Update on the West Point Lake Models

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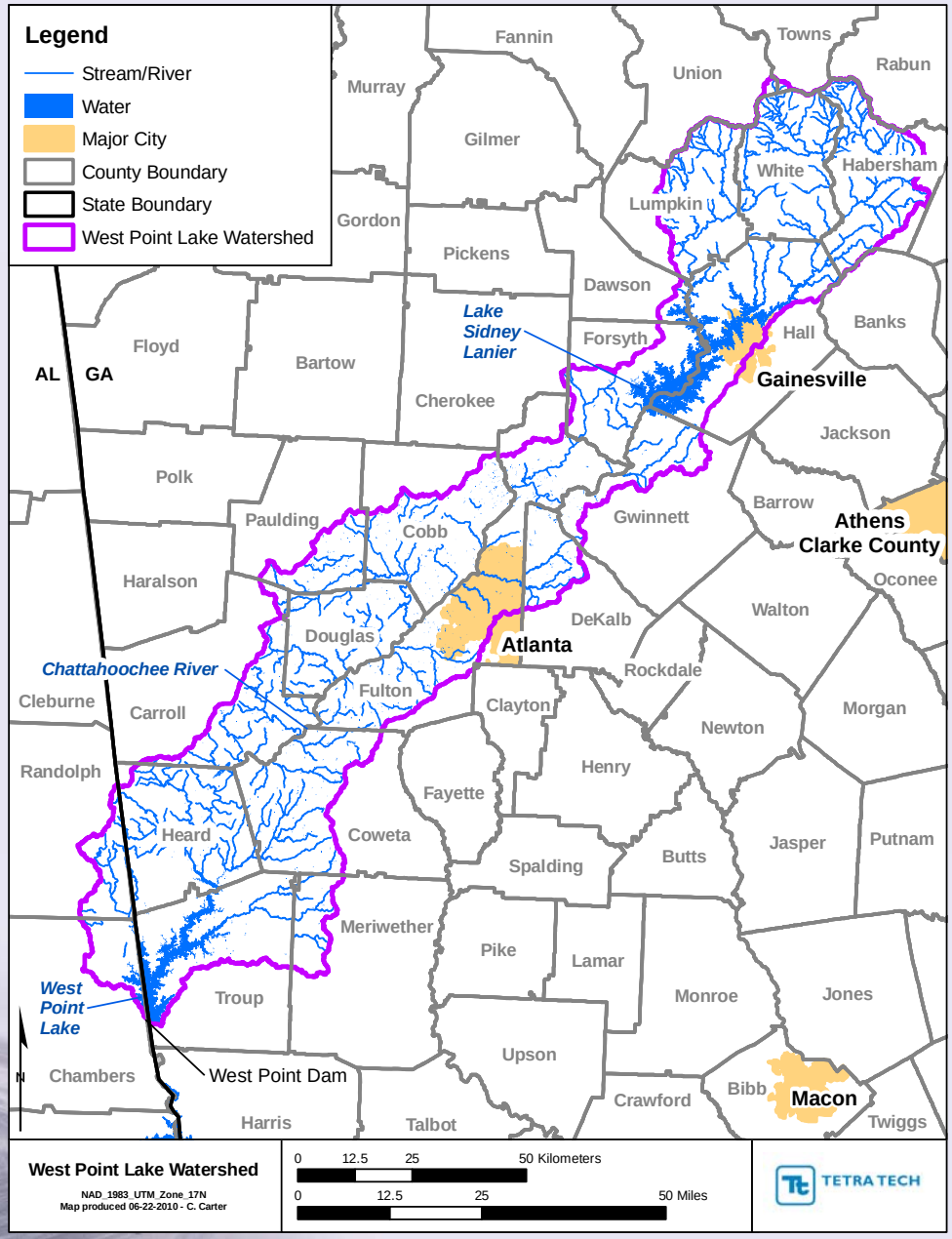
20 January 2011

Outline

- Tools and Models Used
- Model Linkage
- Data Sources
- Watershed Model
- Lake Model
- Scenarios
- Next Steps
- Questions

West Point Lake Watershed



Database and Models Used

- **Database Management**
  - Water Resources Database (WRDB)
- **Watershed Model**
  - Loading Simulation Program C++ (LSPC)
- **Lake Hydrodynamic Model**
  - Environmental Fluid Dynamics Code (EFDC)
- **Lake Water Quality Model**
  - Environmental Fluid Dynamics Code (EFDC)

Model Linkage

Models

Outputs

LSPC

Subwatershed Flows

Subwatershed Concentrations
(Chl-a, TN, NH3, NOx, OrgN, TP, PO4, OrgP, BOD, DO, Temp, TSS, Fecal)

Flows

Temperatures

Concentrations

EFDC

Water Surface Elevation

Temperatures

Lake Concentrations
(Chl-a, TN, NH3, NOx, OrgN, TP, PO4, OrgP, BOD, DO, Temp)

Data Sources

Data Source	Data Type
U.S. Army Corps of Engineers – Mobile District (Corps)	Water Surface Elevation West Point Dam Flows
Georgia Environmental Protection Division (GAEPD)	Point Source Discharges Water Withdrawals Temperature Profiles Dissolved Oxygen Profiles River and Lake Water Quality Algal Growth Potential Tests GIS Coverages
United States Geological Survey (USGS)	Flow Temperature Dissolved Oxygen
United States Environmental Protection Division – Region 4 (USEPA4)	Nutrient Fluxes Sediment Oxygen Demand
Kingfisher Maps, Inc.	Lake Bathymetry
Georgia Automated Environmental Monitoring Network (GAEMN)	Meteorological
National Climatic Data Center (NCDC)	Meteorological
University of Georgia-NARSAL Georgia Land Use Trends (GLUT)	Land Use (2008)
City of Lagrange	Lake Water Quality (Data Starts in 2008)

Model Simulation Periods

- **Watershed Model (LSPC)**
  - January 1, 1998 through December 31, 2007
  - Spin-up year in 1997

- **Lake Model (EFDC)**
  - January 1, 2001 through December 31, 2007
  - Spin-up 30 days

Model Calibration Stations

- **Watershed Model (LSPC)**
  - 34 USGS Stations with at least 1-year of data (data includes flow and water quality)
  - 42 GAEPD Stations for water quality
- **Lake Model (EFDC)**
  - USACE Forebay Station (Water Surface Elevation)
  - 2 GAEPD Stations for water quality

Chattahoochee River Watershed Model

Loading Simulation Program C++ (LSPC)

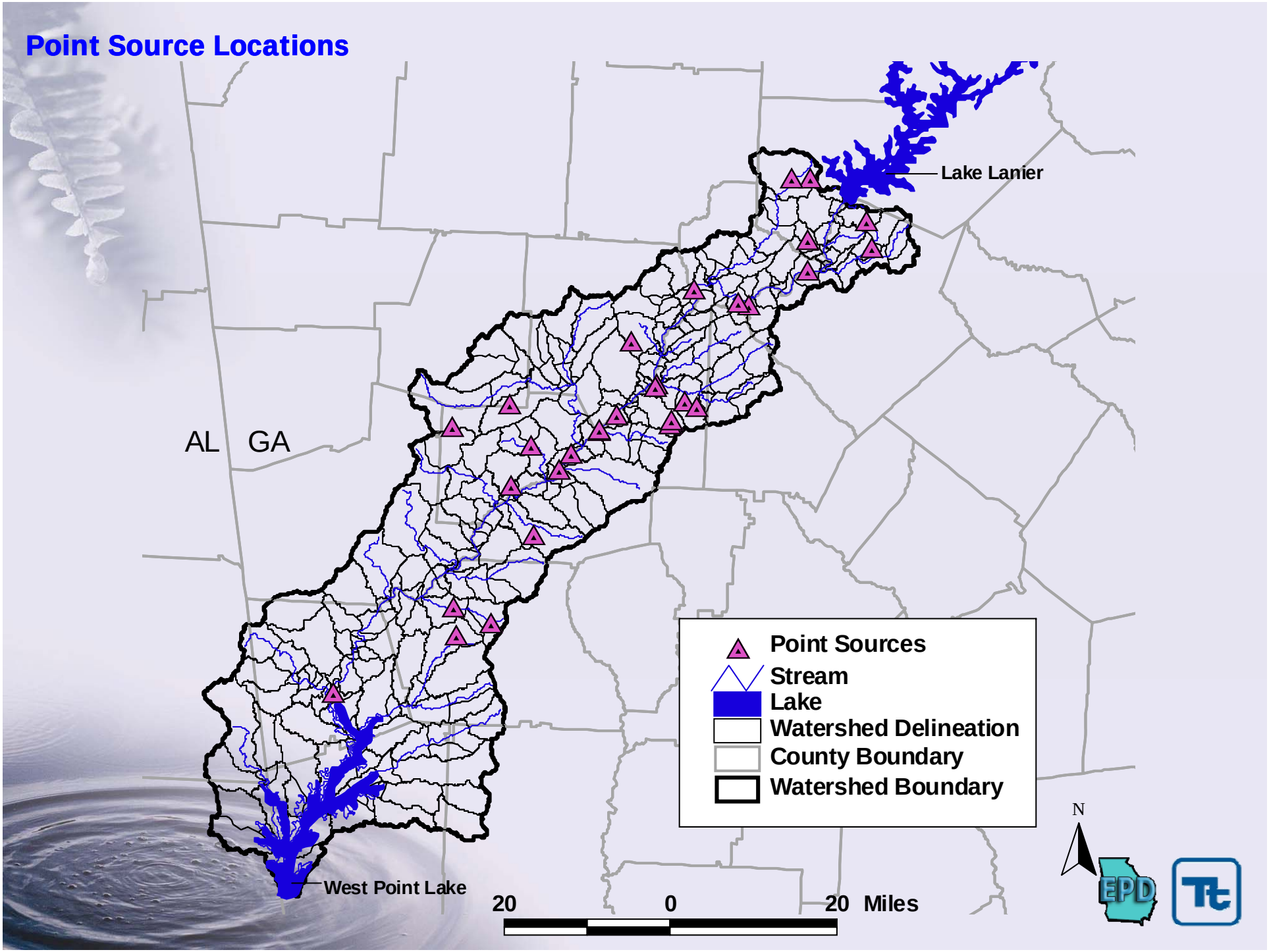
Watershed Inputs (Coverages)

- Georgia 12-digit HUC Coverage
- National Hydrography Dataset (NHD)
- Digital Elevation Map (DEM)
- UGA Georgia Land Use Trend (GLUT)
  - 2008 Land Use
  - 19 Classes
  - Pervious and Impervious
- SSURGO Soil Coverage
- Agricultural Irrigated Areas
- Land Application Systems
- Septic Systems
- Chicken Houses (Lanier Watershed)

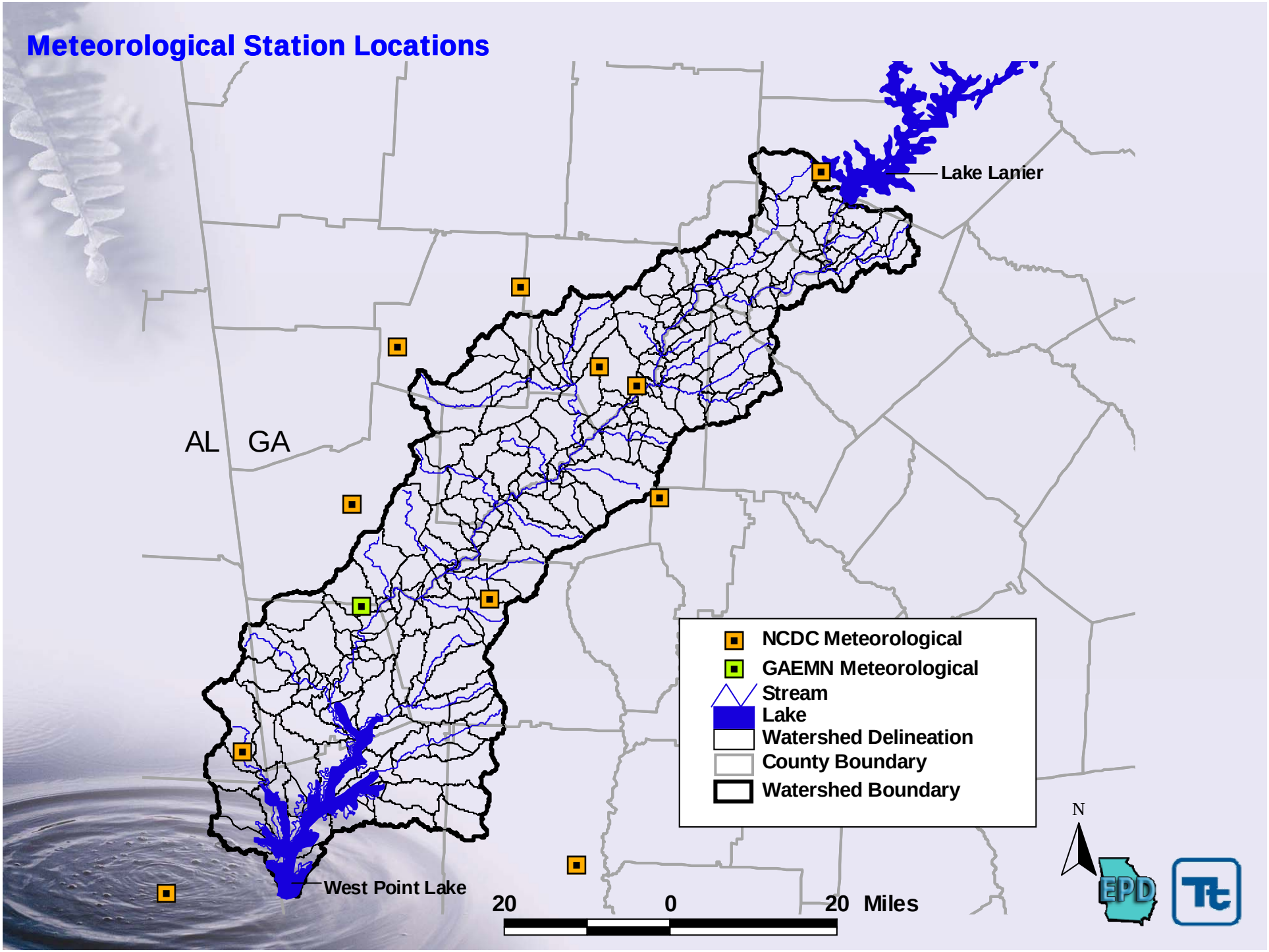
Watershed Inputs

- Buford Dam Discharge
- Meteorological (12 Stations)
  - 11 NCDC
  - 1 GAEMN
- Point Sources (30 Total)
  - 23 Municipal
  - 2 Industrial
  - 1 PID
  - 4 CSO
- Water Withdrawals (33 Total)

