Appendix A – ESTIMATOR Model Results for Northwest Branch and Northeast Branch Sediment Loads

Introduction

The U. S. Geological Survey (USGS) ESTIMATOR model (Cohn *et al*., 1989; 1992) was used to estimate suspended solids loads for the Northeast Branch (NEB) and Northwest Branch (NWB) tributaries of the Anacostia River. ESTIMATOR is a multiple regression model that predicts average daily concentration and load based on independent variables representing flow, season, and time. ESTIMATOR regression results and the daily average flow records for the time period of interest, 1995 through 2004, were used to compute time series of daily, monthly, and annual sediment loads for both tributaries. The daily load time series were used as inputs for the TAM/WASP model of suspended solids and water clarity in the tidal Anacostia. The monthly load time series were used to calibrate the HSPF watershed model (Phase 3) for the non-tidal Anacostia.

Summary of Data

Average daily flow data is available from the USGS gage stations, 01649500 on the NEB and 01651000 on the NWB. Suspended solids concentration data for the study period, 1995 through 2004, are available from a number of programs and special studies, and are from two different types of laboratory analyses, total suspended solids (TSS) and suspended sediment concentration (SSC). In this report, the phrase "suspended solids concentration" will be used to refer to both TSS and SSC data. Available suspended solids concentration data are listed in Table 1 and discussed below.

> ***USGS/MDE 2003-2004 stormwater monitoring study of the NEB and NWB***: The USGS, with funding from MDE, and additional funding from Prince George's County, has installed automated sampling devices at its gage stations on the NEB (station 01649500) and the NWB (station 01651000), and has collected samples since July of 2003. Each storm flow sample collected by the automatic sampling devices represents water quality at a single point in time, and is analyzed for SSC. Data for the time period, July 2003 through September 2004, were available for use in this project (Brenda Majedi, private communication).
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> ***MDE 2003 water quality monitoring***: In 2003, MDE collected water quality data, including TSS, at the USGS gage stations on the NEB (station 01649500) and the NWB (station 01651000) in support of its TMDL program. At the time of this study, provisional data were available (Elinor Zetina, private communication).
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> ***Academy of Natural Sciences – Patrick Center for Environmental Research (ANS-PCER) 1998 stormwater runoff study***: The ANS-PCER stormwater runoff study included data, including TSS, from samples collected at the USGS gage stations on the NEB (station 01649500) and NWB (station 01651000) (Velinsky *et al*., 1999).

ICPRB NEB and NWB 1995-1996 stormwater monitoring project: A year-long study of toxics contaminants in the NEB and NWB was conducted by ICPRB in 1995-96. Analyses for six base flow and twelve storm flow samples are available for TSS (Gruessner *et al*., 1997).

LTCP 1999-2000 monitoring of the NEB and NWB: As part of the DCWASA LTCP study, the Occoquan Water Monitoring Laboratory (OWML) installed automatic sampling devices at the USGS gage stations on the NEB (station 01649500) and the NWB (station 01651000) to provide data for load estimates of constituents of interest for that project, including TSS (MWCOG/OWML, 2001). During storm flow conditions, composite samples were collected at equal-flow intervals over periods of time ranging from 0.3 to 1.2 days.

ANS-PCER 2002 toxic chemicals monitoring study: The ANS-PCER study of toxic chemicals in the Anacostia main channel for the DCDOH included samples collected adjacent to the USGS gage station on the NEB (station 01649500) and at a location on the NWB, at US Highway 1, that was above head-of-tide during all sampled storm events. Water quality data, including TSS and organic carbon, were collected on four separate dates in May, June, August, and October of 2002 and post-storm time series data were collected in October, 2002 (private communication, David Velinsky).

Table 1. Tributary monitoring data sets - solids and water clarity-related parameter values

Study	Study ID	Time Period	Parameter	Sample Type	Sampling Method	No. Samples NEB/NWB
USGS/MDE automated sampler monitoring	USGS/MDE	Jul 2003 – Sep 2004	SSC	Discrete grab	Automated sampling device	40/40
MDE water quality monitoring	MDE	2003	TSS	Discrete grab	Manual	17/18
ANS-PCER stormwater runoff study	ANS/EPA	1998	TSS	Discrete grab	Manual	9/9
ICPRB study	ICPRB/DC	1995 - 1996	TSS	Discrete grab	Manual	17/17
LTCP upstream boundary conditions	OWML/DC WASA	1999 - 2000	TSS	Composite	Automated sampling device	40/38
ANS-PCER toxics study	ANS/DC	2002	TSS	Discrete grab	Manual	9/10

The data from the six studies listed in Table 1 were judged to be sufficiently comparable to be combined into single data sets: a set of 132 suspended solids observations for the NEB and a set of 132 suspended solids observations for the NWB. These data sets are plotted in Figures 1 and 2 and tabulated in Tables 5 and 6. Though the LTCP data were derived from composite rather than discrete samples, they were judged to be acceptable because the time period of the composites, 0.3 to 1.2 days, was comparable to the averaging time period for the daily flows values used in the ESTIMATOR analysis. SSC data and TSS data are based on two different laboratory analytical methods that have been found to produce slightly different results (Gray *et al*., 2000), with SSC data considered to be more reliable. SSC data are obtained from a measurement of the mass of all sediment contained in the volume of water comprising the sample, whereas TSS is commonly a measurement of the mass of sediment contained in a sub-sample of the original sample. SSC measurements have been found to be higher than paired TSS measurements in cases where there is a significant amount of sand in the sample (25% sand or greater). Thus, the SSC measurements from the USGS/MDE study would be expected to be higher than corresponding TSS measurements might have been, especially in the case of high-flow samples.

