APPENDIX A

Model Description

A calibrated mathematical model of Antietam Creek was developed by MDE for simulating dissolved oxygen (DO) conditions in Antietam Creek from the Maryland-Pennsylvania border to its confluence with the Potomac River. The model was converted to a computer spreadsheet model and updated for the Antietam Creek TMDL analysis. The model uses the Streeter-Phelps equation to simulate DO concentrations in Antietam Creek. The model uses creek background and point source loadings of carbonaceous biological demand (CBOD) and nitrogenous biological demand (NBOD) as DO sags, and simulates oxygen addition through atmospheric reaeration and photosynthesis. Reaeration values are computed for stream segments using Tsivoglou's formula. Model coefficients were calibrated against stream survey data collected during the summers of 1996 and 1997.

Input Data

The model requires input data for segment drainage area, segment elevation, and segment length to calculate tributary flows, stream velocities and rearation rates. Tributary stream flows for each segment are calculated by multiplying the corresponding segment drainage area by the stream flow runoff rate. The stream flow runoff rate is determined by selecting a representative reference stream gaging station on Antietam Creek. USGS gaging station 01619500 on Antietam Creek near Sharpsburg, Maryland was selected. The input data is shown in Table A1 and Figure A1.

SEGMENT	STREAM LENGTH mi	DRAINAGE AREA mi^2	Elevation Drop Through Segment ft
Background	-	110.380	-
32	1.630	0.000	42
33	2.100	4.662	16
34	4.300	26.992	23
35	3.030	11.951	6
36	1.570	25.796	11
1	1.345	0.331	6
2	0.739	0.651	3
3	0.417	0.000	2
4	0.341	1.417	1
5	0.518	1.307	2
6	0.625	0.466	5
7	0.587	0.959	5
8	0.928	1.457	7

Table A1: Model Input Data

SEGMENT	STREAM LENGTH mi	DRAINAGE AREA mi^2	Elevation Drop Through Segment ft
9	0.833	1.214	7
10	0.189	5.525	2
11	0.606	1.997	7
12	0.511	0.175	6
13	0.795	0.259	7
14	0.549	0.337	5
15	0.739	0.347	7
16	0.360	1.123	3
17	0.246	0.558	2
18	0.417	0.206	3
19	0.606	0.488	5
20	0.464	34.022	4
21	0.739	0.750	6
22	0.379	0.198	6
23	0.417	0.295	7
24	0.502	2.989	8
25	0.587	0.231	3
26	0.455	0.619	2
27	1.400	0.000	2
28	3.660	31.917	18
29	1.740	8.233	10
30	2.660	2.879	22
31	0.140	7.678	2

Table A1: Model Input Data, Continued

The segment numbering scheme from the original model has been used in this updated TMDL model to maintain consistency.

Water Quality Input Data

Input data from seventeen water quality sampling sites on Antietam Creek and three on the tributaries were examined. The Maryland Department of the Environment (MDE) collected the water chemistry data from these sites during the summers of 1996 and 1997. The location of the water quality stations where stream data measurements were taken are shown in Figures A1, A2 and A3.

