Appendix M
Model Configuration, Calibration and Validation

Basin: Georgia-Florida Coastal Plain (GaFl)

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Watershed Background

The Georgia-Florida Coastal Plain drainages weres 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 Georgia-Florida Coastal Plain model covers an area of about 17.500 mi^2 in portions of Georgia and Florida. The modeled area includes 15 HUC8s in two groups, one group draining to Tampa Bay (HUC 0310) and the remainder in southern Georgia and northwest Florida (in HUC 0311 and 0312; Figure 1). The watershed contains an EPA ORD Ecosystems Research Area (in the Tampa Bay drainage) and Tampa Bay is part of EPA's National Estuary Program.

Climate in the watershed is humid subtropical and influenced by air masses from the Gulf of Mexico. Average annual rainfall is around 45 to 53 inches per year, while the average annual temperatures is around 70 – 72 °F. The majority of precipitation is associated with summer convective storms, and tropical storms cross the area frequently. The study area has a climatic range from temperate in the north to subtropical in the south and along the Gulf Coast.

The major land uses in the watershed include forest, agriculture (citrus and row crops), wetlands, urban, and rangeland. Forested areas cover approximately 34 percent of the watershed. Much of the forest lands are softwood pines used to manufacture paper products (facial tissue, toilet paper, hand towels, bags, and boxes). Wetlands occupy about 26 percent of the watershed. Cultivated land covers approximately 11 percent, while developed land occupies over 10 percent of the area.

The populations of cities in the watershed increased from 10 to 30 percent between 1990 and 1999. The largest city in the watershed is Tampa, FL. Most water used in the watershed is derived from groundwater, primarily from the highly productive Floridan aquifer system.

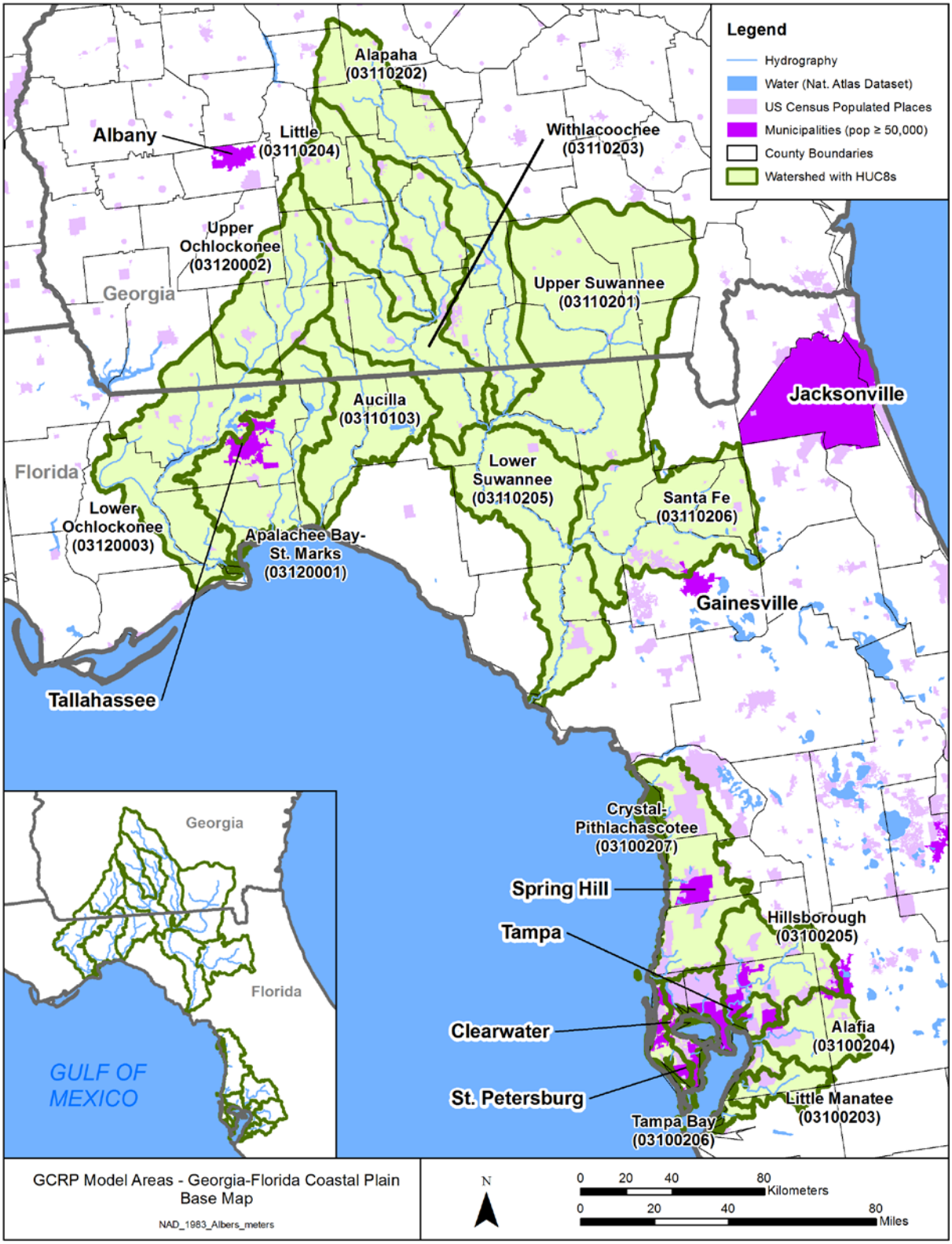

Figure 1. Location of the Georgia-Florida Coastal Plain model.

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 STATSGO major soils. The distribution of land use in the watershed is summarized in Table 2.

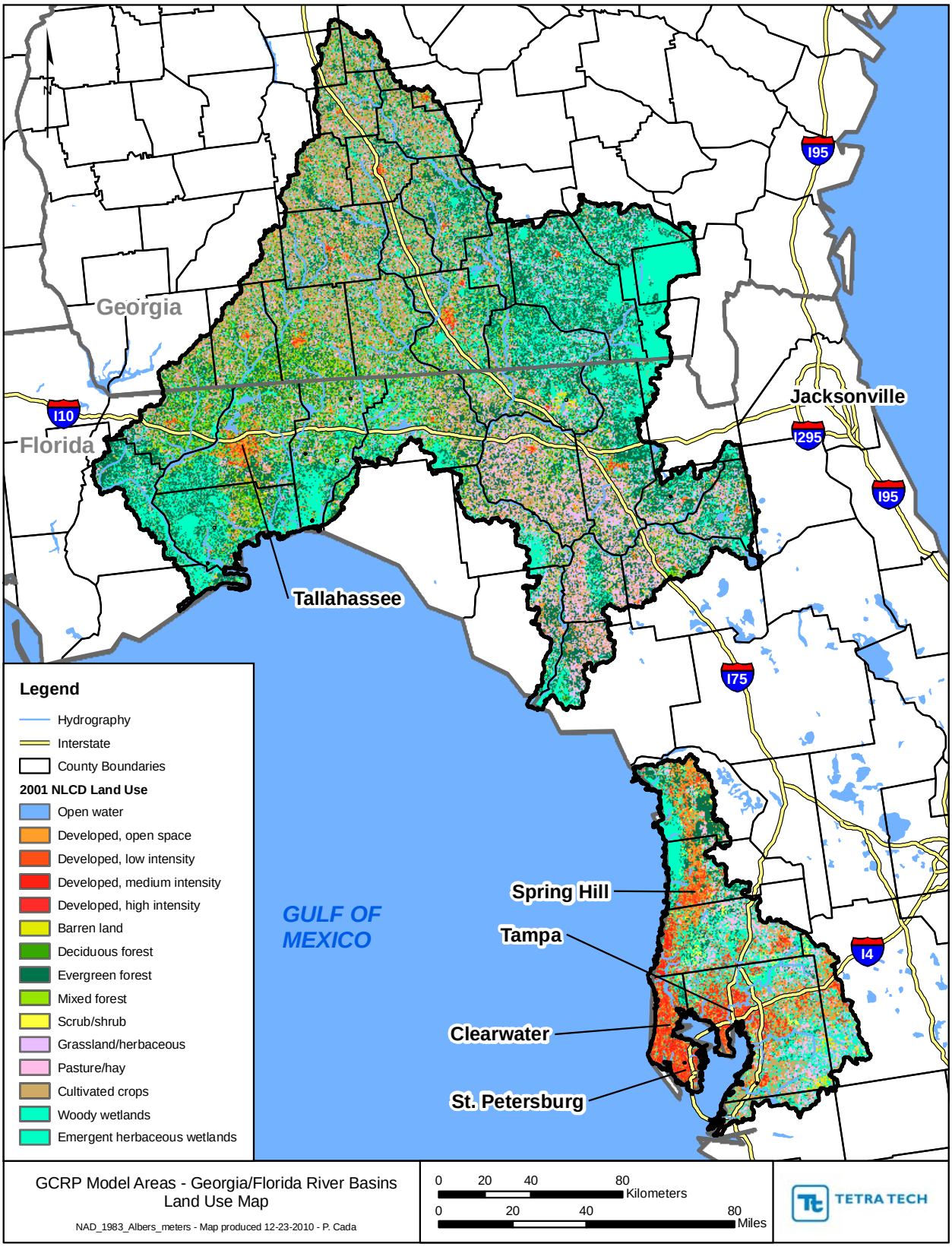

Figure 2. Land use in the Georgia-Florida Coastal Plain model.

