CE-QUAL-W2 Model for Lake Murray—Progress Report on Calibration and Applications

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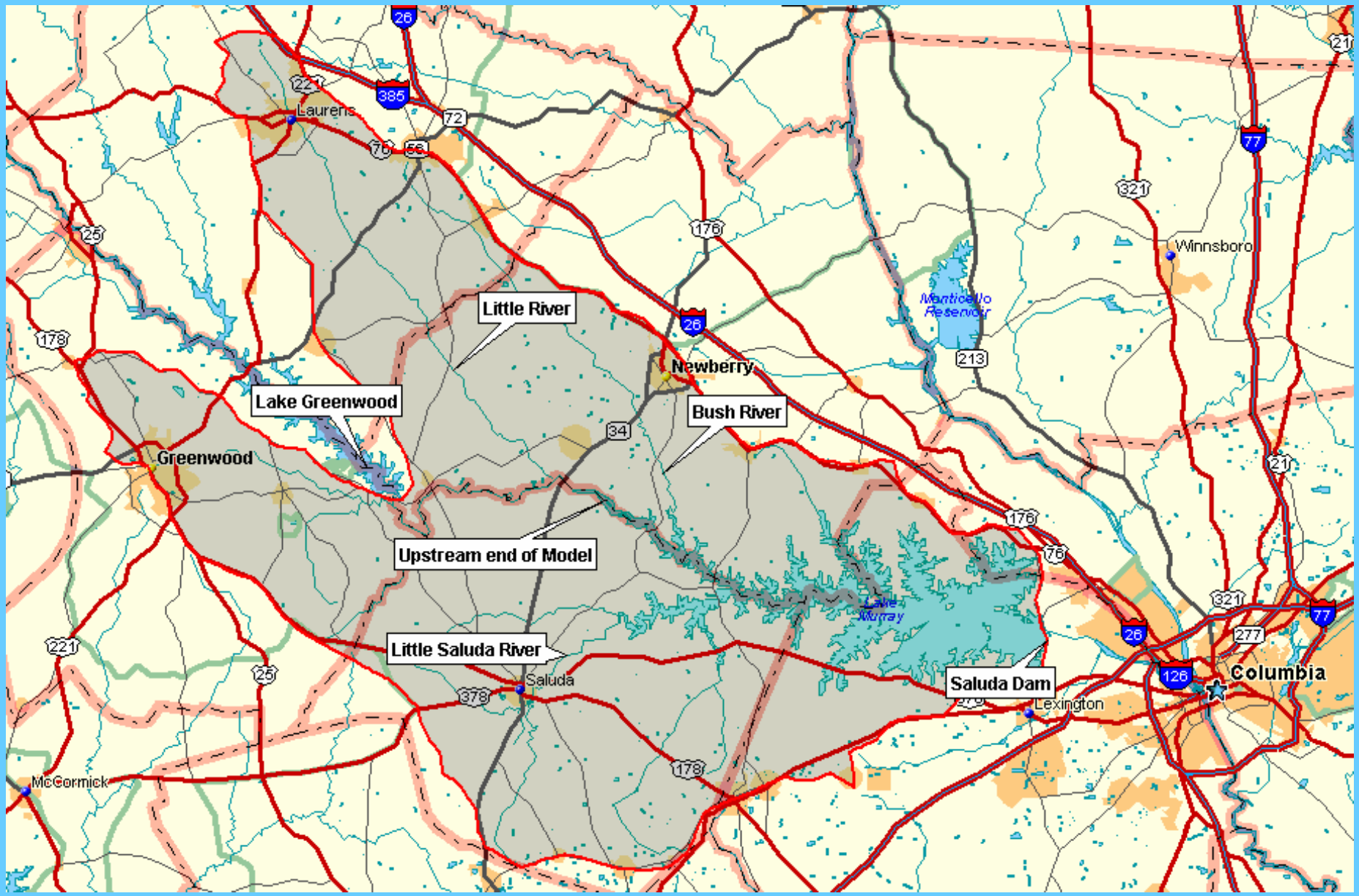
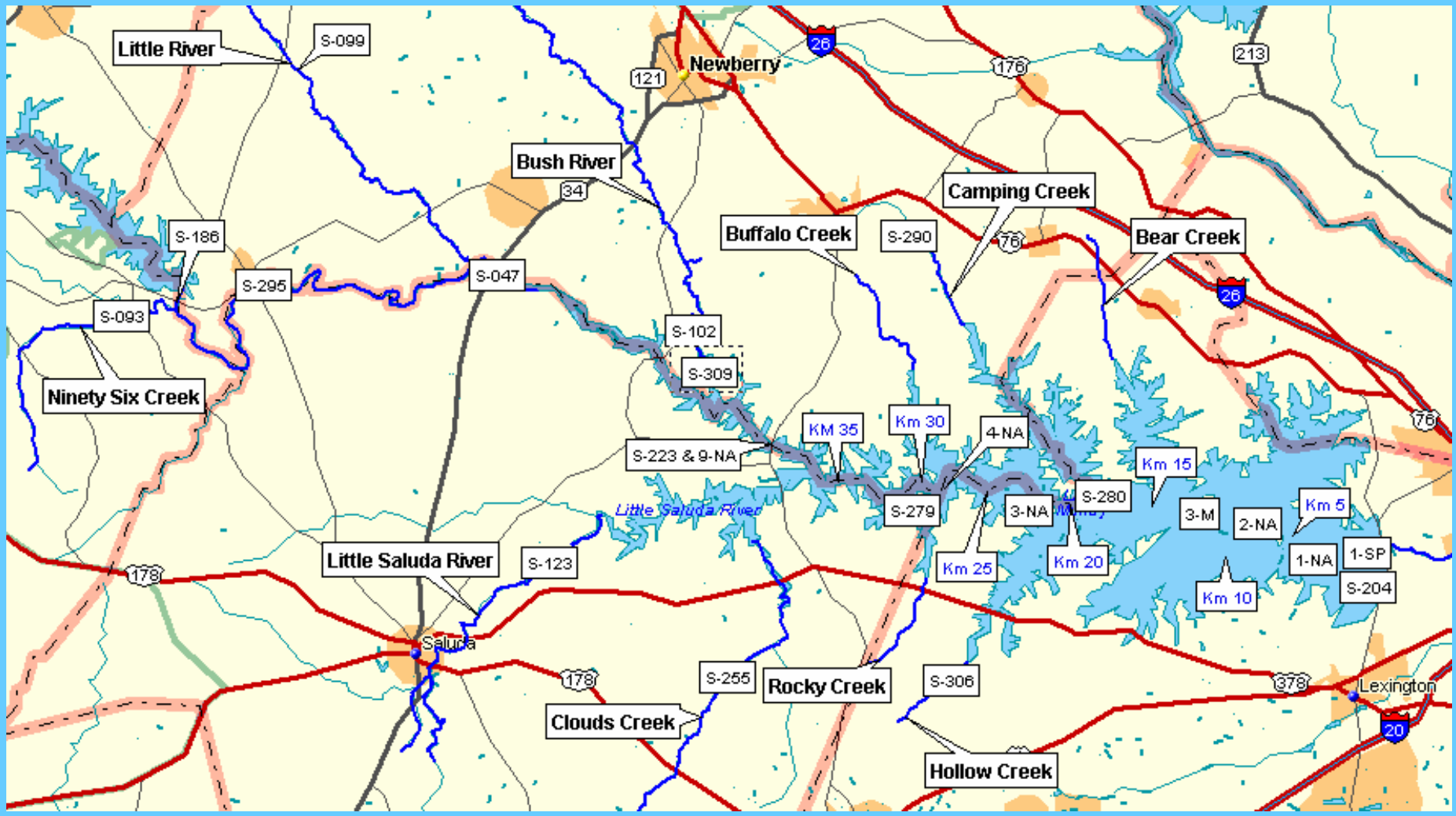
Overview of Presentation

- Present the calibration of the CE-QUAL-W2 model that will be used to simulate water quality in Lake Murray
- Illustrate use of the model to explore management strategies for improving water quality and uses of the lake

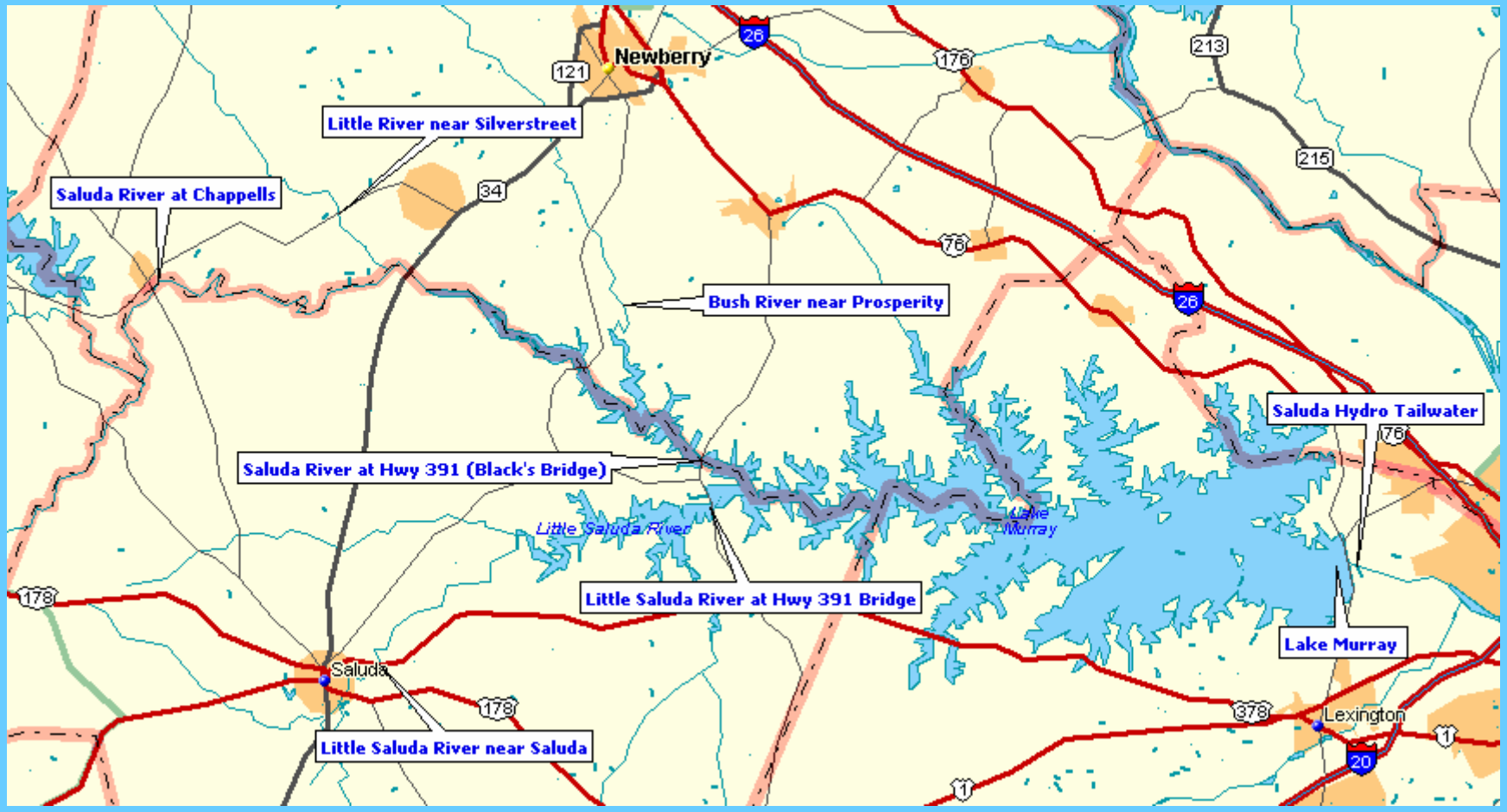
Lake Murray Watershed



Primary SCDHEC and SCE&G Monitoring Stations used for Lake Murray Water Quality Analyses



Map of Lake Murray Watershed Showing Location of USGS Monitors



Summary of Key Issues to be Addressed Using the CE-QUAL-W2 Model

- Low DO in the releases from Saluda Hydro,
- Restrictions for operating Unit 5 due to entrainment of blue-back herring,
- Effects of project operations and water quality on Striped Bass habitat, including fish kills that have occurred in the past
- DO less than the State standard in the inflow regions of the lake,

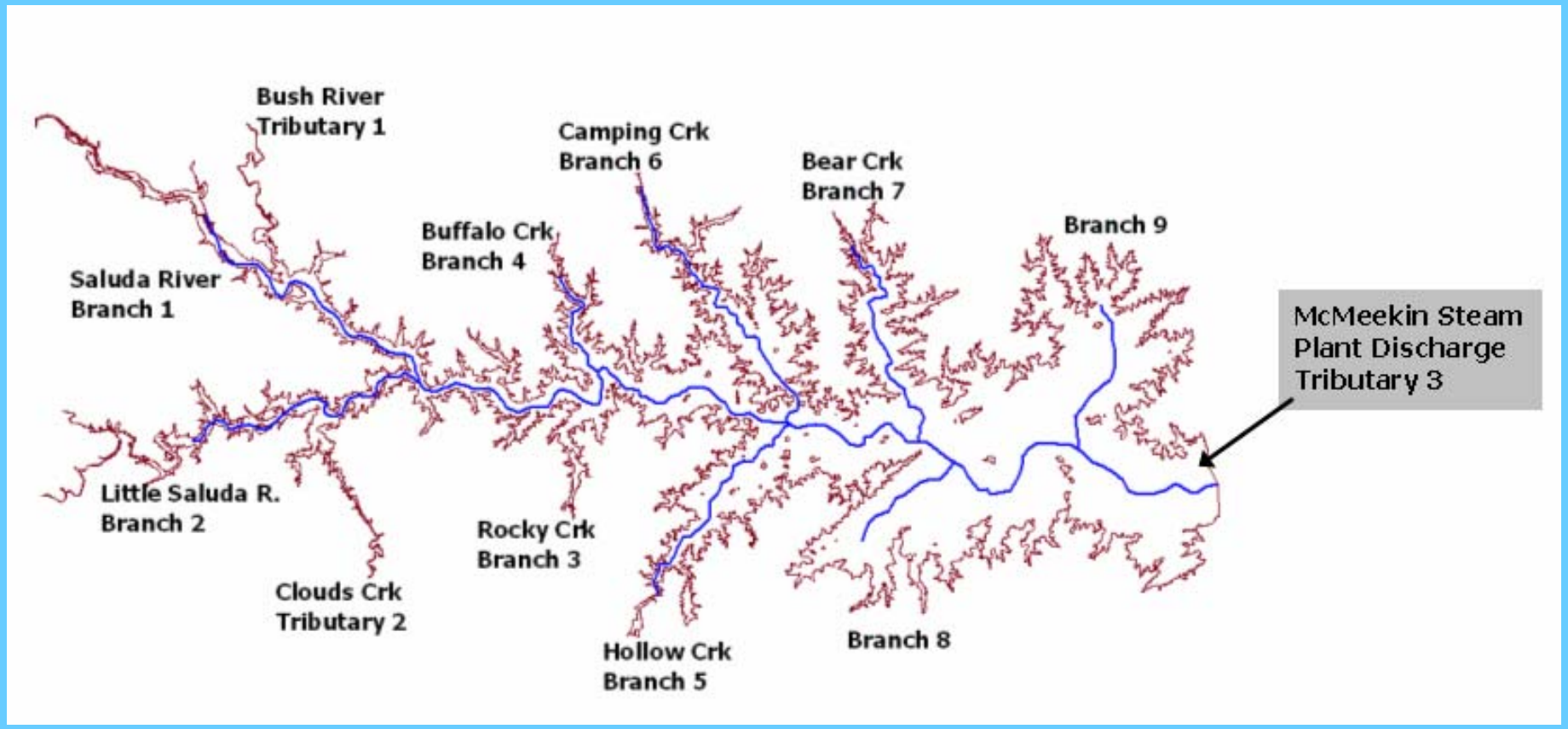
Other issues not being addressed at this time using the model:

- low pH in Lower Saluda River (LSR)
- eutrophication in the upper regions of Lake Murray

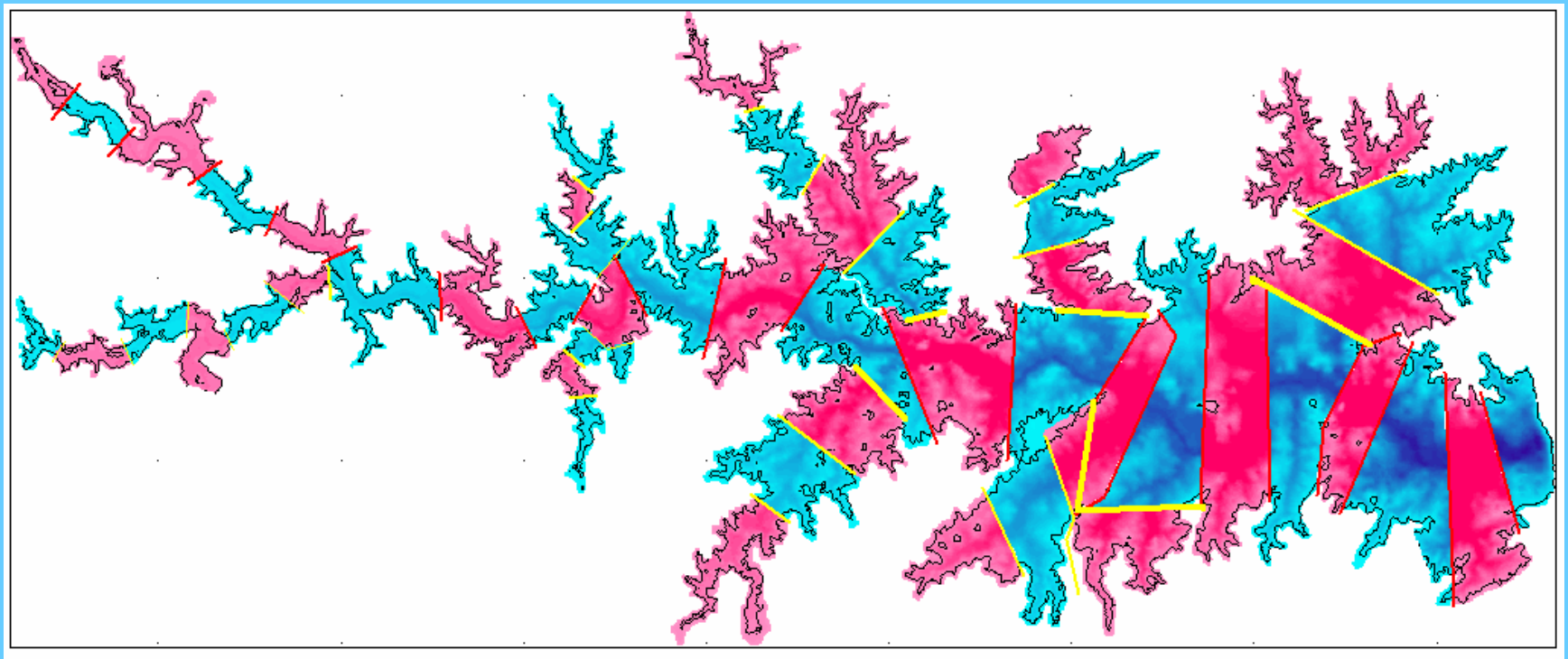
Physical Characteristics of Lake Murray

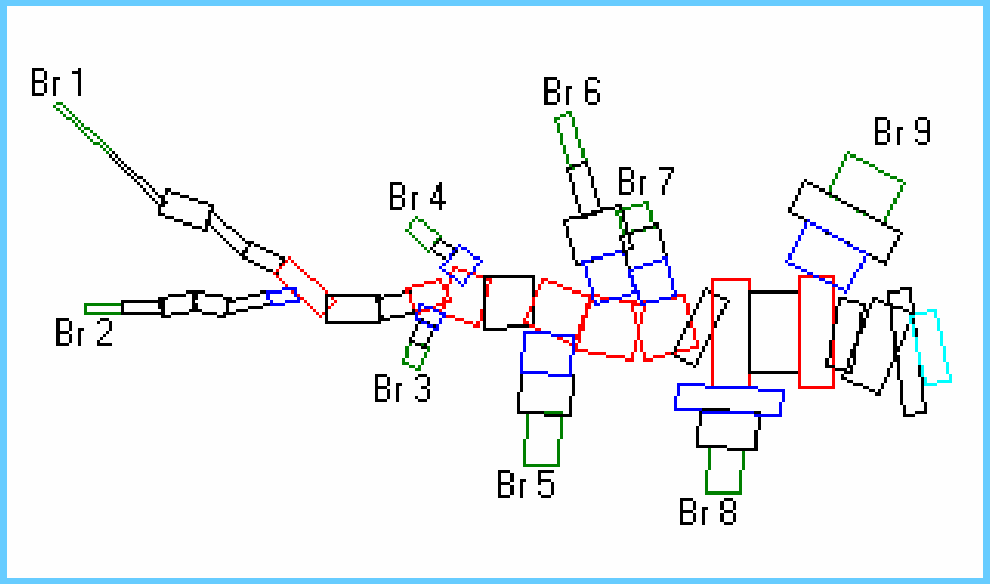
	U.S. Customary System	Metric System
Maximum depth	175 feet	53.3 m
Total lake volume	2,317,000 ac-ft	2,636 hm^3
Average Annual Flow	2778 cfs	78.7 cms
Nominal Residence Time	417 days	417 days
Depth of outlets, Units 1-4	175 feet	53 m
Depth of outlets, Unit 5	110 feet	33.5 m
Flow Capacity - Units 1-4	3000 cfs	85 cms
Flow Capacity, Unit 5	6000 cfs	170 cms

Plan view of Lake Murray with all Branches and Tributaries that are Included in the Model

