Overview for 2008

Annual Loading = 174.8 vs. 175 lbs limit (JN)

3 Month Loading = 60.8 (Apr) and 55.8 (May) lbs vs. 55 lbs limit

Hatchery Flow = 6.24 vs. 20 mgd limit

5,029 passed vs. 20,000 Adult Coho limit

181 passed vs. 1,000 Adult Chinook limit

Lake TP Concentration: 7.7 mg/m^3 volume - weighted

63% vs. 95% compliance with 8 mg/m^3 goal

Annual Average Hatchery P Mass Balance methodology has been completed.

Hatchery Bio-Energetic, Process & Feeding Model – development & calibration underway.

JN and Sigma sampling sites consolidated.

Watershed P and Flow Mass Balance have been refined & completed.

Long-term model for phosphorus in water and sediments completed for Lake.

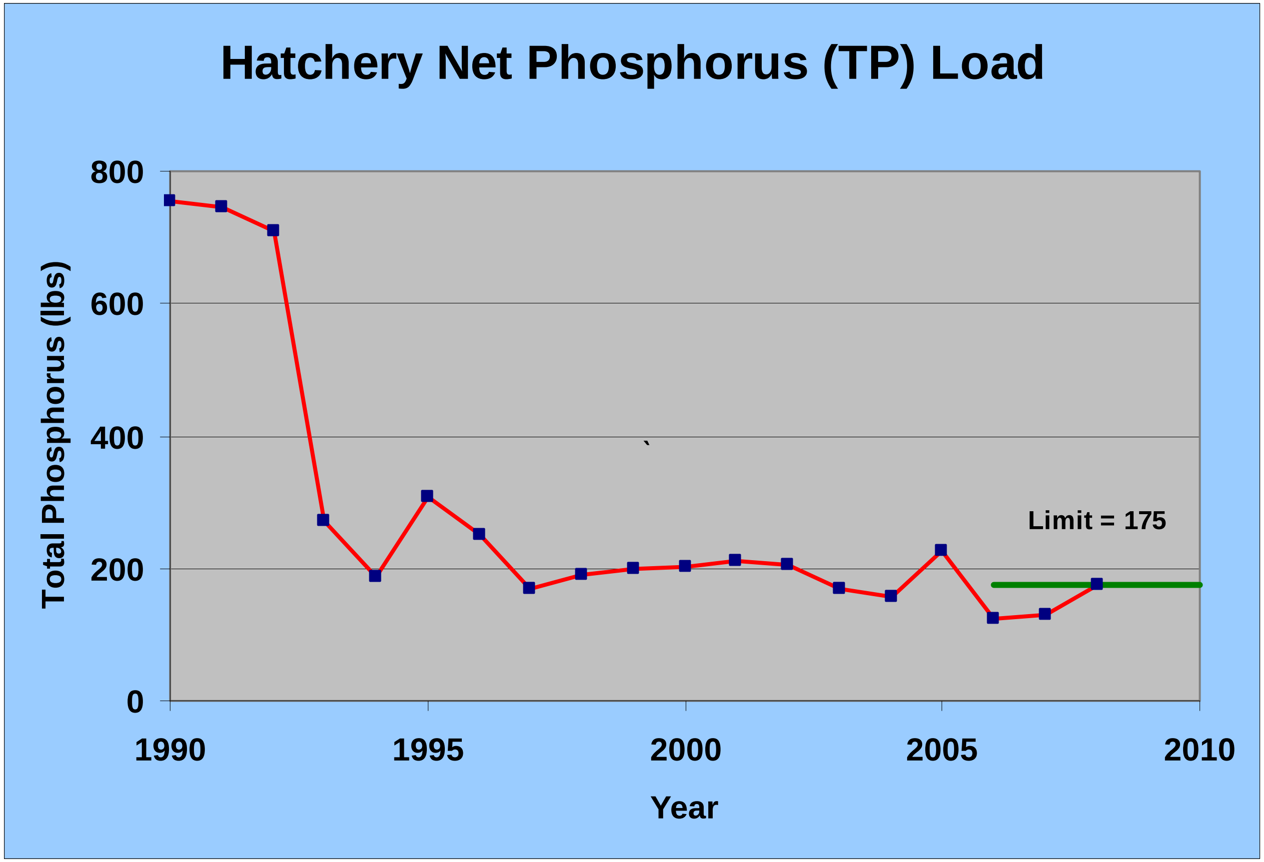
TMDL manuscript completed and submitted to ASCE for peer review

Special Studies: Bio-availability study report preparation underway.

CMU billing and NPDES reporting connected to database.

Database documentation meeting scheduled for summer 2009.

Figure 1. Overview of 2008 Annual Report.

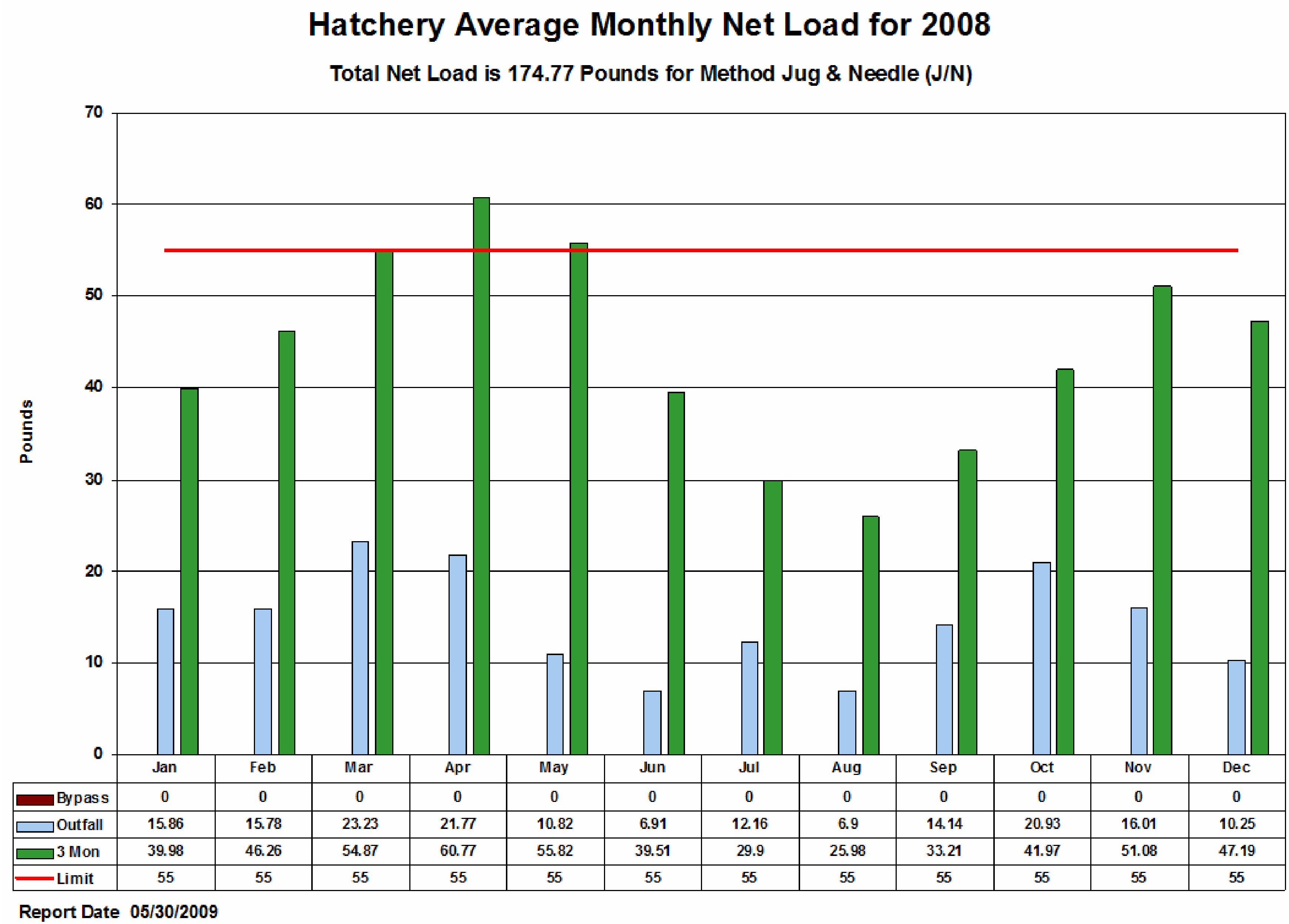


Why worry as long as the load is below 175 Lbs/Yr?

What factors cause load to go up like 2005 & 2008?
Why 3 Month violations for the past 3 years?
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. Hatchery phosphorus loading changes over time.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bypass	0	0	0	0	0	0	0	0	0	0	0	0
Outfall	15.86	15.78	23.23	21.77	10.82	6.91	12.16	6.9	14.14	20.93	16.01	10.25
3 Mon	39.98	46.26	54.87	60.77	55.82	39.51	29.9	25.98	33.21	41.97	51.08	47.19
Limit	55	55	55	55	55	55	55	55	55	55	55	55

Figure 3. Hatchery monthly phosphorus loads.

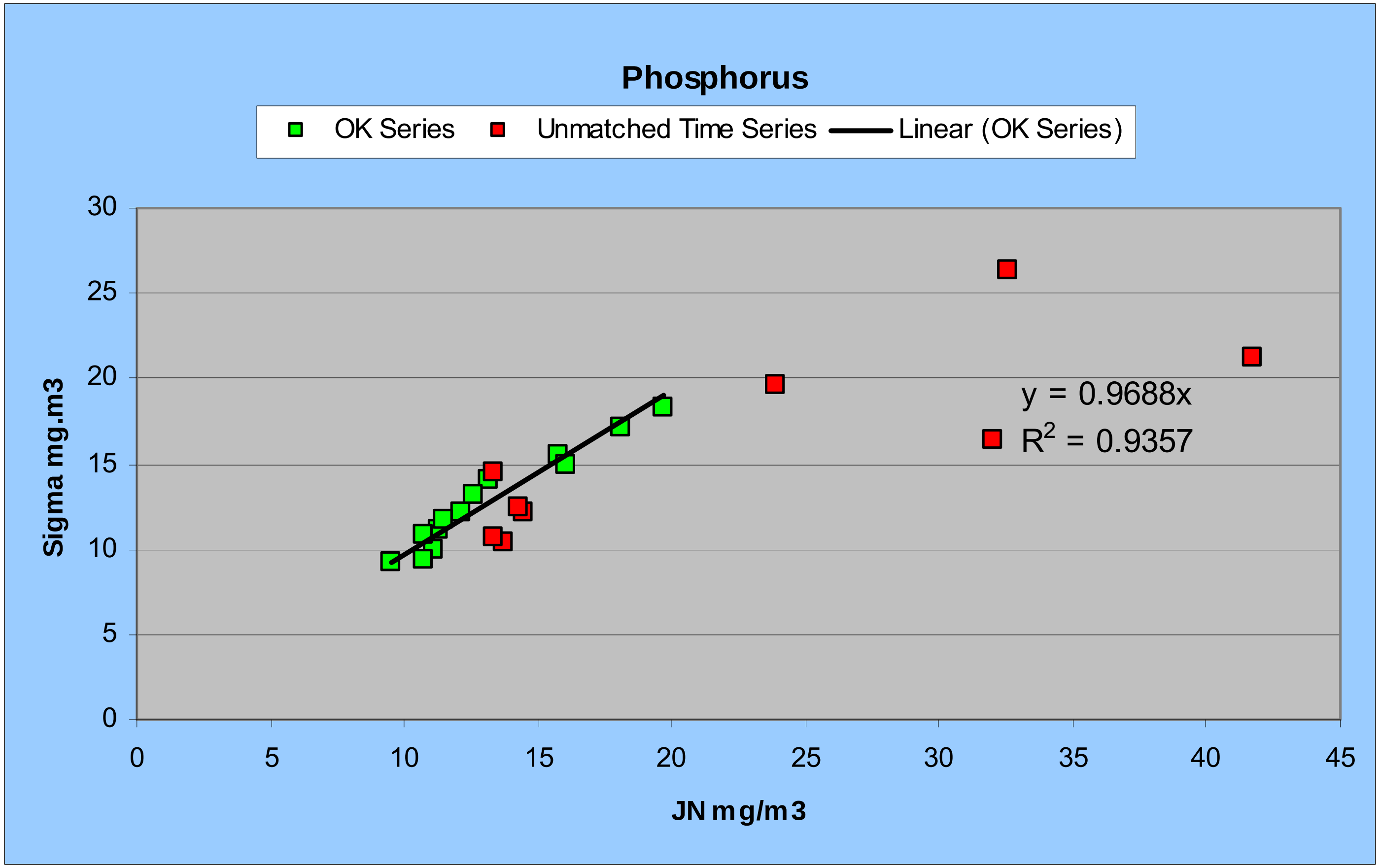


Figure 4. Phosphorus using JN vs Sigma equipment for Brundage Spring site.

