Overview for 2006

Annual Loading = 123.3 vs. 225 lbs limit

Maximum 3 Month Loading = 45.8 (Jan) vs. 70 lbs limit

Hatchery Flow = 6.9 vs. 20 mgd limit

6,721 passed vs. 20,000 Adult Coho limit

433 passed vs. 1,000 Adult Chinook limit

Lake TP Concentration: 8.0 mg/m^3 volume - weighted

47% vs. 95% compliance with 8 mg/m^3 goal

Annual Average Hatchery P Mass Balance has been completed.

Hatchery Bio-Energetic and Process Model – calibration nearly completed.

Storm event and tributary data have been collected. Correlations developed.

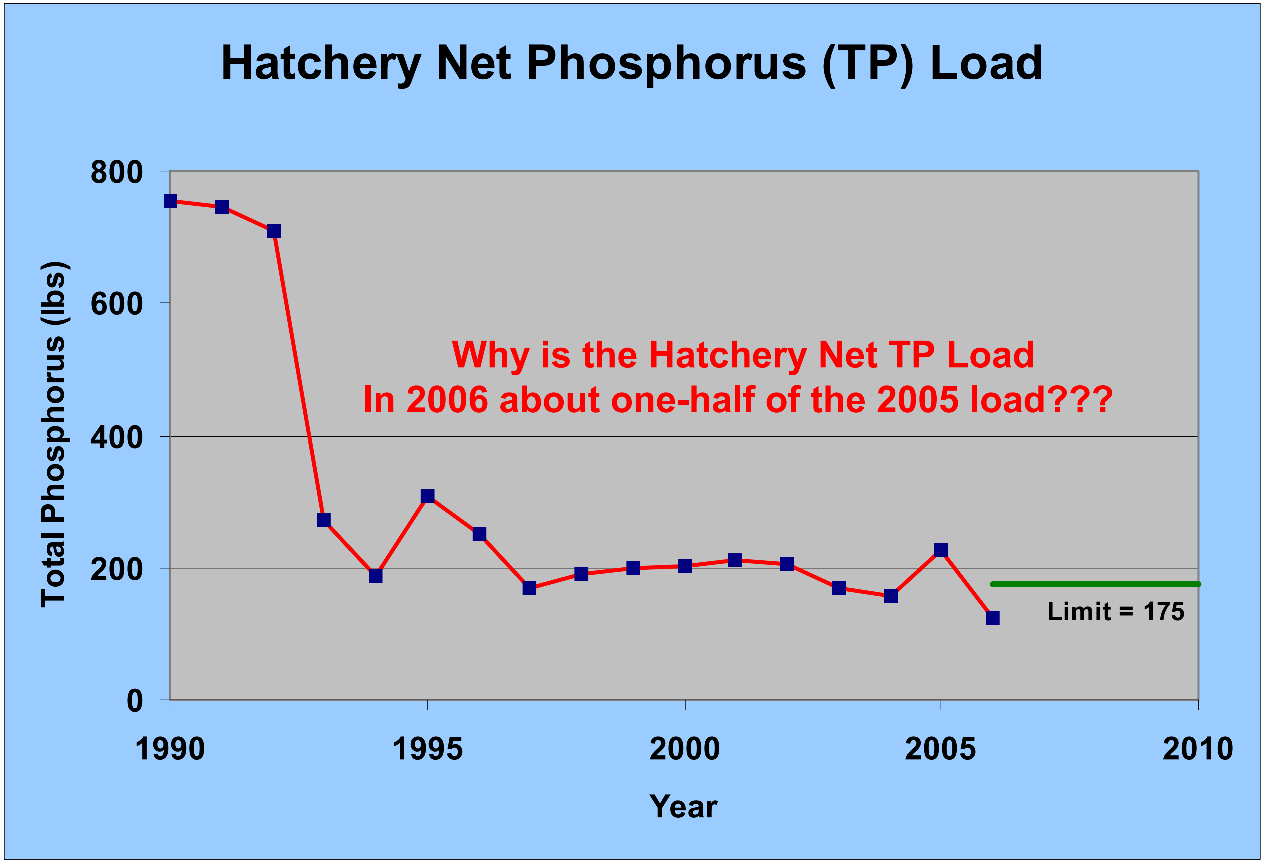
Watershed P and Flow Mass Balance have been completed.

BASINS model draft report submitted.

Special Studies: Bio-availability study plan being developed.

Steady State and Preliminary Seasonal Water Quality Models Developed for Lake

Figure 1. Overview of 2006 Annual Report.



Why worry as long as the load is below 175 Lbs/Yr?

Suppose load goes up next year like 2005?
Suppose you want to increase production in the future, what is the non-compliance risk?
Suppose you want to control loading from another MDNR Hatchery facility?

We need to quantitatively understand the link between
Net Load and Fish Production Activities and Plant Operations

Figure 2.

Law of Mass Balance: Accumulation = In – Out

- **Can be applied to any material: Water, Phosphorus**

- **Can be applied over any time scale: Minutes, Annual**

- **Can be applied over any space scale: Individual Tank, Hatchery, Lake, Watershed**

Figure 3.

Law of Mass Balance: Accumulation = In – Out

Accumulation is the amount of material at the END of a time period minus the amount of material at the START of the time period.

Accumulation = END – START Can be 0, <0, or >0

Case 1: Accumulation = 0 Flow Rate In = Flow Rate Out

Outlet Flow = River + Creek + Spring

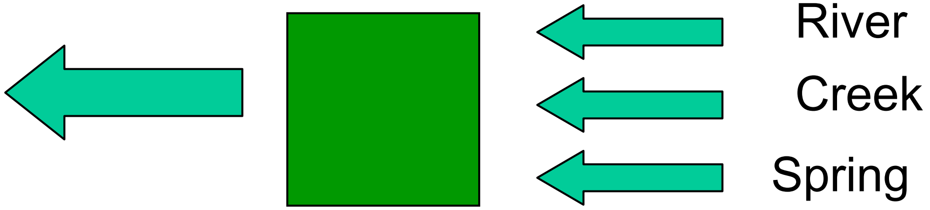


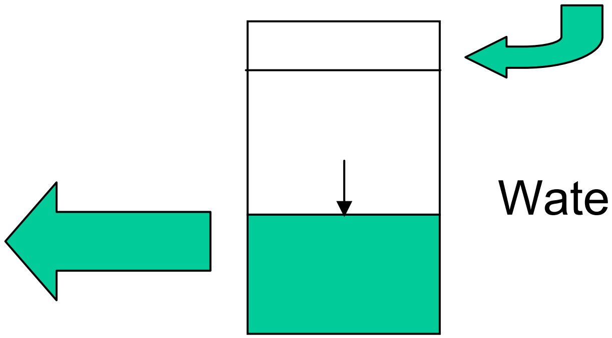
Figure 4.

Law of Mass Balance: Accumulation = In –Out

Case 2: Accumulation < 0

END < START

Flow Rate In is less than Flow Rate Out



Example: surface water level in clarifier drops because flow to sludge tank is greater than inflow from filter backwash

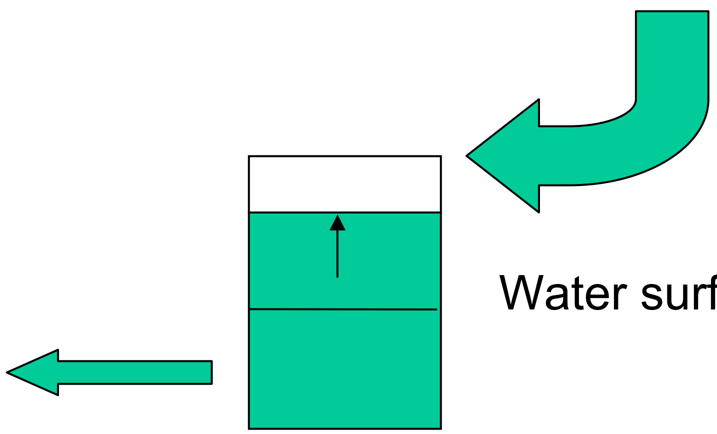
Figure 5.

Law of Mass Balance: Accumulation = In –Out

Case 3: Accumulation > 0

END > START

Flow Rate In is greater than Flow Rate Out



Water surface rises in tank

Accumulation > 0

Example: surface water level in clarifier increases after pumping to sludge tank
When Rate Out = 0

Figure 6.

Law of Mass Balance: Accumulation = In – Out

Law applies to Phosphorus as well as Water !

<u>Accumulation Terms</u>

Change in Fish Tissue P in system
Change of P stored in tank

[Can = 0 or be < or > 0]

<u>Input Terms</u>

P in fish food
P in source water
P in fry tissue

<u>Output Terms</u>

P in shipped, planted or mort fish tissue
P in outlet discharge
P trucked away
P buried to bottom of pond

Others ?? If not then

Note: This equation is not hypothetical and must hold if everything is measured accurately.

Figure 7.

Phosphorus Mass Balance:

End	-	Start	=	Inputs	-	Outputs
Fish Tank		Fish Tank		Source Water Food Fry		Discharge Planted Fish Shipped Fish Mort Fish Trucked Sludge Pond Loss

Special Case : Fish and Tank at End = Start

Then Σ Inputs = Σ Outputs

Source + Food + Fry = Discharge + Planted + Shipped + Morts + Trucked + Pond Loss

Discharge - Source = Food + Fry - Planted - Shipped - Morts - Trucked - Pond Loss

Figure 8.

General Case: **Outputs = Inputs + Start - End**

Outputs	Inputs	Start - End
Discharge	Source Water	Fish
Planted Fish	Food	Tank
Shipped Fish	Fry	
Mort Fish		
Trucked Sludge		
Pond Loss		

Definitions & Assumptions

Net Load = Discharge – Source Water

Harvest = Σ [Planted + Shipped + Mort] Harvest = Fish that leave the Hatchery

Fish Increase = Fish End – Fish Start

Production = Fish Increase + Harvest – Fry In Production = Actual Net Growth of new Fish Biomass

Tank Increase = Tank End – Tank Start

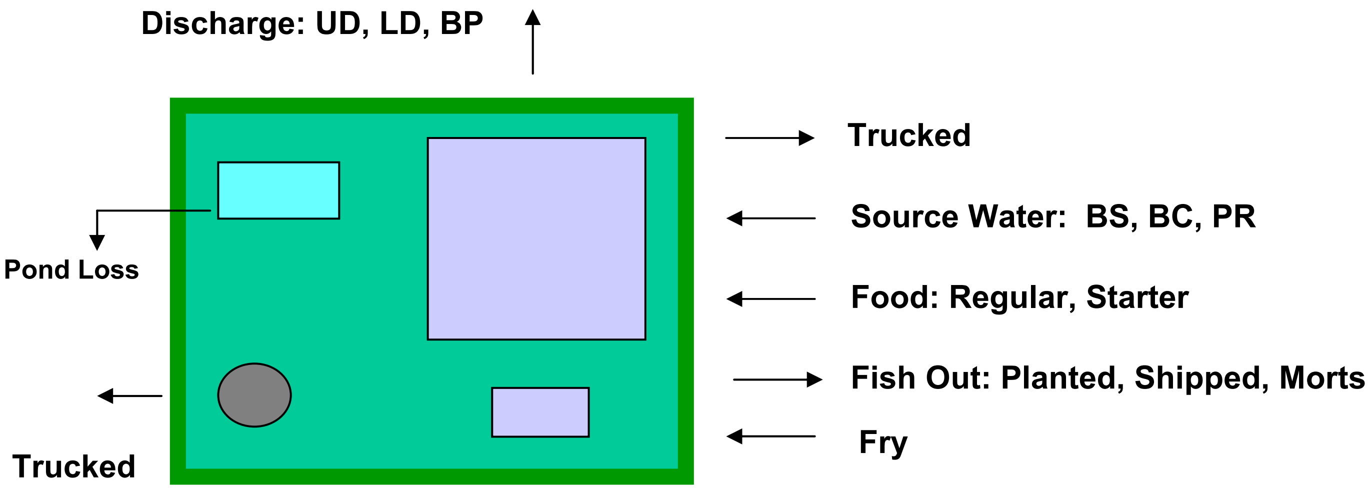
Discharge – Source = Food – [Harvest + Fish End – Fish Start – Fry] - Trucked – Pond + [Tank Start – Tank End]

Net Load = Food – Production - Trucked Sludge – Pond Loss – Tank Increase

Fish Rearing Activities | **Plant Operations**

Observe that Production ≠ Harvest because some of the Harvest could come from stock depletion.

Figure 9.



Net Load = Food – Production - Trucked Sludge – Pond Loss – Tank Increase

Fish Rearing Activities | **Plant Operations**

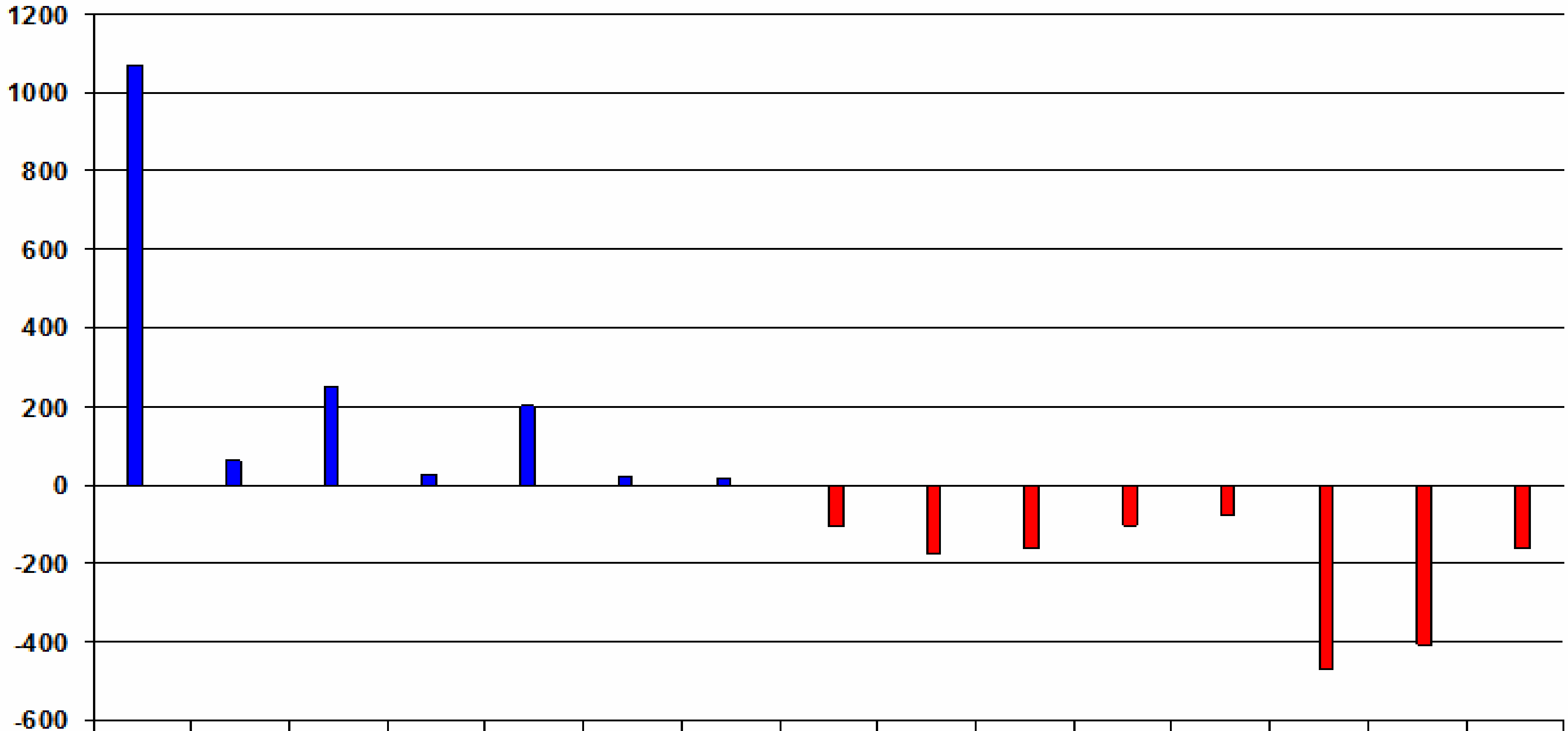
Note that only the terms that cross the system boundaries are included in the mass balance equation. Internal activities are not included.

Figure 10.

Hatchery Phosphorus Mass Balance for 2004

Total Sources: 1653.32 lbs, Total Losses: 1657.47 lbs

Method: Jug & Needle



	Feed	Spring	Creek	River	Fish Start	Tank Start	Fry In	Fish Morts	Ship'd	Planted	Pond Loss	Sludge Trucked	Outlets	Fish End	Tank End
Sources	1070.98	62.09	249.32	25.32	203.52	23.6	18.49	0	0	0	0	0	0	0	0
Losses	0	0	0	0	0	0	0	-106.44	-172.14	-160.47	-101.93	-74.59	-471.18	-407.3	-163.41

Report Date 03/31/2007

Figure 11.

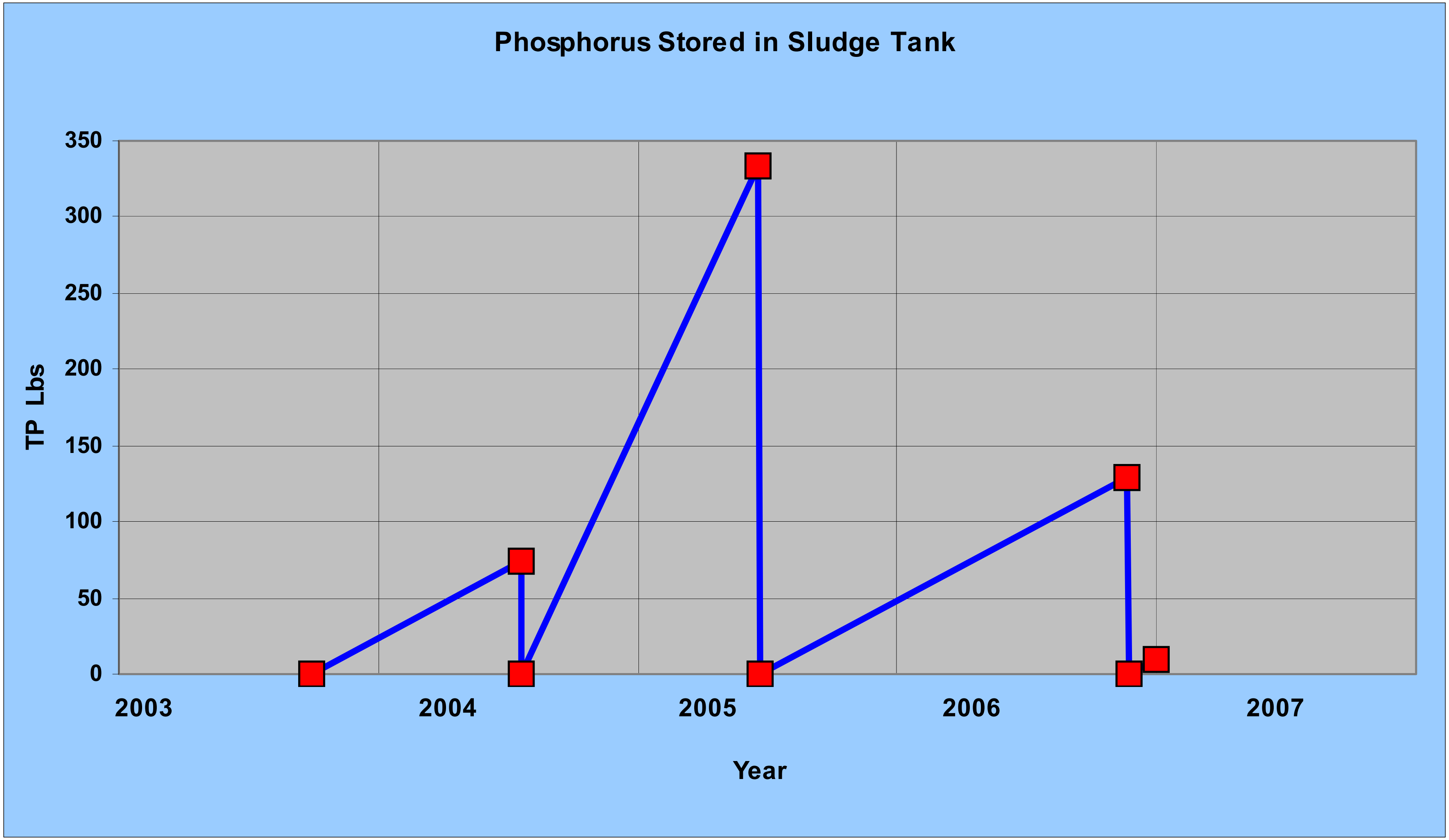
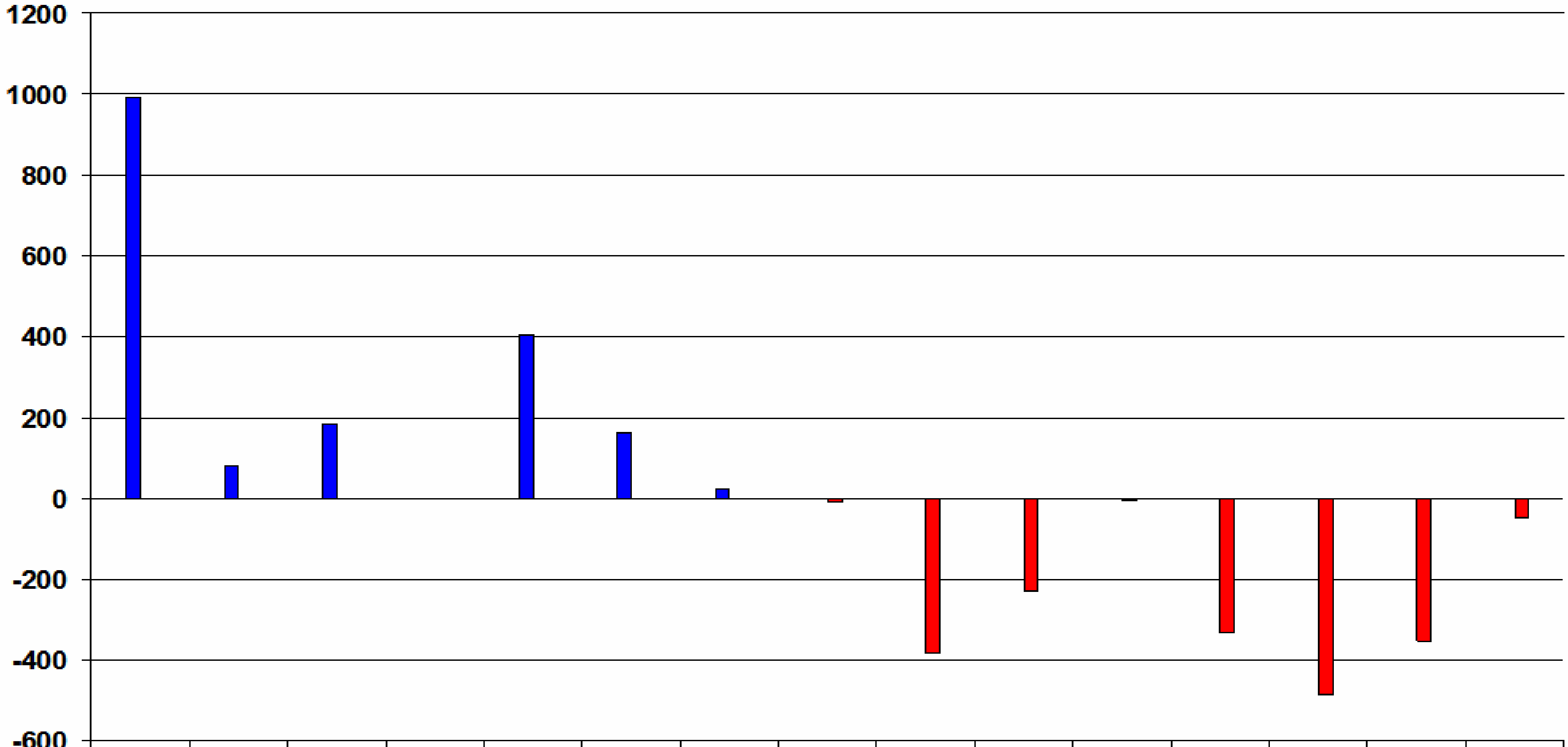


Figure 12. Trucked and Stored Phosphorus in Sludge Tank.

Hatchery Phosphorus Mass Balance for 2005

Total Sources: 1851.08 lbs, Total Losses: 1842.04 lbs

Method: Jug & Needle



	Feed	Spring	Creek	River	Fish Start	Tank Start	Fry In	Fish Morts	Ship'd	Planted	Pond Loss	Sludge Trucked	Outlets	Fish End	Tank End
Sources	992.73	81.4	182.92	0	407.29	163.41	23.33	0	0	0	0	0	0	0	0
Losses	0	0	0	0	0	0	0	-7.66	-383.05	-228.16	-3.69	-332.92	-486.79	-351.82	-47.96

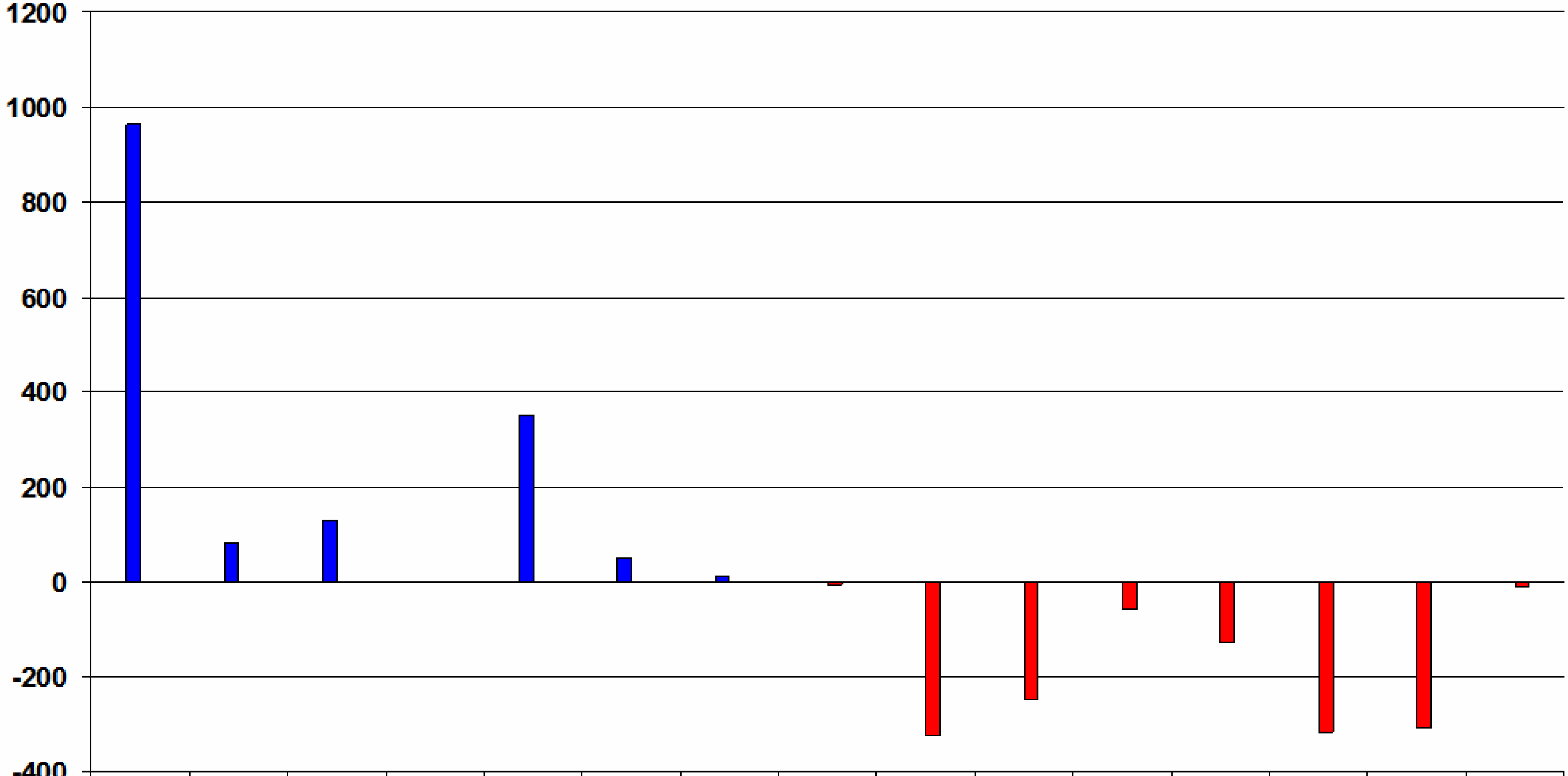
Report Date 03/31/2007

Figure 13.

Hatchery Phosphorus Mass Balance for 2006

Total Sources: 1579.43 lbs, Total Losses: 1402.24 lbs

Method: Jug & Needle



	Feed	Spring	Creek	River	Fish Start	Tank Start	Fry In	Fish Morts	Ship'd	Planted	Pond Loss	Sludge Trucked	Outlets	Fish End	Tank End
Sources	962.58	78.31	127.35	0	351.86	47.96	11.38	0	0	0	0	0	0	0	0
Losses	0	0	0	0	0	0	0	-5.48	-325.04	-247.29	-58.93	-128.46	-316.28	-310.57	-10.19

Report Date 03/31/2007

Figure 14.

%P	0.4

Year	Food	-	Prod	-	Tank Increase	-	Trucked	-	Pond Loss		Mass Bal Net Load	Measure Net Load
2001	1272.4	-	616.50	-		-		-	37.18	=	618.72	209.08
2002	1018.7	-	562.79	-		-		-	24.6	=	431.31	195.85
2003	703.79	-	357.70	-	23.51	-		-	84.78	=	237.81	109.84
2004	1070.98	-	624.34	-	139.44	-	74.57	-	101.93	=	130.69	134.45
2005	992.73	-	540.07	-	-114.94	-	332.9	-	3.7	=	231.00	222.47
2006	962.58	-	525.15	-	-38.36	-	128.45	-	58.93	=	288.41	110.62

summer 2006 raceway A		31500	gal
solids removal	day	119	m3
July 13 to Oct 25 2006	196 to 300	191,000	mg/m3
		50	Lbs

Why Doesn't this work every year??

System is working differently?

Inaccurate measurements?

Figure 15.