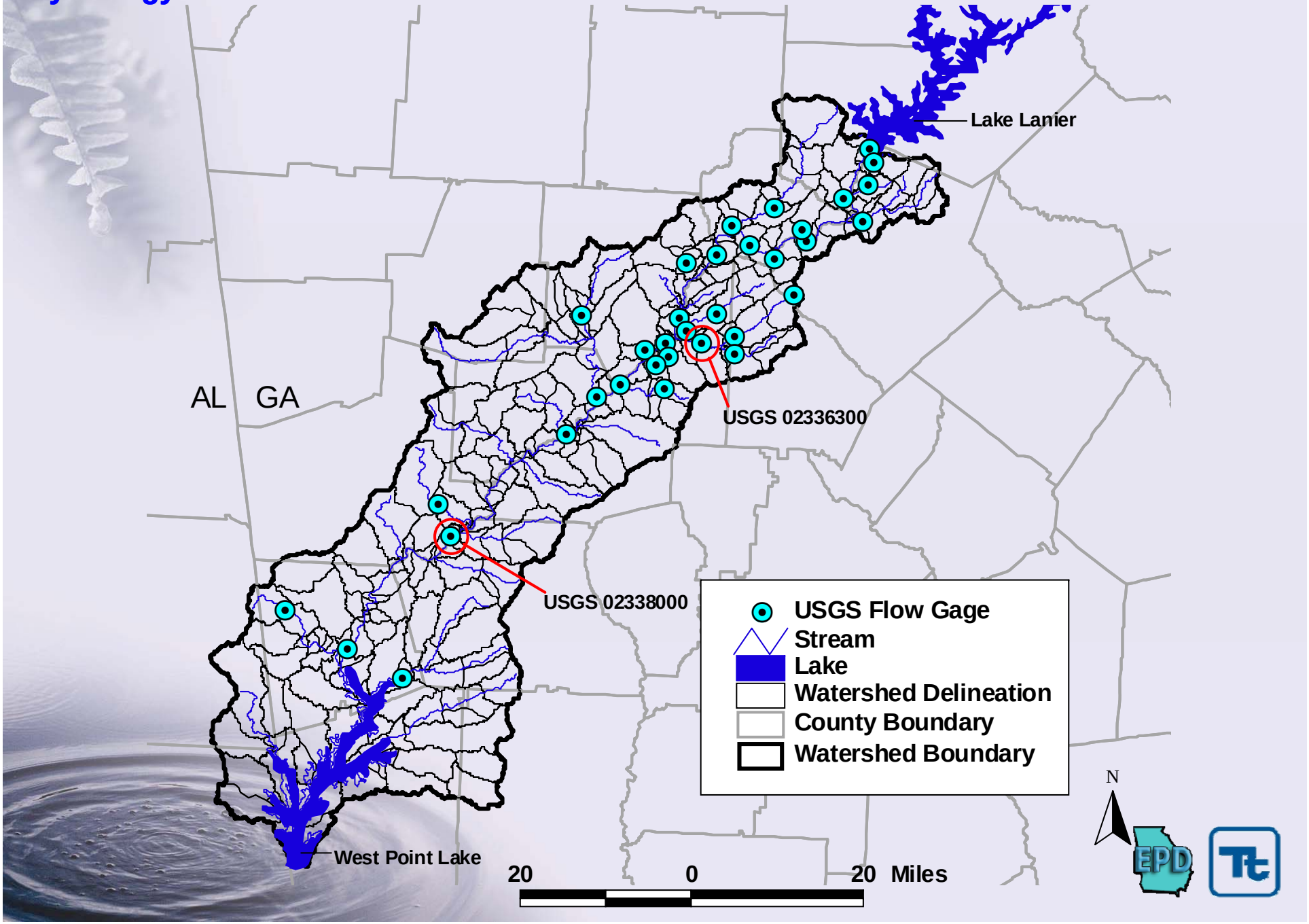
Point Source Locations



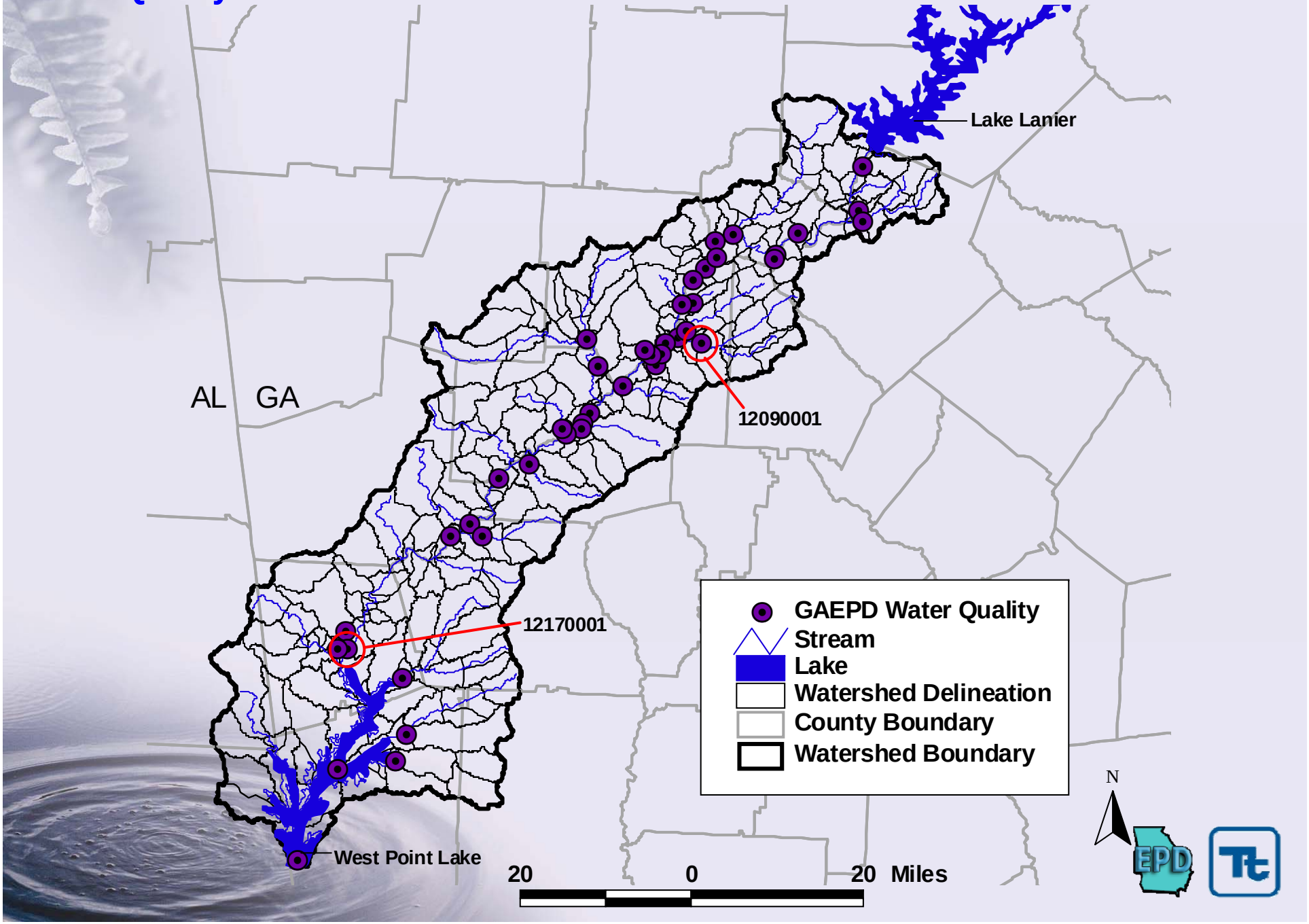
Meteorological Station Locations



Hydrology Calibration Locations for LSPC Model



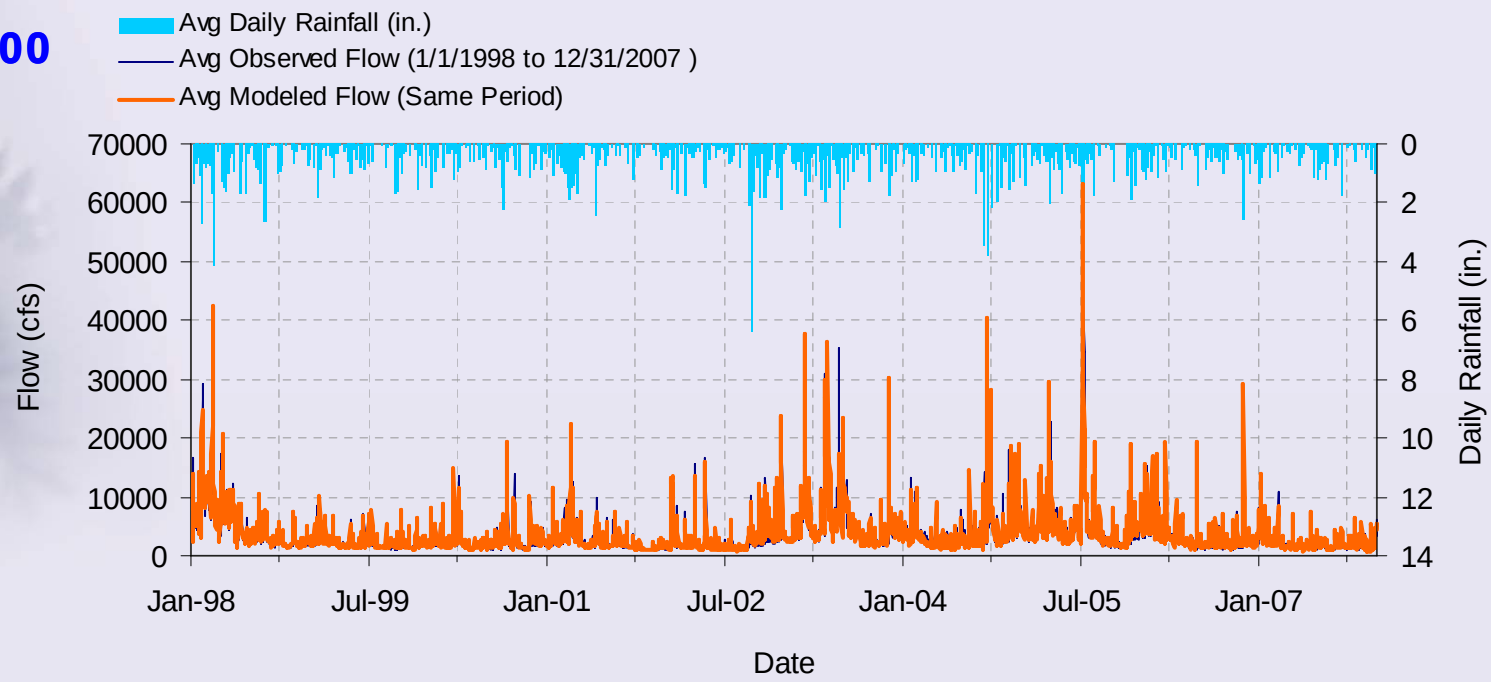
Water Quality Calibration Locations for LSPC Model

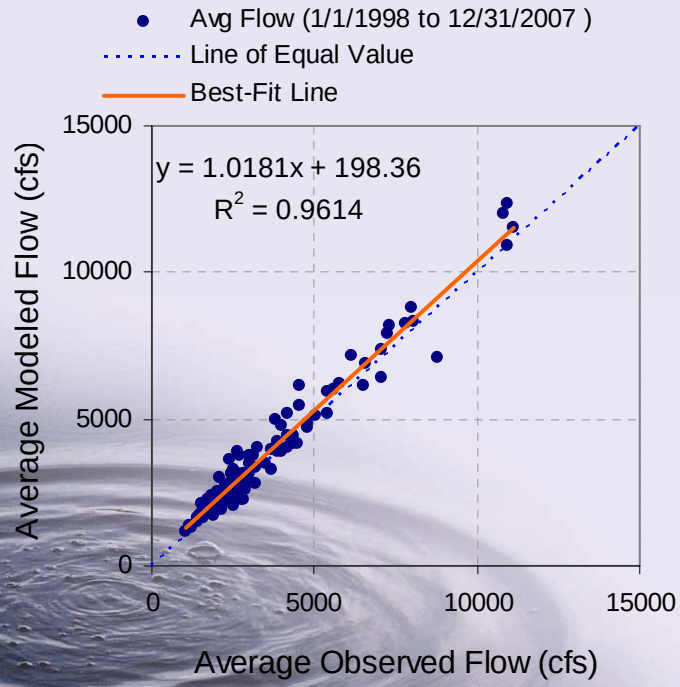


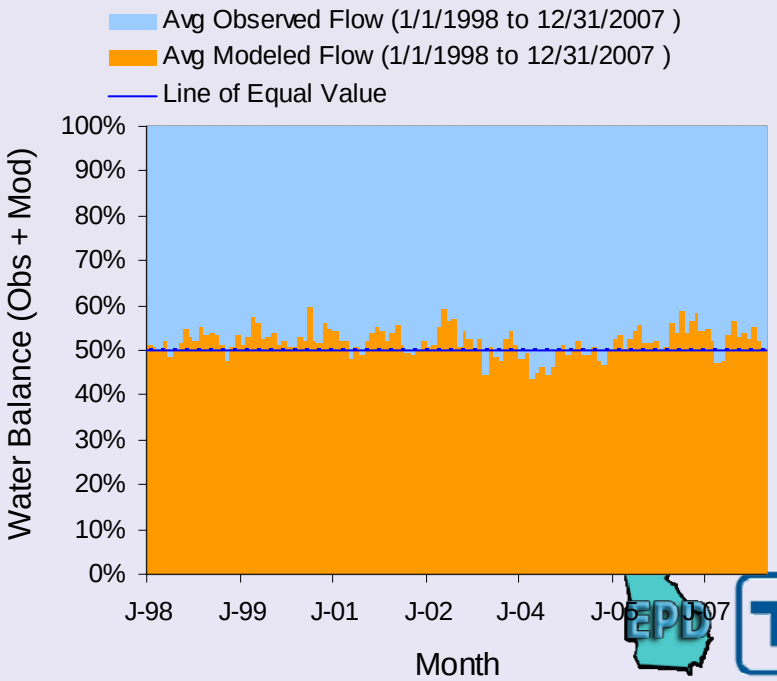
Example Watershed Calibration Locations

- Hydrology
  - 02338000 – Chattahoochee River near Whitesburg, GA
  - 02336300 – Peachtree Creek at Atlanta
- Water Quality
  - 12170001 – Chattahoochee River at U.S. 27 near Franklin, GA
  - 12090001 – Peachtree Creek at Northside Drive near Atlanta

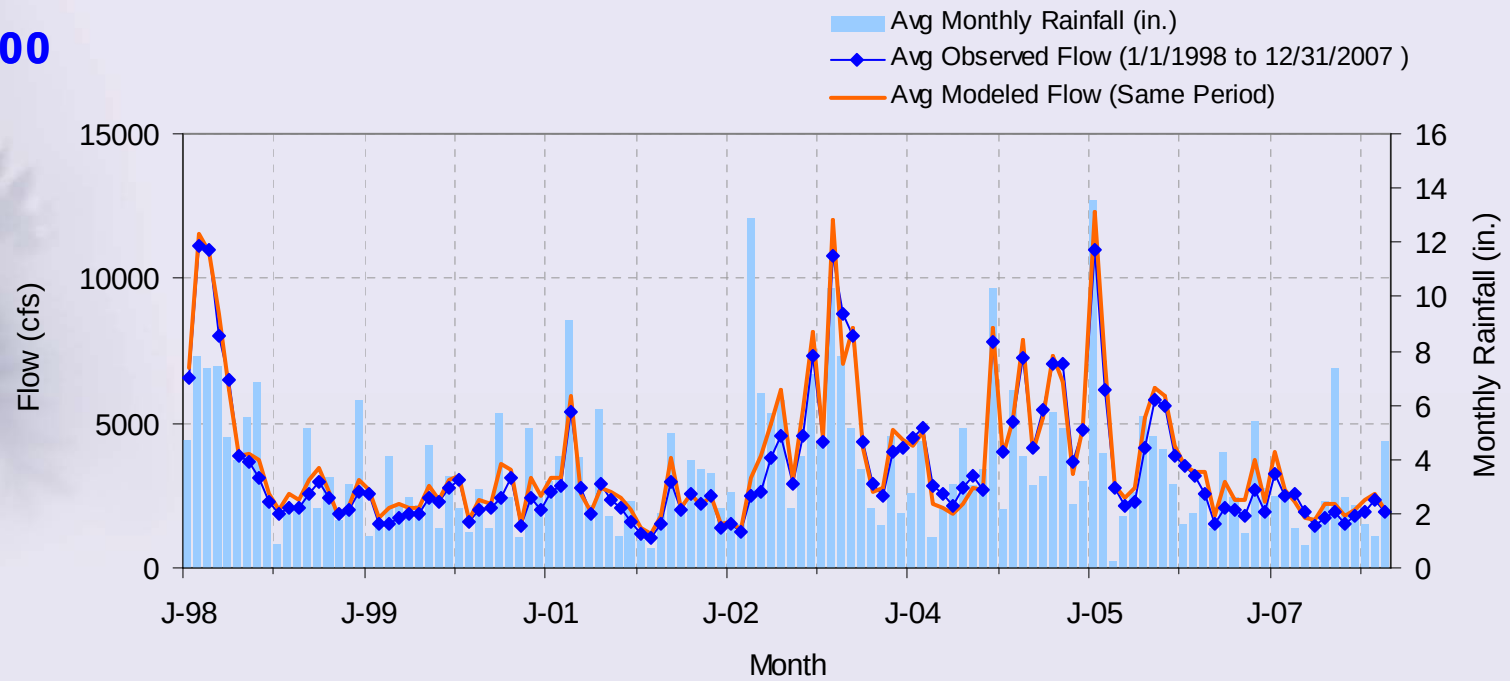
02338000

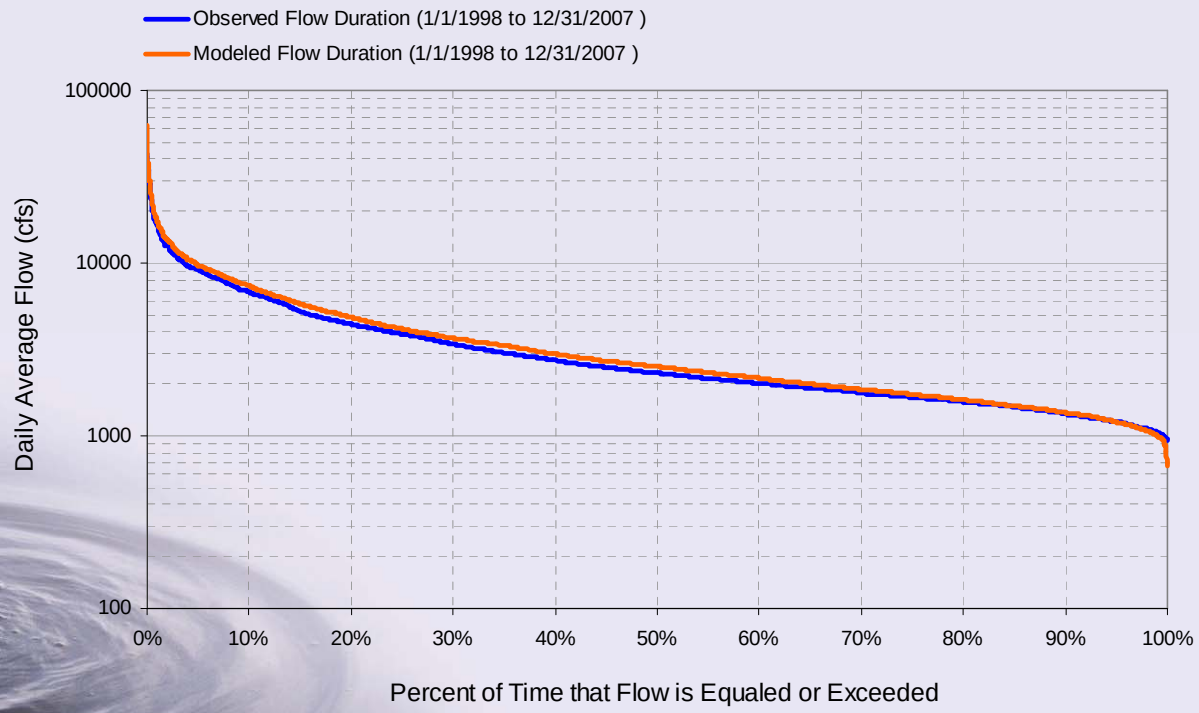

Avg Daily Rainfall (in.)
Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (Same Period)
Flow (cfs)
Daily Rainfall (in.)
70000
60000
50000
40000
30000
20000
10000
0
0
2
4
6
8
10
12
14
Jan-98
Jul-99
Jan-01
Jul-02
Jan-04
Jul-05
Jan-07
Date


Avg Flow (1/1/1998 to 12/31/2007)
Line of Equal Value
Best-Fit Line
y = 1.0181x + 198.36
R2 = 0.9614
Average Modeled Flow (cfs)
Average Observed Flow (cfs)
15000
10000
5000
0
0
5000
10000
15000


Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (1/1/1998 to 12/31/2007)
Line of Equal Value
Water Balance (Obs + Mod)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
J-98
J-99
J-01
J-02
J-04
J-05
J-07
Month

02338000

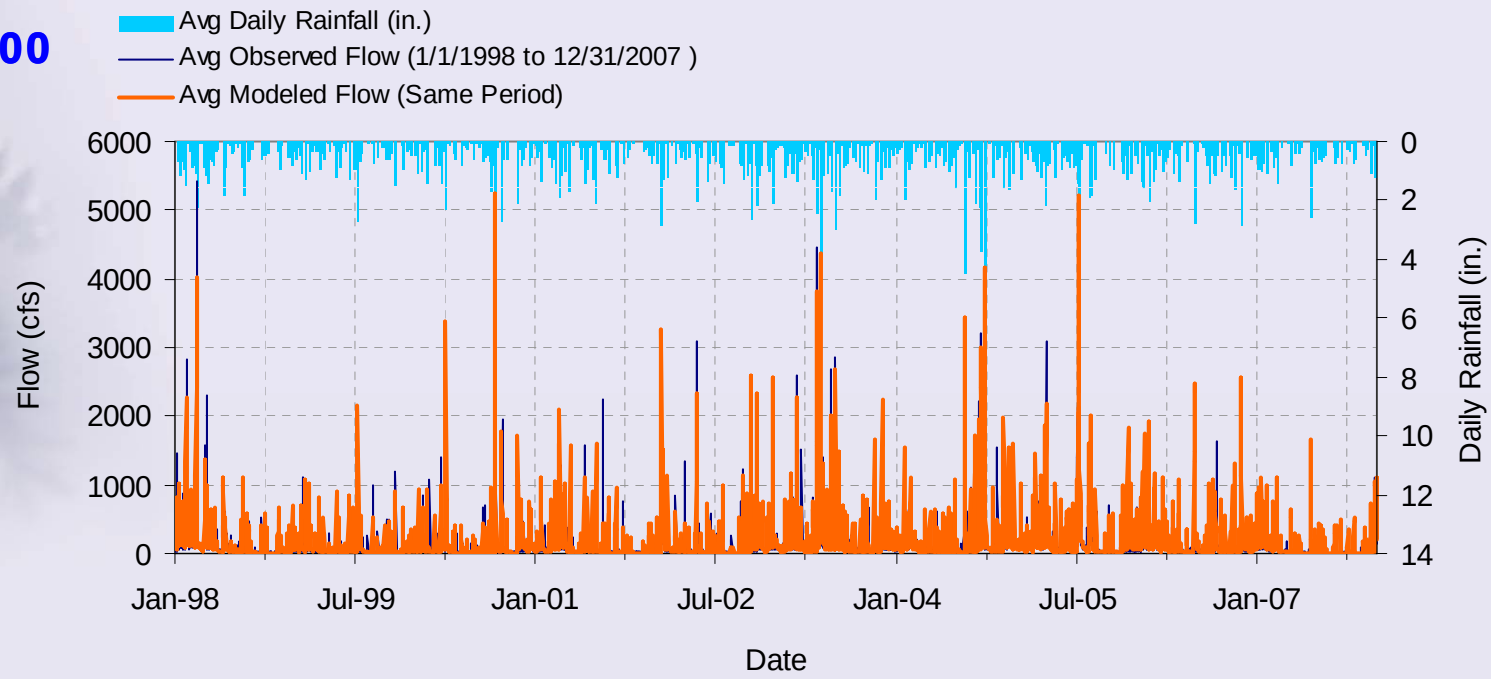

Avg Monthly Rainfall (in.)
Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (Same Period)
Flow (cfs)
15000
10000
5000
0
Monthly Rainfall (in.)
16
14
12
10
8
6
4
2
0
J-98
J-99
J-01
J-02
J-04
J-05
J-07
Month