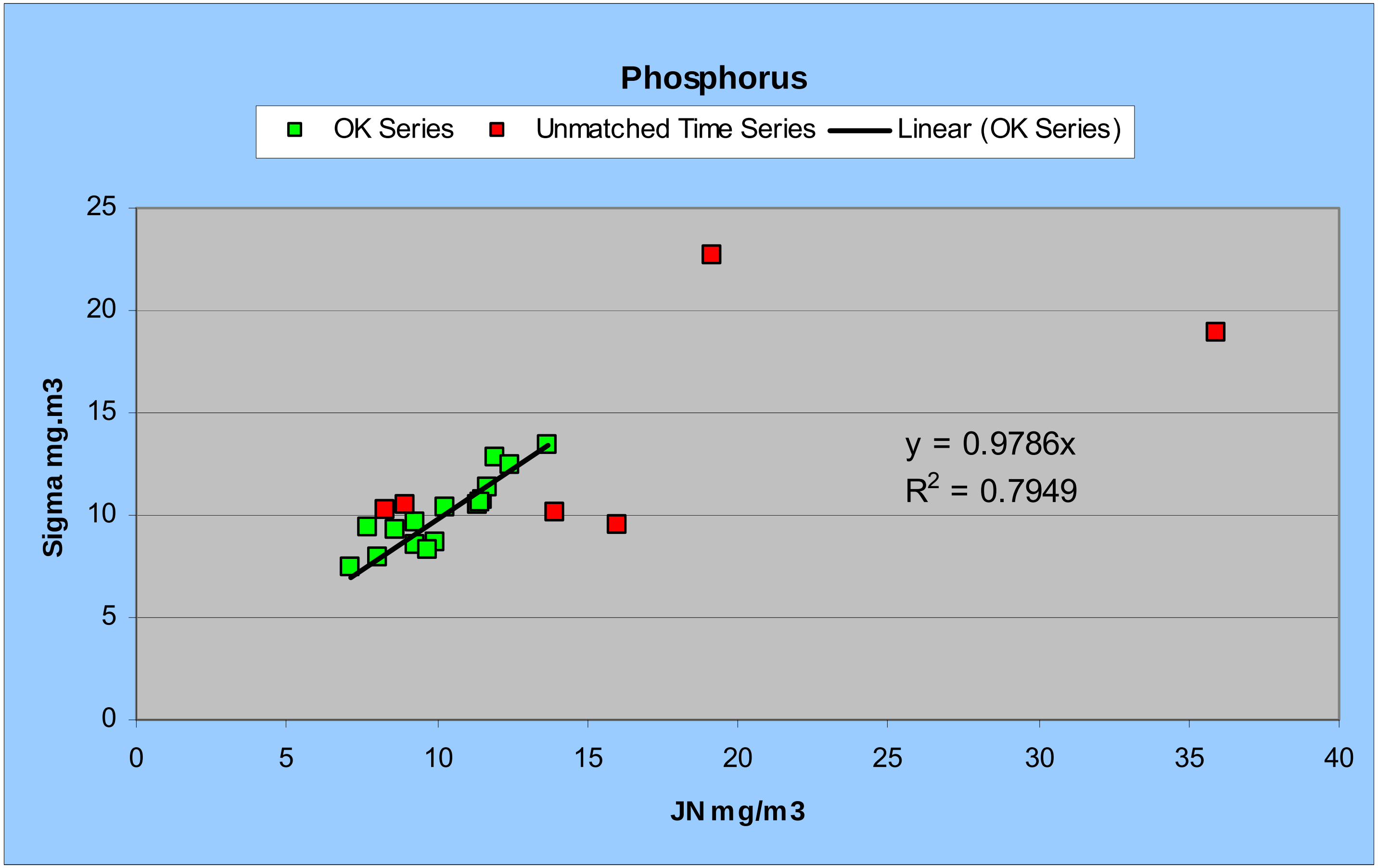


Figure 5. Phosphorus using JN vs Sigma equipment for Brundage Creek site.

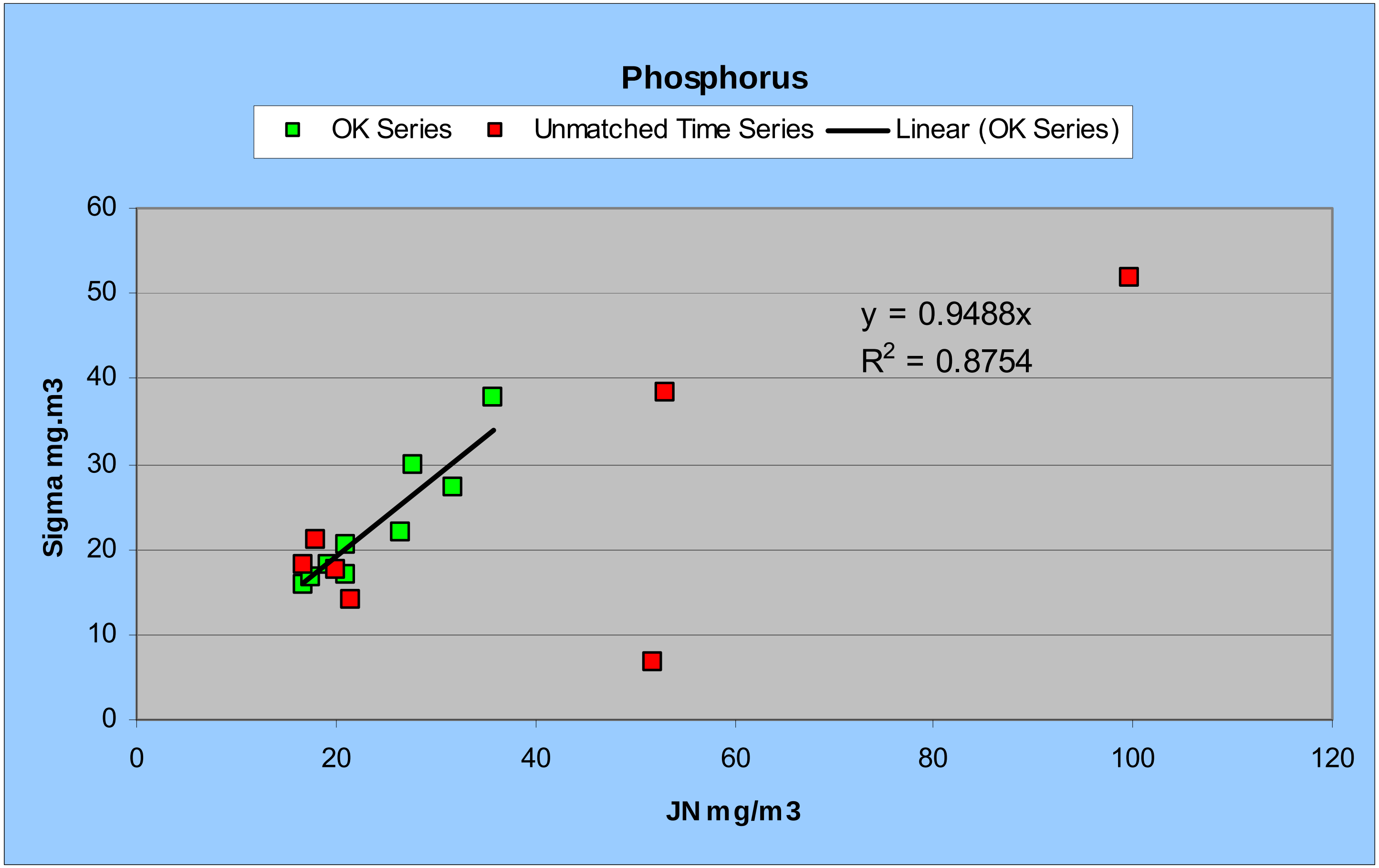


Figure 6. Phosphorus using JN vs Sigma equipment for Pond Inlet site.

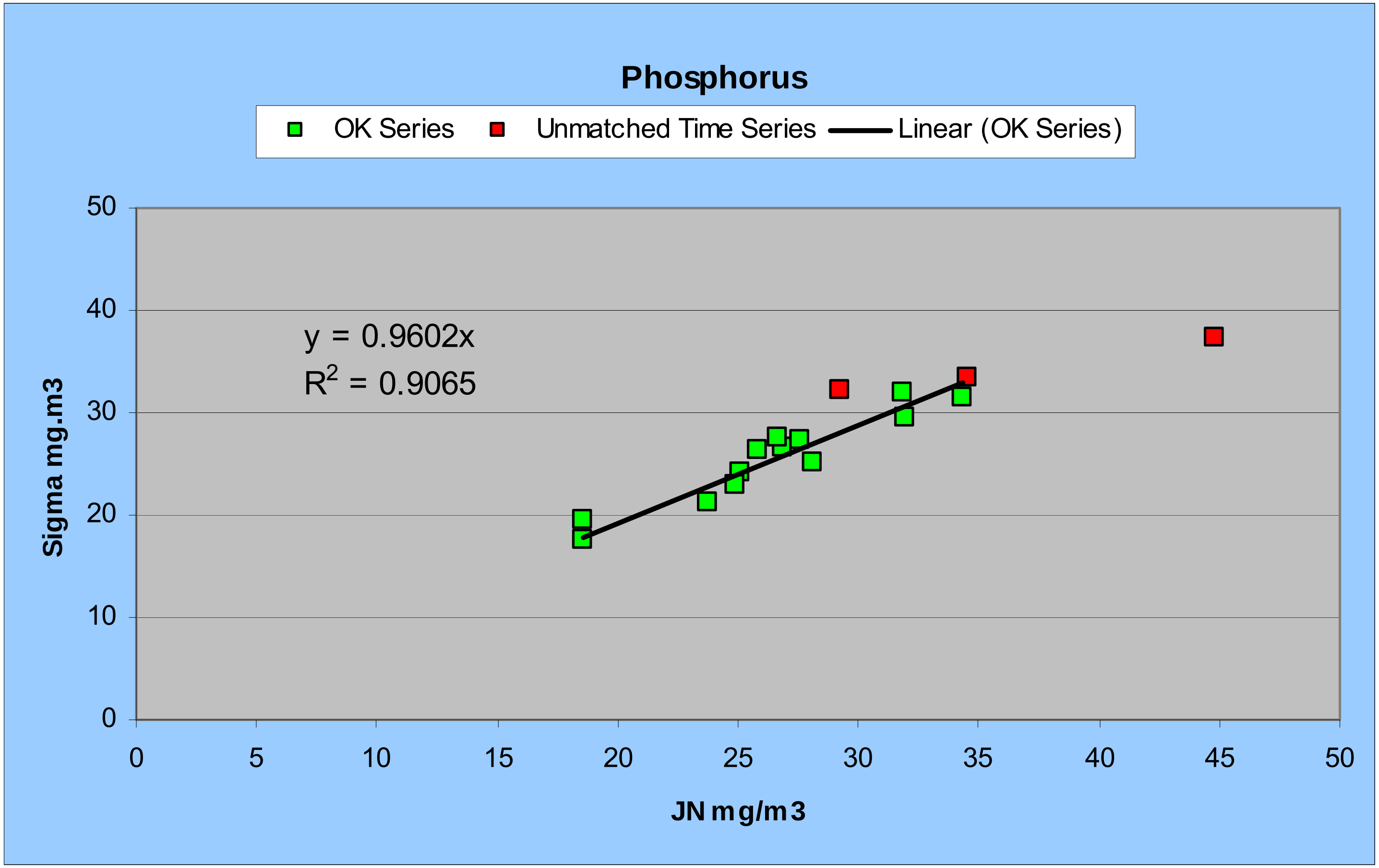


Figure 7. Phosphorus using JN vs Sigma equipment for Upper Discharge site.

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

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

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

Tank Retention = Trucked + Tank End – Tank Start

Pond Retention = Inputs to Pond from Screens, Clarifier, and Tank overflows - Discharge

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

Net Load = Food – Production – Tank Retention – Pond Retention

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

Figure 8. Definition of terms in Mass Balance Equation.

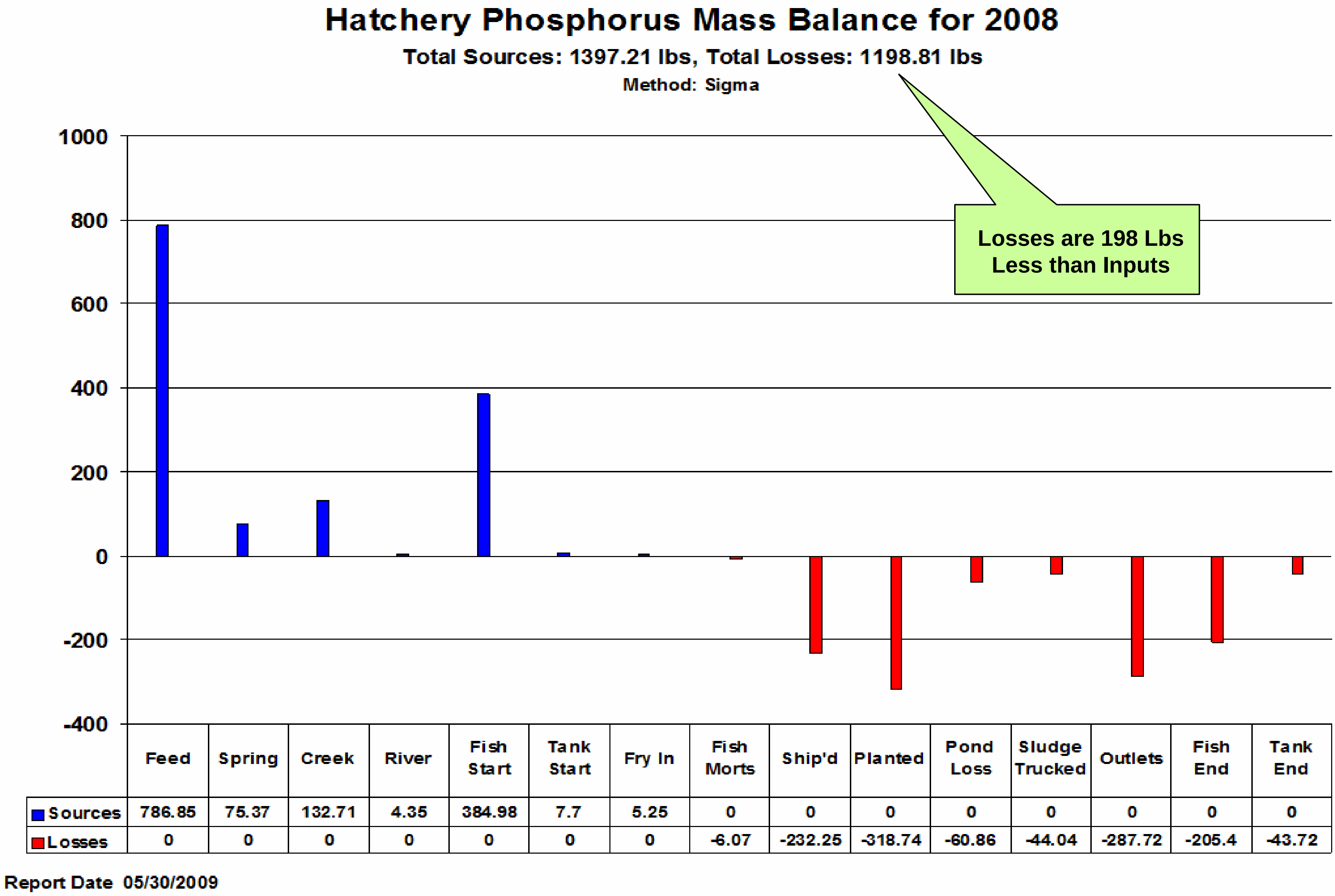


Figure 9. Hatchery Mass Balance for 2008 (Sigma).