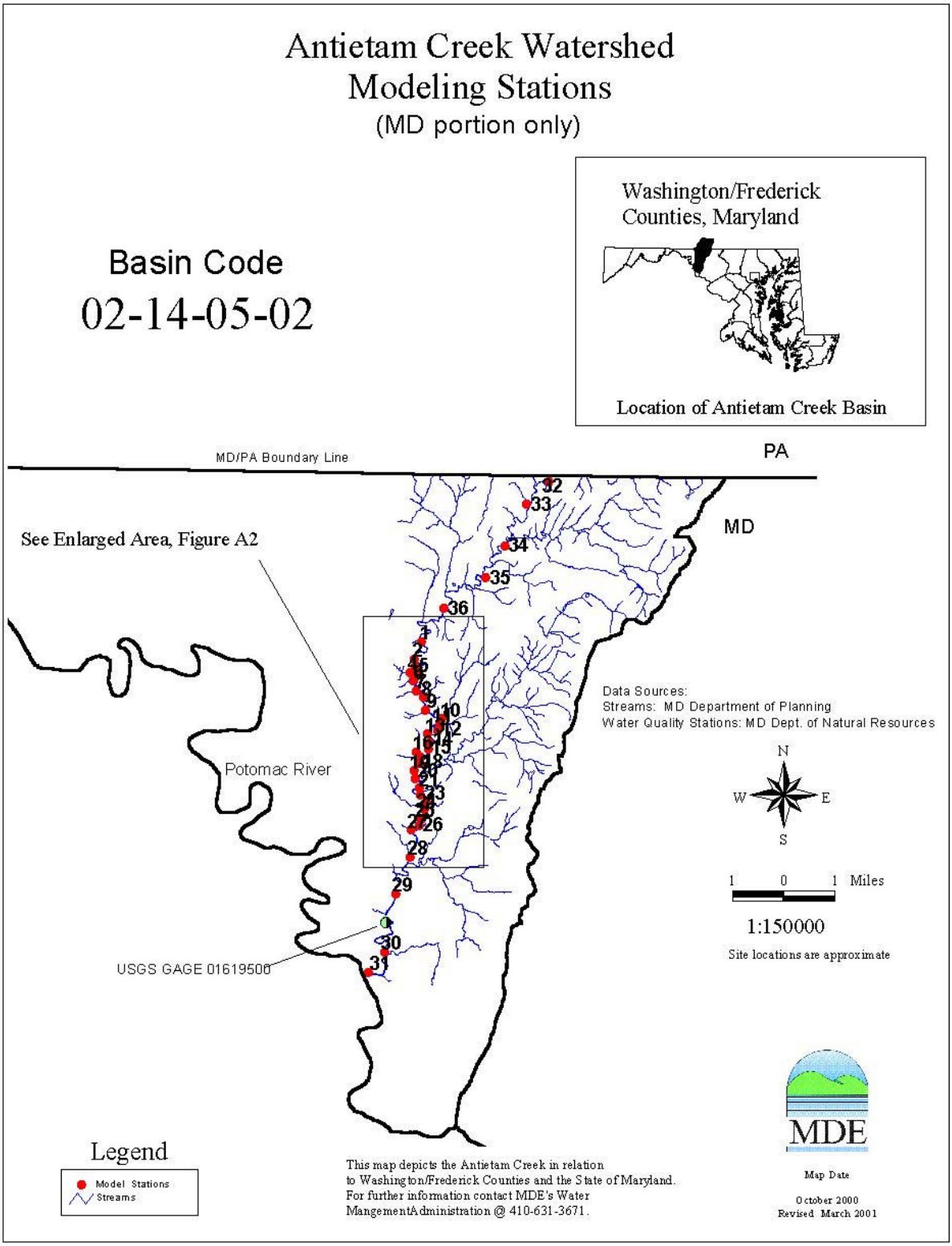

Figure A1. Location of Modeling Station Points

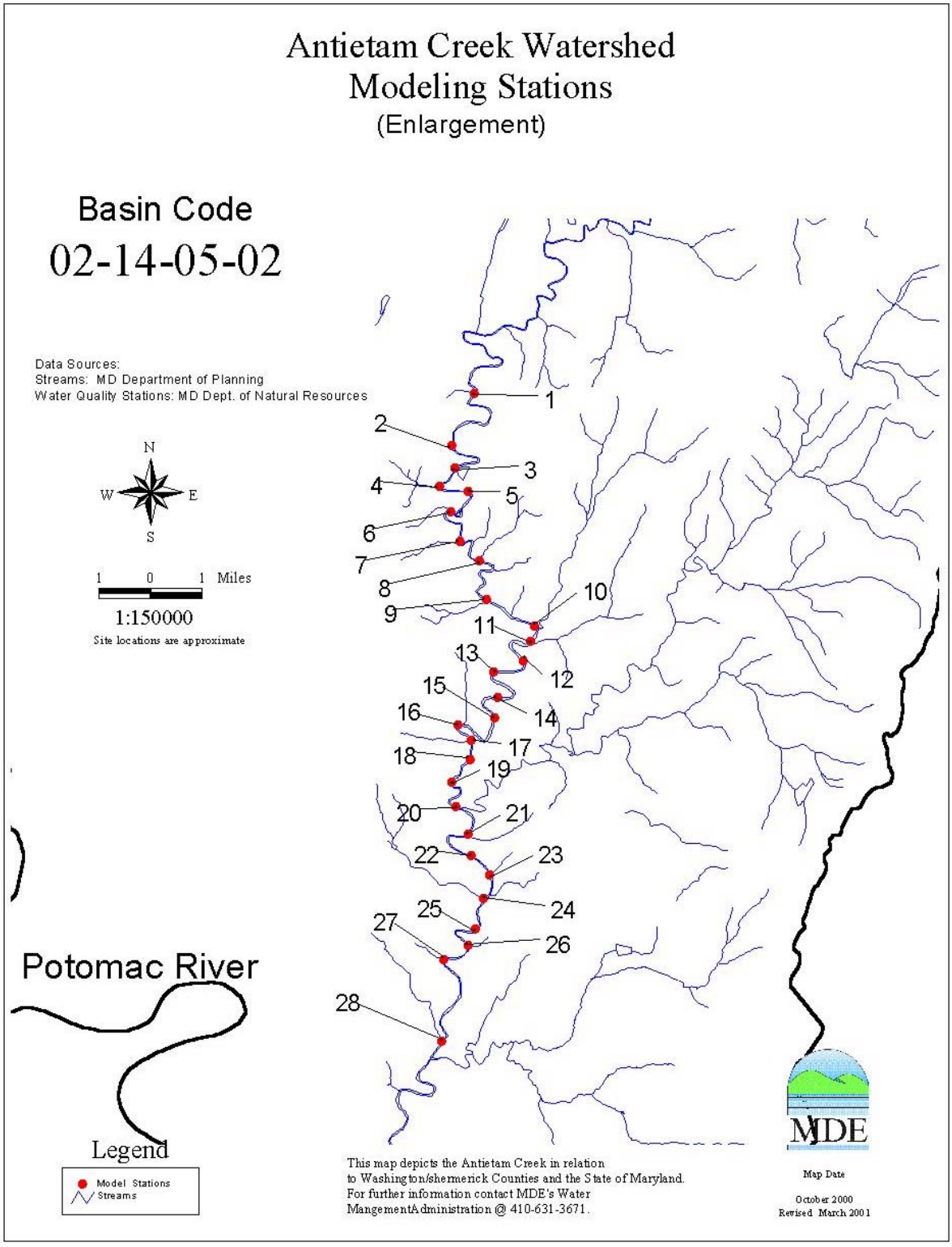

Figure A2. Locations of Modeling Station Points, Enlarged Area

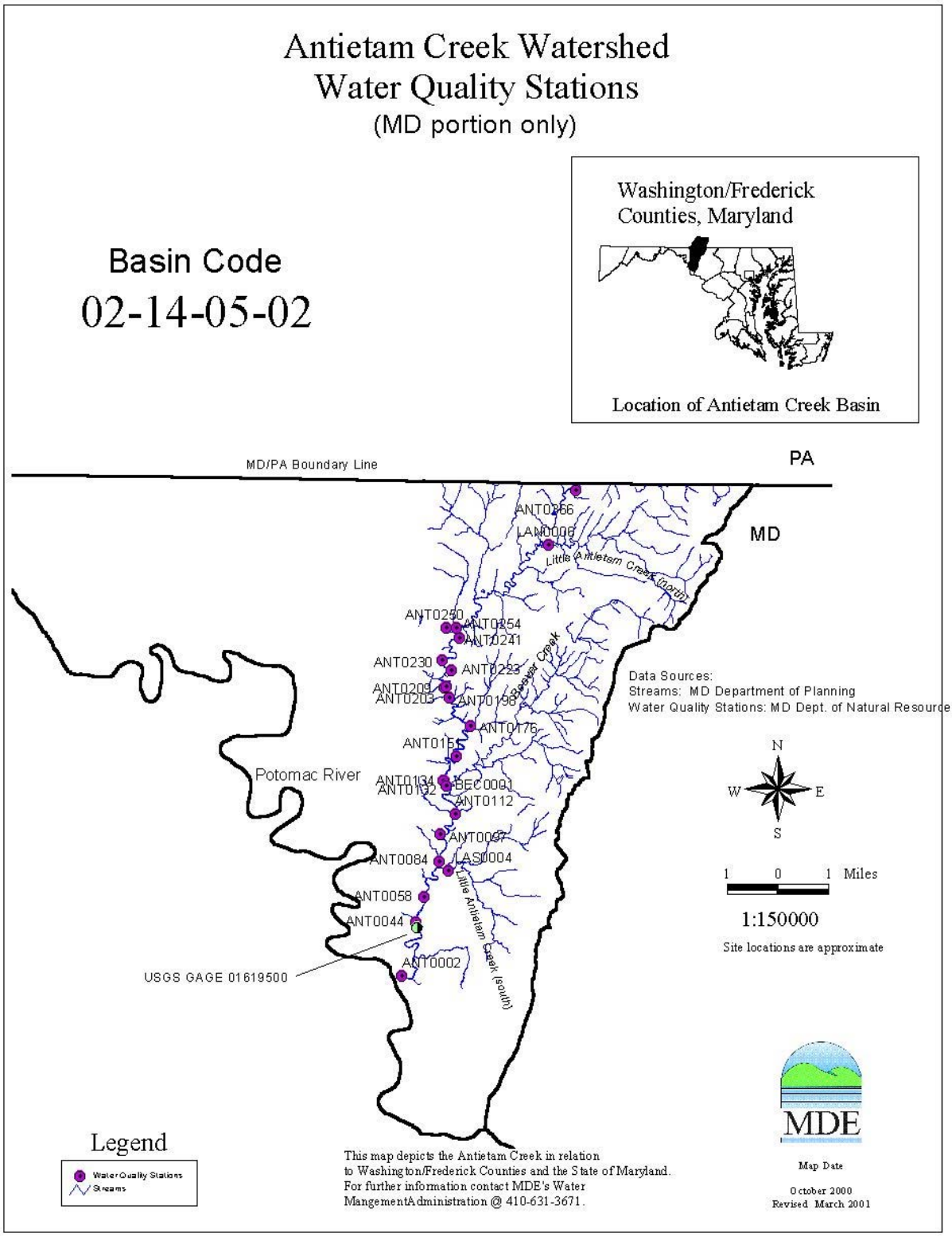

Figure A3. Antietam Creek Water Quality Station Locations in Maryland

Model CBOD, NBOD and Dissolved Oxygen Calibration

Calibration of the model for CBOD, NBOD and dissolved oxygen were achieved through the adjustment of the carbonaceous deoxygenating rate (k_c) and the nitrogeneous deoxygenating rate (k_n). Since the flow at the USGS gaging station did not reach the 7Q10 flow during the summer survey months, the sampled day with the lowest recorded flow and the corresponding water quality data, was used in the calibration runs. The observed water quality data and model predictions are shown in Table A2 and in Figures A4 through A6.

SEGMENT	River Mile	7/16/97 CBOD mg/l	Model CBOD mg/l	7/16/97 NBOD mg/l	Model NBOD mg/l	7/16/97 DO mg/l	Model DO mg/l
SEG32	37.2	3.00	2.42	3.50	2.90	7.30	7.85
SEG35	26.6	6.00	1.52	3.04	2.02	7.20	7.37
SEG36	25.7	1.50	1.92	2.25	2.14	8.10	7.79
SEG02	23.2	3.00	1.86	2.76	2.58	9.30	7.92
SEG06	21.7	4.50	1.57	2.71	2.28	7.40	7.59
SEG07	20.6	4.50	1.53	2.90	2.23	7.90	7.89
SEG10	18.2	3.00	1.48	4.42	2.11	8.20	8.33
SEG15	15.7	-	1.26	-	1.89	8.40	8.56
SEG19	13.7	3.00	1.27	2.39	1.79	8.10	8.25
SEG24	11.3	-	1.27	-	1.78	8.60	8.33
SEG27	9.6	6.00	1.10	2.35	1.65	7.90	8.07
SEG28	8.2	6.00	2.13	2.07	1.51	7.60	7.82
SEG29	5.7	13.50	1.91	2.35	1.19	7.20	7.86
SEG30	2.8	1.50	1.64	2.35	1.04	7.30	7.98
SEG31	0.14	4.50	1.69	2.55	1.08	7.50	8.00

