Special Publication SJ98-SP10

Black Creek Basin
Comprehensive Floodplain Management Study
Phase II

Section 22
Planning Assistance to States

U. S. Army Corps of Engineers
Jacksonville District

October 1997

Final

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Errata Sheet

Page	Items	Comment
I	4.1.1 Meteorological	Should read Meteorological Data
ii	5.0 Discussions and Conclusions	Should read Summary and Conclusions
4-70	Table 4-16 Stanard Deviation (mg/l)	Should read Standard Deviation
6-1	Section 6.0 REFERENCES	Should read 6.0 REFERENCES

SJRWMD Comment:

Page 4-31, Section 4.1.5 Water Quality Data

Observed Water Quality Concentrations

add as paragraph 2:

> In order to contribute to excessive algal growth, nutrients must be in bioavailable forms: NO_x, NH_4, PO_4, or in organic forms which can be readily broken down and their elemental forms liberated. Total nutrient estimates, such as those modeled here, encompass a wide range of chemical forms and bioavailability, and thus are not necessarily indicative of eutrophication potential.

No in-stream attenuation of nutrient loading was included in these simulations and should have been included. This would have reduced the event mean concentrations listed in Table 4-6, page 4-32.

EXECUTIVE SUMMARY

This report describes the data reconnaissance, model development, model calibration and results of the hydrologic, hydraulic and water quality simulation of the Black Creek Basin using the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM). The SWMM blocks utitilized included the RUNOFF Block for hydrologic simulation, the TRANSPORT Block for simple flow and pollutant routing and the EXTRAN Block for detailed hydraulic simulation.

The SWMM RUNOFF Block accepts rainfall hyetographs and evaporation data and makes a step-by-step accounting of infiltration losses, surface detention, overland flow, channel flow and the constituents washed from the basin, leading to the calculation of a number of hydrographs and pollutographs. The TRANSPORT Block utilizes a kinematic wave approach to propogate flows and pollutants only in the downstream direction. The EXTRAN Block is a dynamic flow routing model that routes flows through an open and/or closed conduit system solving the full dynamic equations for gradually varied flow (St. Venant equations) using an explicit solution technique.

The model study included a reconnaissance task where the data of various agencies were researched and gathered for model development and calibration. The data reconnaissance located an adequate amount of data for model development and calibration. However, further model refinements can be made through the collection of additional data. This particulary applies to the water quality simulation where the model may be improved by gathering more water quality data.

The model developed for the Black Creek Basin includes the simulation of 171 subbasins, 10 land uses, 5 pollutants, 141 detailed stream reaches and 61 simplified stream reaches. Flows were calibrated for volume and peak flows at two loactions. Stages were calibrated at four locations, and pollutants were calibrated at five locations.

The model results were examined and compared to previous studies. The SWMM model created for the Black Creek Basin produces reliable results for the simulation of the hydrology, hydraulics and pollutants of the basin.

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1.0 OBJECTIVES

The work completed for Phase II of the Black Creek Basin Comprehensive Floodplain Management Study consisted of the development and application of basic water quantity and quality models for the Black Creek Basin. The models compute discharges and nonpoint source pollutant loadings from the Black Creek Basin. Simulated discharges were used to determined the 10-, 25-, and 100-year flood profiles in the primary hydrologic systems. The models constitute the basic framework for the development of a Master Stormwater Management Plan for the entire Black Creek Basin. The models are capable of predicting the effects of changing land use on surface runoff and nonpoint source pollutant loads.

2.0 STUDY AREA DESCRIPTION

The Black Creek Basin is located within the lower St. Johns River drainage basin in northeast Florida (Figure 2-1). The basin is approximately 484 square miles in area and is irregularly shaped (Figure 2-2). The basin drains nearly all of Clay County and portions of Duval County. The basin also drains very small portions of Baker, Bradford, and Putnam Counties. The main drainage features of the basin are Black Creek and its two forks. The North Fork and South Fork converge east of the City of Middleburg to form Black Creek, which flows east to its outfall at the St. Johns River. The North Fork of Black Creek begins at Kingsley Lake near Camp Blanding (Figure 2-2). The North Fork initially flows northward and curves nearly 135 degrees to the southeast near the City of Maxville. The North Fork continues southeast to its confluence with the South Fork. The South Fork begins at Varnes Lake in the Camp Blanding State Wildlife Management Area (Figure 2-2). The South Fork flows north-northeast through Penny Farms and continues to its confluence with the North Fork. The average gradient of the North Fork channel is approximately 5.0 feet per mile with bank elevations ranging from 170 ft. NGVD near Lake Kingsley to 10 ft. NGVD near Middleburg. The average gradient of the South Fork channel is approximately 4.8 feet per mile with bank elevation ranging from 120 ft. NGVD near Lake Varnes to 10 ft. NGVD near Middleburg. The average channel gradient of Black Creek from Middleburg to the St. Johns River is approximately 0.5 feet per mile with bank elevations ranging from 10 ft. NGVD at Middleburg to less than 5 ft. NGVD at the outfall to the St. Johns River.

2.1 Topography

Landscape features within the Black Creek Basin range from relatively low and flat, as in the far northern portion of the basin, to moderate slopes in the southern portion of the basin. Ground slopes in the northern flat area are as low as 0.1 percent and ground slopes in the southern portion of the basin are as high as 5 percent. Surface elevations range from 5.0 feet NGVD, at the outfall to the St. Johns River, to greater than 200 feet NGVD in the western part of the basin. The ground surface drops gently toward surface water features with an average slope of approximately 0.6 percent. Isolated slopes near streams may be as high as 10 percent.

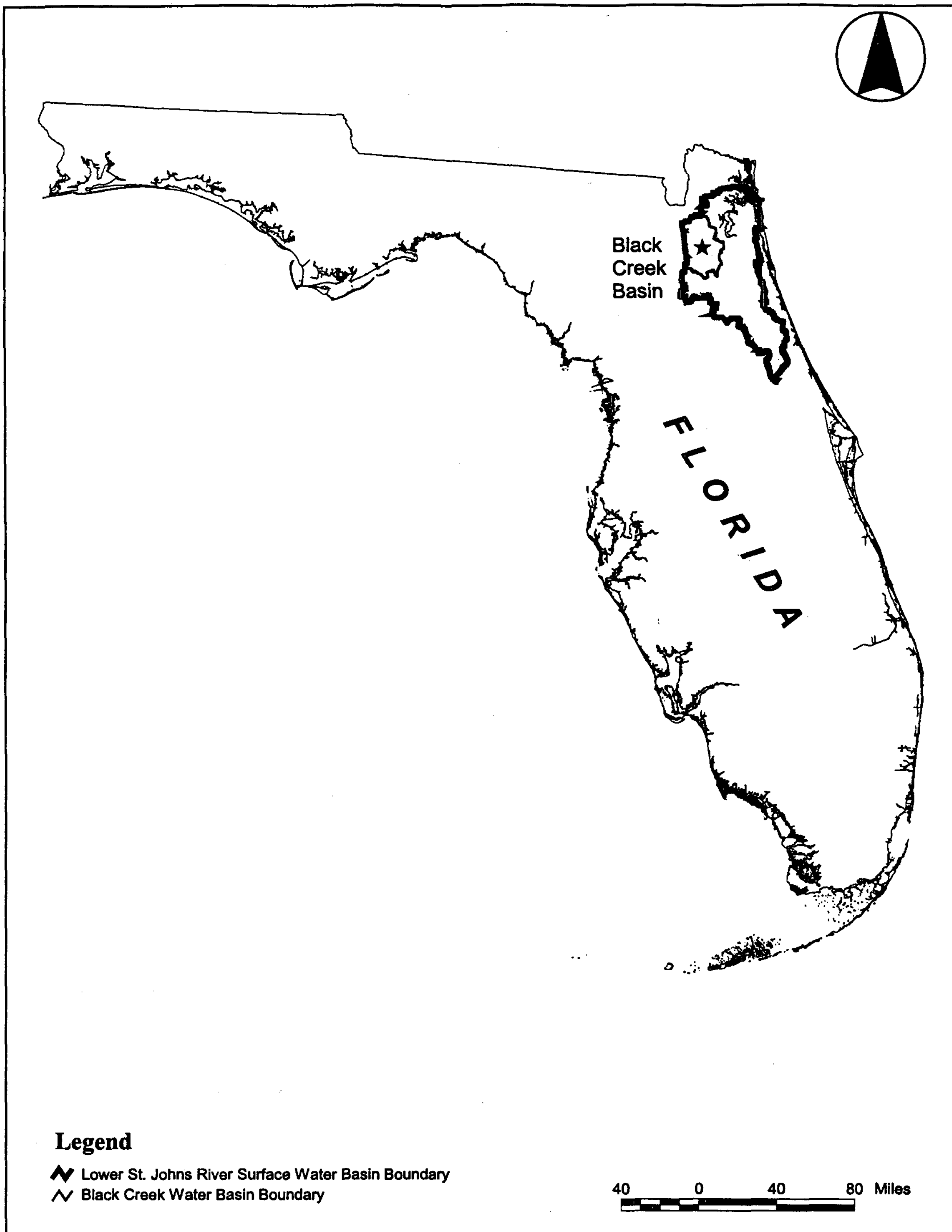


Figure 2-1
Lower St. Johns River Surface Water Basin

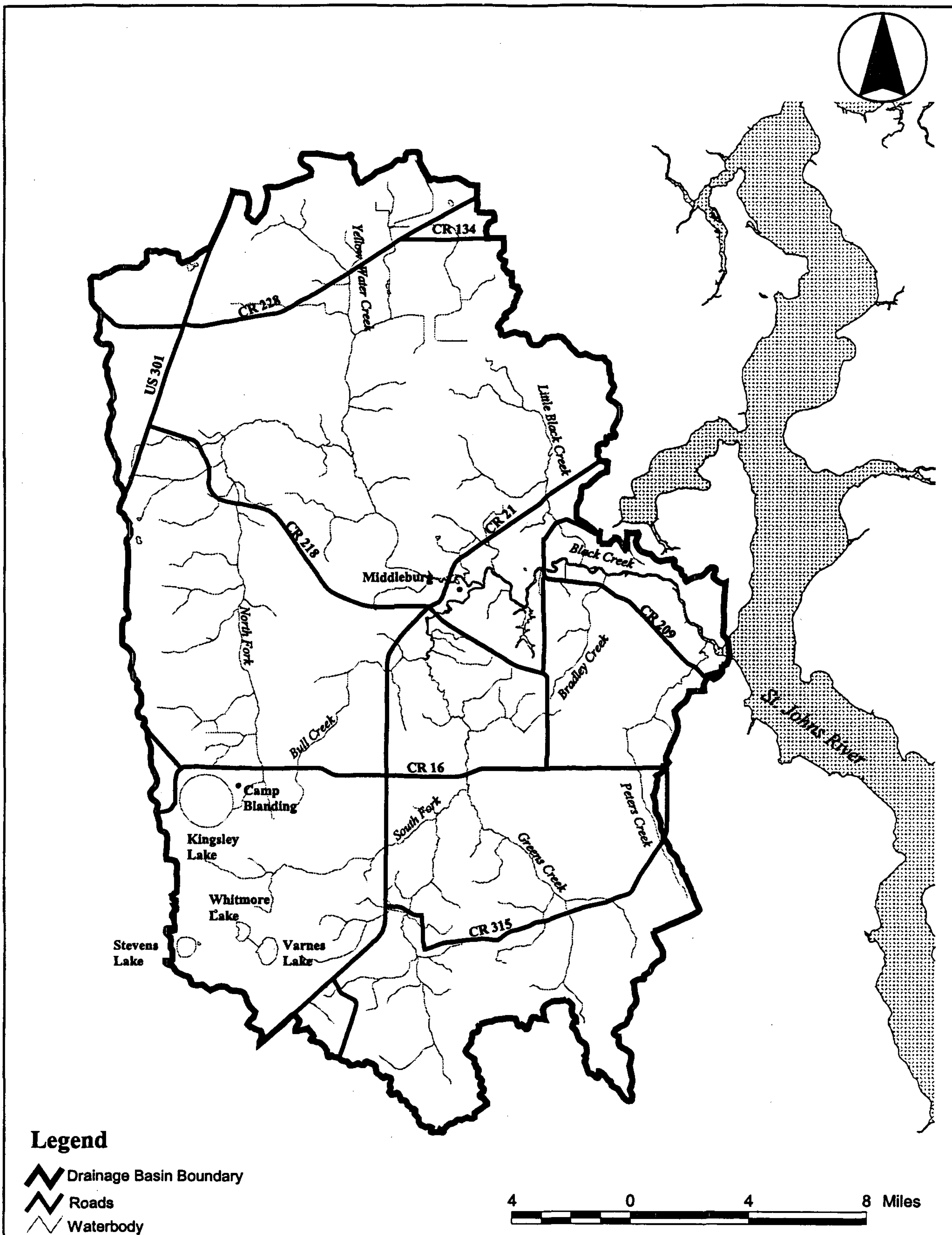


Figure 2-2
Black Creek Basin

2.2 Soils

The soils of the Black Creek Basin were identified by the U.S. Natural Resource Conservation Service (NRCS) for the counties of Baker, Bradford, Duval, Clay and Putnam Counties. One hundred twenty-eight (128) individual soil types are contained within the Black Creek Basin. Each soil type has been assigned to one of the four hydrologic soil groups (HSG) based on its runoff potential. Many soils have been assigned to two hydrologic soil groups, representing a drained and undrained condition. Table 2-1 presents the acreages and percentages of the HSG's within the basin.

TABLE 2-1
Black Creek Basin Hydrologic Soil Groups

HSG	Area (ac.)	Percent of Total (%)
A	53,122	17.1
B	1,419	0.5
C	66,991	21.6
D	49,283	15.9
A/D	6,617	2.1
B/D	126,201	40.7
Water	4,269	1.4
Unknown	1,875	0.6
Total	309,777	100.0

Assuming that all soils within the basin are undrained, HSG D is the soil group which covers the greatest portion of the basin, approximately 60 percent. HSG C, A, and B account for 22, 17 and 1 percent of the basin, respectively. Figure 2-3 is a map of the HSG coverage within the Black Creek Basin.

2.3 Land Use

The land uses of the Black Creek Basin were identified by the Florida Department of Natural Resources (FDNR). One hundred and five (105) individual Florida Land Use Classification Code

(FLUCC) land uses were identified within the Black Creek Basin. The Black Creek Basin is a moderately developed basin. Approximately 54 percent of the total basin area is developed. The largest developed land use within the basin is silviculture, comprising approximately 37 percent of the basin. Residential and commercial land uses account for approximately 11 percent of the basin, and are clustered around the city of Middleburg, and the suburbs of Jacksonville in the northeastern porton of the basin. Residential and commercial land uses are also concentrated around the basin's two military installations, Camp Blanding and Cecil Field (Figure 2-4). Other land uses within the basin include pasture and dairies (4%), farming (1%) and mining (1%). Table 2-2 presents the distribution of land uses in the Black Creek Basin. Figure 2-4 is a map of the land uses within the Black Creek Basin.

TABLE 2-2
Black Creek Basin Land Uses

Land Use	Area (ac)	Percent of Total (%)
Residential	29,982	9.7
Commercial	5,102	1.6
Mining	2,496	0.8
Dairies/Pasture	13,695	4.4
Crops	2,693	0.9
Natural - Forest	70,465	22.7
Natural - Open/Shrub	6,435	2.1
Tree Plantation	72,341	23.4
Forest Regeneration	42,161	13.6
Water/Wetland	64,408	20.8
Total	309778	100.00

2.4 Climate

The climate of the Black Creek Basin is classified as humid subtropical, with an average summer maximum temperature of 90 degrees Fahrenheit. In the winter, the Black Creek Basin experiences below freezing temperatures an average of 10 to 15 times per year. Average annual rainfall for the basin is approximately 52 inches. Pan evaporation, measured at Gainesville, averages 57 inches annually. The largest portion of the annual rainfall falls between June and September when convective activity generates showers and thunderstorms.

2.5 Hydrogeology

The hydrogeology of the Black Creek Basin has been researched extensively by Toth (1993). The following discussion has been obtained from *Volume 1 of the Lower St. Johns River Basin Reconnaissance - Hydrogeology* (Toth, 1993). The hydrogeologic framework of the Black Creek Basin ground water flow system consists of three aquifer systems: the Floridan, intermediate, and surficial. The Floridan aquifer consists of limestone formations from the Paleocene and Eocene epochs (57.8 to 66.4 million years ago). The intermediate aquifer system consists of Miocene (23.7 million years ago) deposits of the Hawthorn Group and undifferentiated post-Hawthorn Group sediments. The surficial aquifer system consists of late and post-Miocene surficial deposits. The Hawthorn Group consists of Miocene clay, limestone and layers of interbedded sand and shell, and serves as a confining layer that separates the Floridan aquifer system from the overlying surficial aquifer system.

Surficial deposits in the Black Creek Basin, above the Hawthorn Formation, are approximately 150 feet thick. Below the surficial deposits, the intermediate aquifer (Hawthorn Group) is 200 to 300 feet thick. Below the intermediate aquifer, the Floridan aquifer is found from depths of 300 to 500 feet below ground surface.

The Floridan aquifer system contributes to river flow in the Black Creek Basin indirectly through diffuse upward leakage. In the case of the St. Johns River, however, the Floridan aquifer system contributes directly to the river through spring flow. The intermediate aquifer system also contribures indirectly to stream flow in Black Creek through diffuse upward leakage. The surficial aquifer system can discharge directly to the streams and rivers of the Black Creek Basin.

3.0 DATA RECONNAISSANCE

For hydrologic and hydraulic simulation of the basin, data are required to define physical features within the basin. The necessary data include topography, stream cross-sections, culvert sizes, subbasin area, land use, soils, etc. In addition, hydrologic and meteorologic data are required to define input and to facilitate calibration of water quantity and quality. These data were obtained by researching numerous sources and interviewing personnel at the St. Johns River Water Management (SJRWMD), U.S. Army Corps of Engineers - Jacksonville District, U.S. Geological Survey (USGS), U.S. Natural Resource Conservation Service (NRCS), Florida Department of Environmental Protection (FDEP), National Oceanic and Atmospheric Administration (NOAA), other government agencies, and the in-house Dames & Moore resource library. The data are described in the following subsections.

3.1 Topographic Maps

The topography of the Black Creek Basin is used to delineate subbasins within the basin. Topographic information is also necessary to define parameters in the hydrologic portion of the simulation models. The Black Creek Basin covers, in whole or in part sixteen (16) USGS 7½ minute quadrangle (quad) topographic maps. All quad maps utilized for this study are of the same scale (1:24,000), however mapping of contour intervals varied between 5 and 10 feet. Figure 3-1 illustrates the coverage of the Black Creek Basin on the USGS quad maps. Table 3-1 is a list of the quad maps covering the Black Creek Basin.

More detailed topographic data for selected portions of the basin are available from two sets of contoured aerials; each with its own map scale and contour interval. The SJRWMD produced a set of contoured aerials that were photographed and mapped in 1985. The set entitled "Black Creek Drainage Basin - Aerial Photography with Contours" contains 35 one square mile land sections that approximately encompasses the area of Black Creek from Middleburg downstream to its outfall into the St. Johns River. The sections are at a scale of 1" = 200' and have a one foot contour interval. Table 3-2 lists the available sections from this set.

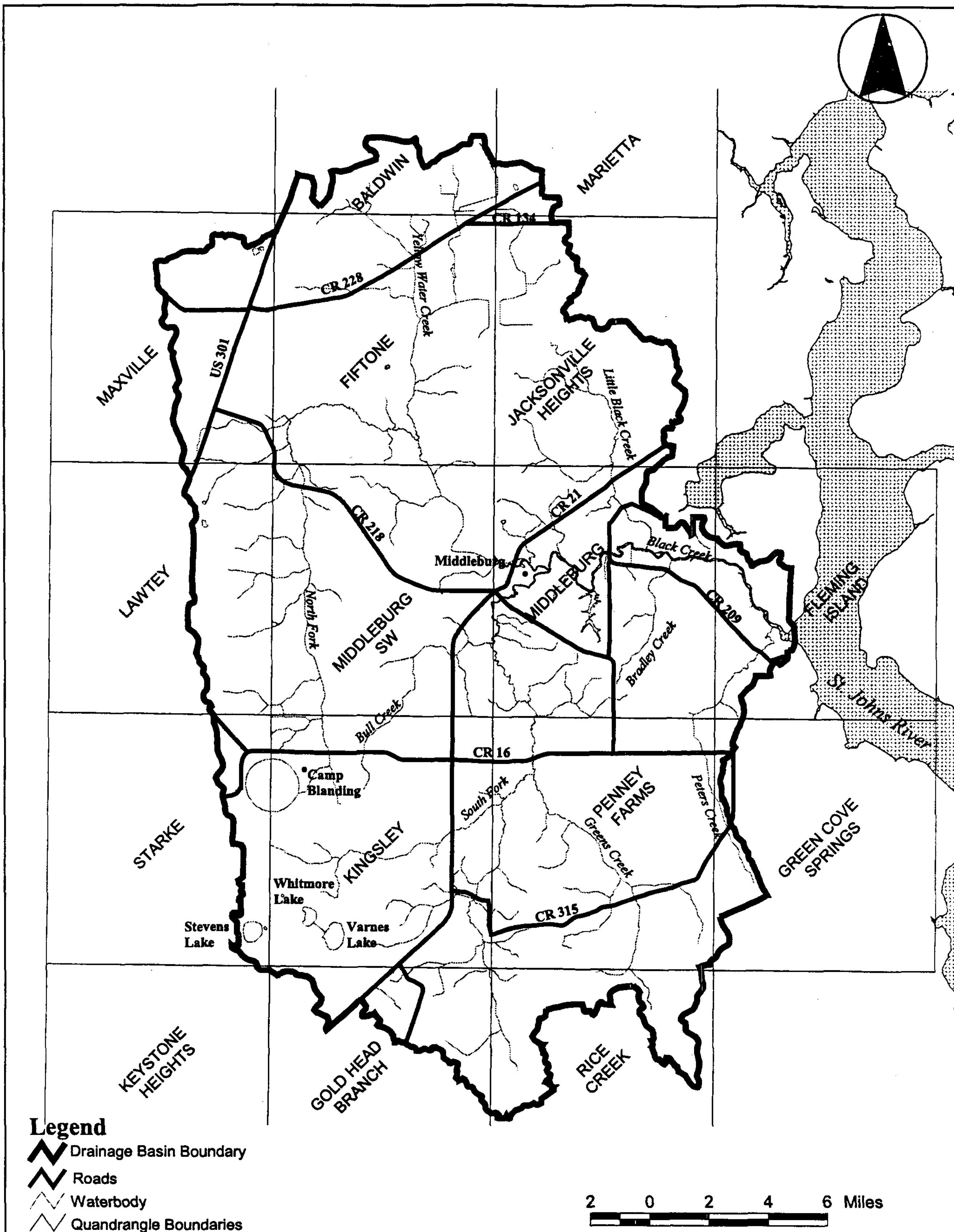


Figure 3-1
Black Creek Basin USGS Quadrangle Boundaries

TABLE 3-1
Black Creek Basin USGS Quadrangle Maps

Quad Name	Contour Interval	Latest Revision Date
Baldwin	5	1992
Fiftone	10	1993
Fleming Island	5	1992
Green Cove Springs	5	1991
Gold Head Branch	10	1978
Jacksonville Heights	10	1993
Keystone Heights	10	1993
Kingsley	10	1992
Lawtey	5	1988
Marietta	5	1992
Maxville	5	1984
Middleburg	10	1993
Middleburg SW	10	1993
Penny Farms	10	1970
Rice Creek	10	1978
Starke	10	1978

TABLE 3-2
Black Creek Basin Aerial Photography with Contours

Sections	Township	Range
10, 11, 12, 13 & 14	5 South	24 East
1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20 & 29	5 South	25 East
7, 8, 17, 18, 19, 20, 21, 28 & 29	5 South	26 East

A second set of contoured aerials was produced by Engineering Methods and Applications, Inc. and is untitled. The set was photographed in 1988 and mapped in 1989. The maps do not correspond to sections and only selected portions of each map have been contoured, These being areas immediately adjacent to the streams. The 30 maps in th set are at a scale of 1" = 500' with a contour interval of two feet. Principal areas mapped include the North Fork Black Creek (upstream of

Middleburg), Duckwater Branch, Big Branch, Bull Creek, Mill Creek, Dillaberry Branch, Polander Branch, Grog Branch, Little Black Creek, South Prong Double Branch and Bradley Creek.

3.2 Climate

3.2.1 Rainfall

Rainfall input is necessary to the hydrologic portion of the simulation models. In order to simulate the hydrology of the basin, rainfall data at short time intervals are necessary to reproduce the dynamics of changing rainfall intensity, soil infiltration, pollutant washoff, and runoff rates. Extensive rainfall records for the Black Creek Basin were available from the St. Johns River Water Management District (SJWMD) databases. These data were available in daily or hourly increments. As stated above, hourly records are more desirable, although daily rainfall records are also of use in selecting storm events with widespread basin coverage.

Table 3-3 lists the station identification and period of record of rainfall gages in and around the Black Creek Basin for which daily and hourly data are available. Figure 3-2 shows the locations of these rainfall gages.

3.2.2 Synthetic Storms

Peak discharges for a drainage basin are often calculated by rainfall-runoff models using hypothetical or synthetic storm data. Two basic components of a hypothetical storm are the total rainfall amount during the storm event (depth) and the time distribution of rainfall (rainfall distribution). Generalized rainfall distributions, developed by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA), have been extensively used throughout the United States for calculating peak discharges. Generalized distributions, however, lack accuracy because they are based on the rainfall magnitudes and patterns occurring over a large region. Distributions developed for a specific drainage basin or site-specific distributions predict peak discharges more accurately and are therefore more desirable. Procedures for developing site-specific hypothetical storm distributions utilized in this study effort were described by Rao (1988a).

TABLE 3-3
Black Creek Basin Daily Rainfall Gages

Daily Rainfall Data			
Station ID	Period of Record		Responsible Agency
	Begin	End [1]	
1150	7/1/92	12/31/96	SJRWM
1180	7/1/91	12/31/96	SJRWM
1471	1/1/96	12/31/96	SJRWM
1473	1/1/96	12/31/96	SJRWM
1479	1/1/96	12/31/96	SJRWM
1481	1/1/96	12/31/96	SJRWM
ASHBY	7/24/89	9/28/91	SJRWM
BLACKCK	8/1/89	9/30/91	SJRWM
BLACKCRK	7/17/89	1/31/97	SJRWM
CAMPBLAN	4/17/89	2/12/91	SJRWM
CAMPNOAA	7/2/48	1/26/58	NOAA
CLAYHILL	4/17/89	2/12/91	SJRWMD
EAGLEHAR	12/1/92	2/28/97	SJRWMD
GBONELK	2/21/91	2/23/97	SJRWMD
LKGEORGE	12/1/94	3/1/97	SJRWMD
LKHALL	1/16/92	2/22/97	SJRWMD
LKWASH	5/1/92	1/31/97	SJRWMD
LOSCORD	7/1/90	1/31/96	USGS
NORMANDY	6/1/90	1/31/96	USGS
PENDOGFR	4/17/89	2/12/91	SJRWMD
SLKASBUR	7/24/89	9/25/91	SJRWMD
SMITHKEY	1/16/92	10/1/96	SJRWMD
SPRINGLK	10/30/90	10/27/96	SJRWMD
WHITSAND	2/21/91	2/18/97	SJRWMD

[1] Available data at time of study.

Hourly Rainfall Data			
Station ID	Period of Record		Responsible Agency
	Begin	End [1]	
1190	4/4/91	3/1/97	SJRWMD
1214	1/1/91	3/1/97	SJRWMD
1220	7/15/91	3/1/97	SJRWMD
1475	1/18/96	3/1/97	SJRWMD
1483	1/25/96	3/1/97	SJRWMD
1485	1/24/96	3/1/97	SJRWMD
1487	1/26/96	3/1/97	SJRWMD

[1] Available data at time of study.

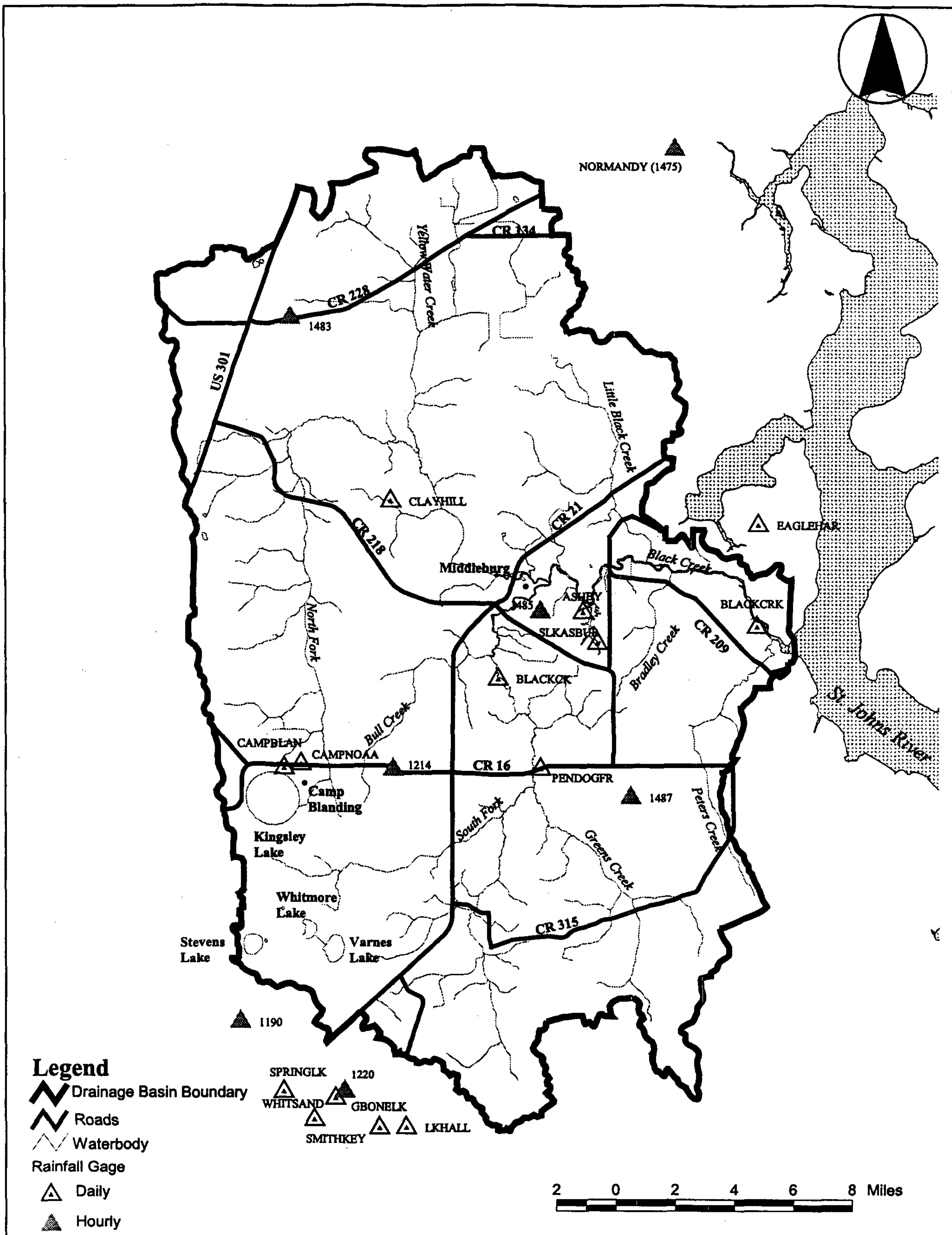


Figure 3-2
Black Creek Basin Rainfall

Site-specific hypothetical rainfall distributions and depths were developed by Rao (1991 and 1988b) for the Black Creek Basin. The resulting cumulative rainfall depths for the three rainfall frequency distributions used in this study, as well as the unitless rainfall mass curves for the 10-, 25-, and 100-year 24-hour rainfall distributions used in this study were developed from this work.

Rainfall depths for a particular return period vary spatially. Rao (1988b) studied the variability of the rainfall depths and produced isopluvial maps (lines of equal rainfall) for the SJRWMD. Figures 3-3 through 3-5 are the isohyetal maps for the 10-, 25- and 100-year 24-hour rainfall depths.

3.2.3 Evaporation

Evaporation data input is necessary to the hydrologic portion of the simulation models. However, evaporation data are seldomly collected. Two stations that report pan evaporation data to NOAA are located in northeast Florida, Gainesville and Lake City. The Gainesville evaporation data were selected for use in this study because the station is geographically closer to the Black Creek Basin. Daily Class A pan evaporation records from the Gainesville station are available from 1967 to the present. It has been demonstrated that evapotranspiration rates from actual watersheds may be related to pan evaporation rates through empirically derived reduction coefficients (Chow, 1964).

3.3 Geographic Information System (GIS) Data

With sufficient data, the GIS software is capable of quickly computing area-weighted averges for hydrologic coefficients related to land use and soils. Using the GIS, drainage divides can also be calculated for watershed subbasins based upon physical features such as topography. Therefore, data for soils and land uses were obtained for the Black Creek Basin as GIS coverages.

3.3.1 Soils

The SJRWMD provided the soils of the Black Creek Basin as a GIS ARC/INFO coverage. The soils of Baker, Bradford, Duval, Clay and Putnam Counties were needed to study the Black Creek Basin. The counties' soil maps were digitized by SJRWMD from NRCS soil surveys. Individual soils were mapped using a map unit identification (MUID) number. The number combines a county identification number and a soils number for each delineated soils polygon. Individual soils mapped

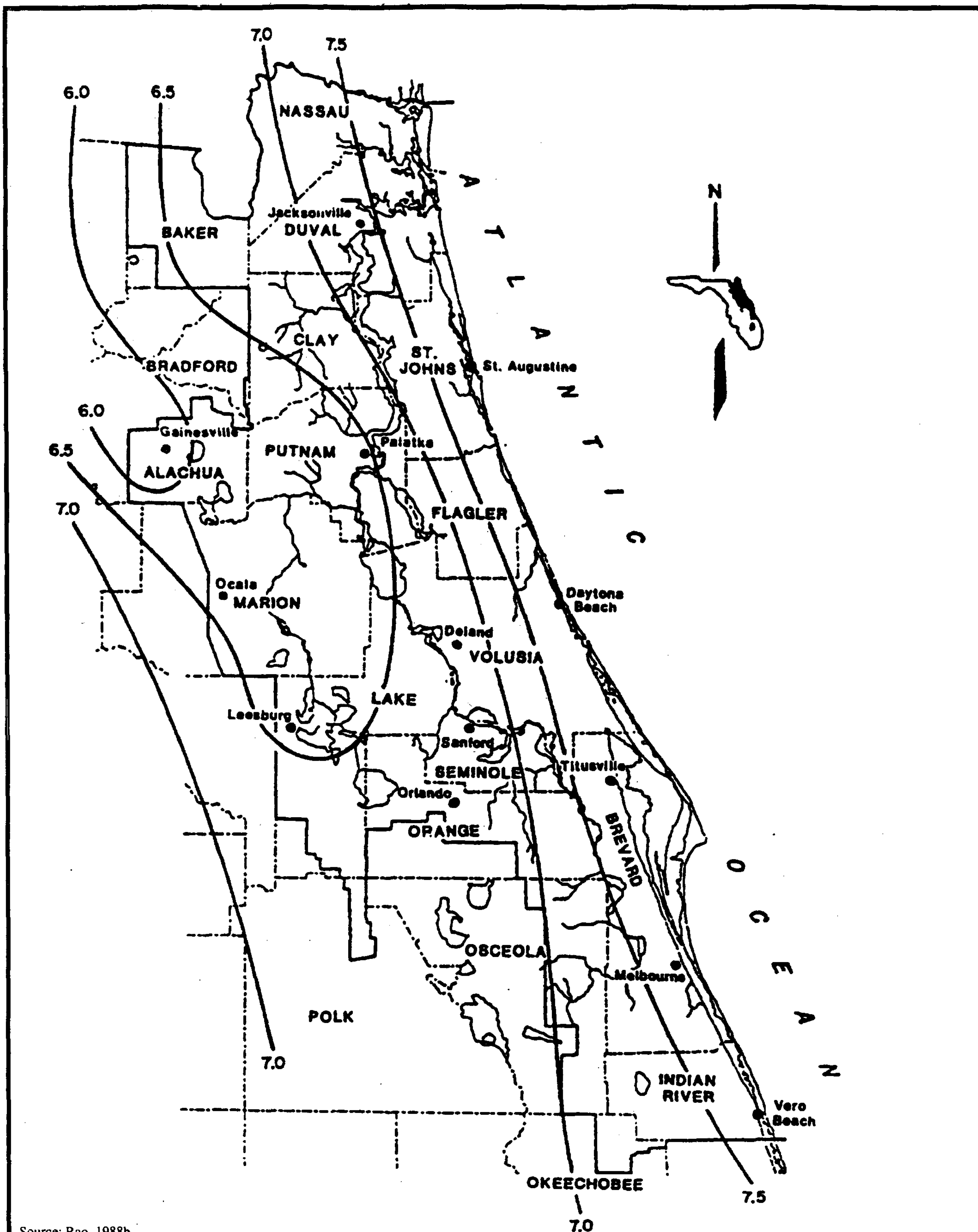
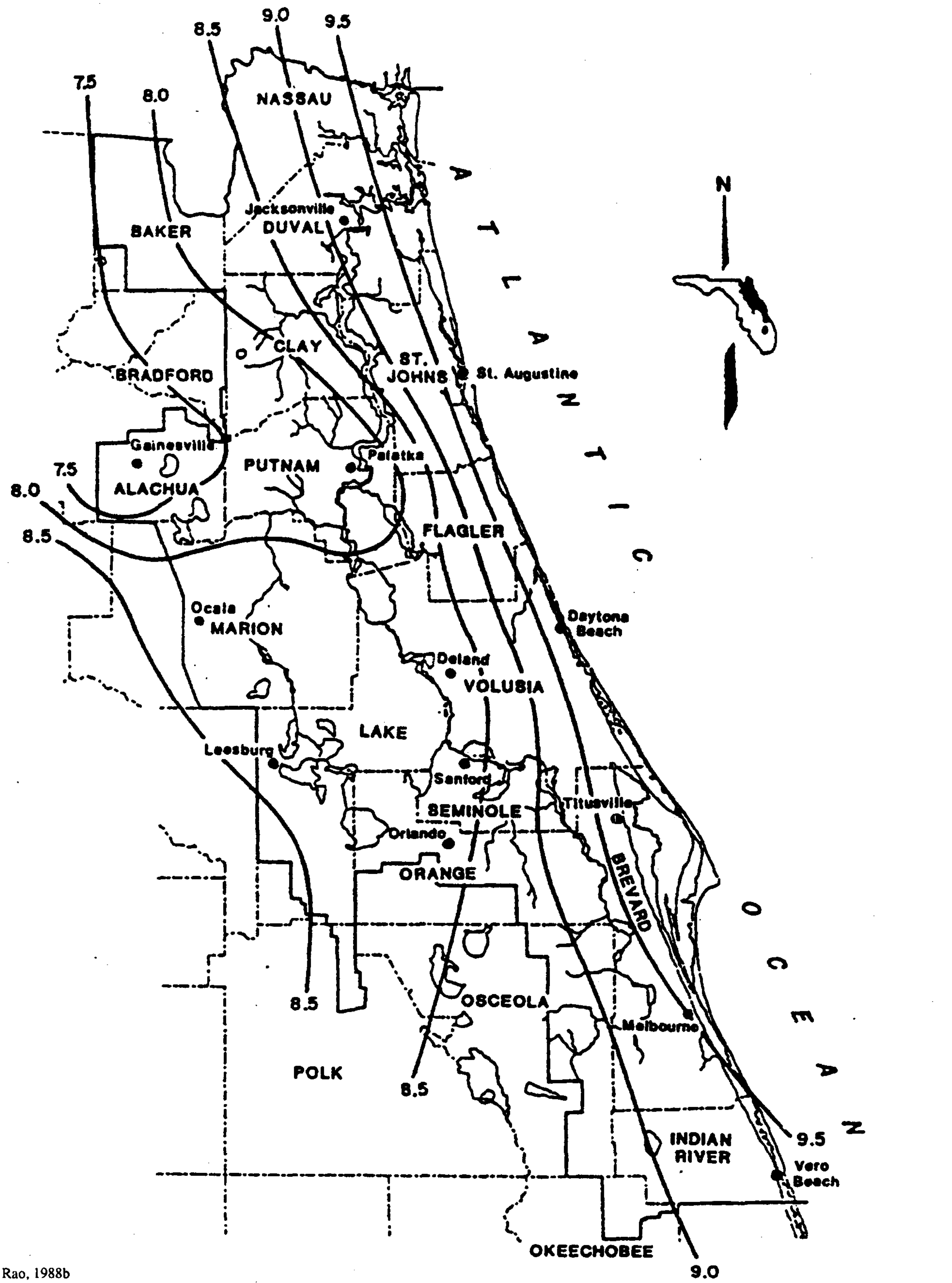
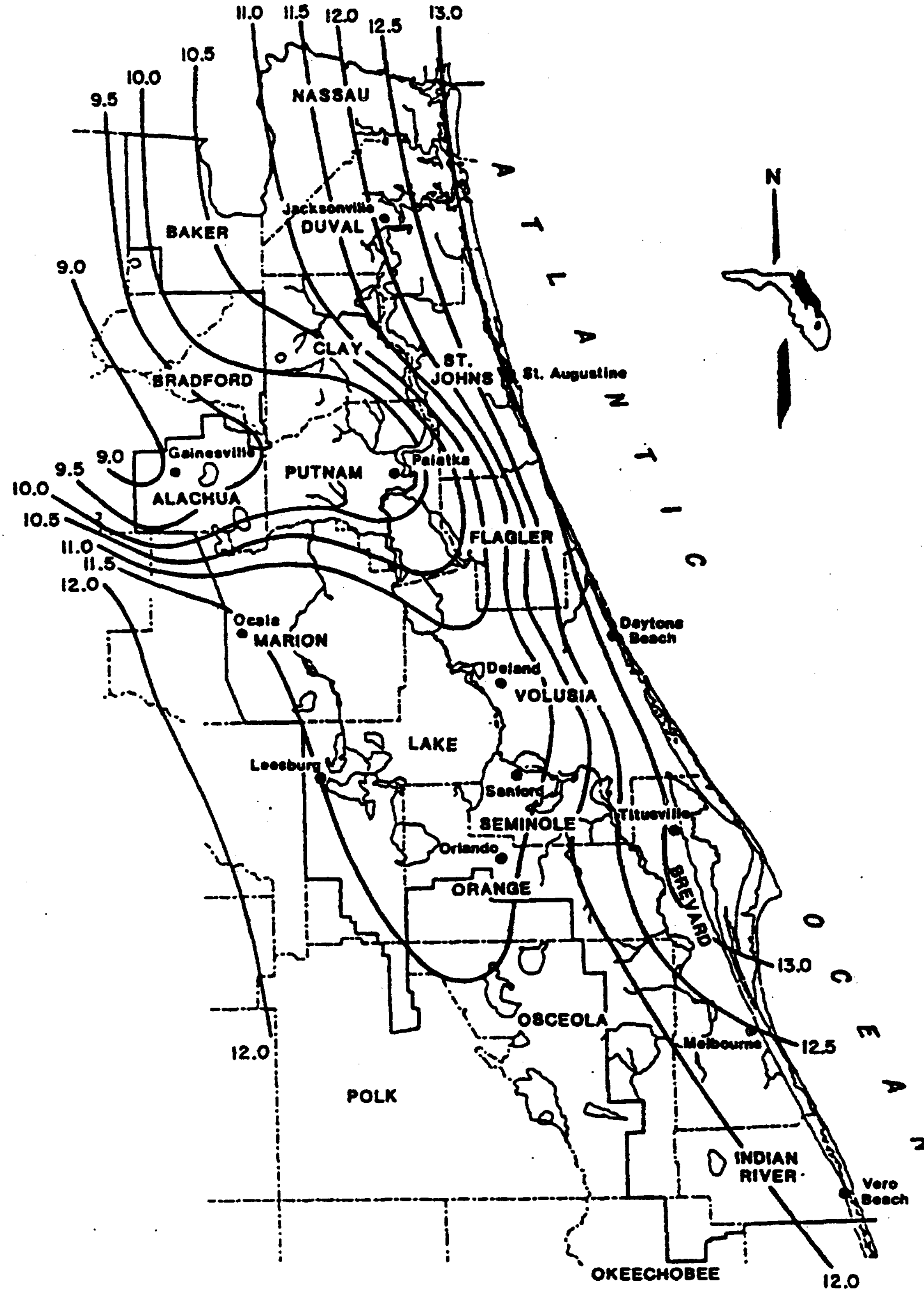


Figure 3-3
10-Year 24-Hour Maximum Rainfall for Northeast Florida (Inches)



Source: Rao, 1988b

Figure 3-4
25-Year 24-Hour Maximum Rainfall for Northeast Florida (Inches)



Source: Rao, 1988b

Figure 3-5
100-Year 24-Hour Maximum Rainfall for Northeast Florida (Inches)

in one county were not always mapped in another county using the same number (i.e. there were instances where the same soil was mapped using different MUIDs from county to county). These anomalies were identified and eliminated. One hundred twenty-eight (128) individual soil types are contained within the Black Creek Basin.