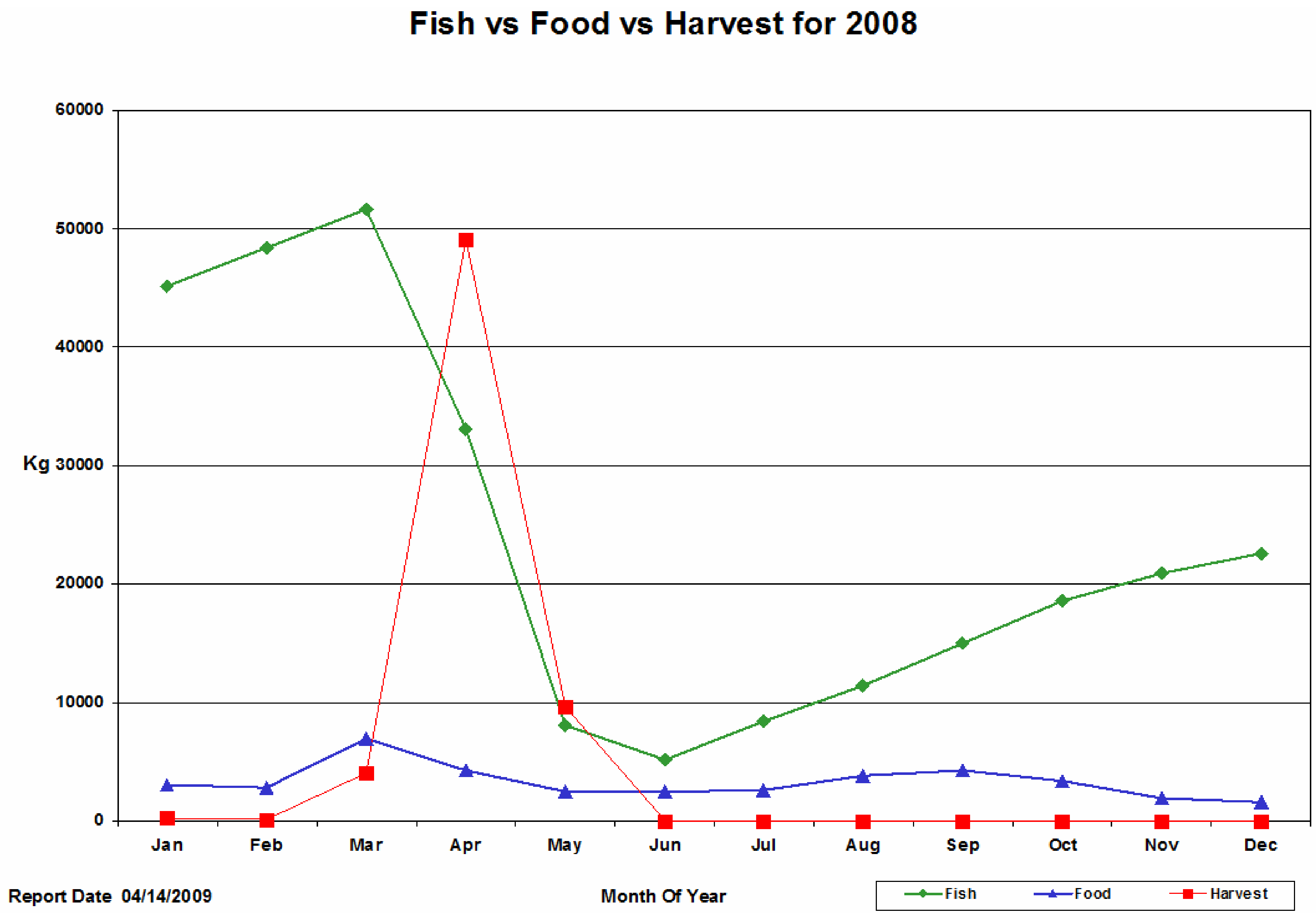


Figure 10. Month data for fish, food, and harvest for 2008.

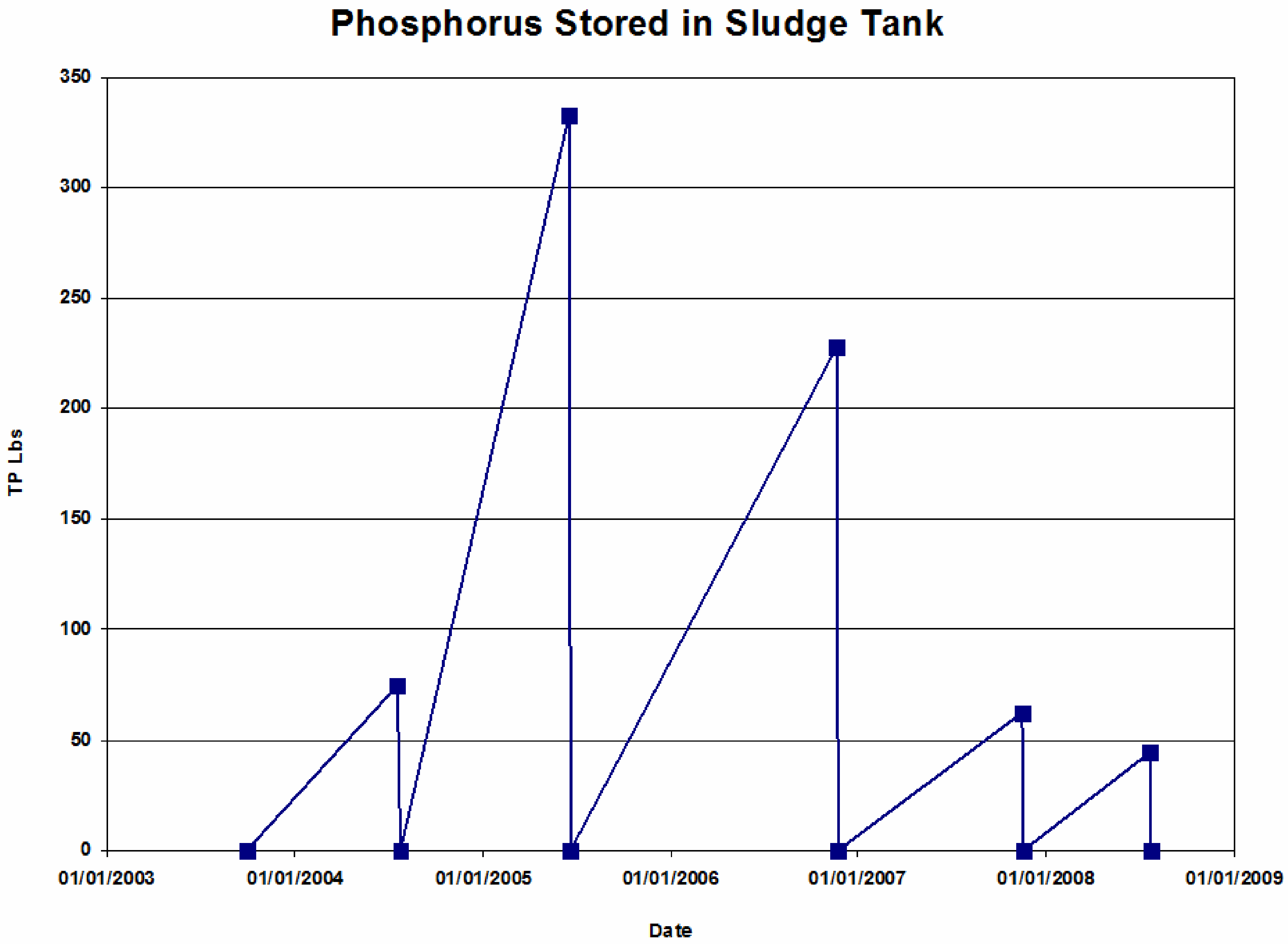


Figure 11. Sludge Tank Trucking Events

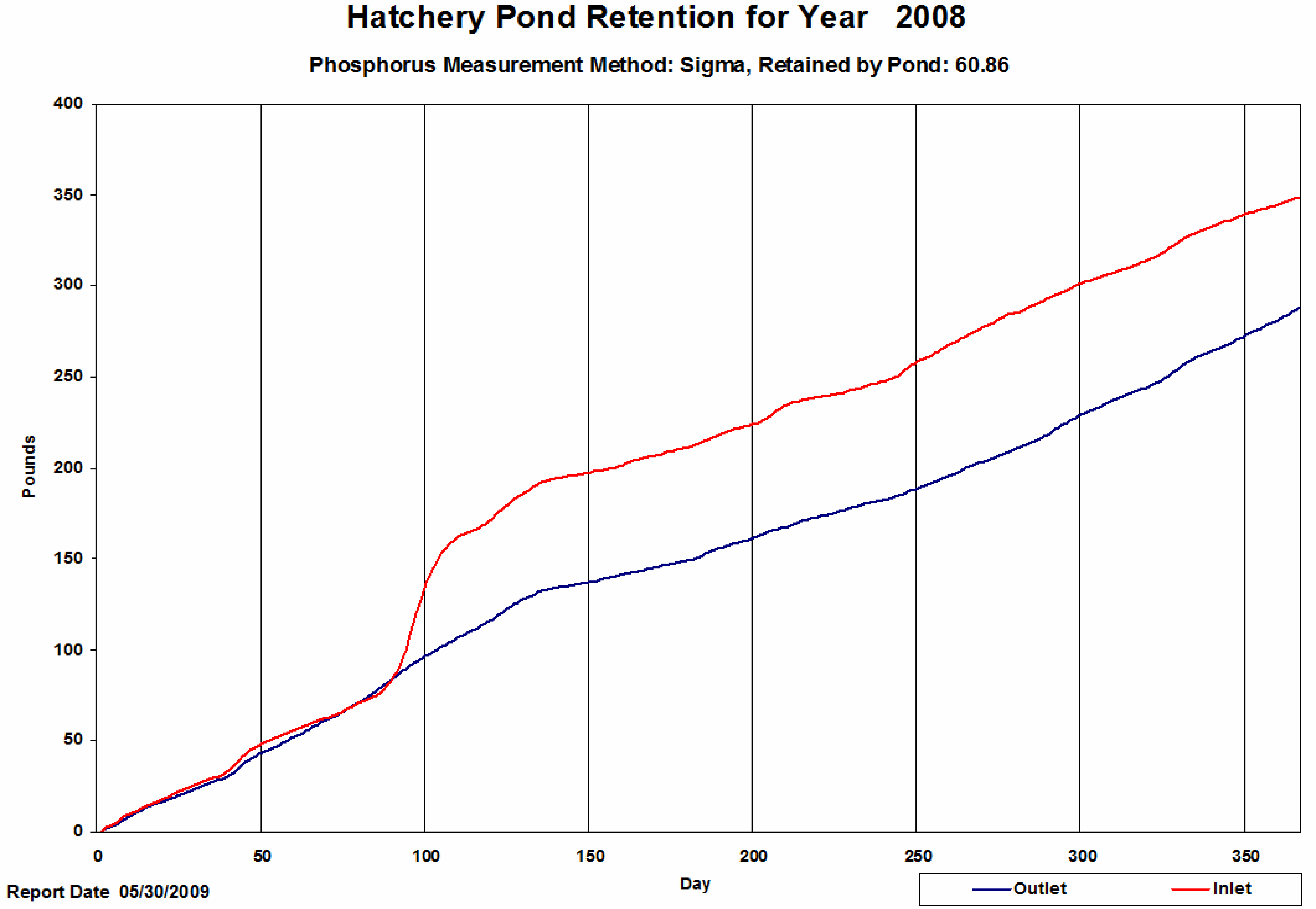


Figure 12. Pond retention data for 2008.

Measured Out - In	Food - Σ Out	Food In	Production	Tank Retention	Pond Retention	Year	Method
210	619	1272	617	0	37	2001	JN
206	431	1019	563	0	25	2002	JN
171	238	704	358	24	85	2003	JN
100	127	704	358	24	195	2003	Sigma
161	134	1071	624	214	99	2004	JN
135	185	1071	624	214	47	2004	Sigma
231	199	993	540	255	-1	2005	JN
201	253	993	540	255	-55	2005	Sigma
127	235	963	525	150	53	2006	JN
100	284	963	525	150	4	2006	Sigma
130	298	1016	552	63	102	2007	JN
104	115	1016	552	63	285	2007	Sigma
175	345	787	372	65	5	2008	JN
103	289	787	372	65	61	2008	Sigma

Annual Totals in Lbs P

Typically the Measured Load is 100 to 200 Lbs P LOWER than what is expected based on Production Activities and Facility Operations

Net Load Determined by Direct Measurement

Net Load Expected if Measurements of Food, Production, Tank, and Pond are accurate

If we knew for sure that Pond was ineffective, Maybe we could by-pass or dredge. If we knew for sure that the Trucked P is going down, maybe we could maintain the filters better. If we knew for sure that we are using “excess” food, maybe we could cut back without affecting Production.

Figure 13. Hatchery phosphorus mass balance for various years.

$\boxed{\text{Net Load = Food – Production – Tank Retention – Pond Retention}}$

Net Load	Fish Rearing Activities	Plant Operations

Typical Operation:

Assume Fish Inventory at the End = Start
Tank Contents at the End = Start

Food Use = 50,000 KG @ 0.9 % P = 990 Lbs P (conversion Ratio = 1.0)
Production = 50,000 KG @ 0.4 % P = 440 Lbs P

= 550 Lbs Excess
= - 175 Limit
= $\boxed{\text{375 Lbs}}$

What can be done to eliminate the 375 Lbs ??? (Note it must be eliminated to meet Agreement)

1. Reduce the Conversion Ratio = Food Applied/Fish Produced
2. Reduce fish production.
3. Increase Screen Efficiency so that more P can be removed from the tank by truck.
4. Increase P removal in pond, and eventually remove from the Hatchery by dredging.

Figure 14. Mass balance expressed in operational terms.

MDNR Biomass Predictor Model

$\boxed{\text{New weight} = (\text{last weight} - \text{mortality weight}) + (\text{food fed quantity} / \text{conversion ratio})}$

Coho Conversion Ratio = 1.1
Chinook Conversion Ratio = 0.95

Example (March 2009)

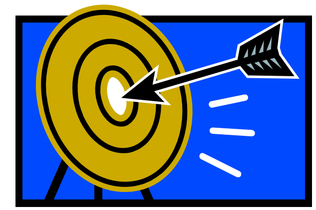
Old Fish = 28,664 KG
New Fish = 34,089 KG

Food = 4759 KG @ 0.94%P

Mort = 90.8 KG

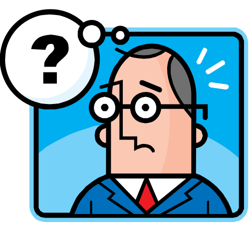
New Weight = 28,664 – 90.8 + 4759/1.1 = 32,900 KG

Works Pretty Well !!!!