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 Georgia-Florida Coastal Plain (2001 NLCD) (mi^2)

HUC 8 watershed	Open water	Developed[a]				Barren land	Forest	Shrub and Grassland	Pasture/Hay	Cultivated	Wetland	Total
		Open space	Low density	Medium density	High density							
Little Manatee 03100203	3.28	12.89	5.92	3.77	0.41	11.02	8.32	9.61	35.45	51.00	64.58	206.25
Alafia 03100204	14.54	57.09	20.05	8.94	1.69	18.31	16.32	63.67	42.11	19.43	154.34	416.49
Hillsborough 03100205	6.95	109.61	52.21	30.46	9.82	1.53	36.32	30.35	115.04	15.32	238.80	646.41
Tampa Bay 03100206	14.74	85.28	97.65	66.80	23.62	0.60	16.16	17.35	22.23	30.04	115.03	489.49
Crystal-Pithlachascotee 03100207	13.46	171.27	155.40	66.08	14.78	2.96	193.61	49.35	78.46	2.07	304.20	1,051.64
Aucilla 03110103	2.56	37.36	4.58	0.88	0.40	0.87	407.91	80.61	48.99	79.08	301.57	964.81
Upper Suwannee 03110201	8.51	92.49	21.25	2.83	1.05	9.98	930.65	304.63	51.51	40.42	1,144.83	2,608.16
Alapaha 03110202	11.15	83.39	22.97	5.34	3.31	1.38	648.83	141.50	110.92	390.06	364.90	1,783.76
Withlacoochee 03110203	7.96	82.00	22.55	6.45	3.29	0.95	565.93	133.57	115.66	362.75	209.62	1,510.74
Little 03110204	6.22	38.31	13.15	2.53	1.09	0.88	263.72	57.54	83.81	282.16	126.03	875.42
Lower Suwannee 03110205	8.63	85.64	16.23	1.66	0.35	2.02	536.15	295.65	204.14	158.13	193.62	1,502.22
Santa Fe 03110206	19.51	70.92	15.33	3.41	0.97	4.47	534.92	268.37	166.54	68.38	202.26	1,355.07
Apalachee Bay-St. Marks 03120001	4.47	91.70	19.32	7.09	2.23	2.36	560.43	90.09	33.53	33.62	295.04	1,139.88
Upper Ochlockonee 03120002	5.53	42.28	13.04	2.11	1.11	1.11	328.10	67.64	62.55	264.89	113.10	901.45
Lower Ochlockonee 03120003	18.55	70.17	12.40	2.08	0.69	3.27	679.84	91.14	37.14	76.99	490.00	1,482.26
Total	121.29	950.82	413.86	167.24	52.89	30.87	5,666.23	1,597.45	1,015.47	1,788.59	3,860.20	15,664.90

[a]The percent imperviousness applied to each of the developed land uses is as follows: open space (7.20%), low density (31.87%), medium density (60.14%), and high density (87.47%).

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 Georgia-Florida Coastal Plain model

NPDES ID	Name	Design flow (MGD)	Observed flow (MGD) (1991-2006 average)
FL0029033	CITY OF QUINCY WWTP	1.5	1.0
FL0025518	ARVAH B. HOPKINS GENERATING	1.9	0.3
GA0001279	AFFINITY FOODS OF GA		0.5
GA0024082	THOMASVILLE WPCP	6.5	3.7
GA0001678	ENGELHARD CORPORATION		1.1
FL0001465	GOLDKIST INC - LIVE OAK PROCES	1.5	1.3
GA0024911	ADEL WPCP	2.5	1.3
GA0000124	TIFTON ALUMUNUM CO		0.3
FL0027880	JASPER-WWTP	1.2	0.7
GA0020222	VALDOSTA (MUD CREEK WPCP)	3.2	2.1
GA0025852	ASHBURN (WPCP)	1.2	0.9
FL0028126	STARKE-MUNICIPAL STP	1.7	1.7
FL0002518	ST. MARKS POWDER, INC.	0.8	21.4
FL0025526	SAM O. PURDOM GEN STATION		21.0
FL0027839	MONTICELLO-STP	1.0	10.7
FL0026557	PLANT CITY STP	8.0	3.6
FL0040983	HILLSBOROUGH CTY VALRICO WWTP	6.0	5.2
FL0029653	AOC, LLC		0.1
FL0000523	CF INDUSTRIES - BARTOW PHOS.		4.0
FL0001589	MOSAIC FERTILIZER, LLC - BARTO		1.7
FL0034657	CORONET INDUSTRIES INC		62.7
FL0043869	TAMPA ELEC-POLK POWER STATION		2.7
FL0028061	HILLSBOROUGH CO-SOUTHWEST WTP	4.0	1.6
FL0030406	TARPON SPRINGS STP	4.0	3.2
FL0021326	DUNEDIN-MAINLAND STP	6.0	5.8
FL0021857	CLEARWATER-MARSHALL ST STP	10.0	6.7
FL0034789	MID-COUNTY SERVICES, INC	0.9	1.1
FL0000159	PROGRESS ENERGY CRYSTAL RIVER	0.7	0.0

NPDES ID	Name	Design flow (MGD)	Observed flow (MGD) (1991-2006 average)
FL0036366	PROGRESS ENERGY CRYSTAL R 4&5	99.0	4.0
FL0027821	RIVER OAKS AWWTP	10.0	8.0
FL0021865	CLEARWATER-EAST WWTF	4.3	10.2
FL0026603	LARGO, CITY OF	15.0	9.1
FL0000264	IMC-AGRICO CO - PORT SUTTON	0.5	3.1
FL0000809	TAMPA ELEC COMPANY-FJ GANNON		0.2
FL0020940	HOWARD F CURREN AWTP	96.0	148.8
FL0040614	HILLSBORO CO - FALKENBURG RD A	6.0	9.3
FL0027651	CITY OF OLDSMAR	2.3	1.2
FL0041670	NORTHWEST REGIONAL WRF	5.0	3.5

Most of these point sources have reasonably complete monitoring for total phosphorus and total suspended solids (TSS). In the Georgia-Florida Coastal basin more dischargers also report total nitrogen (unlike other study areas) due to 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, total suspended solids 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 Penman-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 2002. A total of 51 precipitation stations were identified for use in the Georgia-Florida Coastal watershed model with a common period of record of 10/1/1971-9/30/2002 (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 Georgia-Florida Coastal Plain model

COOP ID	Name	Latitude	Longitude	Temperature	Elevation (m)
097276	QUITMAN 2 NW	30.7836	-83.5691	x	56
098666	THOMASVILLE 3 NE	30.8673	-83.9318	x	79
090140	ALBANY 3 SE	31.5339	-84.1488	x	55
098703	TIFTON	31.4462	-83.4766	x	116
096087	MOULTRIE 2 ESE	31.1769	-83.7492	x	104
080478	BARTOW	27.8986	-81.8432	x	38
081046	BROOKSVILLE CHIN HILL	28.6164	-82.3657	x	73
084731	LAKE CITY 2 E	30.1854	-82.5942	x	59