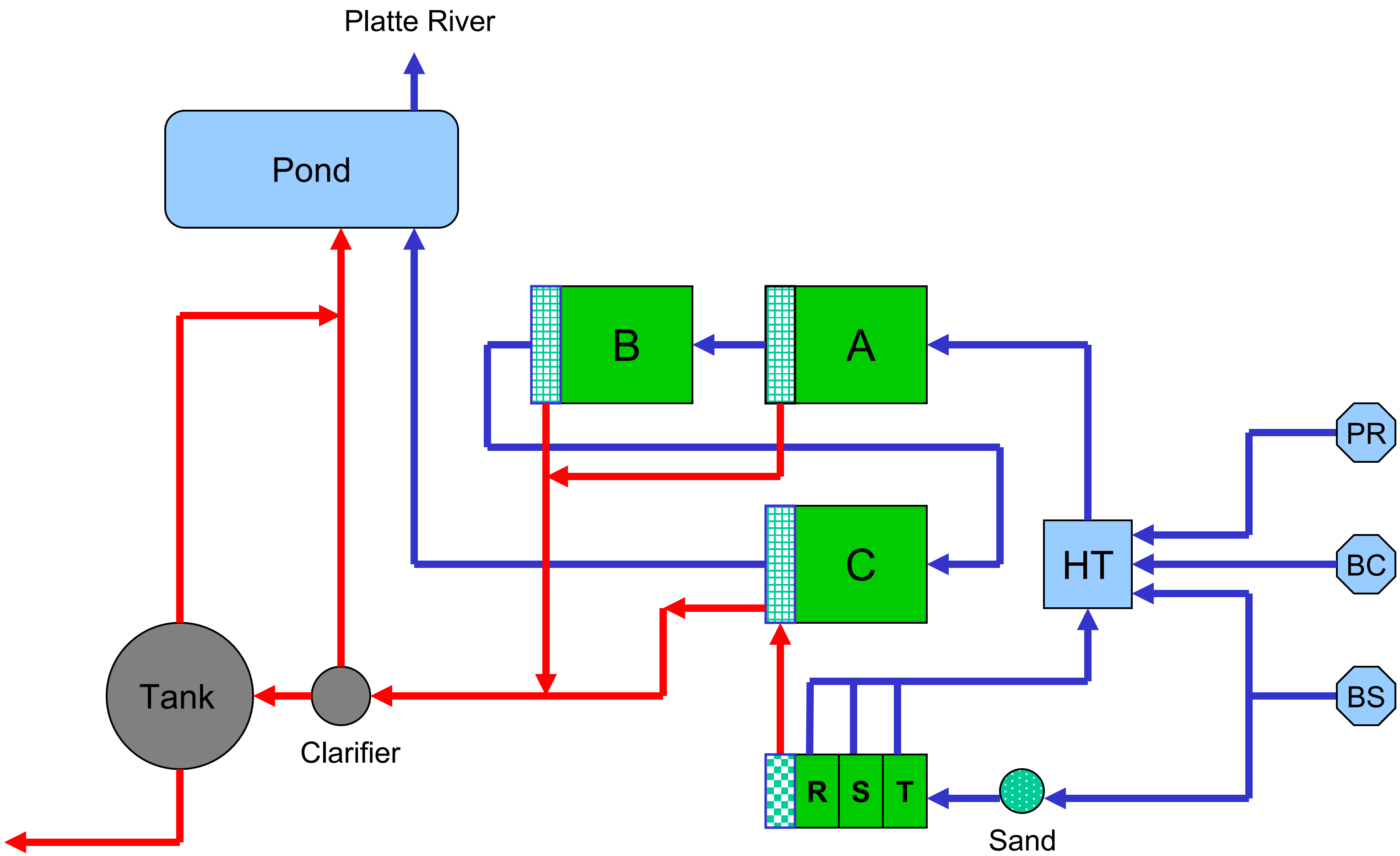


Figure 16. Major Components of Dynamic Hatchery Process Model .

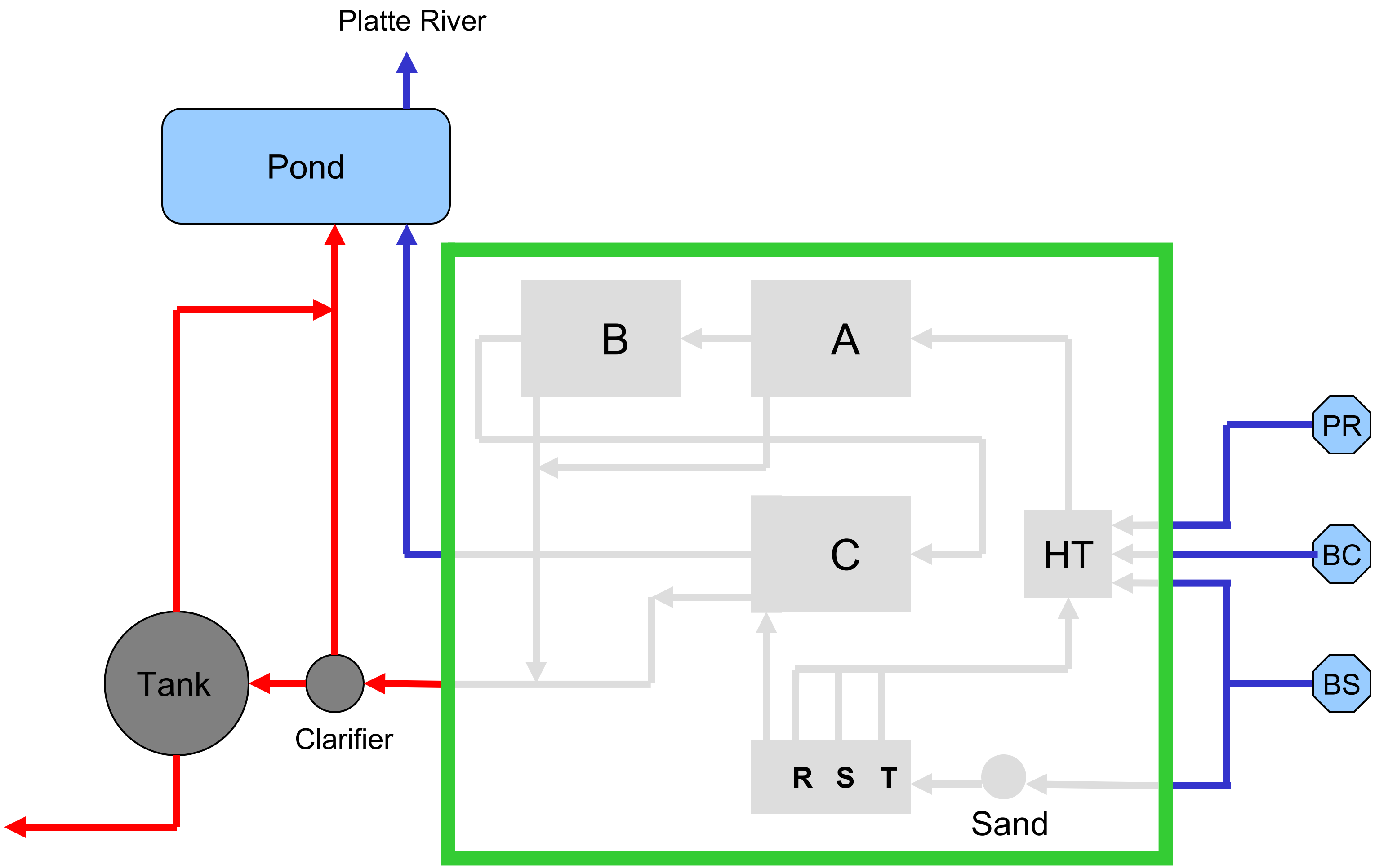


Figure 17. Major Hatchery Components and Flows.

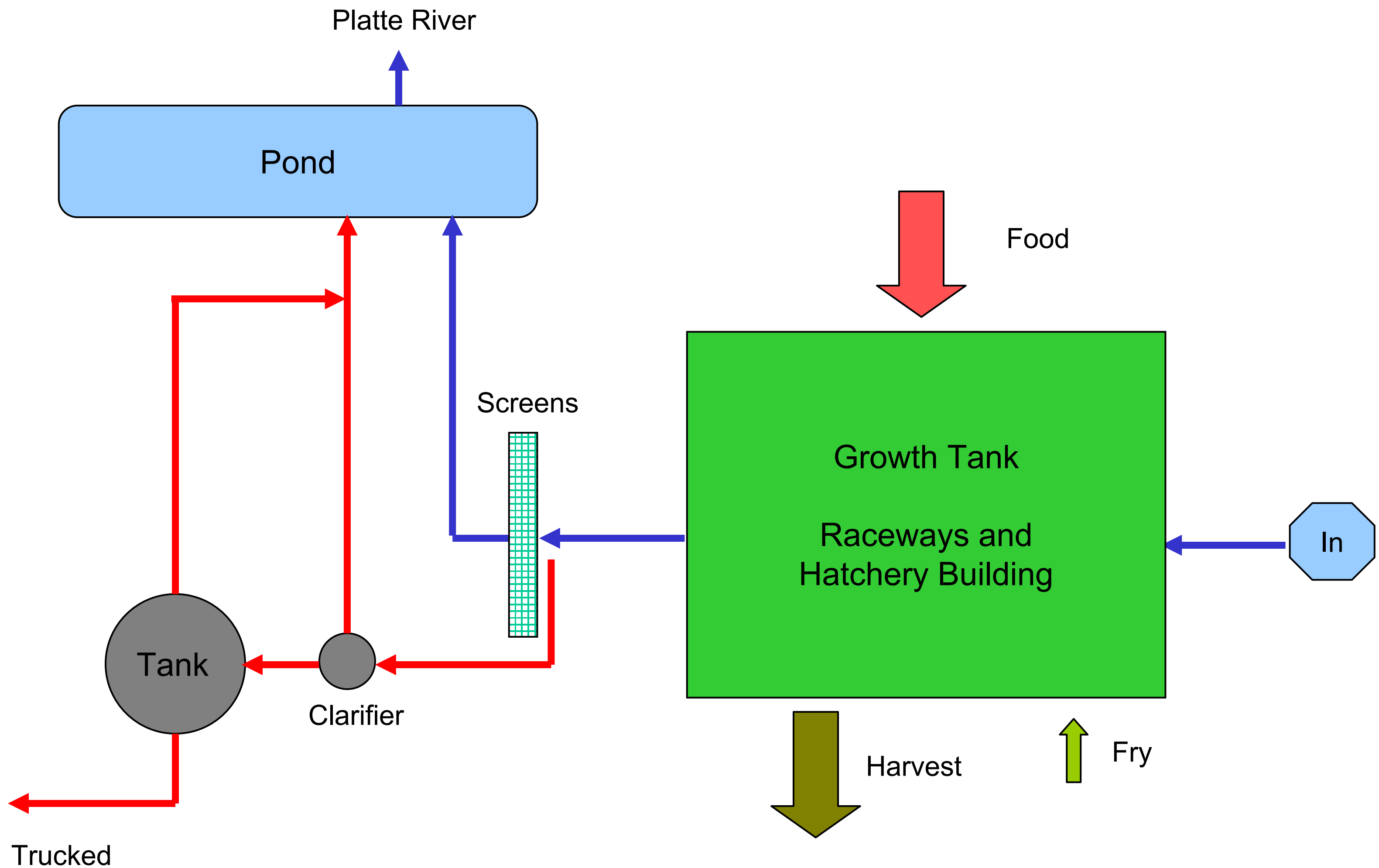


Figure 18. Major Hatchery Components and Flows.

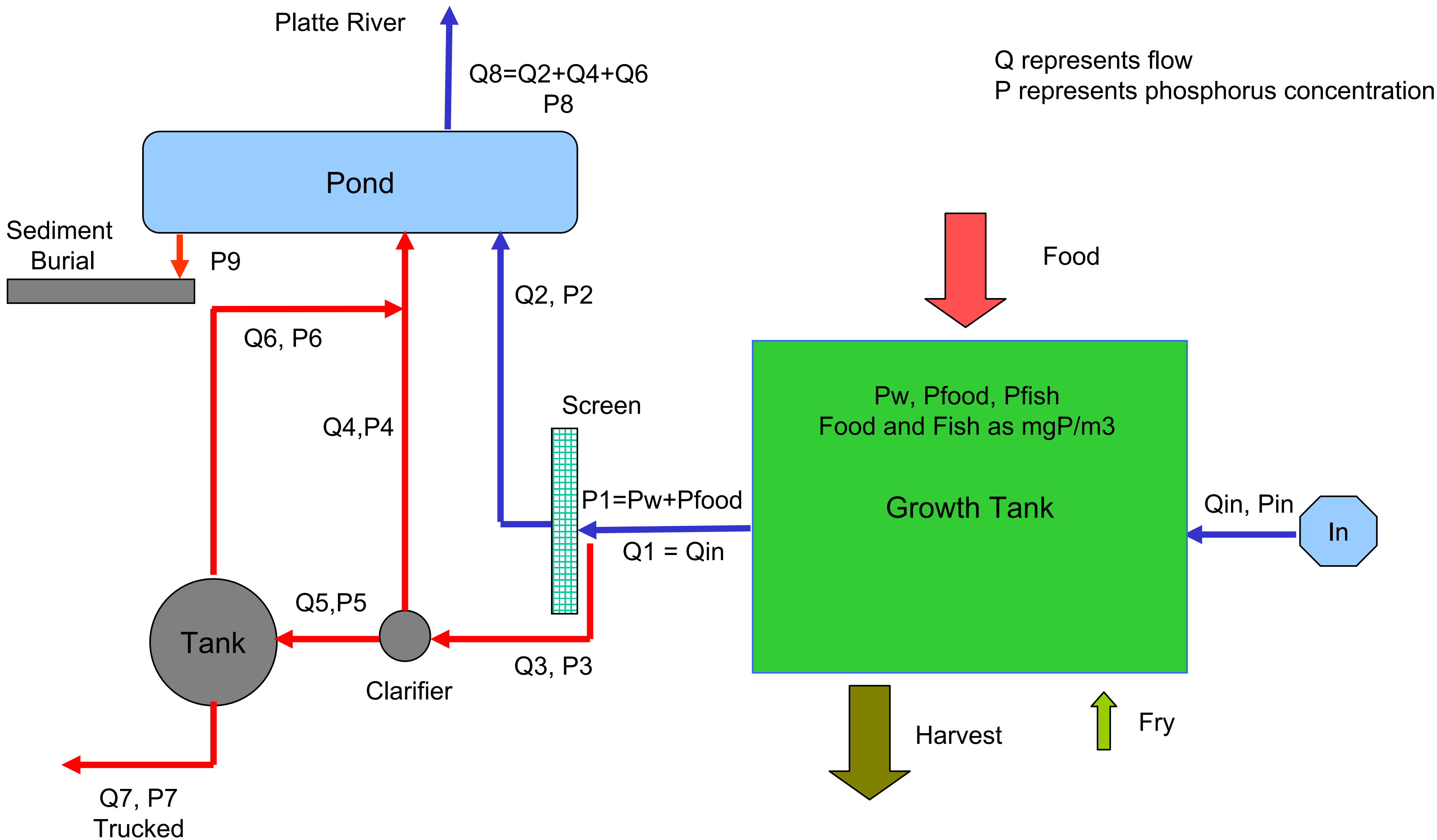


Figure 19. Major Hatchery Components and Flows.

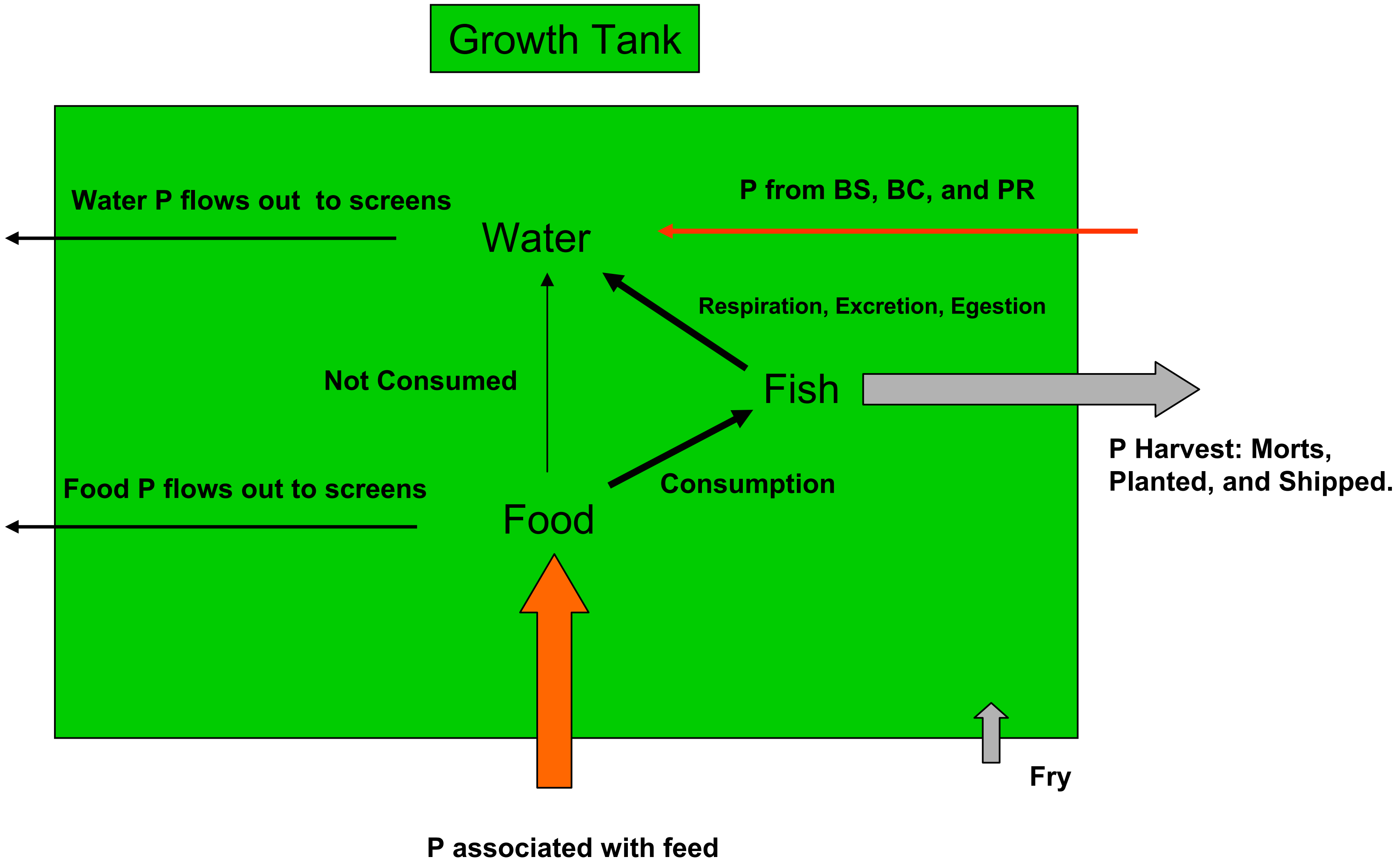
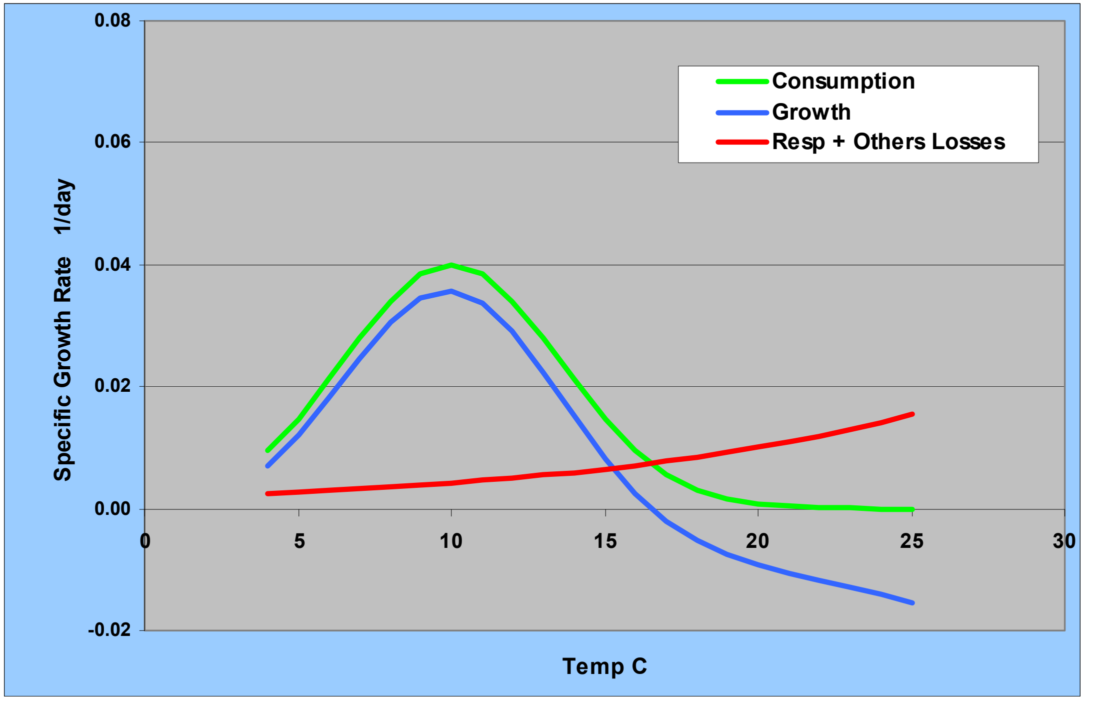


Figure 20. Growth Tank Model Mechanisms.

C_{opt}	Max Consum Rate	1/day	0.04
β	Consum Shape Factor	–	0.04
T_{opt}	Opt Consum Temp	C	10

R_{20}	Respiration at 20 C	1/day	0.01
Θ_r	Resp Shape Factor	–	1.09

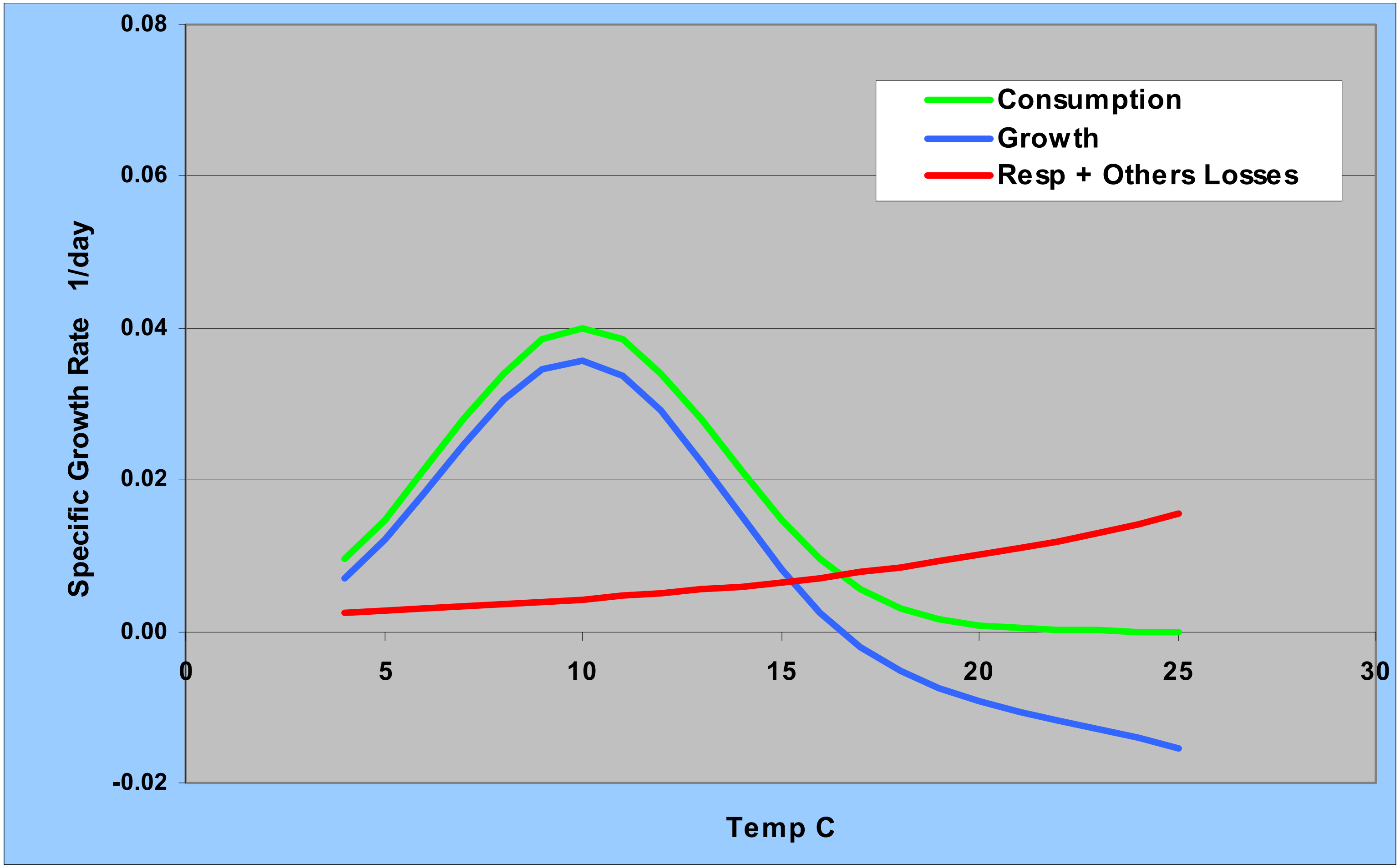
Temp C	Model Consumption	Model Growth	Model Resp
4.0	0.0095	0.0070	0.0025
5.0	0.0147	0.0120	0.0027
6.0	0.0211	0.0181	0.0030
7.0	0.0279	0.0246	0.0033
8.0	0.0341	0.0305	0.0036
9.0	0.0384	0.0346	0.0039
10.0	0.0400	0.0358	0.0042
11.0	0.0384	0.0338	0.0046
12.0	0.0341	0.0291	0.0050
13.0	0.0279	0.0224	0.0055
14.0	0.0211	0.0151	0.0060
15.0	0.0147	0.0082	0.0065
16.0	0.0095	0.0024	0.0071
17.0	0.0056	-0.0021	0.0077
18.0	0.0031	-0.0053	0.0084
19.0	0.0016	-0.0076	0.0092
20.0	0.0007	-0.0093	0.0100
21.0	0.0003	-0.0106	0.0109
22.0	0.0001	-0.0118	0.0119
23.0	0.0000	-0.0129	0.0130
24.0	0.0000	-0.0141	0.0141
25.0	0.0000	-0.0154	0.0154



$$\text{Consumption Rate} = C_{opt} \exp\{ -\beta^*(T-T_{opt})^2 \}$$

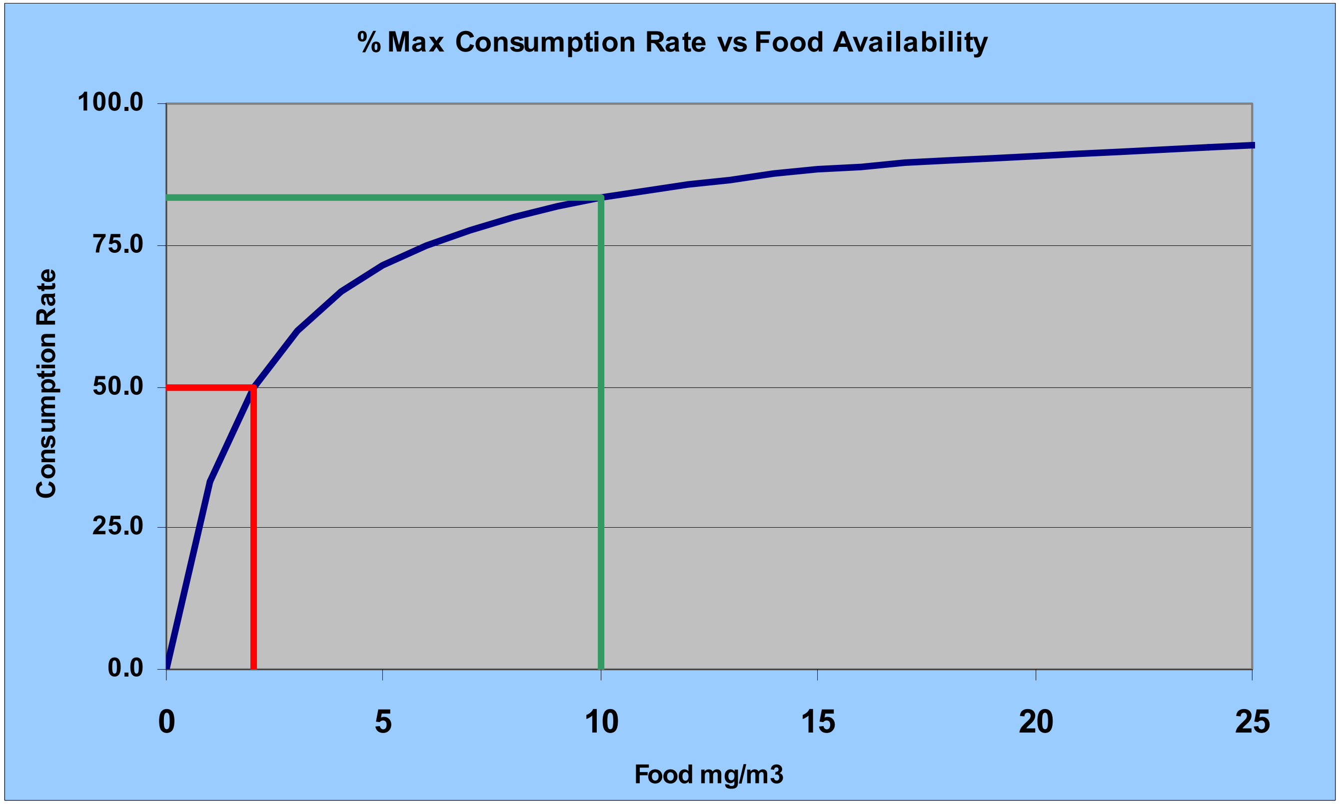
$$\text{Respiration} = R_{20}{}^* \ \theta^{(T-20)}$$

Figure 21.



Optimum temperature for consumption and growth is 10 C
20 days required for small fish to double size under absolute perfect conditions
Respiration rate doubles between 10 and 18 C
Fish are no longer bio-energetically viable above 17 C
Fish grow half as fast at 6 C and 13 C compared to 10C
Fish stop eating above 20 C
Under optimum conditions 90% of food is converted to new biomass
Under optimum conditions 10% of food is lost through respiration, egestion, and excretion
Efficiency reduces to 50/50 at 15 C

Figure 22.



$$\text{Food Limitation} = \text{Food} / (K_f + \text{Food})$$

Figure 23. Model Equations for Food Uptake as a function of Food Availability.