However:

4,759 KG of Fish Food contains = 4,759(0.0094) = 44.7 KG or 98.3 Lbs of P
4,759 KG of New Fish Biomass contains = 4,759(0.004) = 19.0 KG or 41.9 Lbs of P



What happens to the other 25.7 KG or 56.4 Lbs of P ???? (compare to limit)

What would happen to the Conversion Ratio and Production if the % P of the Food went up or down ??
What would happen to the Conversion Ratio and Production if the Temperature was lower or higher ??

What would happen if 4,759 KG of Food was fed to 4,759 KG of Fish ?? Would the Fish really Double ??

Suppose the 4,759 KG of Food was supplied in 1 week instead of 1 month, would the same increase be attained??

Can we generalize the DNR model using what we know about Bio-Energetics
along with insights and experiences of the staff to obtain quantitative answers to these questions?

Figure 15. Discussion of MDNR biomass predictor model.

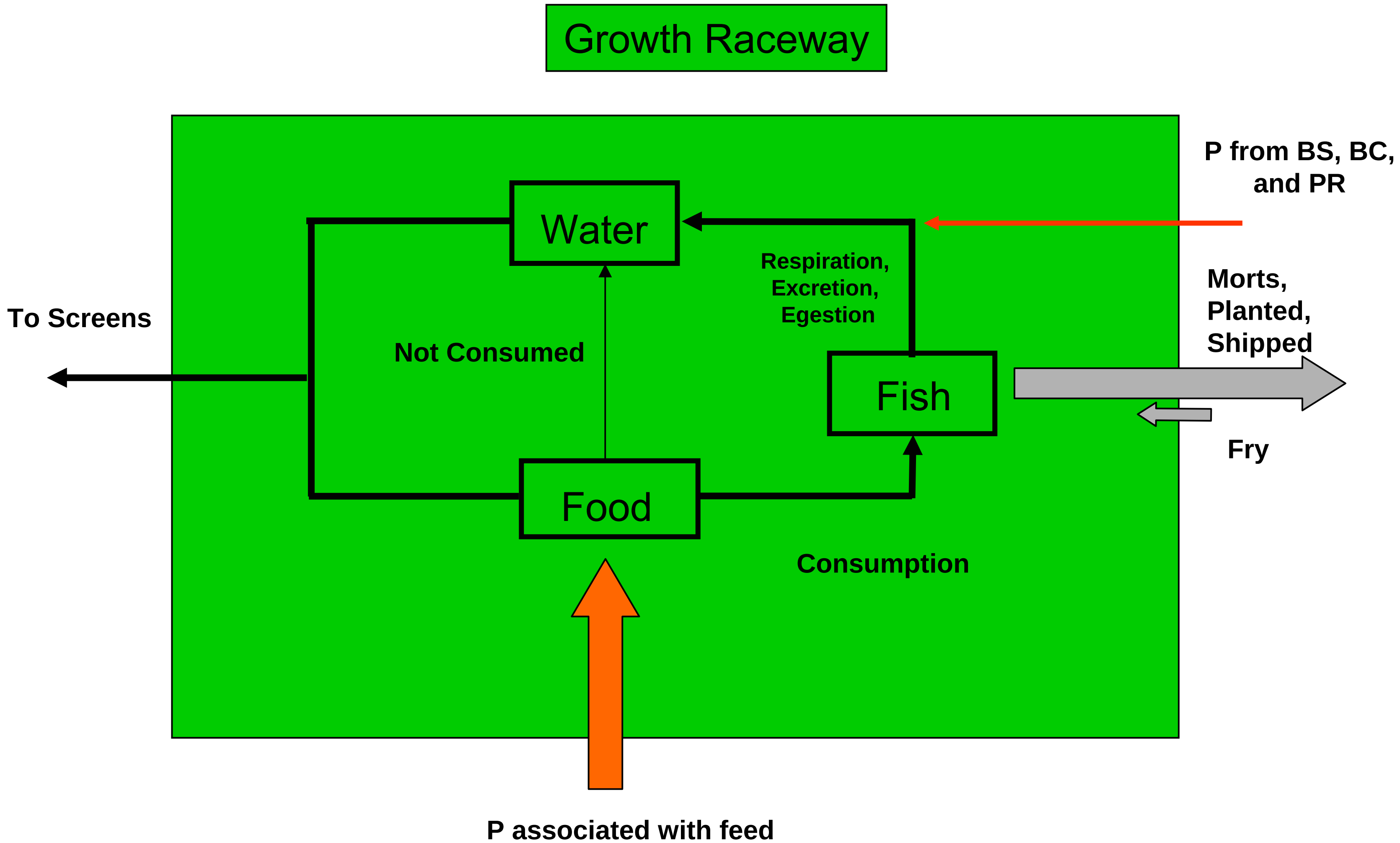
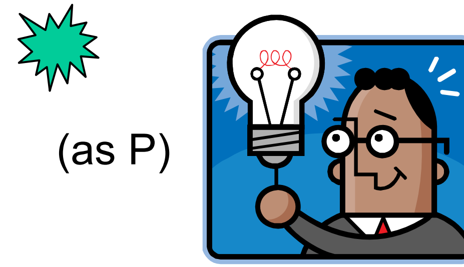


Figure 16. Fish growth model mechanisms.

Proposal For New Bio-Energetics Based Fish Phosphorus Model



Change = Gains - Losses

$$dFishP/dt = CP(T) * FishP - LP(T) * FishP \qquad \text{(as P)}$$

Rate of Change of fish biomass P

CP(T) is the consumption rate of phosphorus in the food. It is a function of temperature and the size of the fish. CP(T) is based on bioenergetics.

Units = 1/day

LP(T) is the loss rate of phosphorus. It is a function of temperature, the size of the fish, and the activity level. Includes all losses from urine and fecal matter. UP(T), and FP(T) are based on bioenergetics.

Units = 1/day

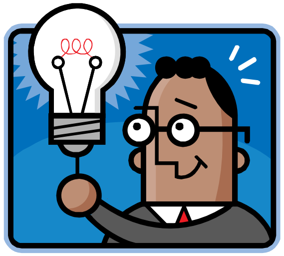
$$dFishP/dt = \Delta\, FishP \;/\; \Delta\, time = (New\ FishP - Old\ FishP) \;/\; \Delta\, time$$

Note: New Fish = Increase in inventory + morts + Harvest

$$\boxed{New\ FishP = Old\ FishP + [CP(T) - LP(T)] * Old\ FishP * \Delta\, time}$$

$$\boxed{\text{New weight} = \text{(last weight - mortality weight)} + \text{(food fed quantity / conversion ratio)}}$$

Figure 17. Bio-energetic based phosphorus mass balance model.



dFishP/dt = CP(T) * FishP - LP(T) * FishP (as P)

Must include food Limitation factor

CP(T)* FishP (KG/Day) = Food Application Rate if Food Application Rate < CP(T)*FishP
CP(T)* FishP (KG/Day) = CP(T)*FishP if Food Application Rate > CP(T)*FishP

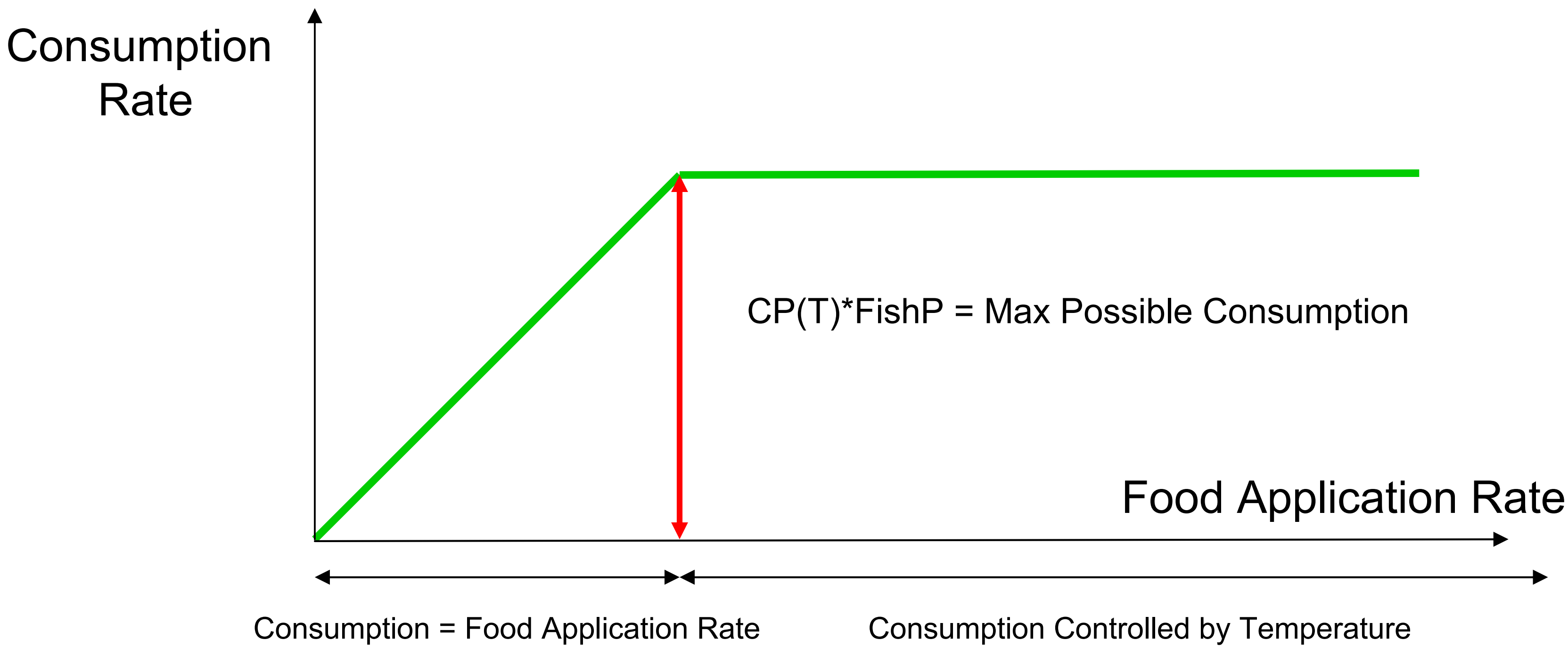


Figure 18. Relationship between food consumption rate and food supply rate.

$$dFishP/dt = CP(T) * FishP - LP(T) * FishP \quad \text{(as P)}$$

CP(T)* FishP (KG/Day) = Food Application Rate if Food Application Rate < CP(T)*FishP
CP(T)* FishP (KG/Day) = CP(T)*FishP if Food Application Rate > CP(T)*FishP

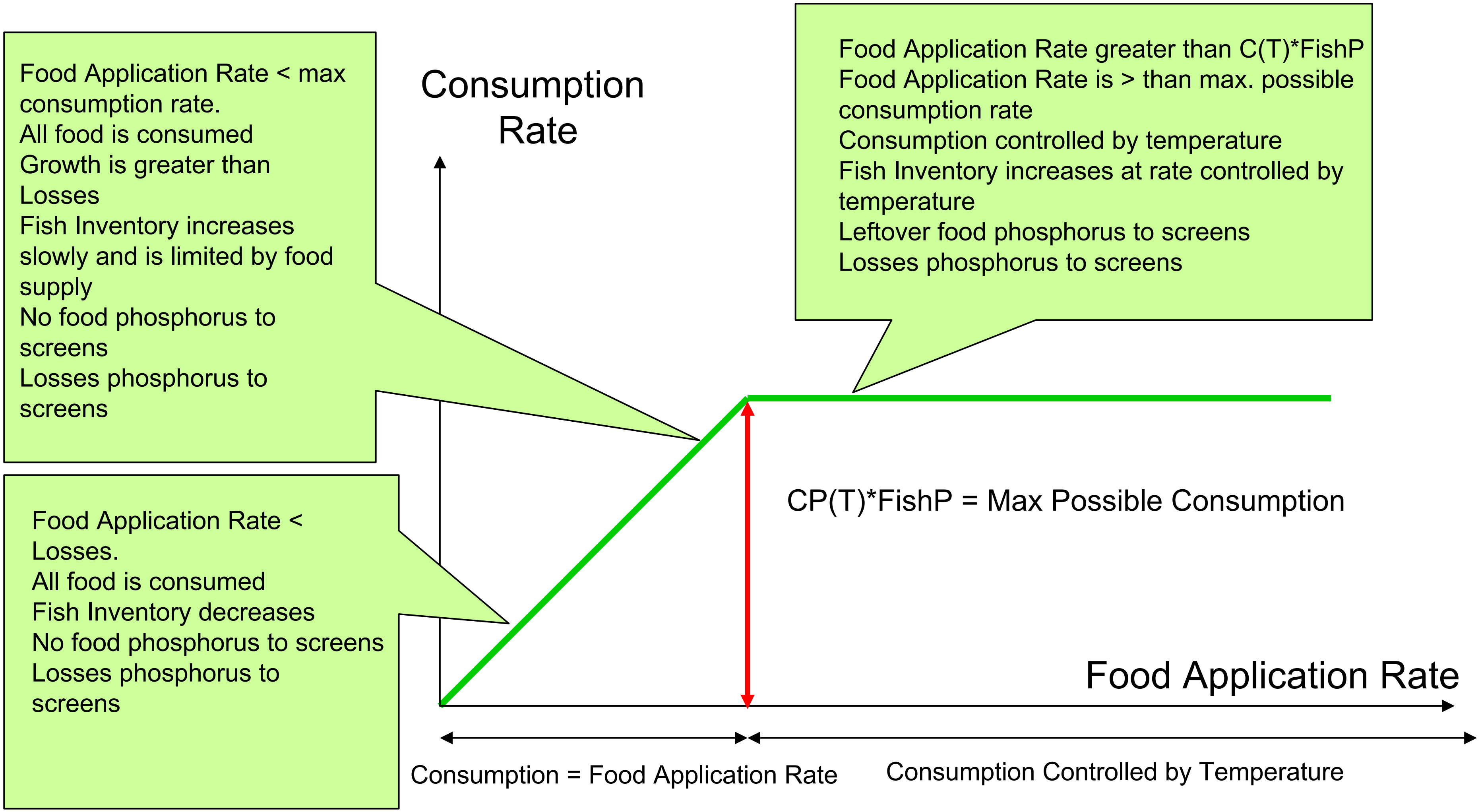


Figure 19. Discussion of three phases of consumption.