3.3.2 Land Use

The Black Creek Basin 1990 land use information was available from the SJRWMD as a GIS ARC/INFO coverage. Land use data, categorized using the Florida Land Use Classification Codes (FLUCC) by the Florida Department of Natural Resorces (FDNR), were available for the entire Black Creek Basin. One hundred and five (105) individual FLUCC land uses were identified within the Black Creek Basin.

3.3.3 Subbasin Boundaries

The USGS has delineated subbasins for the major tributaries of the Black Creek Basin. These subbasins were available from the SJRWMD as a GIS ARC/INFO coverage. The USGS had subdivided the Black Creek Basin into 97 subbasins.

3.4 Water Quantity Data

3.4.1 Stream Flow

Stream flow data is used to calibrate the hydrologic and hydraulic portions of the simulation models. There is plentiful stream gage data for the Black Creek Basin. Stream flow data within the Black Creek Basin was measured by the USGS at ten stations. The locations are shown on Figure 3-6. Eight stations have been discontinued or were only temporary stations. The two remaining stations are the South Fork Black Creek near Penny Farms and the North Fork Black Creek near Middleburg. Table 3-4 is a summary of the available stream gage data for the Black Creek Basin.

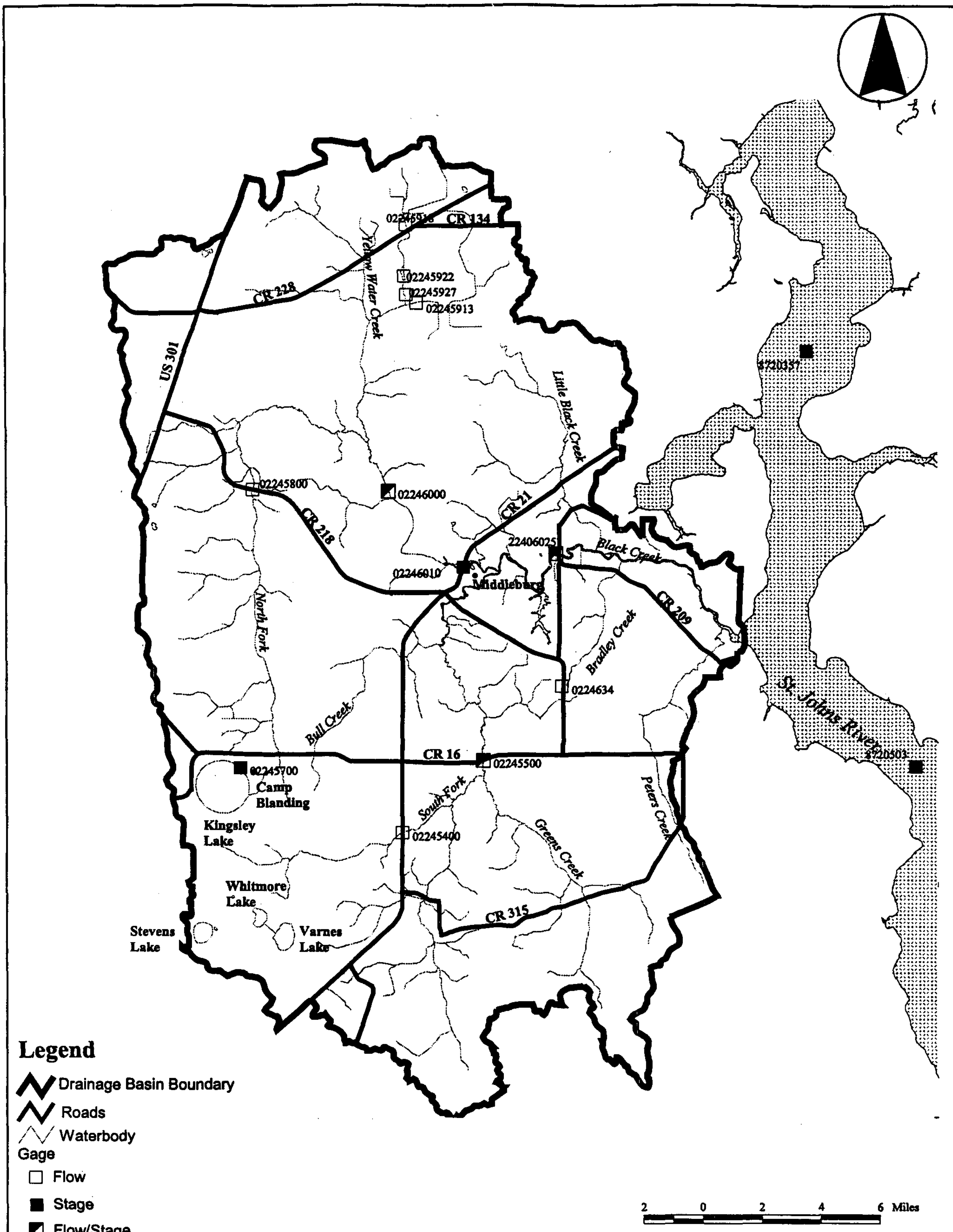


Figure 3-6
Black Creek Basin Stream/Lake Gages

TABLE 3-4
Black Creek Basin Flow and Stage Data

			Flow			Stage		
				Period of Record			Period of Record	
Station	Station Name	Source	Type	Begin	End	Type	Begin	End
2245400	South Fork Black Creek near Camp Blanding, FL	USGS	Daily Avg.	10/2/57	1/1/61			
2245500	South Fork Black Creek near Penney Farms, FL	USGS	Daily Avg.	10/2/39	Present	Daily Avg.	10/2/67	Present
2245800	North Fork Black Creek near Highland, FL	USGS	Daily Avg.	10/2/57	10/1/60			
2246000	North Fork Black Creek near Middleburg, FL	USGS	Daily Avg.	10/2/31	Present	Daily Avg.	11/19/31	Present
2246010	North Fork Black Creek at Middleburg, FL	USGS				Daily Avg.	4/23/81	Present
2246025	Black Creek near Doctors Inlet, FL	USGS	Daily Avg.	6/17/81	10/1/95	Daily Avg.	6/17/81	Present
2245700	Lake Kingsley	USGS				Daily Avg.	6/16/45	10/1/95
2245913	Sal Taylor Creek near Maxville, FL	USGS	Daily Avg.	6/18/92	10/1/93			
2245918	Rowell Creek near Fiftone, FL	USGS	Daily Avg.	6/11/92	10/1/93			
2245922	Rowell Cr. at Lake Fretwell Dam near Maxville, FL	USGS	Daily Avg.	6/26/92	9/30/93			
2245927	Rowell Creek near Maxville, FL	USGS	Daily Avg.	6/19/92	10/1/93			
2246034	Bradley Creek near Penny Farms, FL	USGS	Daily Avg.	10/12/83	10/5/88			
872-0357	St. Johns River at Buckman Bridge	FDEP				6 min.	10/3/95	Present
872-0503	St. Johns River at Shands Bridge	FDEP				6 min.	10/3/95	Present

3.4.2 Stream/Lake Stage

Stream stage data are used as input into the hydraulic portion of the simulation models as a boundary condition at outfalls. Stage data are also used to calibrate the hydraulic portions of the simulation models. Stream and lake stage data are available for five stations (Figure 3-6). The period of record for each gage is listed in Table 3-4.

3.5 Water Quality Data

In-stream water quality data are used in the estimation of non-point source pollutant loads. The measured pollutant concentrations can be used in the calibration of water quality models. The SJRWMD collects water quality samples at seven (7) sites within the Black Creek Basin. The location of the sites are shown in Figure 3-7. At varying times, and to varying degrees, water quality samples have been analyzed for the following constituents: biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia (NH_3), total Kjeldahl nitrogen (TKN), nitrate + nitrite (No_x), total phosphorous (TP), dissolved phosphorous (DP), ortho-phosphate (Ortho-P), lead (Pb), and zinc (Zn). Table 3-5 lists the approximate monitoring periods, frequency and analyzed parameters for the seven water quality stations.

3.6 Point Source Discharges

Point source discharges to the Black Creek Basin may adversely affect the in-stream water quality. Point source discharge data may be necessary as input to the water quality portion of the simulation model. By specifying the point source discharge pollutant loads as input to the water quality model, the non-point source pollutant loads may be simulated independent of the point source loads. Point source discharge data are maintained by the Florida Department of Environmental Protection (FDEP) in their capacity as a permitting agency. A search of the FDEP permits database and data maintained by the SJRWMD was conducted to identify point source discharges within the limits of the Black Creek Basin. The search indicated approximately 13 facilities that discharge industrial or municipal waste water within the basin. Table 3-7 list the facilities, process type, and effluent discharge for which data were available. Figure 3-8 is a map showing the point source locations.

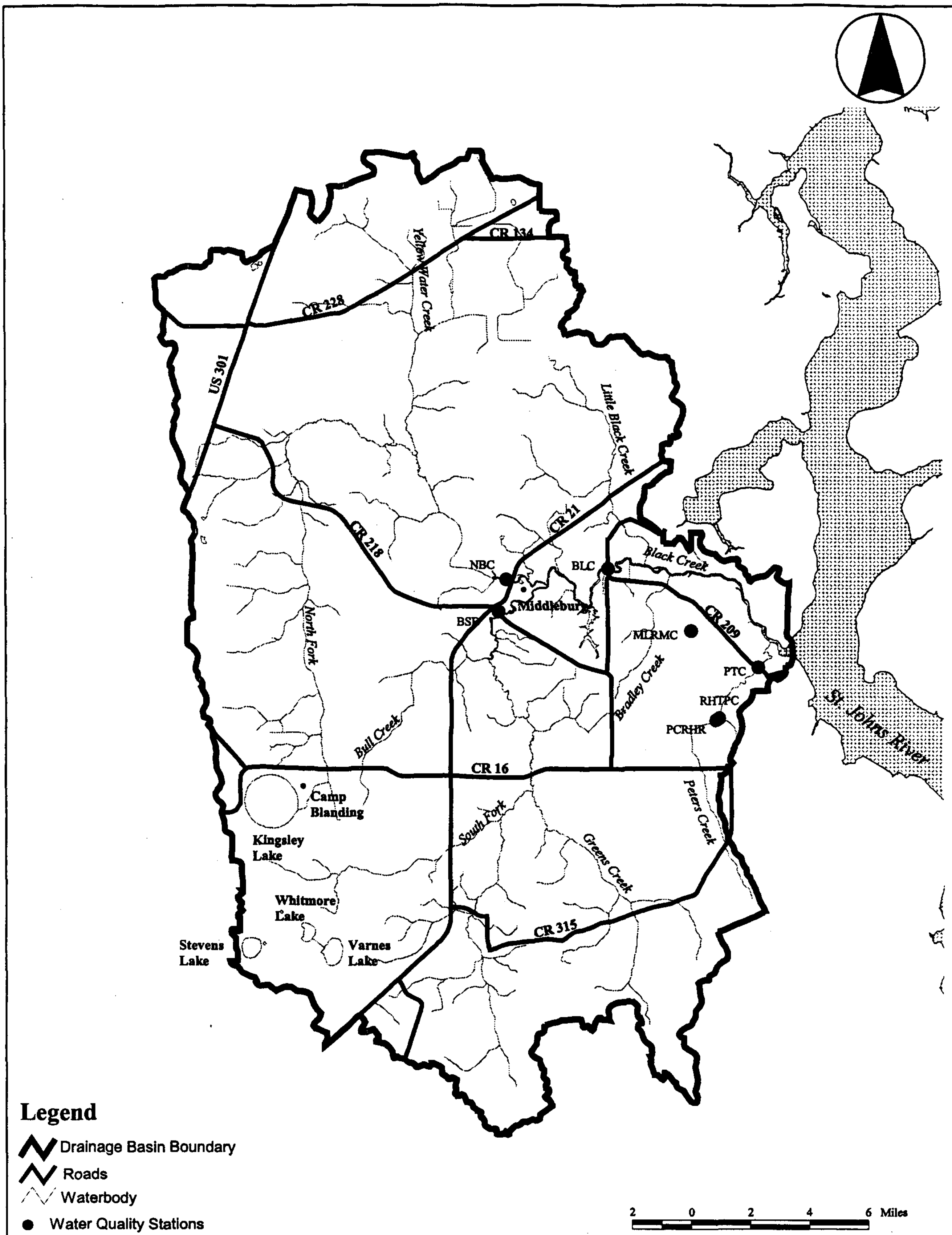


Figure 3-7
Black Creek Basin Water Quality Sampling Stations

TABLE 3-5

Black Creek Basin Water Quality Sampling Stations

Station	Location	Period	Frequency	Parameters
BLC	Black Creek at CR 739	1984-1989 1991-1996	bi-monthly monthly	BOD, TSS, NH3, TKN, NOx, TP, DP, Pb, Zn, Ortho-P
BSF	South Fork of Black Creek at Rt. 218	1990-1996	monthly	BOD, TSS, NH3, TKN, NOx, TP, DP, Pb, Zn, Ortho-P
MLRMC	Mill Log Creek	1995-1996	intermittent	BOD, TSS, NH3, TKN, NOx, TP, Pb, Zn, Ortho-P
NBC	North Fork of Black Creek at SR 21	1991-1996	monthly	BOD, TSS, NH3, TKN, NOx, TP, DP, Pb, Zn, Ortho-P
PCRHR	Peters Creek	1994-1995	intermittent	BOD, TSS, NH3, TKN, NOx, TP, Pb, Zn, Ortho-P
PTC	Peters Creek at CR 209	1984-1989 1994-1996	bi-monthly monthly	BOD, TSS, NH3, TKN, NOx, TP, DP, Pb, Zn, Ortho-P
RHTCP	Tributary to Peters Creek	1994-1995	intermittent	BOD, TSS, NH3, TKN, NOx, TP, Pb, Zn, Ortho-P

TABLE 3-6

Black Creek Basin Point Source Discharges

Map ID	Facility Name	Treatment Process	Effluent Discharge
1	E. I. Dupont De Nemours Highlands Mine	Neutralization and sedimentation	Boggy Branch of North Fork of Black Creek
2	Middleburg Senior High Schl.	Extended aeration	one evap/perc pond
3	Lake Asbury Elem. Schl.	Extended aeration	drainfield
4	Ridaught Landing WWTP	Activated Sludge (AWT)	two ponds to Black Creek
5	Middleburg Elem. Schl.	Extended aeration	two drainfields
6	Middleburg 21/218 Cntr.	Extended aeration	drainfield
7	Middleburg Bluffs	Extended aeration	two evap/perc ponds
8	Grande Olde Plaza	Extended aeration, chlorination, dechlorination, filtration by slow sand filters	South Fork Black Creek
9	Brairwood of Middleburg	Extended aeration	sprayfield
10	Penny Farms Retirement Cntr.	Septic-sand filter	South Fork of Black Creek
11	Camp Blanding WWTP	Extended aeration	South Fork of Black Creek
12	USN Cecil Field	Activated sludge (AWT)	Rowell Creek
13	Mid-Clay WWTP	Extended aeration	two drainfields

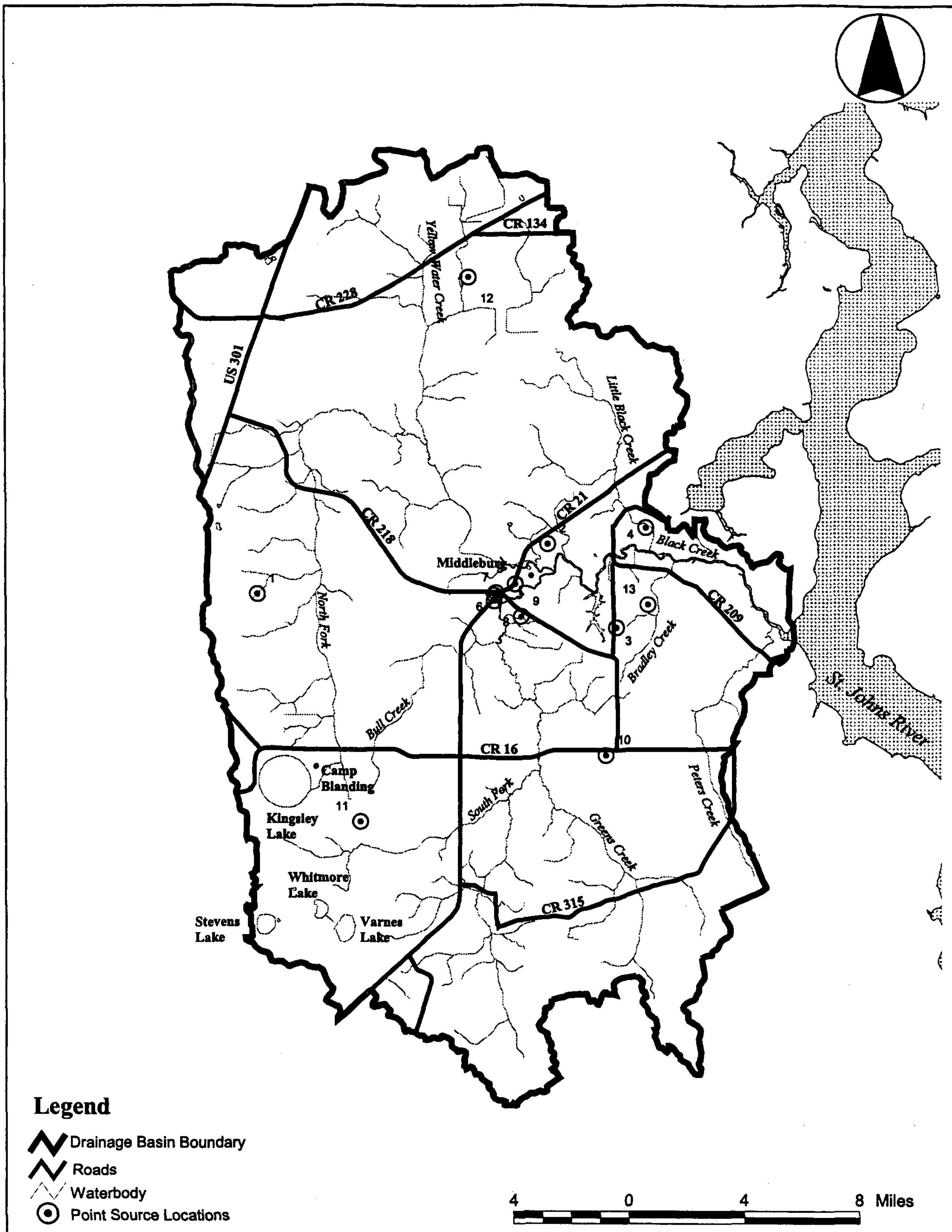


Figure 3-8
Black Creek Basin Point Source Locations

3.7 Hydraulic Data

In order to model the hydraulic system of the Black Creek Basin, the physical dimensions of the stream network must be known. This information was available from three principal sources: field survey, previous model input, and field investigation.

A special purpose survey of the South Fork of Black Creek was conducted by Clay & Associates, Inc. In 1990. The survey collected stream cross-section and structure finished floor data for the South Fork of Black Creek from State Road 218 to upstream of State Road 16. Some data were also collected for Greens Creek immediately upstream of South Fork of Black Creek.

The U.S. Army Corps of Engineers commissioned a survey of a portion of the South Fork of Black Creek. The survey collected stream cross-sectional and structure finished floor data for the South Fork of Black Creek from the confluence with the North Fork to County Road 18. The survey data were presented in a twelve-sheet set entitled "Black Creek Basin Section 22 Study" dated March, 1995.

Engineering Methods and Applications, Inc. completed the "Clay County Flood Insurance Study" in 1992. For that study, stream cross-section and structure data were collected for a large portion of the Black Creek Basin. These data were coded into HEC-2 model input. Model input files were obtained through the U.S. Army Corps of Engineers for use in this study. Model input files for the following areas were available: Black Creek, North Fork Black Creek, Bull Creek, Big Branch, Bradley Creek, Dillaberry Branch, Duckwater Branch, Grog Creek, Polander Branch, Tributary 2 to North Fork Black Creek, Tributary 1 to Little Black Creek, South Prong Double Branch, Mill Creek, and Little Black Creek. Figure 3-9 illustrates the location of the available cross-section data for the Black Creek Basin.

Hydraulic data concerning the operation of the Lake Asbury Dam were available from the U.S. Army Corps of Engineers (USACOE, 1978). The report included both stage-discharge and stage-area-volume relationships for Lake Asbury.

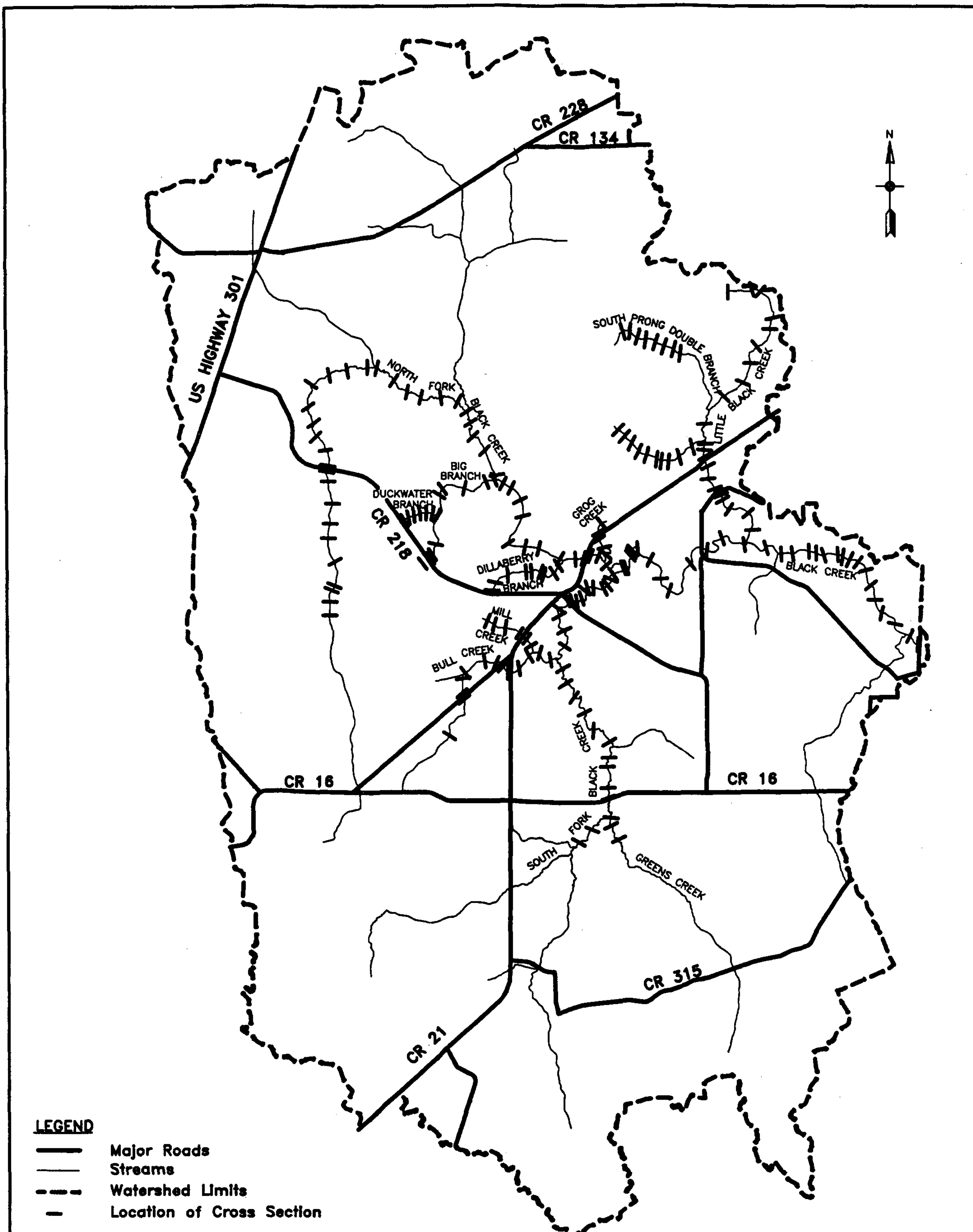


Figure 3-10
Black Creek Basin Cross Section Locations

4.0 WATERSHED SIMULATION

The modeling of the Black Creek Basin was accomplished using the U.S. Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) Version 4.3. The SWMM model is separated into blocks that accomplish specific modeling objectives. Separate approaches were used to model water quantity and water quality of the Black Creek Basin. For water quantity, the SWMM RUNOFF Block was use to simulate rainfall on the watershed and the corresponding runoff. The SWMM TRANSPORT Block was used to route flows in the upper reaches of the Black Creek Basin. The SWMM EXTRAN Block was then used to model flows and stages in the lower portions of the Black Creek Basin. The flows and stages were calibrated to an intense storm during October 1996. The calibrated model was used to predict peak flood flows and stages for the 10-, 25- and 100-year, 24-hour storm events.

For water quality modeling, the SWMM RUNOFF Block was used to simulate runoff and pollutant loads from the watershed, and then the SWMM TRANSPORT Block was used to route the flows and pollutant loads through the entire Black Creek Basin stream network. The flows were calibrated to a 13 month period from February 1, 1996 through February 28, 1997. Water quality parameters were calibrated for the year 1994 due to the availability of water quality data. The following sections describe the various data used in the model construction and calibration.

4.1 Data

4.1.1 Meteorological

Rainfall

Extensive hourly rainfall data exists for the period from February 1, 1996 through February 28, 1997. Seven rainfall gages in and around the Black Creek Basin recorded hourly rainfall for this period. The seven rainfall gages were 1190, 1214, 1220, 1475, 1483, 1485 and 1487, and are shown on Figure 3-2. For this study, a Thiessen polygon rainfall network was created from the seven rainfall gages (Figure 4-1) for calibration purposes. The rainfall simulated in each subbasin was estimated by determining the approximate location of each subbasin's centroid and identifying the rainfall polygon where it was located. The rainfall period chosen contains many storm events

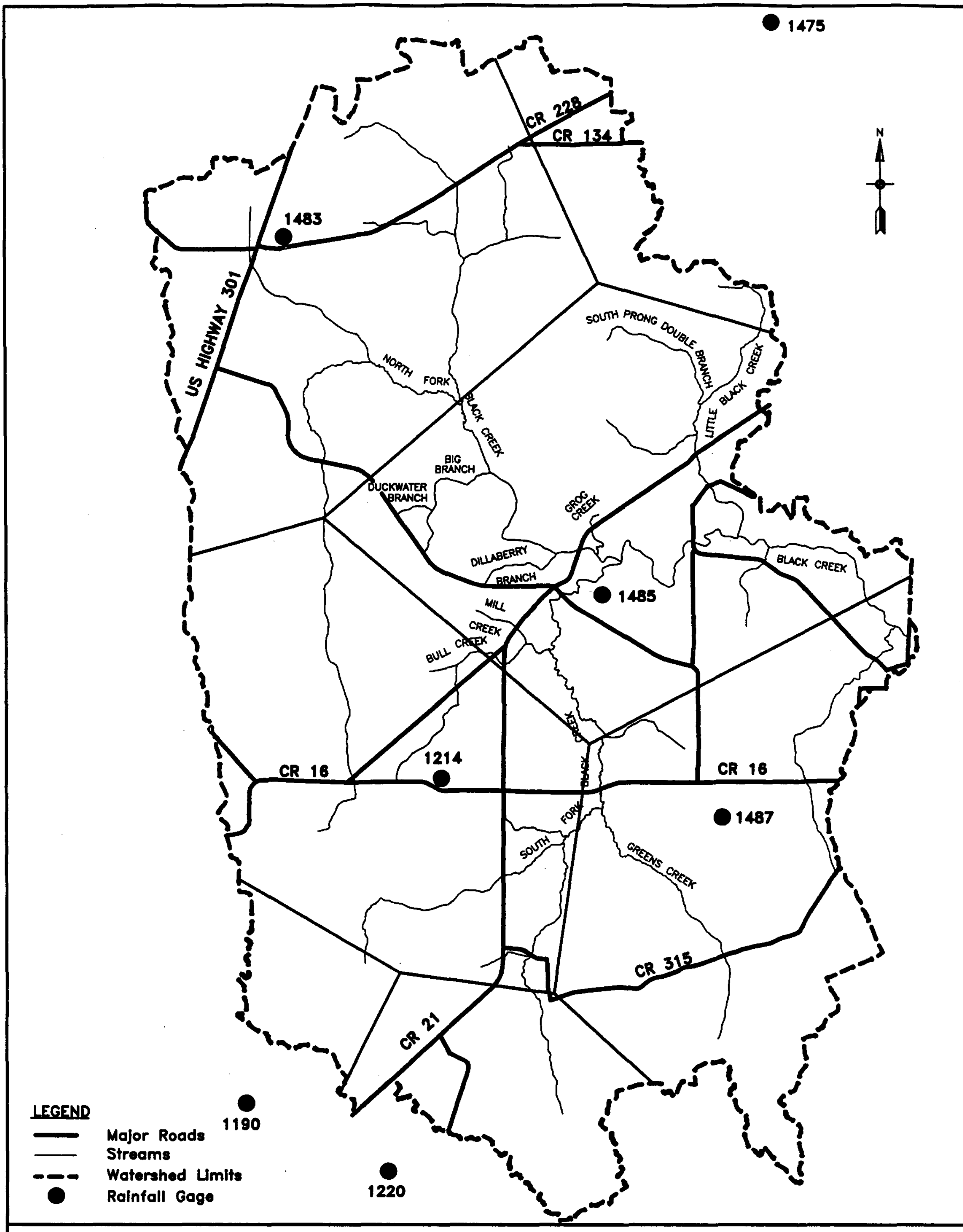


Figure 4–1
Black Creek Basin Theissan Polygon Network

including a large flood event in October 1996. Figures 4-2 through 4-8 present the total daily rainfall amounts at the seven rainfall gages for the 1996/1997 period.

For the calibration of water quality parameters, the 12 month period of 1995 was used because of the relative abundance of measure in-stream water quality data. The hourly rainfall as recorded at gage 1214 was applied to the entire Black Creek Basin for water quality parameters calibration. Figure 4-9 presents the total daily rainfall for this gage during the 1995 period.

Evaporation

Evaporation data was available from a station located in Gainesville which measured the daily Class A pan evaporation rate. The SWMM input of evaporation data is the average monthly potential evaporation from the watershed in inches per day. Figure 4-10 is a graph of the average monthly pan evaporation rates as measured at Gainesville for 1996. The maximum monthly average daily evaportation rate occurred during July (0.21 in./day) and the minimum monthly average daily evaporation rate occurred during December (0.07 in./day). The total annual 1996 evaporation as measured at Gainesville was 52.37 inches. It has been shown that evaporation from land surfaces vary from 60 to 80 percent of Class A pan evaporation rates (Chow, 1964).

Measured evaporation rates were also used for the water quality parameters calibration period (1995). Figure 4-11 is a graph of the average monthly pan evaporation rates as measured at Gainesvill for 1995.