Growth Tank Mass Balance Equations

Accumulation of Water P in Growth Tank = Input P from Source water – overflow of P to Screens
+ Food P not consumed by fish
+ respired, egested, and excreted P from fish

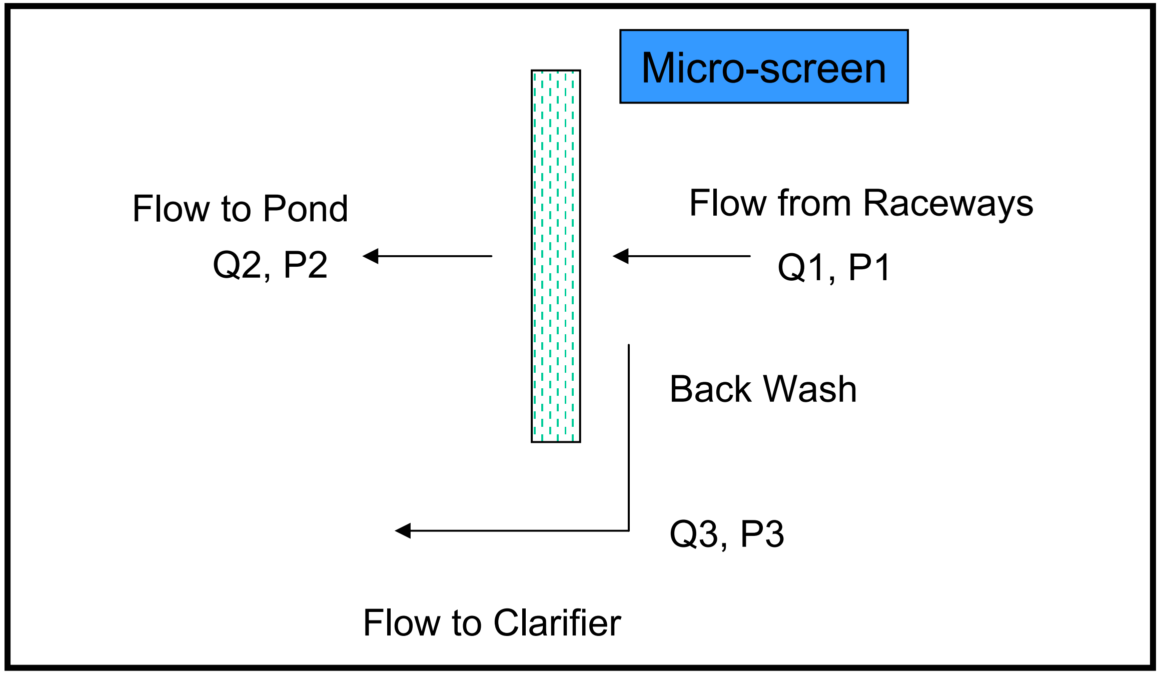
Accumulation of Food P in Growth Tank = Food application rate – consumption by fish
– food that escapes consumption
– overflow to screens

Net Growth

Accumulation of Fish Tissue P in Growth Tank = {Consumption – (respiration + egestion + excretion)}
– Harvest of P associated with fish tissue

Morts + Shipped + Planted - Fry

Figure 24. Growth Tank Model Equations.



Performance Criteria

% P Retained by Screen
Total Inflow used for Backwash

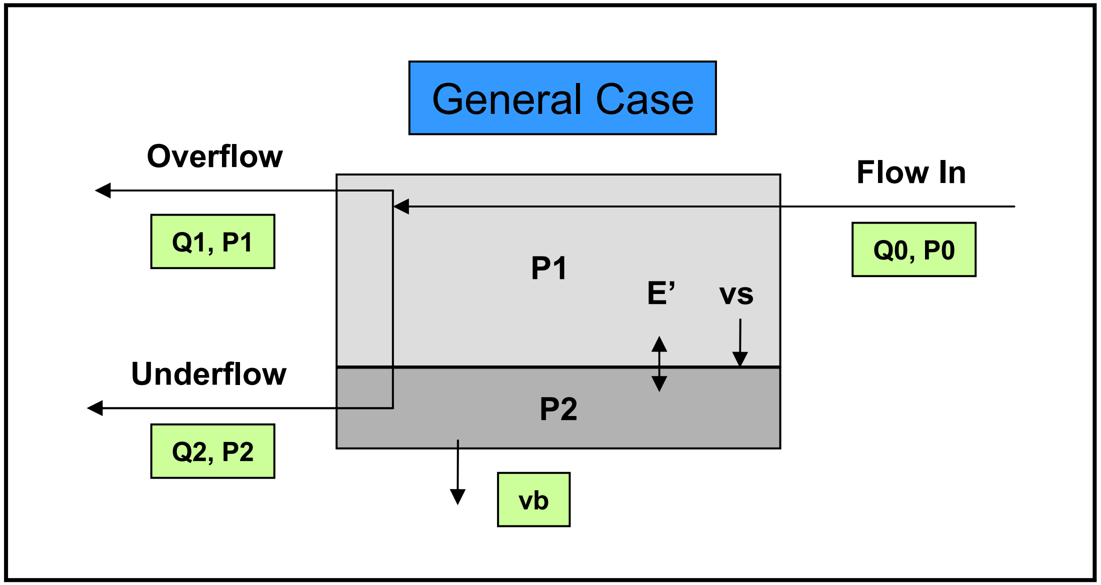
% P Retained by Screen = (1- c2/c1) x 100

Flow used for Backwash = Q3

P2 = P1 (1 - % retained /100)

P3 = (Q1 x P1 – Q2 x P2) / Q3

Figure 25. Screen Model Mechanisms and Equations.



vs = settling velocity of particles in clarifier
E' = Exchange between top and bottom by dispersion
vb = loss to bottom sediments

$$V1\ dP1/dt = Q0\ P0 - Q1\ P1 - Q2\ P1 - vs\ A\ P1 + E(P2 - P1)$$

$$V2\ dP2/dt = + Q2\ P1 + vs\ A\ P1 - E(P2 - P1) - Q2\ P2 - vb\ A\ P2$$

SS Solution:

$$P2 = P1\ (Q2 + vs\ A)/(Q2 + E + vb\ A)$$

$$P1 = Q0\ P0\ /[Q0 + vs\ A - E(Q2 + vs\ A)/(Q2 + E + vb\ A)]$$

Figure 26. General Tank Model Mechanisms and Equations.

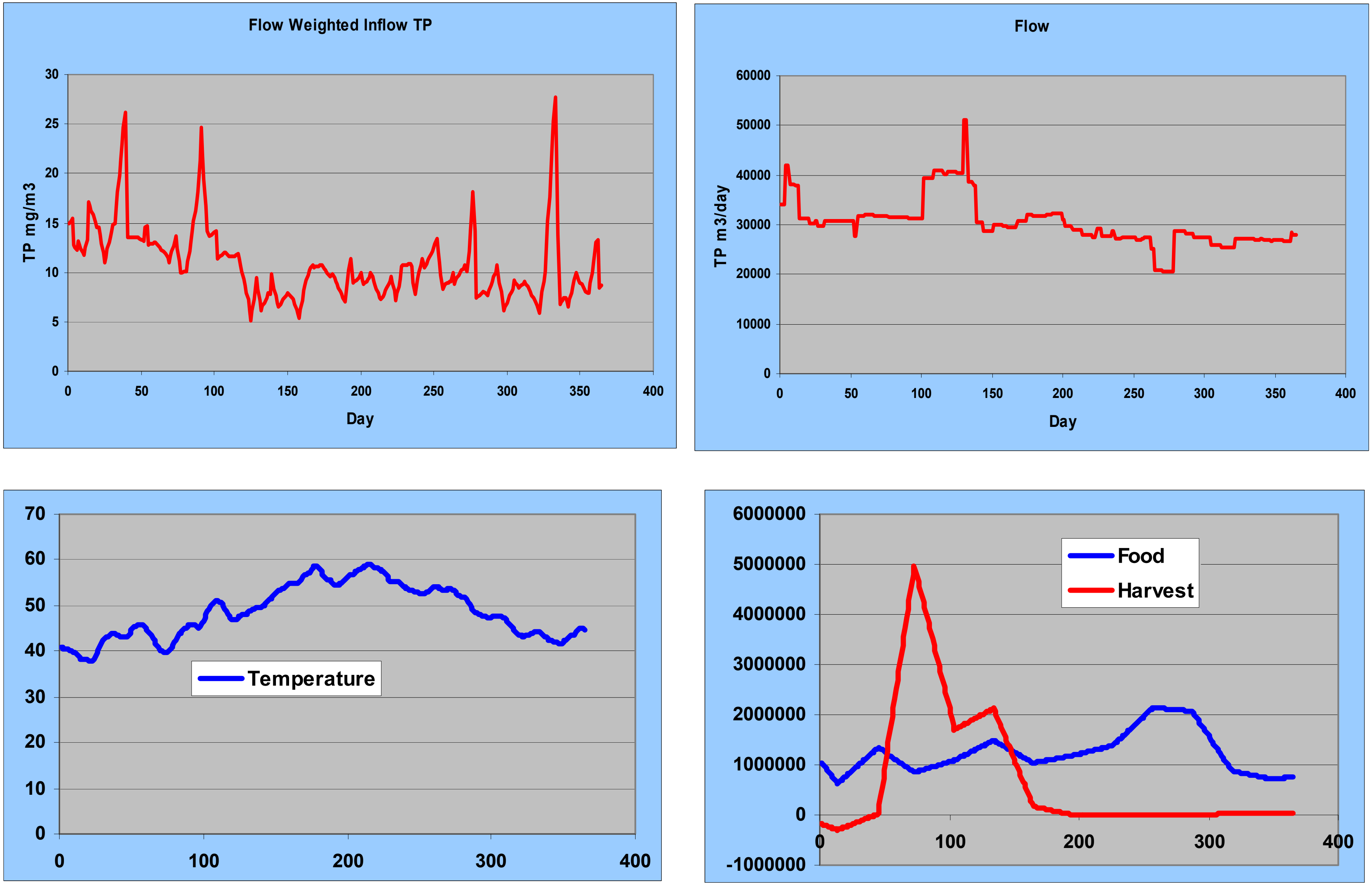


Figure 27. Model forcing functions.

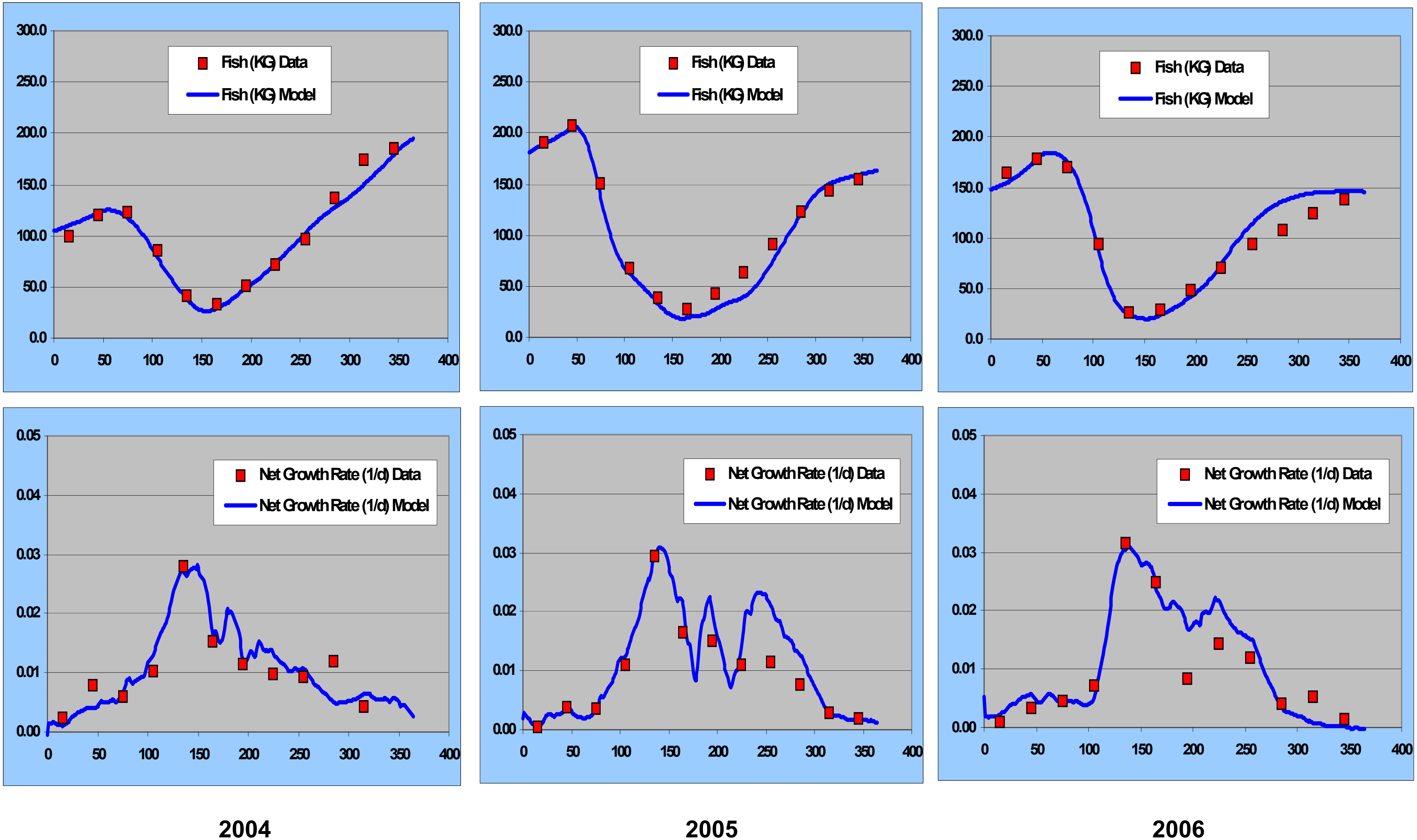


Figure 28. Model Simulation and Measurements for Fish Stock and Growth Rate for 2004, 2005, and 2006.

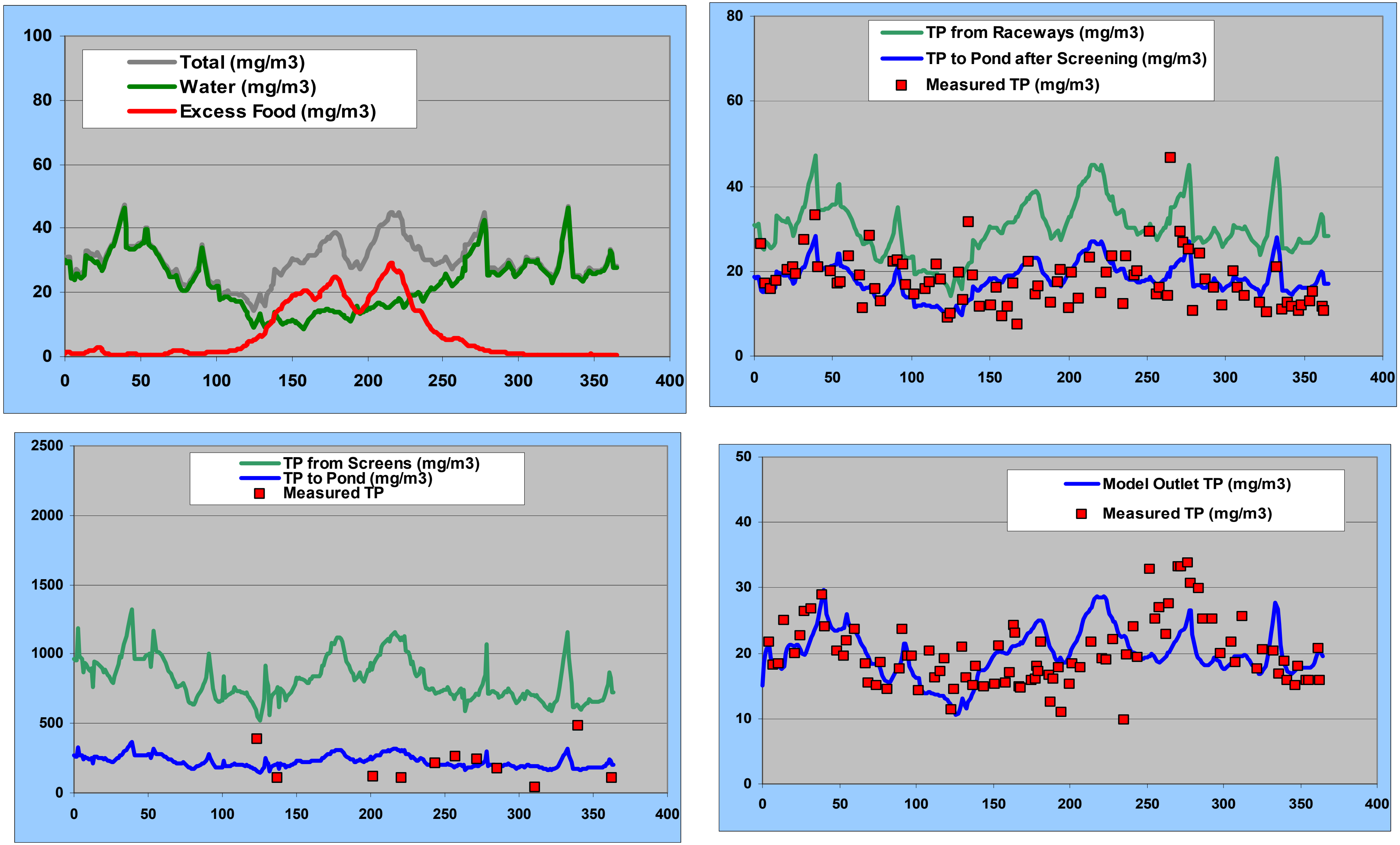


Figure 29. Model simulations for 2005.

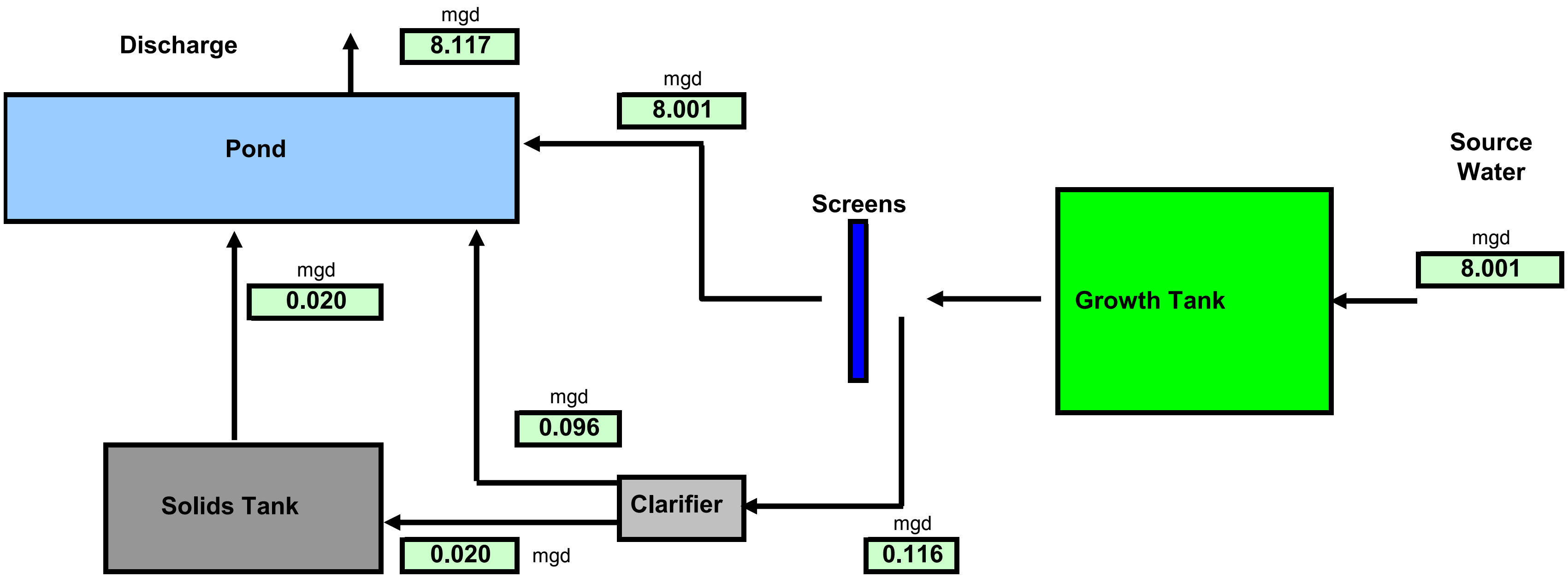


Figure 30. 2005 Flow Balance.

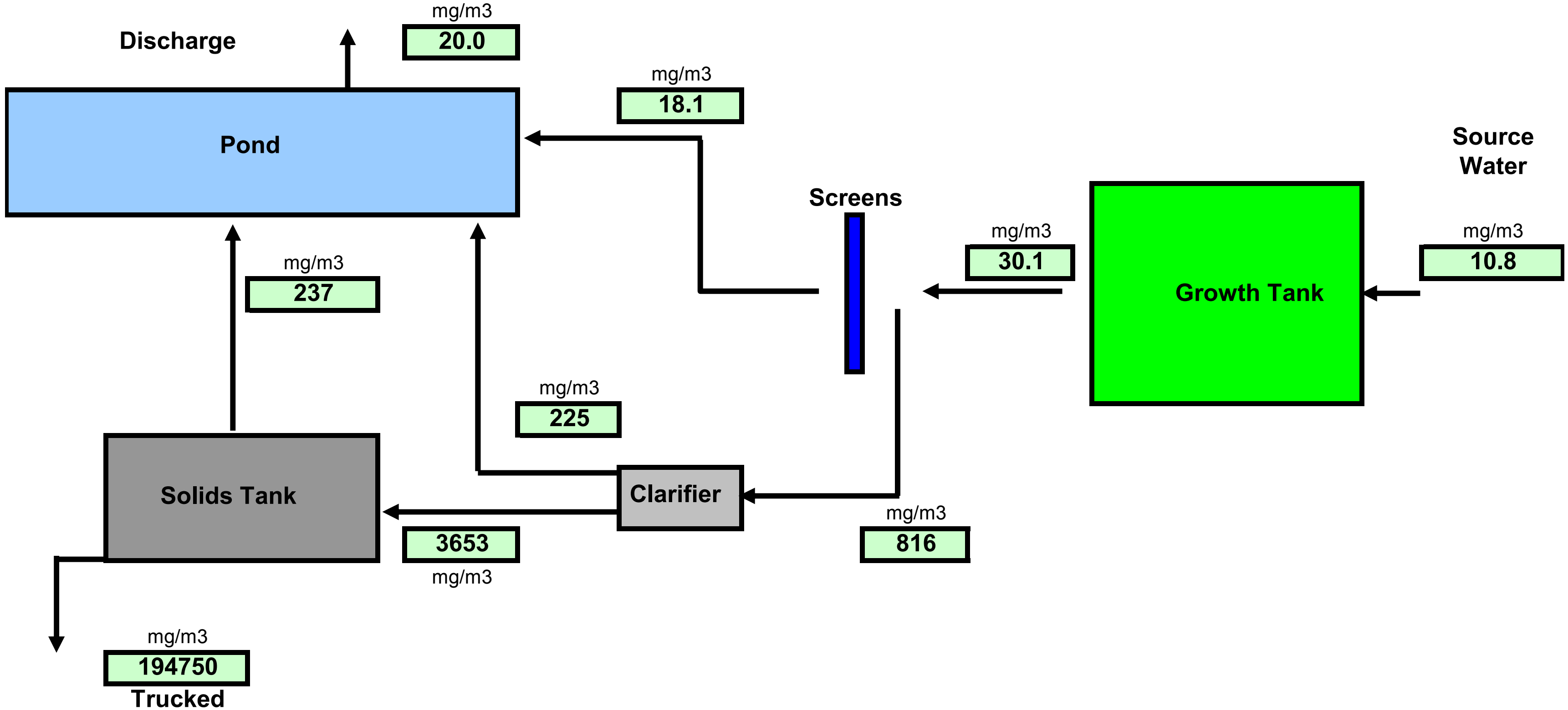


Figure 31. 2005 Model calculated phosphorus concentrations.

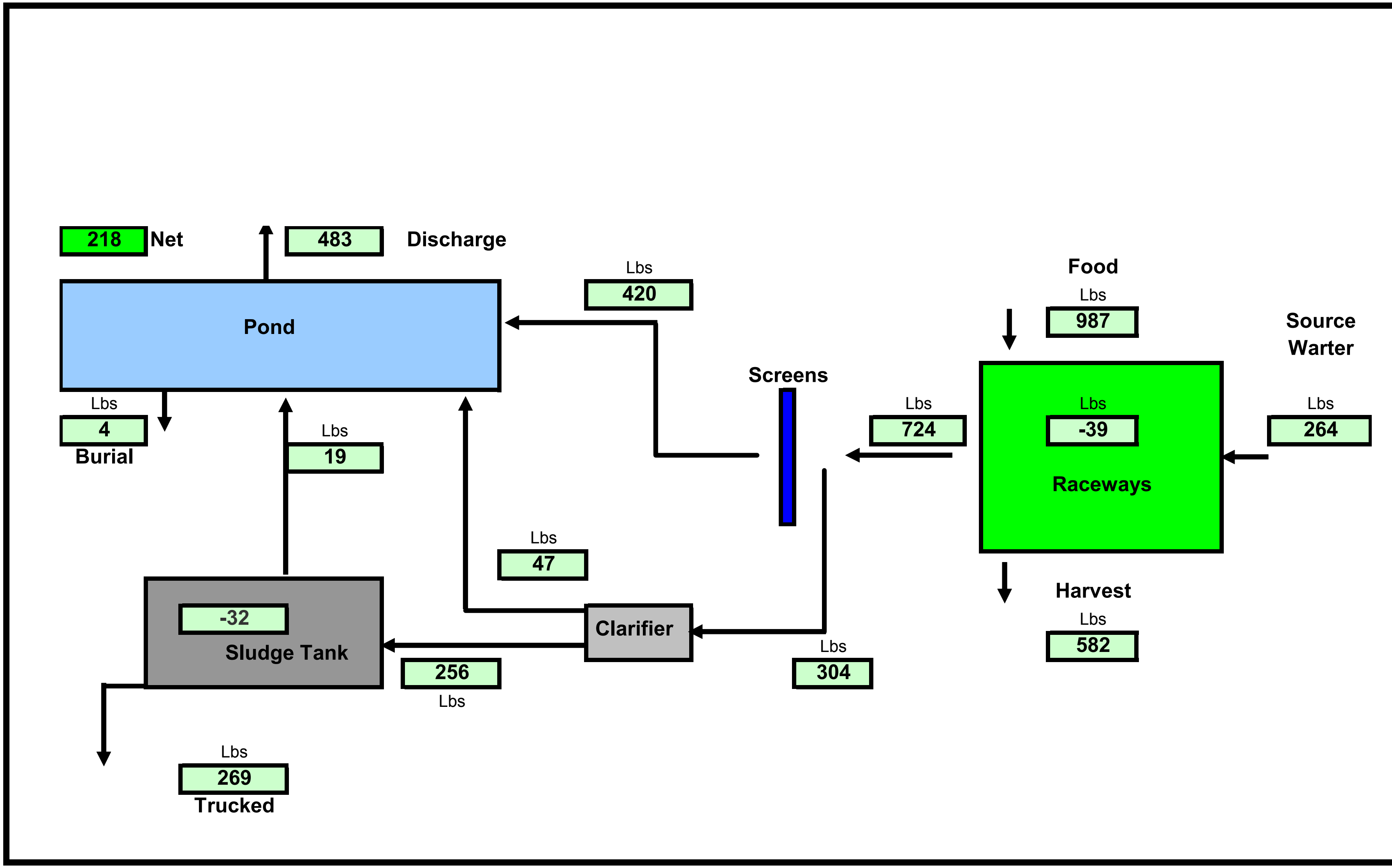


Figure 32. Model Simulation of Total Phosphorus Loads (Lbs) for 2005.

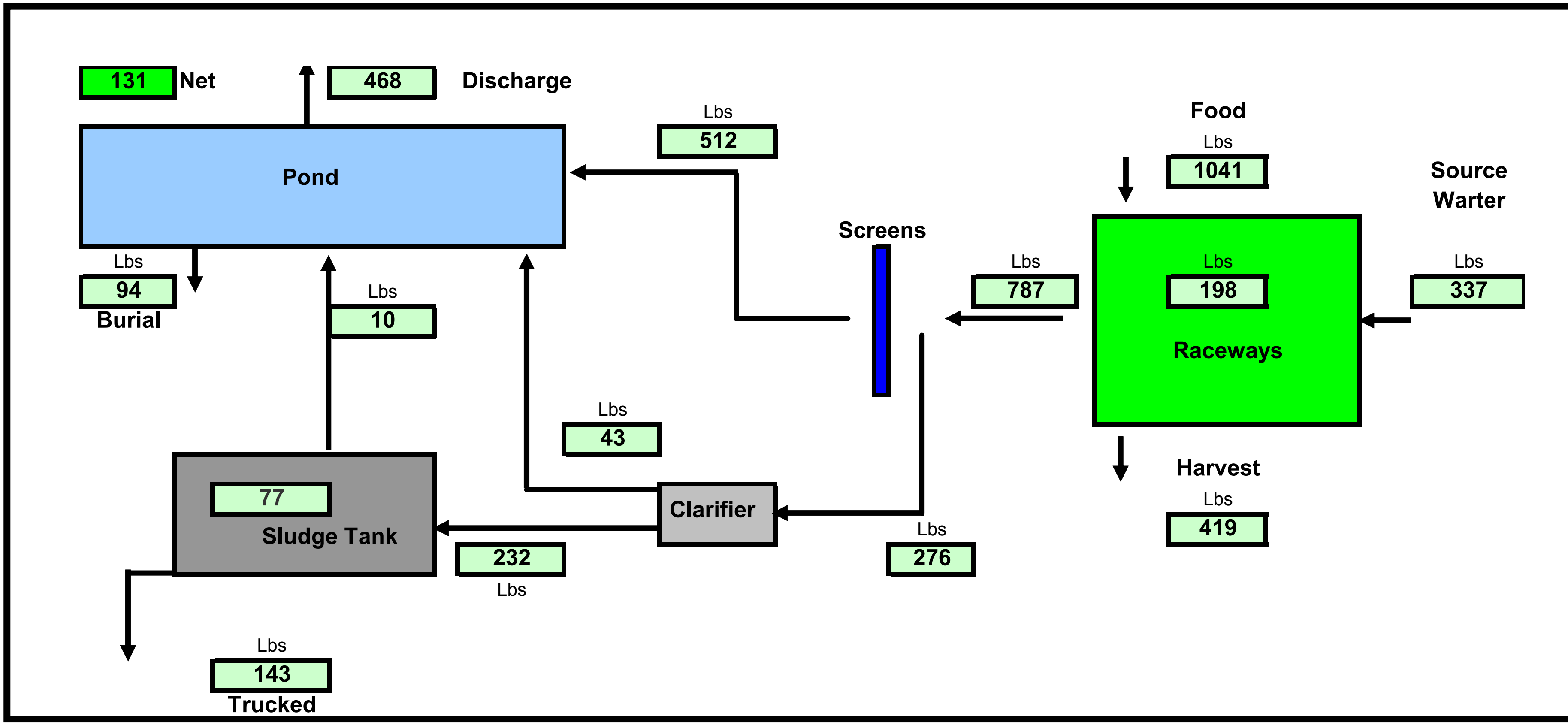


Figure 33. Model Simulation of Total Phosphorus Loads (Lbs) for 2004.