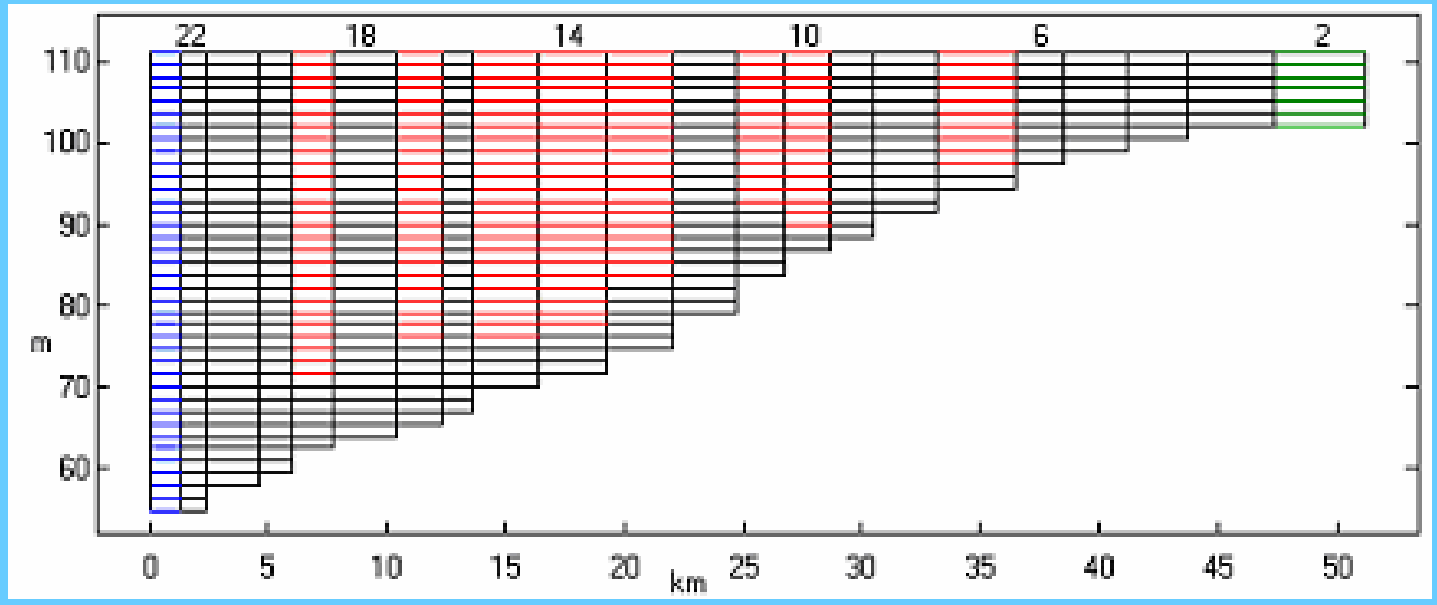


Plan View of Lake Murray Showing CE-QUAL-W2 Segmentation

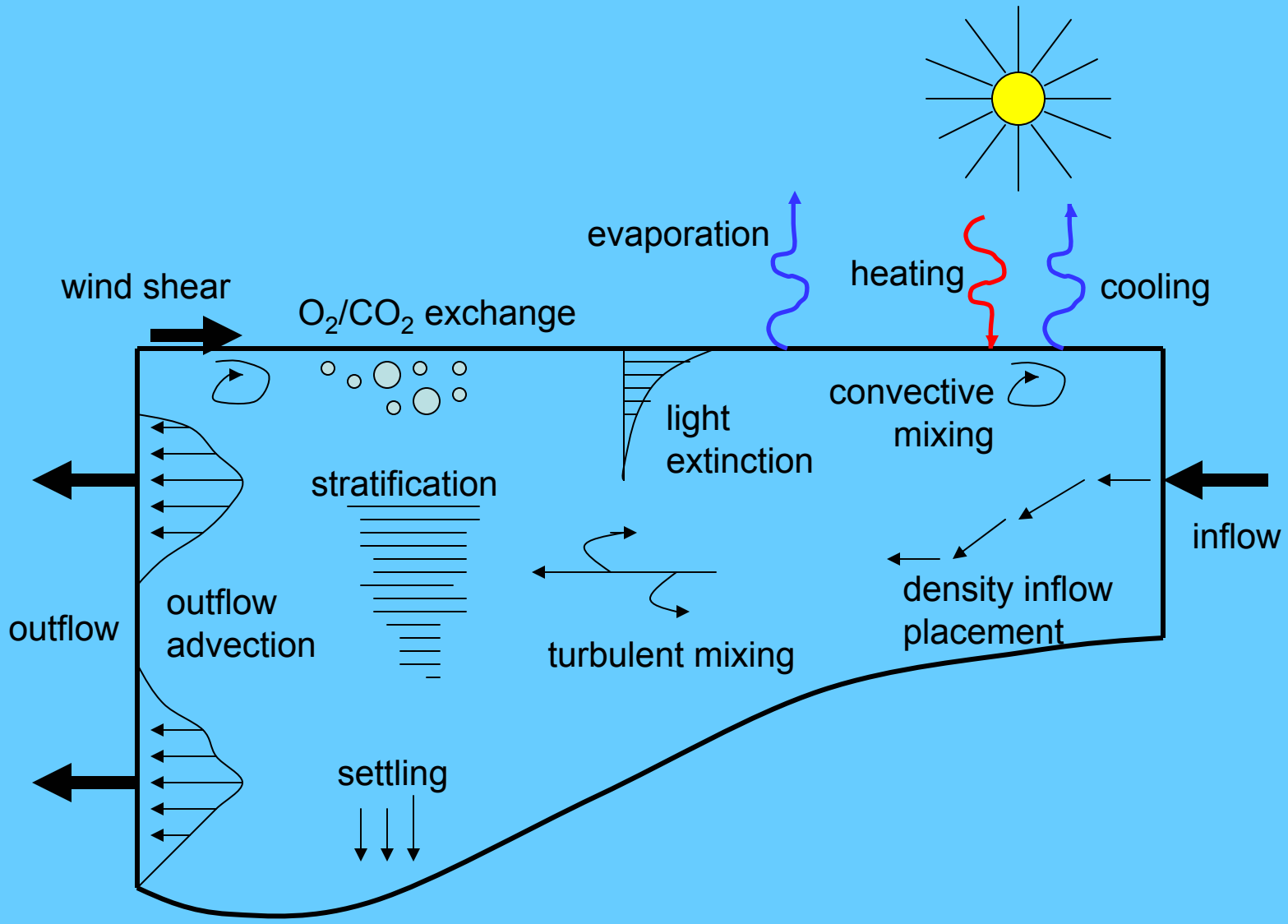




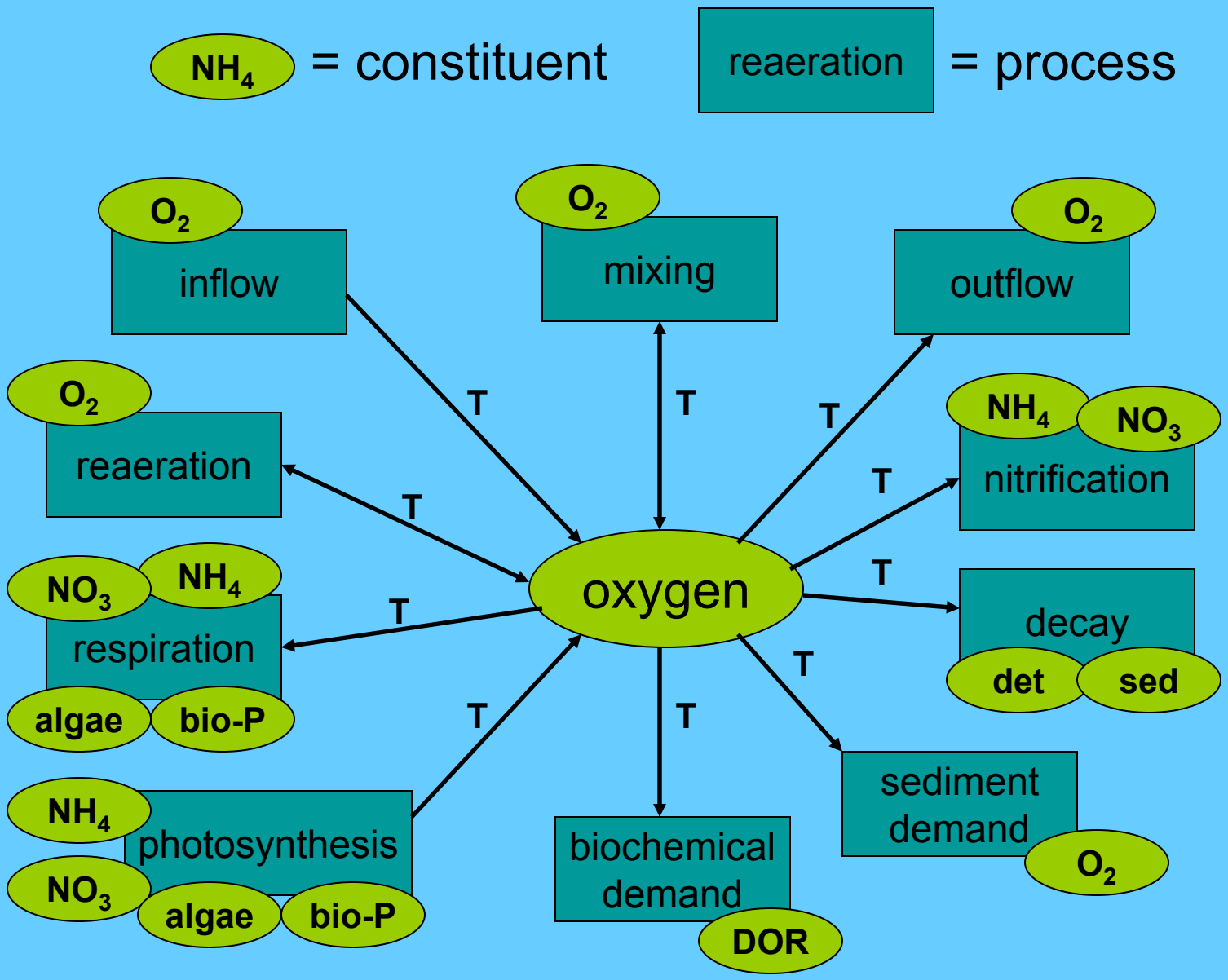
CE-QUAL-W2 Bathymetry for the Main Branch (Branch 1) of Lake Murray



Physical processes



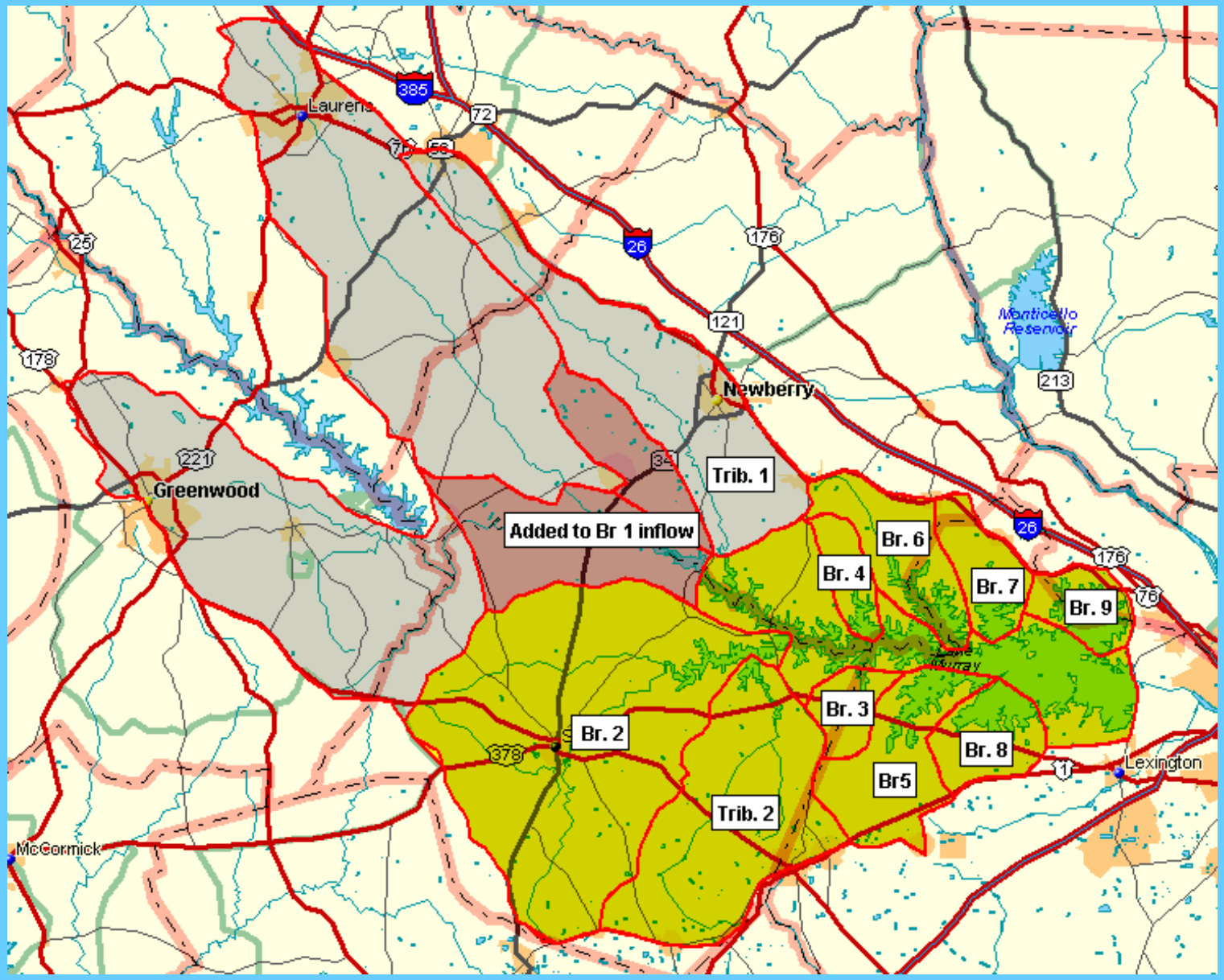
Highly coupled constituents



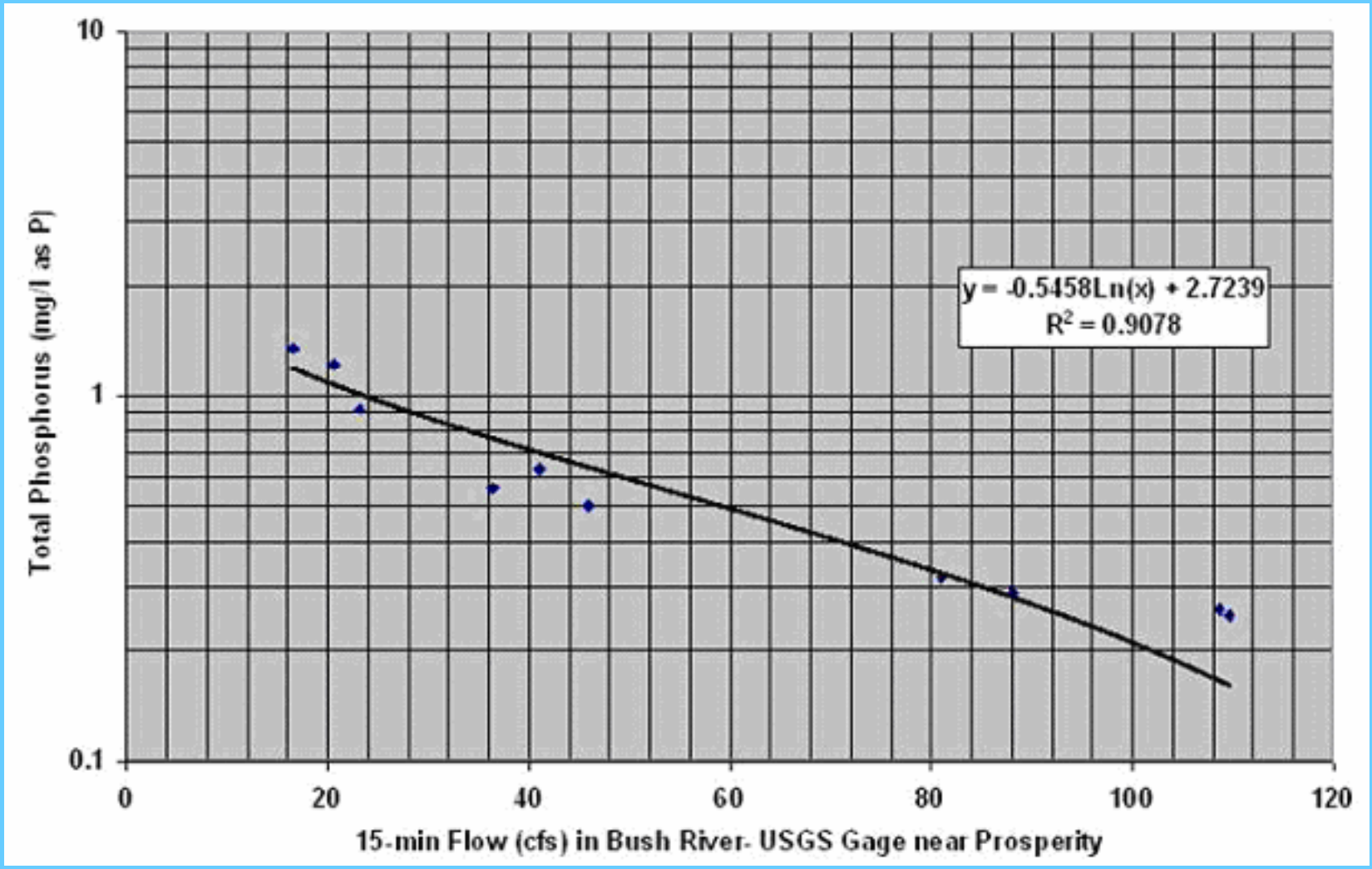
Model Upgrade Features

- Increased calibration focus at station located 6 Km (~ 4mi) upstream from the dam (for fish habitat issues)
- Refined withdrawal zone for Unit 5 (for fish habitat issues and DO in the releases)
- Sensitivity to TP in Saluda River inflow to Lake Murray
- Upgraded features for organic matter (labile and refractory nutrient cycling, sediment releases)
- Phosphorus settling
- Wuest wind drag coefficient to allow more mixing at low wind speeds

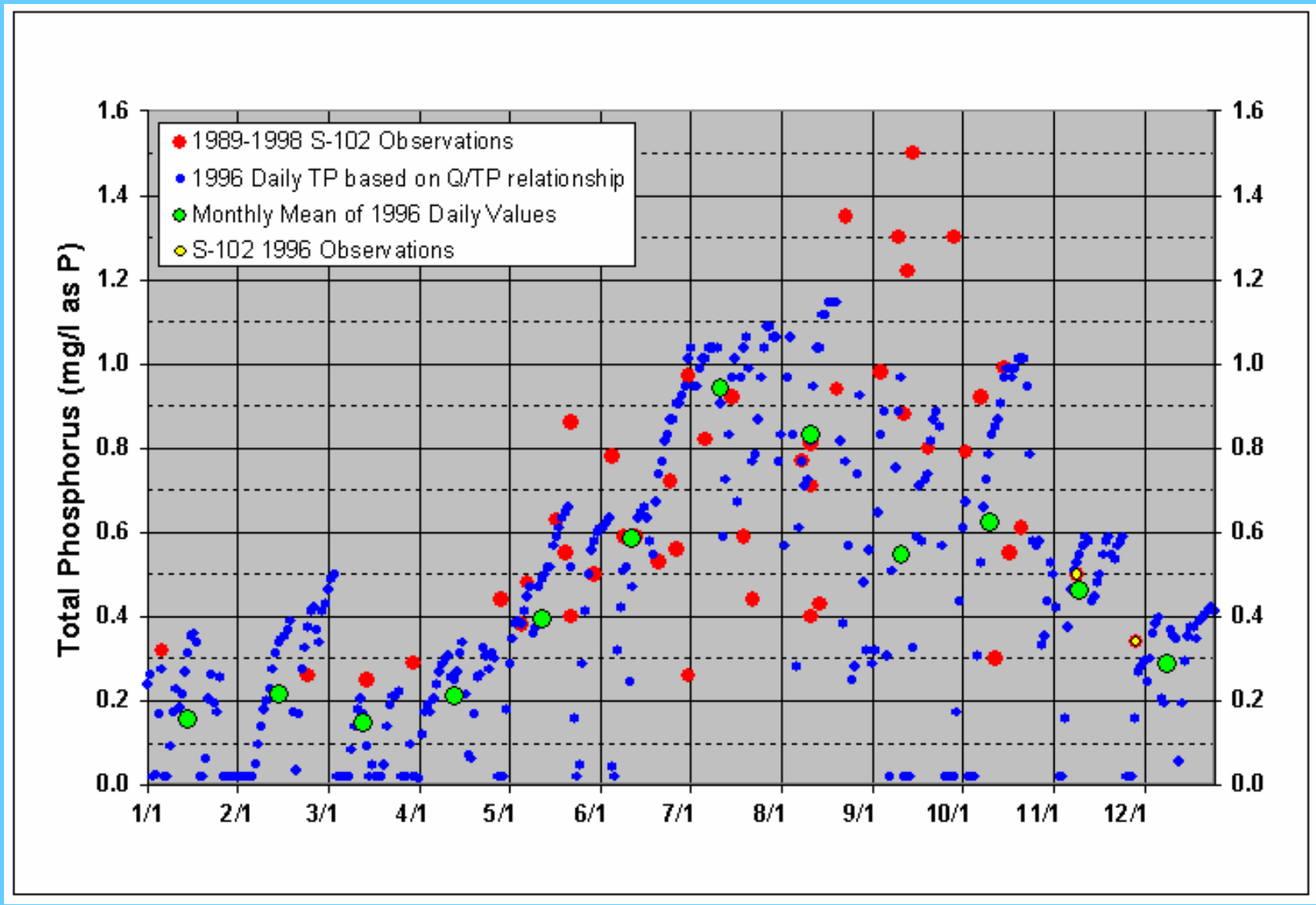
Map of Subwatershed Drainage Area Boundaries



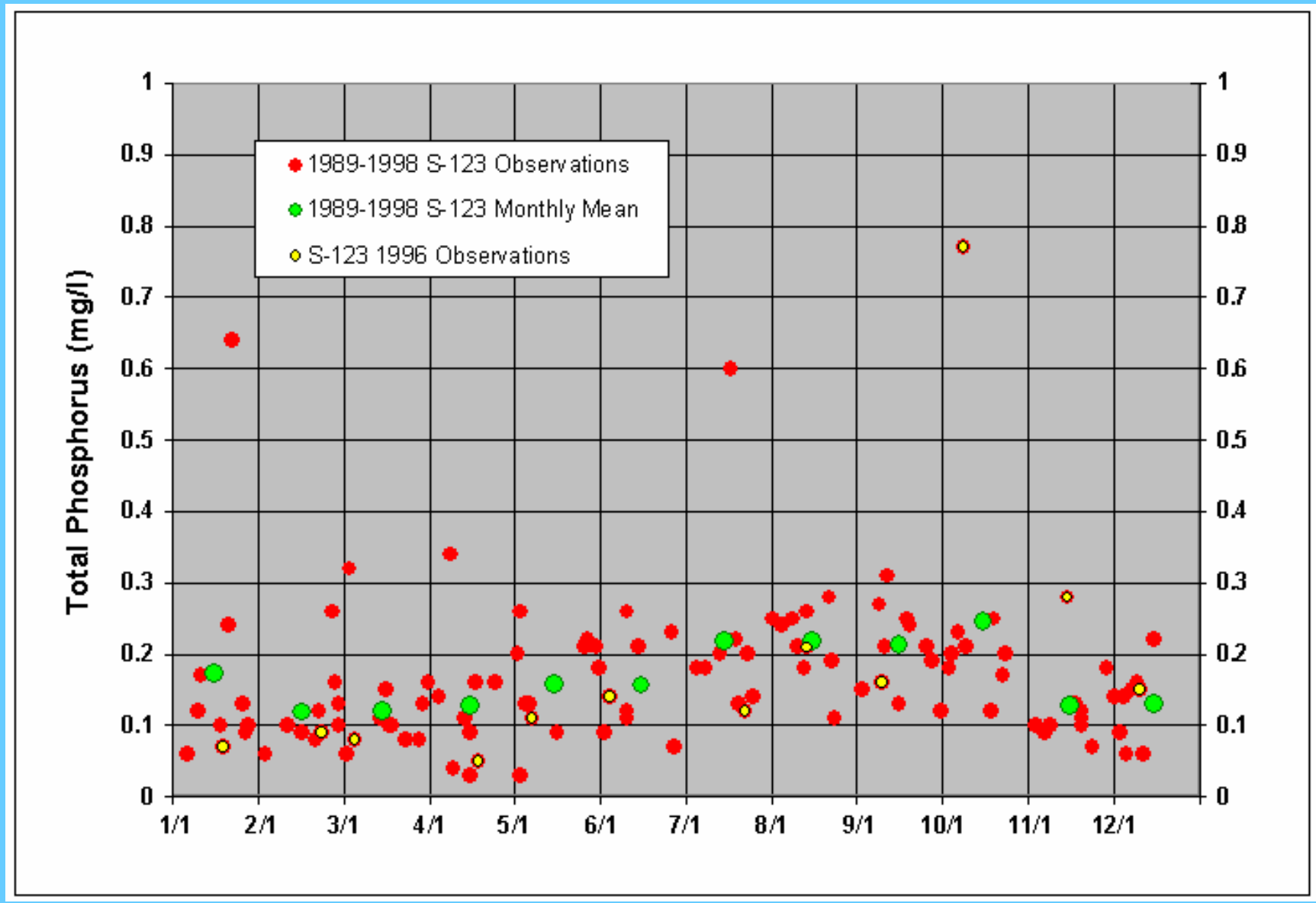
Phosphorus versus Flow Relationship found in the Bush River (Station S-102) using 1997 data



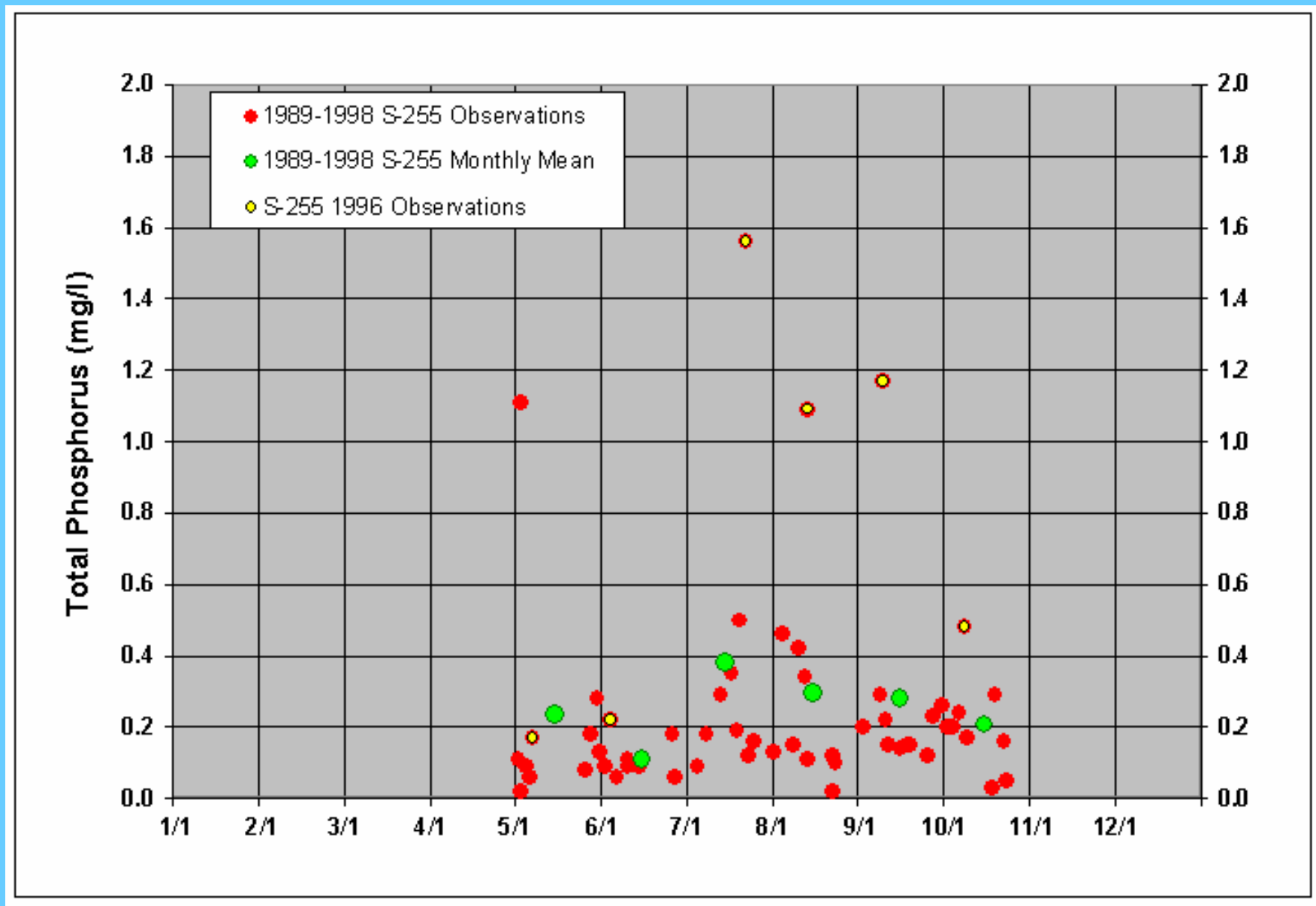
1996 Inflow Phosphorus Analysis for Bush River Inflow to Lake Murray



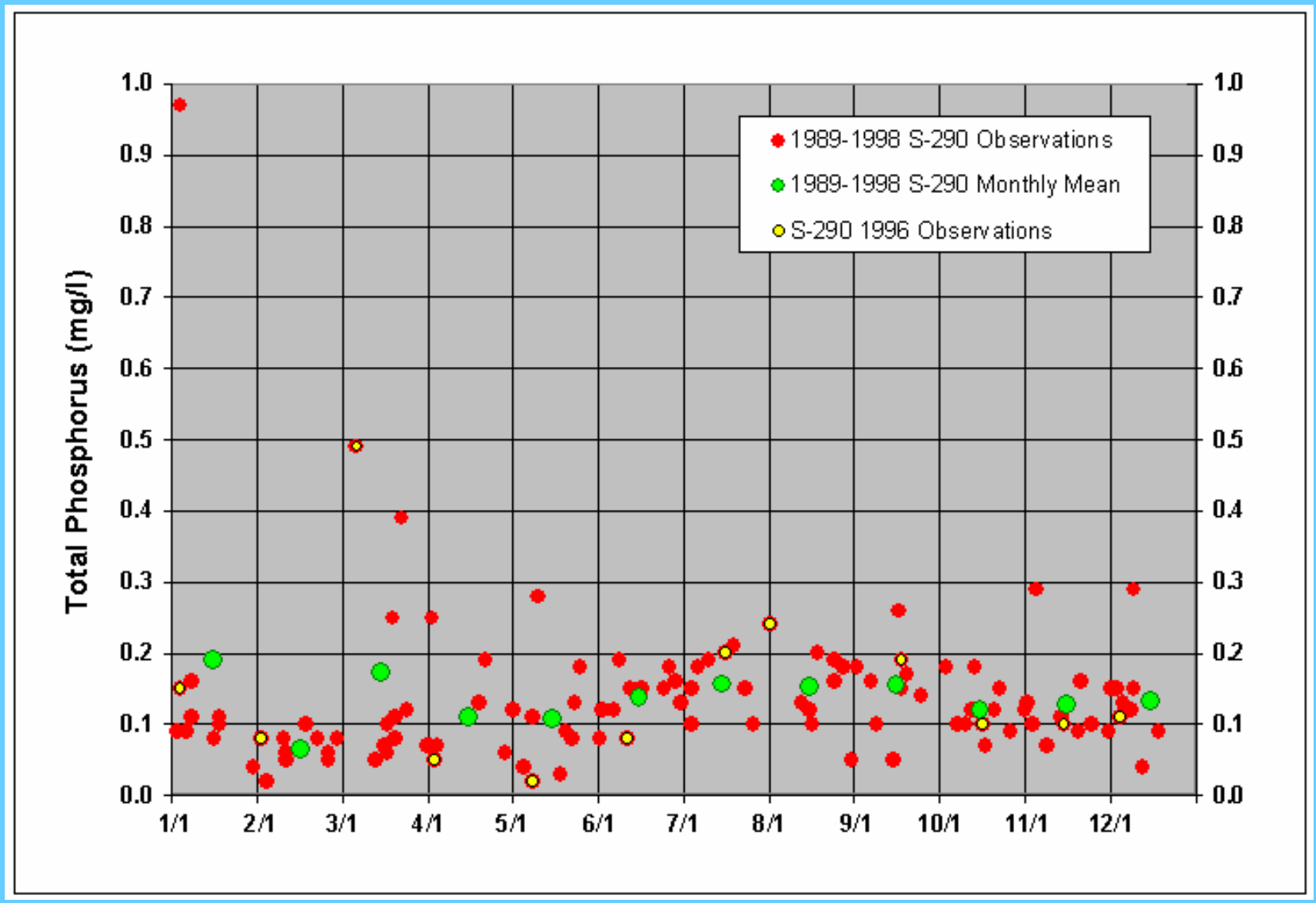
Total Phosphorus in the Little Saluda River