COOP ID	Name	Latitude	Longitude	Temperature	Elevation (m)
085275	MADISON	30.4517	-83.4119	x	37
087205	PLANT CITY	28.0236	-82.1422	x	37
087851	SAINT LEO	28.3379	-82.2600	x	58
099186	WAYCROSS 4 NE	31.2515	-82.3127	x	44
084273	INGLIS 3 E	29.0254	-82.6157		9
084797	LAKELAND	28.0207	-81.9218		44
080975	BRANFORD	29.9625	-82.9107		9
082391	DOWLING PARK 1 W	30.2498	-83.2593		16
088758	TALLAHASSEE WSO AP	30.3932	-84.3533	x	17
088788	TAMPA WSCMO AP	27.9615	-82.5403	x	6
090586	BAINBRIDGE INTL PAPER C	30.8229	-84.6175		58
093312	FARGO	30.6908	-82.5632		35
096879	PEARSON	31.2928	-82.8422		62
082008	CROSS CITY 2 WNW	29.6497	-83.1663	x	13
083956	HIGH SPRINGS	29.8287	-82.5972	x	20
084289	INVERNESS 3 SE	28.8032	-82.3124	x	12
085879	MONTICELLO WTP	30.4923	-83.7832	x	30
087025	PERRY	30.0987	-83.5742	x	14
087886	ST PETERSBURG	27.7632	-82.6272	x	2
088824	TARPON SPRINGS SWG PLNT	28.1500	-82.7500	x	2
090010	ABBEVILLE 4 S	31.9381	-83.3078		73
091500	CAMILLA 3 SE	31.1904	-84.2035	x	53
092266	CORDELE	31.9848	-83.7758	x	94
092783	DOUGLAS	31.4890	-82.8205	x	71
093386	FITZGERALD	31.7108	-83.2516	x	113
093460	FOLKSTON 3 SW	30.7987	-82.0181		9
083986	HILLSBOROUGH RVR ST PK	28.1429	-82.2269		16
086880	PARRISH	27.6089	-82.3478	x	18
093465	FOLKSTON 9 SW	30.7400	-82.1277	x	37
087440	RAIFORD STATE PRISON	30.0678	-82.1928	x	37
085539	MAYO	30.0565	-83.1818	x	20
085099	LIVE OAK	30.2890	-82.9650	x	37
084394	JASPER	30.5229	-82.9446	x	45
098974	VALDOSTA 2 S	30.8056	-83.2736		81

COOP ID	Name	Latitude	Longitude	Temperature	Elevation (m)
083153	FORT GREEN 12 WSW	27.5706	-82.1377		34
089795	WOODRUFF DAM	30.7220	-84.8742		33
089120	USHER TOWER	29.4084	-82.8186	x	10
094429	HOMERVILLE 5 N	31.0767	-82.8002	x	57
090406	ASHBURN 3 ENE	31.7003	-83.6230	x	133
080945	BRADENTON 5 ESE	27.4467	-82.5014	x	6
087429	QUINCY 3 SSW	30.6001	-84.5499	x	75
089430	WEEKI WACHEE	28.5175	-82.5755	x	6

Watershed Segmentation

The Georgia-Florida Coastal basin was divided into 108 subwatersheds for the purposes of modeling (Figure 3). Ochlockonee River at USGS 02329000 was chosen for initial calibration. The model encompasses the complete watershed and does not require specification of any upstream boundary conditions for application.

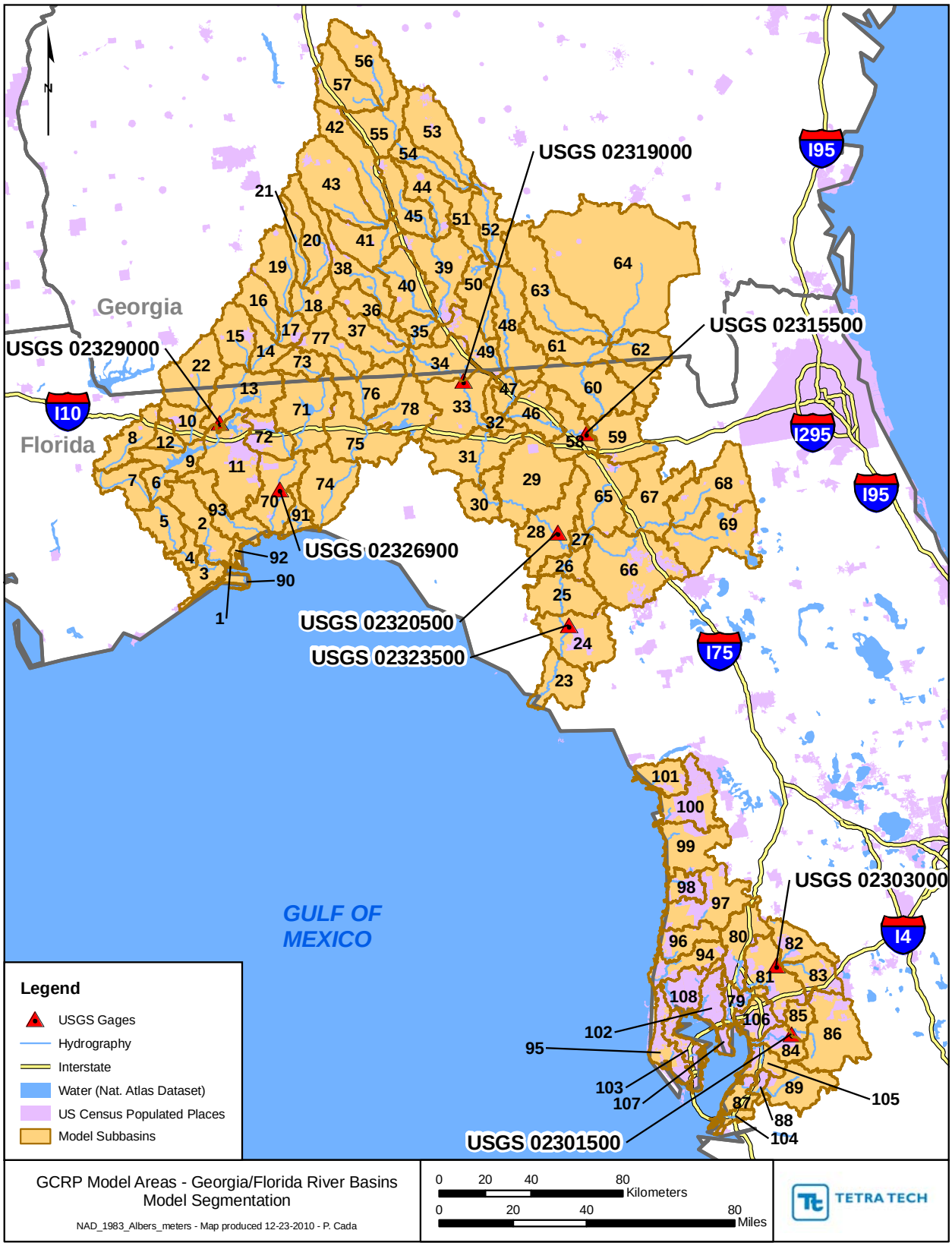

Figure 3. Model segmentation and USGS stations utilized for the Georgia-Florida Coastal Plain.

Calibration Data and Locations

The specific site chosen for initial calibration was the Ochlockonee River at Havana, FL, a flow and water quality monitoring location that approximately coincides with the mouth of an 8-digit HUC at its outflow to the Ochlockonee River. The Ochlockonee River 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 Ochlockonee River were not fully transferable to other portions of the Georgia-Florida Coastal basin, and additional calibration was conducted at multiple gage locations.

Table 5. Calibration and validation locations in the Georgia-Florida Coastal Plain

Station name	USGS ID	Drainage area (mi^2)	Hydrology calibration	Water quality calibration
Alafia River at Lithia, FL	02301500	335	x	x
Hillsborough River near Zephyrhills, FL	02303000	220	x	x
Suwanee River at White Springs, FL	02315500	2430	x	
Withlacoochee River near Pinetta, FL	02319000	2120	x	
Suwanee River near Branford, FL	02320500	7880	x	x
Suwanee River near Wilcox, FL	02323500	9640	x	
St. Marks River near Newport, FL	02326900	535	x	
Ochlockonee River at Havana, FL	02329000	1140	x	x

The model hydrology calibration period was set to Water Years 1992-2002 (within the 32-year period of record for modeling). Hydrologic validation was then performed on Water Years 1982-1992. Water quality calibration used calendar years 1992-2002, while validation used 1982-1992.