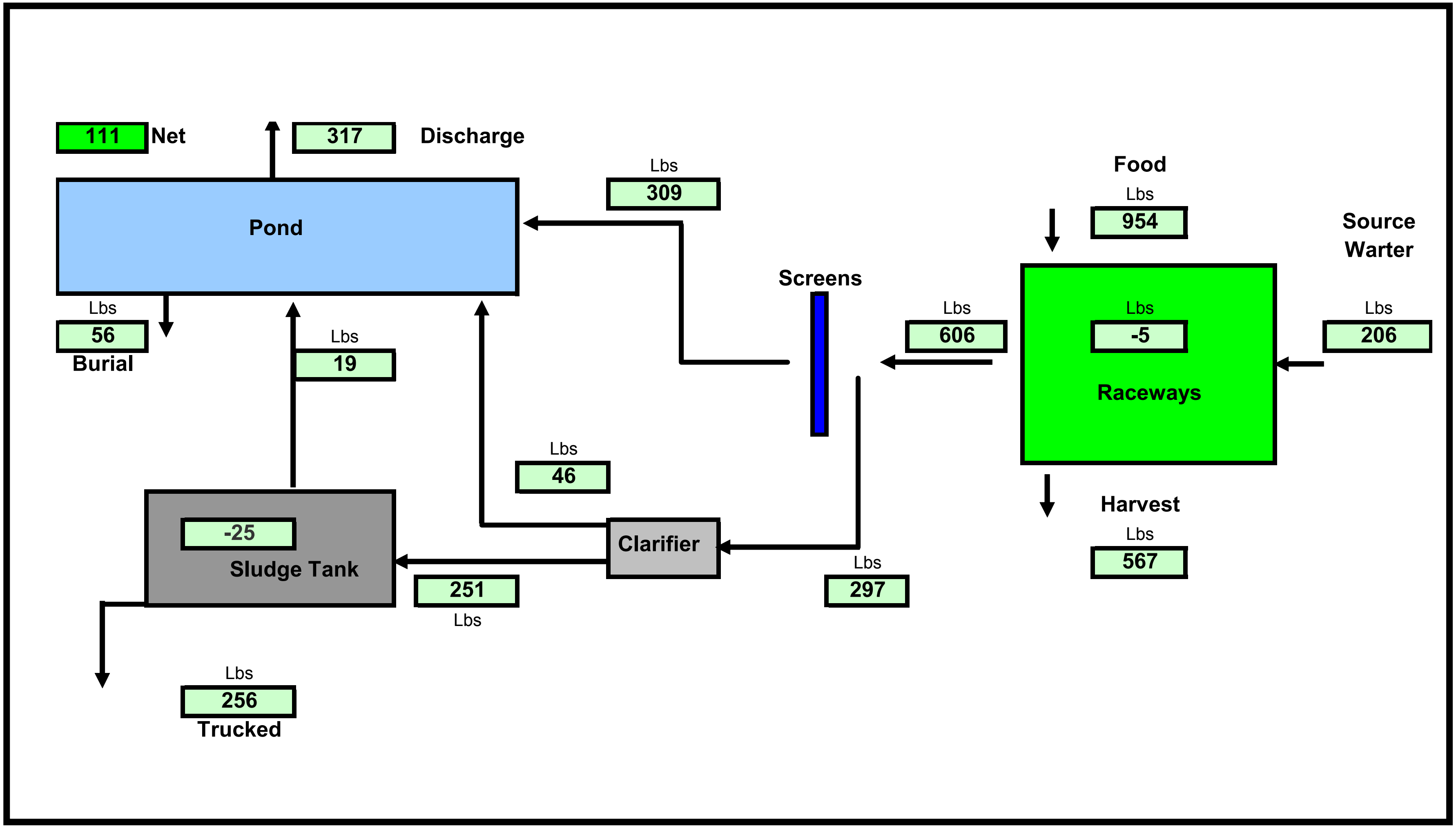


Figure 34. Model Simulation of Total Phosphorus Loads (Lbs) for 2006.

Calibration Parameter Values	2004	2005	2006
Max Consumption Rate	0.04	0.04	0.04
Consumption Shape Factor	0.04	0.04	0.04
Optimum Consumption Temp	10	10	10
Respiration at 20 C	0.01	0.01	0.01
Respiration Shape Factor	1.09	1.09	1.09
Raceway Water Initial Condition	30	30	30
Food Initial Condition	1	1	1
Fish Initial Condition	58000	100000	82000
Sludge Tank Start Condition	23.5	163	48.01
Outlet Initial Condition	15	15	15
Pond Sediment Initial Condition	130	130	130
Food Waste Rate in Raceways	0	0	0
% P Retention by Screens	39	40	45
Screen Backwash Flow Rate	0.136	0.116	0.096
Selltling Loss Rate in Clarifier	25	25	25
Release Rate from Solids in Clarifier	0.01	0.01	0.01
Flow to Sludge Tank	0.02	0.02	0.02
Settling Loss Rate in Sludge Tank	40	40	40
Release Rate from Solids in Sludge Tank	0.04	0.04	0.03
Day of 1st Cleaning	200	168	324
Day of 2nd Cleaning			
Settling Loss Rate in Pond	1.34	0.28	1.1
Release Rate from Solids in Pond	0.05	0.05	0.05
Solids Burial Rate in Pond	0.02	0.02	0.02
Food Mult	1	1	1
Harvest Mult	1	1	1
Temperature Mult	1	1	1

Model Results vs Data		2004	2005	2006
Average Temperature	Data	48.6	48.6	47.7
Food	Data	1041	987	954
Production	Model	617	543	562
Production	Data	624	540	525
Tank Increase	Model	75	-48	-27
Tank Increase	Data	139	-115	-38
Trucked	Model	141	256	236
Trucked	Data	75	333	128
Total to Tank	Model	216	208	209
Total to Tank	Data	214	218	90
Pond Loss	Model	97	26	77
Pond Loss	Data	102	4	59
Net Load	Model	133	224	112
Net Load	Data	135	223	111

Calibration

Adjust screen efficiency to match tank change and trucked
Adjust settling rate to match pond loss

Figure 35.

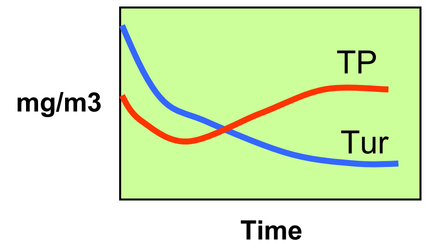
Recommendations

Monitoring

- Measure fish tissue P monthly or more often
- Verify measurements of food P
- Measure flows and TP in and out of screens, clarifier, and sludge tank
- Record daily raceway temperatures
- Measure the amount of P in the sludge tank more accurately
- Measure cleaning loss more accurately

Experiments

Bucket Experiment for inflow to clarifier and tank.
Use to estimate settling and release rates.



Model Refinements

- Expand Model to separate individual raceways, screens, and recycle
- Main Hatchery Building activities??
- Separate Fish Age Classes ??
- Include More Detailed Food Composition Bio-Energetics ??
- Refine fish metabolism formulations ??

Figure 36. Recommendations to Improve Hatchery Process Model.

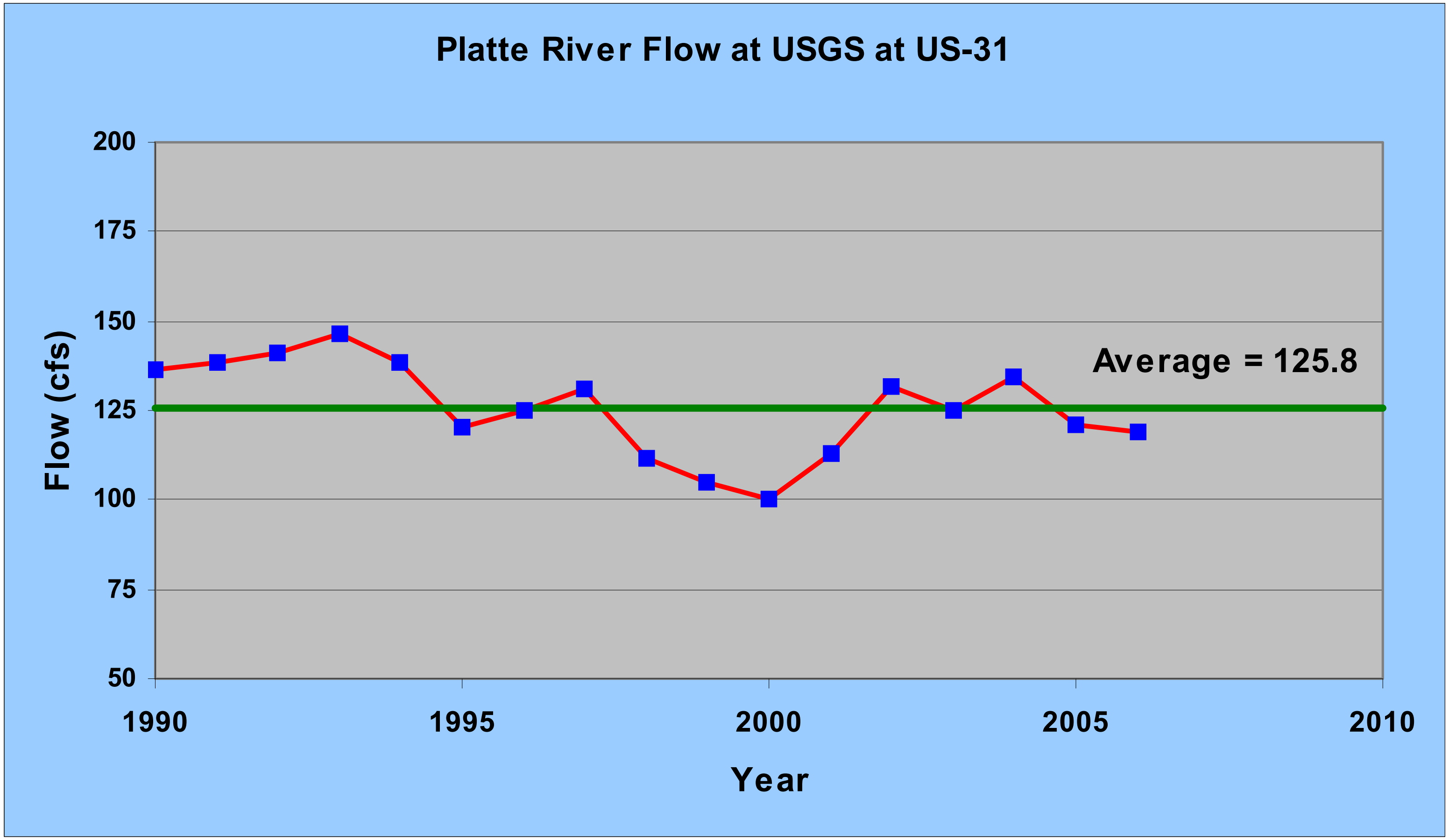
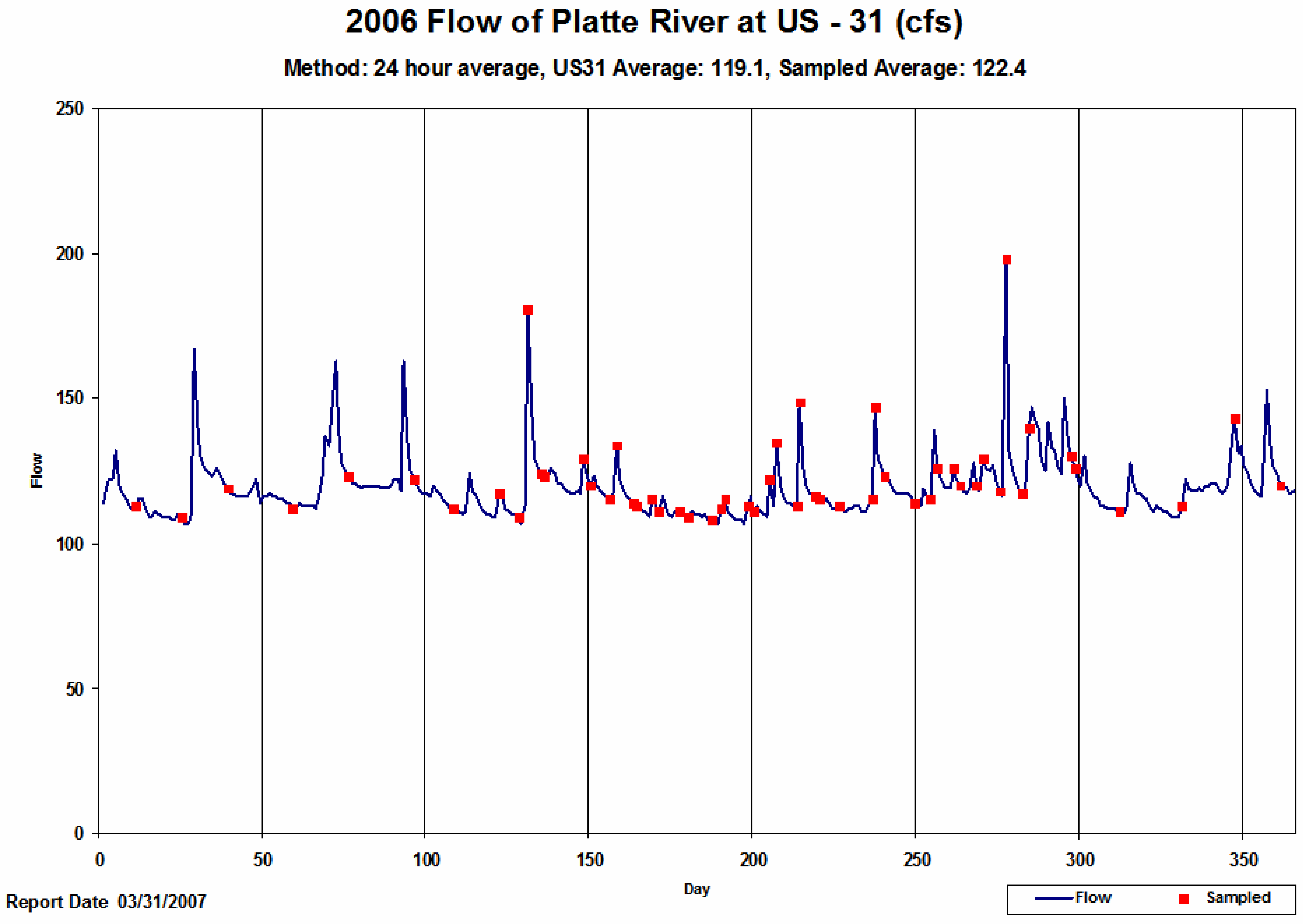


Figure 37. Annual Average USGS Flow of Platte River at US 31.



2006 Flow of Platte River at US - 31 (cfs)
Method: 24 hour average, US31 Average: 119.1, Sampled Average: 122.4
250
200
150
100
50
0
Flow
0
50
100
150
200
250
300
350
Day
Report Date 03/31/2007
Flow
Sampled

Figure 38.

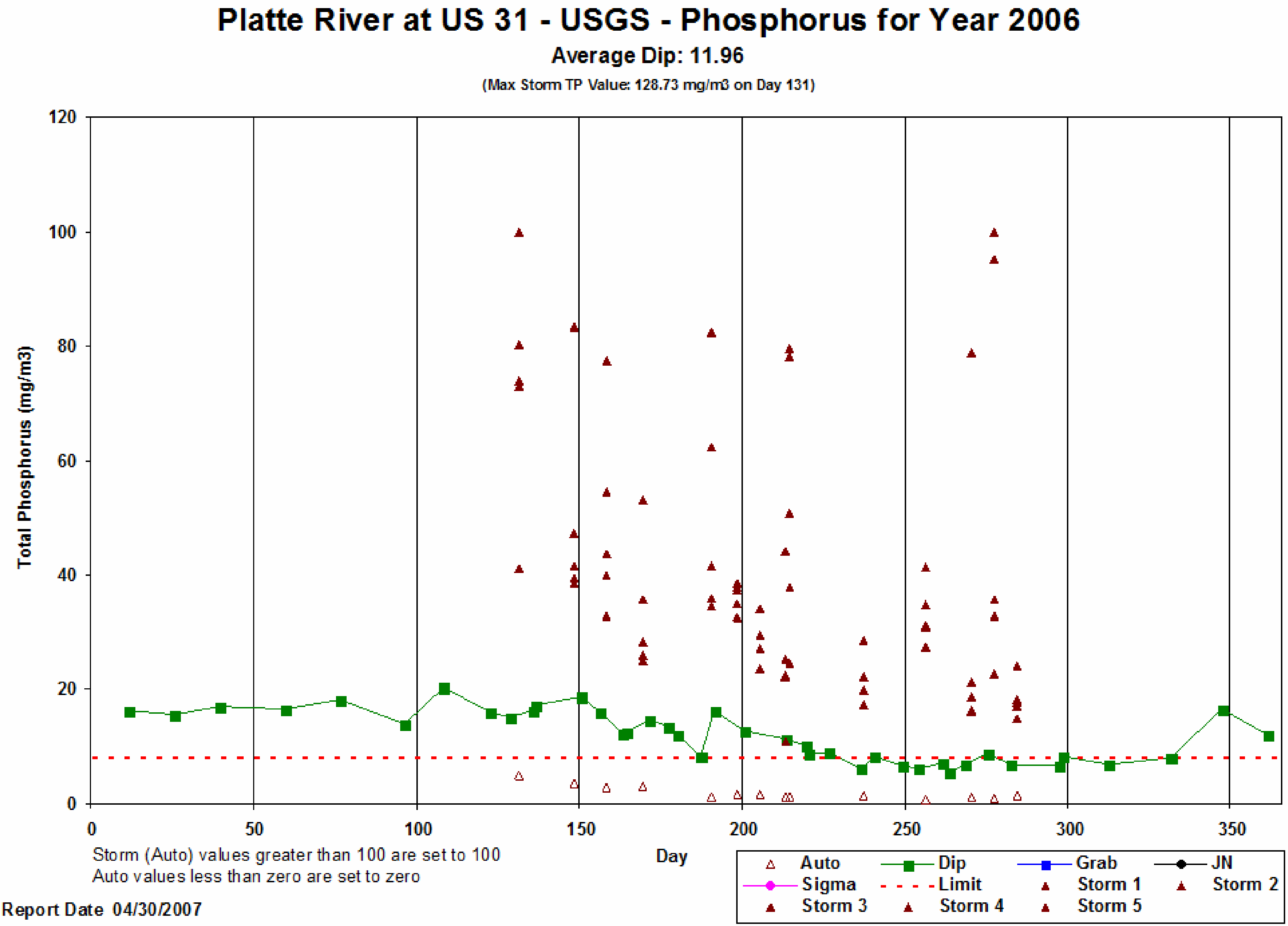
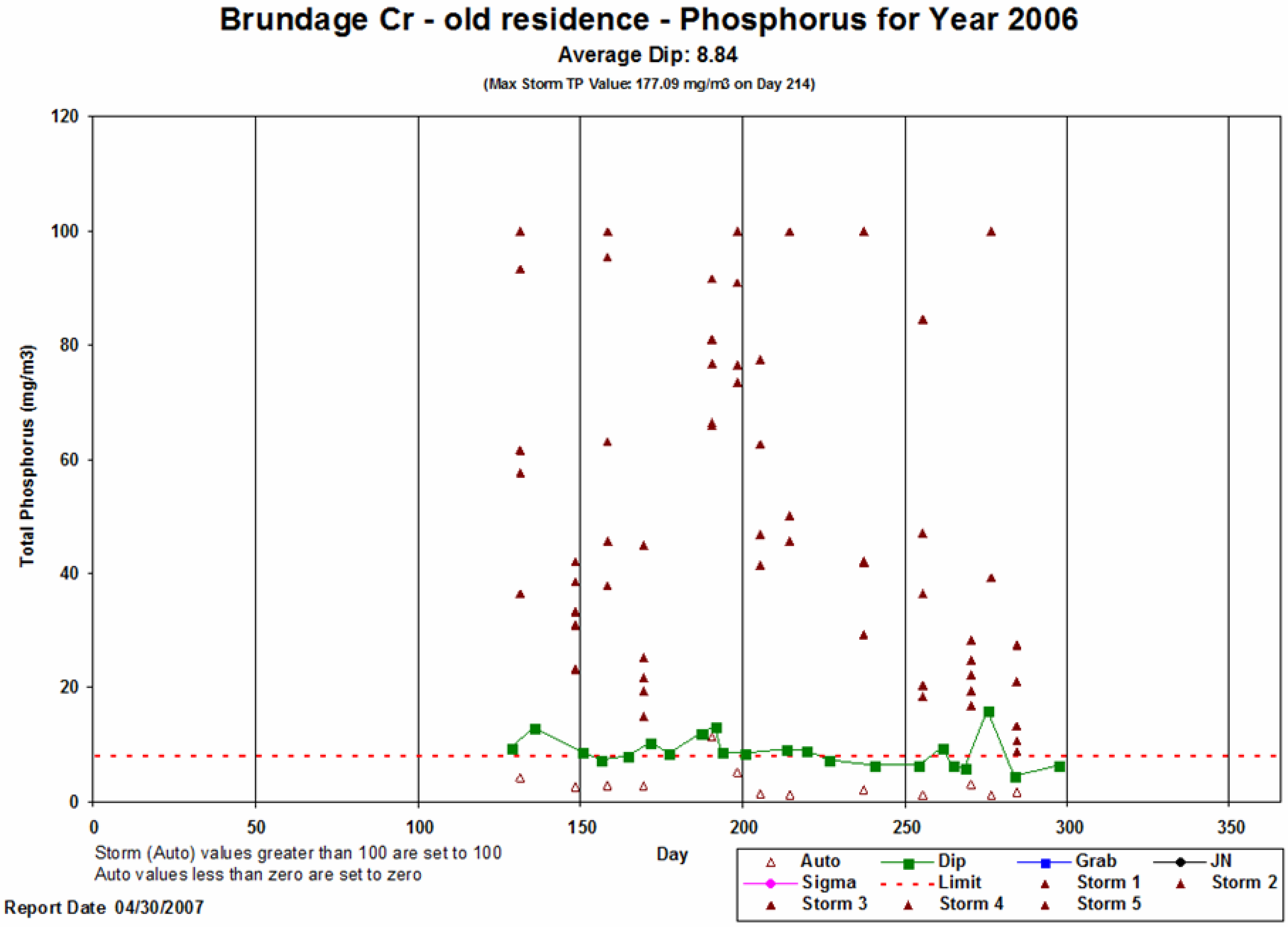
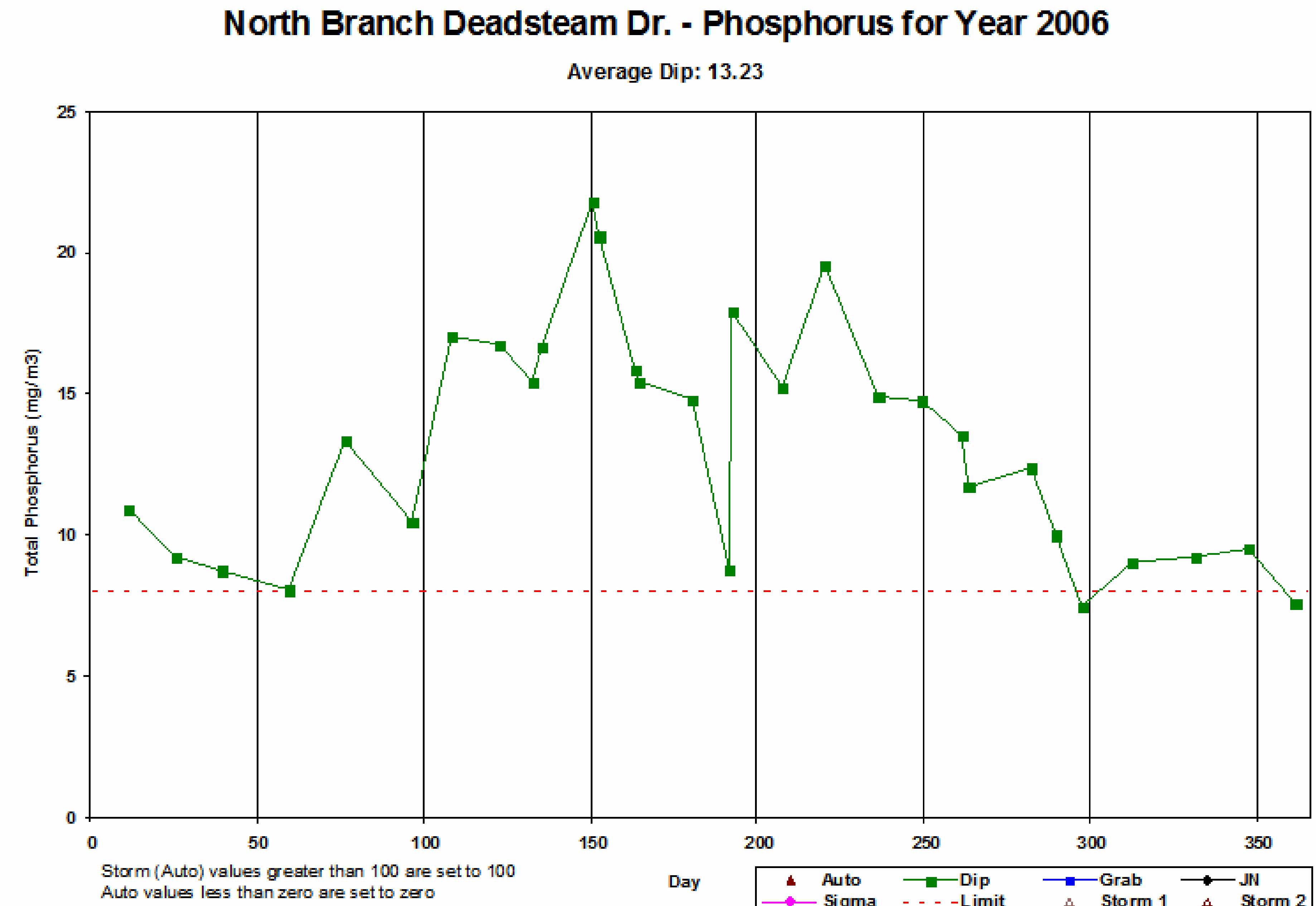

Platte River at US 31 - USGS - Phosphorus for Year 2006
Average Dip: 11.96
(Max Storm TP Value: 128.73 mg/m3 on Day 131)
Total Phosphorus (mg/m3)
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Day
Storm (Auto) values greater than 100 are set to 100
Auto values less than zero are set to zero
Report Date 04/30/2007
Auto
Dip
Grab
JN
Sigma
Limit
Storm 1
Storm 2
Storm 3
Storm 4
Storm 5

Figure 39.



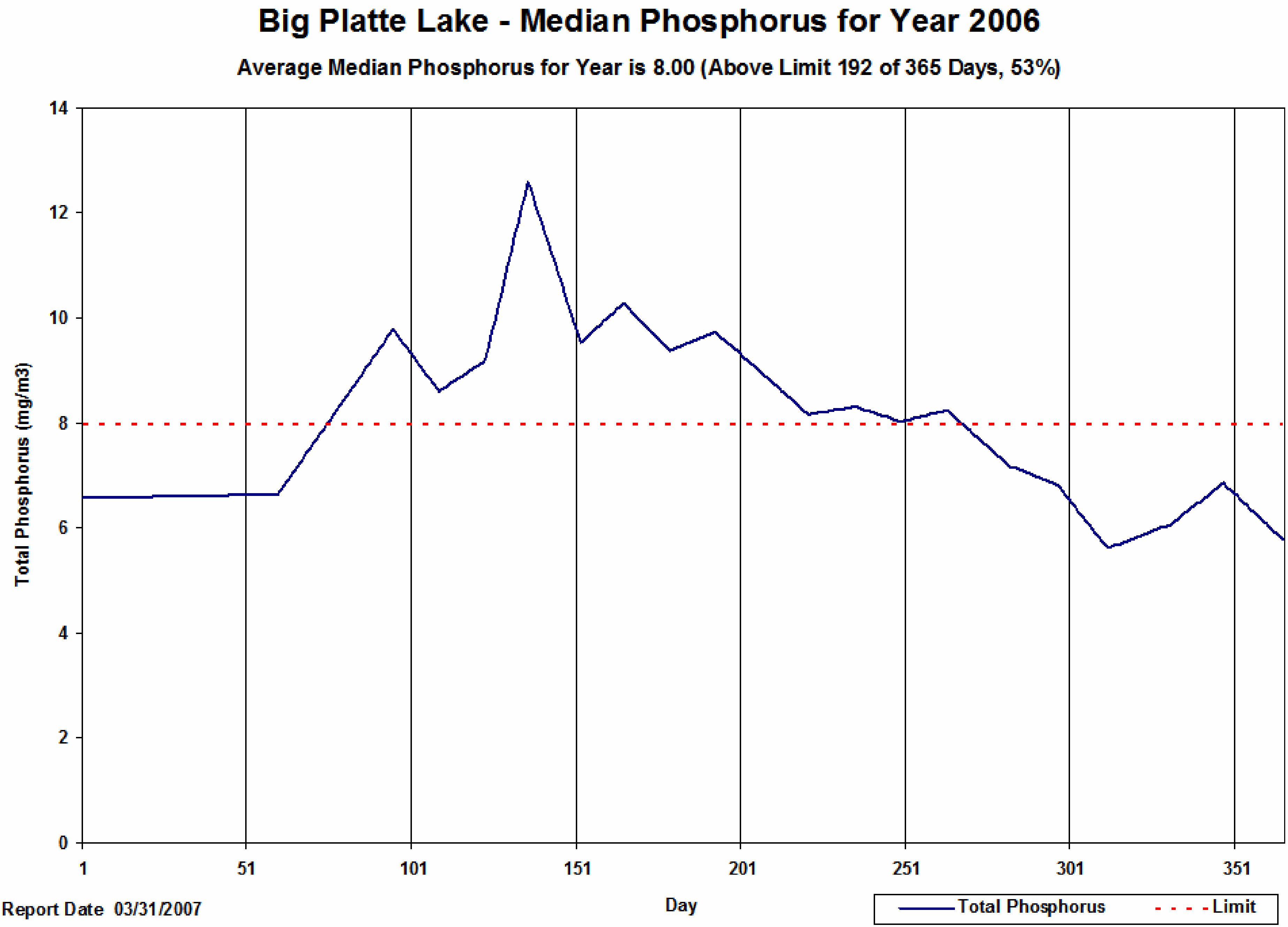
Brundage Cr - old residence - Phosphorus for Year 2006
Average Dip: 8.84
(Max Storm TP Value: 177.09 mg/m3 on Day 214)
Total Phosphorus (mg/m3)
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Day
Storm (Auto) values greater than 100 are set to 100
Auto values less than zero are set to zero
Report Date 04/30/2007
Auto
Dip
Grab
JN
Sigma
Limit
Storm 1
Storm 2
Storm 3
Storm 4
Storm 5

Figure 40.