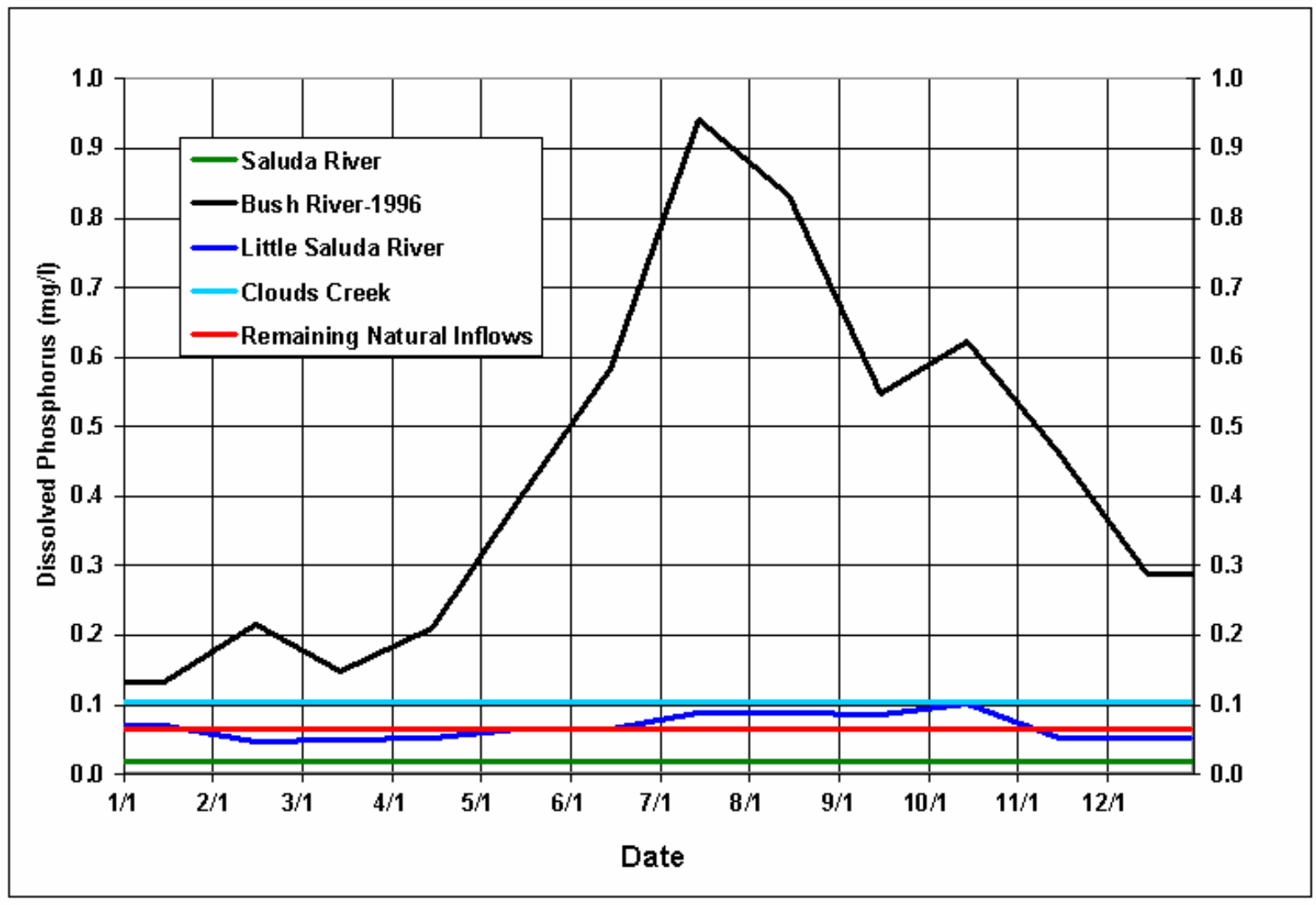
Total Phosphorus Clouds Creek



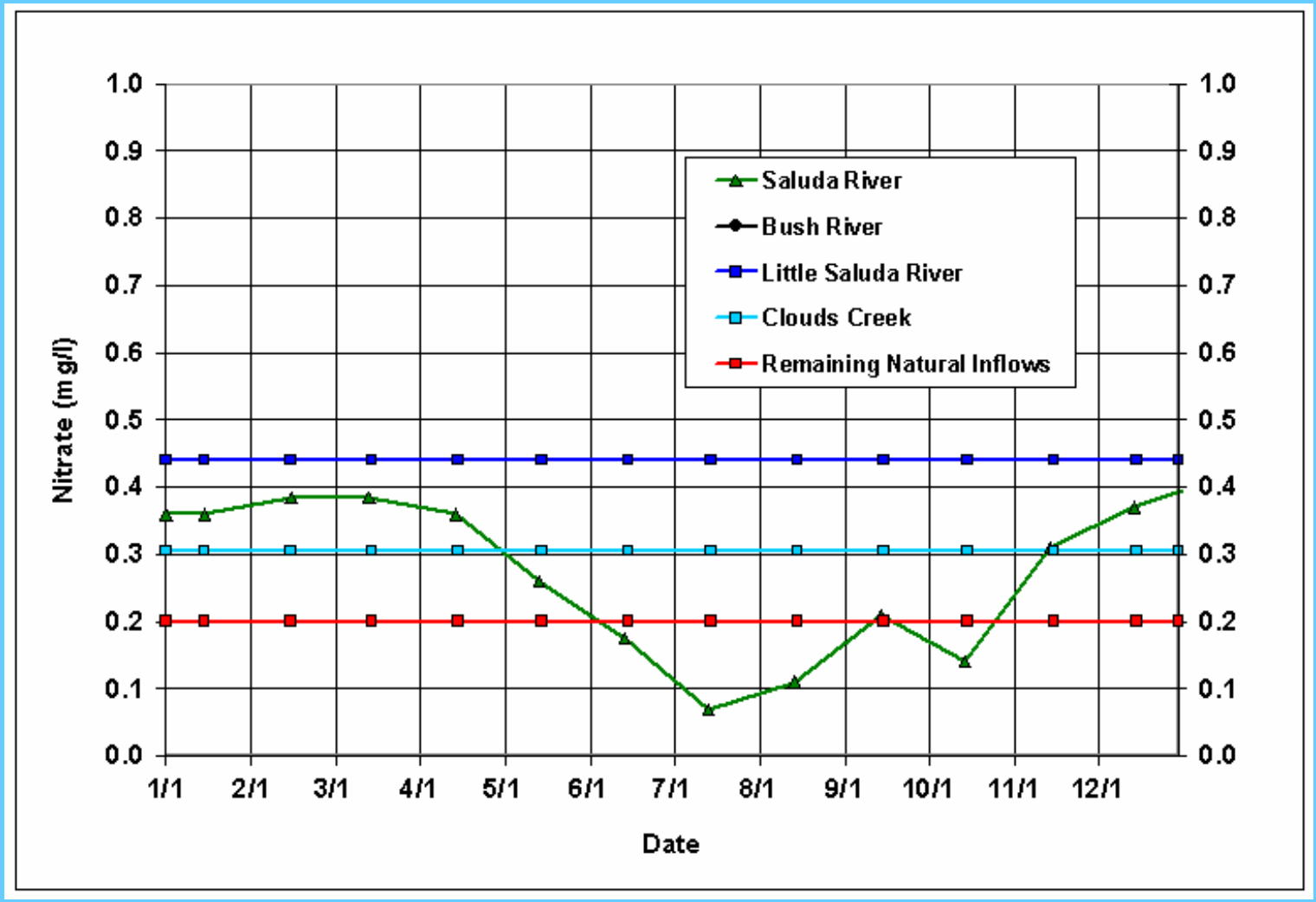
Total Phosphorus in Camping Creek



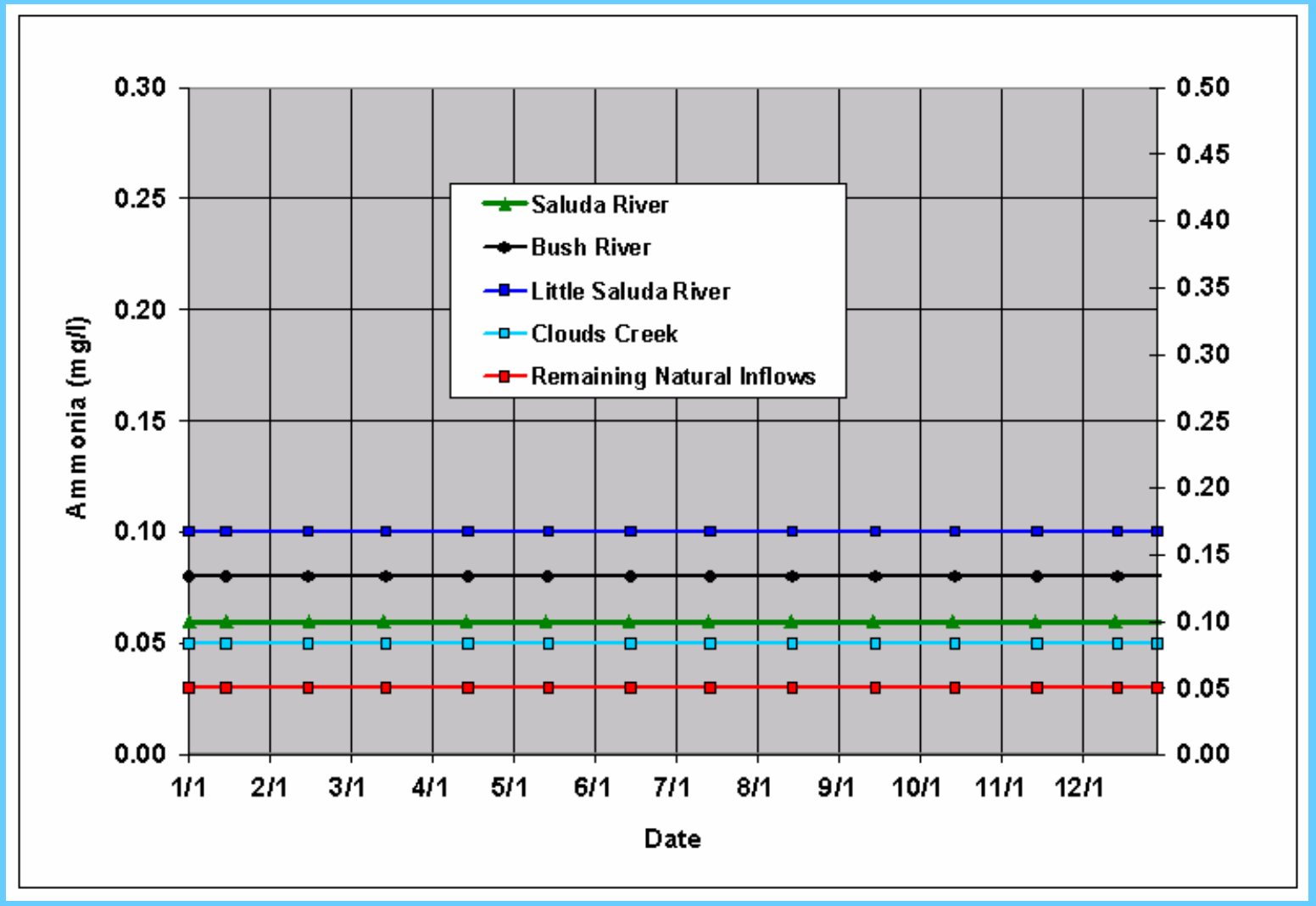
Inflow Dissolved Phosphorus Concentrations for Model Inflows to Lake Murray



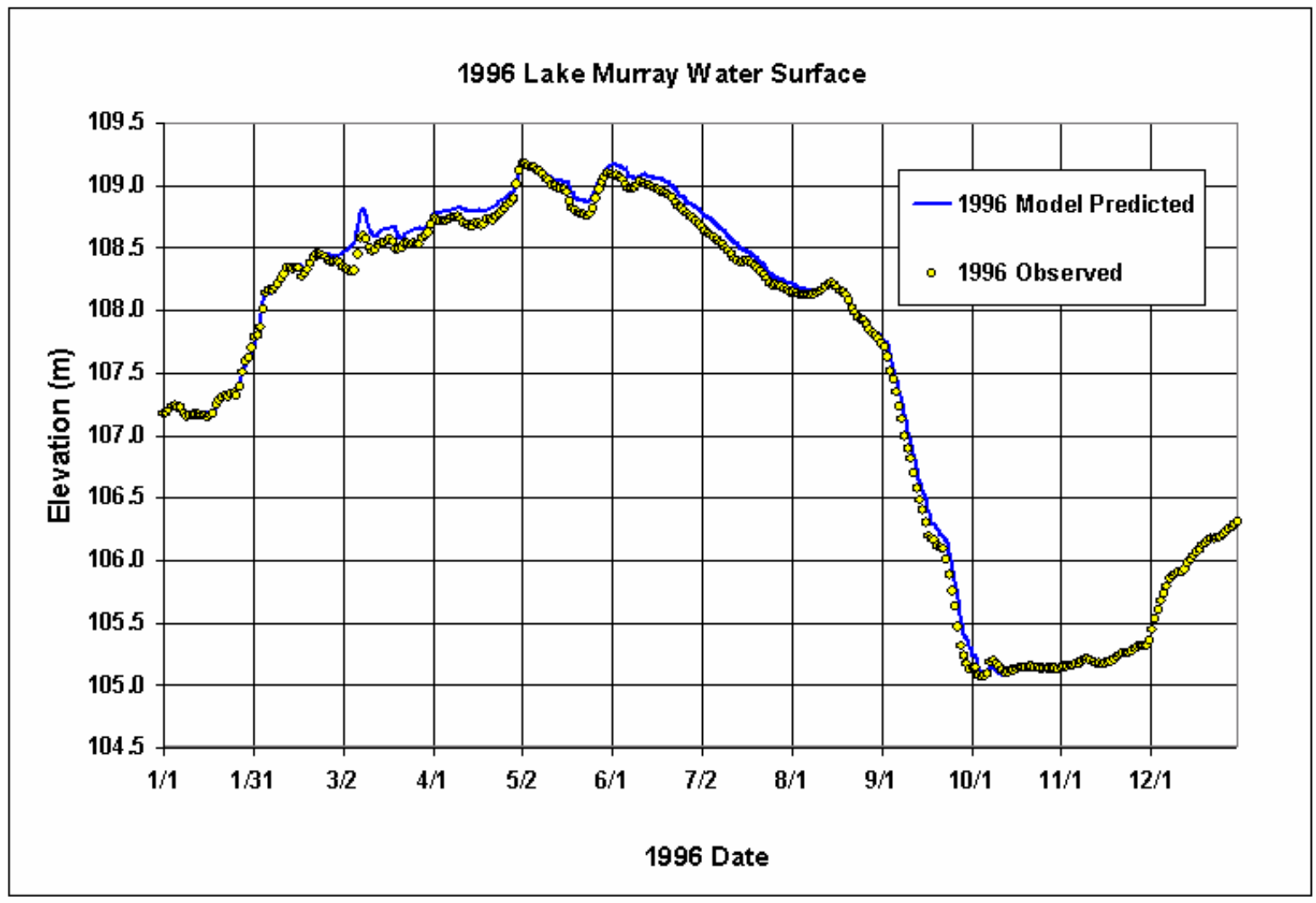
Nitrate Concentrations in the Inflows to the Lake Murray CE-QUAL-W2 Model



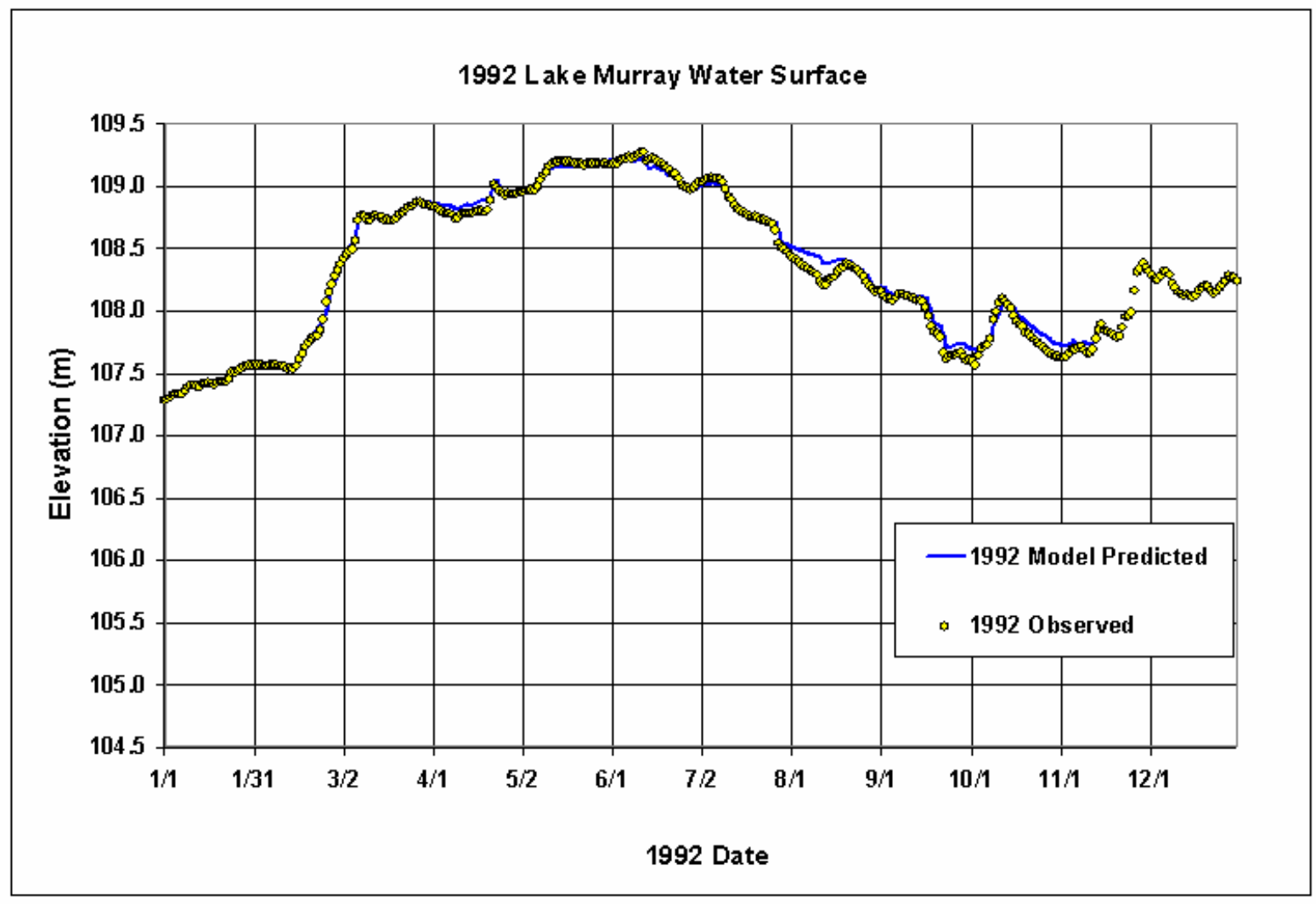
Ammonium Concentrations in the Inflows to the Lake Murray CE-QUAL-W2 Model



1996 Modeled and Measured Lake Murray Headwater Elevations



1992 Modeled and Measured Lake Murray Headwater Elevations



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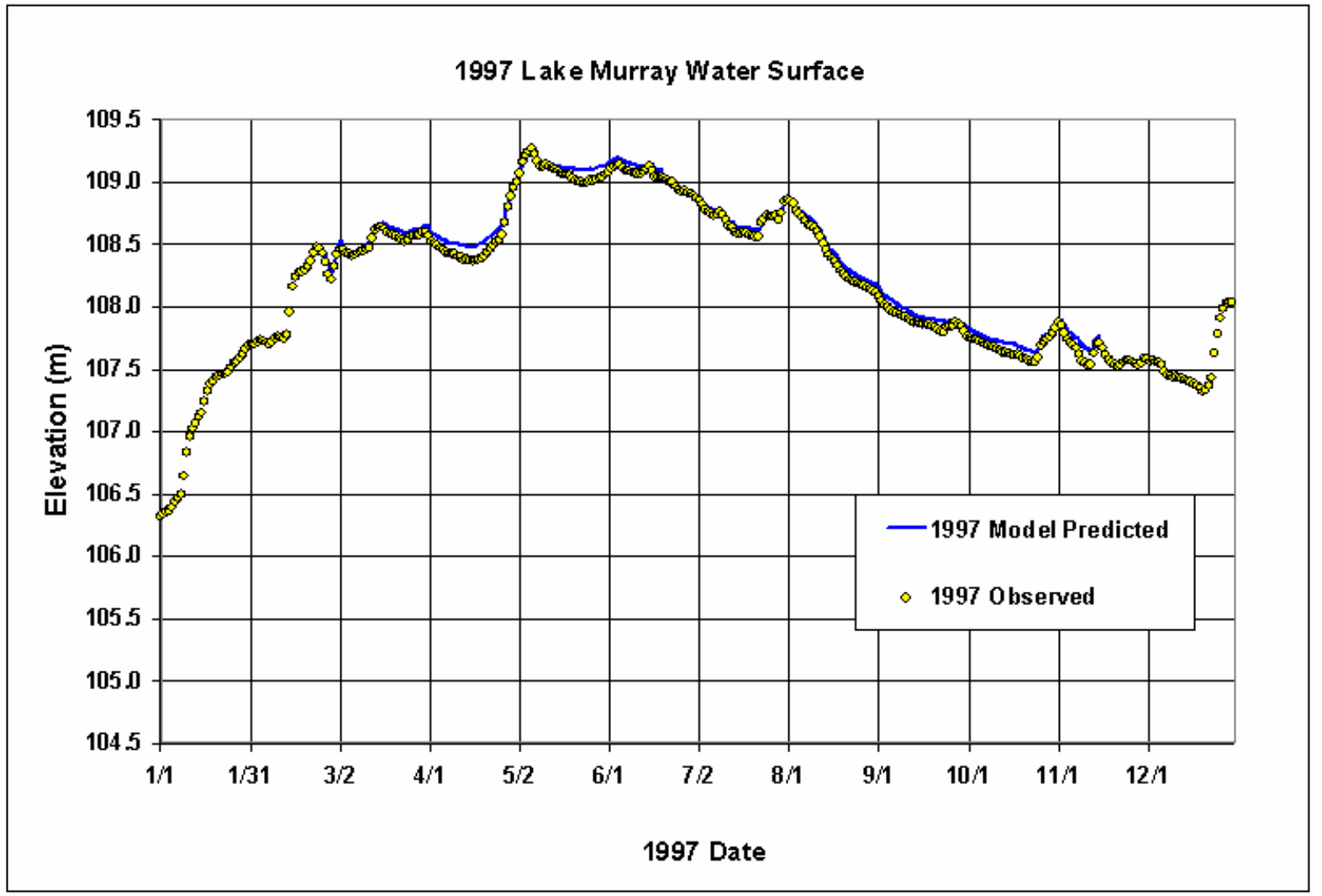
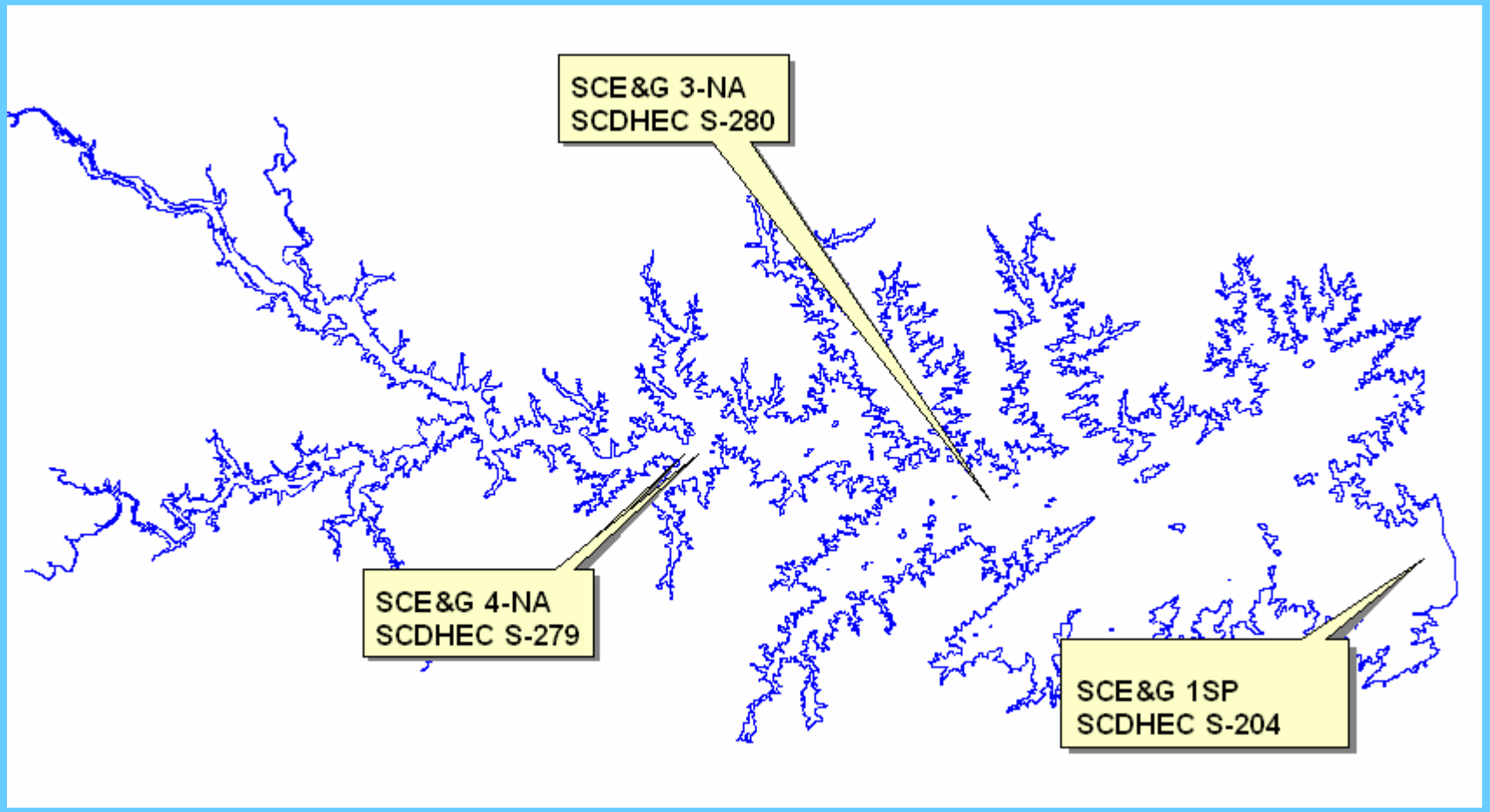
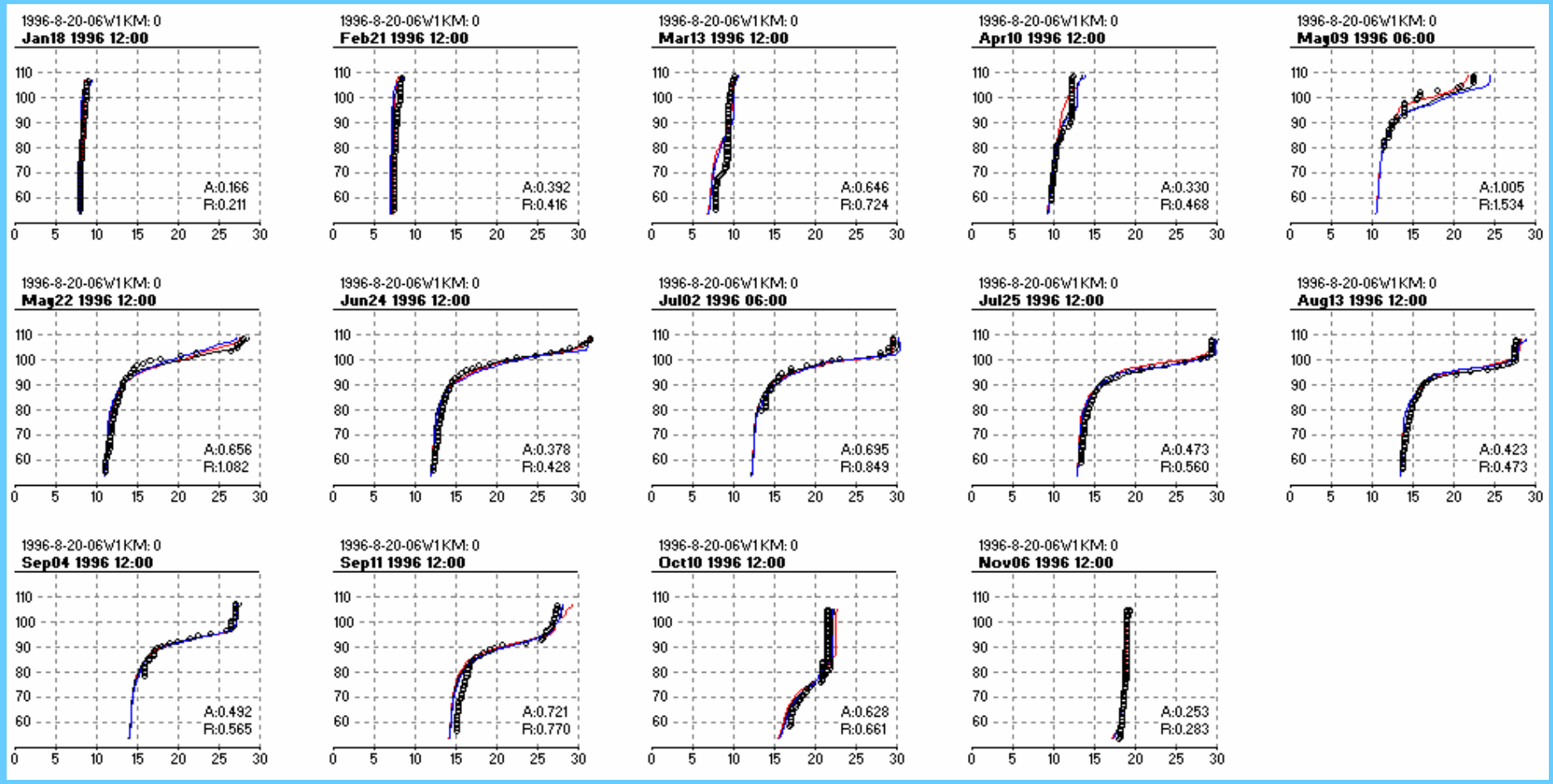


