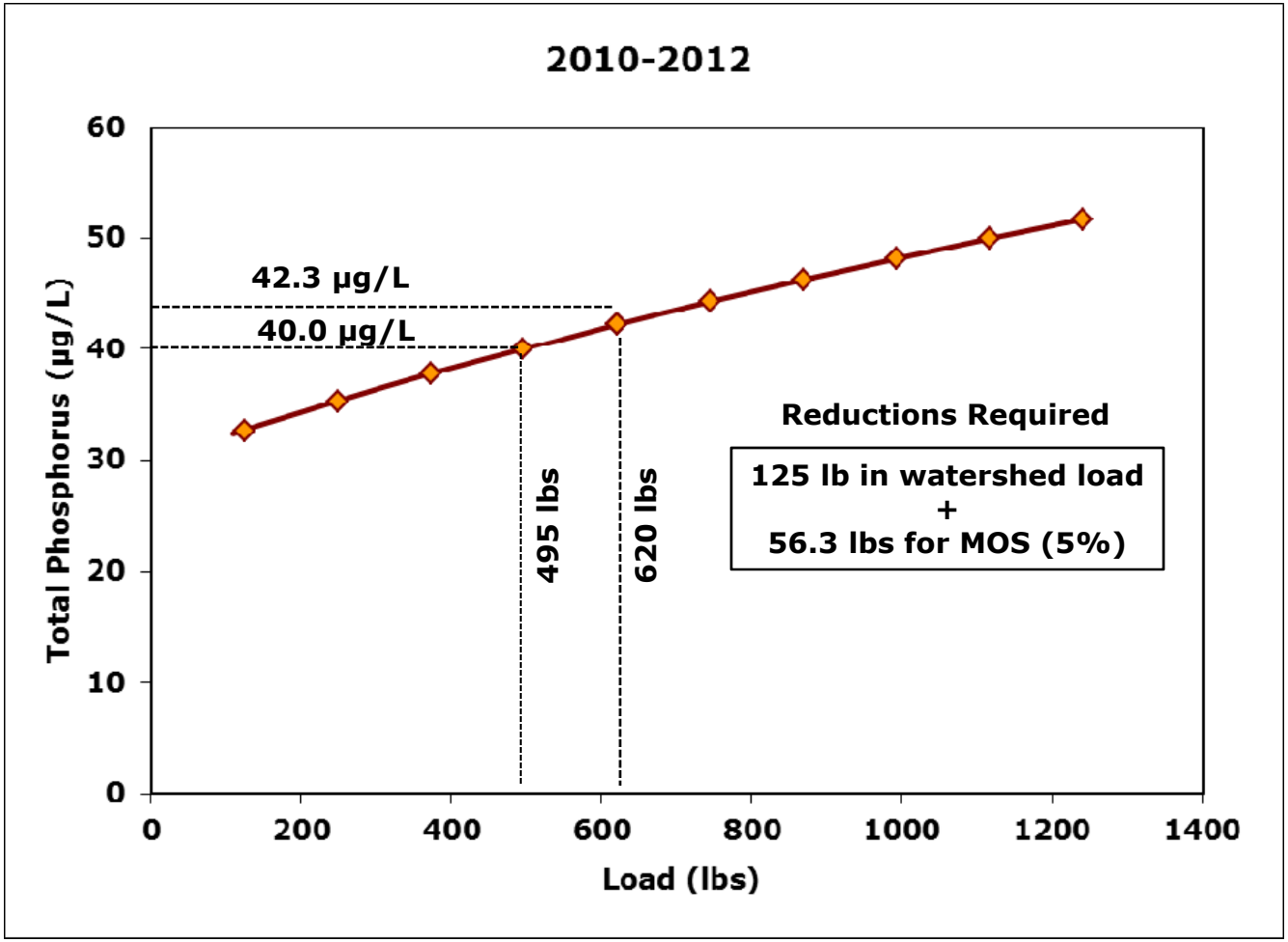
Load	Annual TP Load		
	kg	**pounds**	**%**
Atmospheric	28.2	62.2	5.0%
Internal	257.5	567.7	45.4%
Watershed	282.0	621.7	49.7%
Total	567.7	1251.6	100.0%



Fish Lake BATHTUB Model
In-Lake TP Load Response



Fish Lake BATHTUB Model In-Lake TP Load Response



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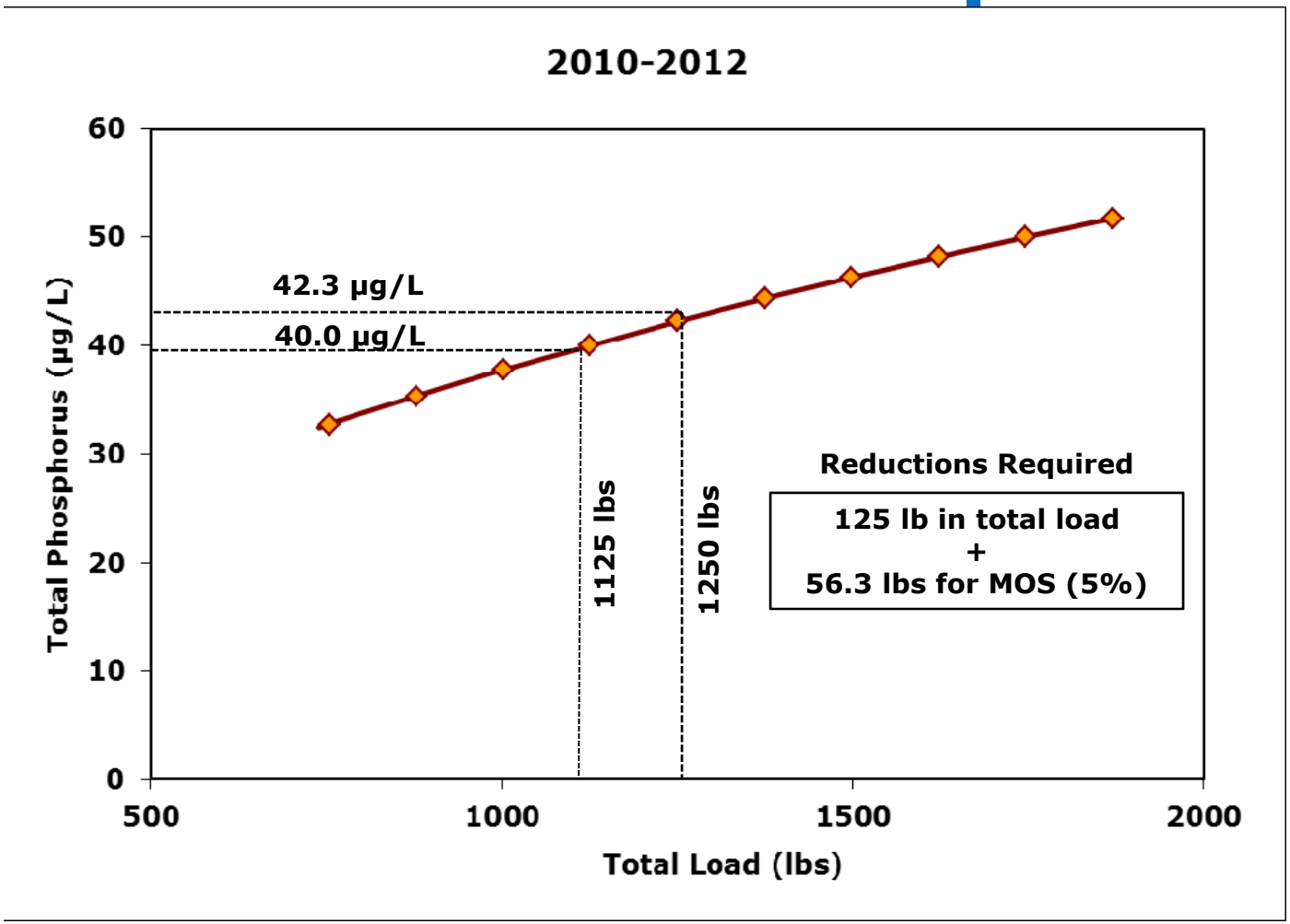


Reminder of Methodology Used to Set Allocations

- Allocate load (after subtracting MOS) among:
  - Permitted wastewater dischargers
  - Construction and Industrial stormwater
  - Municipal Separate Storm Sewer Systems (MS4s)
  - Non-permitted sources (i.e. all areas not expected to drain through a permitted MS4 stormwater conveyance system)

Allocation Methodology (con't)

- Allocations made proportionate to area in contributing watershed
- No waste load allocation = not permitted to discharge
- MnDOT and Hennepin County road ROW
  - Assigned as part of WLA if within 2010 urbanized area
  - Assigned as part of LA if outside 2010 urbanized area

Allocation Methodology (con't)

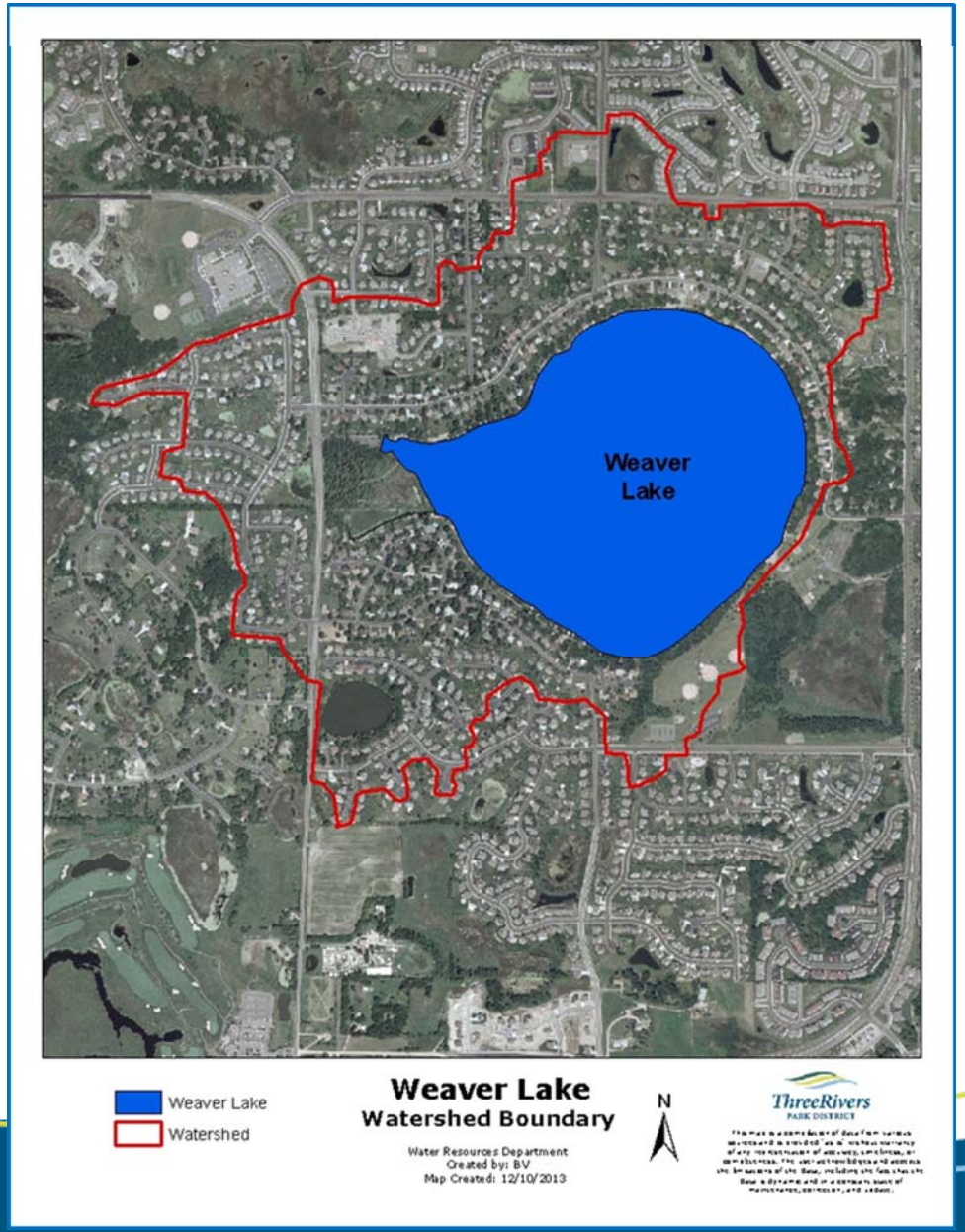
- For lakes, guidance from MPCA is to reduce loadings from permitted sources first to try to achieve in-lake water quality goals.
- Reductions from non-permitted sources (e.g. internal load) can be called for if achievable watershed load reductions are not sufficient.