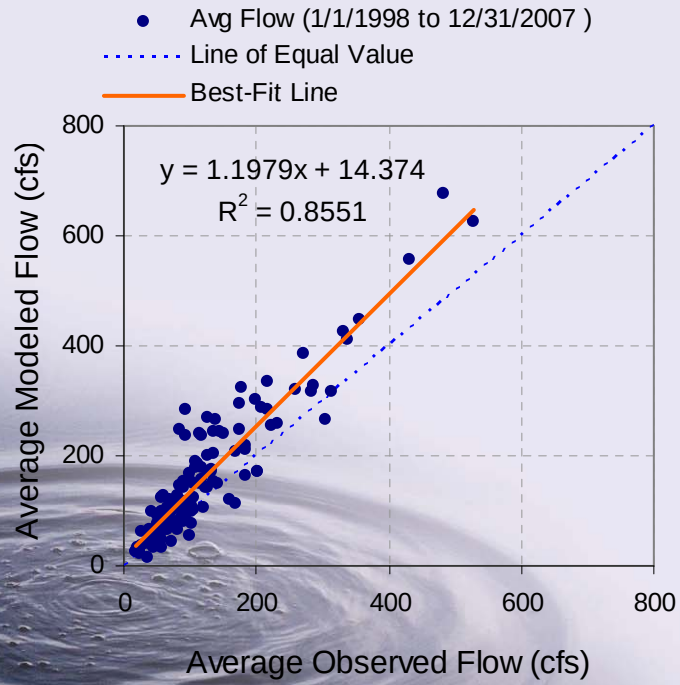

Observed Flow Duration (1/1/1998 to 12/31/2007)
Modeled Flow Duration (1/1/1998 to 12/31/2007)
Daily Average Flow (cfs)
100000
10000
1000
100
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time that Flow is Equaled or Exceeded

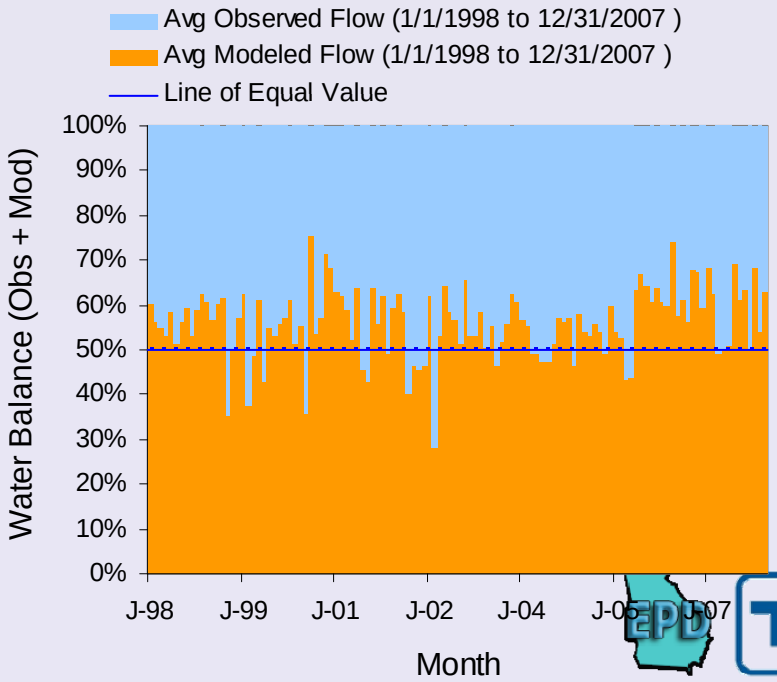
02338000

LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 301		USGS 02338000 CHATTAHOOCHEE RIVER NEAR WHITESBURG, GA	
10-Year Analysis Period: 1/1/1998 - 12/31/2007 Flow volumes are (inches/year) for upstream drainage area		Hydrologic Unit Code: 3130002 Latitude: 33.4770577 Longitude: -84.9007722 Drainage Area (sq-mi): 2430	
Total Simulated In-stream Flow:	**20.51**	Total Observed In-stream Flow:	**19.05**
Total of simulated highest 10% flows:	**6.59**	Total of Observed highest 10% flows:	**6.06**
Total of Simulated lowest 50% flows:	**4.89**	Total of Observed Lowest 50% flows:	**4.68**
Simulated Summer Flow Volume (months 7-9):	**4.85**	Observed Summer Flow Volume (7-9):	**4.38**
Simulated Fall Flow Volume (months 10-12):	**4.42**	Observed Fall Flow Volume (10-12):	**3.76**
Simulated Winter Flow Volume (months 1-3):	**6.30**	Observed Winter Flow Volume (1-3):	**5.96**
Simulated Spring Flow Volume (months 4-6):	**4.93**	Observed Spring Flow Volume (4-6):	**4.94**
Total Simulated Storm Volume:	**8.32**	Total Observed Storm Volume:	**6.85**
Simulated Summer Storm Volume (7-9):	**2.01**	Observed Summer Storm Volume (7-9):	**1.65**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	7.65	10	
Error in 50% lowest flows:	4.46	10	
Error in 10% highest flows:	8.68	15	
Seasonal volume error - Summer:	10.71	30	
Seasonal volume error - Fall:	17.52	30	
Seasonal volume error - Winter:	5.72	30	
Seasonal volume error - Spring:	-0.24	30	
Error in storm volumes:	**21.43**	**20**	
Error in summer storm volumes:	22.33	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.644	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.548	as E or E' approaches 1.0	

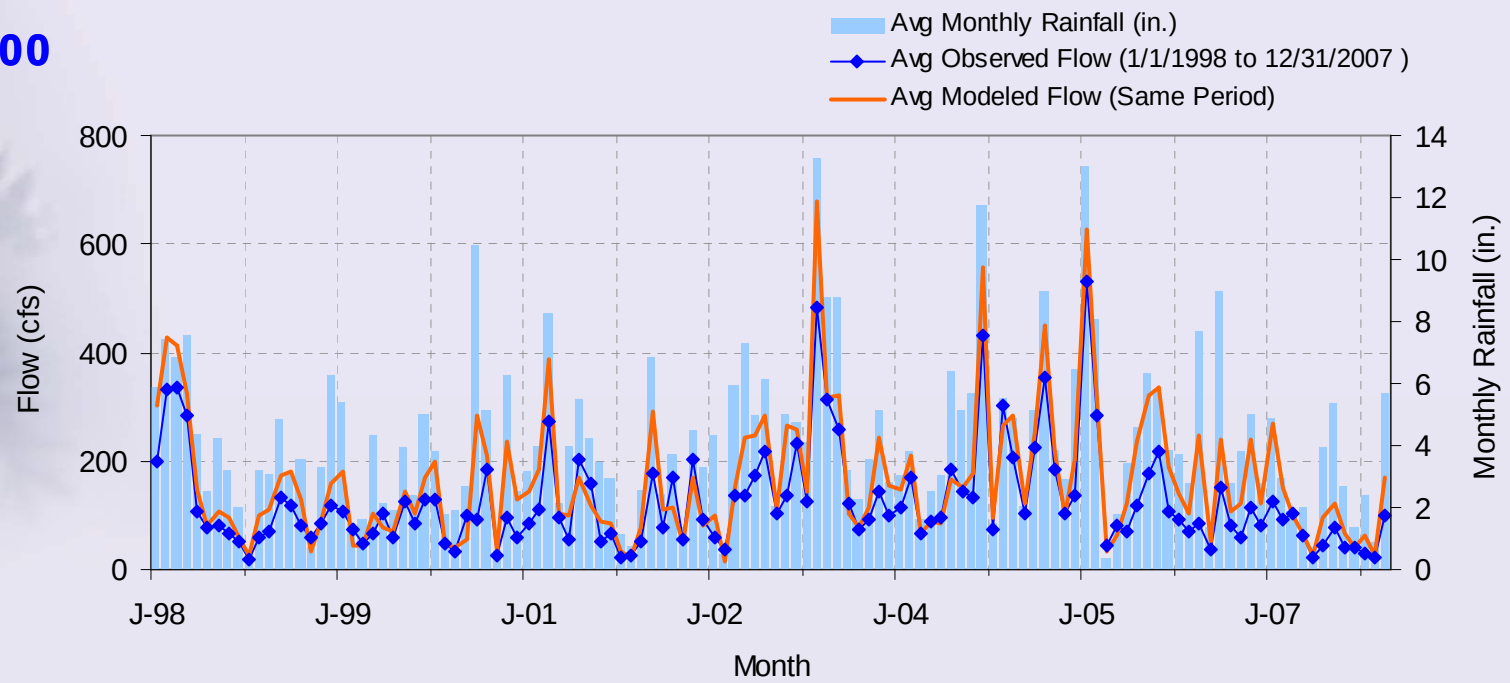
02336300

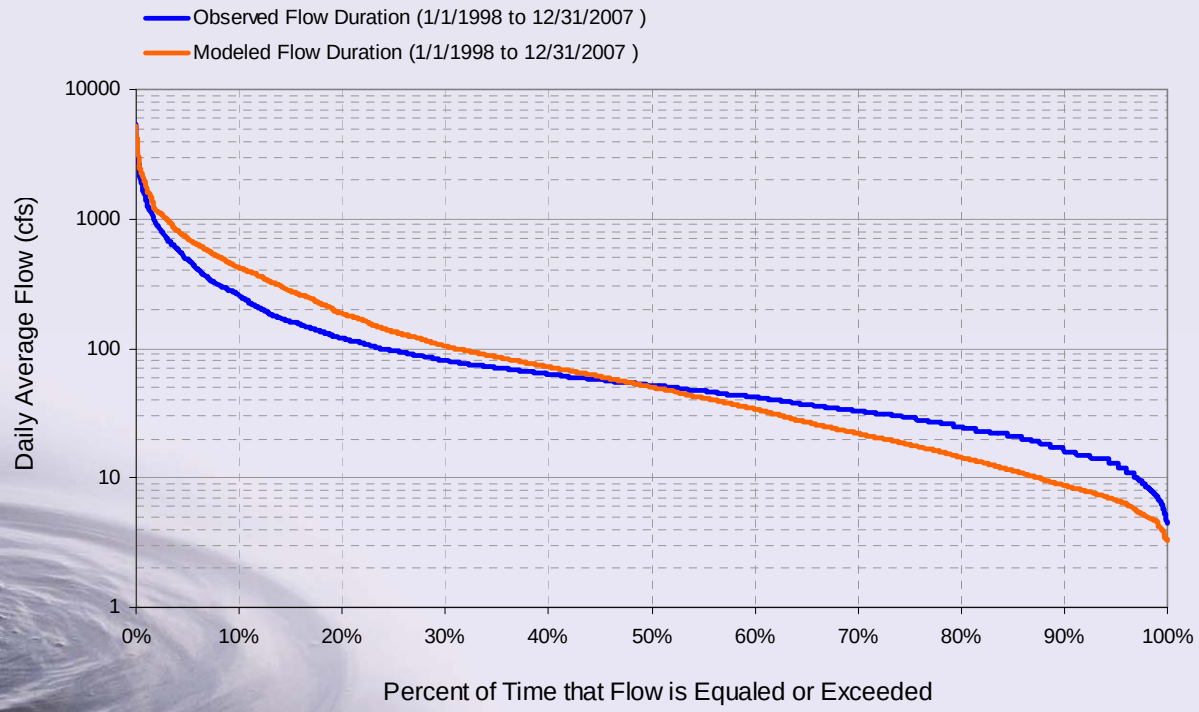

Avg Daily Rainfall (in.)
Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (Same Period)
Flow (cfs)
Daily Rainfall (in.)
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
14
Jan-98
Jul-99
Jan-01
Jul-02
Jan-04
Jul-05
Jan-07
Date


Avg Flow (1/1/1998 to 12/31/2007)
Line of Equal Value
Best-Fit Line
y = 1.1979x + 14.374
R2 = 0.8551
Average Modeled Flow (cfs)
Average Observed Flow (cfs)
800
600
400
200
0
0
200
400
600
800

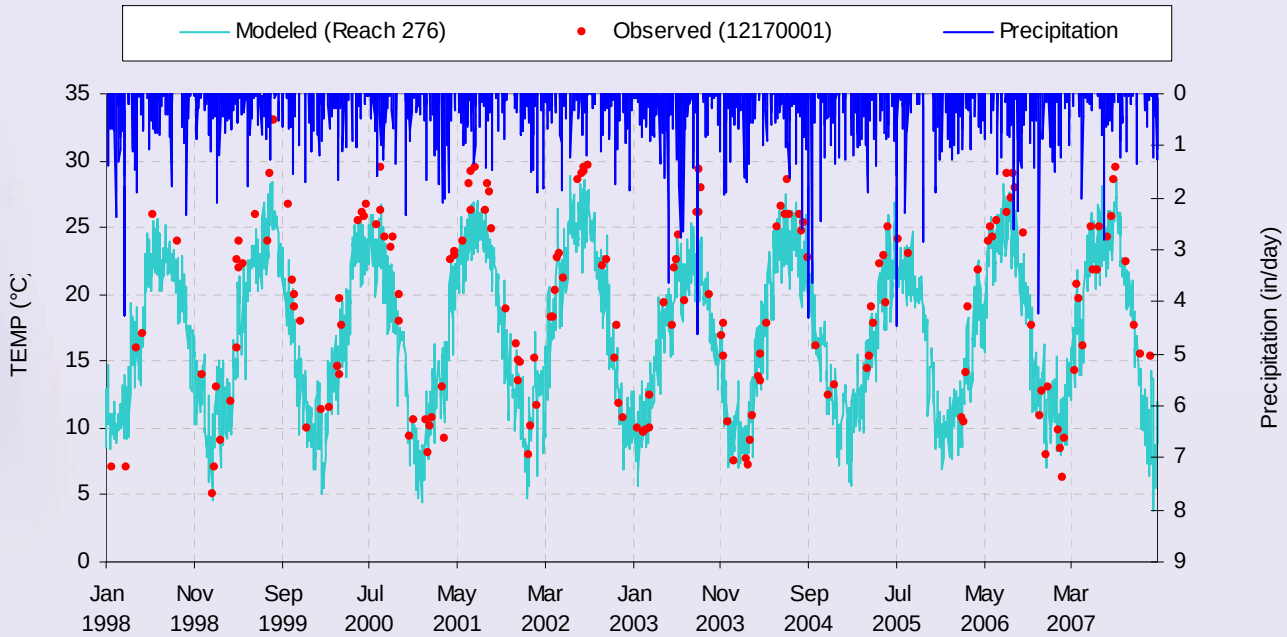

Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (1/1/1998 to 12/31/2007)
Line of Equal Value
Water Balance (Obs + Mod)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
J-98
J-99
J-01
J-02
J-04
J-05
J-07
Month

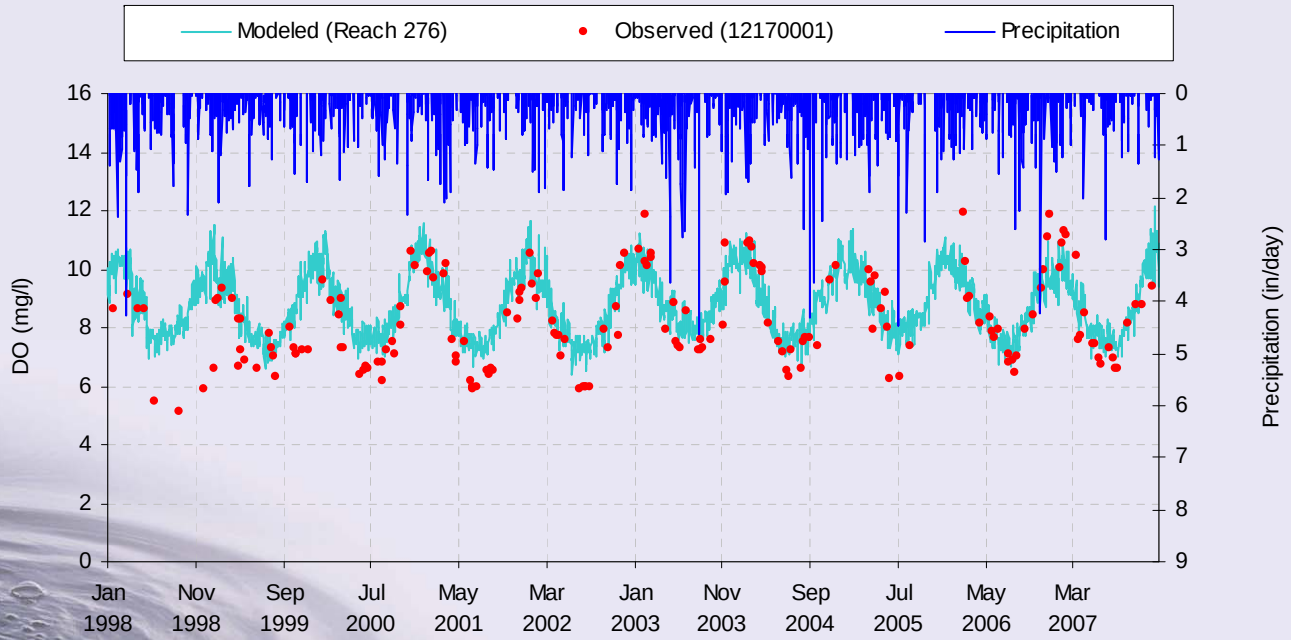
02336300


Avg Monthly Rainfall (in.)
Avg Observed Flow (1/1/1998 to 12/31/2007)
Avg Modeled Flow (Same Period)
Flow (cfs)
Monthly Rainfall (in.)
800
600
400
200
0
14
12
10
8
6
4
2
0
J-98
J-99
J-01
J-02
J-04
J-05
J-07
Month