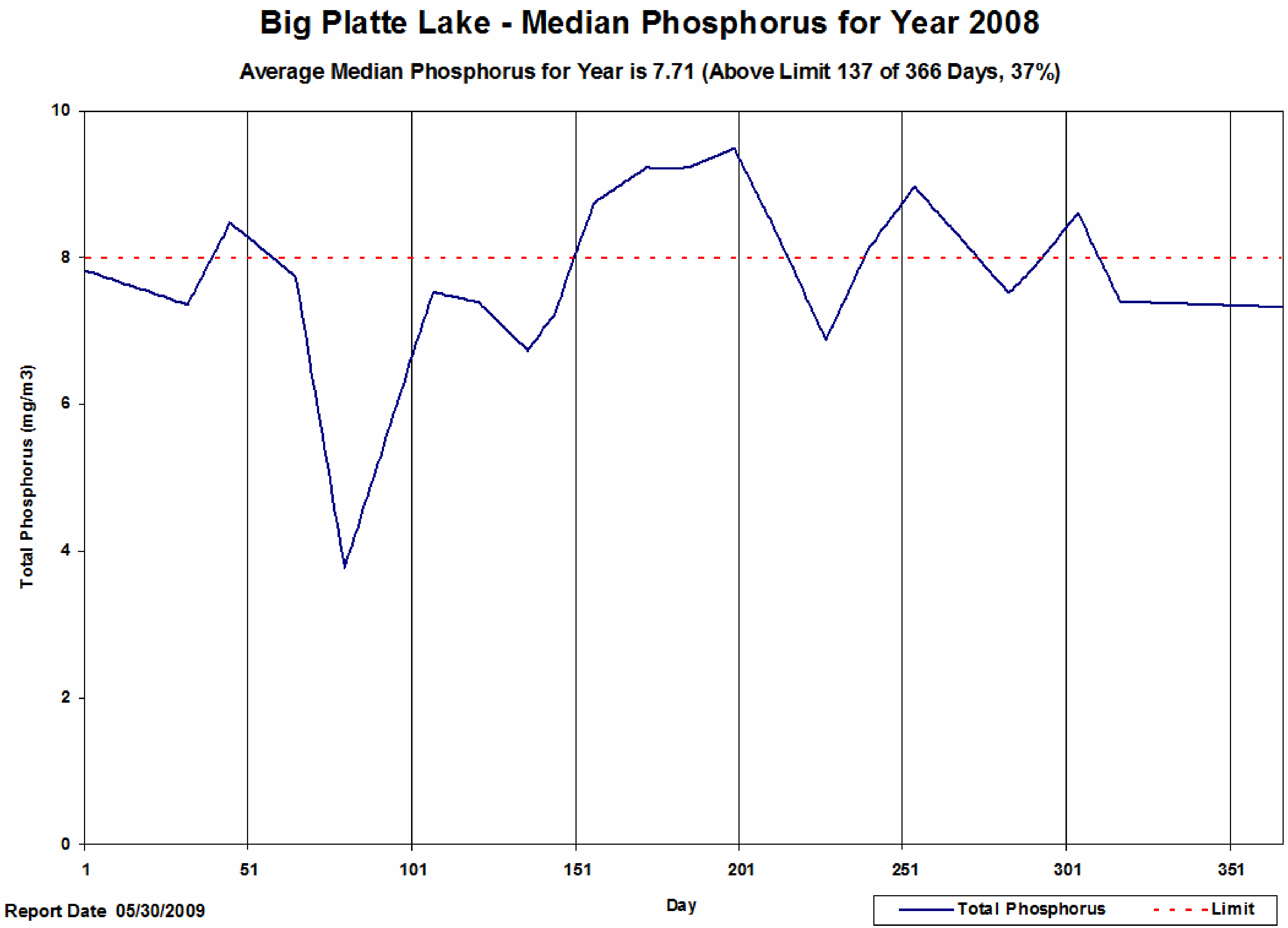


Figure 20. Volume-weighted total phosphorus concentration in Big Platte Lake for 2008.

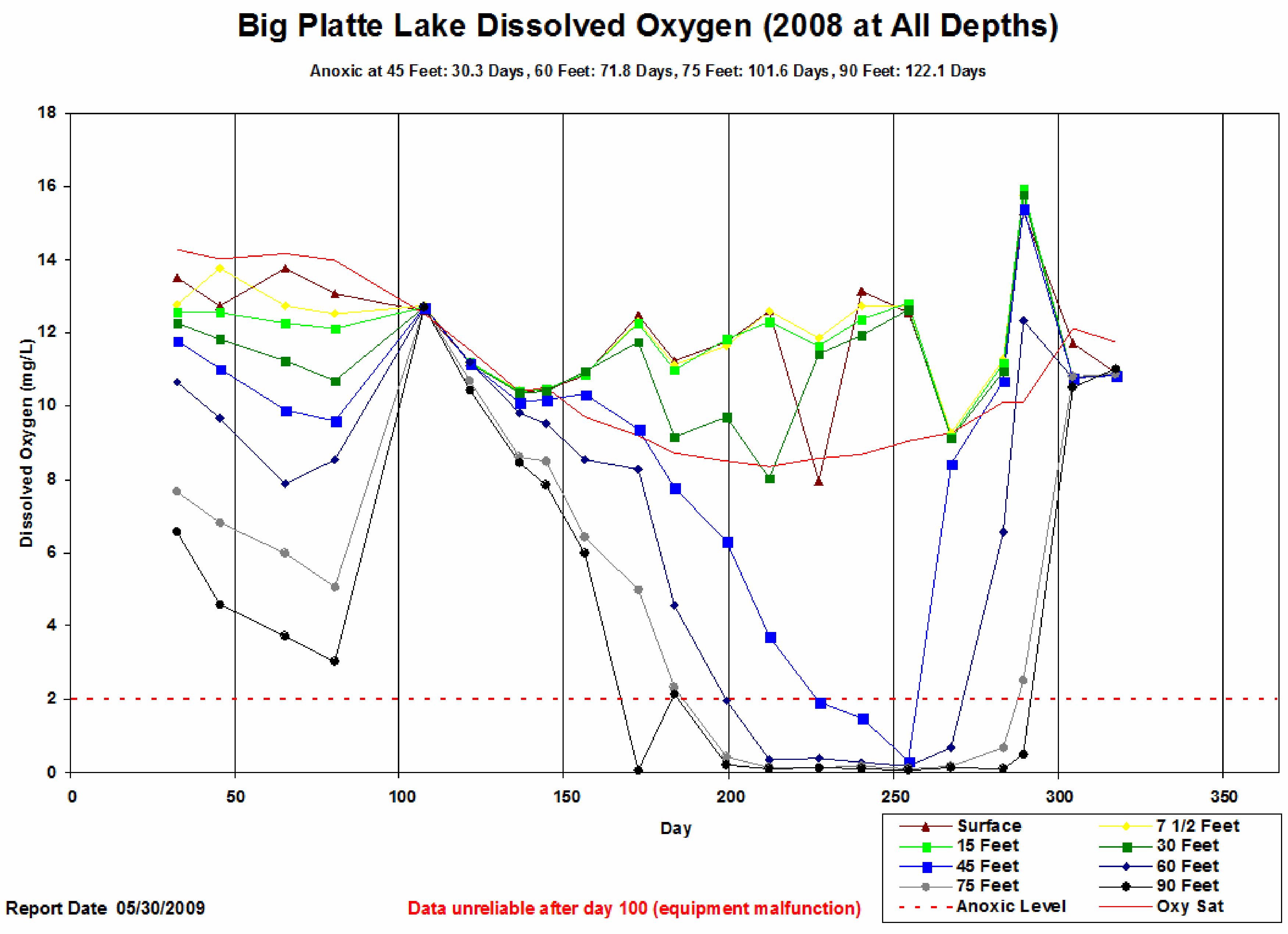


Figure 21. Dissolved oxygen as a function of depth for 2008.

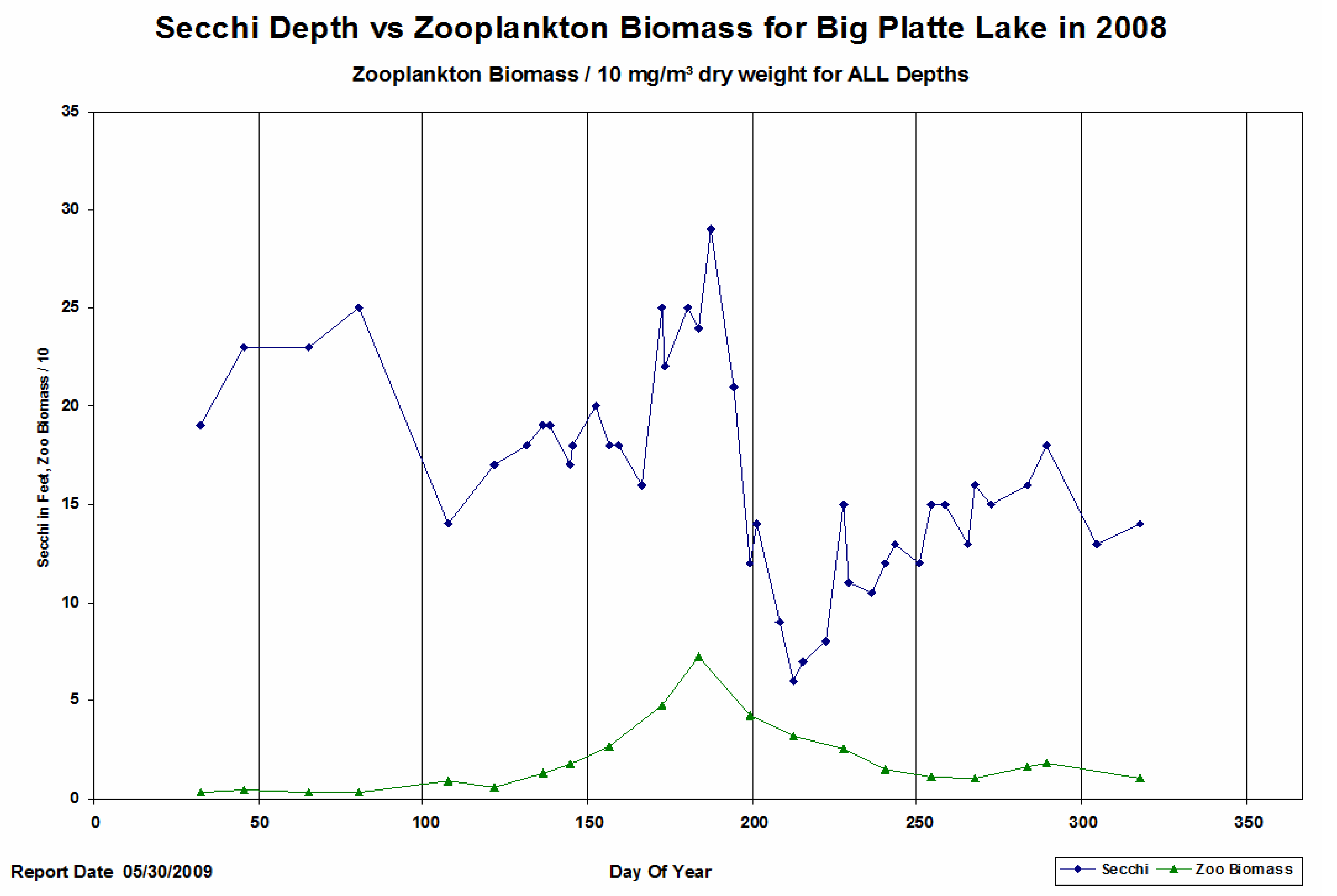


Figure 22. Secchi depth and zooplankton biomass for 2008.

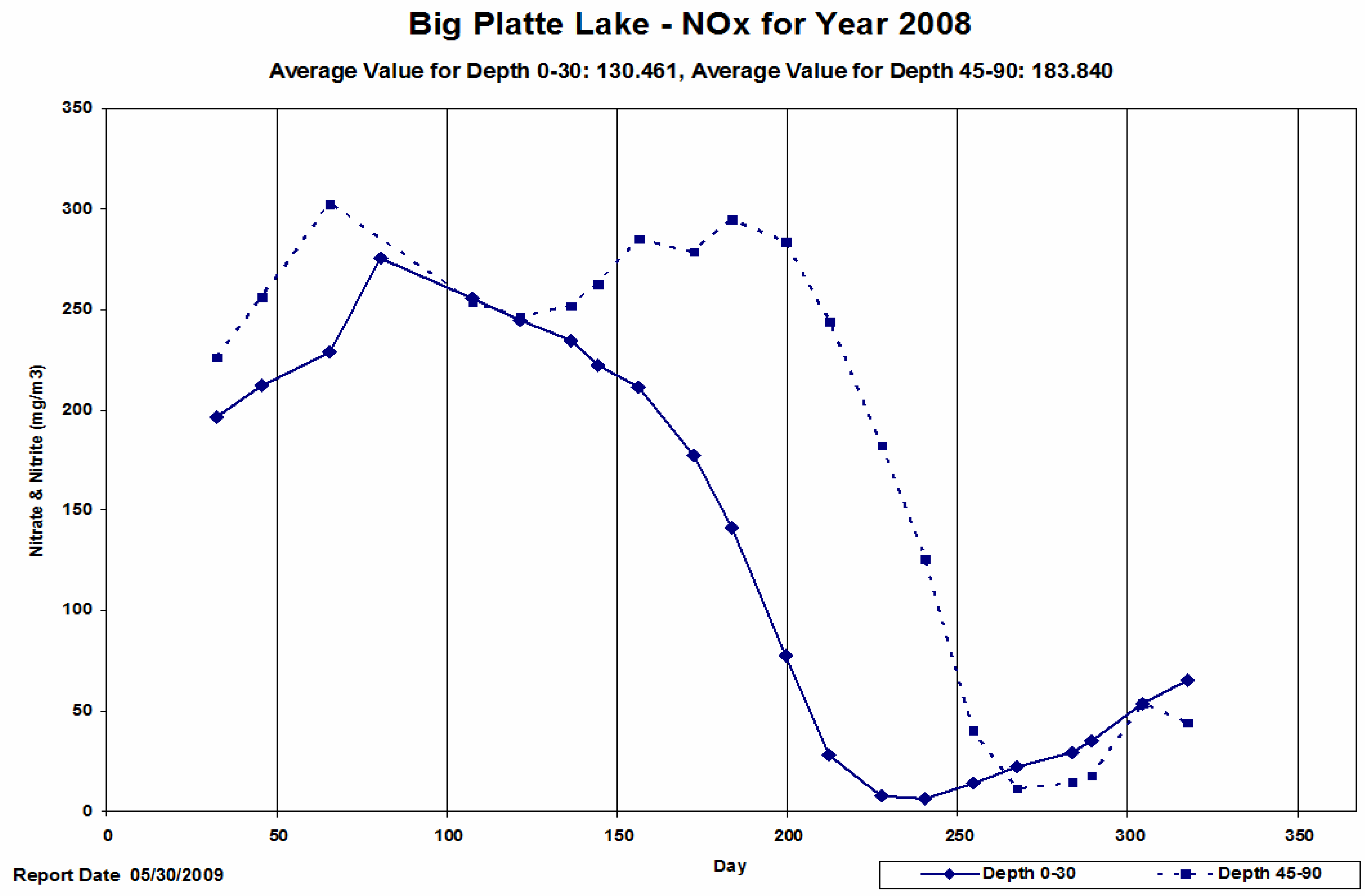


Figure 23. Nitrate concentrations at surface and bottom of Big Platte Lake for 2008.