Preliminary Allocations For Fish Lake

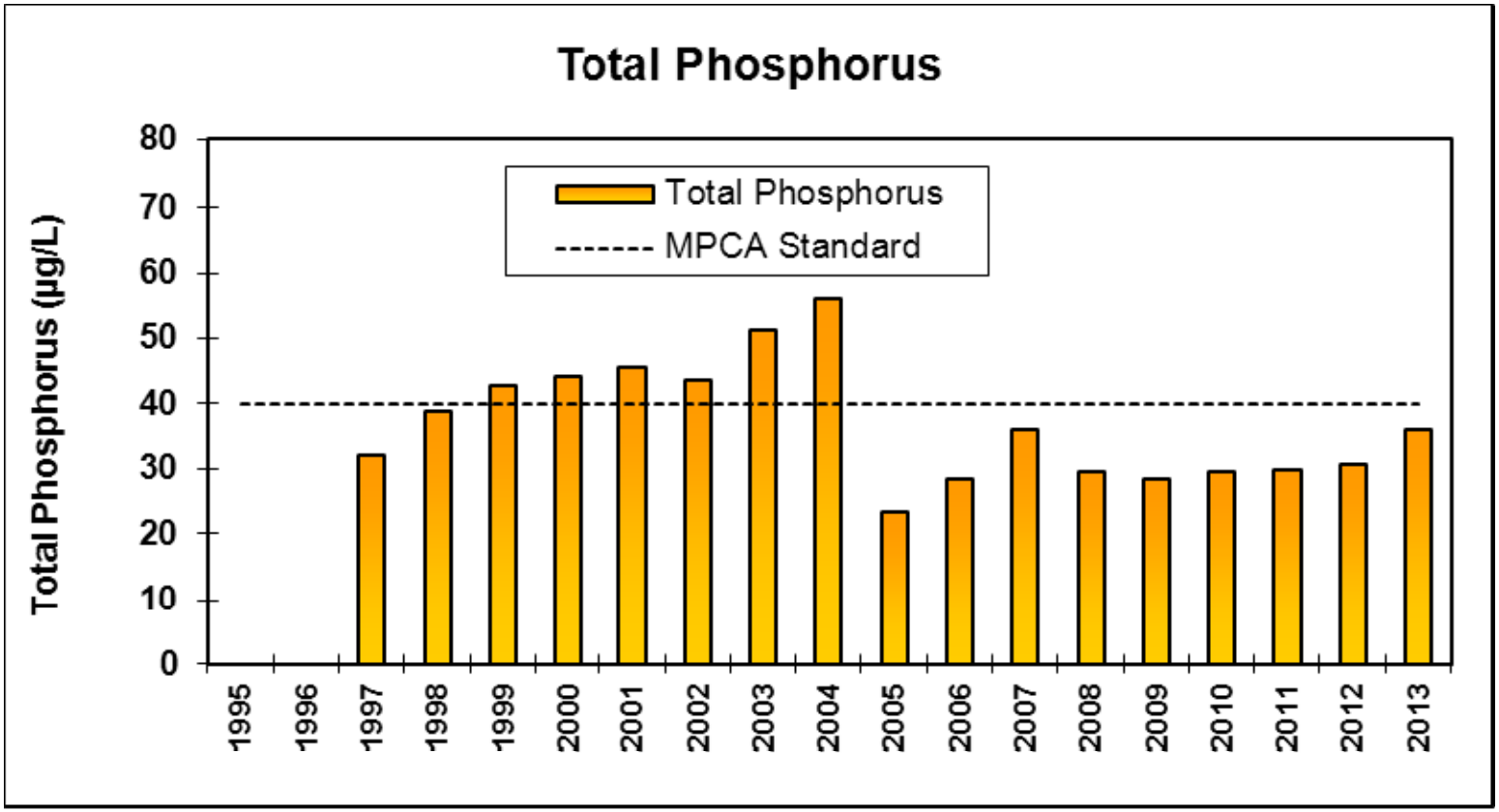
Fish Lake TMDL Summary (AUID 27-0118)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		1251.6	3.429	1125	3.082	126.6	10.1%
5% EXPLICIT MOS		0.0	0.000	56.25	0.154	56.3	4.5%
TOTAL REDUCTION						***182.9***	***14.6%***
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.029	10.7	0.029	0.0	0.0%
	Maple Grove MS4	558.7	1.531	391.7	1.073	167.0	29.9%
	Plymouth MS4	40.0	0.110	28.1	0.077	12.0	29.9%
	Hennepin County MS4	8.5	0.023	6.0	0.016	2.6	29.9%
	MnDOT MS4	3.8	0.010	2.6	0.007	1.1	29.9%
Load Allocations	Non-MS4 Runoff	0.0	0.000	0	0.000	0.0	0.0%
	Upstream Lakes	0.0	0.000	0	0.000	0.0	0.0%
	Atmospheric Deposition	62.2	0.170	62	0.170	0.2	0.0%
	Internal Load	567.7	1.555	567.7	1.555	0.0	0.0%

Weaver Lake Characteristics

- 152 acres in area
- 187 ac. watershed
- Watershed: lake area ratio - 1.2:1
- Max depth – 57 ft.
- % littoral – 50%
- Classified as "deep"
- "Flushing" time ~ 13 yrs.



Weaver Lake


Total Phosphorus
Total Phosphorus (µg/L)
80
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Total Phosphorus
MPCA Standard
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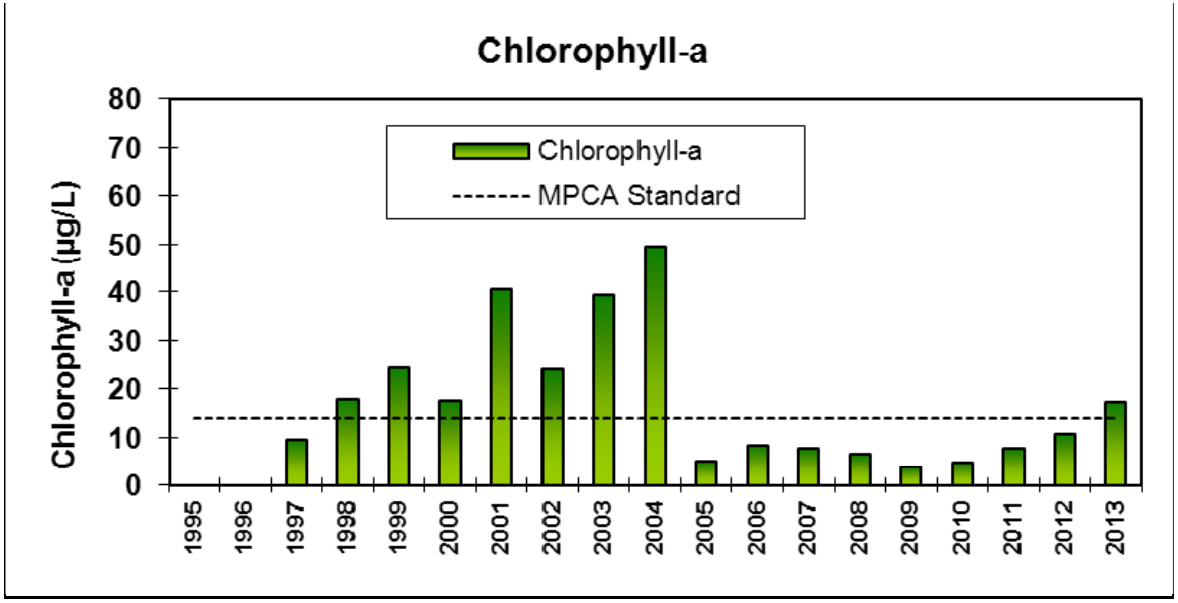
Weaver Lake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Chlorophyll-a (µg/L)
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Chlorophyll-a
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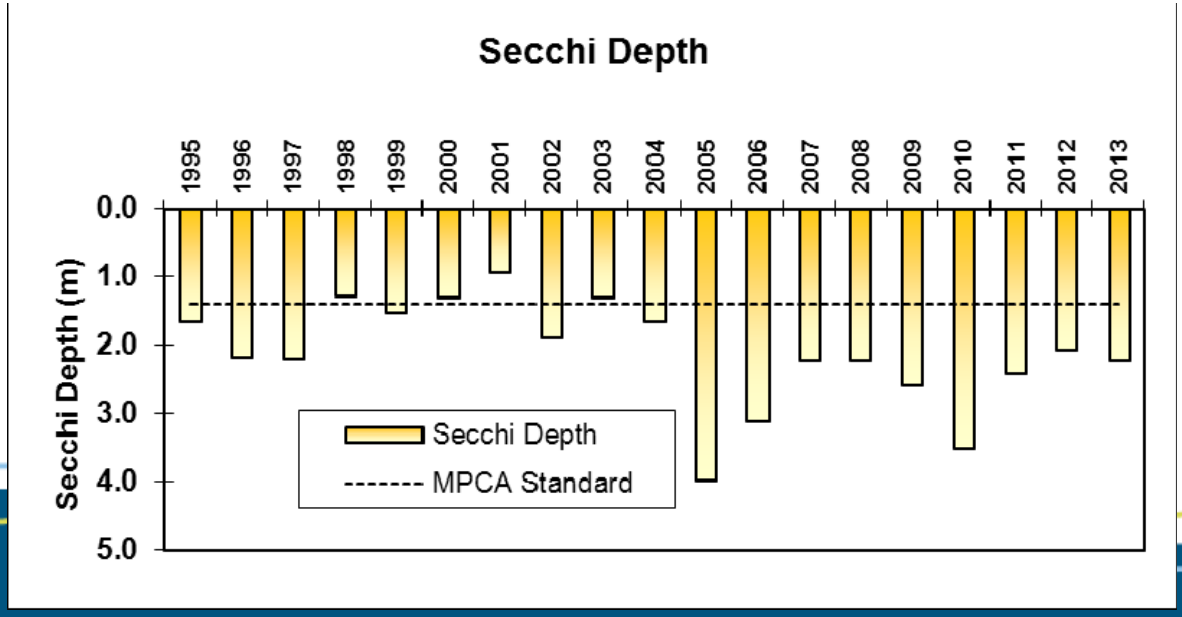
Secchi Depth
Secchi Depth (m)
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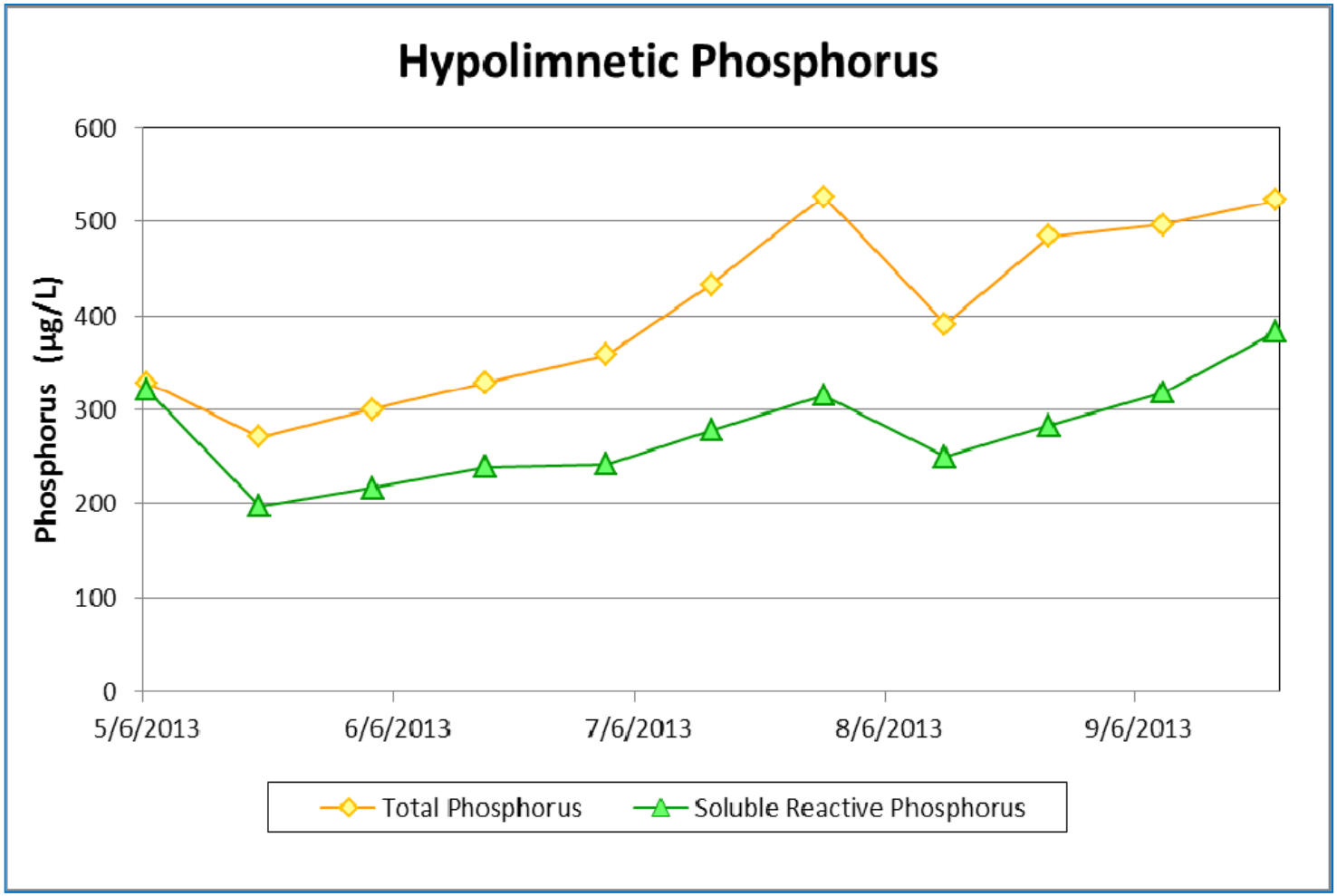
Secchi Depth
MPCA Standard