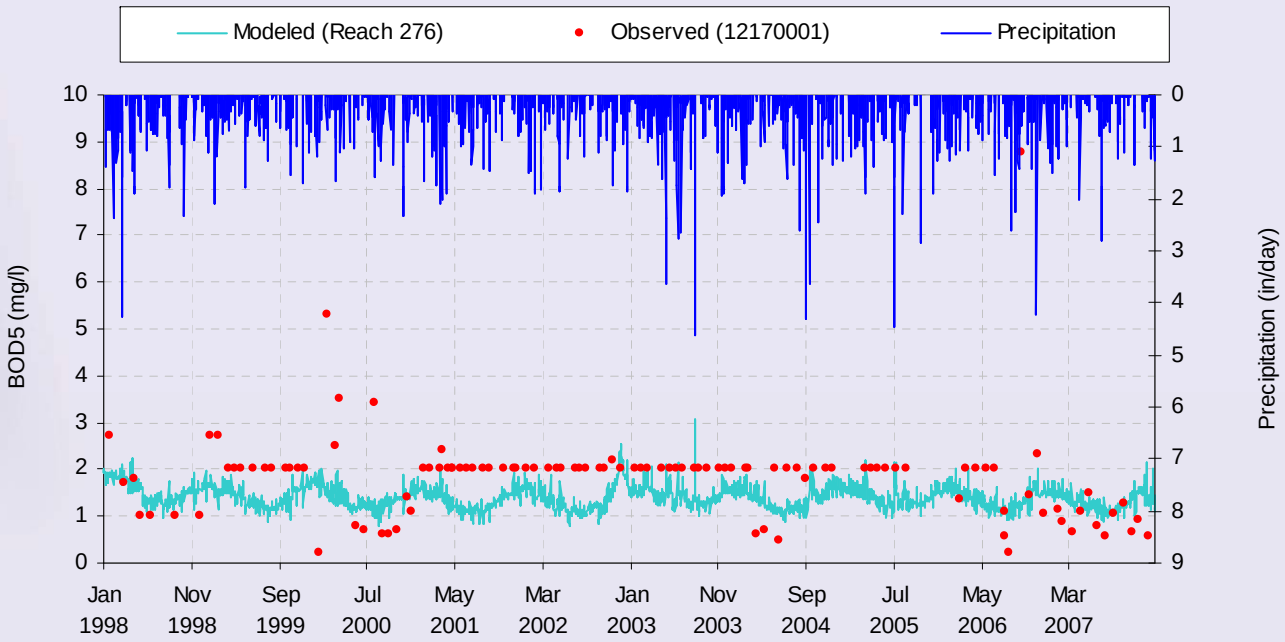

Observed Flow Duration (1/1/1998 to 12/31/2007)
Modeled Flow Duration (1/1/1998 to 12/31/2007)
Daily Average Flow (cfs)
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time that Flow is Equaled or Exceeded

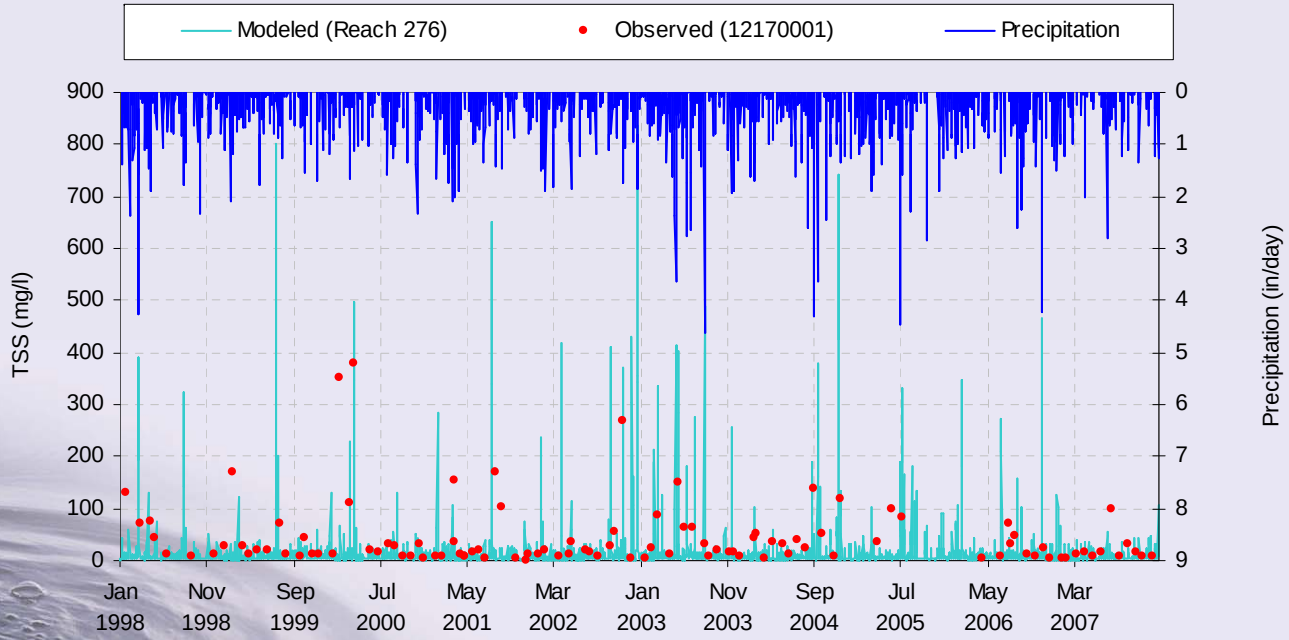
12170001


Modeled (Reach 276)
Observed (12170001)
Precipitation
TEMP (°C)
Precipitation (in/day)
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

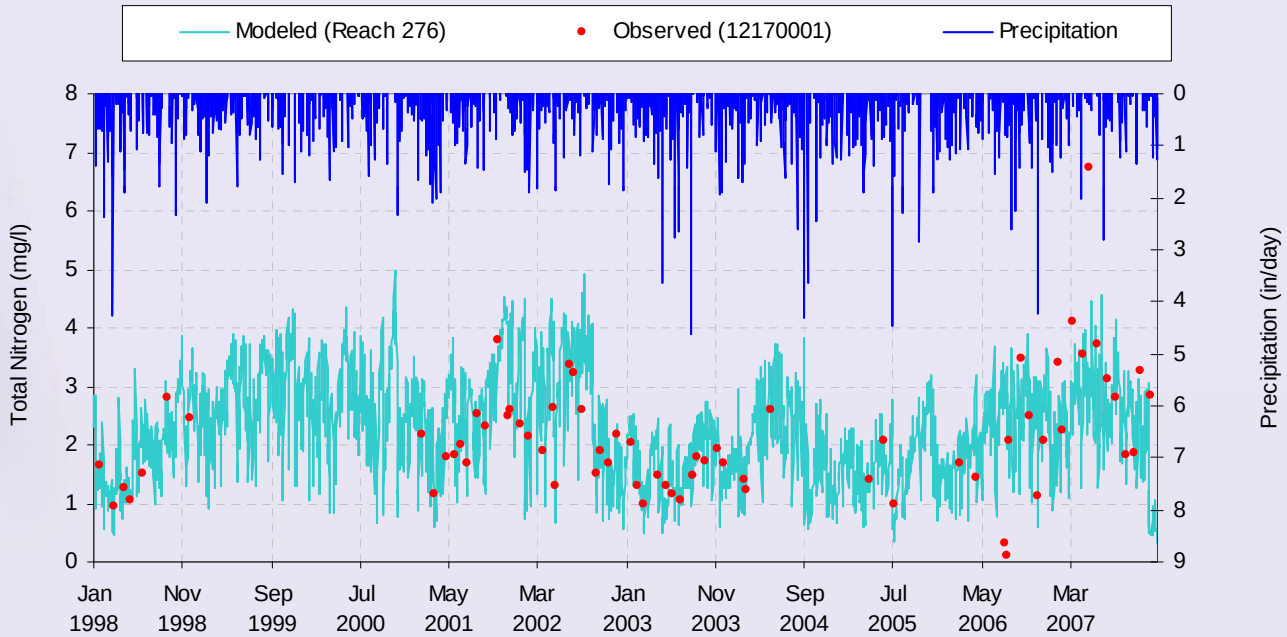

Modeled (Reach 276)
Observed (12170001)
Precipitation
DO (mg/l)
Precipitation (in/day)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

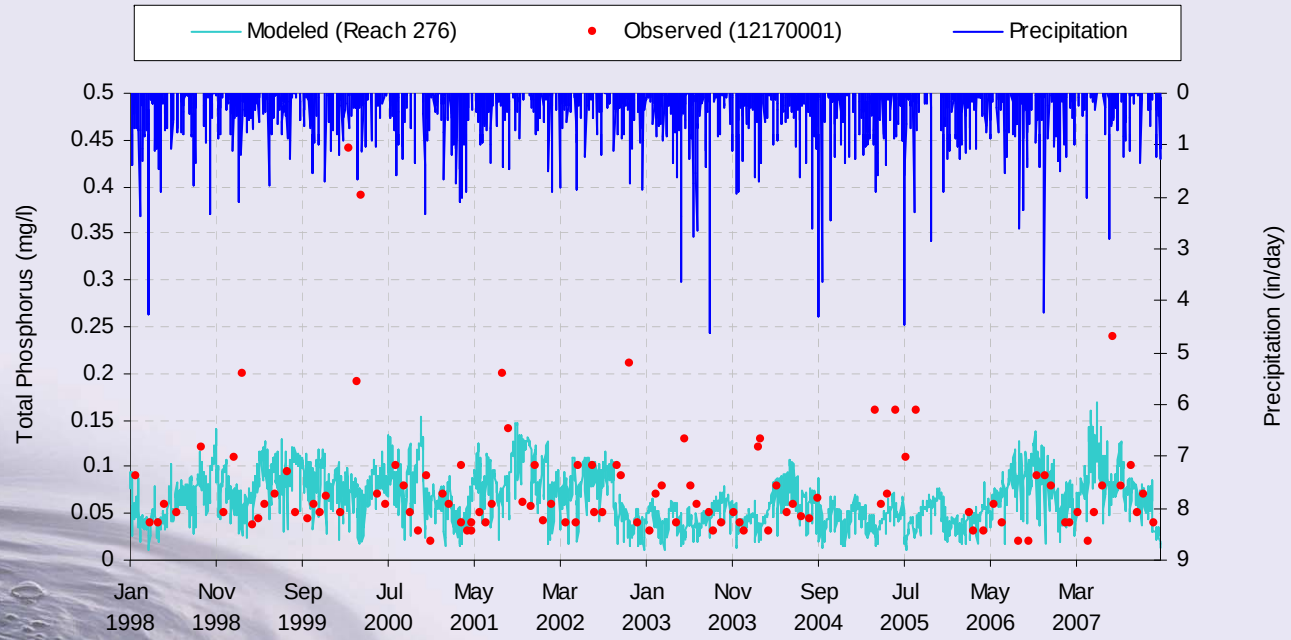
12170001


Modeled (Reach 276)
Observed (12170001)
Precipitation
BOD5 (mg/l)
Precipitation (in/day)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

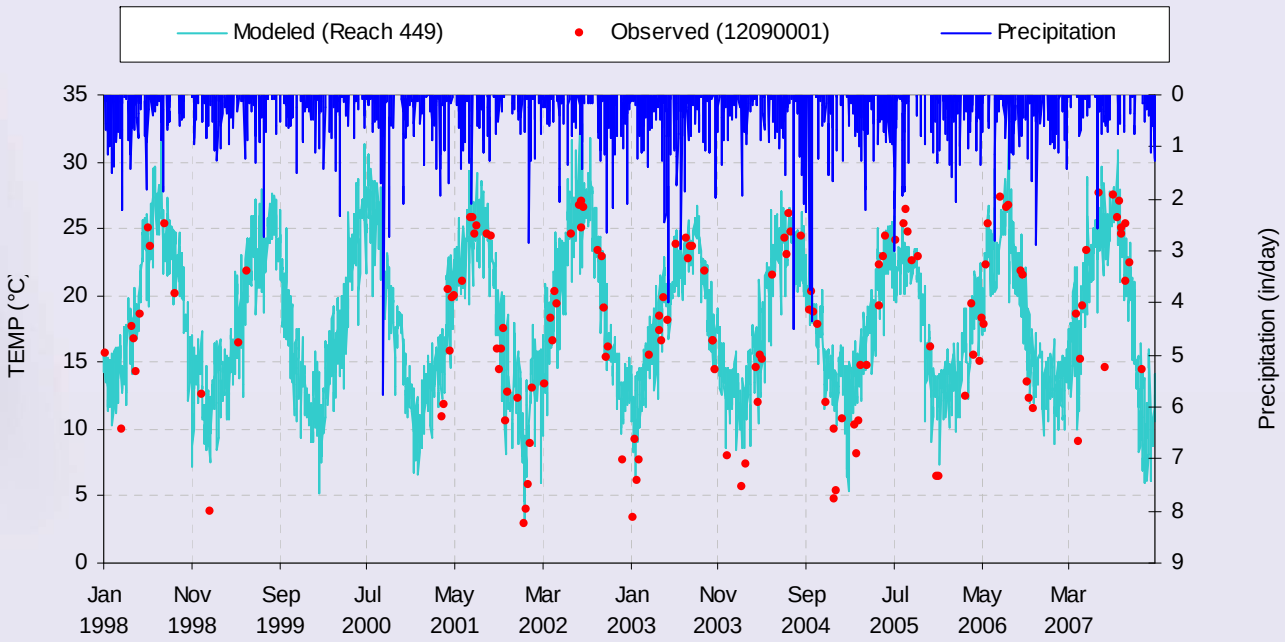

Modeled (Reach 276)
Observed (12170001)
Precipitation
TSS (mg/l)
Precipitation (in/day)
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

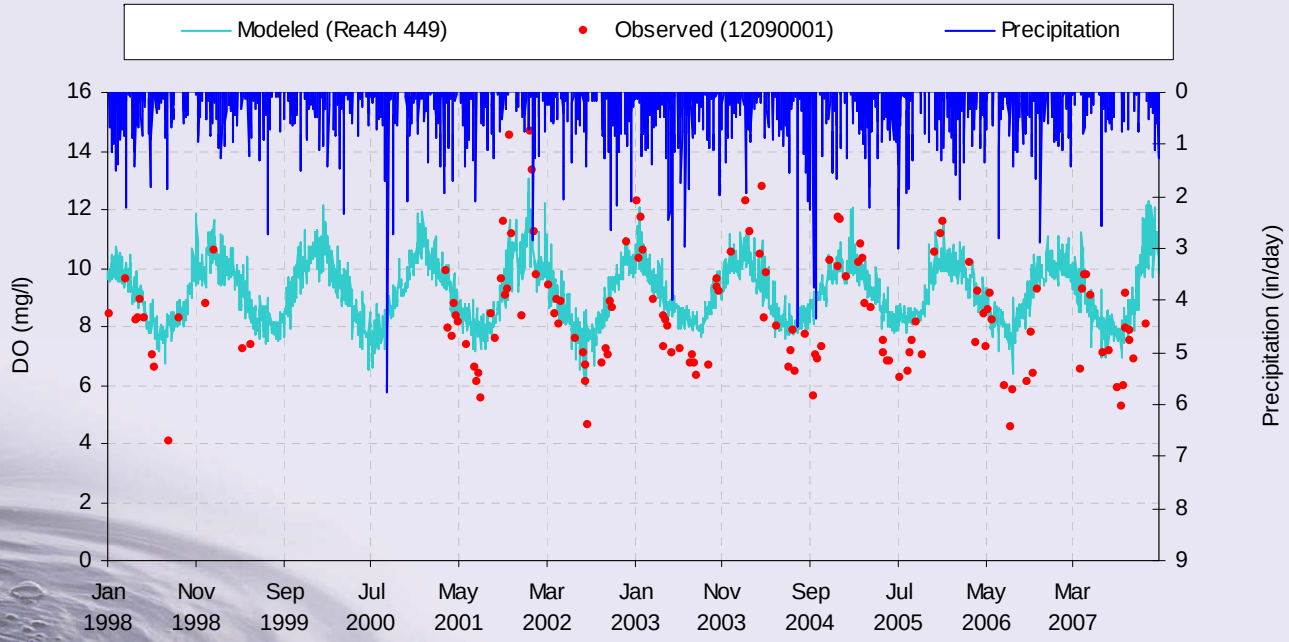
12170001


Modeled (Reach 276)
Observed (12170001)
Precipitation
Total Nitrogen (mg/l)
Precipitation (in/day)
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

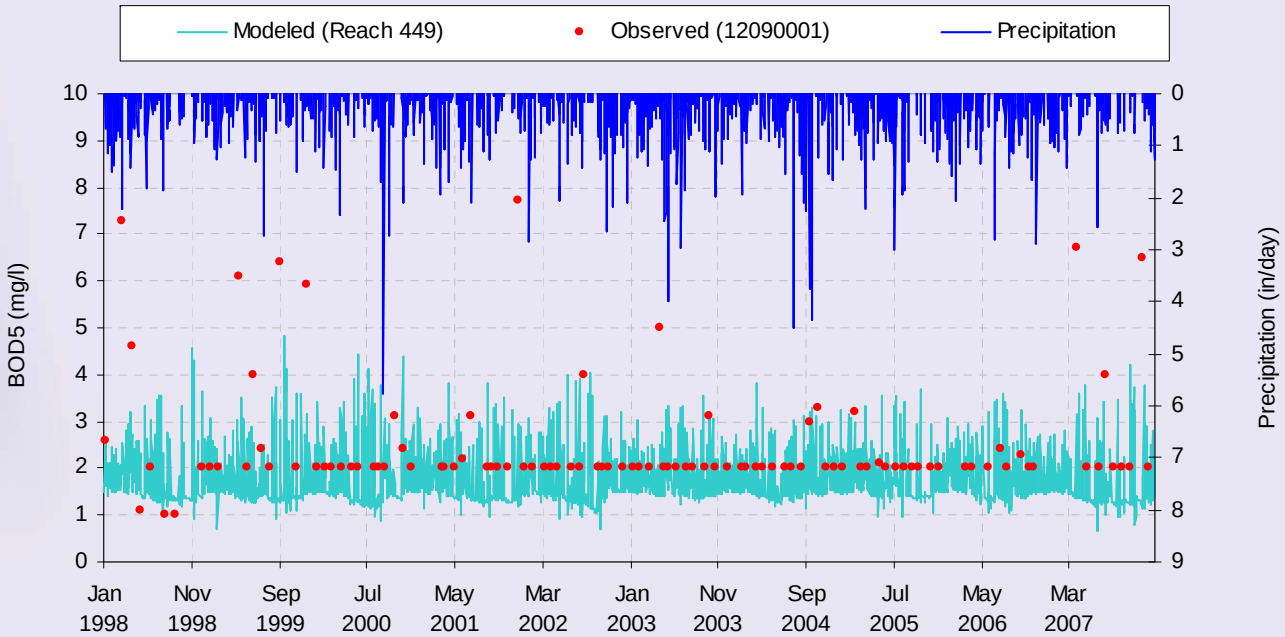

Modeled (Reach 276)
Observed (12170001)
Precipitation
Total Phosphorus (mg/l)
Precipitation (in/day)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