4.1.2 Hydrologic Data

Observed Stages

The results of the hydraulic modeling were calibrated using the stages measured at four USGS gages throughout the Black Creek Watershed. The average daily stages as measured at the USGS gages 02246025, 02246010, 02246000, and 0224550 (refer to Figure 3-7) were plotted verses the simulated stages at the EXTRAN Block nodes 10020, 16004, 16014 and 26024, respectively. Refer to Figure 4-12 for the SWMM model link-node diagram. The high stages recorded during the October 1996

Figure 4-2

Station 1190 Rainfall (1996/1997)

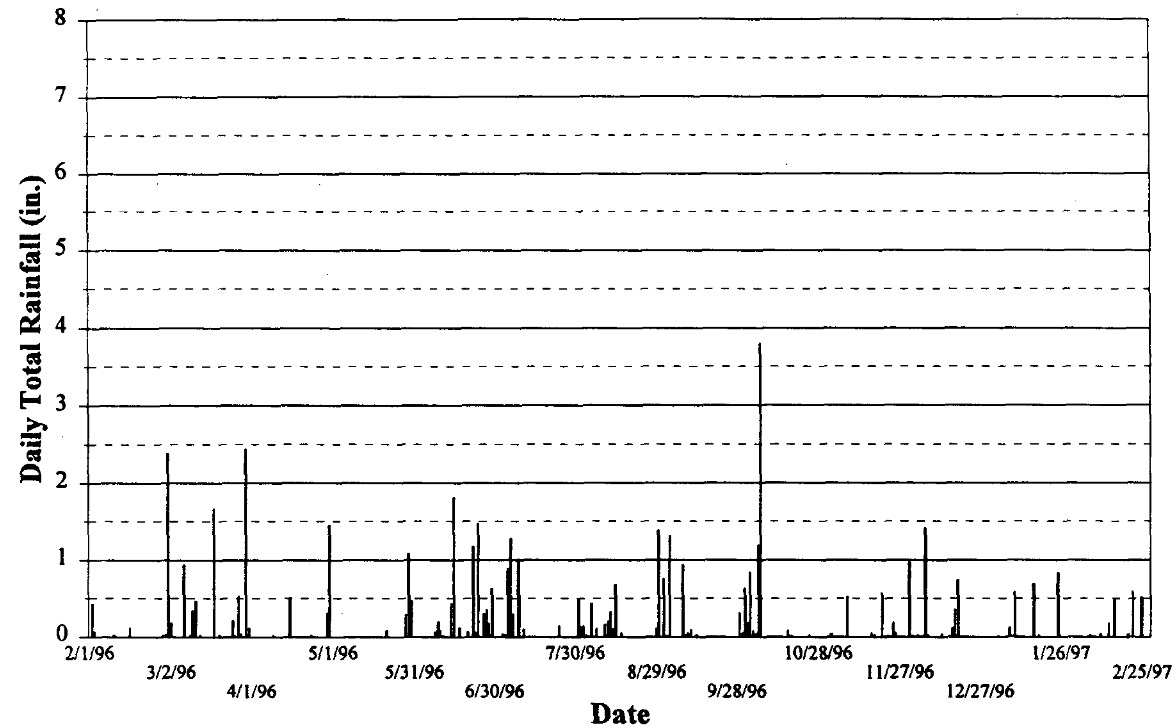


Figure 4-3

Station 1214 Rainfall (1996/1997)

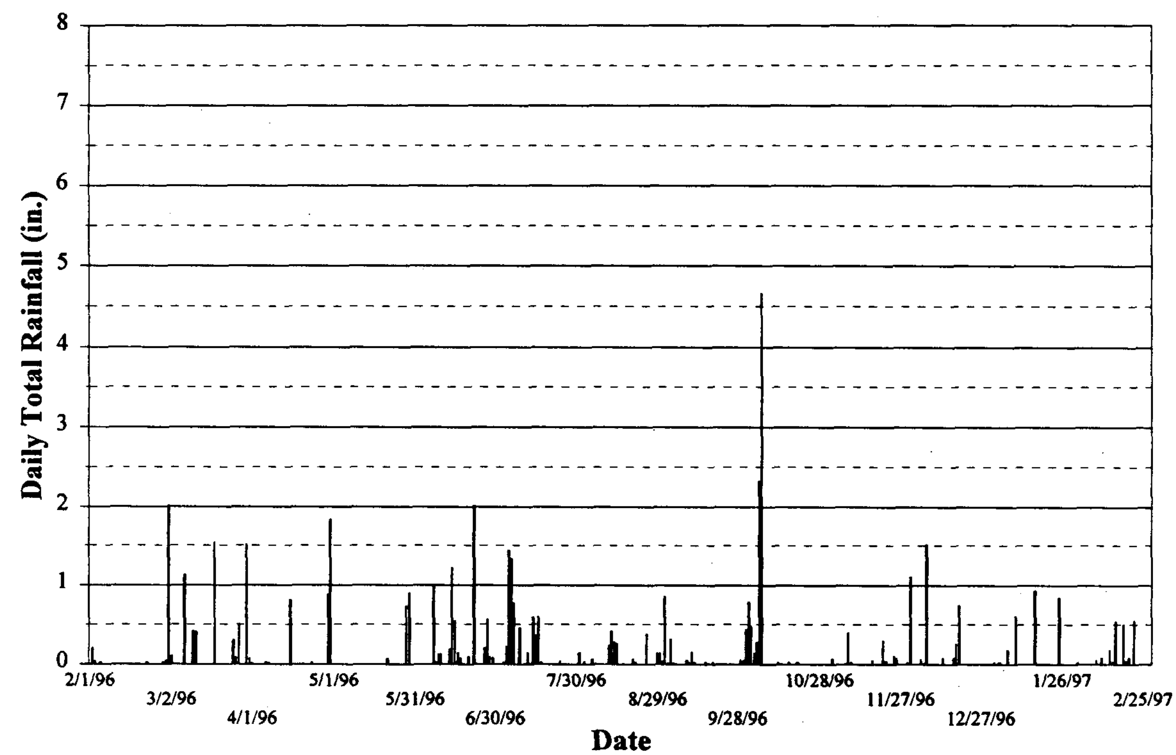


Figure 4-4

Station 1220 Rainfall (1996/1997)

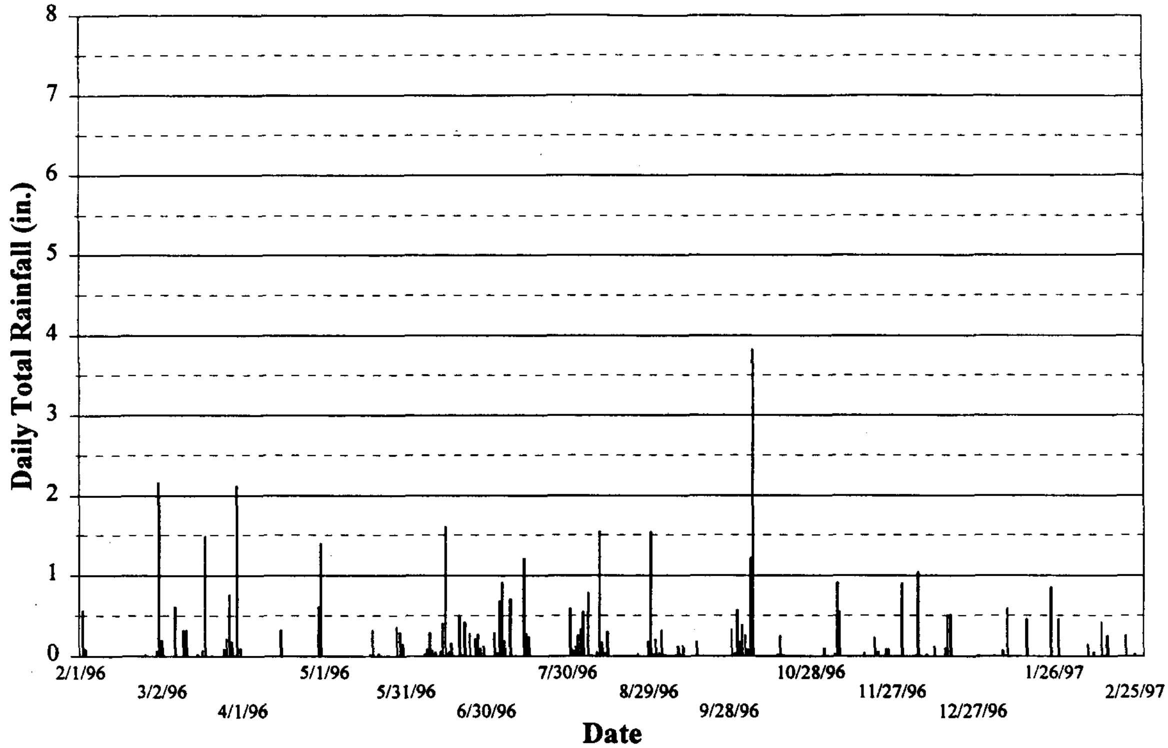


Figure 4-5

Station 1475 Rainfall (1996/1997)

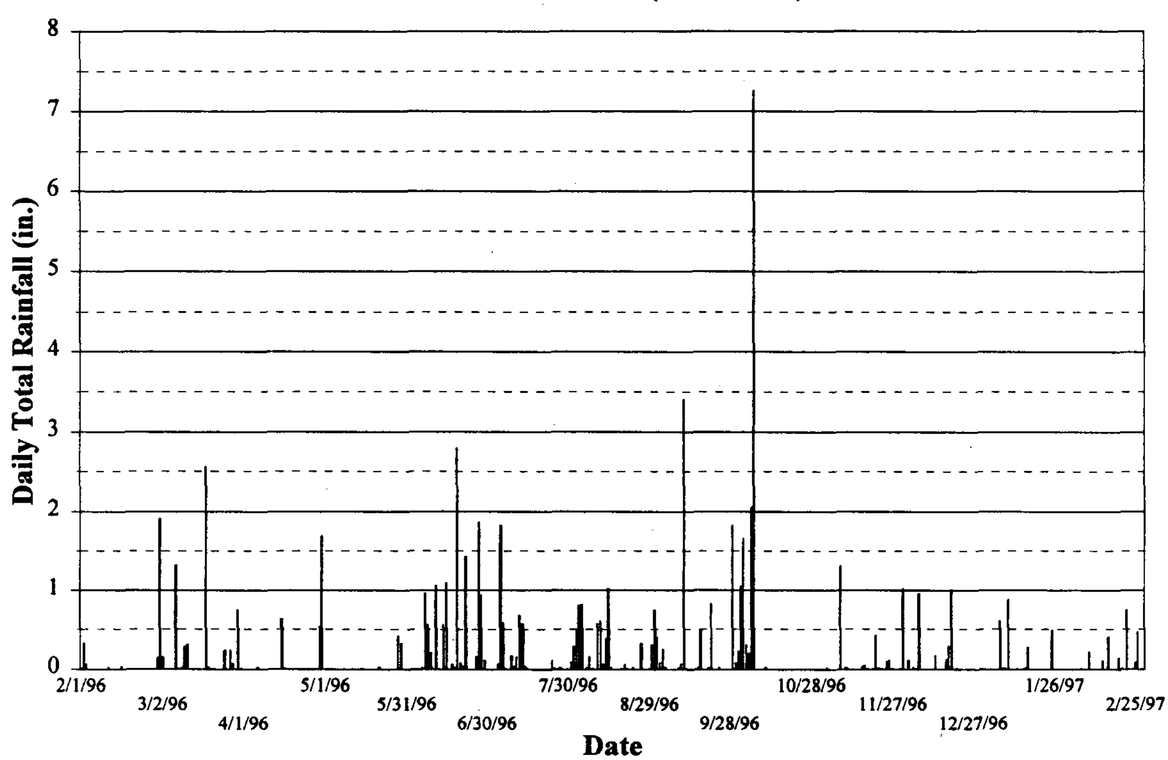


Figure 4-6

Station 1483 Rainfall (1996/1997)

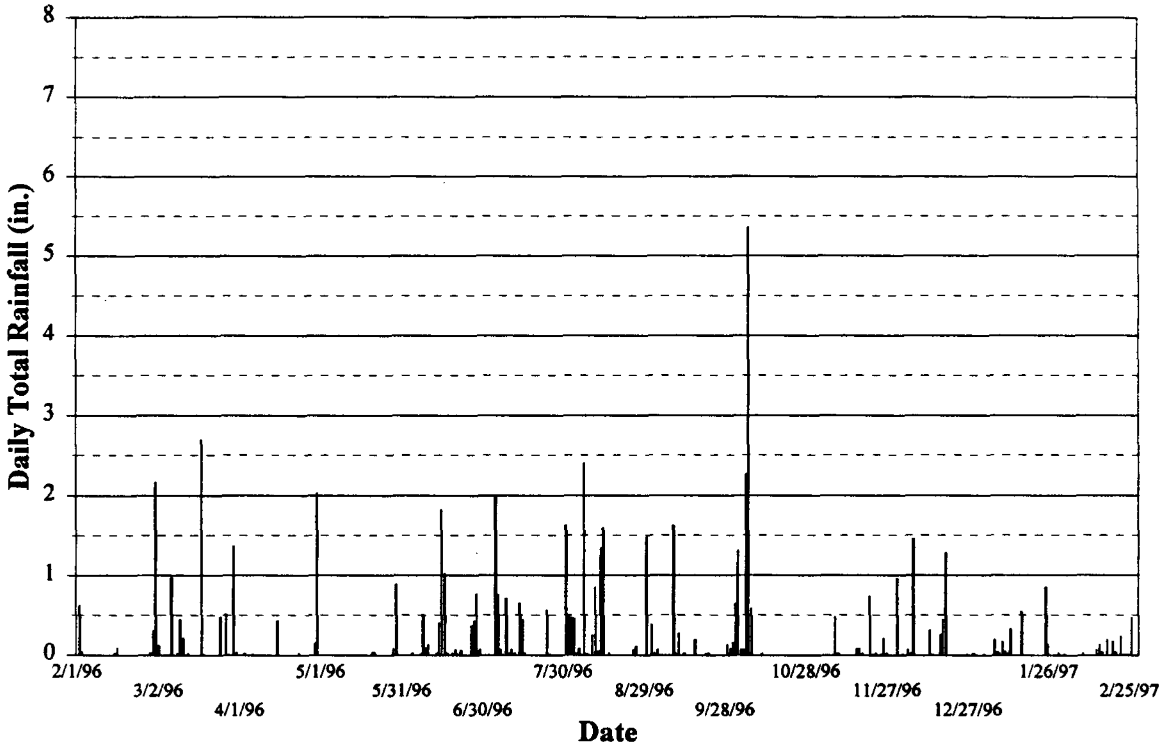


Figure 4-7

Station 1485 Rainfall (1996/1997)

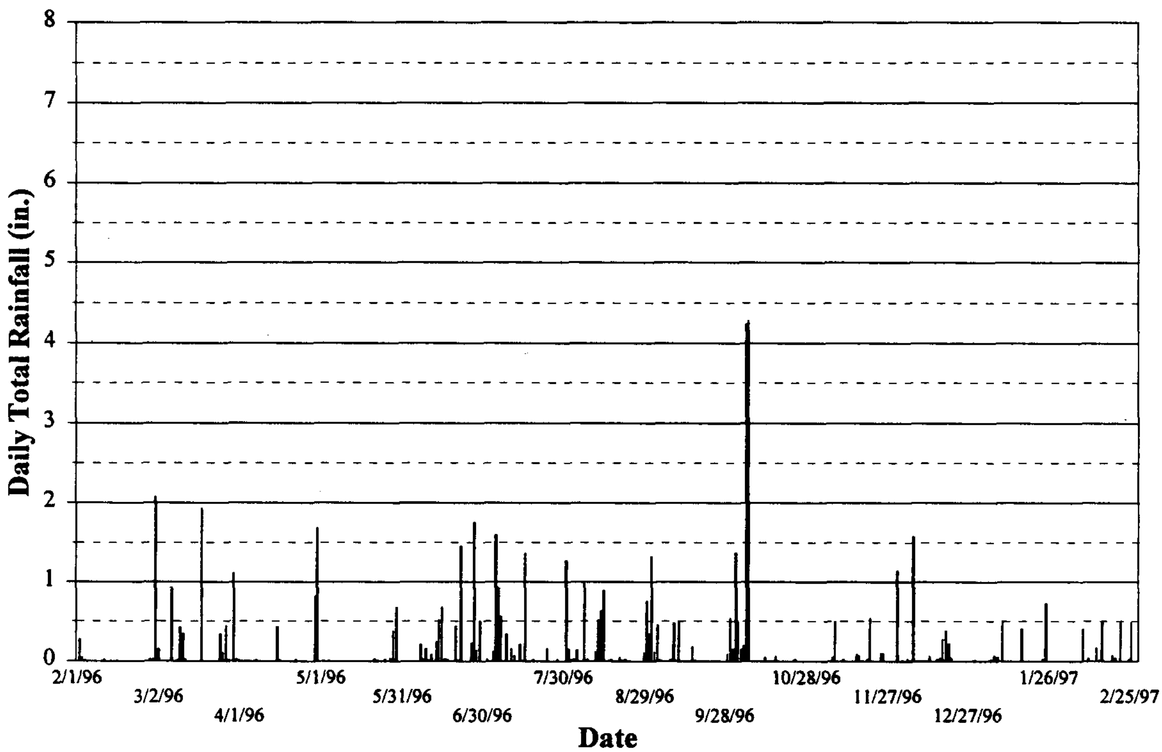


Figure 4-8

Station 1487 Rainfall (1996/1997)

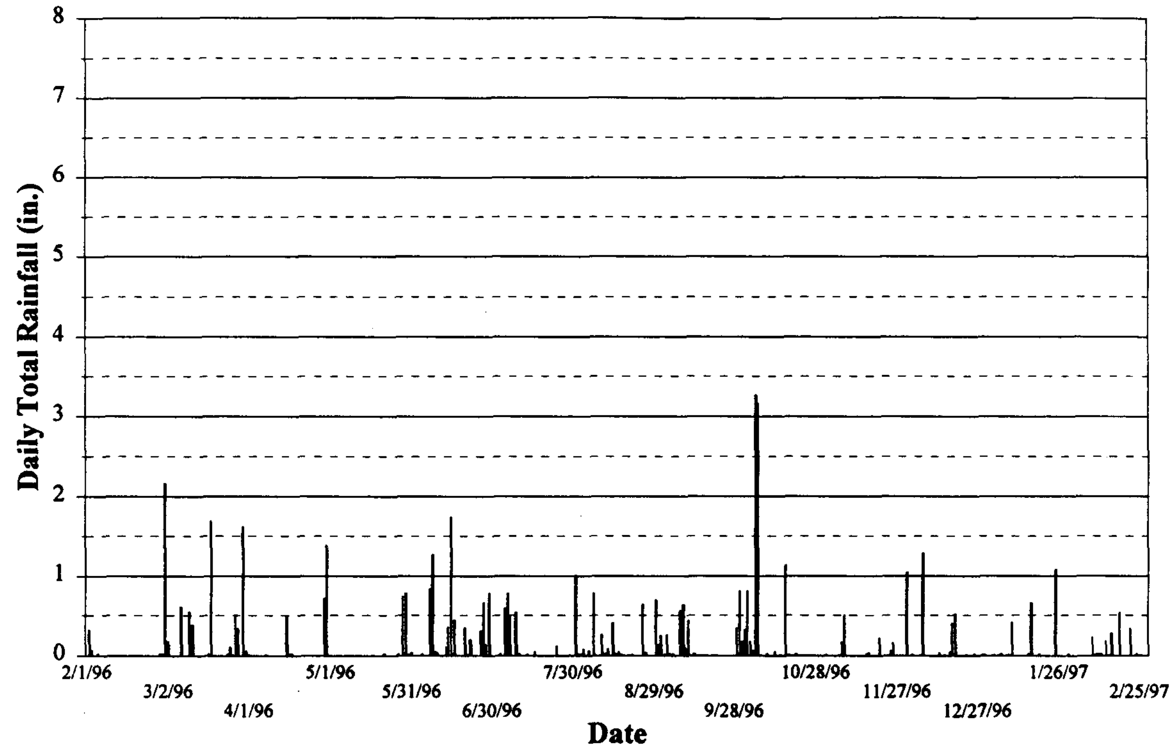


Figure 4-9

Station 1214 Rainfall (1995)

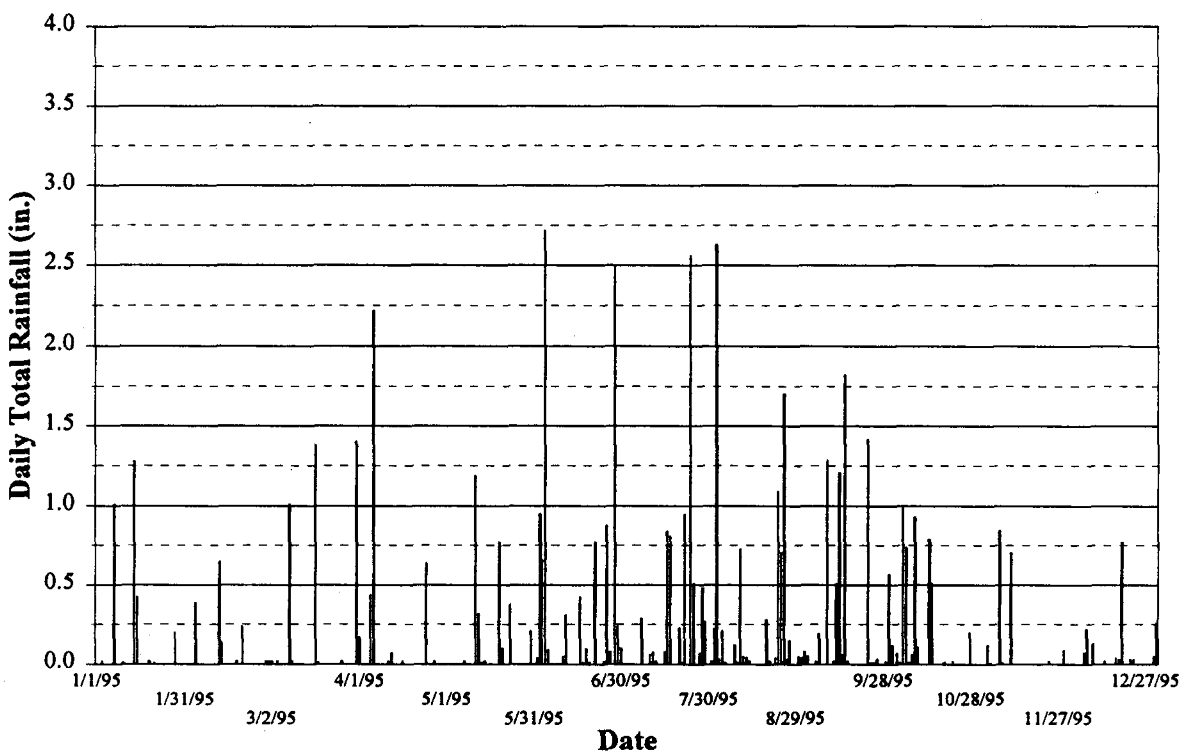


Figure 4-10

Gainesville Pan Evaporation (1996)

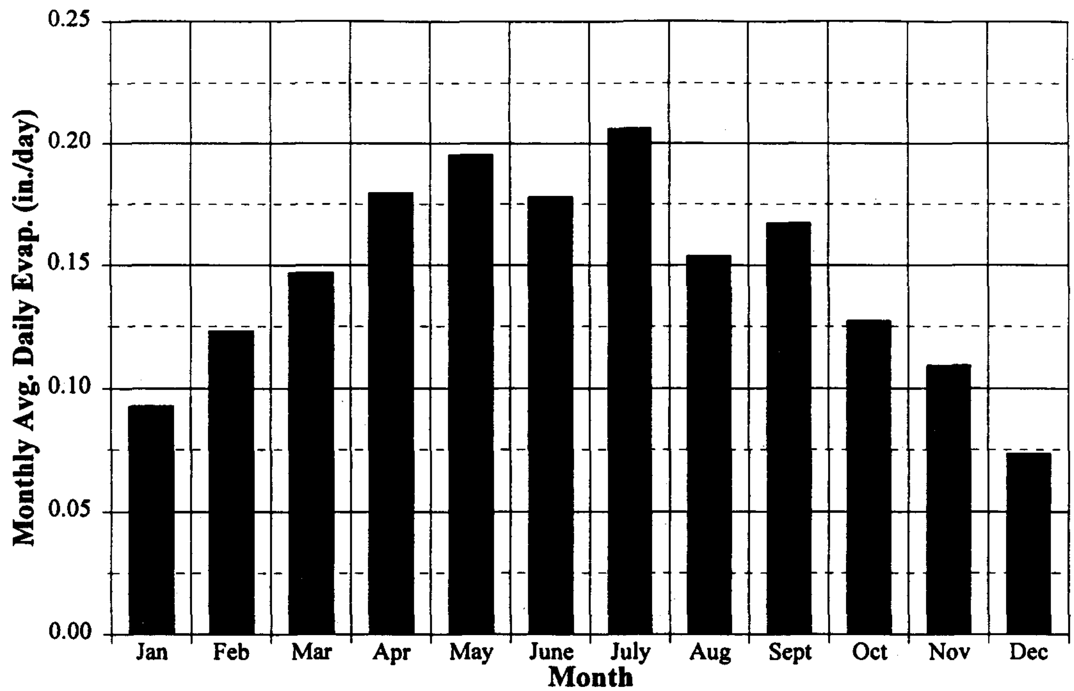
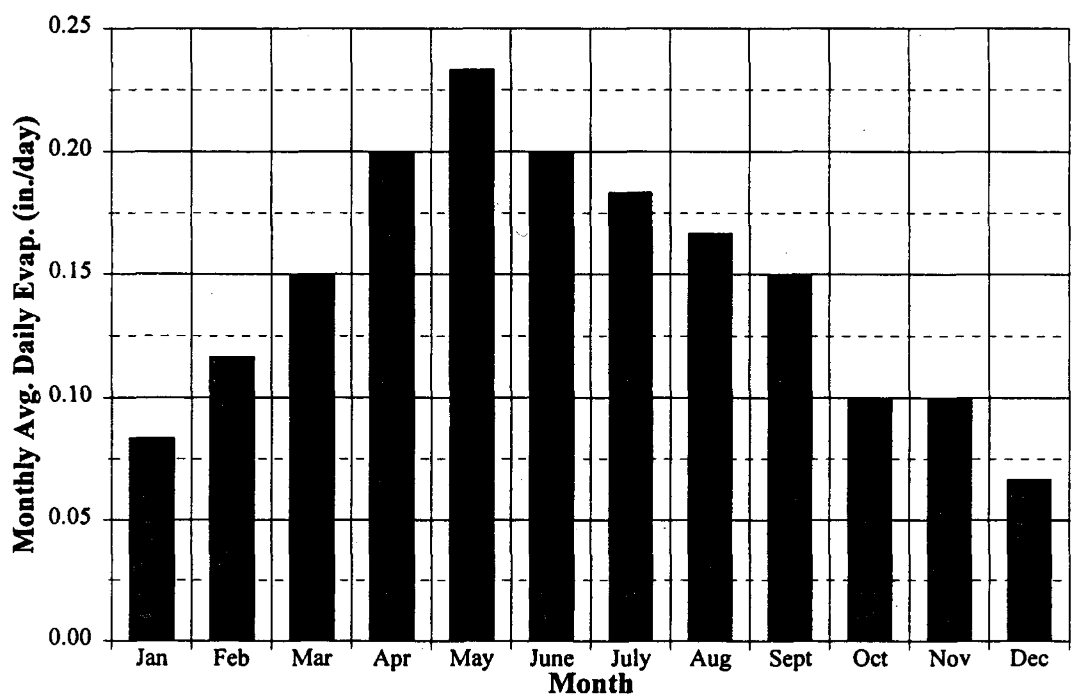


Figure 4-11

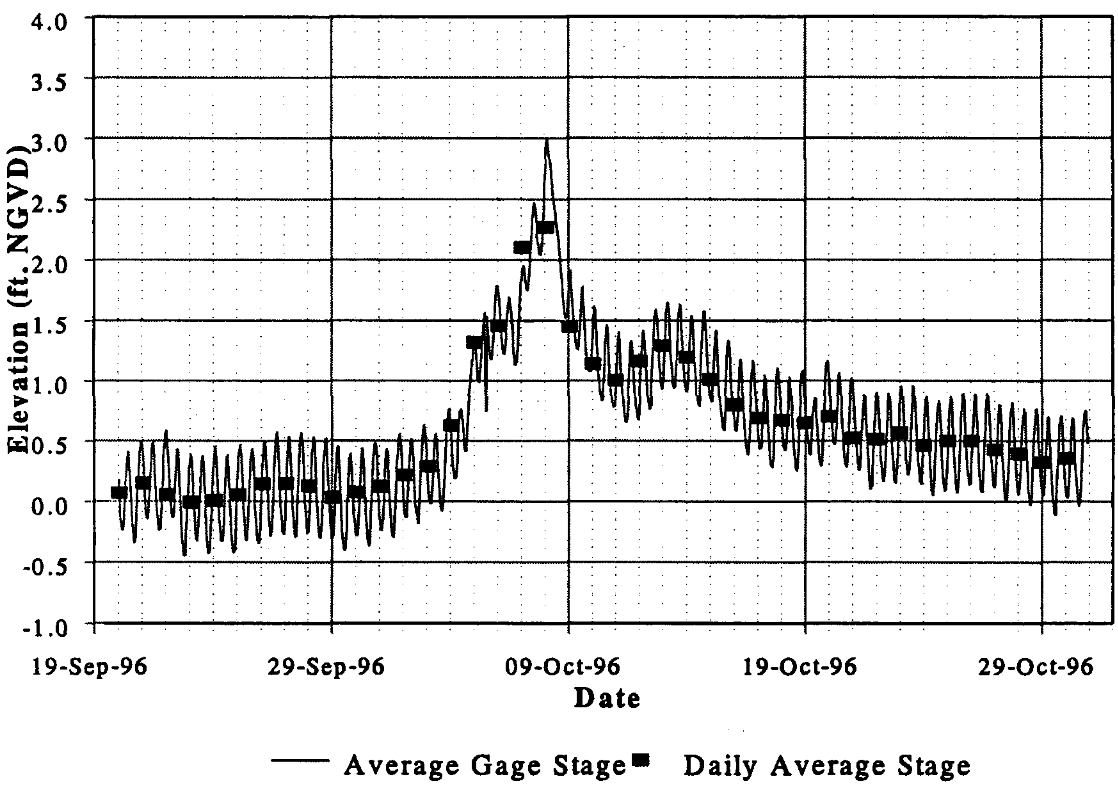
Gainesville Pan Evaporation (1995)



storm event were used for calibration. This event was chosen since the EXTRAN Blocks is intended to simulate flood event stages for large synthetic storms.

The observed stages of the St. Johns River were used to develop model input for the tailwater condition of the Black Creek Basin. The Black Creek outfall is approximately midway between the two FDEP gages 872-0357 and 872-0503 (refer to Figure 3-6). For this reason, the tailwater condition at the outfall of Black Creek was calculated as the average of the measured elevations at the two FDEP gages. The stage of the St. Johns River at Black Creek was input in the SWMM model as a series of daily average stages. Figure 4-13 is a plot of the stage of the St. Johns River at Black Creek and the calculated daily average stages.

Figure 4-13
St. Johns River Stage at Black Creek



Observed Discharges

Flow calibration was conducted by comparing measured stream flows at two USGS gages to the SWMM simulated flows. The gages used for comparison were 02246000 and 02245500 (refer to Figure 3-7). Both flow volume and peaks were considered. More emphasis was placed on the data gathered at the USGS gage station 02245500 because USGS documents (USGS, 1992) rated the records at gage 02246000 as poor. The stage-discharge rating curve for gage 02246000 is affected by tide on many days and interferes with the accurate measurement of flow.

Base Flow

Base flow was entered as a model input to the SWMM TRANSPORT Block. Base Flow was estimated using the "Moving Minimum Average Method" as discussed by Perry (1995). This method determines the base flow portion of measured stream flow by first calculating a moving minimum flow, then calculating a moving average of the moving minimum flow. The "window", or period of the moving average calculation, is the time of storage (time of direct runoff for the basin). To determine the time of storage of the basin, isolated storm events were identified, and their resulting runoff hydrographs were examined at the two available gages (02245500 and 0224600). From these hydrographs it was estimated that the time of direct runoff was approximately 30 days. Therefore, the period of the moving minimum flow and moving minimum averages were 30 days.

Measured flows at the two gages (02246000 and 02245500) and the minimum flow in a 30-day moving window for each gage were plotted. From these values, the average of the minimum flows in a 30-day window for each gage was determined. Figures 4-14 and 4-15 are examples of the base flow determination for the two available gages.

The values resulting from the calculation discussed above are the base flow at any given time at the gage location. To distribute the base flow spatially across the watershed, the contributing area of each gage was determined. The base flows were divided by the contributing areas to determine a base flow per unit area. The values calculated at the two gages were very similar. Therefore, a monthly average base flow per unit area was calculated by averaging the two base flow per unit areas for the subject month during the calibration period. The average monthly base flow per unit area was then used to spatially input base flow at 14 locations throughout the watershed. The locations

Figure 4-14

Black Creek Basin Base Flow (02246000)

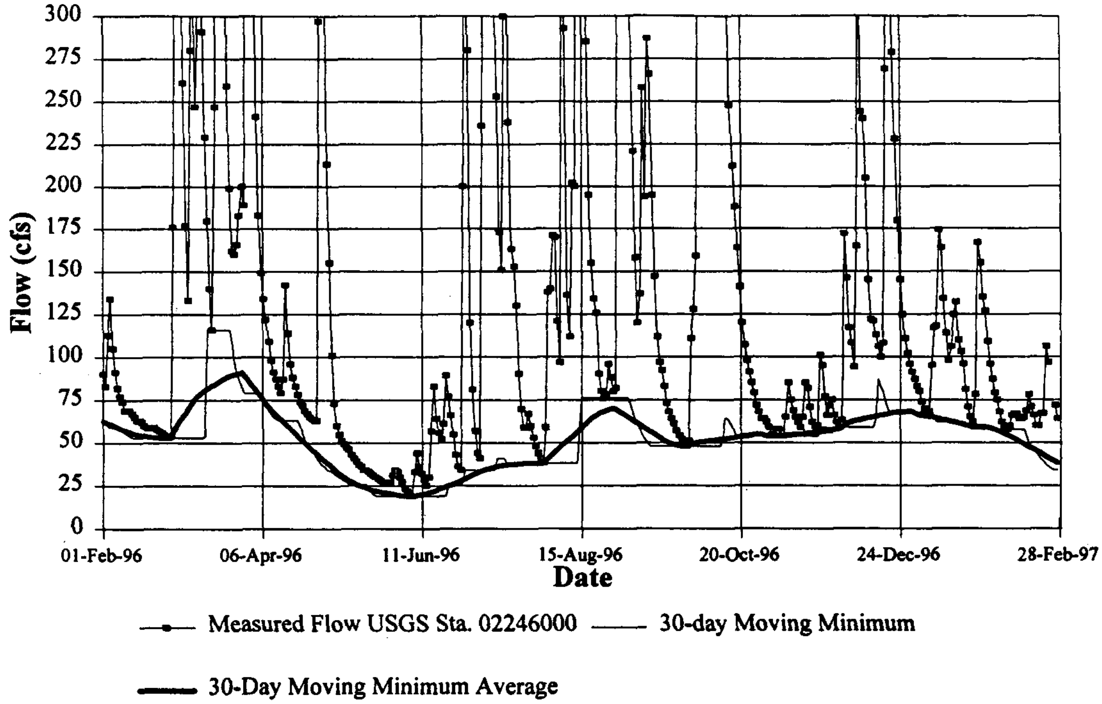
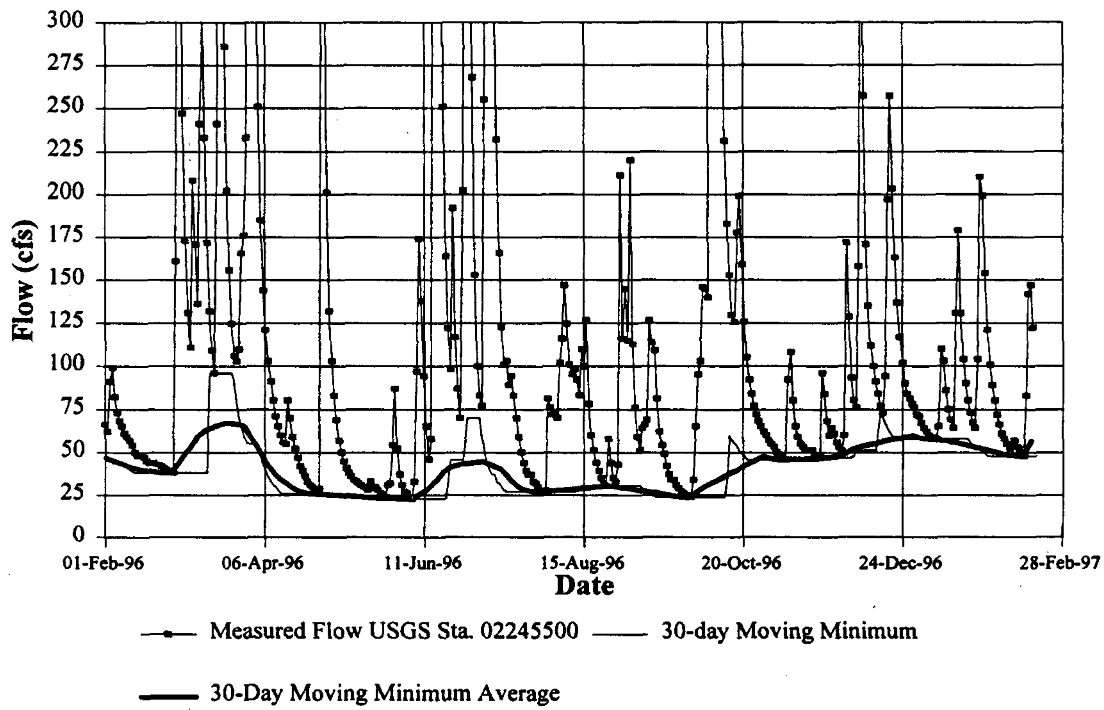


Figure 4-15

Black Creek Basin Base Flow (02245500)



were chosen at locations along the North and South Forks of Black Creek and Black Creek where major tributaries entered the stream network. The incremental contributing area (not considering areas for which base flow was already input) of each location was determined and multiplied by the average base flow per unit area to determine the incremental flow at each location. The locations where base flow was entered in the model are listed in Table 4-1. Refer to Figure 4-12 for the location of the input nodes.

TABLE 4-1

Black Creek Basin Base Flow Input Nodes

Base Flow Input Nodes						
10004	10016	10028	26026	16012	16018	16030
10014	10020	26010	16006	16014	16020	16042

4.1.3 Watershed Data

Subbasin Delineation

The 97 subbasins identified by the USGS (Section 3.3.3) were transferred to the USGS quad maps. The USGS subbasins were confirmed and revised as necessary. The original USGS subbasins were then further subdivided using the topographic data contained on the USGS quad maps to provide a finer level of detail. The subdividing of the USGS subbasins allowed for the analysis of contributing areas and drainage features within the Black Creek Basin. The subdividing also accounted for points of interest such as stream gaging stations and water quality sampling stations.

The subdivided Black Creek subbasins were digitzed and entered into a ACR/INFO GIS coverage for further analyses. Figure 4-12 shows the 171 subbasins delineated for the Black Creek Basin.

Land Use

A land use analysis was conducted using the GIS land use coverage (refer to Section 3.3.2). The analysis of the Black Breek Basin identified 107 land uses as described by the FLUCC system. Table 4-2 is a list of the existing (1990) FLUCC land uses and associated areas found in the Black

TABLE 4-2
Black Creek Basin Existing (1990) FLUCC Land Uses

FLUCC	Area (acres)	Percent of Total	Description
1000	32,133	10.37	URBAN AND BUILT-UP
1100	21,727	7.01	residential, low density - less than two dwelling units per acre.
1200	3,682	1.19	residential, med. density - two to five dwelling units per acre.
1290	2	0.00	medium density under construction
1300	164	0.05	residential, high density
1400	353	0.11	commercial and services. condominiums and motels combined.
1470	26	0.01	mixed commercial and services
1480	2	0.00	cemeteries
1490	17	0.01	commercial and services under construction, as per zoning.
1500	17	0.01	industrial
1520	49	0.02	timber processing
1550	37	0.01	other light industry
1600	44	0.01	extractive
1610	19	0.01	strip mines
1611	2	0.00	strip mines - clays
1613	101	0.03	strip mines - heavy metals
1620	143	0.05	sand and gravel pits
1630	86	0.03	rock quarries
1633	2	0.00	rock quarries - phosphate
1650	140	0.05	abandoned lands
1660	1	0.00	reclaimed lands
1700	218	0.07	institutional
1730	1,186	0.38	military
1800	122	0.04	recreational
1810	16	0.01	swimming beach
1820	371	0.12	golf course
1830	5	0.00	race tracks
1850	22	0.01	parks and zoos
1900	112	0.04	open land
1910	26	0.01	undeveloped land within urban areas
1920	3,442	1.11	inactive land with street pattern but without structures

TABLE 4-2 (Continued)
Black Creek Basin Existing (1990) FLUCC Land Uses

FLUCC	Area (acres)	Percent of Total	Description
2000	16,580	5.35	AGRICULTURE
2100	45	0.01	cropland and pastureland
2110	7,608	2.46	improved pastures
2120	3,065	0.99	unimproved pastures
2130	2,102	0.68	woodland pastures
2140	426	0.14	row crops
2150	456	0.15	field crops
2160	1,372	0.44	mixed crops: used if crop type cannot be determined
2200	29	0.01	tree crops
2210	22	0.01	citrus groves
2230	67	0.02	other groves
2240	94	0.03	abandoned tree crops
2300	32	0.01	feeding operations
2310	514	0.17	cattle feeding operations
2320	198	0.06	poultry feeding operations
2400	43	0.01	nurseries and vineyards
2500	35	0.01	specialty farms
2510	102	0.03	horse farms
2520	27	0.01	dairies
2600	192	0.06	other open lands - rural
2610	148	0.05	fallow cropland
3000	4,865	1.57	RANGELAND
3100	255	0.08	herbaceous
3200	3,702	1.20	shrub and brushland
3300	896	0.29	mixed rangeland
3430	3	0.00	
3600	10	0.00	

TABLE 4-2 (Continued)
Black Creek Basin Existing (1990) FLUCC Land Uses

FLUCC	Area (acres)	Percent of Total	Description
4000	184,967	59.71	UPLAND FORESTS
4100	180	0.06	upland coniferous forests
4110	33,802	10.91	pine flatwoods
4120	25,970	8.38	longleaf pine - xeric oak
4130	29	0.01	sand pine
4210	2	0.00	xeric oak
4300	2	0.00	upland hardwood forests continued
4330	161	0.05	western everglades hardwoods
4340	10,288	3.32	hardwood - conifer mixed
4400	72,341	23.35	tree plantations
4410	26	0.01	coniferous pine
4430	42,161	13.61	forest regeneration
4460	1	0.00	
4640	5	0.00	
5000	4,132	1.33	WATER
5100	830	0.27	streams and waterways
5120	4	0.00	
5200	2,347	0.76	lakes
5300	951	0.31	reservoirs

TABLE 4-2 (Continued)
Black Creek Basin Existing (1990) FLUCC Land Uses

FLUCC	Area (acres)	Percent of Total	Description
6000	60,275	19.46	WETLANDS
6100	14	0.00	wetland hardwood forests
6110	314	0.10	bay swamps
6150	18,428	5.95	river/lake swamp (bottomland)
6200	2,190	0.71	wetland coniferous forest
6210	3,870	1.25	cypress
6300	26,202	8.46	wetland forested mixed
6310	1	0.00	
6340	80	0.03	
6360	3	0.00	
6400	3	0.00	vegetated non-forested wetlands
6410	2,423	0.78	freshwater marshes
6430	1,509	0.49	wet prairies
6440	266	0.09	emergent aquatic vegetation
6460	4,954	1.60	mixed scrub-shrub wetland
6500	17	0.01	non-vegetated wetland
6660	0	0.00	
7000	2,073	0.67	BARREN LAND
7200	16	0.01	sand other than beaches
7340	0	0.00	
7400	1,870	0.60	disturbed land
7420	157	0.05	borrow areas
7430	19	0.01	spoil areas
7600	10	0.00	

TABLE 4-2 (Continued)
Black Creek Basin Existing (1990) FLUCC Land Uses

FLUCC	Area (acres)	Percent of Total	Description
8000	4,753	1.53	TRANSPORTATION, COMMUNICATION AND UTILITIES
8110	2,317	0.75	airports
8120	12	0.00	railroads
8130	9	0.00	bus and truck terminals
8140	746	0.24	roads and highways: only four land divided highways with medians
8200	14	0.00	communications
8300	5	0.00	utilities
8310	33	0.01	electrical power facilities
8320	1,538	0.50	electrical power transmission lines
8330	11	0.00	water supply plants
8340	27	0.01	sewage treatment plants
8350	41	0.01	solid waste disposal
Grand Total	309,778.0 acres 484.0 sq. mi.		

