Report on Nutrient Synoptic Surveys in the Upper Monocacy River Watershed, Frederick County, Maryland, April 2004 as part of the Watershed Restoration Action Strategy.

Maryland Department of Natural Resources
Watershed Services
Landscape and Watershed Analysis
Management Studies
December, 2004

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Acknowledgements

This work was supported by the 2004 319(h) grant from U.S. Environmental Protection Agency # C9-00-3497-02-0.

This work supports Department of Natural Resources Outcomes –
#2 Healthy Maryland watershed lands, streams, and non-tidal rivers.
#3 A natural resources stewardship ethic for Marylanders.
#4 Vibrant local communities in balance with natural systems.

Cover photo: Fishing Creek off Mountaindale Rd. by Niles Primrose

Comments or questions about this report can be directed to :
Niles L. Primrose
MD Dept of Natural Resources
Watershed Services
Landscape and Watershed Analysis
Management Studies.

nprimrose@dnr.state.md.us
410-260-8804

Executive Summary

A nutrient synoptic survey was conducted during April, 2004 in the Upper Monocacy watershed as part of the Upper Monocacy WRAS. Samples were analyzed from 105 sites throughout the watershed. Nitrate/nitrite concentrations were found to be excessive in eleven subwatersheds, high in seven, moderately elevated in twenty-six others, and baseline in the remaining sixty-one subwatersheds. Instantaneous nitrate/nitrite yields were found to be excessive in twenty-eight subwatersheds, high in nineteen, moderate in twenty, and baseline in the remaining 37. Excessive concentrations of orthophosphate were found in twenty-one subwatersheds, high concentrations in thirteen, moderate concentrations in thirty, and the remaining forty below baseline. Orthophosphate yields were found to be excessive in two subwatersheds, high in one subwatershed, moderate in eleven, and baseline in the remaining ninety. The majority of the elevated nitrate/nitrite concentrations and/or yields appear to be associated with animal and row crop agriculture in the Glade Creek, Tuscarora Creek, Hunting Creek and Owens Creek watersheds. The elevated orthophosphate concentrations and yields were concentrated in the Monacacy flood plain and appear to be associated with phosphorus rich soils in systems that had fine suspended sediment loads lingering in the water column. No anomalies were found in the insitu measurements of dissolved oxygen, or temperature. Fifteen subwatersheds had relatively high conductivity (>300mmhos/cm) typical of limestone influence. Two subwatersheds had extremely high conductivity (> 800 mmhos/cm) that did not appear to be associated with the local limestone geology. Thirteen subwatersheds in the Fishing Creek drainage had extremely low conductivity (<50 mmohs/cm) indicative of streams susceptible to acid deposition degradation. Elevated pH values generally followed the high conductivity due to the buffering characteristics of limestone. Depressed ph values (<6.5) followed the low conductivity indicative of the low buffering capacity of these streams.

Table of Contents

List of Tables Page

List of Figures

Introduction

A nutrient synoptic survey was conducted during April, 2004 in the Upper Monocacy watershed as part of the Upper Monocacy Watershed Restoration Action Strategy.

Nutrient synoptic sampling was scheduled for early spring to coincide with the period of maximum nitrogen concentrations in the free flowing fresh water streams. The major proportion of the nitrogen compounds are carried dissolved in the ground water rather than in surface runoff. The higher nitrogen concentrations in the late winter and early spring reflect the higher proportion of nitrogen rich shallow ground water present in the base flow at this time of year. Nitrogen concentrations are reduced in summer as the proportion of shallow ground water is reduced through plant uptake, and replaced by deeper ground water that may have lower nitrate concentrations, or has been denitrified through interaction with anoxic conditions in the soils below the streambed. Point sources can also contribute to in stream nitrate concentrations.

Orthophosphate is generally transported bound to suspended sediments in the water column. In stream orthophosphate concentrations can also be produced through mobilization of sediment bound phosphorus in anoxic water column and/or sediment conditions, sediment in surface runoff from areas having had surface applied phosphorus, ground water from phosphorus saturated soils, and point source discharges.

Ranges used for nutrient concentrations and yields (Table 1) were derived from work done by Frink (1991). The low end values are based on estimated nutrient exports from forested watersheds, and the high end values are based on estimated nutrient exports from intensively agricultural watersheds. As an additional benchmark, the Chesapeake Bay Program uses 1 mg/L total nitrogen as a threshold for indicating anthropogenic impact. The dissolved nitrogen fraction looked at in these synoptic surveys constitutes approximately 50% to 70% of the total nitrogen.

Table 1. Nutrient Ranges and Rating

Rating	NO2+NO3 Concentration mg/L	NO2+NO3 Yield Kg/ha/day	PO4 Concentration mg/L	PO4 Yield Kg/ha/day
Baseline	<1	<.01	<.005	<.0005
Moderate	1 to 3	.01 to .02	.005 to .01	.0005 to .001
High	3 to 5	.02 to .03	.01 to .015	.001 to .002
Excessive	>5	>.03	>.015	>.002

A Note of Caution

Estimates of annual dissolved nitrogen loads/yields from spring samples will result in inflated load estimates, but the relative contributions of subwatersheds should remain reasonably stable. More accurate nitrate/nitrite load/yield estimates need to include sampling during the growing season to account for potential lower concentrations and discharges. Storm flows can also significantly impact loads delivered to a watershed outlet.

The tendency of orthophosphate to be transported bound to sediments makes any estimates of annual orthophosphate loads/yields derived from base flow conditions very conservative. More accurate estimates of orthophosphate loads/yields in a watershed must include samples from storm flows that carry the vast majority of the sediment load of a watershed. Residual suspended sediments from recent rains, or instream activities of livestock or construction can produce apparently elevated orthophosphate concentrations and yields at base flow.

METHODS

Water Chemistry Sampling

Synoptic water chemistry samples were collected in early spring throughout the watershed. Sampling was halted for a minimum of 24 hours after rainfall events totaling more than .25 inches. Grab samples of whole water (500 ml) were collected just below the water surface at mid-stream and filtered using a 0.45 micron pore size (Gelman GF/C) filter. The samples were stored on ice and frozen on the day of collection. Filtered samples were analyzed by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory (CBL) for dissolved inorganic nitrogen (NO_3, NO_2), and dissolved inorganic phosphorus (PO_4). All analyses were conducted in accordance with U.S. Environmental Protection Agency (EPA) protocols. Stream discharge measurements were taken at the time of all water chemistry samples. Water temperature, dissolved oxygen, pH, and conductivity were measured in the field with a Hydrolab Surveyor II at selected sites at the time of water quality collections. Watershed areas used to calculate nutrient yields per unit area were determined from a digitized watershed map using Arcview software.

Where sites are nested in a watershed the mapped concentration data for the downstream site is shown only for the area between the sites. Yield calculations for a downstream site are based on the entire area upstream of the site, but are mapped showing just the area between sites. The downstream sites therefore illustrate the cumulative impact from all upstream activities.

Results

A nutrient synoptic survey was conducted during April, 2004 in the Upper Monocacy watershed as part of the Upper Monocacy WRAS. Samples were collected at 105 sites throughout the watershed. The sample from one site was lost in transit to the laboratory. While all sampling was conducted in Frederick County, some of the streams sampled drained portions of Adams County Pennsylvania. Station locations are listed in Table 2 and mapped in Figure 1. The nutrient concentration and yield data is shown in Table 3.

Nitrate/nitrite concentrations were found to be excessive in eleven subwatersheds, high in seven, moderately elevated in twenty-six others, and baseline in the remaining sixty-one subwatersheds (Figure 2). Instantaneous nitrate/nitrite yields were found to be excessive in twenty-eight subwatersheds, high in nineteen, moderate in twenty, and baseline in the remaining 37 (Figure 3). Excessive concentrations of orthophosphate were found in twenty-one subwatersheds, high concentrations in thirteen, moderate concentrations in thirty, and the remaining forty below baseline (Figure 4). Orthophosphate yields were found to be excessive in two subwatersheds, high in one subwatershed, moderate in eleven, and baseline in the remaining ninety (Figure 5). No anomalies were found in the insitu measurements of dissolved oxygen, or temperature (Table 4). Fifteen subwatersheds had relatively high conductivity (>300mmhos/cm) typical of limestone influence (Figure 6). Two subwatersheds had extremely high conductivity (> 800 mmhos/cm) that did not appear to be associated with the local limestone geology. Thirteen subwatersheds in the Fishing Creek drainage had extremely low conductivity (<50 mmohs/cm) indicative of streams susceptible to acid deposition degradation. Elevated pH values generally followed the high conductivity due to the buffering capacity of limestone influenced water (Figure 7).

Additional testing was done in the two subwatersheds (97, 98) with extremely high conductivity and elevated nitrate/nitrite concentrations. Samples were collected at four sites within number 97 and two sites in number 98 (Figure 8). The samples were tested for presence of optical brighteners, an additive of clothes detergents, and fluoride an additive of drinking water. The results shown in Table 5 indicate that brighteners were present, but fluoride was undetectable at a .5 mg/L minimum concentration.