SWAT Modeling

Assumptions

Hydrology Calibration

A spatial calibration approach was adopted for GCRP-SWAT modeling for the Georgia-Florida Coastal basin. A systematic adjustment of parameters was adopted and some adjustments were 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 (Ochlockonee River) includes nine subwatersheds and is generally representative of the general land use characteristics of the overall watershed. 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 upper portion of the Georgia-Florida Coastal basin predicted by the SWAT model over the 32-year simulation period is as follows:

```
PRECIP =   1323.6 MM
SNOW FALL =    1.53 MM
SNOW MELT =     1.52 MM
SUBLIMATION =     0.01 MM
SURFACE RUNOFF Q =   167.16 MM
LATERAL SOIL Q =   18.39 MM
TILE Q =     0.00 MM
GROUNDWATER (SHAL AQ) Q =   223.44 MM
REVAP (SHAL AQ => SOIL/PLANTS) =  104.93 MM
DEEP AQ RECHARGE =    44.75 MM
TOTAL AQ RECHARGE =  374.05 MM
TOTAL WATER YLD =   397.68 MM
PERCOLATION OUT OF SOIL =  369.14 MM
ET =    766.5 MM
PET =   1576.8MM
TRANSMISSION LOSSES =    11.31 MM
```

The water balance of the lower portion of the Georgia-Florida Coastal basin predicted by the SWAT model over the 32-year simulation period is as follows:

```
PRECIP =   1314.8 MM
SNOW FALL =    0.10 MM
SNOW MELT =     0.10 MM
SUBLIMATION =     0.00 MM
SURFACE RUNOFF Q =   169.83 MM
```

```
LATERAL SOIL Q =   31.62 MM
TILE Q =     0.00 MM
GROUNDWATER (SHAL AQ) Q =   143.04 MM
REVAP (SHAL AQ => SOIL/PLANTS) =  100.62 MM
DEEP AQ RECHARGE =   162.45 MM
TOTAL AQ RECHARGE =  406.12 MM
TOTAL WATER YLD =   344.49 MM
PERCOLATION OUT OF SOIL =  409.81 MM
ET =    701.1 MM
PET =   1678.8MM
TRANSMISSION LOSSES =     0.00 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_N1 (Manning's "n" value for tributary channels)
- CH_N2 (Manning's "n" value for main channels)

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

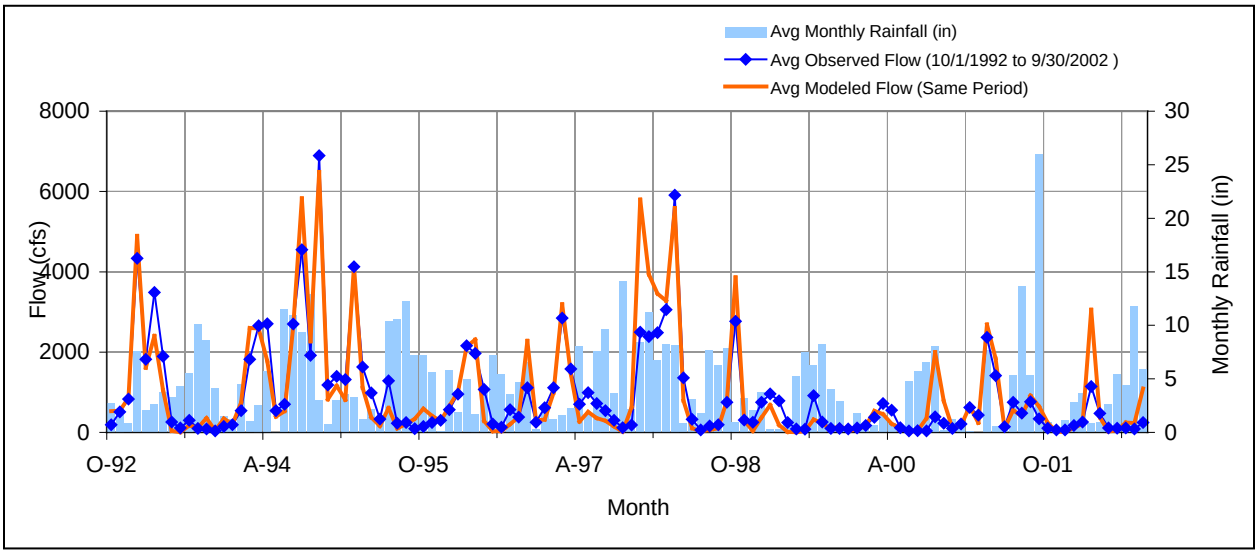

Figure 4. Mean monthly flow at USGS 02329000 Ochlockonee River at Havana, FL – calibration period.

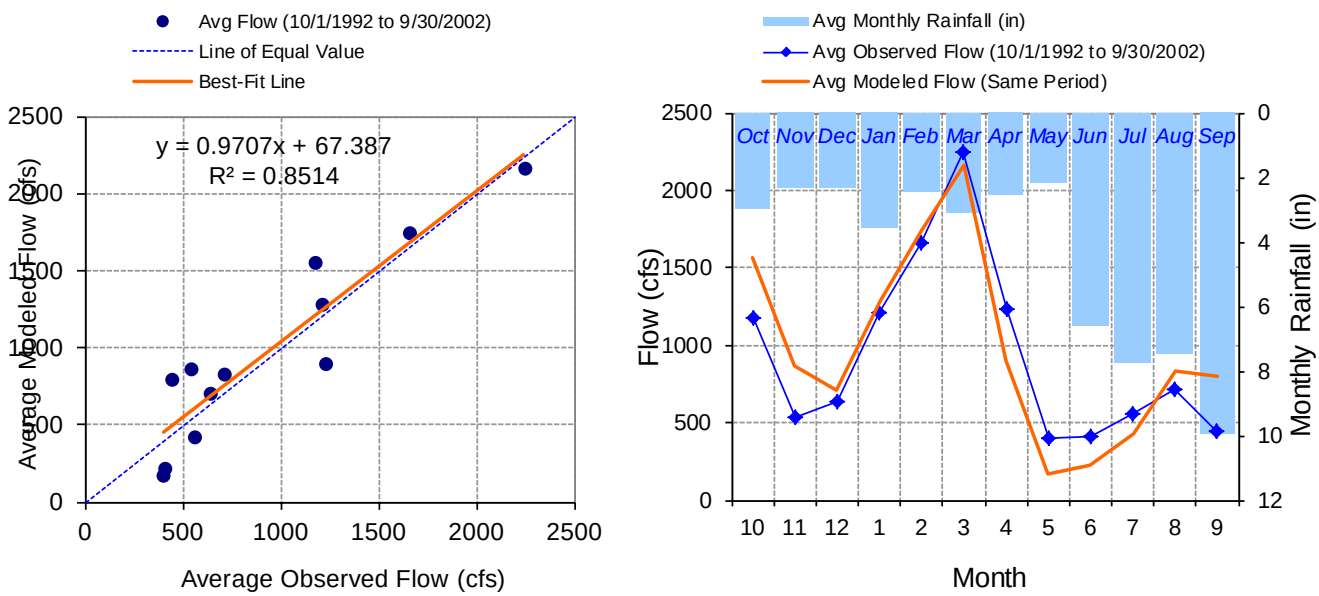

Figure 5. Seasonal regression and temporal aggregate at USGS 02329000 Ochlockonee River at Havana, FL – calibration period.

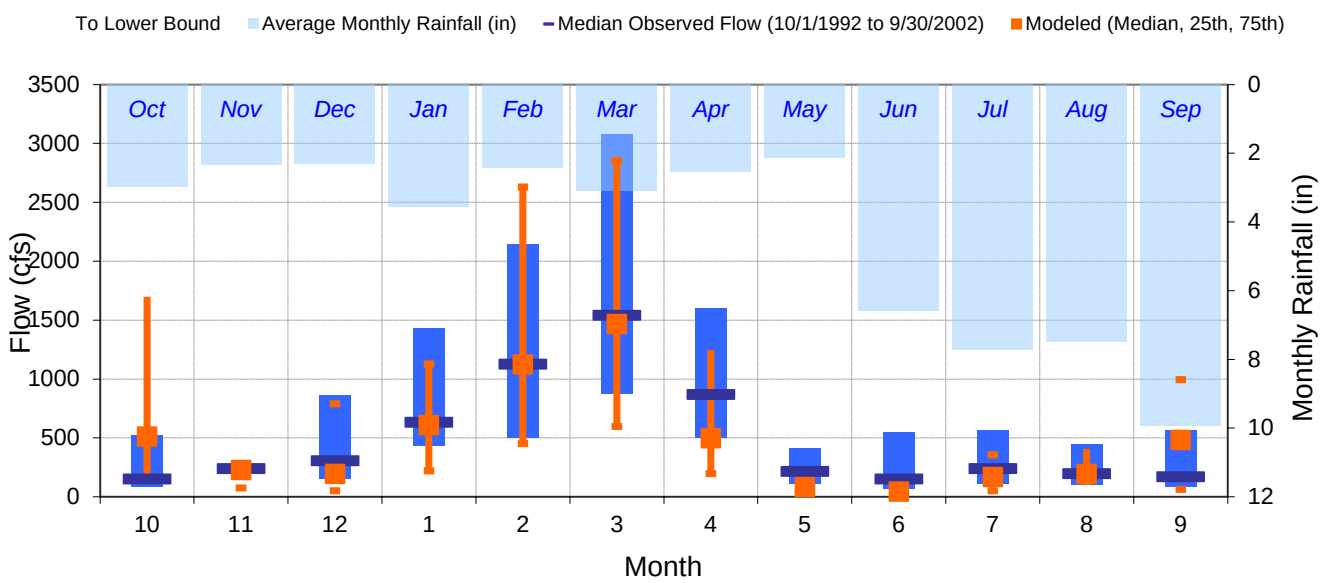

Figure 6. Seasonal medians and ranges at USGS 02329000 Ochlockonee River at Havana, FL – calibration period.

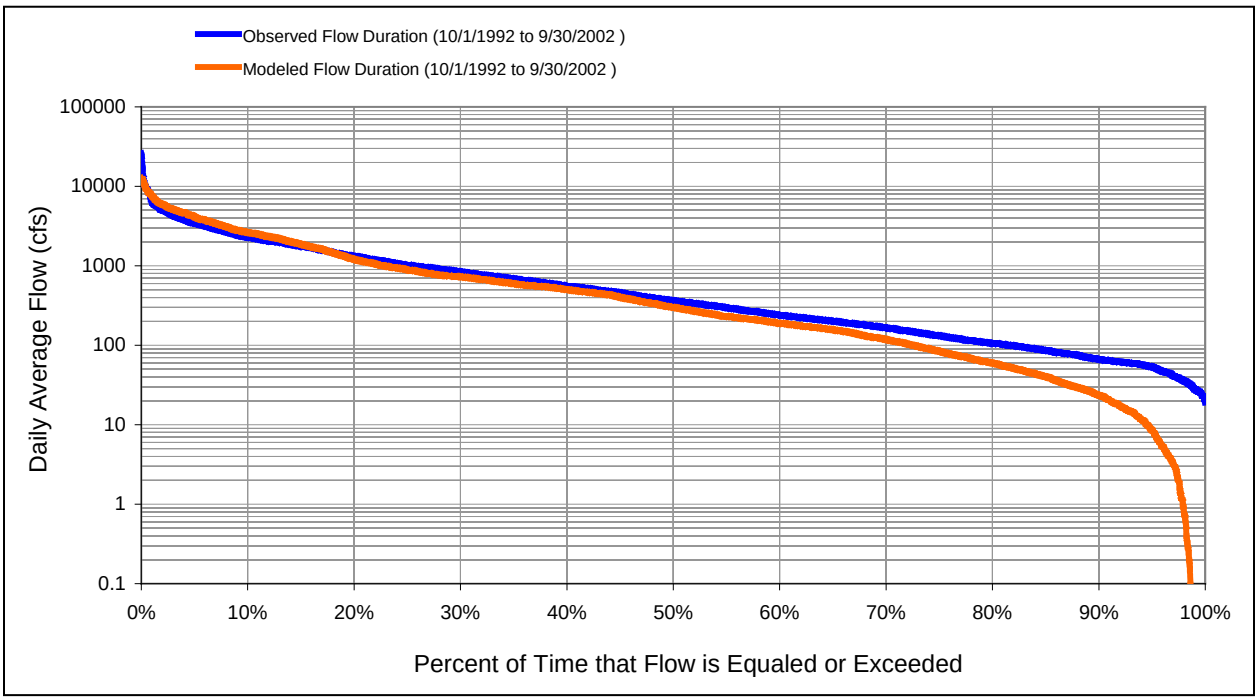

Figure 7. Flow exceedance at USGS 02329000 Ochlockonee River at Havana, FL – calibration period.