Creek Basin. For modeling purposes, the 107 FLUCC land uses were aggregated into general land use categories. The aggregation was completed for two purposes. First, more general land use descriptions are necessary to calculate area weighted hydrologic parameters. The SWMM model requires five land use dependent hydrologic parameters to be determined for each subbasin. These land use dependent hydrologic parameters of SWMM; directly connected impervious area (DCIA), depression storages (impervious and pervious areas), and roughness coefficients (impervious and pervious areas) have generally been reported in literature for general land use definitions such as residential, commercial, and industrial. By aggregating the Black Creek Basin FLUCC land uses, reported literature values for land use dependent hydrologic coefficients are used as initial estimates. Calibration is then used to refine the initial values.

A second purpose for aggregating the FLUCC land uses was to aid in water quality simulation. The most recent version (Version 4.3) of the SWMM model allows the simulation of pollutant washoff from up to ten (10) land uses. Therefore, the Black Creek Basin FLUCC land uses were aggregated into ten aggregated land uses. The aggregated land uses were chosen to adequately describe the existing land uses within the watershed. The aggregation had to balance the needs of calculating land use dependent hydrologic parameters and water quality simulation. Table 4-3 is a description of the FLUCC land use aggregation. The aggregated land uses by subbasin are presented in Appendix A. Refer to Figure 2-4 for a map of the aggregated land uses of the Black Creek Basin.

Soils

A soils analysis was conducted using the GIS soils coverage (refer to Section 3.3.1). The SWMM model has two options to simulate the infiltration of rainfall. The two options are the Green-Ampt and Horton equations. The Horton's infiltration equation (Equation 4-1) was selected over the Green-Ampt equation due to the greater availability of literature data and familiarity created by multiple applications in previous watershed studies. The Horton's infiltration equation is shown as Equation 4-1.

TABLE 4-3
Black Creek Basin Aggregated Land Uses

FLUCC	Area (ac.)	Percent of Total (%)	Description
Residential			
Total	29,982	9.68	
1100	21,727	7.01	residential, low density - less than two dwelling units per acre.
1200	3,682	1.19	residential, med. density - two to five dwelling units per acre.
1920	3,442	1.11	inactive land with street pattern but without structures
1820	371	0.12	golf course
2600	192	0.06	other open lands - rural
1300	164	0.05	residential, high density
1650	140	0.05	abandoned lands
1800	122	0.04	recreational
1900	112	0.04	open land
1910	26	0.01	undeveloped land within urban areas
1290	2	0.00	medium density under construction
1480	2	0.00	cemeteries
Commercial			
Total	5,102	1.65	
8110	2,317	0.75	airports
1730	1,186	0.38	military
8140	746	0.24	roads and highways: only four land divided highways with medians
1400	353	0.11	commercial and services. condominiums and motels combined.
1700	218	0.07	institutional
1520	49	0.02	timber processing.
1550	37	0.01	other light industry
8310	33	0.01	electrical power facilities
8340	27	0.01	sewage treatment plants
1470	26	0.01	mixed commercial and services
1850	22	0.01	parks and zoos
1500	17	0.01	industrial
1490	17	0.01	commercial and services under construction, as per zoning.
8200	14	0.00	communications
8120	12	0.00	railroads
8330	11	0.00	water supply plants
8130	9	0.00	bus and truck terminals
8300	5	0.00	utilities
1830	5	0.00	race tracks

TABLE 4-3 (Continued)
Black Creek Basin Aggregated Land Uses

FLUCC	Area (ac.)	Percent of Total (%)	Description
			Mining
Total	2,496	0.81	
7400	1,870	0.60	disturbed land
7420	157	0.05	borrow areas
1620	143	0.05	sand and gravel pits
1613	101	0.03	strip mines - heavy metals
1630	86	0.03	rock quarries
1600	44	0.01	extractive
8350	41	0.01	solid waste disposal
1610	19	0.01	strip mines
7430	19	0.01	spoil areas
7600	10	0.00	
1611	2	0.00	strip mines - clays
1633	2	0.00	rock quarries - phosphate
1660	1	0.00	reclaimed lands
7340	0	0.00	
			Dairies/Pasture
Total	13,695	4.42	
2110	7,608	2.46	improved pastures
2120	3,065	0.99	unimproved pastures
2130	2,102	0.68	woodland pastures
2310	514	0.17	cattle feeding operations
2320	198	0.06	poultry feeding operations
2510	102	0.03	horse farms
2100	45	0.01	cropland and pastureland
2300	32	0.01	feeding operations
2520	27	0.01	dairies

TABLE 4-3 (Continued)
Black Creek Basin Aggregated Land Uses

FLUCC	Area (ac.)	Percent of Total (%)	Description
			Crops
Total	2,693	0.87	
2160	1,372	0.44	mixed crops: used if crop type cannot be determined
2150	456	0.15	field crops
2140	426	0.14	row crops
2610	148	0.05	fallow cropland
2240	94	0.03	abandoned tree crops
2230	67	0.02	other groves
2400	43	0.01	nurseries and vineyards
2500	35	0.01	specialty farms
2200	29	0.01	tree crops
2210	22	0.01	citrus groves
			Natural: Forest
Total	70,465	22.75	
4110	33,802	10.91	pine flatwoods
4120	25,970	8.38	longleaf pine - xeric oak
4340	10,288	3.32	hardwood - conifer mixed
4100	180	0.06	upland coniferous forests
4330	161	0.05	western everglades hardwoods
4130	29	0.01	sand pine
4410	26	0.01	coniferous pine
4640	5	0.00	
4300	2	0.00	upland hardwood forests continued
4210	2	0.00	xeric oak
			Natural: Open/Shrub
Total	6,435	2.08	
3200	3,702	1.20	shrub and brushland
8320	1,538	0.50	electrical power transmission lines
3300	896	0.29	mixed rangeland
3100	255	0.08	herbaceous
1810	16	0.01	swimming beach
7200	16	0.01	sand other than beaches
3600	10	0.00	
3430	3	0.00	

TABLE 4-3 (Continued)
Black Creek Basin Aggregated Land Uses

FLUCC	Area (ac.)	Percent of Total (%)	Description
Tree Plantation			
Total	72,341	23.35	
4400	72,341	23.35	tree plantations
4460	1	0.00	
Forest Regeneration			
Total	42,161	13.61	
4430	42,161	13.61	forest regeneration
Water/Wetland			
Total	64,408	20.79	
6300	26,202	8.46	wetland forested mixed
6150	18,428	5.95	river/lake swamp (bottomland)
6460	4,954	1.60	mixed scrub-shrub wetland
6210	3,870	1.25	cypress
6410	2,423	0.78	freshwater marshes
5200	2,347	0.76	lakes
6200	2,190	0.71	wetland coniferous forest
6430	1,509	0.49	wet prairies
5300	951	0.31	reservoirs
5100	830	0.27	streams and waterways
6110	314	0.10	bay swamps
6440	266	0.09	emergent aquatic vegetation
6340	80	0.03	
6500	17	0.01	non-vegetated wetland
6100	14	0.00	wetland hardwood forests
5120	4	0.00	
6360	3	0.00	
6400	3	0.00	vegetated non-forested wetlands
6310	1	0.00	
6660	0.1	0.00	
Grand Total	309,778	100	

$$f_p = f_c + (f_o - f_c)e^{-kt} \quad \text{(Eq. 4-1)}$$

where f_p = infiltration capacity into soil (ft/sec),
f_c = minimum or ultimate value of f_p (ft/sec),
f_o = maximum or initial value of f_p (ft/sec),
t = time from beginning of storm, and
k = decay coefficient (sec^{-1}).

The parameters required to simulate infiltration using the Horton equation are maximum infiltration, minimum infiltration and the decay rate. The maximum and minimum infiltration rates can be related to the Hydrologic Soils Group (HSG) of soils as defined by the NRCS. Therefore, it was necessary to determine the ARGA of each HSG within each subbasin.

The GIS analysis identified 128 individual soils within the Black Creek Basin. The HSG of each soil was determined from the data available from the NRCS (SCS, 1986). Many soils are identified by dual HSG B/D signifying drained and undrained conditions. Initially, it was assumed that all soils identified with dual HSG were undrained (HSG D). Under further analysis and through calibration it was determined that many of the soils would act under the drained condition (HSG B). Many of the soils identified as dual HSG have been improved for silviculture. Since this improvement would include the construction of roads and ditches that would lower the water table and increase infiltration, an HSG B designation was determined through calibration to be appropriate.

Some soils identified in the GIS analysis were not defined by the soils survey. In this case, the HSG was assumed to be D. Finally, water as defined by the soils survey was assigned HSG D. Table 4-4 describes the soils and HSGs within the Black Creek Basin. Refer to Figure 2-3 for a map of the HSGs of the Black Creek Basin. A list of HSGs by subbasin is presented in Appendix B.

TABLE 4-4
Black Creek Basin Soils

MUID	Area (acre)	Soil Name	HSG	Assigned HSG
Baker County				
30002	37.1		UNK	D
30011	51.1	BOULOGNE	B/D	B
30021	5.2	HURRICANE	C	C
30023	1284.8	LEON	B/D	B
30024	175.0	LEON	B/D	B
30026	24.4	KINGSFERRY	B/D	B
30028	54.5	MANDARIN	C	C
30030	68.8	MURVILLE	A/D	A
30040	3.6	PAMLICO	D	D
30043	355.3	POTTSBURG	B/D	B
30045	12.6		UNK	D
30046	21.4	OSIER	A/D	A
Bradford County				
70013	0.2	HURRICANE	C	C
70015	9.2	POTTSBURG	B/D	B
70019	102.9	LEON	B/D	B
Clay County				
190001	8008.2	ALBANY	C	C
190002	5316.6	BLANTON	A	A
190003	25730.8	HURRICANE	C	C
190004	3252.2	OCILLA	C	C
190005	12263.9	PENNEY	A	A
190006	13312.0	MANDARIN	C	C
190007	6116.4	CENTENARY	A	A
190008	10402.5	SAPELO	D	D
190009	28920.2	LEON	B/D	B
190010	16915.8	ORTEGA	A	A
190011	4267.6	ALLANTON	B/D	B
190012	1160.1	SURRENCY	D	D
190013	5271.2	MEGGETT	D	D
190014	337.8	ORTEGA	A	A
190015	186.6	QUARTZIPSAMENTS	A	A
190016	247.5	HURRICANE	C	C
190017	659.5	PLUMMER	B/D	B

TABLE 4-4 (Continued)
Black Creek Basin Soils

MUID	Area (acre)	Soil Name	HSG	Assigned HSG
Clay County (Continued)				
190018	7866.3	RIDGEWOOD	C	C
190019	2924.9	OSIER	A/D	A
190020	718.5	SCRANTON	A/D	A
190021	356.2	GOLDHEAD	B/D	B
190022	6638.5	PELHAM	B/D	B
190023	100.1	SAPELO	D	D
190024	465.4	URBAN LAND	UNK	D
190025	3518.5	MAUREPAS	D	D
190026	3.7		UNK	D
190027	2264.7	PAMLICO	D	D
190028	252.1	SANTEE	D	D
190029	17888.1	RUTLEGE	B/D	B
190030	125.7	ARENTS	B	B
190031	14856.4	POTTSBURG	B/D	B
190032	1293.5	BLANTON	B	B
190034	1026.2	PENNEY	A	A
190035	9.2		UNK	D
190036	1116.6	ORTEGA	A	A
190037	846.7	RIDGEWOOD	C	C
190038	1581.9	SURRENCY	D	D
190039	4690.4	MEADOWBROOK	B/D	B
190040	1652.1	OUSLEY	C	C
190041	466.2	ALBANY	C	C
190042	2883.3	OSIER	A/D	A
190043	1782.8	PAMLICO	D	D
190045	4.4		UNK	D
190046	1115.6	PLUMMER	B/D	B
190047	4497.9	NEWNAN	C	C
190049	1170.1	SAPELO	D	D
190050	1757.1	LEON	B/D	B
190051	1429.8	POTTSBURG	B/D	B
190052	1773.2	MEGGETT	D	D
190054	92.4	TROUP	A	A
190056	7329.4	KERSHAW	A	A

TABLE 4-4 (Continued)
Black Creek Basin Soils

MUID	Area (acre)	Soil Name	HSG	Assigned HSG
Clay County (Continued)				
190058	6862.0	ALLANTON	D	D
190059	2953.3	LYNN HAVEN	B/D	B
190060	973.0	RIDGELAND	B/D	B
190061	1403.1	WESCONNETT	D	D
190062	1872.5	NEILHURST	A	A
190063	2638.7	SOLITE	B/D	B
190064	721.5	ONA	B/D	B
190065	2909.0	MEADOWBROOK	B/D	B
190067	2.5		UNK	D
190099	4098.8	WATER		D
Duval County				
310002	922.8	ALBANY FINE SAND	C	C
310007	1306.4	ARENTS	UNK	D
310012	448.2	BLANTON FINE SAND	A	A
310014	5951.0	BOULOGNE FINE SAND	B/D	B
310022	2117.6	EVERGREEN-WESCONNETT	D	D
310024	103.5	HURRICANE AND RIDGEWOOD	C	C
310028	29.9		UNK	D
310032	5183.6	LEON FINE SAND	B/D	B
310035	1102.0	LYNN HAVEN FINE SAND	B/D	B
310036	5.6	MANDARIN FINE SAND	C	C
310038	344.3	MASCOTTE FINE SAND	B/D	B
310040	29.2	MAUREPAS MUCK	D	D
310042	4.1	NEWHAN-COROLLA	A	A
310044	4436.0	MASCOTTE-PELHAM COMPLEX	B/D	B
310046	80.9	ORTEGA FINE SAND	A	A
310049	157.2	PAMLICO MUCK, DEPRESSIONAL	D	D
310050	9.1	PAMLICO MUCK	D	D
310051	8737.0	PELHAM FINE SAND	B/D	B
310052	4.2		UNK	D
310055	39.5	PITS	D	D
310056	855.1	POTTSBURG FINE SAND	B/D	B
310058	372.9	POTTSBURG FINE SAND	B/D	B
310062	332.3	RUTLEGE MUCKY FINE SAND	B/D	B

TABLE 4-4 (Continued)
Black Creek Basin Soils

MUID	Area (acre)	Soil Name	HSG	Assigned HSG
Duval County (Continued)				
310063	2015.7	SAPELO FINE SAND	D	D
310066	4989.5	SURRENCY LOAMY FINE SAND	D	D
310067	1236.0	SURRENCY LOAMY FINE SAND	D	D
310069	711.3	URBAN LAND	D	D
310071	124.2	URBAN LAND-LEON-BOULOGNE COMPLEX	B/D	B
310073	50.5	URBAN LAND-MASCOTTE-SAPELO COMPLEX	D	D
310075	16.3	URBAN LAND-HURRICANE-ALBANY COMPLEX	C	C
310078	29.8	YONGES FINE SANDY LOAM	D	D
310079	94.6	YULEE CLAY	D	D
310080	744.0	GOLDHEAD, WET, AND LYNN HAVEN SOILS	B/D	B
310081	114.5	STOCKADE FINE SANDY LOAM	B/D	B
310082	2538.7	PELHAM FINE SAND	B/D	B
310086	84.5	YULEE CLAY	D	D
310099	170.1	WATER		D
Putnam County				
1070001	13.1	CANDLER	A	A
1070002	0.3	CANDLER	A	A
1070003	213.2	MYAKKA	B/D	B
1070006	1.8	TAVARES	A	A
1070007	14.5	IMMOLOKEE	B/D	B
1070016	0.8	ADAMSVILLE	C	C
1070019	108.2	POMONA	D	D
1070022	6.9	TOMOKA	B/D	B
1070025	1.8	NARCOOSSEE	C	C
1070031	4.3	MYAKKA	D	D
1070035	342.5	MALABAR	B/D	B
1070037	10.4	ONA	B/D	B
1070042	5.2	RIVIERA	D	D
1070045	0.1	ASTATULA	A	A
1070051	54.6	SURRENCY	D	D

Watershed Characteristics

Stream cross section data were entered in the model for stream reaches for which the data was available. The reaches include Black Creek, portions of the South Fork of Black Creek, portions of the North Fork of Black Creek, Little Black Creek, Bradley Creek, Grog Creek, Dillaberry Creek, Big Branch, Duckwater Branch, Bull Creek, and Mill Creek. Refer to Section 3.7 for details of the available cross section data. In the portions of the steam network where detailed data were not available, stream channels were simulated as trapezoidal sections. Input for these sections (width, depth and side slopes) were estimated from field investigations and USGS Quad Maps.

Other hydraulic features such as road bridges and culverts were entered in the SWMM model from available data. The physical dimensions of the features were developed from field investigations and data contained in the available HEC-2 model files created for the *Flood Insurance Study - Clay County, Florida* (FEMA, 1992).

Storage features were simulated for three lakes or lake systems; Lake Ashby, Kingsley Lake and the system of Lakes Varnes, Whitmore and Stevens. Refer to Figure 4-12 for the location of the storage nodes. Simulation data for the Lake Ashby storage feature were taken from data contained in the U.S. Army Corps of Engineers *Lake Ashby Dam - Phase I - Inspection Report National Dam Safety Program* (USACOE, 1978). Simulation data for the other two storage features were developed from data contained on the USGS quad maps.

4.1.4 Synthetic Rainfall

The flood stages in the modeled systems were simulated for three rainfall events. The rainfall events were the 10-, 25- and 100-year, 24-hour storms. The input for the three storms were developed from site-specific hypothetical rainfall distributions as developed by Rao (1988a) for the Black Creek Basin. Table 4-5 lists the cumulative rainfall depths for the three rainfall frequency distributions used in this study. Figure 4-16 illustrates the unitless rainfall mass curves for the 10-, 25, and 100-year, 24-hour rainfall distributions.

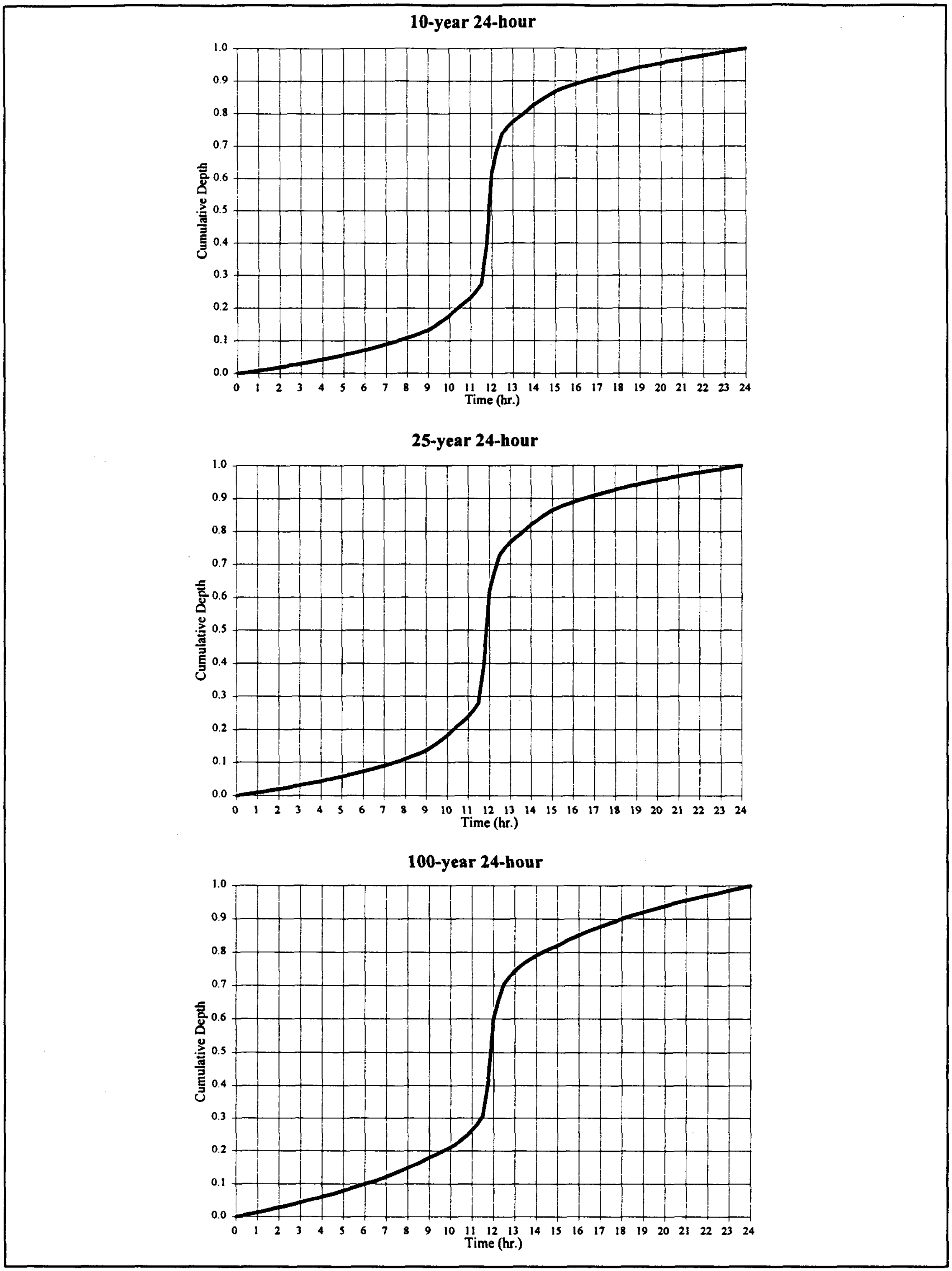
The rainfall depths for each storm event were determined from the isohyetal maps of maximum rainfall (refer to Figures 3-3 through 3-5). The center of the Black Creek Basin was used as the point

TABLE 4-5
Black Creek Basin Rainfall Distributions

Time (hr)	Cummulative Rainfall Depth			Time (hr)	Cummulative Rainfall Depth			Time (hr)	Cummulative Rainfall Depth		
	10-year	25-year	100-year		10-year	25-year	100-year		10-year	25-year	100-year
0.25	0.002	0.002	0.003	8.25	0.115	0.118	0.157	16.25	0.897	0.895	0.859
0.50	0.005	0.005	0.007	8.50	0.121	0.124	0.164	16.50	0.902	0.900	0.866
0.75	0.007	0.007	0.010	8.75	0.128	0.130	0.172	16.75	0.907	0.905	0.872
1.00	0.010	0.010	0.014	9.00	0.134	0.137	0.181	17.00	0.912	0.910	0.878
1.25	0.012	0.012	0.017	9.25	0.144	0.147	0.188	17.25	0.916	0.914	0.884
1.50	0.015	0.015	0.021	9.50	0.155	0.158	0.196	17.50	0.920	0.919	0.890
1.75	0.017	0.018	0.025	9.75	0.166	0.170	0.204	17.75	0.925	0.923	0.895
2.00	0.020	0.021	0.029	10.00	0.178	0.183	0.213	18.00	0.929	0.927	0.901
2.25	0.023	0.023	0.032	10.25	0.192	0.197	0.223	18.25	0.932	0.931	0.906
2.50	0.026	0.026	0.036	10.50	0.206	0.212	0.234	18.50	0.936	0.935	0.911
2.75	0.028	0.029	0.040	10.75	0.219	0.225	0.247	18.75	0.940	0.939	0.916
3.00	0.031	0.032	0.044	11.00	0.233	0.240	0.263	19.00	0.944	0.942	0.921
3.25	0.034	0.035	0.048	11.25	0.251	0.259	0.282	19.25	0.947	0.946	0.926
3.50	0.037	0.038	0.053	11.50	0.274	0.283	0.306	19.50	0.950	0.949	0.930
3.75	0.040	0.041	0.057	11.75	0.390	0.398	0.412	19.75	0.954	0.953	0.935
4.00	0.044	0.044	0.061	12.00	0.618	0.611	0.597	20.00	0.957	0.956	0.939
4.25	0.047	0.048	0.066	12.25	0.684	0.676	0.657	20.25	0.960	0.959	0.944
4.50	0.050	0.051	0.070	12.50	0.738	0.730	0.706	20.50	0.963	0.962	0.948
4.75	0.054	0.055	0.075	12.75	0.758	0.751	0.727	20.75	0.966	0.965	0.952
5.00	0.057	0.058	0.080	13.00	0.774	0.767	0.744	21.00	0.969	0.968	0.956
5.25	0.061	0.062	0.085	13.25	0.787	0.781	0.758	21.25	0.972	0.971	0.960
5.50	0.064	0.066	0.090	13.50	0.799	0.793	0.771	21.50	0.975	0.974	0.964
5.75	0.068	0.070	0.095	13.75	0.813	0.807	0.781	21.75	0.977	0.977	0.968
6.00	0.072	0.074	0.100	14.00	0.826	0.821	0.791	22.00	0.980	0.980	0.972
6.25	0.076	0.078	0.106	14.25	0.837	0.833	0.799	22.25	0.983	0.982	0.975
6.50	0.081	0.082	0.110	14.50	0.848	0.845	0.807	22.50	0.985	0.985	0.979
6.75	0.085	0.087	0.117	14.75	0.858	0.855	0.815	22.75	0.988	0.988	0.983
7.00	0.090	0.091	0.123	15.00	0.868	0.865	0.822	23.00	0.990	0.990	0.986
7.25	0.094	0.096	0.129	15.25	0.874	0.872	0.830	23.25	0.993	0.993	0.990
7.50	0.099	0.101	0.136	15.50	0.880	0.878	0.838	23.50	0.995	0.995	0.993
7.75	0.104	0.106	0.143	15.75	0.886	0.884	0.845	23.75	0.998	0.998	0.997
8.00	0.110	0.112	0.149	16.00	0.892	0.890	0.852	24.00	1.000	1.000	1.000

Figure 4-16

Black Creek Basin Rainfall Mass Curves



to determine the rainfall depth for each storm. Linear interpolation was used if necessary. The rainfall depths determined for the 10-, 25- and 100-year, 24-hour storm events were 6.75, 8.25 and 10.50 inches, respectively.

4.1.5 Water Quality Data

Observed Water Quality Concentration

In-stream water quality data were used in the estimation of non-point source pollutant load parameters and the calibration of those parameters. The water quality portions of the SWMM model were calibrated at five locations: NBC, BSF, BLC, PTC, and PCRHR. Refer to Figure 3-8 for the location of these stations. The model simulates five non-point source water quality parameters: total nitrogen (TN), total phosphorous (TP), total suspended solids (TSS), lead (Pb) and zinc (Zn). The model was calibrated for the one year period of 1995. Table 4-6 lists the measured water quality parameters that were used for the calibration of the model. The values for TN were calculated from the measured values of its constituents.

The observed water quality data were also used to calculate initial input values. The non-point source pollutant loads were simulated using a simple rating curve method that relates pollutant load to flow by a coefficient and an exponent. A separate rating curve was entered for each water quality parameter and for each of the ten simulated land uses. For the rating curve method, the following equation was used by the SWMM program to calculate the pollutant wash-off:

$$POFF = RCOEF * WFLOW^{WASHPO} \qquad \text{(Eq. 4-2)}$$

where: $POFF$ = constituent load (mg/sec)
$RCOEF$ = wash-off coefficient
$WFLOW$ = subbasin runoff (cfs)
$WASHPO$ = runoff rate exponent

The SWMM User's Manual (Huber, et al, 1988) suggests that if the load verses flow data tend to plot as a straight line on a log-log graph, the rating curve method will adequately simulate the pollutant wash-off. Therefore, the flow verses load as measured at the NBC station were plotted on

TABLE 4-6
Black Creek Basin Observed Water Quality Concentrations

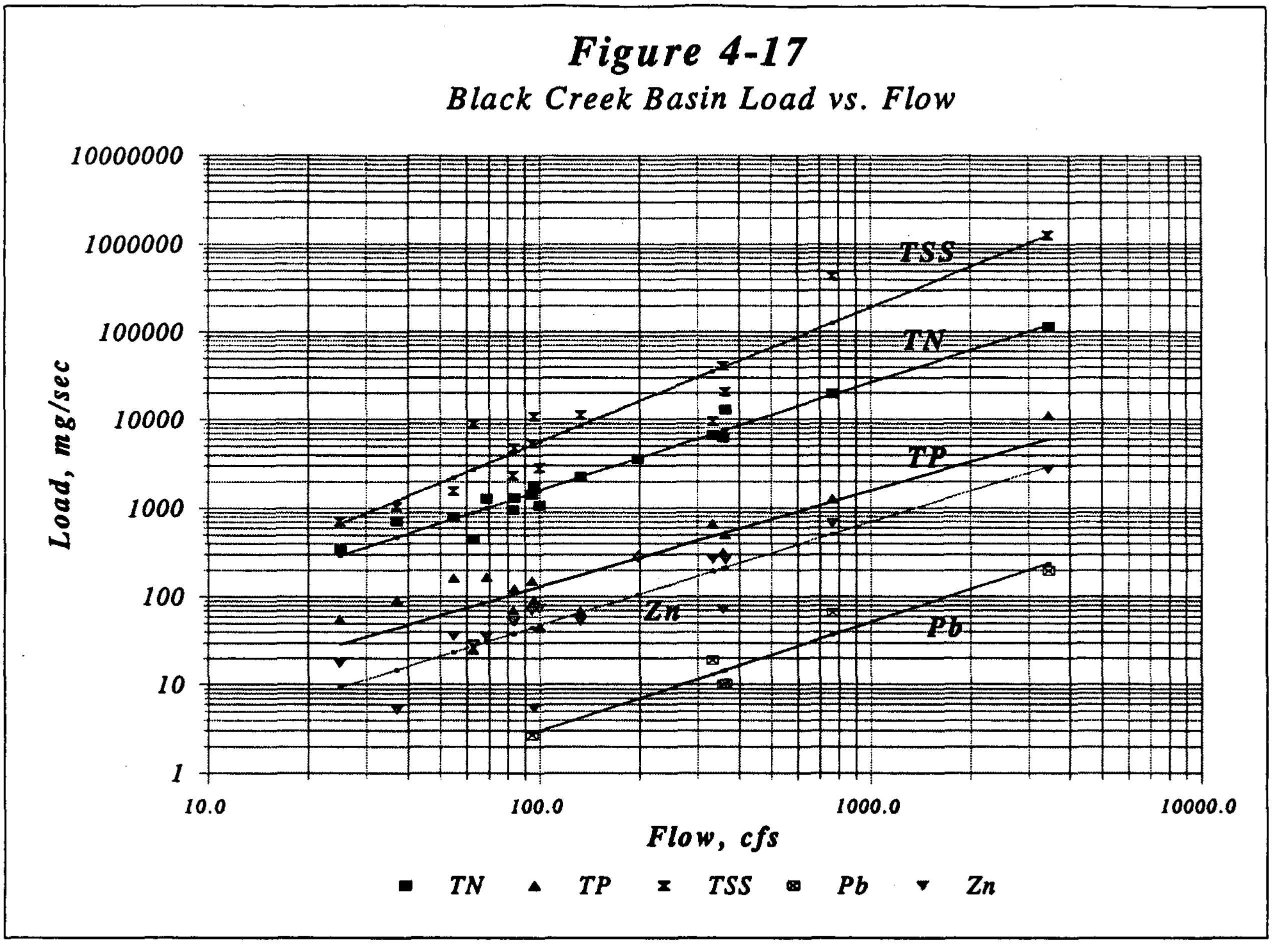
Date	Station					Station				
	BLC	PTC	PCRHR	NBC	BSF	BLC	PTC	PCRHR	NBC	BSF
	TN(mg/l)					TP (mg/l)				
Jan 26, 1995	0.70	0.88		0.60	0.60	0.08	0.16		0.02	0.09
Feb 16, 1995	0.67	0.82		0.64	0.53	0.07	0.16,0.18		0.05	0.10
Mar 16, 1995	0.71	0.83		0.55	0.45	0.09			0.05	0.11
Apr 6, 1995	0.74	1.15,1.07	0.84			0.08	0.23 0.22	0.03		
Apr 13, 1995	0.86,0.55	1.04		0.51	0.44	0.06				
May 23, 1995						0.18	0.18		0.11	0.22
Jun 5, 1995	0.47	1.37,1.33	0.80			0.12	0.22	0.06		
Jun 15, 1995	0.97			0.65	0.65	0.10	0.16		0.09	0.14
Jul 17, 1995	0.66	0.84	0.63			0.09	0.14	0.02		
Jul 18, 1995	0.85	0.98		1.18	0.89	0.10	0.17		0.11	0.11
Aug 25, 1995	0.73	0.85, 0.87				0.09	0.23,0.22			
Aug 31, 1995	1.39	1.72		1.25	1.15	0.09	0.31		0.05	0.12
Sep 14, 1995	0.89	1.28		0.91	0.86	0.07	0.24		0.06	0.11
Oct 15, 1995	0.96	1.94, 1.81				0.08	0.38,0.37			
Oct 19, 1995	0.99	1.21		0.71	0.72	0.07	0.22		0.07	0.12
Nov 20, 1995	0.76	0.86		0.38	0.34	0.06	0.11		0.02	0.09
Dec 11, 1995	0.52	0.75		0.53	0.44	0.09	0.18		0.06	0.13
	Pb (ug/l)					Zn (ug/l)				
Jan 26, 1995	0	0		0	1	13	18		14	11
Feb 16, 1995	3	0		0	0	22	12		49	17
Mar 16, 1995	0	0		0	0	24	17		22	21
Apr 6, 1995	0	0, 0	1			20	14, 21	16		
May 23, 1995	0	0		0	0	16	16		23	16
Jun 5, 1995	0	0	0			24	20	18		
Jun 15, 1995	1	0		0	1	16	16		18	18
Jul 17, 1995	1	1	1			9	11	16		
Jul 18, 1995	2	0		2	1	25	23		28	24
Aug 25, 1995	1.12	0.01, 0.01				4	4, 4			
Aug 31, 1995	1	0		1	1	26	22		25	20
Sep 14, 1995	1	0		3	2	31	19		31	51
Oct 15, 1995	1	2, 2				23	32, 26			
Oct 19, 1995	2	1		2	2	25	26		28	26
Nov 20, 1995	1	0		0	1	24	29		26	90
Dec 11, 1995	0	0		1	0	22	42		26	32
Oct 19, 1995	2	2	1		2					

TABLE 4-6 (Continued)
Black Creek Basin Observed Water Quality Concentrations

Date	Station				
	BLC	PTC	PCRHR	NBC	BSF
	TSS (mg/l)				
Jan 26, 1995	2	2	3		2
Feb 16, 1995					0
Feb 16, 1995	0	1	0		1
Mar 16, 1995	1	1	2		
Apr 6, 1995	3			6	3, 3
May 23, 1995	1	1	1		1
Jun 5, 1995	0			2	13
Jun 15, 1995	0	1	0		3
Jul 17, 1995	1			3	2
Jul 18, 1995	14	13	13		2
Aug 25, 1995	2				1, 4
Aug 31, 1995	3	2	2		2
Sep 14, 1995	1	11	20		3
Oct 15, 1995	3				24, 30

a log-log graph. This site was chosen because of the available flow data at the USGS Station 02246000 immediately upstream of the water quality station. The other water quality stations could not be utilized due to the lack of flow data. The data plotted favorably for all simulated parameters. A best fit straight line for each parameter was determined using straight line regression techniques. The associated coefficients of determination (r^2) were 0.96, 0.81, 0.89, 0.94, and 0.78 for TN, TP, TSS, Pb and Zn, respectively. Figure 4-17 is a log-log graph of flow verses load at the water quality sampling station NBC.

The slope of the best fit line is the runoff rate exponent (WASHPO) in the model input. The calculated values were 1.22, 1.08, 1.53, 1.24, and 1.16 for TN, TP, TSS, Pb and Zn, respectively. Initially, these values were entered in the model and subsequently adjusted during the calibration process. The Y-intercept of the best fit line is the wash-off coefficient (RCOEFF) in the model input. However, the values calculated from the observed data represents an aggregated condition for the land uses contributing to the water quality station. Therefore, the values can not be entered



directly in the SWMM mode input. The values were used to determine the relative magnitude of the wash-off coefficient. The relationship of the various land-use dependent wash-off coefficients were determined from event mean concentrations listed by Harper (1994). Some land uses were not listed in the reference and in these cases, professional judgement was used to estimate initial values for these land uses.

Point Source Discharges

The available point source discharge data is sumarized in Table 4-7. Of those listed, only five discharge directly to the surface waters of the Black Creek Basin. These include the E.I Dupont De Nemours Highlands Mine, Rideout Landing wastewater treatment plant (WWTP), Penny Farms Retirement WWTP, Camp Blanding WWTP and Cecil Field WWTP. The Rideout Landing and Cecil Field WWTPs are advanced wastewater treatment plants that achieve a greater level of water quality treatment. All other identified point sources discharge to systems that will greatly improve

TABLE 4-7
Black Creek Basin Point Source Discharges Effluent Data

Map ID	Facility Name	Design Capacity (MGD)	Mon. Avg. Flow (MGD)	Average Concentration (mg/l)		
				TN	TP	TSS
1	E. I. Dupont De Nemours Highlands Mine	10.000	6.528			4.120
2	Middleburg Senior High Schl.	0.050	0.014			
3	Lake Asbury Elem. Schl.	0.040	0.003			
4	Ridaught Landing WWTP	1.300	0.684	2.656	0.901	2.790
5	Middleburg Elem. Schl.	0.040	0.009			
6	Middleburg 21/218 Cntr.	0.005	0.004			
7	Middleburg Bluffs	0.012	0.006			
8	Grande Olde Plaza	0.040	0.018			
9	Brairwood of Middleburg	0.010	0.006			
10	Penny Farms Retirement Cntr.	0.090	0.065	4.918		8.862
11	Camp Blanding WWTP	0.900	0.643	4.157	0.150	3.940
12	USN Cecil Field	1.200	0.651			
13	Mid-Clay WWTP	0.150				

the water quality of their effluent. These systems include percolation and evaporation ponds, spray fields, and drain fields.