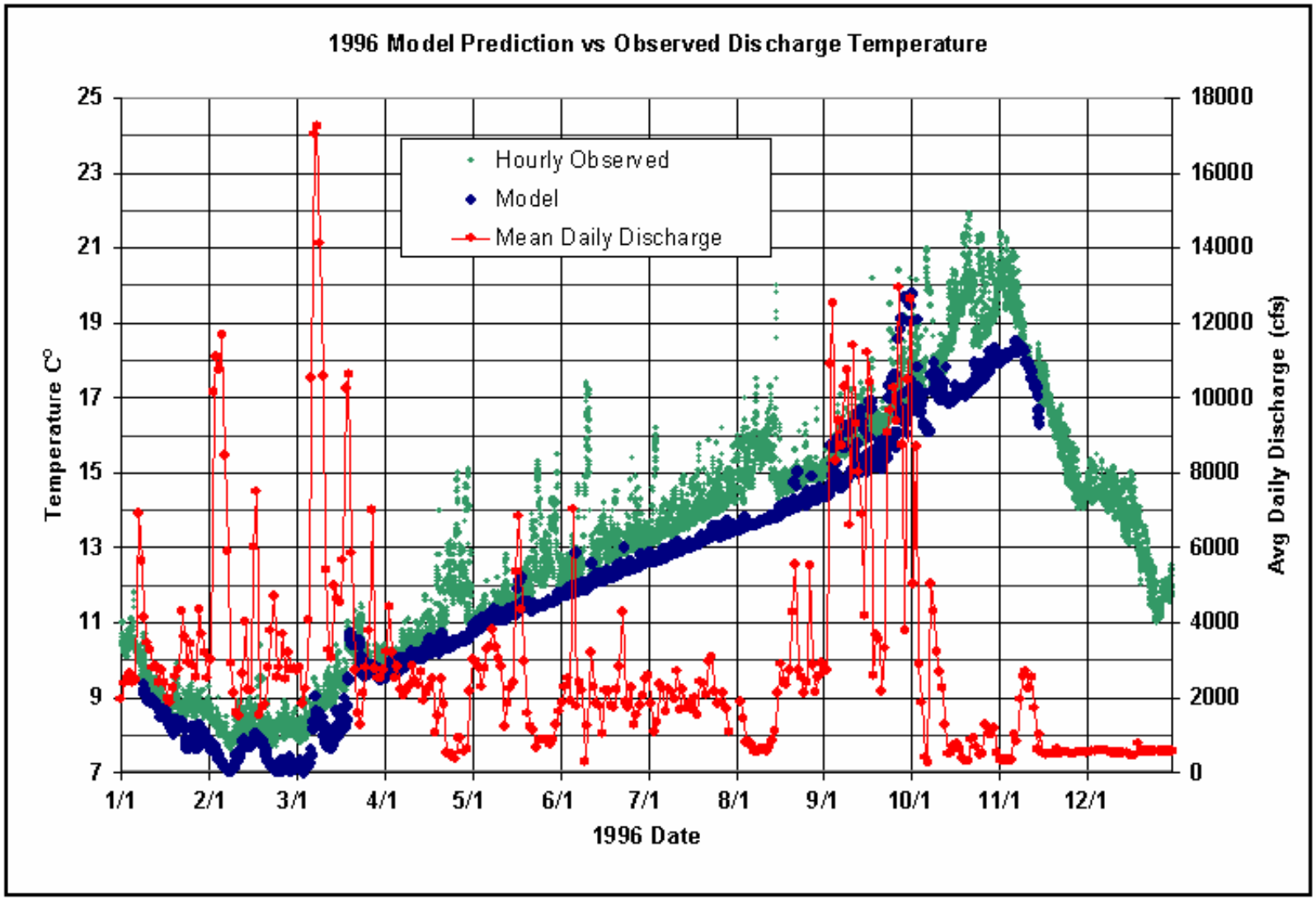
Primary Water Quality Calibration Locations



1996 Lake Murray Forebay Temperature Profiles
Model vs. Data



1996 Comparison of Modeled versus Measured Saluda Release Temperatures



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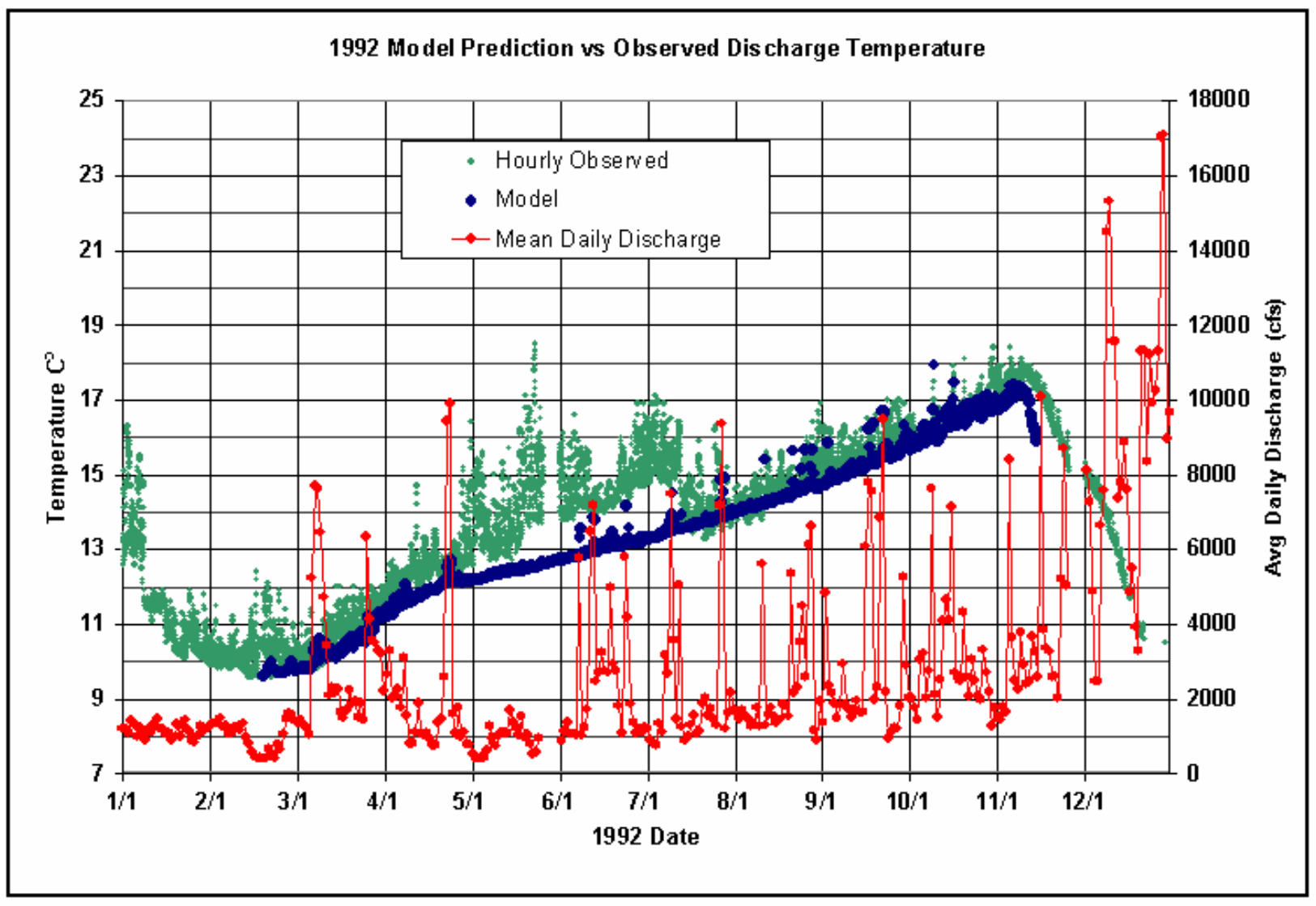

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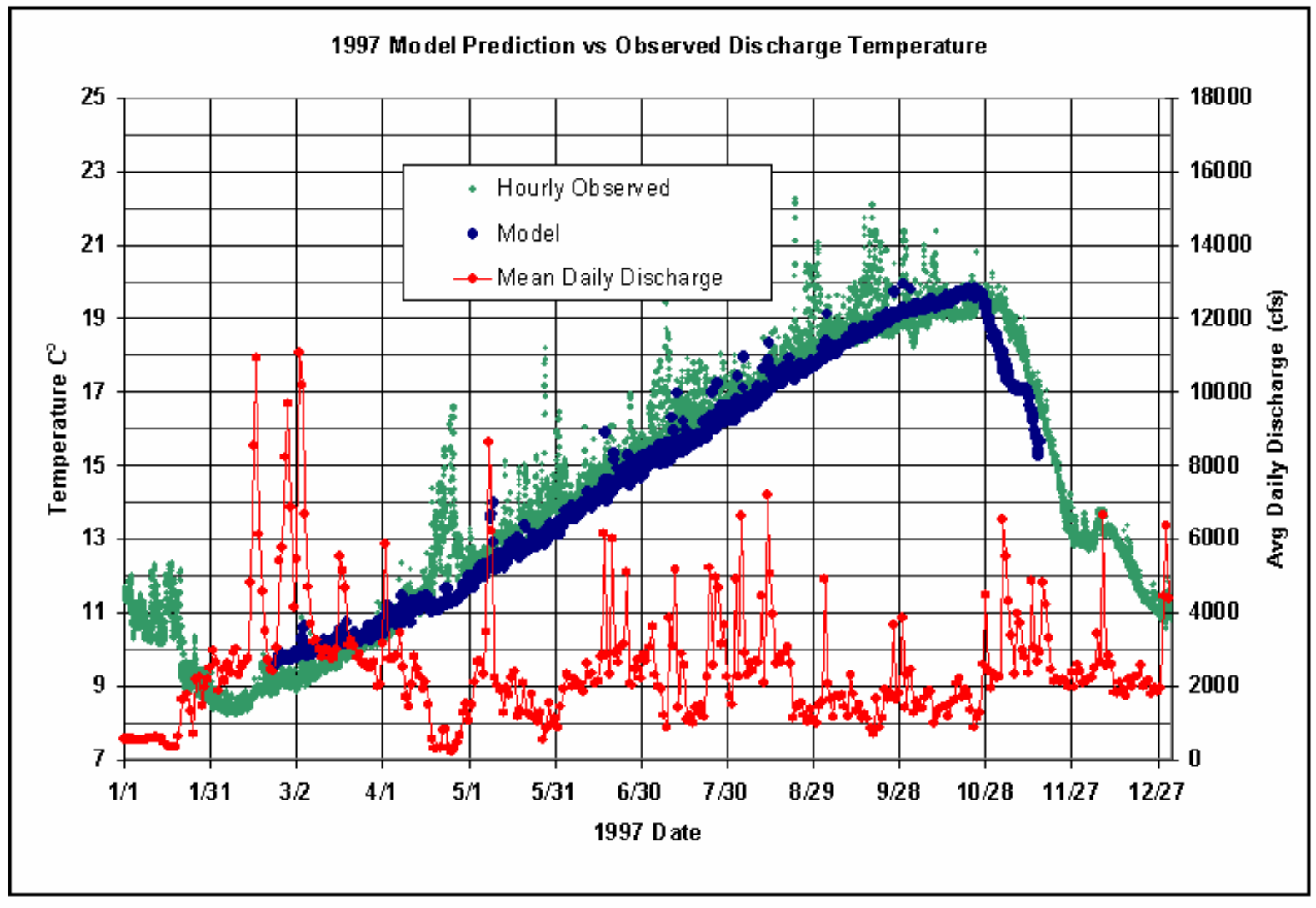
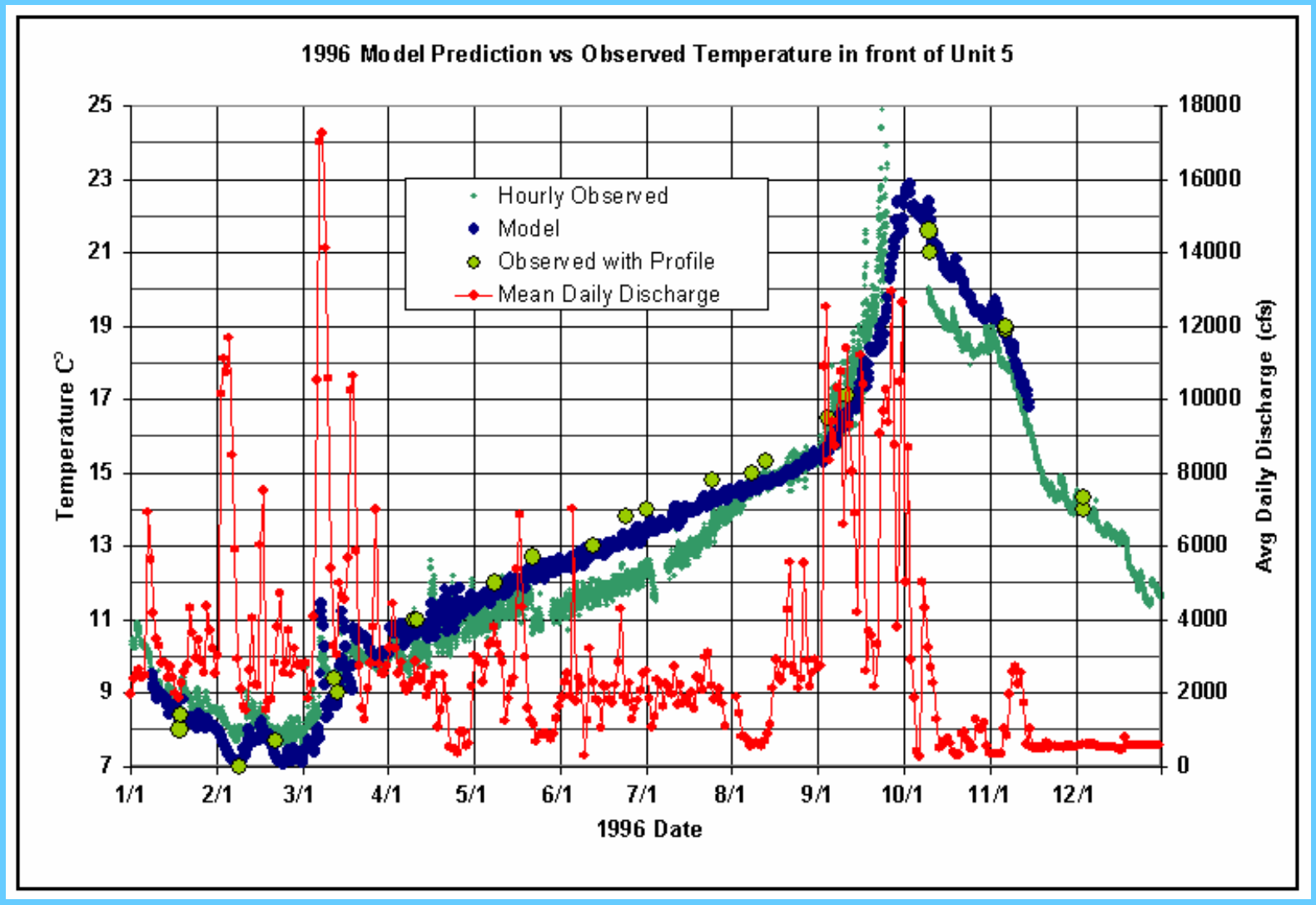


1996 Comparison of Modeled versus Measured Temperature in Front of the Unit 5 Intake



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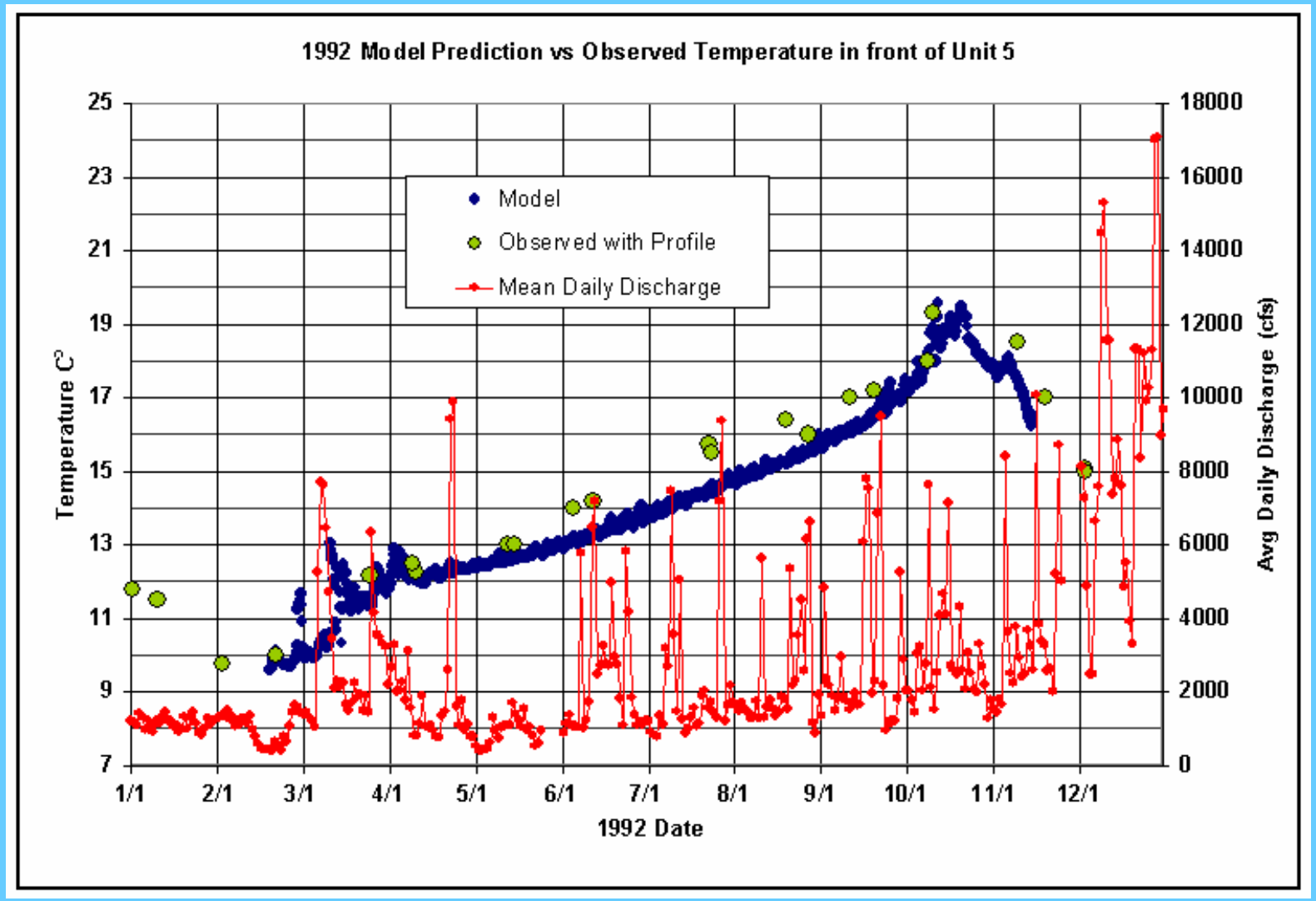