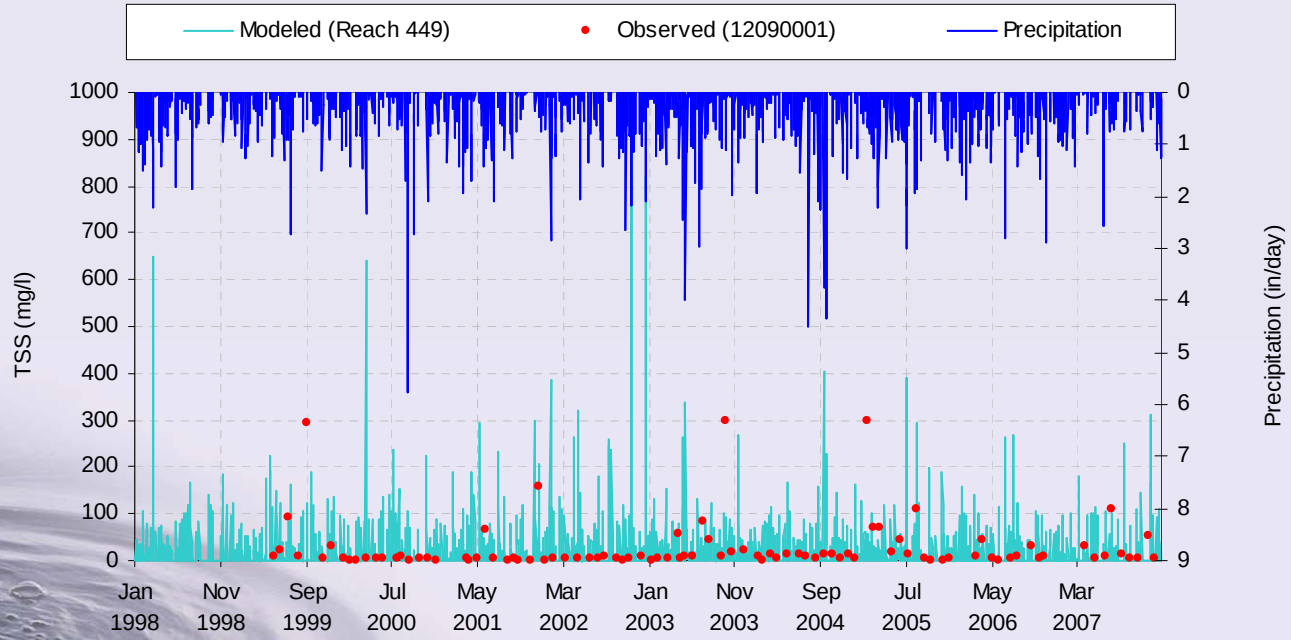
12090001


Modeled (Reach 449)
Observed (12090001)
Precipitation
TEMP (°C)
Precipitation (in/day)
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

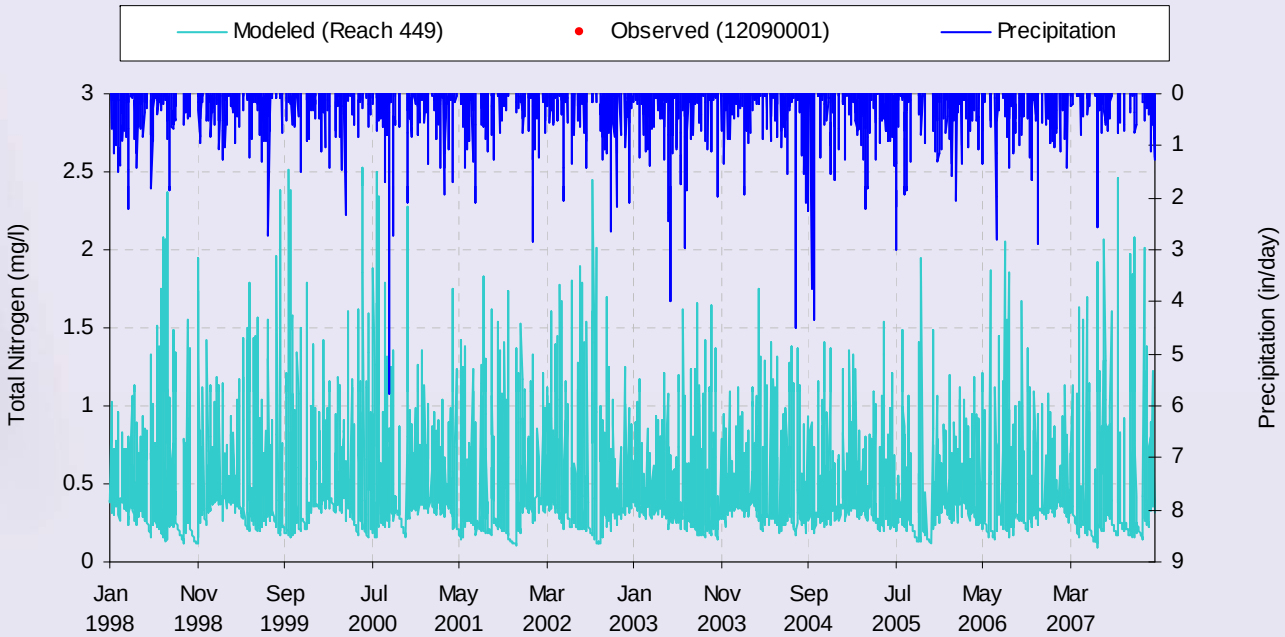

Modeled (Reach 449)
Observed (12090001)
Precipitation
DO (mg/l)
Precipitation (in/day)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

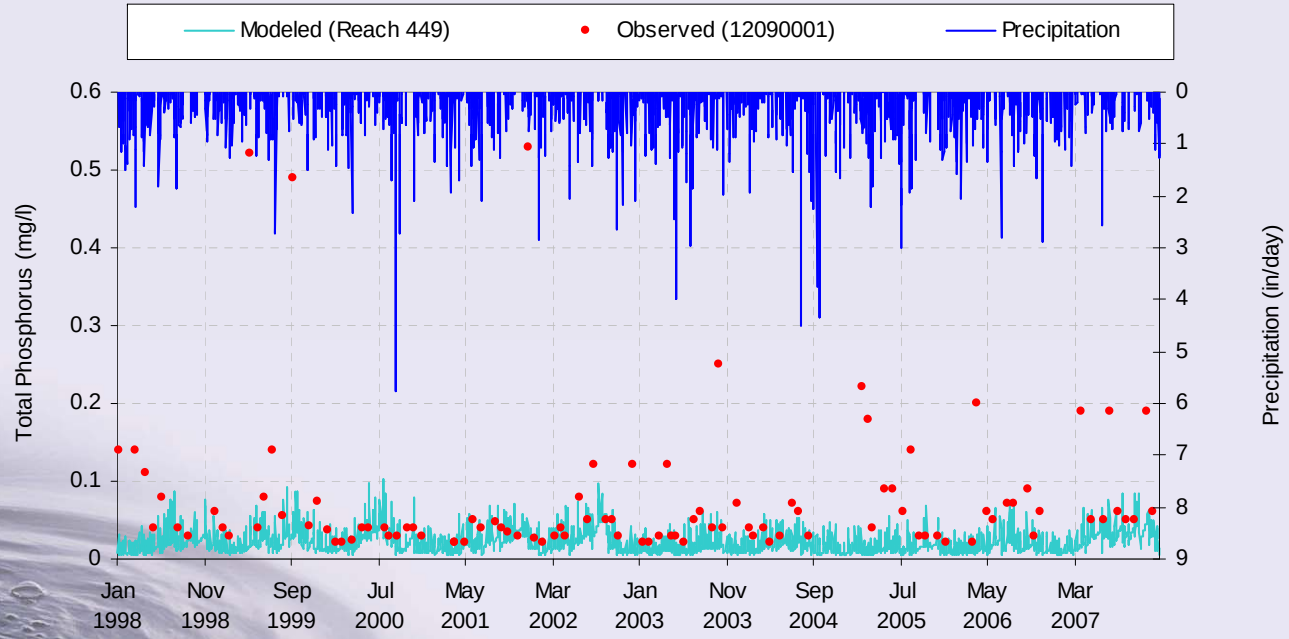
12090001


Modeled (Reach 449)
Observed (12090001)
Precipitation
BOD5 (mg/l)
Precipitation (in/day)
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007


Modeled (Reach 449)
Observed (12090001)
Precipitation
TSS (mg/l)
Precipitation (in/day)
1000
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

12090001

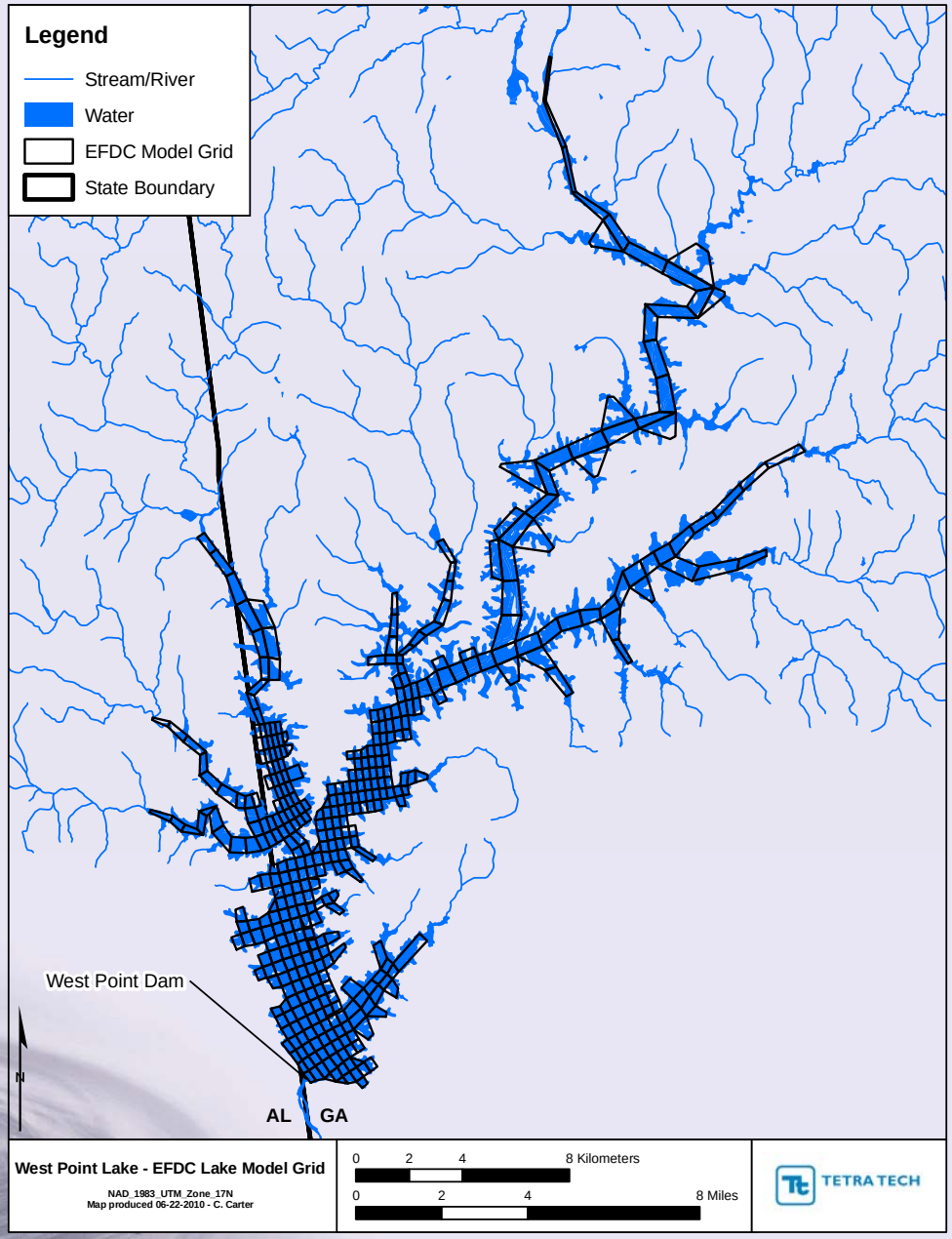

Modeled (Reach 449)
Observed (12090001)
Precipitation
Total Nitrogen (mg/l)
Precipitation (in/day)
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007


Modeled (Reach 449)
Observed (12090001)
Precipitation
Total Phosphorus (mg/l)
Precipitation (in/day)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
Jan 1998
Nov 1998
Sep 1999
Jul 2000
May 2001
Mar 2002
Jan 2003
Nov 2003
Sep 2004
Jul 2005
May 2006
Mar 2007

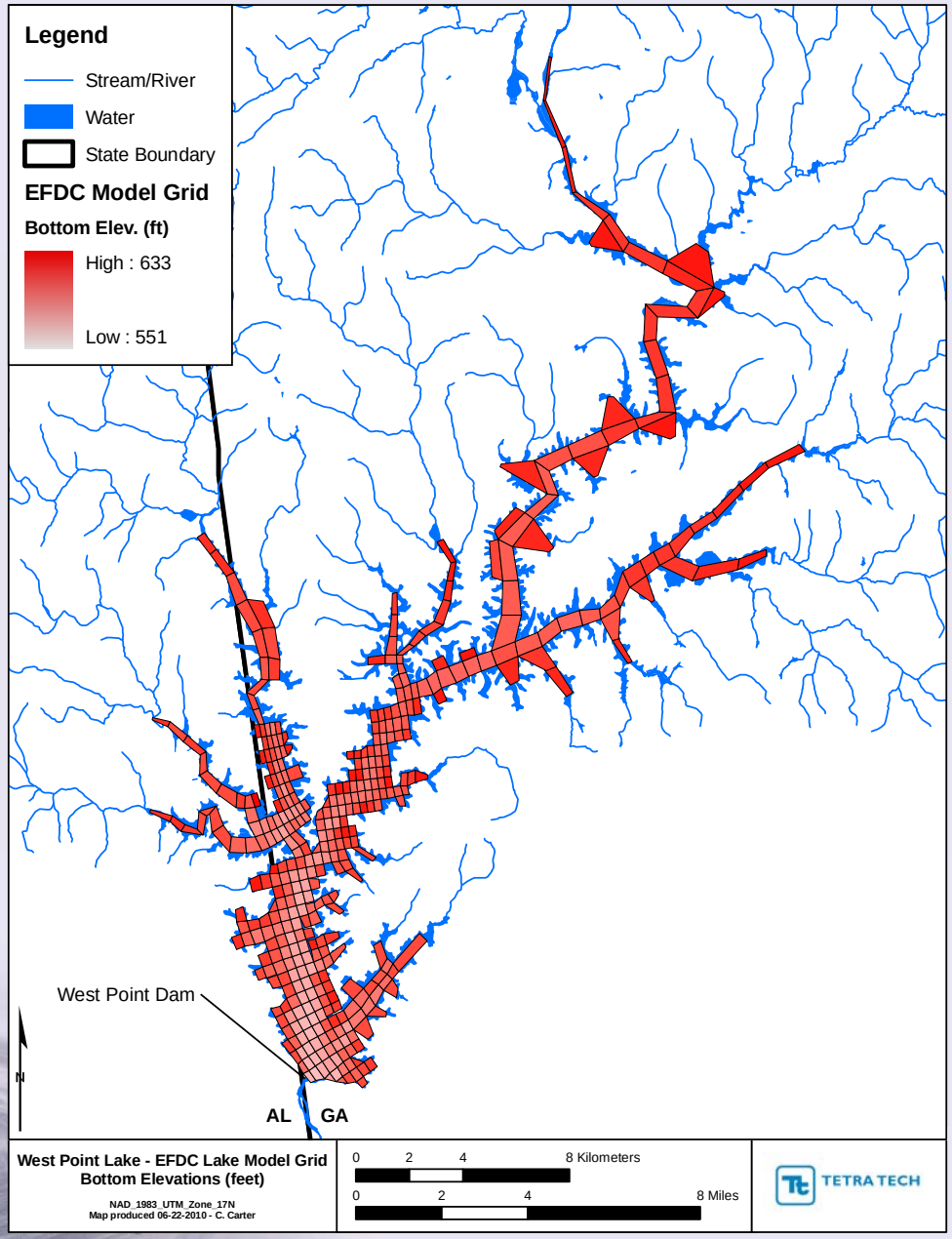
West Point Lake Instream Hydrodynamic Model

Environmental Fluid Dynamics Code (EFDC)