Table A2. Antietam Creek CBOD, NBOD, DO and Calibrated Model Predictions

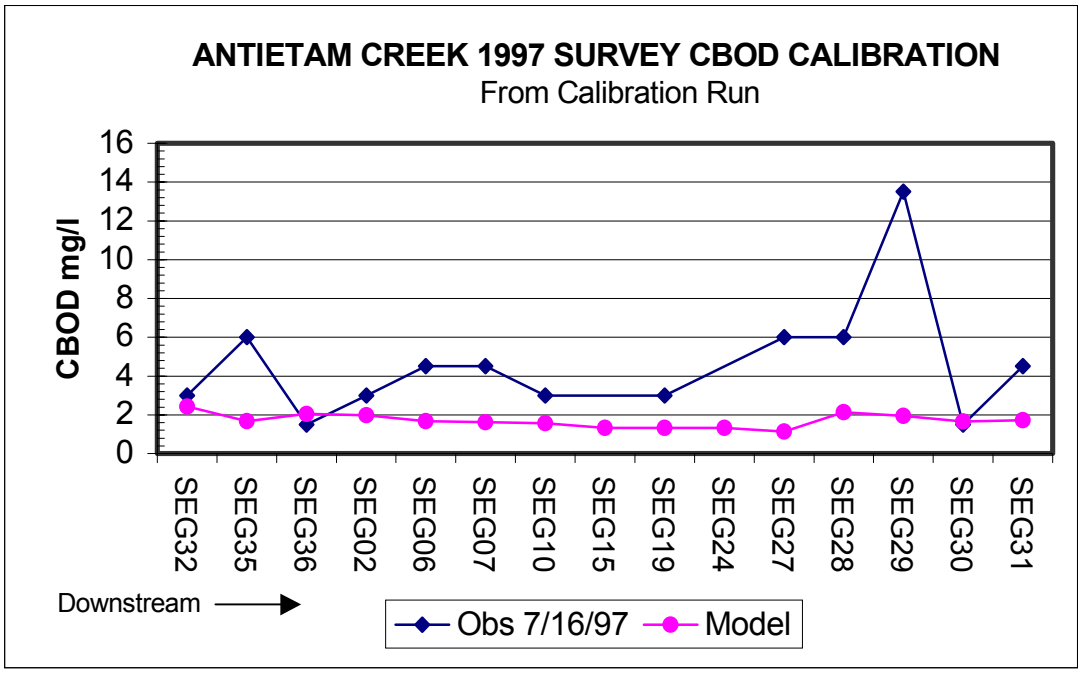

Figure A4. Antietam Creek CBOD and Model Predictions

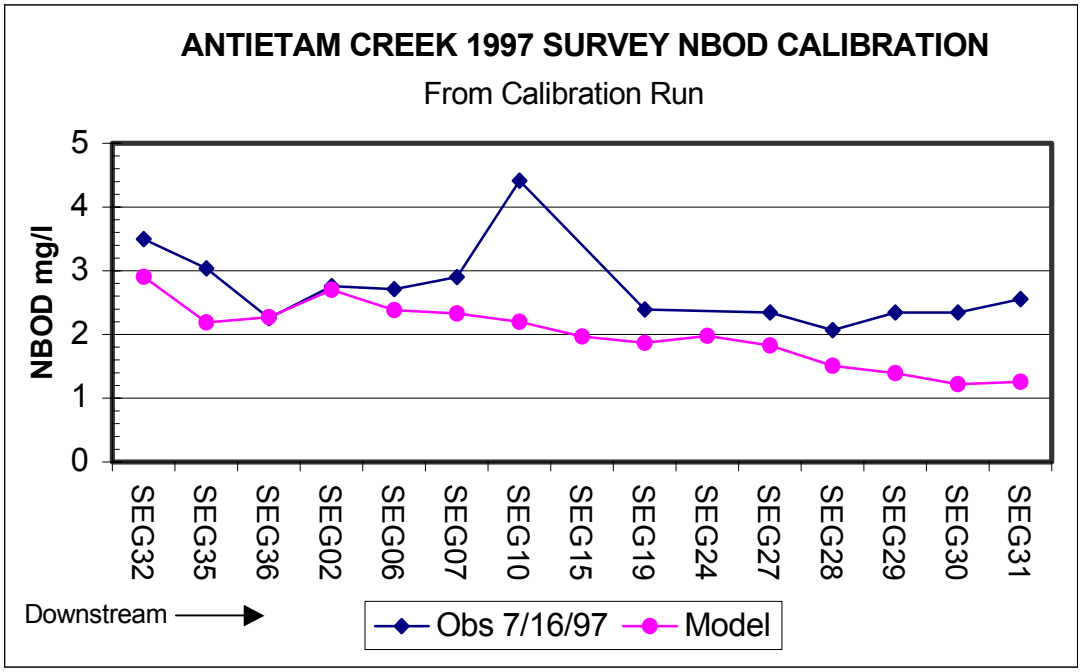

Figure A5. Antietam Creek NBOD and Model Predictions

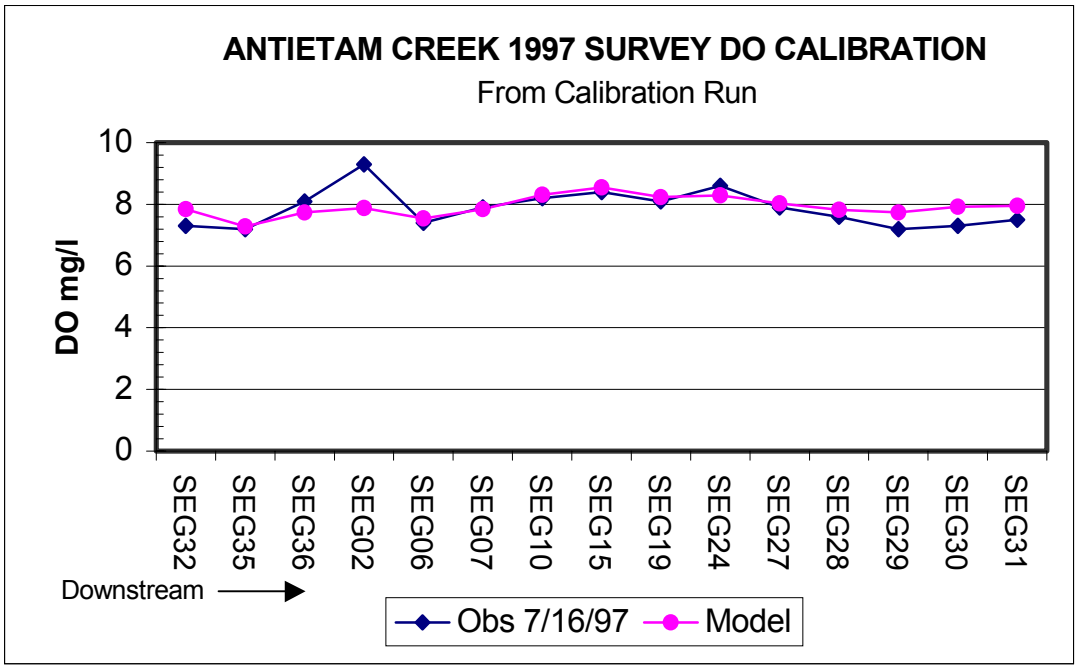

Figure A6. Antietam Creek DO and Model Predictions

Model CBOD, NBOD and Dissolved Oxygen Verification

As stated above, the flow at the USGS gaging station did not reach the 7Q10 flow during the summer survey months. The sampled day with the next lowest recorded flow and the corresponding water quality data, was used in the verification runs. The observed water quality data and model predictions are shown in Table A3 and Figures A7 through A9.

SEGMENT	River Mile	6/24/97 CBOD mg/l	Model CBOD mg/l	6/24/97 NBOD mg/l	Model NBOD mg/l	6/24/97 DO mg/l	Model DO mg/l
SEG32	37.2	9.00	7.20	6.04	4.89	8.10	7.26
SEG35	26.6	6.00	3.65	6.80	3.34	6.80	6.25
SEG36	25.7	7.50	3.72	4.63	3.24	8.00	7.25
SEG02	23.2	9.00	4.12	6.15	4.34	8.70	7.72
SEG06	21.7	4.50	3.44	4.80	3.81	7.60	7.02
SEG07	20.6	4.50	3.34	6.78	3.72	8.80	7.54
SEG10	18.2	6.00	3.06	10.50	3.45	8.50	8.01
SEG15	15.7	-	2.56	-	3.07	8.40	8.65
SEG19	13.7	3.00	2.37	5.17	2.88	8.40	8.15

Table A3. Antietam Creek CBOD, NBOD, DO and Verified Model Predictions

SEGMENT	River Mile	6/24/97 CBOD mg/l	Model CBOD mg/l	6/24/97 NBOD mg/l	Model NBOD mg/l	6/24/97 DO mg/l	Model DO mg/l
SEG24	11.3	-	2.51	-	2.79	8.60	8.23
SEG27	9.6	4.50	2.15	3.47	2.55	8.10	7.75
SEG28	8.2	3.00	1.97	5.19	2.20	8.00	7.74
SEG29	5.7	6.00	1.69	4.20	1.81	7.50	7.56
SEG30	2.8	4.50	1.44	5.14	1.54	7.60	7.84
SEG31	0.14	6.75	1.50	5.84	1.57	8.20	7.87

Table A3. Antietam Creek CBOD, NBOD, DO and Verified Model Predictions, Continued