Table 2. Upper Monocacy WRAS Nutrient Synoptic Sampling Locations
(UT = unnamed tributary)

Site	Location	date	lat	long
UM 0	Glade Cr at Retreat Rd	19-Apr-04	39.47689	77.38310
UM 1	Glade Cr at Fountain Rock Rd	19-Apr-04	39.47589	77.37204
UM 2	Dublin Br at Biggs Ford Rd	19-Apr-04	39.48145	77.37070
UM 3	Glade Cr at Pennsylvania Ave	19-Apr-04	39.48477	77.35941
UM 5	Glade Cr at Heritage Farm Park	19-Apr-04	39.49933	77.35204
UM 7	Glade Cr at Glade Rd	19-Apr-04	39.51688	77.33718
UM 8	Broad Rn at Geisbert Rd	19-Apr-04	39.54877	77.35185
UM 9	Broad Rn at Rt 550	19-Apr-04	39.55446	77.33749
UM 10	UT to Monocacy at Legore Rd	19-Apr-04	39.57981	77.30187
UM 11	UT to Monocacy at Hiney Rd	19-Apr-04	39.57981	77.30187
UM 12	UT to Monocacy at Detour Rd	19-Apr-04	39.58163	77.28689
UM 13	Cattail Br at Bridgeport Rd	19-Apr-04	39.67476	77.24523
UM 14	Cattail Br at Bolinger School Rd	19-Apr-04	39.69913	77.26096
UM 15	UT to Cattail Br at Bolinger School Rd	19-Apr-04	39.69641	77.27253
UM 16	UT to Monocacy at Bridgeport Rd	19-Apr-04	39.67211	77.26379
UM 18	Toms Cr at Sixes Rd	19-Apr-04	39.63992	77.28152
UM 19	Toms Cr at Four Points Rd	20-Apr-04	39.67136	77.30074
UM 20	Middle Cr at Rt 140	20-Apr-04	39.69970	77.29681
UM 21	Flats Rn at Rt 15	20-Apr-04	39.70006	77.31534
UM 22	Toms Cr at Rt 15	20-Apr-04	39.69417	77.32363
UM 22	Flats Rn at Seton Ave	20-Apr-04	39.70879	77.32147
UM 24	Flats Rn at Irishtown Rd	20-Apr-04	39.71840	77.32739
UM 26	Toms Cr at Annandale Rd	20-Apr-04	39.70370	77.34485
UM 27	Turkey Cr at Annandale Rd	20-Apr-04	39.70346	77.35364

UM 28	Turkey Cr at Hampton Valley Rd	20-Apr-04	39.70035	77.37373
UM 29	Stony Rn at Bolinger Rd	19-Apr-04	39.65421	77.31210
UM 30	Stony Rn at Old Frederick Rd	19-Apr-04	39.66990	77.33734
UM 31	Owens Cr at Longs Mill Rd	21-Apr-04	39.58551	77.33524
UM 32	UT to Owens Cr at Longs Mill Rd	21-Apr-04	39.58551	77.33524
UM 33	Owens Cr at Old Frederick Rd	21-Apr-04	39.60806	77.35193
UM 34	Beaver Br at Rt 77	21-Apr-04	39.60587	77.33064
UM 35	Beaver Br at Appolds Rd	21-Apr-04	39.62394	77.33257
UM 36	Beaver Br at Old Frederick Rd	21-Apr-04	39.64515	77.34443
UM 37	Beaver Br at Old Kiln Rd	21-Apr-04	39.66077	77.35454
UM 38	UT to Owens Cr at Old Frederick Rd	21-Apr-04	39.60785	77.35190
UM 39	UT to Owens Cr at Rt 77	21-Apr-04	39.61120	77.33866
UM 40	Owens Cr at Apple Church Rd	21-Apr-04	39.63064	77.37136
UM 41	UT to Owens Cr at Apple Church Rd	21-Apr-04	39.63064	77.37136
UM 42	Owens Cr at Roddy Rd	21-Apr-04	39.64108	77.39407
UM 43	Little Owens Cr at Old Kiln Rd	20-Apr-04	39.64949	77.38619
UM 44	Little Owens Cr at Kelbaugh Rd	20-Apr-04	39.66784	77.38150
UM 45	Creagers Br at Longs Mill Rd	21-Apr-04	39.58216	77.35171
UM 47	Hunting Cr off Shiprock Rd	29-Apr-04	39.55186	77.36179
UM 49	Sandy Rn at ANgleberger Rd	28-Apr-04	39.55841	77.39016
UM 50	Sandy Rn at Hesong Br Rd	28-Apr-04	39.55293	77.41705
UM 51	Little Hunting Cr at Wilhyde Rd	28-Apr-04	39.56516	77.38790
UM 52	Hunting Cr at Wilhyde Rd	28-Apr-04	39.56516	77.38790
UM 53	Little Hunting Cr at Hessong Bridge Rd	28-Apr-04	39.56481	77.41415
UM 54	Litle Hunting Cr at Blacks Mill Rd	28-Apr-04	39.57199	77.42469
UM 55	UT to Hunting Cr at Rt 15 (north)	28-Apr-04	39.56606	77.43230
UM 56	UT to Hunting Cr at Rt 15 (south)	28-Apr-04	39.56148	77.43110
UM 57	Buzzard Br at Catoctin Hollow Rd	27-Apr-04	39.58560	77.46302
UM 58	Little Hunting Cr at Catoctin Hollow Rd	27-Apr-04	39.58560	77.46302
UM 59	Graceham Rn at Layman Rd	28-Apr-04	39.59389	77.39626
UM 60	Hunting Cr at Layman Rd	28-Apr-04	39.59389	77.39626
UM 61	UT to Hunting Cr at Moser Rd	28-Apr-04	39.60385	77.39910
UM 62	Hunting Cr at Moser Rd	28-Apr-04	39.61248	77.40954
UM 63	High Rn at Pryor Rd	28-Apr-04	39.60715	77.47115
UM 64	Muddy Rn at Brice Rd	28-Apr-04	39.59669	77.42142
UM 65	Fishing Cr at Devilbiss Rd	29-Apr-04	39.50795	77.38173
UM 66	Fishing Cr at Lenhart Rd	29-Apr-04	39.52177	77.38592
UM 67	UT to Fishing Cr at Utica Rd	28-Apr-04	39.52781	77.40240
UM 68	Fishing Cr at Lewistown Rd	28-Apr-04	39.53543	77.40614
UM 69	Fishing Cr at Rt 15	29-Apr-04	39.53431	77.42348
UM 70	Muddy Rn ar Rt 15	22-Apr-04	39.48972	77.39827
UM 71	Muddy Rn at Bartgis Rd	22-Apr-04	39.49385	77.41488
UM 72	Tuscarora Cr at Island Pkwy	22-Apr-04	39.45813	77.38810
UM 74	Tuscarora Cr at Willowbrook Rd	22-Apr-04	39.97113	77.41264
UM 75	Little Tuscarora Cr at Willowbrook Rd	22-Apr-04	39.97113	77.41264
UM 76	Tuscarora Cr at Opossumtown Pike	22-Apr-04	39.49136	77.43134
UM 77	Whiterock Rn at Opossumtown Pike	22-Feb-04	39.49136	77.43134

UM 78	UT to Tuscarora Cr at Bethel Rd	22-Apr-04	39.49991	77.44783
UM 79	Tuscarora Cr at Putman Rd	22-Apr-04	39.50308	77.44250
UM 81	Fishing Cr at Putman Rd	27-Apr-04	39.52000	77.45273
UM 84	Little Fishing Cr at Mountaindale Rd	27-Apr-04	39.52845	77.46819
UM 85	Fishing Cr off Mountaindale Rd	27-Apr-04	39.52845	77.46819
UM 86	UT to Fishing Cr at Fishing Cr Rd	27-Apr-04	39.53506	77.48076
UM 87	UT to Fishing cr at Delauter Rd	27-Apr-04	39.54405	77.48035
UM 88	Fishing Cr at Delauter Rd	27-Apr-04	39.54405	77.48035
UM 89	Clifford Br at Bethel Rd	27-Apr-04	39.48317	77.45802
UM 90	Whiterock Rn at Pear LA	27-Apr-04	39.49082	77.44187
UM 91	UT to Clifford Br off Hamburg Rd	27-Apr-04	39.49028	77.47363
UM 92	Clifford Br off HAmburg Rd	27-Apr-04	39.49028	77.47363
UM 93	Little Tuscarora Cr at Martz Rd	22-Apr-04	39.46996	77.43154
UM 94	Little Tuscarora Cr at Yellow Springs Rd	22-Apr-04	39.46531	77.44937
UM 95	UT to Little Tuscarora Cr at Rock Springs Rd	22-Apr-04	39.45961	77.46114
UM 96	UT to Little Tuscarora Cr at White Flint Dr	22-Apr-04	39.47211	77.45568
UM 97	UT to Monocacy at MArket St	22-Apr-04	39.44321	77.39529
UM 98	UT to Monocacy at Market St	22-Apr-04	39.43925	77.39841
UM 100	Hunting Cr off Catoctin Hollow Rd	27-Apr-04	39.61955	77.46657
UM 101	Hauver Br at Park rd	27-Apr-04	39.62876	77.46291
UM 102	St MAry's Rn at Rt 15	20-Apr-04	39.69417	77.32363
UM 103	Owens Cr off Rt 550	28-Apr-04	39.64927	77.42573
UM 104	UT to Owens Cr at Tylers Valley Rd	28-Apr-04	39.65813	77.44270
UM 105	UT to Owens Cr at Raven Rock Rd	28-Apr-04	39.67678	77.47115
UM 106	Owens Cr at Raven Rock Rd	28-Apr-04	39.67678	77.47115
UM 107	Owens Cr off Rt 550	28-Apr-04	39.66547	77.45042
UM 108	Friends Cr at Hornets Nest rd	20-Apr-04	39.71729	77.39253
UM 109	Friends Cr at Friends Cr Rd	20-Apr-04	39.70950	77.42432
UM 110	UT to Friends Cr at Friends Cr Rd	20-Apr-04	39.70950	77.42432
UM 111	UT to Friends Cr at Sabillisville Rd	20-Apr-04	39.68981	77.45293
UM 114	UT to Friends Cr at Harbaugh Valley Rd	20-Apr-04	39.70111	77.45399
UM 113	UT toFriends Cr at Harbaugh Rd	20-Apr-04	39.71438	77.43724
UM 112	UT to Friends at Harbaugh rd	20-Apr-04	39.71817	77.43135
UM 118	Muddy Cr at Masser Rd	27-Apr-04	39.50473	77.42766
UM 119	UT to Muddy at Masser Rd	27-Apr-04	39.50668	77.42445