Weaver Lake


Hypolimnetic Phosphorus
Phosphorus (µg/L)
600
500
400
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5/6/2013
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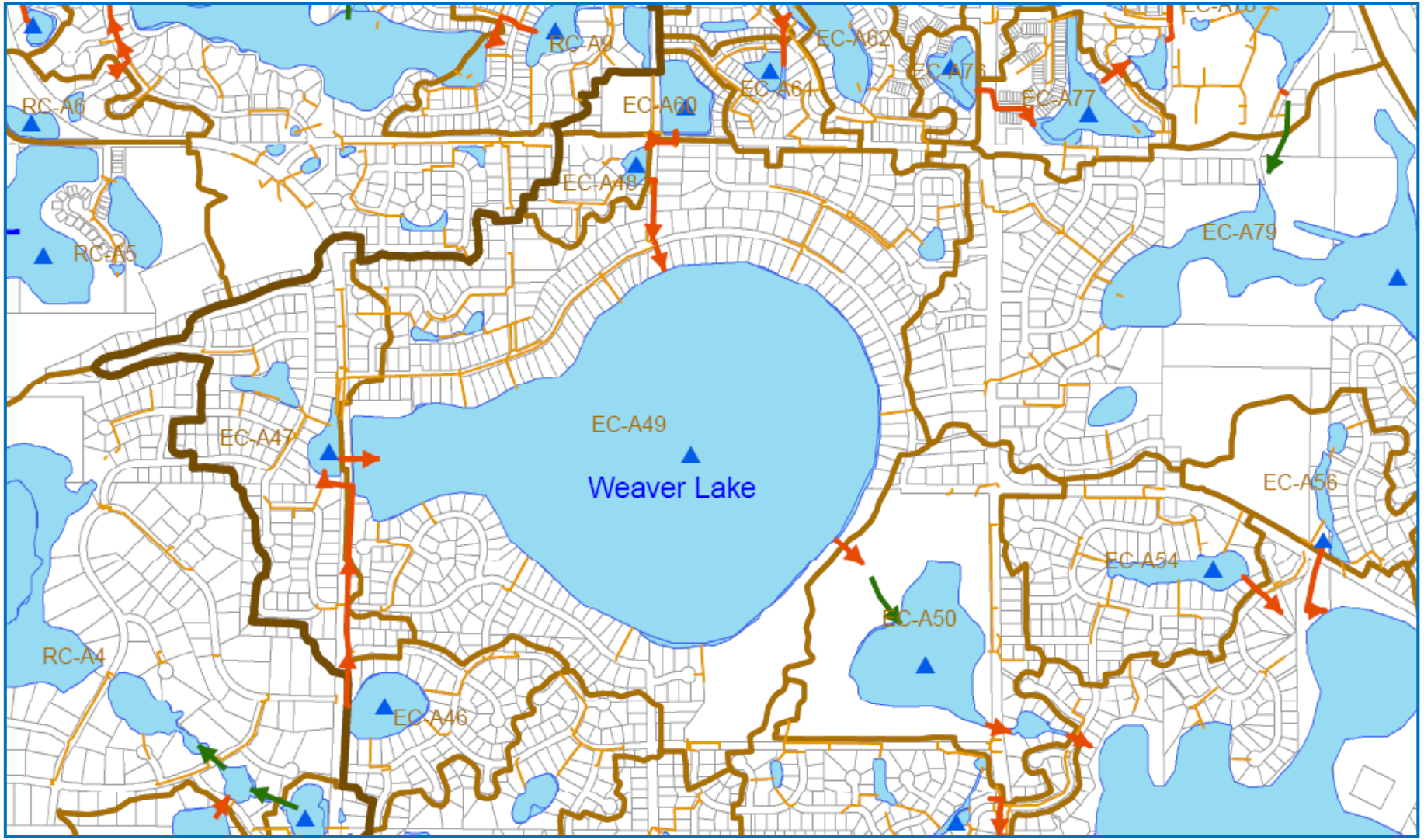
7/6/2013
8/6/2013
9/6/2013
Total Phosphorus
Soluble Reactive Phosphorus

Weaver Lake

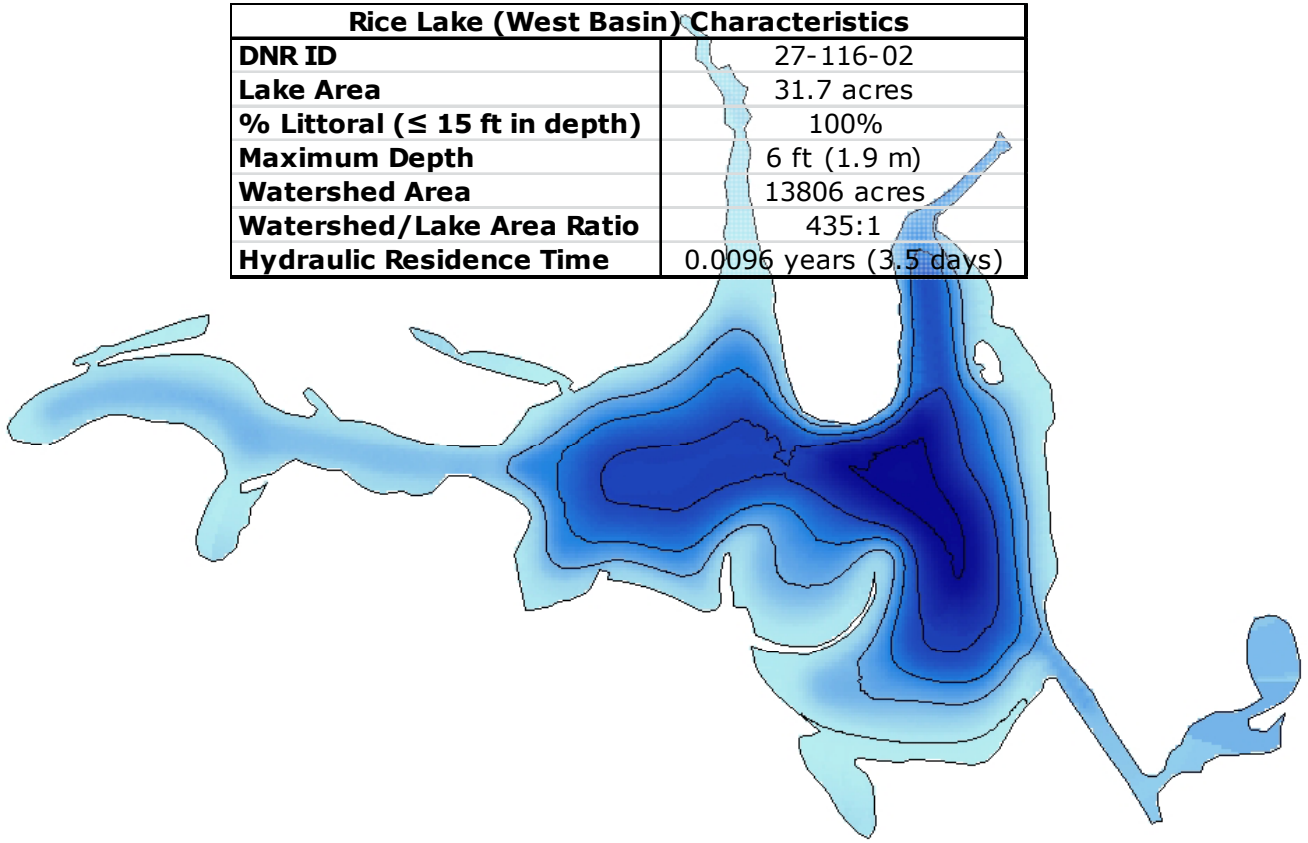

RC-A6
RC-A5
RC-A4
EC-A60
EC-A62
EC-A64
EC-A77
EC-A48
EC-A79
EC-A49
Weaver Lake
EC-A47
EC-A56
EC-A54
EC-A50
EC-A46

Weaver Lake-Protection Strategy Elements

- Inventory/assess/maintain key detention basins in watershed (especially two-cell basin west of lake that receives first-flush diversion runoff)
- Continue control of curly-leaf pondweed
- Periodically assess internal loading and address through suitable control measures if necessary
- Implement information, education and outreach effort throughout watershed

Rice Lake – West Basin

Rice Lake (West Basin) Characteristics	
DNR ID	27-116-02
Lake Area	31.7 acres
% Littoral (≤ 15 ft in depth)	100%
Maximum Depth	6 ft (1.9 m)
Watershed Area	13806 acres
Watershed/Lake Area Ratio	435:1
Hydraulic Residence Time	0.0096 years (3.5 days)