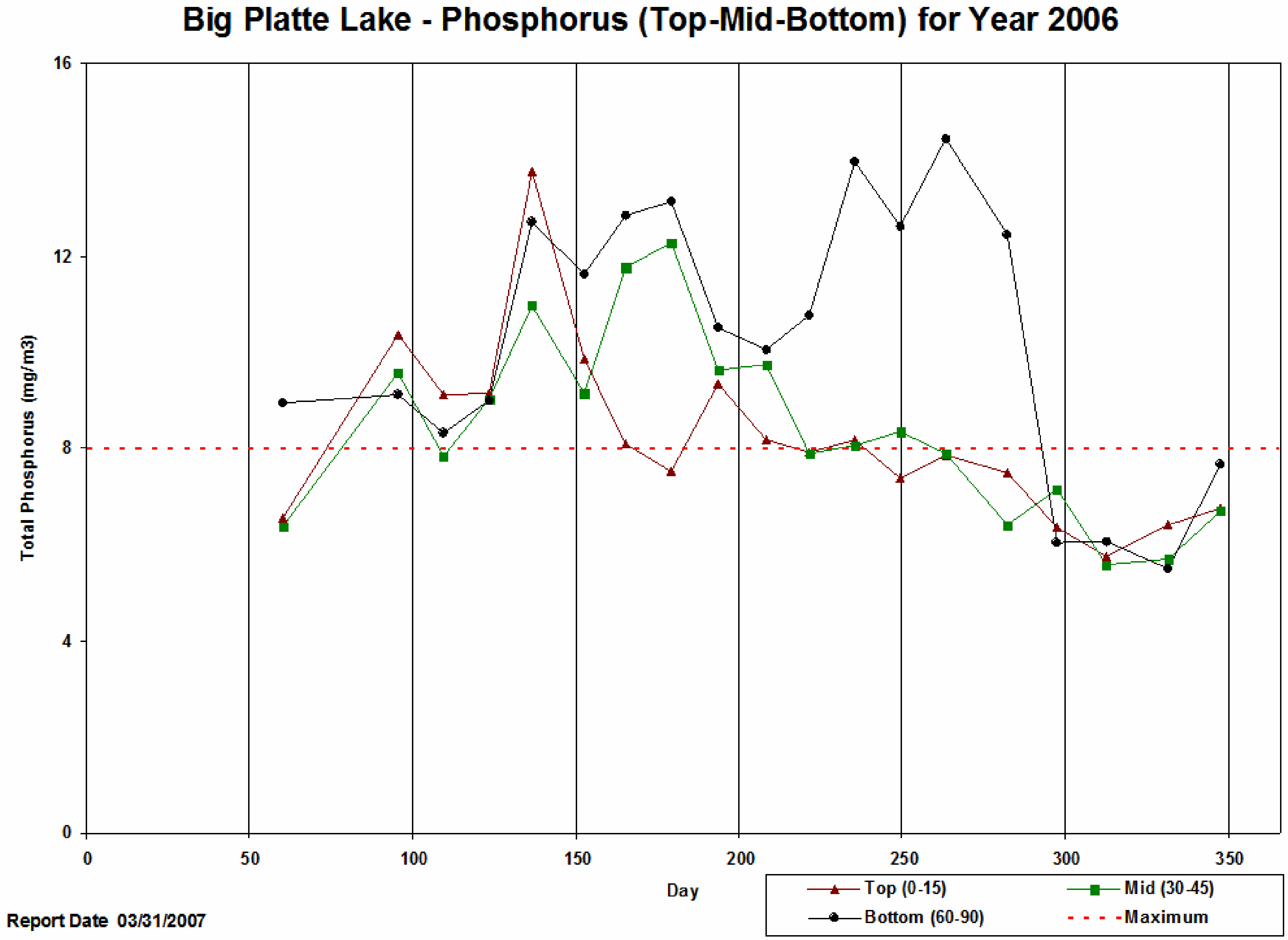
Report Date 03/31/2007

Figure 41.



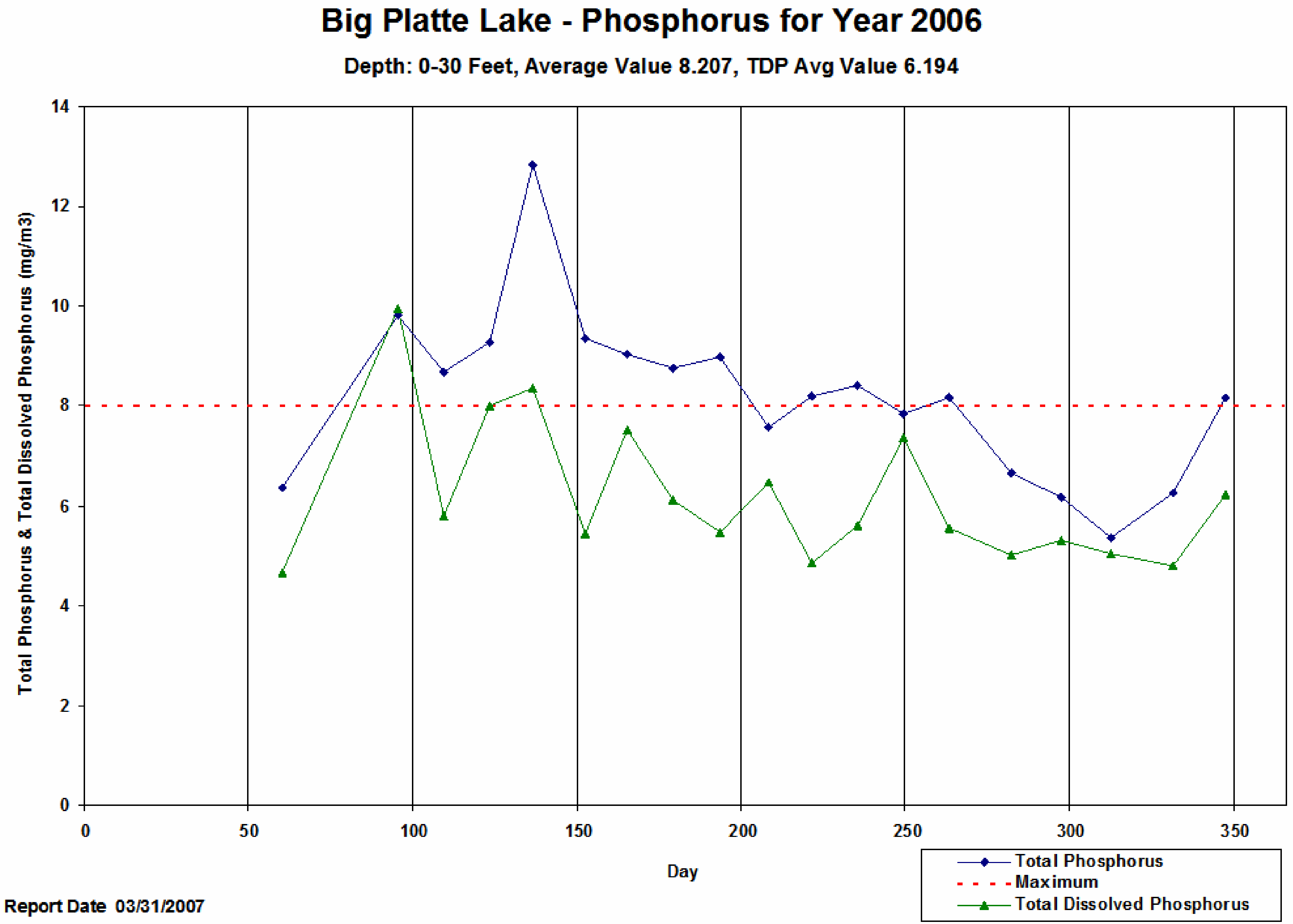
Report Date 03/31/2007

Figure 42.



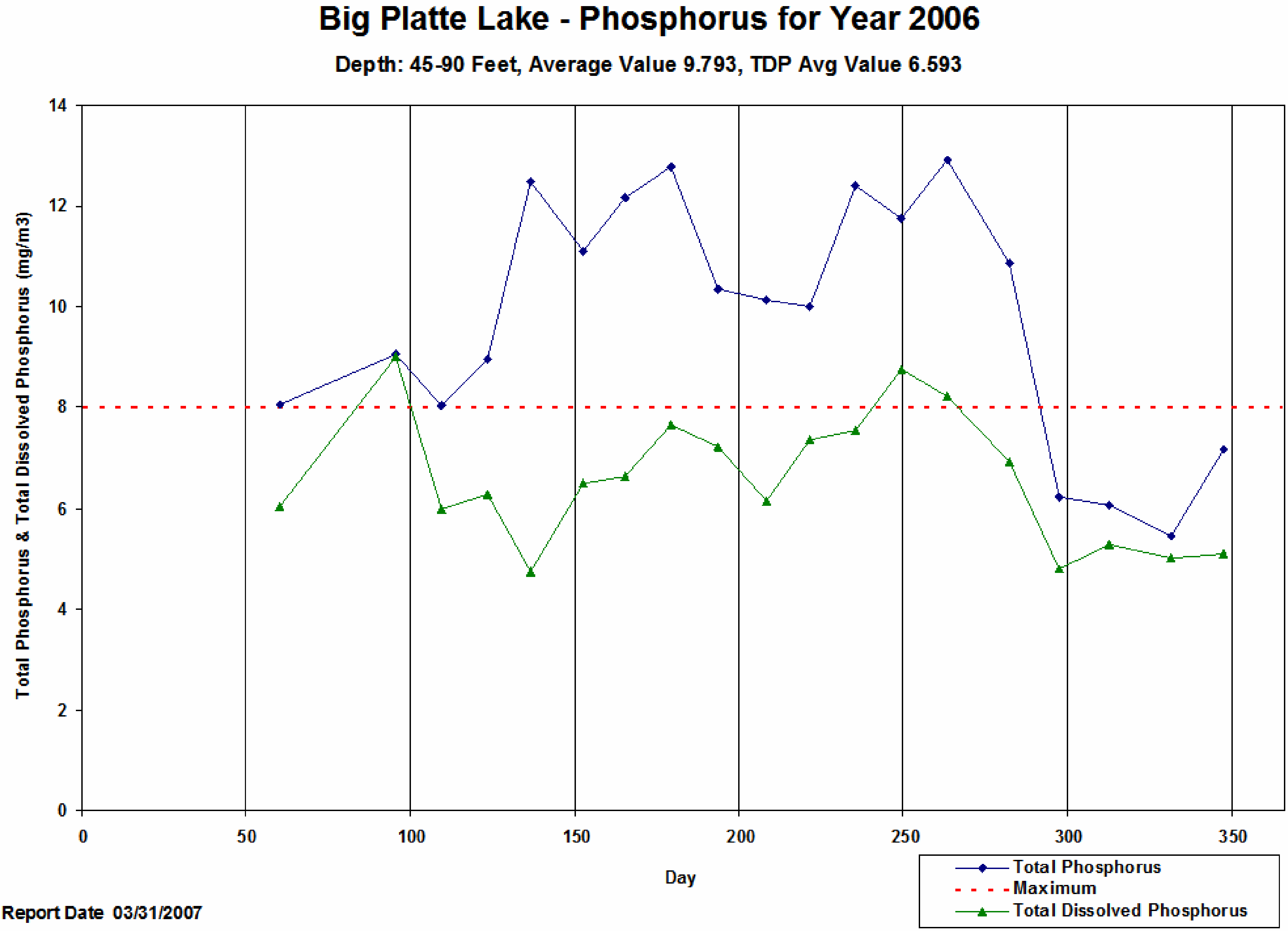
Big Platte Lake - Phosphorus (Top-Mid-Bottom) for Year 2006
16
12
8
4
0
Total Phosphorus (mg/m3)
0
50
100
150
200
250
300
350
Day
Top (0-15)
Mid (30-45)
Bottom (60-90)
Maximum
Report Date 03/31/2007

Figure 43.



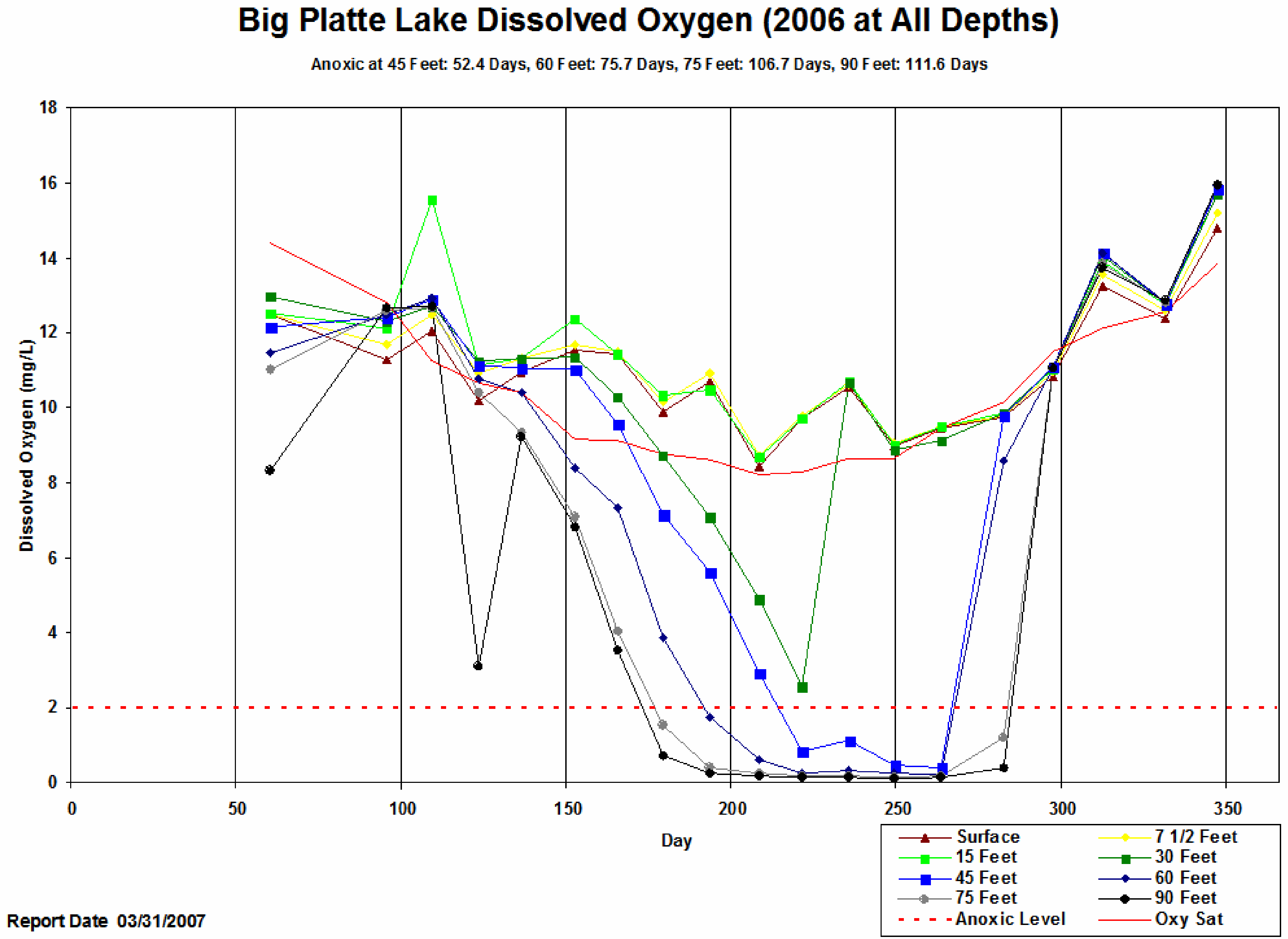
Big Platte Lake - Phosphorus for Year 2006
Depth: 0-30 Feet, Average Value 8.207, TDP Avg Value 6.194
Total Phosphorus & Total Dissolved Phosphorus (mg/m3)
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
Day
Total Phosphorus
Maximum
Total Dissolved Phosphorus
Report Date 03/31/2007

Figure 44.



Report Date 03/31/2007

Figure 45.



Report Date 03/31/2007

Figure 46.

Secchi Comparison 2005 and 2006

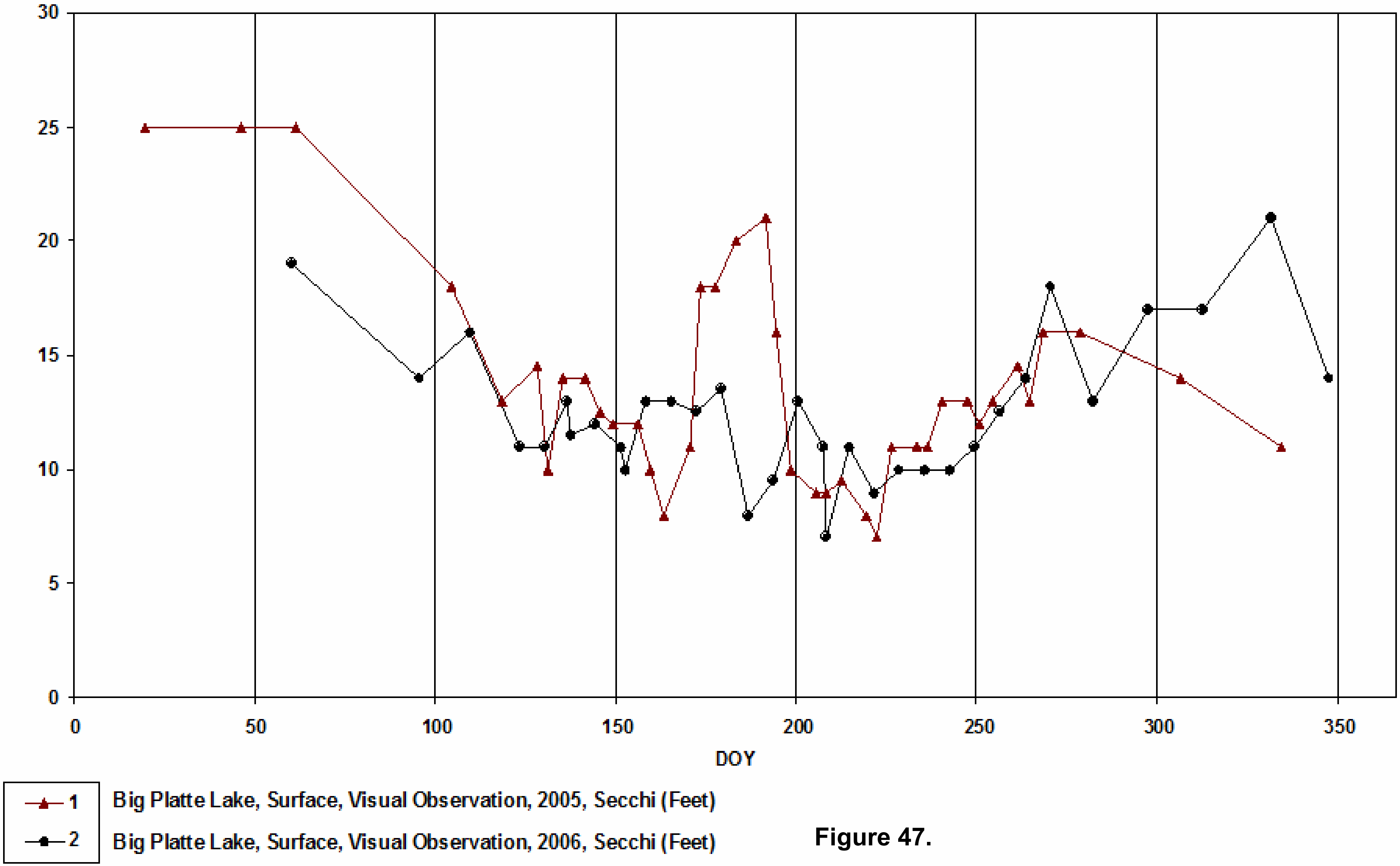
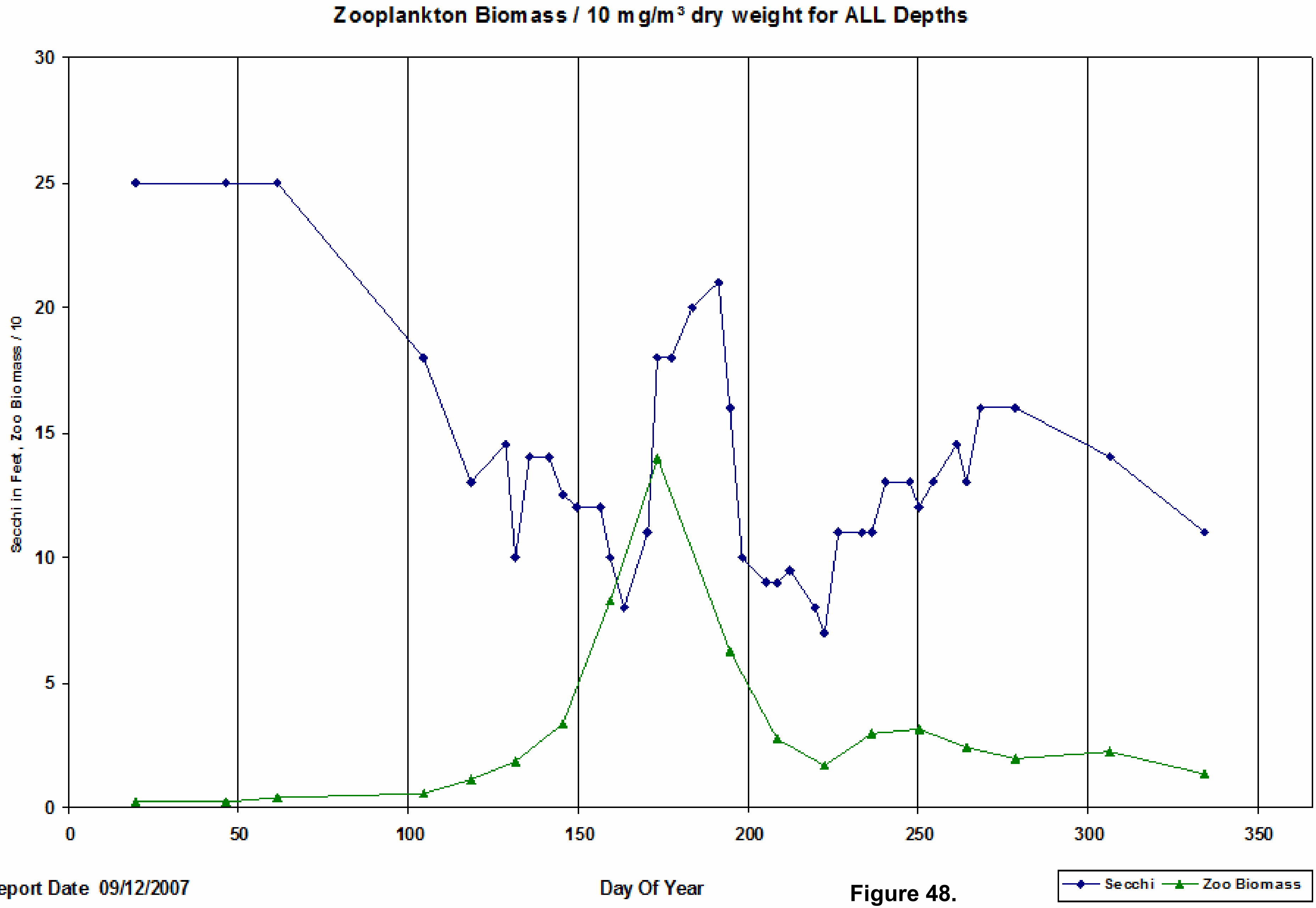


Figure 47.

Secchi Depth vs Zooplankton Biomass for Big Platte Lake in 2005



Report Date 09/12/2007

Figure 48.

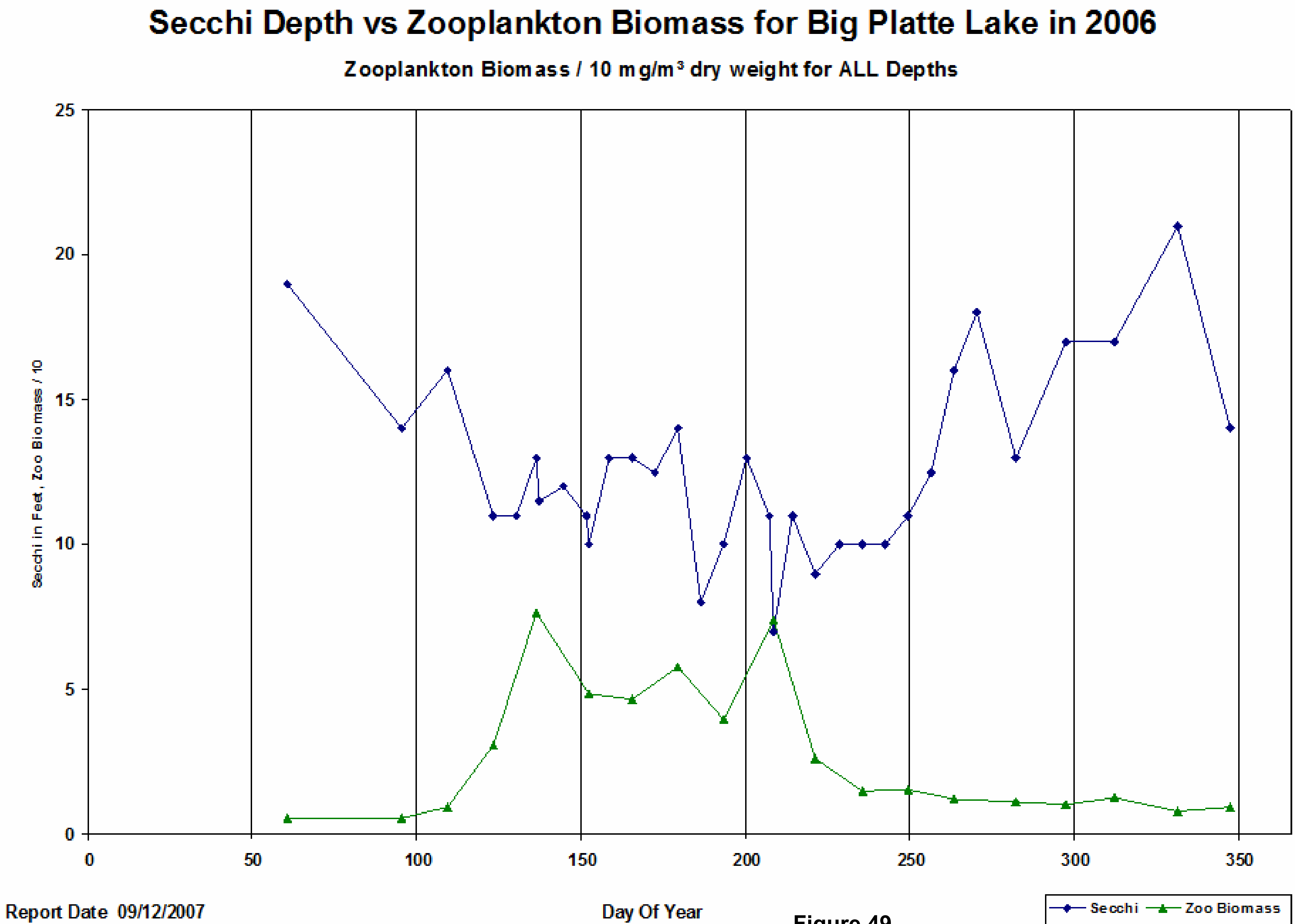

Secchi Depth vs Zooplankton Biomass for Big Platte Lake in 2006
Zooplankton Biomass / 10 mg/m³ dry weight for ALL Depths
Secchi in Feet, Zoo Biomass / 10
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Day Of Year
Report Date 09/12/2007
Secchi
Zoo Biomass

Figure 49.

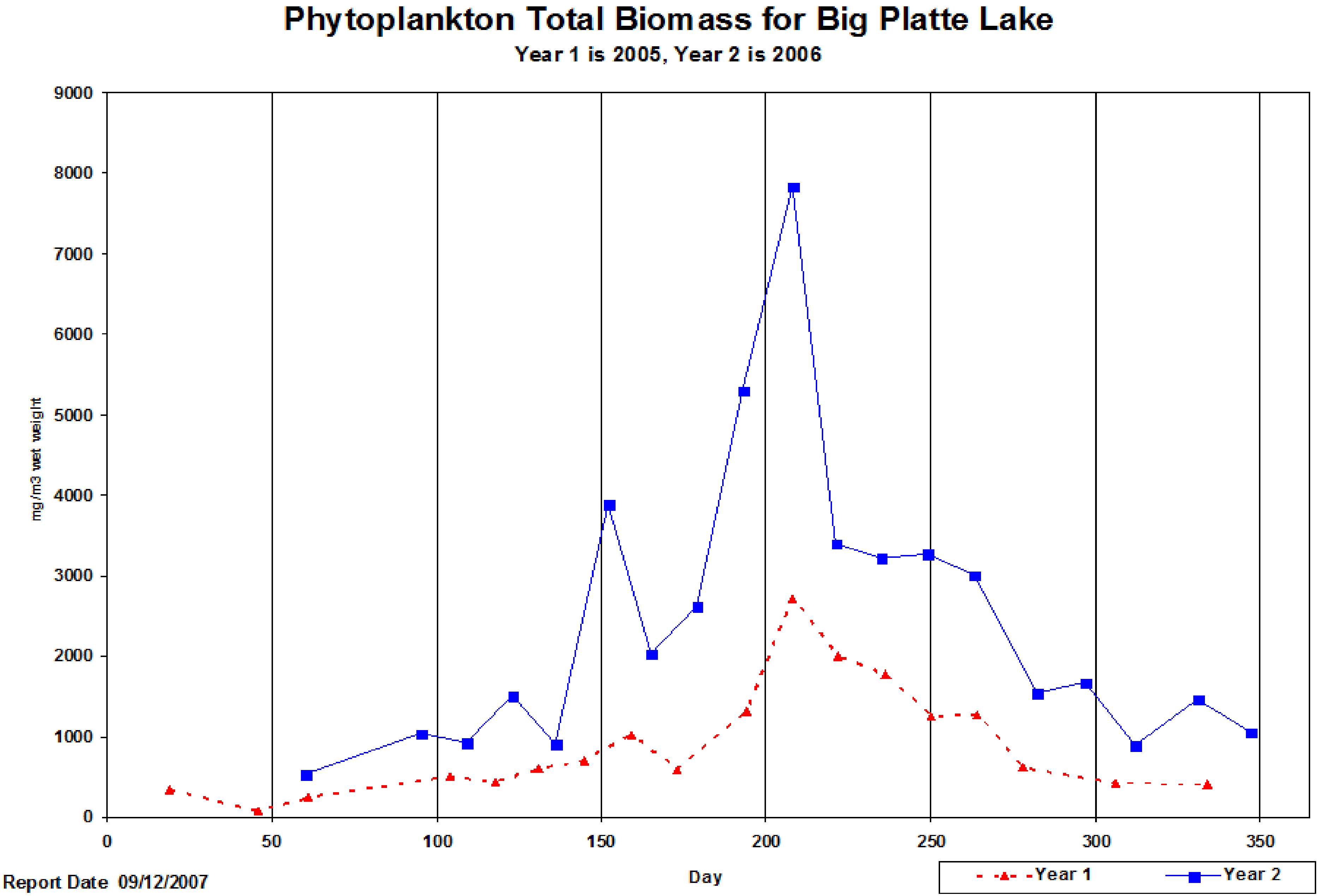

Phytoplankton Total Biomass for Big Platte Lake
Year 1 is 2005, Year 2 is 2006
mg/m3 wet weight
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
350
Day
Report Date 09/12/2007
Year 1
Year 2

Figure 50.

