APPENDIX A

Land Use Distribution in the Hiwassee River Watershed

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds

Land Use	Hiwassee River Subwatersheds									
	Agency Creek		Price Creek		Rogers Creek		Spring Creek		Hiwassee River	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	3260	36.4	1464	41.7	16813	52.1	4329	40.1	4385	28.8
Emergent Herbaceous Wetlands	21	0.2	0	0.0	1	0.0	0	0.0	161	1.1
Evergreen Forest	1838	20.5	827	23.5	5264	16.3	787	7.3	3089	20.3
High Intensity Commercial/Industrial/Transp.	12	0.1	0	0.0	25	0.1	15	0.1	229	1.5
High Intensity Residential	0	0	0	0	0	0	0	0	24	0.2
Low Intensity Residential	31	0.3	3	0.1	55	0.2	30	0.3	179	1.2
Mixed Forest	1531	17.1	613	17.4	5337	16.5	1248	11.6	2360	15.5
Open Water	0	0.0	1	0.0	20	0.1	2	0.0	769	5.0
Other Grasses (Urban/recreation; e.g. parks)	10	0.1	0	0.0	8	0.0	14	0.1	133	0.9
Pasture/Hay	1798	20.1	491	14.0	3719	11.5	3452	32.0	2293	15.0
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	14	0.0	12	0.1	155	1.0
Row Crops	364	4.1	110	3.1	616	1.9	812	7.5	806	5.3
Transitional	0	0.0	0	0.0	210	0.7	94	0.9	105	0.7
Woody Wetlands	98	1.1	6	0.2	189	0.6	0	0.0	557	3.7
Total	8963	100.0	3515	100.0	32271	100.0	10795	100.0	15245	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	North Mouse Creek		Chestuee Creek		Little Chestuee Creek		Hawkins Branch		Dairy Branch	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	11684	25.2	4753	19.1	1448	25.3	93	15.8	20	7.2
Emergent Herbaceous Wetlands	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Evergreen Forest	7053	15.2	4034	16.2	1334	23.3	66	11.2	26	9.3
High Intensity Commercial/Industrial/Transp.	1173	2.5	98	0.4	8	0.1	0	0.0	0	0.0
High Intensity Residential	220	0.5	45	0.2	0	0.0	0	0.0	0	0.0
Low Intensity Residential	805	1.7	361	1.5	14	0.2	9	1.5	0	0.0
Mixed Forest	9308	20.1	5255	21.1	1673	29.3	134	22.7	19	6.8
Open Water	22	0.0	17	0.1	4	0.1	1	0.2	4	1.4
Other Grasses (Urban/recreation; e.g. parks)	430	0.9	222	0.9	0	0.0	0	0.0	0	0.0
Pasture/Hay	12175	26.3	7697	30.9	1052	18.4	241	40.8	155	55.6
Quarries/Strip Mines/Gravel Pits	84	0.2	0	0.0	0	0.0	0	0.0	0	0.0
Row Crops	2985	6.4	2195	8.8	134	2.3	44	7.5	53	19.0
Transitional	141	0.3	223	0.9	51	0.9	1	0.2	0	0.0
Woody Wetlands	238	0.5	0	0.0	0	0.0	0	0.0	0	0.0
Total	46322	100.0	24901	100.0	5719	100.0	590	100.0	279	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	South Mouse Creek		Woolen Mill Branch		Fillauer Branch		Chatata Creek		Little Chatata Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	1599	16.2	185	12.0	495	18.9	5888	28.1	1530	22.8
Evergreen Forest	746	7.6	43	2.8	203	7.7	2030	9.7	482	7.2
High Intensity Commercial/Industrial/Transp.	996	10.1	318	20.6	163	6.2	299	1.4	263	3.9
High Intensity Residential	826	8.4	226	14.6	226	8.6	58	0.3	53	0.8
Low Intensity Residential	2536	25.7	486	31.5	767	29.2	508	2.4	335	5.0
Mixed Forest	1433	14.5	136	8.8	435	16.6	3049	14.6	912	13.6
Open Water	6	0.1	4	0.3	1	0.1	2	0.0	1	0.0
Other Grasses (Urban/recreation; e.g. parks)	868	8.8	110	7.1	266	10.1	321	1.5	242	3.6
Pasture/Hay	495	5.0	13	0.8	3	0.1	7324	35.0	2307	34.5
Row Crops	340	3.5	18	1.1	66	2.5	1444	6.9	570	8.5
Transitional	5	0.1	3	0.2	2	0.1	8	0.0	1	0.0
Total	9851	100.0	1542	100.0	2625	100.0	20931	100.0	6696	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	Oostanaula Creek (Mile 42.7)		Oostanaula Creek (Mile 34.2)		Oostanaula Creek (Mile 26.6)		Oostanaula Creek (Mile 5.7)		Oostanaula Creek at the Mouth	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	460	23.9	1538	13.4	925	14.2	5244	31.8	2785	35.3
Evergreen Forest	251	13.1	1632	14.2	1369	20.9	2266	13.8	2070	26.2
High Intensity Commercial/Industrial/Transp.	0	0.0	48	0.4	331	5.1	56	0.3	0	0.0
High Intensity Residential	0	0.0	0	0.0	168	2.6	7	0.0	0	0.0
Low Intensity Residential	1	0.1	28	0.2	775	11.9	192	1.2	11	0.1
Mixed Forest	433	22.6	2111	18.3	1609	24.6	3653	22.2	1788	22.7
Open Water	9	0.5	10	0.1	3	0.0	8	0.0	0	0.0
Other Grasses (Urban/recreation; e.g. parks)	0	0.0	14	0.1	328	5.0	130	0.8	0	0.0
Pasture/Hay	546	28.5	4754	41.3	804	12.3	4009	24.3	847	10.7
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0	0	0.0	6	0.1
Row Crops	219	11.4	1288	11.2	223	3.4	820	5.0	293	3.7
Transitional	0	0.0	93	0.8	0	0.0	97	0.6	89	1.1
Total	1921	100.0	11517	100.0	6535	100.0	16482	100.0	7890	100.0

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Hiwassee River watershed. The location of these monitoring stations is shown in Figures 4-10. Monitoring data recorded at these stations for E. coli and fecal coliform are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
AGENC002.1ME	6/10/03	**1299**	**NA**
	6/23/03	**1986**	**NA**
	6/25/03	**3190**	**NA**
	7/9/03	**9800**	**NA**
	7/10/03	**2240**	**NA**
HIWAS013.4MM	12/15/98	**980**	860
	3/9/99	170	770
	6/8/99	2	13
	9/14/99	19	16
	12/14/99	13	430
	3/15/00	260	**3900**
	6/19/00	4	15
	9/5/00	9	19
	12/4/00	93	93
	3/14/01	**>2400**	**5000**
	9/11/01	4	38
	3/25/02	170	190
	9/4/02	3	7
	12/17/02	52	160
	3/26/03	40	56
	6/17/03	**2400**	**2100**
	9/8/03	27	**NA**
	12/2/03	54	70
	3/9/04	**1200**	770
HIWAS015.6MM	4/27/98	27	70
	4/28/98	51	104
	7/13/98	20	34
	7/14/98	17	110
	7/15/98	13	112
	5/3/99	260	240
	5/4/99	120	140
	8/30/99	36	60
	8/31/99	25	30
	9/1/99	48	39

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
FILLA000.3BR	5/28/03	**>2419**	**NA**
	6/2/03	54.6	**NA**
	6/5/03	770	**NA**
	6/9/03	**1732**	**NA**
	6/11/03	**1299**	**NA**
	6/23/03	**1080**	**NA**
WMILL000.8BR	3/3/04	**>2419**	**NA**
SMOUS012.7BR	5/28/03	727	**NA**
	6/2/03	**1413**	**NA**
	6/5/03	**1413**	**NA**
	6/9/03	**>2419**	**NA**
	6/11/03	**1986**	**NA**
	6/23/03	**1520**	**NA**
LCHAT000.3BR	5/28/03	**980**	**NA**
	6/2/03	920	**NA**
	6/5/03	866	**NA**
	6/9/03	**1119**	**NA**
	6/11/03	**1413**	**NA**
	6/23/03	378	**NA**
CHATA000.5BR	8/27/02	200	92
	10/21/02	410	770
	11/12/02	**23590**	**25000**
	12/18/02	200	460
	1/28/03	740	270
	3/24/03	630	560
	4/29/03	**1320**	**1500**
	5/19/03	**4000**	**5200**
	8/19/03	**1210**	850
	11/4/03	310	560
	1/13/04	**960**	640
	5/11/04	520	730

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
HAWKI000.3PO	12/30/02	4	8
	2/24/03	**1553**	**1500**
	3/17/03	61	70
	5/14/03	921	630
	6/4/03	96	84
	7/21/03	76	80
	8/27/03	150	400
	10/7/03	649	**2000**
	11/20/03	**1300**	**1200**
HAWKI001.3PO	12/30/02	**>2419**	**2800**
	2/24/03	**7540**	**7800**
	3/17/03	152	138
	5/14/03	**>2419**	**3600**
	6/4/03	260	400
	7/21/03	**>2419**	**22000**
	8/27/03	**2590**	**2700**
	10/7/03	816	**1200**
	11/20/03	**2920**	**2000**
	2/11/04	113	66
DAIRY000.4BR	2/24/03	**21720**	**17000**
	3/17/03	308	470
	5/14/03	**1553**	**2300**
	6/4/03	488	600
	7/21/03	291	360
	8/27/03	649	930
	10/7/03	63	60
	11/20/03	**>2419**	**2800**
DAIRY001.2BR	2/24/03	**36540**	**17000**
	3/17/03	6	10
	5/14/03	**>2419**	**11600**
	6/4/03	**>2419**	**4200**
	7/21/03	328	300
	8/27/03	7	20
	10/7/03	8	10
	11/20/03	**>2419**	**5300**
	2/11/04	**>2419**	**3000**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
LCHES001.6MM	5/28/03	727	**NA**
	6/2/03	648	**NA**
	6/5/03	**1203**	**NA**
	6/9/03	**1046**	**NA**
	6/11/03	**>2419**	**NA**
CHEST042.5MM	3/2/98	249	168
	3/11/98	411	350
	4/13/98	770	660
	4/14/98	**1120**	**1030**
	4/15/98	687	690
	11/30/98	172	172
	12/1/98	157	130
	2/23/99	460	170
	5/17/99	870	600
	5/18/99	210	970
	8/16/99	250	560
	8/17/99	820	570
	11/15/99	120	90
	11/17/99	160	100
	5/28/03	547	**NA**
	6/2/03	517	**NA**
	6/5/03	**1553**	**NA**
	6/9/03	**1986**	**NA**
	6/11/03	816	**NA**
OOSTA005.8MM	10/22/02	411	300
	2/19/03	**1986**	**1900**
	8/20/03	461	340
	11/5/03	219	420
	1/14/04	236	176

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA026.6MM	3/26/02	**NA**	**10000**
	5/22/02	**NA**	400
	10/1/02	30	120
	10/29/02	610	**1210**
	11/19/02	350	140
	12/17/02	160	290
	1/21/03	30	120
	2/25/03	560	50
	3/25/03	80	60
	4/29/03	130	200
	6/3/03	720	960
	6/17/03	**1600**	960
	7/30/03	450	560
	9/3/03	50	140
	10/1/03	50	40
	11/18/03	400	460
	12/9/03	340	380
	1/26/04	**1690**	**1850**
	2/9/04	200	880
	3/15/04	320	230
	4/26/04	210	180
	5/24/04	60	150
	6/14/04	90	140
OOSTA028.4MM	12/16/82	**NA**	**19200**
	3/8/83	**NA**	**1290**
	6/7/83	**NA**	420
	9/20/83	**NA**	**4400**
	12/13/83	**NA**	**3300**
	3/13/84	**NA**	**14500**
	6/12/84	**NA**	100
	9/11/84	**NA**	230
	12/11/84	**NA**	**8700**
	3/12/85	**NA**	420
	9/10/85	**NA**	**2300**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
OOSTA028.4MM	12/10/85	**NA**	280
	3/11/86	**NA**	30
	6/18/86	**NA**	670
	9/23/86	**NA**	400
	12/9/86	**NA**	**150000**
	3/10/87	**NA**	**40000**
	6/9/87	**NA**	**1730**
	9/15/87	**NA**	70
	12/8/87	**NA**	400
	3/15/88	**NA**	10
	6/7/88	**NA**	720
	9/13/88	**NA**	800
	12/13/88	**NA**	200
	3/7/89	**NA**	**12000**
	6/7/89	**NA**	**4500**
	3/15/90	**NA**	**15000**
	6/13/90	**NA**	980
	9/11/90	**NA**	**3000**
	12/12/90	**NA**	30
	3/12/91	**NA**	**3000**
	6/11/91	**NA**	460
	9/10/91	**NA**	**1000**
	12/4/91	**NA**	**26000**
	6/9/92	**NA**	**31000**
	6/10/92	**NA**	**31000**
	9/15/92	**NA**	420
	12/9/92	**NA**	480
	3/31/93	**NA**	**14700**
	6/23/93	**NA**	**1400**
	12/6/93	**NA**	**12800**
	3/14/94	**NA**	810
	6/20/94	**NA**	**1400**
	9/13/94	**NA**	960
	12/12/94	**NA**	**1320**
	3/13/95	**NA**	**1260**
	6/12/95	**NA**	**7600**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA028.4MM	9/18/95	**NA**	**2700**
	12/11/95	**NA**	250
	3/18/96	**NA**	**1600**
	6/10/96	**NA**	**17000**
	12/15/98	**>2419**	**8000**
	3/9/99	**2400**	**2900**
	5/24/99	**NA**	**3900**
	6/8/99	200	97
	6/14/99	**NA**	200
	7/19/99	**NA**	670
	8/11/99	**NA**	280
	9/13/99	**2400**	240
	12/7/99	820	830
	3/7/00	370	600
	6/12/00	140	200
	9/19/00	870	930
	12/11/00	160	320
	3/13/01	**2400**	**8700**
	9/11/01	200	170
	3/25/02	1	10
	10/22/02	260	270
	2/19/03	**1553**	**1800**
	7/30/03	560	250
	8/20/03	411	440
	9/3/03	120	300
	10/1/03	70	380
	11/5/03	365	220
	11/18/03	400	690
	12/9/03	310	320
	1/14/04	345	220
	1/26/04	**1650**	**1720**
	2/9/04	600	850
	3/15/04	250	300
	4/26/04	160	480
	5/24/04	80	170
	6/14/04	60	80

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA030.0MM	3/26/02	**NA**	**12000**
	5/22/02	**NA**	**2900**
	10/1/02	160	550
	10/29/02	**2900**	**6000**
	11/19/02	550	710
	12/17/02	300	210
	1/21/03	300	410
	2/25/03	340	250
	3/25/03	60	120
	4/29/03	40	240
	6/3/03	**1200**	**1300**
	6/17/03	**1740**	**1680**
	7/30/03	120	270
	9/3/03	90	220
	10/1/03	150	210
	11/18/03	60	80
	12/9/03	170	160
	1/26/04	**2760**	**2850**
	2/9/04	150	190
	3/15/04	100	280
	4/26/04	920	870
	5/24/04	140	270
	6/14/04	50	330
OOSTA030.1MM	3/26/02	**NA**	**14000**
	5/22/02	**NA**	**3500**
	10/1/02	130	510
	10/29/02	**2500**	**6000**
	11/19/02	**1350**	560
	12/17/02	510	420
	1/21/03	190	230
	2/25/03	380	220
	3/25/03	100	100
	4/29/03	100	230
	6/3/03	600	840

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA030.1MM	6/17/03	**1740**	**1560**
	7/30/03	240	380
	9/3/03	90	130
	10/1/03	130	260
	11/18/03	80	50
	12/9/03	220	200
	1/26/04	**1990**	**2200**
	2/9/04	**980**	**1200**
	3/15/04	250	370
	4/26/04	180	310
	5/24/04	200	360
	6/14/04	80	400
OOSTA033.6MM	7/30/03	**2750**	**2140**
	9/3/03	410	500
	10/1/03	400	870
	11/18/03	**1200**	**1180**
	12/9/03	890	740
	1/26/04	**2090**	**2120**
	2/9/04	800	1000
	3/15/04	210	250
	4/26/04	880	**1130**
	5/24/04	520	**1100**
	6/14/04	250	**1490**
OOSTA035.1MM	7/30/03	**1250**	**1850**
	9/3/03	100	310
	10/1/03	290	720
	11/18/03	40	120
	12/9/03	190	120
	1/26/04	**2610**	**2500**
	2/9/04	100	100
	3/15/04	280	330
	4/26/04	720	**1410**
	5/24/04	380	810
	6/14/04	130	50

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
NMOUS004.2MM	8/27/02	100	200
	10/21/02	310	380
	11/12/02	**8620**	**9000**
	12/18/02	100	130
	1/28/03	200	88
	3/24/03	410	200
	4/29/03	200	370
	5/19/03	**4570**	**5000**
	8/19/03	410	800
	11/4/03	310	320
	1/13/04	410	330
	5/11/04	310	130
SPRIN003.8MM	6/10/03	517	**NA**
	6/23/03	770	**NA**
	6/25/03	**1120**	**NA**
	7/9/03	**1046**	**NA**
	7/10/03	770	**NA**
SPRIN015.6MM	6/10/03	**980**	**NA**
	6/23/03	**1046**	**NA**
	6/25/03	866	**NA**
	7/9/03	686	**NA**
	7/10/03	**1119**	**NA**
ROGER002.7MM	6/10/03	517	**NA**
	6/23/03	435	**NA**
	6/25/03	613	**NA**
	7/9/03	461	**NA**
	7/10/03	770	**NA**
ROGER014.2MM	6/10/03	920	**NA**
	6/23/03	816	**NA**
	6/25/03	**1203**	**NA**
	7/9/03	**1413**	**NA**
	7/10/03	**1413**	**NA**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
PRICE004.4ME	6/10/03	547	**NA**
	6/23/03	248	**NA**
	6/25/03	360	**NA**
	7/9/03	**980**	**NA**
	7/10/03	**1986**	**NA**

APPENDIX C

Load Duration Curve Development
and
Determination of Required Load Reductions

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. When a water quality target (or criterion) concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

C.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the Hiwassee River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03565500, located on Oostanaula Creek near Sanford, located at mile 5.7 on Oostanaula Creek (see Appendix D for details of calibration). The data used, in each case, included the period of record from 7/1/94 – 6/30/04. For example, a flow-duration curve for North Mouse Creek at RM 4.2 was constructed using simulated daily mean flow for the period from 7/1/94 through 6/30/04 (RM 4.2 corresponds to the location of monitoring station NMOUS004.2MM). This flow duration curve is shown in Figure C-13 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure and are shown in Figures C-1 thru C-16. Flow duration curves were not developed for the Hiwassee River mainstem impaired waterbody due to unsuitable conditions for modeling.

C.2 Development of Load Duration Curves and Determination of Required Load Reductions

E. coli and fecal coliform load duration curves for impaired waterbodies in the Hiwassee River Watershed were developed from the flow duration curves developed in Section C.1 and available water quality monitoring data. Load duration curves were developed using the following procedure (North Mouse Creek is shown as an example):

1. A target load duration curve was generated for North Mouse Creek by applying the fecal coliform target concentration of 900 cts./100 mL (1,000 cts./100mL - MOS) to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1) and plotting the results. The fecal coliform target maximum load corresponding to each ranked daily mean flow is:

$(\text{Target Load})_{\text{North Mouse Creek}}$ = (900 cts./100 mL) x (Q) x (UCF)

where: Q = daily mean flow
UCF = the required unit conversion factor

For E. coli, the target concentration of 847 cts./100 mL was applied to generate load duration curves corresponding to the E. coli water quality standard (see Section 5.0).

2. Daily loads were calculated for each of the water quality samples collected at monitoring station NMOUS004.2MM (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. NMOUS004.2MM was selected for LDC analysis because it was the monitoring station on North Mouse Creek with the most exceedances of the target concentration.

   Note: In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.

3. Using the flow duration curves developed in C.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting fecal coliform and E. coli load duration curves for are shown in Figures C-45 and C-46.

4. For cases where the existing load exceeded the target maximum load at a particular PDFE, the reduction required to reduce the sample load to the target load was calculated.

5. The 90^{th} percentile value for all of the fecal coliform sampling data at NMOUS004.2MM monitoring site was determined. If the 90^{th} percentile value exceeded the target maximum fecal coliform concentration, the reduction required to reduce the 90^{th} percentile value to the target maximum concentration was calculated.

6. Step 5 was repeated for E. coli data at NMOUS004.2MM.

7. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean fecal coliform concentration was determined and compared to the target geometric mean fecal coliform concentration of 180 cts/100 mL (200 cts/100mL – MOS). If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

8. Step 7 was repeated for the E. coli data at NMOUS004.2MM.

9. The load reductions required to meet the target maximum and target 30-day geometric mean concentrations of both fecal coliform and E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for North Mouse Creek. The determination of required load reductions for North Mouse Creek is shown in Tables C-30 and C-31.

Load duration curves and required load reductions of other impaired waterbodies were derived in a similar manner and are shown in Figures C-17 through C-49 and Tables C-1 through C-34. For the Hiwassee River mainstem impaired waterbody, where flows were not simulated due to unsuitable conditions for modeling (ref.: Section 8.5), load duration curves could not be developed. However, required load reductions were derived according to step 5 and are shown in Tables C-35 through C-38.