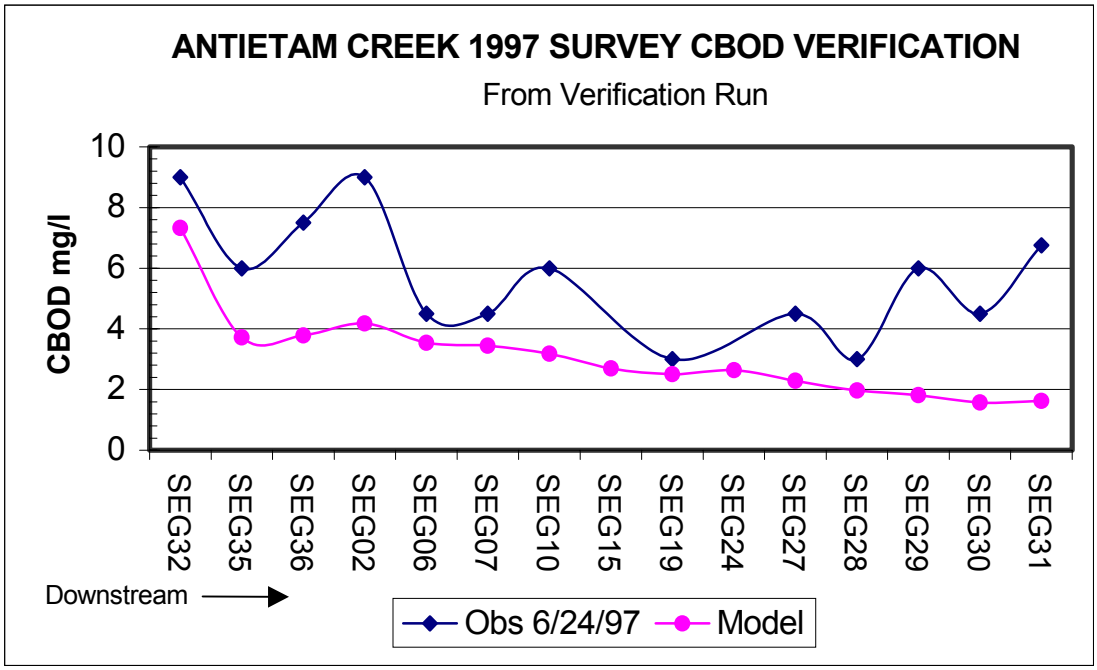

Figure A7. Antietam Creek CBOD and Model Predictions

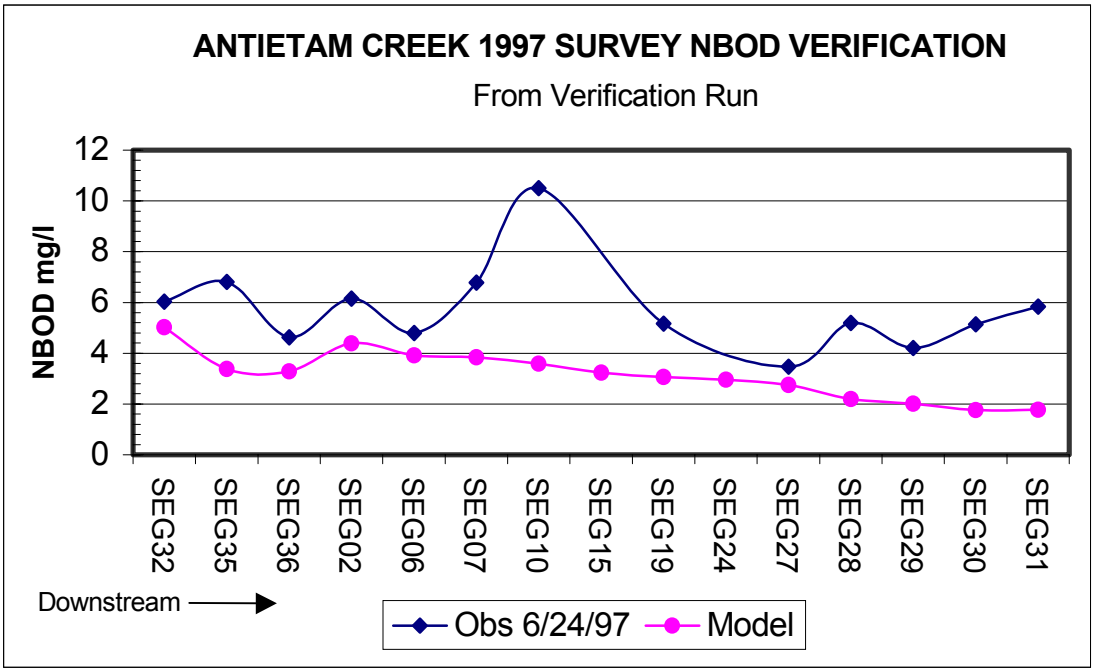

Figure A8. Antietam Creek NBOD and Model Predictions

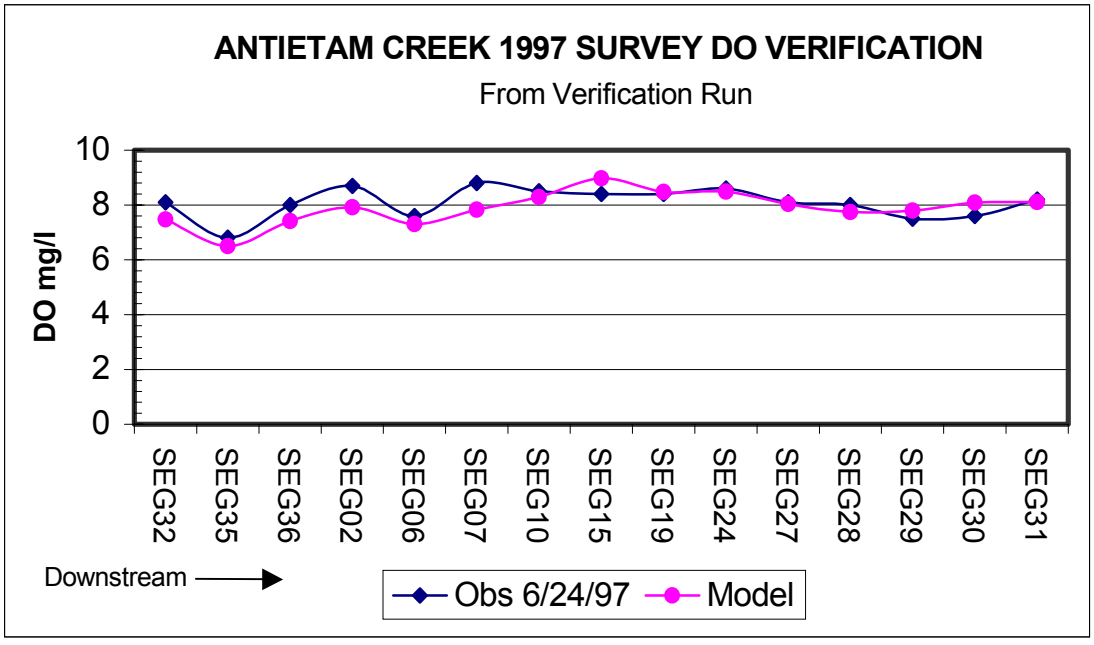

Figure A9. Antietam Creek DO and Model Predictions

Application of the Model

After calibration and verification of the model, the input data was assembled to simulate 7Q10 low-flow and average streamflow conditions. The following sections discuss the development of the summer condition model input data sets.

Estimation of Summer Stream Temperature

The model was calibrated using a 90th percentile stream temperature developed from a frequency distribution of the a stream temperature data set taken during the 1996 and 1997 summer stream surveys. A 90th percentile stream temperature 23.5 degrees Celsius was obtained from the temperature data shown in Table A4.

Station	Year	Month	Day	Water Temp	Station	Year	Month	Day	Water Temp
ANT0002	96	5	22	19.4	ANT0002	97	5	28	16.0
ANT0044	96	5	22	18.8	ANT0044	97	5	28	15.8
ANT0058	96	5	22	18.5	ANT0058	97	5	28	15.5
ANT0084	96	5	22	18.8	ANT0084	97	5	28	15.7
ANT0097	96	5	22	19.4	ANT0097	97	5	28	16.0
ANT0112	96	5	22	-	ANT0112	97	5	28	-
ANT0132	96	5	22	-	ANT0132	97	5	28	-
ANT0151	96	5	22	-	ANT0151	97	5	28	-
ANT0176	96	5	22	18.3	ANT0176	97	5	28	16.6
ANT0198	96	5	22	18.9	ANT0198	97	5	28	17.0
ANT0203	96	5	22	-	ANT0203	97	5	28	-
ANT0223	96	5	22	18.2	ANT0223	97	5	28	16.5
ANT0241	96	5	22	17.9	ANT0241	97	5	28	16.1
ANT0250	96	5	22	18.3	ANT0250	97	5	28	15.6
ANT0366	96	5	22	15.5	ANT0366	97	5	28	13.4
ANT0002	96	6	6	17.3	ANT0002	97	6	24	21.8
ANT0044	96	6	6	16.8	ANT0044	97	6	24	22.2
ANT0058	96	6	6	16.6	ANT0058	97	6	24	22.1
ANT0084	96	6	6	16.6	ANT0084	97	6	24	22.1
ANT0097	96	6	6	17.0	ANT0097	97	6	24	22.4
ANT0112	96	6	6	-	ANT0112	97	6	24	-
ANT0132	96	6	6	-	ANT0132	97	6	24	
ANT0151	96	6	6	-	ANT0151	97	6	24	-
ANT0176	96	6	6	16.7	ANT0176	97	6	24	22.9
ANT0198	96	6	6	17.1	ANT0198	97	6	24	22.9
ANT0203	96	6	6	-	ANT0203	97	6	24	-
ANT0223	96	6	6	16.9	ANT0223	97	6	24	22.6

Table A4. Antietam Creek Stream Temperature in Degrees Celsius

Station	Year	Month	Day	Water Temp	Station	Year	Month	Day	Water Temp
ANT0241	96	6	6	16.5	ANT0241	97	6	24	21.9
ANT0250	96	6	6	16.3	ANT0250	97	6	24	21.8
ANT0366	96	6	6	15.0	ANT0366	97	6	24	19.4
ANT0002	96	7	2	20.4	ANT0002	97	7	16	24.3
ANT0044	96	7	2	20.2	ANT0044	97	7	16	24.6
ANT0058	96	7	2	19.9	ANT0058	97	7	16	24.0
ANT0084	96	7	2	19.8	ANT0084	97	7	16	24.5
ANT0097	96	7	2	20.2	ANT0097	97	7	16	24.7
ANT0112	96	7	2	-	ANT0112	97	7	16	24.5
ANT0132	96	7	2	-	ANT0132	97	7	16	24.4
ANT0151	96	7	2	-	ANT0151	97	7	16	23.9
ANT0176	96	7	2	19.2	ANT0176	97	7	16	23.3
ANT0198	96	7	2	19.8	ANT0198	97	7	16	23.5
ANT0203	96	7	2	-	ANT0203	97	7	16	23.3
ANT0223	96	7	2	19.4	ANT0223	97	7	16	23.5
ANT0241	96	7	2	19.3	ANT0241	97	7	16	22.9
ANT0250	96	7	2	19.3	ANT0250	97	7	16	22.9
ANT0366	96	7	2	17.4	ANT0366	97	7	16	22.3
ANT0002	97	5	14	13.2					
ANT0044	97	5	14	13.4					
ANT0058	97	5	14	13.4					
ANT0084	97	5	14	13.2					
ANT0097	97	5	14	13.6					
ANT0112	97	5	14	-					
ANT0132	97	5	14	-					
ANT0151	97	5	14	-					
ANT0176	97	5	14	13.8					
ANT0198	97	5	14	13.9					
ANT0203	97	5	14	-					
ANT0223	97	5	14	13.6					
ANT0241	97	5	14	13.2					
ANT0250	97	5	14	13.1					
ANT0366	97	5	14	11.1					

Table A4. Antietam Creek Stream Temperature in Degrees Celsius, Continued

Estimation of Summer Stream Water Quality

Antietam Creek background and tributary summer condition water quality shown in Table A5 below was used as model input data. The input data was estimated from the water quality data shown in Tables A12 through A32.

SEGMENT	CBOD mg/l	NBOD mg/l	DO mg/l
MD/PA Line	4.07	2.81	7.30
SEG 32	4.50	3.22	8.73
SEG 33	4.50	3.22	8.73
SEG 34	3.21	2.35	9.46
SEG 35	4.50	3.22	8.73
SEG 36	4.50	3.22	8.73
SEG 01	4.50	3.22	8.73
SEG 02	4.50	3.22	8.73
SEG 03	4.50	3.22	8.73
SEG 04	4.50	3.22	8.73
SEG 05	4.50	3.22	8.73
SEG 06	4.50	3.22	8.73
SEG 07	4.50	3.22	8.73
SEG 08	4.50	3.22	8.73
SEG 09	4.50	3.22	8.73
SEG 10	4.50	3.22	8.73
SEG 11	4.50	3.22	8.73
SEG 12	4.50	3.22	8.73
SEG 13	4.50	3.22	8.73
SEG 14	4.50	3.22	8.73
SEG 15	4.50	3.22	8.73
SEG 16	4.50	3.22	8.73
SEG 17	4.50	3.22	8.73
SEG 18	4.50	3.22	8.73
SEG 19	4.50	3.22	8.73
SEG 20	2.57	2.53	9.97
SEG 21	4.50	3.22	8.73
SEG 22	4.50	3.22	8.73
SEG 23	4.50	3.22	8.73

Table A5. Model Water Quality Input Data

SEGMENT	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 24	4.50	3.22	8.73
SEG 25	4.50	3.22	8.73
SEG 26	4.50	3.22	8.73
SEG 27	4.50	3.22	8.73
SEG 28	3.86	2.35	9.46
SEG 29	4.50	3.22	8.73
SEG 30	4.50	3.22	8.73
SEG 31	4.50	3.22	8.73

Table A5. Model Water Quality Input Data, Continued

Estimation of 7-Day, 10-Year Low Flow

The USGS gaging station 01619500 located on Antietam Creek near Sharpsburg, Maryland was used to estimate the Antietam Creek 7Q10 low-flow. Listed below are USGS gaging station 01619500 statistics.