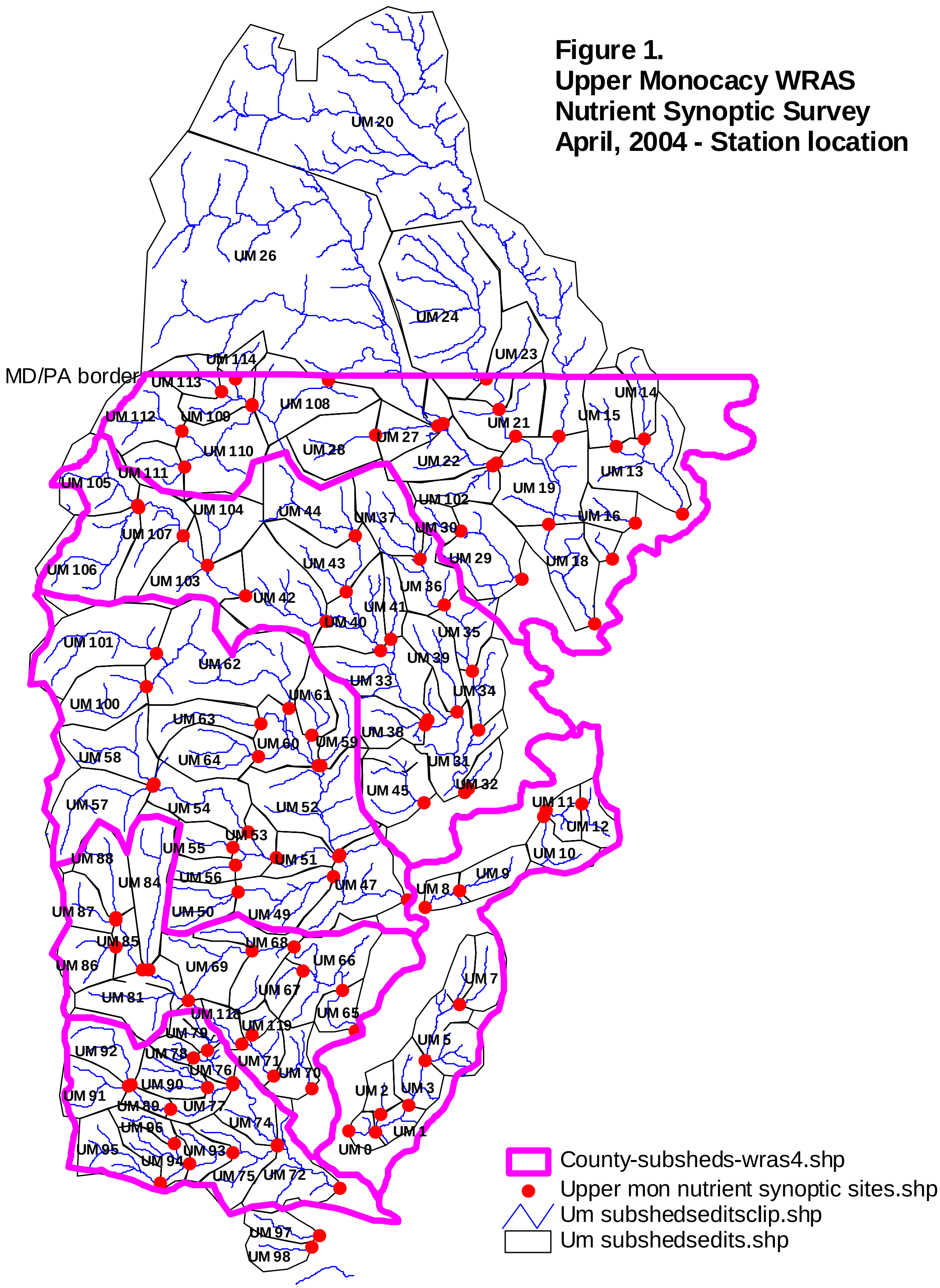

**Figure 1.
Upper Monocacy WRAS
Nutrient Synoptic Survey
April, 2004 - Station location**

Table 3. Upper Monocay WRAS Nutrient Synoptic Results

Site	Date	Area Hect	L/sec	PO4 mg/L	NO23 mg/L	PO4/k/h/d	NO23/k/h/d
UM 0	04/19/04	1764	388	0.004	8.01	0.000076	0.152299
UM 1	04/19/04	1650	349	0.004	6.70	0.000073	0.122418
UM 2	04/19/04	170	3	0.007	3.91	0.000009	0.005044
UM 3	04/19/04	1319	132	0.009	7.94	0.000078	0.068605
UM 5	04/19/04	713	133	0.017	8.19	0.000274	0.132055
UM 7	04/19/04	299	80	0.004	8.57	0.000093	0.198796
UM 8	04/19/04	463	42	0.102	6.53	0.000800	0.051226
UM 9	04/19/04	314	28	0.087	8.14	0.000664	0.062157
UM 10	04/19/04	299	41	0.073	6.58	0.000854	0.076998
UM 11	04/19/04	407	31	0.044	4.64	0.000291	0.030396
UM 12	04/19/04	220	18	0.312	5.61	0.002233	0.040159
UM 13	04/19/04	1518	76	0.037	3.76	0.000161	0.016320
UM 14	04/19/04	294	40	0.079	6.01	0.000937	0.071248
UM 15	04/19/04	434	5	0.050	4.52	0.000048	0.004321
UM 16	04/19/04	260	9	0.054	4.20	0.000156	0.012109
UM 18	04/19/04	22915	5028	0.009	0.75	0.000171	0.014219
UM 19	04/20/04	22308	5154	0.010	0.76	0.000200	0.015172
UM 20	04/20/04	6652	1203	0.002	0.67	0.000031	0.010471
UM 21	04/20/04	3045	259	0.003	0.01	0.000022	0.000074
UM 22	04/20/04	11657	3219	0.004	0.80	0.000095	0.019089
UM 23	04/20/04	2485	165	0.004	0.01	0.000023	0.000057
UM 24	04/20/04	1973	103	0.003	0.01	0.000014	0.000045
UM 26	04/20/04	7510	3074	0.006	0.77	0.000212	0.027235
UM 27	04/20/04	898	210	0.005	0.44	0.000101	0.008905
UM 28	04/20/04	610	109	0.003	0.41	0.000046	0.006307
UM 29	04/19/04	924	64	0.011	1.89	0.000065	0.011230
UM 30	04/19/04	176	28	0.004	2.04	0.000055	0.028047
UM 31	04/21/04	10375	1721	0.006	0.98	0.000086	0.014049
UM 32	04/21/04	140	11	0.085	1.08	0.000588	0.007475
UM 33	04/21/04	6992	2659	0.005	1.06	0.000164	0.034833
UM 34	04/21/04	1724	140	0.007	0.76	0.000049	0.005341
UM 35	04/21/04	1377	117	0.006	0.79	0.000044	0.005805
UM 36	04/21/04	989	160	0.004	0.84	0.000056	0.011728
UM 37	04/21/04	583	122	0.003	0.95	0.000054	0.017220
UM 38	04/21/04	325	8	0.060	3.87	0.000135	0.008704
UM 39	04/21/04	401	16	0.035	0.38	0.000118	0.001276
UM 40	04/21/04	6531	1439	0.004	0.94	0.000076	0.017890
UM 41	04/21/04	188	28	0.028	2.56	0.000363	0.033205
UM 42	04/21/04	4412	1088	0.005	1.04	0.000107	0.022165
UM 43	04/20/04	1381	523	0.004	0.79	0.000131	0.025865
UM 44	04/20/04	824	440	0.003	0.15	0.000138	0.006914
UM 45	04/21/04	609	20	0.024	0.93	0.000067	0.002602
UM 47	04/29/04	10929	3633	0.029	0.83	0.000833	0.023837
UM 49	04/28/04	959	258	0.012	1.24	0.000279	0.028830