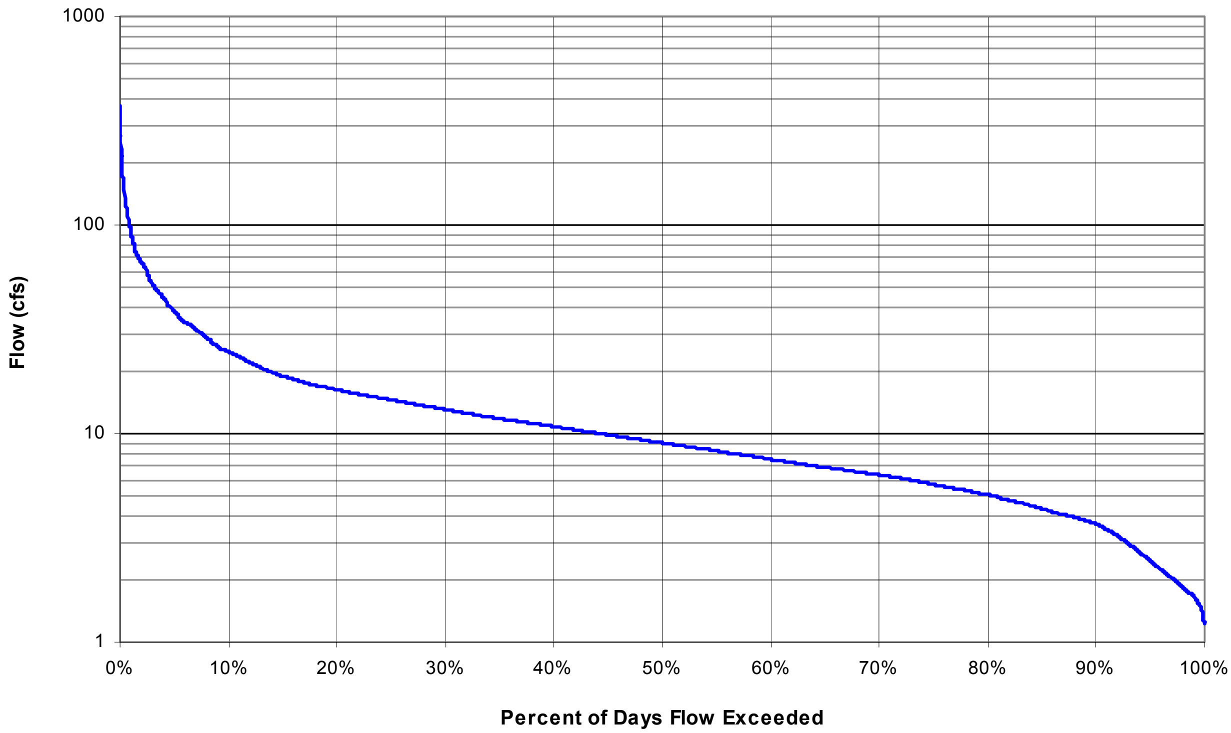


Figure C-1. Flow Duration Curve for Agency Creek at Mile 2.1

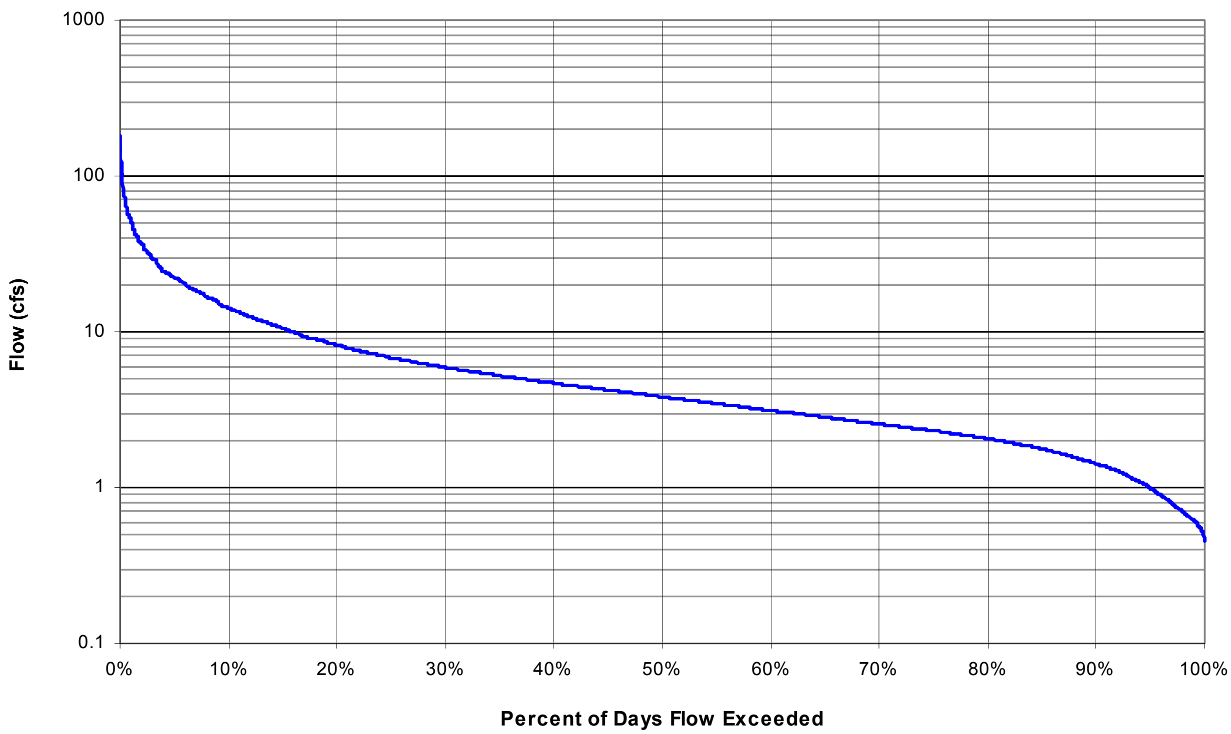


Figure C-2. Flow Duration Curve for Fillauer Branch at Mile 0.3

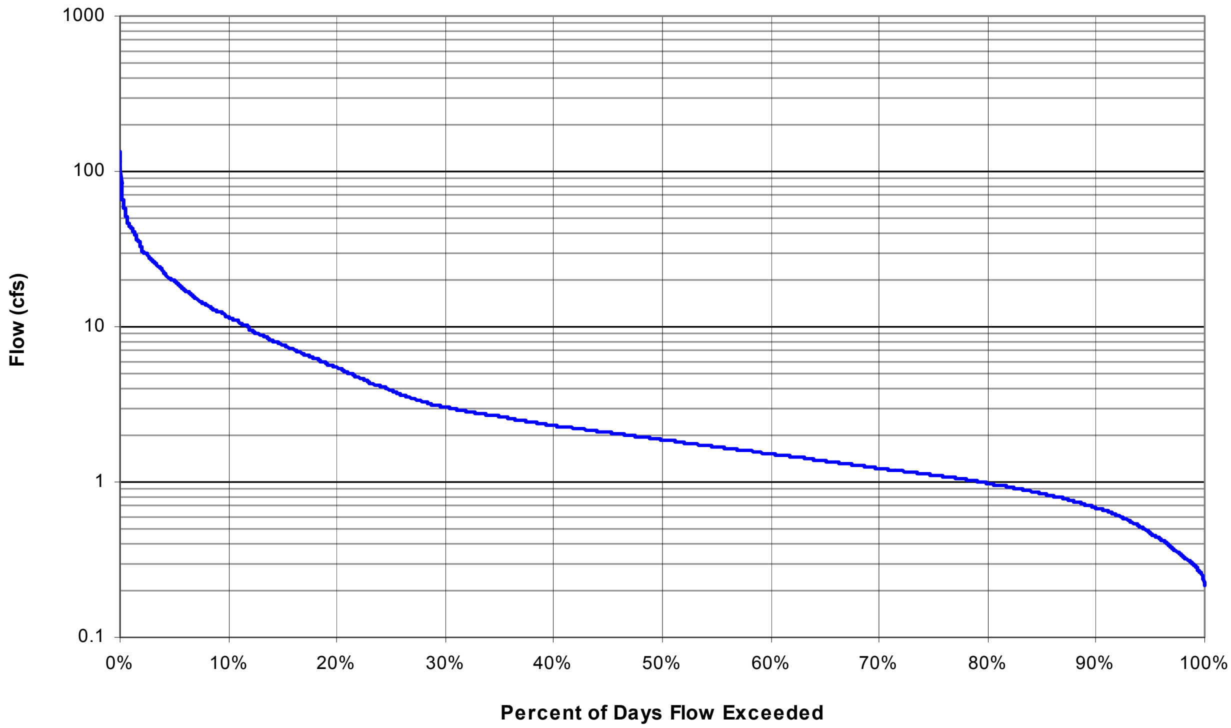


Figure C-3. Flow Duration Curve for Woolen Mill Branch at Mile 0.8

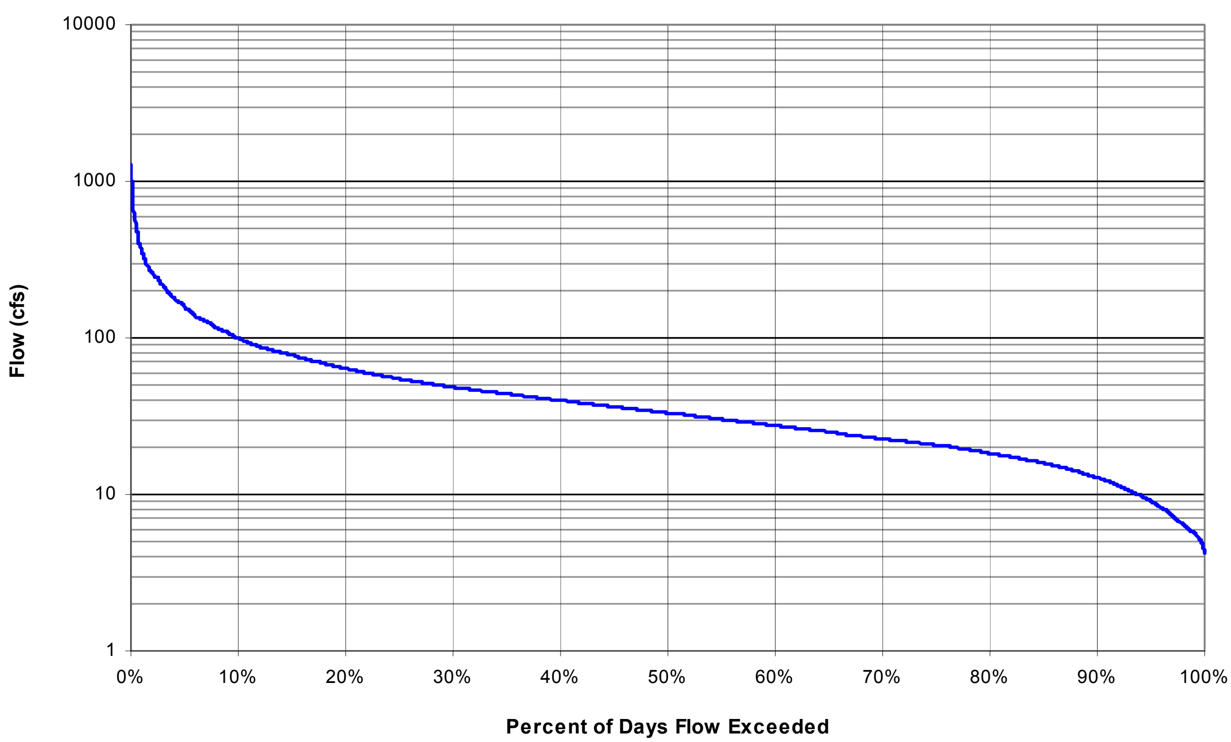


Figure C-4. Flow Duration Curve for South Mouse Creek at Mile 12.7

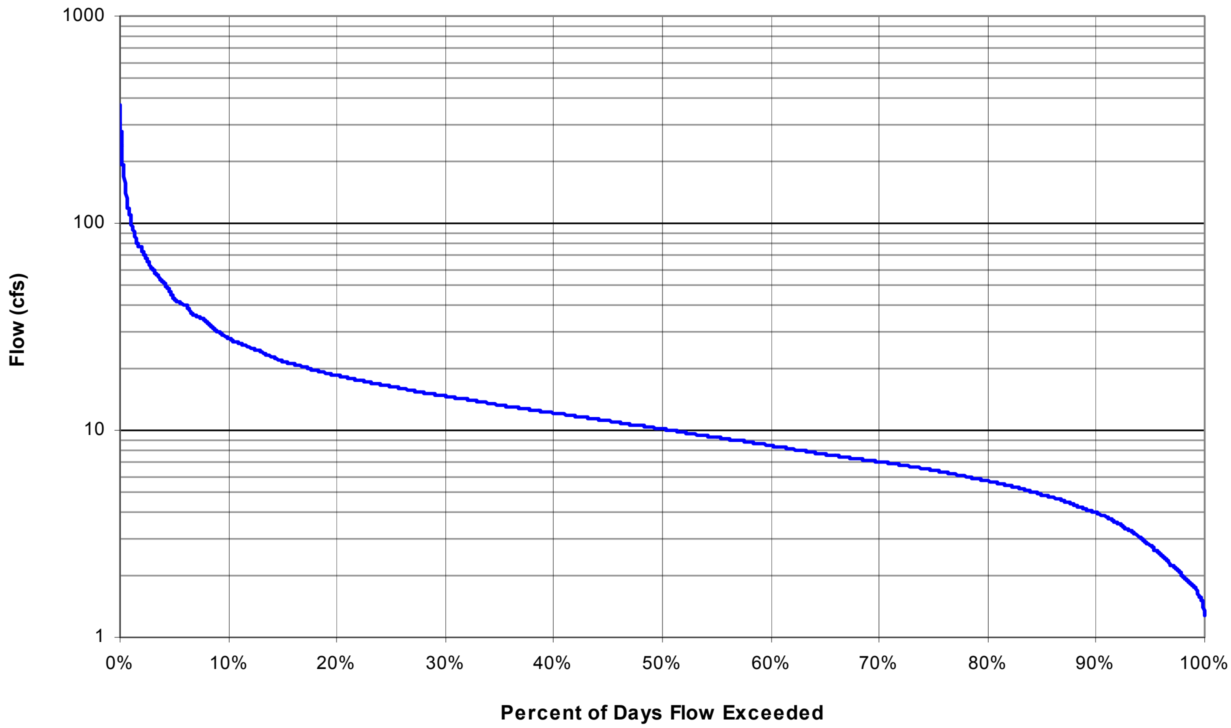


Figure C-5. Flow Duration Curve for Little Chatata Creek at Mile 0.3

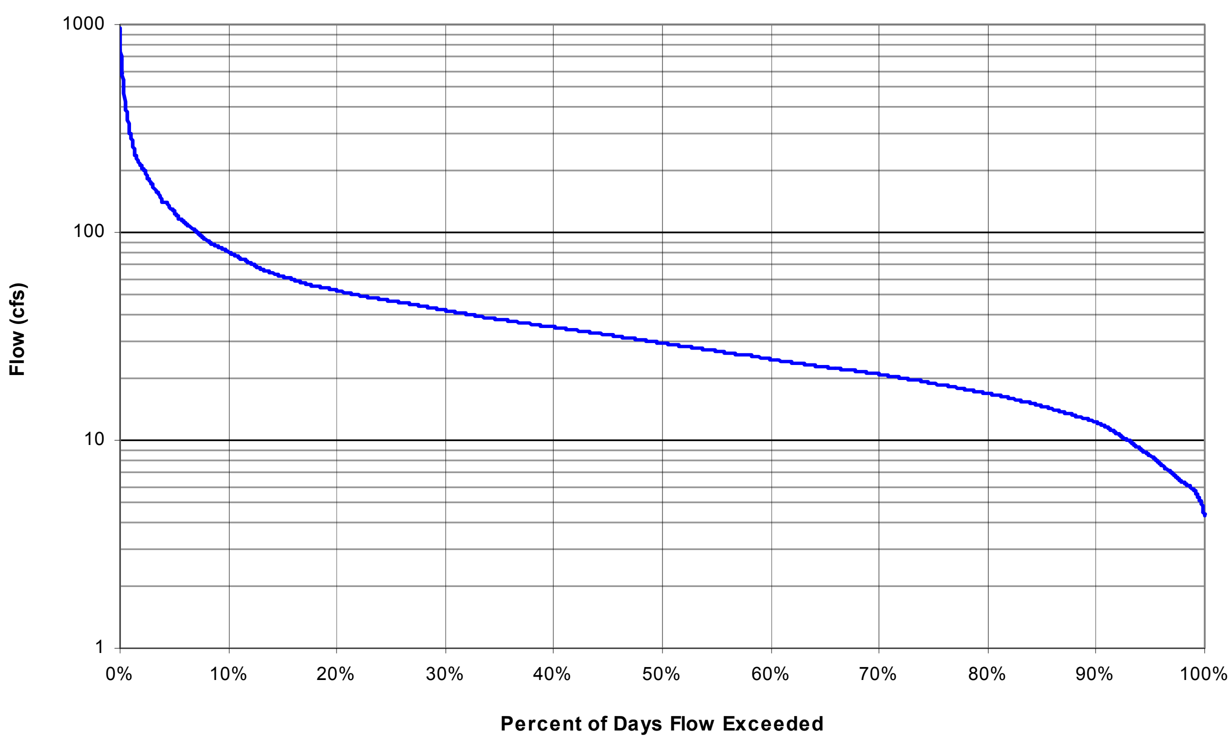


Figure D-6. Flow Duration Curve for Chatata Creek at Mile 0.5

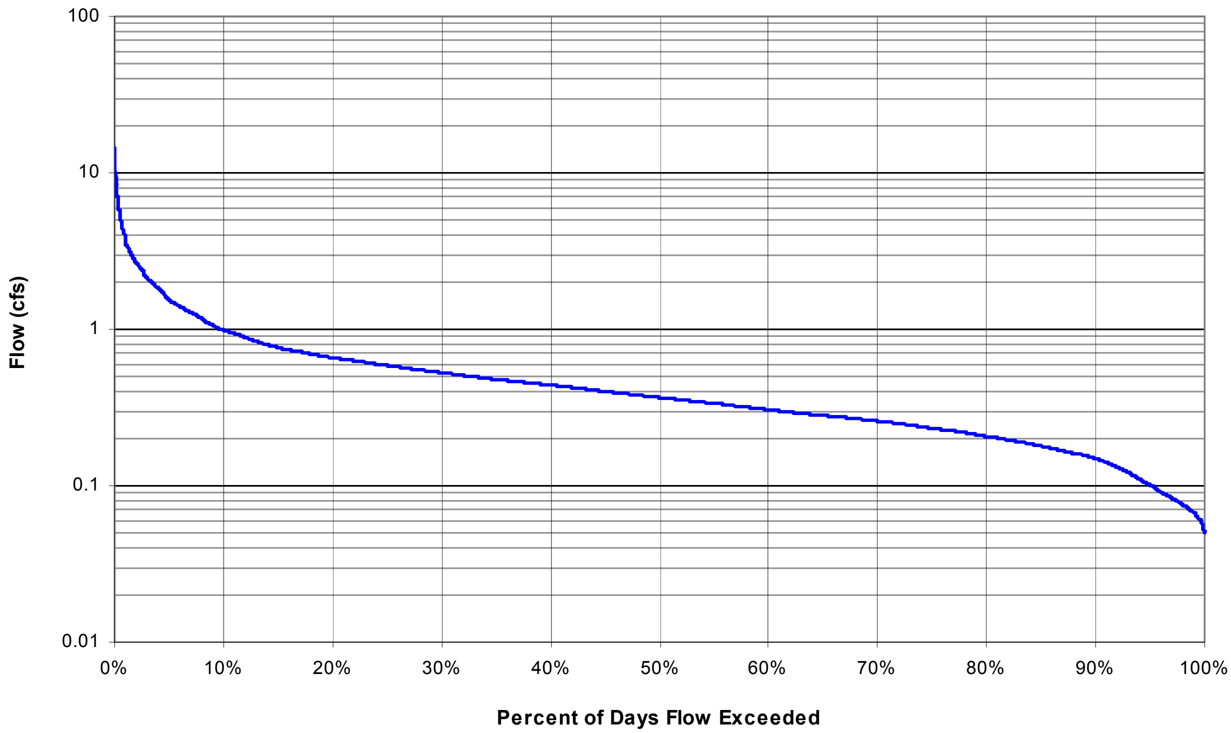


Figure C-7. Flow Duration Curve for Hawkins Branch at Mile 1.3

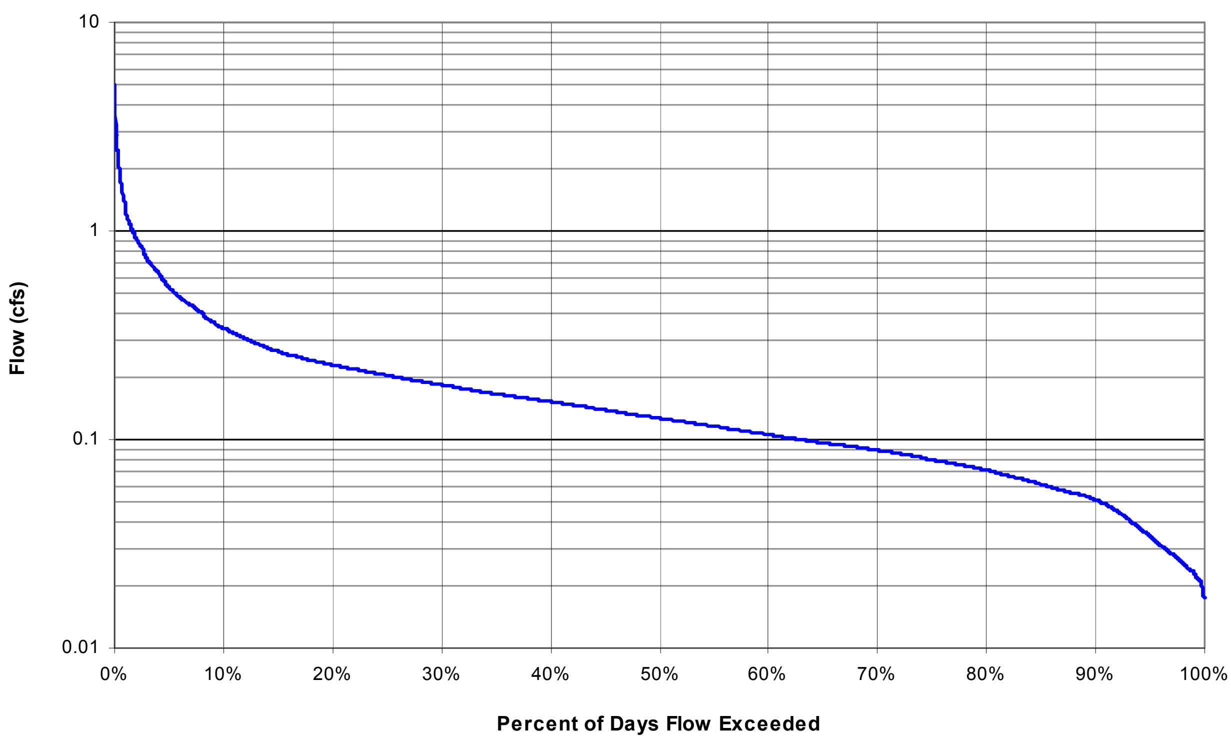


Figure C-8. Flow Duration Curve for Dairy Branch at Mile 1.2

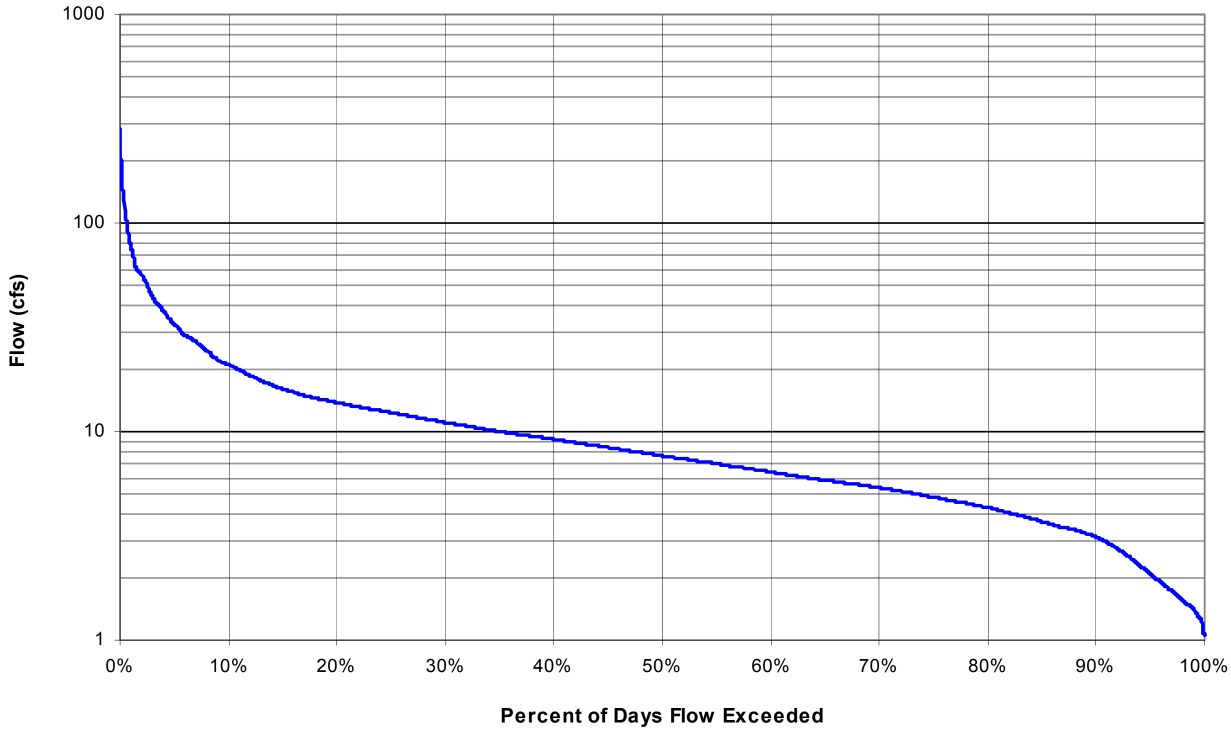


Figure C-9. Flow Duration Curve for Little Chestuee Creek at Mile 1.6

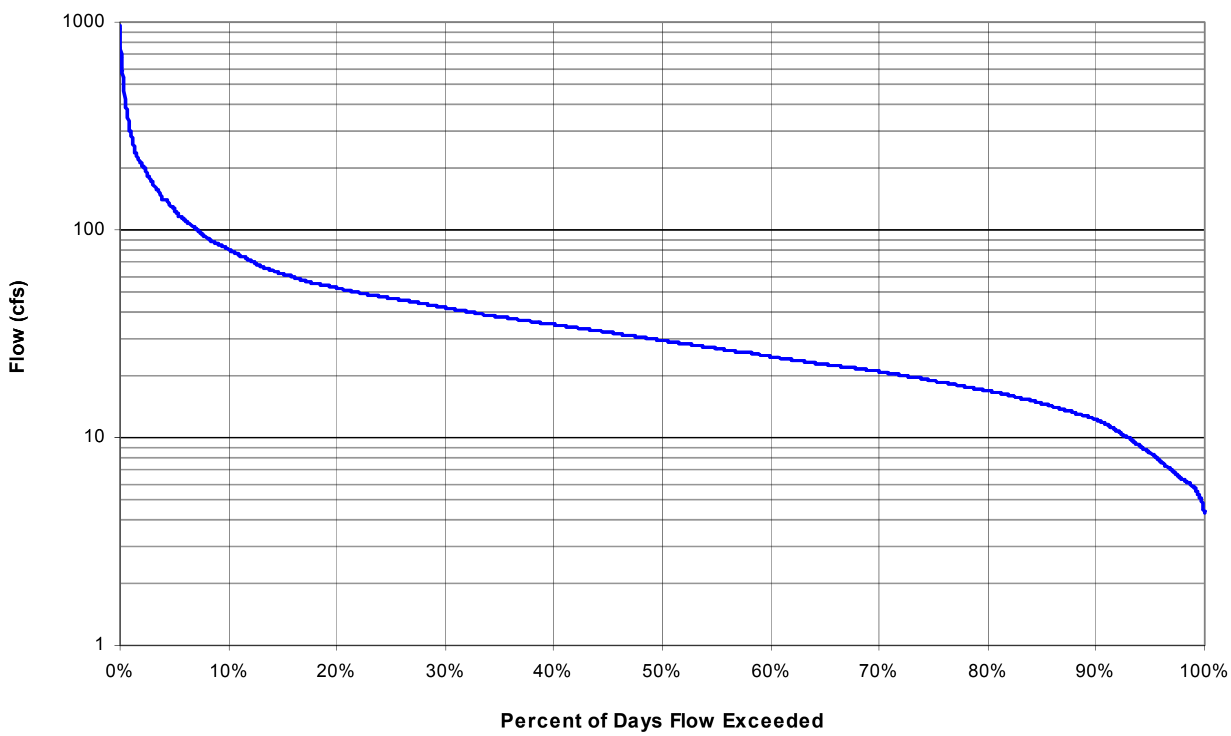


Figure C-10. Flow Duration Curve for Chestuee Creek at Mile 45.2

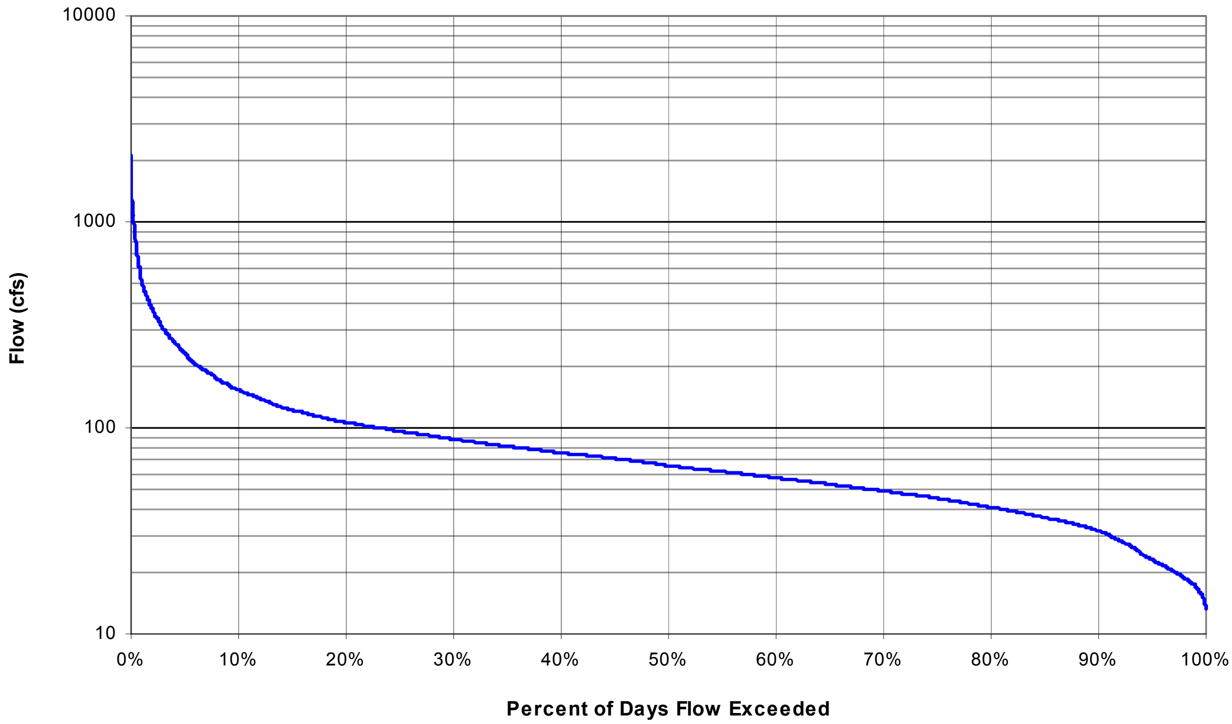


Figure C-11. Flow Duration Curve for Oostanaula Creek at Mile 5.7

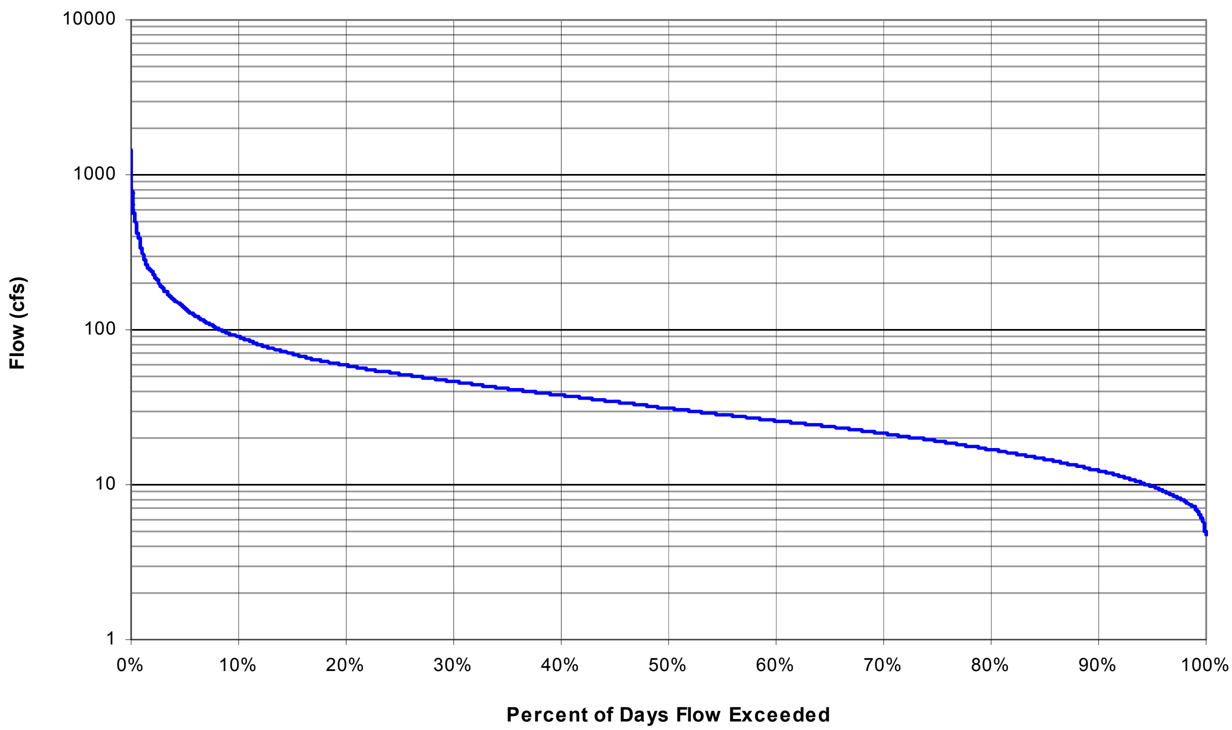


Figure C-12. Flow Duration Curve for Oostanaula Creek at Mile 28.4