Rice Lake-West Bathymetry

Contours

Depth_m

High : 1.85

Low : 0

Rice Lake-West Basin

Bathymetric Map

Water Resources Department

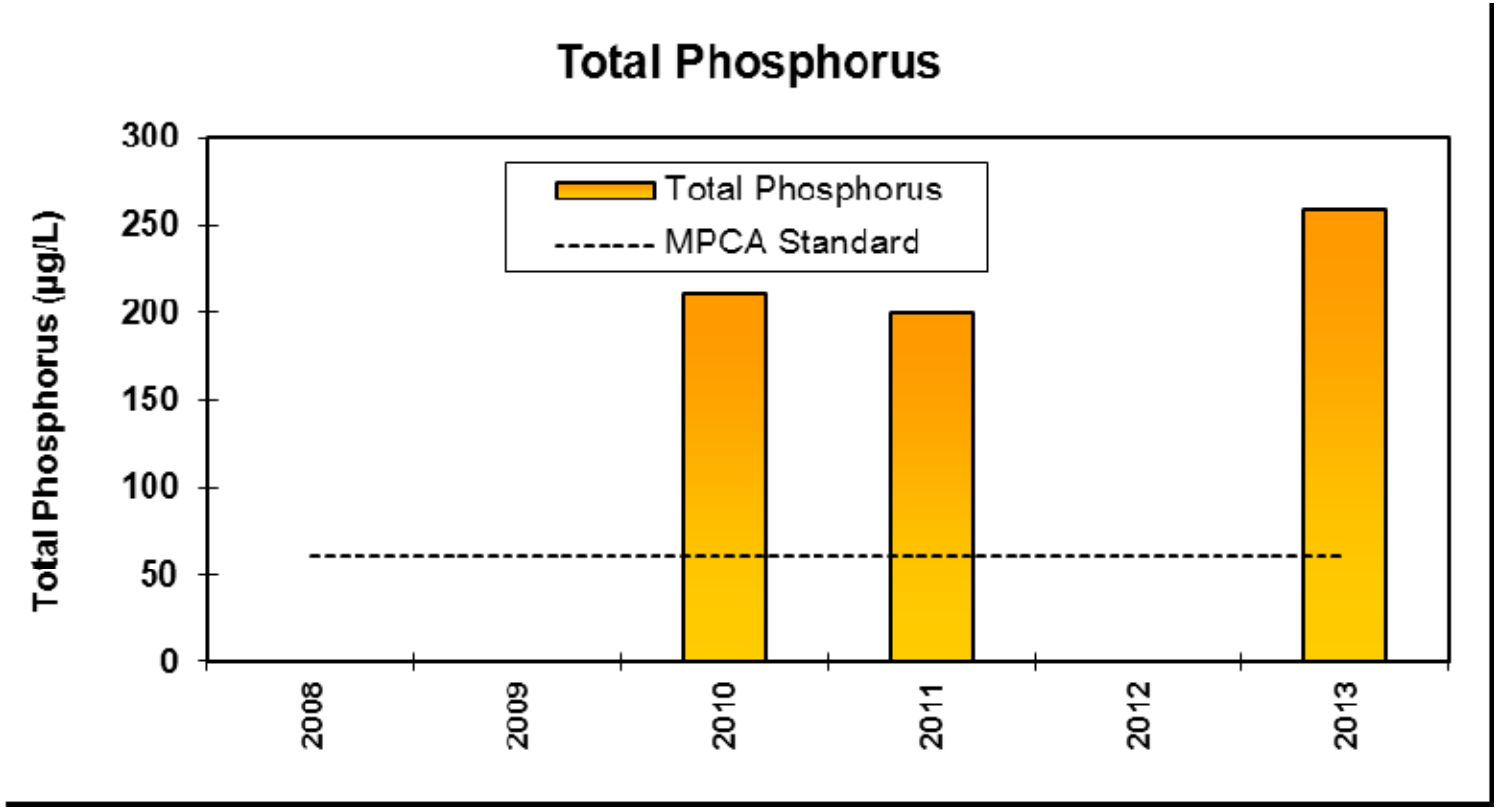
Created by: BV

Map Created: 12/05/2013

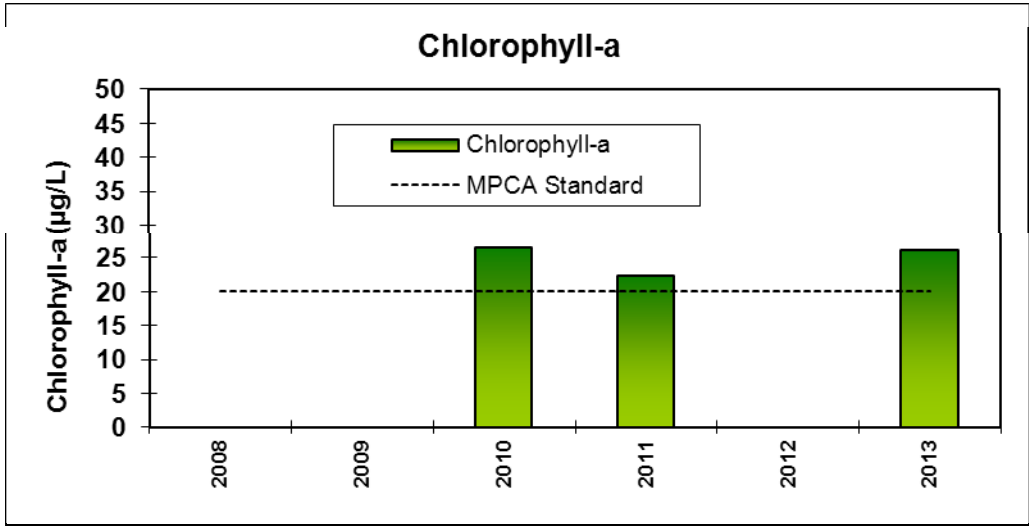
N

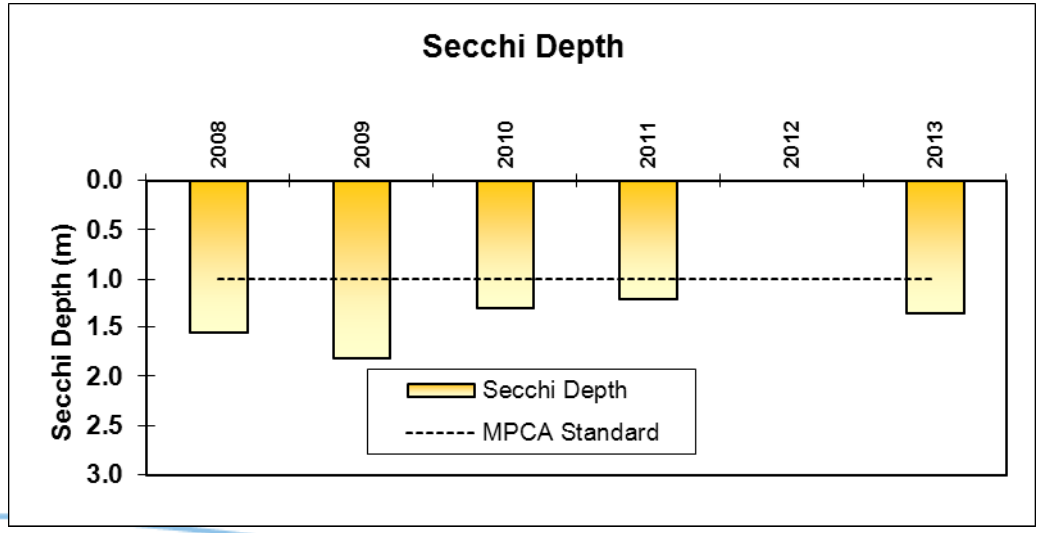
ThreeRivers PARK DISTRICT

Rice Lake – West Basin



Rice Lake – West Basin





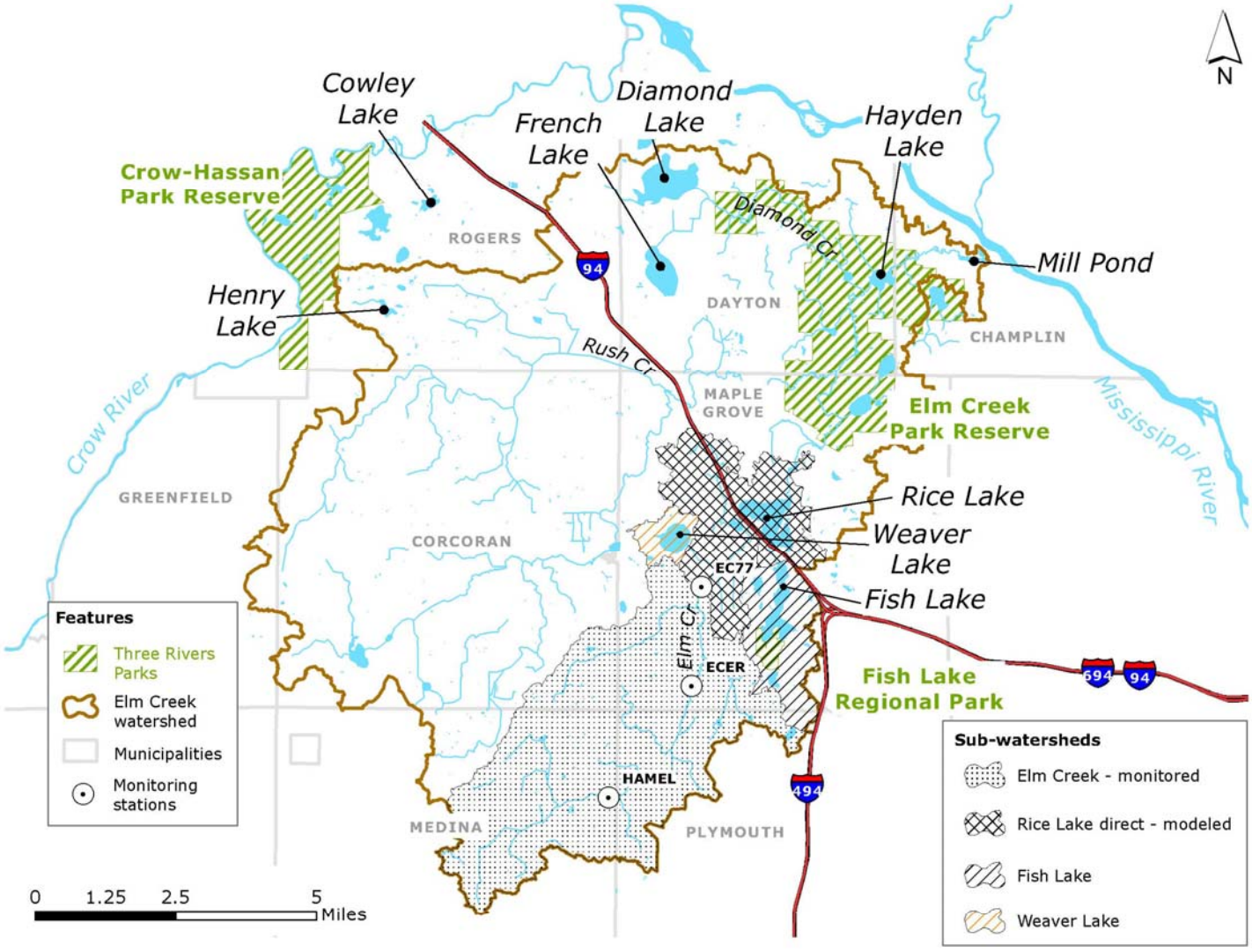
Rice Lake – West Basin

Minnesota Rules Chapter 7050.0150(4) states that in order to be considered a lake/reservoir, a water body must have a hydraulic residence time of at least 14 days which is to be determined using a flow equal to the 122-day ten-year low flow (122Q10) measured June 1st through September 30th.

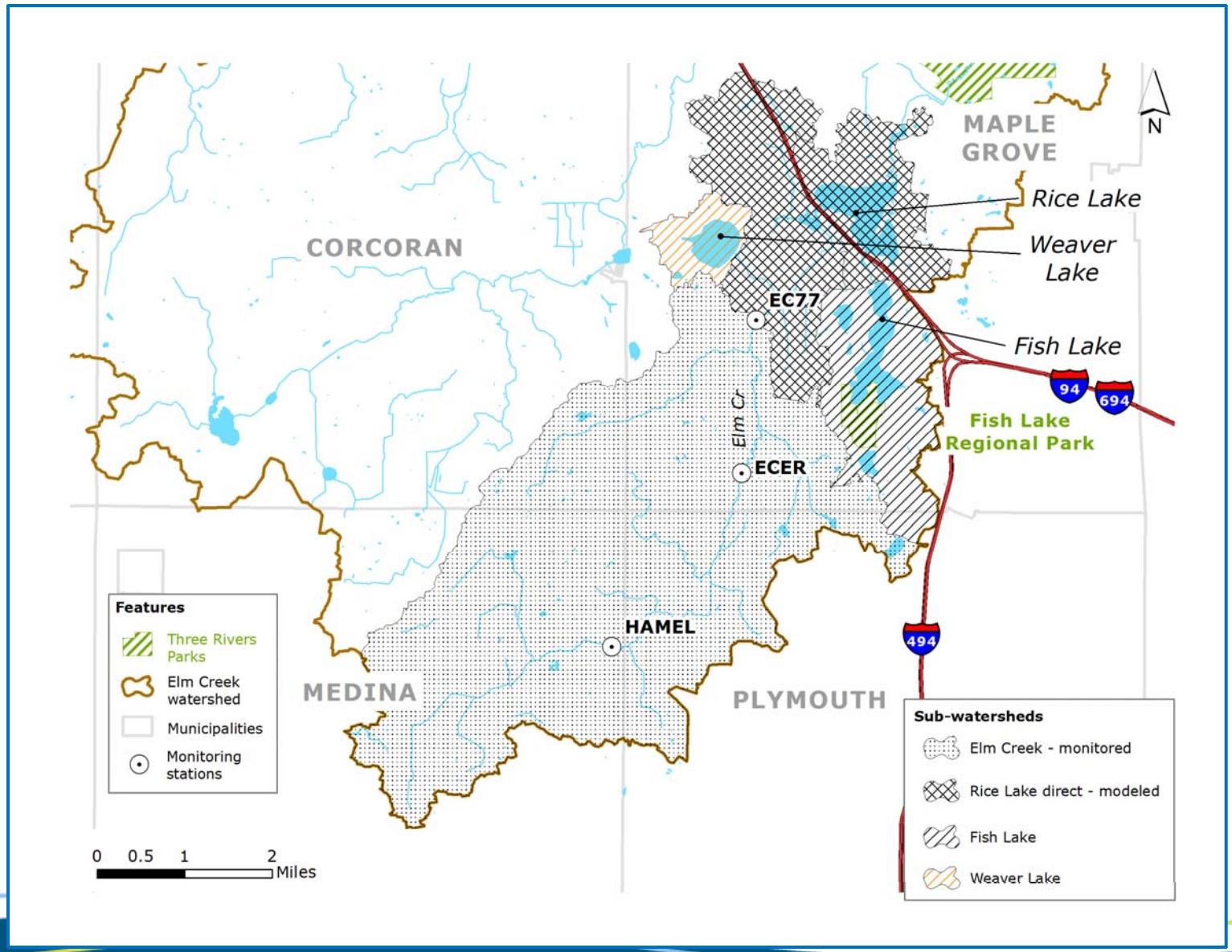
Question:
Based on the short residence time (3.5 days) for average conditions.

