Appendix J
Model Configuration, Calibration and Validation

Basin: Neuse-Tar

Contents

Watershed Background **1**
Water Body Characteristics 1
Soil Characteristics 2
Land Use Representation 2
Point Sources 5
Meteorological Data 6
Watershed Segmentation 7
Calibration Data and Locations 8
SWAT Modeling **9**
Assumptions 9
Hydrology Calibration 9
Hydrology Validation 13
Hydrology Results for Larger Watershed 16
Water Quality Calibration and Validation 18
Water Quality Results for Larger Watershed 20
References **22**

Tables

Table 1. Aggregation of NLCD land cover classes 2
Table 2. Land use distribution for the Albemarle-Pamlico basin (2001 NLCD) (mi^2) 4
Table 3. Major point source discharges in the Albemarle-Pamlico basin 5
Table 4. Precipitation stations for the Albemarle-Pamlico watershed model 6
Table 5. Calibration and validation locations in the Albemarle-Pamlico basin 8
Table 6. Summary statistics at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period 13
Table 7. Summary statistics at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period 16
Table 8. Summary statistics (percent error): all stations - calibration period 17
Table 9. Summary Statistics (percent error): All Stations - Validation Period 17
Table 10. Model fit statistics (observed minus predicted) for monthly sediment loads using stratified regression at USGS 02091500 Contentnea Creek near Hookerton, NC 19
Table 11. Model fit statistics (observed minus predicted) for monthly phosphorus loads using stratified regression at USGS 02091500 Contentnea Creek near Hookerton, NC 20
Table 12. Model fit statistics (observed minus predicted) for monthly total nitrogen loads using averaging estimator at USGS 02091500 Contentnea Creek near Hookerton, NC 20
Table 13. Summary statistics for water quality at all stations – calibration period 1993-2003 21
Table 14. Summary statistics for water quality at all stations – validation period 1983-1993 21

Figures

Figure 1. Location of the Albemarle-Pamlico basin. 2
Figure 2. Land use in the Albemarle-Pamlico basin. 2
Figure 3. Model segmentation and USGS stations utilized for the Albemarle-Pamlico basin. 7
Figure 4. Mean monthly flow at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period. 10
Figure 5. Seasonal regression and temporal aggregate at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period. 11
Figure 6. Seasonal medians and ranges at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period. 11
Figure 7. Flow exceedance at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period. 12
Figure 8. Mean monthly flow at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period. 14
Figure 9. Seasonal regression and temporal aggregate at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period. 14
Figure 10. Seasonal medians and ranges at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period. 15
Figure 11. Flow exceedance at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period. 15
Figure 12. Fit for monthly load of TSS at USGS 02091500 Contentnea Creek near Hookerton, NC. 18
Figure 13. Fit for monthly load of total phosphorus at USGS 02091500 Contentnea Creek near Hookerton, NC. 19
Figure 14. Fit for monthly load of total nitrogen at USGS 02091500 Contentnea Creek near Hookerton, NC. 20

Watershed Background

The Albemarle-Pamlico basin was selected as one of the 15 non-pilot application watersheds for the 20 Watershed study. Watershed modeling for the non-pilot areas is accomplished using the SWAT model only, and model calibration and validation results are presented in abbreviated form.

Water Body Characteristics

The Albemarle-Pamlico study area is located in North Carolina and Virginia. The western headwaters are in the Blue Ridge and Valley and Ridge physiographic regions. Streams descend through the Piedmont province to the Coastal Plain Province (Spruill et al. 1998).

Anthropogenic impacts are significant, including both human-modified land uses and manmade reservoirs. In general, the study area is a patchwork of forested and agricultural lands, with several significant urban areas, mostly in the Piedmont.

Modeling for the 20 Watershed study focused on the 8 HUC8s constituting of the Neuse and Pamlico River drainages (Figure 1). These watersheds are located entirely within North Carolina, and drain to two important estuaries (Pamlico and Neuse Estuaries) that have been impacted by excess nutrient loads.

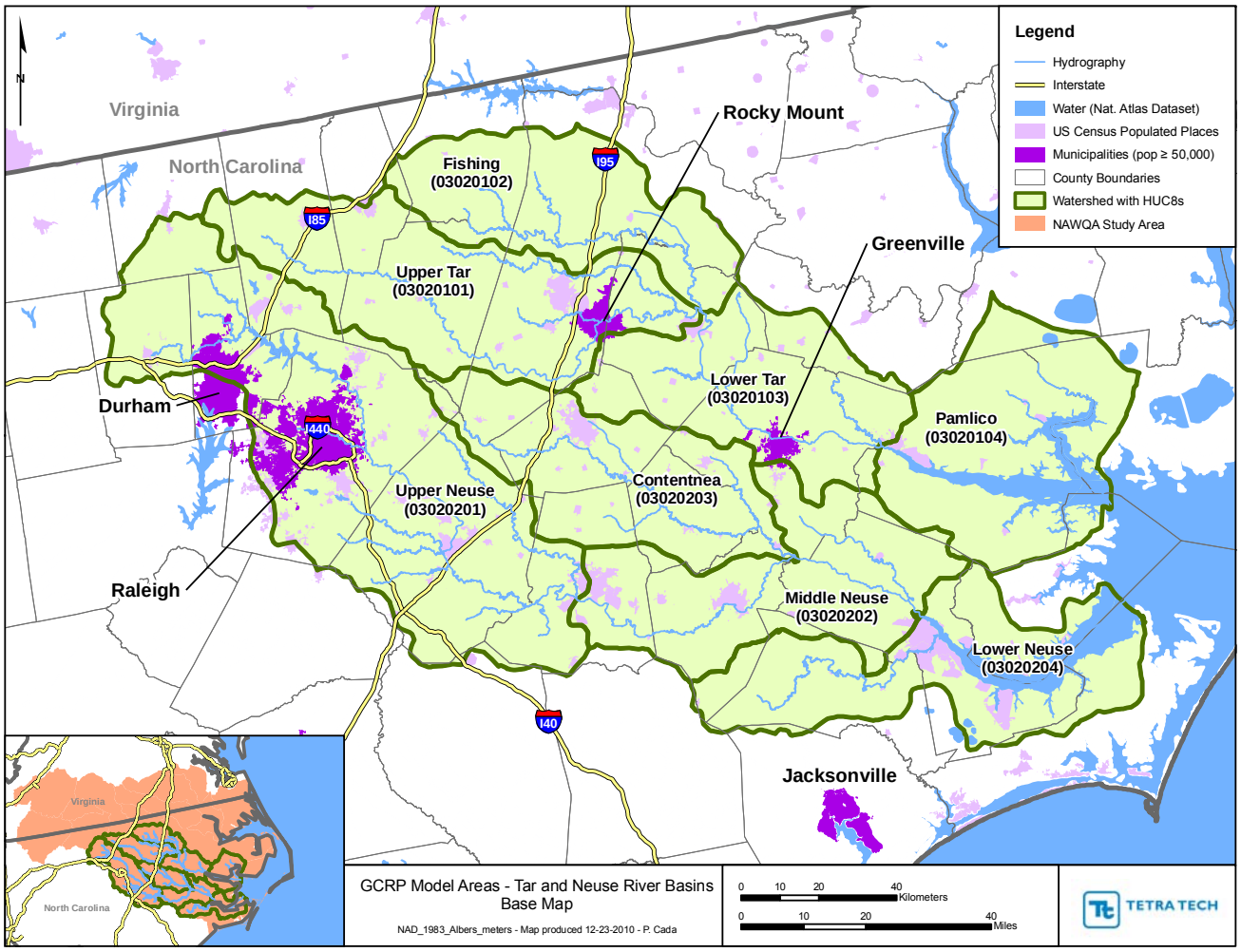

Figure 1. Location of the Albemarle-Pamlico basin.

Soil Characteristics

Soils in the watershed are described in STATSGO soil surveys. SWAT uses information drawn directly from the soils data layer to populate the model.

Land Use Representation

Land use/cover in the watershed is based on the 2001 National Land Cover Database (NLCD) coverage (Figure 2). NLCD land cover classes were aggregated according to the scheme shown in Table 1 for representation in the 20 Watershed model. SWAT uses the built-in hydrologic response unit (HRU) overlay mechanism in the ArcSWAT interface. SWAT HRUs are formed from an intersection of land use and SSURGO major soils. The distribution of land use in the watershed is summarized in Table 2.