ESTIMATOR Model

Suspended solids loads were calculated from available data for the time period, 1995-2004, using the USGS ESTIMATOR computer program developed by Tim Cohn and others. ESTIMATOR is a 7-parameter, log-linear regression model that uses stream discharge, time, and season to predict daily, monthly, and annual in-stream constituent concentrations using the following equation:

$$\ln[C] = \beta_0 + \beta_1 \ln[Q/Q_c] + \beta_2 (\ln[Q/Q_c])^2 + \beta_3 [T - T_c] + \beta_4 [T - T_c]^2 + \beta_5 \sin[2*\pi T] + \beta_6 \cos[2*\pi T] + \varepsilon$$

where

ln[]	=	natural logarithm function;
C	=	measured constituent concentration (mg/L);
β_0 - β_6	=	coefficients of the regression model;
Q	=	mean daily discharge on the day the sample was taken (ft^3/sec);
Q_c	=	centering variable defined such that β_1 and β_2 are statistically independent;
T	=	decimal time (year);
T_c	=	centering variable defined such that β_3 and β_4 are statistically independent;
π	=	3.14169;
ε	=	independent random error.

The coefficients of the regression model, β_0 through $\beta_{6,}$ are computed from the observed concentration data by ordinary least squares (or by minimum variance, in the case of censored data). β_0 is a constant, β_1 and β_2 describe the relation between discharge and concentration, β_3 and β_4 describe long-term time trends in concentration, and β_5 and β_6 describe seasonal variations in concentration (Cohn *et al*., 1992). The centering variables, Q_c and T_c, are used to reduce covariance among the independent parameters and to enhance the precision of the load estimates. It is assumed that model errors, ε, are independent and normally distributed, with zero mean and variance and that constituent concentrations fit the specified log-linear model.

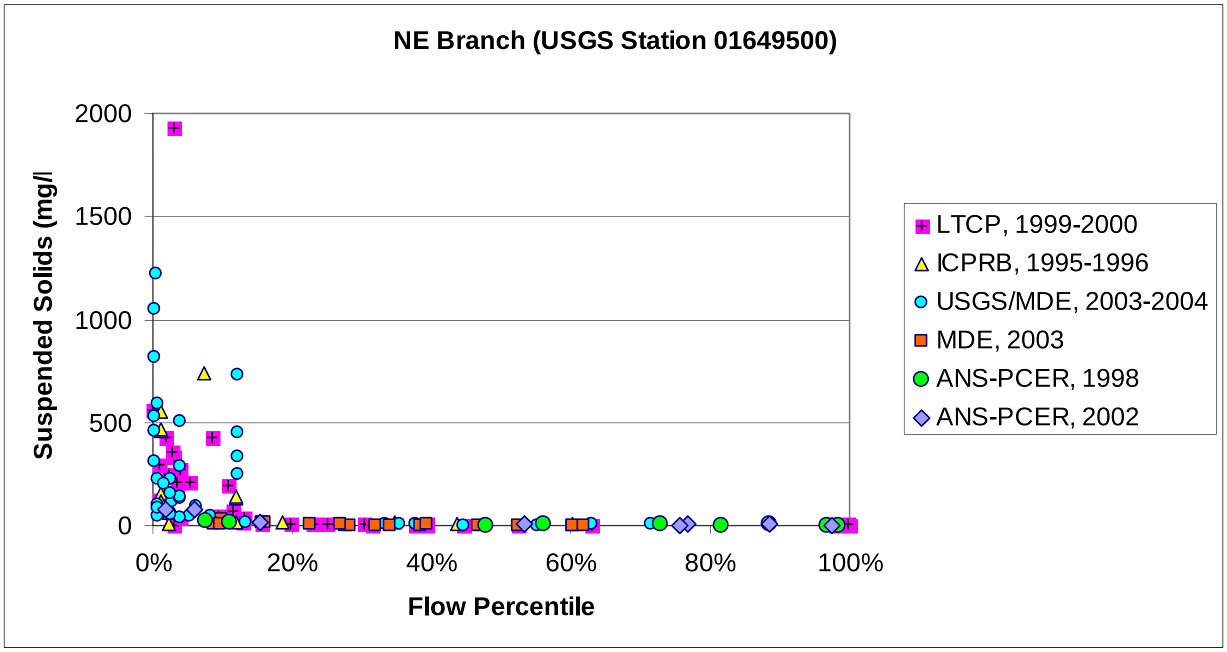

Figure 1. Available suspended solids data for the Northeast Branch of the Anacostia, 1995-2004

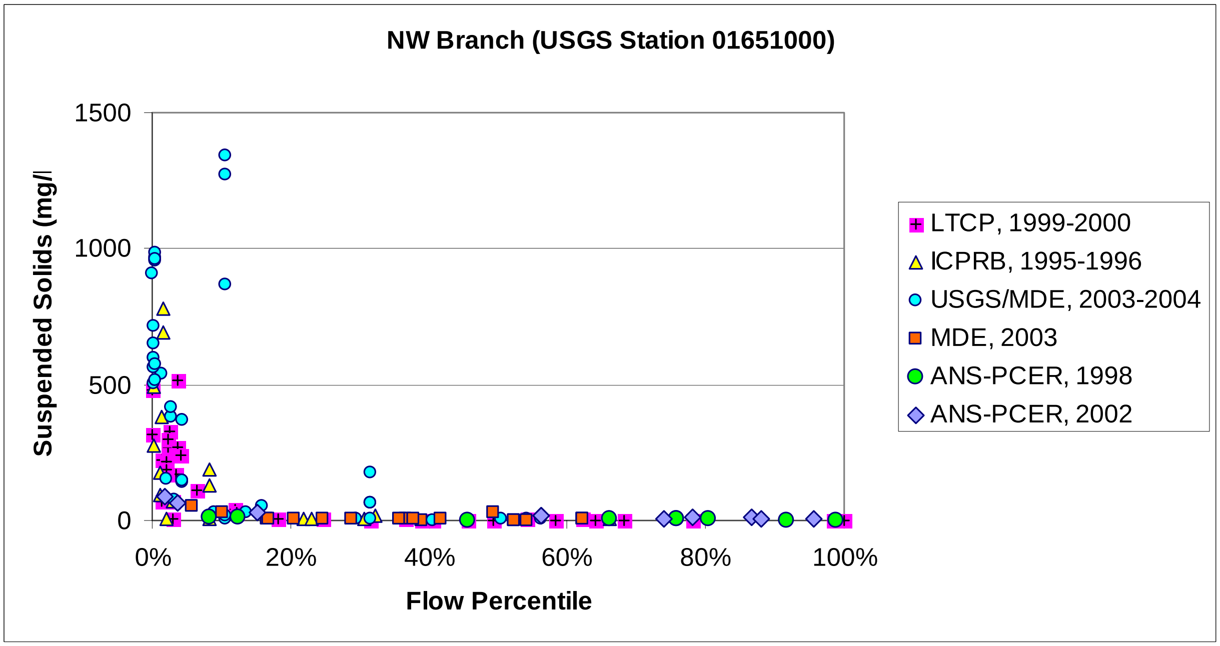

Figure 2. Available suspended solids data for the Northwest Branch of the Anacostia, 1995-2004