Should Rice Lake – West Basin be classified as a shallow lake or a wide portion within the channel of Elm Creek?

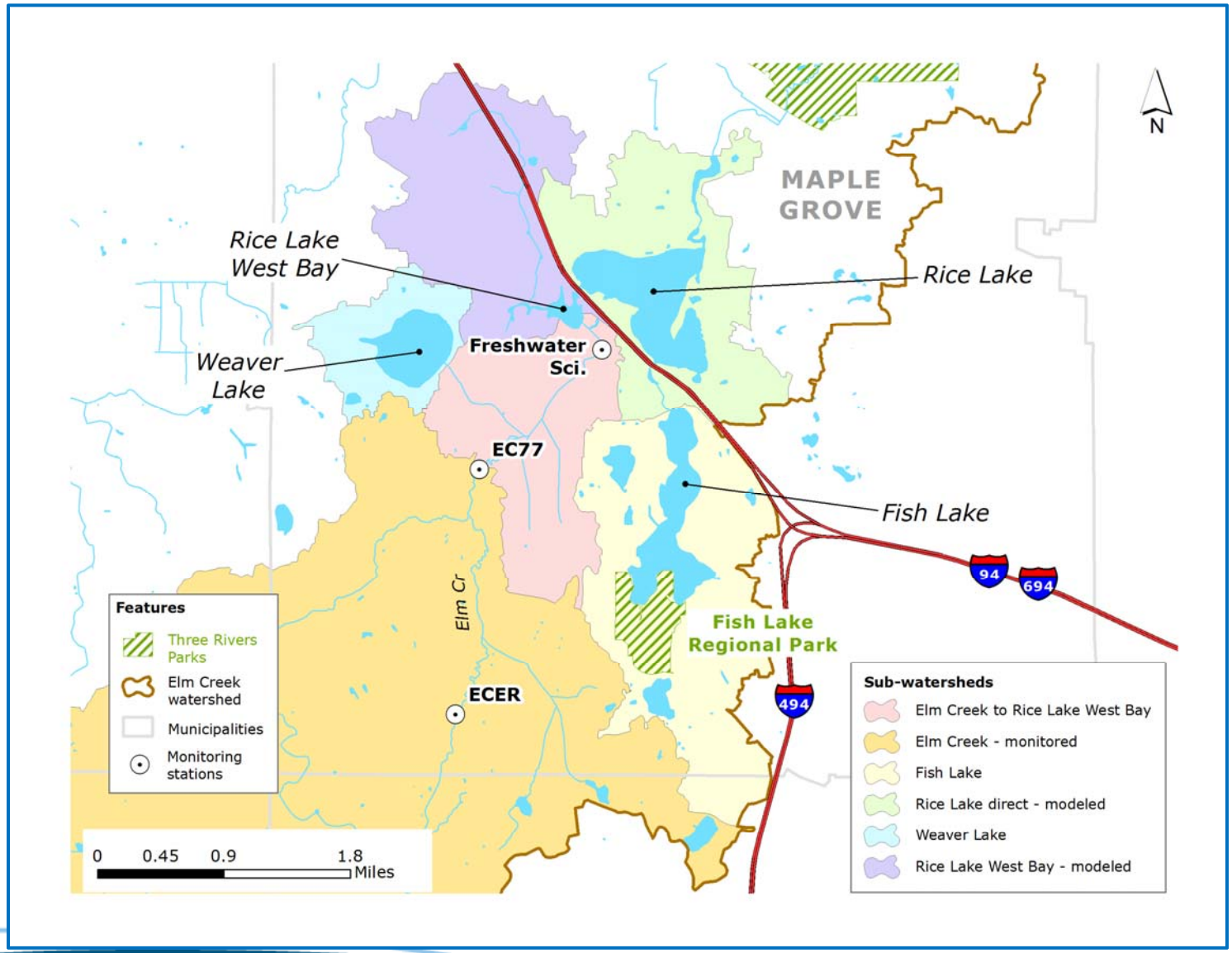
Rice Lake – West Basin



Rice Lake – West Basin



Rice Lake – West Basin

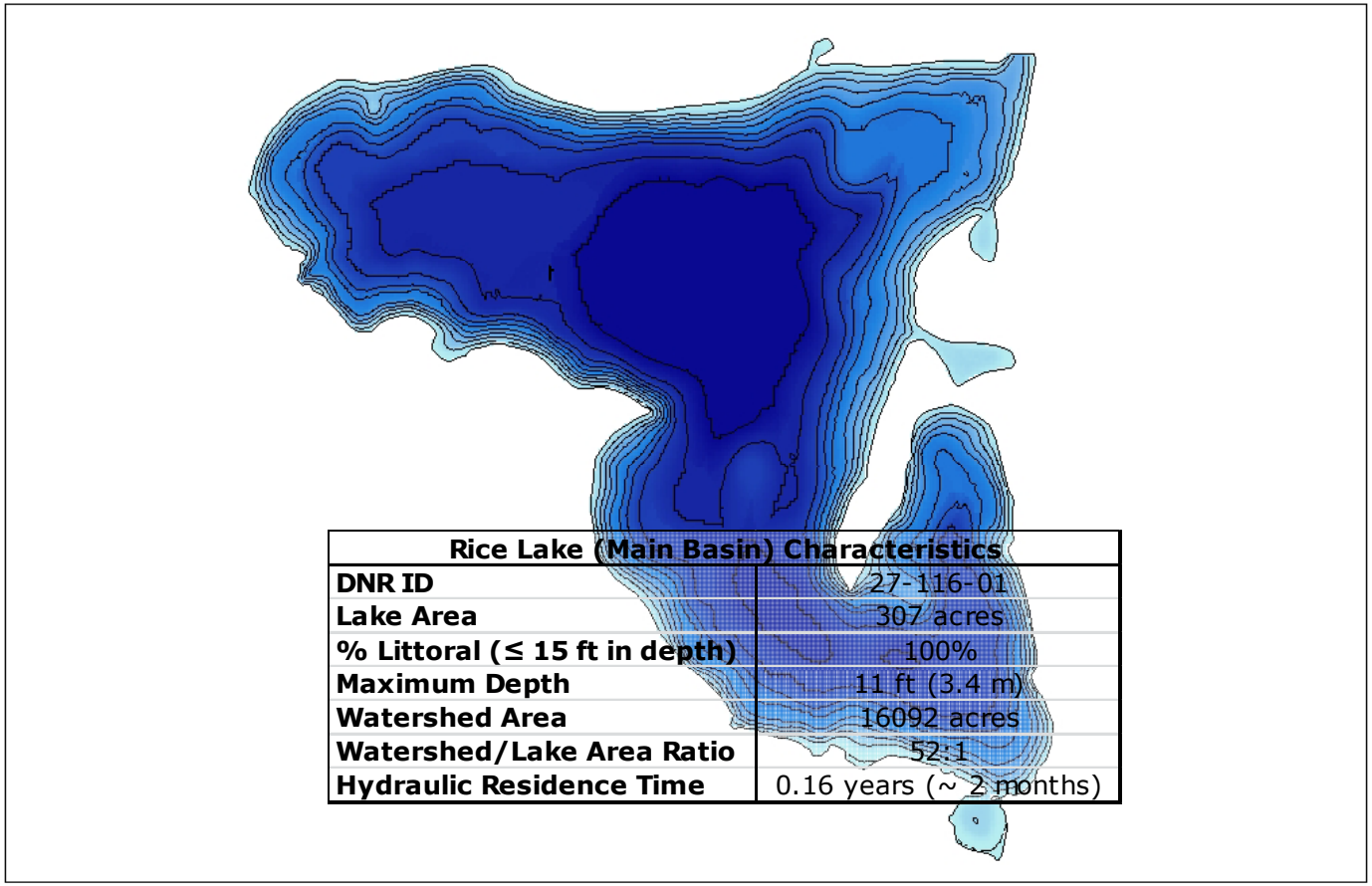


Rice Lake – West Basin

Minnesota Rules Chapter 7050.0150(4) states that in order to be considered a lake/reservoir, a water body must have a hydraulic residence time of at least 14 days which is to be determined using a flow equal to the 122-day ten-year low flow (122Q10) measured June 1st through September 30th.

Flow Data	122Q10			Rice-West Volume	Residence Time
	cfs	ft3/day	m3/day	m3	days
1991-2012	5.658	488870.7	13845.11	135457.13	9.78
2001-2012	4.860	419897.9	11891.76	135457.13	11.39

Rice Lake – Main Basin



Rice Lake (Main Basin) Characteristics	
DNR ID	27-116-01
Lake Area	307 acres
% Littoral (≤ 15 ft in depth)	100%
Maximum Depth	11 ft (3.4 m)
Watershed Area	16092 acres
Watershed/Lake Area Ratio	52:1
Hydraulic Residence Time	0.16 years (~ 2 months)