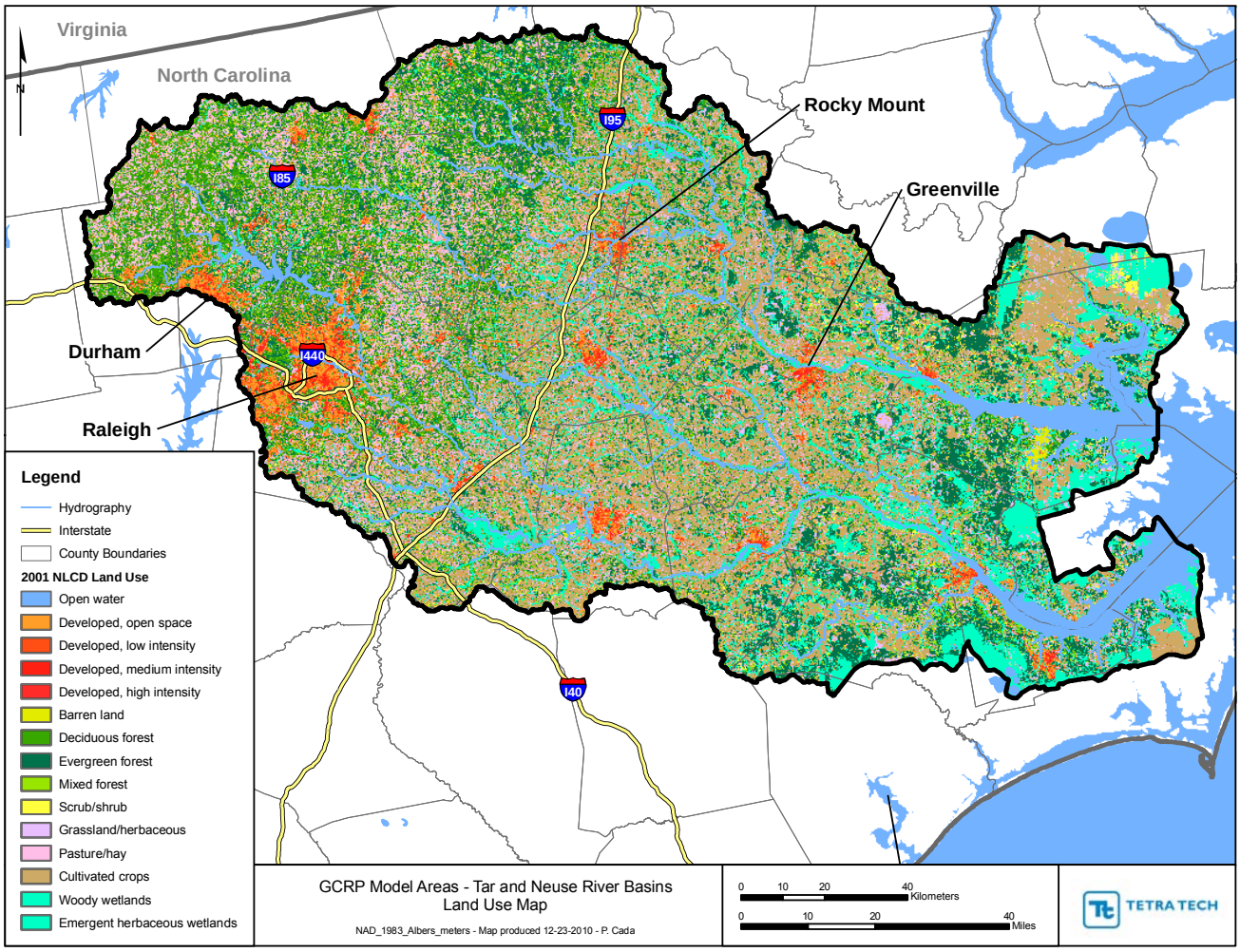

Figure 2. Land use in the Albemarle-Pamlico basin.

Table 1. Aggregation of NLCD land cover classes

NLCD class	Comments	SWAT class
11 Water	Water surface area usually accounted for as reach area	WATR
12 Perennial ice/snow		WATR
21 Developed open space		URLD
22 Dev. Low Intensity		URMD
23 Dev. Med. Intensity		URHD
24 Dev. High Intensity		UIDU
31 Barren Land		SWRN
41 Forest	Deciduous	FRSD
42 Forest	Evergreen	FRSE
43 Forest	Mixed	FRST
51-52 Shrubland		RNGB
71-74 Herbaceous Upland		RNGE
81 Pasture/Hay		HAY
82 Cultivated		AGRR
91-97 Wetland	Emergent & woody wetlands	WETF, WETL, WETN
98-99 Wetland	Aquatic bed wetlands (not emergent)	WATR

Table 2. Land use distribution for the Albemarle-Pamlico basin (2001 NLCD) (mi^2)

HUC 8 watershed	Open water	Developed[a]				Barren land	Forest	Shrubland	Pasture/Hay	Cultivated	Wetland	Total
		Open space	Low density	Medium density	High density							
Upper Tar 03020101	11.64	84.09	22.61	7.81	2.79	2.47	594.84	114.65	211.12	159.52	88.60	1,300.14
Fishing 03020102	2.68	41.35	4.21	0.51	0.10	1.81	445.62	75.63	77.19	151.06	88.42	888.58
Lower Tar 03020103	6.26	54.59	17.73	6.94	2.17	0.35	261.71	126.81	27.51	335.41	136.28	975.74
Pamlico 03020104	187.40	36.59	6.15	1.22	0.21	9.70	245.15	125.34	6.54	260.70	242.26	1,121.25
Upper Neuse 03020201	40.40	250.12	98.15	38.15	9.86	4.72	912.62	208.95	291.40	320.55	173.56	2,348.46
Middle Neuse 03020202	9.98	60.70	18.83	6.15	2.10	0.80	292.67	132.32	29.60	334.36	206.50	1,094.01
Contentnea 03020203	9.50	59.52	18.00	4.89	1.25	0.70	244.28	88.57	70.54	364.69	136.14	998.09
Lower Neuse 03020204	180.21	45.89	13.78	4.27	1.49	0.41	296.42	108.70	4.75	161.94	276.91	1,094.76
Total	448.06	632.86	199.46	69.93	19.96	20.94	3,293.30	980.97	718.65	2,088.23	1,348.66	9,821.03

[a]The percent imperviousness applied to each of the developed land uses is as follows: open space (7.17%), low density (30.90%), medium density (61.05%), and high density (87.31%).

Point Sources

There are numerous point source discharges in the watershed. Only the major dischargers, generally defined as those with a design flow greater than 1 MGD are included in the simulation (Table 3). The major dischargers are represented at long-term average flows, without accounting for changes over time or seasonal variations.

Table 3. Major point source discharges in the Albemarle-Pamlico basin

NPDES ID	Name	Design flow (MGD)	Observed flow (MGD) (1991-2006 average)
NC0001881	PHILLIPS PLATING COMPANY INC	0.10	0.02
NC0003191	WEYERHAEUSER N R CO NEW BERN C	32.00	19.74
NC0003255	PCS PHOSPHATE CO INC AURORA MI	NA	62.83
NC0003417	CP&L CO DBA PROG ENRG CAROLINA	1.40	2.38
NC0003760	E I DUPONT DE NEMOURS E I DUPO	3.60	1.58
NC0003816	US MCAS CHERRY PT MCALF ATLANT	3.50	1.99
NC0020231	LOUISBURG WWTP	1.37	0.79
NC0020389	BENSON WWTP	1.50	1.50
NC0020605	TARBORO WWTP	5.00	2.10
NC0020648	WASHINGTON WWTP	3.65	1.76
NC0020834	WARRENTON WWTP	2.00	0.36
NC0023841	DURHAM NORTH DURHAM WRF	20.00	5.90
NC0023906	WILSON WWTP	14.00	10.52
NC0023931	GREENVILLE UTIL COMMISSION GUC	17.50	9.08
NC0024236	KINSTON REG WTR RECLAMATION FA	11.85	1.73
NC0025054	OXFORD WWTP	3.50	1.30
NC0025348	NEW BERN WWTP	7.00	3.26
NC0025453	CLAYTON LITTLE CREEK WWTP	2.50	1.10
NC0026042	ROBERSONVILLE WWTP	1.80	1.22
NC0026433	HILLSBOROUGH WWTP	3.00	1.15
NC0029033	RALEIGH NEUSE RIVER WWTP	75.00	47.24
NC0029572	FARMVILLE WWTP	3.50	2.05
NC0030317	ROCKY MOUNT TAR RIVER REG WWTP	21.00	11.76
NC0030716	JOHNSTON CO DEPARTMENT OF PUBL	7.00	4.15
NC0030759	RALEIGH SMITH CREEK WWTP	2.40	0.87
NC0032077	CONTENTNEA METRO SWRG DIS CONT	2.85	1.49
NC0048879	CARY NORTH CARY WRF	12.00	2.45

NC0064050	APEX WATER RECLAMATION FAC	3.60	4.58
NC0065102	CARY SOUTH CARY WRF	12.80	7.69
NC0066516	FUQUAY VARINA TERRIBLE CRK WWT	1.00	0.18
NC0069311	FRANKLIN CO PUBLIC UTIL FRANKL	1.00	0.41

Most of these point sources have reasonably complete monitoring for total phosphorus and total suspended solids (TSS). Many dischargers in the Albemarle-Pamlico basin also report total nitrogen (unlike other study areas) because of concerns over nitrogen impacts on the coastal estuaries. The point sources were initially represented in the model with the median of reported values for total phosphorus, TSS and total nitrogen.