Chlorophyll Comparison for 2005 and 2006

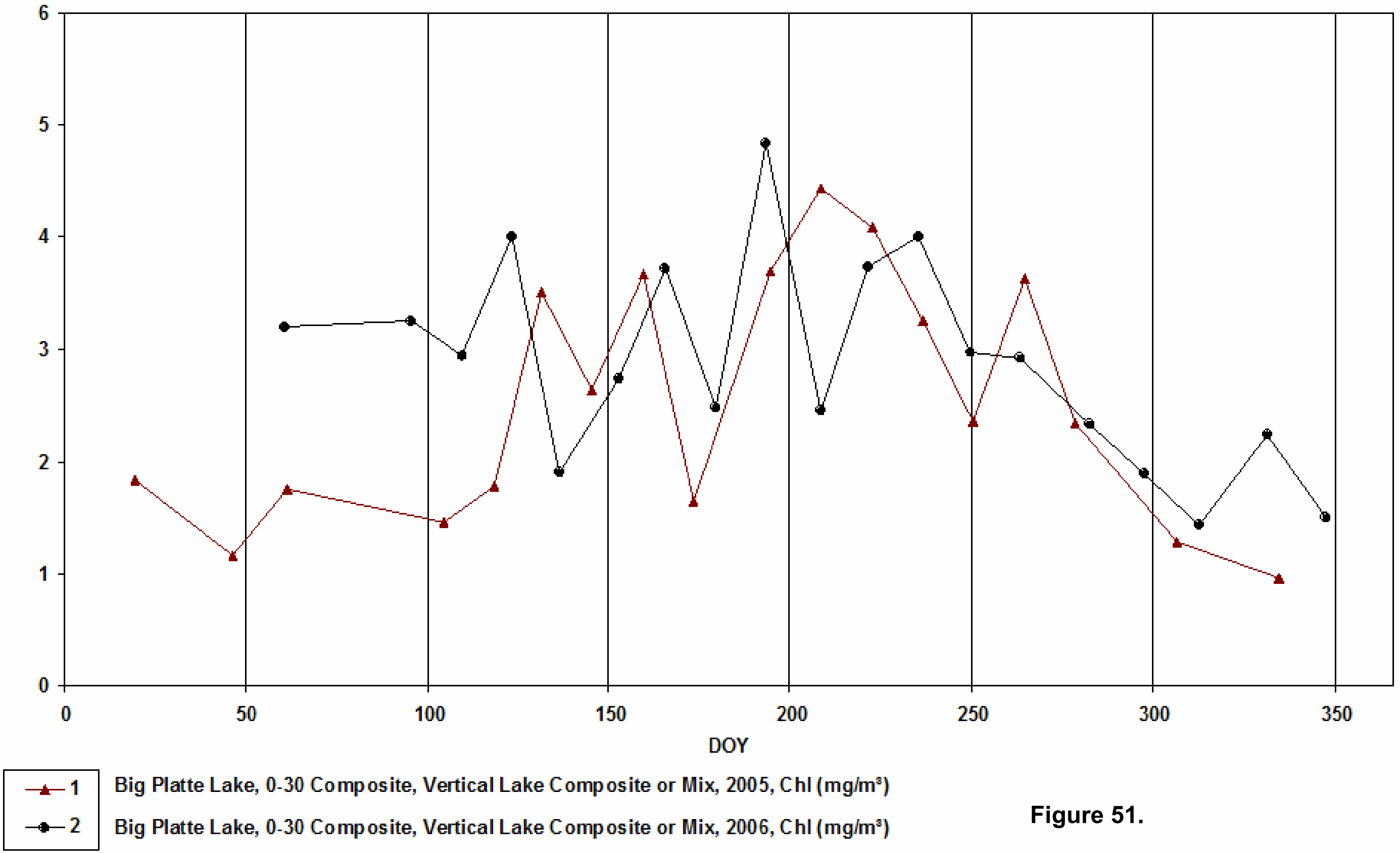


Figure 51.

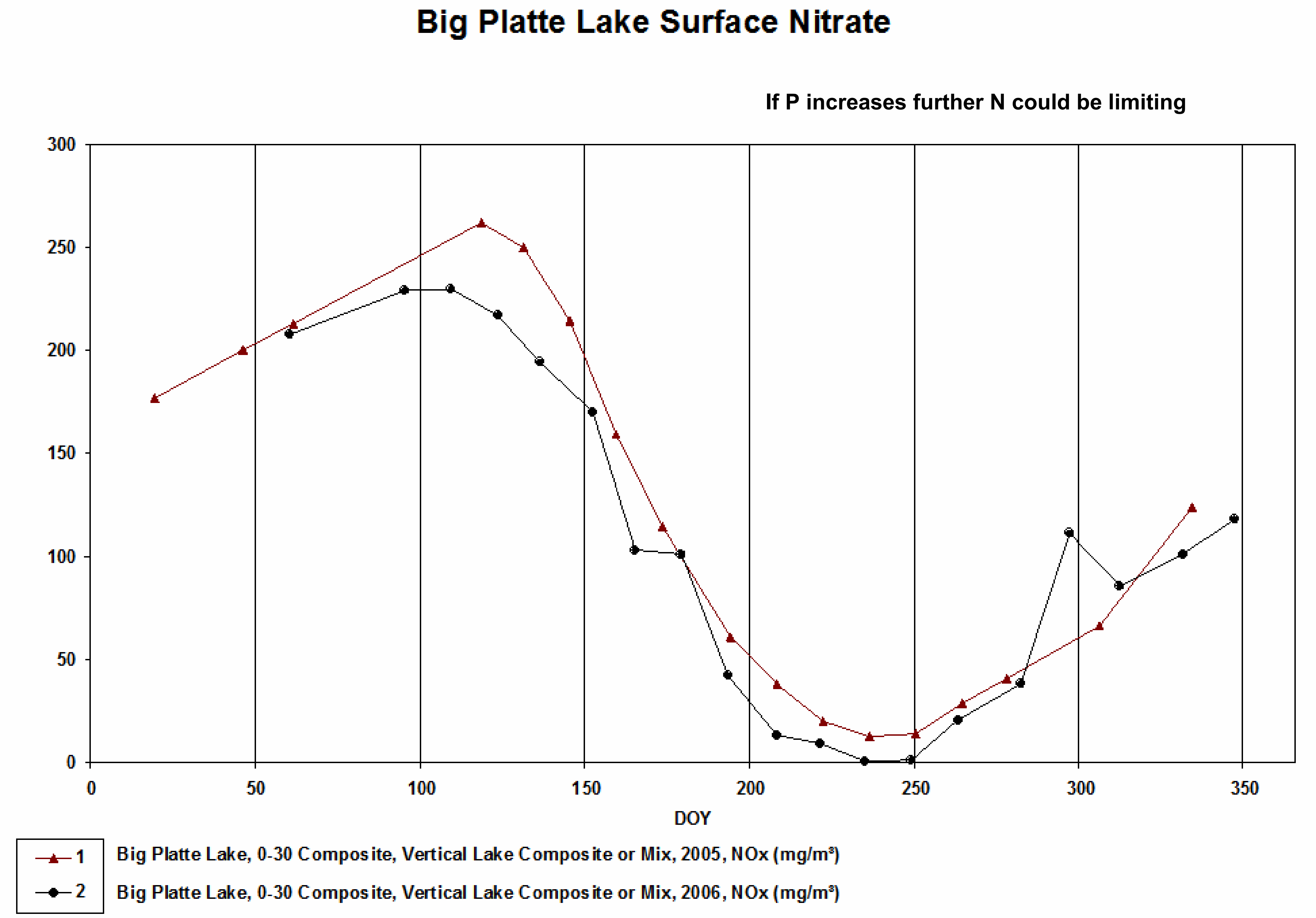
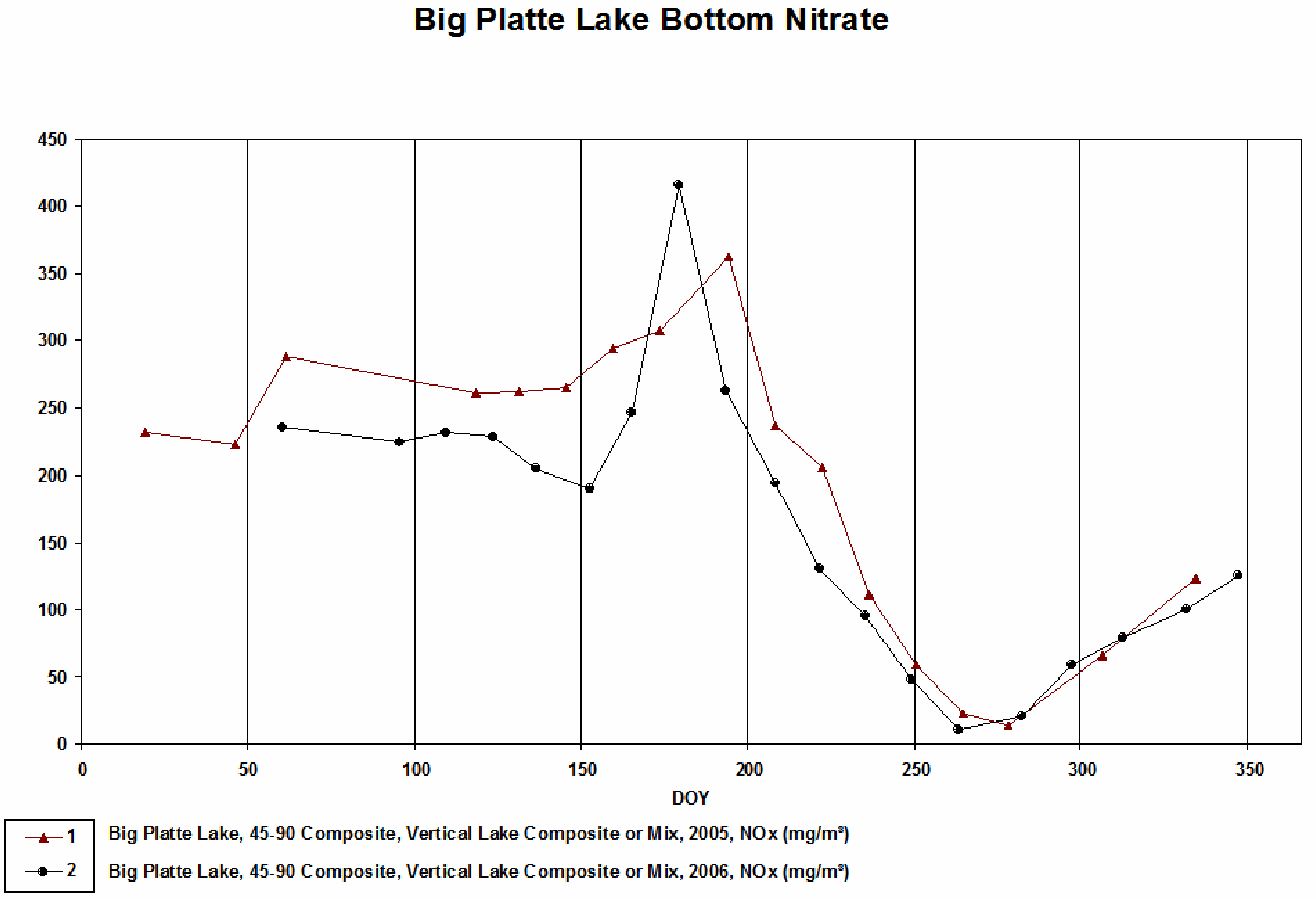

Big Platte Lake Surface Nitrate
If P increases further N could be limiting
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2005, NOx (mg/m³)
2 Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2006, NOx (mg/m³)

Figure 52.



Big Platte Lake Bottom Nitrate
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
DOY
1
Big Platte Lake, 45-90 Composite, Vertical Lake Composite or Mix, 2005, NOx (mg/m³)
2
Big Platte Lake, 45-90 Composite, Vertical Lake Composite or Mix, 2006, NOx (mg/m³)

Figure 53.

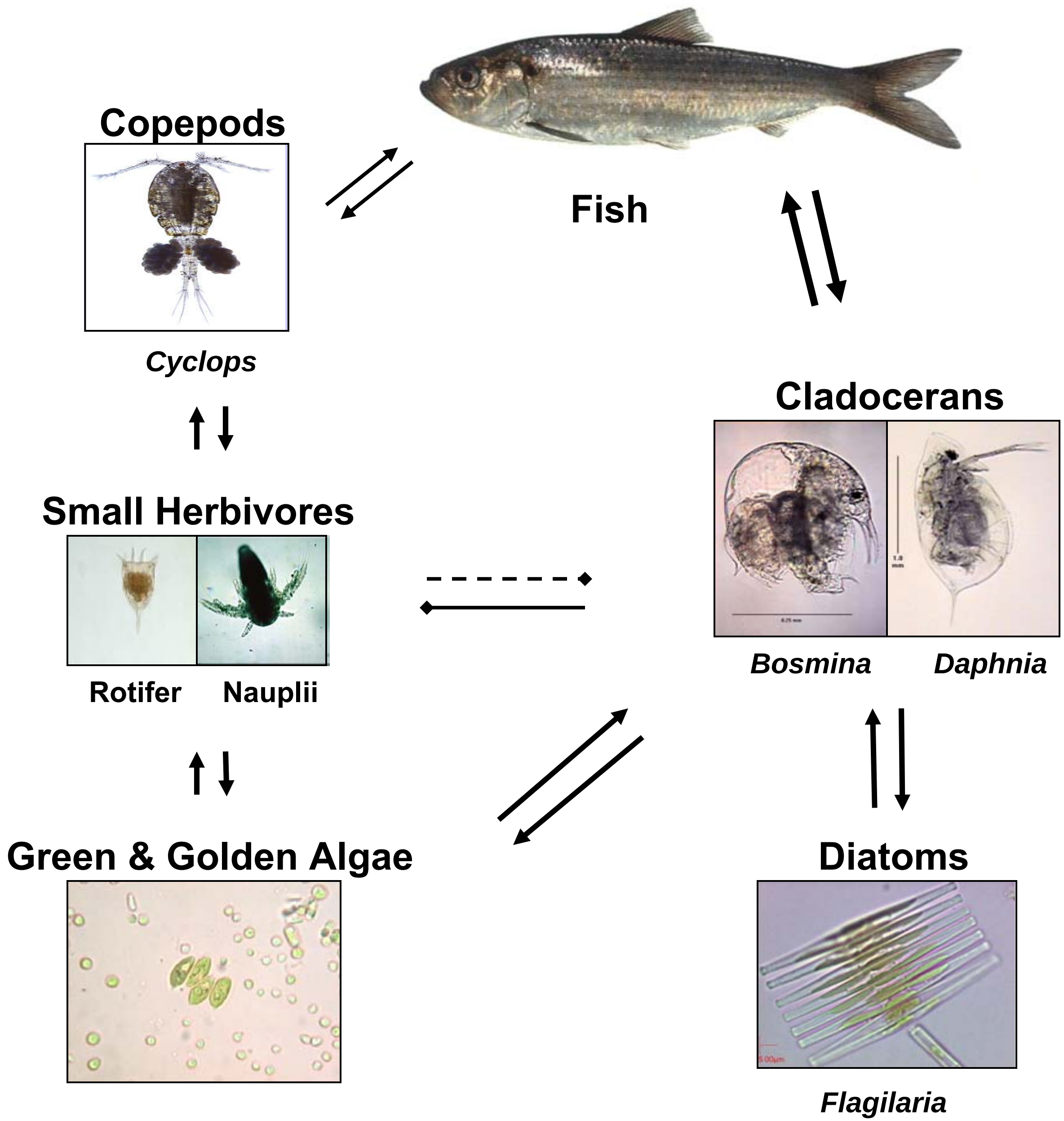
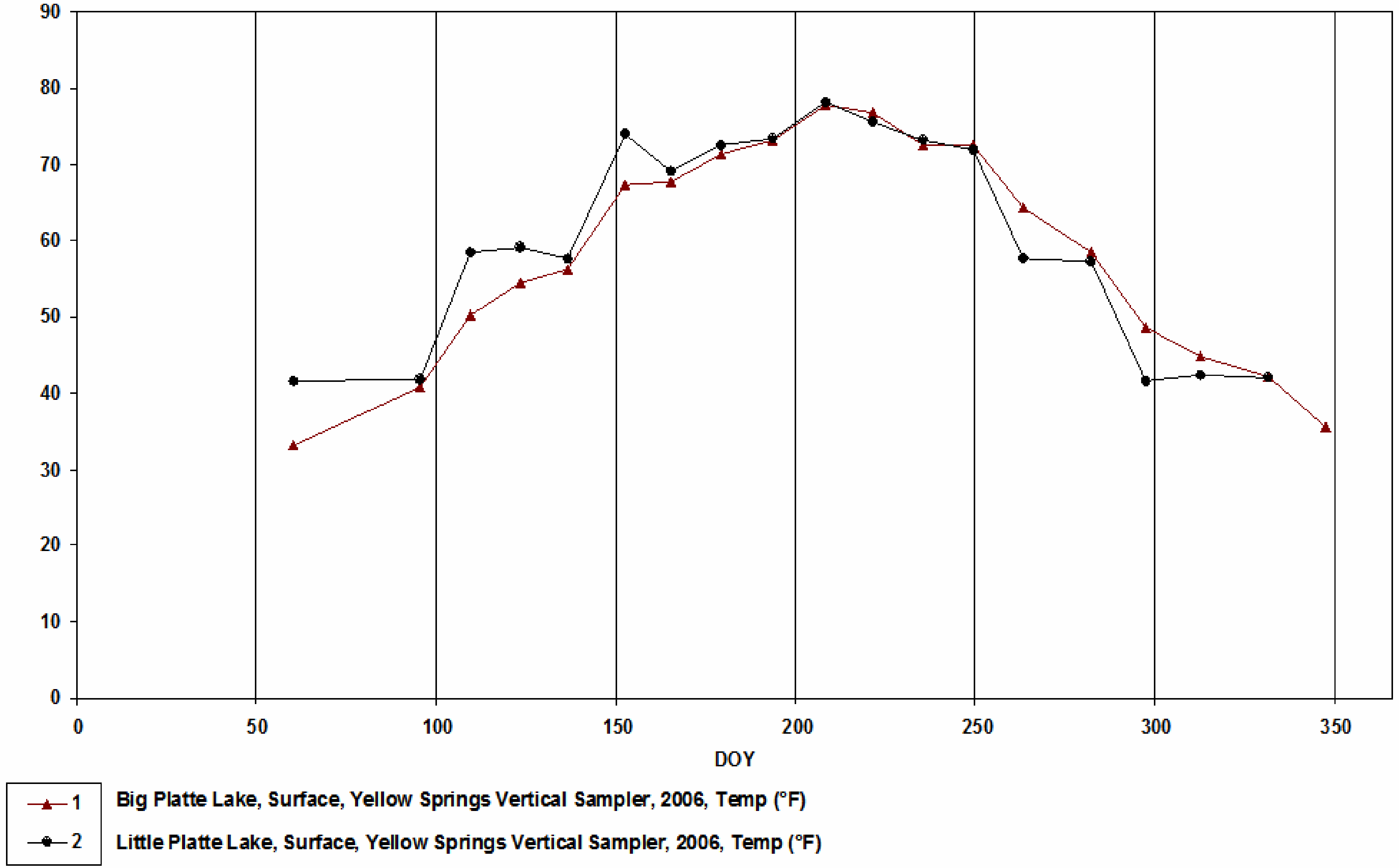


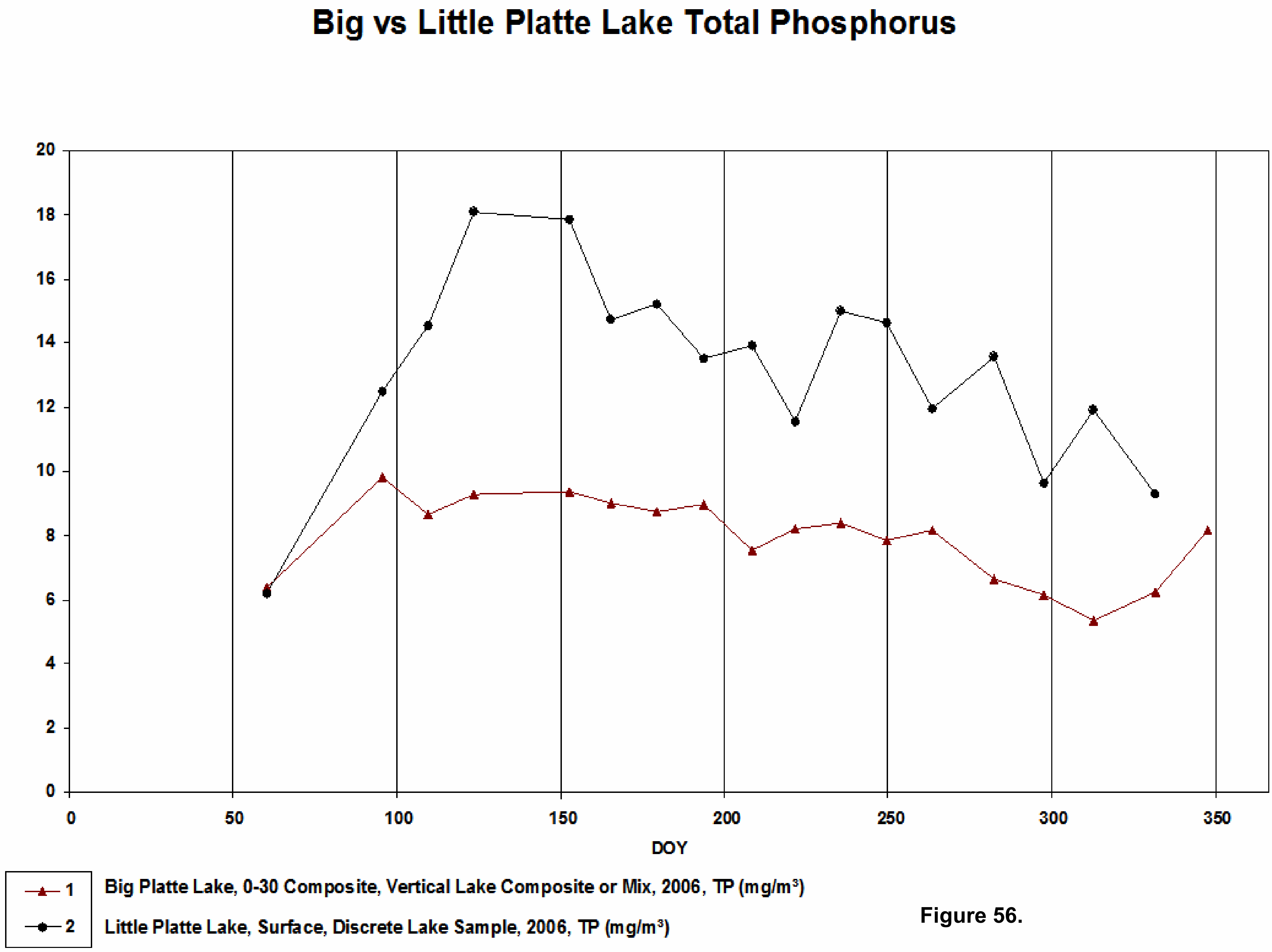
Figure 54. Food Web for Big Platte Lake.

Big vs Little Platte Lake Temperature



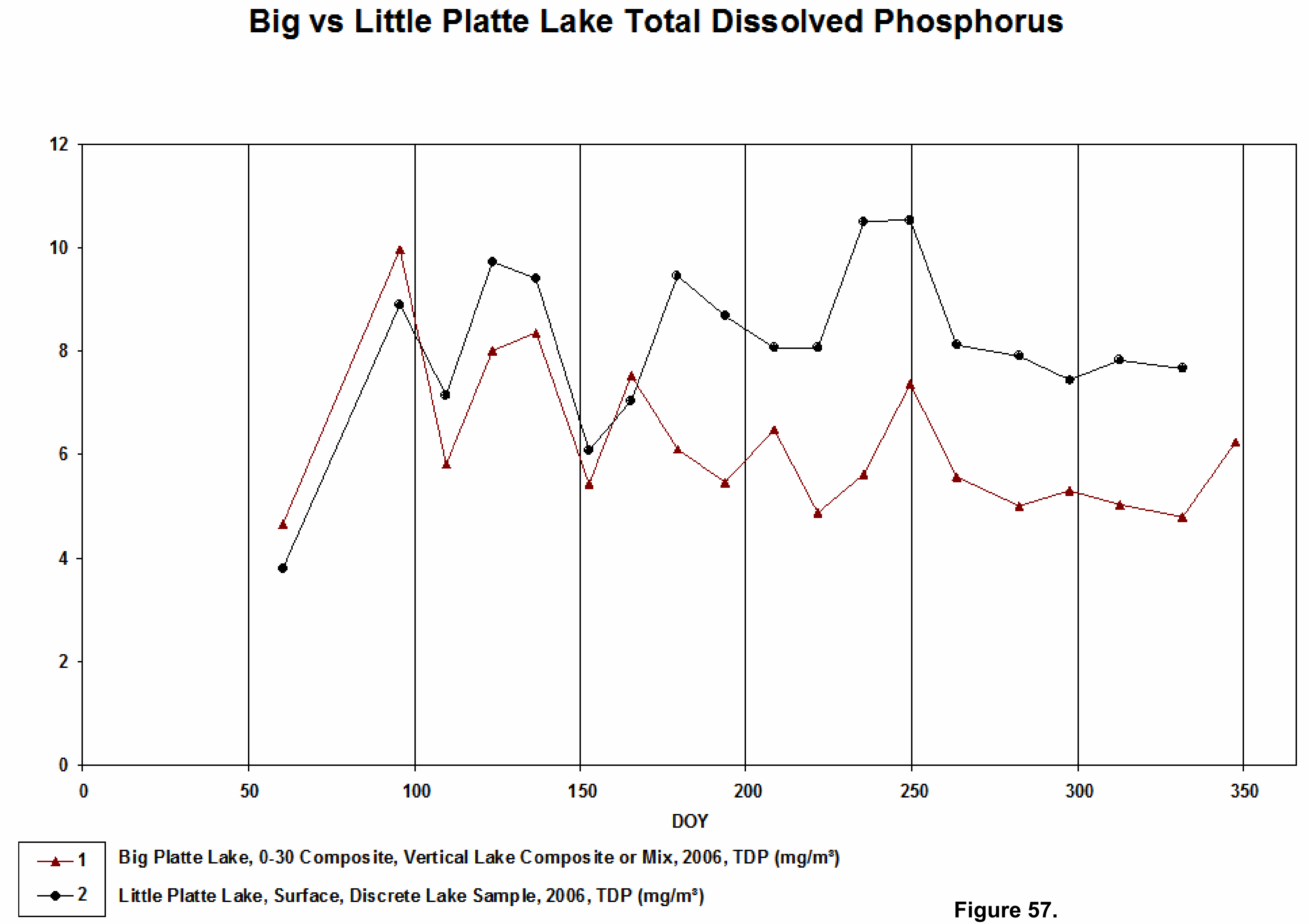
Report Date 03/25/2006

Figure 55.



Big vs Little Platte Lake Total Phosphorus
20
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2006, TP (mg/m³)
2 Little Platte Lake, Surface, Discrete Lake Sample, 2006, TP (mg/m³)

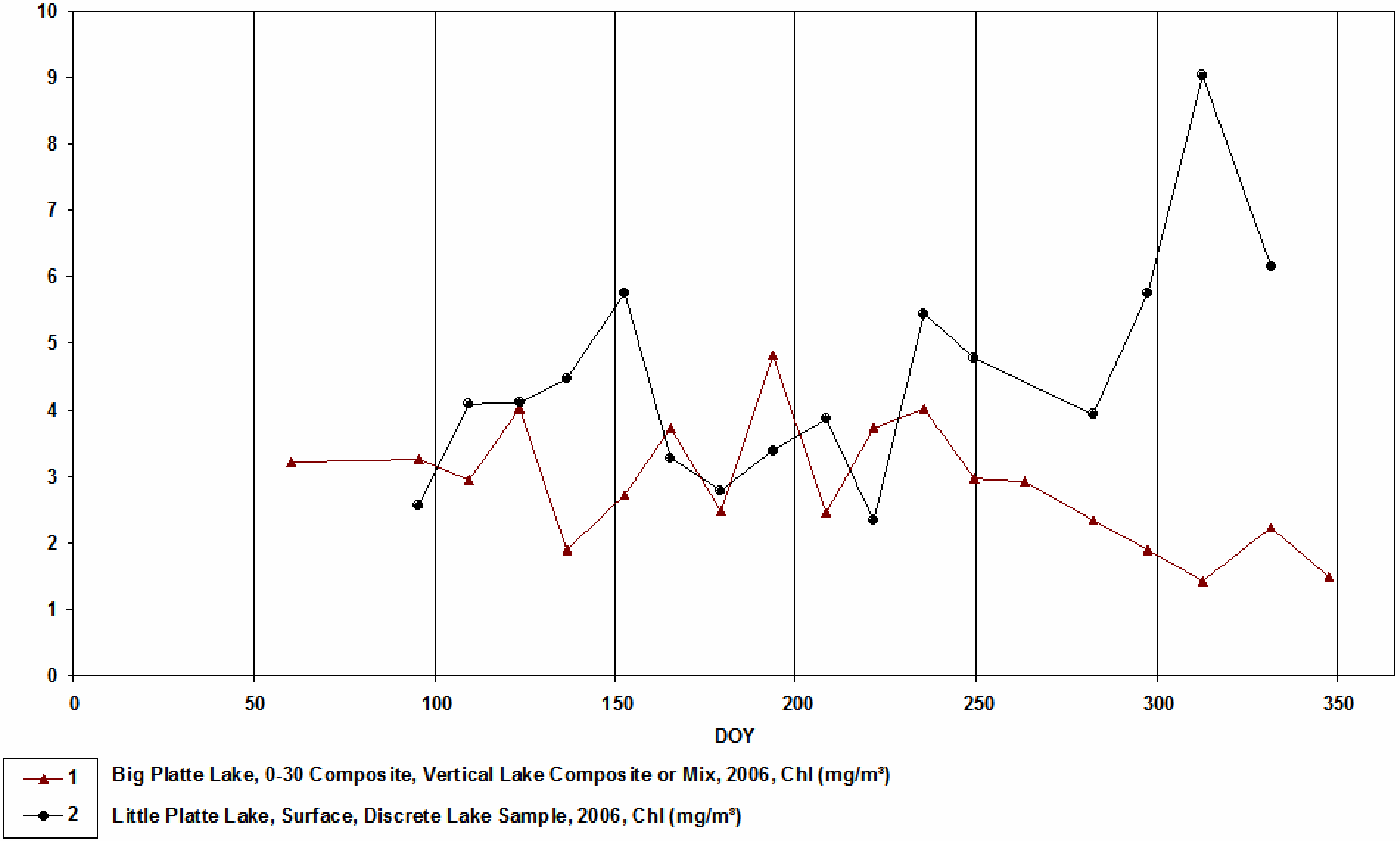
Figure 56.



Big vs Little Platte Lake Total Dissolved Phosphorus
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2006, TDP (mg/m³)
2 Little Platte Lake, Surface, Discrete Lake Sample, 2006, TDP (mg/m³)

Figure 57.

Big vs Little Platte Lake Chlorophyll



Report Date 03/25/2006

Figure 58.