West Point Lake Hydrodynamic and Water Quality Model Grid

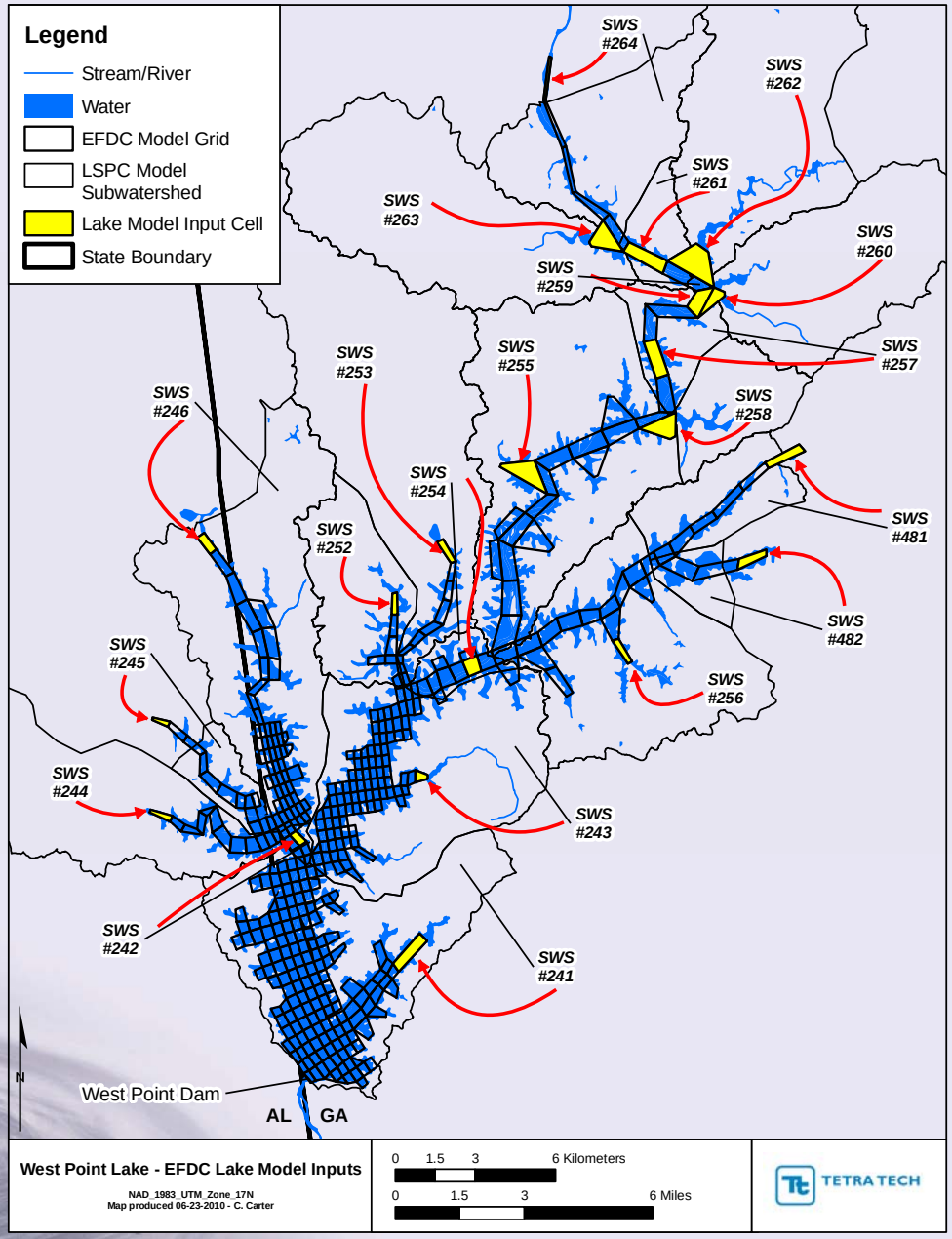


West Point Lake Grid Bottom Elevation

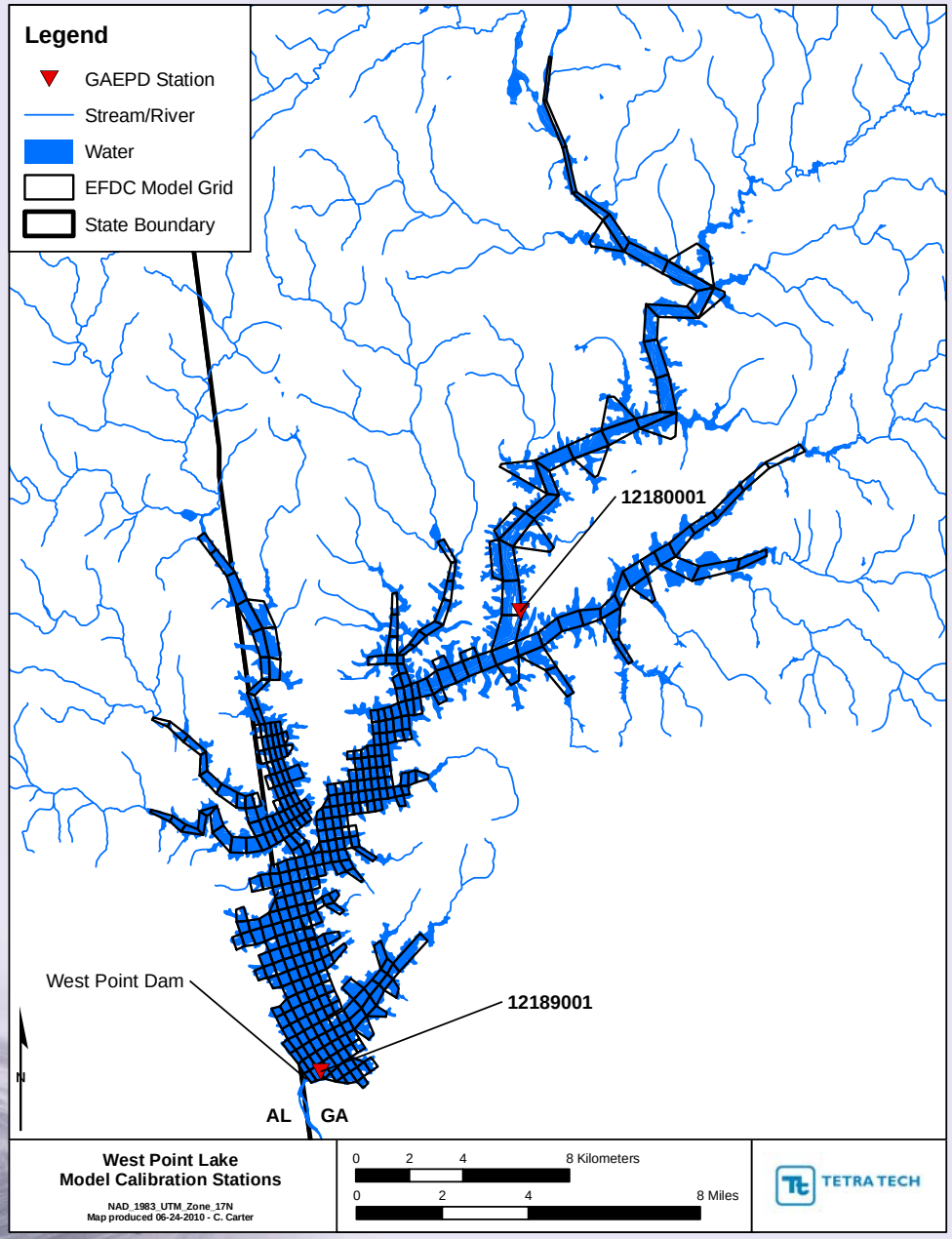


LSPC Watershed Inputs to West Point Lake

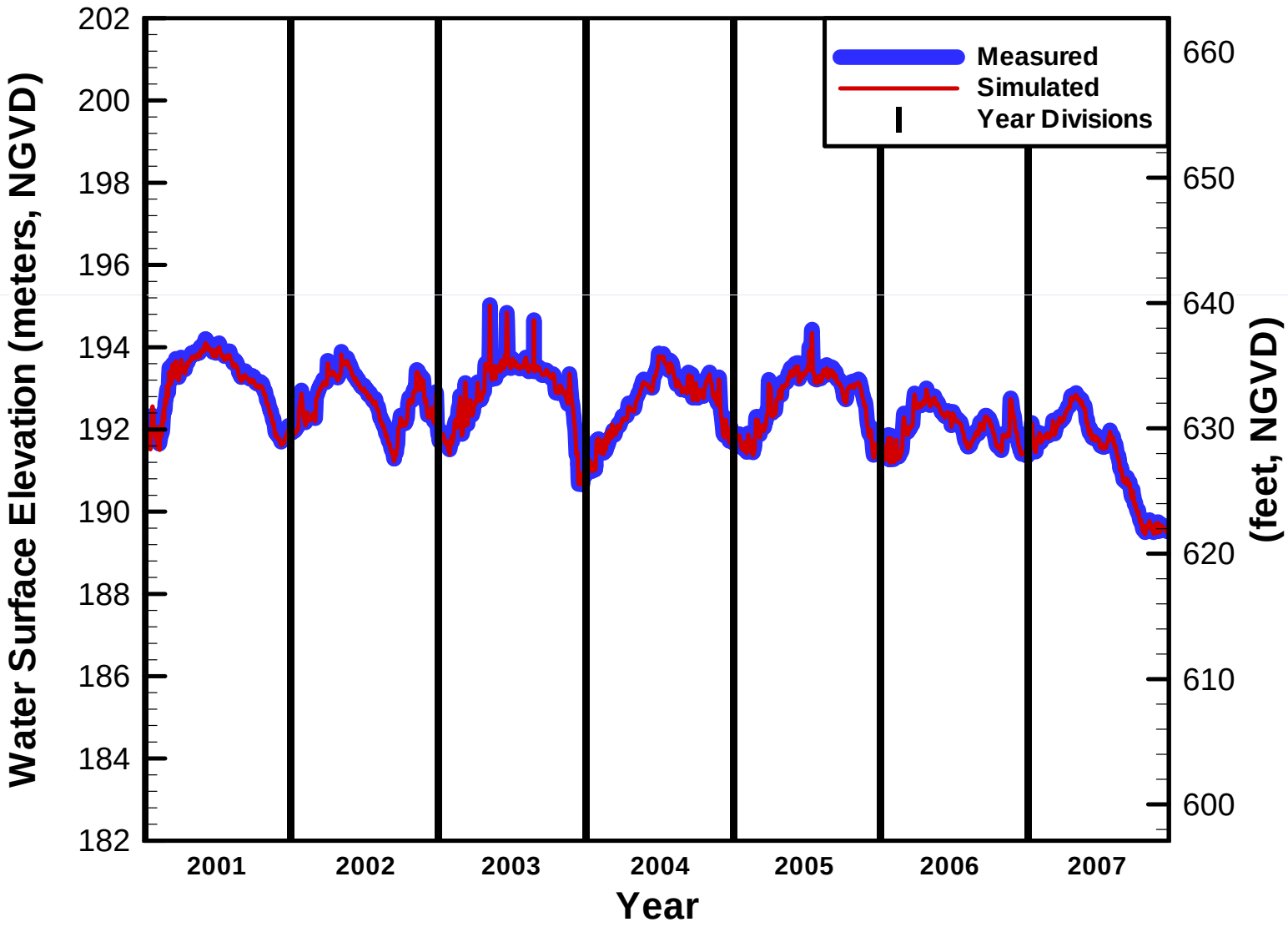
21 Total Inputs



Hydrology and Water Quality Calibration Locations for EFDC Model

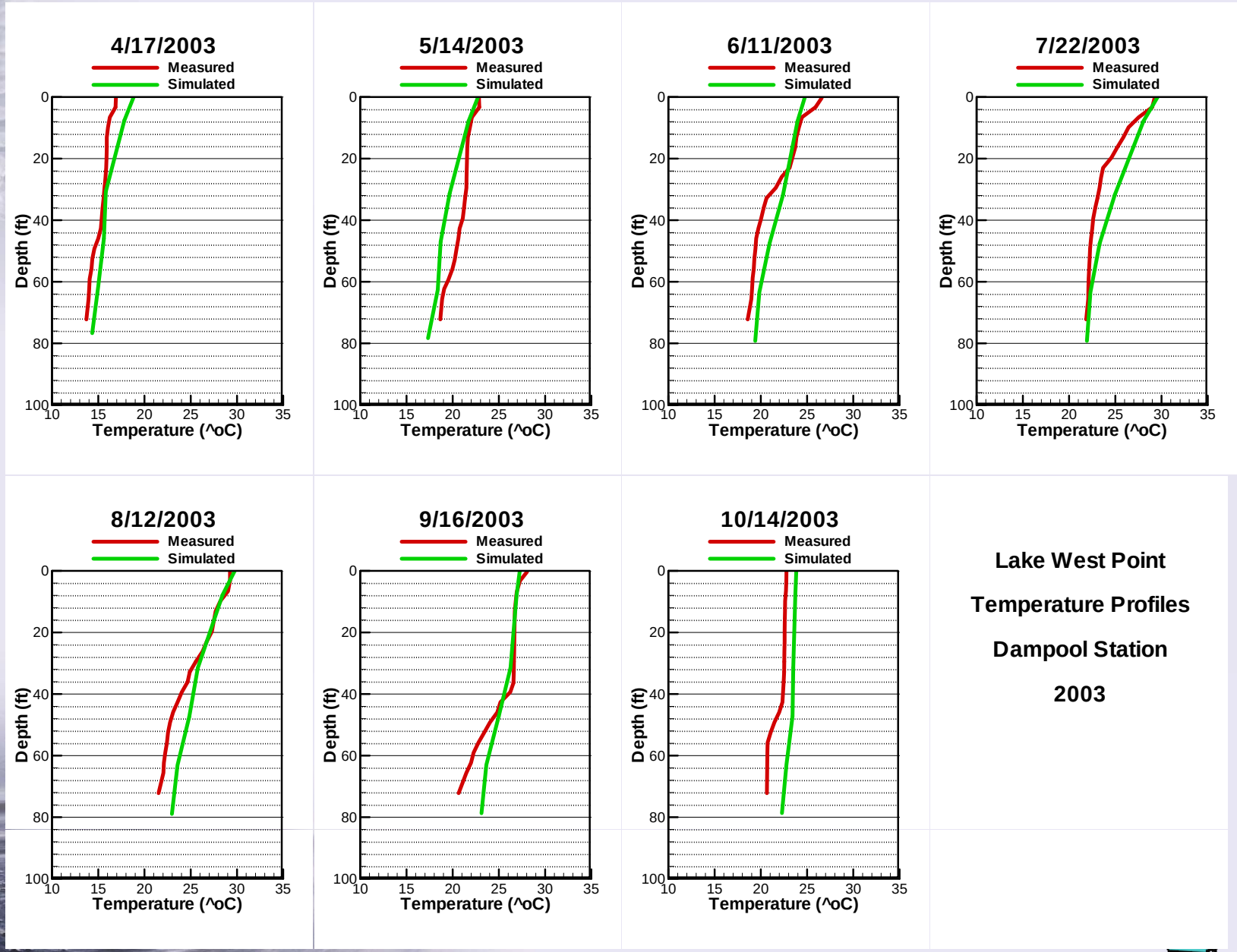


12189001 – Dampool (Forebay)



12189001 – Dampool (Forebay)

Wet Year



Lake West Point

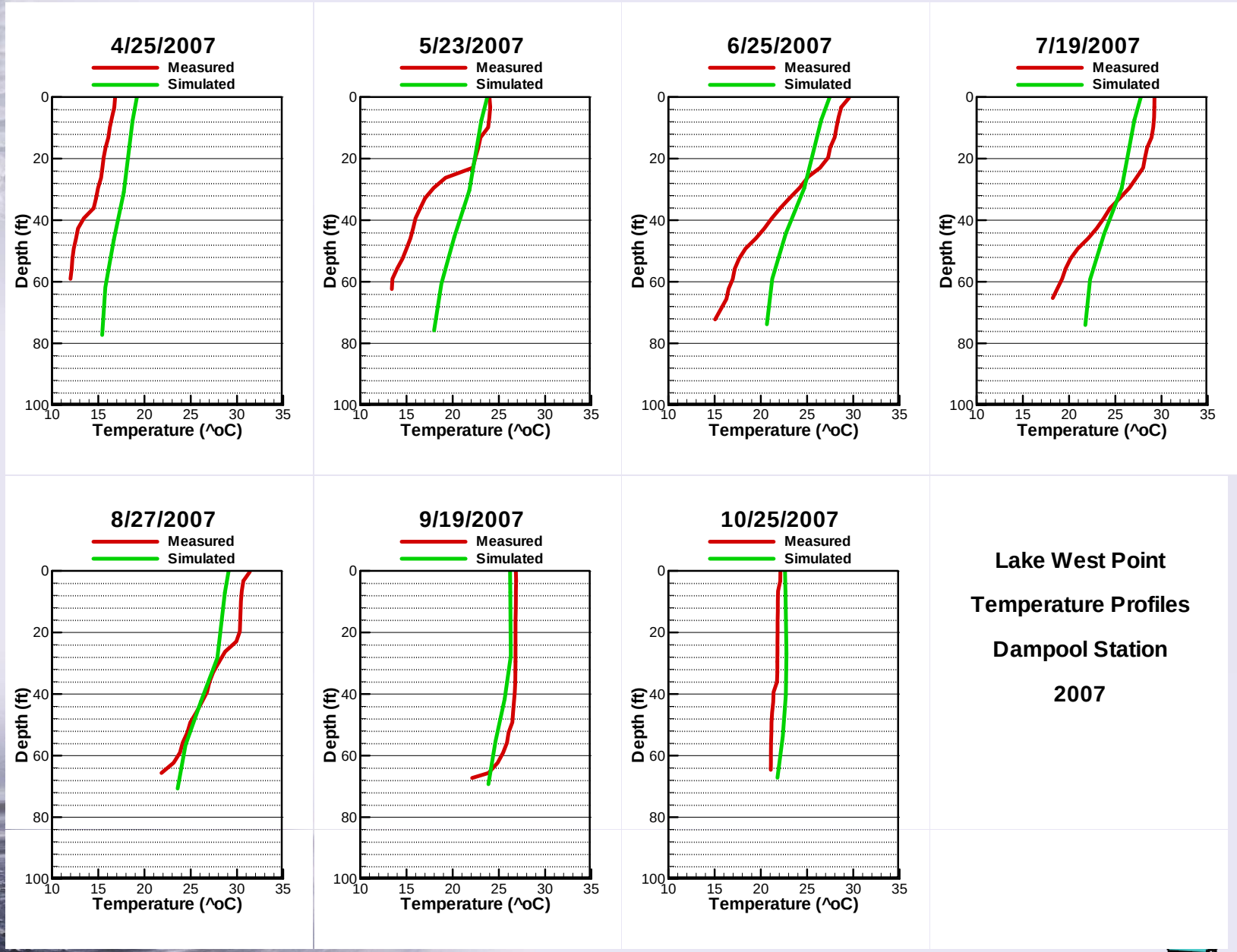
Temperature Profiles

Dampool Station

2003

12189001 – Dampool (Forebay)

Dry Year



Lake West Point

Temperature Profiles

Dampool Station

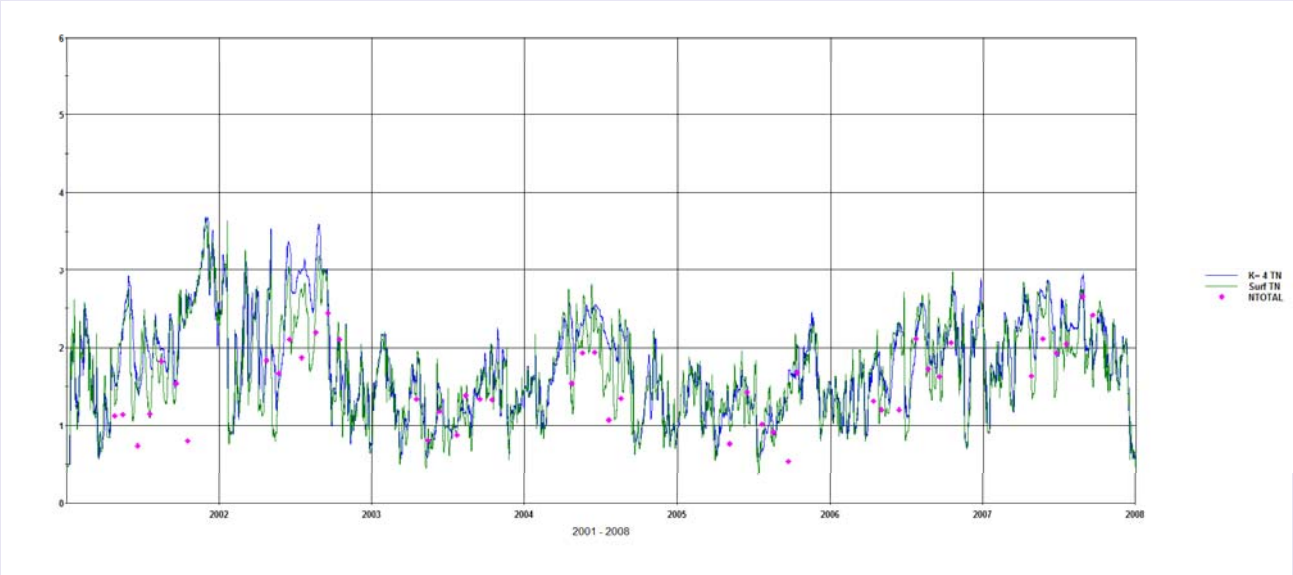
2007

West Point Lake Instream Water Quality Model

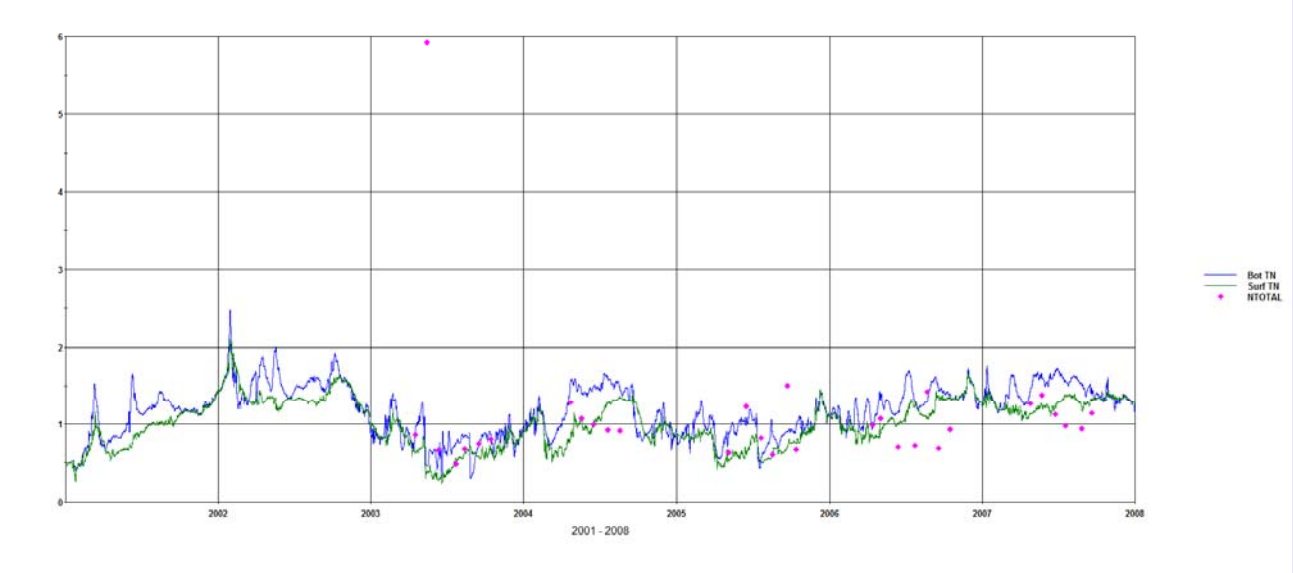
Environmental Fluid Dynamics Code (EFDC)