UM 50	04/28/04	387	217	0.008	0.89	0.000387	0.043020
UM 51	04/28/04	2870	1677	0.006	0.64	0.000303	0.032321
UM 52	04/28/04	6584	2830	0.025	0.95	0.000928	0.035279
UM 53	04/28/04	2585	1412	0.005	0.58	0.000236	0.027383
UM 54	04/28/04	1850	1071	0.004	0.51	0.000200	0.025516
UM 55	04/28/04	252	26	0.014	1.51	0.000127	0.013650
UM 56	04/28/04	198	24	0.003	0.25	0.000031	0.002601
UM 57	04/27/04	794	23	0.004	0.40	0.000010	0.000999
UM 58	04/27/04	487	1382	0.001	0.61	0.000245	0.149643
UM 59	04/28/04	305	17	0.012	5.01	0.000056	0.023424
UM 60	04/28/04	4980	2497	0.000	0.00	0.000000	0.000000
UM 61	04/28/04	295	42	0.008	2.20	0.000099	0.027242
UM 62	04/28/04	3292	1508	0.003	0.74	0.000119	0.029287
UM 63	04/28/04	428	309	0.004	0.34	0.000249	0.021188
UM 64	04/28/04	529	179	0.002	0.33	0.000058	0.009626
UM 65	04/29/04	4851	1596	0.012	0.67	0.000341	0.019041
UM 66	04/29/04	4634	1595	0.010	0.63	0.000297	0.018733
UM 67	04/28/04	169	13	0.044	1.37	0.000283	0.008821
UM 68	04/28/04	3729	1385	0.005	0.25	0.000160	0.008019
UM 69	04/29/04	3190	1124	0.006	0.22	0.000183	0.006698
UM 70	04/22/04	1079	974	0.014	2.87	0.001092	0.223878
UM 71	04/22/04	774	17	0.031	0.98	0.000058	0.001824
UM 72	04/22/04	7149	1269	0.005	1.54	0.000077	0.023623
UM 74	04/22/04	2288	881	0.007	0.71	0.000233	0.023634
UM 75	04/22/04	1612	261	0.006	2.57	0.000084	0.035920
UM 76	04/22/04	378	51	0.006	0.60	0.000070	0.006998
UM 77	04/22/04	1519	365	0.009	0.18	0.000187	0.003737
UM 78	04/22/04	114	12	0.010	0.55	0.000093	0.005125
UM 79	04/22/04	116	24	0.008	0.57	0.000145	0.010341
UM 81	04/27/04	2654	1088	0.002	0.22	0.000071	0.007792
UM 84	04/27/04	688	288	0.003	0.27	0.000108	0.009750
UM 85	04/27/04	1299	656	0.001	0.19	0.000044	0.008295
UM 86	04/27/04	389	92	0.001	0.12	0.000020	0.002449
UM 87	04/27/04	272	98	0.002	0.04	0.000062	0.001242
UM 88	04/27/04	440	129	0.001	0.06	0.000025	0.001517
UM 89	04/27/04	1006	229	0.002	0.12	0.000039	0.002364
UM 90	04/27/04	318	92	0.029	0.67	0.000721	0.016652
UM 91	04/27/04	383	112	0.001	0.05	0.000025	0.001261
UM 92	04/27/04	512	191	0.001	0.13	0.000032	0.004178
UM 93	04/22/04	1143	327	0.009	1.70	0.000222	0.041973
UM 94	04/22/04	751	236	0.004	1.28	0.000109	0.034802
UM 95	04/22/04	463	99	0.004	0.40	0.000074	0.007424
UM 96	04/22/04	169	33	0.006	2.19	0.000101	0.036779
UM 97	04/22/04	206	90	0.001	2.35	0.000038	0.088666
UM 98	04/22/04	221	19	0.001	3.55	0.000007	0.026620
UM 100	04/27/04	644	374	0.002	1.04	0.000100	0.052098
UM 101	04/22/04	1028	583	0.014	1.15	0.000686	0.056341

UM 102	04/20/04	307	18	0.006	0.62	0.000030	0.003117
UM 103	04/28/04	3252	1867	0.009	1.29	0.000446	0.063992
UM 104	04/28/04	476	208	0.003	0.16	0.000113	0.006035
UM 105	04/28/04	624	664	0.010	1.06	0.000919	0.097456
UM 106	04/28/04	931	207	0.003	2.08	0.000058	0.039894
UM 107	04/28/04	2120	1290	0.010	1.47	0.000526	0.077266
UM 108	04/20/04	3346	740	0.003	0.74	0.000057	0.014138
UM 109	04/20/04	789	195	0.006	1.05	0.000128	0.022444
UM 110	04/20/04	1787	462	0.006	0.82	0.000134	0.018318
UM 111	04/20/04	308	77	0.010	0.97	0.000216	0.020952
UM 112	04/20/04	651	125	0.003	0.69	0.000050	0.011473
UM 113	04/20/04	275	71	0.003	0.90	0.000067	0.020134
UM 114	04/20/04	151	37	0.009	1.26	0.000190	0.026631
UM 118	04/27/04	151	21	0.253	1.65	0.002976	0.019411
UM 119	04/27/04	108	13	0.008	0.04	0.000086	0.000431

Table 4. Upper Monocacy WRAS Insitu Water Quality

Site	date	time	temp	pH	cond	do
UM 0	19-Apr-04	1015	15.2	7.71	572	11.08
UM 1	19-Apr-04	1030	15.1	7.37	594	9.25
UM 2	19-Apr-04	1105	19.2	8.19	534	10.65
UM 3	19-Apr-04	1120	16.4	8.08	531	12.82
UM 5	19-Apr-04	1155	15.8	8.16	519	11.89
UM 7	19-Apr-04	1220	20.0	8.03	519	11.60
UM 8	19-Apr-04	1250	18.5	8.34	305	10.09
UM 9	19-Apr-04	1315	18.9	7.61	295	10.09
UM 10	19-Apr-04	1330	21.7	7.99	321	9.51
UM 11	19-Apr-04	1340	22.8	8.30	259	9.64
UM 12	19-Apr-04	1425	22.1	7.45	278	9.32
UM 13	19-Apr-04	1515	23.6	9.69	301	13.31
UM 14	19-Apr-04	1555	22.1	7.72	325	9.50
UM 15	19-Apr-04	1540	23.4	9.09	281	12.72
UM 16	19-Apr-04	1500	23.0	8.92	257	10.33
UM 18	19-Apr-04	1625	19.0	9.24	163	13.99
UM 19	20-Apr-04	800	15.6	7.42	169	8.24
UM 20	20-Apr-04	845	16.6	7.79	169	9.34
UM 21	20-Apr-04	915	17.3	8.43	269	10.53
UM 22	20-Apr-04	940	14.5	7.52	146	9.74
UM 22	20-Apr-04	1015	18.0	8.27	234	9.39
UM 24	20-Apr-04	1055	18.4	8.29	207	9.82
UM 26	20-Apr-04	1130	15.5	8.55	172	11.07
UM 27	20-Apr-04	1155	15.2	7.48	90	9.47
UM 28	20-Apr-04	1215	16.3	7.27	84	8.77
UM 29	19-Apr-04	1720	23.1	9.21	236	11.09
UM 30	19-Apr-04	1800	19.0	7.74	263	9.25
UM 31	21-Apr-04	815	14.5	7.70	144	9.02