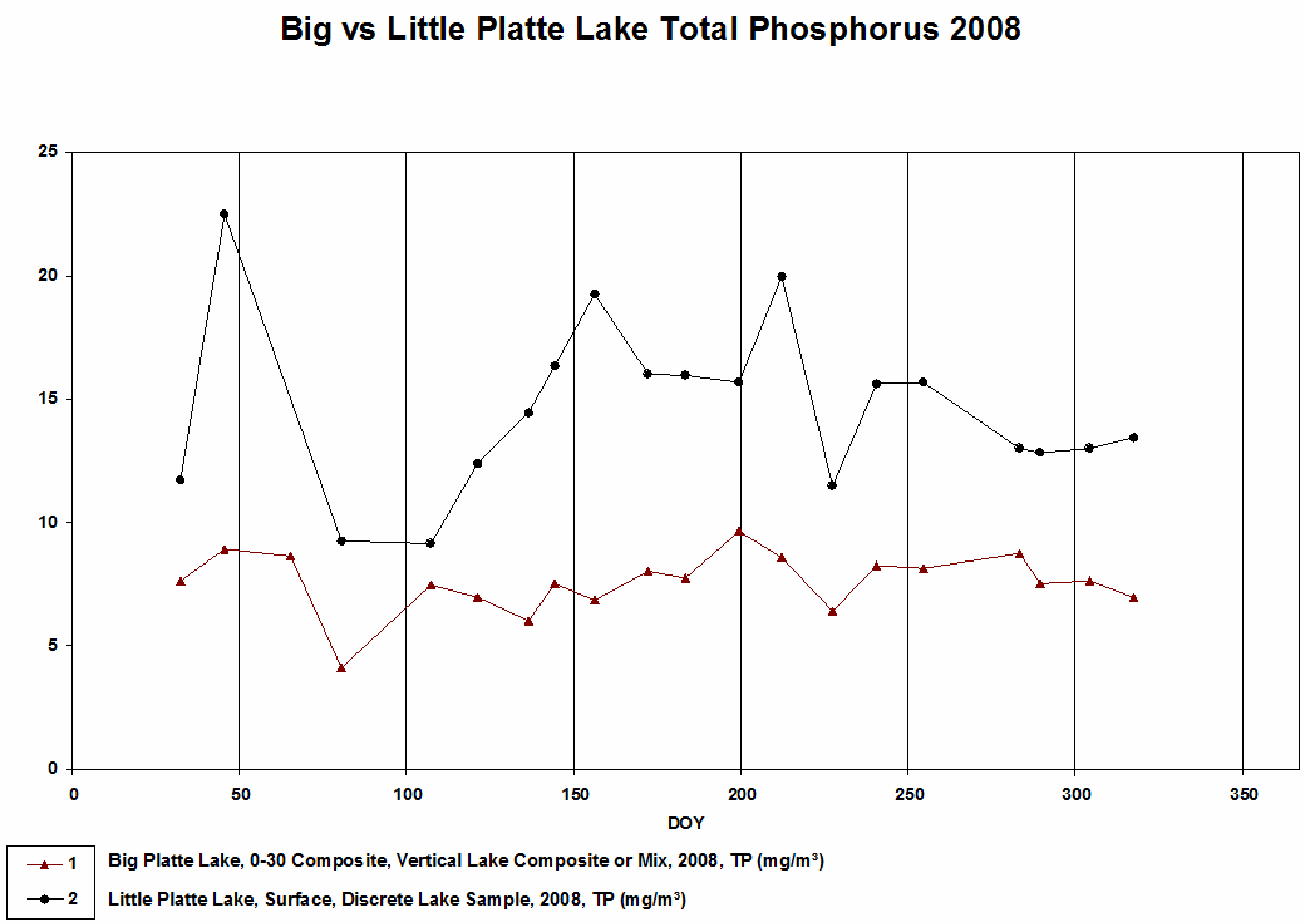


Figure 24. Comparison between total phosphorus in Big and Little Platte Lakes for 2008.

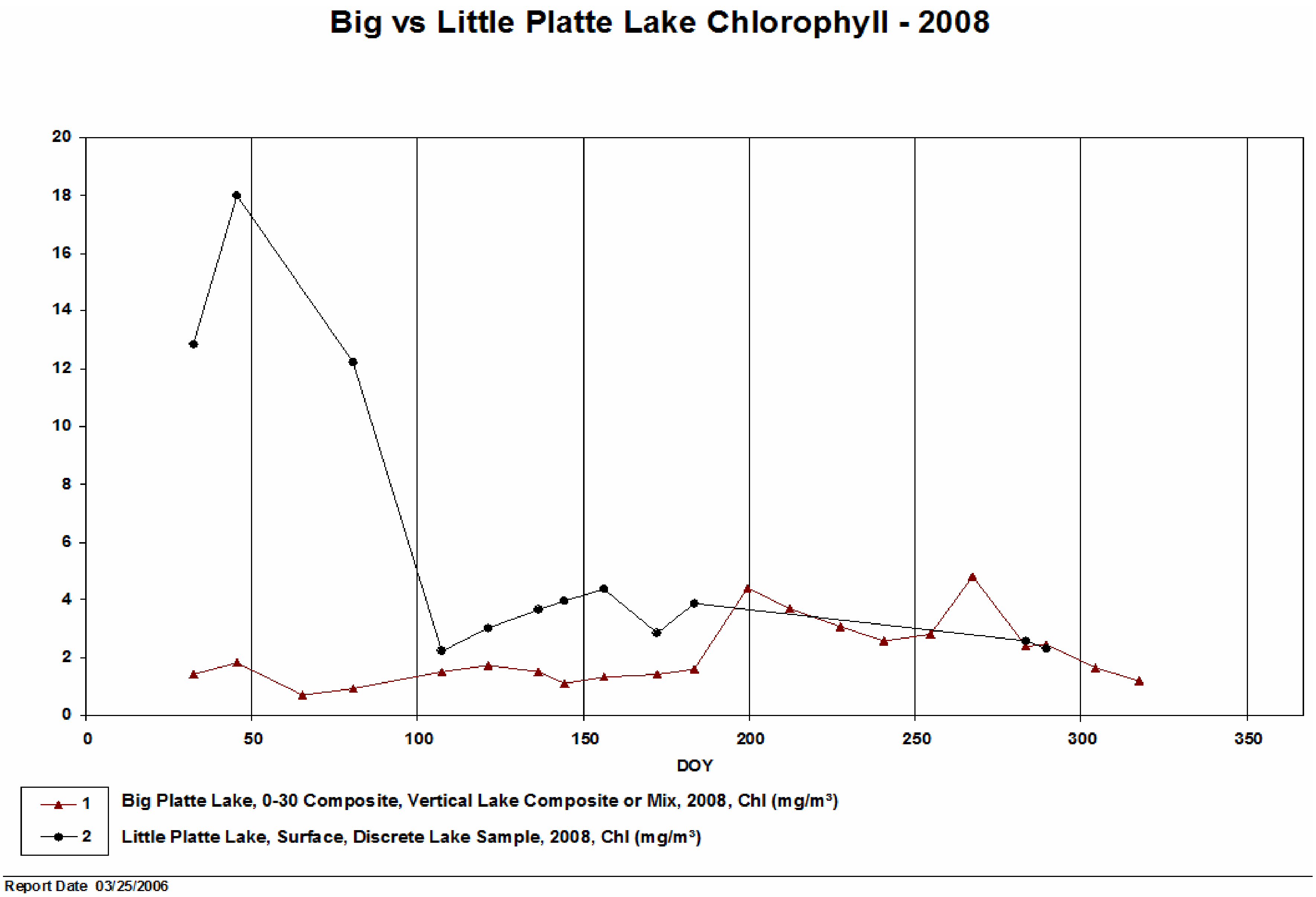


Figure 25. Comparison between chlorophyll in Big and Little Platte Lakes for 2008.

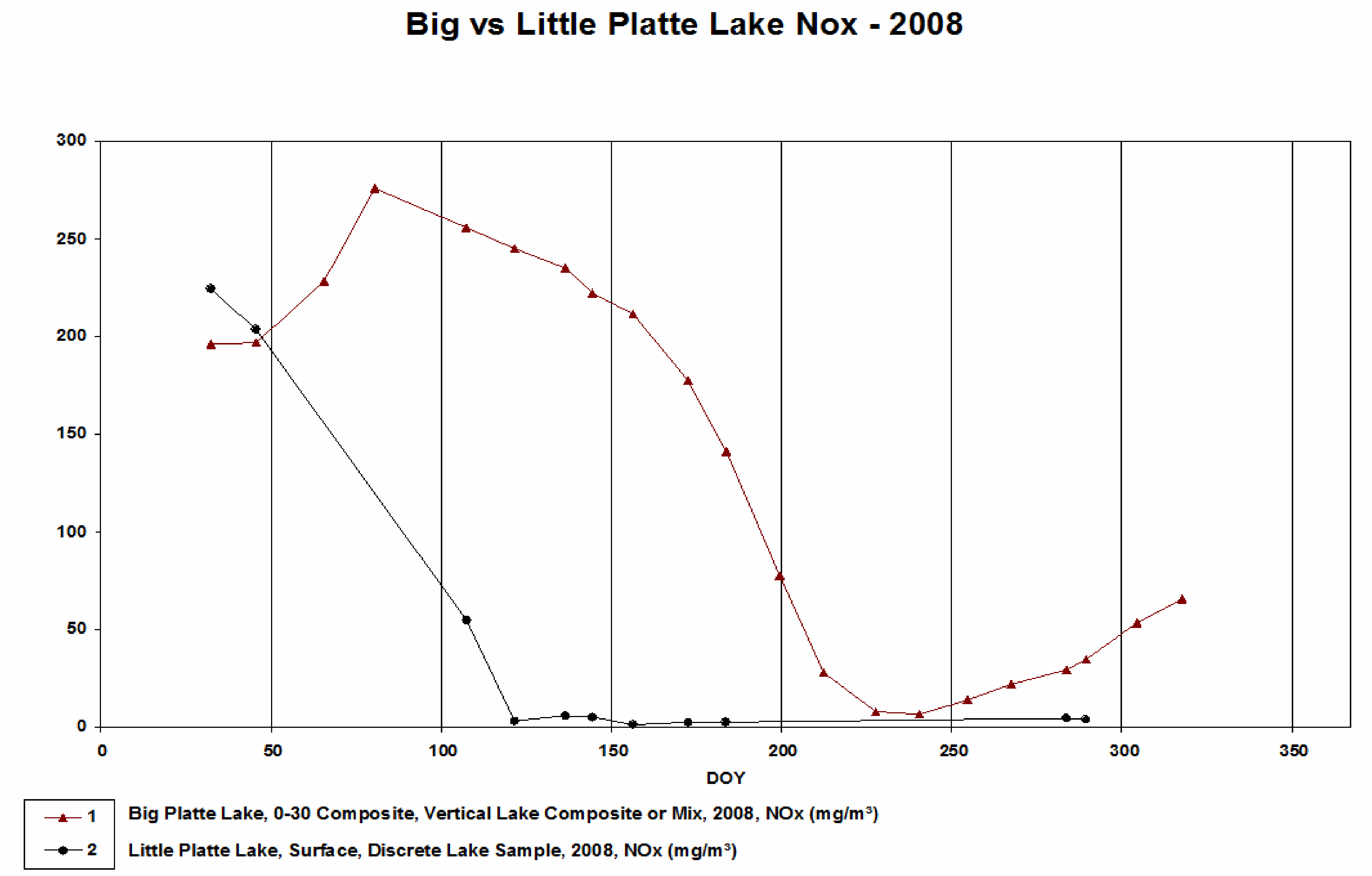


Figure 26. Comparison between nitrate + nitrite in Big and Little Platte Lakes for 2008.