ESTIMATOR requires a complete record of daily discharge that covers at least the time period of the calibration dataset and the time period selected by the user over which loads are to be estimated. It is also important to obtain a sufficient number of water quality samples that thoroughly characterize the relationship between constituent concentration and flow. The more data available, the more accurate the load estimates, but a minimum of 10 observations are recommended for each regression coefficient used, and 20 percent of the observations should be above the minimum detection limit (Baier *et al*., 1995; Cohn, 2002). This translates into a minimum of 70 observations for a 7-parameter analysis. Ideally, half of the samples should be obtained during high flow, and the rest should be distributed uniformly throughout the year because constituent concentrations can be greatly affected by the amount of discharge at the time of sampling.

Results

The ESTIMATOR model was used to estimate daily, monthly, and annual suspended sediment loads for both the NEB and NWB tributaries for the time period, January 1995 through September 2004. Input data consisted of daily average flow data from the two most downstream USGS gage stations, 01649500 on the NEB and 01651000 on the NWB, and available suspended solids data, given in Tables 5 and 6. A graph of the average of monthly values appears in Figure 3. The month with the highest average load is September, due to the very high storm flows that occur during hurricanes that reach the Washington, DC area. Results for annual loads are given in Table 2 and shown graphically in Figure 4. The highest annual loads occurred in 2003, which was the year with high annual flow for the period of record at the two gage stations, 1939 – present.

Table 2. ESTIMATOR Predictions of Mean Sediment Loads

	NEB Annual Load (kg/day)			NWB Annual Load (kg/day)		
CalendarYear	Predicted	95% Confidence Interval		Predicted	95% Confidence Interval	
1995	31,096	9,837	75,121	15,166	4,756	36,821
1996	123,274	27,192	361,494	77,633	17,666	224,140
1997	32,388	9,177	83,287	13,555	4,285	32,762
1998	67,148	13,980	202,564	26,068	8,230	63,047
1999	122,342	7,143	589,794	67,621	4,213	320,224
2000	16,995	6,824	35,467	12,604	4,557	28,106
2001	31,117	5,872	98,341	24,125	4,668	75,362
2002	14,271	4,902	32,831	8,571	3,056	19,276
2003	217,319	53,988	599,836	171,076	36,449	510,323

ESTIMATOR gives values and measures of statistical significance for all of the 7 coefficients of the regression equation, β_0 through β_6. For both tributaries, one or both coefficients for flow and seasonality variables were statistically significant, showing that suspended solids concentrations are dependent on stream flow (*i.e.*, daily discharge) and on season. For the NEB, neither of the coefficients, β_3 and β_4, representing the effects of long-term trends in time, was statistically significant. For the NWB, β_3 was determined by ESTIMATOR to be significant, suggesting that suspended solids concentrations increased over the time period, 1995 through 2004. However, it was decided that this result was more likely due to the inclusion of both TSS and SSC data in the sample sets, rather than actual changes in watershed loads in this time period. Because the SSC data were collected during the end of the study period, 2003-2004, they likely biased the later years of the sample set toward higher suspended solids values (see discussion above). To check this hypothesis, the NWB ESTIMATOR run was re-done without the SSC data, and the significance of β_3 was found to disappear. Therefore, it was concluded that the NEB and NWB sample sets were not of sufficient quality to determine long-term time trends. The final ESTIMATOR runs for both the NEB and the NWB were done without inclusion of the coefficients, β_3 and β_4.

Coefficients of determination for the final ESTIMATOR runs (dropping coefficients representing long-term trends in time) were R^2 = 68.4 for the NEB and R^2 = 73.5 for the NWB. Comparisons of ESTIMATOR results with observed data are shown in Figures 5 and 6. The solid curves are plots of predicted suspended solids concentrations as a function of flow only, neglecting the effects of seasonality. The circles are plots of predicted suspended solids concentrations as a function of both flow and seasonality. Clearly the ESTIMATOR is too simple a model to fully capture the flow dependence of suspended solids concentrations. For both the NEB and the NWB, ESTIMATOR somewhat over-predicts suspended solids concentrations for mid-flows of 10 to 100 mg/L, and somewhat under-predicts suspended solids concentrations for the highest flows, of > 1000 mg/L.