Meteorological Data

The required meteorological time series for the 20 Watershed SWAT simulations are precipitation and air temperature. The 20 Watershed simulations do not include water temperature and uses a degree-day method for snowmelt. SWAT estimates Penmann-Monteith potential evapotranspiration using a statistical weather generator for inputs other than temperature and precipitation. These meteorological time series are drawn from the BASINS4 Meteorological Database (USEPA 2008), which provides a consistent, quality-assured set of nationwide data with gaps filled and records disaggregated. Scenario application requires simulation over 30 years, so the available stations are those with a common 30-year period of record (or one that can be filled from an approximately co-located station) that covers the year 2001. A total of 40 precipitation stations were identified for use in the Albemarle-Pamlico watershed model with a common period of record of 10/1/1973-9/30/2004 (Table 4). Temperature records are sparser; where these are absent temperature is taken from nearby stations with an elevation correction.

Table 4. Precipitation stations for the Albemarle-Pamlico watershed model

COOP ID	Latitude	Longitude	Temperature	Elevation (m)
NC310241	36.2912	-77.9822	x	101
NC310576	35.1500	-76.7167	x	3
NC310674	35.4993	-76.6864		2
NC311241	36.1279	-79.4068		195
NC311285	36.1414	-78.7736		108
NC311606	34.9833	-76.2999	x	2
NC311677	35.9086	-79.0794	x	152
NC311820	35.6408	-78.4633	x	91
NC311881	35.0248	-78.2758	x	48
NC312500	35.3247	-78.6881	x	61
NC312515	36.0425	-78.9625		122
NC312827	36.1686	-77.6749		34
NC313232	36.1050	-78.4591		114
NC313510	35.3445	-77.9646	x	33
NC313555	36.0504	-79.3727		201
NC313638	35.6401	-77.3983	x	10
NC313969	36.3482	-78.4119	x	146
NC314684	35.1967	-77.5433	x	7
NC314689	35.2975	-77.5721	x	18
NC314962	36.1326	-77.1707	x	15
NC315123	36.1029	-78.3038	x	79
NC315830	34.7337	-76.7357	x	3
NC316108	35.0667	-77.0499	x	5
NC316135	35.4486	-76.2108	x	1
NC316853	35.8722	-76.6591	x	6
NC317069	35.8707	-78.7864	x	127
NC317074	35.7283	-78.6843	x	128

COOP ID	Latitude	Longitude	Temperature	Elevation (m)
NC317079	35.7945	-78.6988	x	122
NC317319	36.4783	-77.6717	x	64
NC317395	35.9100	-77.8892		40
NC317400	35.8936	-77.6805		34
NC317499	36.2119	-78.8568		165
NC317516	36.3469	-78.8858	x	216
NC317994	35.5164	-78.3457	x	46
NC318500	35.8848	-77.5386	x	11
NC318706	35.0667	-77.3499		9
NC319100	35.5554	-77.0721		3
NC319440	35.8529	-77.0306	x	6
NC319476	35.6939	-77.9455	x	34
VA444414	36.6003	-78.3011	x	76

Watershed Segmentation

The Albemarle-Pamlico basin was divided into 71 subwatersheds for the purposes of modeling (Figure 3). The initial calibration watershed (Contentnea Creek) is highlighted. The model encompasses the complete watershed and does not require specification of any upstream boundary conditions for application.

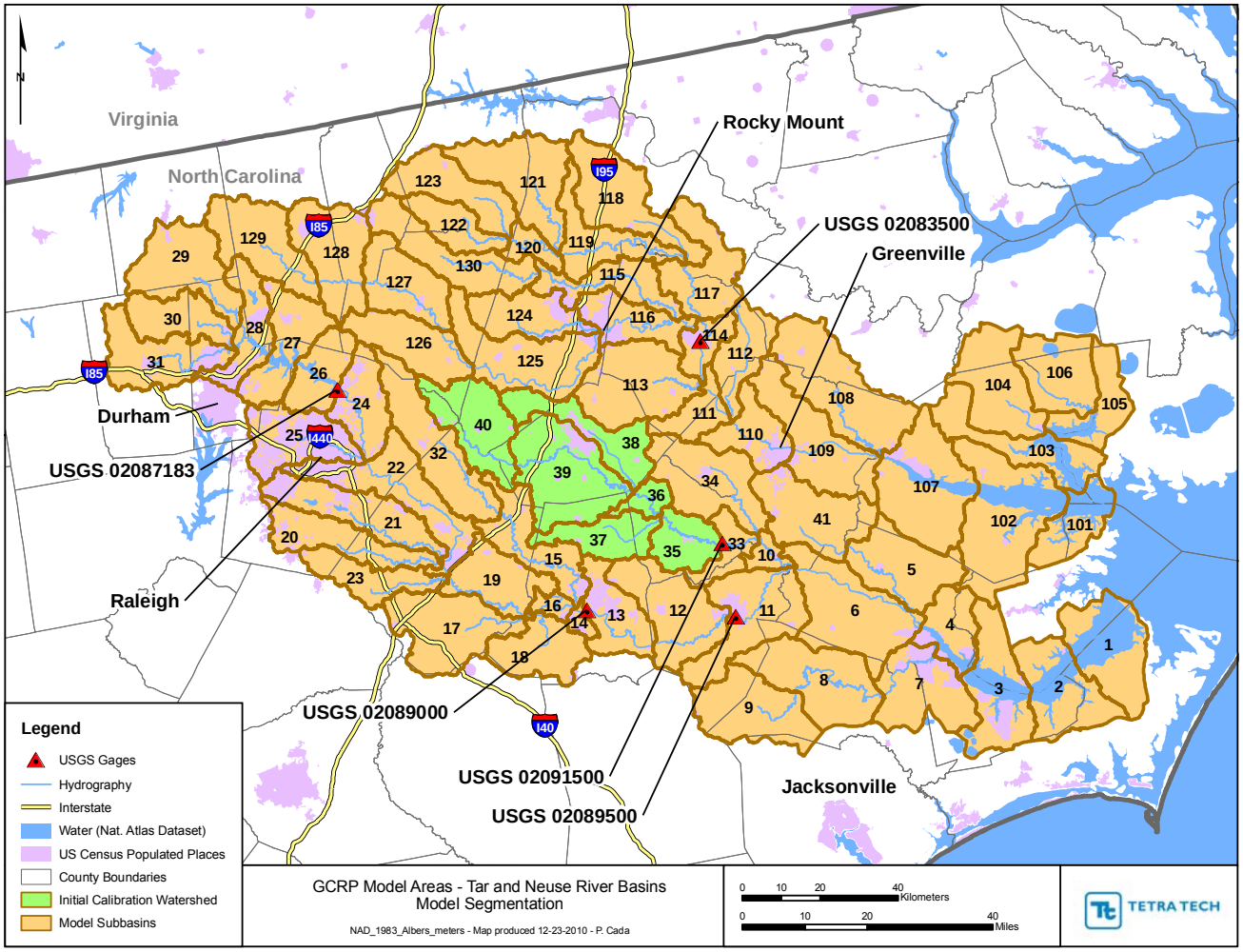

Figure 3. Model segmentation and USGS stations utilized for the Albemarle-Pamlico basin.

Calibration Data and Locations

The specific site chosen for initial calibration was the Contentnea Creek near Hookerton (USGS 02091500), a flow and water quality monitoring location that approximately coincides with the mouth of an 8-digit HUC at its outflow to the Neuse River. The Contentnea Creek watershed was selected because there is a good set of flow and water quality data available and the watershed lacks major point sources and impoundments. Additional calibration and validation was pursued at multiple locations (Table 5). Parameters derived on the Contentnea Creek were not fully transferable to other portions of the Albemarle-Pamlico basin, and additional calibration was conducted at multiple gage locations.

Table 5. Calibration and validation locations in the Albemarle-Pamlico basin

Station name	USGS ID	Drainage area (mi^2)	Hydrology calibration	Water quality calibration
Contentnea Creek near Hookerton, NC	02091500	733	X	X
Neuse River near Falls, NC	02087183	771	X	
Neuse River near Goldsboro, NC	02089000	2399	X	
Neuse River at Kinston, NC	02089500	2692	X	X
Tar River at Tarboro, NC	02083500	2183	X	X

The model hydrology calibration period was set to Water Years 1993-2003 (within the 32-year period of record for modeling). Hydrologic validation was then performed on Water Years 1983-1993. Water quality calibration used calendar years 1993-2003, while validation used 1983-1993.

SWAT Modeling

Assumptions

Falls Lake reservoir is the major impoundment in the Albemarle-Pamlico study area that was sufficiently large enough to represent in the model. It is located on the Neuse River. Pertinent reservoir information including surface area and storage at principal (normal) and emergency spillway levels for the reservoir was obtained from the US Army Corps of Engineers. The SWAT model provides four options to simulate reservoir outflow: measured daily outflow, measured monthly outflow, average annual release rate for uncontrolled reservoir, and controlled outflow with target release. Keeping in view the 20 Watershed climate change impact evaluation application to future climate scenarios, it was assumed that the best representation of the reservoir was to simulate it without supplying time series of outflow records. Therefore, the target release approach was used in the GCRP-SWAT model.