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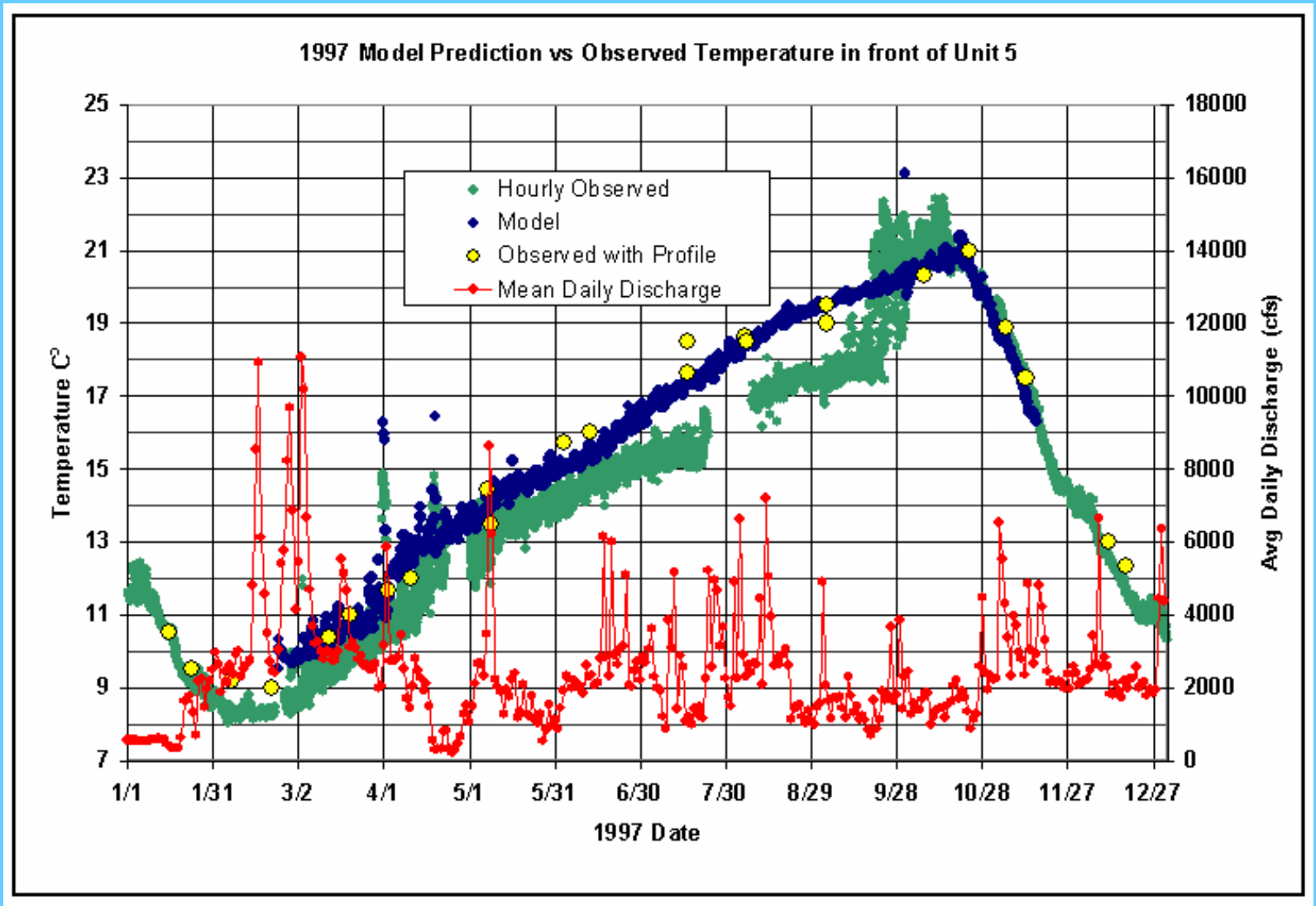
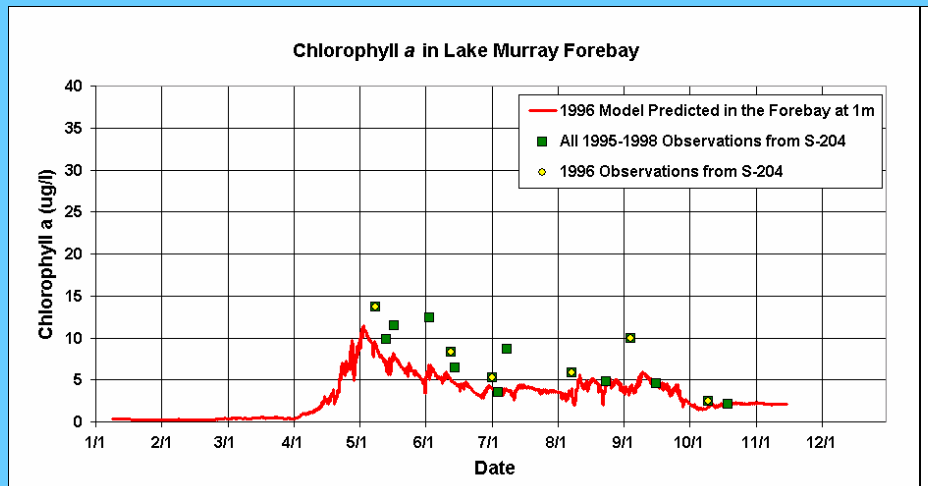
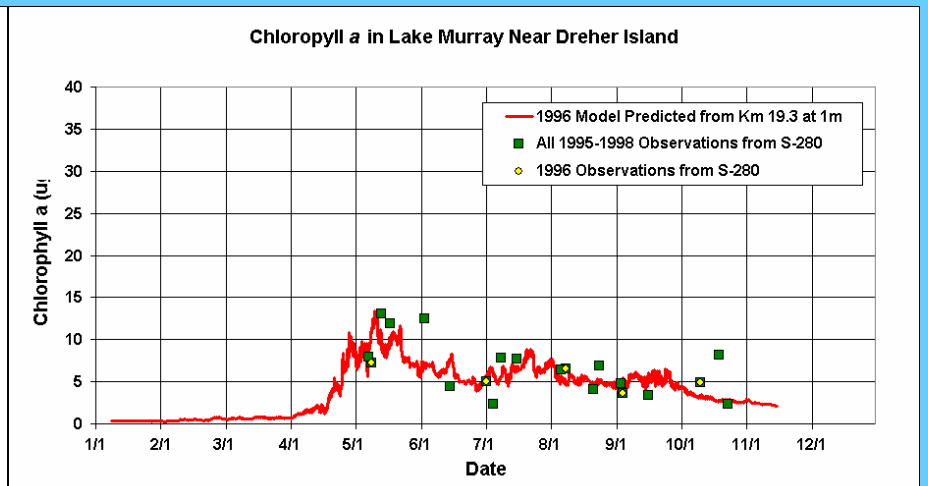
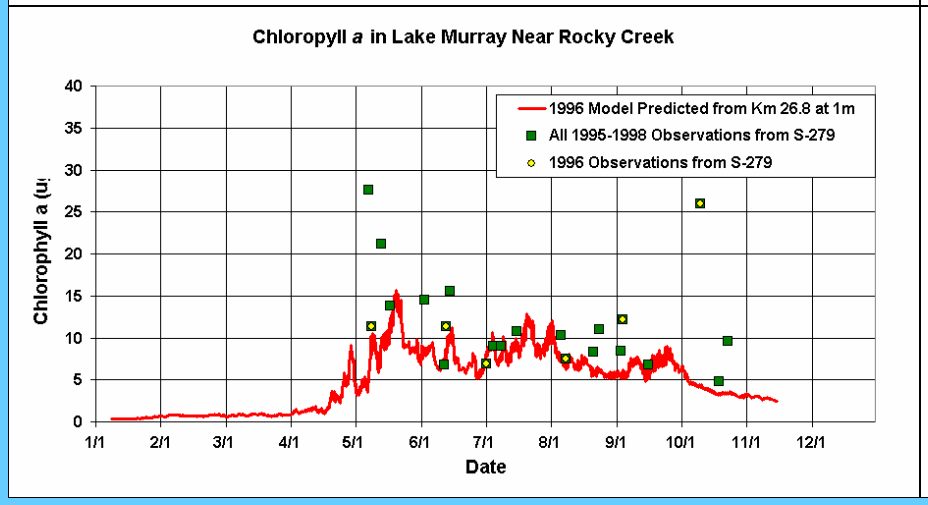
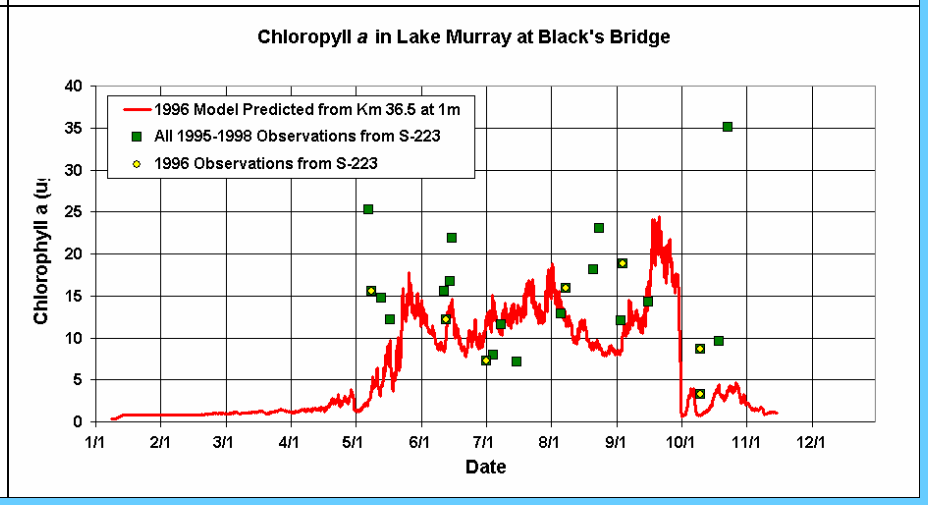


1996 Chlorophyll *a* at Four Locations in Lake Murray Model vs. Data

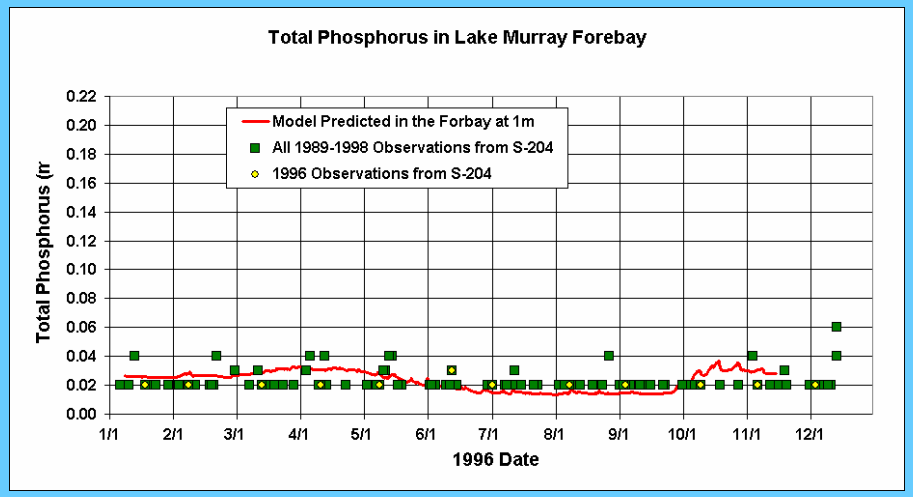


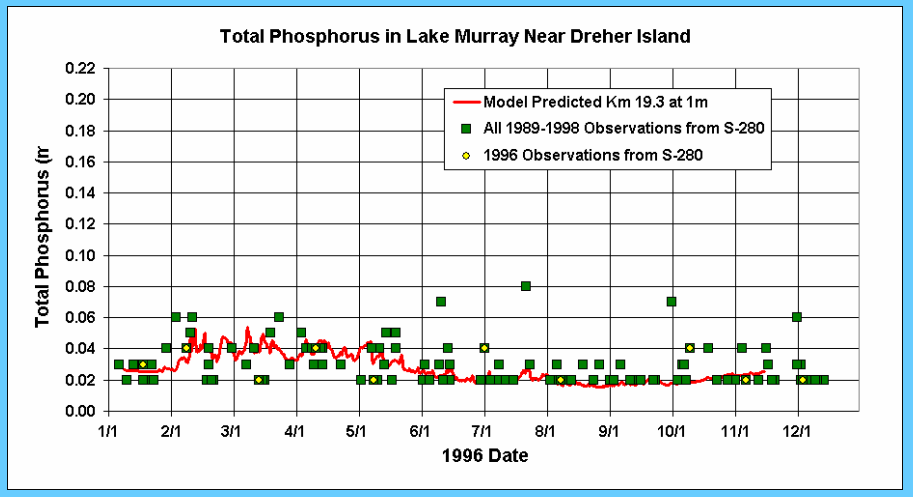


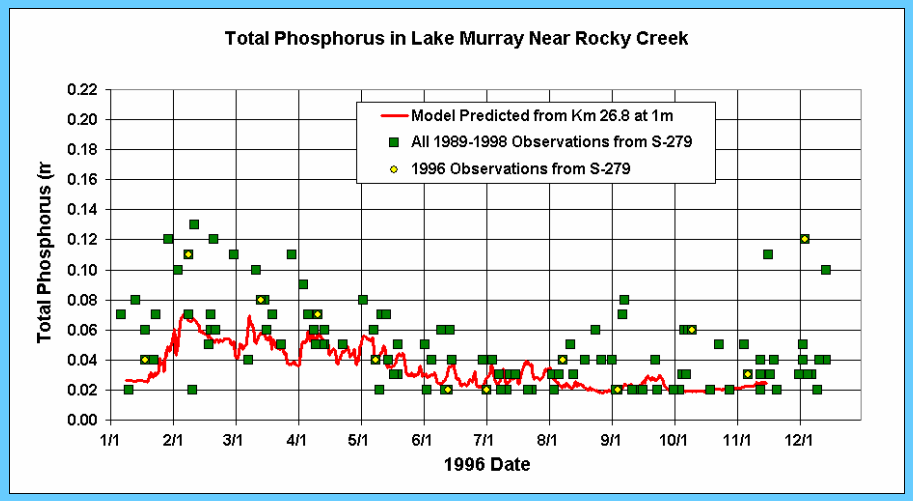


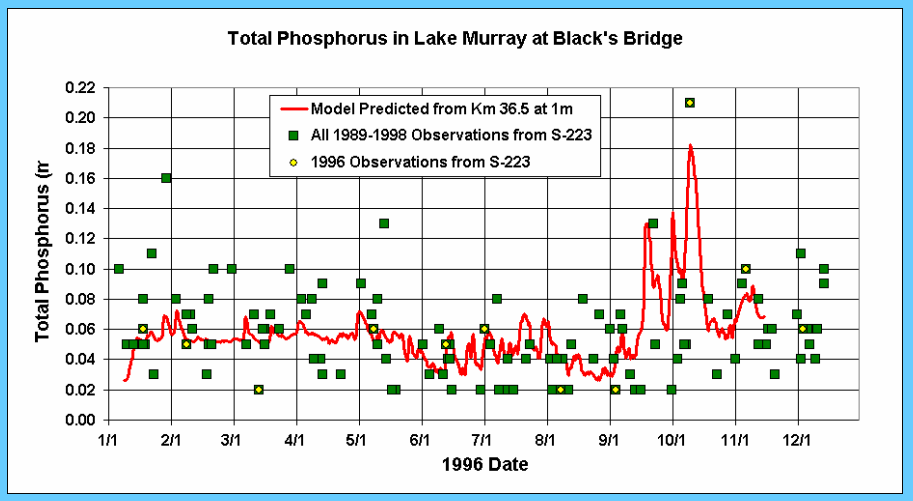


Comparison of Modeled Derived versus Measured Total Phosphorus for 1996 at Four Locations in Lake Murray

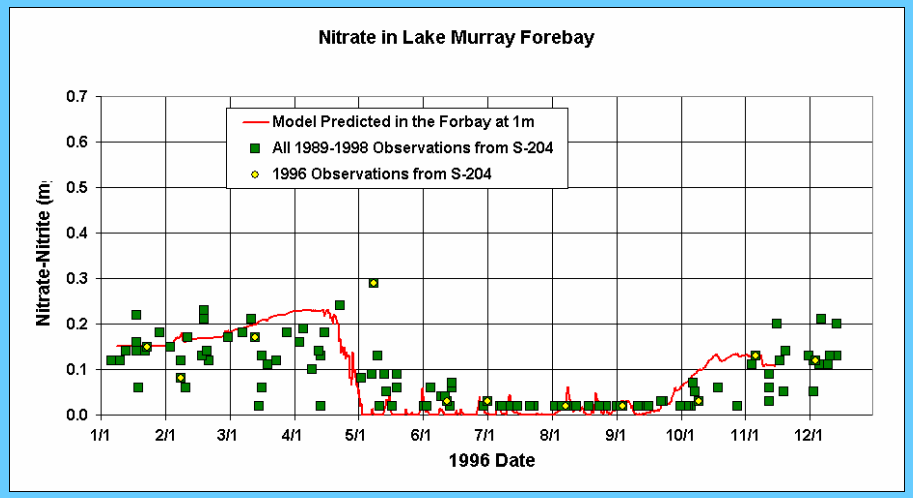


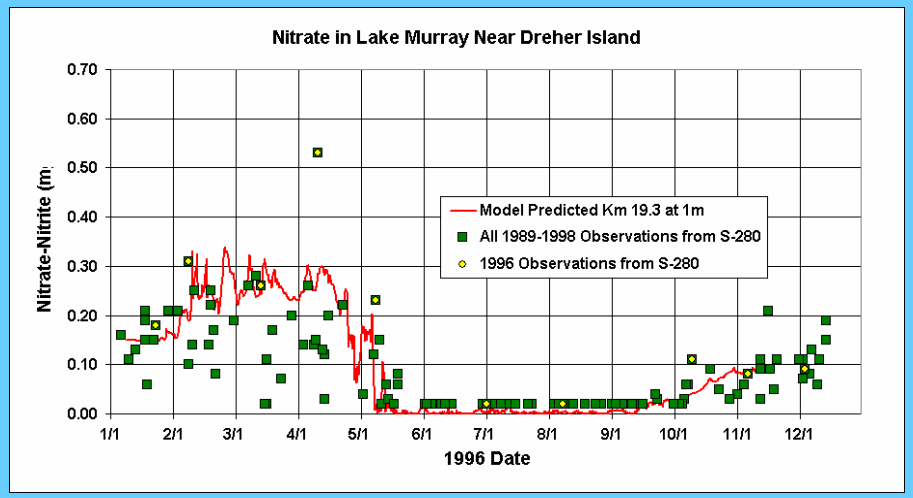


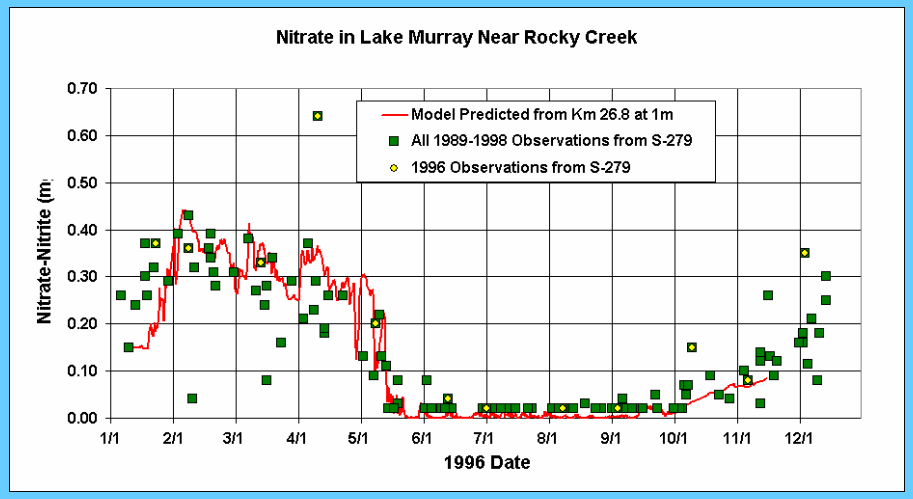


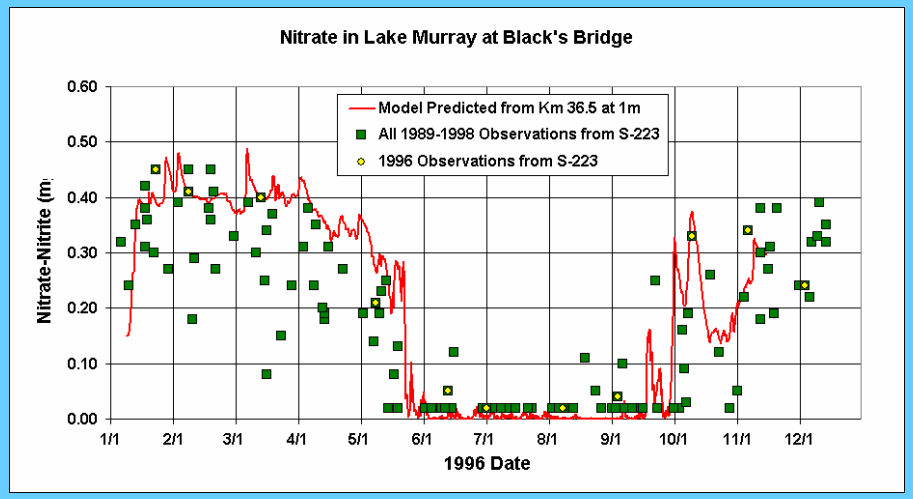


Comparison of Modeled versus Measured Nitrate for 1996 at Four Locations in Lake Murray

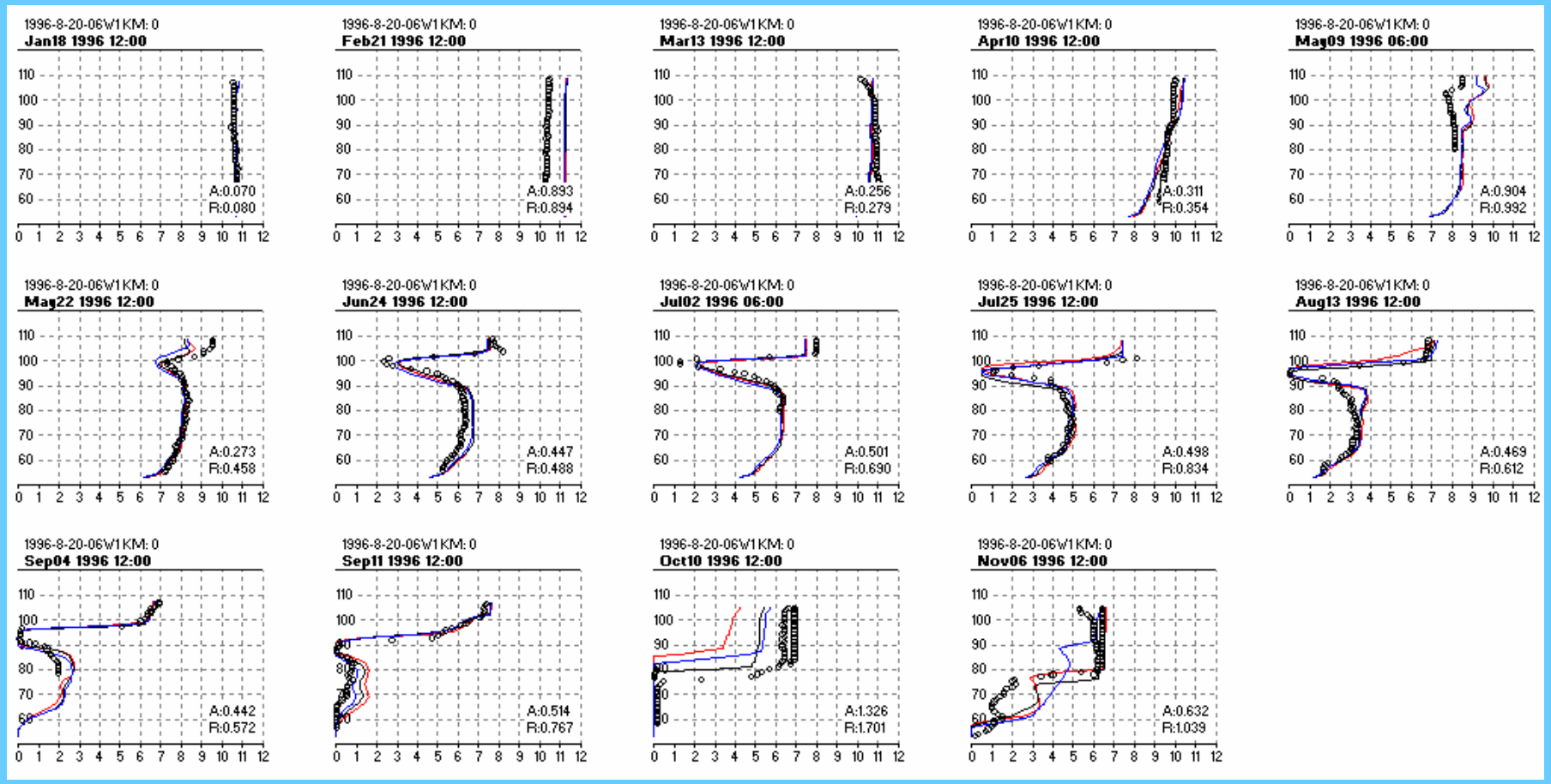




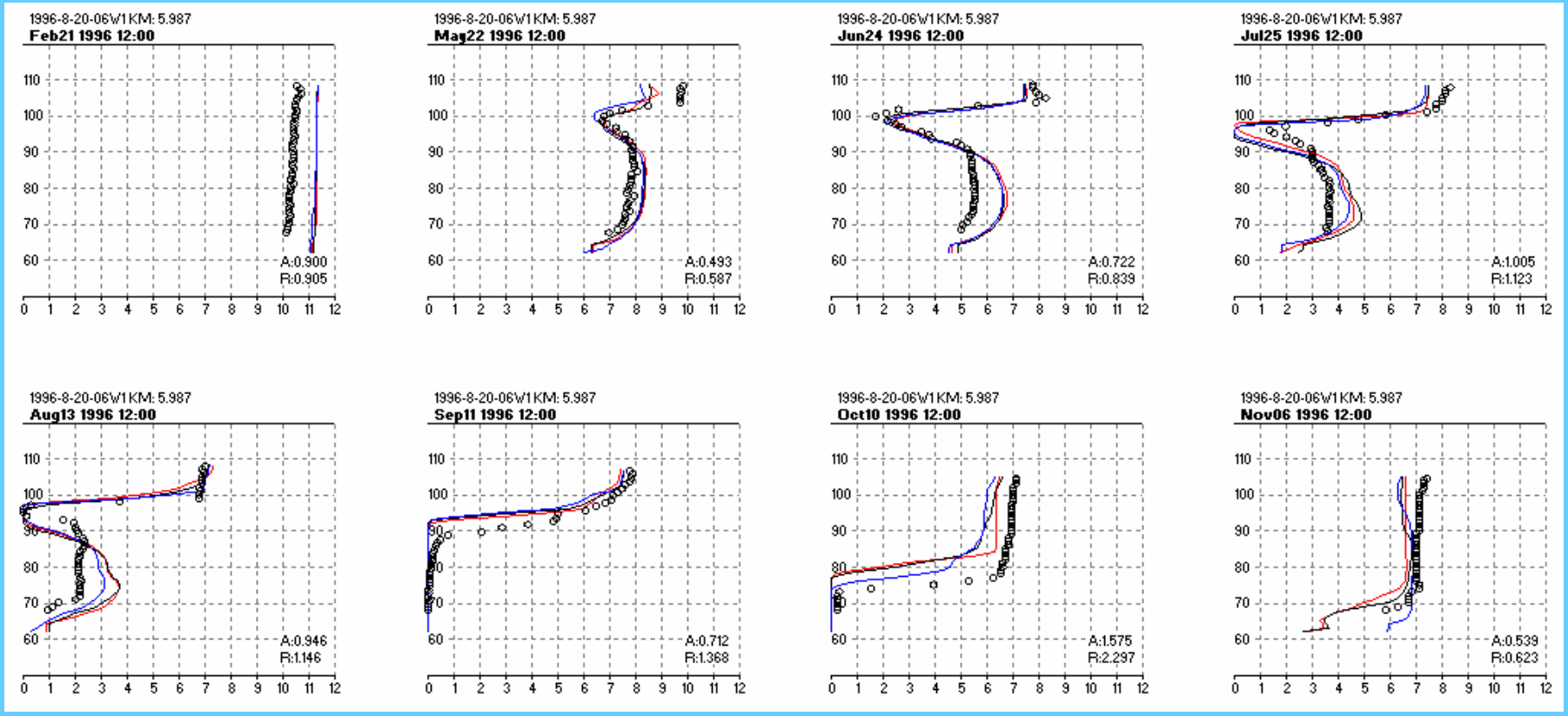




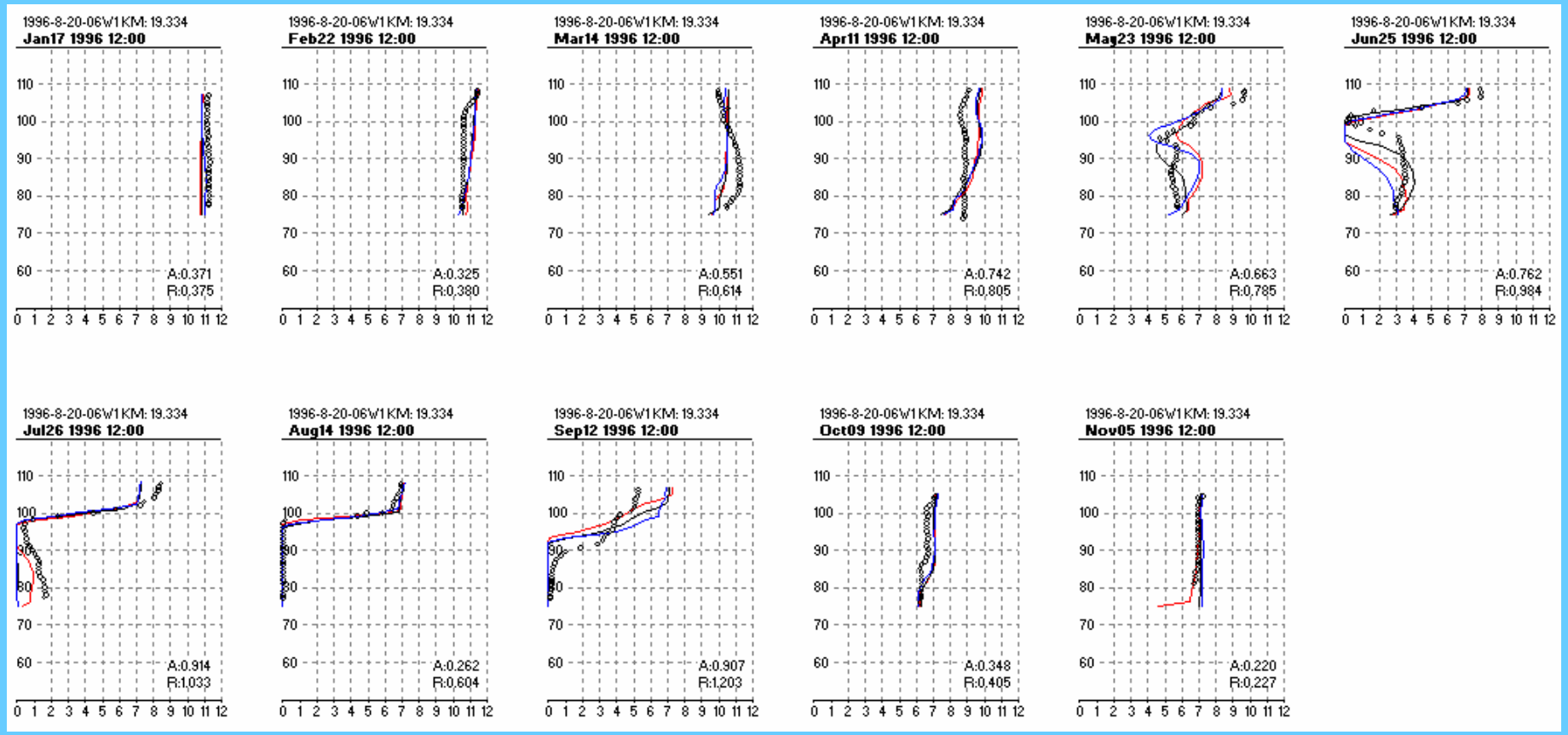
1996 Lake Murray Forebay DO Profiles
Model vs. Data