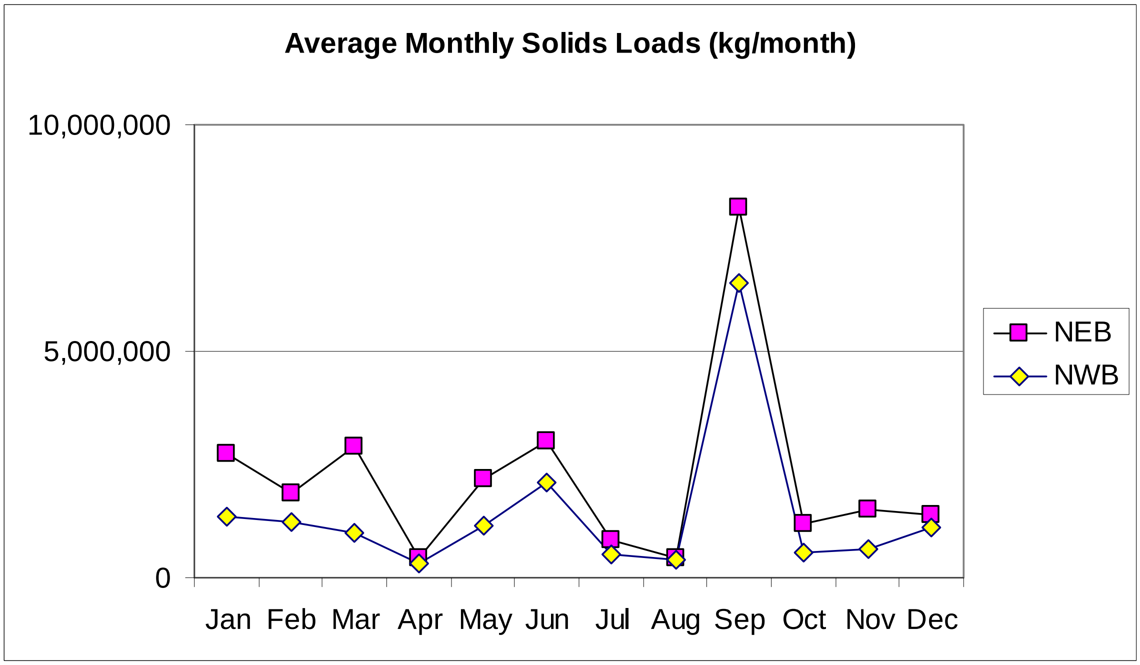

Figure 3. Average monthly suspended sediment loads, 1995-2004

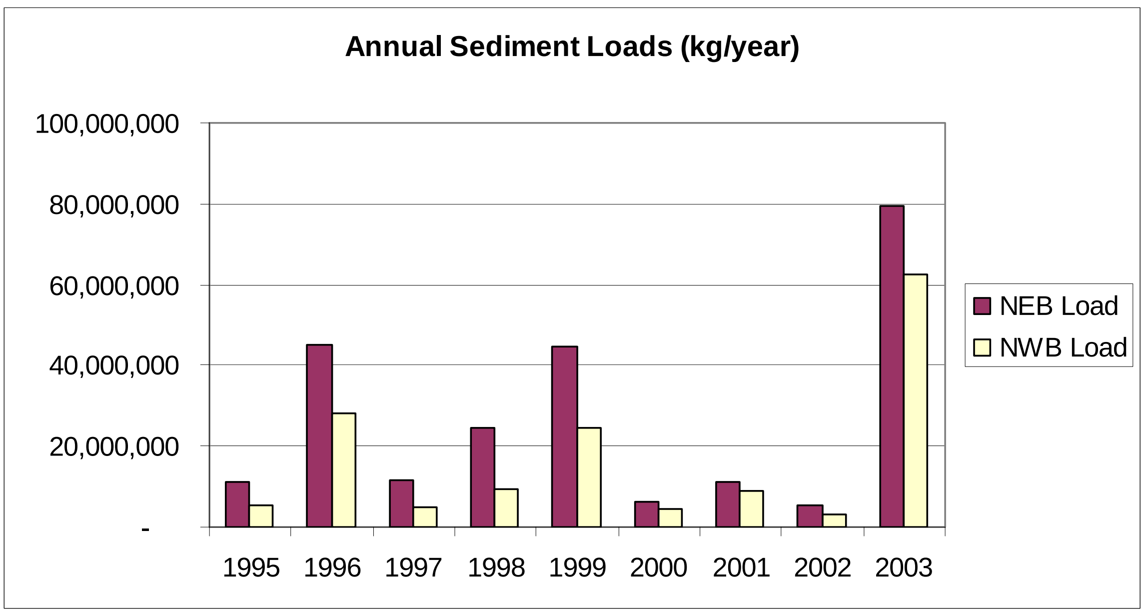

Figure 4. Annual suspended sediment loads, 1995-2003

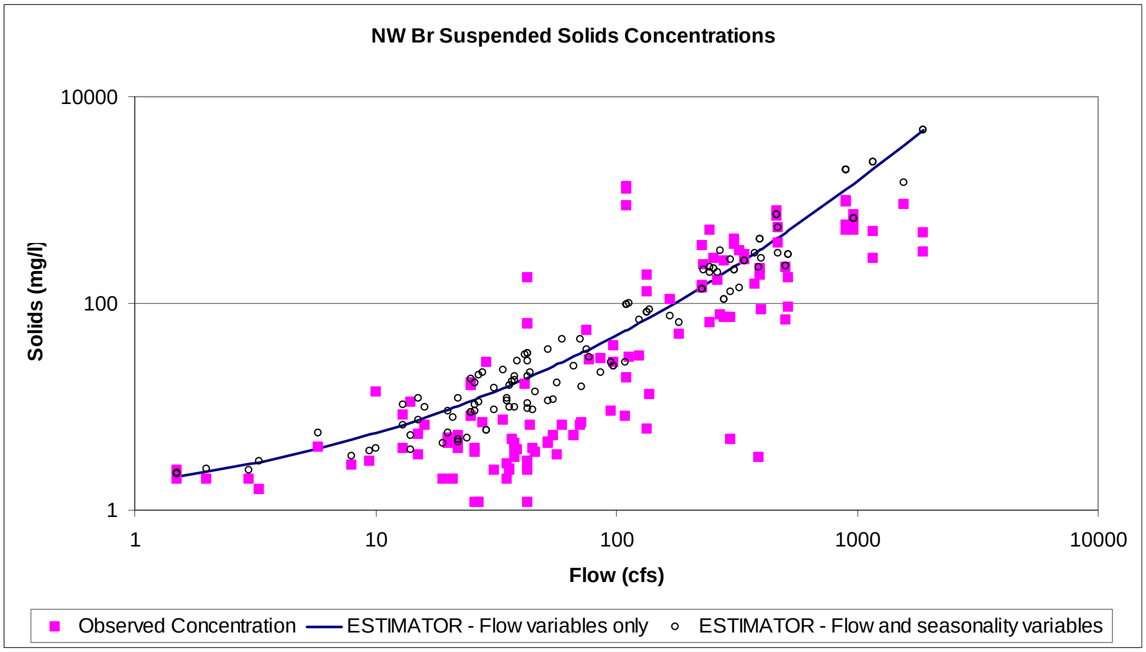

Figure 5. Comparison of observations with ESTIMATOR predictions, Northwest Branch