Station Name:	Antietam Creek near Sharpsburg Maryland
Station Number:	01619500
Latitude (dd.mm.ss):	39.27.01
Longitude (dd.mm.ss):	77.43.52
Drainage Area (square miles):	281
7Q10 Flow (cfs)	64

Model Results for TMDL Scenarios

The following sections present the model results for the TMDL scenarios presented in the main document.

Calibration Run:

SEGMENT	River Mile Above Mouth	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 32	37.2	2.42	2.90	7.85
SEG 33	35.5	2.21	2.67	7.82
SEG 34	33.4	1.89	2.18	7.80
SEG 35	29.1	1.52	2.02	7.37
SEG 36	26.1	1.92	2.14	7.79
SEG 01	24.5	1.87	2.60	7.87
SEG 02	23.2	1.86	2.58	7.92
SEG 03	22.4	1.82	2.56	7.87
SEG 04	22.0	1.80	2.53	7.84
SEG 05	21.7	1.77	2.48	7.81
SEG 06	21.2	1.57	2.28	7.59
SEG 07	20.5	1.53	2.23	7.89
SEG 08	19.9	1.47	2.15	8.22
SEG 09	19.0	1.41	2.09	8.29
SEG 10	18.2	1.48	2.11	8.33
SEG 11	18.0	1.48	2.09	8.47
SEG 12	17.4	1.46	2.07	8.57
SEG 13	16.9	1.42	2.03	8.68
SEG 14	16.1	1.36	2.01	8.70
SEG 15	15.5	1.26	1.89	8.56
SEG 16	14.8	1.36	1.91	8.47
SEG 17	14.4	1.36	1.91	8.44
SEG 18	14.2	1.35	1.89	8.41
SEG 19	13.8	1.27	1.79	8.25
SEG 20	13.1	1.29	1.82	8.34
SEG 21	12.7	1.27	1.80	8.31
SEG 22	11.9	1.26	1.79	8.32
SEG 23	11.6	1.25	1.78	8.32
SEG 24	11.1	1.27	1.78	8.33

Table A6. Model results for Calibration Run

SEGMENT	River Mile Above Mouth	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 25	10.6	1.24	1.75	8.29
SEG 26	10.1	1.21	1.73	8.24
SEG 27	9.6	1.10	1.65	8.07
SEG 28	8.2	2.10	1.27	7.98
SEG 29	4.5	1.91	1.19	7.86
SEG 30	2.8	1.64	1.04	7.98
SEG 31	0.1	1.69	1.08	8.00

Table A6. Model results for Calibration Run, Continued

The calibration run assumed existing 7Q10 low-flow nonpoint source loads in addition to the facility effluent concentrations shown in Table A7 below.

FACILITY	FACILITY FLOW mgd	BOD_5 mg/l	TKN mg/l	DO mg/l
HAGERSTOWN FIBER LIMITED PARTNERSHIP WWTP	*	*	*	*
HAGERSTOWN WATER POLLUTION CONTROL FACILITY WWTP	5.80	1.00	1.60	7.60
FUNKSTOWN WWTP	0.07	8.00	4.80	5.30
MARYLAND CORRECTIONAL INSTITUTE WWTP	0.93	5.50	0.88	5.40
ANTIETAM WWTP	0.10	1.60	2.70	7.00

* Facility not discharging

Table A7. Calibration Run Facility Effluent Concentrations

Model Run 1 Scenario:

SEGMENT	River Mile Above Mouth	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 32	37.2	2.77	2.02	7.52
SEG 33	35.5	2.27	1.77	7.52
SEG 34	33.4	1.64	1.42	7.86
SEG 35	29.1	1.05	1.28	7.31
SEG 36	26.1	2.81	1.77	7.60
SEG 01	24.5	6.98	6.23	7.81
SEG 02	23.2	6.88	6.14	7.74
SEG 03	22.4	6.82	6.54	7.40
SEG 04	22.0	6.61	6.39	7.16
SEG 05	21.7	6.30	6.18	6.84
SEG 06	21.2	5.24	5.42	5.62
SEG 07	20.5	4.98	5.23	6.18
SEG 08	19.9	4.58	4.94	6.80
SEG 09	19.0	4.26	4.69	7.01
SEG 10	18.2	4.22	4.63	7.17
SEG 11	18.0	4.09	4.53	7.62
SEG 12	17.4	3.99	4.45	7.89
SEG 13	16.9	3.83	4.33	8.16
SEG 14	16.1	3.56	4.25	8.16
SEG 15	15.5	3.17	3.87	7.79
SEG 16	14.8	5.18	8.17	7.66
SEG 17	14.4	5.12	8.10	7.63
SEG 18	14.2	5.03	7.99	7.57
SEG 19	13.8	4.59	7.37	6.82
SEG 20	13.1	4.31	6.81	7.22
SEG 21	12.7	4.17	6.66	7.29
SEG 22	11.9	4.11	6.59	7.48
SEG 23	11.6	4.04	6.51	7.64
SEG 24	11.1	3.97	6.41	7.79
SEG 25	10.6	3.83	6.25	7.60
SEG 26	10.1	3.66	6.10	7.39
SEG 27	9.6	3.15	5.67	6.60
SEG 28	8.2	2.08	3.56	6.12
SEG 29	4.5	1.90	3.32	6.36
SEG 30	2.8	1.48	2.64	7.14
SEG 31	0.1	1.52	2.62	7.25

Table A8. Model Results for Model Run 1 Scenario

Model Run 1 Scenario assumed average 7Q10 nonpoint source loads in addition to the facility effluent concentrations shown in Table A9 below.

FACILITY	FACILITY FLOW mgd	BOD_5 mg/l	TKN mg/l	DO mg/l
HAGERSTOWN FIBER LIMITED PARTNERSHIP WWTP	2.00	10	1	5
HAGERSTOWN WATER POLLUTION CONTROL FACILITY WWTP	8.00	12	4	8
FUNKSTOWN WWTP	0.15	30	25	5
MARYLAND CORRECTIONAL INSTITUTE WWTP	1.60	30	20	5
ANTIETAM WWTP	0.163	30	25	5

Table A9. Model Run 1 Scenario Facility Effluent Concentrations

Model Run 2 Scenario:

SEGMENT	River Mile Above Mouth	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 32	37.2	3.05	2.77	7.36
SEG 33	35.5	2.50	2.40	7.35
SEG 34	33.4	1.86	1.89	7.72
SEG 35	29.1	1.19	1.66	7.07
SEG 36	26.1	3.55	2.23	7.66
SEG 01	24.5	7.87	6.60	7.84
SEG 02	23.2	7.76	6.51	7.76
SEG 03	22.4	7.69	6.92	7.41
SEG 04	22.0	7.46	6.77	7.15
SEG 05	21.7	7.14	6.56	6.82
SEG 06	21.2	6.00	5.80	5.53
SEG 07	20.5	5.71	5.61	6.08
SEG 08	19.9	5.29	5.32	6.67
SEG 09	19.0	4.93	5.07	6.88
SEG 10	18.2	4.89	5.01	7.04
SEG 11	18.0	4.74	4.90	7.50
SEG 12	17.4	4.63	4.82	7.78
SEG 13	16.9	4.45	4.70	8.05
SEG 14	16.1	4.15	4.61	8.03

Table A10: Model Results for Model Run 2 Scenario

SEGMENT	River Mile Above Mouth	CBOD mg/l	NBOD mg/l	DO mg/l
SEG 15	15.5	3.72	4.23	7.65
SEG 16	14.8	6.39	9.34	7.52
SEG 17	14.4	6.33	9.27	7.48
SEG 18	14.2	6.21	9.16	7.43
SEG 19	13.8	5.70	8.48	6.60
SEG 20	13.1	5.38	7.91	7.01
SEG 21	12.7	5.22	7.75	7.10
SEG 22	11.9	5.14	7.67	7.33
SEG 23	11.6	5.06	7.59	7.51
SEG 24	11.1	4.98	7.48	7.69
SEG 25	10.6	4.80	7.30	7.47
SEG 26	10.1	4.61	7.14	7.24
SEG 27	9.6	3.99	6.65	6.32
SEG 28	8.2	2.77	4.28	5.71
SEG 29	4.5	2.53	4.07	5.98
SEG 30	2.8	1.99	3.27	6.88
SEG 31	0.1	2.02	3.24	7.01

Table A10. Model Results for Model Run 2 Scenario, Continued

Model Run 2 Scenario assumed existing 7Q10 low-flow nonpoint source loads increased by 10 percent to 25 percent in addition to the facility effluent concentrations and flows shown in Table A11 below.

FACILITY	FACILITY FLOW mgd	BOD_5 mg/l	TKN mg/l	DO mg/l
HAGERSTOWN FIBER LIMITED PARTNERSHIP WWTP	2.63	10	1	7
HAGERSTOWN WATER POLLUTION CONTROL FACILITY WWTP	10.50	10	3.1	8
FUNKSTOWN WWTP	0.15	30	25	5
MARYLAND CORRECTIONAL INSTITUTE WWTP	2.10	30	18	5
ANTIETAM WWTP	0.21	30	25	5

Table A11. Model Run 2 Scenario Facility Effluent Concentrations

List of Model Equations:

The following equations are used in the mathematical model for Antietam Creek:

1. Equations for Conversion of BOD to CBOD and TKN to NBOD:

   As per guidelines of the Surface Discharge Permits Division, the following equations are used to convert BOD and TKN to CBOD and NBOD, respectively:

   CBOD = 1.5 * BOD

   NBOD = 4.6 * TKN

2. The principal equation used to determine the spatial distribution of dissolved oxygen (DO) in Antietam Creek is expressed as:

$$D = D_0 \exp\left(-K_a \frac{x}{U}\right) \qquad \text{2a.}$$

$$+ L_{CO}\left\{\frac{K_d}{K_a - K_r}\left[\exp\left(-K_r \frac{x}{U}\right) - \exp\left(-K_a \frac{x}{U}\right)\right]\right\} \qquad \text{2b.}$$

$$+ L_{NO}\left\{\frac{K_n}{K_a - K_n}\left[\exp\left(-K_n \frac{x}{U}\right) - \exp\left(-K_a \frac{x}{U}\right)\right]\right\} \qquad \text{2c.}$$

$$- \frac{P_a}{K_a}\left[1 - \exp\left(-K_a \frac{x}{U}\right)\right] \qquad \text{2d.}$$

where,

D	=	DO deficit at distance x (m) mg/l
Do	=	DO deficit at x = 0, mg/l
U	=	River velocity, m/day
Lco	=	Total carbonaceous BOD, mg/l
L_{NO}	=	Total nitrogenous BOD, mg/l
K_a	=	Reaeration coefficient, day^{-1}
K_d	=	Effective deoxygenation rate, day^{-1}
K_r	=	Overall loss rate of BOD, day^{-1}
K_n	=	Overall oxidation rate of nitrogenous BOD, day^{-1}
P_a	=	Average daily oxygen production rate, mg/l/day

Equation 2a describes the decrease of the DO deficit due to atmospheric reaeration. Equations 2b and 2c shows the DO deficits due to oxidation of point source carbonaceous

and nitrogenous BOD, respectively. Equation 2d considers the contribution of DO by gross oxygen production.