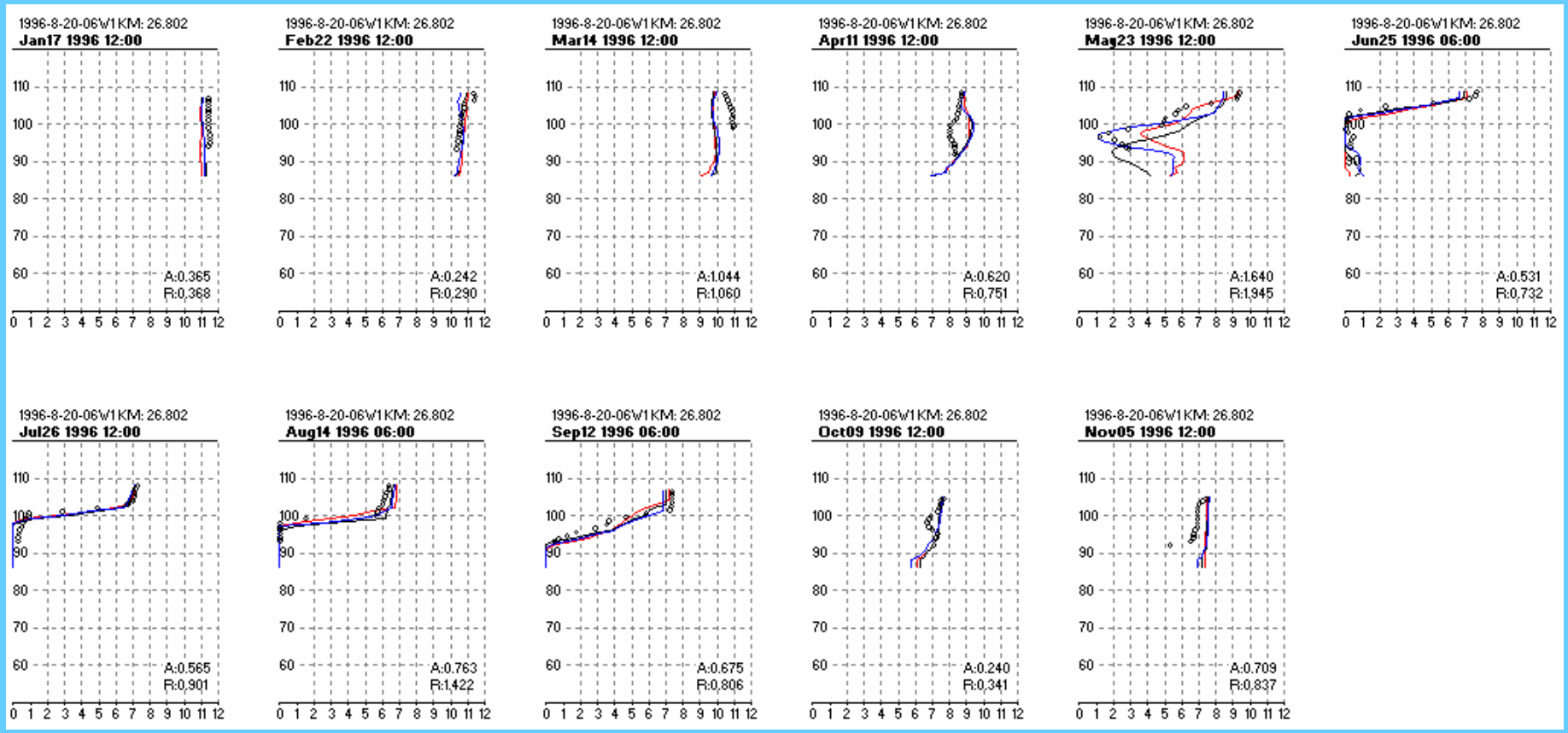
1996 Lake Murray DO Profiles – 6 Km Upstream of Dam Model vs. Data



1996 Lake Murray DO Profiles – 19 Km Upstream of Dam
Model vs. Data



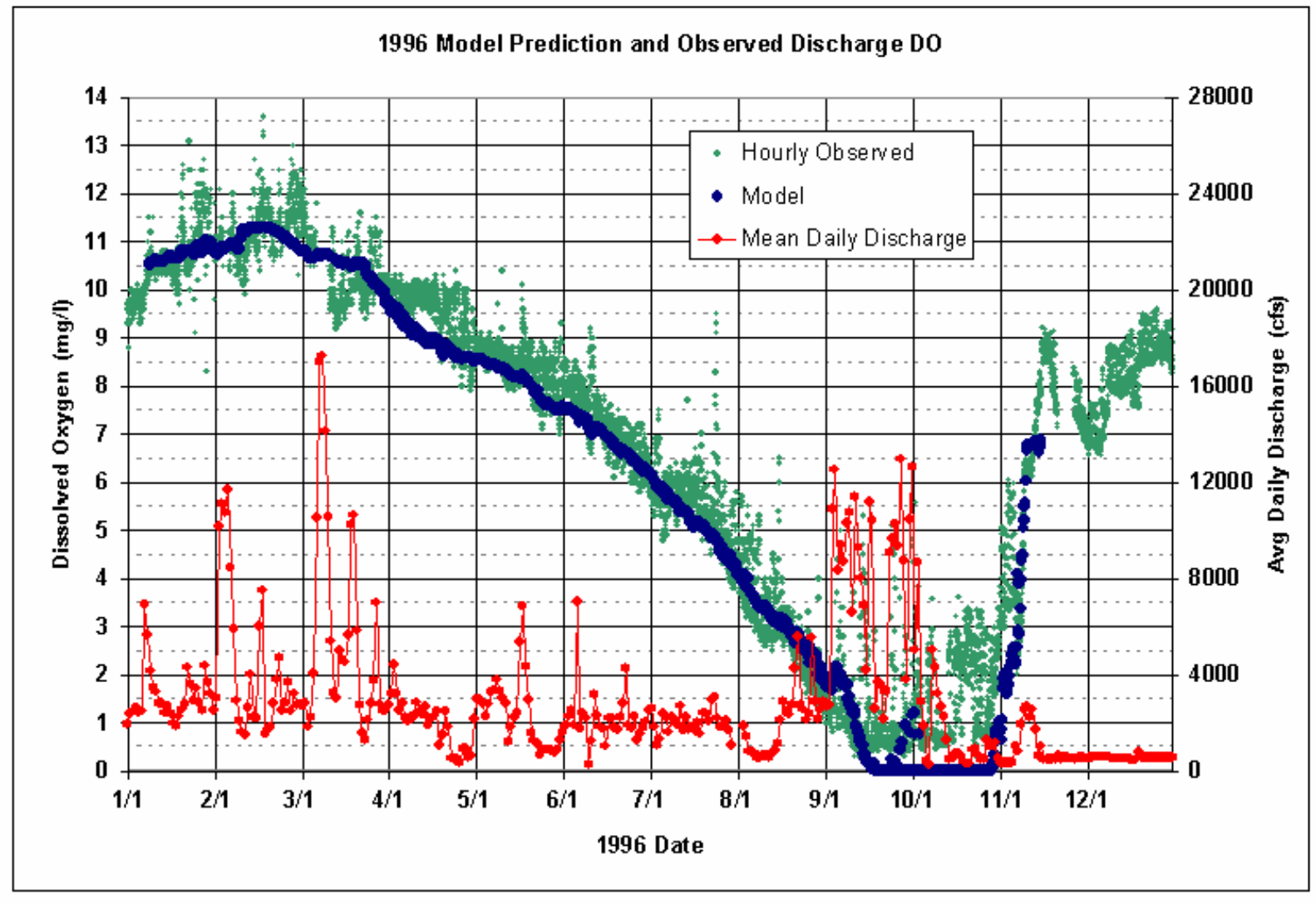
1996 Lake Murray DO Profiles – 27 Km Upstream of Dam
Model vs. Data



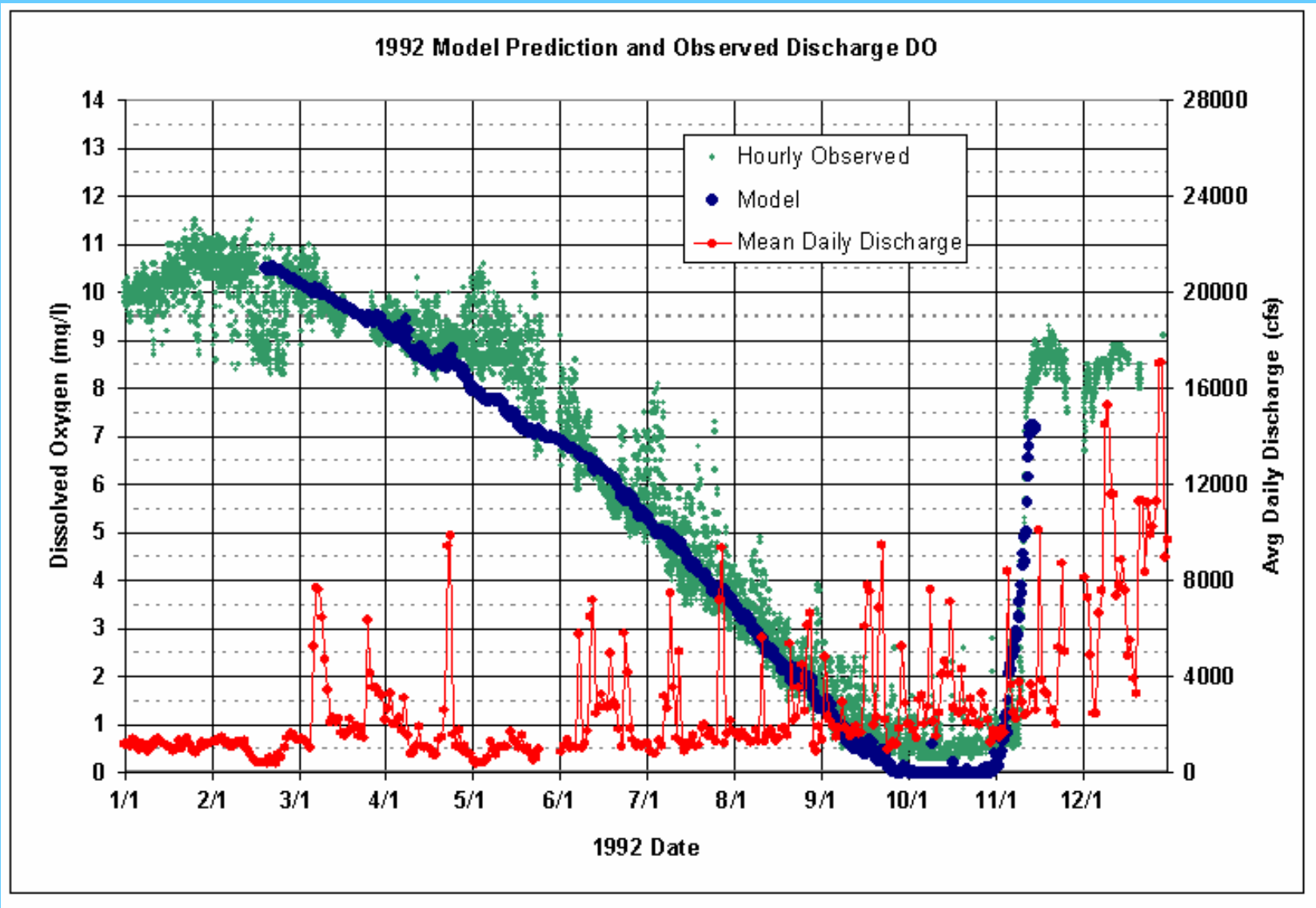
1996 Statistics

	Kilometers From Dam									
	0.0		6		19		27		Overall	
	AME	RMS	AME	RMS	AME	RMS	AME	RMS	AME	RMS
Temperature	0.49	0.67	0.57	0.80	0.63	0.84	0.94	1.28	0.66	0.90
DO	0.56	0.86	0.86	1.21	0.56	0.75	0.68	0.99	0.67	0.95

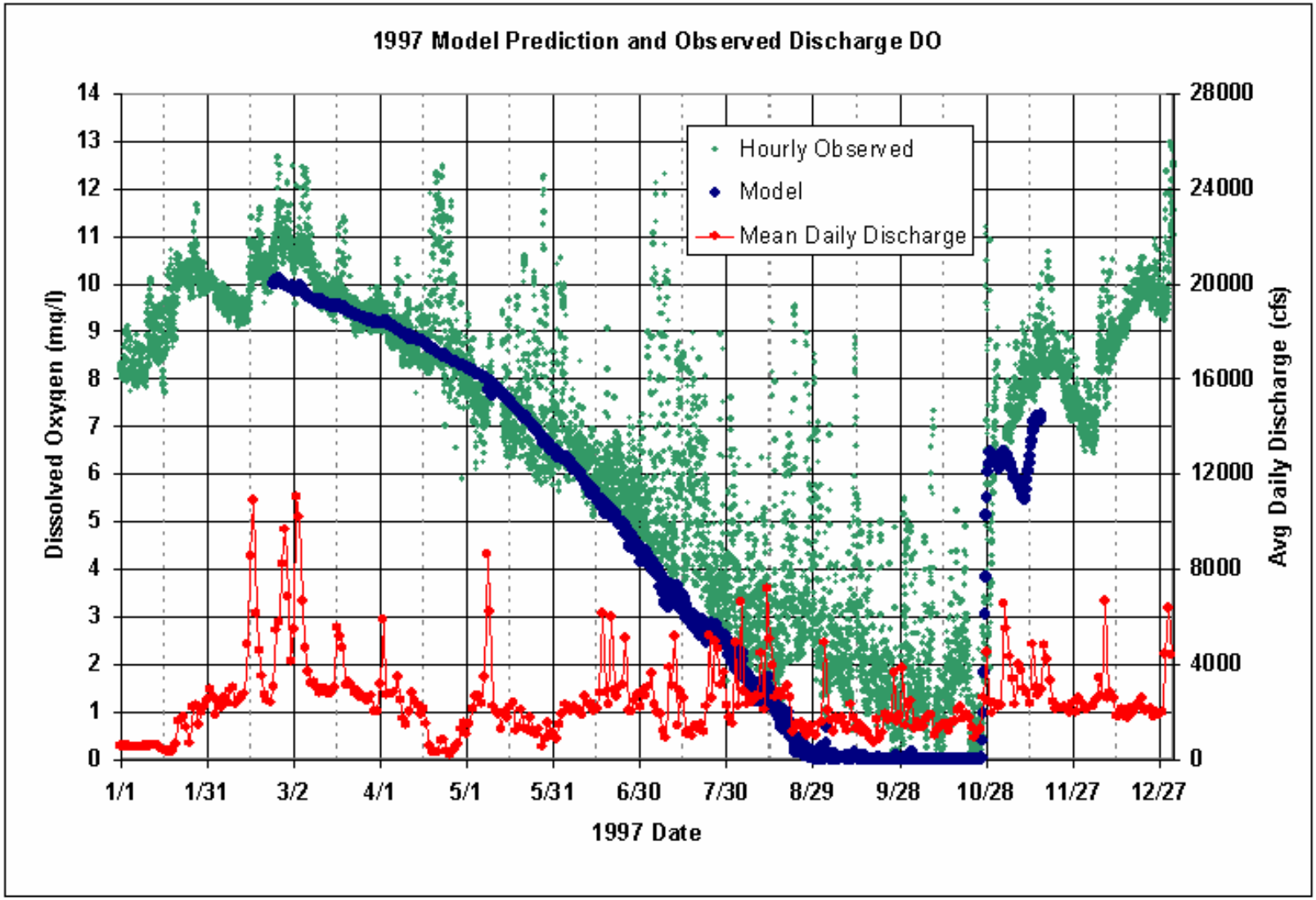
1996 Comparison of Modeled versus Measured Saluda Release DO



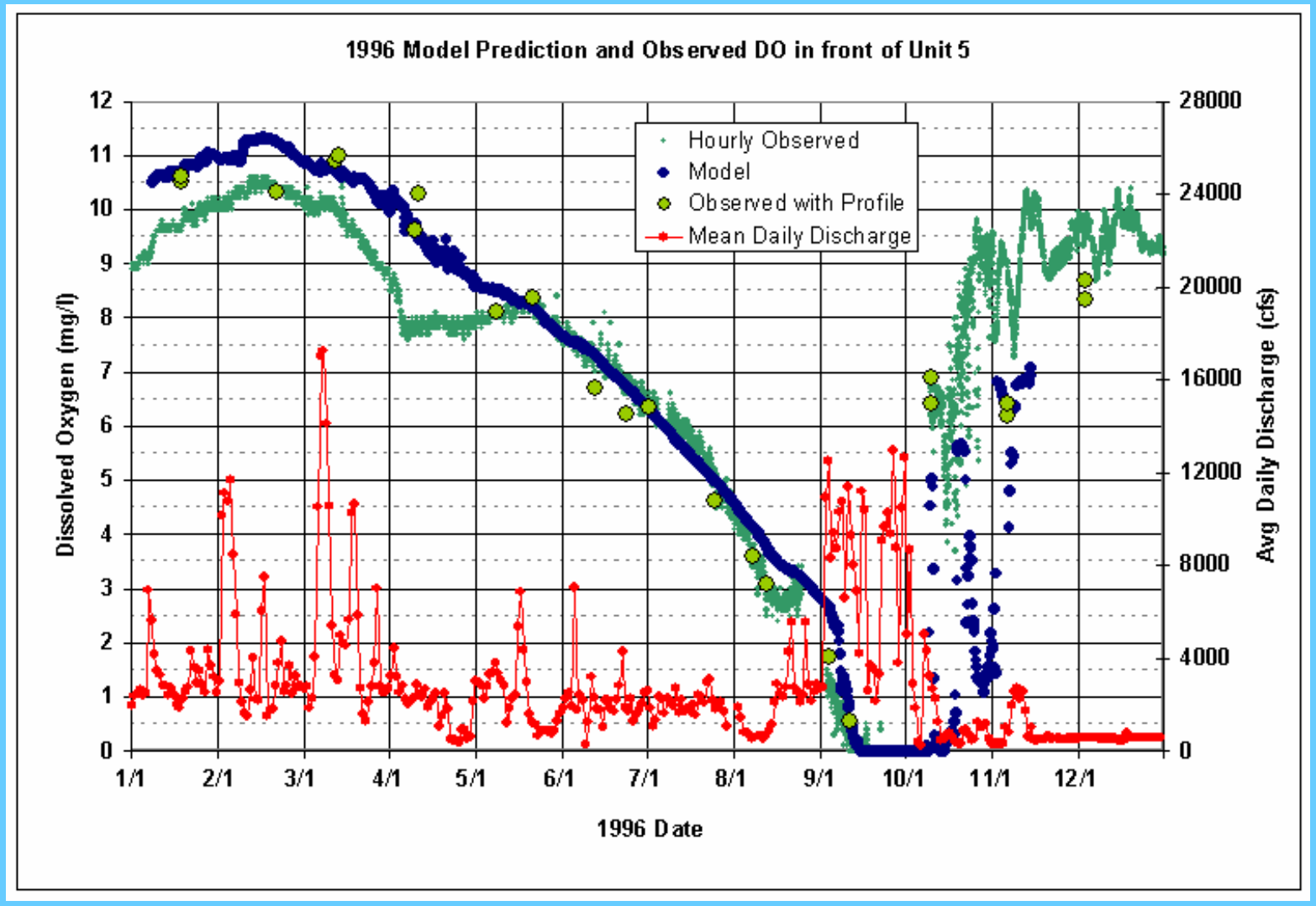
1992 Comparison of Modeled versus Measured Saluda Release DO



1997 Comparison of Modeled versus Measured Saluda Release DO



1996 Modeled versus Measured DO at the level of the Unit 5 Intake



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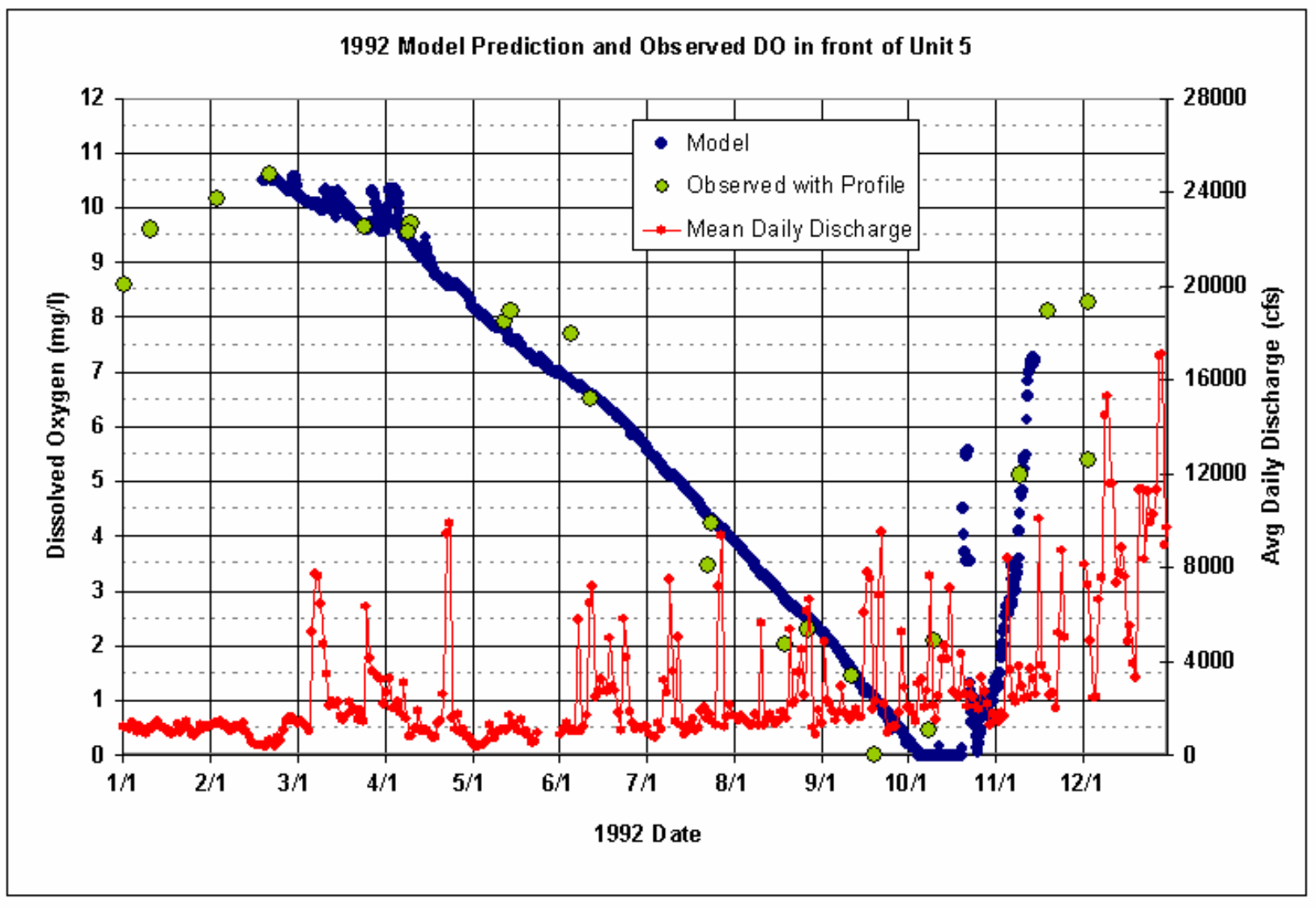