Hydrology Calibration

A spatial calibration approach was adopted for GCRP-SWAT modeling for the Albemarle-Pamlico basin. A systematic adjustment of parameters has been adopted and some adjustments are applied throughout the basin. Most of the calibration efforts were geared towards getting a closer match between simulated and observed flows at the outlet of calibration focus area.

Land Use / Soil / Slope Definition

A 5/10/5 percent threshold was used for land use/soil/slope in the SWAT model while defining the HRUs. Urban land use classes were exempted from the HRU overlay thresholds.

The calibration focus area (Contentnea Creek) includes five subwatersheds and is generally representative of the general land use characteristics of the overall watershed with the exception of a higher percentage of cultivated lands. The parameters were adjusted within the practical range to obtain reasonable fit between the simulated and measured flows in terms of Nash-Sutcliffe modeling efficiency and the high flow and low flow components as well as the seasonal flows.

The water balance of the whole Albemarle-Pamlico basin predicted by the SWAT model over the 32-year simulation period is as follows:

```
PRECIP =   1234.6 MM
SNOW FALL =   40.57 MM
SNOW MELT =    40.17 MM
SUBLIMATION =     0.39 MM
SURFACE RUNOFF Q =   170.61 MM
LATERAL SOIL Q =   18.20 MM
TILE Q =     0.00 MM
GROUNDWATER (SHAL AQ) Q =   223.76 MM
REVAP (SHAL AQ => SOIL/PLANTS) =   40.29 MM
DEEP AQ RECHARGE =    13.90 MM
TOTAL AQ RECHARGE = 277.94 MM
TOTAL WATER YLD =   410.46 MM
PERCOLATION OUT OF SOIL = 276.02 MM
ET =    763.0 MM
PET =   1433.2MM
```

```
TRANSMISSION LOSSES =     2.10 MM
```

Hydrologic calibration adjustments focused on the following parameters:

- CN2 (initial SCS runoff curve number for moisture condition II)
- ESCO (soil evaporation compensation factor)
- SURLAG (surface runoff lag coefficient)
- SOL_AWC (available water capacity of the soil layer, mm water/mm of soil)
- ALPHA_BF (baseflow alpha factor, days)
- GW_DELAY (groundwater delay time, days)
- GWQMIN (threshold depth of water in the shallow aquifer required for return flow to occur, mm)
- GW_REVAP (groundwater "revap" coefficient)
- CH_N2 (Manning's "n" value for main channels)

Calibration results for the Contentnea Creek are summarized in Figure 4, Figure 5, Figure 6, Figure 7 and Table 6.

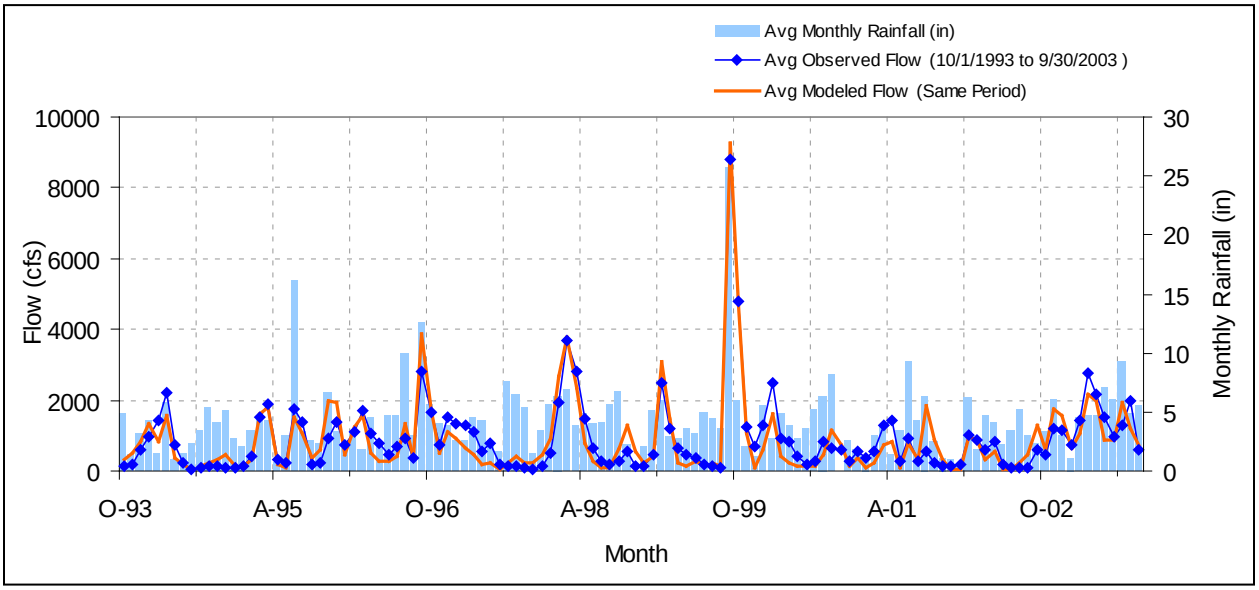

Figure 4. Mean monthly flow at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period.

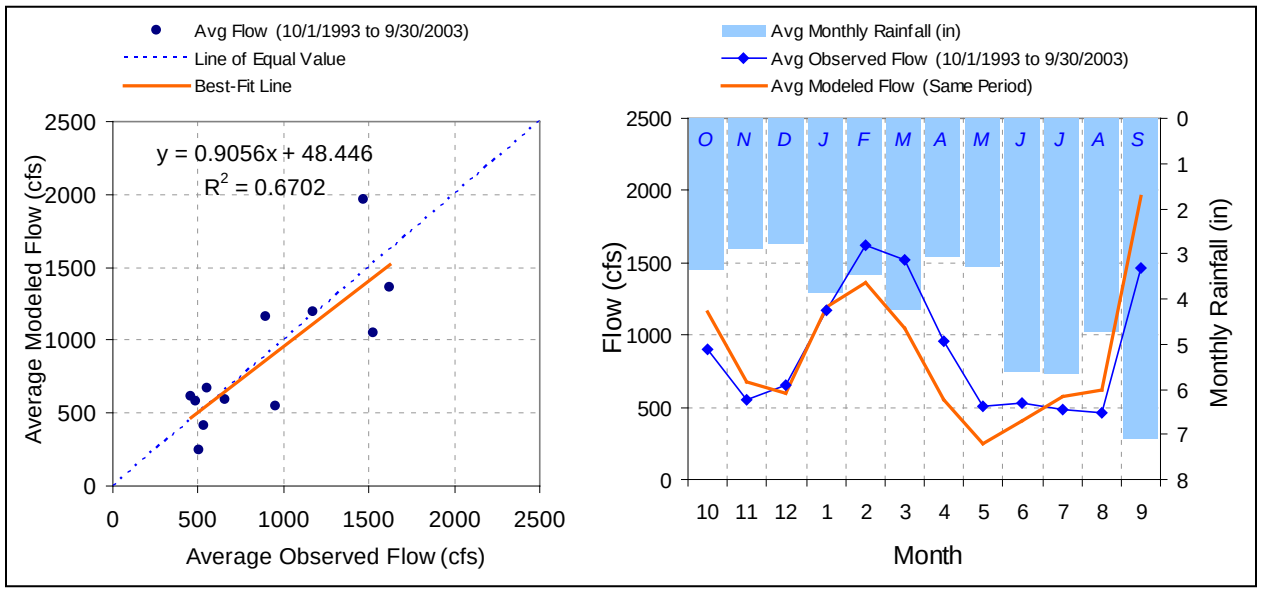

Figure 5. Seasonal regression and temporal aggregate at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period.