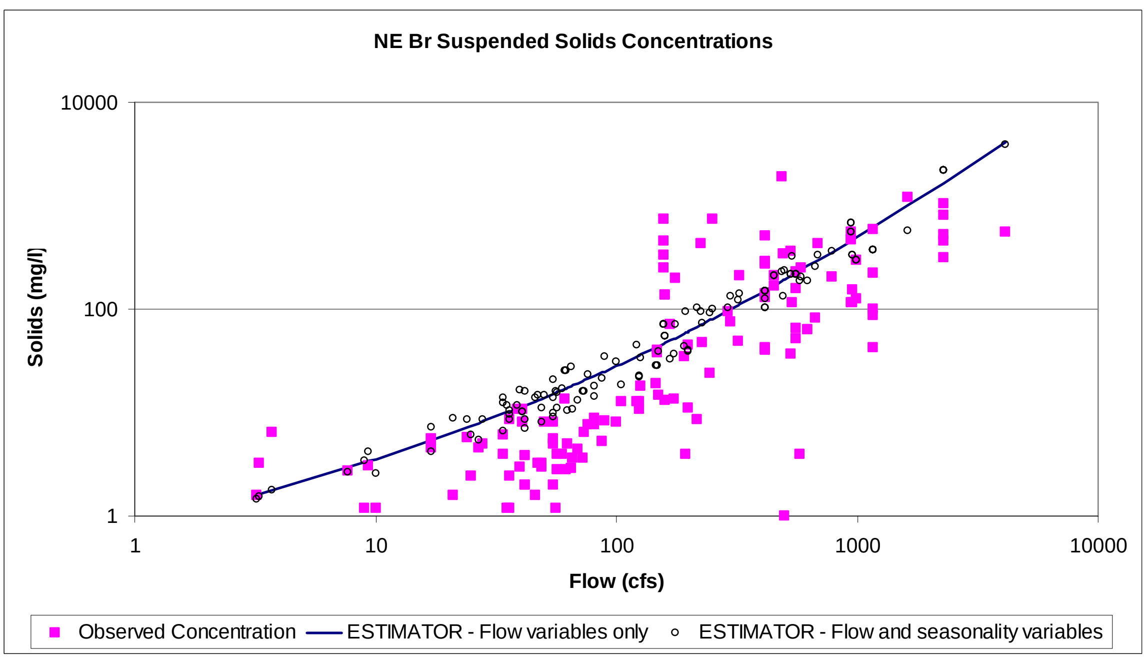

Figure 6. Comparison of observations with ESTIMATOR predictions, Northeast Branch

Table 5. Northeast Branch Suspended Solids Data Used in ESTIMATOR Model

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01649500	ICPRB/DC	9/27/1995	10:00 AM	36	8.5	
01649500	ICPRB/DC	11/7/1995	10:45 AM	74	6.4	
01649500	ICPRB/DC	1/23/1996	10:15 AM	105	12.8	
01649500	ICPRB/DC	3/19/1996	10:00 AM	576	4	
01649500	ICPRB/DC	4/26/1996	3:00 PM	50	8	
01649500	ICPRB/DC	11/14/1995	1:15 PM	958	154	
01649500	ICPRB/DC	11/14/1995	7:30 PM	958	114	
01649500	ICPRB/DC	11/15/1995	9:30 AM	626	64	
01649500	ICPRB/DC	4/30/1996	12:45 PM	160	13	
01649500	ICPRB/DC	4/30/1996	4:15 PM	160	138	
01649500	ICPRB/DC	4/30/1996	7:30 PM	160	136	
01649500	ICPRB/DC	7/13/1996	8:30 AM	942	462	
01649500	ICPRB/DC	7/13/1996	11:15 AM	942	468	
01649500	ICPRB/DC	7/12/1996	8:00 PM	61	13.6	
01649500	ICPRB/DC	9/6/1996	1:00 PM	949	552	
01649500	ICPRB/DC	9/6/1996	6:45 PM	949	114	
01649500	ICPRB/DC	9/7/1996	11:15 AM	250	740	
01649500	MDE	1/6/2003	11:20 AM	125	12.8	
01649500	MDE	2/3/2003	10:35 AM	42	3.8	
01649500	MDE	3/3/2003	11:15 AM	192	34.7	
01649500	MDE	3/17/2003	10:55 AM	73	3.6	
01649500	MDE	4/21/2003	10:15 AM	56	2.4	<
01649500	MDE	5/5/2003	10:30 AM	47	3.2	
01649500	MDE	5/19/2003	10:25 AM	122	12.6	
01649500	MDE	6/2/2003	10:40 AM	89	8.4	
01649500	MDE	6/16/2003	11:10 AM	217	8.6	
01649500	MDE	7/7/2003	9:40 AM	195	4.0	
01649500	MDE	7/21/2003	11:10 AM	65	2.9	
01649500	MDE	8/4/2003	10:20 AM	62	2.8	
01649500	MDE	8/18/2003	10:46 AM	55	5.0	
01649500	MDE	9/8/2003	11:00 AM	35	2.4	<
01649500	MDE	9/22/2003	12:35 PM	76	7.6	
01649500	MDE	10/6/2003	10:25 AM	36	2.4	<
01649500	MDE	10/20/2003	10:30 AM	36	2.4	
01649500	USGS/MDE	7/23/2003	9:15 AM	540	115	
01649500	USGS/MDE	8/19/2003	10:30 AM	42	2.0	
01649500	USGS/MDE	9/24/2003	8:00 AM	320	49	
01649500	USGS/MDE	10/28/2003	11:30 AM	415	42	
01649500	USGS/MDE	11/18/2003	10:00 AM	57	4.0	
01649500	USGS/MDE	12/11/2003	9:00 AM	1620	1220	
01649500	USGS/MDE	12/16/2003	9:45 AM	198	11	
01649500	USGS/MDE	1/13/2004	11:30 AM	63	5.0	
01649500	USGS/MDE	2/6/2004	9:15 AM	1170	43	
01649500	USGS/MDE	2/6/2004	9:45 AM	1170	87	
01649500	USGS/MDE	2/6/2004	10:15 AM	1170	101	
01649500	USGS/MDE	2/6/2004	11:45 AM	1170	225	
01649500	USGS/MDE	2/6/2004	1:15 PM	1170	591	