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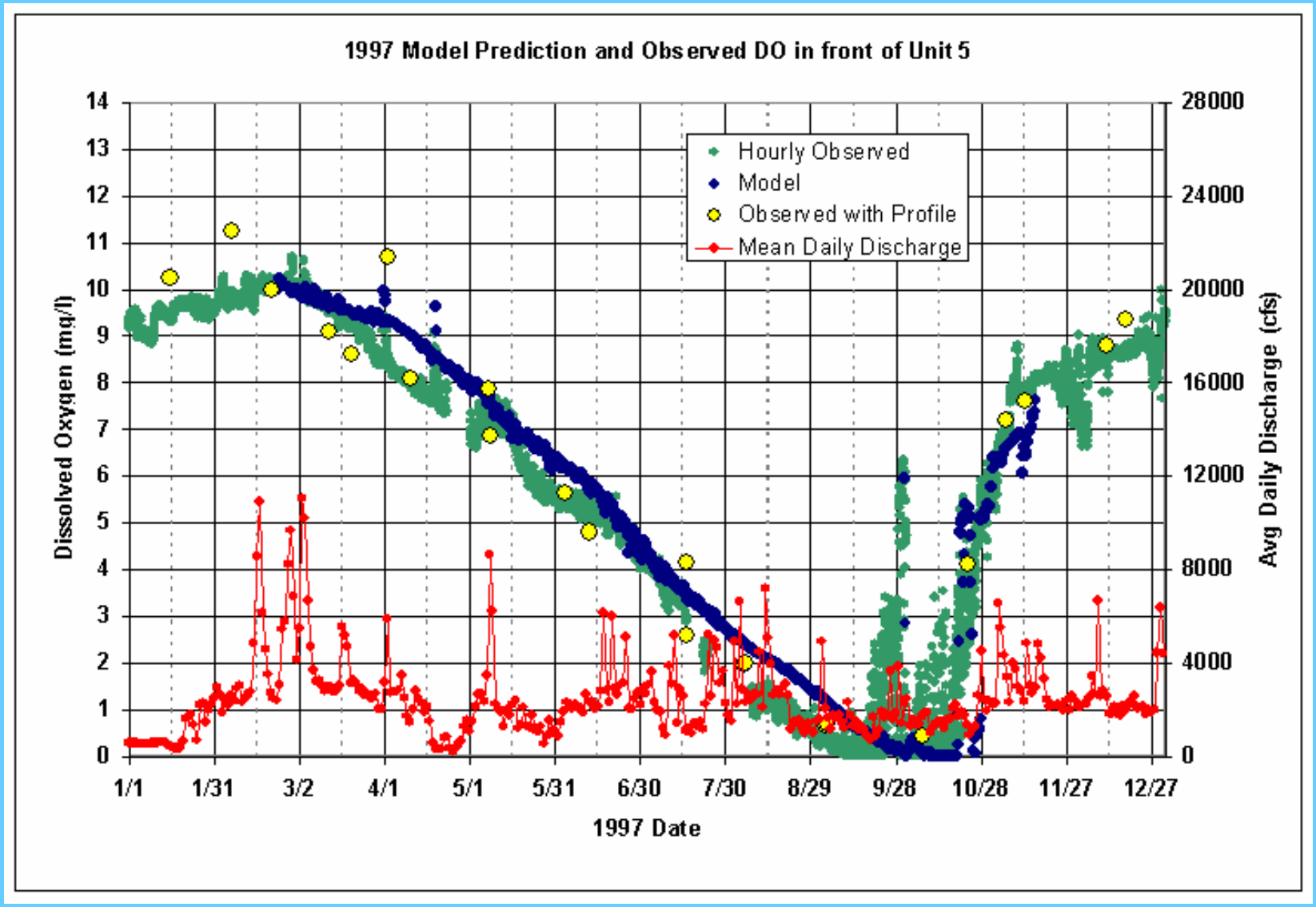
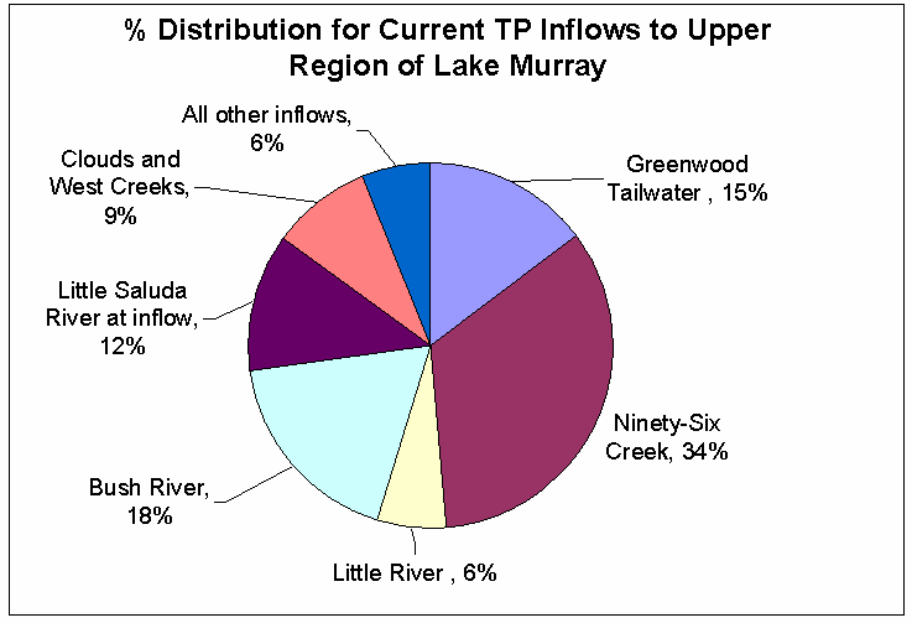
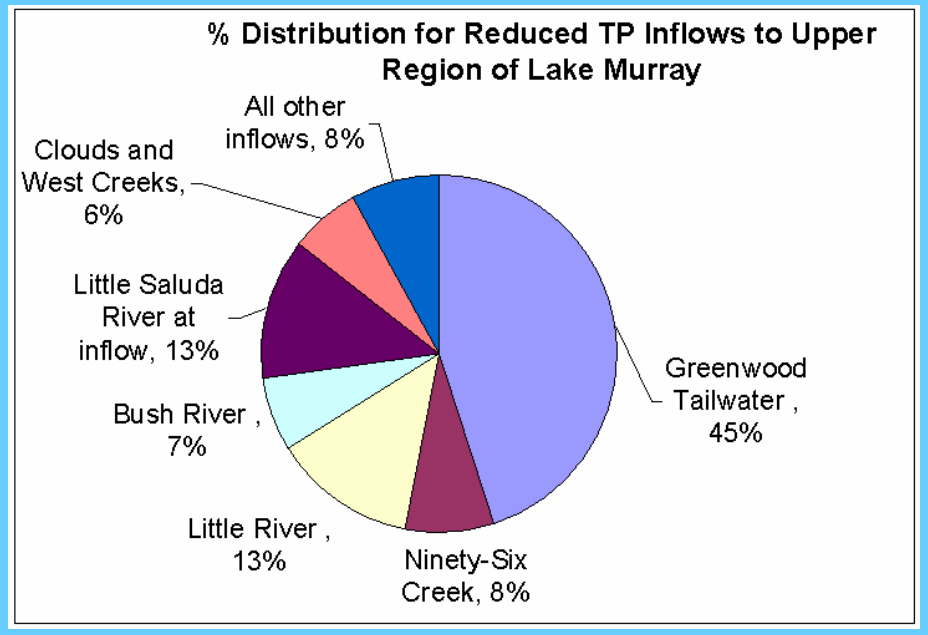


Distribution of TP Loads to the Upper Region of Lake Murray

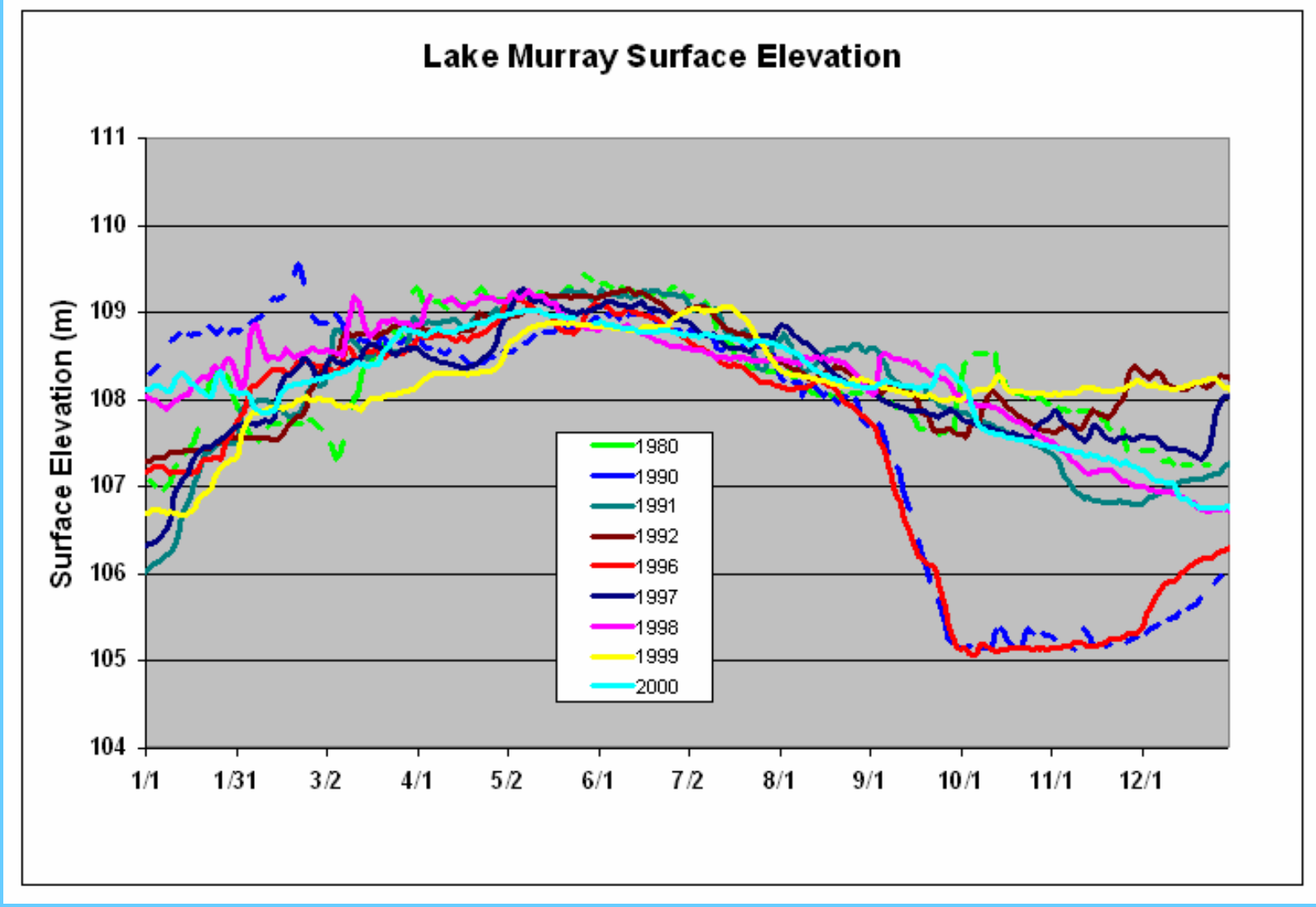
Current



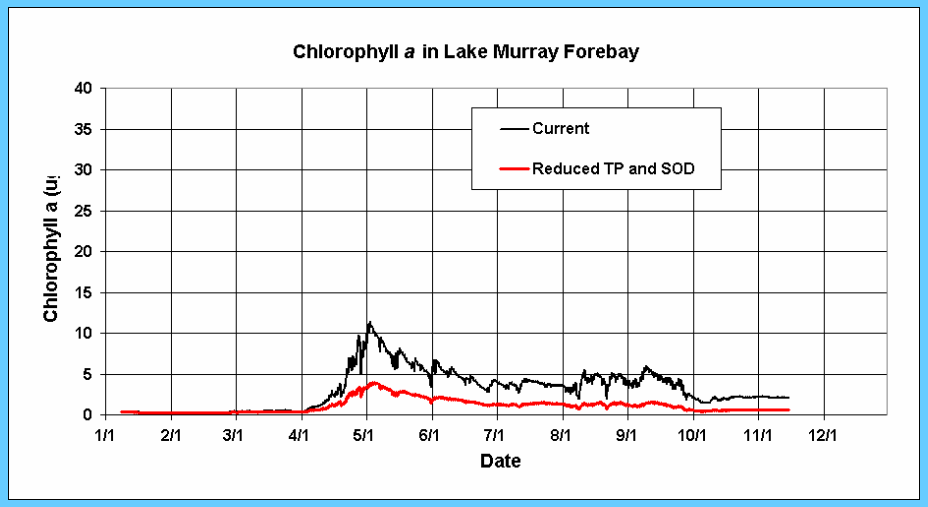
Assumed Reductions in TP

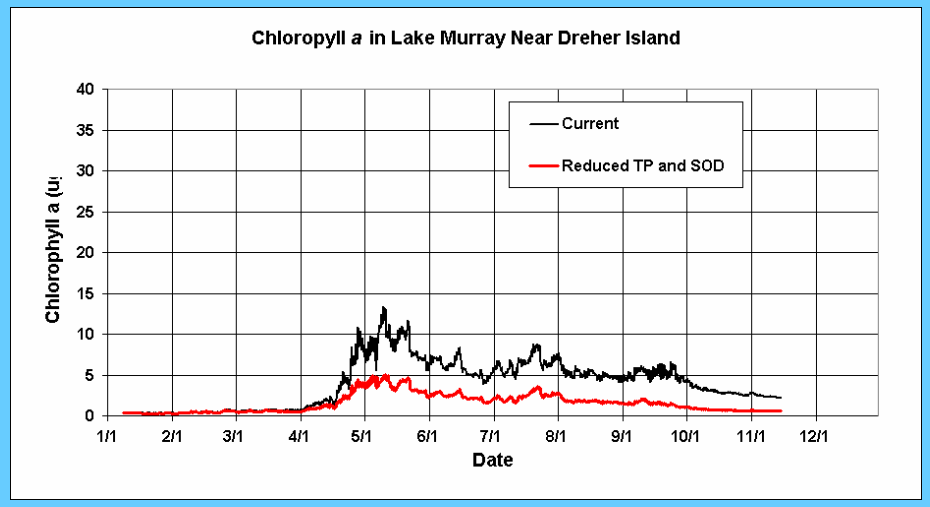


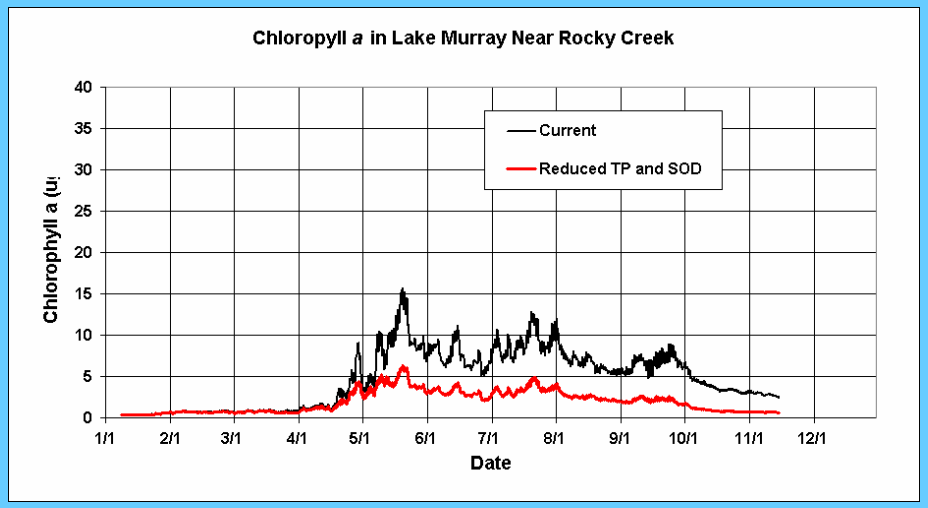
Comparison of Water Surface Elevations for Various Years at Lake Murray

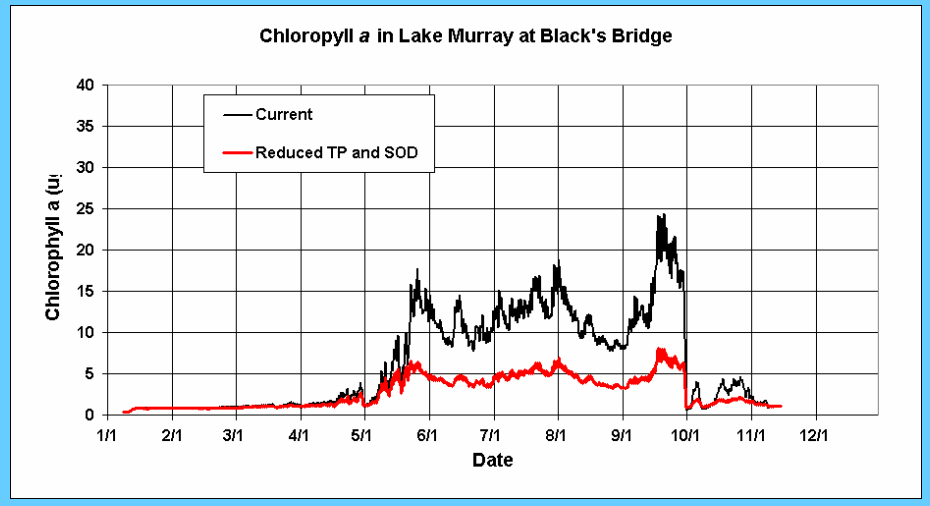


Comparison of 1996 Current and Reduced Phosphorus Predictions of Chlorophyll *a* at 1 Meter Depth at Four Locations in Lake Murray

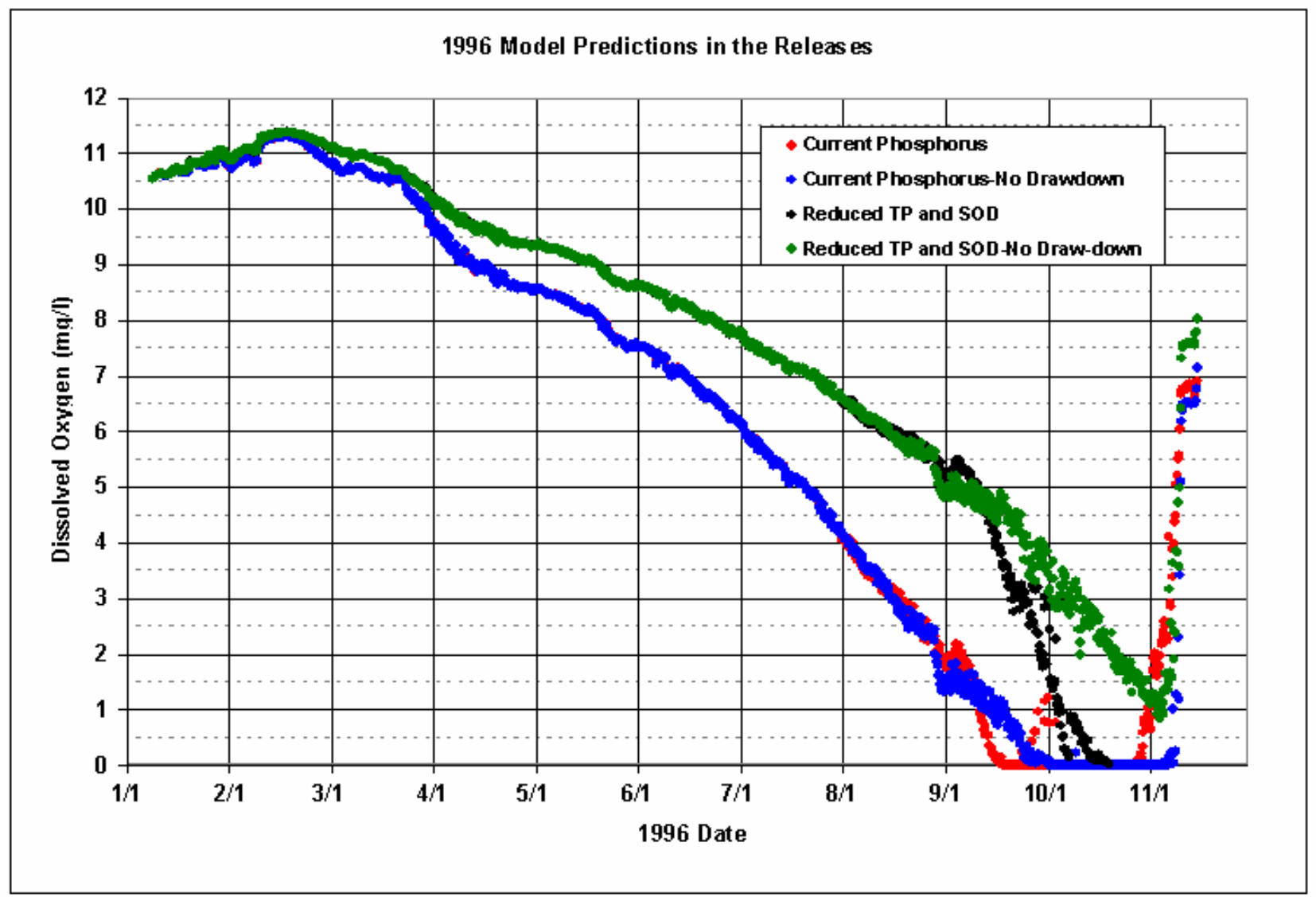




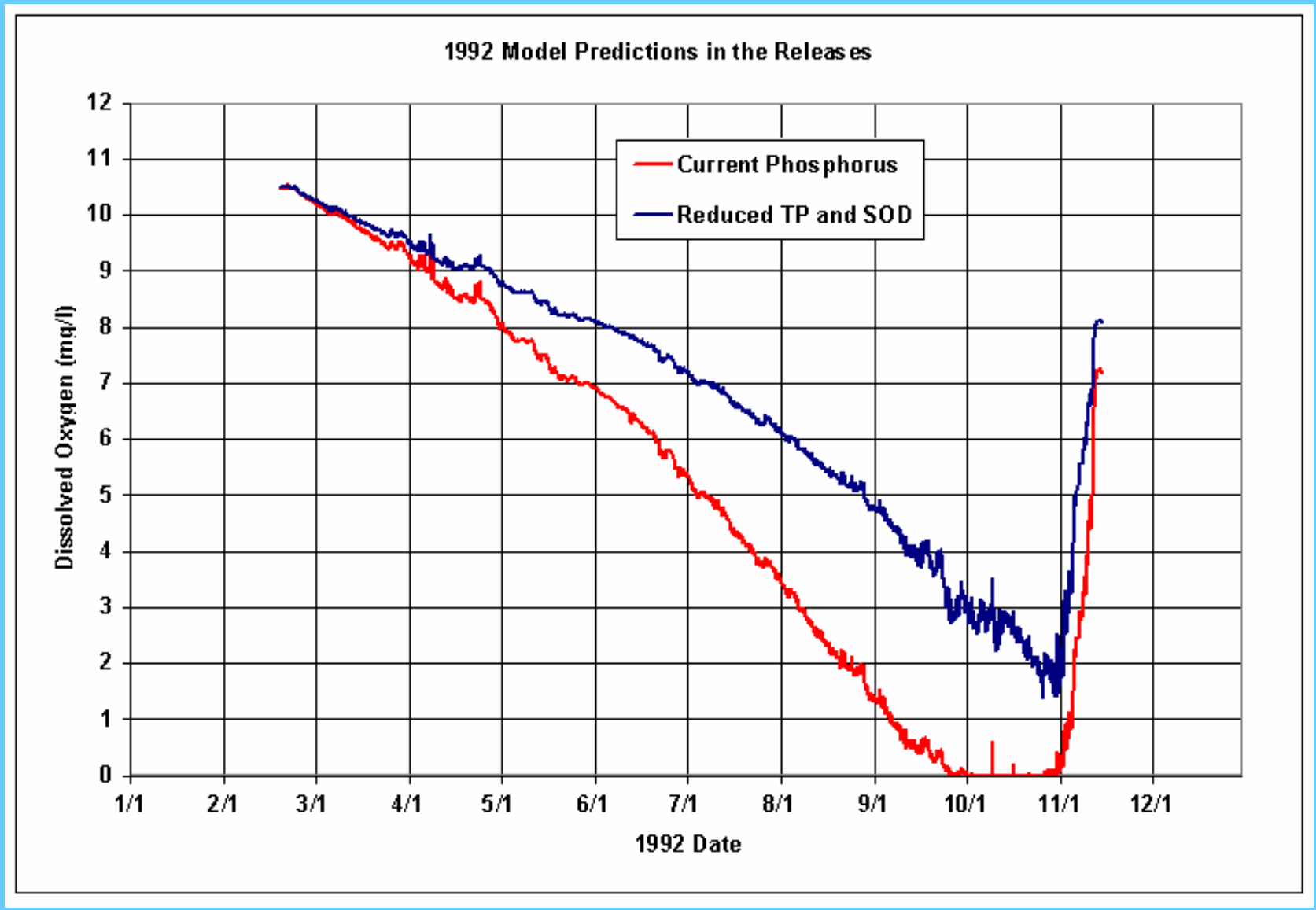




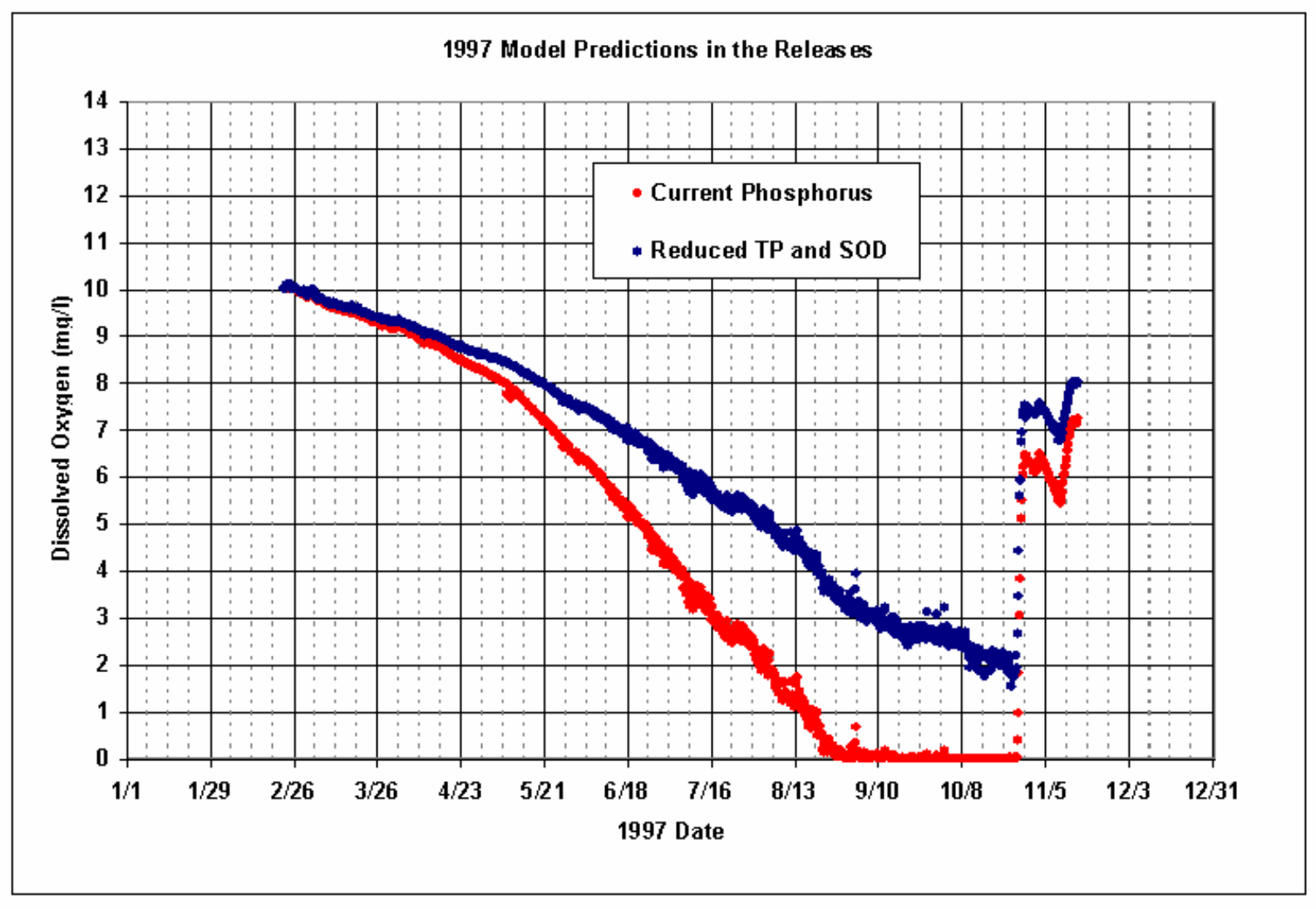
1996 Discharge DO for Current and Reduced Phosphorus, and without the Special Drawdown