UM 32	21-Apr-04	830	15.0	7.38	305	8.50
UM 33	21-Apr-04	1045	14.3	8.15	135	10.63
UM 34	21-Apr-04	930	15.4	7.50	157	9.50
UM 35	21-Apr-04	1130	16.4	8.50	145	10.50
UM 36	21-Apr-04	1200	16.2	8.66	135	10.95
UM 37	21-Apr-04	1240	16.0	7.46	101	9.30
UM 38	21-Apr-04	1020	14.5	7.36	185	10.02
UM 39	21-Apr-04	1000	14.4	7.70	189	9.85
UM 40	21-Apr-04	1340	16.7	8.41	123	9.82
UM 41	21-Apr-04	1410	22.2	8.98	308	11.24
UM 42	21-Apr-04	1315	15.2	7.87	122	9.79
UM 43	20-Apr-04	1730	18.4	7.97	111	9.08
UM 44	20-Apr-04	1635	15.7	7.13	81	8.89
UM 45	21-Apr-04	1445	22.6	9.92	223	13.14
UM 47	29-Apr-04	810	9.9	7.22	141	9.57
UM 49	28-Apr-04	855	7.9	7.69	211	10.98
UM 50	28-Apr-04	830	9.2	7.49	188	10.22
UM 51	28-Apr-04	920	8.3	7.43	82	10.86
UM 52	28-Apr-04	940	9.2	7.39	151	9.91
UM 53	28-Apr-04	805	8.0	7.10	79	10.46
UM 54	28-Apr-04	730	8.0	7.00	64	10.06
UM 55	28-Apr-04	1600	13.6	7.18	101	9.27
UM 56	28-Apr-04	1620	12.4	6.62	36	9.21
UM 57	27-Apr-04	1650	10.3	5.67	17	10.45
UM 58	27-Apr-04	1635	11.9	6.71	56	10.06
UM 59	28-Apr-04	1040	9.9	7.30	184	9.95
UM 60	28-Apr-04	1020	9.9	7.61	53	10.91
UM 61	28-Apr-04	1115	12.1	7.95	425	11.46
UM 62	28-Apr-04	1135	11.0	7.62	122	10.35
UM 63	28-Apr-04	1250	9.9	6.50	24	10.46
UM 64	28-Apr-04	1225	10.8	6.69	64	10.07
UM 65	29-Apr-04	1000	10.7	7.05	71	10.02
UM 66	29-Apr-04	935	10.8	7.00	70	10.19
UM 67	28-Apr-04	1645	15.6	7.14	270	8.91
UM 68	28-Apr-04	1710	14.0	7.21	53	9.32
UM 69	29-Apr-04	855	10.8	6.91	41	10.11
UM 70	22-Apr-04	1630	22.0	8.50	333	9.50
UM 71	22-Apr-04	1610	20.6	7.22	262	8.53
UM 72	22-Apr-04	1155	16.3	7.90	208	10.48
UM 74	22-Apr-04	1230	16.6	7.64	106	9.44
UM 75	22-Apr-04	1240	17.3	7.80	232	10.57
UM 76	22-Apr-04	1500	20.5	8.46	155	9.61
UM 77	22-Feb-04	1515	17.8	7.63	73	9.01
UM 78	22-Apr-04	1535	17.6	7.07	69	9.11
UM 79	22-Apr-04	1550	19.0	7.44	113	8.58
UM 81	27-Apr-04	1530	13.5	6.39	32	9.37
UM 84	27-Apr-04	1440	12.4	5.97	20	9.59

UM 85	27-Apr-04	1500	12.3	6.17	35	9.38
UM 86	27-Apr-04	1410	13.3	4.61	39	9.08
UM 87	27-Apr-04	1335	11.7	5.65	33	9.48
UM 88	27-Apr-04	1320	12.3	6.26	24	9.70
UM 89	27-Apr-04	1135	12.0	6.62	48	9.89
UM 90	27-Apr-04	1110	13.1	7.64	136	9.72
UM 91	27-Apr-04	1200	12.3	5.41	24	9.67
UM 92	27-Apr-04	1210	11.9	6.10	48	9.74
UM 93	22-Apr-04	1310	18.2	7.71	141	9.71
UM 94	22-Apr-04	1400	18.2	7.41	125	8.95
UM 95	22-Apr-04	1430	17.2	6.77	63	8.96
UM 96	22-Apr-04	1335	17.7	7.23	205	9.36
UM 97	22-Apr-04	1110	16.1	7.87	868	9.42
UM 98	22-Apr-04	1100	14.4	7.62	982	9.35
UM 100	27-Apr-04	1715	12.2	6.66	82	10.10
UM 101	27-Apr-04	1740	11.8	7.00	121	10.26
UM 102	20-Apr-04	no	sample			
UM 103	28-Apr-04	1520	12.2	7.09	115	9.66
UM 104	28-Apr-04	1330	12.9	7.13	87	9.65
UM 105	28-Apr-04	1405	11.9	7.24	99	9.88
UM 106	28-Apr-04	1425	12.6	7.42	159	9.32
UM 107	28-Apr-04	1450	12.8	7.38	118	9.74
UM 108	20-Apr-04	1250	15.4	8.39	158	9.05
UM 109	20-Apr-04	1340	17.0	8.53	199	9.56
UM 110	20-Apr-04	1330	15.9	8.73	164	9.60
UM 111	20-Apr-04	1555	18.0	7.61	167	9.28
UM 114	20-Apr-04	1525	15.5	8.29	199	10.19
UM 113	20-Apr-04	1430	17.1	8.21	230	9.75
UM 112	20-Apr-04	1415	16.2	7.22	173	9.51
UM 118	27-Apr-04	1015	14.0	7.55	397	8.46
UM 119	27-Apr-04	1035	15.5	8.04	215	8.36

Figure 2.
Upper Monocacy WRAS
Nutrient Synoptic ,
April, 2004 -
NO2 + NO3 Conc. mg/L

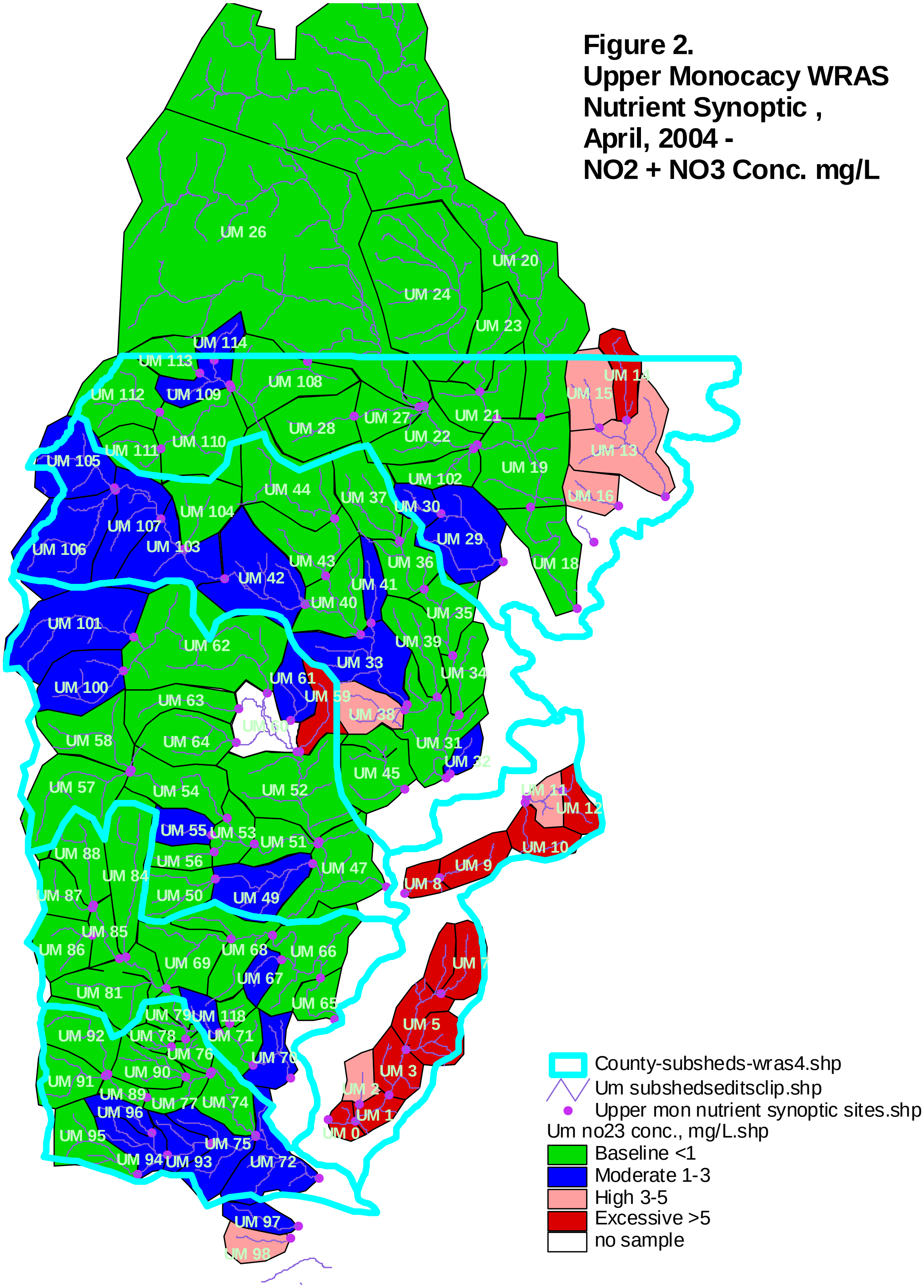

Figure 3.
Upper Monocacy WRAS
Nutrient Synoptic ,
April, 2004 -
NO2 + NO3 Yield Kg/H/day