The overall loss rate (K_r) is equal to the sum of the effective deoxygenation rate (K_d) and the effective loss rate due to settling (K_s). For effluents at secondary treatment level with suspended solids of less than 30 mg/l, K_s may not be important due to the absence of any significant particulate BOD. In this case, the overall loss rate (Kr) can be approximated by the effective deoxygenation rate (K_d)

The effects of atmospheric reaeration and waste inputs on the dissolved oxygen levels in the creek are dependent on temperature. Higher temperature increases the rate of atmospheric reaeration. Higher temperatures also increase the rate of oxidation in the creek. The temperature effects on the rate coefficients are approximated by:

$$K_{a,T} = K_{a,25°C}\,(1.022)^{T-25}$$
$$K_{d,T} = K_{d,T'}\,(1.047)^{T-T'}$$
$$K_{n,T} = K_{n,T'}\,(1.08)^{T-T'}$$

where, T = 90th Percentile Stream Temperature for the summer period, °C
T' = segment station stream temperature

The reaeration coefficient, K_a, at 25 °C can be estimated by the Tsivoglou and Wallace equation, which gives:

$$K_{a,25°C} = 7776\ v\ S \quad \text{if } Q < 10 \text{ cfs}$$
$$= 4665.6\ v\ S \quad \text{if } 10 \text{ cfs} < Q < 3000 \text{ cfs}$$
$$= 2592\ v\ S \quad \text{if } Q > 3000 \text{ cfs}$$

where, v = the stream velocity in fps
S = the slope in ft/ft

3. Saturation Dissolved Oxygen was estimated from tables in Standard Methods for the Examination of Water and Wastewater (1975) and input at each modeling point.

WATER QUALITY DATA

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0002	960522	19.400	8.400	6.000	0.772	0.037	5.616	0.172
ANT0002	960606	17.300	8.000	3.000	-	0.019	-	0.147
ANT0002	960702	20.400	7.800	1.000	1.433	0.075	6.233	0.318
ANT0002	970514	13.200	9.900	1.000	0.000	0.025	5.289	0.669
ANT0002	970528	16.000	8.600	1.000	0.626	0.050	5.511	0.269
ANT0002	970624	21.800	8.200	4.500	1.269	0.022	5.451	0.318
ANT0002	970716	24.300	7.500	3.000	0.555	0.002	5.440	0.041
ANT0002 Average		**18.914**	**8.343**	**2.786**	**0.776**	**0.033**	**5.590**	**0.276**

Table A12. Water Quality Station ANT0002

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0043	970716	24.100	7.400	-	-	-	-	-
ANT0043 Average		**24.100**	**7.400**	-	-	-	-	-

Table A13. Water Quality Station ANT0043

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0044	960522	18.800	8.500	6.000	0.723	0.045	5.728	0.193
ANT0044	960606	16.800	8.800	3.000	-	0.024	-	0.150
ANT0044	960702	20.200	8.100	1.000	0.861	0.031	5.761	0.245
ANT0044	970514	13.400	9.800	1.000	0.000	0.030	5.030	0.139
ANT0044	970528	15.800	8.300	1.000	0.646	0.055	5.406	0.211
ANT0044	970624	22.200	7.600	3.000	1.117	0.029	5.957	0.292
ANT0044	970716	24.600	7.300	1.000	0.510	0.009	5.641	0.016
ANT0044 Average		**18.829**	**8.343**	**2.286**	**0.643**	**0.032**	**5.587**	**0.178**

Table A14. Water Quality Station ANT0044

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0058	960522	18.500	8.600	6.000	0.723	0.048	5.759	0.174
ANT0058	960606	16.600	8.800	2.000	-	0.021	-	-
ANT0058	960702	19.900	8.200	2.000	0.718	0.024	5.618	0.246
ANT0058	970514	13.400	10.000	1.000	0.041	0.031	4.979	0.131
ANT0058	970528	15.500	8.200	1.000	0.690	0.062	5.350	0.206
ANT0058	970624	22.100	7.500	4.000	0.914	0.034	5.723	0.302
ANT0058	970716	24.000	7.200	9.000	0.510	0.012	5.574	0.043
ANT0058 Average		**18.571**	**8.357**	**3.571**	**0.599**	**0.033**	**5.501**	**0.184**

Table A15. Water Quality Station ANT0058

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0084	960522	18.800	8.700	4.000	0.662	0.029	5.792	0.175
ANT0084	960606	16.600	9.000	3.000	-	0.026	-	0.159
ANT0084	960702	19.800	8.400	2.000	0.861	0.060	5.661	0.222
ANT0084	970514	13.200	11.100	1.000	0.000	0.021	5.091	0.171
ANT0084	970528	15.700	8.800	2.000	0.592	0.047	5.182	0.189
ANT0084	970624	22.100	8.000	2.000	1.128	0.031	5.608	0.289
ANT0084	970716	24.500	7.600	4.000	0.450	0.009	5.937	0.144
ANT0084 Average		**18.671**	**8.800**	**2.571**	**0.616**	**0.032**	**5.545**	**0.193**

Table A16. Water Quality Station ANT0084

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0097	960522	19.400	8.800	5.000	0.629	0.033	5.827	0.174
ANT0097	960606	17.000	9.200	3.000	-	0.023	-	0.146
ANT0097	960702	20.200	8.400	1.000	0.798	0.029	5.598	0.200
ANT0097	970514	13.600	11.300	1.000	0.000	0.025	5.288	0.161
ANT0097	970528	16.000	9.100	1.000	0.411	0.052	5.031	0.187
ANT0097	970624	22.400	8.100	3.000	0.754	0.028	5.553	0.257
ANT0097	970716	24.700	7.900	4.000	0.510	0.008	5.774	0.117
ANT0097 Average		**19.043**	**8.971**	**2.571**	**0.517**	**0.028**	**5.512**	**0.177**

Table A17. Water Quality Station ANT0097

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0112	970716	24.500	8.600	-	-	-	-	-
ANT0112 Average		**24.500**	**8.600**	-	-	-	-	-

Table A18. Water Quality Station ANT0112

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0132	970716	24.400	8.300	-	-	-	-	-
ANT0132 Average		**24.400**	**8.300**	-	-	-	-	-

Table A19. Water Quality Station ANT0132

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0134	960522	19.800	9.500	5.000	0.594	0.035	6.115	0.225
ANT0134	960606	17.800	9.800	4.000	-	0.023	-	0.166
ANT0134	960702	20.300	8.500	1.000	0.647	0.026	5.847	0.170
ANT0134	970514	14.400	13.000	2.000	0.071	0.022	5.751	0.261
ANT0134	970528	16.400	9.600	1.000	0.778	0.053	5.798	0.285
ANT0134	970624	22.700	8.400	2.000	1.124	0.039	6.273	0.378
ANT0134	970716	25.300	8.100	2.000	0.520	0.024	5.662	0.140
ANT0134 Average		**19.529**	**9.557**	**2.429**	**0.622**	**0.032**	**5.908**	**0.232**

Table A20. Water Quality Station ANT0134

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0151	970716	23.900	8.400	-	-	-	-	-
ANT0151 Average		**23.900**	**8.400**	-	-	-	-	-

Table A21. Water Quality Station ANT0151

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0176	960522	18.300	8.600	7.000	0.562	0.058	6.164	0.171
ANT0176	960606	16.700	9.700	4.000	-	0.040	-	0.118
ANT0176	960702	19.200	8.300	1.000	0.772	0.031	5.872	0.161
ANT0176	970514	13.800	10.800	1.000	0.000	0.028	5.739	0.224
ANT0176	970528	16.600	9.700	1.000	0.602	0.063	5.892	0.249
ANT0176	970624	22.900	8.500	4.000	2.282	0.040	7.997	0.374
ANT0176	970716	23.300	8.200	2.000	0.960	0.018	6.592	0.016
ANT0176 Average		**18.686**	**9.114**	**2.857**	**0.863**	**0.040**	**6.376**	**0.188**

Table A22. Water Quality Station ANT0176

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0198	960522	18.900	8.500	6.000	0.624	0.062	6.093	0.179
ANT0198	960606	17.100	9.500	4.000	-	0.049	-	0.149
ANT0198	960702	19.800	8.200	3.000	0.798	0.047	6.098	0.191
ANT0198	970514	13.900	10.600	3.000	0.183	0.032	5.640	0.175
ANT0198	970528	17.000	9.600	1.000	0.642	0.070	5.772	0.239
ANT0198	970624	22.900	8.800	3.000	1.474	0.034	6.839	0.397
ANT0198	970716	23.500	7.900	3.000	0.630	0.018	6.575	0.288
ANT0198 Average		**19.014**	**9.014**	**3.286**	**0.725**	**0.045**	**6.170**	**0.231**

Table A23: Water Quality Station ANT0198

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0203	970716	23.300	7.500	-	-	-	-	-
ANT0203 Average		**23.300**	**7.500**	-	-	-	-	-