The cumulative impact of the pollutant loads of the five point sources that do discharge to the surface waters of the Black Creek Basin were analyzed. The pollutant loads for TN, TP, TSS, Pb and Zn for the point sources and for the entire watershed were estimated. Known point source flows and pollutant concentrations were used when available. Pollutant concentrations typical for secondary WWTP were used when no measured data was available. For the watershed load, measured pollutant concentrations were averaged and multiplied by a typical annual flow volume. From this analysis it was determined that the cumulative load of the five point sources is less than one percent of the total annual watershed load. For this reason, point source discharges were not simulated in any of the water quality modeling.

4.2 Water Quantity Modeling

4.2.1 Model Framework

Water quantity simulation was conducted for two purposes. In order to simulate non-point source pollutant loads from the watershed, the flows and volumes of runoff must be simulated accurately. The second purpose of water quantity simulation was to allow the prediction of flood elevations resulting from the synthetic flood events in the watershed. Both simulation purposes require the use of meteorologic and hydrologic subbasin data contained in the RUNOFF Block.

RUNOFF

The RUNOFF Block in the SWMM model was used to simulate the rainfall-runoff process. The model uses a kinematic wave approximation to route surface runoff over pervious and impervious surfaces. The model accounts for infiltration (using either Horton's Equation or the Green-Ampt Equation), evaporation, snowmelt and abstractions (or depression storage).

In the RUNOFF Block, eleven variables were entered for each subbasin that describe the rainfall-runoff relationship for each individual subbasin. The width, area, directly connected impervious area (DCIA), slope, impervious Manning's "n", pervious Manning's "n", impervious depression storage, pervious depression storage, maximum infiltration rate, minimum infiltration rate and infiltration decay rate were required as input for each subbasin. Each variable describes a different aspect of a subbasin and was calculated using appropriate methods. The width, area and slope were determined from the overland flow and topographic features of each subbasin. DCIA, pervious Manning's "n" and pervious depression storage were calculated according to the percentages of land uses within each subbasin. Maximum and minimum infiltration rates were determined from the percentages of HSGs within each subbasin. Pervious Manning's "n", pervious depression storage and infiltration decay rate were assumed constant throughout the basin.

The area of each subbasin was determined from the GIS analysis. The slope and width were calculated using the area and overland flow data. As suggested by the SWMM User's Manual (Huber, et al. 1988), the overland flow path was estimated to include the maximum distance from the outer edge of the subbasin to its outfall. Overland flow paths were determined by examining the

USGS quad maps. Any small drainage feature that was not to be modeled hydraulically was included in the overland flow paths. Up to three representative overland flow paths were determined for each subbasin. Multiple flow paths were determined to allow for the averaging of overland flow conditions (length and slope). For each overland flow path, the elevation of the initial flow point (usually at the outer edge of the subbasin), the elevation of the outfall point, and the length of overland flow were determined. The slope of each overland flow path was determined by dividing the change in elevation by the length. The slope entered in the SWMM input was an average slope as determined from three representative overland flow paths. The width of the subbasin was initially determined as suggested by the SWMM User's Manual (Huber et al., 1988) as the area divided by the overland flow path. The average overland flow path was used in this calculation.

The variables of directly connected impervious area (DCIA), pervious Manning's "n" and pervious depression storage are related to the land uses within each subbasin. Thus, for each variable, an area weighted average was determined based upon the land uses within the subbasin. The area of each land use within an individual subbasin was multiplied by its land use specific value. The products were then summed for each subbasin and divided by the total area of each subbasin to obtain a land-use area weighted average. Initial values of DCIA, pervious Manning's "n" and pervious depression were first estimated by examining other watershed studies. Tables 4-8 through 4-10 describe typical values for DCIA, roughness coefficient (Manning's "n") and depression storage, respectively. Final land-use related values used in the Black Creek Basin model are presented in the following calibration section.

The infiltration parameters of the SWMM input are HSG-related. Therefore, as with the land-use related parameters, an area weighted average value related to the HSG was calculated for each infiltration parameter for each subbasin. Initial values for the maximum and minimum infiltration rates for each HSG were determined from literature and previous watershed studies. Table 4-11 lists typical HSG infiltration parameters. Final HSG-related values used in the modeling of the Black Creek Basin are presented in the following calibration section.

TABLE 4-8
Typical DCIA Values

Source	DCIA (%)						
	Comm.	Agric./ Open	LDR	HDR	Multi-Family	Uplands	Water/ Wetlands
Norma Park Drainage Study (CDM, 1989)	82	5	---	---	30	---	---
Rocky Creek Stormwater Master Plan (CDM, 1986b)	90	1	12	35	75	0	100
Sarasota County Stormwater Master Plan (CDM, 1987)	50-95	0-5	2-30	25-80	25-80	0-5	100
North St. Johns County Stormwater Management Study (Seaburn & Robertson, 1986)	90	5	15	40	50	5	100
Bystre Lake Stormwater Master Plan (Dames & Moore, 1989)	85	8	8	40	40	5	100
Winter Haven Stormwater Master Plan (Dames & Moore, 1990), Lakeland Stormwater Master Plan (Dames & Moore, 1992a)	90	5	18	38	38	5	100
Lake Seminole (Dames & Moore, 1992b)	93	5	30	60	63	---	---
City of St. Petersburg Stormwater Management Master Plan (PBS&J, 1992)	90	0	32	86	---	---	100
LWWM Initial Application to the Lake Thonotossassa Watershed (Dames & Moore, 1994a)	50	1	50	50	50	0	100
LWWM Application to the Little Manatee Watershed (Dames & Moore, 1994b)	30	5	30	30	30	5	100
LWWM Application to the Winter Haven Chain of Lakes (Dames & Moore, 1994c)	60	0-5	40	40	40	---	100
Allen's Creek Watershed Computer Model - Task II Report - Draft (Dames & Moore, 1996)	50	5	35	45	---	---	100

TABLE 4-9

Typical Overland Manning's "n" Values

Source	Manning's "n" (a)
Digital Simulation in Hydrology (Crawford and Lindsley, 1966)	0.012 - 0.40
Roughness Coefficients for Routing Surface Runoff (Engman, 1986)	0.01 - 0.63
Norma Park Drainage Study (CDM, 1989)	0.04 - 0.30
Rocky Creek Stormwater Master Plan (CDM, 1986b)	0.04 - 0.30
Sarasota County Stormwater Master Plan (CDM, 1987)	0.017 - 0.32
Bystre Lake Stormwater Master Plan (Dames & Moore, 1989)	0.01 - 0.35
City of St. Petersburg Stormwater Management Master Plan (PBS&J, 1992)	0.02 - 0.10
LWWM Initial Application to the Lake Thonotosassa Watershed (Dames & Moore, 1994a)	0.05 - 0.15
LWWM Application to the Little Manatee Watershed (Dames & Moore, 1994b)	0.10 - 0.45
LWWM Application to the Winter Haven Chain of Lakes (Dames & Moore, 1994c)	0.01 - 0.40
Allen's Creek Watershed Computer Model - Task II Report - Draft (Dames & Moore, 1996)	0.10 -0.30

(a) Note: includes pervious and impervious values.

TABLE 4-10

Typical Depression Storage Values

Source	Depression Storage (in.)	
	Imperv.	Perv.
Introduction to Hydrology (Viessman, et al., 1977)	0.006 - 0.11	---
SWMM Ver. 4.0 User's Manual (Huber & Dickinson, 1988)	---	0.10
A Method of Computing Urban Runoff (Hicks, 1944)	---	0.10 - 0.20
Norma Park Drainage Study (CDM, 1989)	0.15	0.50
Rocky Creek Stormwater Master Plan (CDM, 1986b)	0.10	0.20
North St. Johns County Stormwater Management Study (Seaburn & Robertson, 1986)	0.018 - 0.21	0.10-.20
Sarasota County Stormwater Master Plan (CDM, 1987)	0.10	0.10
Bystre Lake Stormwater Master Plan (Dames & Moore, 1989)	0.10	0.25
Lake Seminole (Dames & Moore, 1992b)	0.30	0.35
LWWM Initial Application to Lake Thonotosassa Watershed (Dames & Moore,	0.30	0.10 - 2.0
LWWM Application to the Little Manatee River Watershed (Dames & Moore, 1994b)	0.10	0.10 - 0.30
LWWM Application to the Winter Haven Chain of Lakes (Dames &	0.0 - 0.40	0.06
Allen's Creek Watershed Computer Model - Task II Report - Draft	0.06	0.05-0.10

TABLE 4-11
Typical Soils Infiltration Values

Source	Infiltration Rate (in./hr.)							
	A		B		C		D	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
How Much Water Enters the Soils (Musgrave 1955)	---	.45-.30	---	.30-.15	---	.15-.05	---	.05-.00
Rocky Creek Stormwater Management Master Plan (CDM, 1986b)	---	---	---	---	---	---	10	0.45
MSSM User's Manual from stormwater study in South Venice Gardens, Sarasota (CDM, 1986a)	10	1	8	0.5	5	0.25	3	0.1
Norma Park Drainage Study (CDM, 1988)	---	---	---	---	---	---	8	0.7
Sarasota County Stormwater Master Plan (Average Dry Conditions) (CDM, 1987)	4	0.96	3.2	0.48	2.05	0.23	1.1	0.14
Sarasota County Stormwater Master Plan (Average Wet Conditions) (CDM, 1987)	2.8	0.96	2	0.48	1.25	0.23	0.65	0.14
Urban Drainage Design and Stormwater Control (Rao, 1986)	10	1	8	0.5	5	0.25	3	0.1
Bystre Lake Stormwater Management Master Plan (Dames & Moore, 1989)	3.6	0.41	3.1	0.25	2.7	0.15	2.2	0.07
Lake Seminole (Dames & Moore, 1992b)	5	3	3	2	2	1	1	0.1
LWWM Initial Application to Lake Thonotosassa Watershed (Dames & Moore, 1994a)	2.7	0.41	1.9	0.25	1.2	0.15	0.6	0.07
LWWM Application to the Little Manatee River Watershed (Dames & Moore, 1994b)	2.7	0.3	1.9	0.09	1.2	0.05	0.6	0.03
LWWM Application to the Winter Haven Chain of Lakes (Dames & Moore, 1994c)	10	1	8	0.5	5	0.25	3	0.1
Allen's Creek Watershed Computer Model - Task II Report - Draft (Dames & Moore, 1996)	1.5	0.3	0.75	0.15	0.4	0.05	0.1	0.001

The remaining SWMM hydrologic input variables of impervious Manning's "n", impervious depression storage and infiltration decay rate are assumed to be constant for all land uses and HSGs. Impervious Manning's "n" represents the roughness factor for overland flow for the DCIAs. Impervious depression storage represents the surface storage (puddling) for DCIA that must be filled before runoff commences. DCIA is largely comprised of paved surfaces (roadways, parking lots, etc.) so there is little variability in the runoff characteristics between land uses and soils condition. For this reason impervious Manning's "n" and impervious depression storage are constant for all subbasins. The final values used in the modeling of the Black Creek Basin are presented in the following calibration section.

The infiltration decay rate variable controls the length of time during the rainfall event simulations that the infiltration rate decreases from the maximum value to the minimum value. Due to the limited research conducted for this variable, the decay rate is constant for all HSGs and therefore constant for all subbasins. The final decay rate used in the modeling of the Black Creek Basin is presented in the following calibration section.

TRANSPORT

The resulting runoff simulated by the hydrologic portions of the SWMM model were routed through the Black Creek Basin stream network using the TRANSPORT Block of the SWMM model. This model uses "elements" to describe various features of a drainage network. An element may be a natural channel, culvert, point of confluence, or storage feature (lake). All features necessary for the routing of subbasin runoff were input in the TRANSPORT Block. The portions of the stream network where detailed data (surveyed cross-section) were available were simulated as natural sections and the input included the cross-sectional data. The portions of the steam network where detailed data were not available, stream channels were simulated as trapezoidal sections. Input for these sections (width, depth and side slopes) were estimated from field investigations. Figure 4-12 is a schematic of the model for the Black Creek Basin.

EXTRAN

The EXTRAN modeling of the Black Creek Basin built upon the work described in the previous sections. The RUNOFF Block was used to simulate runoff and portions of the TRANSPORT Block were used to route flows in the upper reaches of the stream network. The lower reaches of the stream network were then simulated utilizing the EXTRAN Block. Figure 4-12 depicts the portions of the watershed modeled hydraulically using the EXTRAN Block (primary routing) and using the TRANSPORT Block (secondary routing).

The EXTRAN Block is a dynamic flow routing model that routes inflow hydrographs through an open channel and/or closed conduit system, computing the time history of flows and heads throughout the system. The program solves the full dynamic equations for gradually varied flow (St. Venant equations) using an explicit solution technique to step forward in time. EXTRAN can model parallel pipes, looped systems, lateral diversions such as weirs, orifices, pumps, and partial surcharge within the system.

The model input to the EXTRAN Block is similar to that of the TRANSPORT Block. Conduits (natural or man-made) are described and joined by nodes (confluences, points of interest, points of inflow, etc.). Storage features are also simulated. The principal difference between each Block's input is that the EXTRAN Block requires a tailwater condition. Since the EXTRAN Block considers tailwater effects, the tailwater condition of Black Creek's outfall to the St. Johns River was entered.

4.2.2 Model Calibration

The period chosen for flow calibration was from February 1, 1996 to February 28, 1997. This 13 month calibration period was selected due to the extensive rainfall data and the extensive stream gage data. The period is also desirable due to the large number of storm events including a large storm event during October, 1996. Also, by using a recent period to calibrate the model, the model conditions will reflect existing conditions.

Flow calibration was conducted by comparing measured stream flows at the two USGS gages to the SWMM simulated flows. Both flow volume and peaks were considered.

Average daily measured stream flows were compared to average daily simulated flows. Hydrologic parameters were adjusted according to land use or HSG specific values to reproduce the stream flow volumes and peaks. The area weighted land uses parameters (DCIA, pervious depression storage and pervious overland Manning's "n") were adjusted by varying the land use specific parameters within accepted ranges. The area weighted soils parameters (maximum and minimum infiltration) were adjusted by varying the HSG specific parameters within accepted ranges. Watershed constant parameters (impervious depression storage, impervious overland Manning's "n" and infiltration decay rate) were adjusted equally over the entire watershed.

The above parameters were adjusted until simulated stream flow volumes were near measured flow volumes. Initially, the subbasin width was adjusted to simulate peak flows. This follows the calibration technique presented in the SWMM User's Manual (Huber, et al., 1988). By reducing the basin width, the calibration accounts for the high amounts of storage in upland and wetland features within the watershed. This storage slowly releases runoff from the relatively large subbasins simulated in the Black Creek Basin.

The above described calibration method tended to cause an over estimation of infiltration, and thus affect the volume calibration. A alternative method was sought. A method described by Brink (1994) was utilized. This calibration method involved the retention of the previously calculated subbasin widths and the insertion of a routing channel for each subbasin. This trapezoidal channel represents the subbasins internal routing that is not explicitly modeled by the SWMM model. The channel lengths were derived from the overland flow lengths determined for each subbasin. The channel width was used as a calibration parameter to reproduce the hydrograph shapes. It was not necessary to adjust hydraulic coefficients in the TRANSPORT Block.

Figures 4-18 through 4-21 illustrate the flow calibration results. Simulated flow volumes for the two USGS gage were simulated within 10 percent over the 13 month calibration period. The error for flow volume was 6.9% and -7.5% as measured at the USGS gages 02246000 and 02245500, respectively. The peak flood flows for the October 1996 event were simulated within -3% and 12% for the 02246000 and 02245500 gages, respectively. The average daily peak flow measured at the USGS gage 02246000 was 10,000 cfs and the simulated peak flow was 9,680 cfs. The average daily peak flow measured at the USGS gage 02245500 was 4,590 cfs and simulated peak flow was 4,590 cfs. Table 4-12 lists the final calibrated parameters of the Black Creek Basin.

The EXTRAN model was calibrated using the stages measured at four USGS gages throughout the Black Creek Watershed. The average daily stages as measured at the USGS gages; 02246025, 02246010, 02246000, and 0224550 (refer to Figure 3-7) were plotted verses the simulated stages at the appropriate EXTRAN Block nodes (refer to Figure 4-12) for the October 1996 storm event. This event was chosen since the EXTRAN Blocks is intended to simulate flood event stages for large synthetic storms. Calibration was achieved by adjusting Manning's "n" values (mainly for the overbanks). Figures 4-22 through 4-25 are the comparison calibration plots for the four gages. The flow as measured at the two available gages (02246000 and 02245500) and the simulated flow are plotted in Figures 4-26 and 4-27. The stage comparison is excellent at the downstream gages (02246025 and 02246010). Both the peak stage, shape and timing are accurately simulated. The simulated stages at the upstream gages (0224600 and 02245500) is not as favorable, however, it adequately simulates the time-stage series.

Figure 4-18

USGS Gage 02245500

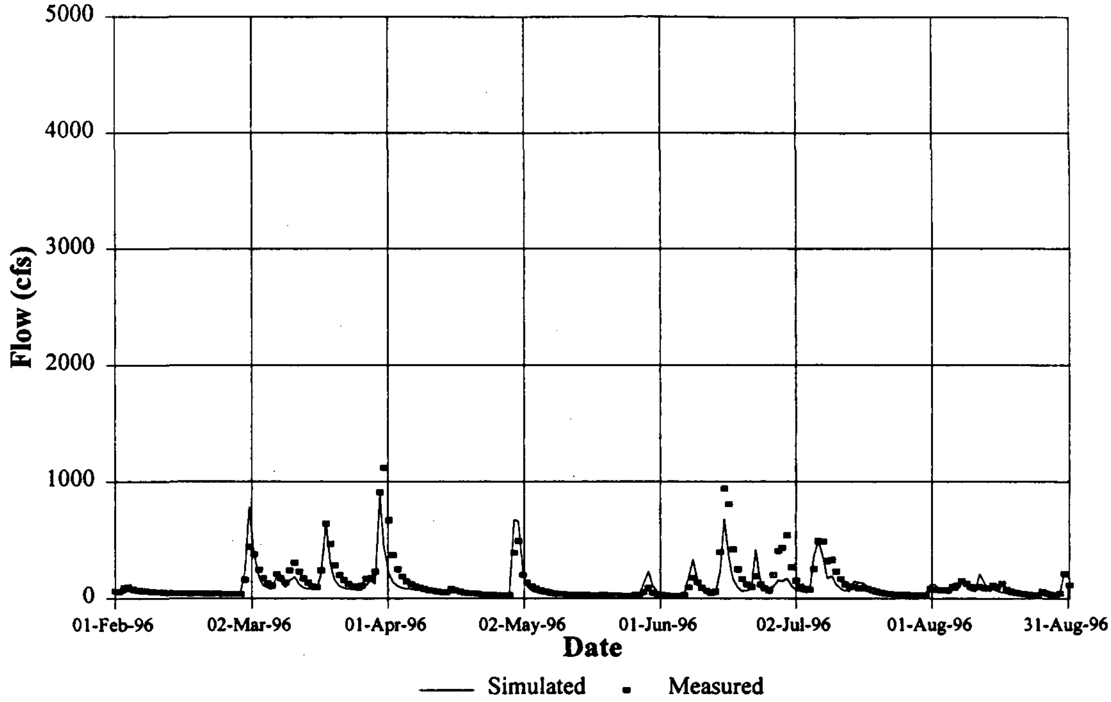


Figure 4-19

USGS Gage 02245500

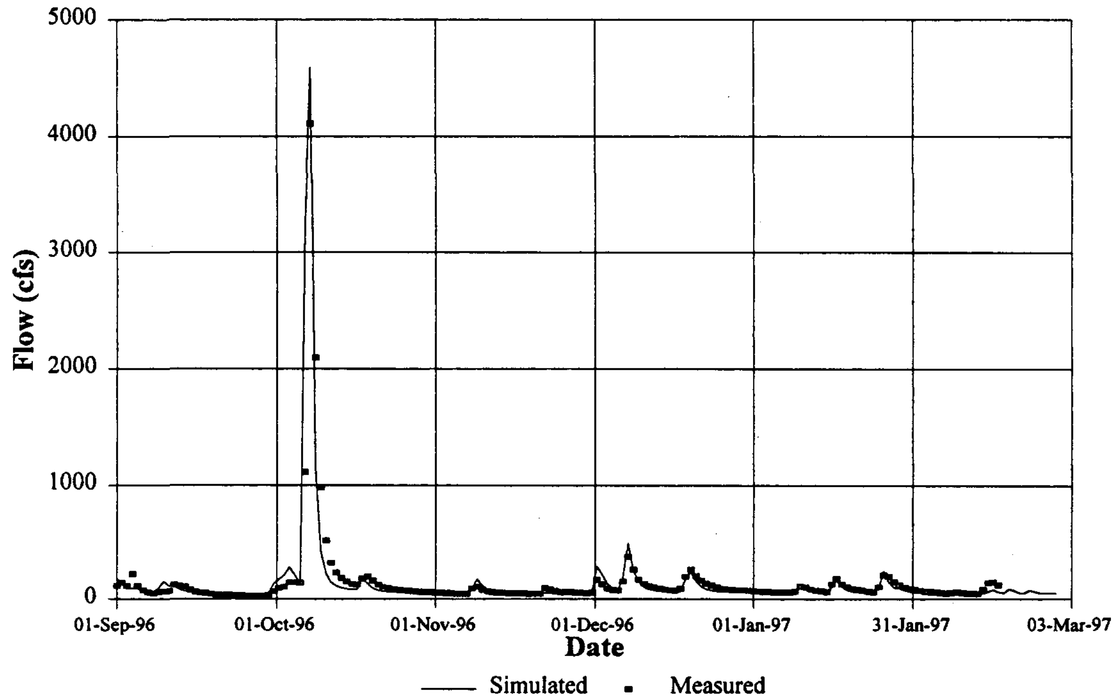


Figure 4-20

USGS Gage 02246000

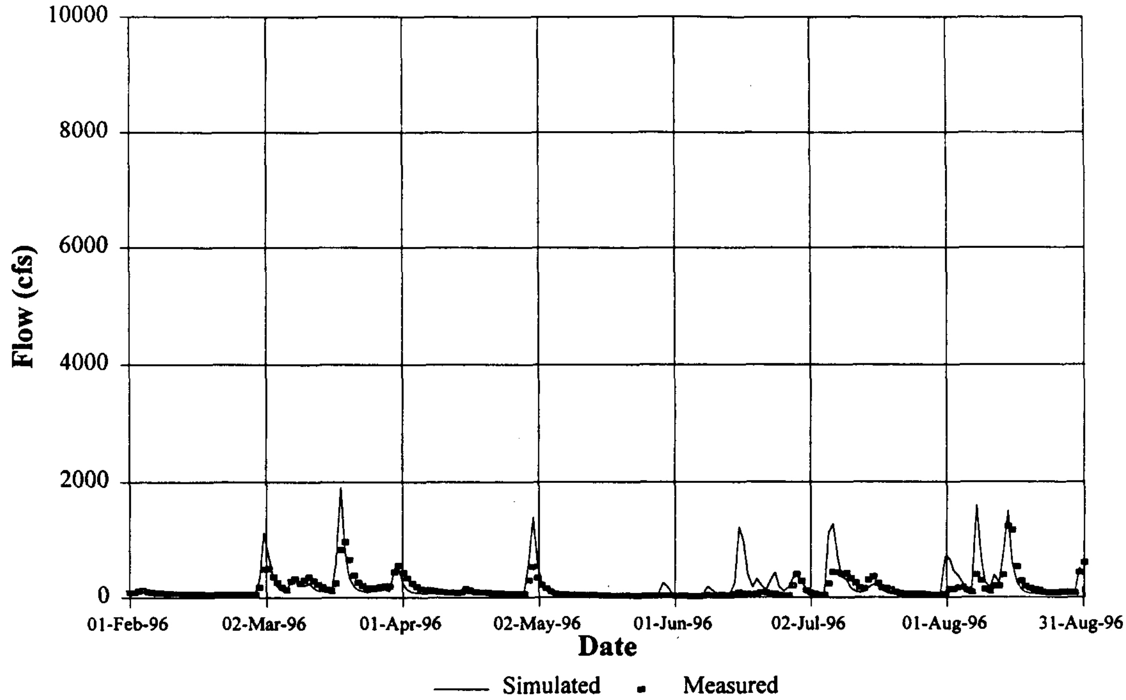


Figure 4-21

USGS Gage 02246000

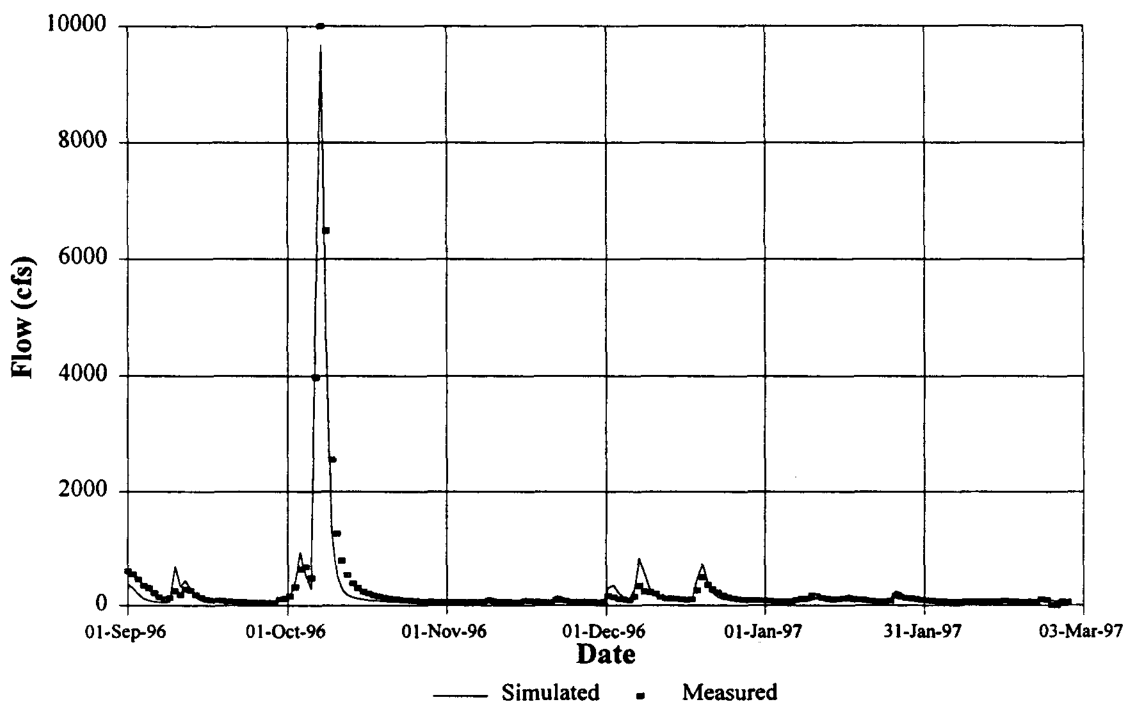


Figure 4-22

USGS Gage 02246025 - Extran Node 10020

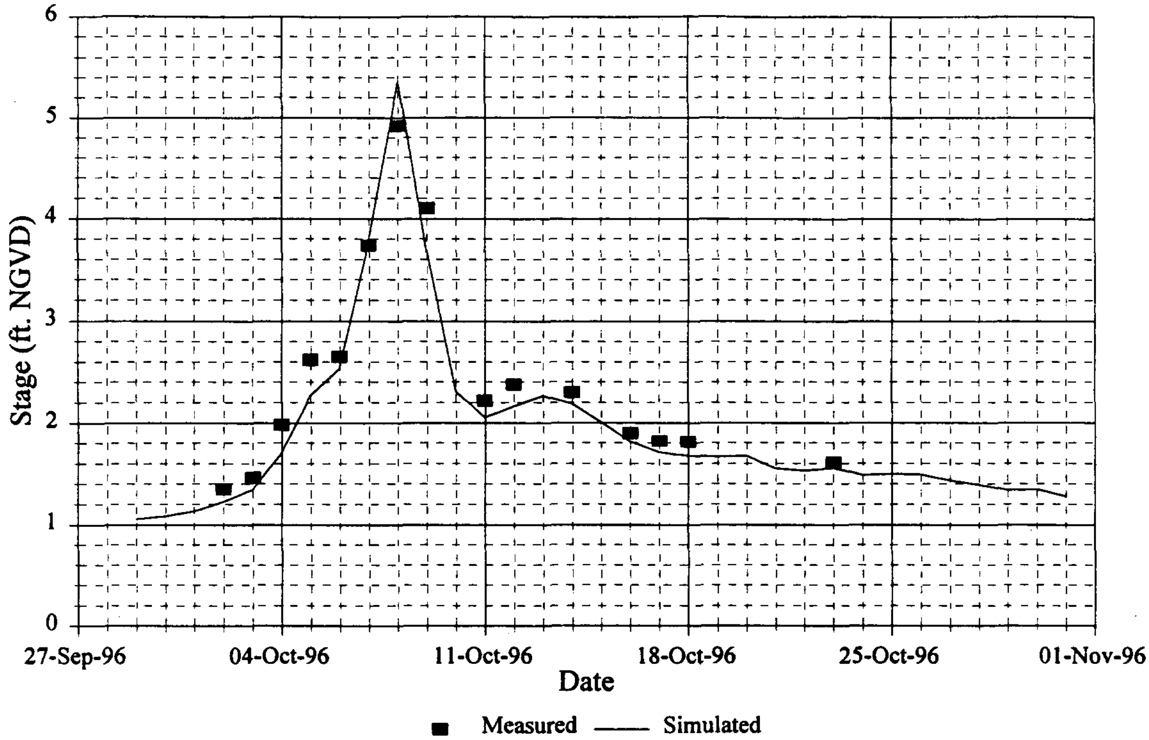


Figure 4-23

USGS Gage 02246010 - Extran Node 16004

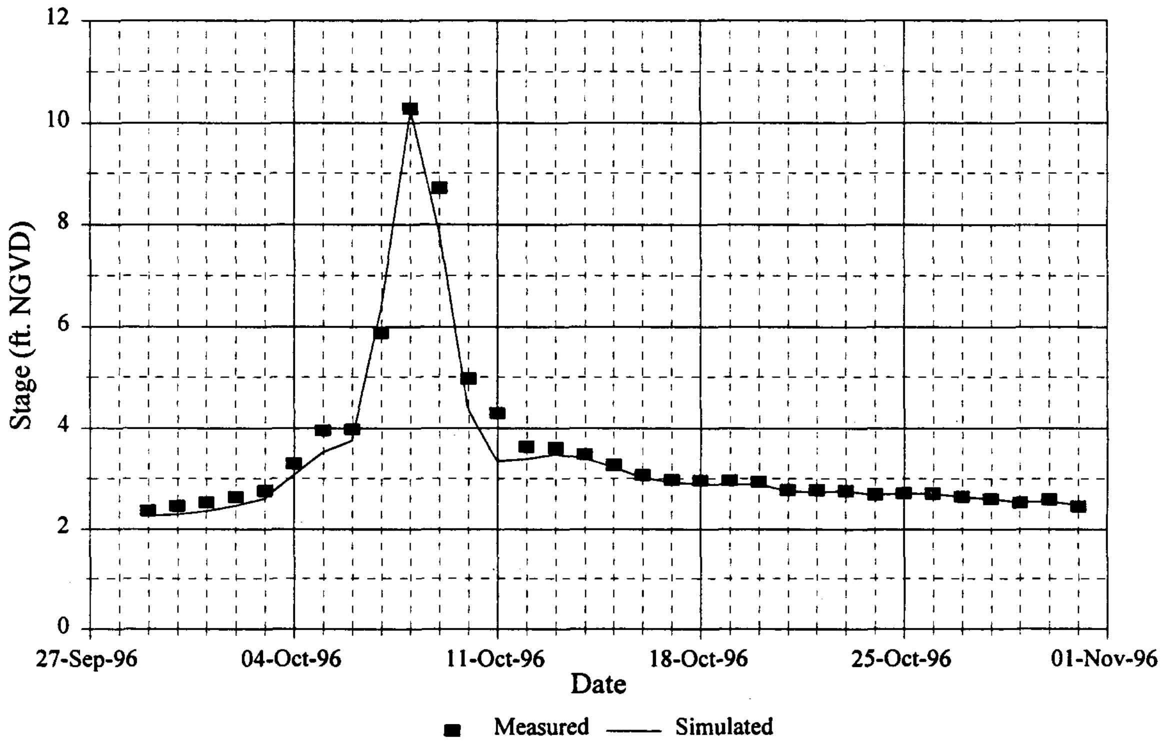


Figure 4-24

USGS Gage 02246000 - Extran Node 16014

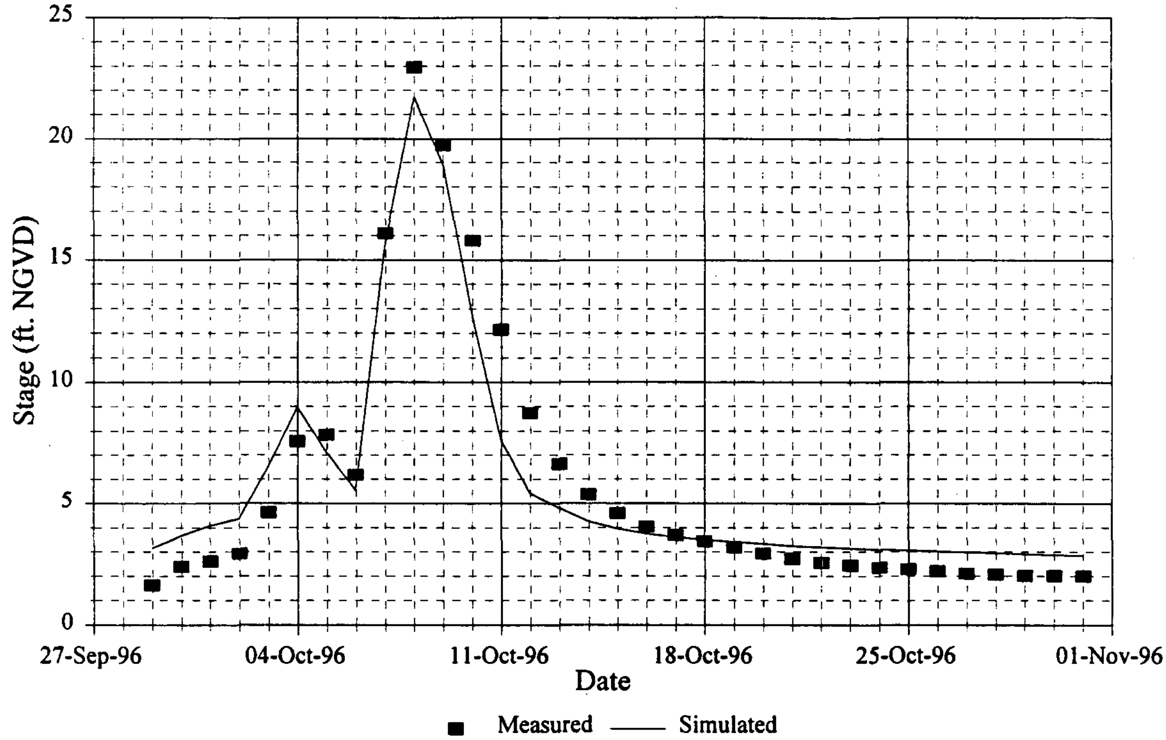


Figure 4-25

USGS Sta. 02245500 - Extran Node 26024

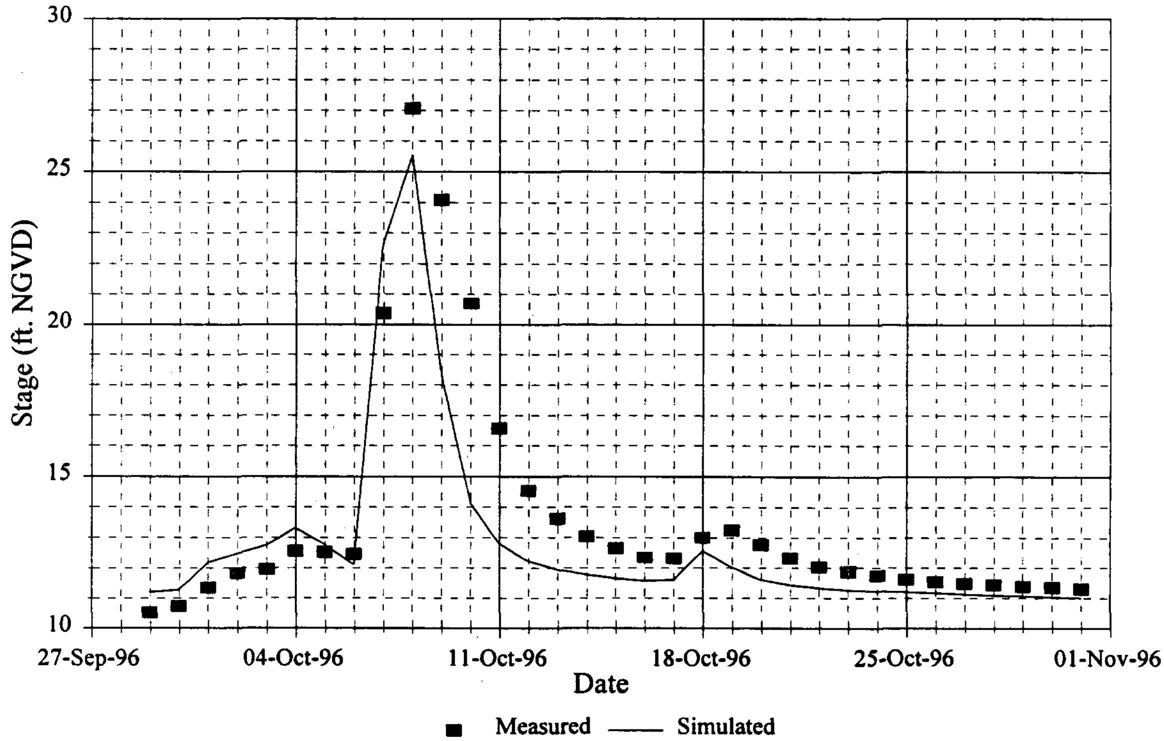


Figure 4-26

USGS Gage 02246000 - Extran Node 16014

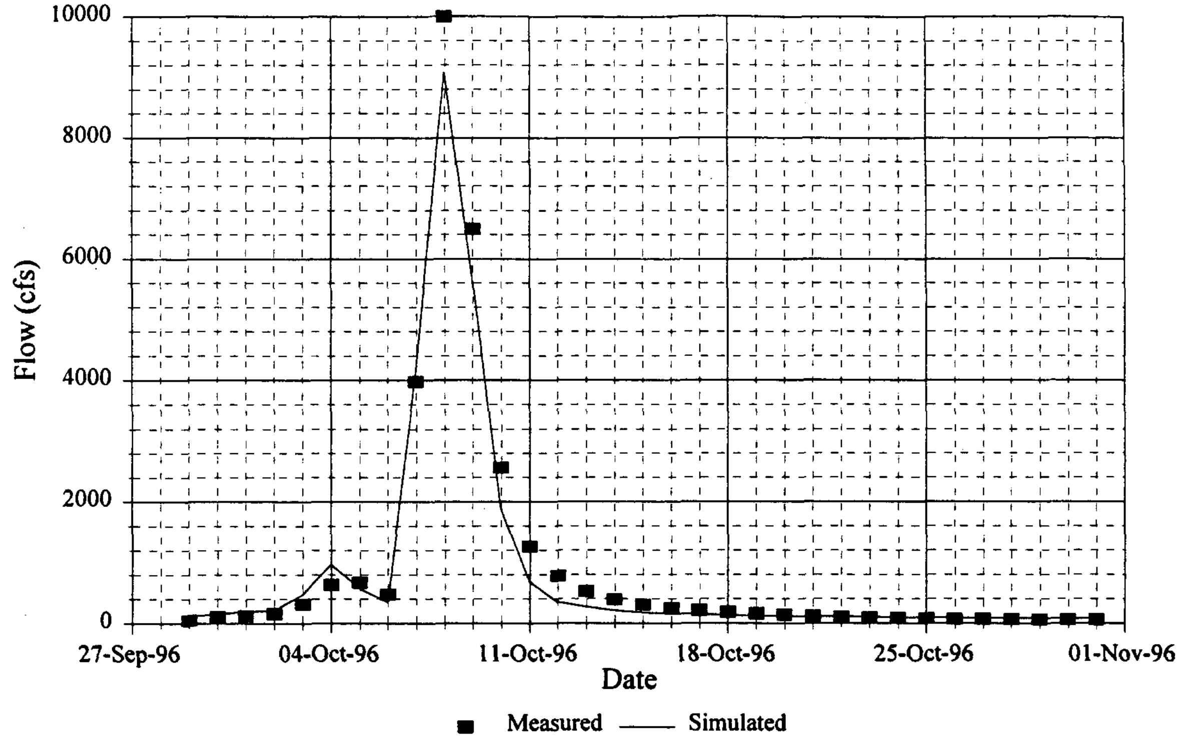


Figure 4-27

USGS Sta. 02245500 - Extran Node 26024

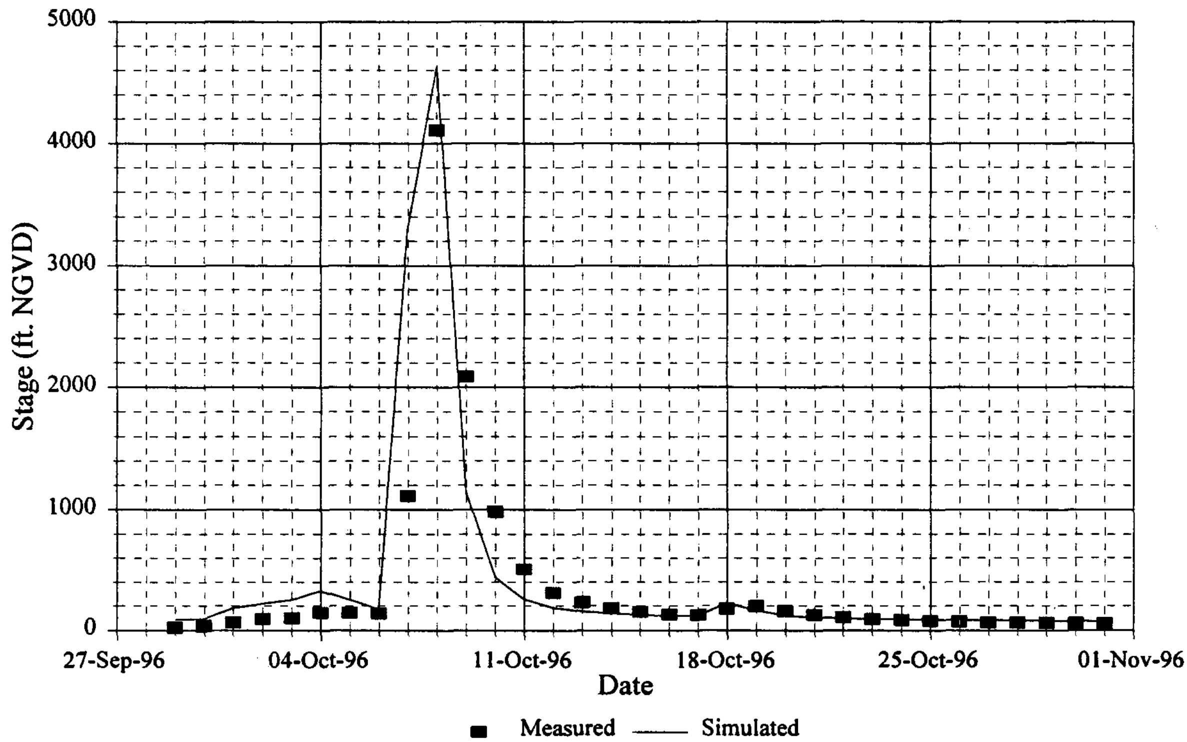


TABLE 4-12
Black Creek Basin Calibrated Parameters

Land Use	DCIA (%)	Pervious Manning's "n"	Pervious Depression Storage (in)
Residential	30	0.23	0.05
Commercial	45	0.23	0.05
Mining	25	0.23	0.10
Dairies/Pastures	10	0.23	0.10
Crops	10	0.23	0.08
Natural: Forest	10	0.30	0.10
Natural: Open/Shrub	10	0.30	0.10
Tree Plantation	10	0.38	0.10
Forest Regeneration	10	0.40	0.10
Water/Wetlands	100	0.28	0.20
HSG	**Maximum Infiltration (in/hr)**	**Minimum Infiltration (in/hr)**	**Decay Rate (1/sec)**
A	1.40	0.10	0.00139
B	1.20	0.09	
C	0.80	0.03	
D	0.30	0.008	
Impervious Manning's "n"			0.065
Impervious Depression Storage (in)			0.01