Table 6. Summary statistics at USGS 02329000 Ochlockonee River at Havana, FL – calibration period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 13 10-Year Analysis Period: 10/1/1992 - 9/30/2002 Flow volumes are (inches/year) for upstream drainage area		USGS 02329000 OCHLOCKONEE RIVER NR HAVANA, FLA. Hydrologic Unit Code: 3120003 Latitude: 30.55408644 Longitude: -84.3840715 Drainage Area (sq-mi): 1140	
Total Simulated In-stream Flow:	**11.57**	Total Observed In-stream Flow:	**11.10**
Total of simulated highest 10% flows:	**6.08**	Total of Observed highest 10% flows:	**5.32**
Total of Simulated lowest 50% flows:	**0.66**	Total of Observed Lowest 50% flows:	**0.93**
Simulated Summer Flow Volume (months 7-9):	**2.06**	Observed Summer Flow Volume (7-9):	**1.72**
Simulated Fall Flow Volume (months 10-12):	**3.14**	Observed Fall Flow Volume (10-12):	**2.36**
Simulated Winter Flow Volume (months 1-3):	**5.10**	Observed Winter Flow Volume (1-3):	**5.01**
Simulated Spring Flow Volume (months 4-6):	**1.27**	Observed Spring Flow Volume (4-6):	**2.00**
Total Simulated Storm Volume:	**3.36**	Total Observed Storm Volume:	**3.51**
Simulated Summer Storm Volume (7-9):	**0.58**	Observed Summer Storm Volume (7-9):	**0.53**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	4.25	10	
Error in 50% lowest flows:	**-28.91**	**10**	
Error in 10% highest flows:	14.27	15	
Seasonal volume error - Summer:	19.83	30	
Seasonal volume error - Fall:	**33.10** >>	**30** Clear	
Seasonal volume error - Winter:	1.60	30	
Seasonal volume error - Spring:	**-36.43**	**30**	
Error in storm volumes:	-4.28	20	
Error in summer storm volumes:	10.50	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.711	Model accuracy increases as E or E' approaches 1.0	
Baseline adjusted coefficient (Garrick), E':	0.539		
Monthly NSE	0.793		

Hydrology Validation

Hydrology validation for Ochlockonee River was performed for the period 10/1/1982 through 9/30/1992. 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).

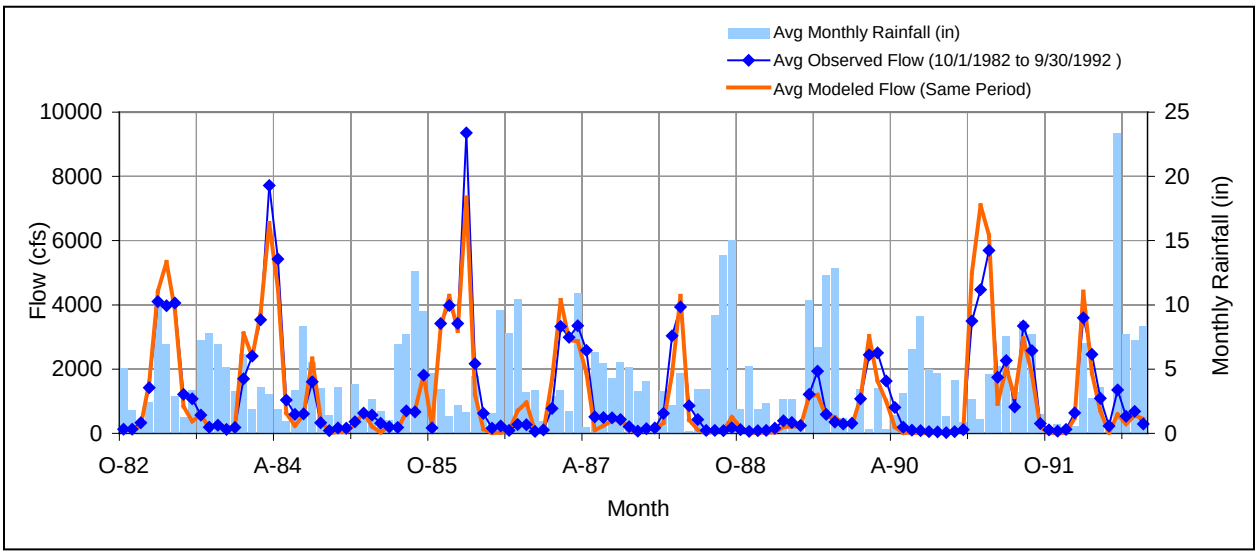

Figure 8. Mean monthly flow at USGS 02329000 Ochlockonee River at Havana, FL – validation period.

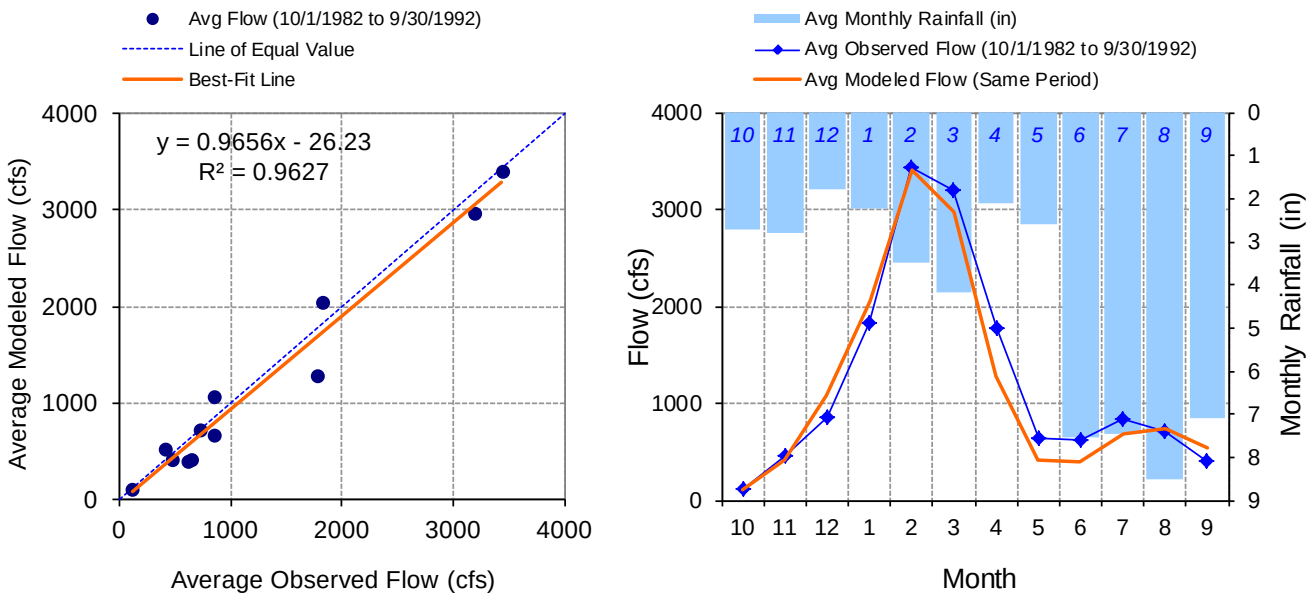

Figure 9. Seasonal regression and temporal aggregate at USGS 02329000 Ochlockonee River at Havana, FL – validation period.

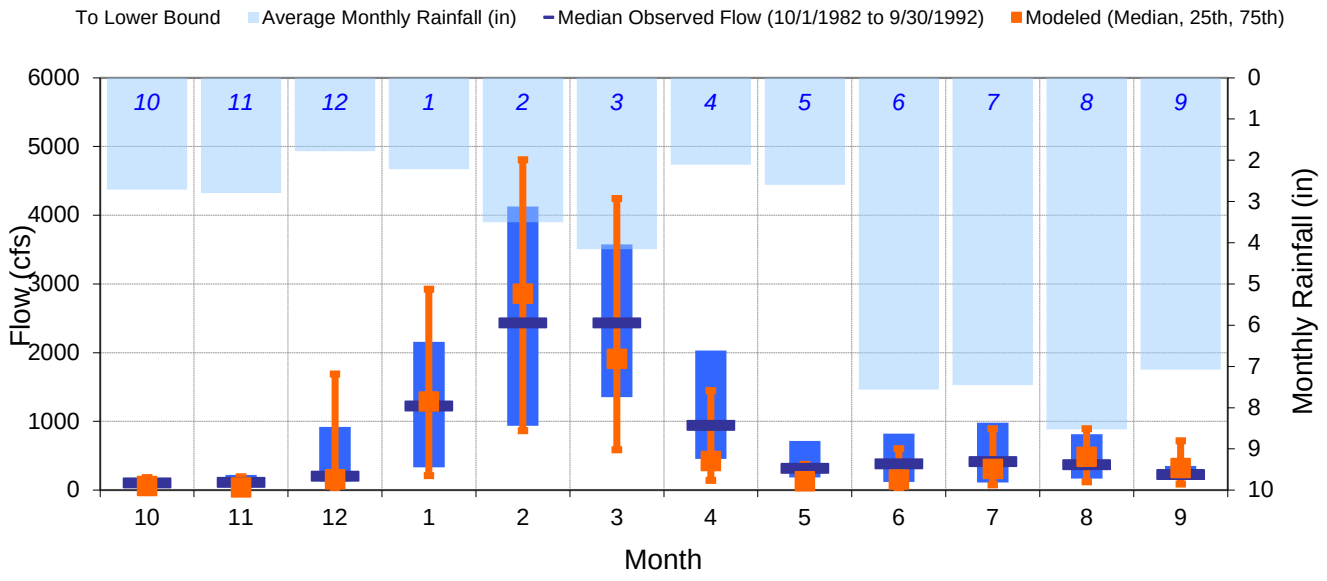

Figure 10. Seasonal medians and ranges at USGS 02329000 Ochlockonee River at Havana, FL – validation period.