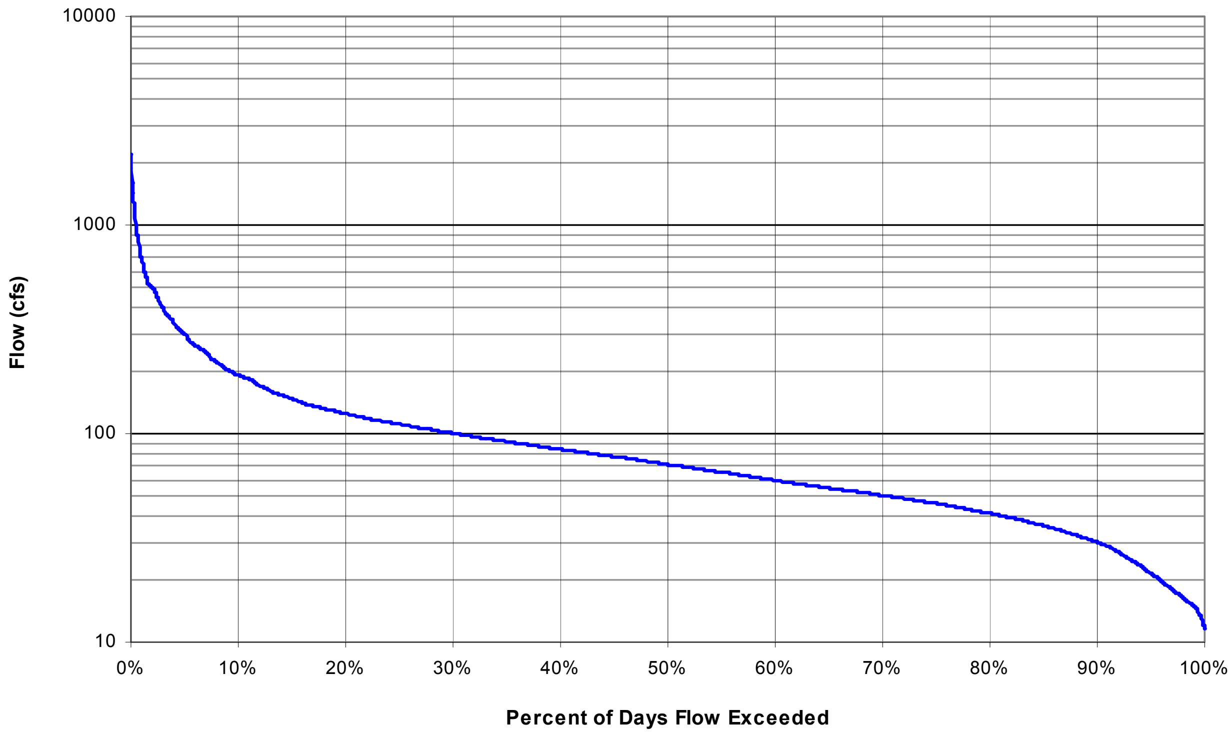


Figure C-13. Flow Duration Curve for North Mouse Creek at Mile 4.2

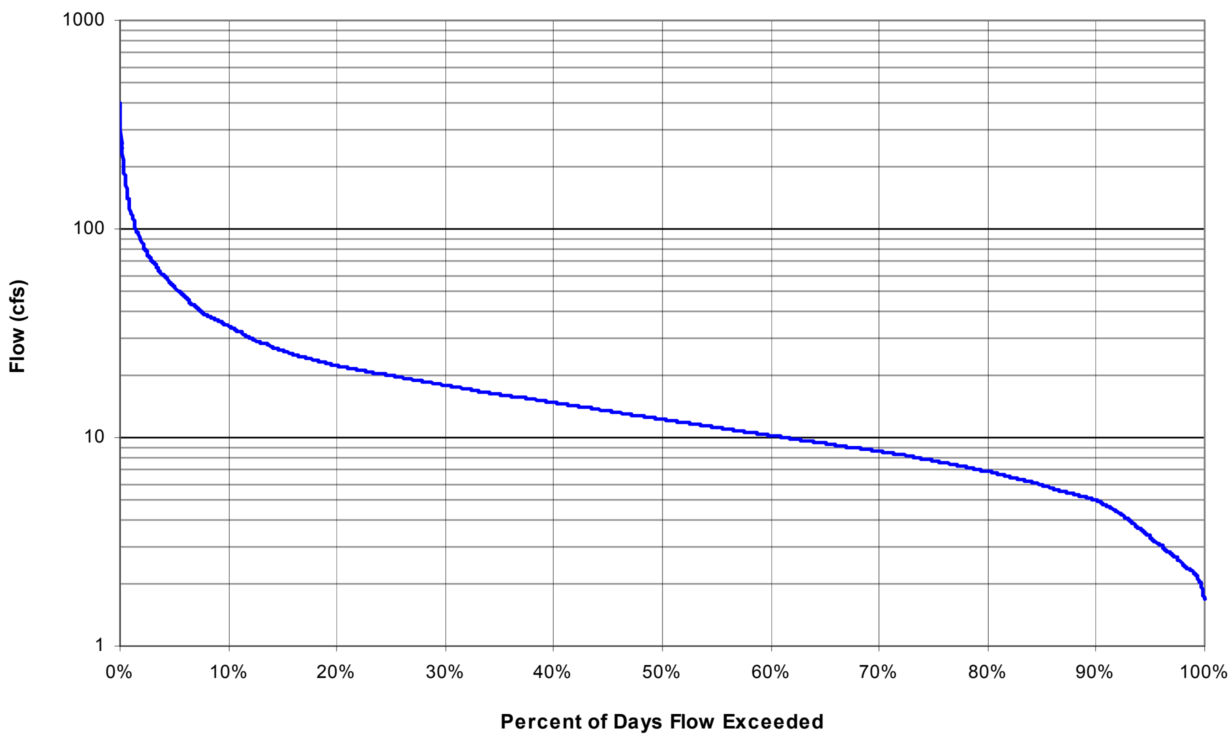


Figure C-14. Flow Duration Curve for Spring Creek at Mile 15.6

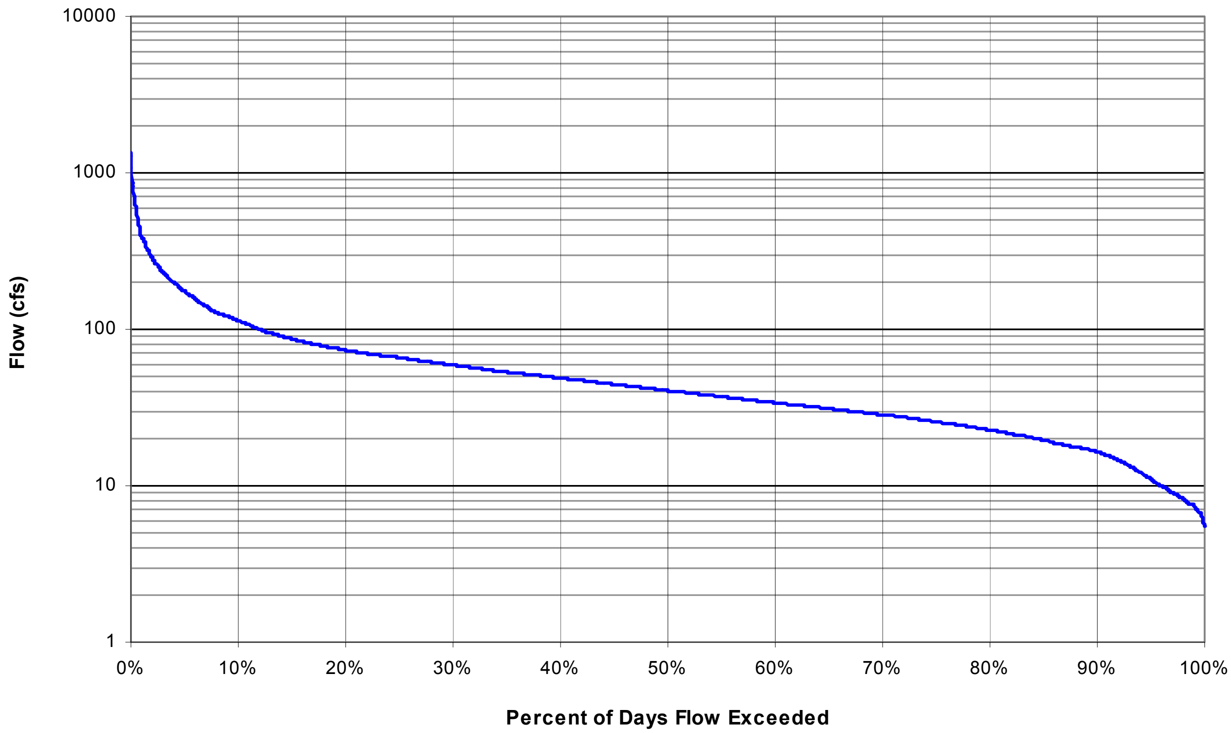


Figure C-15. Flow Duration Curve for Rogers Creek at Mile 14.2

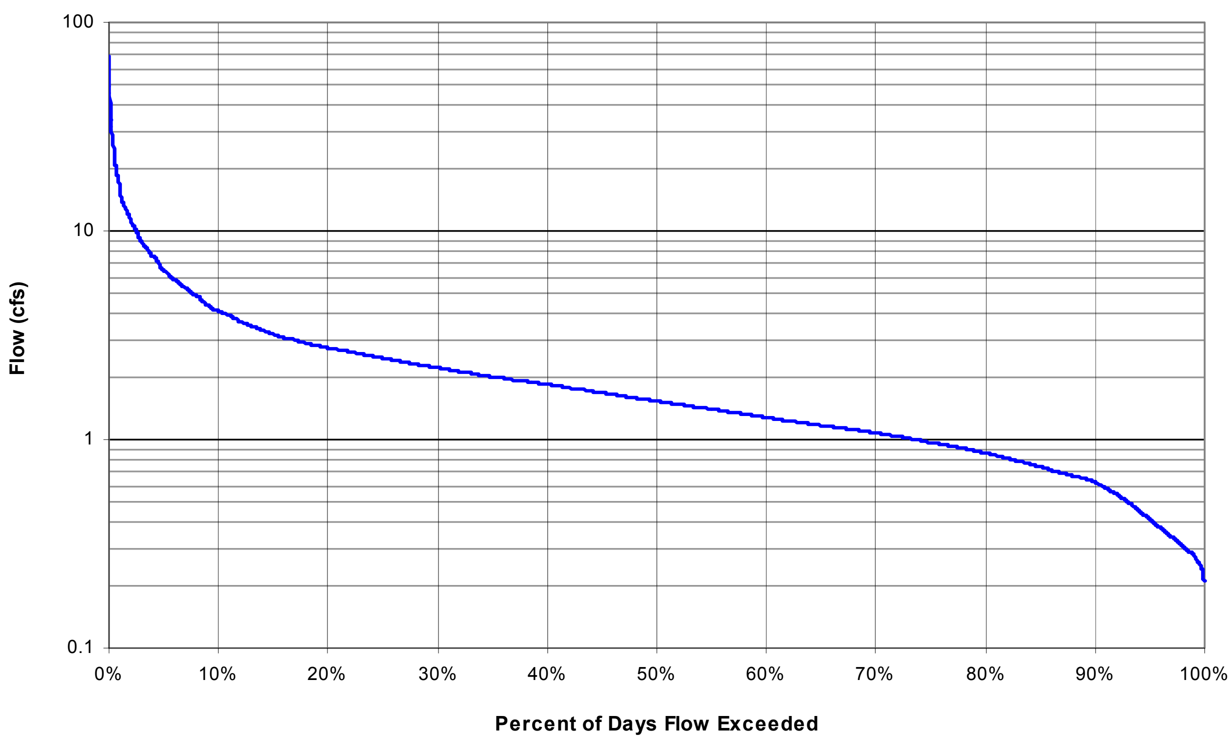


Figure C-16. Flow Duration Curve for Price Creek at Mile 4.4

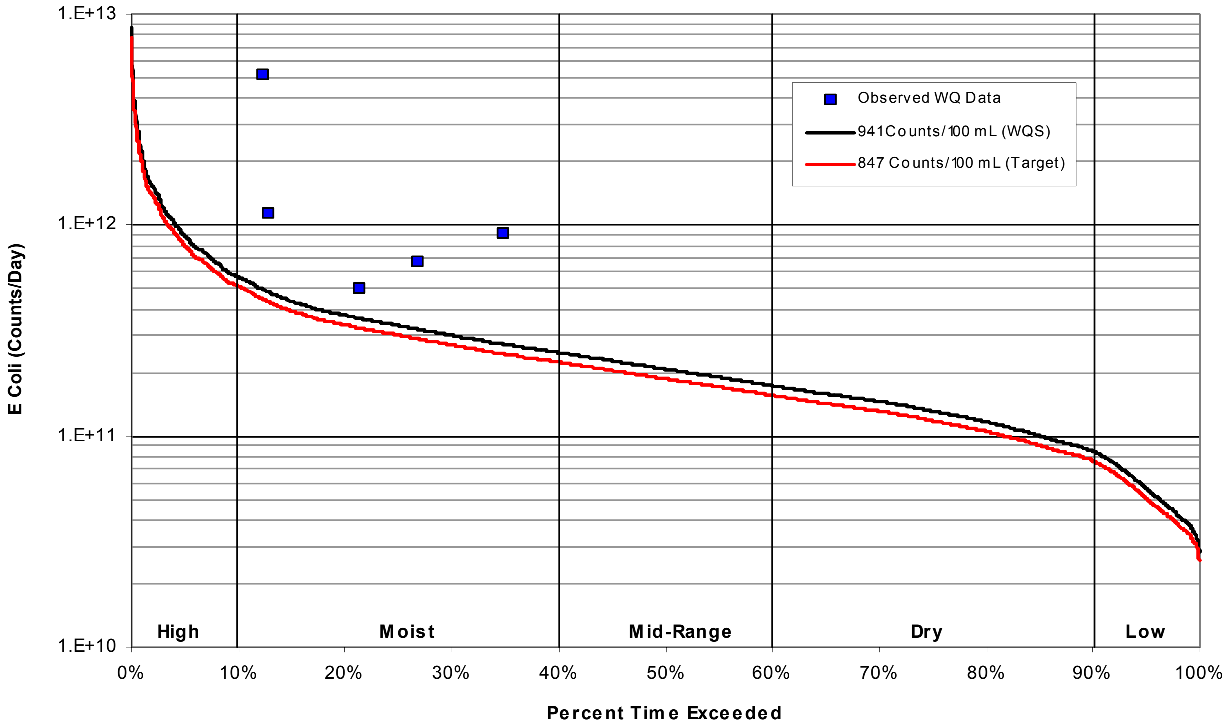


Figure C-17. E. Coli Load Duration Curve for Agency Creek at Mile 2.1

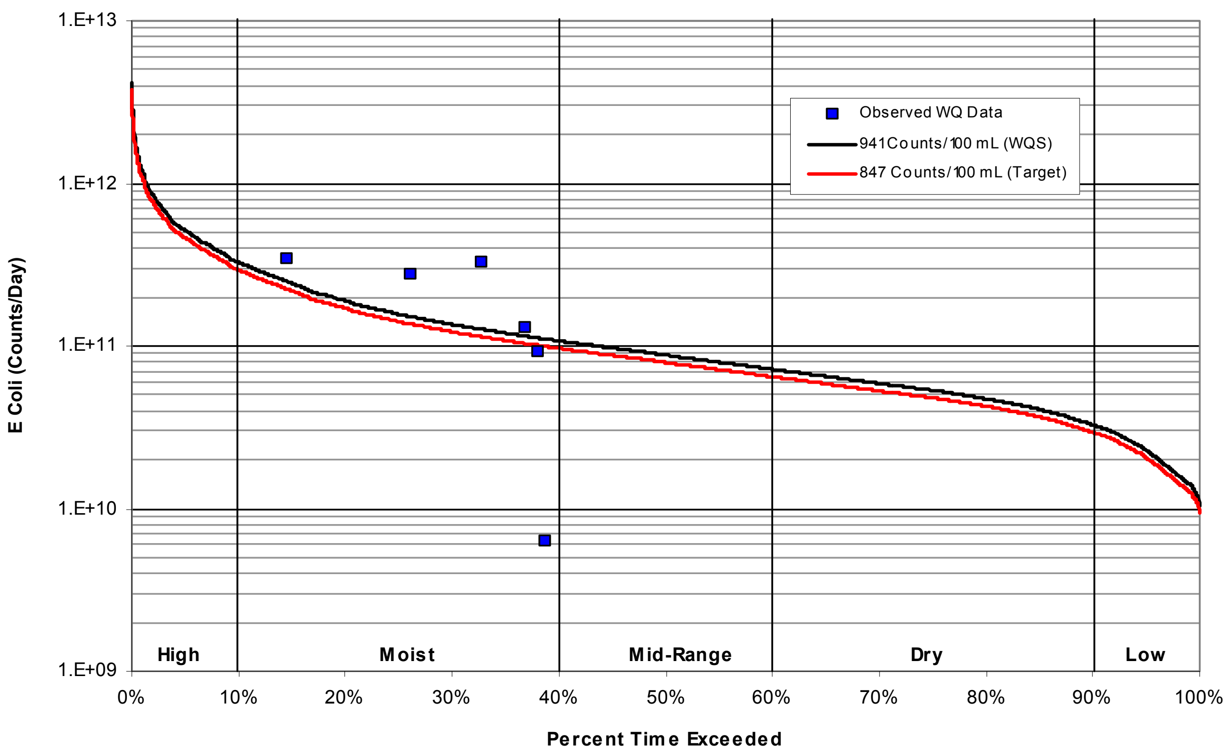


Figure C-18. E. Coli Load Duration Curve for Fillauer Branch at Mile 0.3

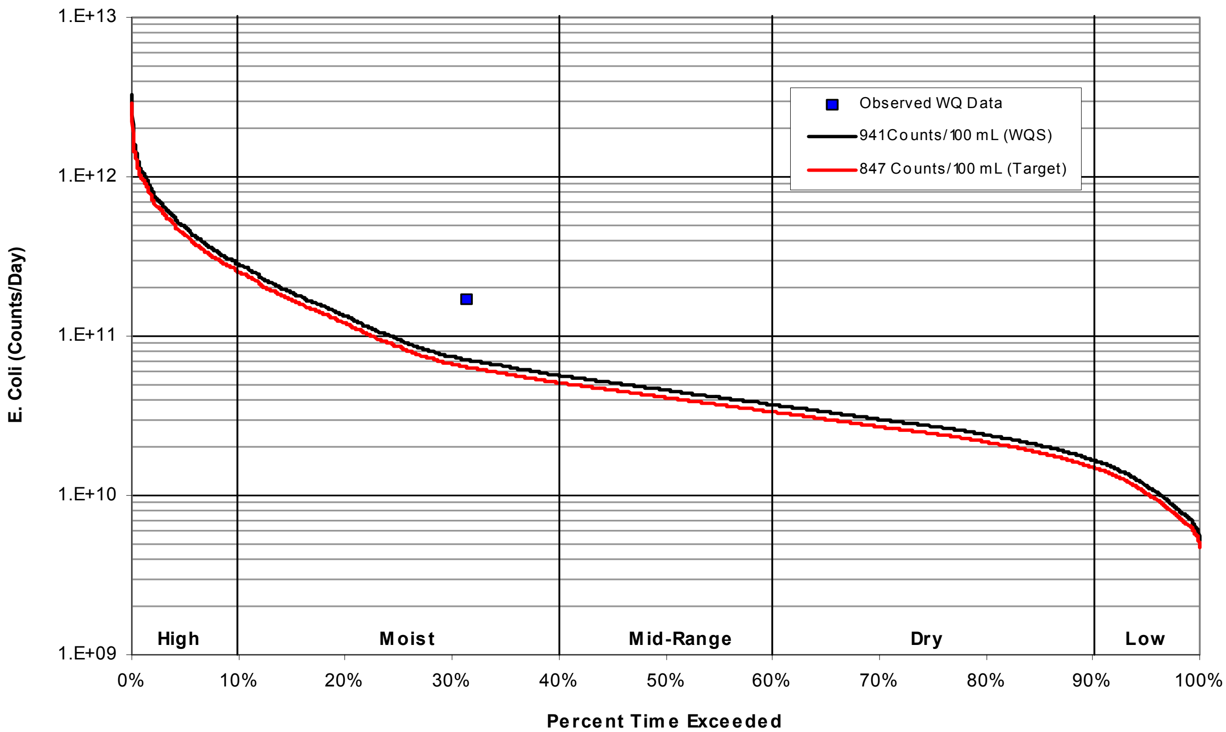


Figure C-19. E. Coli Load Duration Curve for Woolen Mill Branch at Mile 0.8

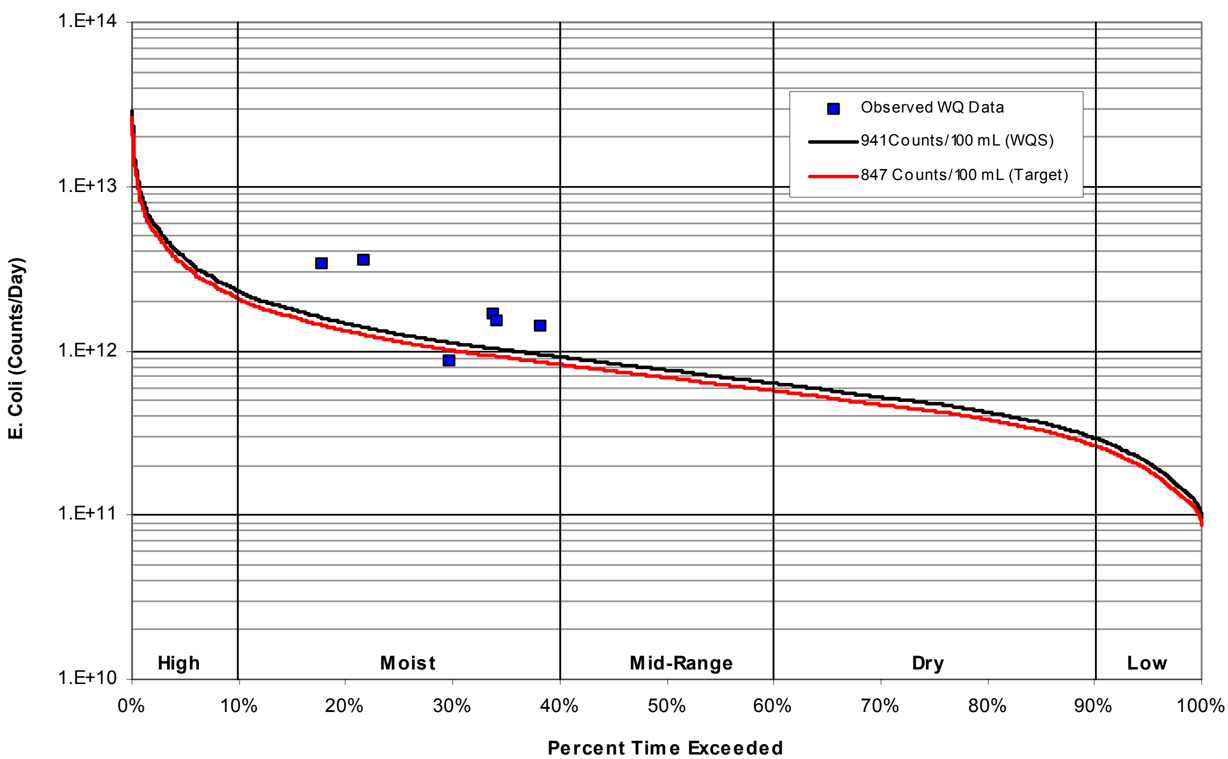


Figure C-20. E. Coli Load Duration Curve for South Mouse Creek at Mile 12.7

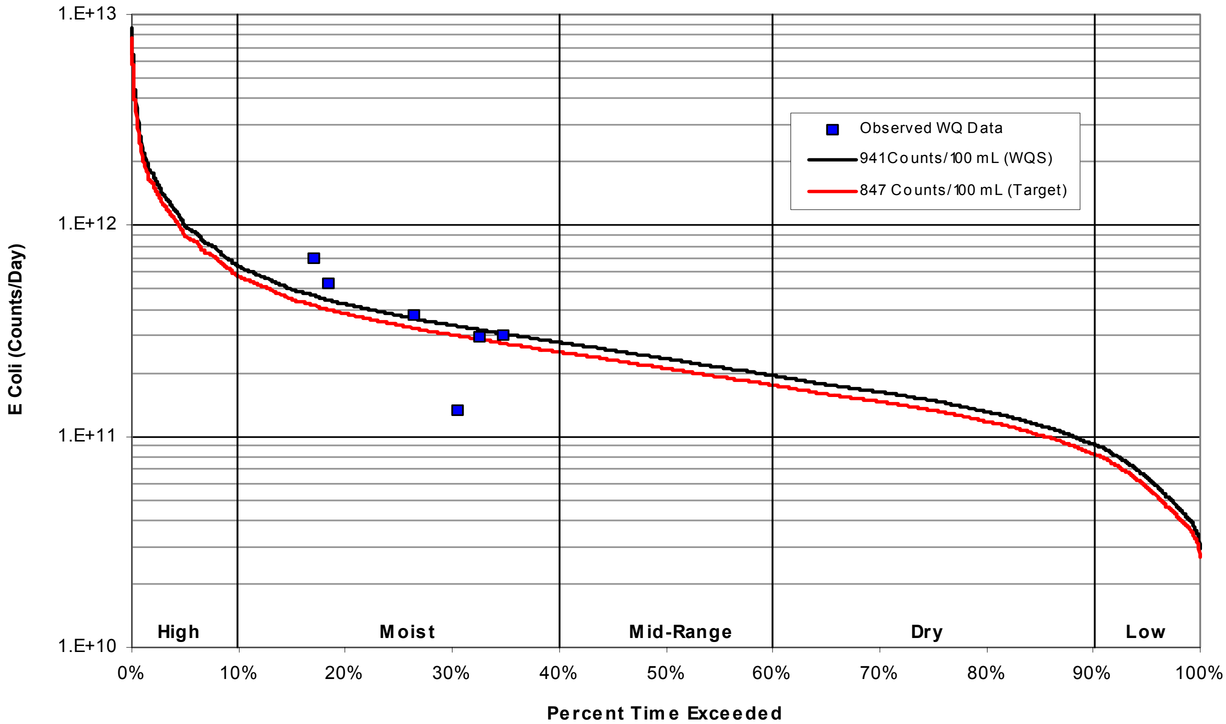


Figure C-21. E. Coli Load Duration Curve for Little Chatata Creek at Mile 0.3

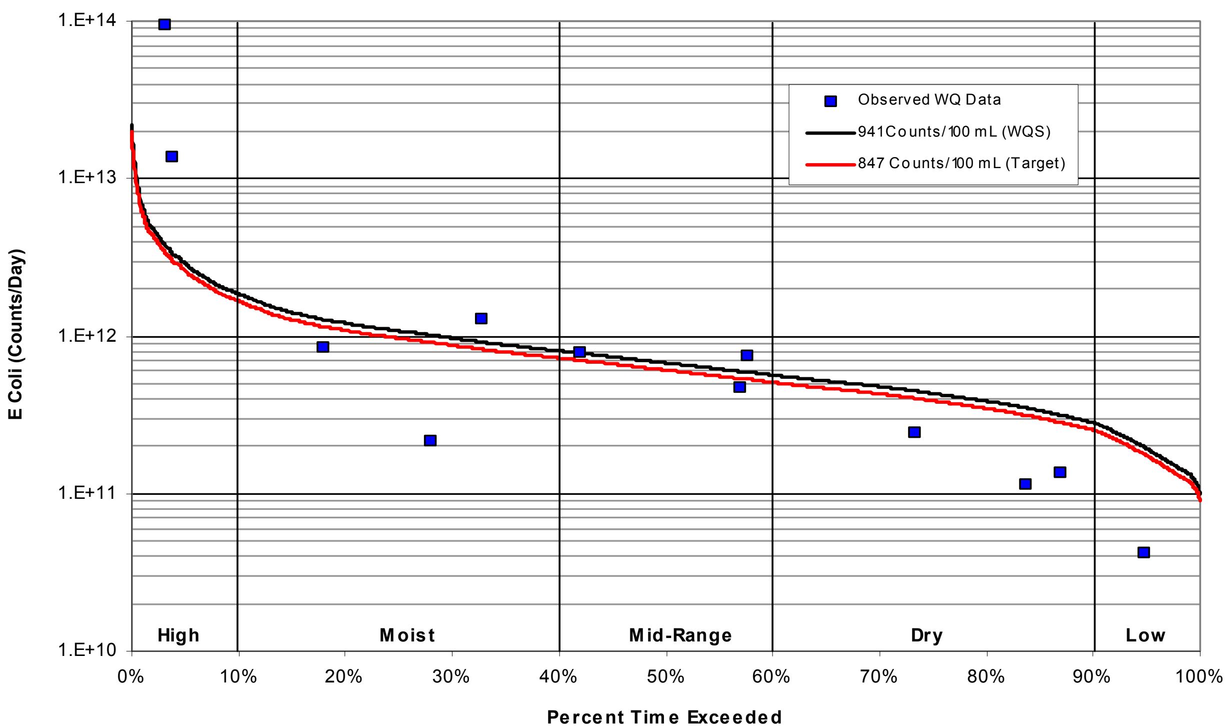


Figure C-22. E. Coli Load Duration Curve for Chatata Creek at Mile 0.5

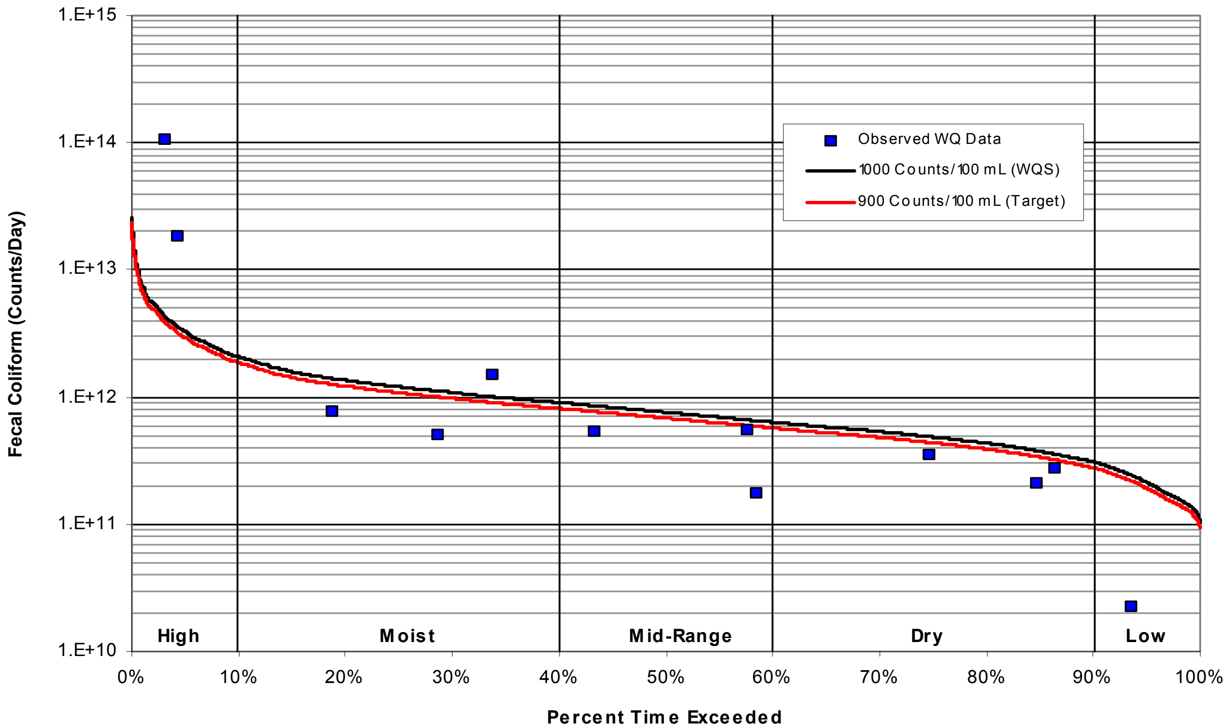


Figure C-23. Fecal Coliform Load Duration Curve for Chatata Creek at Mile 0.5

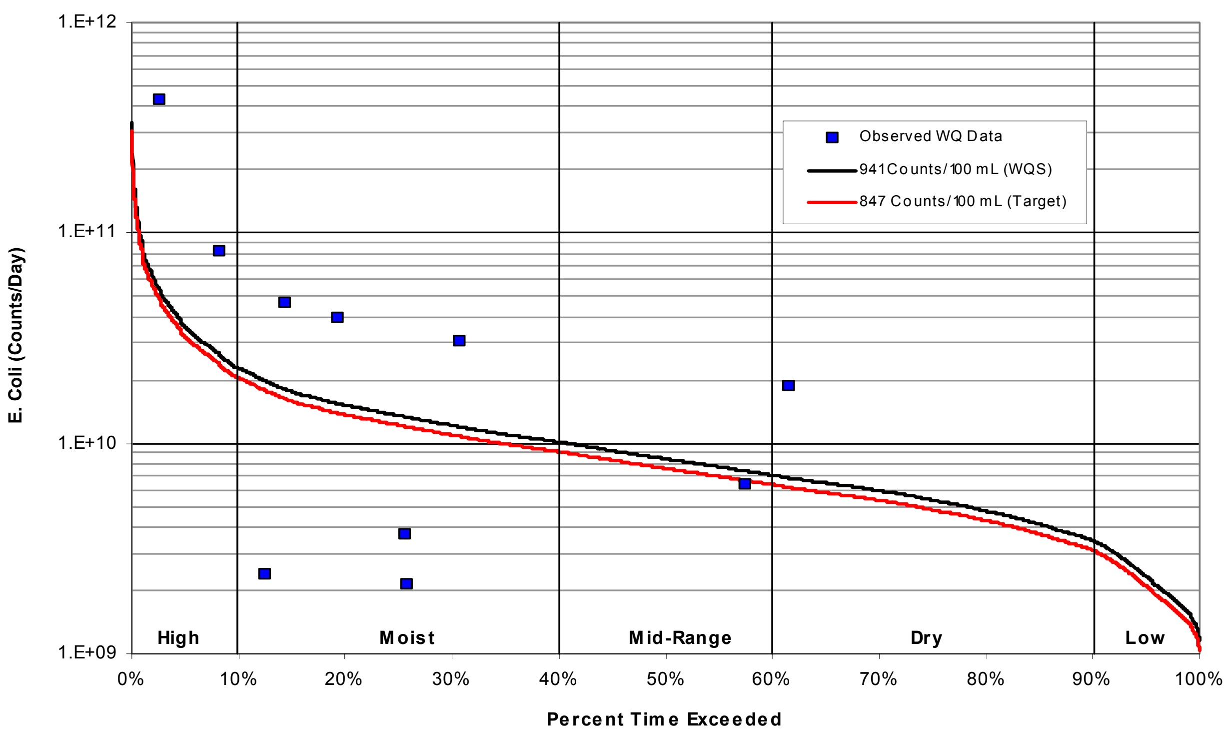