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01649500	USGS/MDE	2/11/2004	10:30 AM	146	19	
01649500	USGS/MDE	3/24/2004	9:30 AM	49	3	
01649500	USGS/MDE	4/12/2004	1:45 PM	416	131	
01649500	USGS/MDE	4/12/2004	3:45 PM	416	139	
01649500	USGS/MDE	4/12/2004	5:45 PM	416	291	
01649500	USGS/MDE	4/12/2004	7:45 PM	416	285	
01649500	USGS/MDE	4/12/2004	11:45 PM	416	508	
01649500	USGS/MDE	4/13/2004	3:45 AM	557	228	
01649500	USGS/MDE	4/13/2004	8:00 AM	557	158	
01649500	USGS/MDE	4/13/2004	4:15 PM	557	52	
01649500	USGS/MDE	4/13/2004	8:15 PM	557	66	
01649500	USGS/MDE	4/14/2004	12:15 AM	228	48	
01649500	USGS/MDE	4/20/2004	9:00 AM	60	4	
01649500	USGS/MDE	5/25/2004	10:00 AM	34	4	
01649500	USGS/MDE	6/23/2004	8:45 AM	34	6	
01649500	USGS/MDE	6/25/2004	4:30 PM	158	249	
01649500	USGS/MDE	6/25/2004	5:30 PM	158	732	
01649500	USGS/MDE	6/25/2004	6:30 PM	158	452	
01649500	USGS/MDE	6/25/2004	7:30 PM	158	331	
01649500	USGS/MDE	7/13/2004	8:30 AM	40	3	
01649500	USGS/MDE	7/28/2004	10:45 AM	2280	1050	
01649500	USGS/MDE	7/28/2004	11:15 AM	2280	818	
01649500	USGS/MDE	7/28/2004	12:30 PM	2280	532	
01649500	USGS/MDE	7/28/2004	1:00 PM	2280	457	
01649500	USGS/MDE	7/28/2004	2:30 PM	2280	311	
01649500	USGS/MDE	9/21/2004	1:00 PM	28	5.0	
01649500	USGS/MDE	9/28/2004	1:15 PM	783	202	
01649500	USGS/MDE	9/29/2004	9:45 AM	291	94	
01649500	ANS/DC	6/24/2002	12:00 PM	9.4	3.1	
01649500	ANS/DC	8/30/2002	12:00 PM	24	5.7	
01649500	ANS/DC	8/28/2002	12:00 PM	299	74.2	
01649500	ANS/DC	10/16/2002	12:00 PM	674	81.4	
01649500	ANS/DC	10/17/2002	5:00 PM	127	17.8	
01649500	ANS/DC	10/18/2002	8:30 AM	41	10.8	
01649500	ANS/DC	10/18/2002	7:30 PM	41	8.0	
01649500	ANS/DC	10/19/2002	9:00 AM	25	2.4	
01649500	ANS/DC	10/21/2002	11:15 AM	17	4.6	
01649500	ANS/EPA	2/25/1998	12:00 PM	173	13.5	
01649500	ANS/EPA	4/30/1998	12:00 PM	46	1.6	
01649500	ANS/EPA	5/4/1998	12:00 PM	246	24	
01649500	ANS/EPA	7/14/1998	12:00 PM	21	1.6	
01649500	ANS/EPA	7/24/1998	12:00 PM	17	5.6	
01649500	ANS/EPA	9/16/1998	12:00 PM	7.7	2.8	
01649500	ANS/EPA	9/23/1998	12:00 PM	39	10.6	
01649500	ANS/EPA	10/19/1998	12:00 PM	10	1.2	
01649500	ANS/EPA	11/12/1998	12:00 PM	27	4.5	
01649500	OWML/DCWASA	8/5/1999	10:45 AM	3.7	6.4	
01649500	OWML/DCWASA	8/12/1999	10:30 AM	3.3	3.2	

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01649500	OWML/DCWASA	8/19/1999	8:55 AM	3.2	1.6	
01649500	OWML/DCWASA	8/26/1999	1:03 AM	224	426	
01649500	OWML/DCWASA	8/27/1999	4:09 AM	175	198	
01649500	OWML/DCWASA	9/2/1999	9:34 AM	9	1.2	
01649500	OWML/DCWASA	9/5/1999	1:50 AM	452	209	
01649500	OWML/DCWASA	9/5/1999	10:30 PM	452	169	
01649500	OWML/DCWASA	9/7/1999	3:05 AM	325	211	
01649500	OWML/DCWASA	9/10/1999	2:40 AM	488	1930	
01649500	OWML/DCWASA	9/9/1999	1:00 PM	502	1.0	
01649500	OWML/DCWASA	9/16/1999	9:54 PM	4130	558	
01649500	OWML/DCWASA	9/17/1999	3:38 PM	689	430	
01649500	OWML/DCWASA	9/23/1999	9:00 AM	100	8.0	
01649500	OWML/DCWASA	9/30/1999	3:52 AM	529	360	
01649500	OWML/DCWASA	9/30/1999	5:08 PM	529	37	
01649500	OWML/DCWASA	10/7/1999	11:05 AM	57	2.8	
01649500	OWML/DCWASA	10/14/1999	9:55 AM	55	5.6	
01649500	OWML/DCWASA	10/21/1999	12:10 PM	87	5.2	
01649500	OWML/DCWASA	11/3/1999	11:00 AM	81	7.6	
01649500	OWML/DCWASA	11/16/1999	1:50 PM	34	0.5	
01649500	OWML/DCWASA	11/27/1999	12:33 AM	414	272	
01649500	OWML/DCWASA	11/27/1999	1:51 PM	414	40	
01649500	OWML/DCWASA	12/1/1999	11:51 AM	55	2.0	
01649500	OWML/DCWASA	12/6/1999	8:20 AM	148	40	
01649500	OWML/DCWASA	12/6/1999	6:28 PM	148	38	
01649500	OWML/DCWASA	12/10/1999	8:02 PM	167	71	
01649500	OWML/DCWASA	12/14/1999	1:10 AM	994	127	
01649500	OWML/DCWASA	12/14/1999	11:07 PM	994	298	
01649500	OWML/DCWASA	12/16/1999	10:35 AM	125	10.8	
01649500	OWML/DCWASA	12/28/1999	11:00 AM	49	3.2	
01649500	OWML/DCWASA	1/13/2000	11:50 AM	66	3.6	
01649500	OWML/DCWASA	1/27/2000	11:47 AM	55	8.0	
01649500	OWML/DCWASA	2/9/2000	11:00 AM	81	8.8	
01649500	OWML/DCWASA	2/11/2000	12:34 AM	200	45	
01649500	OWML/DCWASA	2/23/2000	11:20 AM	69	4.4	
01649500	OWML/DCWASA	2/28/2000	9:15 AM	496	338	
01649500	OWML/DCWASA	3/8/2000	12:05 PM	42	2.0	
01649500	OWML/DCWASA	3/28/2000	1:55 AM	588	250	
01649500	OWML/DCWASA	3/29/2000	11:38 AM	150	14.8	