Table A24. Water Quality Station ANT0203

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0209	960522	18.400	8.500	6.000	0.654	0.056	6.125	0.167
ANT0209	960606	17.100	9.200	5.000	-	0.052	-	0.143
ANT0209	960702	19.900	8.200	1.000	0.698	0.047	5.998	0.220
ANT0209	970514	13.800	10.100	1.000	0.047	0.041	5.463	0.158
ANT0209	970528	16.600	9.300	1.000	0.328	0.076	5.878	0.230
ANT0209	970624	22.900	7.600	3.000	1.044	0.048	6.265	0.348
ANT0209	970716	23.800	7.400	3.000	0.590	0.020	6.234	0.286
ANT0209 Average		**18.929**	**8.614**	**2.857**	**0.560**	**0.049**	**5.994**	**0.222**

Table A25. Water Quality Station ANT0209

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0223	960522	18.200	8.800	5.000	0.728	0.077	6.268	0.175
ANT0223	960606	16.900	9.000	4.000	-	0.071	-	0.157
ANT0223	960702	19.400	8.500	5.000	0.946	0.048	6.046	0.199
ANT0223	970514	13.600	10.300	2.000	0.082	0.041	5.580	0.200
ANT0223	970528	16.500	9.600	1.000	0.482	0.069	5.732	0.278
ANT0223	970624	22.600	8.700	6.000	1.337	0.029	6.589	0.396
ANT0223	970716	23.500	9.300	2.000	0.600	0.003	6.087	0.340
ANT0223 Average		**18.671**	**9.171**	**3.571**	**0.696**	**0.048**	**6.050**	**0.249**

Table A26. Water Quality Station ANT0223

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0230	970716	23.100	8.200	-	-	-	-	-
ANT0230 Average		**23.100**	**8.200**	-	-	-	-	-

Table A27. Water Quality Station ANT0230

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0250	960522	18.300	8.300	5.000	0.546	0.064	5.732	0.089
ANT0250	960606	16.300	9.000	4.000	-	0.048	-	0.077
ANT0250	960702	19.300	8.300	3.000	0.878	0.035	5.778	0.155
ANT0250	970514	13.100	9.600	2.000	0.091	0.059	5.375	0.025
ANT0250	970528	15.600	9.000	1.000	0.309	0.077	5.749	0.402
ANT0250	970624	21.800	6.800	4.000	1.479	0.065	6.319	0.176
ANT0250	970716	22.900	7.200	4.000	0.660	0.036	5.824	0.111
ANT0250 Average		**18.186**	**8.314**	**3.286**	**0.661**	**0.055**	**5.796**	**0.148**

Table A28. Water Quality Station ANT0250

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ANT0366	960522	15.500	9.200	3.000	0.497	0.031	4.707	0.108
ANT0366	960606	15.000	9.900	3.000	-	0.034	-	0.100
ANT0366	960702	17.400	8.600	2.000	0.599	0.040	5.099	0.113
ANT0366	970514	11.100	11.400	2.000	0.000	0.039	4.824	0.025
ANT0366	970528	13.400	10.000	1.000	0.506	0.051	4.726	0.070
ANT0366	970624	19.400	8.100	6.000	1.312	0.055	1.416	0.221
ANT0366	970716	22.300	7.300	2.000	0.760	0.047	5.456	0.361
ANT0366 Average		**16.300**	**9.214**	**2.714**	**0.612**	**0.042**	**4.371**	**0.143**

Table A29. Water Quality Station ANT0366

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BEC0001	960522	18.300	10.100	2.000	0.672	0.029	4.727	0.068
BEC0001	960606	17.100	10.200	2.000	-	0.010	-	0.022
BEC0001	960702	19.500	8.900	1.000	0.607	0.025	4.507	0.067
BEC0001	970514	13.300	11.900	2.000	0.000	0.012	4.513	0.007
BEC0001	970528	15.500	10.600	1.000	0.496	0.026	4.966	0.053
BEC0001	970624	21.200	9.200	3.000	1.047	0.024	5.795	0.076
BEC0001	970716	23.600	8.900	1.000	0.460	0.008	5.501	0.043
BEC0001 Average		**18.357**	**9.971**	**1.714**	**0.547**	**0.019**	**5.002**	**0.048**

Table A30. Water Quality Station BEC0001

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
LAN0006	960522	14.700	9.600	4.000	0.433	0.024	4.668	0.067
LAN0006	960606	14.600	10.000	2.000	-	0.026	-	0.053
LAN0006	960702	17.200	8.800	1.000	0.528	0.020	4.228	0.078
LAN0006	970514	11.400	11.500	1.000	0.000	0.023	4.656	0.023
LAN0006	970528	14.000	10.200	1.000	0.674	0.099	5.494	0.131
LAN0006	970624	20.500	8.200	4.000	0.979	0.030	5.042	0.084
LAN0006	970716	21.800	7.900	2.000	0.440	0.012	5.270	0.363
LAN0006 Average		**16.314**	**9.457**	**2.143**	**0.509**	**0.033**	**4.893**	**0.114**

Table A31. Water Quality Station LAN0006

Station	Date	Watemp	DO	BOD5	TKN	NH3	TN	TP
	yymmdd	°C	mg/	mg/l	mg/l	mg/l	mg/l	mg/l
LAS0004	960522	16.900	9.200	4.000	0.758	0.211	3.800	0.144
LAS0004	960606	15.500	9.400	2.000	-	0.054	-	0.056
LAS0004	960702	18.900	8.600	1.000	0.334	0.022	3.734	0.068
LAS0004	970514	12.600	11.500	1.000	0.000	0.029	3.441	0.049
LAS0004	970528	14.300	9.500	2.000	0.403	0.043	3.883	0.086
LAS0004	970624	18.400	9.100	3.000	0.812	0.024	5.601	0.107
LAS0004	970716	19.600	8.900	11.000	0.400	0.006	3.992	0.121
LAS0004 Average		**16.600**	**9.457**	**3.429**	**0.451**	**0.056**	**4.075**	**0.090**

Table A32. Water Quality Station LAS0004

FINAL

DISCHARGE PERMIT LIMITS FOR WASTEWATER TREATMENT PLANTS

For Hagerstown Fiber Limited Partnership Wastewater Treatment Plant

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (5)

During the effective period of this permit, the permittee is authorized to discharge process wastewater via outfalls 001 through 012.

As specified below, such discharge shall be limited and monitored by the permittee at the discharge from the treatment plant.

PARAMETER	QUANTITY OR LOADING			QUALITY OR CONCENTRATION				FREQUENCY OF ANALYSIS	SAMPLE TYPE	NOTES
	MONTHLY AVERAGE	DAILY MAXIMUM	UNITS	MINIMUM	MONTHLY AVERAGE	DAILY MAXIMUM	UNITS			
Flow	N/A	Report	gpd					Continuous	Recorded	(1)
BOD_5	Report	Next Page			N/A	Report		Daily	24-Hr. Composite	(1)(2)
Total Suspended Solids	1,000	1,000			N/A	Report		Daily	24- Hr. Composite	
Temperature					N/A	75	°F	Daily	i-s	(3)
Dissolved Oxygen				5.0	N/A		mg/l	Daily	Grab	(4)
Total Copper					0.082	0.114	mg/l	1/Month	24- Hr. Composite	
Total Zinc					N/A	0.70	mg/l	1/Month	24- Hr. Composite	
Color					N/A	Report		1/Month	24- Hr. Composite	(1)
pH				6.0		9.0		1/Day	Grab	

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS - continued

There shall be no discharge of floating solids or persistent foam in other than trace amounts. Persistent foam is foam that does not dissipate within one half-hour of point of discharge.

(1) Monitoring required.
(2) See the following table for limits during periods of higher flows and lower temperatures.
(3) See Special Condition G. for alternate temperature limitations.
(4) The monthly average limitation shall be the average of the daily maximum limitations for that month.
(5) Refer to 99-DP-3077 for additional discharge permit conditions.

A flow of 2.0 million gallons per day (mgd) is used in waste allocation calculations

BOD_5 DAILY MAXIMUM LIMITATION MATRIX (lbs/day)

The following graph was developed to present the variable BOD_5 limits. By locating the ambient conditions of flow and temperature on this graph, the daily maximum BOD_5 limitation is determined. For data management purposes, each BOD_5 limitation has been assigned an individual outfall number even though the permittee will discharge through the same outfall pipe.

	Temperature (°F)			
	<60.8	60.8 - 64.4	64.5-67.9	68-72.7
STREAM FLOW (CFS) 30-41	Outfall 001B 826	Outfall 001F 676	Outfall 001J 400	Outfall 001N 167
STREAM FLOW (CFS) 41.1-48	Outfall 001C 1320	Outfall 001G 1110	Outfall 001K 926	Outfall 001O 709
STREAM FLOW (CFS) 48.1-69.9	Outfall 001D 1670	Outfall 001H 1480	Outfall 001L 1200	Outfall 001P 943
STREAM FLOW (CFS) >70	Outfall 001E 1670	Outfall 001I 1670	Outfall 001M 1670	Outfall 001Q 1670

For flows less than 30 cfs or temperatures greater than 72.7°F the limit is 167 lbs/day.

The temperature shall be measured 50 feet downstream of the dam on the same side as the diffuser. See Special Condition G.

The stream flow used for this matrix shall be the daily average flow.

SPECIAL CONDITION

G. ALTERNATE TEMPERATURE LIMITATIONS

1. If the temperature at Outfall 001 is greater than 75°F, the permittee shall check the temperature of Antietam Creek at the following two points:

   a. 50 feet downstream of the confluence of this discharge and the river; and

   b. 50 feet upstream of Outfall 001.

2. The temperature at the downstream point shall be less than or equal to 75°F or the temperature at the upstream point, whichever is greater. If the temperature at the downstream point is less than 68°F, the permittee is not required to check the temperature at the upstream point. The results of this monitoring shall be included on the monthly discharge monitoring reports.

3. The permittee shall install equipment to continuously monitor and record the temperature at the downstream point.

Discharge Permit Limits for Wastewater Treatment Plants, Continued

For Hagerstown Water Pollution Control Plant

EFFLUENT LIMITATIONS, OUTFALL 001 (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below.