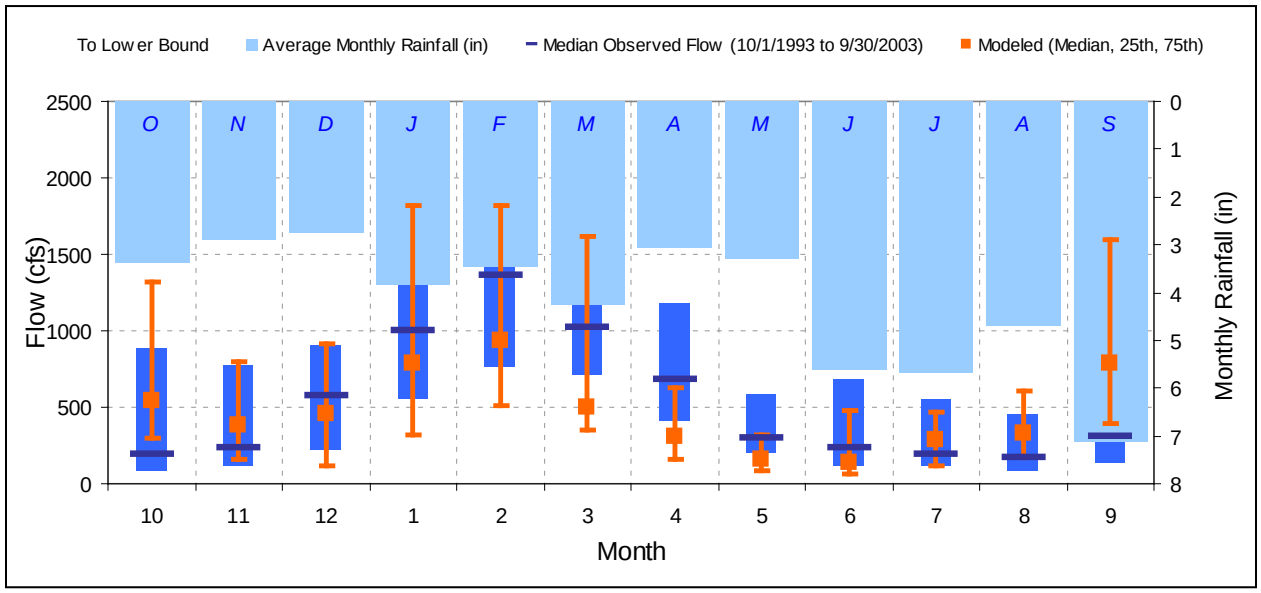

Figure 6. Seasonal medians and ranges at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period.

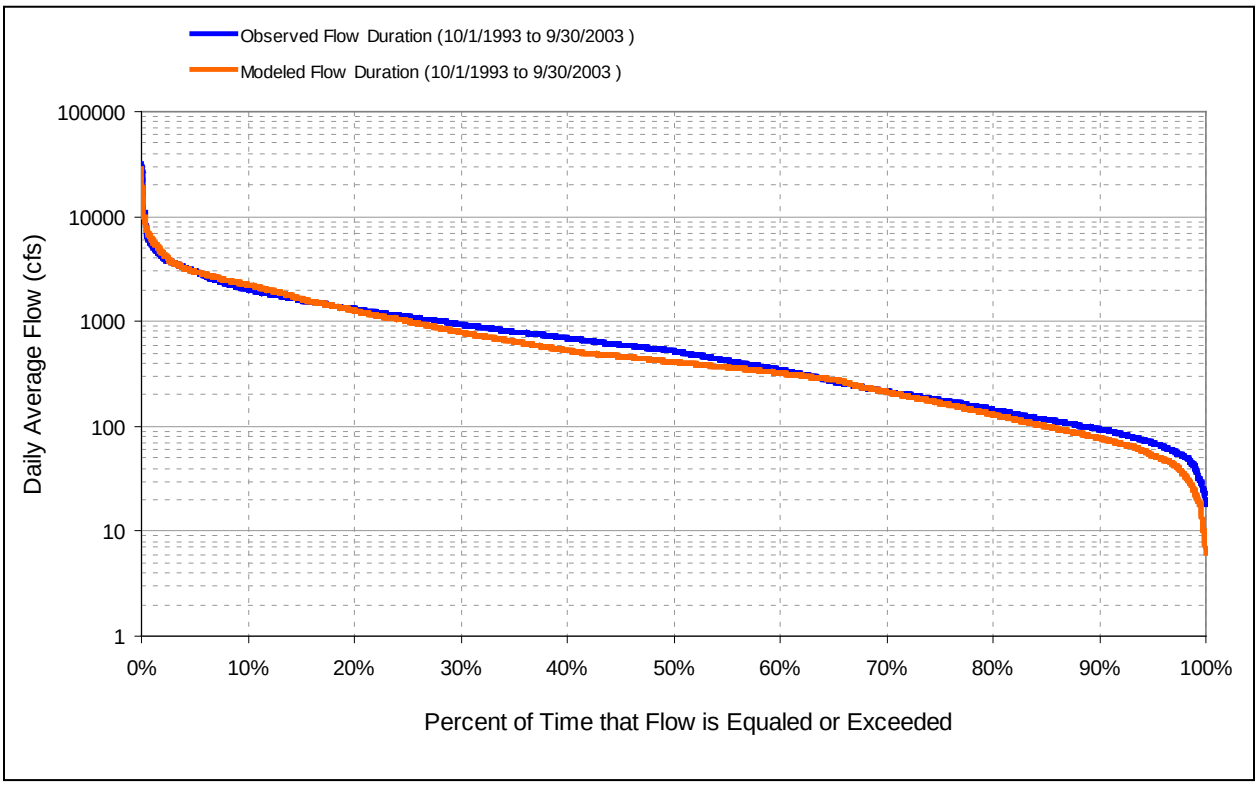

Figure 7. Flow exceedance at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period.

Table 6. Summary statistics at USGS 02091500 Contentnea Creek near Hookerton, NC – calibration period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 35 10-Year Analysis Period: 10/1/1993 - 9/30/2003 Flow volumes are (inches/year) for upstream drainage area		USGS 02091500 CONTENTNEA CREEK AT HOOKERTON, NC Hydrologic Unit Code: 3020203 Latitude: 35.42888889 Longitude: -77.5825 Drainage Area (sq-mi): 733	
Total Simulated In-stream Flow:	**15.98**	Total Observed In-stream Flow:	**16.64**
Total of simulated highest 10% flows:	**7.16**	Total of Observed highest 10% flows:	**7.01**
Total of Simulated lowest 50% flows:	**1.78**	Total of Observed Lowest 50% flows:	**1.97**
Simulated Summer Flow Volume (months 7-9):	**4.86**	Observed Summer Flow Volume (7-9):	**3.72**
Simulated Fall Flow Volume (months 10-12):	**3.79**	Observed Fall Flow Volume (10-12):	**3.29**
Simulated Winter Flow Volume (months 1-3):	**5.48**	Observed Winter Flow Volume (1-3):	**6.56**
Simulated Spring Flow Volume (months 4-6):	**1.85**	Observed Spring Flow Volume (4-6):	**3.06**
Total Simulated Storm Volume:	**3.81**	Total Observed Storm Volume:	**4.35**
Simulated Summer Storm Volume (7-9):	**1.51**	Observed Summer Storm Volume (7-9):	**1.48**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	-3.98	10	
Error in 50% lowest flows:	-9.98	10	
Error in 10% highest flows:	2.15	15	
Seasonal volume error - Summer:	**30.50**	**30**	
Seasonal volume error - Fall:	15.05	30	
Seasonal volume error - Winter:	-16.48	30	
Seasonal volume error - Spring:	**-39.56**	**30**	
Error in storm volumes:	-12.39	20	
Error in summer storm volumes:	2.17	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.678	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.459	as E or E' approaches 1.0	

Hydrology Validation

Hydrology validation for Contentnea Creek was performed for the period 10/1/1983 through 9/30/1993. Results are presented in Figures 8 through 11 and Table 7. The validation achieves a moderately high coefficient of model fit efficiency, but is over on 10 percent highest flow volume, and summer and fall seasonal volumes (Figure 8, Figure 9, Figure 10, Figure 11 and Table 7).

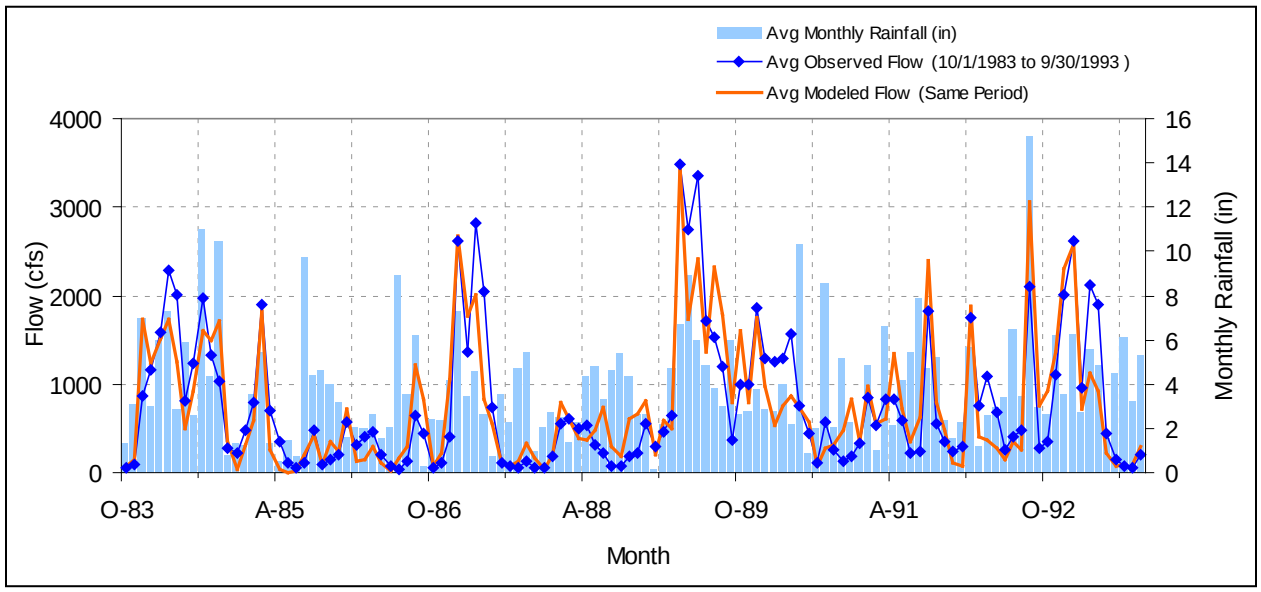

Figure 8. Mean monthly flow at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period.