Figure C-24. E. Coli Load Duration Curve for Hawkins Branch at Mile 1.3

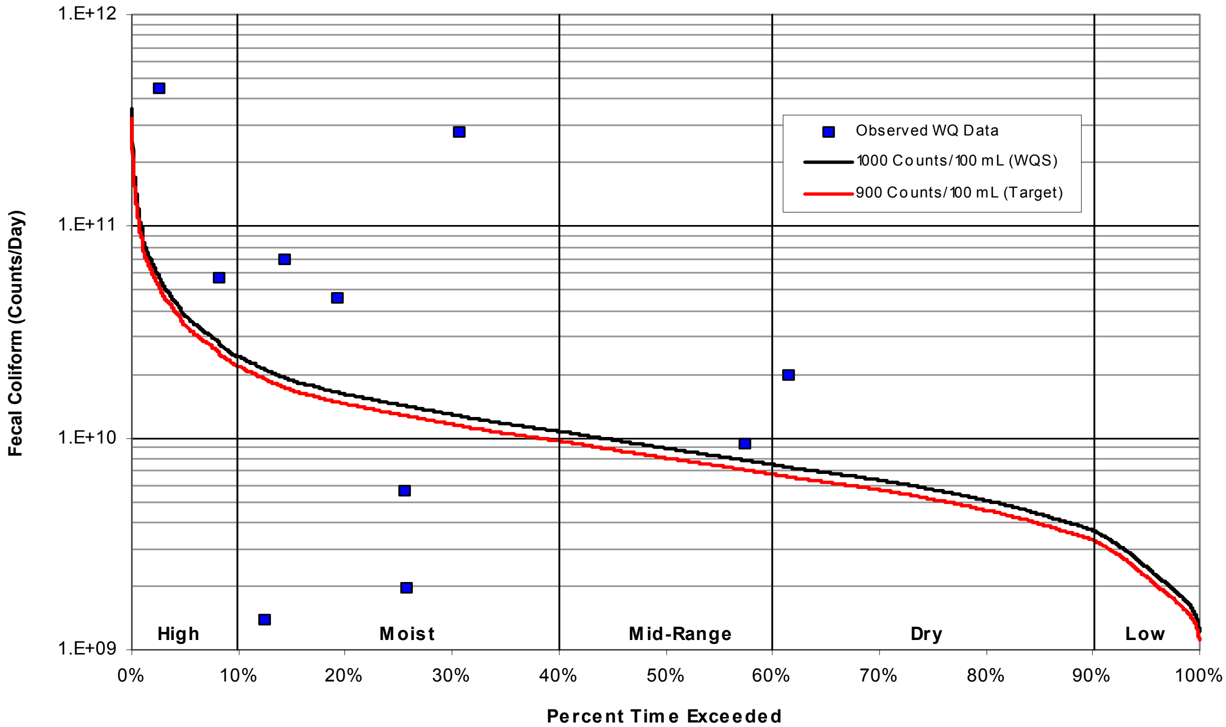


Figure C-25. Fecal Coliform Load Duration Curve for Hawkins Branch at Mile 1.3

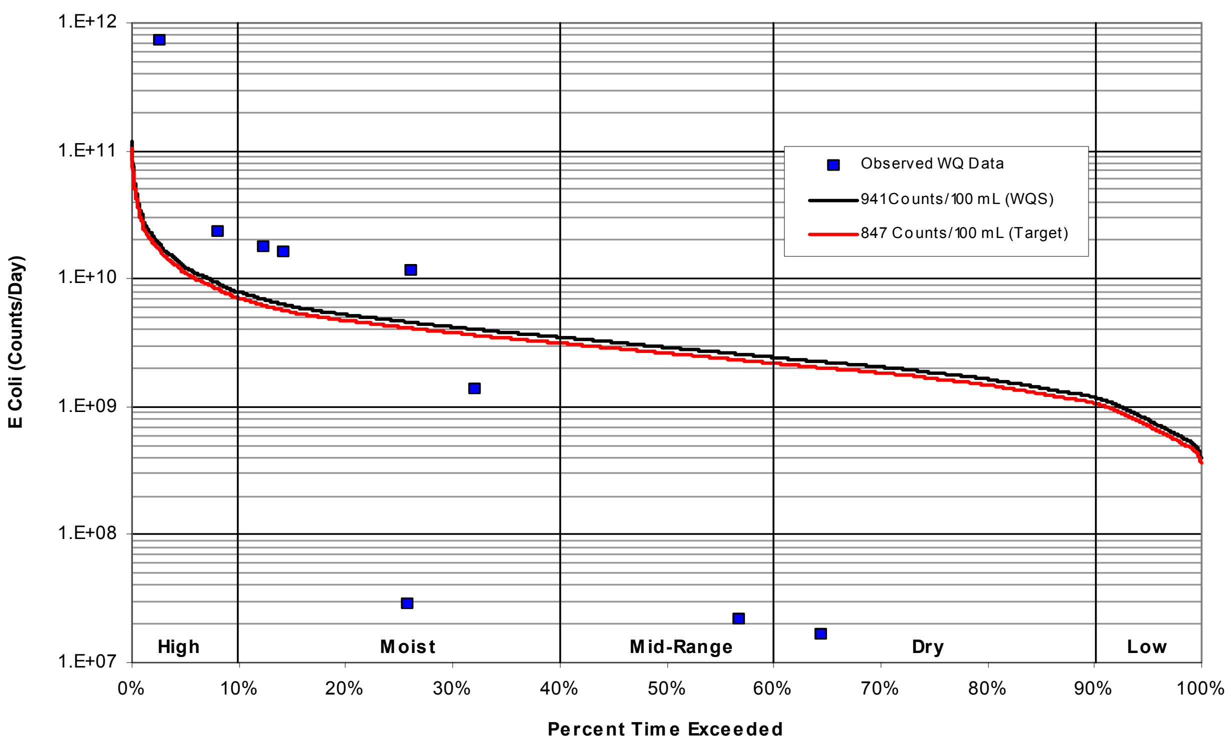


Figure C-26. E. Coli Load Duration Curve for Dairy Branch at Mile 1.2

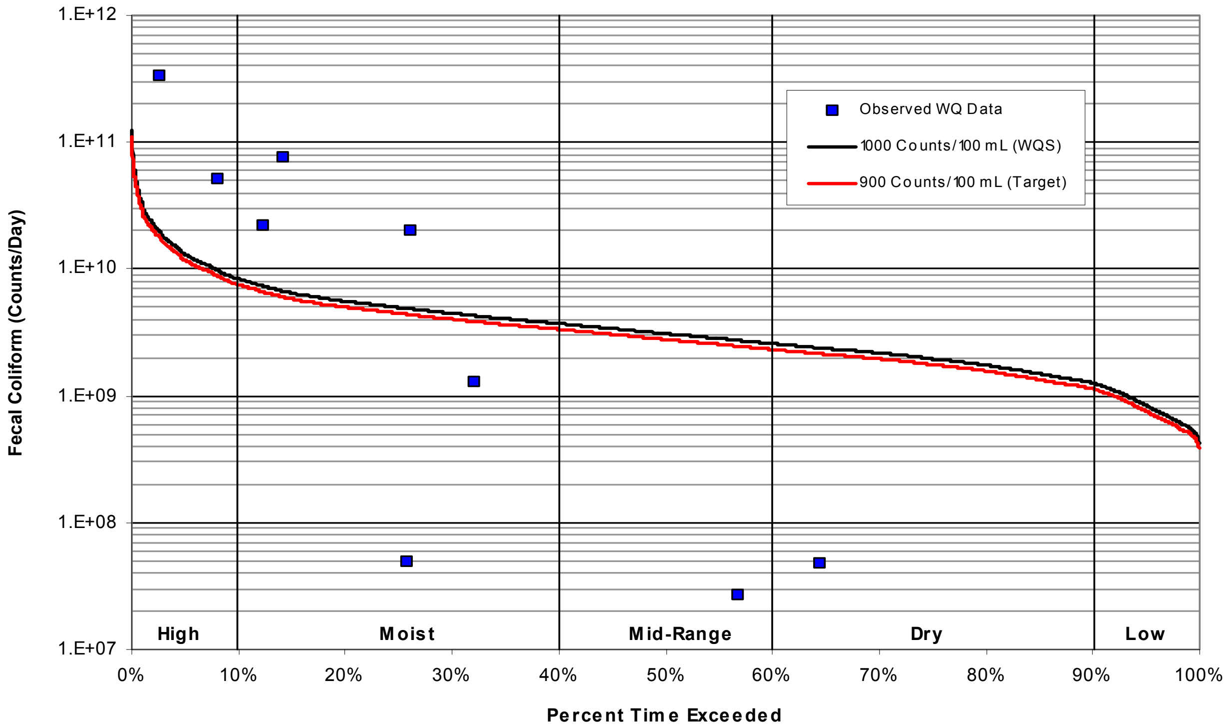


Figure C-27. Fecal Coliform Load Duration Curve for Dairy Branch at Mile 1.2

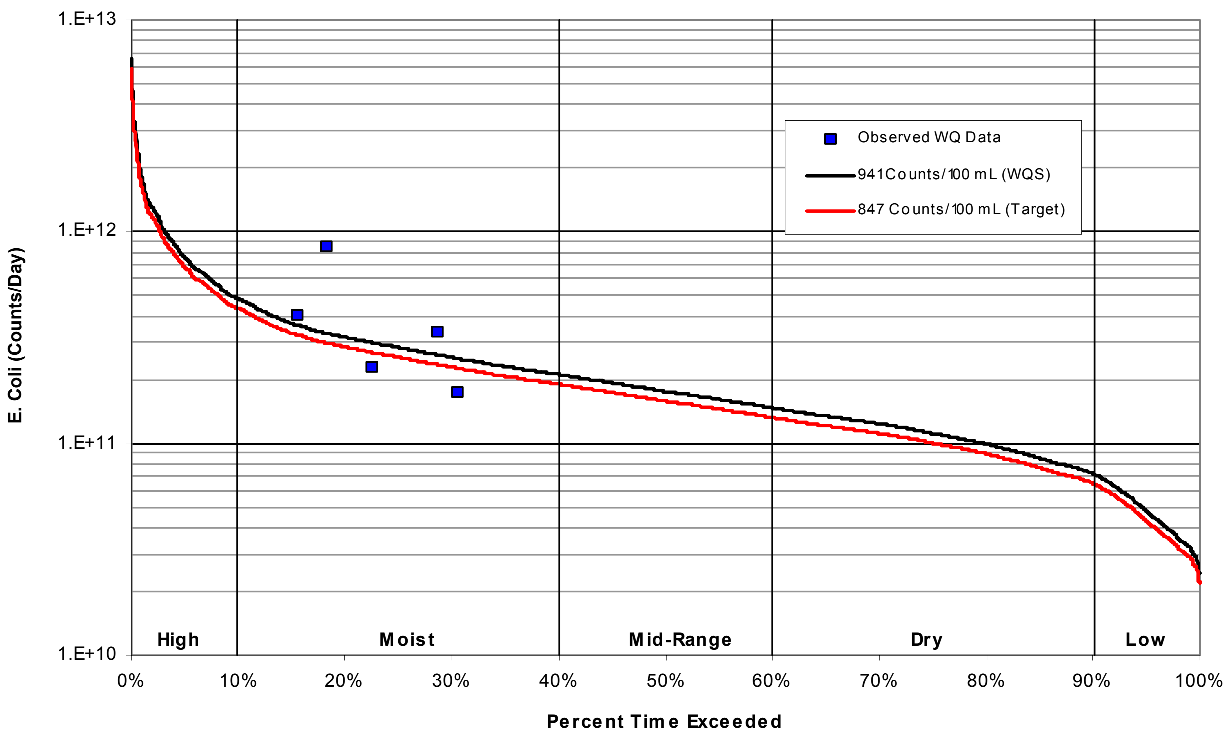


Figure C-28. E. Coli Load Duration Curve for Little Chestuee Creek at Mile 1.6

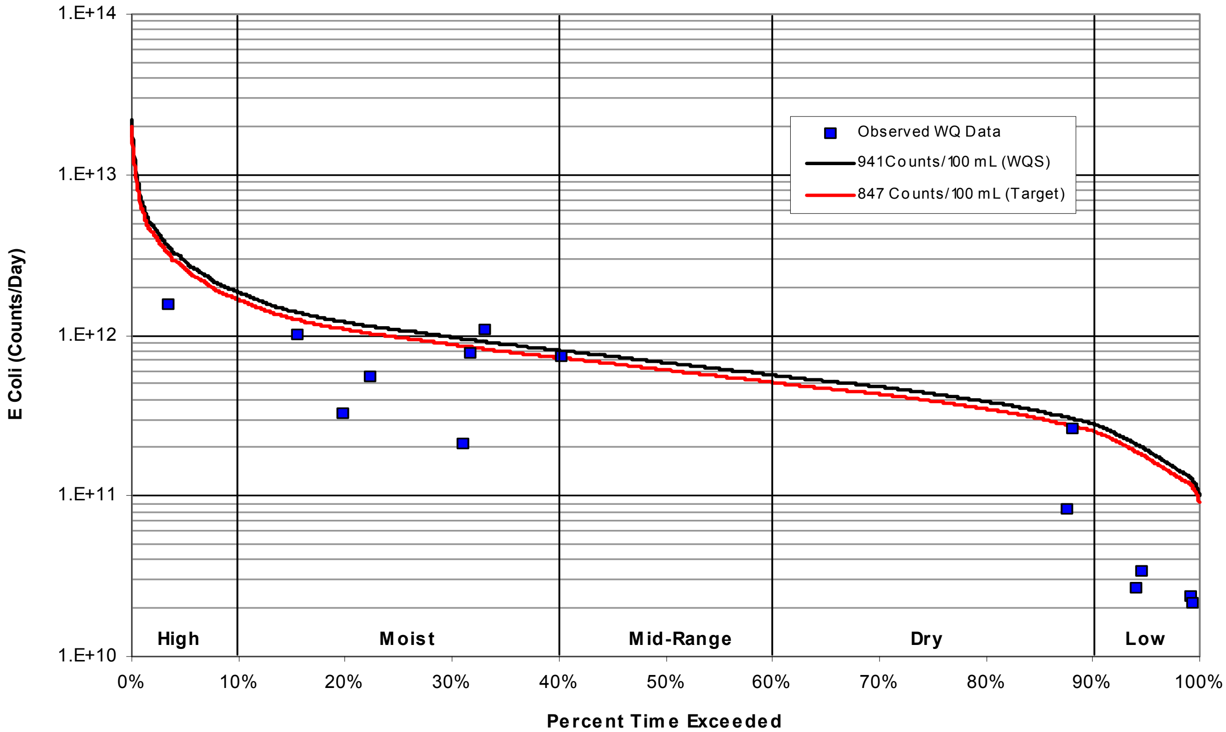


Figure C-29. E. Coli Load Duration Curve for Chestuee Creek at Mile 45.2

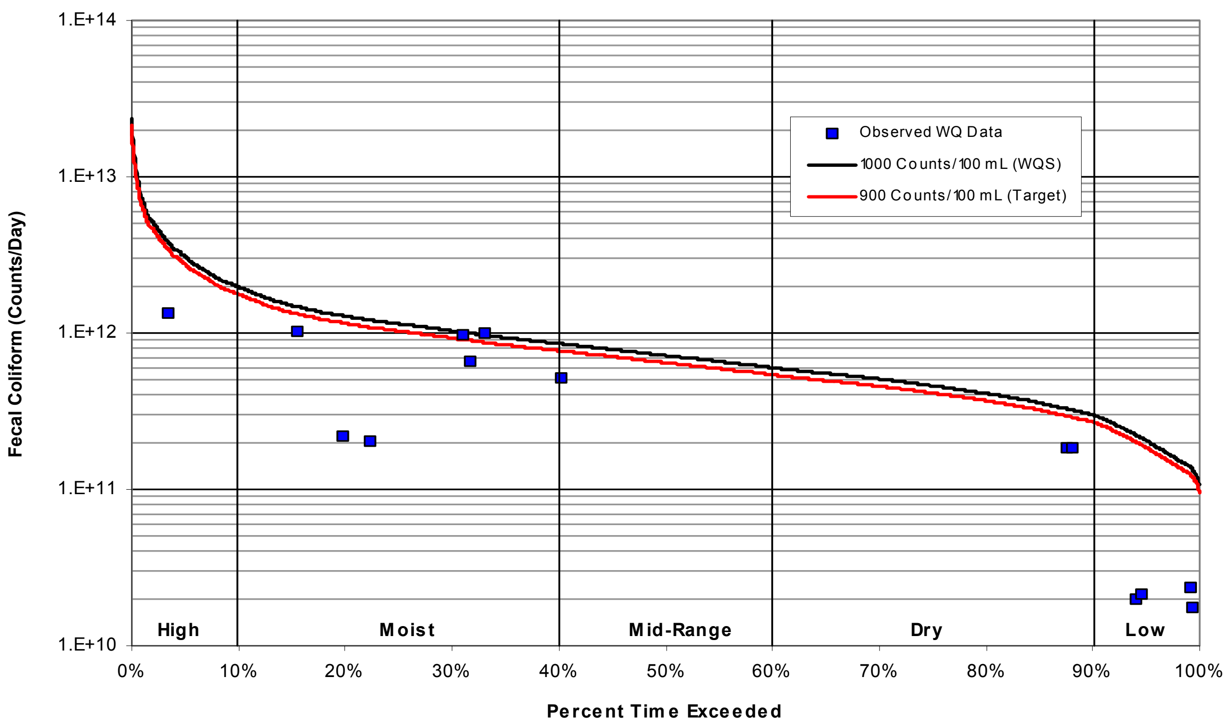


Figure C-30. Fecal Coliform Load Duration Curve for Chestuee Creek at Mile 45.2

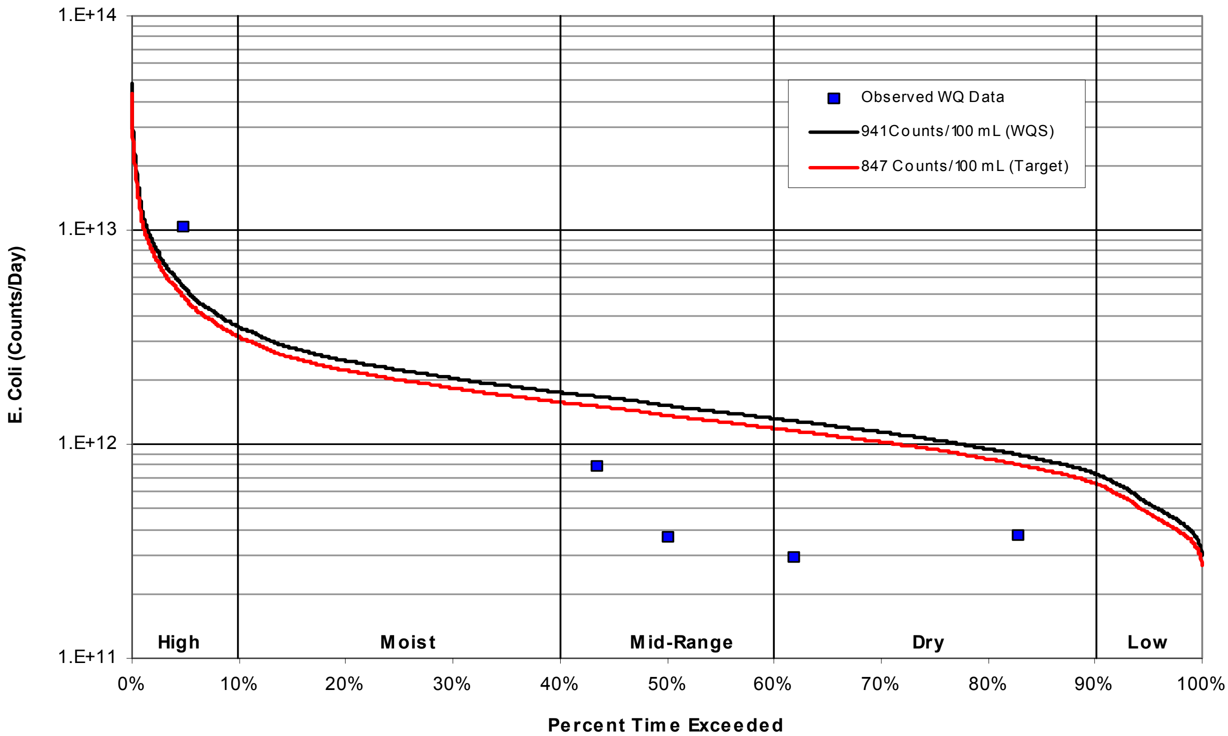


Figure C-31. E. Coli Load Duration Curve for Oostanaula Creek at Mile 5.7

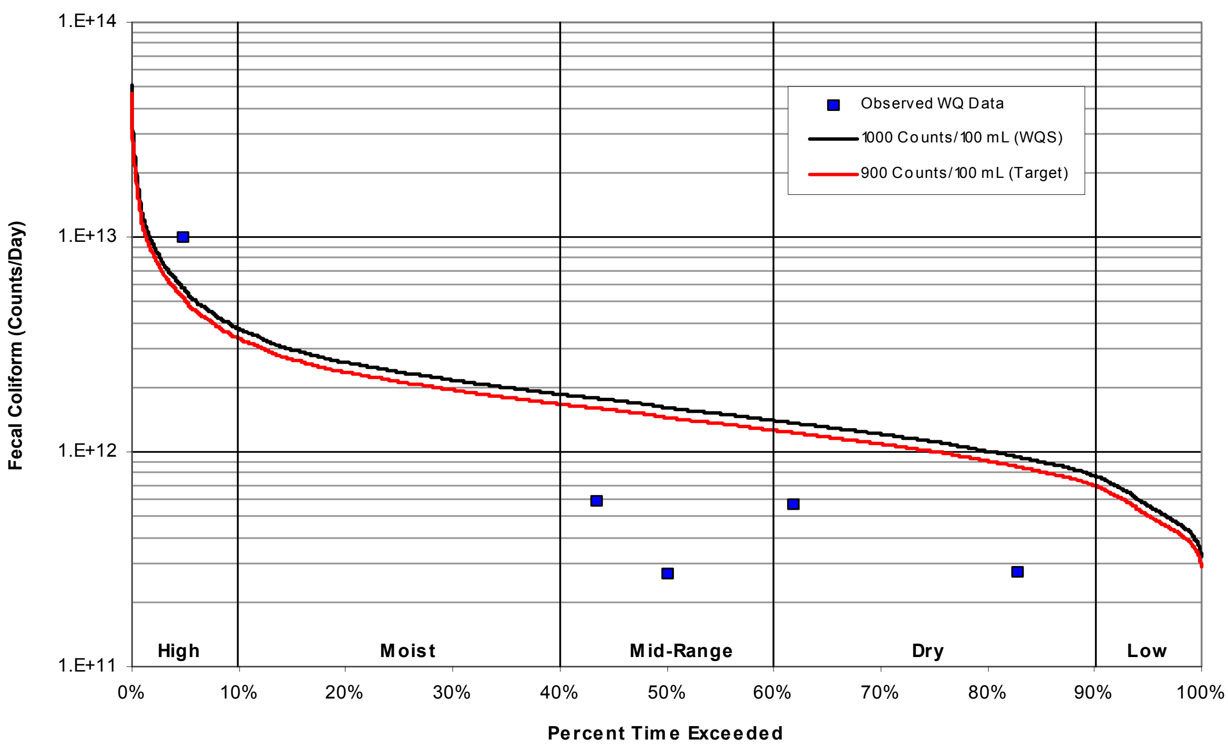


Figure C-32. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 5.7

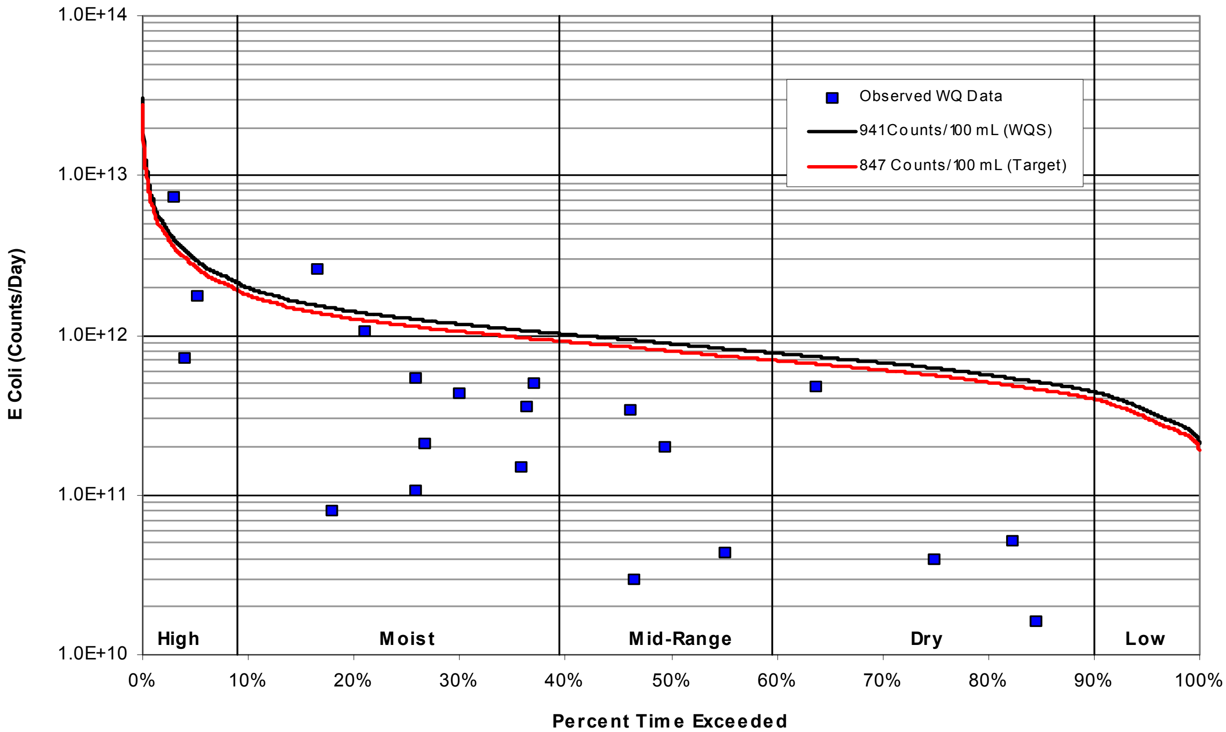


Figure C-33. E. Coli Load Duration Curve for Oostanaula Creek at Mile 26.6

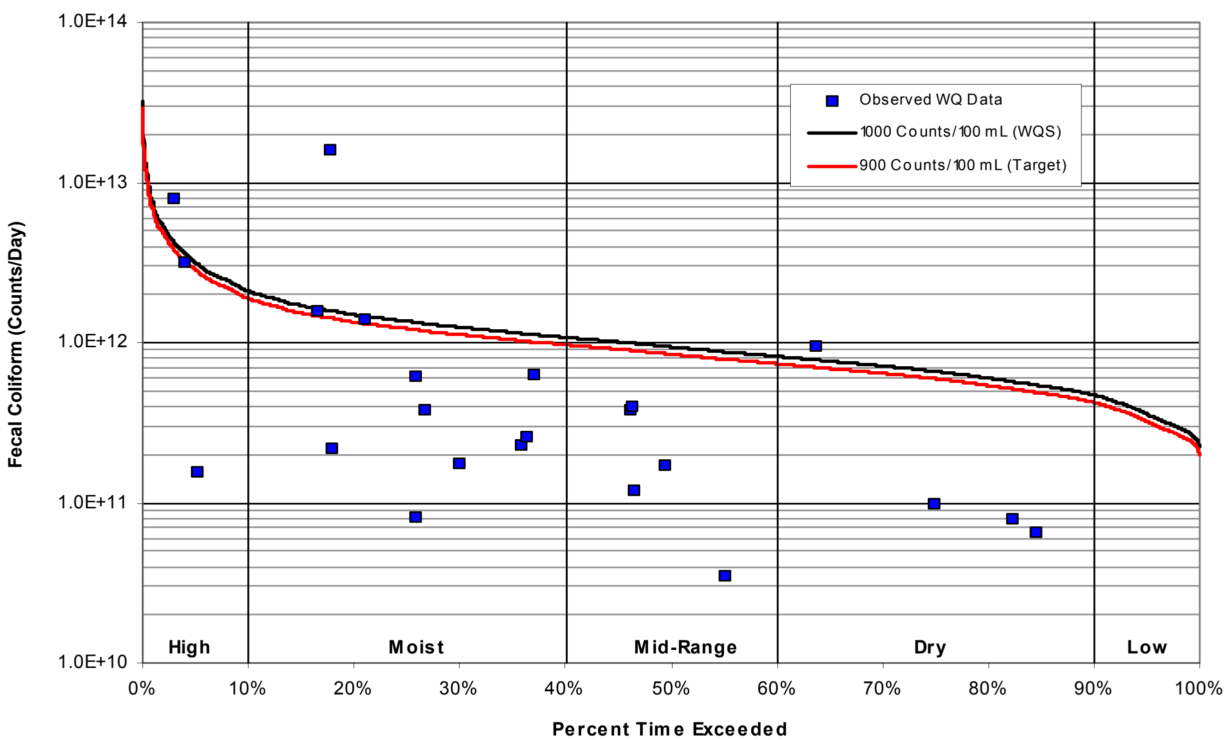


Figure C-34. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 26.6

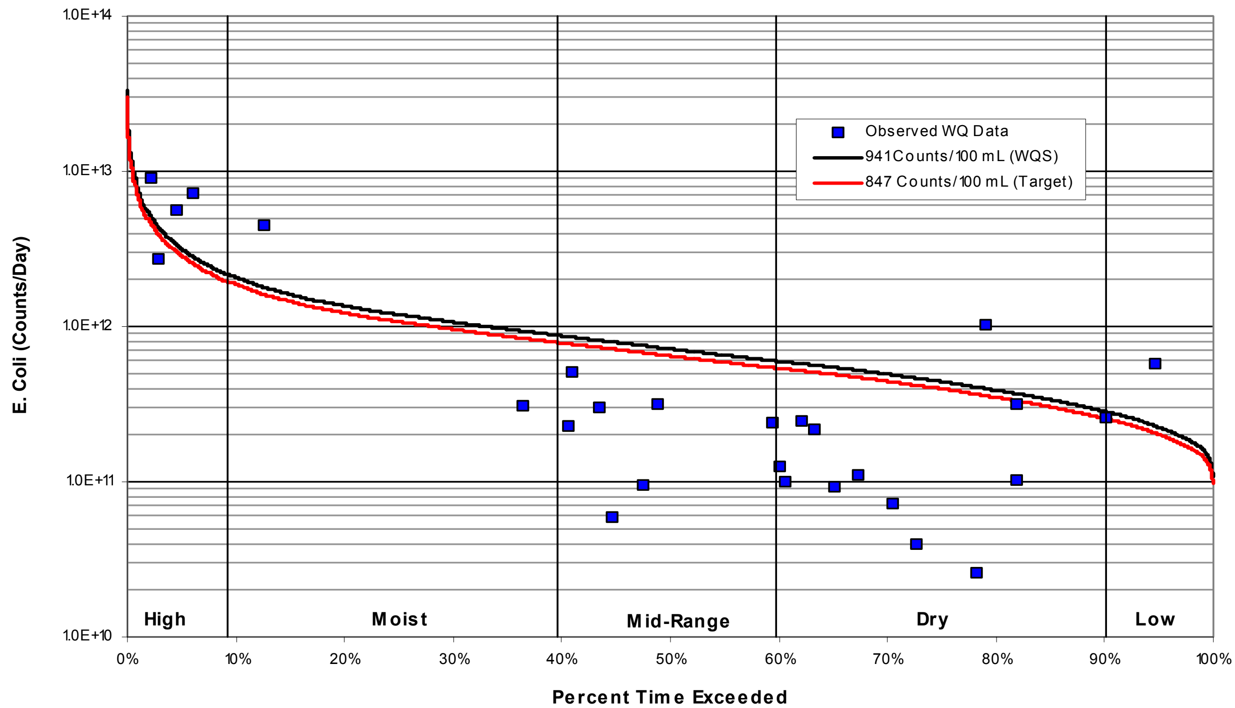


Figure C-35. E. Coli Load Duration Curve for Oostanaula Creek at Mile 28.4