12180001 – Intake

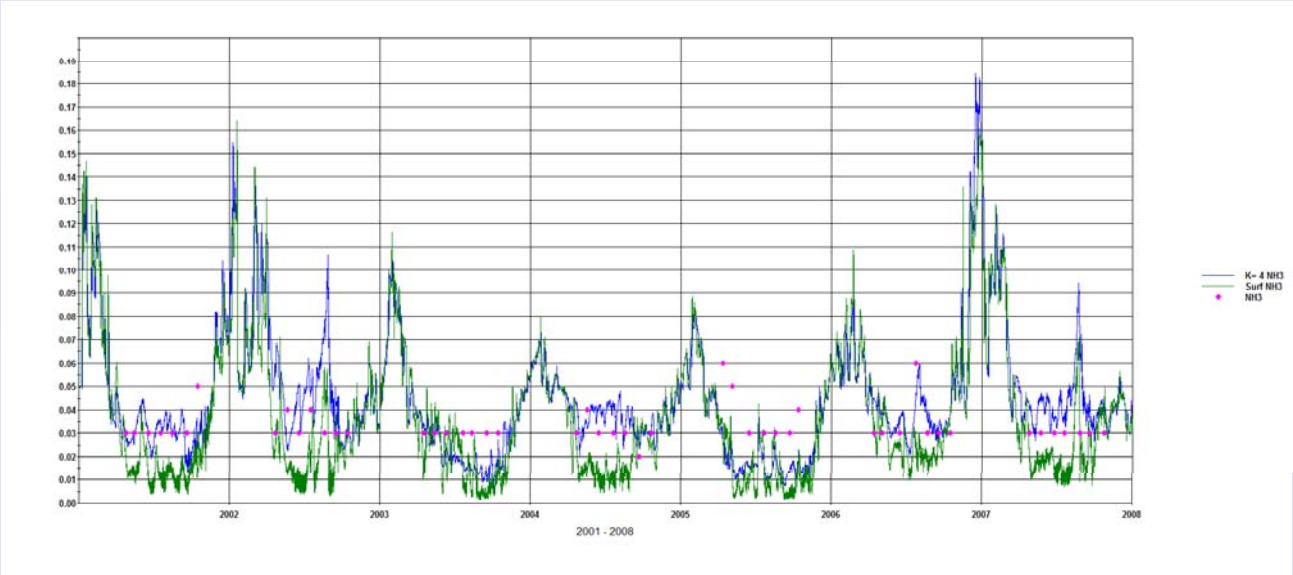
Total Nitrogen



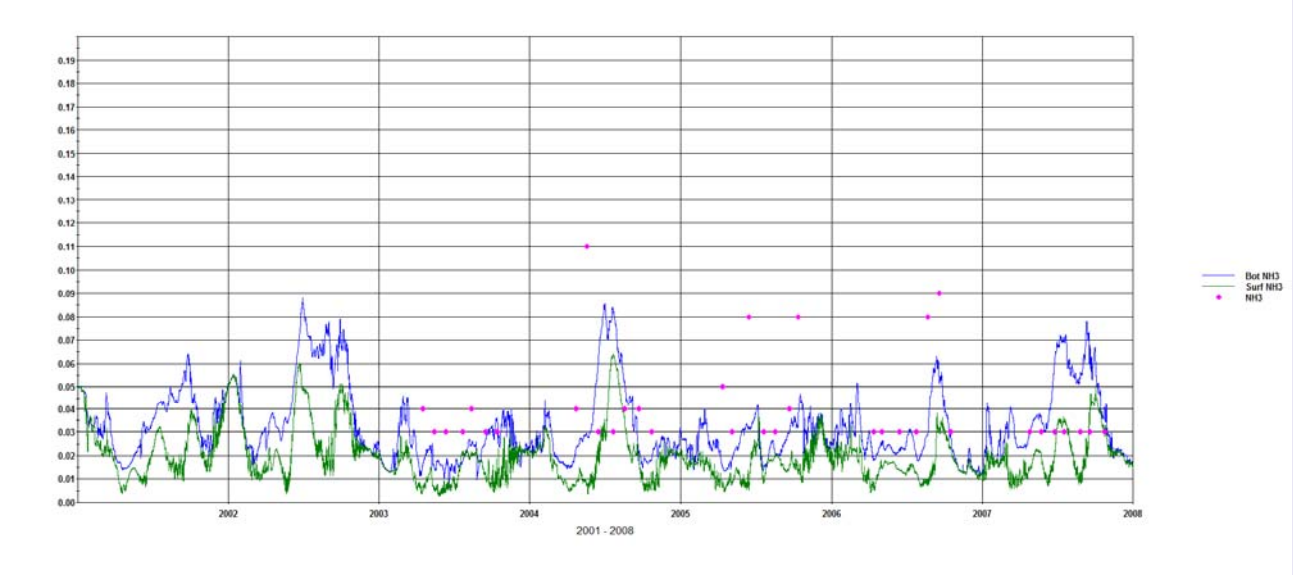
12189001 – Dampool (Forebay)



12180001 – Intake Ammonia

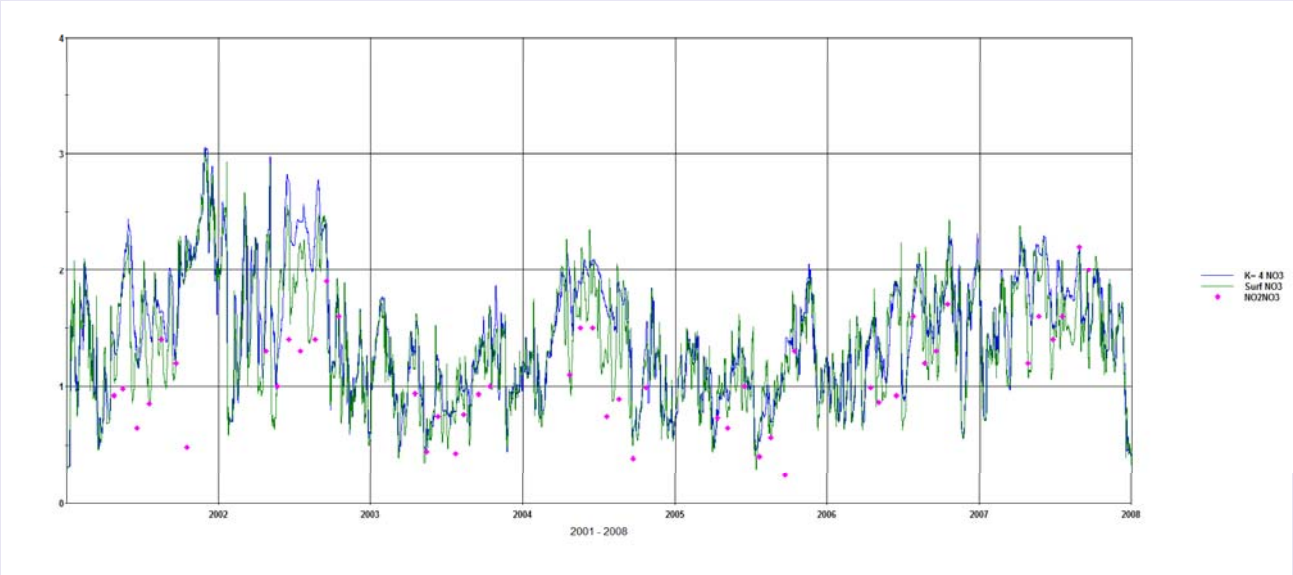


12189001 – Dampool (Forebay)

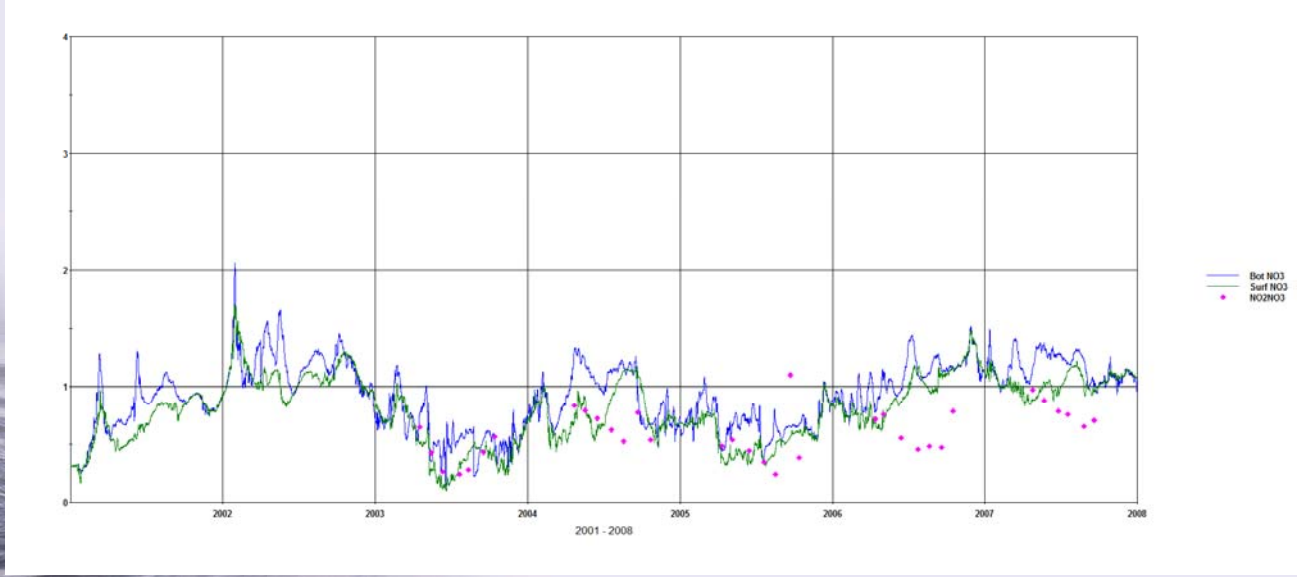


12180001 – Intake

Nitrate + Nitrite

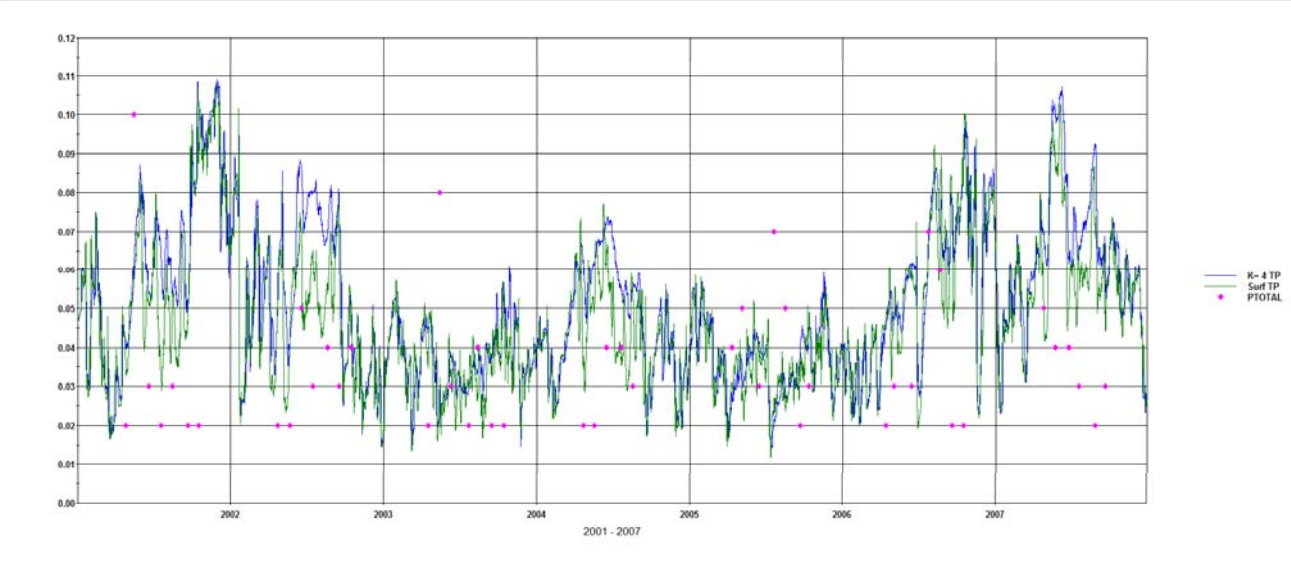


12189001 – Dampool (Forebay)

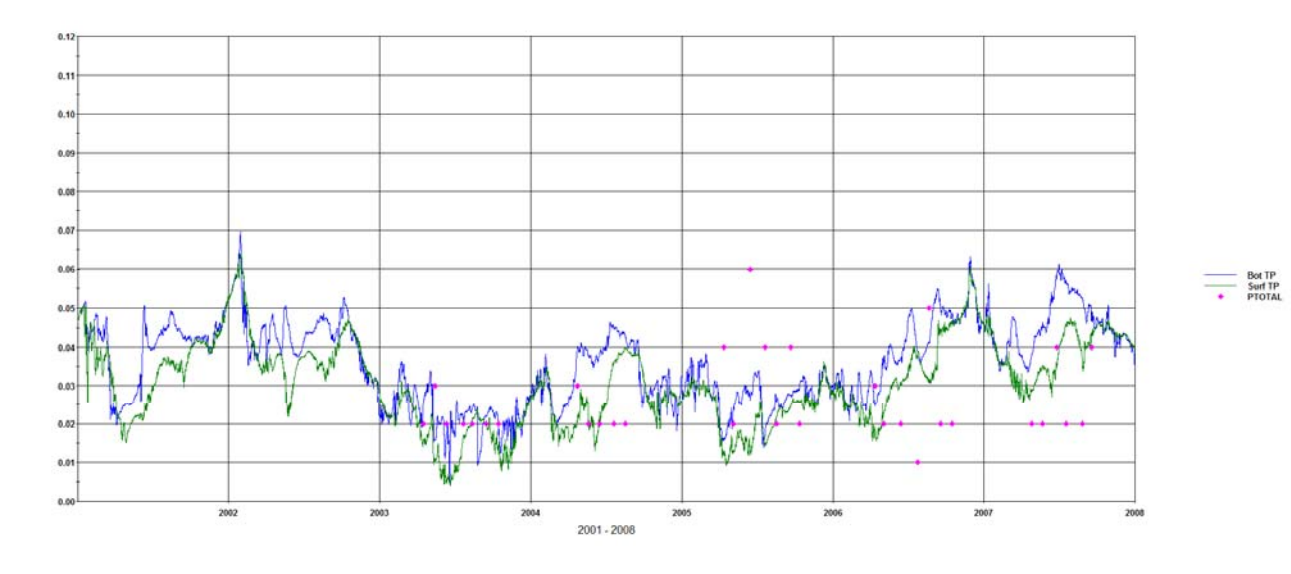


12180001 – Intake

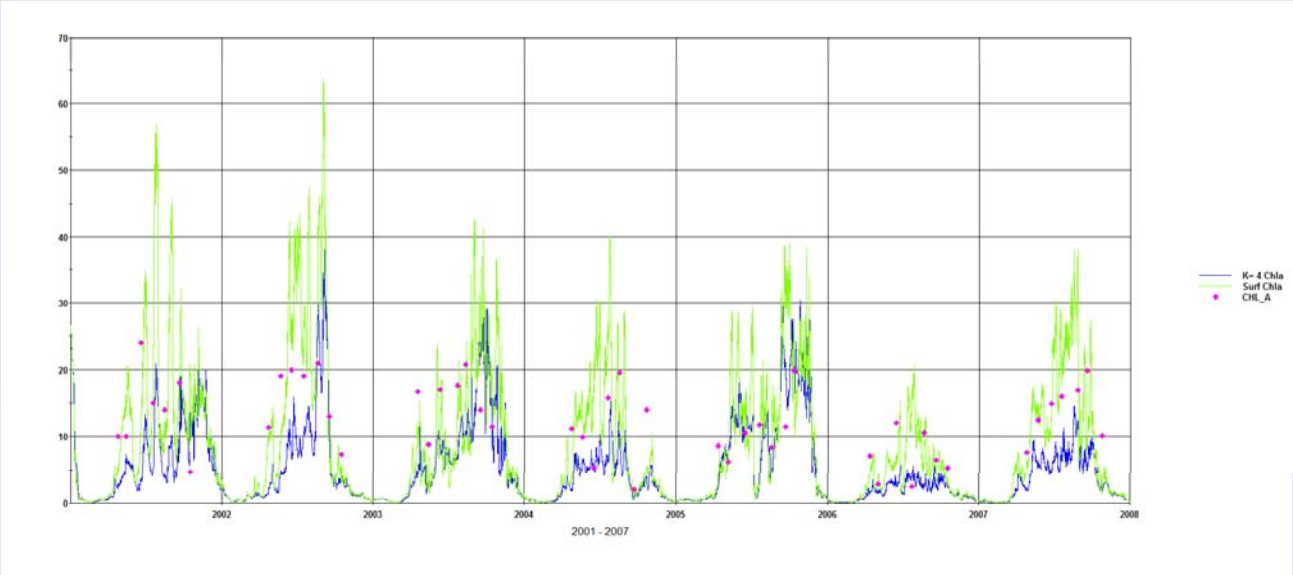
Total Phosphorus



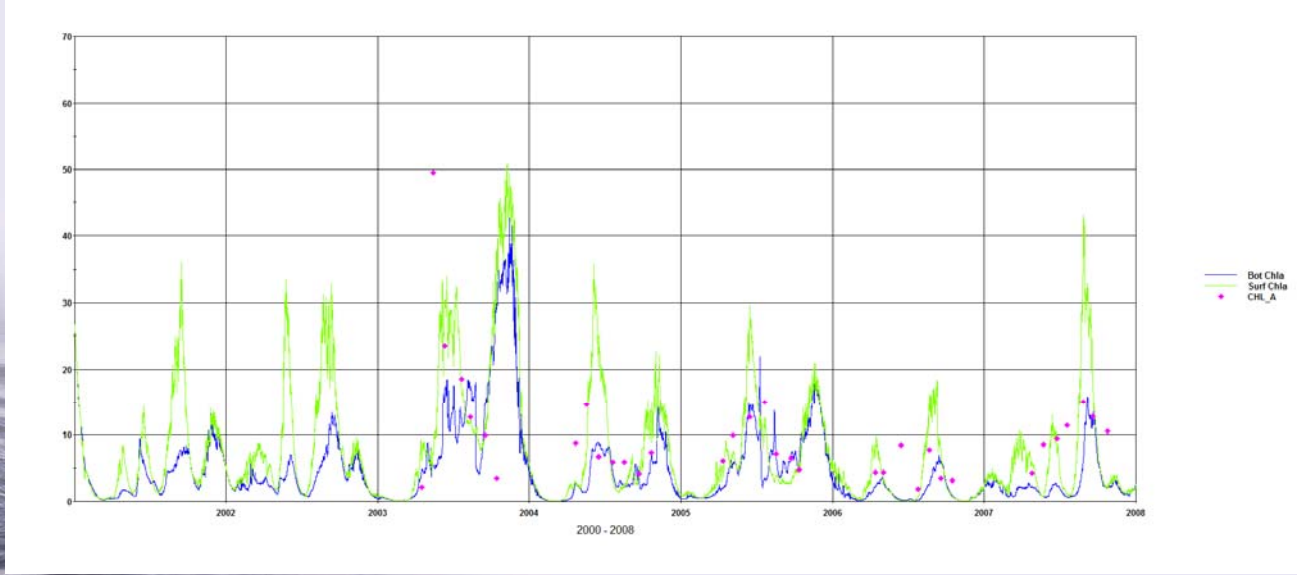
12189001 – Dampool (Forebay)