Effluent Characteristics	Monthly Loading Rate kg/d (lbs/d)	Weekly Loading Rate kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5 5/1 - 9/30	360 (800)	540 (1200)	12	18
10/1 - 4/30	910 (2000)	1400 (3000)	30	45
Total Suspended Solids	910 (2000)	1400 (3000)	30	45
TKN 5/1 - 9/30	121 (267)	181 (400)	4.0	6.0
Total Phosphorus	60 (133)	90 (200)	2.0	3.0
Total Nitrogen	N/A	N/A	N/A	N/A

Effluent Characteristics	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean value	N/A
Total Residual Chlorine	N/A	N/A
Dissolved Oxygen 5/1 - 9/30	N/A	8.0 mg/l at any time
10/1 - 4/30	N/A	5.0 mg/l at any time
pH	8.5	6.5

(1) Refer to 97-DP-0788 for additional discharge permit conditions.

A flow of 8 million gallons per day (mgd) is used in waste allocation calculations.

Discharge Permit Limits for Wastewater Treatment Plants, Continued

For Funkstown Wastewater Treatment Plant (Expired January 31, 2000)

EFFLUENT LIMITATIONS, OUTFALL 001 (2)

The quality of the effluent discharged by the facility shall be limited at all times as shown below.

Effluent Characteristics	Monthly Loading Rate kg/d (lbs/d)	Weekly Loading Rate kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD5	17 (38)	26 (56)	30	45
TSS (1)	51 (110)	N/A	90	N/A

Effluent Characteristics	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean	N/A
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to the nondetectable level.	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	8.5	6.5

(1) The suspended solids limitation of 90 mg/l and loading rate of 51 kg/day (110lbs/day) are for a lagoon wastewater treatment facility which does not utilize sludge recycle. If an alternate form of wastewater treatment is utilized, the average monthly and weekly suspended solids limitations would be 30 mg/l and 45mg/l, respectively. The average monthly and weekly suspended solids loading rates would be 17 kg/day (38 lbs/day), and 26 kg/ day (56 lbs/day), respectively.

(2) Refer to 94-DP-0169 for additional discharge permit conditions.

A flow of 0.15 million gallons per day (mgd) is used in waste allocation calculations

Discharge Permit Limits for Wastewater Treatment Plants, Continued

For Maryland Correctional Institute Wastewater Treatment Plant

EFFLUENT LIMITATIONS OUTFALL 001 (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below:

Effluent Characteristics	Monthly Loading Rate Kg/d (lbs/d)	Weekly Loading Rate Kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	19 (41)	28 (61)	30	45
TSS	19 (41)	28 (61)	30	45

Effluent Characteristics	Maximum	Minimum
Fecal Coliform	200 MPN/100 ml monthly log mean value	Not applicable
Total Residual Chlorine	---------- Not applicable ----------	
Dissolved Oxygen	Not applicable	5.0 mg/l at anytime
pH	8.5	6.5

(1) Refer to 99-DP-0759 for additional discharge permit conditions.

A flow of 1.6 million gallons per day (mgd) is used in waste allocation calculations

Discharge Permit Limits for Wastewater Treatment Plants, Continued

For Antietam Wastewater Treatment Plant

EFFLUENT LIMITATIONS (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below:

Effluent Characteristics	Monthly Loading Rate Kg/d (lbs/d)	Weekly Loading Rate Kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	19 (41)	28 (61)	30	45
TSS	19 (41)	28 (61)	30	45

Effluent Characteristics	Maximum	Minimum
Fecal Coliform	200 MPN/100 ml monthly log mean value	Not applicable
Total Residual Chlorine	---------- Not applicable ----------	
Dissolved Oxygen	Not applicable	5.0 mg/l at anytime
pH	8.5	6.5

(1) Refer to 98-DP-2354 for additional discharge permit conditions.

A flow of 0.163 million gallons per day (mgd) is used in waste allocation calculations

Facilities Performance Data

Summary of 2000 Plant Performance for Hagerstown WWTP

MONTHS	FLOW	BOD5		TSS		TKN		DO	TRC
	mgd	*mg/l*		*mg/l*		*mg/l*		*mg/l*	*mg/l*
	AVG	AVG	MAX	AVG	MAX	AVG	MAX	MIN	MAX
JAN-00	6.4	23.1	31.4	5.9	16.3	14.8	-	16.6	N/A
FEB	8.2	31.5	48.5	11	28	11.3	-	14	N/A
MAR	10.7	34.4	44.3	18.8	32.9	8.5	-	8	N/A
APR	10	27	28.5	10.8	16.7	8.8	-	10.1	N/A
MAY	9	28.2	34.4	9.4	20.3	8.8	9.8	10.4	N/A
JUN	9.5	18	24.9	7.7	10.8	4.1	6	11.9	N/A
JUL	8.5	10.7	13.8	5.3	7.46	2.6	2.8	13.2	N/A
AUG	7.6	21.1	12.9	11.8	6.7	5.4	3.6	9	N/A
SEP	7.1	11.1	22.8	5.9	16.2	3.5	7.5	10.8	N/A
OCT	6.5	4.8	5.2	2.3	2.6	1.8	-	14.1	N/A
NOV	6.3	4.9	5.6	2.1	2.3	1.8	-	15.1	N/A
DEC	6.7	7.1	9.6	2.5	3	2.3	-	17.1	N/A
SUMR AVG	8.3	17.8	21.8	8.0	12.3	4.9	5.9	11.6	N/A
YRLY AVG	**8.0**	**18.5**	**23.5**	**7.8**	**13.6**	**6.1**	**5.9**	**12.5**	**N/A**

Summary of 2000 Plant Performance for Funkstown WWTP

MONTHS	FLOW	BOD_5		TSS	TKN		DO	TRC
	mgd	*mg/l*		*mg/l*	*mg/l*		*mg/l*	*mg/l*
	AVG	AVG	MAX	AVG	AVG	MAX	MIN	MAX
JAN-00	0.061	14.4	18.8	22.4	N/A	N/A	12.3	0
FEB	-	-	-	-	N/A	N/A	-	-
MAR	-	-	-	-	N/A	N/A	-	-
APR	0.099	12.5	18.1	30.8	N/A	N/A	8.6	0
MAY	0.055	22.9	31.8	56.9	N/A	N/A	7	0
JUN	0.077	20.1	31.5	59.3	N/A	N/A	7.2	0
JUL	0.063	8.8	12.6	30	N/A	N/A	7.3	0
AUG	0.067	3.7	5	11.3	N/A	N/A	7.5	0
SEP	0.043	6.9	9.1	13.7	N/A	N/A	7.9	0
OCT	0.043	3.6	5.2	5.4	N/A	N/A	9	0
NOV	0.043	2.5	2.6	4.5	N/A	N/A	10.1	0
DEC	0.042	4.3	5.8	7.2	N/A	N/A	12.4	0
SUMR AVG	0.058	11	15.9	29.4	N/A	N/A	7.7	0
YRLY AVG	**0.059**	**10**	**14.1**	**24.2**	**N/A**	**N/A**	**8.9**	**0**

Facilities Performance Data, Continued

Summary of 2000 Plant Performance for MCI WWTP

MONTHS	FLOW	BOD5		TSS		TKN		DO	TRC
	mgd	*mg/.*		*mg/l*		*mg/l*		*mg/l*	*mg/l*
	AVG	AVG	MAX	AVG	MAX	AVG	MAX	MIN	MAX
JAN-00	0.826	3	4	4	9	-	-	7	0
FEB	0.843	3	5	6	10	-	-	7.5	0
MAR	0.861	4	5	6	11	-	-	7	0
APR	0.872	3	5	5	7	-	-	7	0
MAY	0.894	3	3	6	13	1	1	6.2	0
JUN	0.909	2	3	4	5	1	1	5.8	0
JUL	0.92	3	4	8	15	1	1	6	0
AUG	0.957	2	5	7	9	1	1	5.8	0
SEP	0.925	3	5	8	11	1	1	5.3	0
OCT	0.984	2	3	4	6	-	-	5.9	0
NOV	0.9	1	4	9	12	-	-	6.3	0
DEC	0.858	3	4	6	7	-	-	7.9	0
SUMR AVG	0.932	2.5	3.8	6.2	9.8	1	1	5.8	0
YRLY AVG	**0.896**	**2.7**	**4.2**	**6.1**	**9.6**	**1**	**1**	**6.5**	**0**

Summary of 2000 Plant Performance for Antietam WWTP

MONTHS	FLOW	BOD5		TSS		TKN		DO	TRC
	mgd	*mg/l*		*mg/l*		*mg/l*		*mg/l*	*mg/l*
	AVG	AVG	MAX	AVG	MAX	AVG	MAX	MIN	MAX
JAN-00	0.104	12.4	19.6	10.5	24.2	N/A	N/A	8.8	N/A
FEB	0.101	10.8	14.2	10.1	16.6	N/A	N/A	7	N/A
MAR	0.103	7.5	8.7	5	6.6	N/A	N/A	5.7	N/A
APR	0.104	6.3	7.7	4.2	5.2	N/A	N/A	6.7	N/A
MAY	0.104	4.7	6.7	4.2	8.3	N/A	N/A	7.1	N/A
JUN	0.105	6	10.3	5.6	8.4	N/A	N/A	5.1	N/A
JUL	0.101	8.2	11.1	8.5	10.6	N/A	N/A	5.3	N/A
AUG	0.093	4.9	6.6	9.8	10.6	N/A	N/A	6	N/A
SEP	0.097	2.3	2.9	5.5	9.6	N/A	N/A	6.1	N/A
OCT	0.127	3	6.4	3.7	9.2	N/A	N/A	6.2	N/A
NOV	0.104	3.4	3.8	2.1	3.6	N/A	N/A	7.3	N/A
DEC	0.103	11.9	17.1	13.7	17	N/A	N/A	8.4	N/A
SUMR AVG	0.105	4.9	7.3	6.2	9.5	N/A	N/A	6	N/A
YRLY AVG	**0.104**	**6.8**	**9.6**	**6.9**	**10.8**	**N/A**	**N/A**	**6.6**	**N/A**

Facilities Performance Data, Continued

The Hagerstown Fiber Limited Partnership is currently not in operation. Additionally, the facility was in start-up mode during 1996 and ceased operations in 1997.