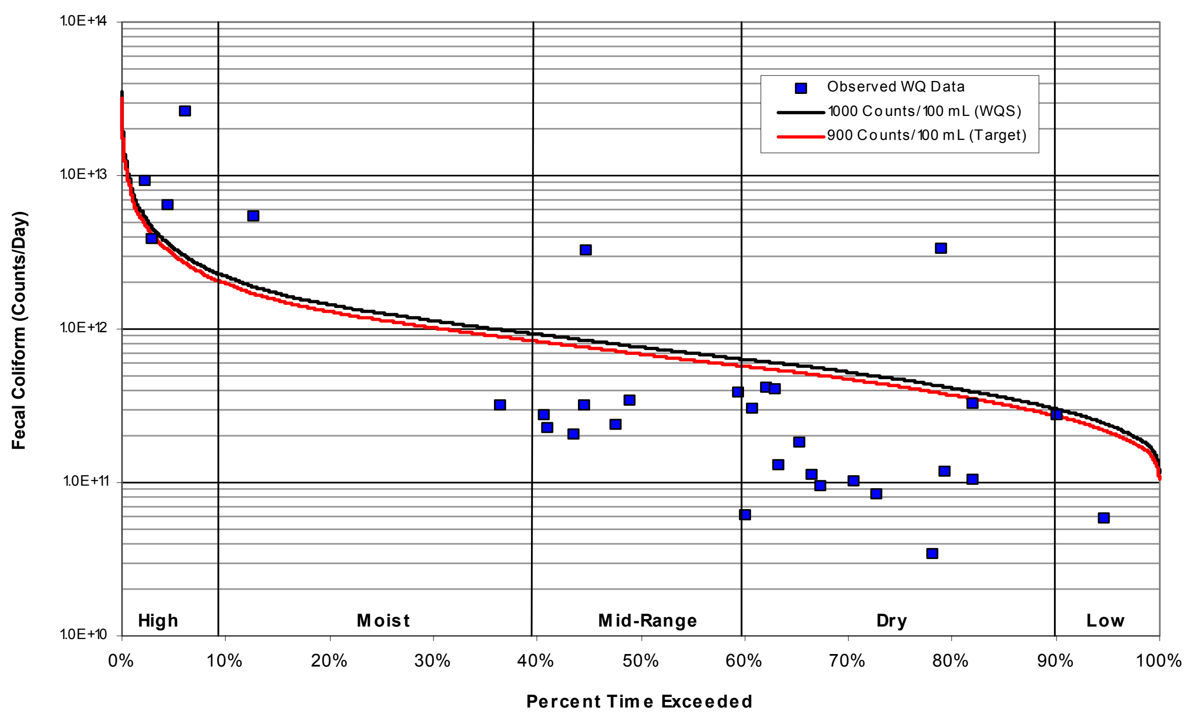


Figure C-36. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 28.4

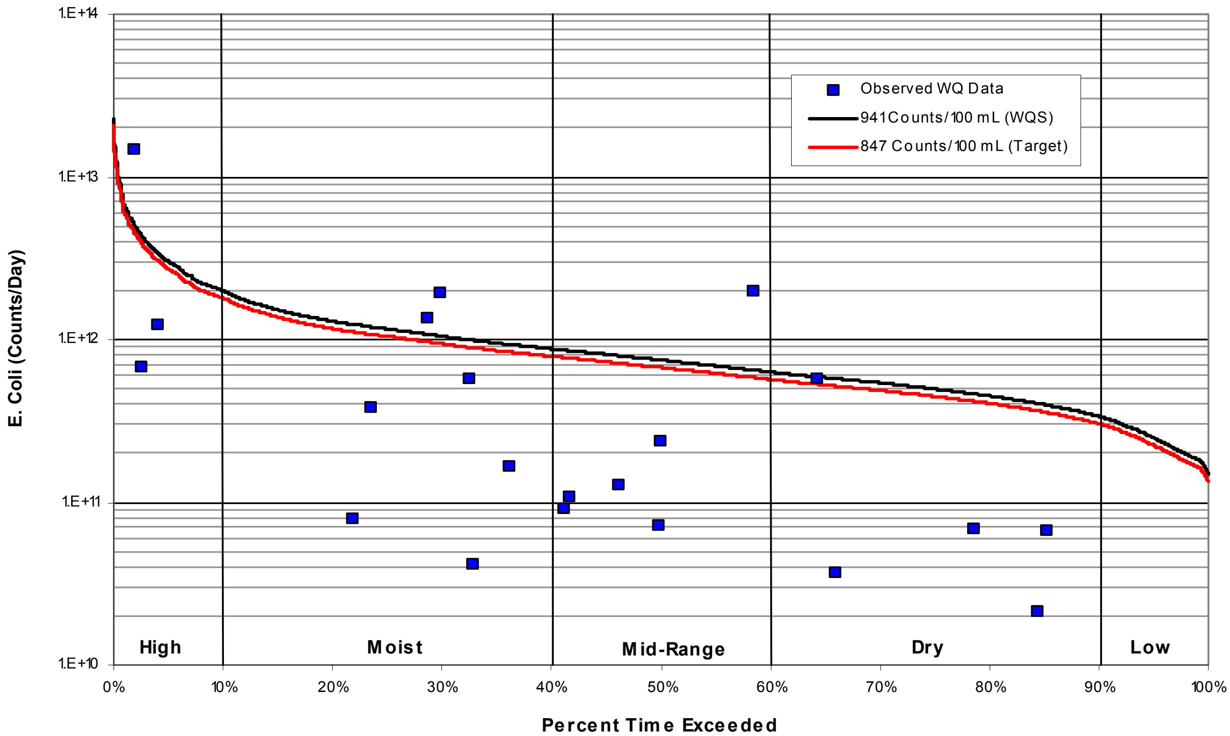


Figure C-37. E. Coli Load Duration Curve for Oostanaula Creek at Mile 30.0

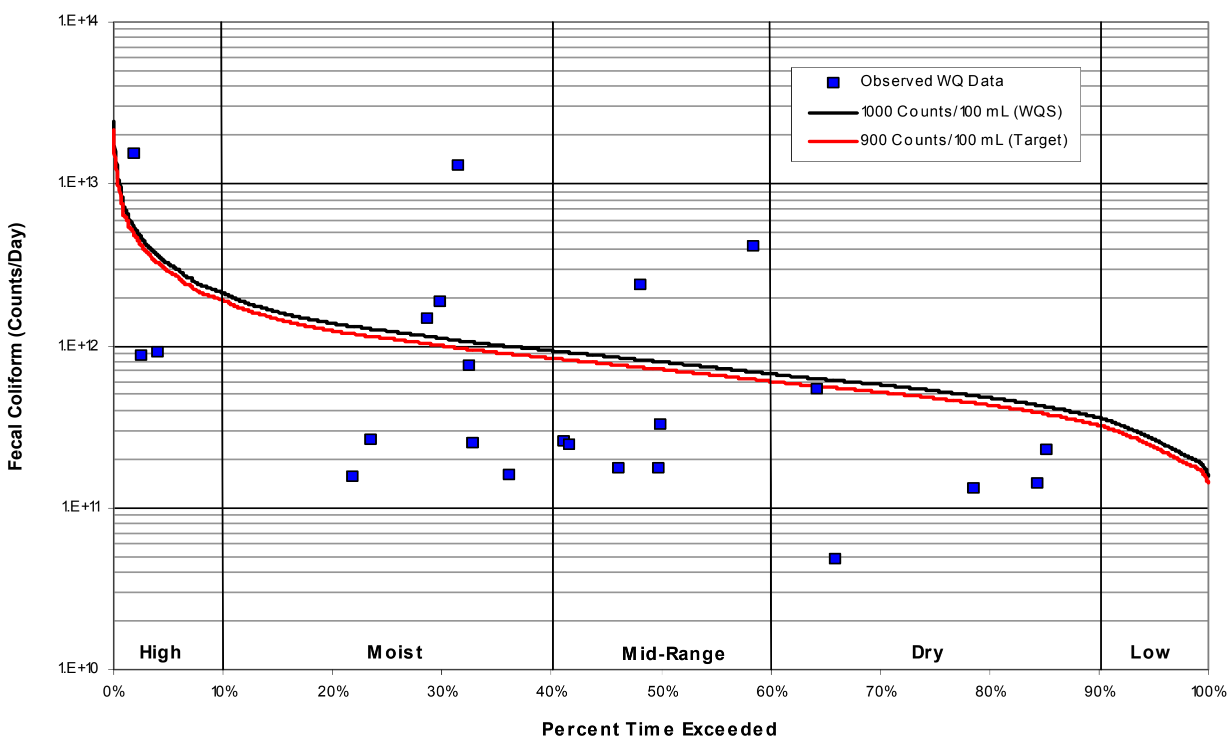


Figure C-38. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 30.0

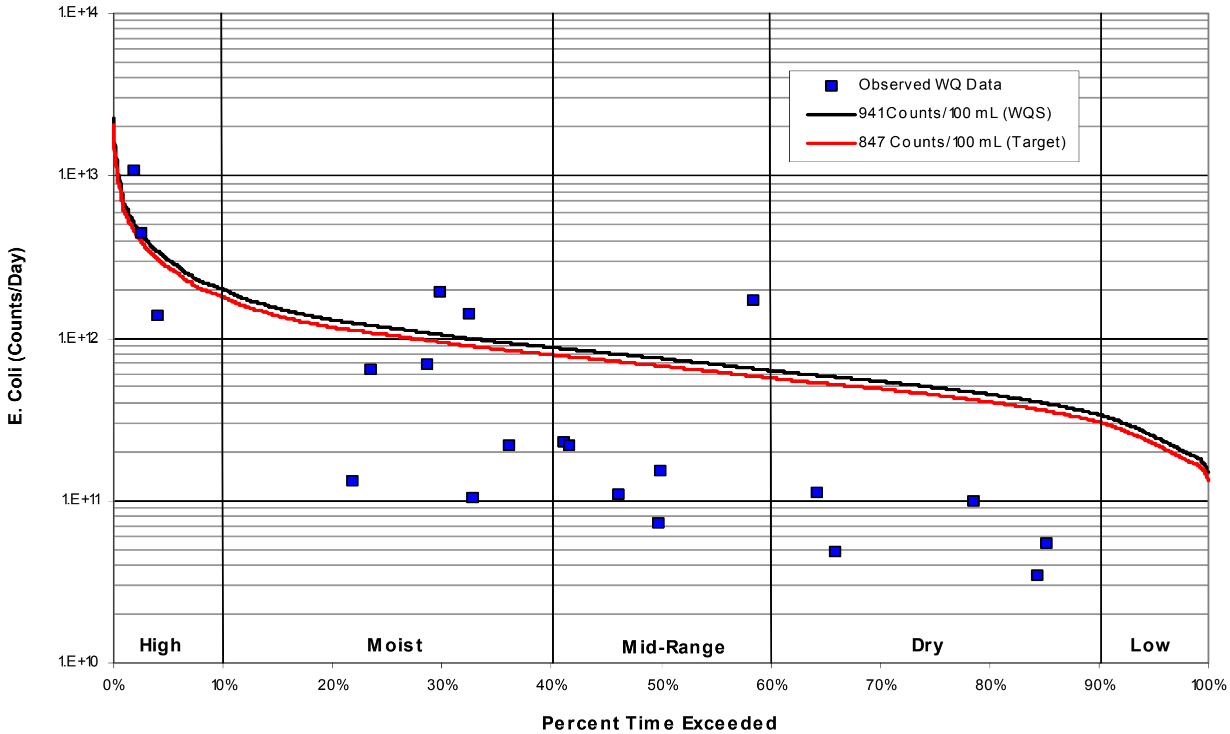


Figure C-39. E. Coli Load Duration Curve for Oostanaula Creek at Mile 30.1

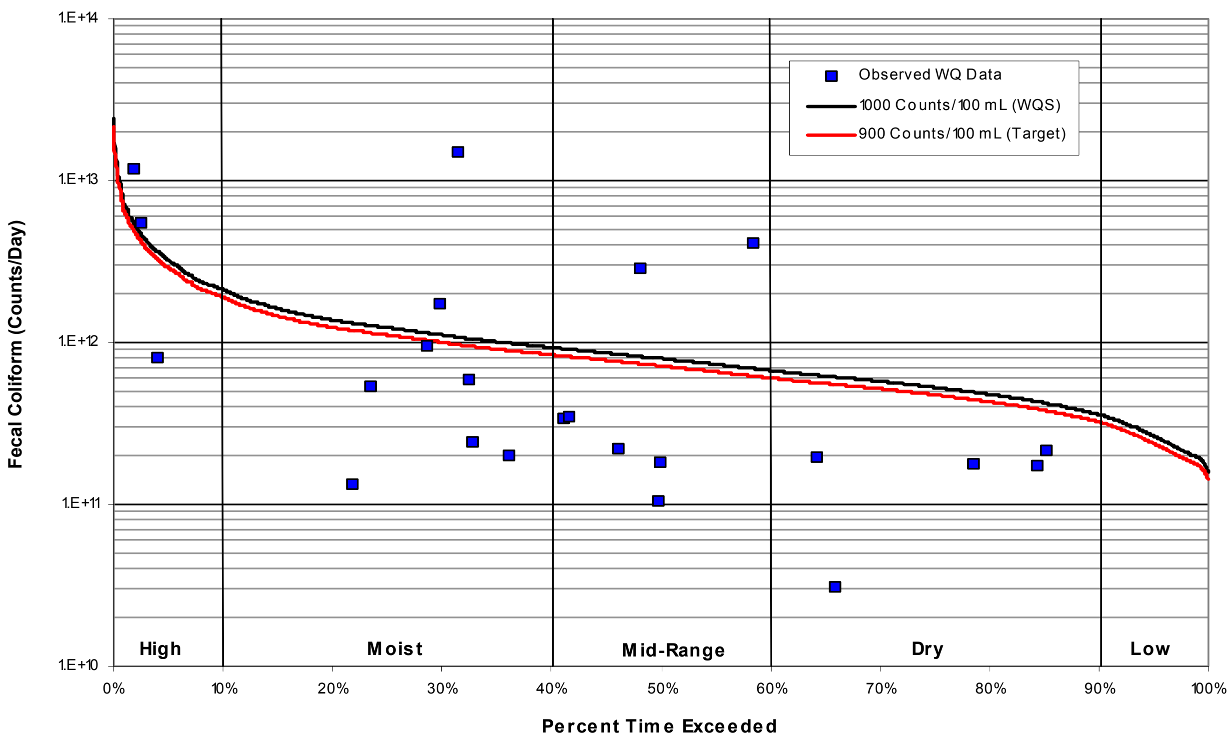


Figure C-40. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 30.1

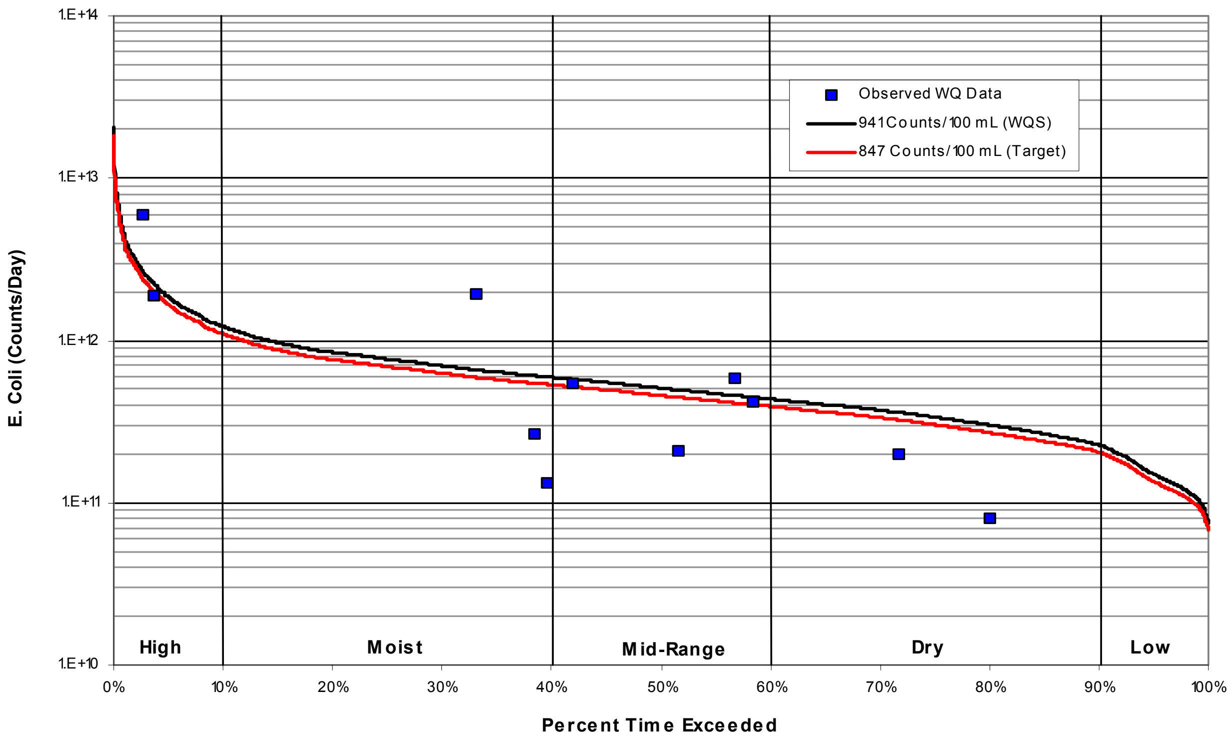


Figure C-41. E. Coli Load Duration Curve for Oostanaula Creek at Mile 33.6

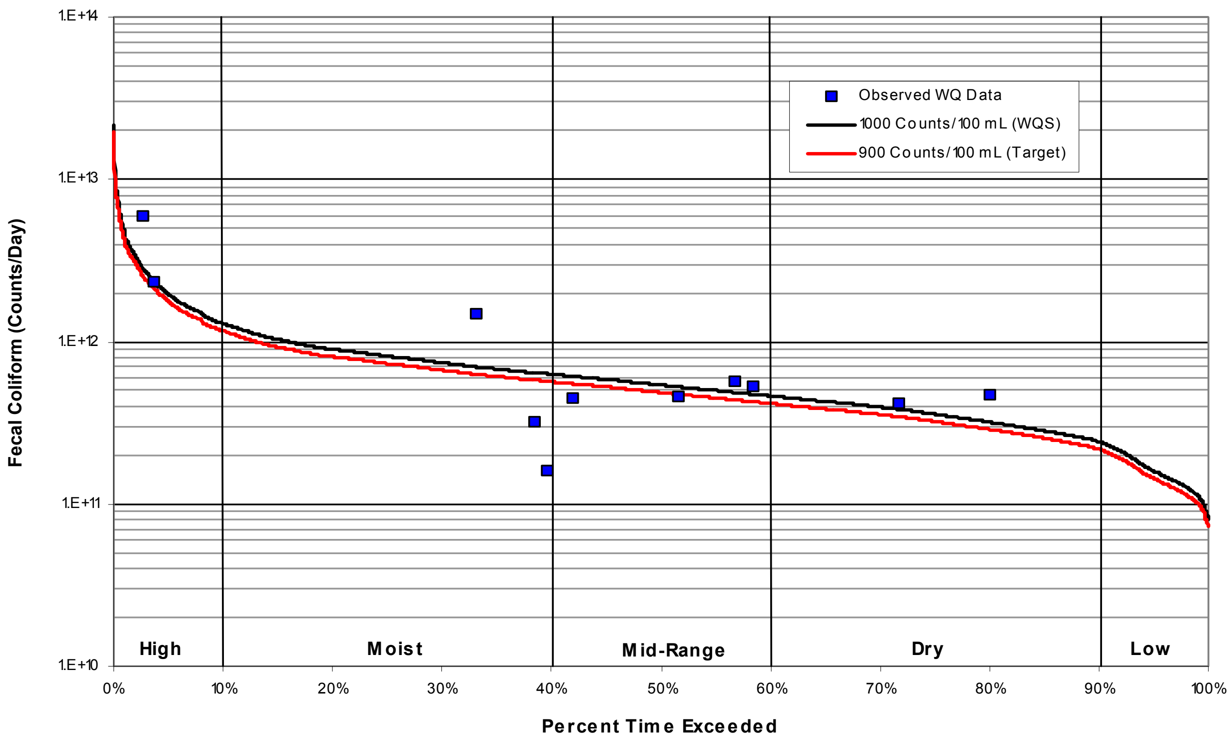


Figure C-42. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 33.6

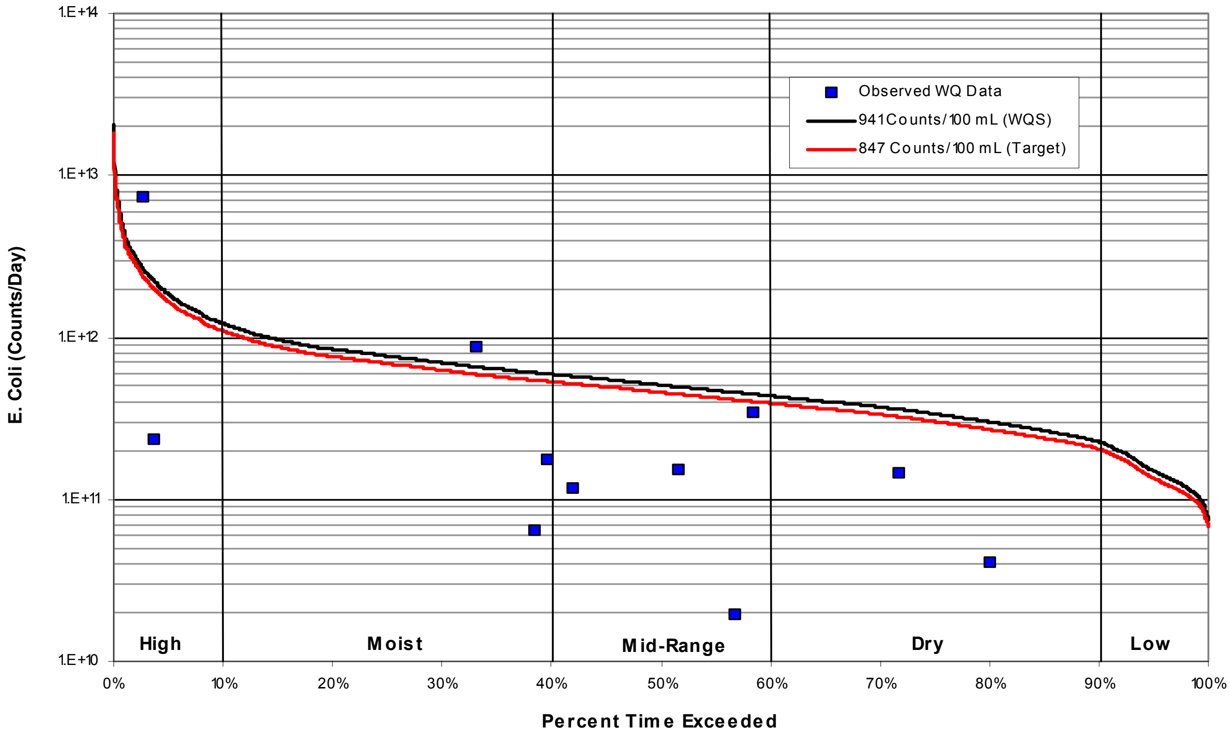


Figure C-43. E. Coli Load Duration Curve for Oostanaula Creek at Mile 35.1

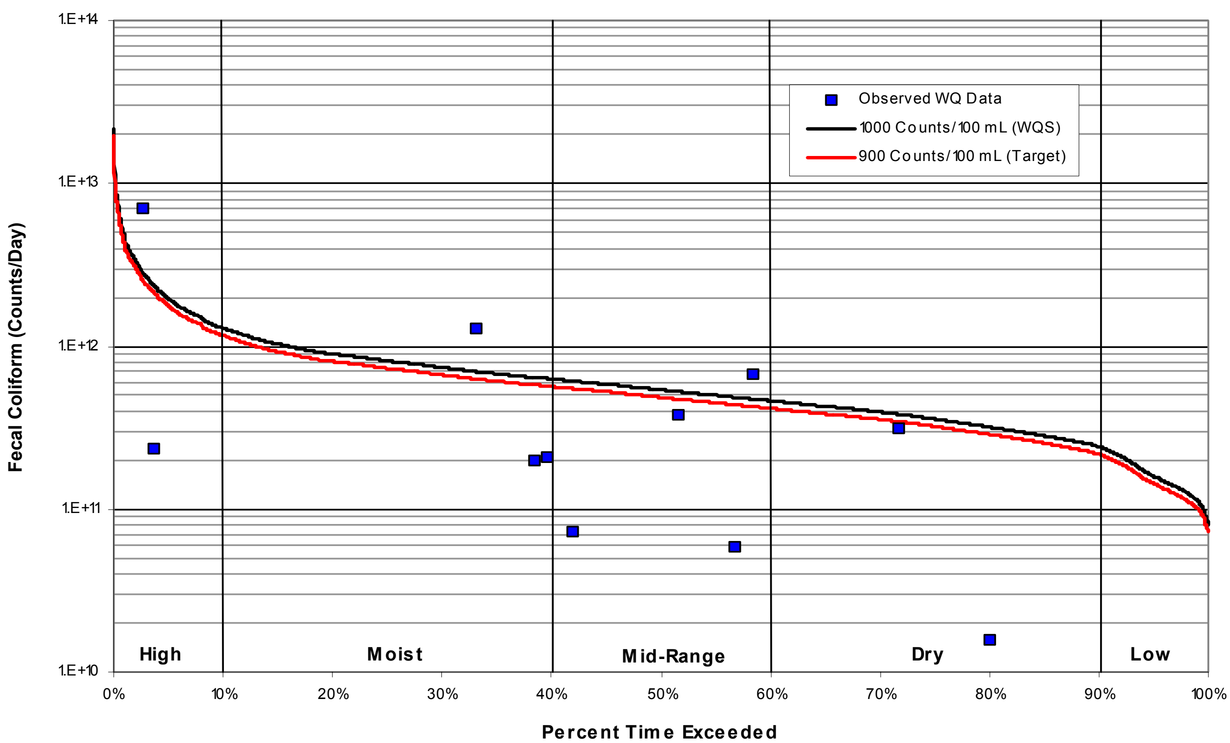


Figure C-44. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 35.1

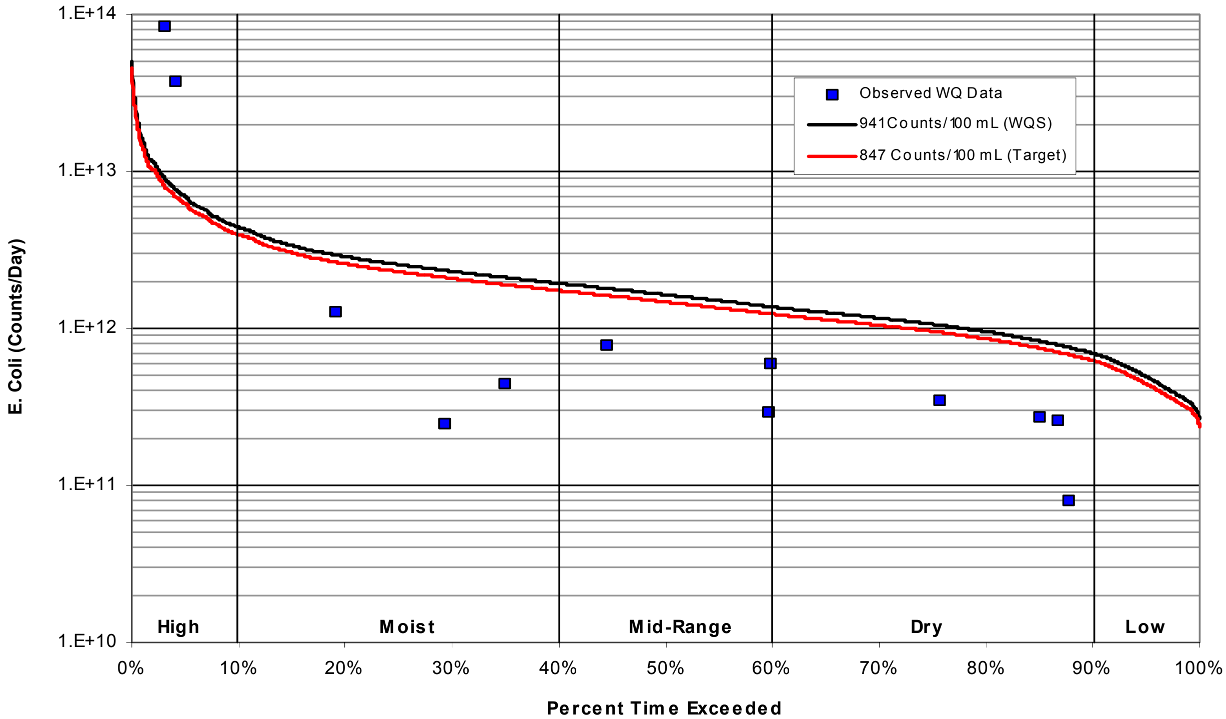


Figure C-45. E. Coli Load Duration Curve for North Mouse Creek at Mile 4.2

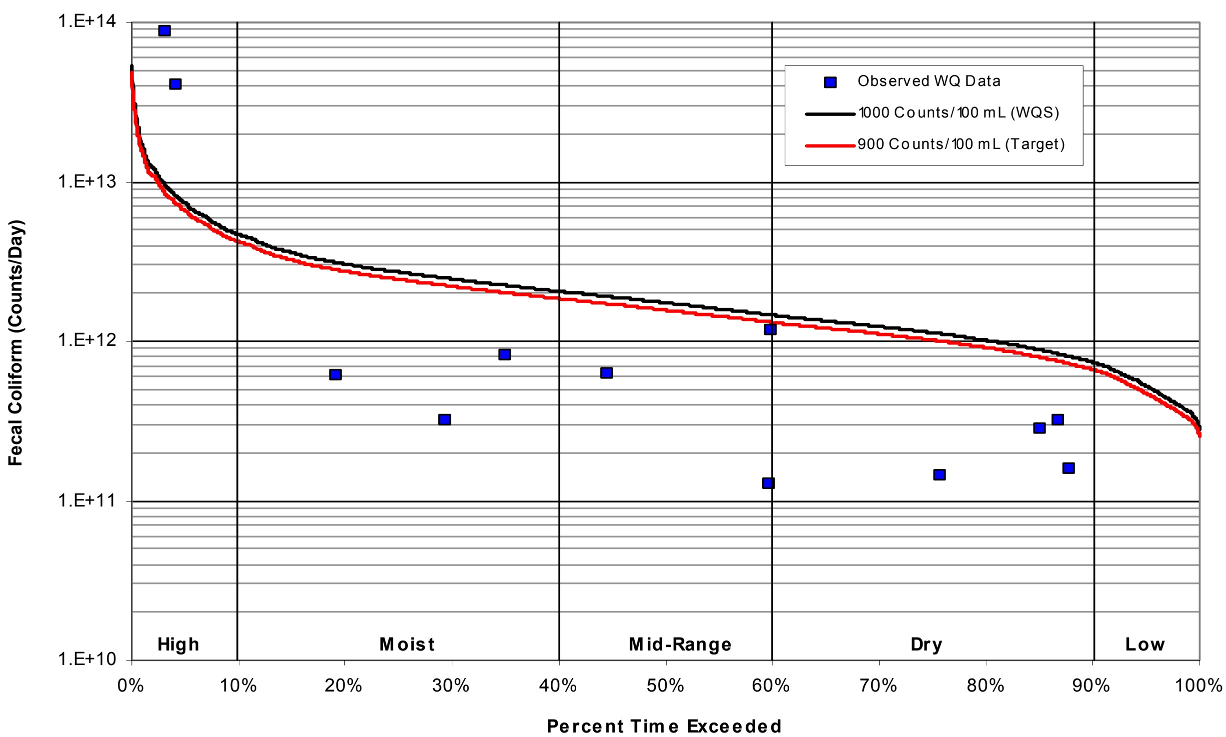


Figure C-46. Fecal Coliform Load Duration Curve for North Mouse Creek at Mile 4.2