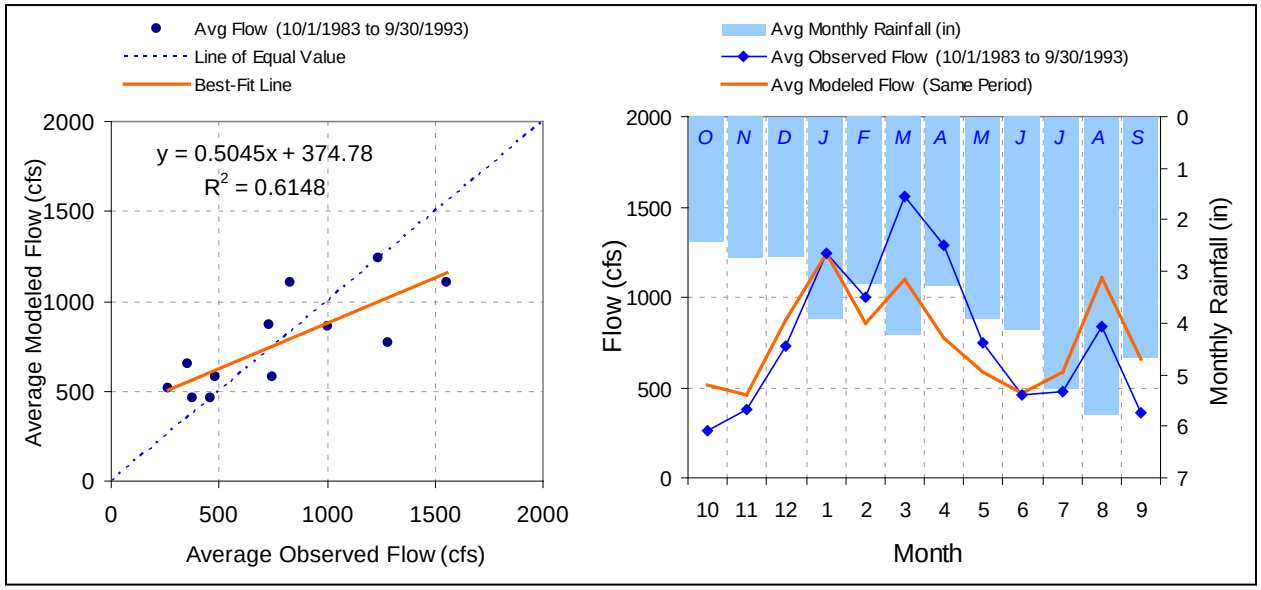

Figure 9. Seasonal regression and temporal aggregate at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period.

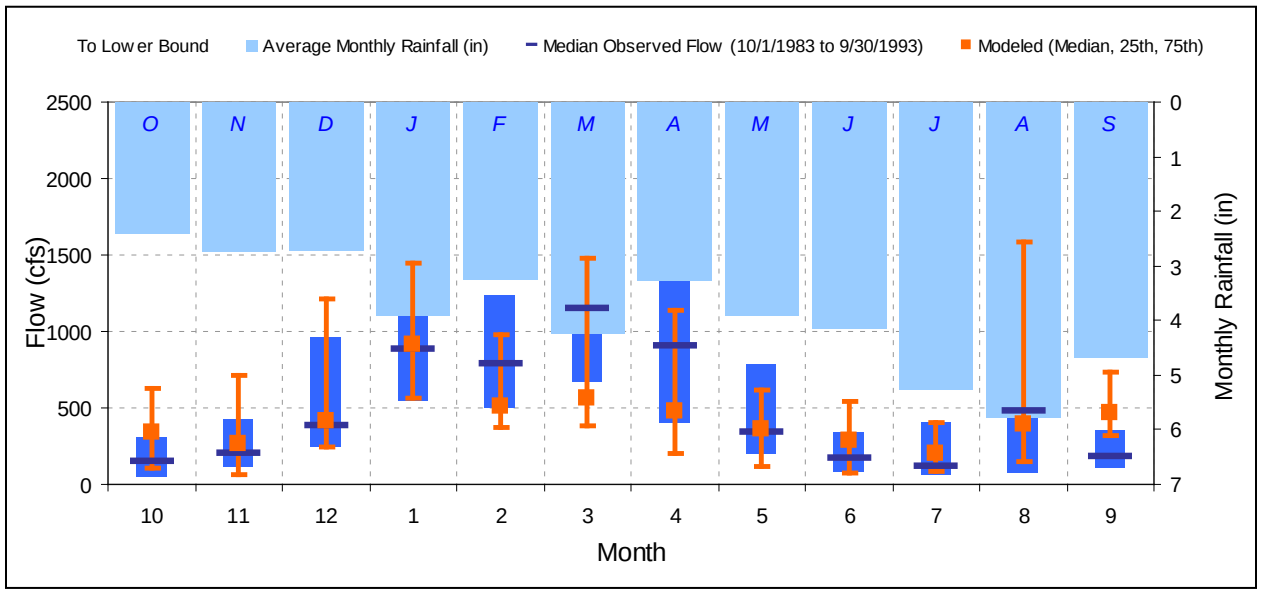

Figure 10. Seasonal medians and ranges at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period.

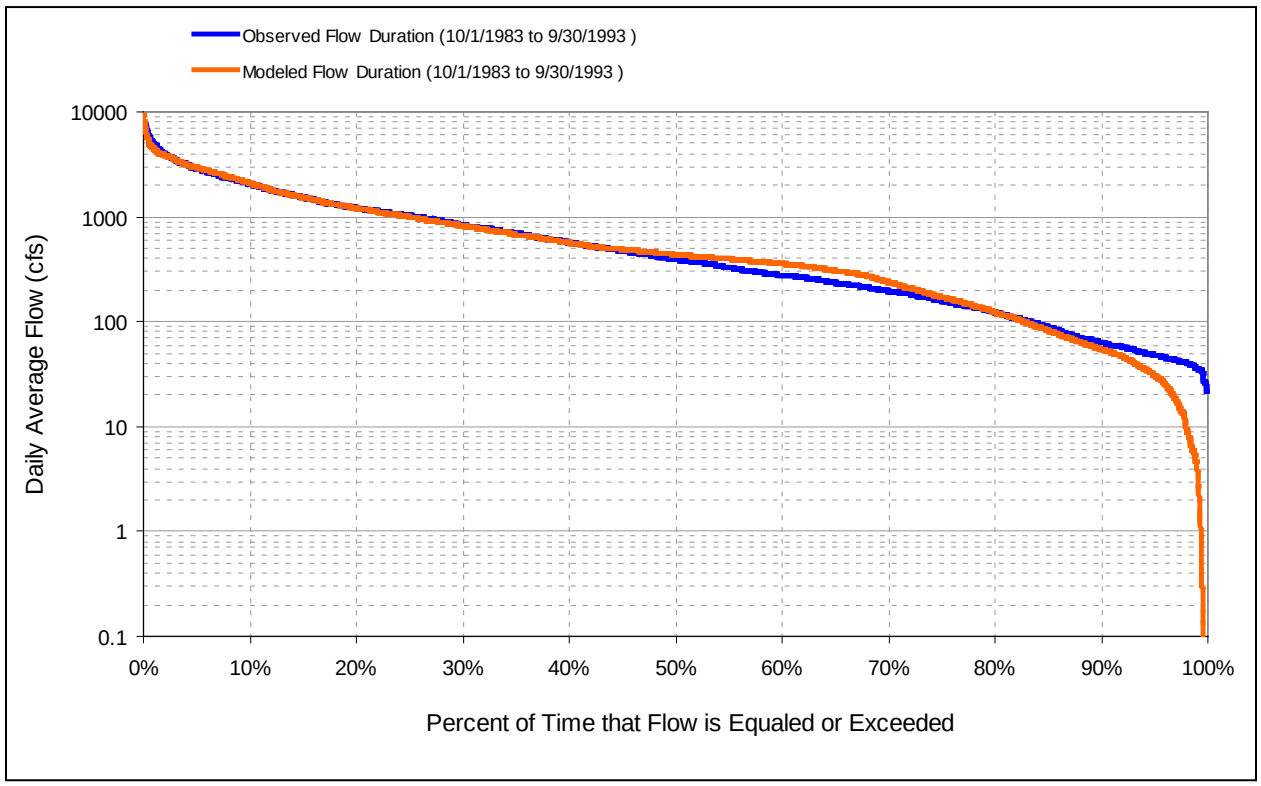

Figure 11. Flow exceedance at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period.