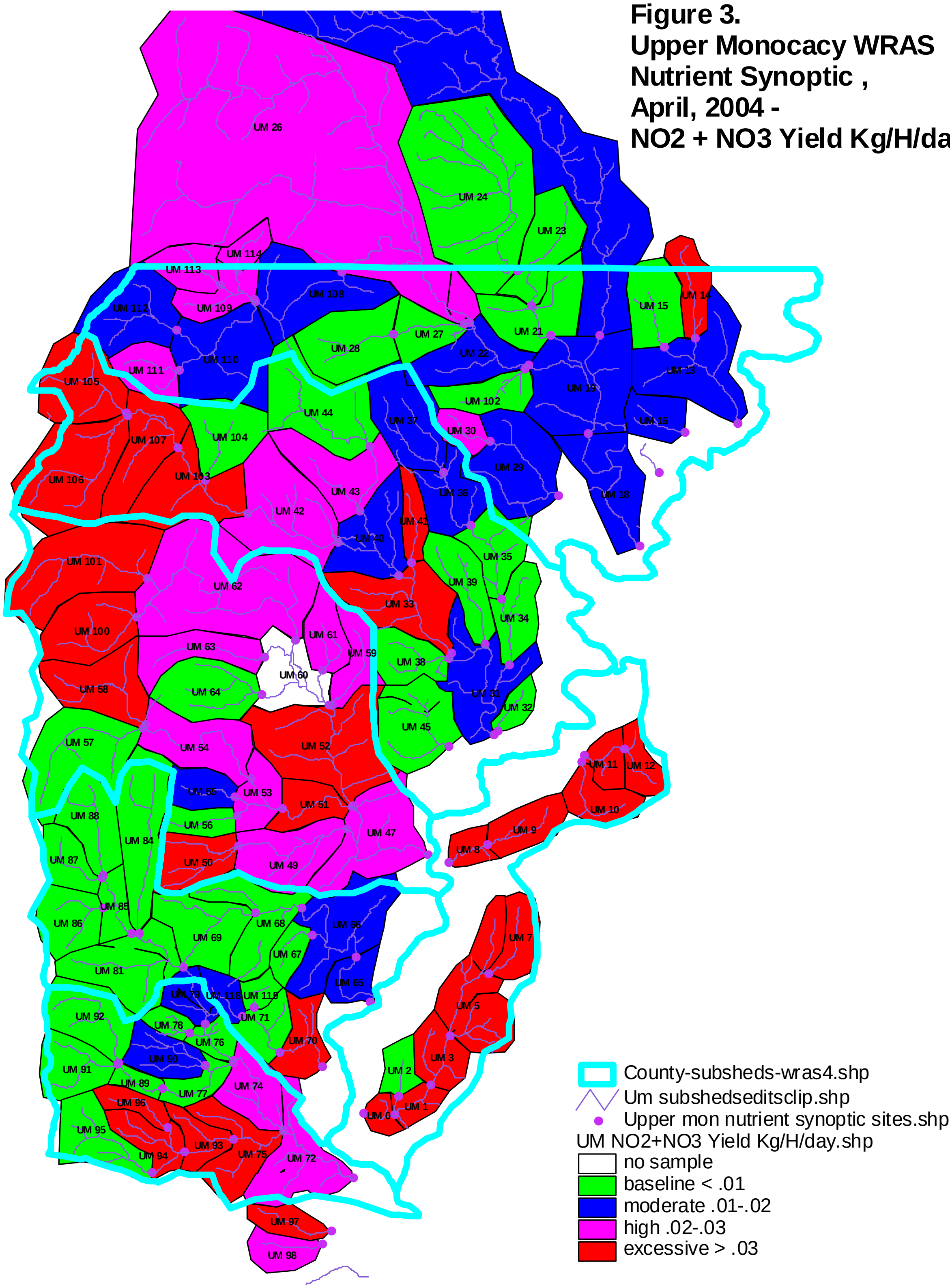

Figure 4.
Upper Monocacy WRAS
Nutrient Synoptic ,
April, 2004 -
PO4 Conc. mg/L

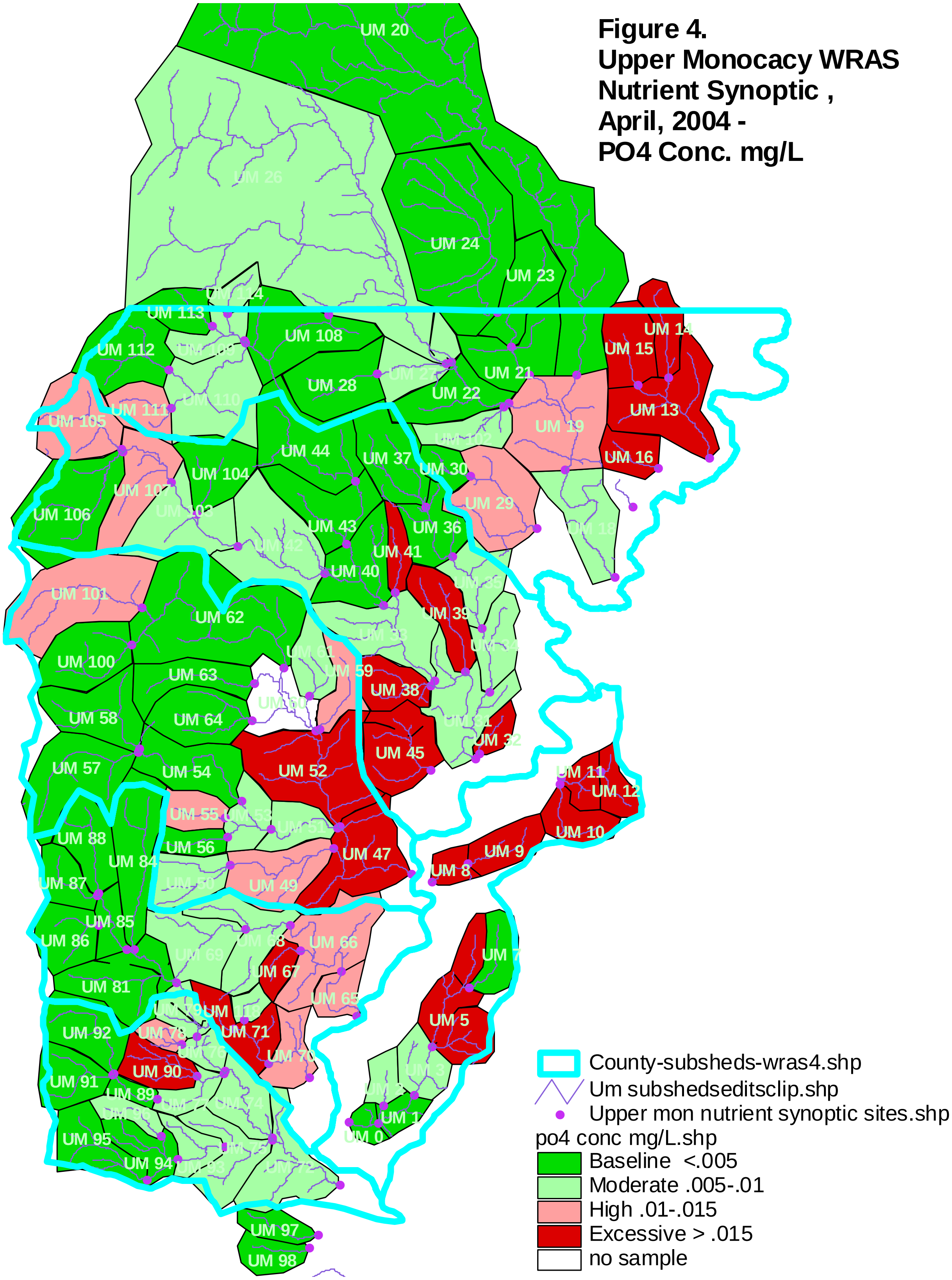

Figure 5.
Upper Monocacy WRAS
Nutrient Synoptic ,
April, 2004 -
PO4 Yield Kg/H/day