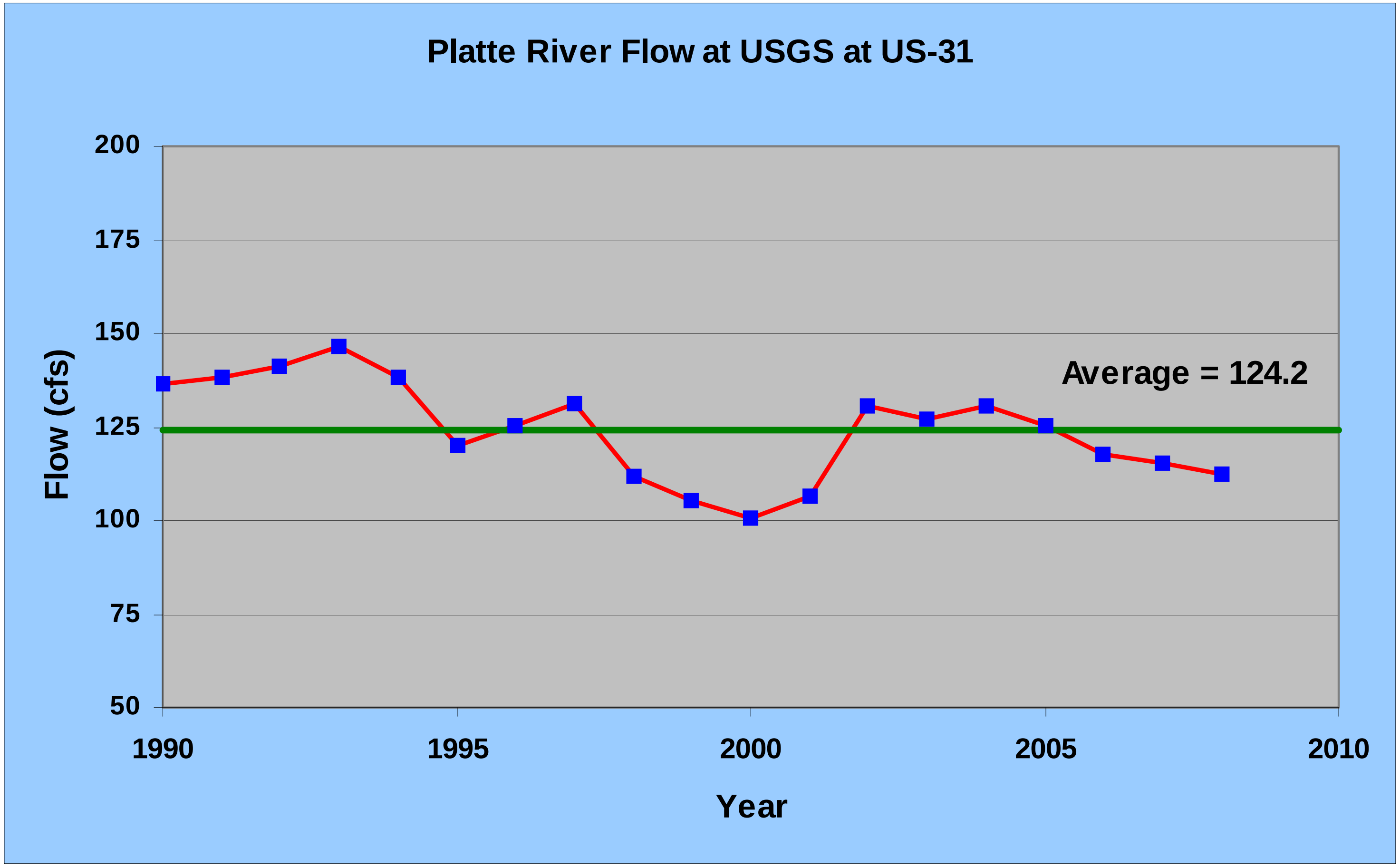


Figure 27. Historical record of annual average flows of Platte River.

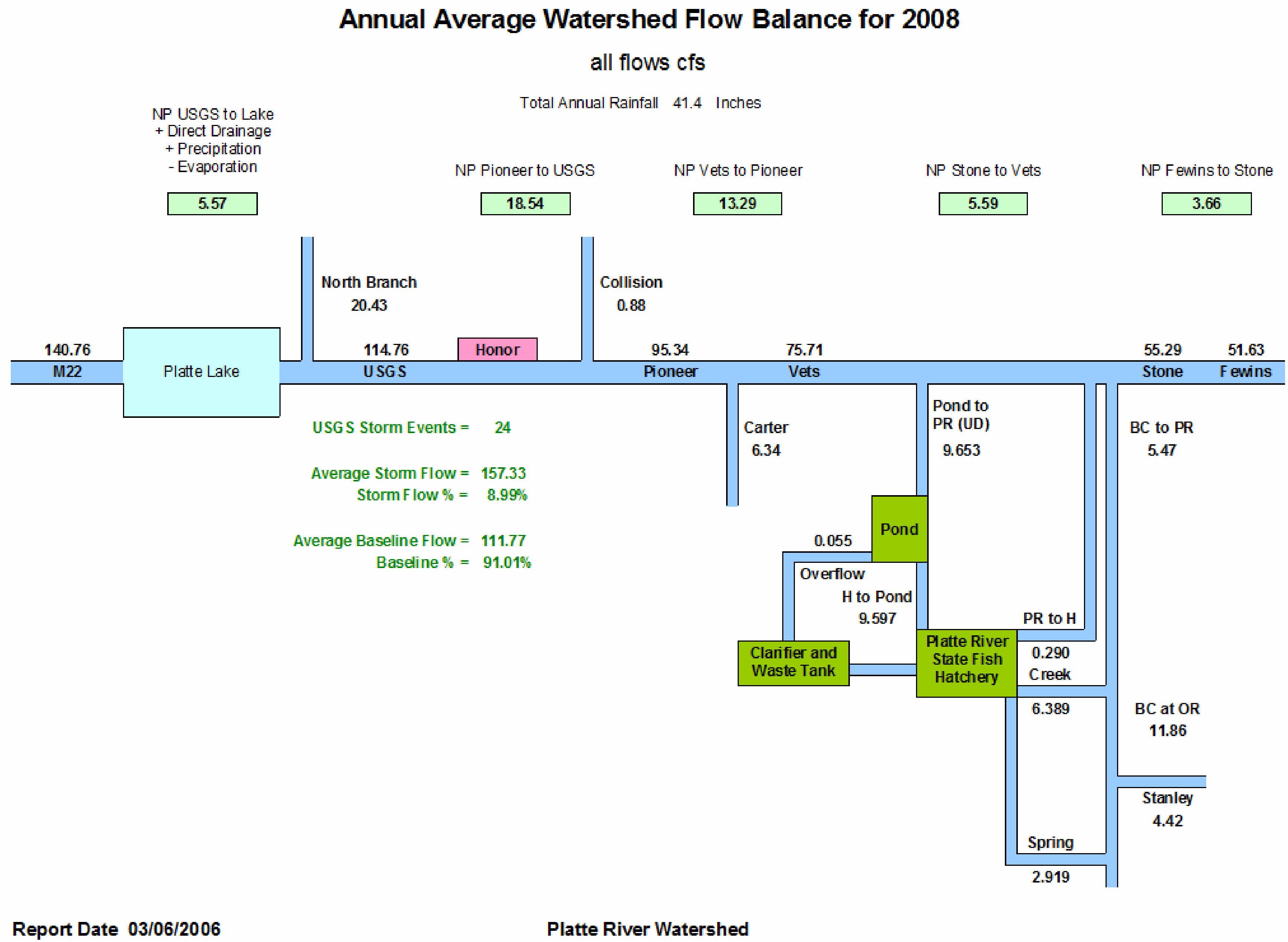


Figure 28. Watershed flow balance for 2008.

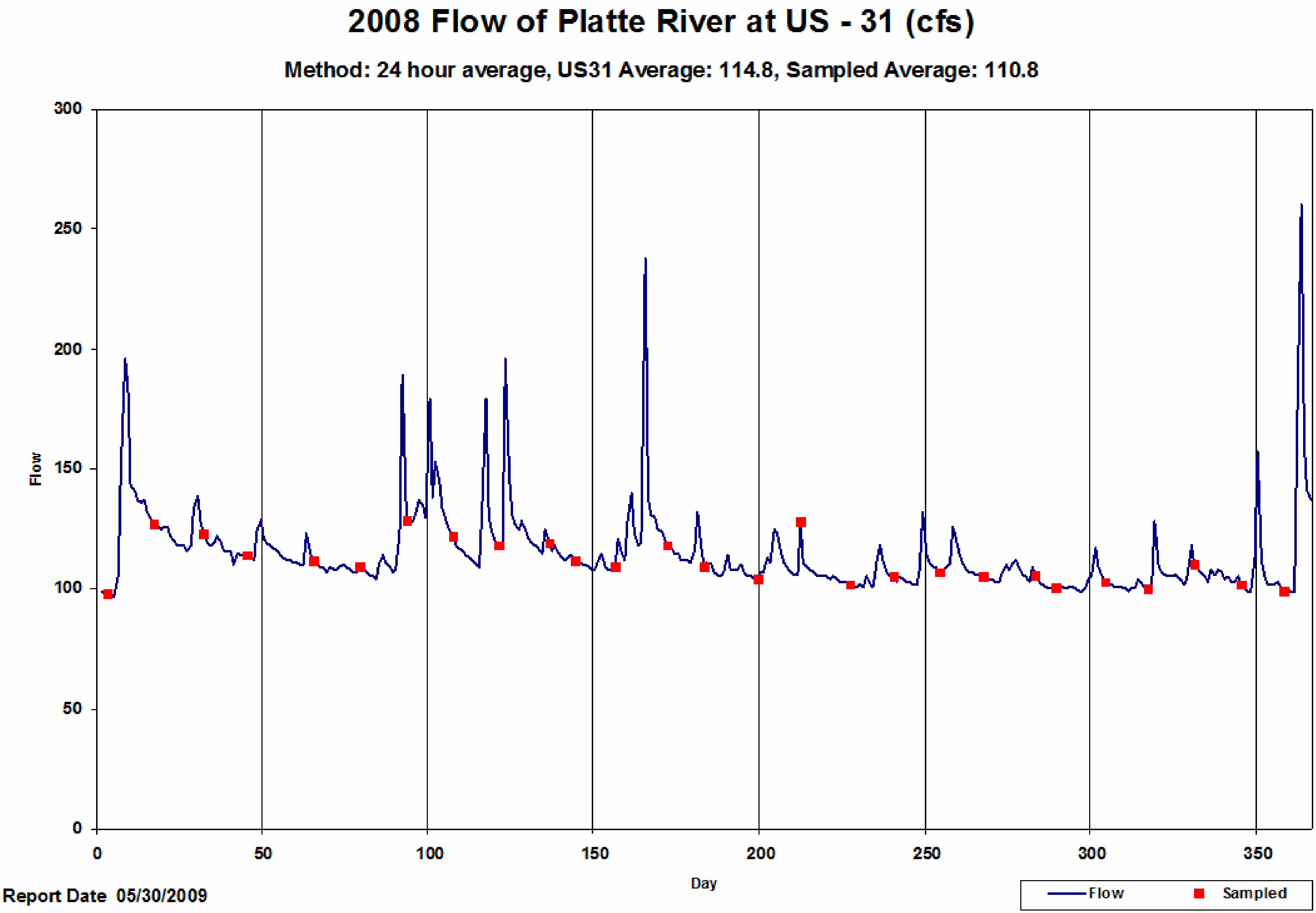


Figure 29. Daily average flows of Platte River at USGS and sampling days.

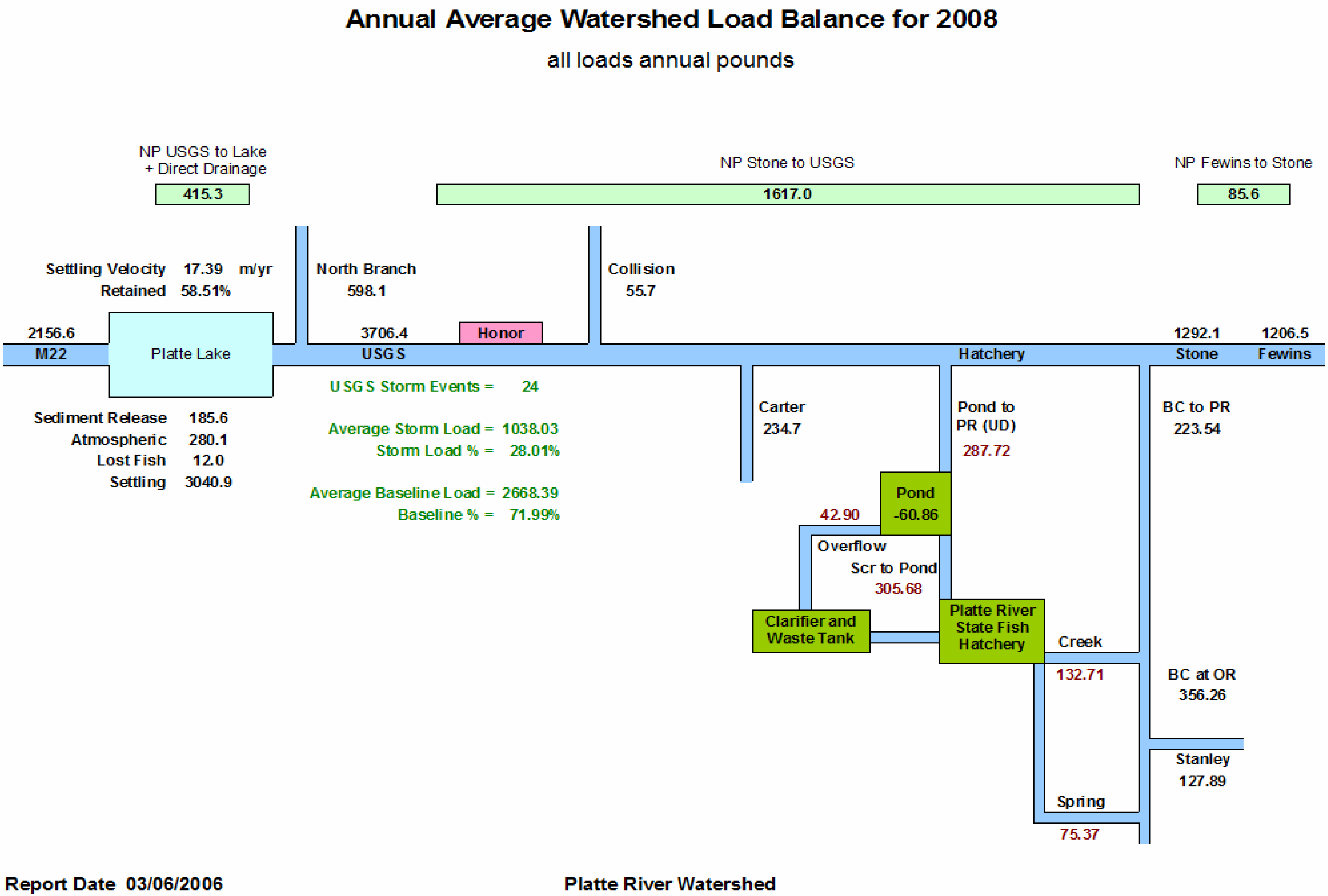
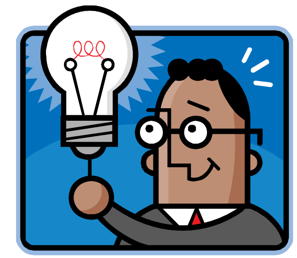


Figure 30. Watershed phosphorus balance for 2008.