4.2.3 Synthetic Storm Simulation

The three synthetic storm events were simulated using the calibrated SWMM model. The changes in input necessary for the simulation were rainfall data and tailwater condition. The rainfall data were the time series rainfall amounts in 15 minute increments for the 10-, 25- and 100-year, 24-hour storm events. The tailwater conditions were derived from the *Flood Insurance Study - Clay County, Florida* (FEMA, 1992). The predicted peak stages of the St. Johns River at the mouth of Black Creek were scaled from the flood profile panel for the River. Peak stages were available for the 10- and 100-year, 24-hour storm events. The 25-year, 24-hour peak stage was interpolated from the other peak stage data. The tailwater conditions were simulated as constant for the entire length of the storm event simulation. The tailwater elevations used were 2.50, 4.20 and 5.00 ft. NGVD for the 10-, 25-, and 100-year, 24-hour storm events, respectively. Table 4-13 is a list of predicted peak stages for the three storm events at nodes throughout the basin. Refer to Figure 4-12 for node locations.

The results of the synthetic storm simulation were compared to those reported in the *Flood Insurance Study - Clay County, Florida* (FEMA, 1992). FEMA used the U.S. Army Corps of Engineers HEC-1 and HEC-2 models to analyze peak flood stages. The HEC-1 model is used to simulate the hydrology of the watershed, while HEC-2 is used to simulate the hydraulics of the stream network. HEC-2 is a non-dynamic model, only simulating the peak flow condition. Table 4-14 is a comparison of the results of the two studies. A comparison of the 10- and 100-year storm events was made. The FEMA study did not analyse a 25-year storm event, therefore, it was not included in the comparison. In most cases, the SWMM simulated results are lower than the FEMA study results. There are many reasons that the SWMM results may be lower than the FEMA results. The most significant reason for the lower flows and stages is the difference in rainfall amounts. For the 100-year, 24-hour storm event, the FEMA study utilized a rainfall depth of 14 inches while this study only used 10.50 inches. Another reason for the lower flows in SWMM is that SWMM will account for the timing of the runoff hydrographs within the watershed , partially dampening the peak flows. HEC-2 does not account for timing of hydrographs and will impose peak flows on other peak flows that may actually be shifted in time (i.e. HEC-2 assumes that all peak flows are occurring simultaneously within the watershed). However, the two models (SWMM and HEC) do appear to accurately predict peak flows and stages throughout the creek system.

4.3 Water Quality Modeling

4.3.1 Model Framework

The water quality modeling of the Black Creek Basin utilized the RUNOFF and TRANSPORT blocks of the SWMM model. The RUNOFF Block was used to simulate the pollutant wash-off processes for the five following constituents; total nitrogen (TN), total phosphorous (TP), total suspended solids (TSS), lead (Pb), and zinc (Zn). The simulation of stormwater quality simulation in the RUNOFF Block was accomplished using land use specific rating curves (Equation 4-2) for each constituent. The amount of pollutant washed off as specified by the rating curve method is mod_ 16042 25yr ? 100yr.

TABLE 4-13
Black Creek Basin Predicted Flood Elevations

Node	Storm Event			Node	Storm Event			Node	Storm Event		
	10-Yr. 24-Hr.	25-Yr. 24-Hr.	100-Yr. 24-Hr.		10-Yr. 24-Hr.	25-Yr. 24-Hr.	100-Yr. 24-Hr.		10-Yr. 24-Hr.	25-Yr. 24-Hr.	100-Yr. 24-Hr.
10000	2.50	4.20	5.00	16009	17.85	19.70	21.57	19004	51.49	52.22	52.87
10002	2.50	4.28	5.49	16010	19.83	21.82	23.84	19006	51.63	52.49	53.36
10004	2.71	4.50	5.34	16012	21.11	22.99	24.99	19008	74.01	74.57	75.16
10006	3.02	4.83	5.90	16014	21.63	23.56	25.55	19010	79.20	83.92	81.07
10008	3.33	5.18	6.37	16016	26.34	28.47	30.72	20000	74.22	74.62	74.94
10009	3.55	5.52	6.84	16018	26.60	28.74	30.99	20002	77.21	77.43	80.13
10010	4.09	6.06	7.50	16019	29.15	30.90	33.30	26000	11.24	13.38	15.60
10012	4.09	6.06	7.50	16020	42.36	43.57	45.21	26001	12.45	14.64	16.88
10014	4.29	6.31	7.82	16022	51.10	52.17	53.60	26002	12.48	14.67	16.92
10016	4.97	6.96	8.70	16024	58.09	58.80	59.69	26004	13.73	16.03	18.36
10017	5.21	7.31	9.16	16026	60.37	60.97	61.85	26006	14.56	16.76	19.01
10018	5.43	7.56	9.47	16028	64.63	65.13	65.83	26008	15.91	18.07	20.29
10020	5.53	7.67	9.59	16030	64.68	65.20	65.90	26010	17.26	19.39	21.58
10021	5.87	8.03	10.02	16031	70.67	71.13	71.76	26011	20.75	22.66	24.61
10022	6.58	8.74	10.83	16032	79.72	80.30	81.08	26012	24.64	26.33	27.99
10026	7.47	9.63	11.83	16034	83.19	83.53	84.00	26014	25.72	27.36	28.95
10028	8.35	10.49	12.74	16036	86.84	87.08	87.39	26016	27.36	28.98	30.49
12000	4.31	6.32	7.84	16038	87.02	87.24	87.53	26018	28.13	29.72	31.41
12002	4.31	6.32	7.84	16040	88.54	88.82	89.17	26020	29.67	31.13	32.64
12003	9.06	9.88	10.76	16041	89.89	90.15	90.47	26022	30.10	31.51	32.97
12004	26.58	27.25	27.79	16042	91.85	93.72	92.98	26024	30.12	31.53	32.99
12006	26.58	27.25	27.80	17002	8.35	9.63	11.83	26026	31.71	32.98	34.22
13000	5.47	7.41	9.36	17004	8.35	9.63	11.83	26028	37.43	38.61	39.23
13001	5.87	7.76	10.34	17006	14.14	14.79	15.42	27000	17.61	19.71	21.96
13002	5.87	7.76	9.85	17008	14.21	15.01	15.59	27002	17.85	19.89	22.12
13004	9.11	10.07	11.21	17010	9.17	11.29	13.63	27004	19.18	20.50	22.51
13006	9.12	10.08	11.22	17012	9.18	11.31	13.66	27006	20.37	21.64	23.20
13008	9.12	10.09	11.22	17014	11.80	12.51	13.69	27008	22.35	23.08	24.23
13010	9.19	10.17	11.32	17016	16.90	17.16	17.45	27010	22.36	23.09	24.24
13012	9.21	10.19	11.35	17018	17.69	20.37	20.65	27012	23.82	24.83	25.92
13013	9.88	10.19	11.35	18000	10.92	12.90	15.15	27014	32.42	33.20	34.06
13014	32.30	32.58	32.87	18002	10.92	12.90	15.15	27016	37.94	38.62	39.40
13016	129.10	128.99	127.72	18003	16.03	16.54	17.07	27018	38.00	38.67	39.45
14000	23.18	23.96	23.68	18004	16.04	16.55	17.10	27020	43.09	43.81	44.68
14002	23.19	23.99	23.73	18005	35.65	36.02	36.39	27022	51.82	52.20	52.62
16000	9.12	11.28	13.62	18006	35.66	36.03	36.41	28000	24.54	25.25	26.02
16002	9.60	11.79	14.20	18007	59.86	60.05	60.23	28002	24.74	25.56	26.48
16004	9.62	11.81	14.22	18008	60.35	60.82	61.47	28004	46.67	47.36	48.10
16006	10.92	12.90	15.15	19000	35.07	35.76	36.38	28006	46.68	47.37	48.12
16008	14.39	16.36	18.46	19002	45.94	46.70	47.51				

TABLE 4-14
Black Creek Basin Flood Studies Comparison

Location	Peak Discharge (cfs)				Peak Stage (ft. NGVD)			
	10-year		100-year		10-year		100-year	
	SWMM	HEC	SWMM	HEC	SWMM	HEC	SWMM	HEC
Black Creek								
Mouth	27,200	24,471	43,500	46,359	2.50	2.50	5.00	5.10
D/S of Little Black Crk.	22,000	22,800	34,100	46,800	5.21	4.60	8.70	9.00
CR 209	21,900	20,400	34,500	43,200	5.43	5.60	9.59	11.00
North/South Fork Confluence	20,100	20,100	33,800	42,700	8.35	8.60	12.74	15.20
North Fork of Black Creek								
Mouth	9,830	9,420	16,700	19,120	8.35	8.75	12.74	15.20
CR 21	9,610		16,300		9.62	9.50	14.22	16.30
Yellow Water Crk. Confluence	8,930	9,280	15,500	18,080	26.60	23.90	30.99	28.50
Long Branch Confluence	5,290	5,680	11,500	11,070	42.36	38.90	46.21	41.30
CR 16	3,410	3,120	5,600	6,250	64.63	65.30	65.90	67.90
South Fork of Black Creek								
Mouth	12,800	11,800	20,200	26,000	8.35	8.75	12.74	15.20
CR 218	13,100		20,600		12.48		16.92	
Bull Creek Confluence	12,800		19,900		17.26		21.58	
CR 16	9,840		13,100		30.12		32.99	

only a function of the rate of runoff. In addition, water quality values were generated using an "enhanced" option that specifies the quality of runoff as dependent upon the percentage of the aggregated land uses within each subbasin. The TRANSPORT Block was utilized to simulate the routing of the pollutants. It was assumed that no in-stream decay of pollutant concentrations occur.

4.3.2 Model Calibration

The resulting in-stream pollutant concentrations were compared to measured values at the following five water quality sampling locations; North Fork Black Creek (NBC), South Fork Black Creek (BSF), Black Creek at Rideout Landing (BLC), Peters Creek at County Road 209 (PTC), and Peters Creek (PCRHR). The calibration simulation period was for the year 1995. This period was chosen due to the large amount of measured water quality data as compared to the water quantity calibration simulation period (February 1, 1996 - February 28, 1997).

SWMM model produced large variations on a day to day basis as storm events are simultaneously applied across the watershed and the stream flow varied between flood flows and low flows. As a visual aid, a 60-day moving average was applied to the simulation results to show water quality trends.

The land-use specific wash-off coefficients (RCOEFF) were varied until the simulated pollutants closely reproduced the measured data. The runoff exponent (WASHPO) were held constant, with a few exceptions. The runoff exponent was held constant for an individual pollutant. That is, the runoff exponent is the same for each land-use rating curve for a particular pollutant.

The resulting calibration plots are included in Figures 4-28 through 4-52. Although not all measured concentrations are simulated accurately, the general concentrations and trends are reproduced in most cases. Errors in the simulation results may be caused by localized watershed or rainfall conditions not accurately reflected in the model. The calibrated model input variables are included in Table 4-15.