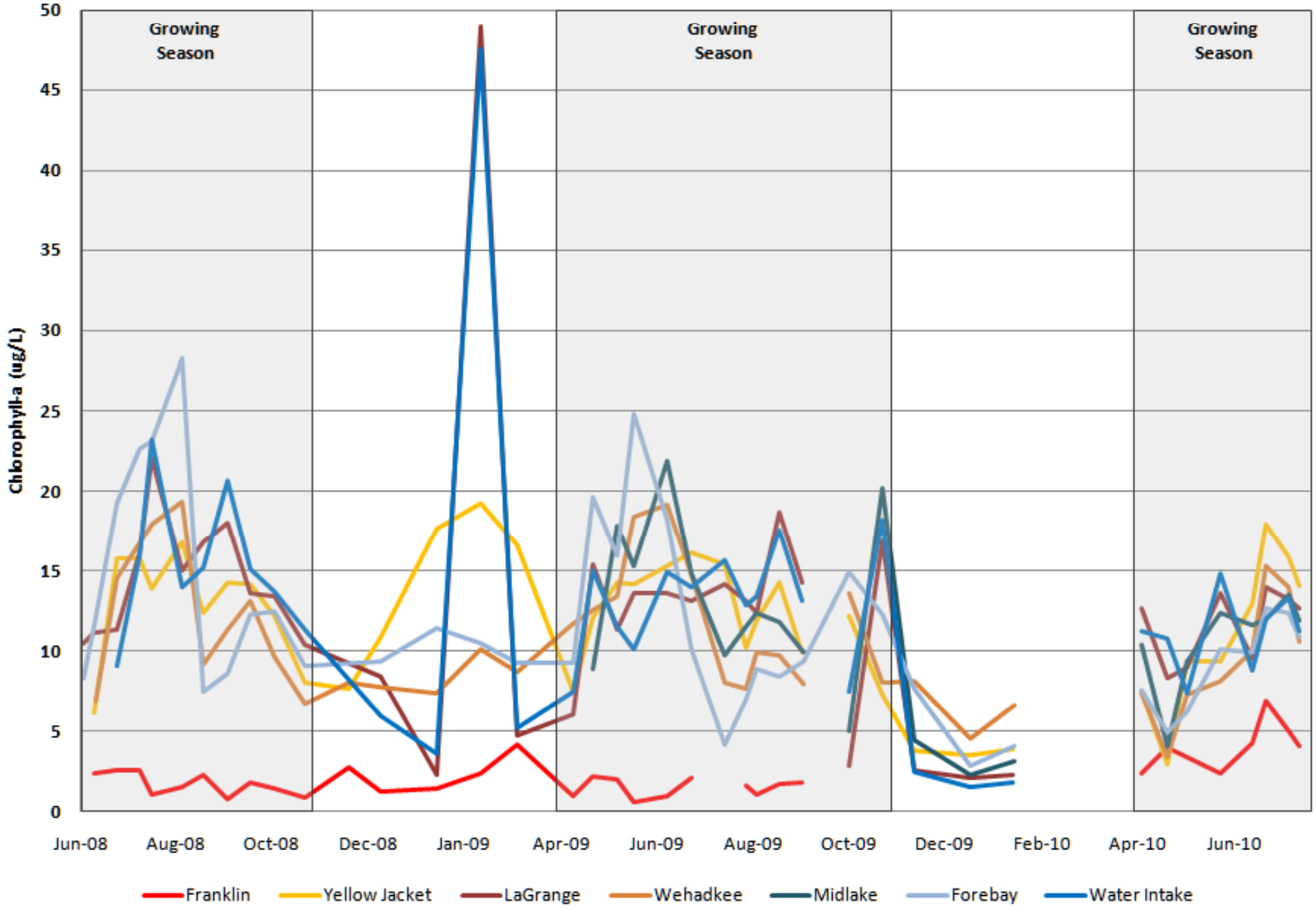
12180001 – Intake Chlorophyll-a



12189001 – Dampool (Forebay)



City of Lagrange Data, Chlorophyll-a

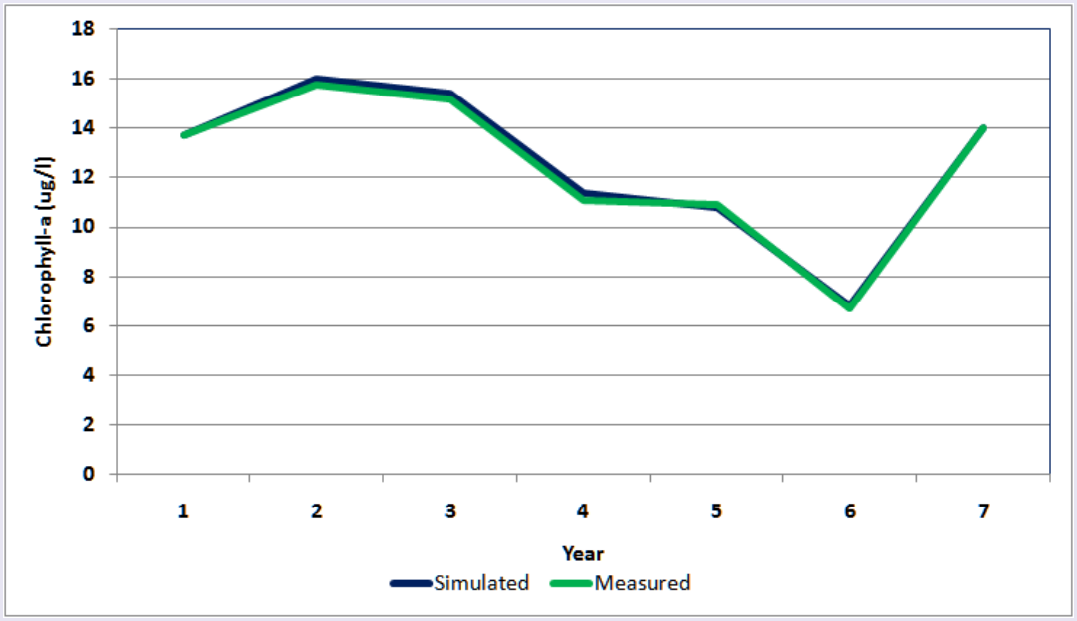


Chlorophyll-a Calibration

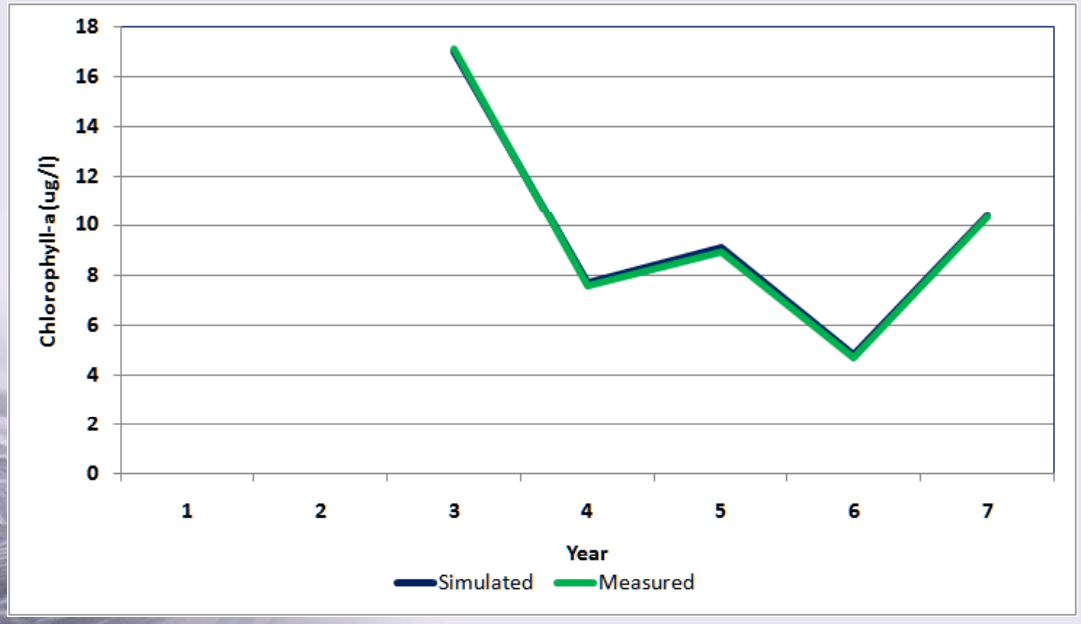
Year	Station	Name	Mean (ug/l)		Difference
			Simulated	Measured	
2001	12180001	Intake	13.7	13.7	0
	12189001	Dampool	--	--	--
2002	12180001	Intake	16	15.8	1
	12189001	Dampool	--	--	--
2003	12180001	Intake	15.4	15.2	1
	12189001	Dampool	17	17.1	-1
2004	12180001	Intake	11.4	11.1	3
	12189001	Dampool	7.7	7.6	1
2005	12180001	Intake	10.8	10.9	-1
	12189001	Dampool	9.1	8.9	2
2006	12180001	Intake	6.8	6.7	1
	12189001	Dampool	4.8	4.7	2
2007	12180001	Intake	14	14	0
	12189001	Dampool	10.4	10.3	1
2001-2007	12180001	Intake	12.6	12.5	1
	12189001	Dampool	9.8	9.7	1

12180001 – Intake

Chlorophyll-a Calibration



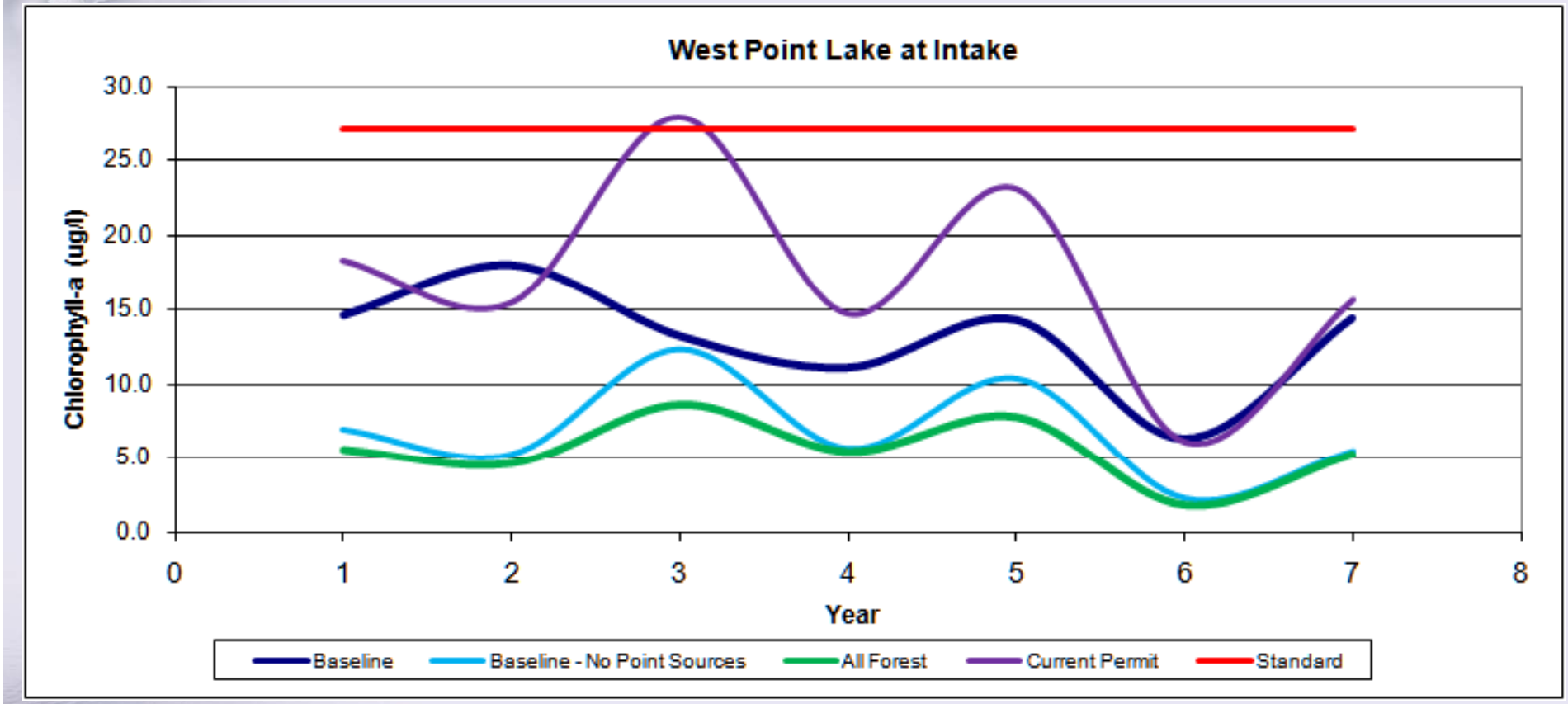
12189001 – Dampool (Forebay)



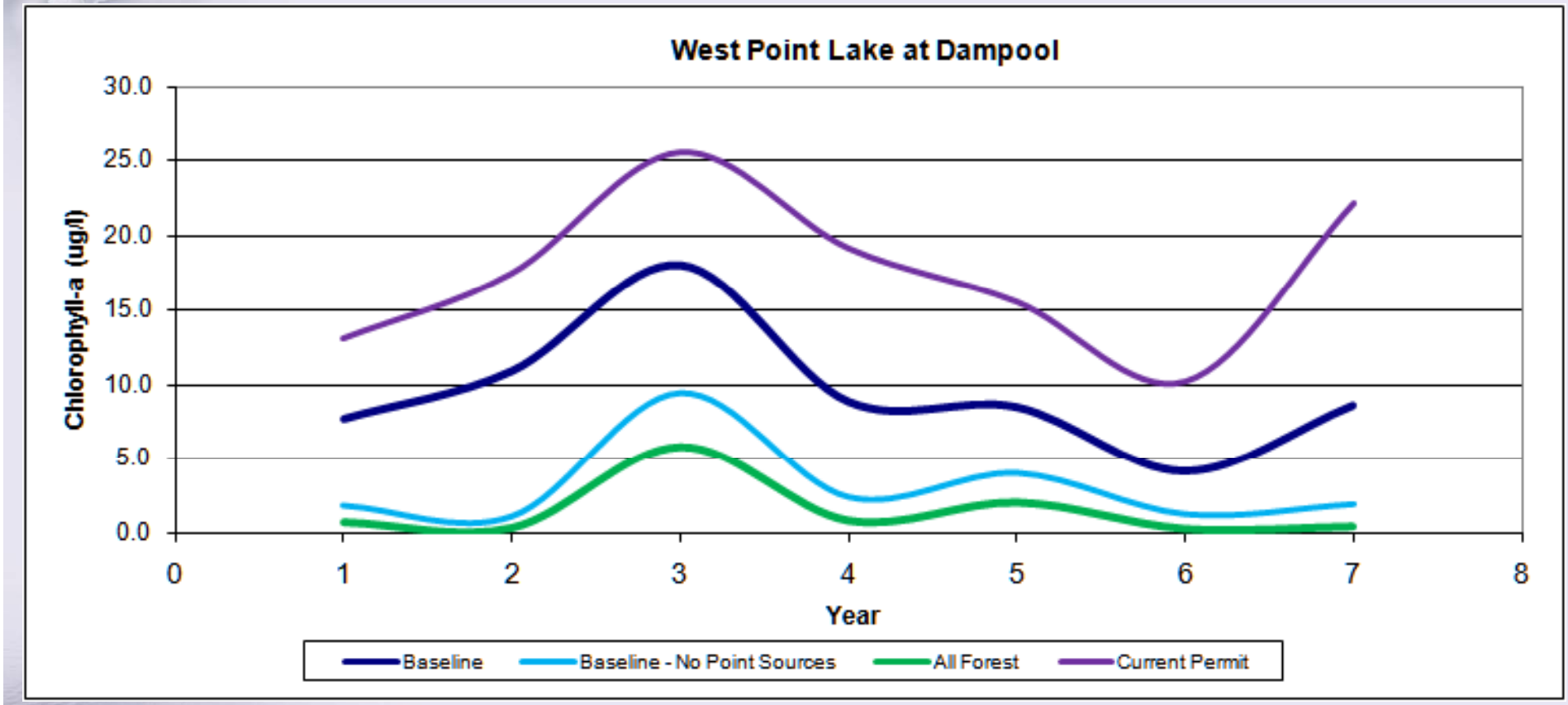
Scenarios Modeled

- **Baseline Condition**
  - Calibrated Model
  - Represents what is currently going on (i.e., DMR)
- **Baseline Condition with Point Sources and Water Withdrawals Removed**
  - Represents the impacts of just land use
- **All Forested**
  - Point Sources, Water Withdrawal and Septics Removed
  - All land use converted to forested
  - Represents a theoretical “natural condition”
- **Current Permit**
  - All Point Sources input at current permit levels
  - Represents full allocation

Growing Season Average Chlorophyll-a at Intake



Growing Season Average Chlorophyll-a at Dampool



Next Steps

- Lake Lanier TMDL
  - Revising Standards
  - Board Review
  - Finalize TMDL
- Update Watershed and Lake calibrations as needed
- Run additional scenarios as needed
- Further discussions on updating the chlorophyll-a standard at the intake
- Further discussions on adding dampool as location for additional chlorophyll-a standard

Questions?