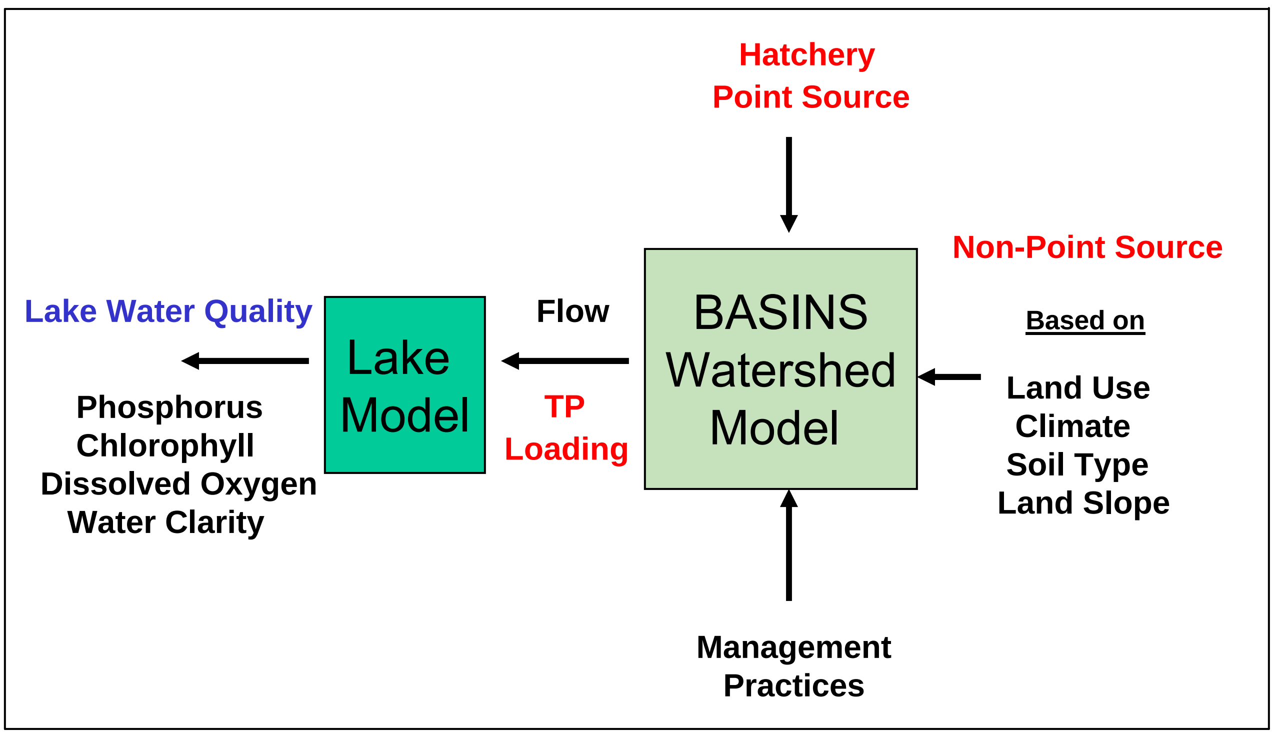
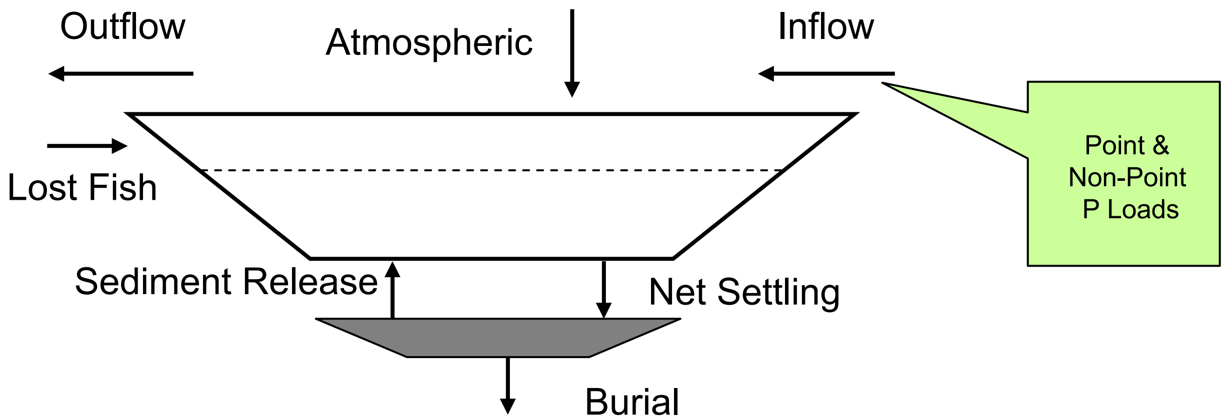


Figure 31. Components of watershed management program.



$$V_w \frac{dP_w}{dt} = W - QP_w - v_s A_s P_w + v_r A_r P_s$$

$$V_s \frac{dP_s}{dt} = v_s A_s P_w - v_r A_r P_s - v_b A_r P_s$$

$$V_h \frac{dDO_h}{dt} = v_e A_r (DO_e - DO_h) - A_r (HOD)$$

Figure 32. Water and sediment model for Big Platte Lake.

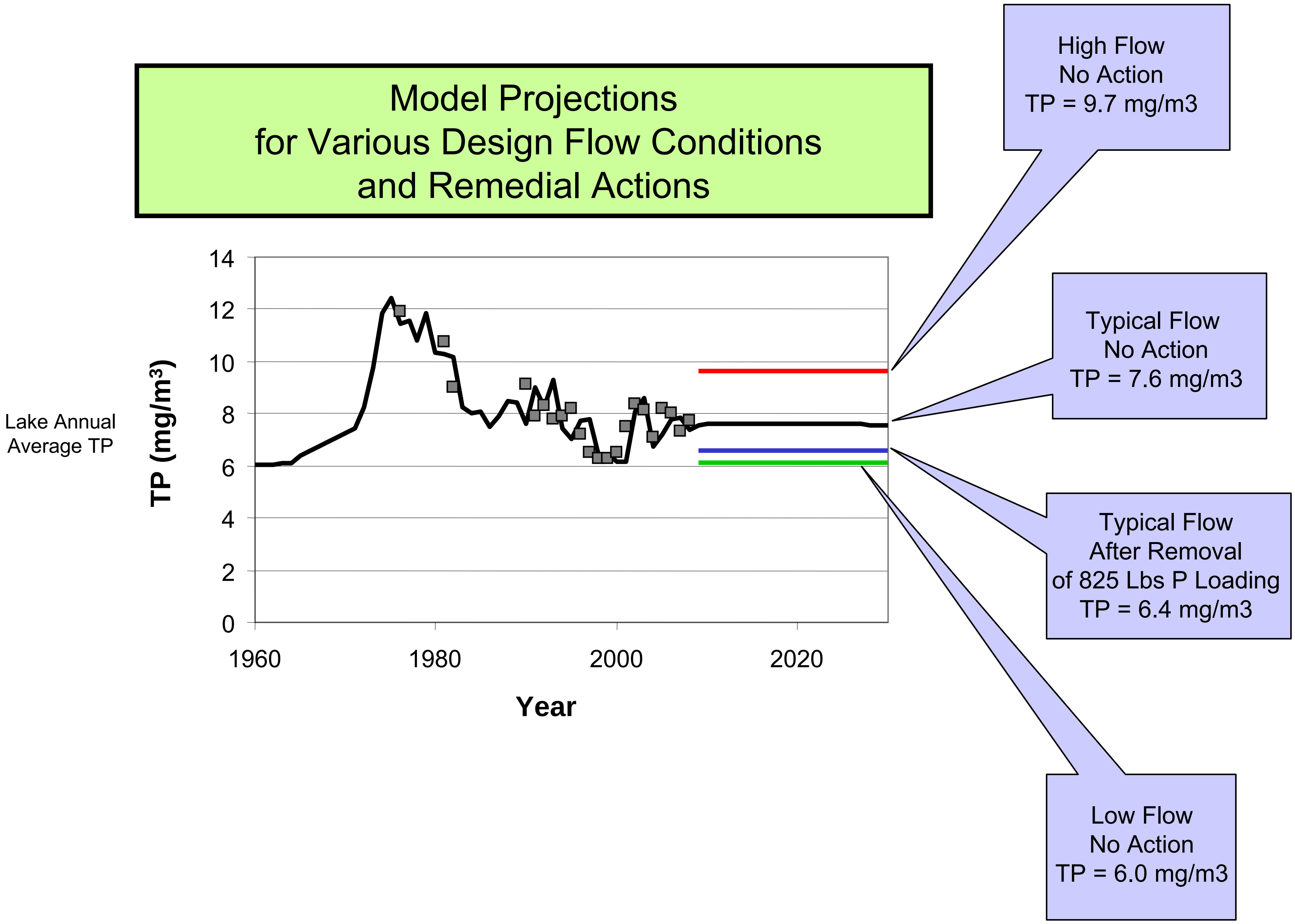


Figure 33. Model validation and projections for total phosphorus in Big Platte Lake.

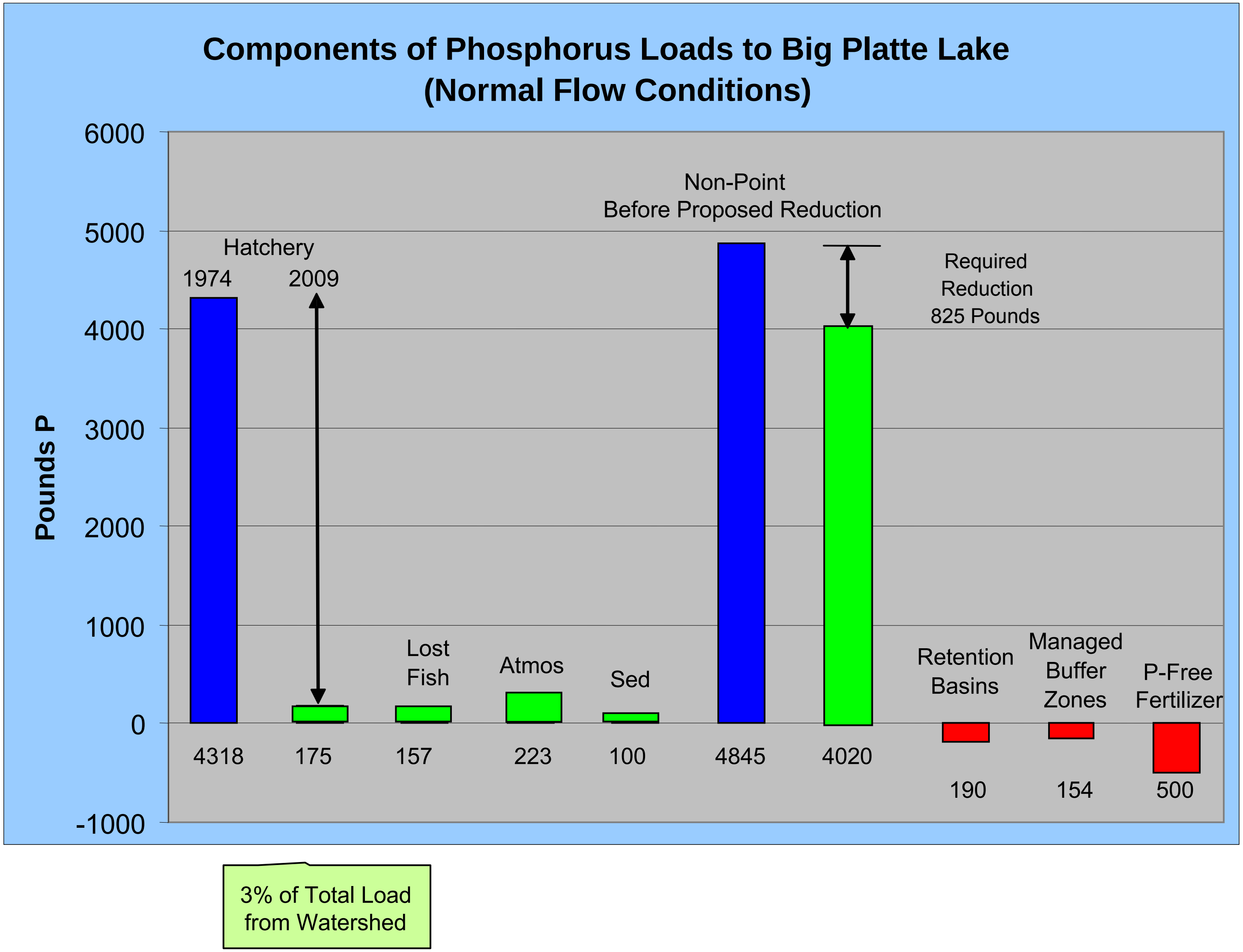


Figure 34. Summary of historical and proposed changes in the phosphorus loading to Big Platte Lake.

	BPL Dates	BPL Depths	BPL Reps	LPL Dates	LPL Depths	LPL Reps	Trib Dates	Trib Sites	Trib Reps	Count	Unit Cost	Sub Total
Alkalinity	20	1	1	0	1	0				20	$ 5.90	$ 118
Calcium	20	1	1	0	1	0				20	$ 9.44	$ 189
TDS	20	1	1	0	1	0				20	$ 5.90	$ 118
TP	20	10	3	0	1	0	20	4	3	840	$ 7.67	$ 6,443
TDP	20	2	0	0	1	0	20	0	0	0	$ 7.67	$ -
NO2 + NO2	20	2	0	0	1	0	20	0	0	0	$ 12.39	$ -
TN	20	2	0	0	1	0	20	0	0	0	$ 32.50	$ -
TDN	20	2	0	0	1	0	20	0	0	0	$ 32.50	$ -
Chlorophyll	20	2	3	0	1	0				120	$ 14.75	$ 1,770
Phytoplankton	3	1	4	0	1	0				12	$ 76.70	$ 920
Zooplankton	3	1	3							9	$ 76.70	$ 690
												$ 10,248

	H Dates	H Sites	H Reps	Tank Dates	Tank Sites	Tank Reps	Special Dates	Special Sites	Special Reps	Count	Unit Cost	Sub Total
TP	100	6	6	2	30	3	10	20	3	4380	$ 7.67	$ 33,595
mg P/mg DW	24	2	3							144	$ 17.50	$ 2,520
% water	24	2	3							144	$ 11.80	$ 1,699
												$ 37,814

Figure 35. Proposed sampling program and costs for 2009.