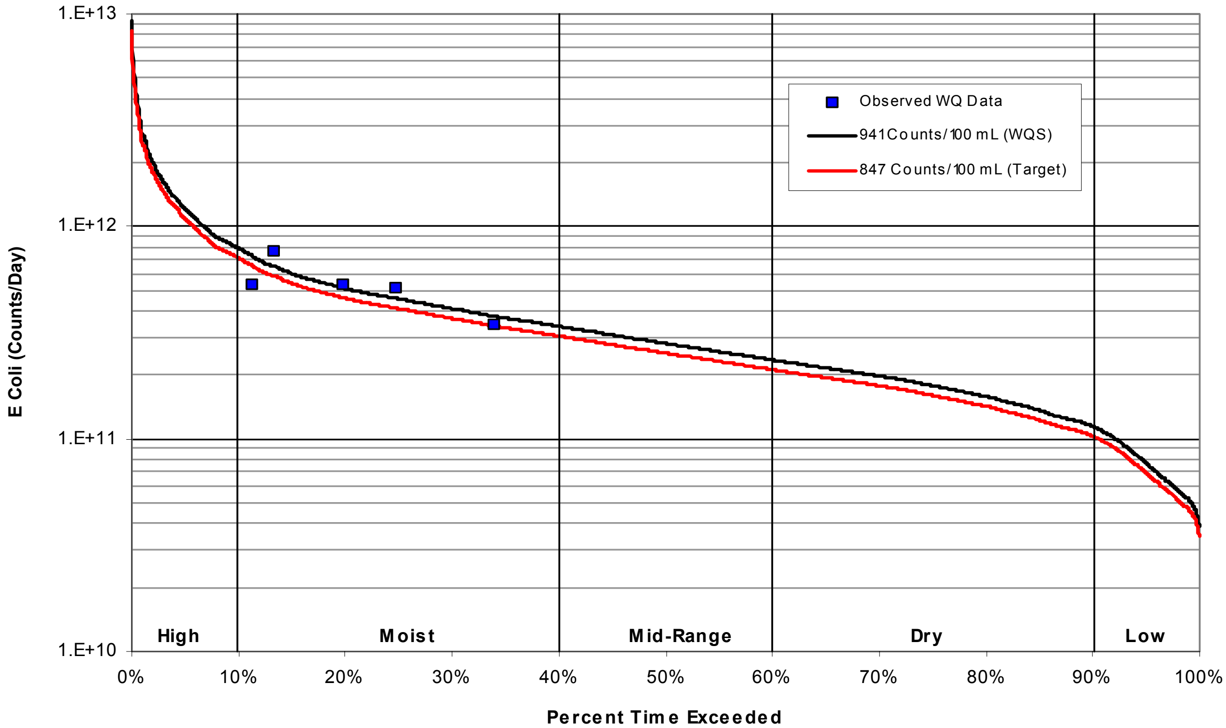


Figure C-47. E. Coli Load Duration Curve for Spring Creek at Mile 15.6

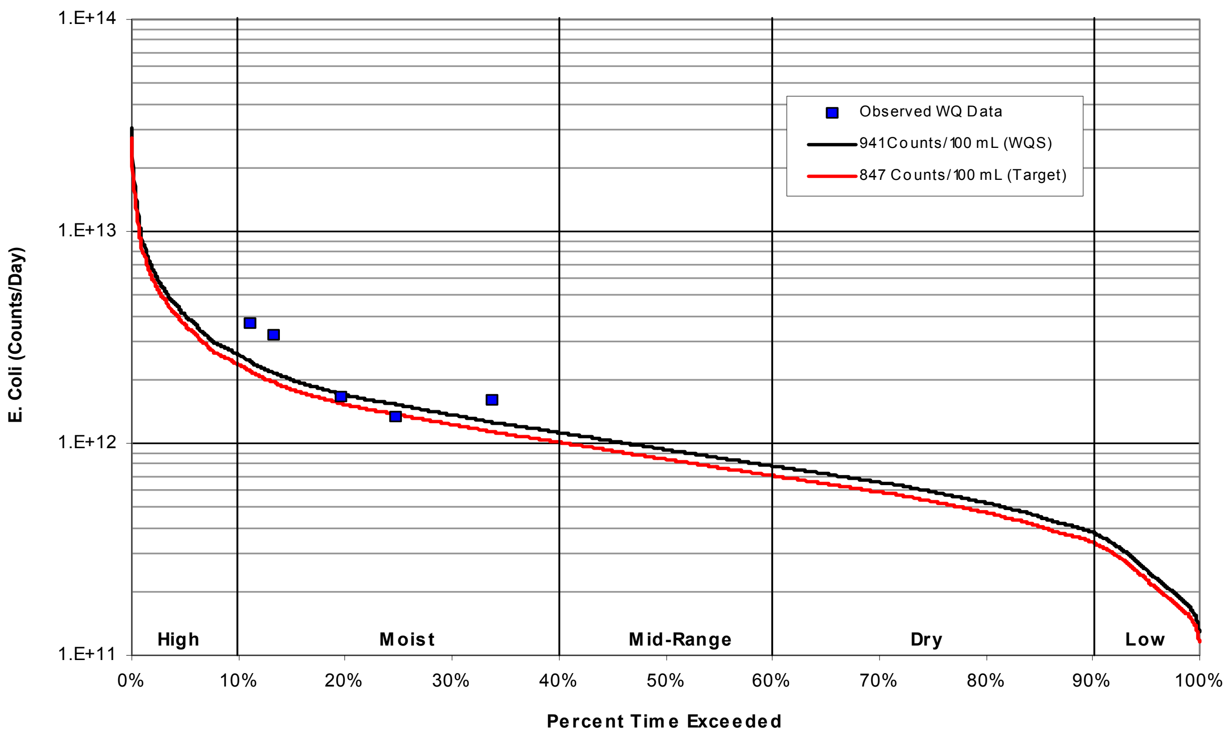


Figure C-48. E. Coli Load Duration Curve for Rogers Creek at Mile 14.2

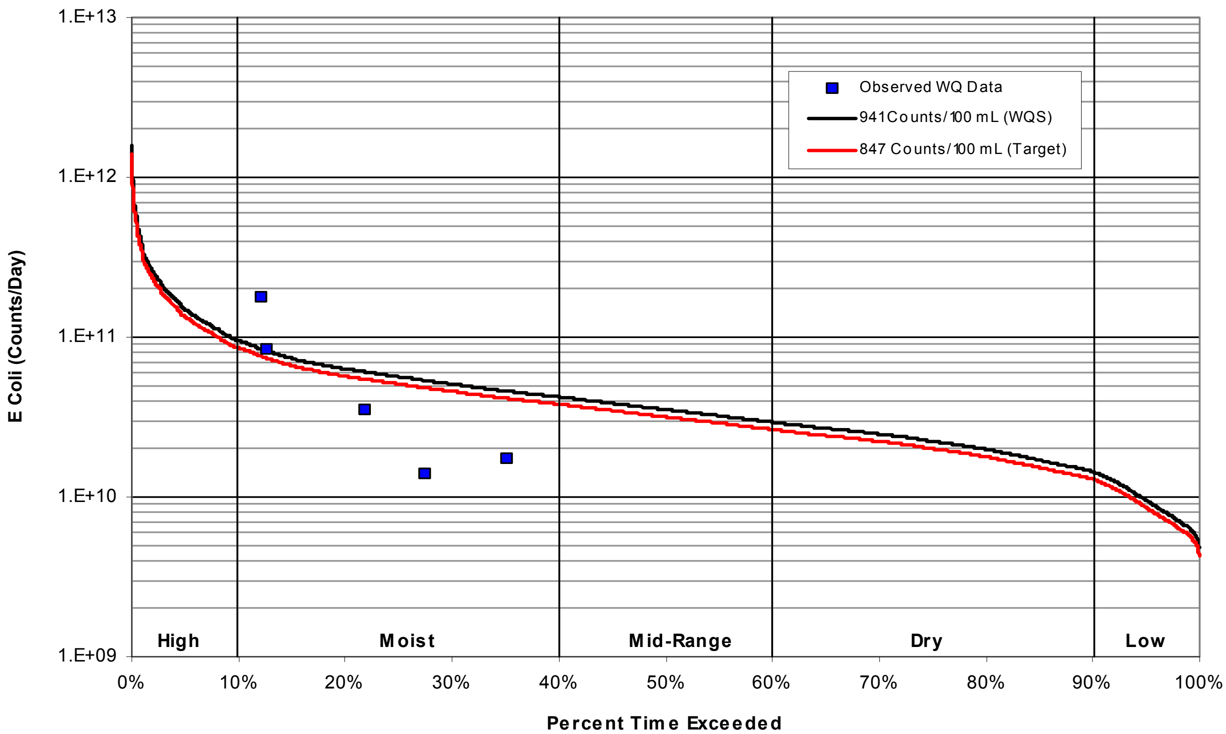


Figure C-49. E. Coli Load Duration Curve for Price Creek at Mile 4.4

Table C-1. Required Load Reduction for Agency Creek at Mile 2.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
12.24%	21.6	7/9/2003	**9800**	**91.4**		
12.76%	21	7/10/2003	**2240**	**62.2**		
21.38%	15.7	6/10/2003	**1299**	**34.8**		
26.72%	14	6/23/2003	**1986**	**57.4**		
34.82%	11.8	6/25/2003	**3190**	**73.4**	**2827**	**96.0**
	90th Percentile (all)		**7156**	**88.2**		

Table C-2. Required Load Reduction for Fillauer Branch at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
14.43%	10.8708	6/11/2003	**1299**	**34.8**		
26.09%	6.60191	6/9/2003	**1732**	**51.1**		
32.71%	5.51426	5/28/2003	**>2419**	**>65.0**		
36.74%	5.00405	6/23/2003	**1080**	**21.6**		
38.05%	4.87425	6/5/2003	770	**NR**		
38.74%	4.80342	6/2/2003	54.6	**NR**	**>792**	**>85.7**
	90th Percentile (all)		**2076**	**>59.2**		

Table C-3. Required Load Reduction for Woolen Mill Branch at Mile 0.8 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
31.399%	2.90026	3/3/04	**>2419**	**>65.0**
	90th Percentile		**NA**	

Table C-4. Required Load Reduction for South Mouse Creek at Mile 12.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
17.66%	70.0191	6/11/2003	**1986**	**57.4**		
21.60%	60.568	6/9/2003	**>2419**	**>65.0**		
29.67%	48.8541	5/28/2003	727			
33.75%	45.0305	6/23/2003	**1520**	**44.3**		
34.03%	44.7699	6/5/2003	**1413**	**40.1**		
38.13%	41.236	6/2/2003	**1413**	**40.1**	**>1482**	**>92.4**
	90th Percentile (all)		**>2203**	**>61.5**		

Table C-5. Required Load Reduction for Little Chatata Creek at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
17.00%	20.2991	6/11/2003	**1413**	**40.1**		
18.34%	19.3147	6/9/2003	**1119**	**24.3**		
26.34%	15.7877	5/28/2003	**980**	**13.6**		
30.50%	14.469	6/23/2003	378	**NR**		
32.52%	13.9591	6/5/2003	866	**NR**		
34.74%	13.3282	6/2/2003	920	**NR**	**881**	**87.2**
	90th Percentile (all)		**1266**	**33.1**		

Table C-6. Required Load Reduction for Chatata Creek at Mile 0.5 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.12%	173.757	11/12/2002	**23590**	**96.4**
4.22%	147.161	5/19/2003	**4000**	**78.8**
18.70%	57.0607	3/24/2003	630	**NR**
28.69%	45.6767	12/18/2002	200	**NR**
33.75%	41.1418	4/29/2003	**1320**	**35.8**
43.25%	34.9013	1/13/2004	**960**	**11.8**
57.51%	27.095	8/19/2003	**1210**	**30.0**
58.50%	26.6846	1/28/2003	740	**NR**
74.62%	19.9954	5/11/2004	520	**NR**
84.62%	15.5471	11/4/2003	310	**NR**
86.45%	14.5339	10/21/2002	410	**NR**
93.54%	9.95873	8/27/2002	200	**NR**
	90th Percentile (all)		**3732**	**77.3**

Table C-7. Required Load Reduction for Chatata Creek at Mile 0.5 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.12%	173.757	11/12/2002	**25000**	**96.4**
4.22%	147.161	5/19/2003	**5200**	**82.7**
18.70%	57.0607	3/24/2003	560	**NR**
28.69%	45.6767	12/18/2002	460	**NR**
33.75%	41.1418	4/29/2003	**1500**	**40.0**
43.25%	34.9013	1/13/2004	640	**NR**
57.51%	27.095	8/19/2003	850	**NR**
58.50%	26.6846	1/28/2003	270	**NR**
74.62%	19.9954	5/11/2004	730	**NR**
84.62%	15.5471	11/4/2003	560	**NR**
86.45%	14.5339	10/21/2002	770	**NR**
93.54%	9.95873	8/27/2002	92	**NR**
	90th Percentile (all)		**4830**	**82.5**

Table C-8. Required Load Reduction for Hawkins Branch at Mile 1.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	2.35495	2/24/2003	**7540**	**88.8**
8.13%	1.16161	11/20/2003	**2920**	**71.0**
12.43%	0.86617	2/11/2004	113	**NR**
14.34%	0.78699	5/14/2003	**>2419**	**>65.0**
19.30%	0.67145	12/30/2002	**>2419**	**>65.0**
25.51%	0.58102	6/4/2003	260	**NR**
25.73%	0.57939	3/17/2003	152	**NR**
30.61%	0.52254	7/21/2003	**>2419**	**>65.0**
57.35%	0.32174	10/7/2003	816	**NR**
61.48%	0.298	8/27/2003	**2590**	**67.3**
	90th Percentile (all)		**>3382**	**>75.0**

Table C-9. Required Load Reduction for Hawkins Branch at Mile 1.3 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	2.35495	2/24/2003	**7800**	**88.5**
8.13%	1.16161	11/20/2003	**2000**	**55.0**
12.43%	0.86617	2/11/2004	66	**NR**
14.34%	0.78699	5/14/2003	**3600**	**75.0**
19.30%	0.67145	12/30/2002	**2800**	**67.9**
25.51%	0.58102	6/4/2003	400	**NR**
25.73%	0.57939	3/17/2003	138	**NR**
30.61%	0.52254	7/21/2003	**22000**	**95.9**
57.35%	0.32174	10/7/2003	**1200**	**25.0**
61.48%	0.298	8/27/2003	**2700**	**66.7**
	90th Percentile (all)		**9220**	**90.2**

Table C-10. Required Load Reduction for Dairy Branch at Mile 1.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	0.81414	2/24/2003	**36540**	**97.7**
8.08%	0.40091	11/20/2003	**>2419**	**>65.0**
12.29%	0.30002	2/11/2004	**>2419**	**>65.0**
14.21%	0.27309	5/14/2003	**>2419**	**>65.0**
25.65%	0.20028	3/17/2003	6	**NR**
26.01%	0.19891	6/4/2003	**>2419**	**>65.0**
31.97%	0.17513	7/21/2003	328	**NR**
56.78%	0.11195	10/7/2003	8	**NR**
64.44%	0.09738	8/27/2003	7	**NR**
	90th Percentile (all)		**>9243**	**>90.8**

Table C-11. Required Load Reduction for Dairy Branch at Mile 1.2 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	0.81414	2/24/2003	**17000**	**94.7**
8.08%	0.40091	11/20/2003	**5300**	**83.0**
12.29%	0.30002	2/11/2004	**3000**	**70.0**
14.21%	0.27309	5/14/2003	**11600**	**92.2**
25.65%	0.20028	3/17/2003	10	**NR**
26.01%	0.19891	6/4/2003	**4200**	**78.6**
31.97%	0.17513	7/21/2003	300	**NR**
56.78%	0.11195	10/7/2003	10	**NR**
64.44%	0.09738	8/27/2003	20	**NR**
	90th Percentile (all)		**12680**	**92.9**

Table C-12. Required Load Reduction for Little Chestuee Creek at Mile 2.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
15.52%	15.7048	6/9/2003	**1046**	**19.0**		
18.26%	14.3745	6/11/2003	**>2419**	**>65.0**		
22.42%	13.0274	5/28/2003	727	**NR**		
28.63%	11.4005	6/5/2003	**1203**	**29.6**		
30.58%	10.9573	6/2/2003	648	**NR**	**>1074.8**	**>89.5**
	90th Percentile (all)		**>1933**	**>56.2**		

Table C-13. Required Load Reduction for Chestuee Creek at Mile 42.5 (1998-1999) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.42%	155.5	3/11/1998	411	**NR**
15.44%	60.5	4/15/1998	687	**NR**
19.68%	53.2	3/2/1998	249	**NR**
22.28%	49.4	2/23/1999	460	**NR**
30.99%	41.3	5/18/1999	210	**NR**
31.76%	40.8	4/13/1998	770	**NR**
33.07%	39.6	4/14/1998	**1120**	**24.4**
40.27%	34.9	5/17/1999	870	**NR**
87.57%	13.4	8/16/1999	250	**NR**
88.07%	13.1	8/17/1999	820	**NR**
94.01%	9.1	11/15/1999	120	**NR**
94.58%	8.7	11/17/1999	160	**NR**
99.12%	5.7	11/30/1998	172	**NR**
99.23%	5.6	12/1/1998	157	**NR**
	90th Percentile (all)		855	0.0

Table C-14. Required Load Reduction for Chestuee Creek at Mile 42.5 (2003) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
14.95%	61.3916	6/9/2003	**1986**	**57.4**		
19.05%	53.8887	6/11/2003	816	**NR**		
22.23%	49.4649	5/28/2003	547	**NR**		
28.83%	43.426	6/5/2003	**1553**	**45.5**		
30.80%	41.45	6/2/2003	517	**NR**	**934**	**87.9**
	90th Percentile (all)		**1813**	**53.3**		

Table C-15. Required Load Reduction for Chestuee Creek at Mile 42.5 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.42%	155.529	3/11/1998	350	**NR**
15.44%	60.5171	4/15/1998	690	**NR**
19.68%	53.1557	3/2/1998	168	**NR**
22.28%	49.3872	2/23/1999	170	**NR**
30.99%	41.2541	5/18/1999	970	**NR**
31.76%	40.8243	4/13/1998	660	**NR**
33.07%	39.5972	4/14/1998	**1030**	12.6
40.27%	34.9085	5/17/1999	600	**NR**
87.57%	13.4245	8/16/1999	560	**NR**
88.07%	13.1375	8/17/1999	570	**NR**
94.01%	9.11817	11/15/1999	90	**NR**
94.58%	8.74417	11/17/1999	100	**NR**
99.12%	5.66696	11/30/1998	172	**NR**
99.23%	5.55664	12/1/1998	130	**NR**
	90th Percentile (all)		886	0.0

Table C-16. Required Load Reduction for Oostanaula Creek at Mile 5.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
4.74%	237.598	2/9/2003	**1986**	**57.4**
43.39%	72.639	8/20/2003	461	**NR**
50.07%	65.525	1/14/2004	239	**NR**
61.79%	55.823	11/5/2003	219	**NR**
82.81%	38.783	10/22/2002	411	**NR**
	90th Percentile (all)		**1376**	**38.4**

Table C-17. Required Load Reduction for Oostanaula Creek at Mile 5.7 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
4.74%	237.598	2/9/2003	**1900**	**52.6**
43.39%	72.639	8/20/2003	340	**NR**
50.07%	65.525	1/14/2004	176	**NR**
61.79%	55.823	11/5/2003	420	**NR**
82.81%	38.783	10/22/2002	300	**NR**
	90th Percentile (all)		**1308**	**31.2**

Table C-18. Required Load Reduction for Oostanaula Creek at Mile 26.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.85%	177.204	1/26/2004	**1690**	**49.9**
4.02%	147.471	2/9/2004	200	**NR**
5.15%	127.382	2/25/2003	560	**NR**
16.56%	66.7518	6/17/2003	**1600**	**47.1**
17.90%	64.6496	9/3/2003	50	**NR**
21.05%	59.6118	6/3/2003	720	**NR**
25.76%	54.8426	3/25/2003	80	**NR**
25.81%	54.8113	11/18/2003	400	**NR**
26.75%	53.7173	12/17/2002	160	**NR**
29.95%	51.0811	11/19/2002	350	**NR**
35.78%	46.664	4/29/2003	130	**NR**
36.33%	46.2359	3/15/2004	320	**NR**
37.01%	45.7707	7/30/2003	450	**NR**
46.07%	40.8052	12/9/2003	340	**NR**
46.51%	40.4335	1/21/2003	30	**NR**
49.36%	38.8447	4/26/2004	210	**NR**
55.16%	35.7121	10/1/2003	50	**NR**
63.70%	31.9908	10/29/2002	610	**NR**
74.82%	27.1331	5/24/2004	60	**NR**
82.32%	23.3038	6/14/2004	90	**NR**
84.45%	22.1901	10/1/2002	30	**NR**
	90th Percentile (all)		720	0.0

Table C-19. Required Load Reduction for Oostanaula Creek at Mile 26.6 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.85%	177.204	1/26/2004	**1850**	**51.4**
4.02%	147.471	2/9/2004	880	**NR**
5.15%	127.382	2/25/2003	50	**NR**
16.56%	66.7518	6/17/2003	960	**NR**
17.68%	64.8794	3/26/2002	**10000**	**91.0**
17.90%	64.6496	9/3/2003	140	**NR**
21.05%	59.6118	6/3/2003	960	**NR**
25.76%	54.8426	3/25/2003	60	**NR**
25.81%	54.8113	11/18/2003	460	**NR**
26.75%	53.7173	12/17/2002	290	**NR**
29.95%	51.0811	11/19/2002	140	**NR**
35.78%	46.664	4/29/2003	200	**NR**
36.33%	46.2359	3/15/2004	230	**NR**
37.01%	45.7707	7/30/2003	560	**NR**
46.07%	40.8052	12/9/2003	380	**NR**
46.35%	40.5731	5/22/2002	400	**NR**
46.51%	40.4335	1/21/2003	120	**NR**
49.36%	38.8447	4/26/2004	180	**NR**
55.16%	35.7121	10/1/2003	40	**NR**
63.70%	31.9908	10/29/2002	**1210**	**25.6**
74.82%	27.1331	5/24/2004	150	**NR**
82.32%	23.3038	6/14/2004	140	**NR**
84.45%	22.1901	10/1/2002	120	**NR**
	90th Percentile (all)		**1160**	**22.4**

Table C-20. Required Load Reduction for Oostanaula Creek at Mile 28.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.17%	221.52	1/26/2004	**1650**	**48.7**
2.89%	187.21	2/9/2004	600	**NR**
4.47%	147.88	2/19/2003	**1553**	**45.5**
6.07%	122.7	3/13/2001	**2400**	**64.7**
12.59%	77.25	3/9/1999	**2400**	**64.7**
36.35%	40.56	12/9/2003	310	**NR**
38.32%	39.09	3/25/2002	1	**NR**
40.57%	37.43	3/15/2004	250	**NR**
40.97%	37.13	7/30/2003	560	**NR**
43.45%	35.41	1/14/2004	345	**NR**
44.55%	34.61	10/1/2003	70	**NR**
47.55%	32.73	9/3/2003	120	**NR**
48.84%	31.76	8/20/2003	411	**NR**
59.32%	26.24	3/7/2000	370	**NR**
59.99%	25.88	6/8/1999	200	**NR**
60.64%	25.65	4/26/2004	160	**NR**
62.03%	25.04	11/18/2003	400	**NR**
63.22%	24.49	11/5/2003	365	**NR**
65.18%	23.65	12/11/2000	160	**NR**
67.26%	22.72	9/11/2001	200	**NR**
70.55%	21.11	6/12/2000	140	**NR**
72.62%	20.17	5/24/2004	80	**NR**
78.15%	17.66	6/14/2004	60	**NR**
78.98%	17.31	12/15/1998	**>2419**	**>65.0**
81.93%	15.96	10/22/2002	260	**NR**
81.96%	15.95	12/7/1999	820	**NR**
90.05%	12.29	9/19/2000	870	**NR**
94.69%	9.9	9/13/1999	**2400**	**64.7**
	90th Percentile (all)		**>2400**	**>64.7**

Table C-21. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.17%	221.52	1/26/2004	**1720**	**47.7**
2.89%	187.21	2/9/2004	850	**NR**
4.47%	147.88	2/19/2003	**1800**	**50.0**
6.07%	122.7	3/13/2001	**8700**	**89.7**
12.59%	77.25	3/9/1999	**2900**	**69.0**
36.35%	40.56	12/9/2003	320	**NR**
38.32%	39.09	3/25/2002	10	**NR**
40.57%	37.43	3/15/2004	300	**NR**
40.97%	37.13	7/30/2003	250	**NR**
43.45%	35.41	1/14/2004	220	**NR**
44.55%	34.61	10/1/2003	380	**NR**
44.75%	34.48	5/24/1999	**3900**	**76.9**
47.55%	32.73	9/3/2003	300	**NR**
48.84%	31.76	8/20/2003	440	**NR**
59.32%	26.24	3/7/2000	600	**NR**
59.99%	25.88	6/8/1999	97	**NR**
60.64%	25.65	4/26/2004	480	**NR**
62.03%	25.04	11/18/2003	690	**NR**
62.84%	24.65	7/19/1999	670	**NR**
63.22%	24.49	11/5/2003	220	**NR**
65.18%	23.65	12/11/2000	320	**NR**
66.46%	23.09	6/14/1999	200	**NR**
67.26%	22.72	9/11/2001	170	**NR**
70.55%	21.11	6/12/2000	200	**NR**
72.62%	20.17	5/24/2004	170	**NR**
78.15%	17.66	6/14/2004	80	**NR**
78.98%	17.31	12/15/1998	**8000**	**88.8**
79.21%	17.2	8/11/1999	280	**NR**
81.93%	15.96	10/22/2002	270	**NR**
81.96%	15.95	12/7/1999	830	**NR**
90.05%	12.29	9/19/2000	930	**NR**
94.69%	9.9	9/13/1999	240	**NR**
	90^{th} Percentile (all)		**2790**	**67.7**

Table C-22. Required Load Reduction for Oostanaula Creek at Mile 30.0 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2760**	**69.3**
2.55%	187.21	2/9/2004	150	**NR**
4.00%	148.57	2/25/2003	340	**NR**
21.74%	53.87	3/25/2003	60	**NR**
23.52%	51.88	12/17/2002	300	**NR**
28.69%	46.75	6/3/2003	**1200**	**29.4**
29.81%	45.72	6/17/2003	**1740**	**51.3**
32.38%	43.2	11/19/2002	550	**NR**
32.74%	43.04	4/29/2003	40	**NR**
36.05%	40.56	12/9/2003	170	**NR**
41.12%	37.43	3/15/2004	100	**NR**
41.58%	37.13	7/30/2003	120	**NR**
46.04%	34.61	10/1/2003	150	**NR**
49.82%	32.73	9/3/2003	90	**NR**
49.99%	32.61	1/21/2003	300	**NR**
58.42%	28.26	10/29/2002	**2900**	**70.8**
64.28%	25.65	4/26/2004	920	**NR**
65.89%	25.04	11/18/2003	60	**NR**
78.57%	20.17	5/24/2004	140	**NR**
84.29%	17.66	6/14/2004	50	**NR**
85.16%	17.22	10/1/2002	160	**NR**
	90th Percentile (all)		**1740**	**51.3**

Table C-23. Required Load Reduction for Oostanaula Creek at Mile 30.0 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2850**	**68.4**
2.55%	187.21	2/9/2004	190	**NR**
4.00%	148.57	2/25/2003	250	**NR**
21.74%	53.87	3/25/2003	120	**NR**
23.52%	51.88	12/17/2002	210	**NR**
28.69%	46.75	6/3/2003	**1300**	**30.8**
29.81%	45.72	6/17/2003	**1680**	**46.4**
31.43%	44.07	3/26/2002	**12000**	**92.5**
32.38%	43.2	11/19/2002	710	**NR**
32.74%	43.04	4/29/2003	240	**NR**
36.05%	40.56	12/9/2003	160	**NR**
41.12%	37.43	3/15/2004	280	**NR**
41.58%	37.13	7/30/2003	270	**NR**
46.04%	34.61	10/1/2003	210	**NR**
48.10%	33.46	5/22/2002	**2900**	**69.0**
49.82%	32.73	9/3/2003	220	**NR**
49.99%	32.61	1/21/2003	410	**NR**
58.42%	28.26	10/29/2002	**6000**	**85.0**
64.28%	25.65	4/26/2004	870	**NR**
65.89%	25.04	11/18/2003	80	**NR**
78.57%	20.17	5/24/2004	270	**NR**
84.29%	17.66	6/14/2004	330	**NR**
85.16%	17.22	10/1/2002	550	**NR**
	90th Percentile (all)		**2890**	**68.9**

Table C-24. Required Load Reduction for Oostanaula Creek at Mile 30.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**1990**	**57.4**
2.55%	187.21	2/9/2004	**980**	**13.6**
4.00%	148.57	2/25/2003	380	**NR**
21.74%	53.87	3/25/2003	100	**NR**
23.52%	51.88	12/17/2002	510	**NR**
28.69%	46.75	6/3/2003	600	**NR**
29.81%	45.72	6/17/2003	**1740**	**51.3**
32.38%	43.2	11/19/2002	**1350**	**37.3**
32.74%	43.04	4/29/2003	100	**NR**
36.05%	40.56	12/9/2003	220	**NR**
41.12%	37.43	3/15/2004	250	**NR**
41.58%	37.13	7/30/2003	240	**NR**
46.04%	34.61	10/1/2003	130	**NR**
49.82%	32.73	9/3/2003	90	**NR**
49.99%	32.61	1/21/2003	190	**NR**
58.42%	28.26	10/29/2002	**2500**	**66.1**
64.28%	25.65	4/26/2004	180	**NR**
65.89%	25.04	11/18/2003	80	**NR**
78.57%	20.17	5/24/2004	200	**NR**
84.29%	17.66	6/14/2004	80	**NR**
85.16%	17.22	10/1/2002	130	**NR**
	90th Percentile (all)		**1740**	**51.3**

Table C-25. Required Load Reduction for Oostanaula Creek at Mile 30.1 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2200**	**59.1**
2.55%	187.21	2/9/2004	**1200**	**33.3**
4.00%	148.57	2/25/2003	220	**NR**
21.74%	53.87	3/25/2003	100	**NR**
23.52%	51.88	12/17/2002	420	**NR**
28.69%	46.75	6/3/2003	840	**NR**
29.81%	45.72	6/17/2003	**1560**	**42.3**
31.43%	44.07	3/26/2002	**14000**	**93.6**
32.38%	43.2	11/19/2002	560	**NR**
32.74%	43.04	4/29/2003	230	**NR**
36.05%	40.56	12/9/2003	200	**NR**
41.12%	37.43	3/15/2004	370	**NR**
41.58%	37.13	7/30/2003	380	**NR**
46.04%	34.61	10/1/2003	260	**NR**
48.10%	33.46	5/22/2002	**3500**	**74.3**
49.82%	32.73	9/3/2003	130	**NR**
49.99%	32.61	1/21/2003	230	**NR**
58.42%	28.26	10/29/2002	**6000**	**85.0**
64.28%	25.65	4/26/2004	310	**NR**
65.89%	25.04	11/18/2003	50	**NR**
78.57%	20.17	5/24/2004	360	**NR**
84.29%	17.66	6/14/2004	400	**NR**
85.16%	17.22	10/1/2002	510	**NR**
	90th Percentile (all)		**3240**	**72.2**

Table C-26. Required Load Reduction for Oostanaula Creek at Mile 33.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2090**	**59.5**
3.723%	96.0258	2/9/2004	800	**NR**
33.151%	28.471	7/30/2003	**2750**	**69.2**
38.489%	26.2992	9/3/2003	410	**NR**
39.584%	25.992	3/15/2004	210	**NR**
41.911%	25.0027	12/9/2003	890	**NR**
51.547%	21.5081	10/1/2003	400	**NR**
56.721%	19.8617	11/18/2003	**1200**	**29.4**
58.363%	19.3883	4/26/2004	880	**NR**
71.640%	15.6601	5/24/2004	520	**NR**
80.044%	13.0269	6/14/2004	250	**NR**
	90th Percentile (all)		**2090**	**59.5**

Table C-27. Required Load Reduction for Oostanaula Creek at Mile 33.6 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2120**	**57.5**
3.723%	96.0258	2/9/2004	1000	**NR**
33.151%	28.471	7/30/2003	**2140**	**57.9**
38.489%	26.2992	9/3/2003	500	**NR**
39.584%	25.992	3/15/2004	250	**NR**
41.911%	25.0027	12/9/2003	740	**NR**
51.547%	21.5081	10/1/2003	870	**NR**
56.721%	19.8617	11/18/2003	**1180**	**23.7**
58.363%	19.3883	4/26/2004	**1130**	**20.4**
71.640%	15.6601	5/24/2004	**1100**	**18.2**
80.044%	13.0269	6/14/2004	**1490**	**39.6**
	90th Percentile (all)		**2120**	**57.5**

Table C-28. Required Load Reduction for Oostanaula Creek at Mile 35.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2610**	**67.5**
3.723%	96.0258	2/9/2004	100	**NR**
33.151%	28.471	7/30/2003	**1250**	**32.2**
38.489%	26.2992	9/3/2003	100	**NR**
39.584%	25.992	3/15/2004	280	**NR**
41.911%	25.0027	12/9/2003	190	**NR**
51.547%	21.5081	10/1/2003	290	**NR**
56.721%	19.8617	11/18/2003	40	**NR**
58.363%	19.3883	4/26/2004	720	**NR**
71.640%	15.6601	5/24/2004	380	**NR**
80.044%	13.0269	6/14/2004	130	**NR**
	90th Percentile (all)		**1250**	**32.2**

Table C-29. Required Load Reduction for Oostanaula Creek at Mile 35.1 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2500**	**64.0**
3.723%	96.0258	2/9/2004	100	**NR**
33.151%	28.471	7/30/2003	**1850**	**51.4**
38.489%	26.2992	9/3/2003	310	**NR**
39.584%	25.992	3/15/2004	330	**NR**
41.911%	25.0027	12/9/2003	120	**NR**
51.547%	21.5081	10/1/2003	720	**NR**
56.721%	19.8617	11/18/2003	120	**NR**
58.363%	19.3883	4/26/2004	**1410**	**36.2**
71.640%	15.6601	5/24/2004	810	**NR**
80.044%	13.0269	6/14/2004	50	**NR**
	90th Percentile (all)		**1850**	**51.4**

Table C-30. Required Load Reduction for North Mouse Creek at Mile 4.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.01%	399.445	11/12/2002	**8620**	**90.2**
4.02%	334.746	5/19/2003	**4570**	**81.5**
19.05%	127.615	3/24/2003	410	**NR**
29.35%	101.868	12/18/2002	100	**NR**
34.88%	91.9124	4/29/2003	200	**NR**
44.46%	78.0895	1/13/2004	410	**NR**
59.62%	60.1605	1/28/2003	200	**NR**
59.73%	60.0222	8/19/2003	410	**NR**
75.72%	45.641	5/11/2004	310	**NR**
85.08%	36.0408	11/4/2003	310	**NR**
86.67%	34.2459	10/21/2002	310	**NR**
87.76%	32.9522	8/27/2002	100	**NR**
	90th Percentile (all)		**4154**	**79.6**