Table 7. Summary statistics at USGS 02091500 Contentnea Creek near Hookerton, NC – validation period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 35 10-Year Analysis Period: 10/1/1983 - 9/30/1993 Flow volumes are (inches/year) for upstream drainage area		USGS 02091500 CONTENTNEA CREEK AT HOOKERTON, NC Hydrologic Unit Code: 3020203 Latitude: 35.42888889 Longitude: -77.5825 Drainage Area (sq-mi): 733	
Total Simulated In-stream Flow:	**14.24**	Total Observed In-stream Flow:	**14.41**
Total of simulated highest 10% flows:	**5.76**	Total of Observed highest 10% flows:	**5.97**
Total of Simulated lowest 50% flows:	**1.79**	Total of Observed Lowest 50% flows:	**1.59**
Simulated Summer Flow Volume (months 7-9):	**3.65**	Observed Summer Flow Volume (7-9):	**2.61**
Simulated Fall Flow Volume (months 10-12):	**2.88**	Observed Fall Flow Volume (10-12):	**2.13**
Simulated Winter Flow Volume (months 1-3):	**4.91**	Observed Winter Flow Volume (1-3):	**5.84**
Simulated Spring Flow Volume (months 4-6):	**2.80**	Observed Spring Flow Volume (4-6):	**3.83**
Total Simulated Storm Volume:	**3.19**	Total Observed Storm Volume:	**3.66**
Simulated Summer Storm Volume (7-9):	**0.99**	Observed Summer Storm Volume (7-9):	**0.96**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	-1.18	10	
Error in 50% lowest flows:	**12.17**	**10**	
Error in 10% highest flows:	-3.49	15	
Seasonal volume error - Summer:	**39.76**	**30**	
Seasonal volume error - Fall:	**35.01**	**30**	
Seasonal volume error - Winter:	-15.83	30	
Seasonal volume error - Spring:	-26.94	30	
Error in storm volumes:	-13.04	20	
Error in summer storm volumes:	2.93	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.635	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.479	as E or E' approaches 1.0	

Hydrology Results for Larger Watershed

As described above, parameters determined for the gage at Contentnea Creek were initially transferred to other gages in the watershed. However, changes to subbasin level parameter were required to fit the model to the observed flows. In all, calibration and validation was pursued at a total of five gages throughout the watershed, including one gage at the outlet of an 8-digit HUC, one gage at the outfall of the Falls Lake reservoir and three gages on the mainstem. Results of the calibration and validation exercise are summarized in Table 8 and Table 9, respectively. Calibration and validation results were acceptable at most gages.

Table 8. Summary statistics (percent error): all stations - calibration period

Station	02091500 Contentnea Creek near Hookerton, NC	02087183 Neuse River near Falls, NC	02089000 Neuse River near Goldsboro, NC	02089500 Neuse River at Kinston, NC	02083500 Tar River at Tarboro, NC
Error in total volume:	-3.98	5.36	-3.95	-3.00	0.23
Error in 50% lowest flows:	-9.98	-11.43	-2.44	-0.14	0.92
Error in 10% highest flows:	2.15	-11.68	-1.26	1.23	-6.55
Seasonal volume error - Summer:	30.50	30.71	20.87	22.20	18.69
Seasonal volume error - Fall:	15.05	21.62	7.54	8.74	29.36
Seasonal volume error - Winter:	-16.48	3.54	-11.38	-9.95	-11.81
Seasonal volume error - Spring:	-39.56	-20.48	-26.07	-26.52	-21.93
Error in storm volumes:	-12.39	-61.90	-14.75	-10.38	-33.68
Error in summer storm volumes:	2.17	-29.11	3.89	2.19	-15.34
Nash-Sutcliffe Coefficient of Efficiency, E:	0.678	0.417	0.736	0.732	0.754
Baseline adjusted coefficient (Garrick), E':	0.459	0.397	0.552	0.535	0.506

Table 9. Summary Statistics (percent error): All Stations - Validation Period

Station	02091500 Contentnea Creek near Hookerton, NC	02087183 Neuse River near Falls, NC	02089000 Neuse River near Goldsboro, NC	02089500 Neuse River at Kinston, NC	02083500 Tar River at Tarboro, NC
Error in total volume:	-1.18	-1.02	-7.60	-8.55	-4.88
Error in 50% lowest flows:	12.17	-29.70	0.60	-2.55	-9.07
Error in 10% highest flows:	-3.49	-26.58	-20.17	-20.42	-20.23
Seasonal volume error - Summer:	39.76	5.54	14.56	14.73	39.72
Seasonal volume error - Fall:	35.01	29.41	16.15	12.09	26.83
Seasonal volume error - Winter:	-15.83	-7.93	-14.24	-14.46	-16.29
Seasonal volume error - Spring:	-26.94	-7.10	-22.37	-24.12	-22.16
Error in storm volumes:	-13.04	-63.68	-28.64	-27.30	-37.61
Error in summer storm volumes:	2.93	-46.92	-22.43	-20.82	-7.61
Nash-Sutcliffe Coefficient of Efficiency, E:	0.635	0.620	0.775	0.767	0.688
Baseline adjusted coefficient (Garrick), E':	0.479	0.451	0.581	0.565	0.485

Water Quality Calibration and Validation

Initial calibration and validation of water quality was done on the Contentnea Creek (USGS 02091500), using 1993-2003 for calibration and 1983-1993 for validation. As with hydrology, water quality calibration was performed on the later period as this better reflects the land use included in the model.

Calibration adjustments for sediment focused on the following parameters:

- SPCON (linear parameter for estimating maximum amount of sediment that can be re-entrained during channel sediment routing)
- SPEXP (exponential parameter for estimating maximum amount of sediment that can be re-entrained during channel sediment routing)
- CH_COV (channel cover factor)
- CH_EROD (channel erodibility factor)
- USLE_P (USLE support practice factor)

Simulated and estimated sediment loads at the Contentnea Creek station for both the calibration and validation periods are shown in Figure 12 and statistics for the two periods are provided separately in Table 10. The key statistic in Table 10 is the relative percent error, which shows the error in the prediction of monthly load normalized to the estimated load. Table 10 also shows the relative average absolute error, which is the average of the relative magnitude of errors in individual monthly load predictions. This number is inflated by outlier months in which the simulated and estimated loads differ by large amounts (which may be as easily due to uncertainty in the estimated load due to limited data as to problems with the model) and the third statistic, the relative median absolute error, is likely more relevant and shows better agreement.

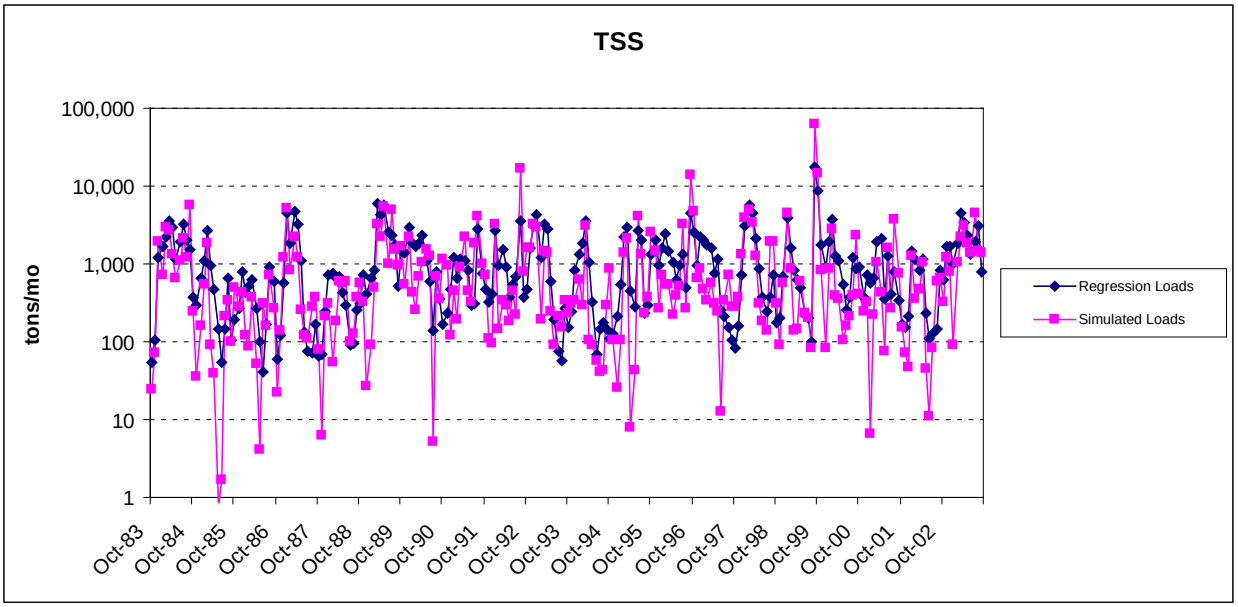

Figure 12. Fit for monthly load of TSS at USGS 02091500 Contentnea Creek near Hookerton, NC.