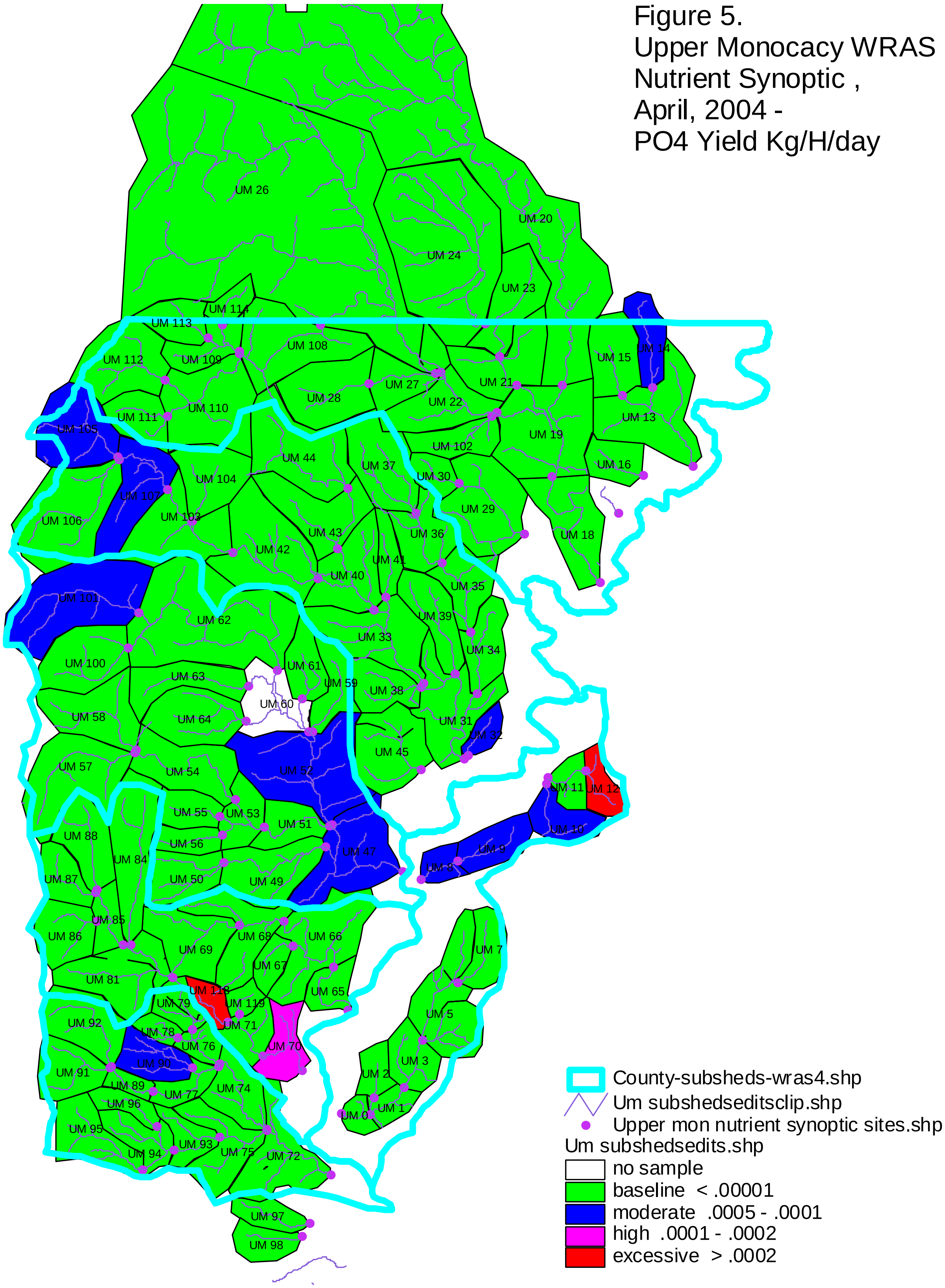

Figure 6.
Upper Monocacy WRAS
Nutrient Synoptic , April, 2004
Specific Conductivity
(micromohs/cm)