Table C-31. Required Load Reduction for North Mouse Creek at Mile 4.2 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.01%	399.445	11/12/2002	**9000**	**90.0**
4.02%	334.746	5/19/2003	**5000**	**82.0**
19.05%	127.615	3/24/2003	200	**NR**
29.35%	101.868	12/18/2002	130	**NR**
34.88%	91.9124	4/29/2003	370	**NR**
44.46%	78.0895	1/13/2004	330	**NR**
59.62%	60.1605	1/28/2003	88	**NR**
59.73%	60.0222	8/19/2003	800	**NR**
75.72%	45.641	5/11/2004	130	**NR**
85.08%	36.0408	11/4/2003	320	**NR**
86.67%	34.2459	10/21/2002	380	**NR**
87.76%	32.9522	8/27/2002	200	**NR**
	90th Percentile (all)		**4580**	**80.3**

Table C-32. Required Load Reduction for Spring Creek at Mile 15.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
11.17%	31.9232	7/9/2003	686	**NR**		
13.30%	28.2467	7/10/2003	**1119**	**24.3**		
19.68%	22.3502	6/10/2003	**980**	**13.6**		
24.75%	19.9739	6/23/2003	**1046**	**19.0**		
33.95%	16.3868	6/25/2003	866	**NR**	**926**	**87.8**
	90th Percentile (all)		**1090**	**22.3**		

Table C-33. Required Load Reduction for Rogers Creek at Mile 14.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
11.09%	106.415	7/9/2003	**1413**	**40.1**		
13.28%	93.6615	7/10/2003	**1413**	**40.1**		
19.57%	74.3695	6/10/2003	920	**NR**		
24.67%	66.5143	6/23/2003	816	**NR**		
33.75%	54.4824	6/25/2003	**1203**	**29.6**	**1125**	**90.0**
	90th Percentile (all)		**1413**	**40.1**		

Table C-34. Required Load Reduction for Price Creek at Mile 4.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
12.02%	3.67979	7/10/2003	**1986**	**57.4**		
12.62%	3.55444	7/9/2003	**980**	**13.6**		
21.74%	2.64973	6/10/2003	547	**NR**		
27.38%	2.33407	6/23/2003	248	**NR**		
35.12%	1.99627	6/25/2003	360	**NR**	**625**	**81.9**
	90th Percentile (all)		**1584**	**46.5**		

Table C-35. Required Load Reduction for Hiwassee River at Mile 13.4 – E. Coli Analysis

Sample Date	E. Coli	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
12/15/98	**980**	**13.6**
3/9/99	170	**NR**
6/8/99	2	**NR**
9/14/99	19	**NR**
12/14/99	13	**NR**
3/15/00	260	**NR**
6/19/00	4	**NR**
9/5/00	9	**NR**
12/4/00	93	**NR**
3/14/01	**>2400**	**>64.7**
9/11/01	4	**NR**
3/25/02	170	**NR**
9/4/02	3	**NR**
12/17/02	52	**NR**
3/26/03	40	**NR**
6/17/03	**2400**	**64.7**
9/8/03	27	**NR**
12/2/03	54	**NR**
3/9/04	**1200**	**29.4**
90th Percentile (all)	**1440**	**29.4**

Table C-36. Required Load Reduction for Hiwassee River at Mile 13.4 – Fecal Coliform Analysis

Sample Date	Fecal Coliform	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
12/15/98	860	**NR**
3/9/99	770	**NR**
6/8/99	13	**NR**
9/14/99	16	**NR**
12/14/99	430	**NR**
3/15/00	**3900**	**76.9**
6/19/00	15	**NR**
9/5/00	19	**NR**
12/4/00	93	**NR**
3/14/01	**5000**	**82.0**
9/11/01	38	**NR**
3/25/02	190	**NR**
9/4/02	7	**NR**
12/17/02	160	**NR**
3/26/03	56	**NR**
6/17/03	**2100**	**57.1**
12/2/03	70	**NR**
3/9/04	770	**NR**
90th Percentile (all)	**2640**	**65.9**

Table C-37. Required Load Reduction for Hiwassee River at Mile 15.6 – E. Coli Analysis

Sample Date	E. Coli	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
4/27/98	27	**NR**
4/28/98	51	**NR**
7/13/98	20	**NR**
7/14/98	17	**NR**
7/15/98	13	**NR**
5/3/99	260	**NR**
5/4/99	120	**NR**
8/30/99	36	**NR**
8/31/99	25	**NR**
9/1/99	48	**NR**
90th Percentile (all)	120	0.0

Table C-38. Required Load Reduction for Hiwassee River at Mile 15.6 – Fecal Coliform Analysis

Sample Date	Fecal Coliform	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
4/27/98	70	**NR**
4/28/98	104	**NR**
7/13/98	34	**NR**
7/14/98	110	**NR**
7/15/98	112	**NR**
5/3/99	240	**NR**
5/4/99	140	**NR**
8/30/99	60	**NR**
8/31/99	30	**NR**
9/1/99	39	**NR**
90th Percentile (all)	140	0.0

APPENDIX D

Dynamic Loading Model Methodology

DYNAMIC LOADING MODEL METHOD

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analysis of E. coli-impaired waters in the Hiwassee River watershed. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF) and is well suited to demonstrate compliance with the 200 counts/100 mL geometric mean standard. LSPC was used to simulate the buildup and washoff of fecal coliform bacteria from land surfaces in response to storm events, loading from point sources, and compute the resulting water quality response. From model output, instream 30-day geometric mean concentrations were computed, critical conditions identified, existing loads determined, and reductions required to meet target concentrations (standard - MOS) were calculated.

D.2 Model Set Up

The Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek watersheds were delineated into subwatersheds in order to facilitate model hydrologic and water quality calibration; and to characterize relative fecal coliform contributions from significant contributing drainage areas. Boundaries were constructed so that subwatershed “pour points” coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the Rf3 stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support water quality model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. Results of the WCS characterization was input into the Fecal Coliform Loading Estimation Spreadsheet (FCLES), developed by Tetra Tech, Inc., to estimate LSPC input parameters associated with fecal coliform buildup (loading rates) and subsequent washoff from land surfaces. In addition, FCLES was used to estimate direct sources of fecal coliform loading to water bodies from leaking septic systems and animals having access to streams. Information from the WCS and FCLES utilities were used as initial input for variables in the LSPC model.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. The pattern and intensity of rainfall affects the buildup and washoff of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Chattanooga Airport meteorological station was available for the time period from January 1970 through June 2004. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (7/1/94 – 6/30/04) used for TMDL analysis.

D.3 Model Calibration

The calibration of the LSPC watershed model involves both hydrology and water quality components. The model must first be calibrated to appropriately represent hydrologic response to meteorological conditions before water quality calibration and subsequent simulations can be performed.

D.3.1 Hydrologic Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. A USGS continuous record station located in the Oostanaula Creek watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Oostanaula Creek near Sanford, USGS Station 03565500, are shown in Table D-1 and Figure D-1.

D.3.2 Water Quality Calibration

After hydrologic calibration, the watershed model was calibrated for water quality through comparison of simulated fecal coliform concentrations to instream monitoring data at a specified location. Watershed data, produced with WCS, were processed through the FCLES spreadsheet to generate fecal coliform loading data for use as <u>initial</u> input to the LSPC model. In the model, in-stream decay of fecal coliform bacteria was estimated using the values reported in Lombardo (1972). For freshwater streams, decay ranges from 0.008 hr^{-1} to 0.13 hr^{-1}, with a median value of 0.048 hr^{-1}. The value of 0.083 hr^{-1} was used as initial input to model simulations.

D.3.2.1 Point Sources

For existing conditions, NPDES facilities located in modeled watersheds are represented as point sources of average (constant) flow and concentration based on the facility's flow and effluent fecal coliform concentration as reported on Discharge Monitoring Reports.

D.3.2.2 Nonpoint Sources

A number of nonpoint source categories are not associated with land loading processes and are represented as direct, instream source contributions in the model. These may include, but are not limited to, failing septic systems, leaking sewer lines, animals in streams, illicit connections, direct discharge of raw sewage, and undefined sources. All other nonpoint sources involve land loading of fecal coliform bacteria and washoff as a result of storm events. Only a portion of the load from these sources is actually delivered to streams due to the mechanisms of washoff (efficiency), decay, and incorporation into soil (adsorption, absorption, filtering) before being transported to the stream. Therefore, land loading nonpoint sources are represented as indirect contributions to the stream. Buildup, washoff, and die-off rates are dependent on seasonal and hydrologic processes.

D.3.2.2.1 Wildlife

Wildlife deposit fecal coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile. In order to account for higher density areas and loading due to other species, a conservative density of 45 animals per square mile was used for modeling purposes. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day. The resulting fecal coliform loading on a unit area basis is 3.52×10^7 counts/acre/day and is considered background.

D.3.2.2.2 Land Application of Agricultural Manure

In the water quality model, livestock populations are distributed to subwatersheds based on information derived from WCS. Fecal coliform loading rates were calculated from livestock populations based on manure application rates, literature values for bacteria concentrations in livestock manure, and the following assumptions:

- Fecal content in manure was adjusted to account for die-off due to known treatment/storage methods.
- Manure application rates from the various animal sources are applied according to application practices throughout the year.
- The fraction of manure available for runoff is dependent on the method of manure application. In the water quality model, the fraction available is estimated based on incorporation into the soil.

Fecal coliform production rates used in the model for beef cattle, dairy cattle, hogs, and chicken are 1.06×10^{11} counts/day/beef cow, 1.04×10^{11} counts/day/dairy cow, 1.24×10^{10} counts/day/hog, and 1.38×10^8 counts/day/chicken (NCSU, 1994).

D.3.2.2.3 Grazing Animals

Cattle spend time grazing on pastureland and deposit feces onto the land. During storm events, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle are assumed to spend all their time in pasture. The percentage of feces deposited during grazing time is used to estimate fecal coliform loading rates from pastureland. Because there is no assumed monthly variation in animal access to pastures in east Tennessee, the fecal loading rate does not vary significantly throughout the year. Therefore, the loading rate to pastureland is assumed to be relatively constant within each subwatershed. However, this rate varies across subwatersheds depending on livestock population. The approximate loads from grazing cattle vary from 3.495×10^{10} to 1.165×10^{11} counts/acre-day. Contributions of fecal coliform from wildlife (as noted in Section D.3.2.2.1) are also included in these rates.

D.3.2.2.4 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation; high intensity residential; and low density residential. Associated with each of these classifications is a percent of the land area that is impervious. A single, area-weighted loading rate from urban areas is used for each subwatershed in the model and is based on the percentage of each urban land use type in the watershed and buildup and accumulation rates referenced in Horner (Horner, 1992). In the water quality calibrated model, this rate varies from 1.0×10^9 to 1.2×10^{10} counts/acre-day and is assumed constant within each subwatershed throughout the year.

D.3.2.2.5 Other Direct Sources

As previously stated, there are a number of nonpoint sources of fecal coliform bacteria that are not associated with land loading and washoff processes. These include animal access to streams, failing septic systems, illicit discharges, and other undefined sources. In each subwatershed, these miscellaneous sources have been modeled as point sources of constant flow and fecal coliform concentration and are referred to as "other direct sources" in this document. The initial baseline values of flow and concentration were estimated using the FCLES spreadsheets and the following assumptions:

- The load attributed to animals having access to streams is initially based on the beef cow population in the watershed. The percentage of animals having access to streams is derived from assumptions on animals in operations that are adjacent to streams and seasonal and behavioral assumptions. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems is based on an assumed failure rate of 20 percent.

Flow and concentration variables were adjusted during water quality calibration to best-fit simulated in-stream fecal coliform concentrations during dry weather conditions.

D.3.2.3 Water Quality Calibration Results

During water quality calibration, model parameters were adjusted within reasonable limits until acceptable agreement between simulation output and instream observed data was achieved. Model variables adjusted include:

- Rate of fecal coliform bacteria accumulation
- Maximum storage of fecal coliform bacteria
- Rate of surface runoff that will remove 90% of stored fecal coliform bacteria
- Concentration of fecal coliform bacteria in interflow
- Concentration of fecal coliform bacteria in groundwater
- Concentration of fecal coliform bacteria and rate of flow of "other direct sources".
- In-stream fecal coliform decay (die-off) rate

At times, a high observed value may not have been simulated in the model due to the absence of rainfall at the meteorological station as compared to localized rainfall occurring in the watershed, or as the result of an unknown source that is not included in the model.

Water quality calibration for the Hiwassee River E. coli-impaired subwatersheds was performed at monitoring locations with adequate water quality data for model calibration. The results of the Hiwassee River subwatershed water quality calibrations for Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek are shown in Figures D-2 through D-5, respectively. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to rainfall events and pollutant loading dynamics.

D.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For TMDL analyses using LSPC, both an explicit and implicit MOS were used. The explicit MOS is 20 counts/100 mL, equal to 10% of the 200 counts/100 mL geometric standard. This results in a target fecal coliform concentration of 180 counts/100 mL. The implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a wide range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; and all land uses connected directly to streams.

Note: In this document, the water quality standard is the instream goal. The term "target concentration" reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 5.0.

D.5 Determination of Existing Loading

The critical condition for nonpoint source fecal coliform loading is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are simulated in the water quality model.

For each modeled subwatershed, the 10-year simulation period was used to generate daily mean instream concentrations. These were used to calculate continuous 30-day geometric mean concentrations that were then compared to the target concentration. The 10-year simulation period contained a range of hydrologic conditions that included both low and high streamflows. The 30-day critical period for each subwatershed is the period preceding the highest simulated violation of the geometric mean standard. The magnitude of the highest peak, together with the corresponding simulated flow, represents the existing fecal coliform loading to the waterbody.

The drainage areas of the waterbody segments (Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek) coincided with HUC-12 subwatersheds, water quality monitoring stations, and the outlets (endpoints) of 303(d)-Listed segments. The waterbody segments were at the "pour points" of these subwatersheds. In addition, the pour points coinciding with water quality monitoring stations had sufficient fecal coliform data for water quality calibration. Existing loads and required load reductions were determined on a subwatershed basis for the Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek waterbodies.

The results of the 10-year simulation used to determine existing conditions for Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek are shown in Figures D-6 through D-9, respectively.

D.6 Determination of TMDL

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

For the purposes of these analyses, fecal coliform TMDLs are expressed as the percent reduction in instream loading required to decrease the existing instream 30-day geometric mean concentration (as defined in Section C.5) to the target of 180 counts/100 mL. The required reduction can be determined directly using the following equation:

$$\text{TMDL} = \text{RILR} = \frac{[(C)\ (Q)\ (\text{Const})]_{\text{Existing}} - [(C)\ (Q)\ (\text{Const})]_{\text{Target}}}{[(C)\ (Q)\ (\text{Const})]_{\text{Existing}}} \times 100$$

where: RILR = Required Instream Load Reduction [%]
C = Instream Concentration [counts/100 mL]
Q = Daily Mean Flow [cfs]
Const = Unit Conversion Constant

Since the streamflow for the existing condition is equal to the streamflow for the target condition:

$$\text{TMDL} = \text{RILR} = \frac{(Q)\ (\text{Const})}{(Q)\ (\text{Const})} \times \frac{[C]_{\text{Existing}} - [C]_{\text{Target}}}{[C]_{\text{Existing}}} \times 100$$

therefore:

$$\text{TMDL} = \text{RILR} = \frac{[C]_{\text{Existing}} - [C]_{\text{Target}}}{[C]_{\text{Existing}}} \times 100$$

As an example, for the subwatershed at the pour point of the 303(d)-Listed segment of Chatata Creek, the simulated 30-day geometric mean concentration for the existing loading condition (ref.: Section D.5) is 2461 counts/100 mL. The required instream load reduction is calculated by:

$$\text{TMDL} = \text{RILR} = \frac{(2461 \text{ cts/100 mL}) - (180 \text{ cts/100 mL})}{(2461 \text{ cts/100 mL})} \times 100$$

$$\text{TMDL} = \text{RILR} = 92.7\%$$

Required load reductions are summarized in Table D-2 for modeled subwatersheds.

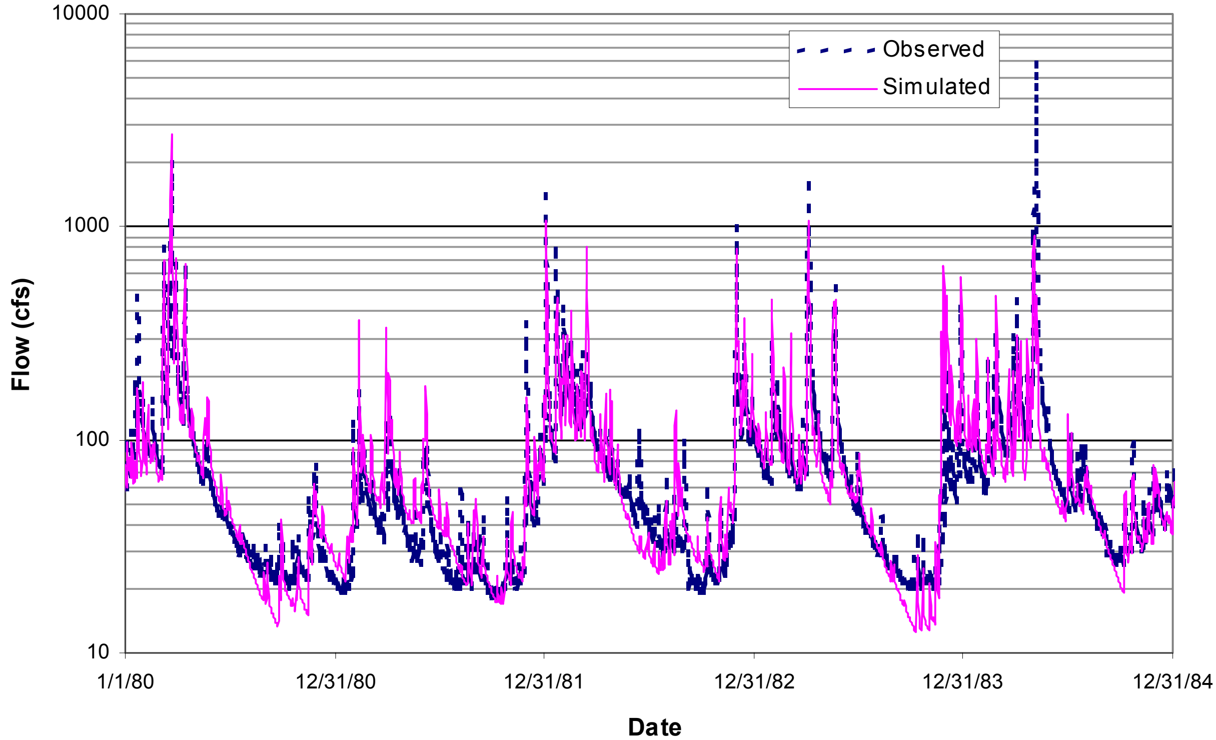
Table D-1. Hydrologic Calibration Summary: Oostanaula Cr. near Sanford (USGS 03565500)

Simulation Name:	OosCAP05		
(Chattanooga Airport Raingage)	Oostanaula Cr. near Sanford (USGS 03565500)	**Watershed Area (ac):**	36480.00
Period for Flow Analysis			
Begin Date:	**01/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/89**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**163.22**	Total Observed In-stream Flow:	**157.99**
Total of highest 10% flows:	**68.93**	Total of Observed highest 10% flows:	**71.81**
Total of lowest 50% flows:	**28.96**	Total of Observed Lowest 50% flows:	**27.01**
Simulated Summer Flow Volume (months 7-9):	**16.63**	Observed Summer Flow Volume (7-9):	**15.35**
Simulated Fall Flow Volume (months 10-12):	**30.75**	Observed Fall Flow Volume (10-12):	**25.59**
Simulated Winter Flow Volume (months 1-3):	**74.61**	Observed Winter Flow Volume (1-3):	**68.62**
Simulated Spring Flow Volume (months 4-6):	**41.23**	Observed Spring Flow Volume (4-6):	**48.43**
Total Simulated Storm Volume:	**130.47**	Total Observed Storm Volume:	**124.96**
Simulated Summer Storm Volume (7-9):	**8.64**	Observed Summer Storm Volume (7-9):	**7.28**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**3.31**	10	
Error in 50% lowest flows:	**7.23**	10	
Error in 10% highest flows:	**-4.01**	15	
Seasonal volume error - Summer:	**8.33**	30	
Seasonal volume error - Fall:	**20.16**	30	
Seasonal volume error - Winter:	**8.73**	30	
Seasonal volume error - Spring:	**-14.86**	30	
Error in storm volumes:	**4.41**	20	

Table D-2. TMDLs for Hiwassee River Waterbodies – Surrogate Fecal Coliform 30-Day Geometric Mean Target

Impaired Waterbody Name	Waterbody ID	Existing Conditions		TMDL - Required Load Reduction
		Date(s) of Max. 30-Day Geom. Mean Concen.	Max. 30-Day Geom. Mean Concentration [cts./100 mL]	[%]
Chatata Creek	TN06020002012 – 1000	11/22/98	2461	92.7
Chestuee Creek	TN06020002082 – 2000	11/22/98	750	75.8
Oostanaula Creek (Mouth)	TN06020002083 – 1000	9/23/96	219	17.8
Oostanaula Creek (Mile 5.7)	TN06020002083 – 2000	9/23/96	252	28.6
Oostanaula Creek (Mile 26.6)	TN06020002083 – 3000	9/22/96	273	34.1
Oostanaula Creek (Mile 34.2)	TN06020002083 – 4000	7/6/03	252	28.6
Oostanaula Creek (Mile 42.7)	TN06020002083 – 5000	NA*	NA*	28.6*
North Mouse Creek	TN06020002084 – 1000	11/23/98	1145	84.3

* No data in impaired waterbody. Percent reduction based on results at Mile 34.2.



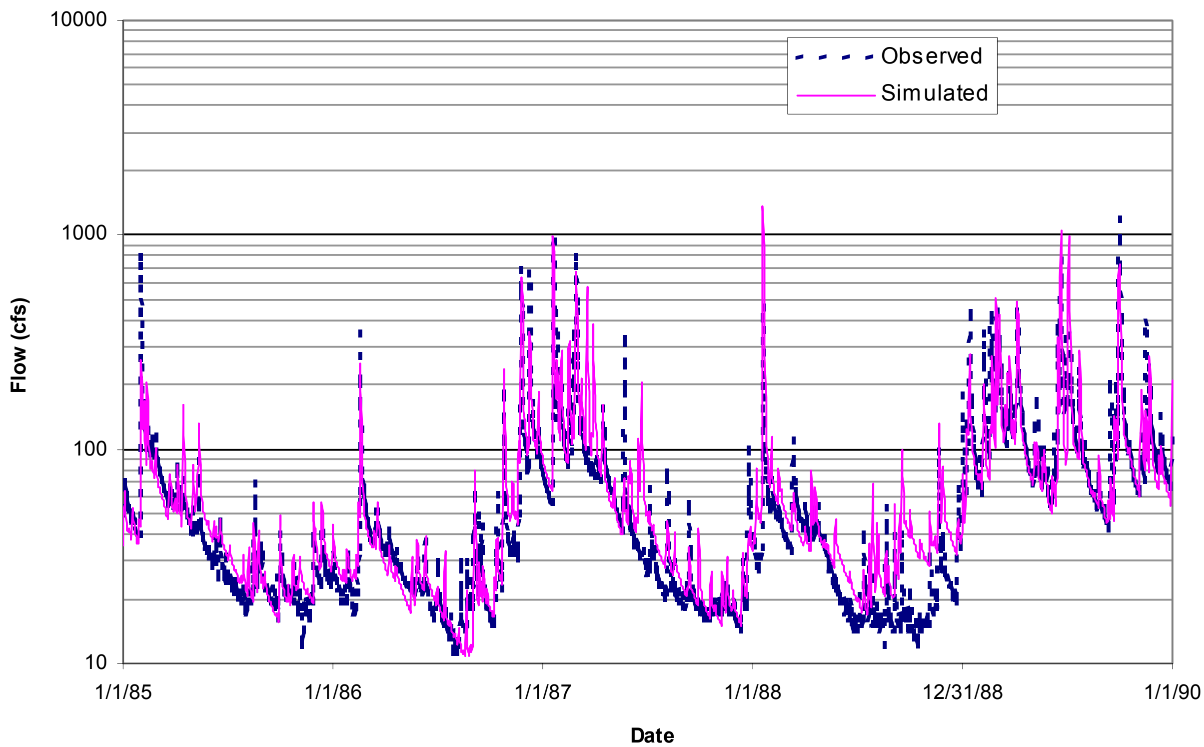


Figure D-1. Hydrologic Calibration: Oostanaula Cr. near Sanford, USGS 03565500 (1980-1989)

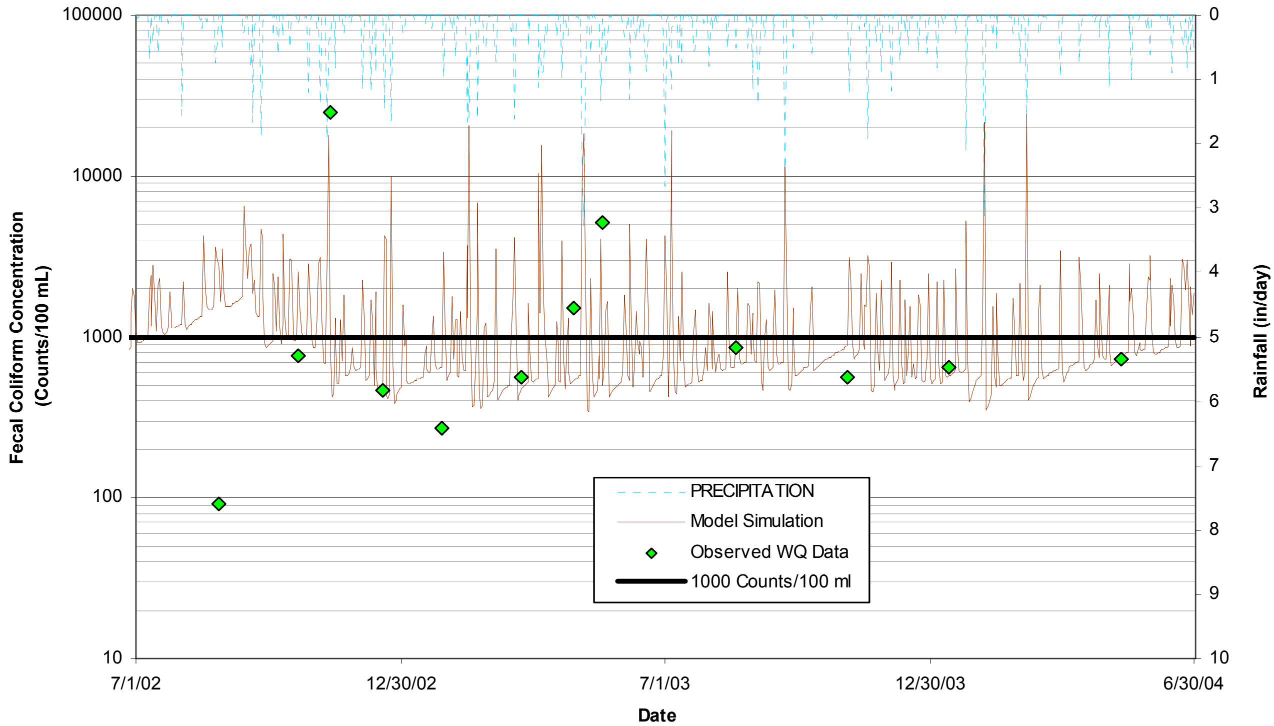


Figure D-2. Water Quality Calibration of Chatata Creek at Mile 0.5 (CHATA000.5BR)

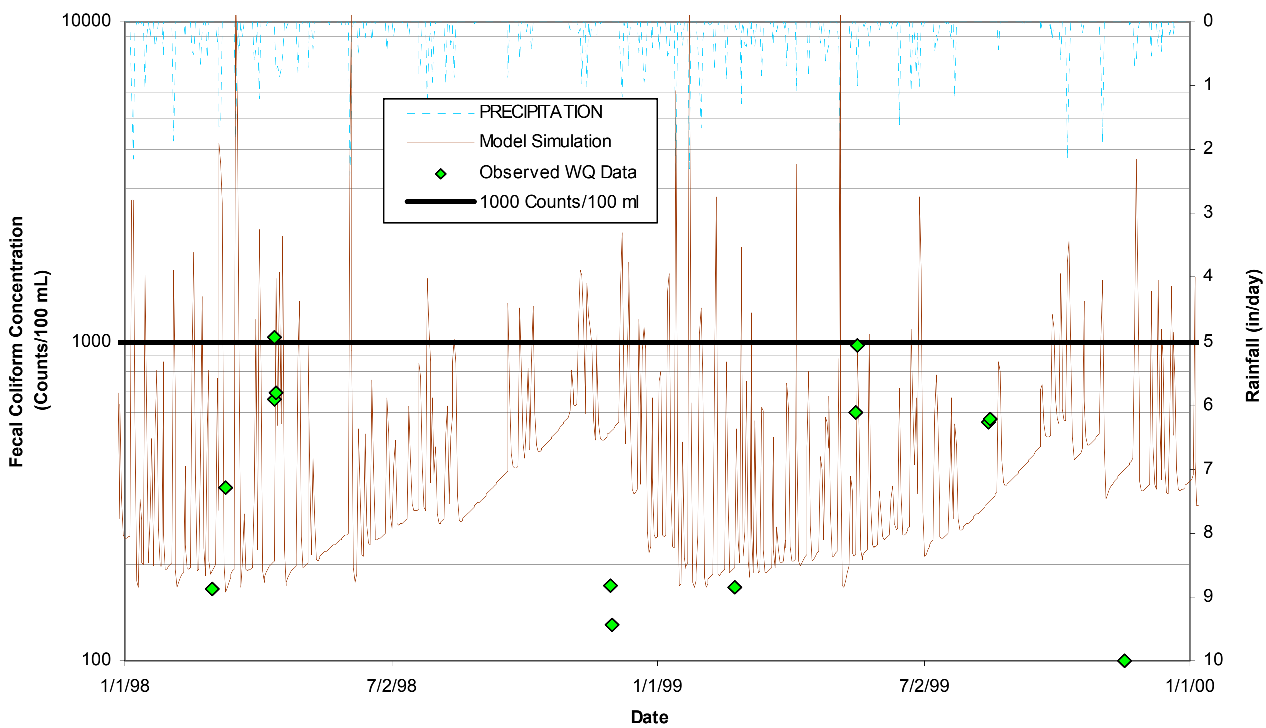


Figure D-3. Water Quality Calibration of Chestuee Creek at Mile 42.5 (CHEST042.5MM)