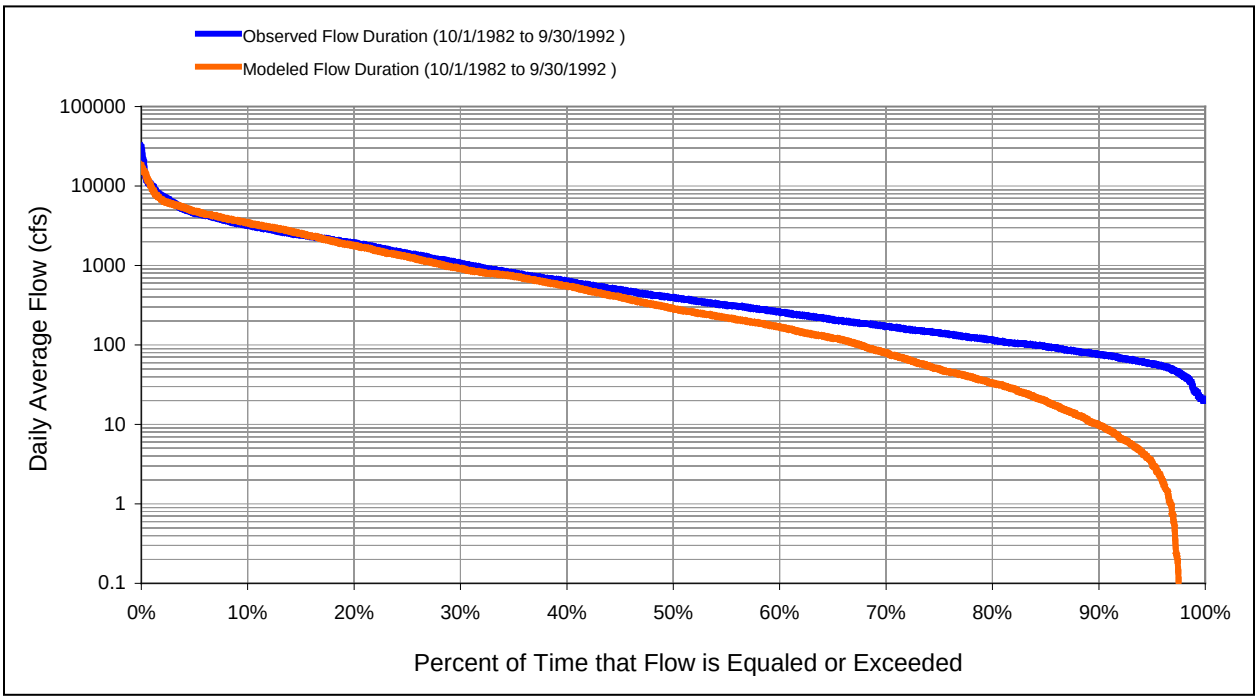

Figure 11. Flow exceedance at USGS 02329000 Ochlockonee River at Havana, FL – validation period.

Table 7. Summary statistics at USGS 02329000 Ochlockonee River at Havana, FL – validation period

SWAT Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM OUTLET 13 10-Year Analysis Period: 10/1/1982 - 9/30/1992 Flow volumes are (inches/year) for upstream drainage area		USGS 02329000 OCHLOCKONEE RIVER NR HAVANA, FLA. Hydrologic Unit Code: 3120003 Latitude: 30.55408644 Longitude: -84.3840715 Drainage Area (sq-mi): 1140	
Total Simulated In-stream Flow:	**13.85**	Total Observed In-stream Flow:	**14.66**
Total of simulated highest 10% flows:	**7.22**	Total of Observed highest 10% flows:	**7.36**
Total of Simulated lowest 50% flows:	**0.51**	Total of Observed Lowest 50% flows:	**0.99**
Simulated Summer Flow Volume (months 7-9):	**1.95**	Observed Summer Flow Volume (7-9):	**1.97**
Simulated Fall Flow Volume (months 10-12):	**1.60**	Observed Fall Flow Volume (10-12):	**1.44**
Simulated Winter Flow Volume (months 1-3):	**8.22**	Observed Winter Flow Volume (1-3):	**8.24**
Simulated Spring Flow Volume (months 4-6):	**2.07**	Observed Spring Flow Volume (4-6):	**3.00**
Total Simulated Storm Volume:	**4.01**	Total Observed Storm Volume:	**4.94**
Simulated Summer Storm Volume (7-9):	**0.53**	Observed Summer Storm Volume (7-9):	**0.61**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	
Error in total volume:	-5.54	10	
Error in 50% lowest flows:	**-48.00**	**10**	
Error in 10% highest flows:	-1.84	15	
Seasonal volume error - Summer:	-1.04	30	
Seasonal volume error - Fall:	11.57 >>	30	Clear
Seasonal volume error - Winter:	-0.26	30	
Seasonal volume error - Spring:	**-31.19**	**30**	
Error in storm volumes:	-18.85	20	
Error in summer storm volumes:	-12.44	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.799	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.649	as E or E' approaches 1.0	
Monthly NSE	0.895		

Hydrology Results for Larger Watershed

As described above, parameters determined for the gage at Ochlockonee River were initially transferred to other gages in the watershed. However, changes to subwatershed level parameters were required to fit the model to the observed flows. In all, calibration and validation was pursued at a total of eight gages throughout the watershed. 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	02301500	02303000	02315500	02319000	02320500	02323500	02326900	02329000