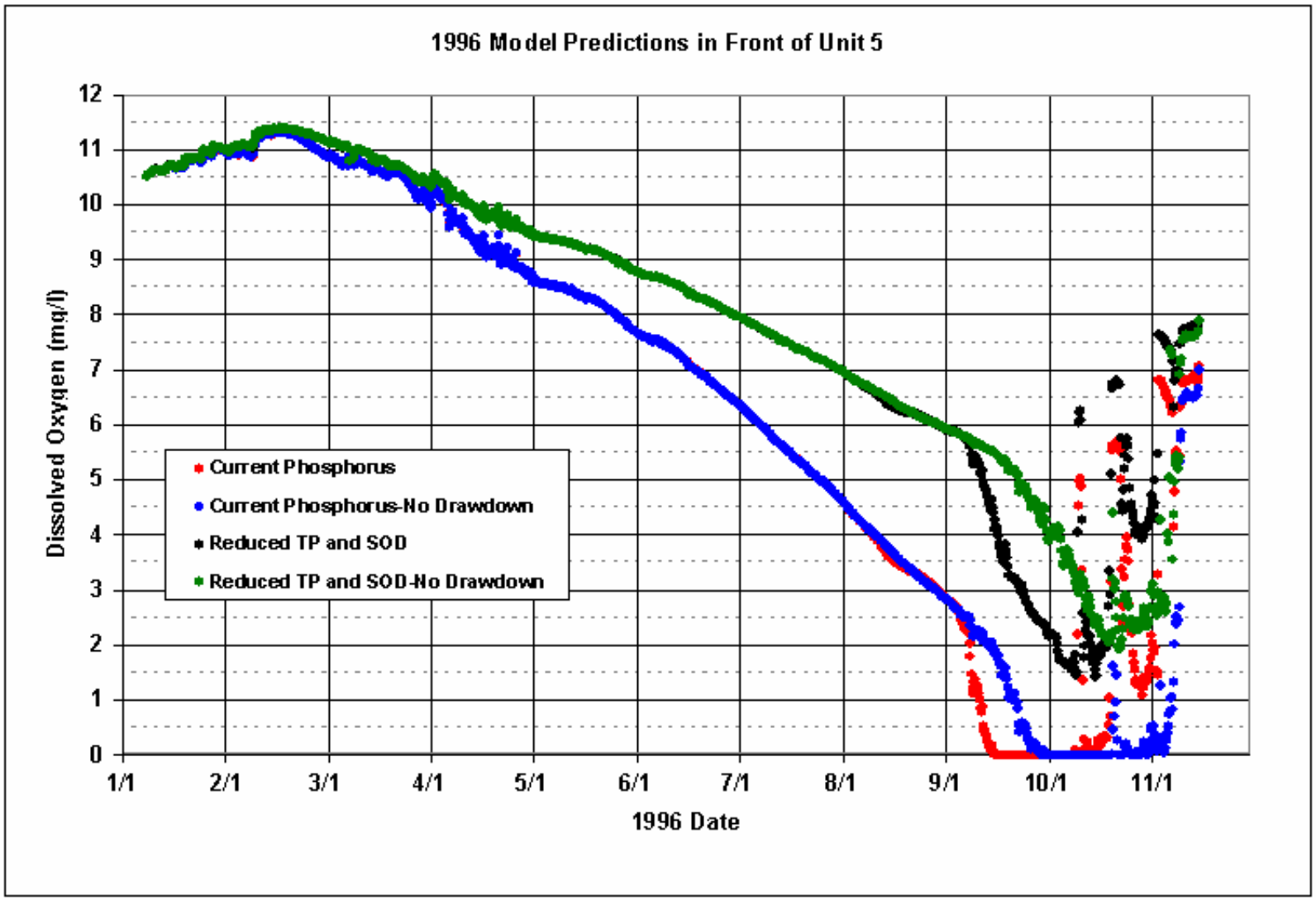
1992 Discharge DO for Current and Reduced Phosphorus



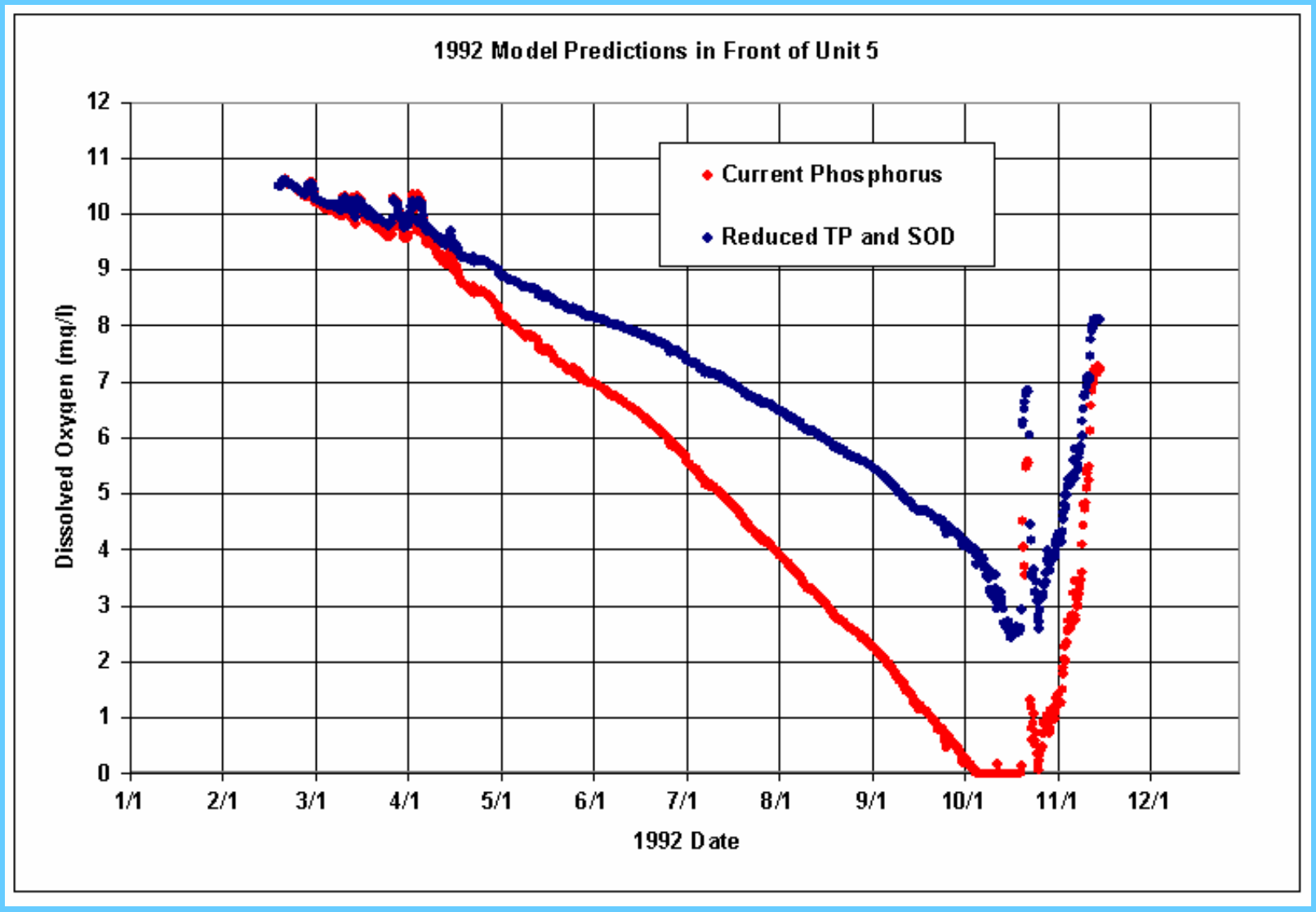
1997 Discharge DO for Current and Reduced Phosphorus



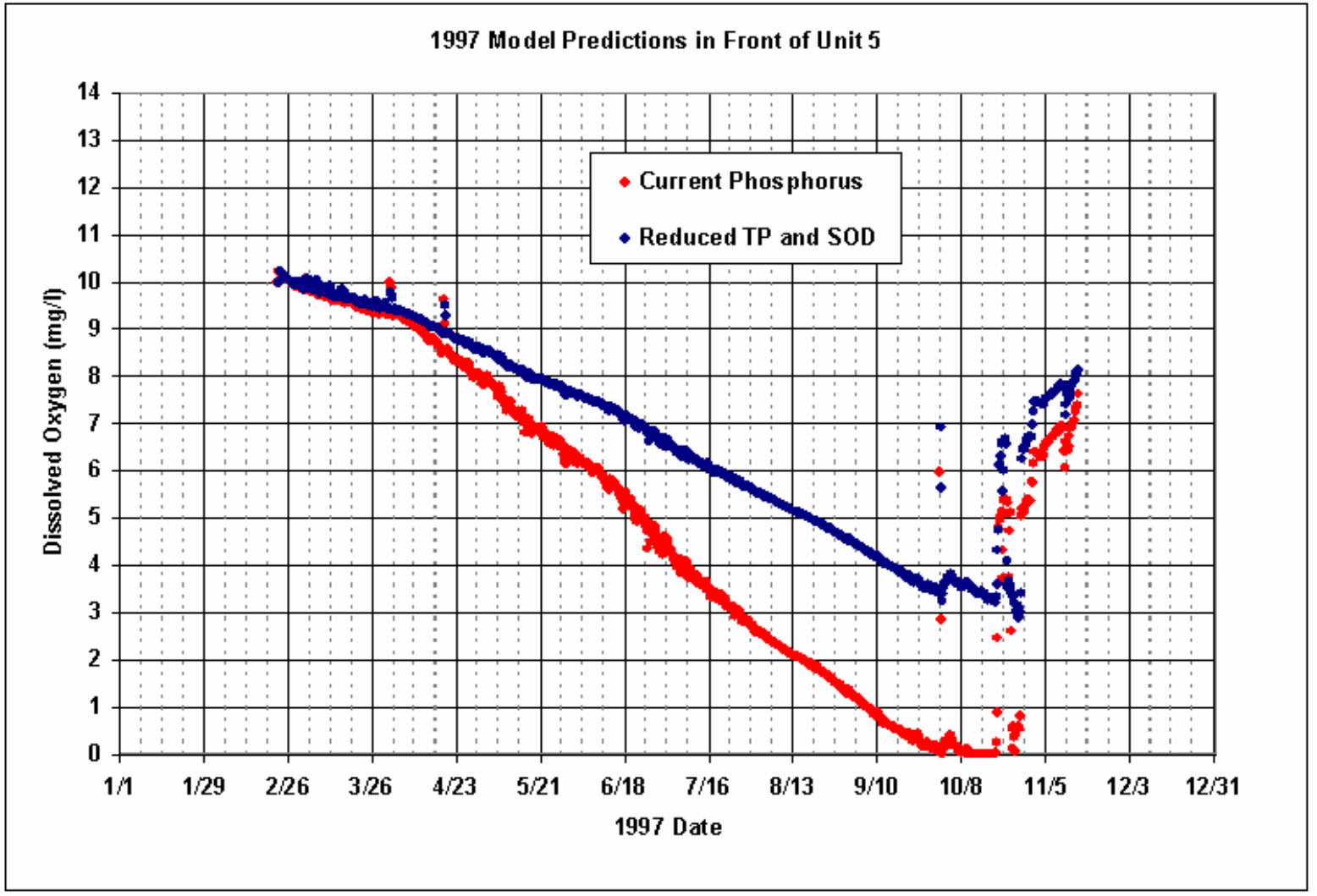
1996 DO at the Elevation of the Unit 5 Intake for Current and Reduced Phosphorus, and without the Special Drawdown



1992 DO at the Level of the Unit 5 Intake for Current and Reduced Phosphorus

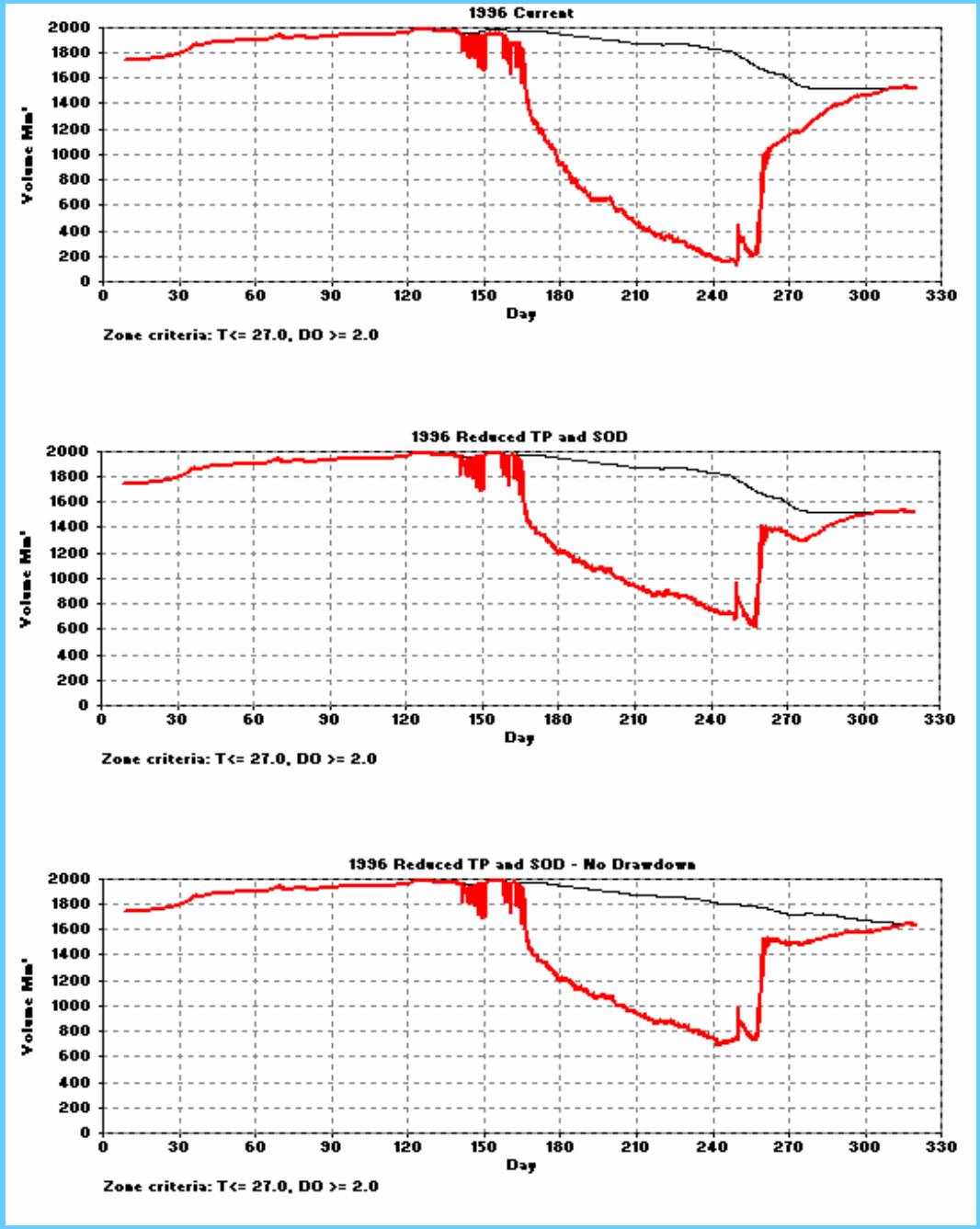


1997 DO at the Level of the Unit 5 Intake for Current and Reduced Phosphorus

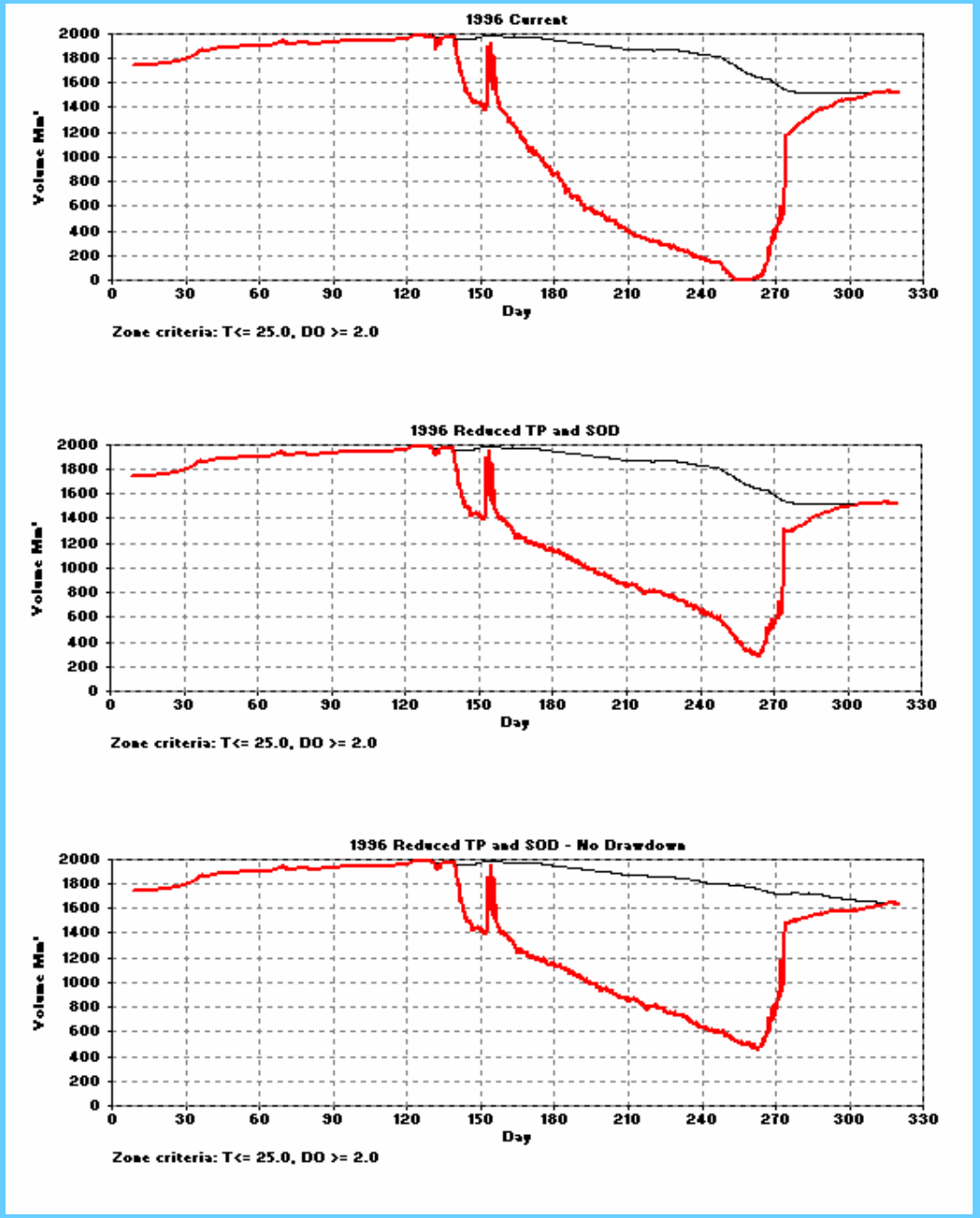


Temperature, DO, Age and Chlorophyll a Animation

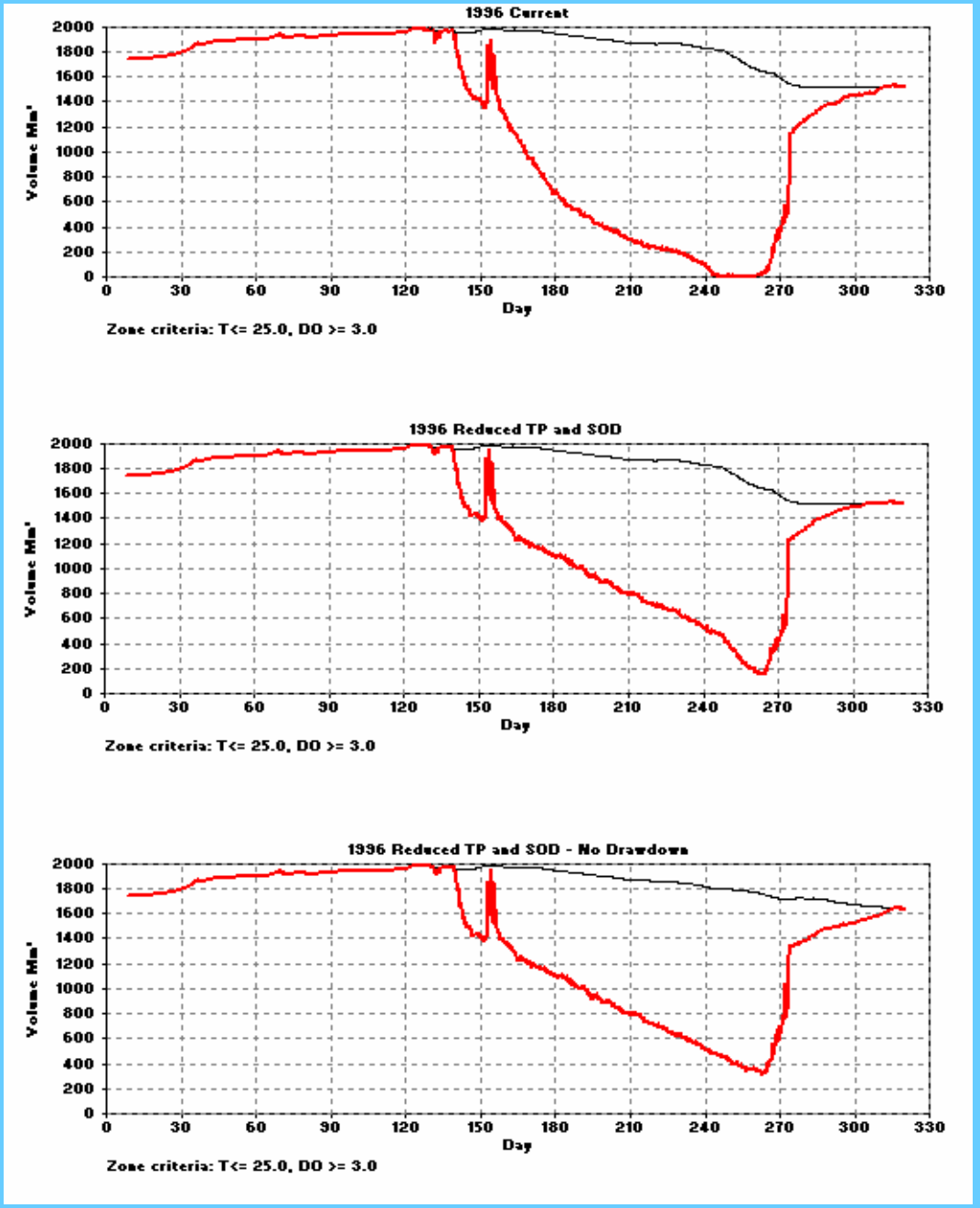
Temp < 27 and DO > 2



Temp < 25 and DO > 2



Temp < 25 and DO > 3



METRICS – Murray 1996	Current	Current-No Drawdown	Reduced TP and SOD	Reduced TP and SOD-No Drawdown
MEAN TOTAL RESERVOIR VOLUME (MM3)	2684	2738	2684	2738
SUM OF VOLUME-DAYS (MM3-DA) WITH DO > 5 MAY-OCT	336403	340241	411162	415248
SUM OF VOL-DAYS (MM3-DA) WITH DO > 5 MAY-OCT AS % OF TOTAL VOL-DAYS MAY-OCT	69%	68%	84%	82%
MINIMUM VOLUME (MM3) WITH DO > 5 MG/L	1267	1263	1581	1689
MINIMUM %VOLUME WITH DO > 5 MG/L	47%	47.30%	65.60%	64.10%
SUM OF VOLUME-DAYS (MM3-DA) WITH DO > 4 MAY-OCT	361968	365365	436548	442955
SUM OF VOL-DAYS (MM3-DA) WITH DO > 4 MAY-OCT AS % OF TOTAL VOL-DAYS MAY-OCT	74%	73%	89%	88%
MINIMUM VOLUME (MM3) WITH DO > 4 MG/L	1345	1352	1714	1881
MINIMUM %VOLUME WITH DO > 4 MG/L	50%	51%	72%	75%
SUM OF VOLUME-DAYS (MM3-DA) WITH DO < 1 MG/L	70304	80120	9610	9901
SUM OF VOL-DAYS (MM3-DA) WITH DO < 1 AS % OF TOTAL VOL-DAYS	8.4%	9.4%	1.1%	1.2%
MAXIMUM VOLUME (MM3) WITH DO < 1 MG/L	926	916	181	170
MAXIMUM %VOLUME WITH DO < 1 MG/L	35%	35%	8%	7%
Striper Preferred Habitat				
SUM OF VOLUME-DAYS (MM3-DA) WITH T<20 AND DO>4 MAY-OCT	109194	117674	154380	166211
SUM OF VOL-DAYS (MM3-DA) WITH T<20 AND DO>4 AS % OF TOTAL VOL-DAYS MAY-OCT	22%	23%	32%	33%
MINIMUM VOLUME (MM3) WITH T<20 AND DO>4	0	0	0	61
MINIMUM %VOLUME WITH T<20 AND DO>4	0.0%	0.0%	0.0%	2.4%
Striper Maximum Tolerable Habitat				
SUM OF VOLUME-DAYS (MM3-DA) WITH T<27 AND DO>2 MAY-OCT	276016	279486	340103	352189
SUM OF VOL-DAYS (MM3-DA) WITH T<27 AND DO>2 AS % OF TOTAL VOL-DAYS MAY-OCT	56%	56%	69%	70%
MINIMUM VOLUME (MM3) WITH T<27 AND DO>2	154	136	806	870
MINIMUM %VOLUME WITH T<27 AND DO>2	6%	5%	33%	33%
SUM OF KM-DAYS WITH DO < 5 MG/L AT SURFACE	48	21	2	2
MAX CONTIG. DISTANCE (KM) WITH DO < 5 AT SURFACE	7.6	7.6	0.0	0.0
MAX CONTIG. DISTANCE (KM) WITH DO < 3 AT SURFACE	0	0	0	0
MINIMUM RELEASE DO (MG/L)	0.0	0.0	0.0	0.8
NUMBER OF DAYS WITH RELEASE DO < 5 MG/L	111	112	58	72
NUMBER OF DAYS WITH RELEASE DO < 3 MG/L	83	86	42	37
MAXIMUM CHL-A CONCENTRATION (UG/L)	29.4	27.2	14.7	10.4
MEAN SURFACE CHL-A CONCENTRATION (UG/L) APR-AUG	5.8	5.8	2.3	2.3

The End