Table 6. Northwest Branch Suspended Solids Data Used in ESTIMATOR

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01651000	ICPRB/DC	9/27/1995	11:30 AM	20	5	
01651000	ICPRB/DC	11/7/1995	11:45 AM	57	3.4	
01651000	ICPRB/DC	1/23/1996	11:45 AM	55	5.2	
01651000	ICPRB/DC	3/19/1996	11:00 AM	391	3.2	
01651000	ICPRB/DC	4/26/1996	1:30 PM	44	6.7	
01651000	ICPRB/DC	11/14/1995	12:30 PM	518	176	
01651000	ICPRB/DC	11/14/1995	8:00 PM	518	92	
01651000	ICPRB/DC	11/15/1995	10:15 AM	300	72	
01651000	ICPRB/DC	4/30/1996	12:00 PM	135	6	
01651000	ICPRB/DC	4/30/1996	5:00 PM	135	186	
01651000	ICPRB/DC	4/30/1996	6:40 PM	135	128	
01651000	ICPRB/DC	7/13/1996	9:20 AM	467	694	
01651000	ICPRB/DC	7/13/1996	12:00 PM	467	780	
01651000	ICPRB/DC	7/12/1996	9:00 PM	42	16.4	
01651000	ICPRB/DC	9/6/1996	2:00 PM	1170	494	
01651000	ICPRB/DC	9/6/1996	7:45 PM	1170	276	
01651000	ICPRB/DC	9/7/1996	12:00 PM	471	380	
01651000	MDE	1/6/2003	10:00 AM	72	7	
01651000	MDE	1/21/2003	10:50 AM	29	27	
01651000	MDE	2/3/2003	10:20 AM	22	4	
01651000	MDE	3/3/2003	10:40 AM	182	50	
01651000	MDE	3/17/2003	10:20 AM	46	3.6	
01651000	MDE	4/21/2003	9:50 AM	36	2.5	
01651000	MDE	5/5/2003	10:15 AM	38	3.2	
01651000	MDE	5/19/2003	10:00 AM	71	6.6	
01651000	MDE	6/2/2003	10:10 AM	52	4.6	
01651000	MDE	6/16/2003	10:45 AM	60	6.6	
01651000	MDE	7/7/2003	9:20 AM	113	30	
01651000	MDE	7/21/2003	10:50 AM	27	2.4	<
01651000	MDE	8/4/2003	10:05 AM	39	3.8	
01651000	MDE	8/18/2003	10:10 AM	34	7.5	
01651000	MDE	9/8/2003	10:45 AM	22	4.6	
01651000	MDE	9/22/2003	11:45 AM	37	4.8	
01651000	MDE	10/6/2003	10:45 AM	27	2.4	<
01651000	MDE	10/20/2003	9:45 AM	26	2.4	<
01651000	USGS/MDE	7/23/2003	12:00 PM	272	77	
01651000	USGS/MDE	8/19/2003	9:00 AM	26	4	
01651000	USGS/MDE	9/24/2003	10:30 AM	125	31	
01651000	USGS/MDE	10/29/2003	12:15 PM	472	538	
01651000	USGS/MDE	11/18/2003	1:15 PM	38	4	
01651000	USGS/MDE	12/11/2003	1:00 PM	1570	906	
01651000	USGS/MDE	12/16/2003	12:15 PM	109	8	
01651000	USGS/MDE	1/13/2004	9:15 AM	45	4	
01651000	USGS/MDE	2/6/2004	12:45 PM	967	648	
01651000	USGS/MDE	2/6/2004	1:45 PM	967	564	
01651000	USGS/MDE	2/6/2004	2:45 PM	967	596	