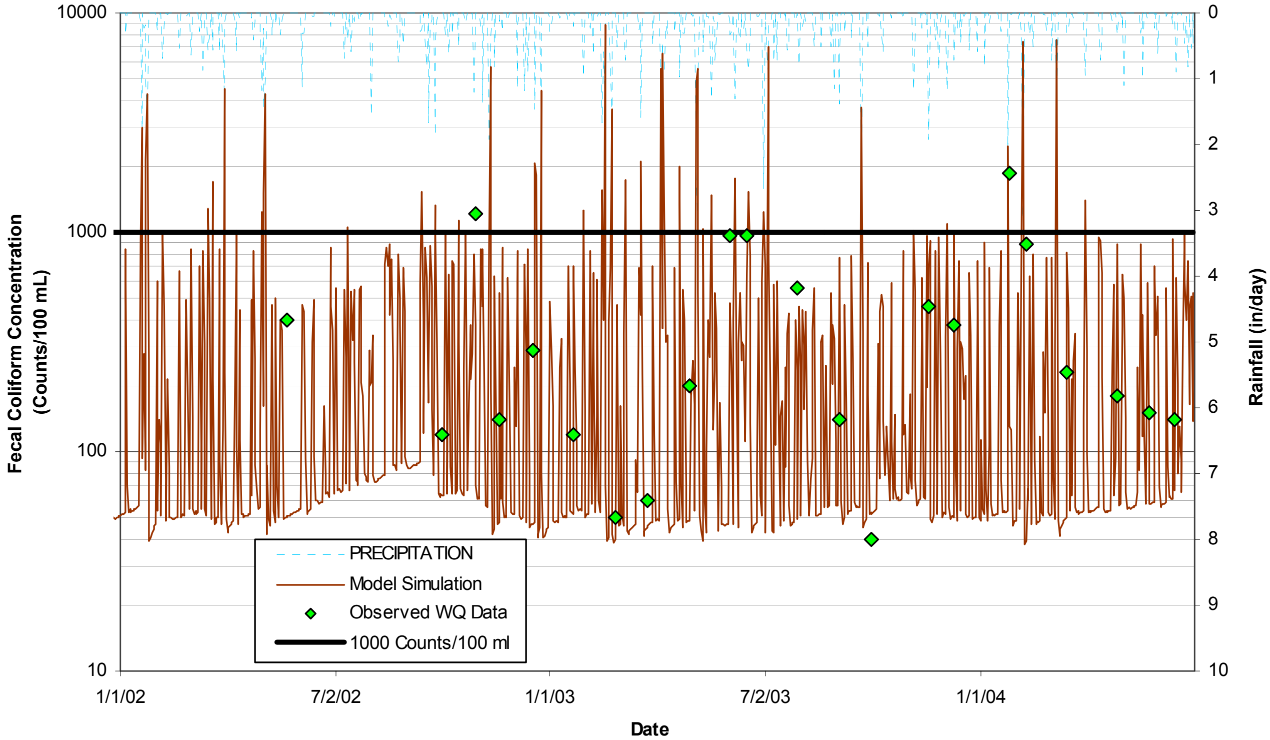


Figure D-4. Water Quality Calibration of Oostanaula Creek at Mile 26.6 (OOSTA026.6MM)

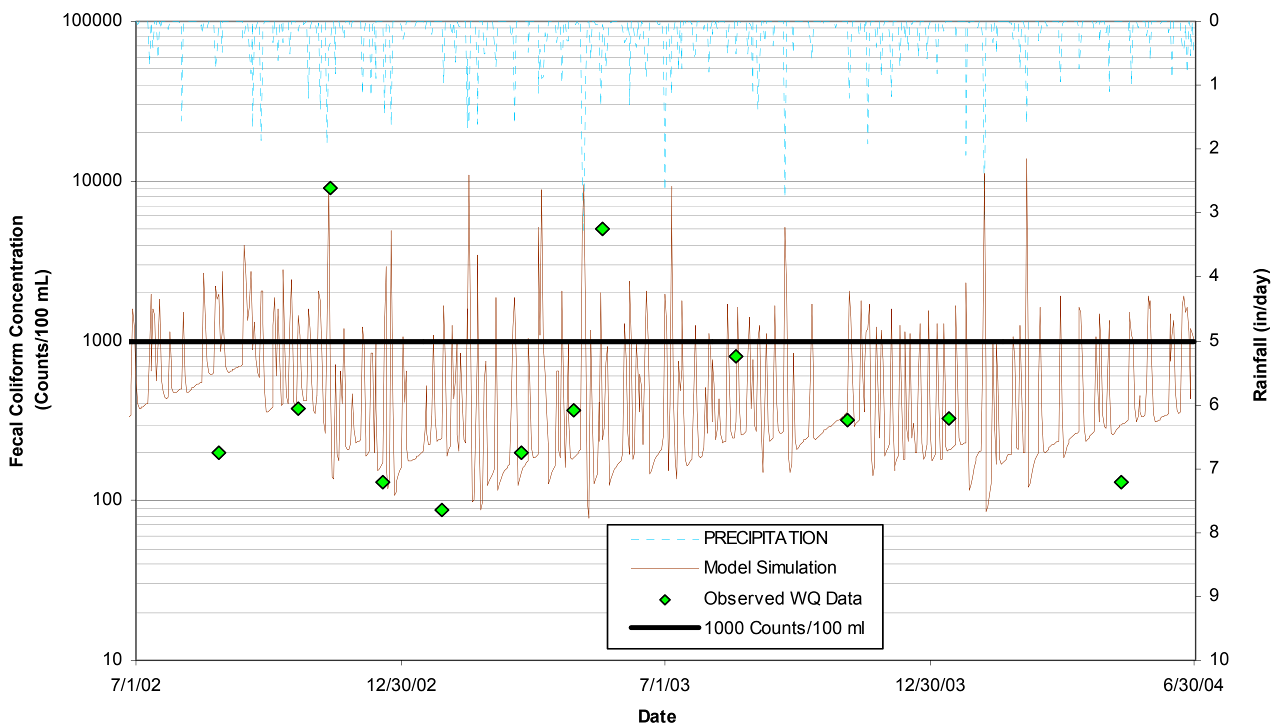


Figure D-5. Water Quality Calibration of North Mouse Creek at Mile 4.2 (NMOUS004.2MM)

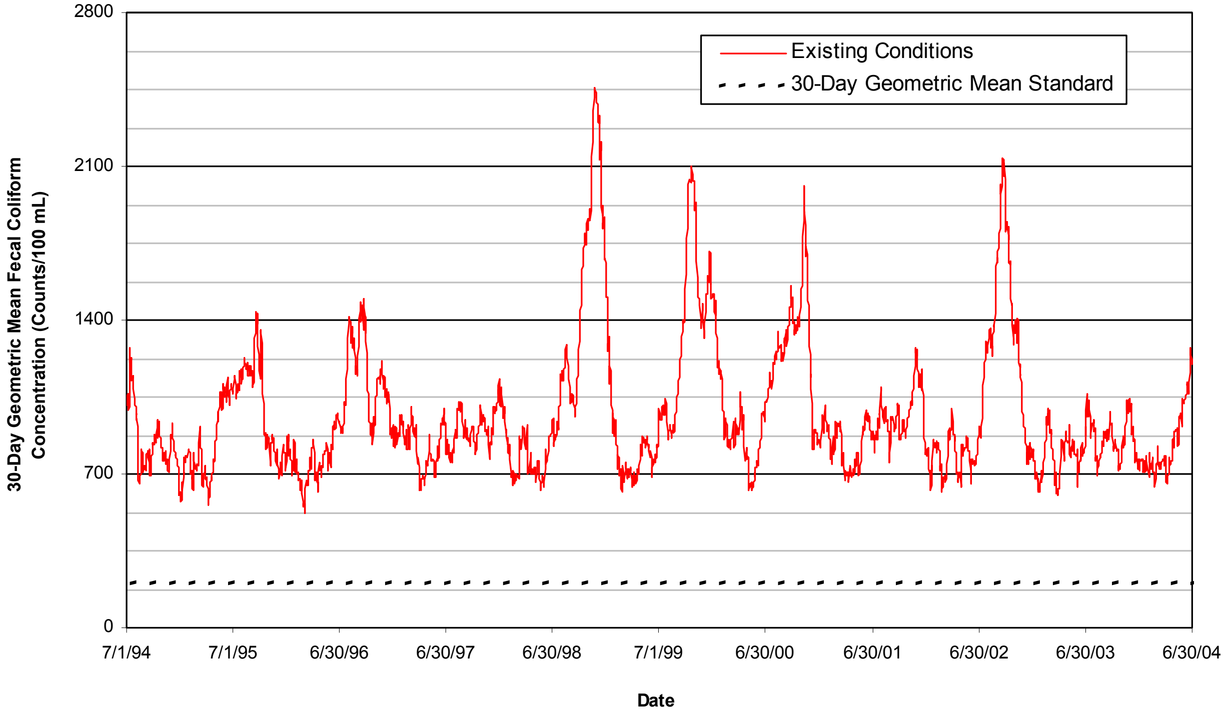


Figure D-6. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Chatata Creek at the Mouth for Existing Conditions.

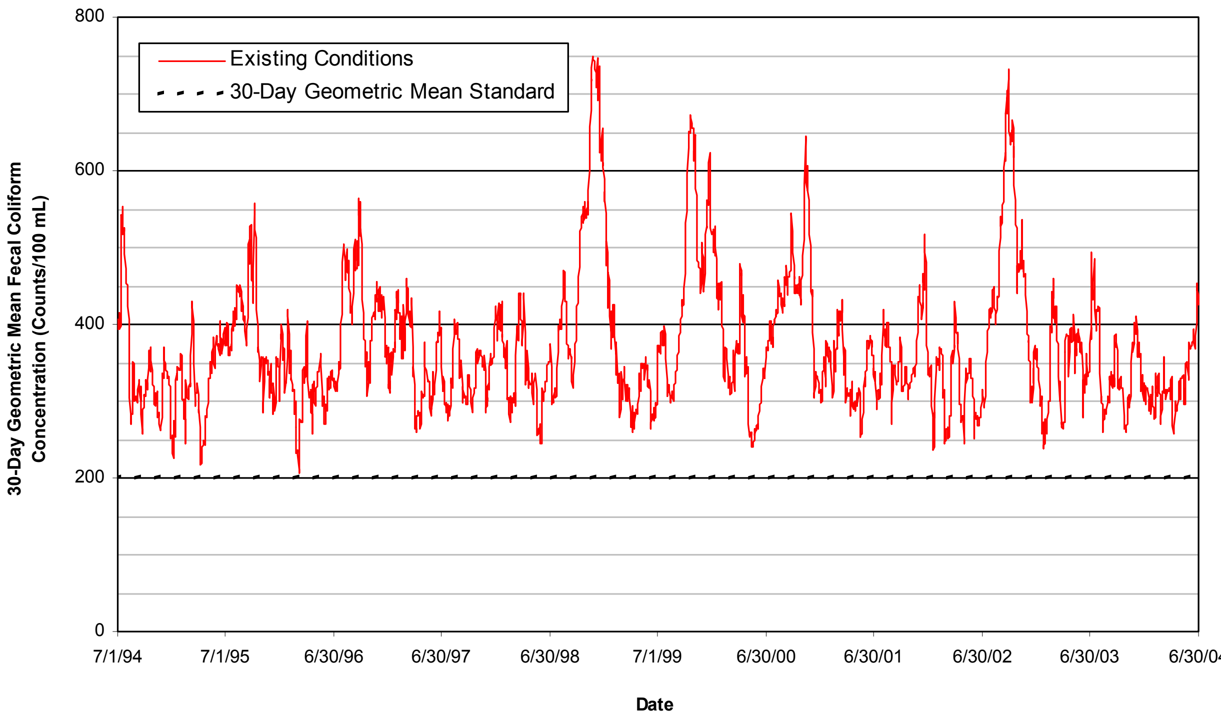


Figure D-7. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Chestuee Creek at the Confluence with Middle Creek for Existing Conditions.

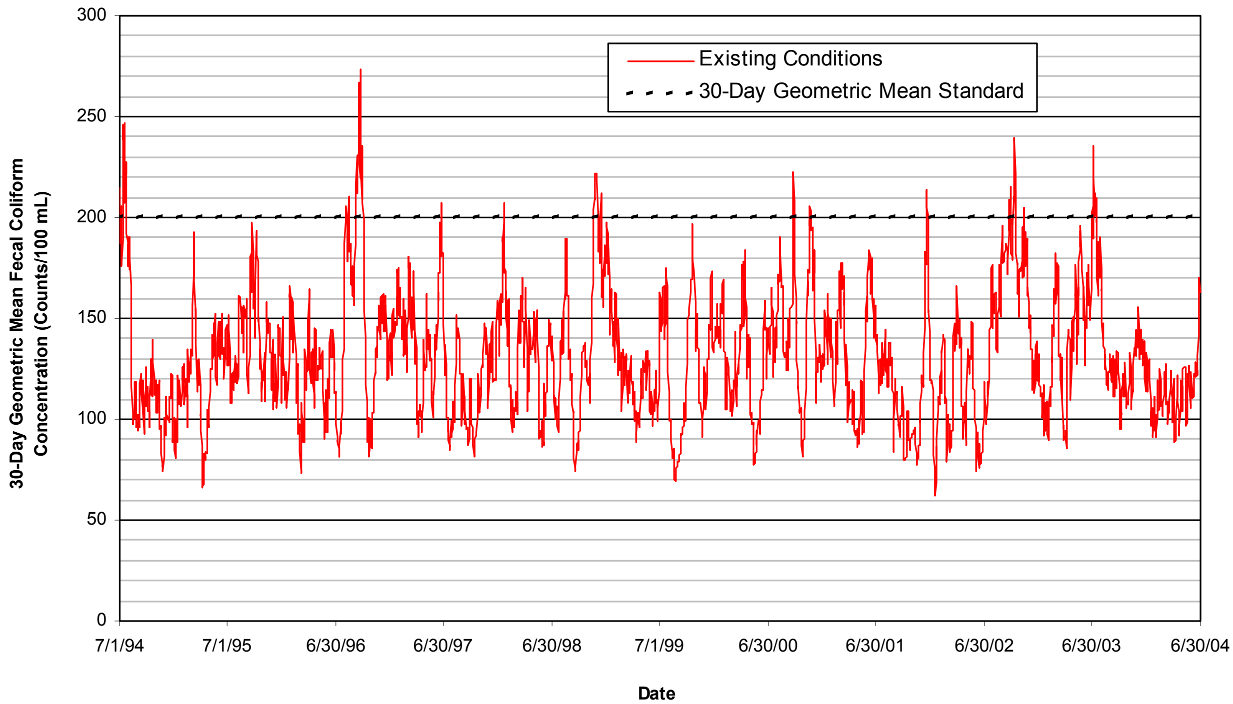


Figure D-8. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Oostanaula Creek at Mile 26.6 for Existing Conditions.

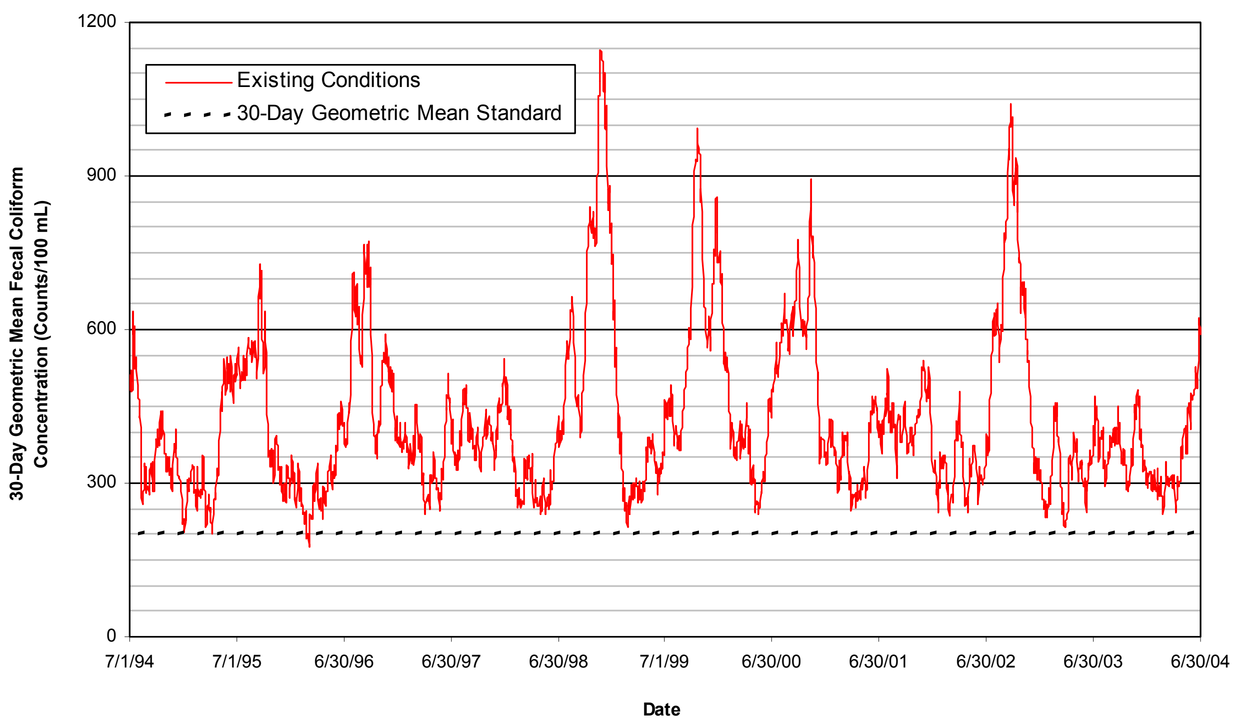


Figure D-9. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for North Mouse Creek at the Mouth for Existing Conditions.

APPENDIX E

Oostanaula Creek TMDL Revisited

REVISED OOSTANAULA CREEK TMDL

TDEC's Division of Water Pollution Control (DWPC) previously developed a fecal coliform TMDL for Oostanaula Creek based on water quality data collected at Mile 28.4 during the period December 1982 through September 1999. USEPA approved the Oostanaula Creek TMDL in May of 2002. The 2002 EPA-approved Fecal Coliform TMDL stated the following: "Fecal coliform grab samples, collected quarterly at the sampling station at mile 28.4 on Oostanaula Creek in the Hiwassee River watershed were used for comparison with the simulated daily model results. Water quality calibration was conducted at mile 28.4 and extended, through model simulation, to the mouth of Oostanaula Creek to complete the TMDL evaluation." The required reduction at mile 28.4, according to the model simulation, was 96.5%. The subsequent reduction of pathogen (fecal coliform) loading to Oostanaula Creek was 98% at the mouth.

Additional pathogen data (E. coli and fecal coliform) collected at mile 28.4 and other monitoring locations on Oostanaula Creek warrants re-examination and revision of the Oostanaula Creek TMDL. Data were collected approximately quarterly for the period 12/82-9/99 for the 2002 EPA-approved Fecal Coliform TMDL at Oostanaula Creek at Mile 28.4. However, nine samples (9/96-9/98) had only sample month and year recorded with sample data because original lab sheets had been misplaced and data spreadsheets did not provide the day of the month these samples were collected. These 9 samples were used in the original analysis, with minimal influence on model results; however, for current Load Duration Curve analysis, the daily flow associated with each sample is critical to the analysis and also was not recorded with the samples. Therefore, these data were not utilized in the current analysis. Data collected after the original TMDL analysis, during the period 12/98-6/04, were used for comparison to the original TMDL (12/82-6/96) by Load Duration Curve analysis (Figure E-1). LDC analysis was chosen because the method provides qualitative and quantitative graphical data representations that are more easily compared than model simulations.

Table E-1 presents the summary results from LDC analyses of historic versus current pathogen data (fecal coliform) at Oostanaula Creek Mile 28.4. Figure E-1 clearly shows significant improvement has been achieved for pathogen loading in Oostanaula Creek. While required load reduction has been reduced from over 95% to approximately 70%, loading has apparently been reduced by nearly an order of magnitude. The numerical results of the LDC analysis are comparable to the previous TMDL model results (EPA-approved TMDL) versus the current TMDL analysis (see Table 8, and Appendices C and D). Complete LDC results are presented in Table C-19 for the current analysis and Table E-2 for the 2002 EPA approved analysis.

Table E-1. Comparison of Fecal Coliform LDC Analyses for Oostanaula Creek Mile 28.4

TMDL Analysis	**2002 EPA-approved**	**Current Analysis (2005)**
Sample Dates	12/82 – 6/96	12/98 – 6/04
Number of Samples	51	32
Number > 1000 Counts/100 mL	28 (54.9%)	6 (18.8%)
90th Percentile (Counts/100 mL) (High Flows)	73,000	6,630
90th Percentile (Counts/100 mL) (Moist Conditions)	27,800	2,384
90th Percentile (Counts/100 mL) (Mid-Range Flows)	13,190	1,260
90th Percentile (Counts/100 mL) (Dry Conditions)	6,990	788
90th Percentile (Counts/100 mL) (Low Flows)	3,770	861
90th Percentile (Counts/100 mL) (All Data)	19,200	2,790
Required Reduction (%)	95.3	67.7

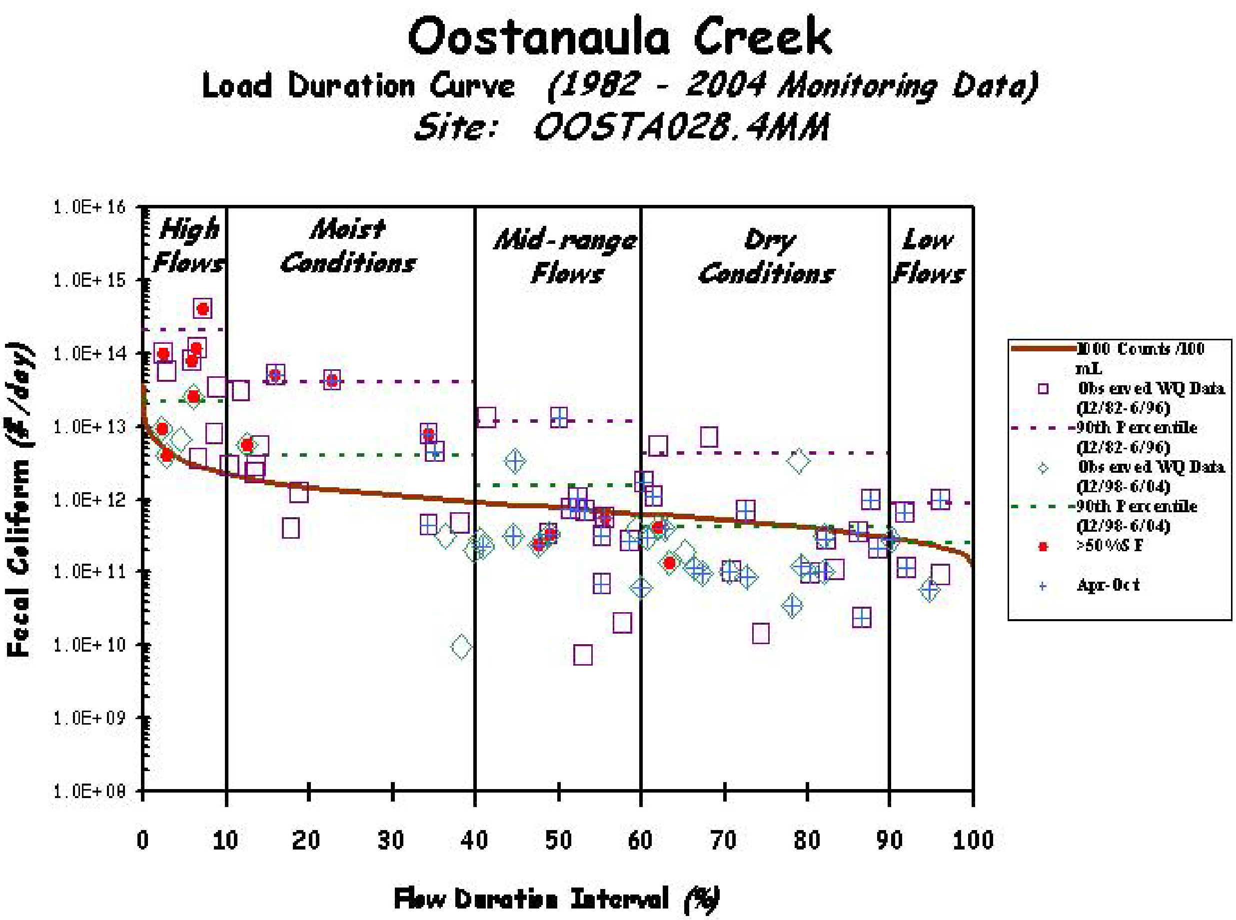


Figure E-1. Oostanaula Creek mile 28.4 historical versus recent fecal coliform monitoring data.

Table E-2. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis (2002 EPA Approved TMDL)

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Conc.	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
12/16/82	209.68	2.451%	**19200**	**95.3**
3/7/89	189.10	2.837%	**12000**	**92.5**
12/4/91	124.70	5.861%	**26000**	**96.5**
3/10/87	116.77	6.496%	**40000**	**97.8**
3/8/83	115.80	6.558%	**1290**	**30.2**
12/9/86	109.30	7.205%	**150000**	**99.4**
12/13/83	98.05	8.512%	**3300**	**72.7**
3/31/93	95.35	8.935%	**14700**	**93.9**
12/12/94	88.31	10.391%	**1320**	**31.8**
3/15/90	81.57	11.685%	**15000**	**94.0**
3/13/95	75.12	13.365%	**1260**	**28.6**
3/18/96	74.26	13.564%	**1600**	**43.8**
3/12/91	73.12	13.925%	**3000**	**70.0**
6/10/92	67.04	15.966%	**31000**	**97.1**
12/11/95	62.98	17.820%	250	**NR**
3/14/94	61.21	18.728%	810	**NR**
6/9/92	54.68	22.598%	**31000**	**97.1**
6/12/95	42.35	34.246%	**7600**	**88.2**
6/7/83	42.24	34.370%	420	**NR**
6/7/89	41.53	35.042%	**4500**	**80.0**
12/9/92	39.19	38.166%	480	**NR**
3/13/84	36.86	41.339%	**14500**	**93.8**
3/12/85	31.84	48.706%	420	**NR**
6/10/96	31.08	50.062%	**17000**	**94.7**
9/13/94	30.40	51.319%	960	**NR**
6/20/94	29.81	52.389%	**1400**	**35.7**
3/15/88	29.54	52.875%	10	**NR**
6/13/90	29.33	53.161%	980	**NR**
6/12/84	28.29	55.189%	100	**NR**
6/11/91	28.25	55.251%	460	**NR**
9/13/88	28.13	55.587%	800	**NR**
12/12/90	27.09	57.554%	30	**NR**
9/15/92	26.50	58.673%	420	**NR**
9/18/95	25.77	60.341%	**2700**	**66.7**

Table E-2. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis (2002 EPA Approved TMDL) (Cont.)

Sample Date	Flow	PDFE	Fecal Coliform Sample Conc.	Fecal Coliform Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
6/9/87	25.28	61.399%	**1730**	**48.0**
12/11/84	25.05	61.996%	**8700**	**89.7**
12/6/93	22.47	67.745%	**12800**	**93.0**
12/13/88	21.06	70.707%	200	**NR**
6/23/93	20.27	72.349%	**1400**	**35.7**
3/11/86	19.45	74.340%	30	**NR**
9/11/84	16.73	80.276%	230	**NR**
6/7/88	15.92	82.068%	720	**NR**
12/10/85	15.42	83.263%	280	**NR**
9/10/91	14.12	86.100%	1000	**NR**
9/15/87	13.96	86.424%	70	**NR**
9/11/90	13.46	87.631%	**3000**	**70.0**
6/18/86	13.08	88.427%	670	**NR**
9/10/85	11.62	91.501%	**2300**	**60.9**
9/23/86	11.48	91.824%	400	**NR**
9/20/83	9.20	95.918%	**4400**	**79.5**
12/8/87	9.13	96.055%	400	**NR**
	90th Percentile (all)		**19200**	**95.3**

APPENDIX F

Determination of WLAs & LAs

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

For pathogen TMDLs in each impaired subwatershed, WLA terms include:

- $[\Sigma WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.

- $[\Sigma WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
  - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
  - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

  Therefore, a WLA of zero has been assigned to this class of facilities.

- $[\Sigma WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events. The percent load reductions for MS4s are considered to be equal to the load reductions developed for TMDLs.

LA terms include:

- $[\Sigma LAs]_{DS}$ is the allowable E. coli load from "other direct sources". These sources include leaking septic systems, leaking collection systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero counts/day (or to the maximum extent practicable).

- $[\Sigma LAs]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events. The percent load reductions for precipitation-induced nonpoint sources are considered to be equal to the load reductions developed for TMDLs (and specified for MS4s).

Explicit MOS has already been incorporated into TMDL development as stated in Appendix C and Appendix E. TMDLs, WLAs, & LAs are applied to the entire subwatershed. WLAs & LAs for Hiwassee River waterbodies are summarized in Table F-1.

Table F-1. WLAs & LAs for Hiwassee River, Tennessee

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Agency Creek (0605)	Agency Creek	TN06020002001 – 0100	**96.0**	**NA[e]**	**NA**	**NA**	**NA**	**96.0**	**0**
0602	Hiwassee River	TN06020002008 – 1000	**65.9**	**1.636 x 10^{11}**	**0**	**NA**	**NA**	**65.9**	**0**
0603	Fillauer Creek	TN06020002009 – 0200	**>92.4**	**NA[e]**	**0**	**NA**	**>85.7**	**>85.7**	**0**
	Woolen Mill Branch	TN06020002009 – 0300		**NA[e]**	**0**	**NA**	**>65.0**	**>65.0**	**0**
	South Mouse Creek	TN06020002009 – 2000		**9.542 x 10^5**	**0**	**NA**	**>92.4**	**>92.4**	**0**
Little Chatata Creek (0601)	Little Chatata Creek	TN06020002012 – 0200	**87.2**	**NA[e]**	**0**	**NA**	**87.2**	**87.2**	**0**
Chatata Creek (0601)	Chatata Creek	TN06020002012 – 1000	**92.7**	**NA[e]**	**0**	**NA**	**92.7**	**92.7**	**0**
Hawkins Branch (0305)	Hawkins Branch	TN06020002018 – 0100	**90.2**	**NA[e]**	**NA**	**NA**	**NA**	**90.2**	**0**
Dairy Branch (0305)	Dairy Branch	TN06020002018 – 0200	**92.9**	**NA[e]**	**NA**	**NA**	**NA**	**92.9**	**0**
0501	Little Chestuee Creek	TN06020002082 – 0200	**89.5**	**NA[e]**	**NA**	**NA**	**NA**	**89.5**	**0**
	Chestuee Creek	TN06020002082 – 2000		**1.193 x 10^9**	**0**	**NA**	**NA**	**87.9**	**0**
0702	Oostanaula Creek	TN06020002083 – 1000	**72.2**	**1.350 x 10^{10}**	**0**	**0**	**NA**	**17.8**	**0**
	Oostanaula Creek	TN06020002083 – 2000		**1.350 x 10^{10}**	**0**	**NA**	**38.4**	**38.4**	**0**
	Oostanaula Creek	TN06020002083 – 3000		**1.350 x 10^{10}**	**0**	**NA**	**72.2**	**72.2**	**0**
0701	Oostanaula Creek	TN06020002083 – 4000	**54.2**	**NA[e]**	**0**	**NA**	**54.2**	**54.2**	**0**
	Oostanaula Creek	TN06020002083 – 5000		**NA[e]**	**NA**	**NA**	**NA**	**54.2**	**0**

Table F-1. WLAs & LAs for Hiwassee River, Tennessee (Cont.)

HUC-12 Subwatershed (06020002__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0801	North Mouse Creek	TN06020002084 – 1000	**84.3**	**2.018×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0802	North Mouse Creek	TN06020002084 – 1000	**84.3**	**7.839×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0803	Spring Creek	TN06020002085 – 1000	**87.8**	**8.109×10^7**	**NA**	**NA**	**NA**	**87.8**	**0**
0604	Rogers Creek	TN06020002087 – 1000	**90.0**	**5.735×10^7**	**NA**	**NA**	**NA**	**90.0**	**0**
Price Creek (0605)	Price Creek	TN06020002088 – 1000	**81.9**	**5.247×10^9**	**0**	**NA**	**NA**	**81.9**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed.

d. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

e. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

APPENDIX G

Public Notice of Proposed Total Maximum Daily Load (TMDL) for Pathogens in the Hiwassee River Watershed (HUC 06020002)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN THE HIWASSEE RIVER WATERSHED (HUC 06020002), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for pathogens in the Hiwassee River watershed, located in southeastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

Twenty (20) waterbodies, listed on Tennessee's Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of E. coli from municipal point sources, collection system failures, pasture grazing, and illicit connections to storm sewers, are addressed in the TMDL. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in the Hiwassee River watershed, and a calibrated dynamic water quality model to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions on the order of 54% - 96% for the impaired waterbodies.

The proposed Hiwassee River pathogen TMDL document can be downloaded from the following website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Dennis M. Borders, P.E., Watershed Management Section
Telephone: 615-532-0706

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than December 26, 2005 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 7th Floor L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.