Error in total volume:	-4.77	-0.21	-8.07	-1.91	2.22	3.45	4.32	4.25
Error in 50% lowest flows:	32.79	8.10	55.83	9.25	14.34	11.46	15.97	-28.91
Error in 10% highest flows:	-10.46	-12.69	-14.74	-9.20	-3.57	1.83	0.32	14.27
Seasonal volume error - Summer:	5.48	8.36	28.40	41.01	10.89	20.53	-6.54	19.83
Seasonal volume error - Fall:	0.84	-2.28	14.11	23.55	19.48	18.31	22.26	33.10
Seasonal volume error - Winter:	-26.89	-17.54	-21.36	-15.83	-7.80	-7.73	1.85	1.60
Seasonal volume error - Spring:	-5.58	13.71	-21.16	-19.73	-2.98	-6.27	3.42	-36.43
Error in storm volumes:	-28.50	-9.30	-12.16	-34.73	19.91	-17.80	18.67	-4.28
Error in summer storm volumes:	-18.37	0.77	0.31	-10.47	48.43	-12.89	-12.42	10.50
Daily Nash-Sutcliffe Coefficient of Efficiency, E:	0.727	0.675	0.823	0.756	0.821	0.802	0.623	0.711
Monthly Nash-Sutcliffe Efficiency:	0.789	0.736	0.858	0.851	0.865	0.838	0.654	0.793

Table 9. Summary statistics (percent error): all stations - validation period

Station	02301500	02303000	02315500	02319000	02320500	02323500	02326900	02329000
Error in total volume:	1.39	3.17	-7.80	-2.51	-11.68	-17.18	-2.87	-5.54
Error in 50% lowest flows:	8.63	-3.25	42.55	-36.60	-22.56	-32.66	-4.93	-48.00
Error in 10% highest flows:	-3.36	-4.80	-19.13	-0.51	-6.19	-4.00	2.96	-1.84
Seasonal volume error - Summer:	3.79	9.87	6.07	-14.33	-20.22	-19.58	-12.90	-1.04
Seasonal volume error - Fall:	54.39	7.84	97.49	29.83	-3.66	-17.71	-3.76	11.57
Seasonal volume error - Winter:	-35.46	-14.76	-13.63	1.90	-6.19	-10.92	1.01	-0.26
Seasonal volume error - Spring:	-7.98	6.66	-30.57	-21.71	-17.18	-22.74	3.05	-31.19
Error in storm volumes:	-19.86	3.38	-7.60	-35.83	26.96	-6.77	11.11	-18.85
Error in summer storm volumes:	-22.13	-3.79	-12.02	-36.70	-0.67	-23.61	-19.59	-12.44
Daily Nash-Sutcliffe Coefficient of Efficiency, E:	0.416	0.720	0.722	0.801	0.850	0.788	0.584	0.799
Monthly Nash-Sutcliffe Efficiency:	0.393	0.760	0.755	0.903	0.893	0.820	0.624	0.895

Water Quality Calibration and Validation

Initial calibration and validation of water quality was done on the Ochlockonee River (USGS 02329000), using 1992-2002 for calibration and 1982-1992 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 Ochlockonee River 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.

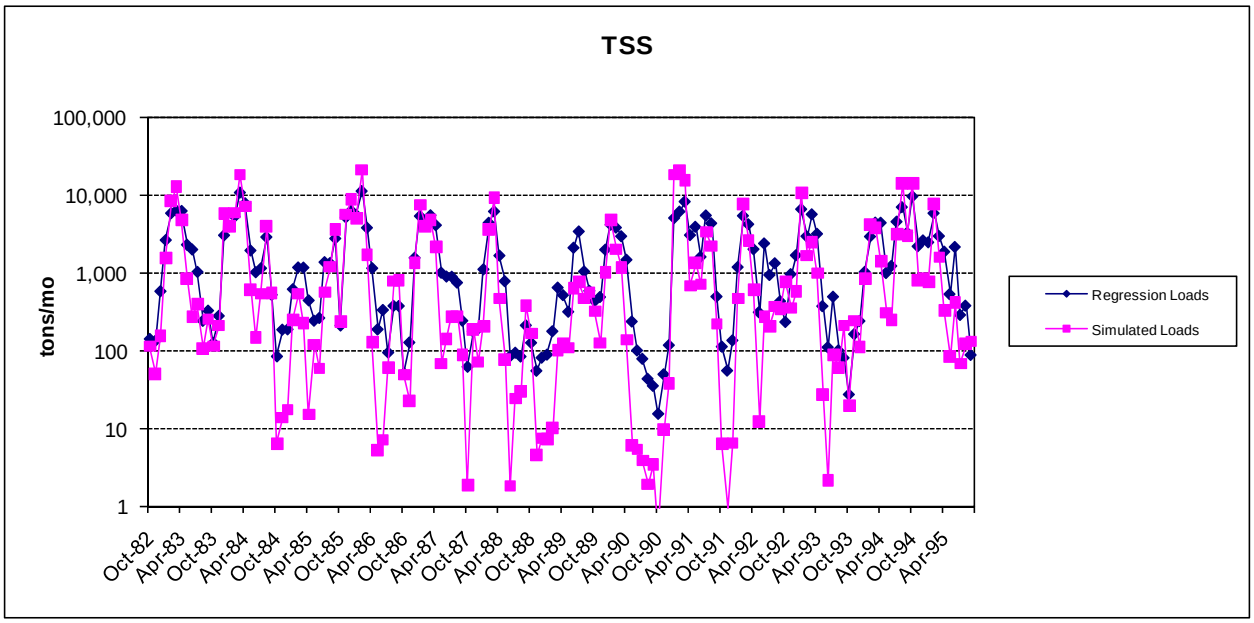

Figure 12. Fit for monthly load of TSS at USGS 02329000 Ochlockonee River at Havana, FL.