Rice Lake-Main Bathymetry

Contours

Depth_m

High : 3.1

Low : 0

Rice Lake-Main Basin

Bathymetric Map

Water Resources Department

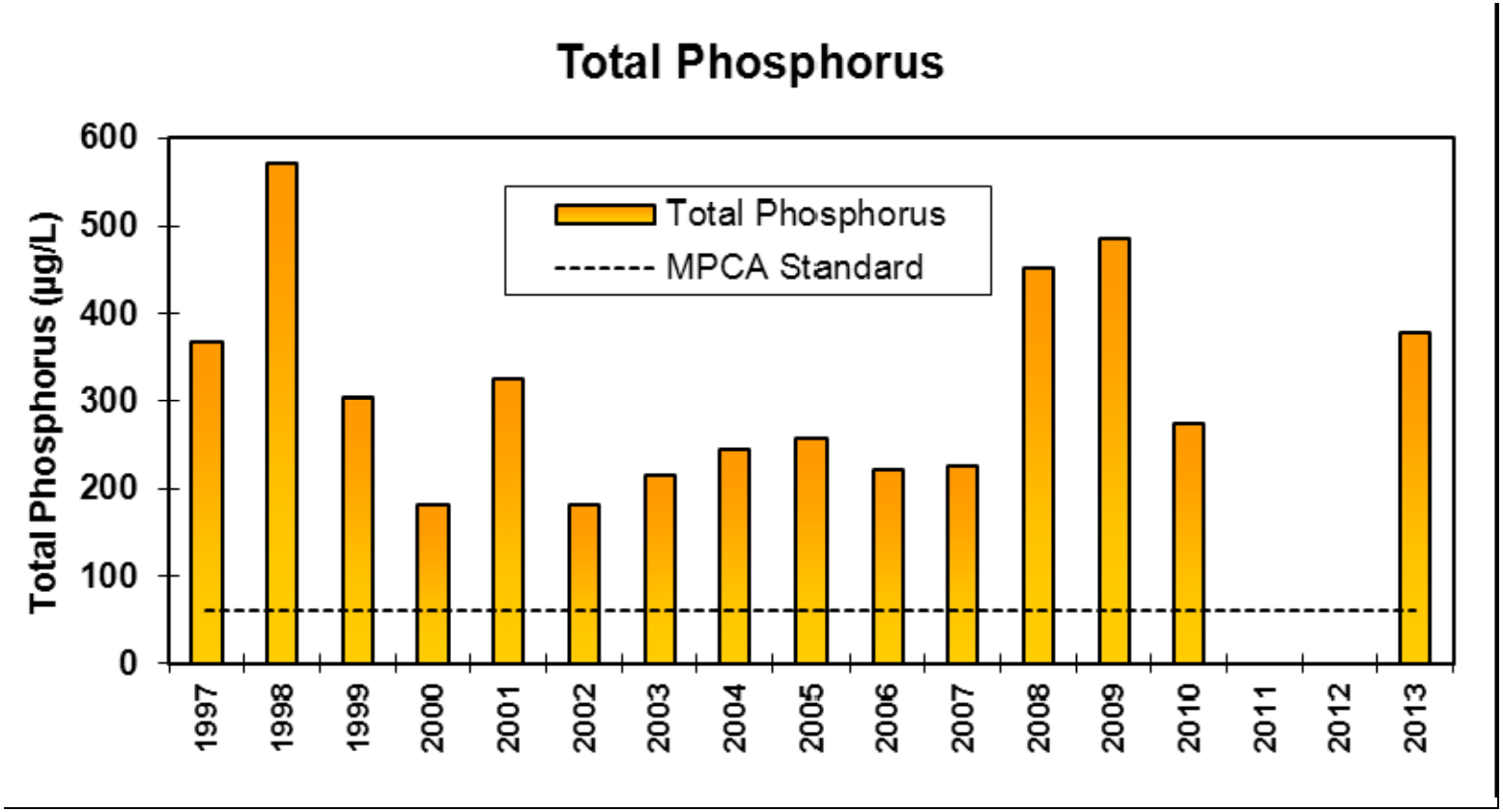
Created by: BV

Map Created: 12/05/2013

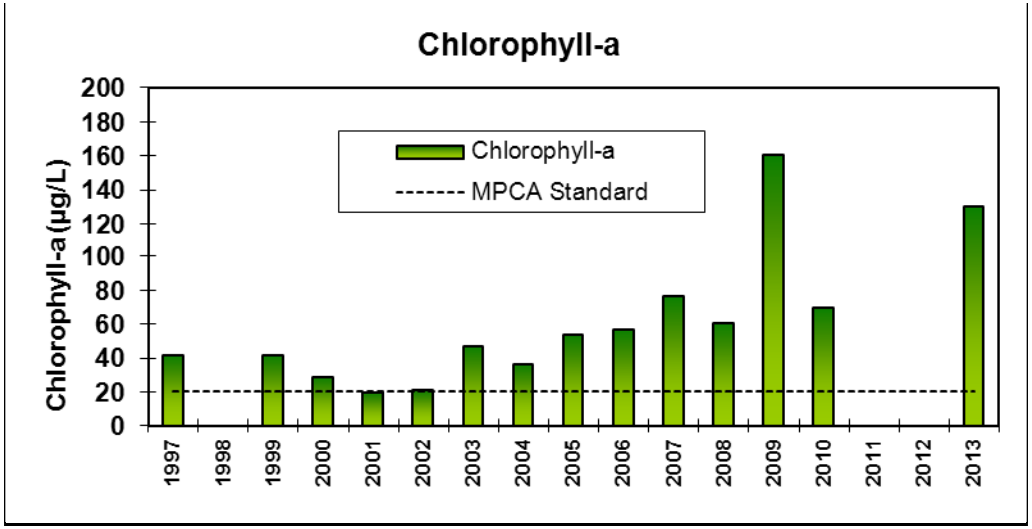
N

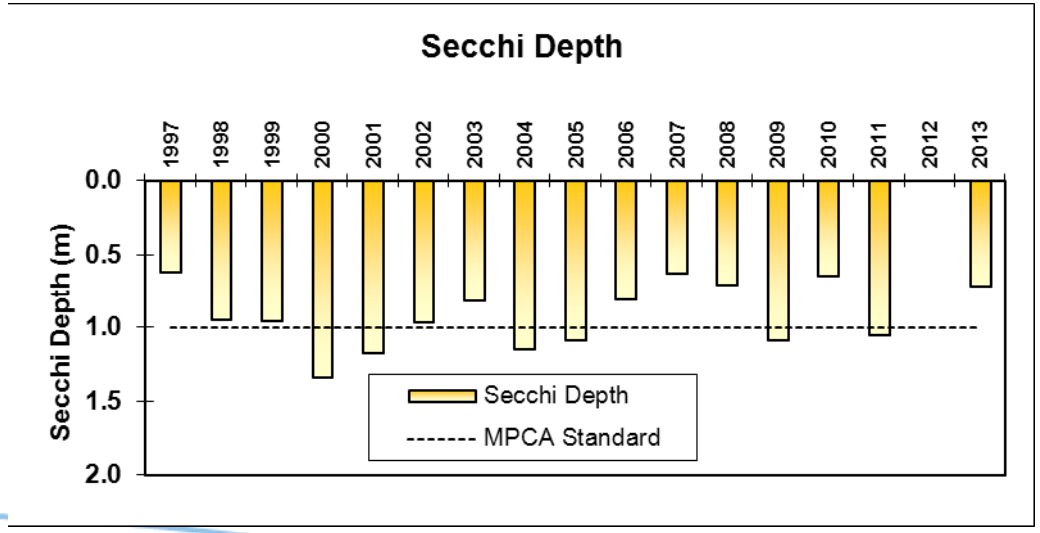
ThreeRivers PARK DISTRICT

Rice Lake – Main Basin

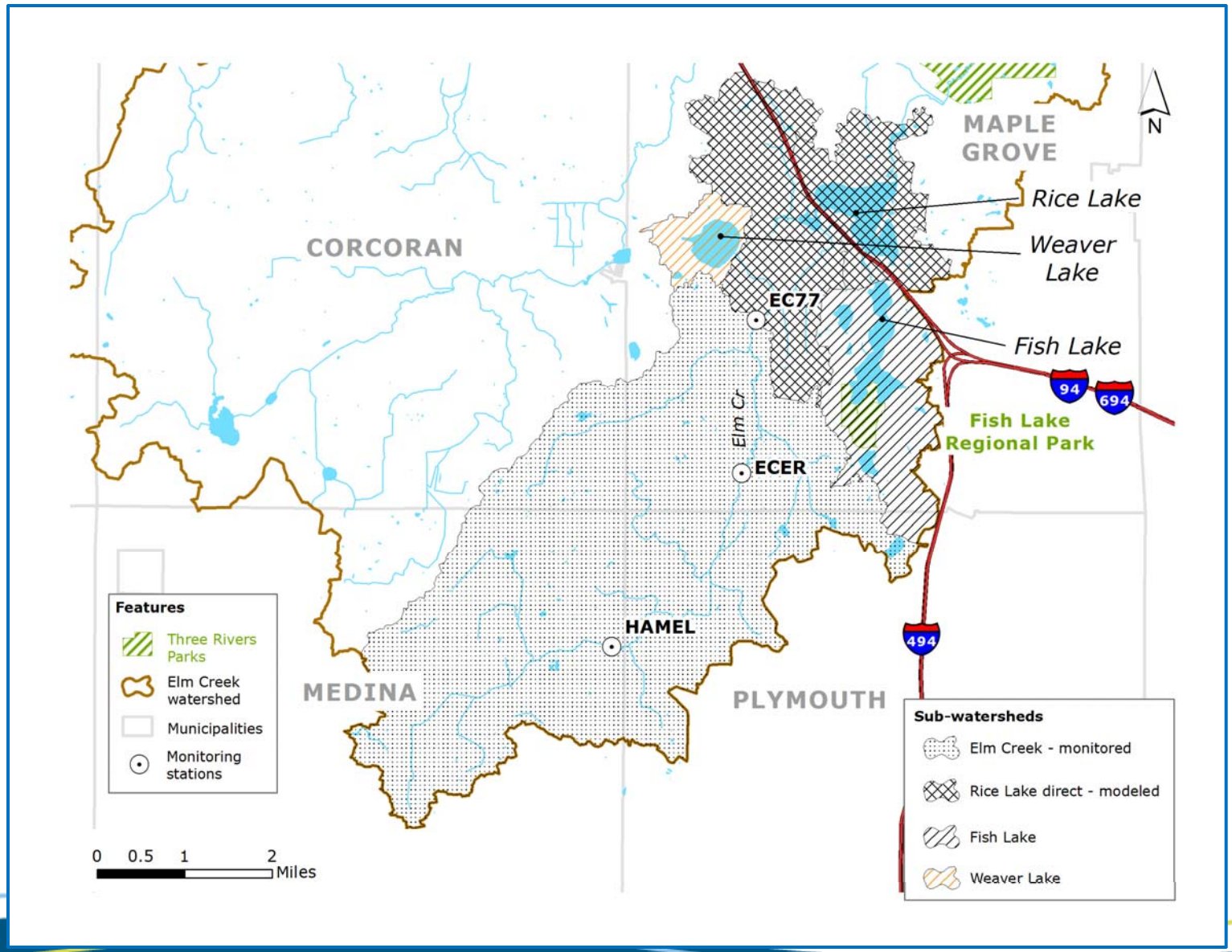


Rice Lake – Main Basin

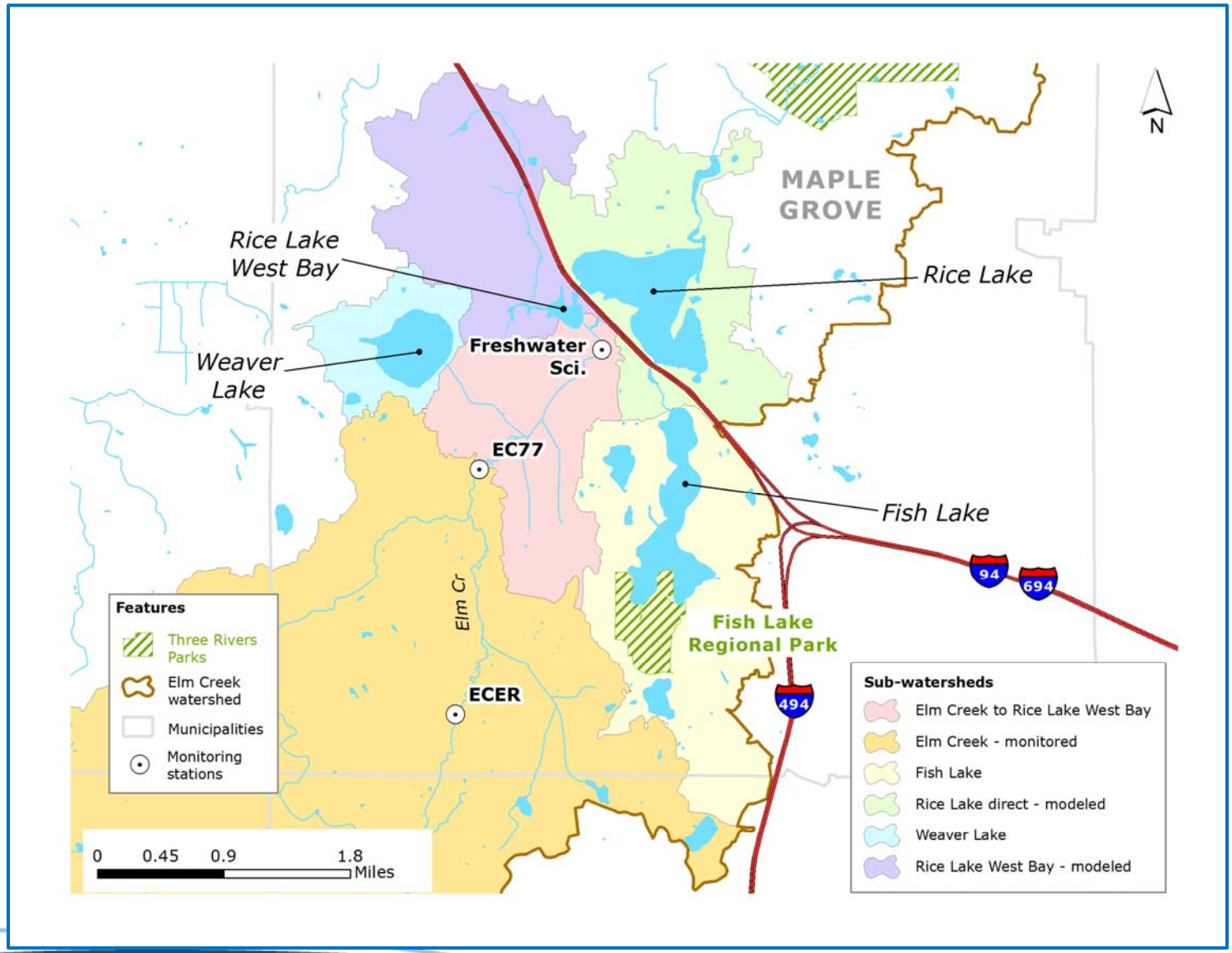




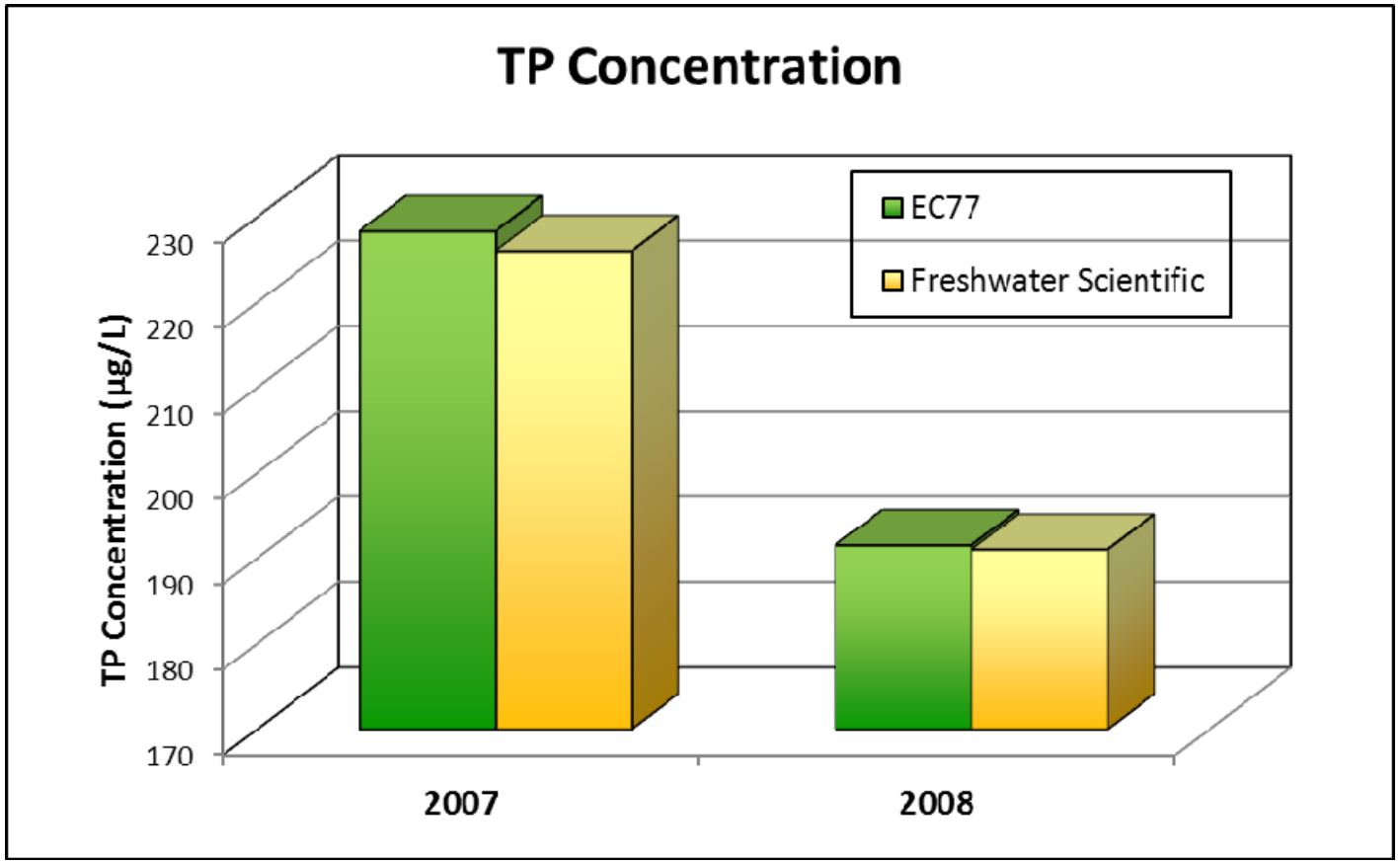
Rice Lake – Main Basin



Rice Lake – Main Basin



Rice Lake – Main Basin
EC77 vs Freshwater Scientific Data



Rice Lake-Main BATHTUB Model Loading Input

- P8 Model was run for years with average precipitation conditions (2010-2012).
- The flow volume and nutrient concentration from the P8 model simulation was averaged for 2010-2012 and was input into the BATHTUB model.

P8 Model Estimates 2010-2012		
Watershed	Volume (Acre-ft)	TP Concentration (µg/L)
EC-77	9469.88	275.0
EC-P53	704.65	275.0
EC-P78	938.54	198.0
Rice-West Direct (EC-A79)	229.26	365.0
Rice-Main Direct (EC-A89)	768.43	377.7
EC-P85	52.15	199.4
Fish Lake	992.31	42.5

BATHTUB Model Internal Loading Input