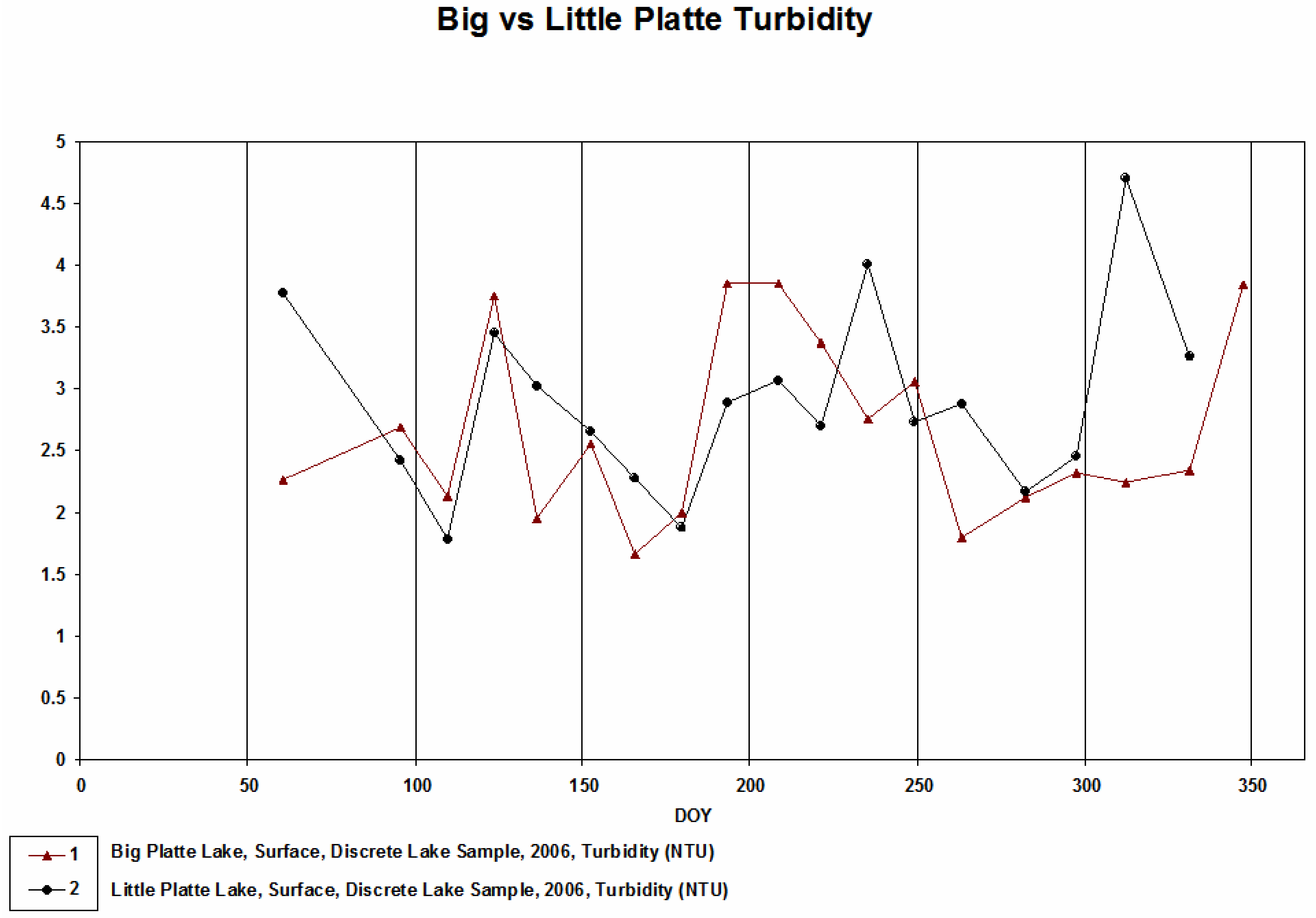
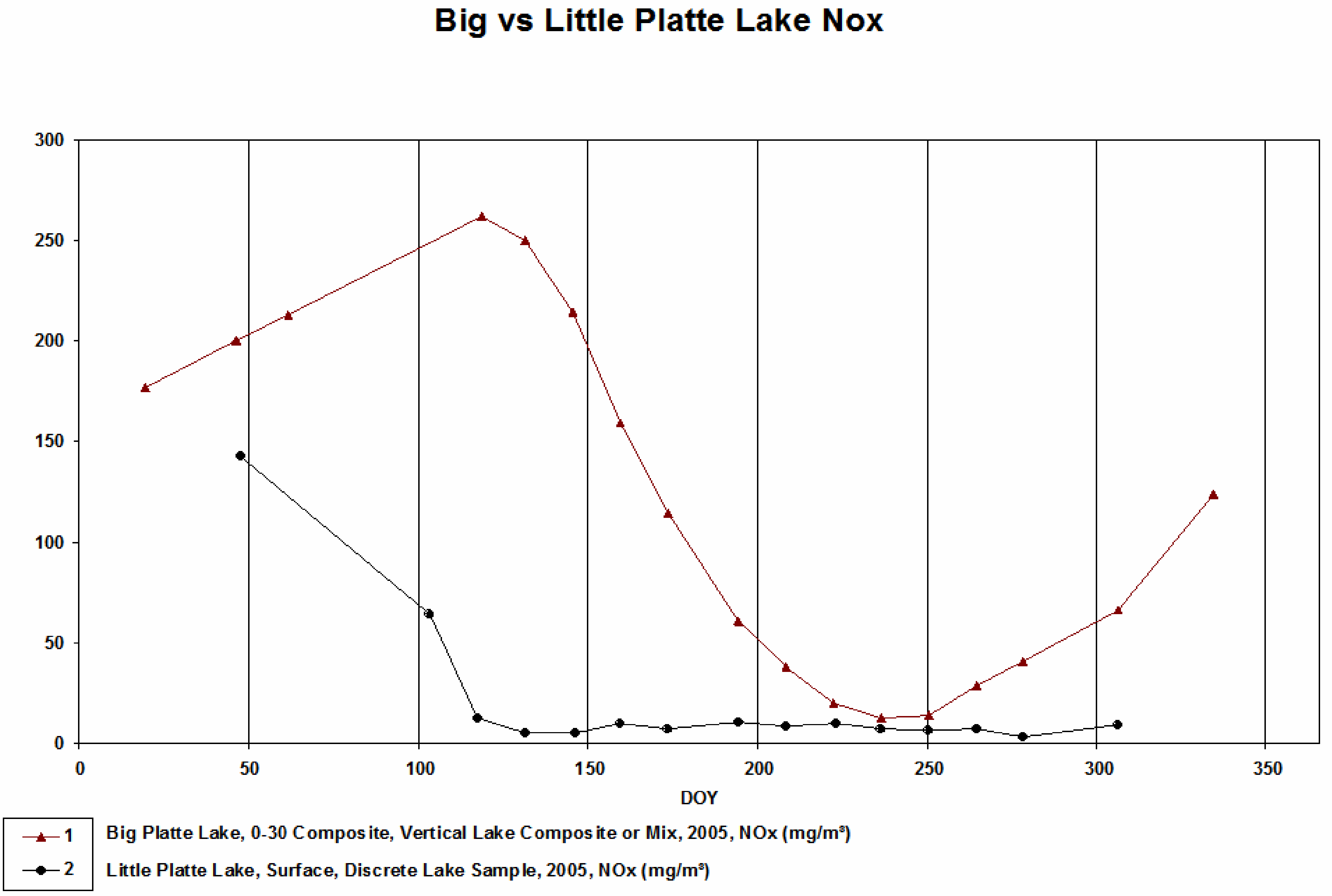

Big vs Little Platte Turbidity
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, Surface, Discrete Lake Sample, 2006, Turbidity (NTU)
2 Little Platte Lake, Surface, Discrete Lake Sample, 2006, Turbidity (NTU)

Figure 59.



Big vs Little Platte Lake Nox
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
DOY
1
Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2005, NOx (mg/m³)
2
Little Platte Lake, Surface, Discrete Lake Sample, 2005, NOx (mg/m³)

Figure 60.

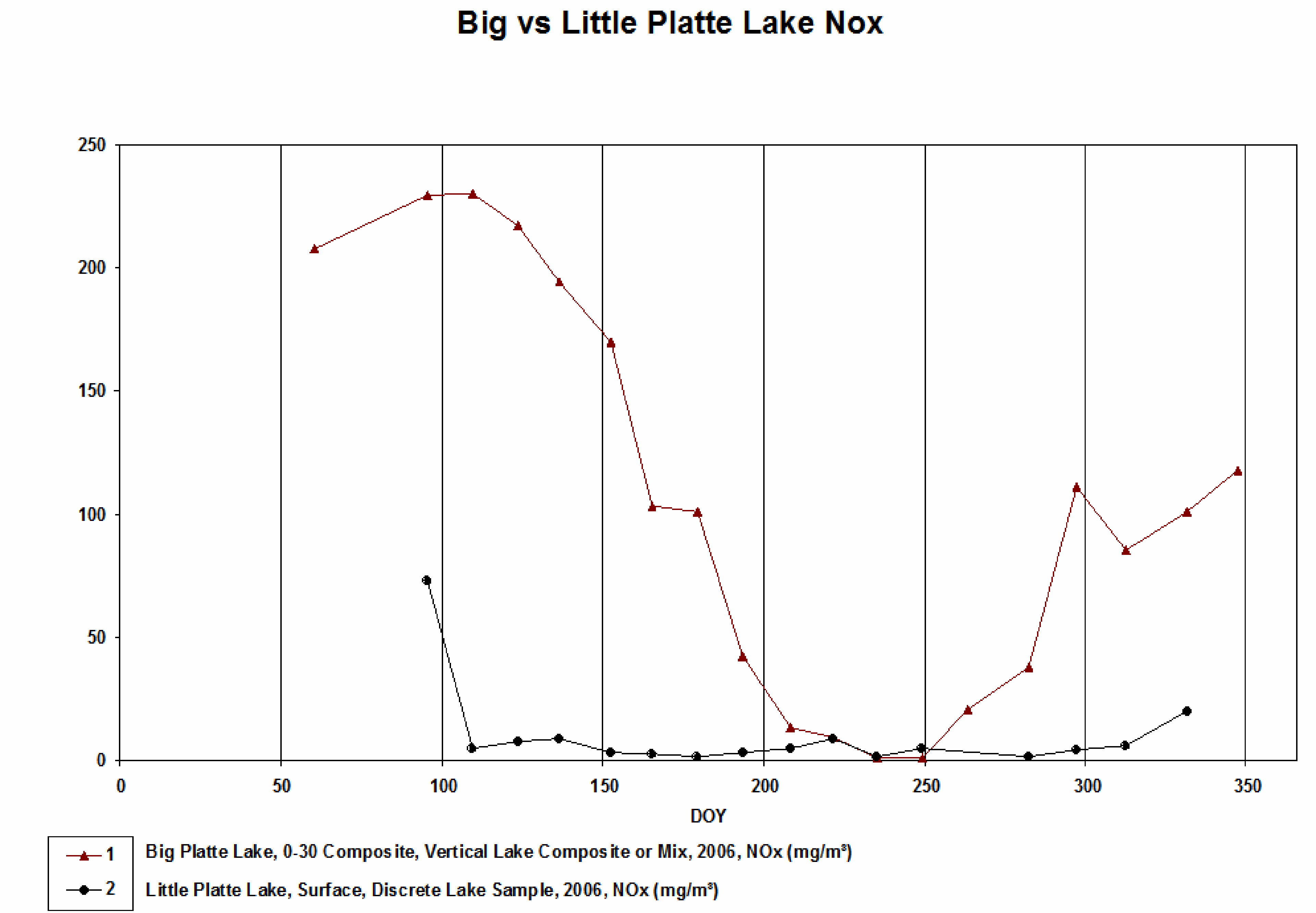

Big vs Little Platte Lake Nox
250
200
150
100
50
0
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2006, NOx (mg/m³)
2 Little Platte Lake, Surface, Discrete Lake Sample, 2006, NOx (mg/m³)

Figure 61.

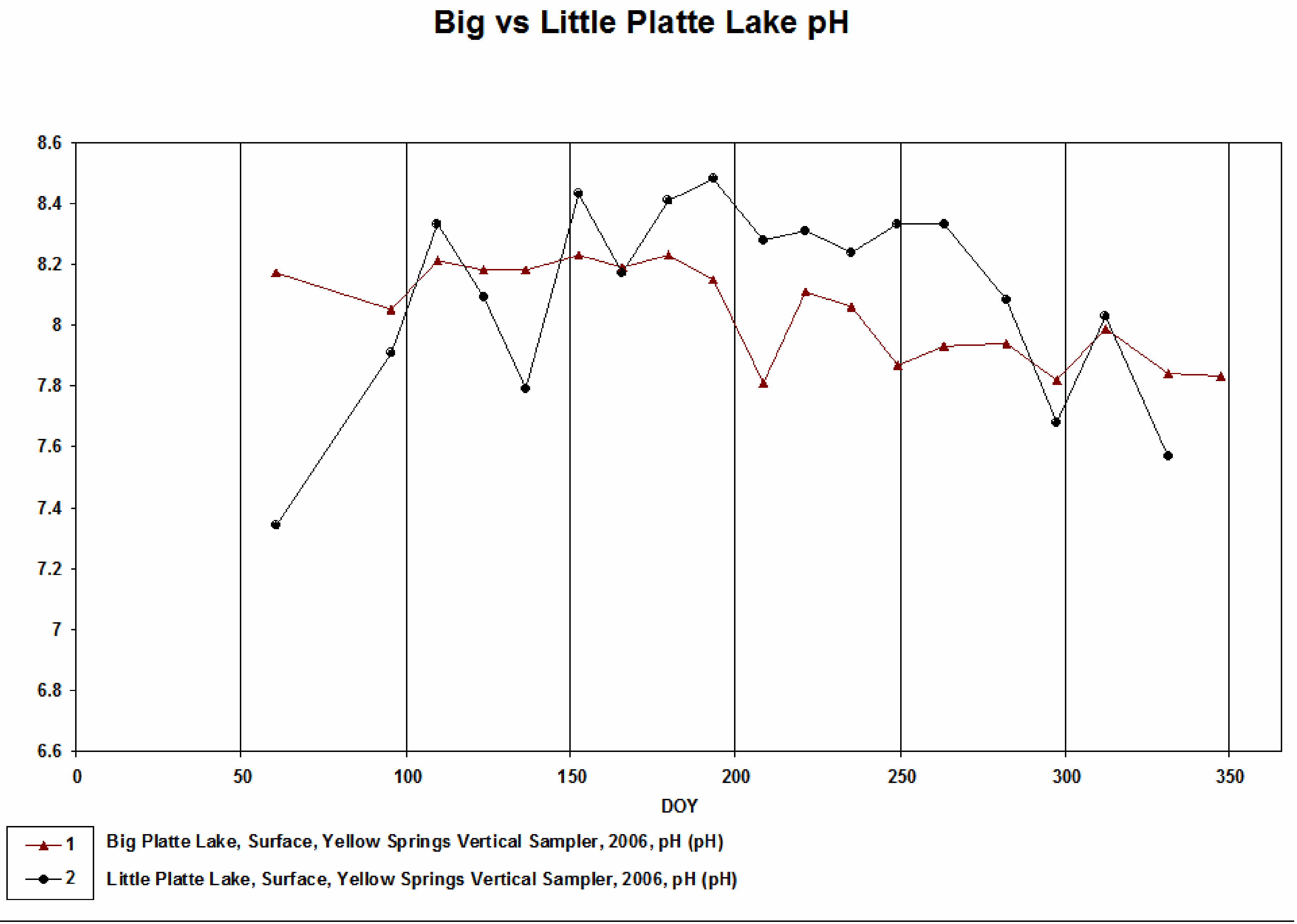

Big vs Little Platte Lake pH
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
0
50
100
150
200
250
300
350
DOY
1 Big Platte Lake, Surface, Yellow Springs Vertical Sampler, 2006, pH (pH)
2 Little Platte Lake, Surface, Yellow Springs Vertical Sampler, 2006, pH (pH)

Figure 62.

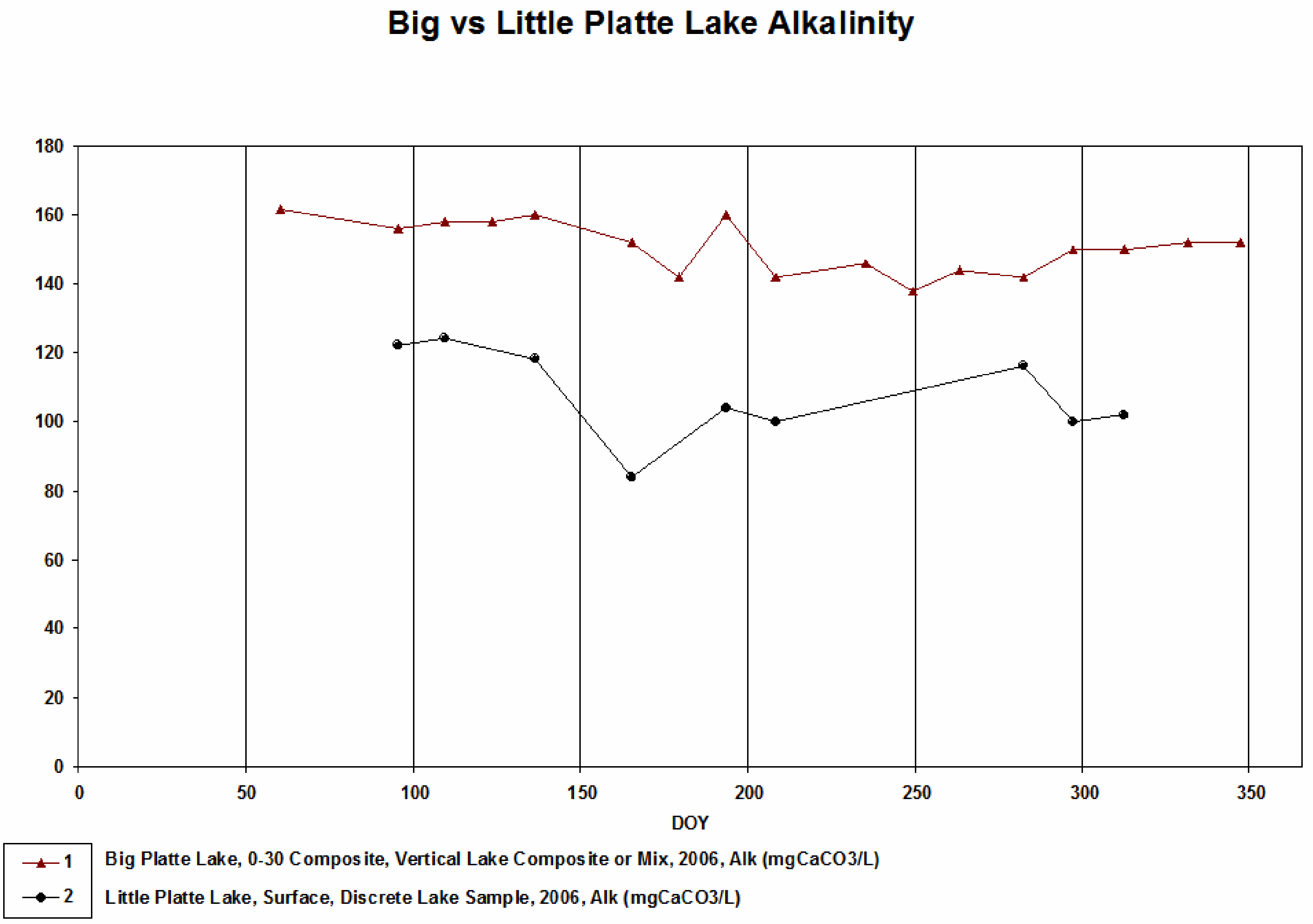

Big vs Little Platte Lake Alkalinity
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
DOY
1
Big Platte Lake, 0-30 Composite, Vertical Lake Composite or Mix, 2006, Alk (mgCaCO3/L)
2
Little Platte Lake, Surface, Discrete Lake Sample, 2006, Alk (mgCaCO3/L)

Figure 63.

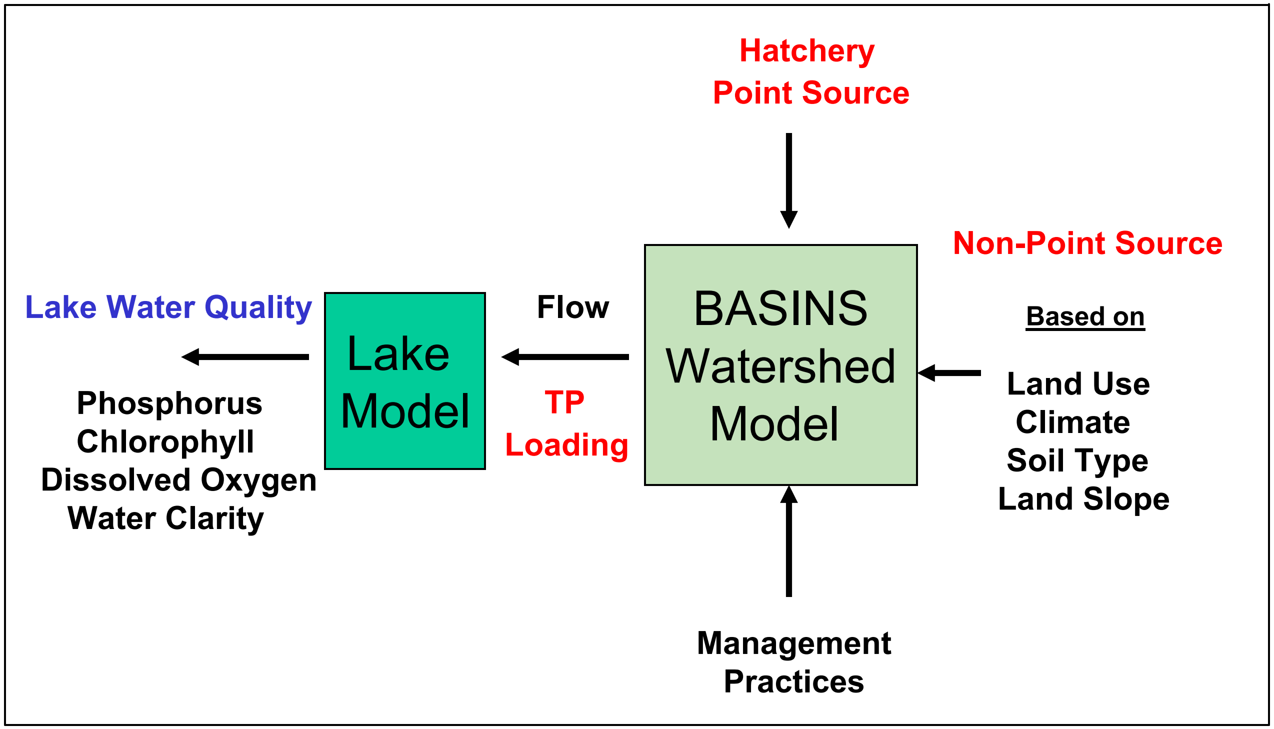


Figure 64. Components of BASINS and Lake Water Quality Model.

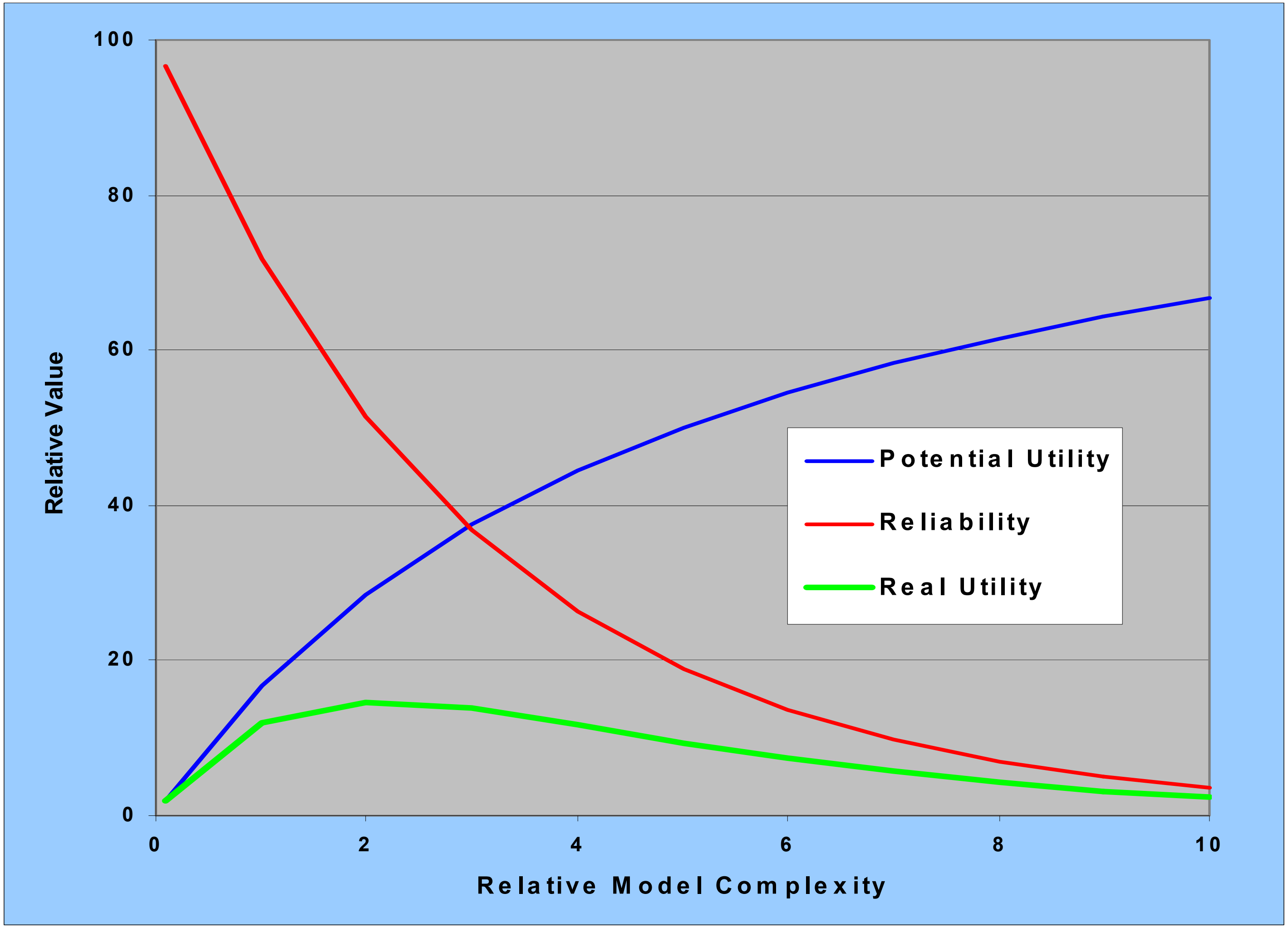
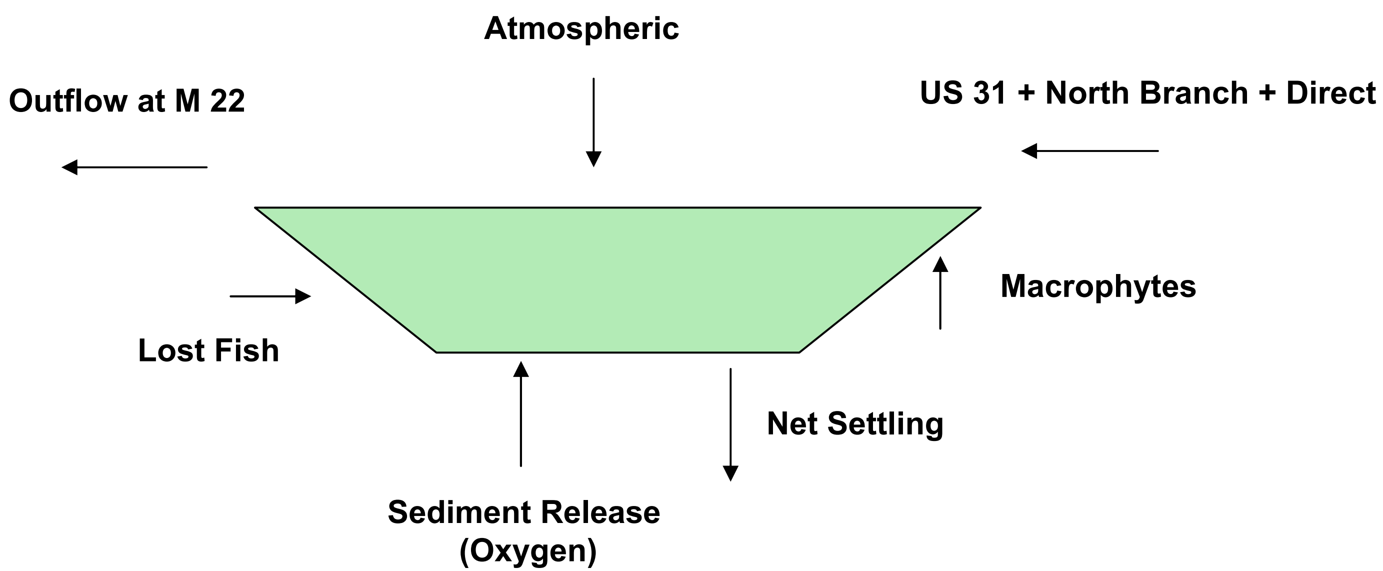


Figure 65. Relative Model Utility vs. Model Complexity.



W = Total Load = US31 + NB + Direct + Atmospheric + Sediment + Lost fish + Macrophytes

p = volume weighted annual average TP of lake

Q = average annual outflow at M22

A = bottom area of lake

v_s = apparent settling velocity (m/y)

At steady state IN = OUT $W = Q\,p + v_s\,A\,p$

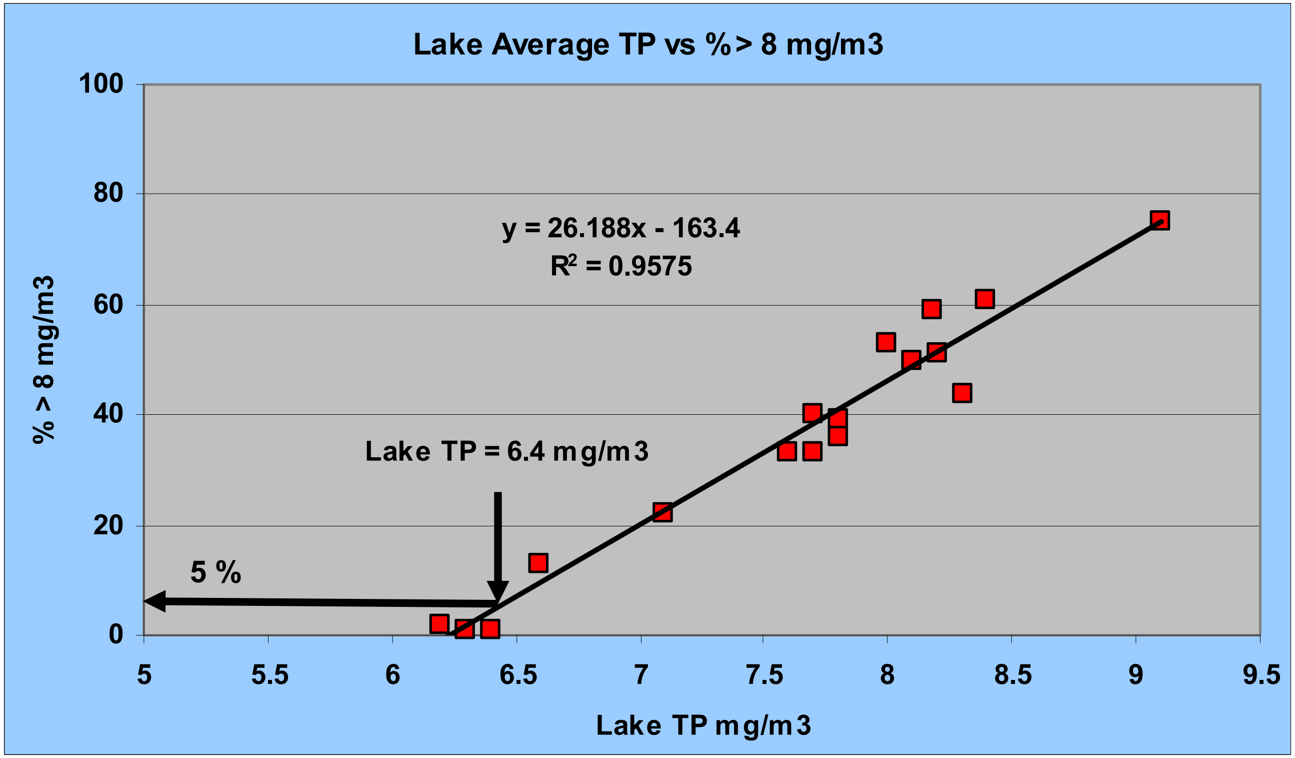
$$p = \frac{W}{(Q + v_s A)}$$

Figure 66.

	cfs Out Flow	lbs TP Hatchery	lbs TP USGS	lbs TP NB	lbs TP Direct	lbs TP Fish	lbs TP Sediment	lbs TP Macro	lbs TP Rain	measure mg/m3 Lake	vs m/yr	lbs Total
1990	131.1	755	5,398	589	522	361	153	85	227	9.1	24.3	7,335
1991	148.6	746	5,026	567	456	342	159	85	225	7.9	25.5	6,860
1992	170.8	708	5,960	735	615	7	239	85	238	8.3	27.2	7,880
1993	185.3	272	4,390	579	443	278	180	85	220	7.8	18.9	6,175
1994	172.2	188	3,857	522	408	239	217	85	200	7.9	16.0	5,528
1995	161.9	308	4,404	597	468	275	205	85	219	8.2	19.7	6,253
1996	166.2	251	4,410	612	486	243	200	85	215	7.2	24.0	6,251
1997	163.8	170	3,325	493	367	113	170	85	168	6.5	17.9	4,720
1998	144.3	190	3,408	509	397	32	225	85	219	6.3	21.7	4,874
1999	140.5	199	2,982	464	344	315	136	85	184	6.3	19.5	4,510
2000	124.4	203	2,729	437	326	203	175	85	173	6.5	17.3	4,129
2001	132.2	212	4,083	627	508	98	372	85	240	7.5	24.0	6,013
2002	166.3	206	4,826	695	567	55	170	85	168	8.4	20.4	6,566
2003	151.1	169	3,220	473	369	120	164	85	179	8.1	12.0	4,611
2004	160.9	158	3,915	577	444	84	169	85	227	7.1	20.3	5,500
2005	157.9	226	4,178	599	475	28	213	85	156	8.2	17.3	5,733
2006	143.5	122	4158	567	450	99	211	85	204	8.0	19.5	5,773
Average	154					170	198	85	204		20.3	

Grant	13.6
K&E	21.8
Walker	17.4
Lung	22.9
Chapra	20.5
Average	19.2

Figure 67.