Table 10. Model fit statistics (observed minus predicted) for monthly sediment loads using stratified regression at USGS 02091500 Contentnea Creek near Hookerton, NC

Statistic	Calibration period (1993-2003)	Validation period (1983-1993)
Relative Percent Error	-19.9%	9.9%
Relative Average Absolute Error	81%	61%
Relative Median Absolute Error	34.7%	33.1%

Calibration adjustments for total phosphorus and total nitrogen focused on the following parameters:

- RHOQ (algal respiration rate at 20° C)
- PHOSKD (phosphorus soil partitioning coefficient)
- PSP (phosphorus availability index)
- RS2 (benthic source rate for dissolved P in the reach at 20° C)
- RS5 (organic P settling rate in the reach at 20° C)
- BC4 (rate constant for mineralization of organic P to dissolved P in the reach at 20° C)
- RS4 (rate coefficient for organic N settling in the reach at 20° C)

Results for the phosphorus simulation are shown in Figure 13 and Table 11. Results for the nitrogen simulation are shown in Figure 14 and Table 12. The model fit is generally acceptable.

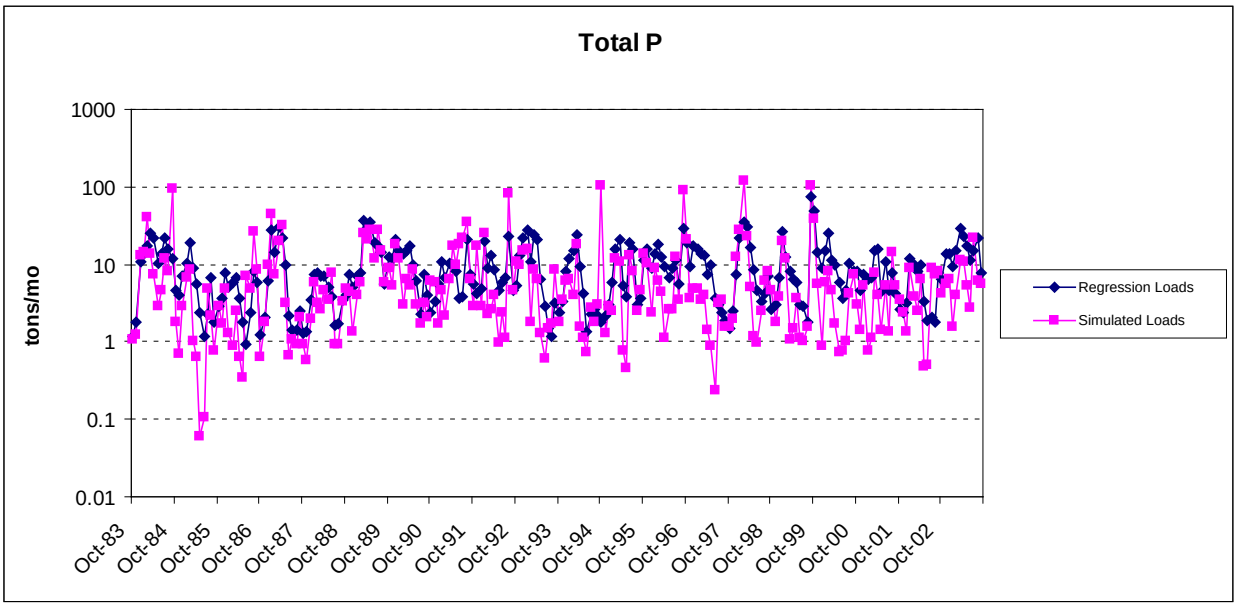

Figure 13. Fit for monthly load of total phosphorus at USGS 02091500 Contentnea Creek near Hookerton, NC.

Table 11. Model fit statistics (observed minus predicted) for monthly phosphorus loads using stratified regression at USGS 02091500 Contentnea Creek near Hookerton, NC

Statistic	Calibration period (1993-2003)	Validation period (1983-1993)
Relative Percent Error	15.9%	5.3%
Average Absolute Error	69%	66%
Median Absolute Error	49.3%	39.3%

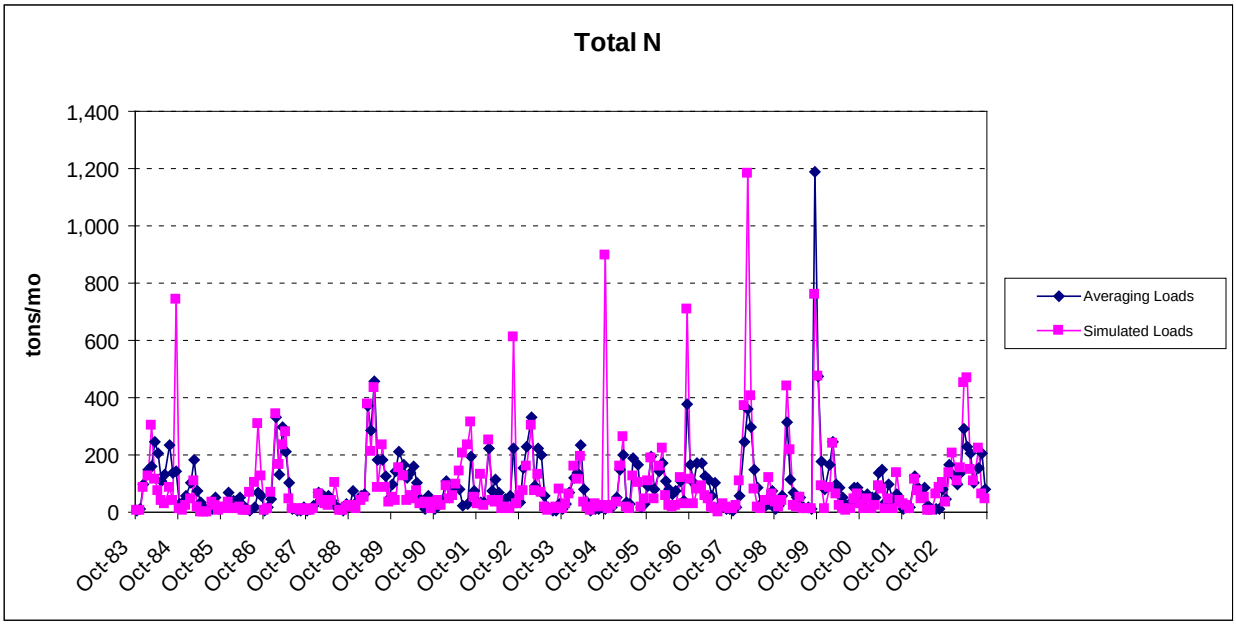

Figure 14. Fit for monthly load of total nitrogen at USGS 02091500 Contentnea Creek near Hookerton, NC.

Table 12. Model fit statistics (observed minus predicted) for monthly total nitrogen loads using averaging estimator at USGS 02091500 Contentnea Creek near Hookerton, NC

Statistic	Calibration period (1993-2003)	Validation period (1983-1993)
Relative Percent Error	-5.6%	5.3%
Average Absolute Error	56%	57%
Median Absolute Error	24.3%	31.6%

Water Quality Results for Larger Watershed

As with hydrology, a spatial calibration approach was adopted. Contentnea Creek watershed SWAT model parameters for water quality were transferred to other portions of the watershed with necessary changes to subwatershed level parameters. Summary statistics for the SWAT water quality calibration and validation at other stations in the watershed are provided in Table 13 and Table 14.

Table 13. Summary statistics for water quality at all stations – calibration period 1993-2003

Station	02091500 Contentnea Creek near Hookerton, NC	02089500 Neuse River at Kinston, NC	02083500 Tar River at Tarboro, NC
Relative Percent Error TSS Load	-19.9%	-6.7%	-5.1%
Relative Percent Error TP Load	15.9%	-10.5%	-0.4%
Relative Percent Error TN Load	-5.6%	-15%	-33.8%

Table 14. Summary statistics for water quality at all stations – validation period 1983-1993

Station	02091500 Contentnea Creek near Hookerton, NC	02089500 Neuse River at Kinston, NC	02083500 Tar River at Tarboro, NC
Relative Percent Error TSS Load	9.9%	17.3%	22.9%
Relative Percent Error TP Load	5.3%	2.5%	13.1%
Relative Percent Error TN Load	5.3%	6.7%	13.5%

References

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USEPA. 2008. Using the BASINS Meteorological Database (Version 2006). BASINS Technical Note 10. Office of Water, U.S. Environmental Protection Agency, Washington, DC.