Figure 4-28

Station: BLC Node: 10020

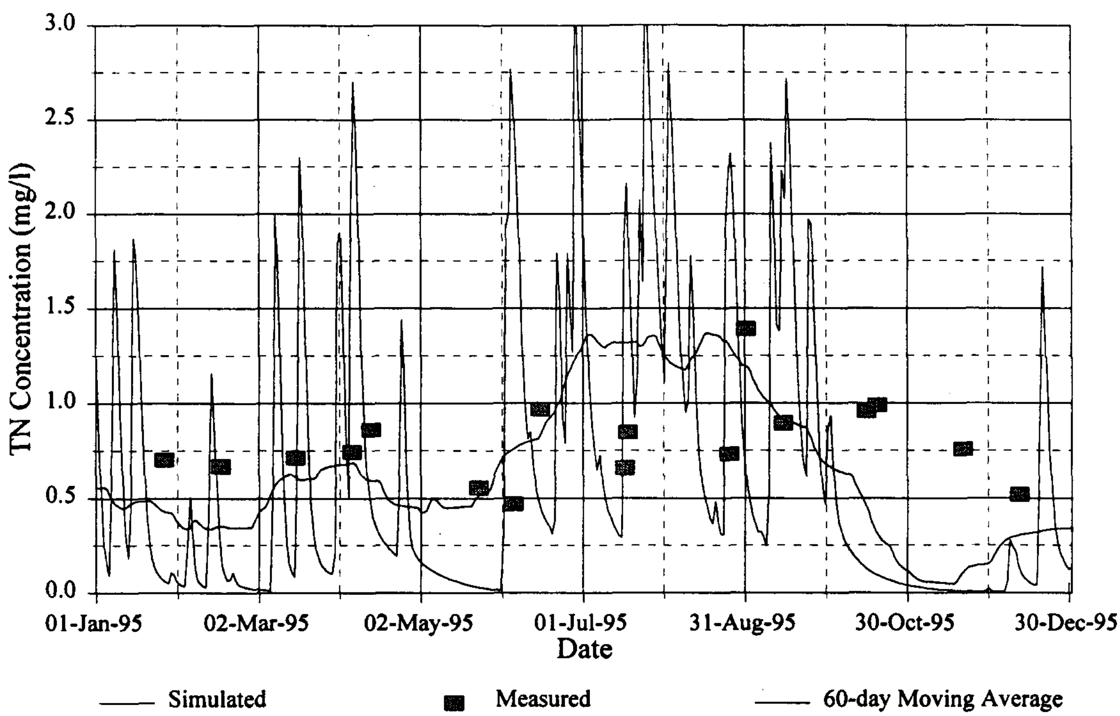


Figure 4-29

Station: PTC Node: 11003

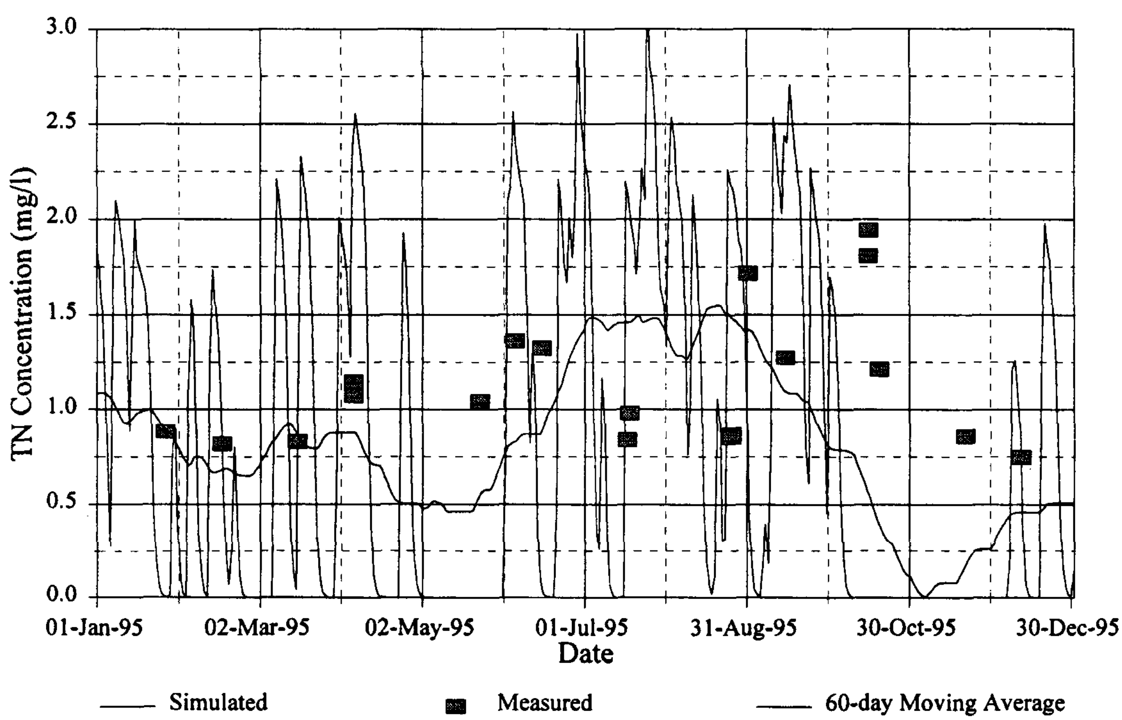


Figure 4-30

Station: PCRHR Node: 11008

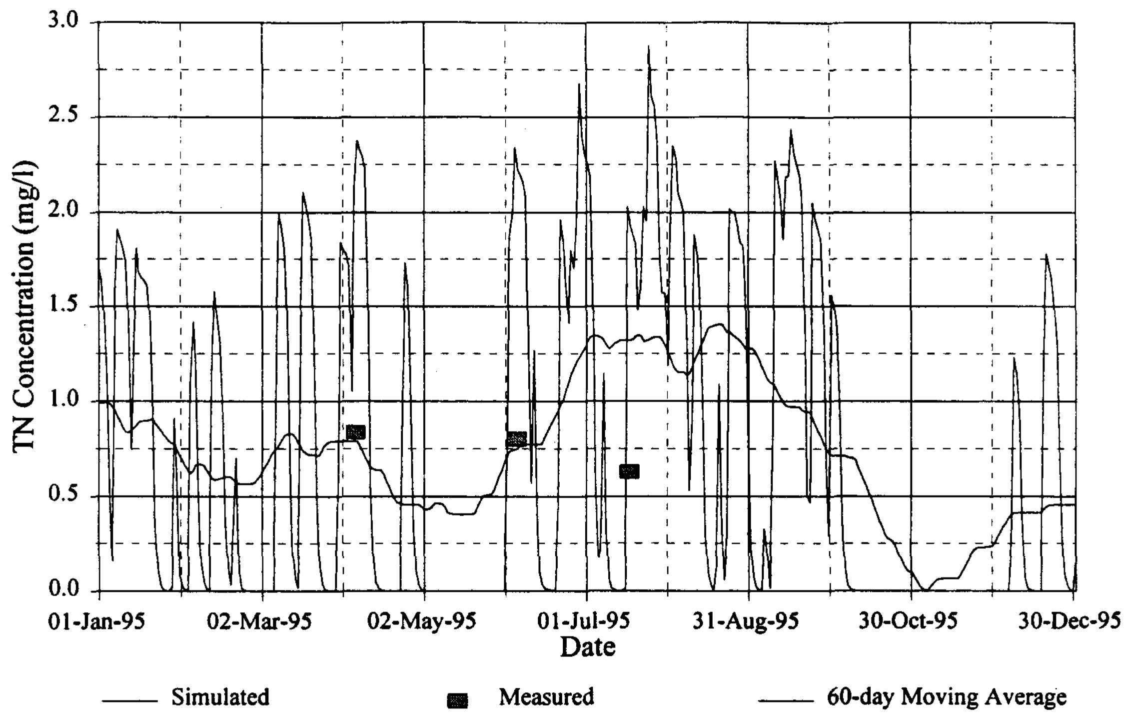


Figure 4-31

Station: NBC Node: 26000

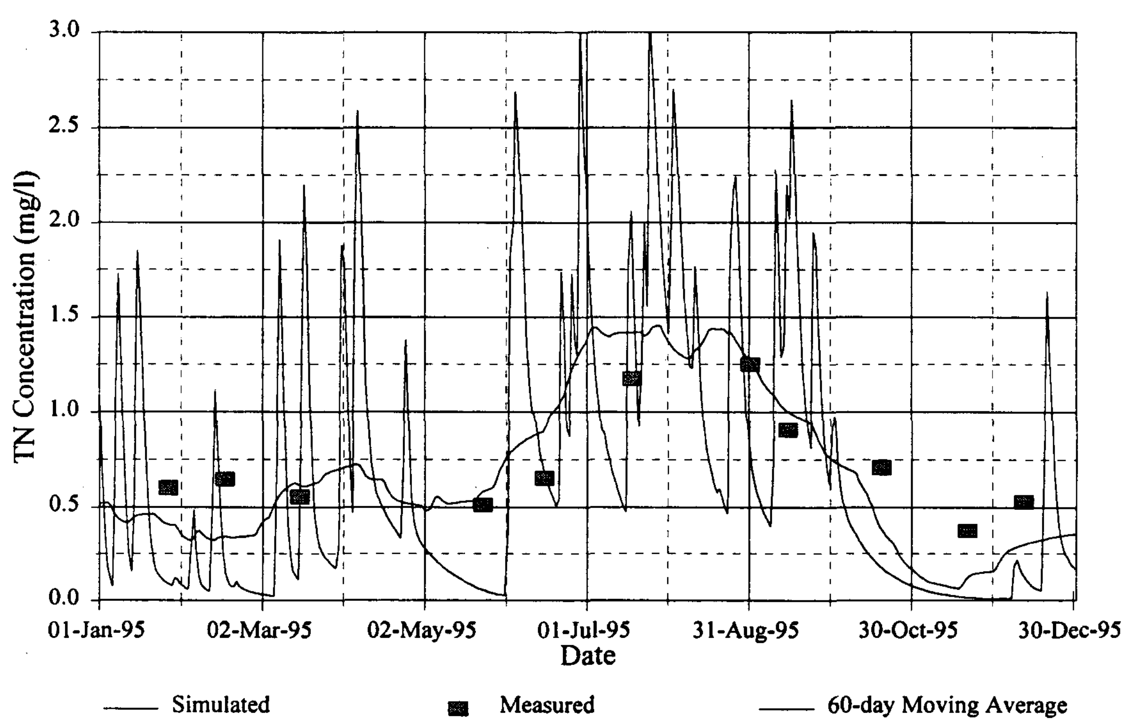


Figure 4-32

Station: BSF   Node: 26002

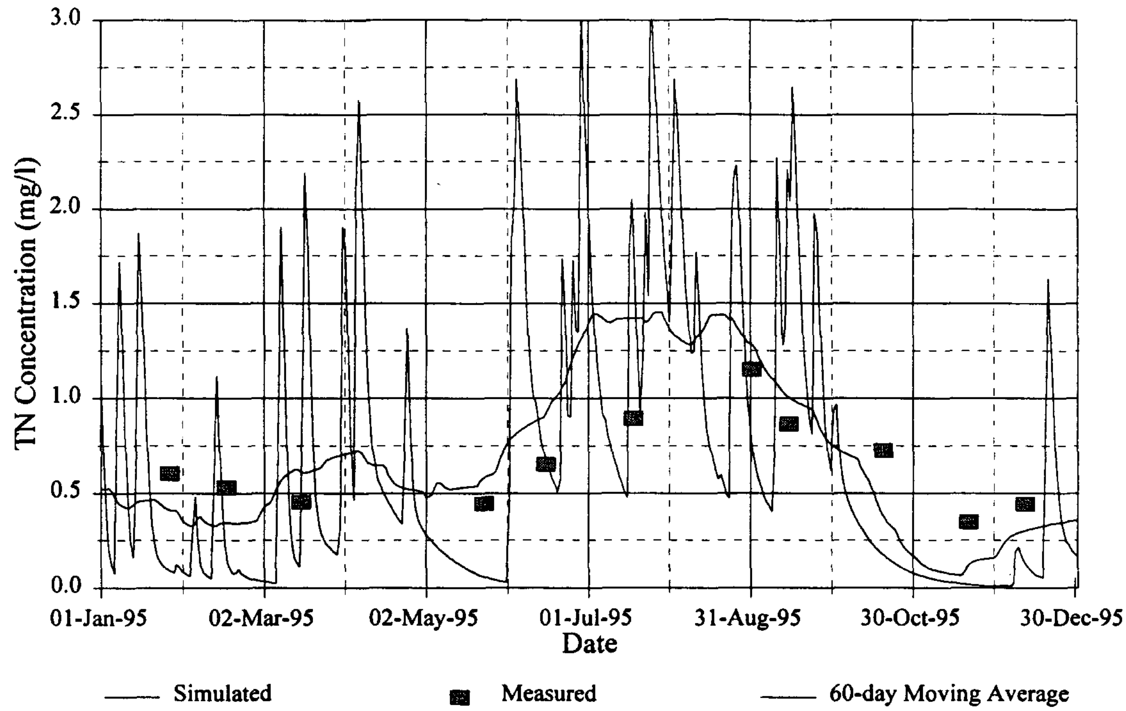


Figure 4-33

Station: BLC Node: 10020

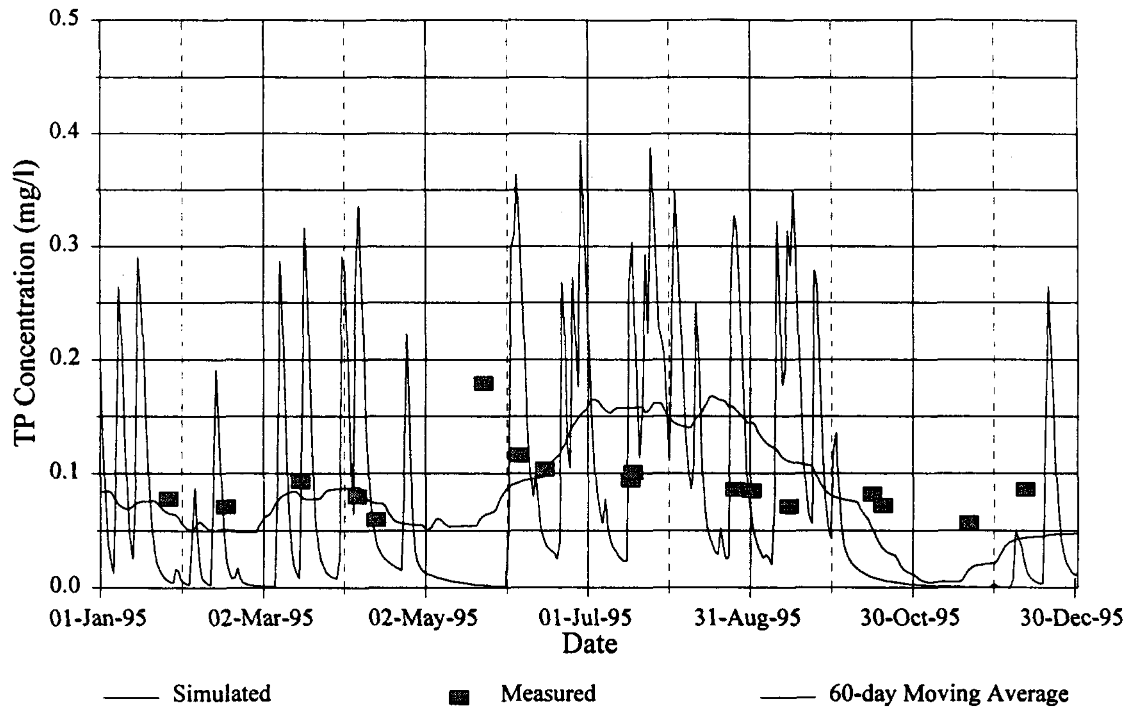


Figure 4-34

Station: PTC Node: 11003

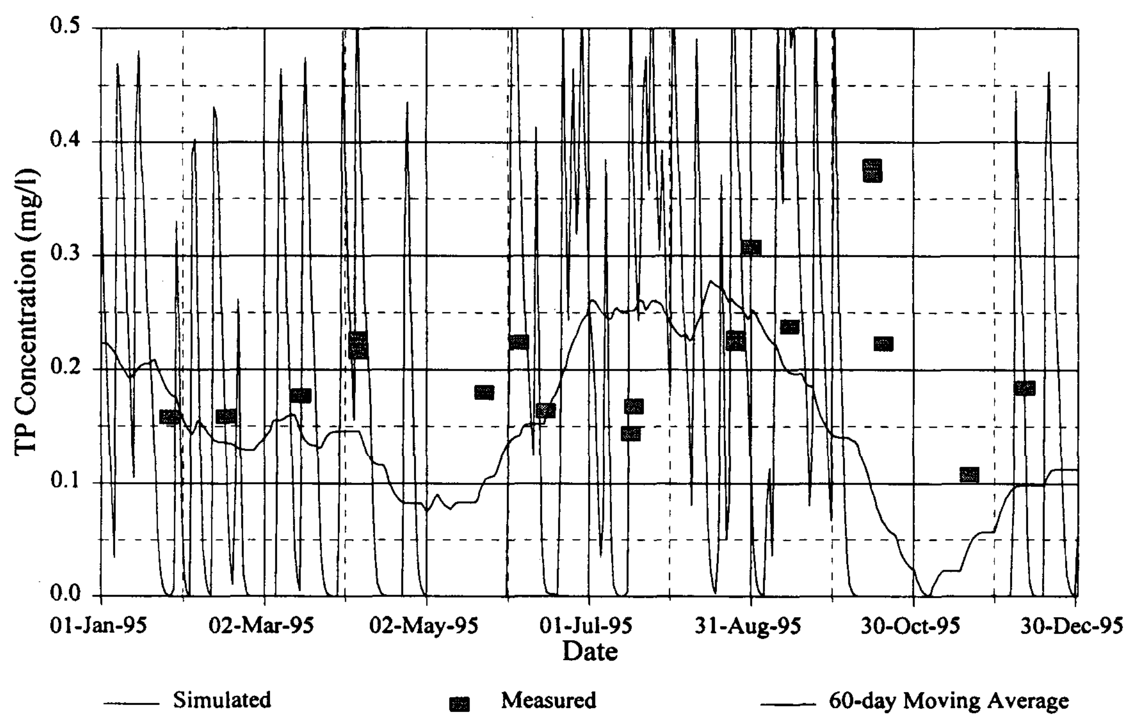


Figure 4-35

Station: PCRHR Node: 11008

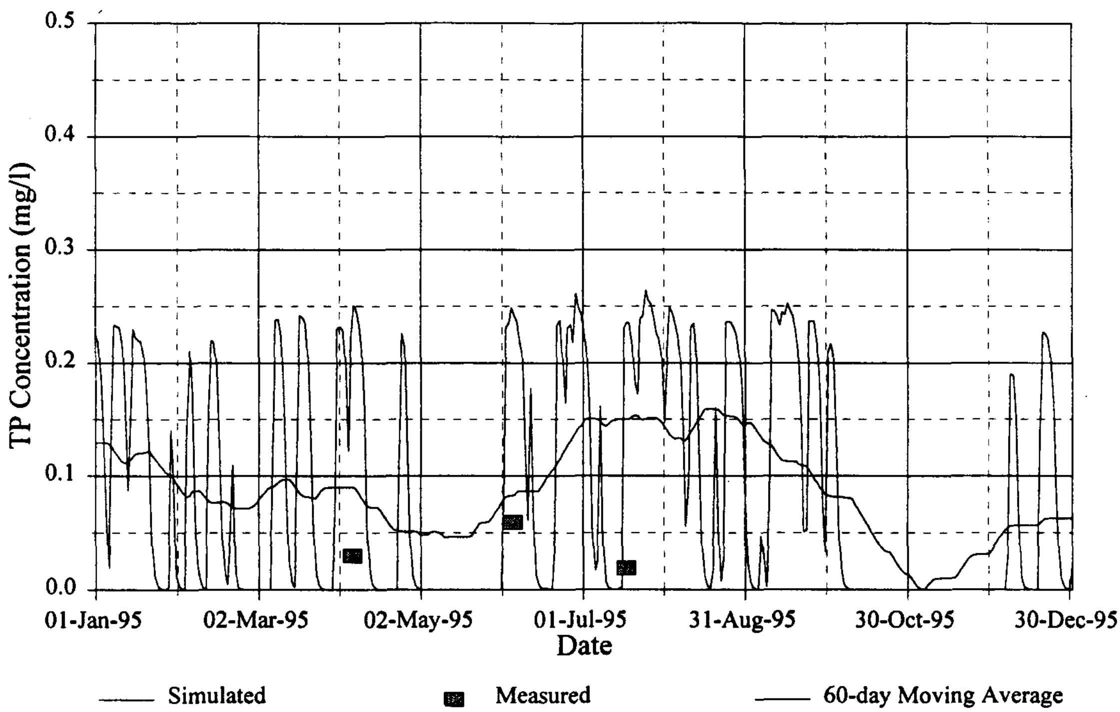


Figure 4-36

Station: NBC Node: 26000

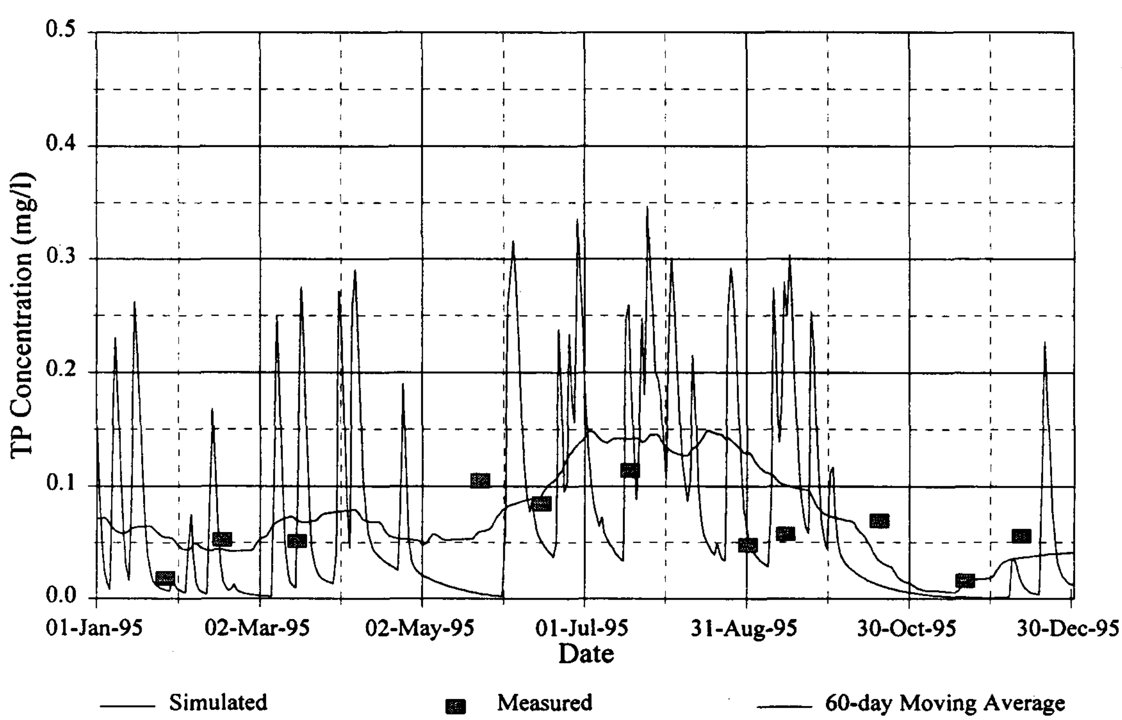


Figure 4-37

Station: BSF Node: 26002

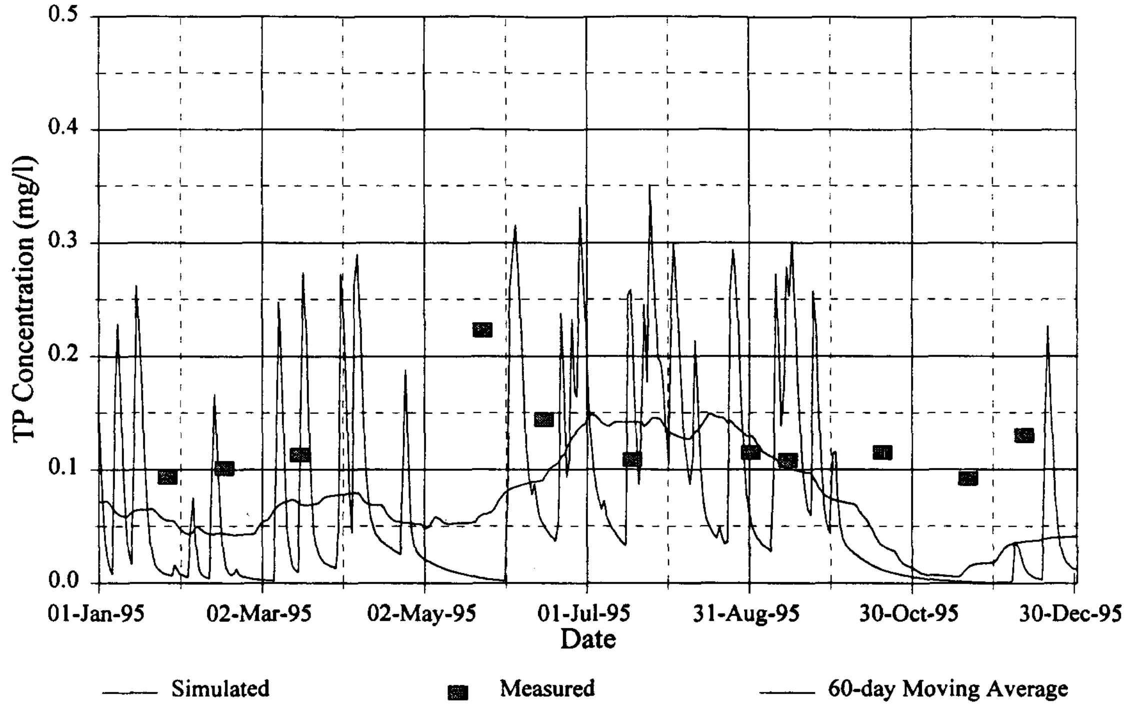


Figure 4-38

Station: BLC Node: 10020

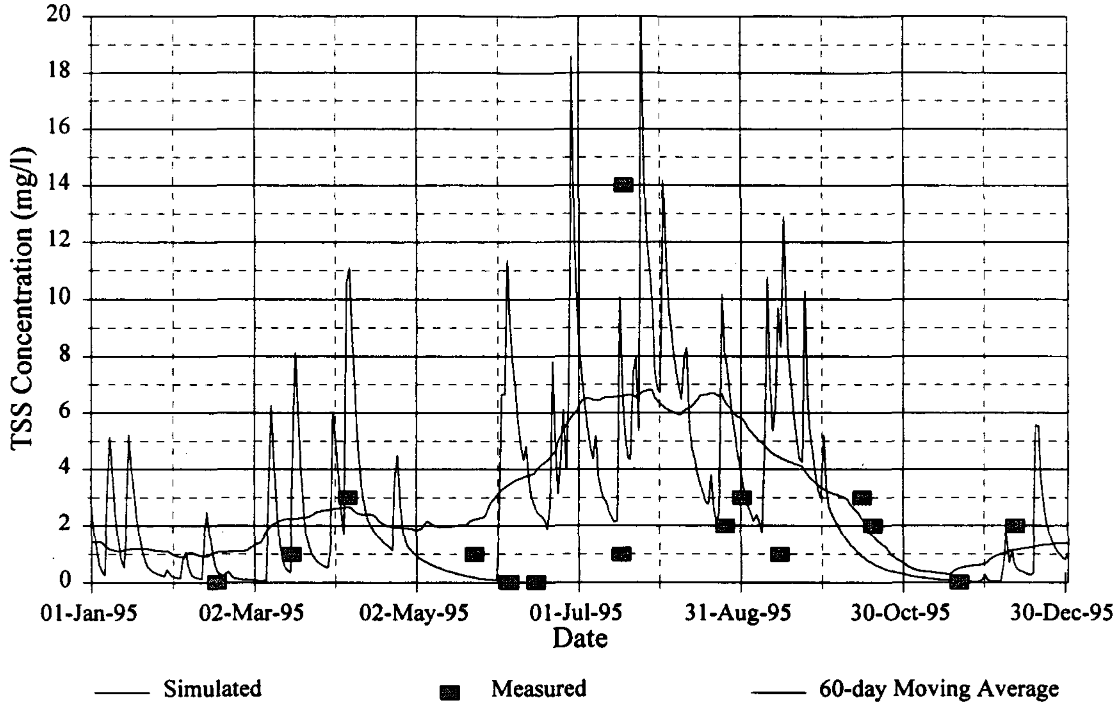


Figure 4-39

Station: PTC Node: 11003

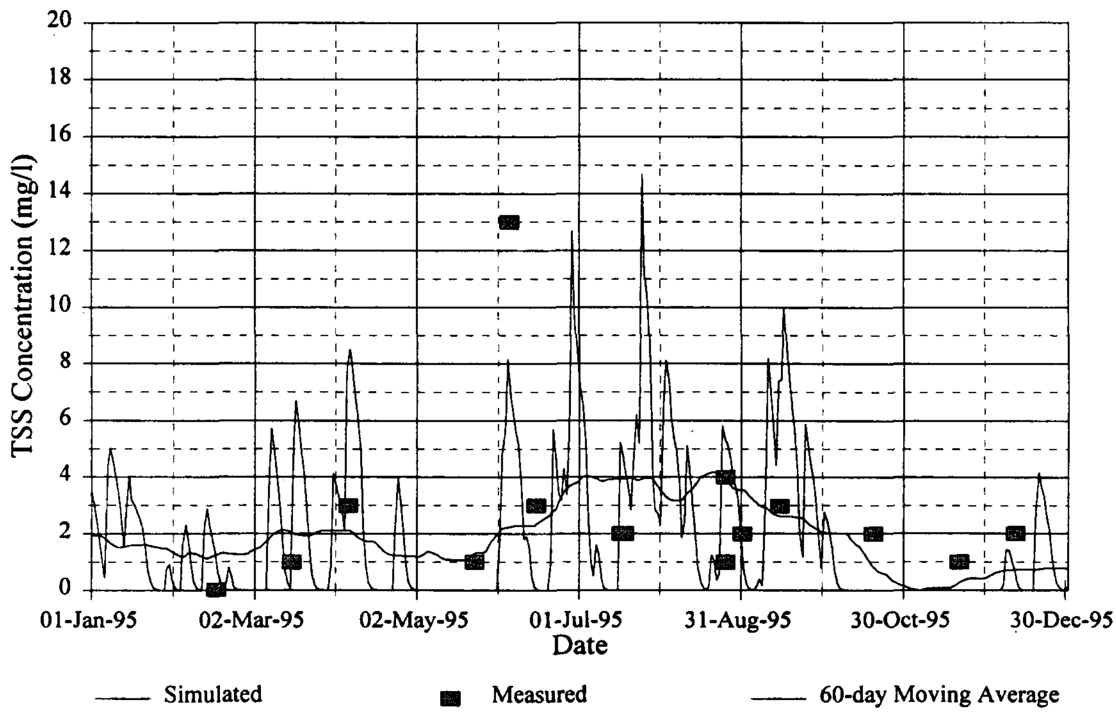


Figure 4-40

Station: PCRHR Node: 11008

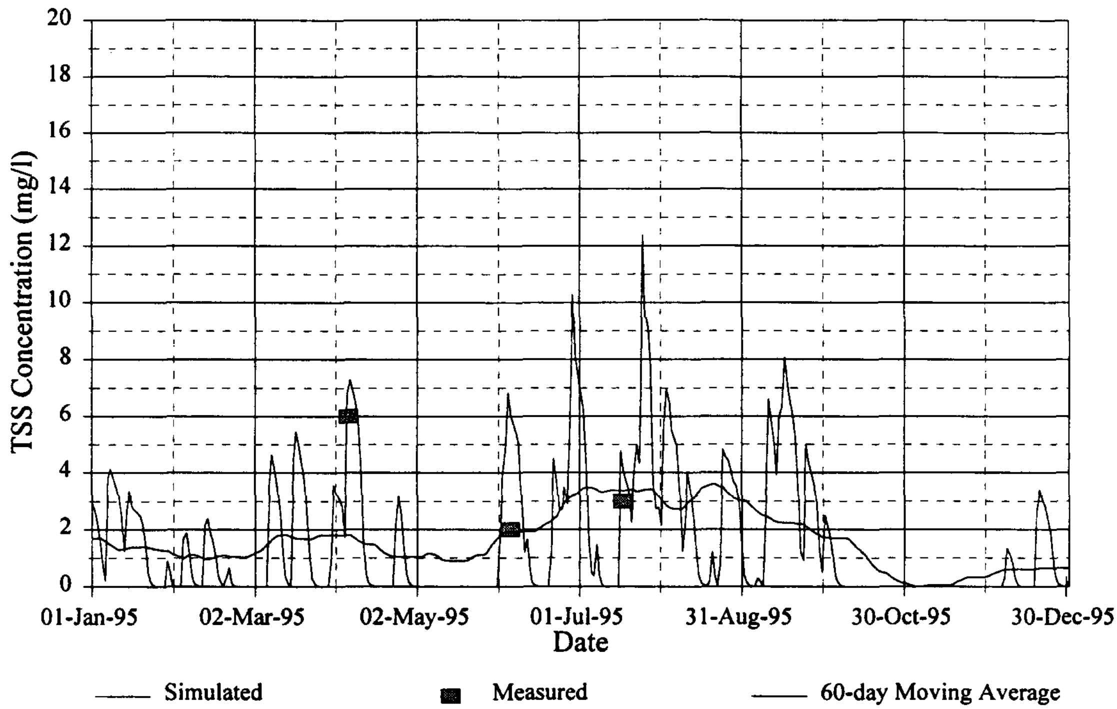


Figure 4-41

Station: NBC Node: 26000

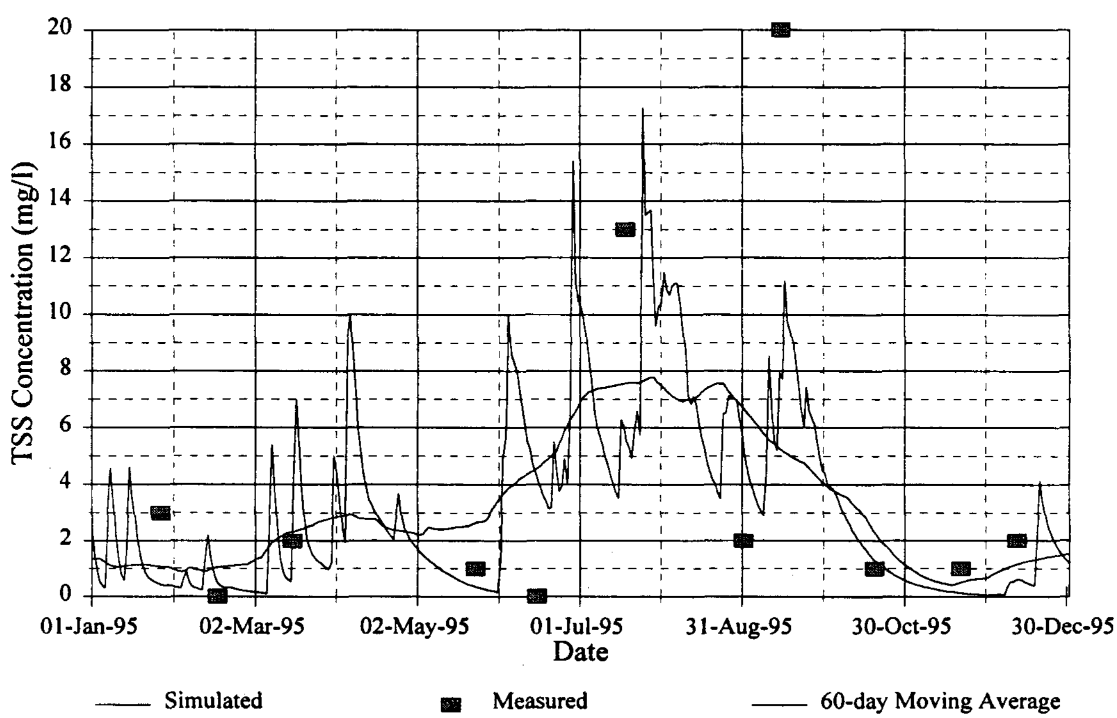


Figure 4-42

Station: BSF Node: 26002

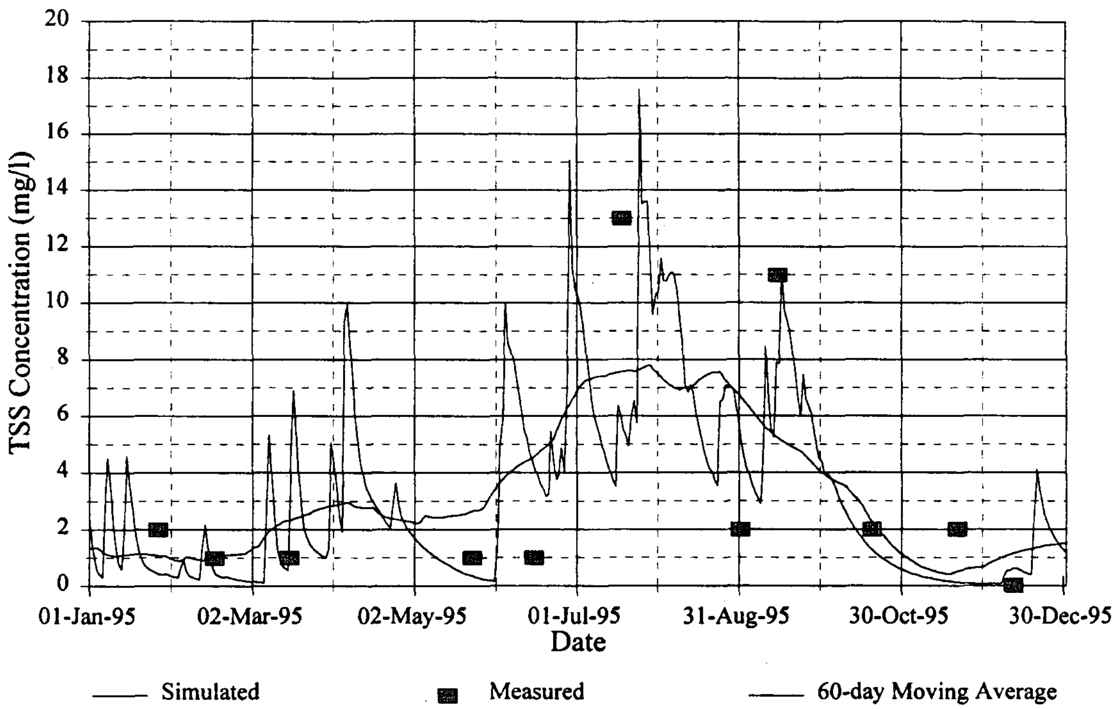


Figure 4-43

Station: BLC Node: 10020

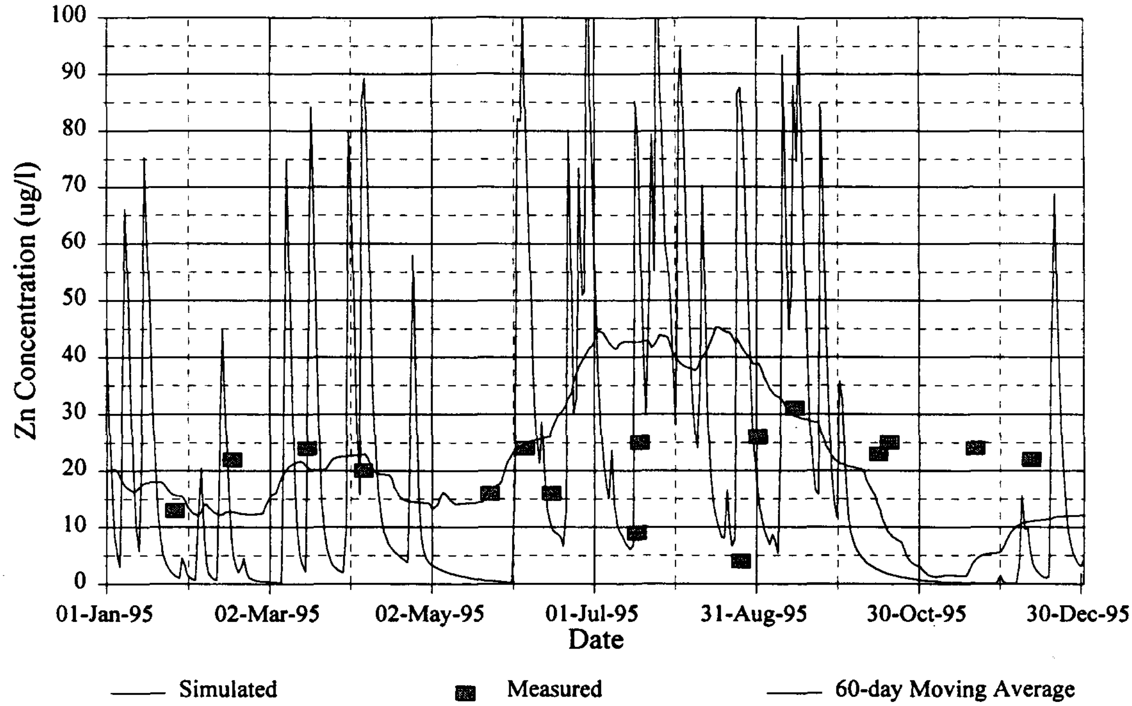


Figure 4-44

Station: PTC Node: 11003

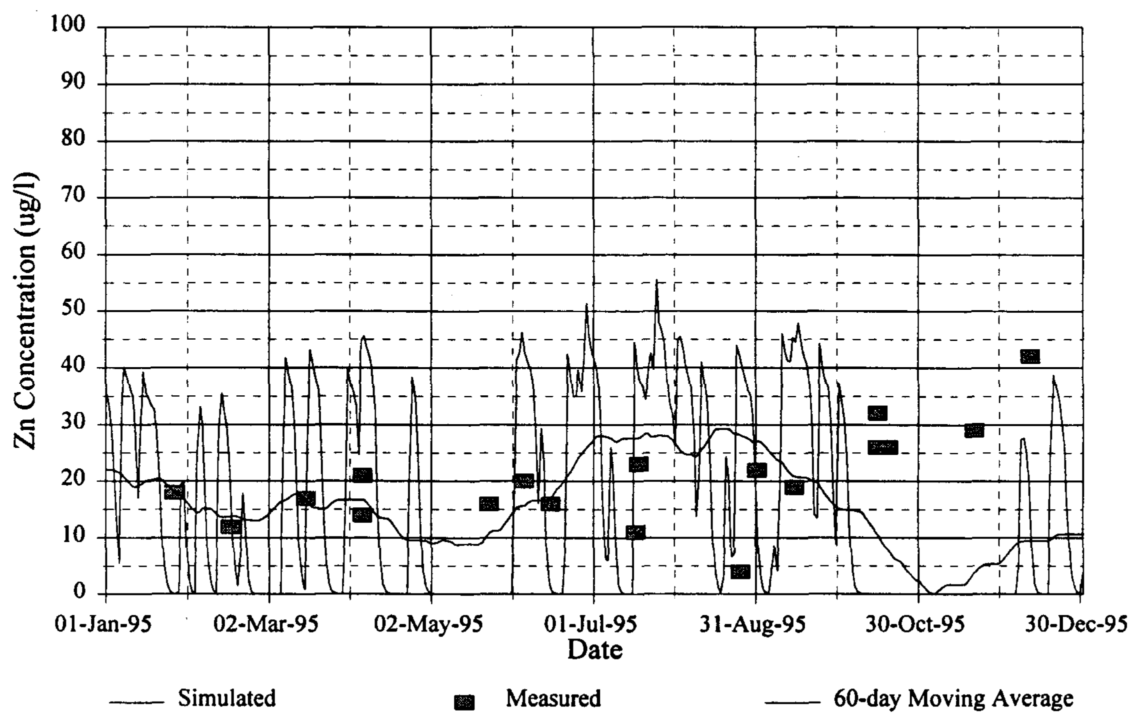


Figure 4-45

Station: PCRHR Node: 11008

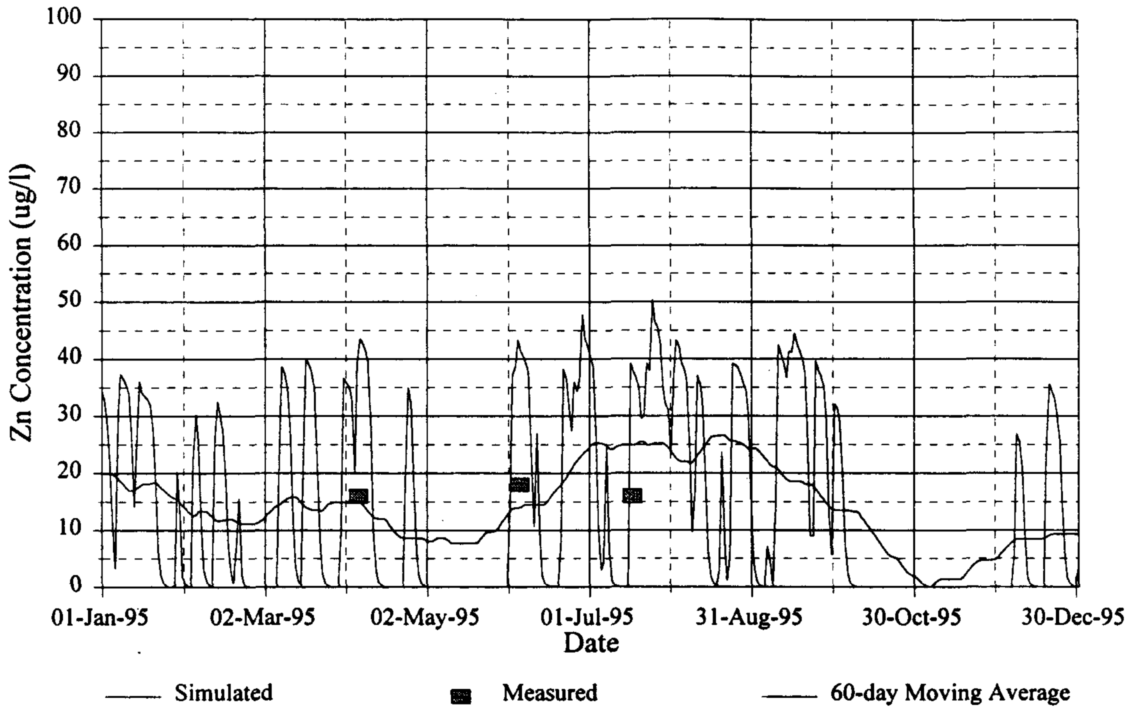


Figure 4-46

Station: NBC Node: 26000

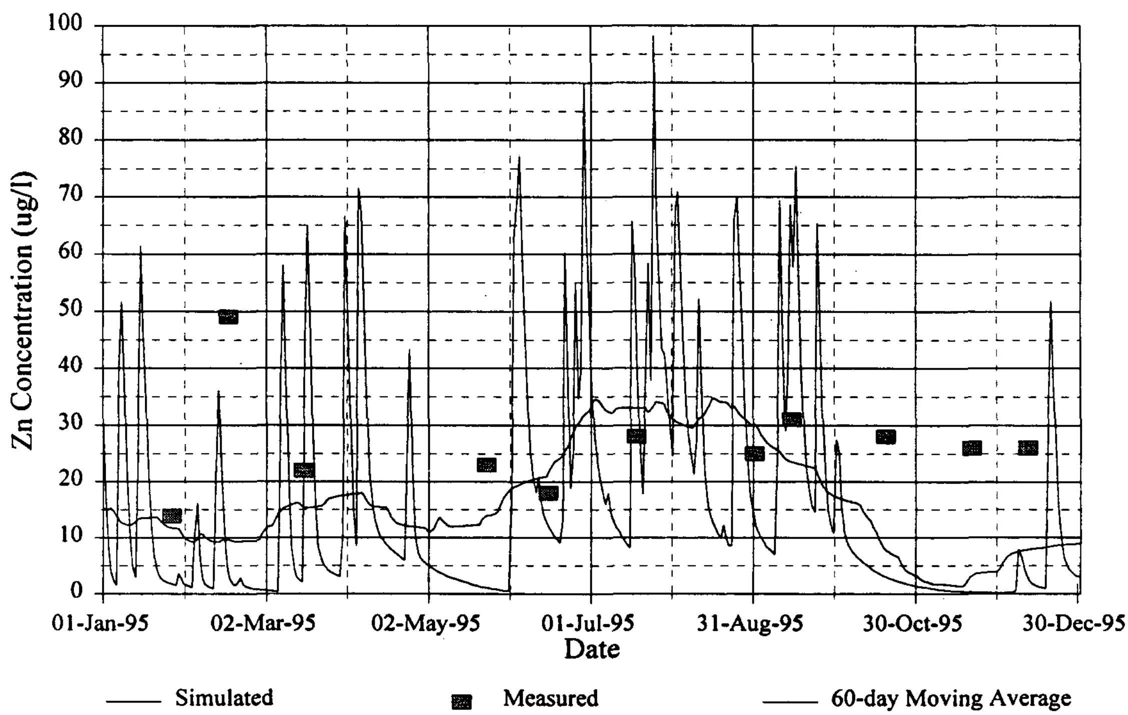


Figure 4-47

Station: BSF Node: 26002

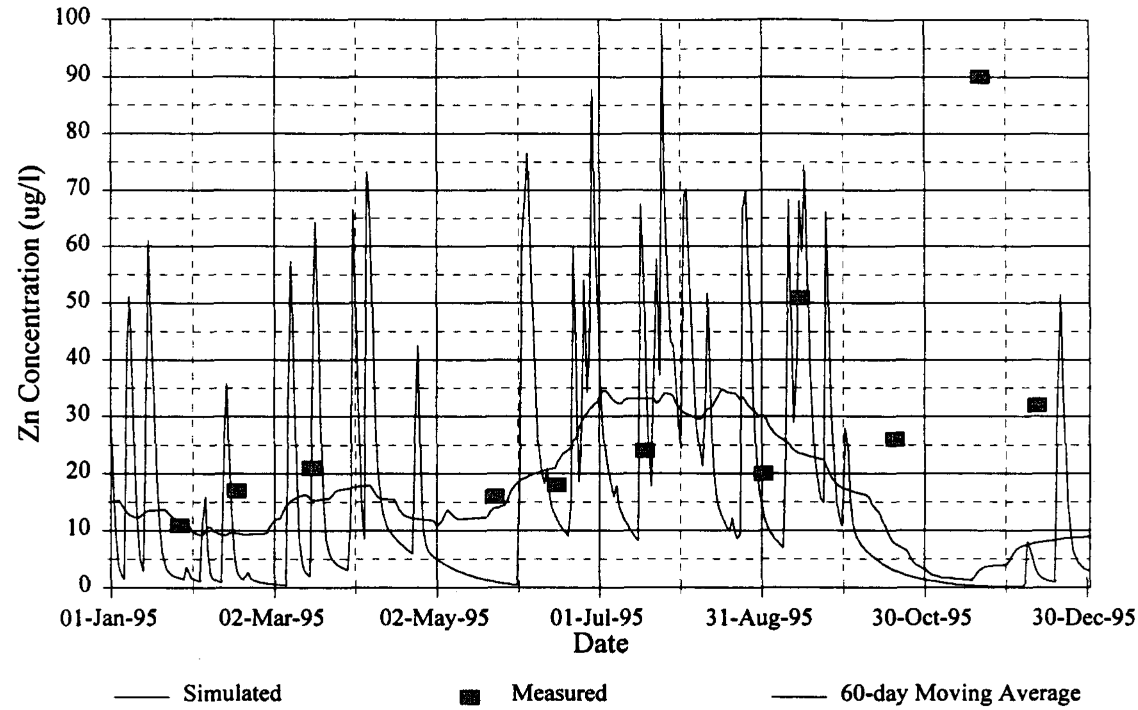


Figure 4-48

Station: BLC Node: 10020

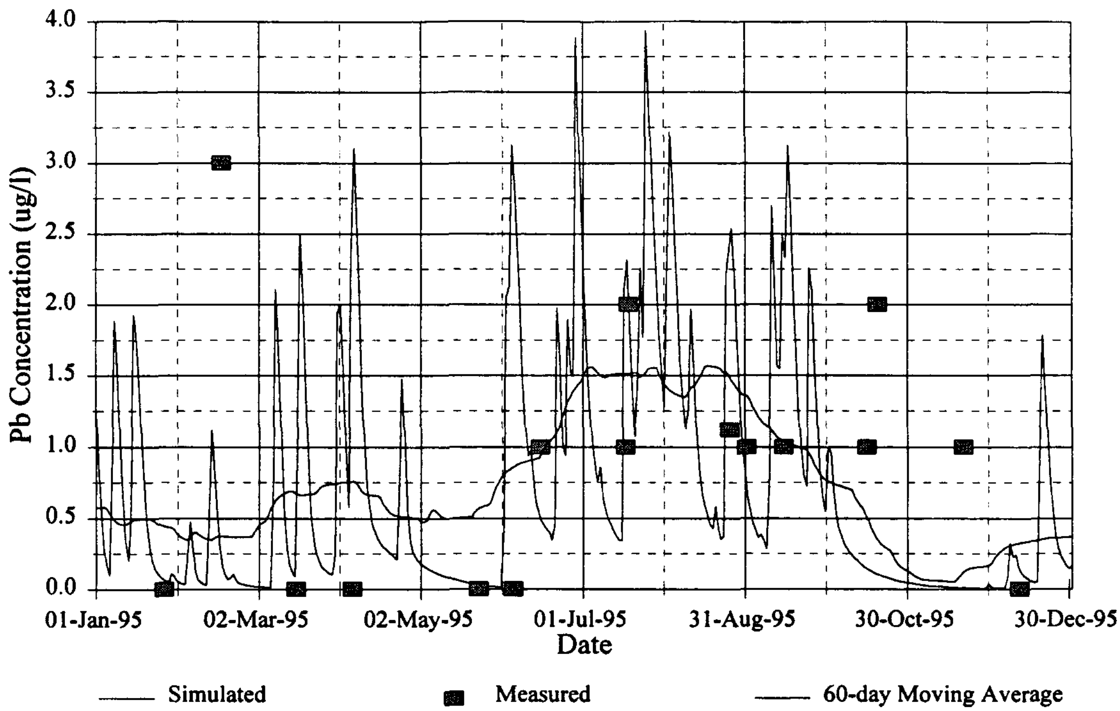


Figure 4-49

Station: PTC Node: 11003

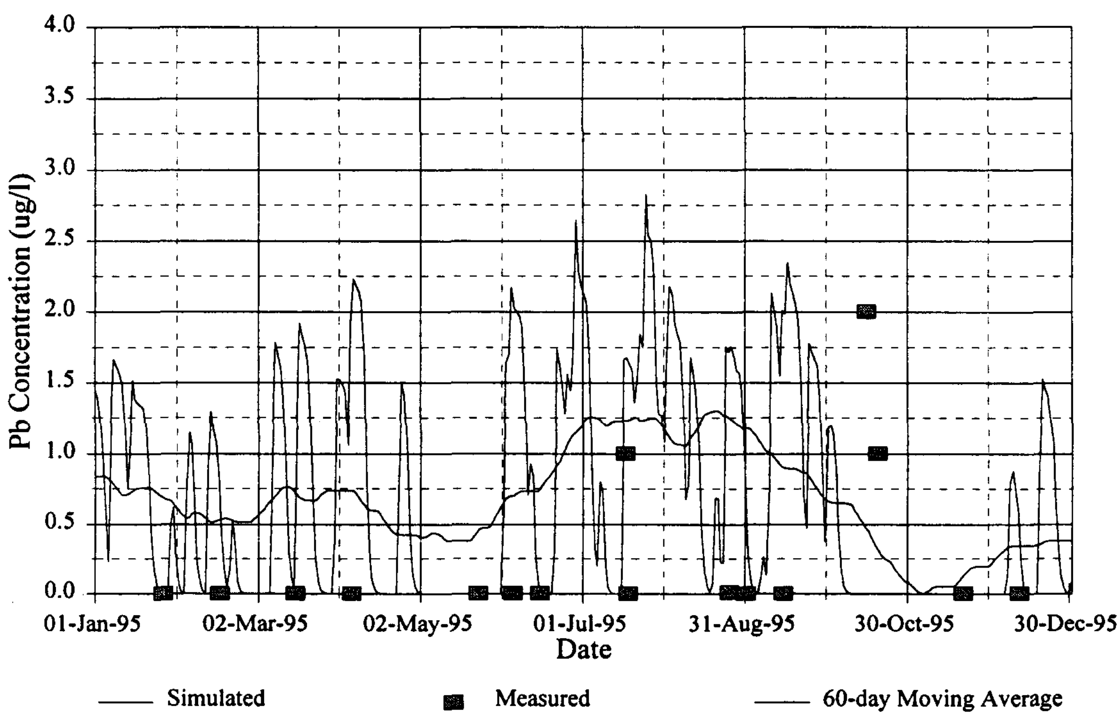


Figure 4-50

Station: PCRHR Node: 11008

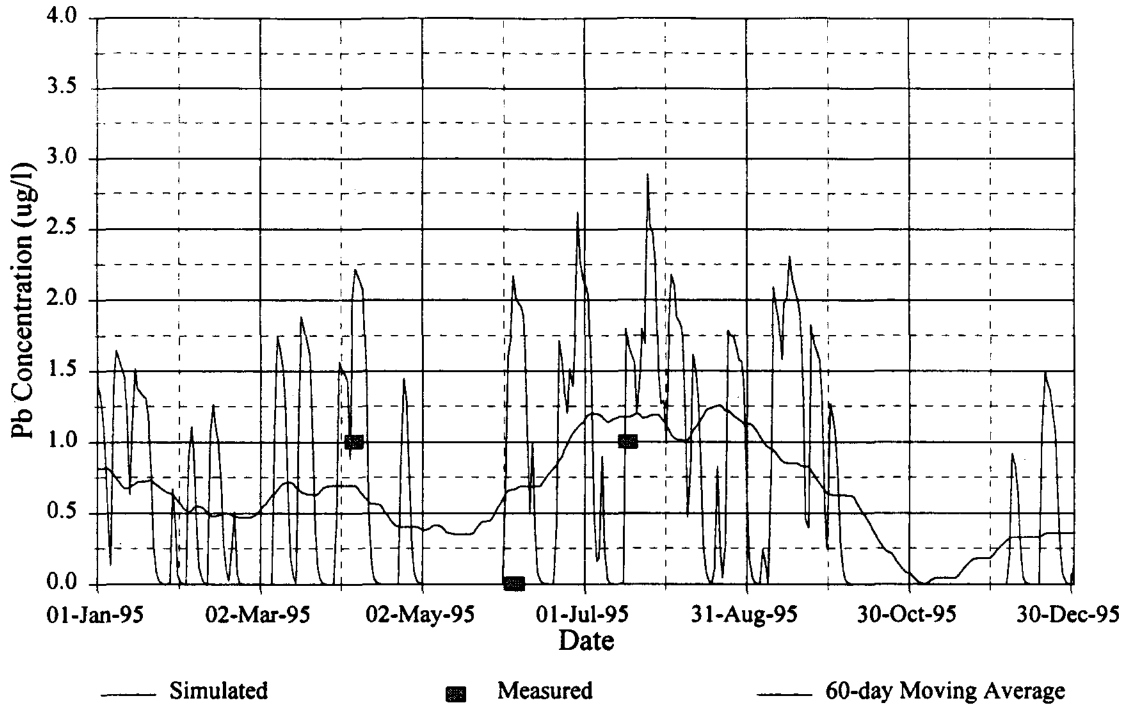


Figure 4-51

Station: NBC Node: 26000

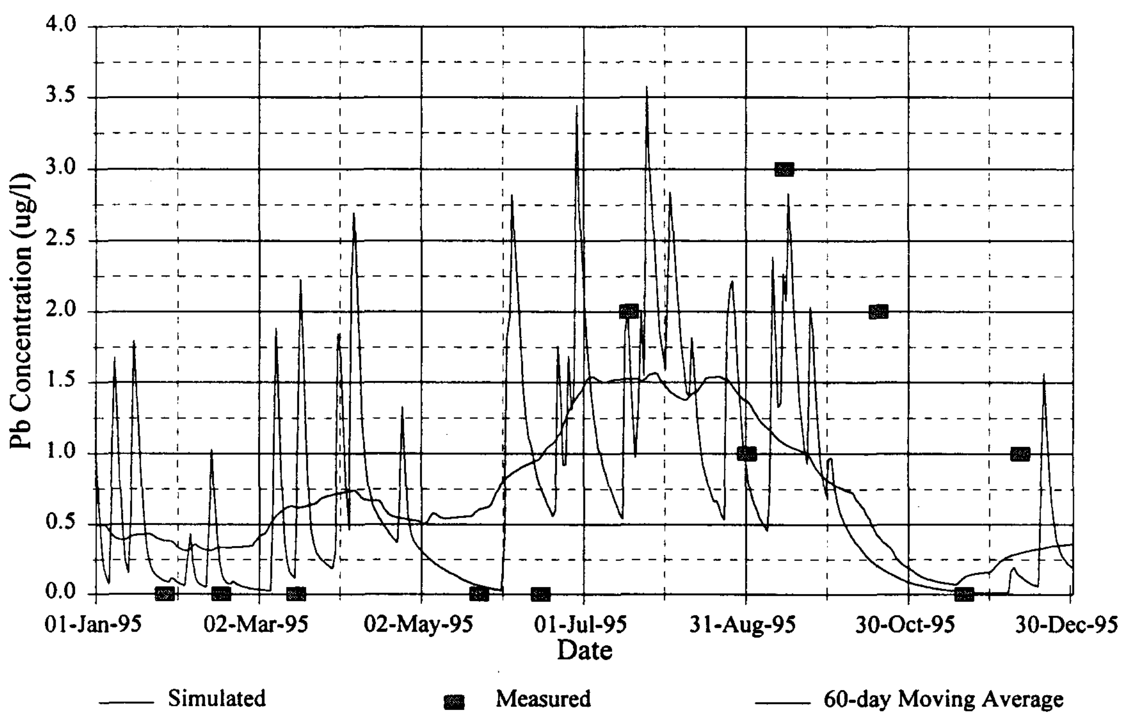


Figure 4-52

Station: BSF Node: 26002

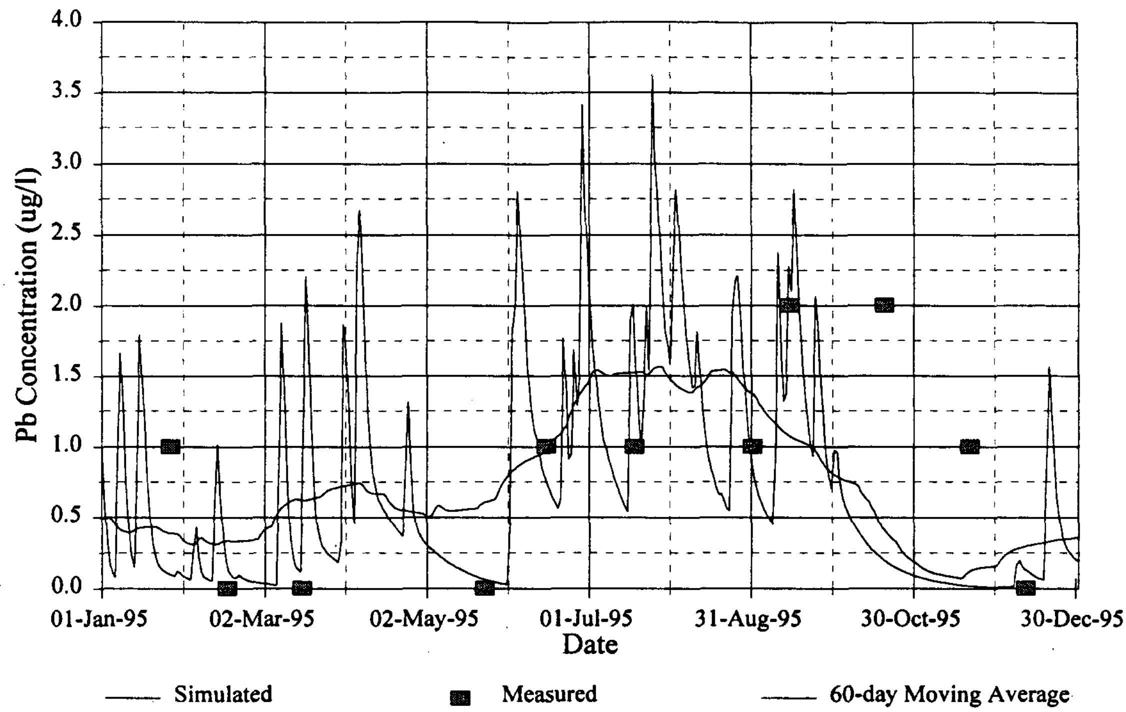


TABLE 4-15

Black Creek Basin Calibrated Water Quality Parameters

	TN		TP		TSS		Zn		Pb	
	RCOEF	WASHPO	RCOEF	WASHPO	RCOEF	WASHPO	RCOEF	WASHPO	RCOEF	WASHPO
Residential	54.59	1.22	16.78	1.08	81.05	1.60	5.615	1.16	0.055	1.30
Commercial	49.54	1.22	16.08	1.08	165.42	1.60	15.841	1.16	0.250	1.30
Mining	30.01	1.22	44.23	1.08	194.06	1.60	14.309	1.16	0.195	1.30
Dairies/Pastures	62.20	1.22	50.00	1.08	74.73	1.60	0.698	1.16	0.024	1.30
Crops	59.29	1.22	18.24	1.08	23.42	1.60	0.698	1.16	0.024	1.30
Natural: Forest	31.45	1.22	2.76	1.08	30.00	1.60	0.698	1.16	0.024	1.30
Natural: Open/Shrub	31.45	1.22	2.76	1.08	23.42	1.60	0.698	1.16	0.024	1.30
Tree Plantation	31.45	1.22	2.76	1.08	23.42	1.60	0.698	1.16	0.024	1.30
Forest Regeneration	31.45	1.22	2.76	1.08	23.42	1.60	0.698	1.16	0.024	1.30
Water/Wetlands	40.13	1.22	10.04	1.08	21.19	1.60	0.698	1.16	0.024	1.30

4.3.3 Prediction of Storm and Annual Loads

The calibrated SWMM model was used to predict the event mean concentrations (EMC) of the various storm events simulated during the calibration period. The SWMM model has built in statistical capabilities that allow for the analysis of the EMCs. The mouth of the Black Creek was chosen as the location to determine the EMCs. The statistical analysis separated the storm events by determining the beginning of a storm event (flow becomes greater than base flow) and the end of a storm (flow returns to base flow). Table 4-16 is a summary of the EMC data simulated for the 18 storm events during the calibration period.