- Sediment cores were collected in 2012 to estimate sediment phosphorus release rates for Rice Lake-Main (Analyzed by William James-STOUT Laboratory).
- Nürenberg equation (1988) was used to estimate anoxic and oxic internal loading for Rice Lake-Main.

	Total Phosphorus	
	Sediment Release Rate	Estimated Internal Load
Conditions	(mg/m2/day)	(lbs)
Anoxia	9.45	1556.0
Oxic	1.17	299.4
Total		1855.4

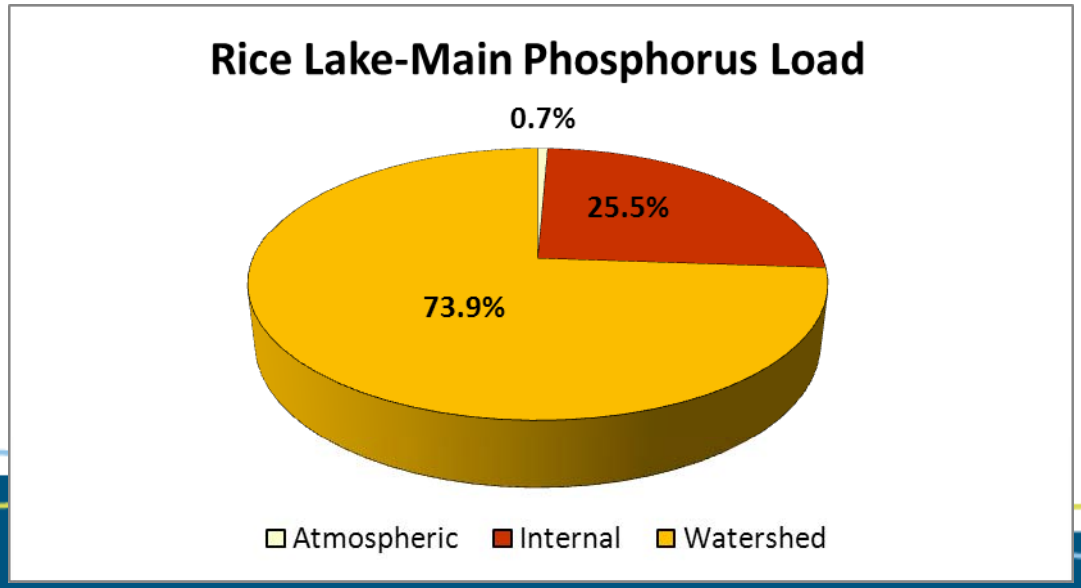
- Curlyleaf Pondweed estimated internal load ranges between: 506.6 lbs to 979.3 pounds (approximately 1.65 to 3.19 lbs/acre).

- Total internal Load Estimated = Nürenberg + Curlyleaf Pondweed
  - Total internal Load ≈ 2362.0 to 2834.7 pounds/year
- TP internal load input into the BATHTUB model for calibration was 3195.2 pounds.

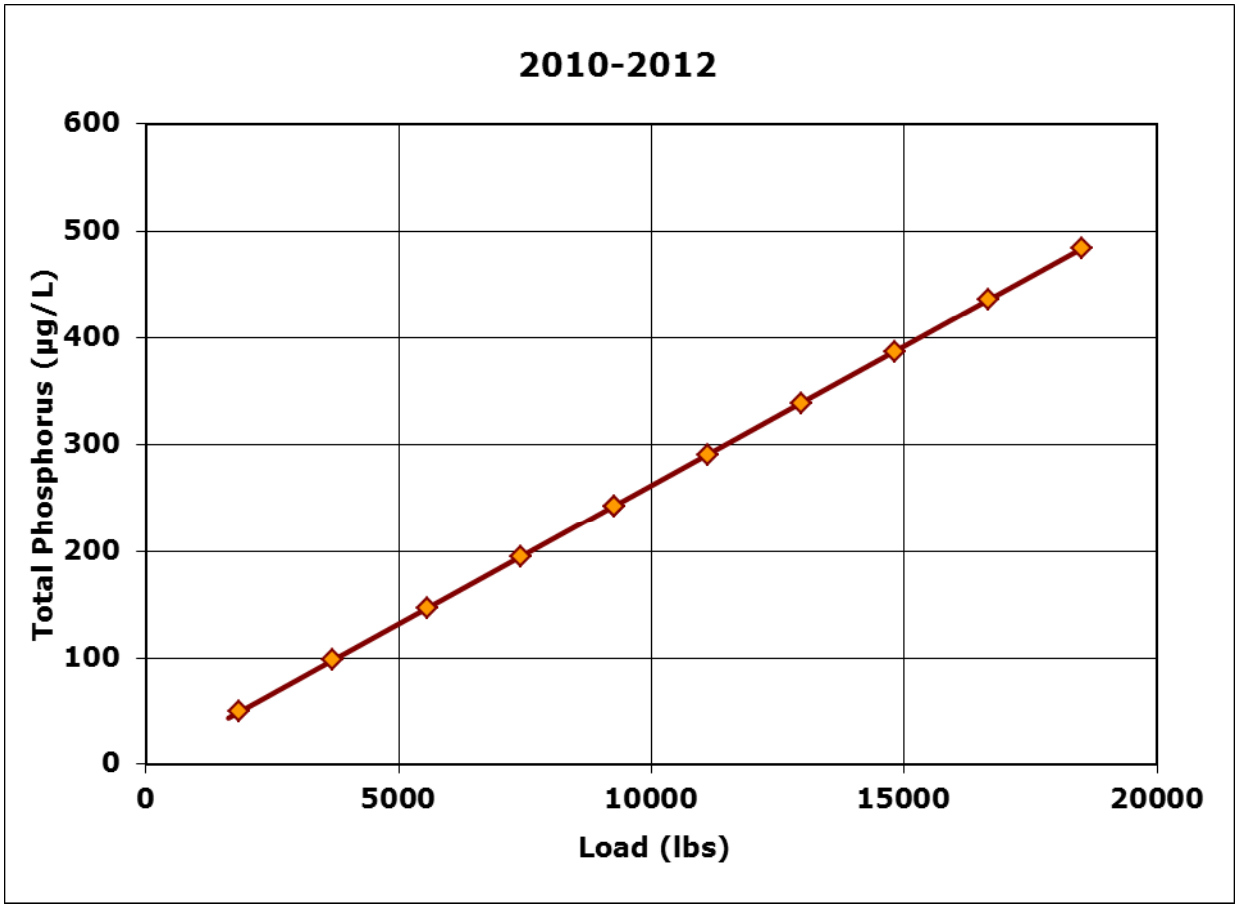
Rice Lake-Main BATHTUB Output

Rice Lake - Main BATHTUB Model Estimates			
Variable	**Predicted**	**Observed**	**Model**
Total Phosphorus (µg/L)	325.7	326.0	Settling Velocity
Chlorophyll-a (µg/L)	100.3	100.4	P, Linear
Secchi (m)	0.8	0.8	Transparency vs Chl-a & Turbidity

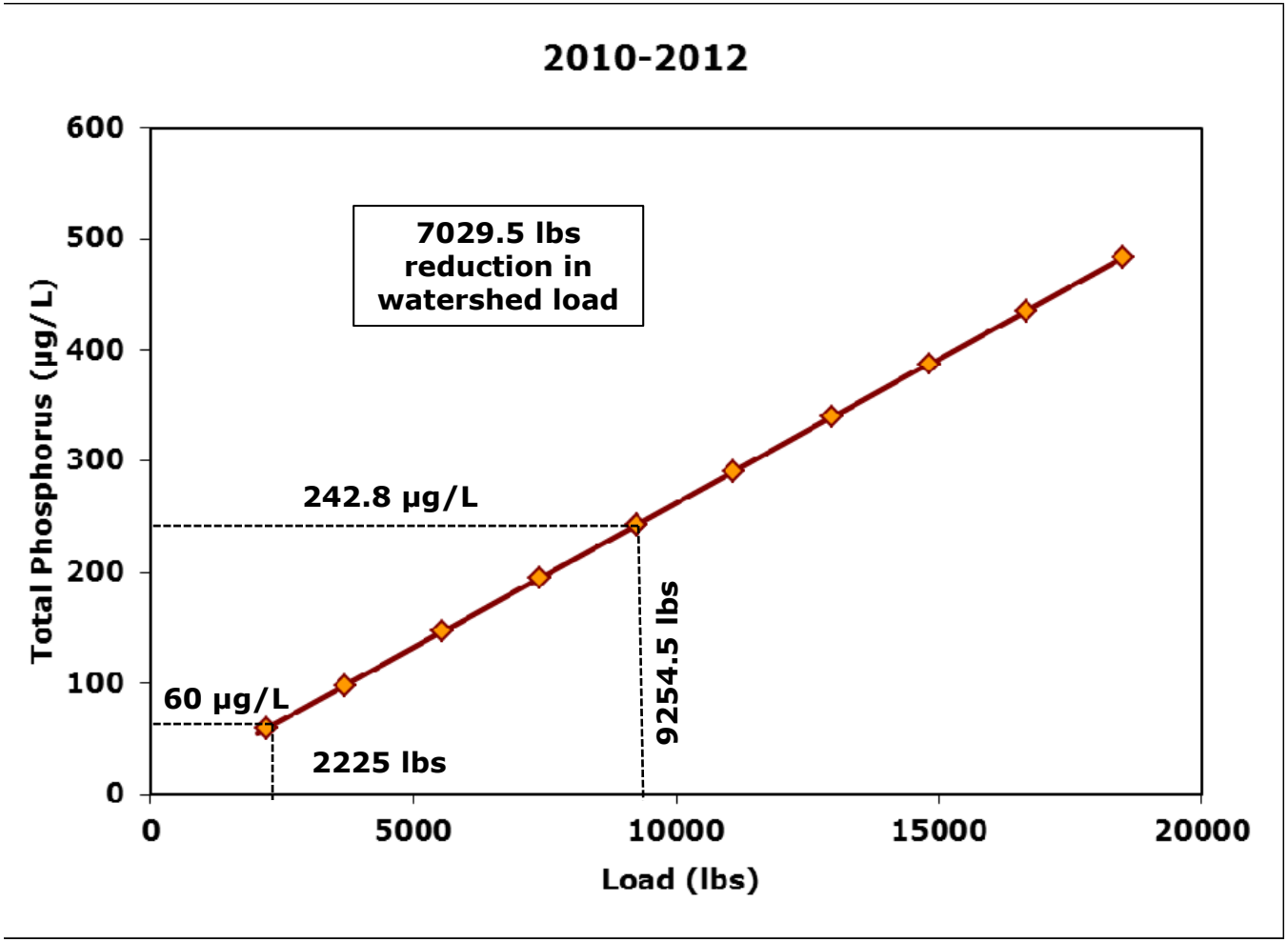
Load	**Annual TP Load**		
	kg	**pounds**	**%**
Atmospheric	37.2	82.0	0.7%
Internal	1449.3	3195.2	25.5%
Watershed	4206.6	9274.0	73.9%
Total	5693.1	12551.1	100.0%