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01651000	USGS/MDE	2/6/2004	7:45 PM	967	713	
01651000	USGS/MDE	2/6/2004	11:45 PM	967	504	
01651000	USGS/MDE	2/11/2004	1:15 PM	86	29	
01651000	USGS/MDE	3/23/2004	10:45 AM	35	2	
01651000	USGS/MDE	4/12/2004	2:45 PM	229	141	
01651000	USGS/MDE	4/12/2004	5:45 PM	229	149	
01651000	USGS/MDE	4/12/2004	8:45 PM	229	144	
01651000	USGS/MDE	4/12/2004	11:45 PM	229	367	
01651000	USGS/MDE	4/13/2004	5:45 AM	310	416	
01651000	USGS/MDE	4/13/2004	9:30 AM	310	378	
01651000	USGS/MDE	4/21/2004	8:45 AM	43	3	
01651000	USGS/MDE	5/26/2004	8:45 AM	43	64	
01651000	USGS/MDE	6/22/2004	8:15 AM	25	8	
01651000	USGS/MDE	7/1/2004	6:00 PM	110	19	
01651000	USGS/MDE	7/1/2004	7:00 PM	110	1340	
01651000	USGS/MDE	7/1/2004	8:00 PM	110	1270	
01651000	USGS/MDE	7/1/2004	9:00 PM	110	868	
01651000	USGS/MDE	7/2/2004	1:00 AM	43	178	
01651000	USGS/MDE	7/2/2004	5:00 AM	43	64	
01651000	USGS/MDE	7/14/2004	9:45 AM	28	7	
01651000	USGS/MDE	7/28/2004	12:00 PM	899	953	
01651000	USGS/MDE	7/28/2004	12:15 PM	899	967	
01651000	USGS/MDE	7/28/2004	12:30 PM	899	982	
01651000	USGS/MDE	7/28/2004	12:45 PM	899	962	
01651000	USGS/MDE	7/28/2004	2:45 PM	899	576	
01651000	USGS/MDE	7/28/2004	4:45 PM	899	514	
01651000	USGS/MDE	9/22/2004	12:30 PM	13	4	
01651000	USGS/MDE	9/28/2004	1:00 PM	375	155	
01651000	USGS/MDE	9/29/2004	9:00 AM	75	55	
01651000	ANS/DC	6/24/2002	12:00 PM	5.8	4.1	
01651000	ANS/DC	8/30/2002	12:00 PM	16	6.7	
01651000	ANS/DC	8/28/2002	12:00 PM	244	65.6	
01651000	ANS/DC	10/16/2002	12:00 PM	401	86.4	
01651000	ANS/DC	10/17/2002	5:30 PM	77	28.4	
01651000	ANS/DC	10/18/2002	8:30 AM	25	16.8	
01651000	ANS/DC	10/18/2002	6:30 PM	25	16	
01651000	ANS/DC	10/19/2002	8:00 AM	14	11	
01651000	ANS/DC	10/20/2002	9:00 AM	10	13.8	
01651000	ANS/DC	10/21/2002	10:30 AM	9.5	3	
01651000	ANS/EPA	2/25/1998	12:00 PM	95	9	
01651000	ANS/EPA	4/30/1998	12:00 PM	31	0.8	
01651000	ANS/EPA	5/4/1998	12:00 PM	137	13	
01651000	ANS/EPA	7/14/1998	12:00 PM	15	5.4	
01651000	ANS/EPA	7/24/1998	12:00 PM	13	8.2	
01651000	ANS/EPA	9/16/1998	12:00 PM	3	2	
01651000	ANS/EPA	9/23/1998	12:00 PM	15	3.4	
01651000	ANS/EPA	10/19/1998	12:00 PM	8	2.7	

LocationID	StudyID	SampleDate	SampleTime	Daily Flow Average (cfs)	Suspended Solids (mg/l)	Qualifier
01651000	ANS/EPA	11/12/1998	12:00 PM	20	4.4	
01651000	OWML/DCWASA	8/5/1999	12:19 PM	1.5	2	
01651000	OWML/DCWASA	8/12/1999	11:48 AM	1.5	2.4	
01651000	OWML/DCWASA	8/19/1999	9:44 AM	2	2	
01651000	OWML/DCWASA	8/25/1999	9:45 PM	230	238	
01651000	OWML/DCWASA	9/2/1999	10:19 AM	3.3	1.6	
01651000	OWML/DCWASA	9/5/1999	2:25 AM	397	185	
01651000	OWML/DCWASA	9/5/1999	11:20 PM	397	218	
01651000	OWML/DCWASA	9/7/1999	2:40 AM	253	272	
01651000	OWML/DCWASA	9/10/1999	2:45 AM	245	517	
01651000	OWML/DCWASA	9/9/1999	12:20 PM	298	4.8	
01651000	OWML/DCWASA	9/16/1999	10:35 AM	1880	318	
01651000	OWML/DCWASA	9/16/1999	9:37 PM	1880	478	
01651000	OWML/DCWASA	9/21/1999	7:27 PM	264	168	
01651000	OWML/DCWASA	9/23/1999	9:46 AM	38	4.4	
01651000	OWML/DCWASA	9/30/1999	3:55 AM	340	300	
01651000	OWML/DCWASA	9/30/1999	4:02 PM	340	268	
01651000	OWML/DCWASA	10/7/1999	11:40 AM	26	3.6	
01651000	OWML/DCWASA	10/14/1999	9:25 AM	21	2	
01651000	OWML/DCWASA	10/21/1999	1:00 PM	35	2.8	
01651000	OWML/DCWASA	11/3/1999	11:50 AM	31	2.4	
01651000	OWML/DCWASA	11/16/1999	2:30 PM	14	0.5	
01651000	OWML/DCWASA	11/27/1999	12:44 AM	282	257	
01651000	OWML/DCWASA	11/27/1999	3:54 PM	282	72	
01651000	OWML/DCWASA	12/1/1999	11:25 AM	19	2	
01651000	OWML/DCWASA	12/6/1999	3:26 PM	97	27	
01651000	OWML/DCWASA	12/10/1999	11:26 PM	98	39	
01651000	OWML/DCWASA	12/14/1999	12:12 AM	504	68	
01651000	OWML/DCWASA	12/14/1999	11:11 PM	504	221	
01651000	OWML/DCWASA	12/16/1999	11:30 AM	52	4.4	
01651000	OWML/DCWASA	12/28/1999	11:40 AM	24	0.5	
01651000	OWML/DCWASA	1/13/2000	12:20 PM	29	0.5	
01651000	OWML/DCWASA	1/27/2000	11:02 AM	22	5.2	
01651000	OWML/DCWASA	2/9/2000	10:22 AM	43	2.4	
01651000	OWML/DCWASA	2/23/2000	11:50 AM	43	1.2	
01651000	OWML/DCWASA	2/28/2000	10:52 AM	325	326	
01651000	OWML/DCWASA	3/8/2000	11:41 AM	36	2.4	
01651000	OWML/DCWASA	3/28/2000	2:10 AM	168	109	
01651000	OWML/DCWASA	3/29/2000	10:42 AM	67	5.2	

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