The EMC data was used to determine the statistical parameters for each pollutant constituent. The mean, median, standard deviation and coefficient of variation was determined for each pollutant. The statistical data is presented in Table 4-17. A frequency analysis was conducted for each pollutant. The analysis was conducted by fitting theoretical frequency distributions to the EMC data. Distributions attempted were the Normal, Log Normal, Log Pearson Type III, Exponential and Extreme Value Type 1. In all cases the Log Pearson Type III was the best fit. Figures 4-53 through 4-57 are the results of the frequency analysis.

TABLE 4-16
Black Creek Basin Simulated Water Quality Data

Date	Runoff Duration (hrs)	Runoff Volume (acre-ft)	EMC					Load (kg)				
			TN	TP	TSS	Pb	Zn	TN	TP	TSS	Pb	Zn
07-Jan-95	116.5	7357	1.7	0.27	4.51	0.0017	0.0600	15286	2395	40552	15.4	544.3
14-Jan-95	150	12856	1.4	0.22	3.43	0.0014	0.0500	21864	3520	53525	22.2	789.3
04-Feb-95	24	668	0.47	0.09	1.04	0.0004	0.0200	379	72	848	0.4	15.9
12-Feb-95	75	3020	0.88	0.16	1.87	0.0008	0.0300	3243	572	6895	3.1	124.3
08-Mar-95	80	5447	1.56	0.24	4.81	0.0016	0.0600	10387	1597	31888	10.9	381.0
17-Mar-95	95	9061	1.84	0.27	6.38	0.0020	0.0700	20321	2980	70308	21.8	725.8
01-Apr-95	84	7641	1.65	0.26	4.55	0.0017	0.0600	15377	2427	42548	15.9	567.0
06-Apr-95	112.5	21813	2.63	0.37	11.26	0.0030	0.0900	69854	9843	299830	78.5	2413.2
24-Apr-95	36.5	1310	1.53	0.27	5.16	0.0016	0.0600	2454	425	8256	2.5	96.2
02-Jun-95	162.5	35366	2.58	0.38	9.85	0.0028	0.0900	111132	16375	423662	121.6	3855.6
22-Jun-95	53.5	2581	1.79	0.3	6.37	0.0019	0.0700	5625	930	20094	5.9	214.6
25-Jun-95	61	3124	1.73	0.29	5.64	0.0018	0.0700	6623	1116	21501	6.8	248.6
28-Jun-95	130	27364	2.91	0.39	14.61	0.0034	0.1000	97070	13064	489888	112.0	3275.0
17-Jul-95	102.5	9706	2.14	0.34	7.66	0.0023	0.0800	25356	4023	90720	26.8	920.8
22-Jul-95	431.5	73572	2.76	0.37	13.78	0.0032	0.0900	248119	33294	1238328	284.9	8300.9
10-Aug-95	85	4130	1.54	0.23	6.76	0.0017	0.0500	7757	1166	34065	8.2	274.9
24-Aug-95	1164	98354	1.86	0.28	7.4	0.0020	0.0600	222718	33113	889056	242.2	7756.6
19-Dec-95	89.5	4698	1.59	0.27	5.2	0.0016	0.0600	9072	1551	29756	9.5	345.6

TABLE 4-16
Black Creek Basin EMC Statistical Data

Pollutant	Total Annual Load (kg)	EMC			
		Mean (mg/l)	Median (mg/l)	Stanard Deviation (mg/l)	Coef. of Variation
TN	973,100	1.81	1.70	0.63	0.346
TP	140,200	0.28	0.27	0.08	0.280
TSS	4,080,000	6.68	5.65	3.68	0.550
Pb	1,073	0.00193	0.00173	0.00076	0.392
Zn	33,530	0.06497	0.06070	0.02001	0.308

Figure 4-53

Black Creek Basin TN EMC Frequency

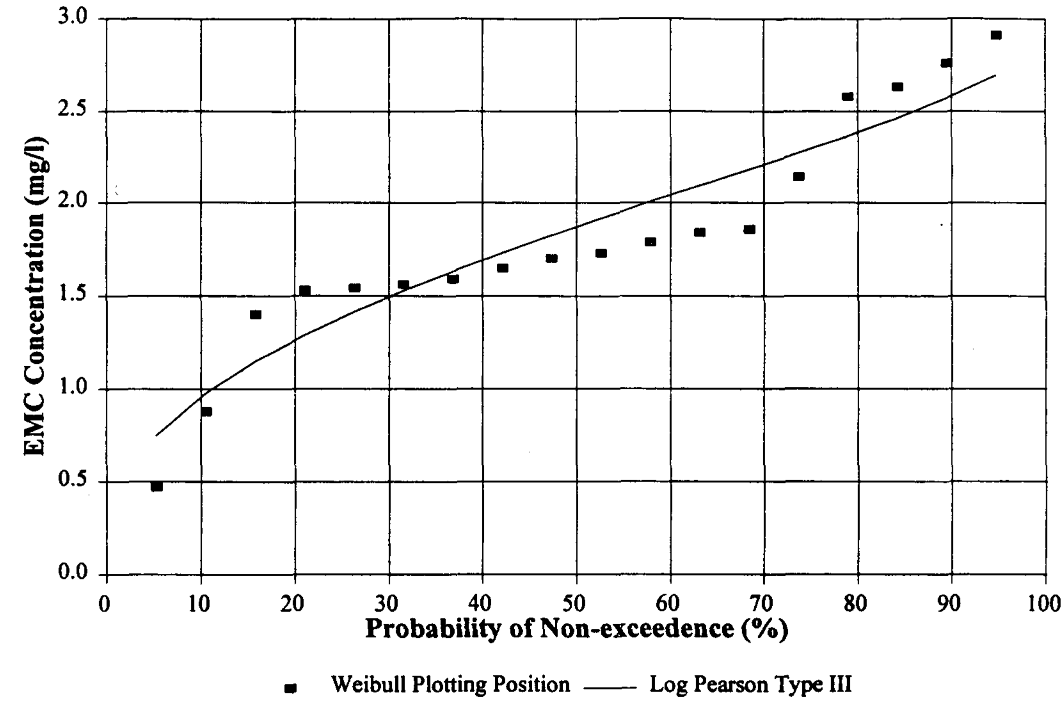


Figure 4-54

Black Creek Basin TP EMC Frequency

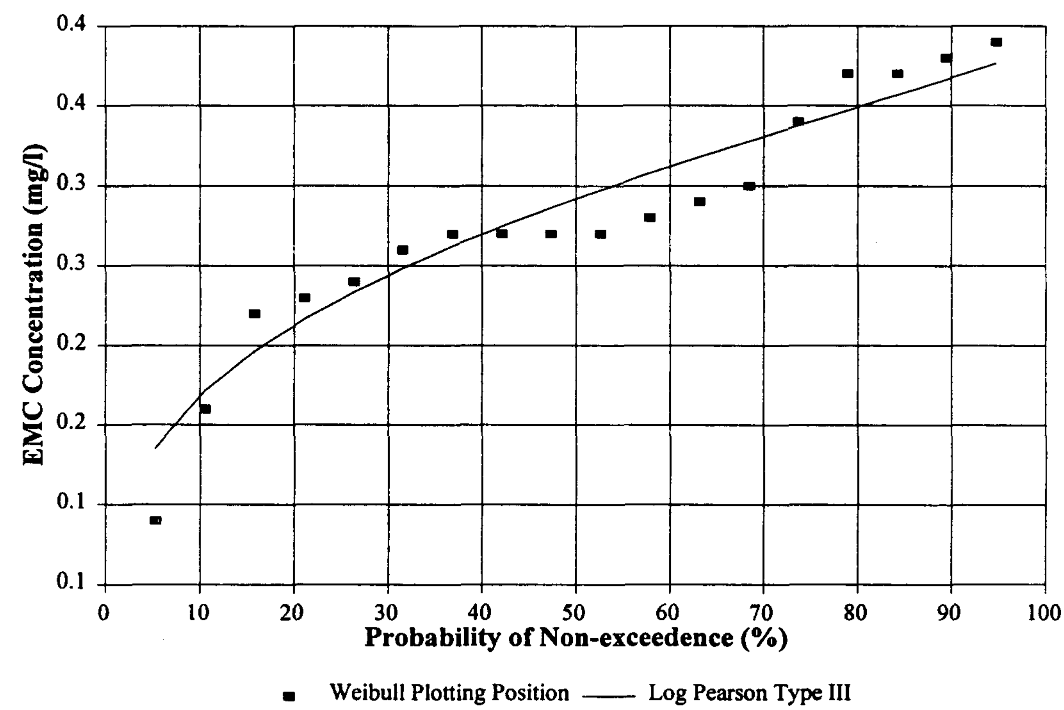


Figure 4-55

Black Creek Basin TSS EMC Frequency

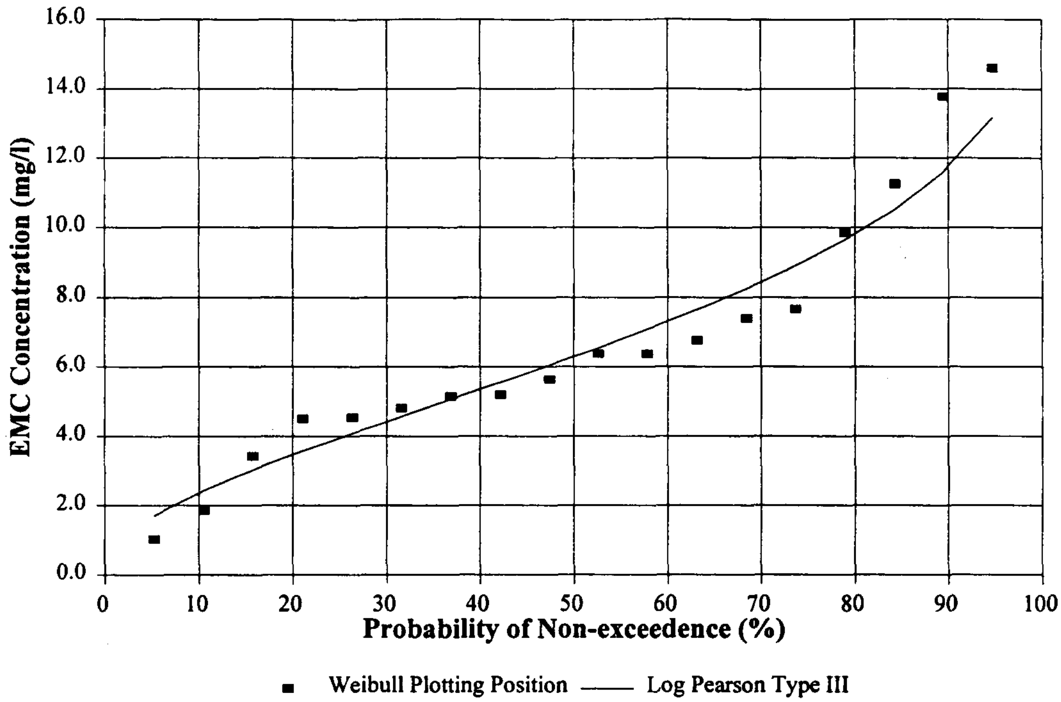


Figure 4-56

Black Creek Basin Pb EMC Frequency

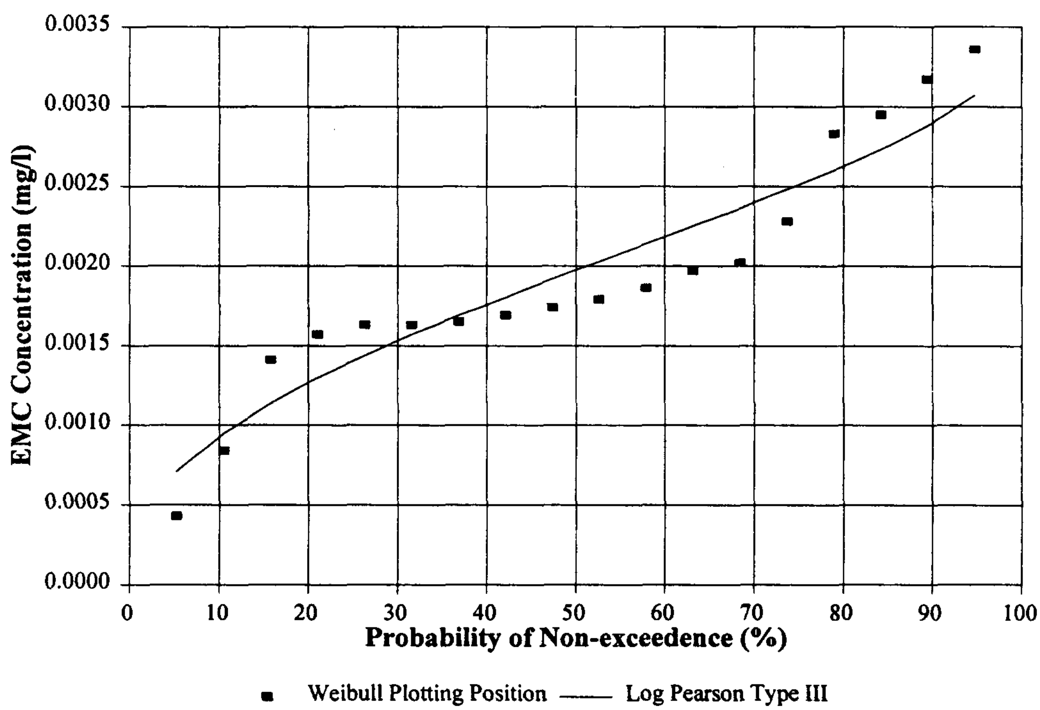
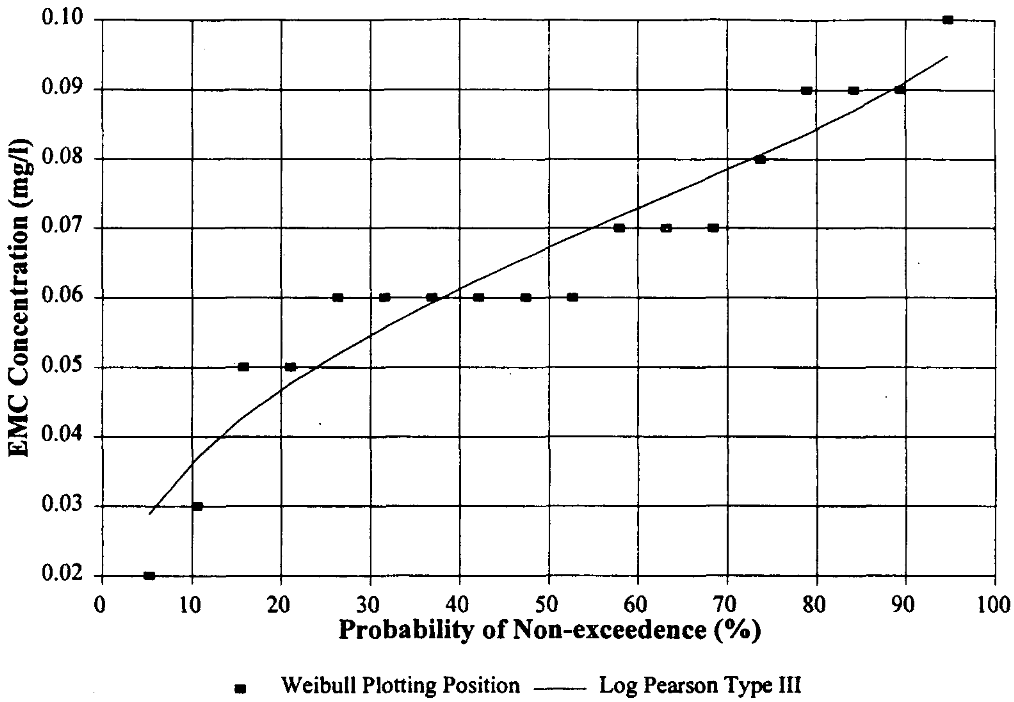


Figure 4-57

Black Creek Basin Zn EMC Frequency



5.0 SUMMARY AND CONCLUSIONS

The work for this phase of the study consisted of the development and application of basic water quantity and water quality models for the Black Creek Watershed. The model computed discharges and non-point source pollutant loads. Simulated discharges from the modeling were used to determine 10-, 25- and 100-year flood elevations in the primary hydrologic system. The models developed for this phase of the study constitute the basic framework for the development of a Master Stormwater Management Plan for the watershed. The models are capable of predicting the effects of changing land uses on the surface runoff and nonpoint source pollutant loads in the watershed.

In satisfaction of the scope of services for this project, the following major project requirements were completed.

The EPA's SWMM / EXTRAN program was used in the simulation of water quantity and water quality.

The SWMM model was used to perform hydrologic and water quality analyses. The EXTRAN block was used to determine flood elevations for a series of synthetic storms.

The water quantity models involved both continuous and event simulation. The length of the continuous simulation was for a 13 month period, using less than one-half hour time steps. Event simulations included the 10-, 25- and 100-year synthetic storms.

The following meteorological time series were used in the models:

- hourly rainfall series for the continuous simulations,
- 15-minute rainfall series for the 24-hour event simulations, and
- daily pan evaporation rates.

The water quality models involved the simulation of nonpoint source pollutant loads generated by surface runoff from the subbasins and the entire watershed, including total nitrogen, total phosphorus, suspended solids, zinc, and lead.

The water quality models involved continuous simulation for a 13 month period, using less than one-half hour time steps. Both the water quantity and water quality models were calibrated to the best available data.

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7.0 APPENDICES

APPENDIX A

Black Creek Basin Aggregated Land Uses by Subbasin

Subbasin	Total	Aggregated Land Use Area (ac)									
		Resid.	Comm.	Mining	Dairies/ Pasture	Crops	Natural: Forest	Natural: Open/Shrub	Tree Plantation	Forest Regen.	Water/ Wetland
1000	2531	164	48	11	40	0	808	135	51	0	1275
1002	1128	33	2	15	122	24	369	36	129	93	306
1004	1469	114	0	74	92	121	70	37	47	31	884
1006	2440	188	17	28	348	162	755	23	333	54	532
1008	1368	275	1	23	133	25	230	6	11	0	664
1010	2250	401	14	41	55	162	845	49	0	0	685
1012	2454	298	24	10	0	117	893	96	0	0	1015
1014	2102	1561	12	0	22	33	146	26	31	0	272
1100	994	212	3	0	55	39	236	43	32	92	281
1102	692	80	0	0	154	4	138	41	91	26	159
1104	446	0	0	0	168	0	101	25	118	0	34
1106	1064	17	0	42	439	3	336	0	38	0	189
1108	1397	0	0	0	655	21	421	79	42	0	179
1110	1151	12	0	0	26	0	707	44	210	0	151
1112	1994	0	0	0	0	4	943	41	251	521	234
1114	2275	113	0	0	213	131	814	22	320	381	282
1116	1751	7	0	0	15	0	824	15	265	392	233
1118	1375	7	0	0	26	3	461	0	529	63	285
1120	908	0	0	0	0	0	21	0	122	716	49
1200	1565	61	0	0	70	255	740	10	8	0	423
1202	2373	40	0	0	268	69	873	177	239	387	320
1300	1263	329	22	6	65	122	350	0	28	0	341
1302	1598	591	82	262	17	150	234	15	0	0	246
1304	1559	300	70	0	77	73	285	17	222	0	516
1306	427	154	102	5	5	0	46	2	0	0	113
1308	1647	464	3	10	32	0	270	20	239	0	608
1310	2164	291	0	1	372	0	567	22	0	0	911
1312	1266	9	93	0	134	0	502	285	4	0	239
1314	537	125	0	13	259	0	30	21	0	0	88
1400	671	2	18	0	36	56	147	65	198	0	149
1402	4186	892	16	30	401	27	1372	202	300	81	865
1500	2958	609	0	0	276	27	804	145	149	6	942
1502	2247	0	157	1	771	0	722	153	0	0	443
1504	2490	0	0	6	560	0	739	172	50	0	965
1600	524	214	35	0	27	0	71	0	0	0	177
1602	680	354	20	0	120	0	60	14	0	0	110
1604	2038	529	0	3	275	0	732	34	61	0	405
1606	1381	400	0	0	102	0	407	79	137	0	257

Black Creek Basin Aggregated Land Uses by Subbasin

Subbasin	Total	Aggregated Land Use Area (ac)									
		Resid.	Comm.	Mining	Dairies/ Pasture	Crops	Natural: Forest	Natural: Open/Shrub	Tree Plantation	Forest Regen.	Water/ Wetland
1608	770	0	0	0	0	0	439	0	132	0	199
1610	1491	50	0	0	0	0	868	0	130	0	442
1612	3244	89	0	0	66	0	1476	95	295	244	979
1614	3626	1	2	0	232	0	2279	26	199	21	866
1616	2441	221	0	4	74	0	807	19	283	334	699
1618	3459	177	56	37	235	8	399	101	323	1592	530
1620	2282	445	0	0	229	13	1099	13	11	0	473
1622	2840	138	30	0	79	2	354	14	1329	542	352
1624	2164	171	3	0	72	0	207	0	655	788	267
1626	2913	964	0	0	174	15	680	35	241	214	590
1628	2831	2	0	0	16	0	159	0	861	1558	235
1630	1118	110	1	0	13	0	315	66	59	162	391
1632	2063	2	0	122	20	0	48	0	1157	369	345
1634	2374	0	0	894	0	0	0	0	60	875	544
1636	716	167	8	6	32	19	82	164	34	56	148
1638	2479	2	0	0	0	0	713	18	908	300	537
1640	2260	0	0	8	0	0	591	0	1174	264	224
1642	502	0	0	0	0	0	146	0	181	0	175
1644	1975	0	0	29	0	0	602	12	960	124	248
1646	1106	0	23	23	23	0	478	0	244	34	279
1648	3517	0	10	32	0	0	799	0	2103	163	410
1650	1334	10	17	0	14	0	1063	0	134	13	83
1652	768	0	0	12	9	0	452	0	148	0	146
1654	979	258	48	22	0	0	189	242	135	25	60
1656	772	339	29	10	0	0	298	0	64	0	33
1658	4439	845	81	74	2	0	850	9	554	360	1664
1700	688	125	47	0	0	49	306	47	0	0	113
1702	887	196	21	0	0	27	346	74	0	83	140
1704	374	14	37	0	0	21	133	13	0	0	156
1706	614	141	0	44	51	78	85	2	0	0	214
1708	1053	423	12	0	0	15	345	42	0	0	217
1800	397	212	0	13	0	0	90	23	0	0	58
1802	617	529	13	5	0	0	21	10	3	0	36
1804	496	437	3	1	18	0	0	2	0	0	36
1900	1212	138	0	0	0	0	741	17	0	0	316
1902	1941	1125	1	0	38	11	397	56	0	0	312
1904	1364	929	15	0	117	0	36	0	8	0	259
1906	673	394	3	0	0	0	124	0	14	64	73

Black Creek Basin Aggregated Land Uses by Subbasin

Subbasin	Total	Aggregated Land Use Area (ac)									
		Resid.	Comm.	Mining	Dairies/ Pasture	Crops	Natural: Forest	Natural: Open/Shrub	Tree Plantation	Forest Regen.	Water/ Wetland
2000	691	565	1	0	23	0	33	14	0	0	54
2002	437	334	0	0	0	0	0	2	50	21	30
2100	748	0	0	0	0	0	378	0	0	0	370
2102	791	3	0	0	0	0	344	35	235	43	131
2104	1584	57	0	0	20	0	609	38	285	70	505
2106	1573	0	0	0	246	0	203	68	540	39	477
2108	2391	63	0	0	88	6	659	78	662	388	447
2110	1472	150	10	7	37	20	274	0	618	111	245
2112	1074	116	3	0	32	0	78	17	366	172	290
2114	789	0	23	0	0	0	1	0	671	25	69
2116	3855	36	280	0	42	0	89	40	1239	1485	644
2118	409	39	0	0	34	0	2	0	180	108	46
2120	2620	55	0	0	252	0	26	74	440	1286	487
2122	914	83	0	0	51	0	39	28	180	307	226
2124	2360	0	32	0	0	0	0	0	197	1094	1038
2200	1705	52	0	0	0	0	60	0	1083	103	408
2202	2275	0	735	0	50	0	22	44	1121	84	218
2204	8076	281	1347	4	918	146	1096	71	1851	650	1712
2300	1603	394	313	0	16	4	144	15	560	22	135
2302	4034	64	194	0	42	0	750	0	1666	379	938
2400	1393	241	5	41	9	0	42	0	551	256	249
2402	2921	56	18	0	5	0	37	20	421	1257	1108
2500	1603	94	2	0	46	0	130	62	447	424	397
2502	1814	200	0	0	33	0	121	12	925	241	281
2504	1041	106	0	0	13	0	175	26	127	385	208
2506	1994	99	57	0	37	0	235	47	388	772	358
2508	523	52	0	0	29	0	25	0	129	236	52
2510	767	235	18	0	109	5	132	0	74	22	172
2512	2229	13	31	0	19	12	218	13	429	1048	446
2514	1300	20	18	0	12	0	58	12	805	91	283
2516	965	21	39	0	17	0	195	15	247	38	394
2518	1507	38	0	0	75	0	10	9	484	524	367
2520	1294	0	0	0	0	0	112	0	661	81	439
2522	1760	0	21	0	0	0	50	0	544	591	554
2600	1212	449	40	7	13	2	335	39	0	0	328
2602	881	432	20	20	1	0	278	17	31	8	75
2604	2310	972	0	0	104	4	138	59	433	11	588
2606	1104	379	2	27	9	0	370	40	0	0	277

Black Creek Basin Aggregated Land Uses by Subbasin

Subbasin	Total	Aggregated Land Use Area (ac)									
		Resid.	Comm.	Mining	Dairies/ Pasture	Crops	Natural: Forest	Natural: Open/Shrub	Tree Plantation	Forest Regen.	Water/ Wetland
2608	1110	435	0	9	264	36	89	49	0	0	228
2610	877	230	0	0	22	0	119	0	286	0	221
2612	913	3	0	0	29	0	49	35	555	122	119
2614	1164	354	0	0	223	2	152	18	230	0	186
2616	1150	0	0	0	0	0	0	31	847	75	197
2618	2226	127	10	15	57	0	182	19	1023	594	198
2620	1454	0	0	0	0	0	18	27	746	329	334
2622	1236	6	0	5	97	28	67	6	582	196	250
2624	817	0	0	0	0	0	171	0	443	154	49
2626	1056	0	0	0	0	0	179	0	624	116	137
2628	633	0	0	0	0	0	229	0	85	264	55
2630	1823	0	0	0	0	0	694	7	695	0	427
2632	1256	0	0	0	0	0	385	40	250	472	109
2634	1906	683	97	48	0	0	808	110	38	38	82
2636	2607	243	240	24	0	0	871	0	128	827	275
2638	1340	0	103	50	0	0	804	11	0	0	371
2640	5316	0	21	26	3	0	3249	347	253	87	1330
2642	3415	0	82	30	0	0	2532	6	0	76	689
2644	1284	0	0	0	0	0	780	0	0	6	498
2700	971	386	14	16	4	0	347	0	5	0	198
2702	1545	126	0	0	2	0	155	5	932	181	144
2704	1845	1152	0	8	29	16	358	1	20	1	260
2706	637	37	0	0	0	0	12	0	304	209	76
2708	2635	62	9	48	134	0	564	0	198	1004	615
2710	1352	3	16	0	0	0	7	0	225	978	124
2712	1263	0	26	0	0	0	299	287	145	267	238
2800	883	454	13	41	26	16	203	3	0	0	126
2802	701	616	0	0	0	0	4	0	0	0	80
2804	496	451	0	0	0	0	3	0	0	0	42
2902	2544	665	0	0	14	0	661	32	620	26	525
2904	2489	0	16	4	3	0	1473	0	646	32	315
3000	3446	64	0	14	99	109	787	28	739	992	615
3002	3561	231	16	0	313	279	467	0	1132	800	323
3100	1528	0	0	2	0	0	498	72	352	404	200
3101	1360	0	0	2	13	0	465	9	340	311	218
3102	2612	4	0	0	0	0	483	0	1169	433	523
3104	1598	0	0	0	0	6	343	58	655	203	334
3106	4115	3	0	0	6	0	342	0	2343	746	674

Black Creek Basin Aggregated Land Uses by Subbasin

Subbasin	Total	Aggregated Land Use Area (ac)									
		Resid.	Comm.	Mining	Dairies/ Pasture	Crops	Natural: Forest	Natural: Open/Shrub	Tree Plantation	Forest Regen.	Water/ Wetland
3108	4229	17	0	0	56	0	136	91	2450	719	760
3110	3862	65	0	98	0	0	403	29	2082	610	576
3112	3663	3	0	10	0	0	227	0	2401	464	559
3114	3665	7	0	3	48	0	84	0	2223	341	959
3116	3044	3	0	0	65	30	40	46	1566	514	781
3200	1963	6	2	0	4	66	122	0	1277	187	299
3202	2337	0	26	0	4	0	597	9	736	694	271
3300	1799	0	0	0	0	0	0	0	587	819	393
3302	2072	0	0	0	43	0	93	0	1330	309	297
3304	2149	26	0	0	132	3	869	15	818	72	215
3306	1446	2	0	0	2	0	22	5	671	650	92
3308	2948	51	0	0	885	0	791	365	33	248	576
3310	4229	8	0	0	42	0	630	88	1335	1423	703
3312	3847	64	0	0	16	0	376	0	1574	666	1150
3314	4306	196	0	6	601	0	1892	394	330	165	722
3400	703	0	0	2	56	0	179	0	155	187	124
3402	1072	0	0	12	0	17	248	0	459	310	26
3404	1045	0	0	0	0	0	614	11	32	149	239
3406	2080	0	0	1	80	0	736	35	380	289	558
TOTAL	309778	29982	5102	2496	13695	2693	70465	6435	72341	42161	64408
PERCENT	100.0%	9.7%	1.6%	0.8%	4.4%	0.9%	22.7%	2.1%	23.4%	13.6%	20.8%

APPENDIX B

Black Creek Basin Hydrologic Soils Groups

Subbasin	Total Area (ac.)	Hydrologic Soils Group Area (ac.)			
		A	B	C	D
1000	2531	171	329	227	1804
1002	1128	134	354	202	438
1004	1469	7	400	111	951
1006	2440	190	1213	433	604
1008	1368	12	259	69	1028
1010	2250	229	539	464	1019
1012	2454	490	598	357	1008
1014	2102	894	169	764	275
1100	994	157	175	199	462
1102	692	236	130	124	203
1104	446	188	70	181	7
1106	1064	532	184	310	38
1108	1397	719	353	279	45
1110	1151	782	260	109	0
1112	1994	853	601	540	0
1114	2275	1093	733	413	36
1116	1751	617	580	554	0
1118	1375	109	741	524	0
1120	908	90	758	55	5
1200	1565	501	369	291	404
1202	2373	804	750	791	28
1300	1263	97	312	239	614
1302	1598	122	684	283	509
1304	1559	349	580	65	565
1306	427	156	234	27	10
1308	1647	502	271	6	867
1310	2164	172	774	281	936
1312	1266	145	712	68	341
1314	537	5	356	96	80
1400	671	30	392	4	245
1402	4186	936	1052	1581	617
1500	2958	491	1162	530	775
1502	2247	93	1668	196	289
1504	2490	391	1184	374	541
1600	524	85	97	139	203
1602	680	17	50	277	336
1604	2038	651	483	364	539
1606	1381	396	340	503	142
1608	770	240	289	91	150
1610	1491	748	500	115	127
1612	3244	1046	973	774	451
1614	3626	1403	617	1172	434
1616	2441	683	1023	502	233
1618	3459	517	1456	1133	353
1620	2282	97	1320	780	86
1622	2840	434	969	1361	76
1624	2164	83	1115	942	24
1626	2913	97	1598	1083	135
1628	2831	339	1476	995	21
1630	1118	32	671	415	0
1632	2063	198	1005	718	143
1634	2374	1209	740	42	384
1636	716	77	387	253	0
1638	2479	96	1551	724	108

Black Creek Basin Hydrologic Soils Groups

Subbasin	Total Area (ac.)	Hydrologic Soils Group Area (ac.)			
		A	B	C	D
1640	2260	135	1094	689	342
1642	502	60	148	127	167
1644	1975	424	534	529	489
1646	1106	90	446	353	216
1648	3517	649	1244	1092	532
1650	1334	273	275	392	394
1652	768	45	109	331	283
1654	979	27	313	415	223
1656	772	292	305	138	37
1658	4439	1130	498	938	1872
1700	688	0	131	45	512
1702	887	135	172	81	499
1704	374	24	116	83	151
1706	614	263	137	46	168
1708	1053	222	209	426	196
1800	397	59	146	149	42
1802	617	85	66	335	131
1804	496	0	19	379	98
1900	1212	581	353	223	54
1902	1941	274	549	1028	90
1904	1364	141	491	664	68
1906	673	41	185	444	3
2000	691	124	191	369	7
2002	437	81	127	230	0
2100	748	230	11	262	245
2102	791	314	154	254	68
2104	1541	168	617	355	401
2106	1616	597	420	343	256
2108	2391	194	790	387	1019
2110	1472	55	815	249	354
2112	1074	0	786	10	278
2114	789	0	584	10	194
2116	3855	0	2815	2	1037
2118	409	0	295	0	114
2120	2620	0	2153	0	467
2122	914	0	758	0	156
2124	2360	0	1543	0	817
2200	1705	195	932	175	403
2202	2275	84	1231	29	931
2204	8076	4	5814	37	2221
2300	1603	7	742	207	647
2302	4034	0	2977	0	1058
2400	1393	32	734	164	464
2402	2921	4	2214	0	703
2500	1603	455	556	439	154
2502	1814	179	824	48	763
2504	1041	33	581	114	312
2506	1994	7	725	449	814
2508	523	0	403	50	70
2510	767	0	380	66	321
2512	2229	24	1097	577	531
2514	1300	0	1037	27	237
2516	965	0	669	10	286
2518	1507	26	1131	37	312

Black Creek Basin Hydrologic Soils Groups

Subbasin	Total Area (ac.)	Hydrologic Soils Group Area (ac.)			
		A	B	C	D
2520	1294	22	1008	7	257
2522	1760	13	1037	4	705
2600	1212	504	121	314	273
2602	881	179	136	348	217
2604	2310	903	564	625	217
2606	1104	328	328	251	196
2608	1110	206	464	300	140
2610	877	378	205	254	40
2612	913	336	395	180	3
2614	1164	358	434	311	61
2616	1150	347	567	157	79
2618	2226	681	754	753	37
2620	1454	668	452	303	32
2622	1236	449	409	341	37
2624	817	106	269	354	88
2628	1056	196	517	276	66
2628	633	109	238	286	0
2630	1823	972	459	319	73
2632	1256	358	326	491	81
2634	1906	759	478	572	97
2636	2607	1603	236	350	418
2638	1340	713	334	201	91
2640	5316	3156	708	622	830
2642	3415	2232	44	541	598
2644	1284	646	113	204	322
2700	971	433	330	156	52
2702	1545	315	806	385	39
2704	1845	788	379	566	112
2706	637	147	317	166	8
2708	2635	969	662	978	26
2710	1352	180	386	421	365
2712	1263	351	265	520	127
2800	883	327	155	310	91
2802	701	100	73	356	172
2804	496	71	37	295	93
2902	2544	379	1130	1007	28
2904	2489	1136	665	658	30
3000	3446	1084	1275	1022	64
3002	3561	334	1787	1421	19
3100	1528	1041	214	201	72
3101	1360	373	639	324	23
3102	2612	701	1256	631	25
3104	1598	562	455	571	10
3106	4115	618	2478	1019	0
3108	4229	116	2779	784	550
3110	3862	177	2705	684	296
3112	3663	164	2085	960	453
3114	3665	106	2723	164	672
3116	3044	15	1933	423	673
3200	1963	335	986	454	188
3202	2337	63	858	893	524
3300	1799	1181	401	207	10
3302	2072	332	970	500	270
3304	2149	29	730	834	557

Black Creek Basin Hydrologic Soils Groups

Subbasin	Total Area (ac.)	Hydrologic Soils Group Area (ac.) A	B	C	D
3306	1446	0	985	229	232
3308	2948	359	1219	889	481
3310	4229	0	2101	778	1351
3312	3847	671	2022	343	811
3314	4306	1013	2255	342	696
3400	703	18	262	268	154
3402	1072	50	602	245	174
3404	1045	229	256	561	0
3406	2080	244	592	1115	128
Total	309777	59739	127620	66991	55427
Percent	100.0%	19.3%	41.2%	21.6%	17.9%

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