Lake Average TP vs % > 8 mg/m3
y = 26.188x - 163.4
R^2 = 0.9575
Lake TP = 6.4 mg/m3
5 %
% > 8 mg/m3
100
80
60
40
20
0
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Lake TP mg/m3

Figure 68.

	(a)		(b)	(c)	(d)	(e)	
	Typical Scenerio		**Goal**	**Typical 2004**	**Low 2000**	**High 1992**	
Out Flow Rate	161	cfs	161	161	115	170	cfs
Upstream	2,033	Lbs		2,033	1,451	2,237	Lbs
Hatchery	175			175	175	175	
Lower Watershed	1,727			1,727	1,124	2,743	
North Branch	606			606	437	869	
Direct	468			468	325	717	
Lost Fish	170			170	170	170	
Sediment Release	198			198	198	198	
Macrophytes	85			85	85	85	
Atmospheric	204			204	204	204	
Total Phosphorus Load	5,666	Lbs	4997	5,666	4,169	7,398	Lbs
Exceeds Goal by	669	Lbs		669	-828	2,401	Lbs
Lake Phosphorus	7.3	mg/m3	6.4	7.3	6.1	9.3	mg/m3
Percent < 8 mg/m3	72	%	95	72	100	19	%

Figure 69.

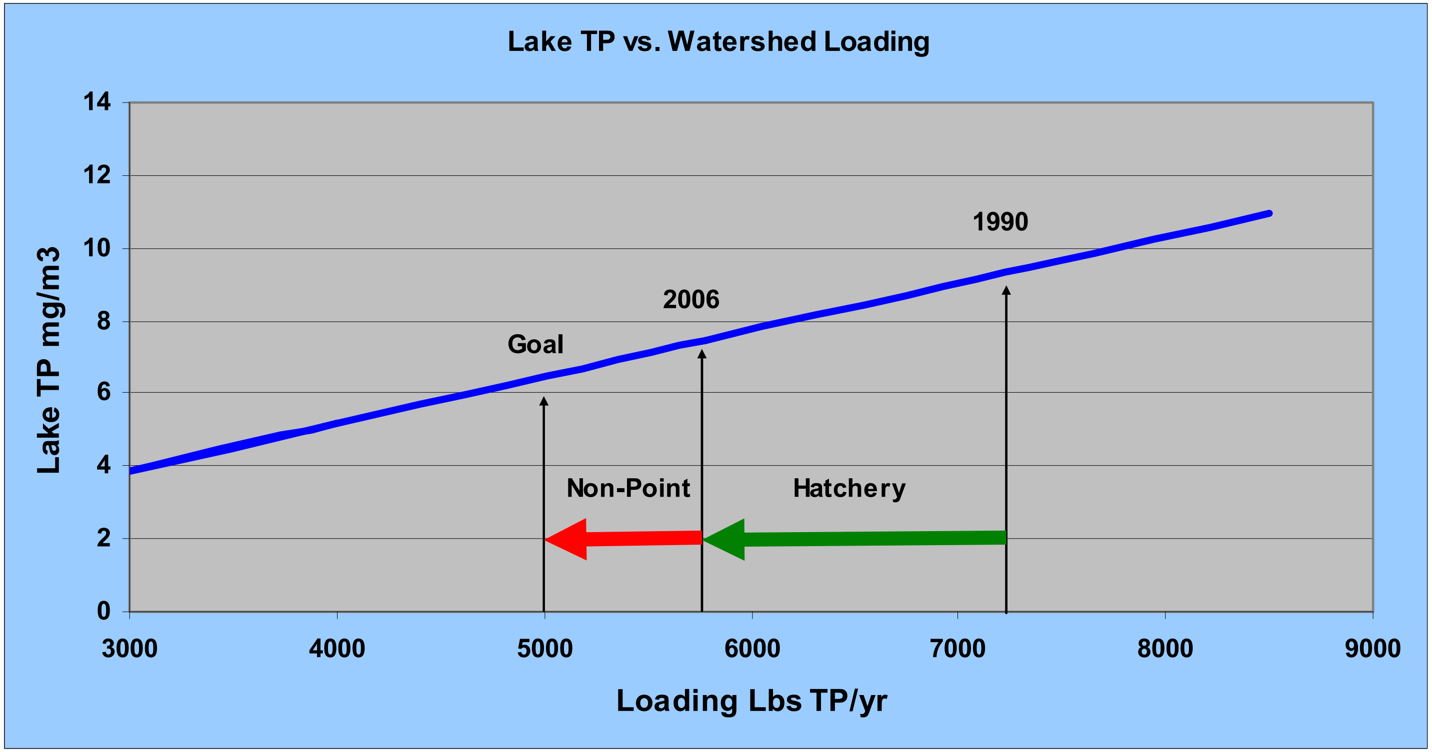

Lake TP vs. Watershed Loading
Lake TP mg/m3
14
12
10
8
6
4
2
0
3000
4000
5000
6000
7000
8000
9000
Loading Lbs TP/yr
1990
2006
Goal
Non-Point
Hatchery

Figure 70.

PLATTE RIVER WATERSHED MODEL - Subwatershed Editor

NB02: North Branch Platte River (Little Platte Lake)

Baseline Loading Condition: Typical (2004)

		Base	Change	New Area	New Load before BMPs	BMP Acres	Removal Efficiency	Mass Removed
Total Load	(lb P/yr)	**314.6**	**0.0**		**314.6**			**0.0**
Land Use								
Forest	(acres)	2358.0		2358.0	84.4			0.0
Barren	(acres)	0.0		0.0	0.0			0.0
Orchards	(acres)	109.0		109.0	5.9			0.0
Pasture	(acres)	414.0		414.0	29.2			0.0
Cropland	(acres)	160.0		160.0	12.6			0.0
LD Residential	(acres)	161.0		161.0	35.2			0.0
Commercial	(acres)	8.0		8.0	5.5			0.0
Wetland	(acres)	70.0		70.0	2.7			0.0
Feed Operation	(acres)	0.0		0.0	0.0			0.0
Non-Point Loads	(lb P/yr)	**175.6**			**175.6**			
Point Sources	(lb P/yr)	**139.0**			**139.0**			
Upstream Load	(lb P/yr)	0.0			0.0			

Scenario 01 Title *Baseline*

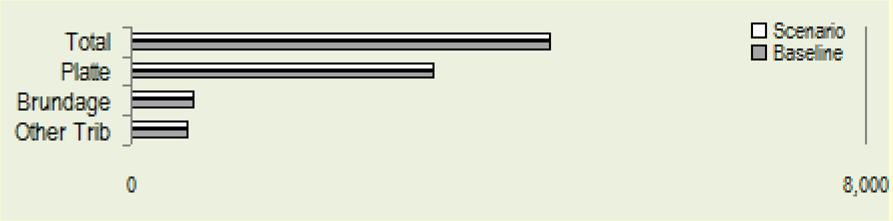
Baseline scenario

Load Scenario | Save Scenario

Export Daily TP Loads | Go To Lake

Figure 71.

PLATTE RIVER WATERSHED MODEL - Load Summary



	Scenario (lb P/yr)	Change	Base (lb P/yr)
00 Upstream to Fewins Rd.	2,033		2,033
01 Fewins Rd. to Brundage Ck.	27		27
02 Brundage Ck. to Vets Park	329		329
03 Vets Park to Carter Ck.	206		206
04 Carter Ck. to Collison Ck.	92		92
05 Collison Ck. to USGS Gage	127		127
06 USGS Gage to lake + direct	468		468
Platte River (upstream+direct)	**3,282**		3,282
01 Kinney Creek	101		101
02 Kinney Creek (to Brundage Ck.)	29		29
03 Brundage Creek (to Kinney Ck.)	136		136
04 Brundage Creek (Kinney to Stanley)	12		12
05 Stanley Creek	363		363
06 Brundage Creek (Stanley Ck. to PR)	28		28
Brundage Creek	**669**		669
01 Carter Creek (upstream)	127		127
02 Carter Creek (to Platte R.)	152		152
Carter Creek	**279**		279
01 Collison Creek (upstream)	112		112
02 Collison Creek (to Platte R.)	61		61
Collison Creek	**173**		173
01 North Branch Platte River (upstream)	291		291
02 North Branch Platte River (LPL)	315		315
North Branch Platte River	**606**		606
	Scenario-Typical	Change	Base-Typical
Total Phosphorus Load	**5,009**		**5,009**

Figure 72.

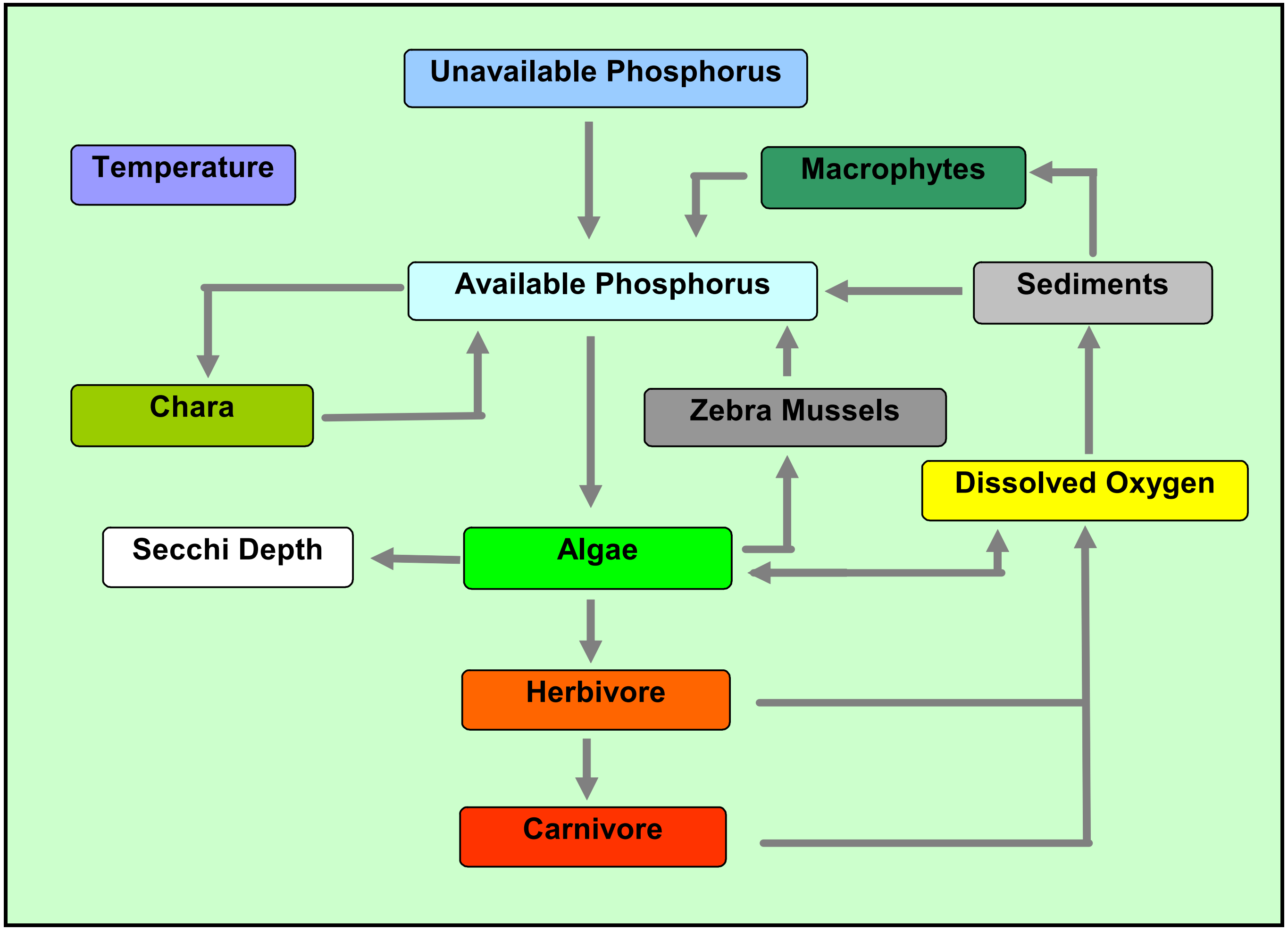


Figure 73. Kinetic Components of Lake Water Quality Model.

Advantages of One-Parameter Model:

One model coefficient (apparent settling velocity) estimated using extensive data
Simple to understand and apply. Easy to defend.

Limitations:

Cannot distinguish between warm and cold years
Does not account for vertical gradients
Does not increase v_s when sediment release of TP decreases
Does not decrease Sediment Oxygen Demand when TP loads decrease
Does not predict changes dissolved oxygen
Does not predict changes in water clarity (the most difficult modeling task)
Does not provide insight into seasonal changes in water quality
Does not explicitly include the effects of macrophytes, Chara, zebra mussels, etc

Does not account for bio-availability of different phosphorus sources Special Study

Figure 74. Comparison of One – Parameter vs. Ecosystem Model.

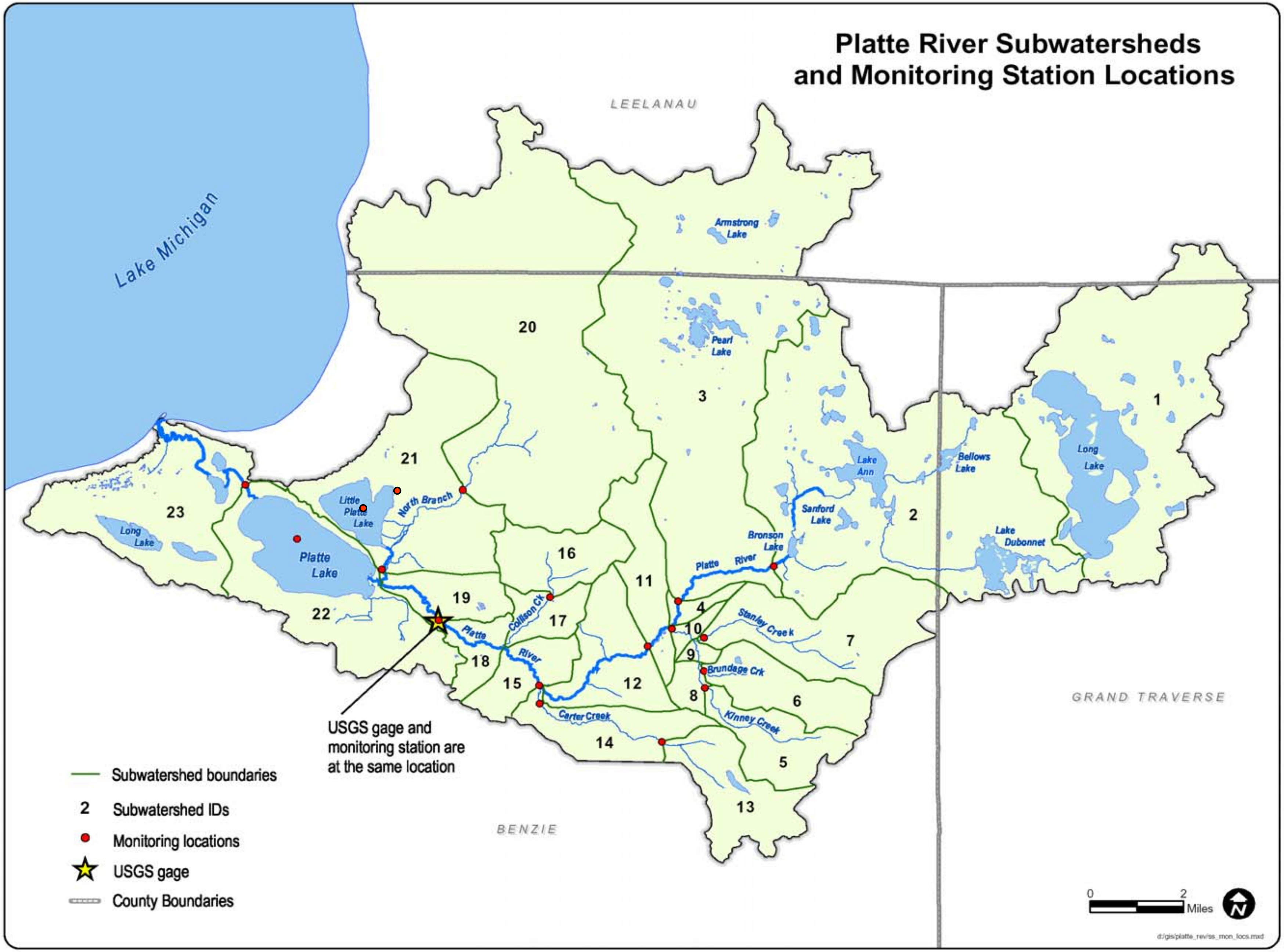
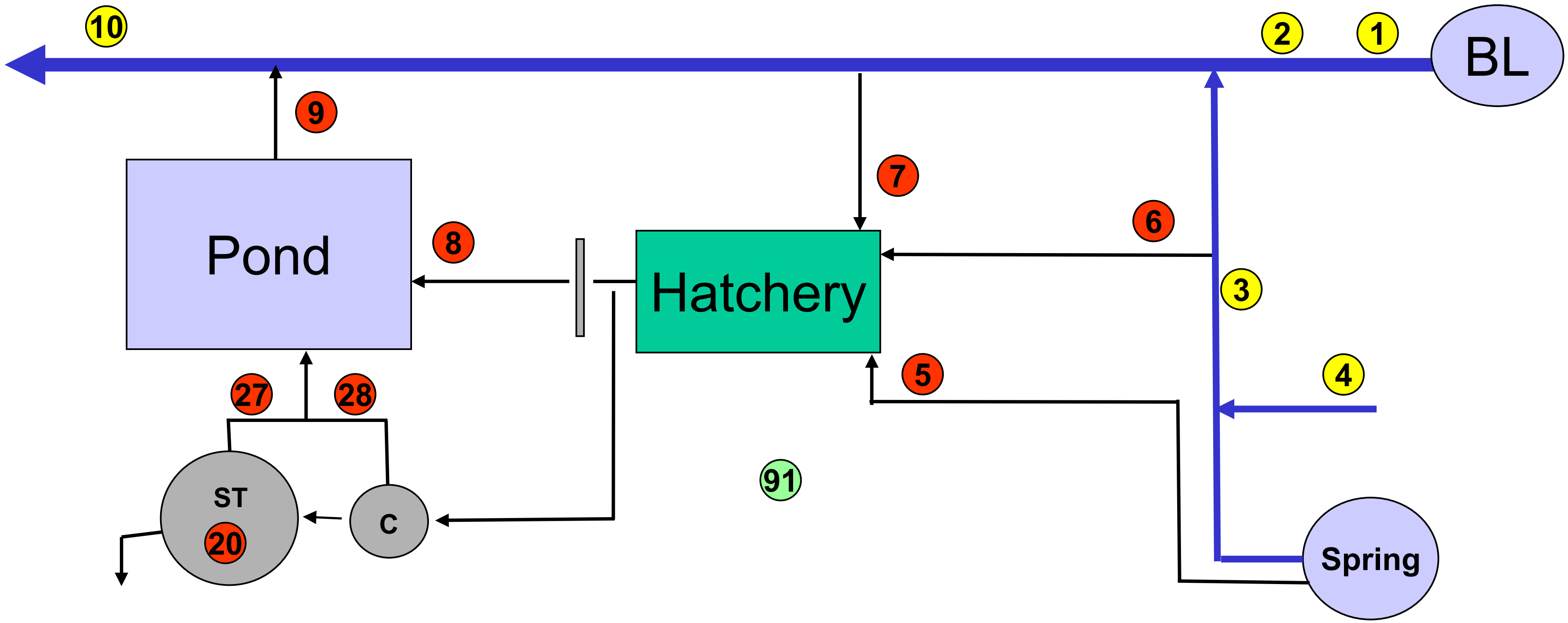
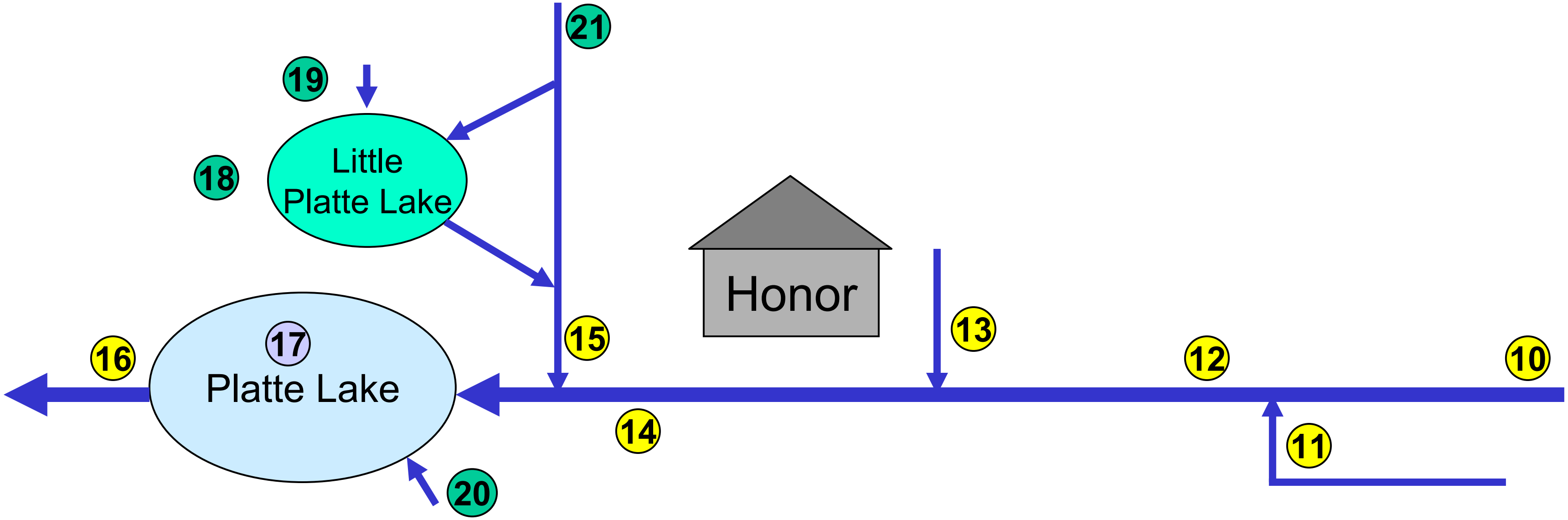


Figure 75. Platte River Sub-Watersheds and Monitoring Locations.



1 Platte River at Fewins Rd
2 Platte River at Stone Bridge
3 Brundage Cr at Old Residence
4 Stanley Creek
5 B. Spring to Hatchery
20 Solids Retention Tank
27 Input to pond from Tank
28 Input to pond from Clarifier
6 B. Creek to Hatchery
7 Platte River to Hatchery
8 Inlet to Pond after Screens
9 Pond Outlet
10 Platte River at Vets Park
91 Weather Station

Figure 76. Hatchery and Upstream Sampling Stations



10	Platte River at Vets Park	14	Platte River at USGS
11	Carter Creek at mouth	15	North Branch at Deadstream
12	Platte River at Pioneer Rd	16	Lake Outlet at M - 22
13	Collison Creek	17	Platte Lake at Center
18	Little Platte Lake	19	Featherstone Creek
21	North Branch at Hooker	20	Tamarack Creek

Figure 77. Lake and Lower Tributary Sampling Stations for 2005.

	BPL Dates	BPL Depths	BPL Reps	LPL Dates	LPL Depths	LPL Reps	Sub-Total
Alkalinity	20	1	1	20	1	1	40
Calcium	20	1	1	20	1	1	40
TDS	20	1	1	20	1	1	40
TP	20	10	3	20	1	3	660
TDP	20	2	3	20	1	3	180
mg P/mg DW	5	1	3	5	1	3	30
% water	5	1	3	5	1	3	30
NO2 + NO2	20	2	3	20	1	3	180
TN	20	2	3	20	1	3	180
Chlorophyll	20	2	3	20	1	3	180
Phytoplankton	20	1	3	20	1	3	120
Zooplankton	20	1	3	0	0	0	60

	Estimated 2007	CMU 2006
Alkalinity	40	40
Calcium	40	40
TDS	40	40
TP	3462	4400
mg P/mg DW	102	80
% water	102	80
NO2 + NO2	570	200
TN	180	0
Chlorophyll	180	350
Phytoplankton	120	175
Zooplankton	60	75

	Trib AS Dates	Trib AS Sites	Trib AS Reps	Trib JH Dates	Trib JH Sites	Trib JH Reps	
TP	20	6	3	10	3	3	450
NO2 + NO2	20	6	3	0	0	0	360

	Storm Dates	Storm Sites	Storm Reps	Rain Dates	Rain Sites	Rain Reps	
TP	12	1	6	10	1	3	102
NO2 + NO2	0	0	0	10	1	3	30

	H Dates	H Sites	H Reps	Tank Dates	Tank Sites	Tank Reps	
TP	100	6	3	1	30	9	2070
mg P/mg DW	12	2	3	0	0	0	72
% water	12	2	3	0	0	0	72

Figure 78. Stations, Sampling Frequency, and Measured Parameters.

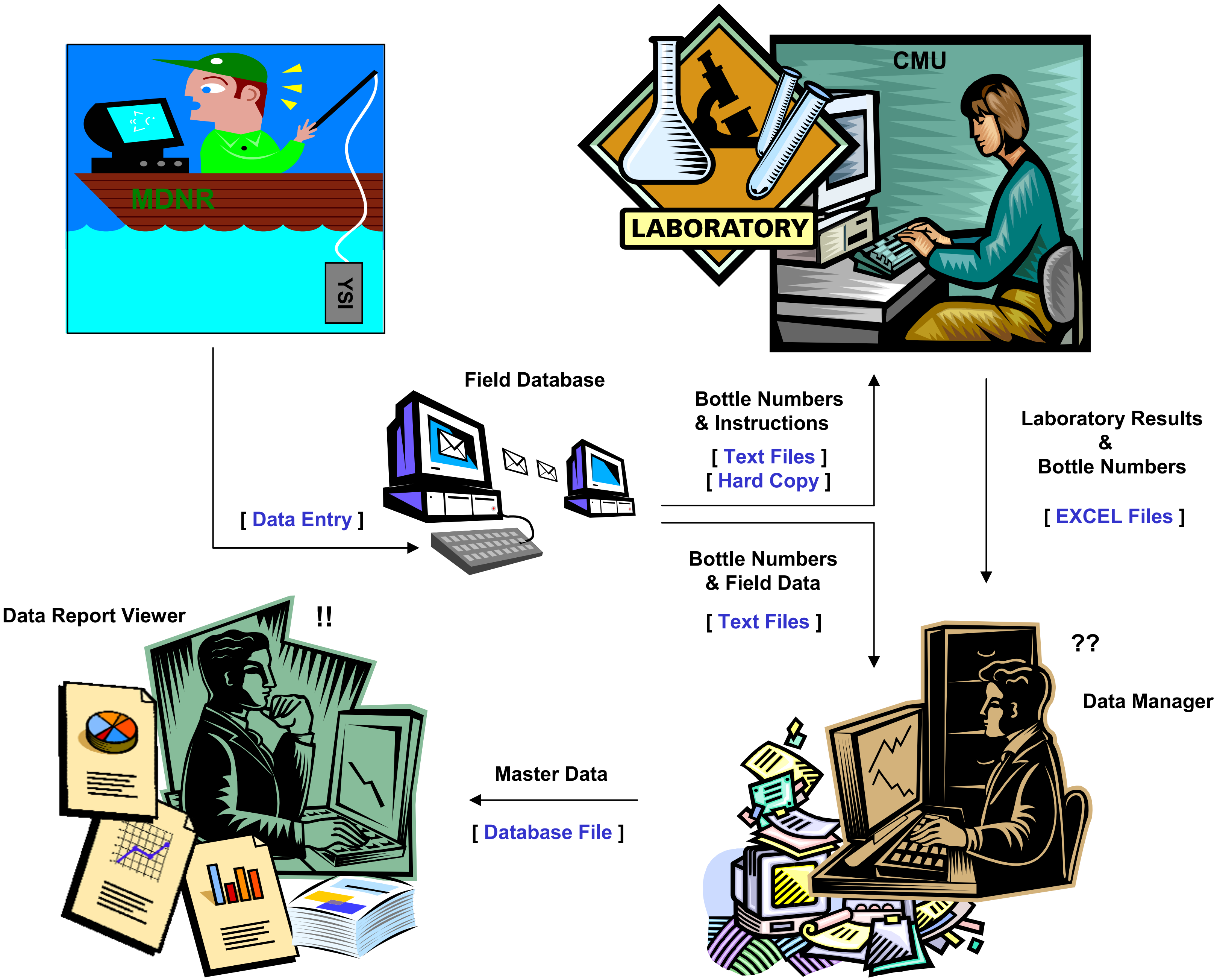


Figure 79. Database Components and Information Flow.