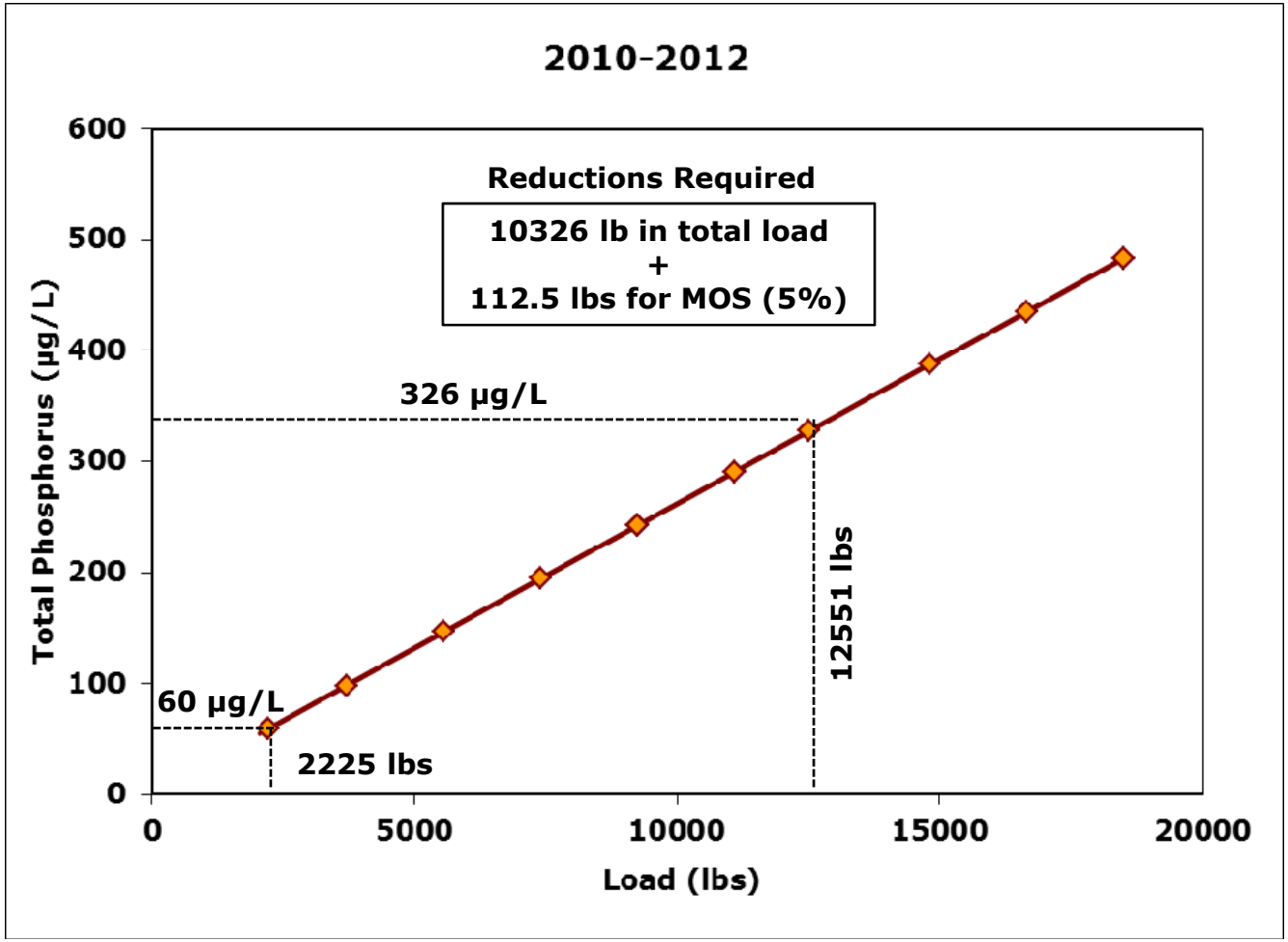
Rice Lake-Main BATHTUB Model In-Lake TP Load Response



Rice Lake-Main BATHTUB Model In-Lake TP Load Response



Rice Lake-Main BATHTUB Model In-Lake TP Load Response



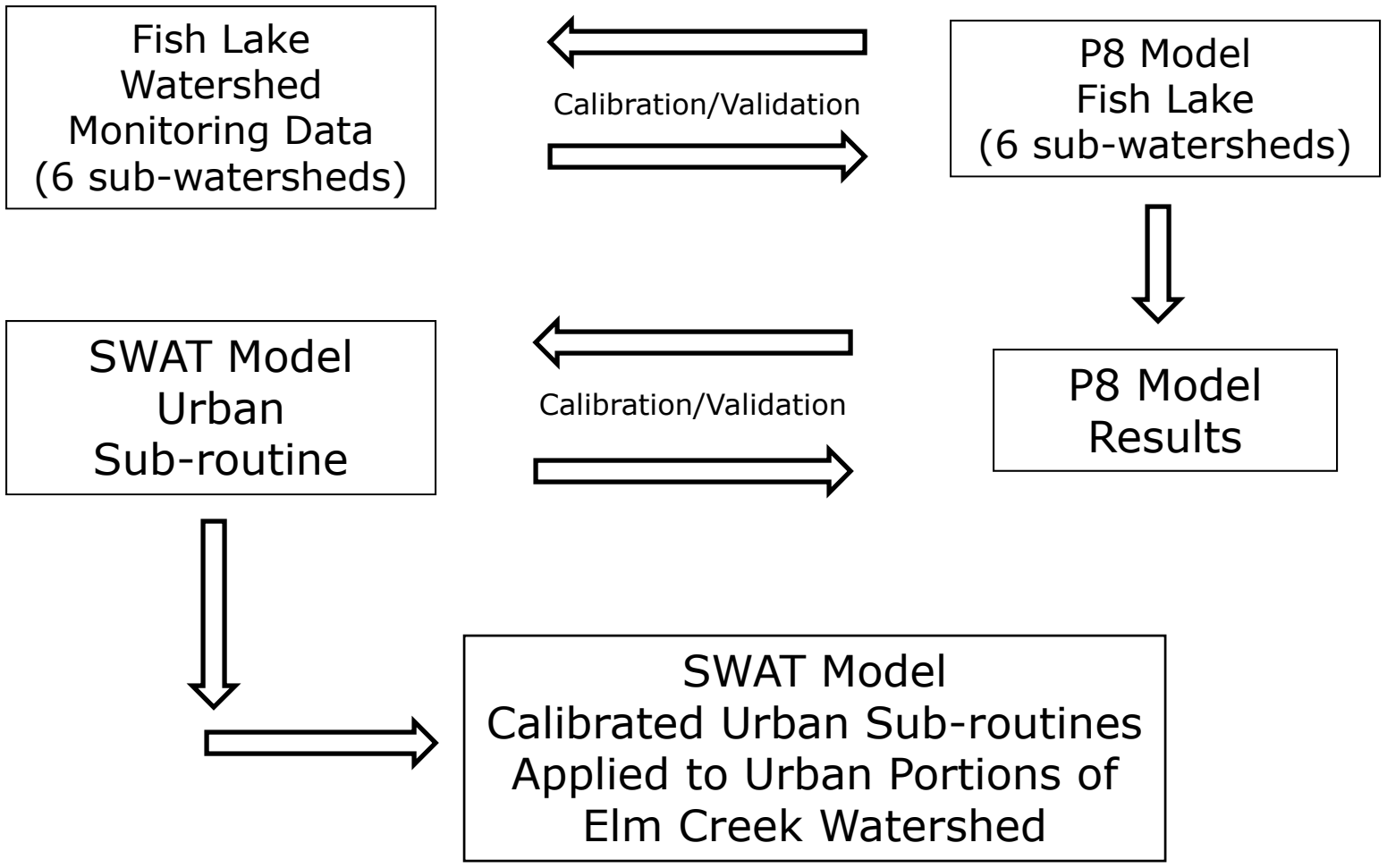
Preliminary Allocations For Rice Lake (Main Basin) Scenario 1 (Full Internal Load Control)

Rice Lake-Main Basin TMDL Summary (AUID 27-0116-01)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		12551.1	34.387	2225	6.096	10326.1	82.3%
5% EXPLICIT MOS		0.0	0.000	111.25	0.305	111.3	0.9%
TOTAL REDUCTION						**10437.4**	**83.2%**
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.058	21.1	0.058	0.0	0.0%
	Maple Grove MS4	3547.0	9.718	736.1	2.017	2810.9	79.2%
	Plymouth MS4	1297.4	3.555	269.2	0.738	1028.2	79.2%
	Medina MS4	1422.3	3.897	295.1	0.809	1127.1	79.2%
	Corcoran MS4	604.7	1.657	125.5	0.344	479.2	79.2%
	Hennepin County MS4	77.0	0.211	16.0	0.044	61.0	79.2%
	MnDOT MS4	171.4	0.470	35.6	0.097	135.8	79.2%
Load Allocations	Non-MS4 Runoff	2018.9	5.531	419.0	1.148	1599.9	79.2%
	Upstream Lakes	114.2	0.313	114.2	0.313	0.0	0.0%
	Atmospheric Deposition	82.0	0.225	82.0	0.225	0.0	0.0%
	Internal Load	3195.2	8.754	0	0.000	3195.2	100.0%

Preliminary Allocations For Rice Lake (Main Basin) Scenario 2 (Partial Internal Load Control)

Rice Lake-Main Basin TMDL Summary (AUID 27-0116-01)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		12551.1	34.387	2225	6.096	10326.1	82.3%
5% EXPLICIT MOS		0.0	0.000	111.25	0.305	111.3	0.9%
TOTAL REDUCTION						**10437.4**	**83.2%**
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.058	21.1	0.058	0.0	0.0%
	Maple Grove MS4	3547.0	9.718	251.8	0.690	3295.1	92.9%
	Plymouth MS4	1297.4	3.555	92.1	0.252	1205.3	92.9%
	Medina MS4	1422.3	3.897	101.0	0.277	1321.3	92.9%
	Corcoran MS4	604.7	1.657	42.9	0.118	561.7	92.9%
	Hennepin County MS4	77.0	0.211	5.5	0.015	71.5	92.9%
	MnDOT MS4	171.4	0.470	12.2	0.033	159.2	92.9%
Load Allocations	Non-MS4 Runoff	2018.9	5.531	143.3	0.393	1875.6	92.9%
	Upstream Lakes	114.2	0.313	114.2	0.313	0.0	0.0%
	Atmospheric Deposition	82.0	0.225	82.0	0.225	0.0	0.0%
	Internal Load	3195.2	8.754	1247.6	3.418	1947.6	61.0%

P8 Modeling Approach for TMDL



Weaver Lake Management History

- Installation of first-flush diversion along northwest shore, treatment in two-celled detention basin west of lake.
- Control of curly-leaf pondweed
- Installation of sump catch basins