Table 10. Model fit statistics (observed minus predicted) for monthly sediment loads using stratified regression at USGS 02329000 Ochlockonee River at Havana, FL

Statistic	Calibration period (1992-1995)	Validation period (1982-1992)
Relative Percent Error	9.5%	-6.6%
Relative Average Absolute Error	55.5%	59.4%
Relative Median Absolute Error	36.7%	24.4%

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.

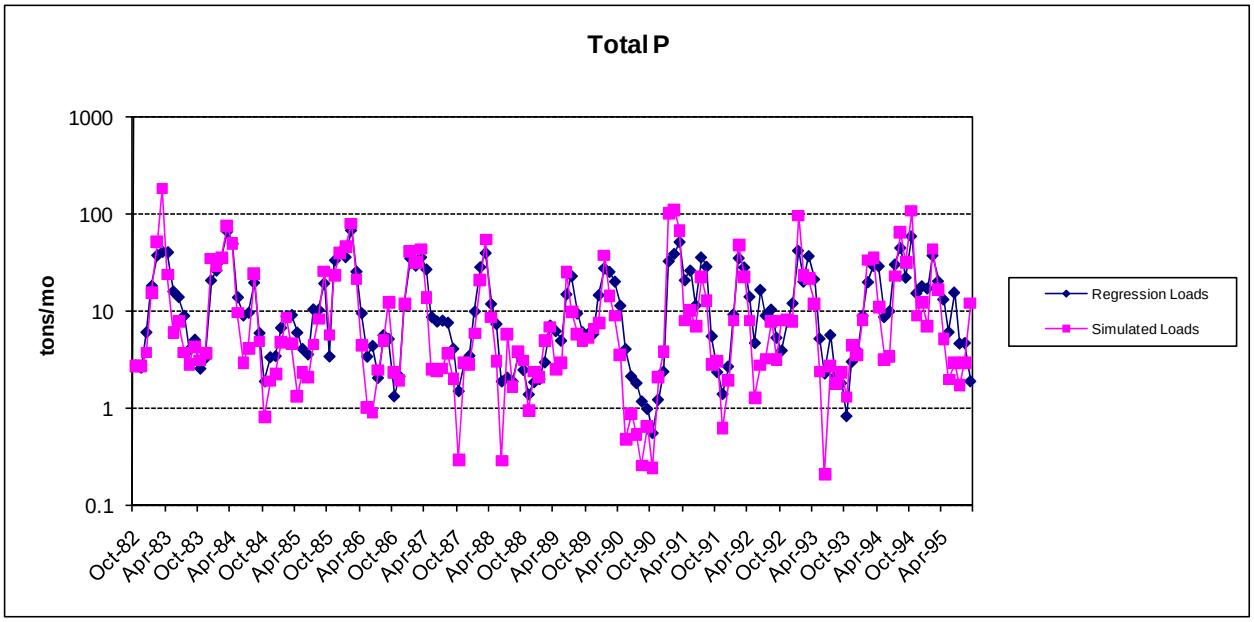

Figure 13. Fit for monthly load of total phosphorus at USGS 02329000 Ochlockonee River at Havana, FL.

Table 11. Model fit statistics (observed minus predicted) for monthly phosphorus loads using stratified regression at USGS 02329000 Ochlockonee River at Havana, FL

Statistic	Calibration period (1992-1995)	Validation period (1982-1992)
Relative Percent Error	-7.4%	-5.8%
Average Absolute Error	48.3%	52.4%
Median Absolute Error	22.8%	34.2%

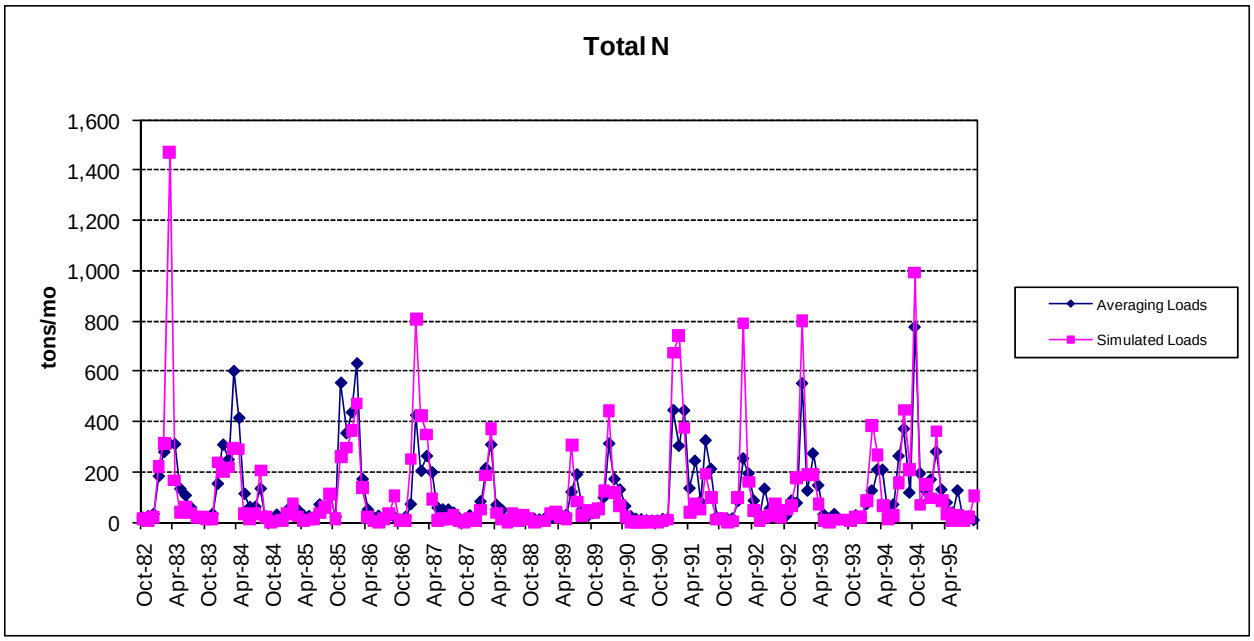

Figure 14. Fit for monthly load of total nitrogen at USGS 02329000 Ochlockonee River at Havana, FL.

Table 12. Model fit statistics (observed minus predicted) for monthly total nitrogen loads using averaging estimator at USGS 02329000 Ochlockonee River at Havana, FL

Statistic	Calibration period (1992-1995)	Validation period (1982-1992)
Relative Percent Error	-8.0%	-5.0%
Average Absolute Error	49.2%	58.6%
Median Absolute Error	32.9%	21.0%

Water Quality Results for Larger Watershed

As with hydrology, a spatial calibration approach was adopted. Ochlockonee River watershed SWAT model parameters for water quality were transferred to other portions of the watershed with necessary changes to subbasin 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 1992-2002

Station	02301500	02303000	02320500	02329000
Relative Percent Error TSS Load	21.4%	10.0%	-12.5%	9.5%
Relative Percent Error TP Load	16.5%	27.1%	6.6%	-7.4%
Relative Percent Error TN Load	24.1%	-4.8%	9.2%	-8.0%

Table 14. Summary statistics for water quality at all stations – validation period 1982-1992

Station	02301500	02303000	02320500	02329000
Relative Percent Error TSS Load	-11.1%	-7.8%	18.1%	-6.6%
Relative Percent Error TP Load	-1.9%	4.2%	10.9%	-5.8%
Relative Percent Error TN Load	-26.1%	-20.2%	15.5%	-5.0%

References

USEPA. 2008. Using the BASINS Meteorological Database (Version 2006). BASINS Technical Note 10. Office of Water, U.S. Environmental Protection Agency, Washington, DC. http://water.epa.gov/scitech/datait/models/basins/upload/2009_04_13_BASINSs_tecnote10.pdf (Accessed June, 2009).