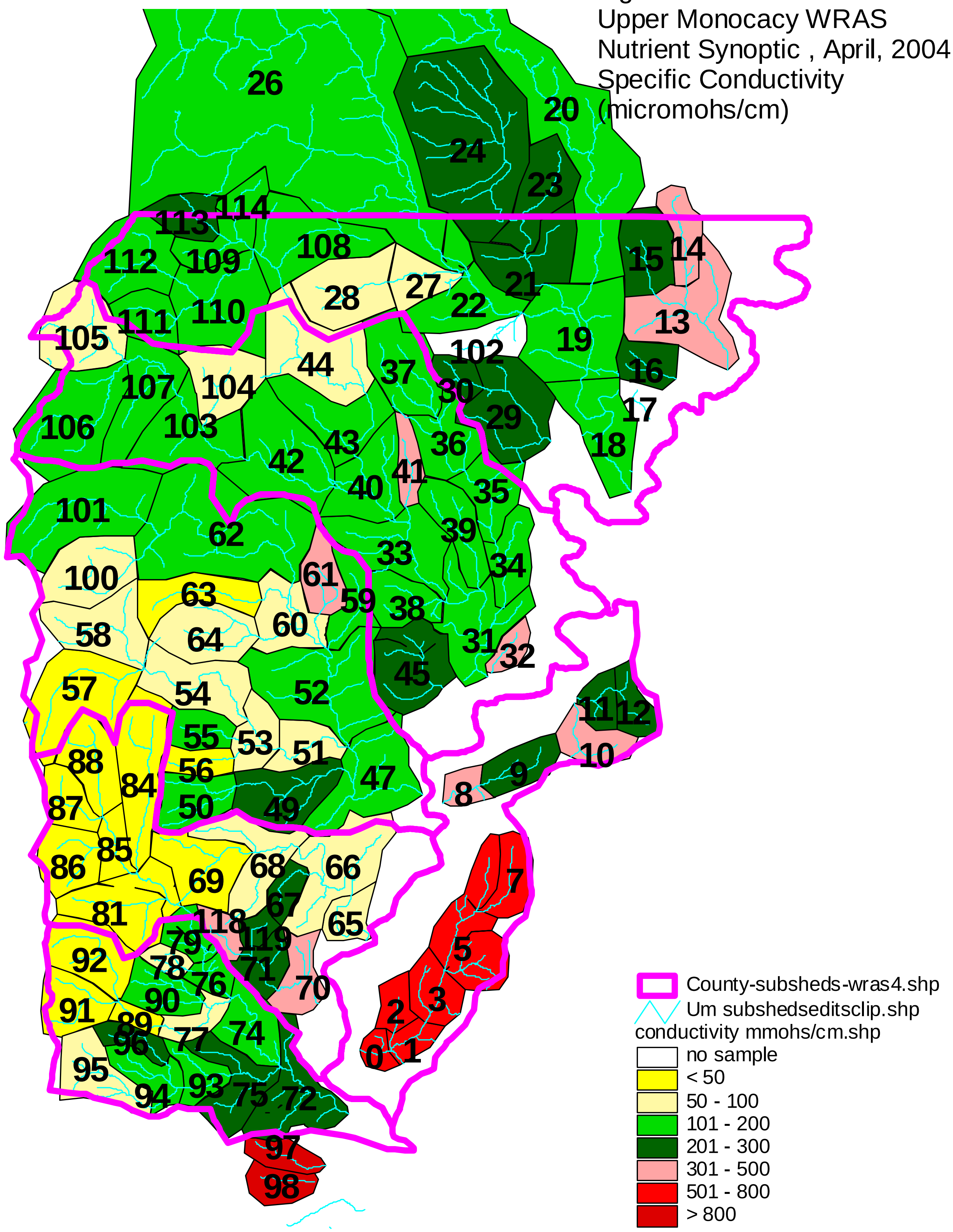

Figure 7.
Upper Monocacy WRAS
Nutrient Synoptic Survey,
April 2004
pH

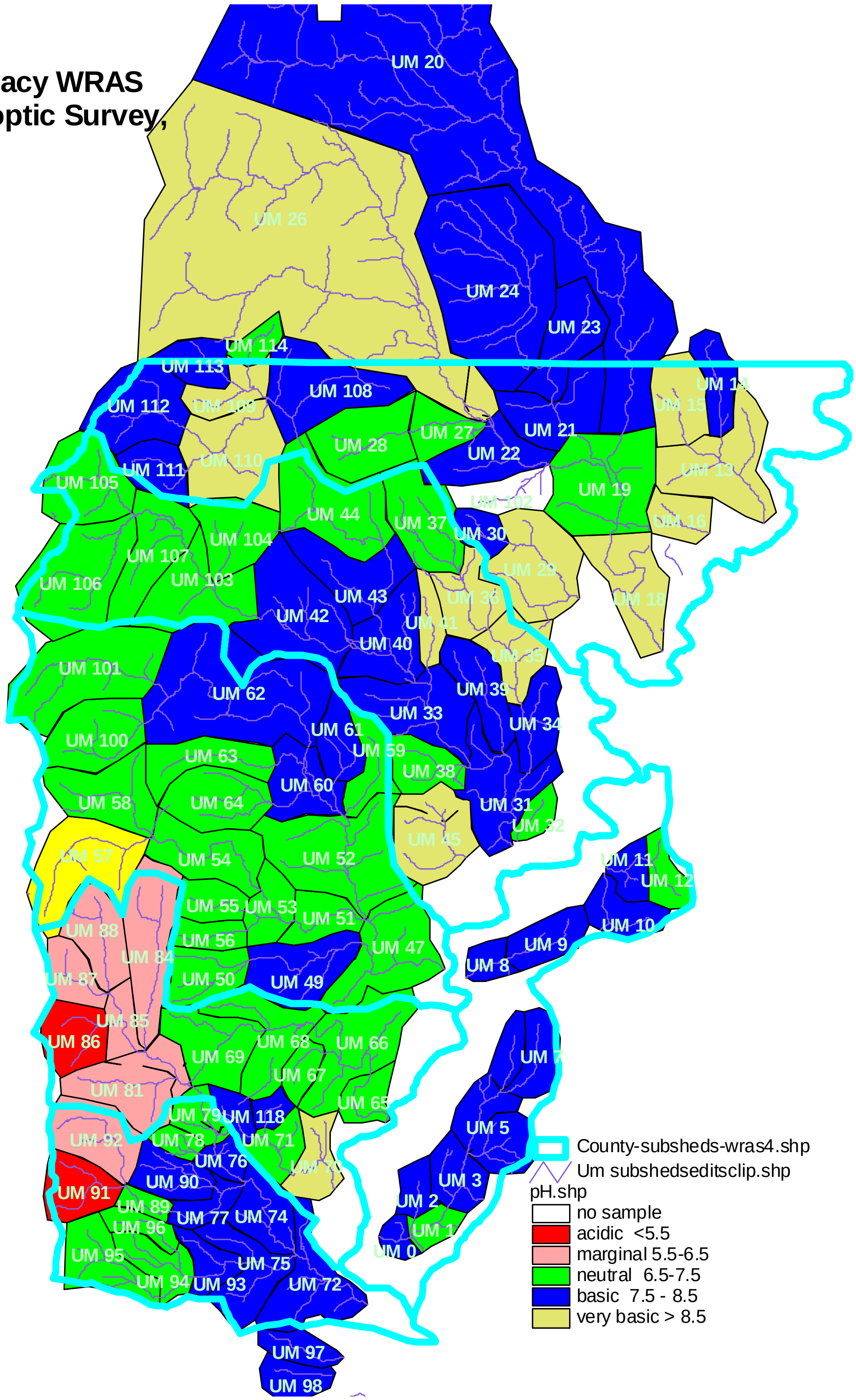

Figure 8. Upper Monocacy WRAS Intensive Sampling Sites, 1 Nov 04

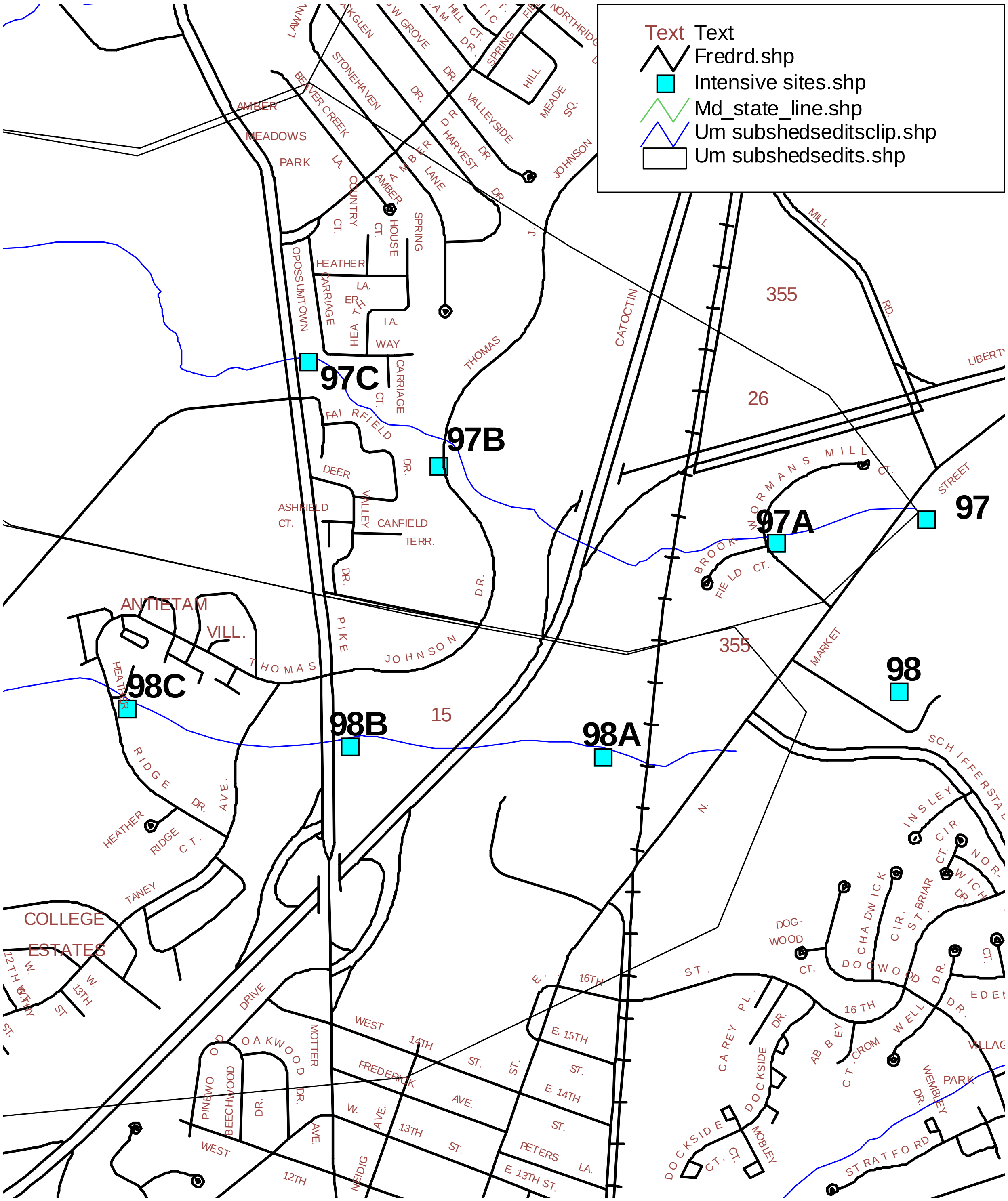

Table 5. Upper Monocay WRAS Intensive - Optical Brightener and Flouride

Sample #	Date	Source	Fluoresence	Flouride
97	1-Nov-04	Unnamed trib to Monocacy w/high spec.cond. (951*)	61.4	< .5 mg/L
97A	1-Nov-04	As above (958)	49.6	< .5 mg/L
97B	1-Nov-04	As above (853)	37.3	< .5 mg/L
97C	1-Nov-04	As above (748)	36.6	< .5 mg/L
98	1-Nov-04	As above (956)	40.1	< .5 mg/L
98A	1-Nov-04	As above (961)	35.1	< .5 mg/L
98B	1-Nov-04	dry		
98C	1-Nov-04	dry		
Pat 99	1-Nov-04	Balto. City tap water deionozed by filter	0.913	
C-1	2-Dec-04	Domestic washing machine	OVER 1000**	
C-2	2-Dec-04	Caroline Co. deep well (@400 ft.) tap water	247	
C-3	2-Dec-04	unnamed trib to Tuckahoe	91.6	
97	2-Dec-04	unnamed trib to Monocacy w/high conductivity	64.9	
L-2	2-Dec-04	Ben's Br at Lake Linganore	132	
Howard-2	2-Dec-04	Trib to Deep Rn (Howard Co) w/high cond (628 mmohs/cm)	165	
Bear Branch	2-Dec-04	Trib to Monocacy from Sugarloaf Mt. No humans upstream	67.3	

* specific conductivity micromohs/cm
** orders of magnitude higher

Discussion

The excessive and high nitrate/nitrite concentrations throughout Glade Creek, Broad Run, and Cattail Creek watersheds appear to be associated with animal and row crop agriculture in the majority of the watershed. The majority of these streams have little or no riparian buffers and considerable animal access to the streams. Figures 9 and 10 show typical channels in these watersheds. Subwatershed number 59 and 38 also had little riparian buffer and animal access to the stream. Application of manure for soil

Figure 9. UM 0 Lower Glade Creek.

Figure 10. UM 13 Lower Cattail Cr.

nutrient amendment in conjunction with direct animal access to streams is extensive throughout these watersheds. These practices are known to contribute significantly to soil and water nutrient levels

Most of the streams that had excessive or high nitrate/nitrite concentrations also had excessive instantaneous yields. There were also a large number of streams that had moderate concentrations that translated into excessive and high yields, particularly in the Tuscarora Creek, Hunting Creek, and Owens Creek watersheds. Yields are dependant on discharge volume related to watershed area. Watersheds with moderate, and even low concentrations, with relatively high groundwater discharge due to snow melt or recent rains will generally have elevated yields.

This scenario appears to fit the Tuscarora Creek, Hunting Creek, and Owens Creek watersheds. Nitrate/nitrite concentrations in these watersheds were generally moderate (< 3 mg/L) or lower, but the ratio of discharge volume to watershed area was relatively high. This situation makes streams with low concentrations of nutrients contribute disproportionately large loads, reflected as high per unit area yields, to downstream water bodies.

Orthophosphate generally travels bound to sediment particles, thus elevated orthophosphate concentrations tend to mirror elevated sediment loads in a water column. Sampling was done during dry weather, and at least 24 hours after a quarter inch or more of rain to minimize influence of suspended sediment. Drainage from storm water control structures and/or livestock and wildlife activity in degraded channels tends to prolong the length of time sediments remain in the water column. Therefore, sampling results from within the prescribed window can be influenced by events outside of the sampling window.

The subwatersheds exhibiting high or excessive orthophosphate concentrations and yields are excellent candidates for the scenario mentioned above. Construction activity and/or degraded stream channels were more prevalent in these subwatersheds than elsewhere in the Upper Monocacy.

As shown in Table 6, the upper Monocay had lower average nitrate/nitrite concentrations than many of the other watersheds that have been sampled, including the lower Monocacy. It should be noted that the lower Monocacy also included one site on Glade Run and one on Israel Creek. The average orthophosphate concentrations in the upper Monocacy were also towards the low end of other watershed averages.

Table 6. Annual & Spring Nutrient Concentration Averages from Other Nutrient Synoptic Surveys

Mg/L	Piney	German Br.	Pocomoke	**Lower Monocacy**	Western Branch	Upper Patuxent	**Upper Monocacy**	Liberty
NO2+NO3 Spring	3.742	3.832	3.734	**3.11**	0.214	0.439	1.731	3.410
NO2+NO3 Annual	4.823	4.704	2.384					
PO4 Spring	0.800	0.043	0.028	**0.013**	0.005	0.012	0.019	0.004
PO4 Annual	1.177	0.067	0.022					

Insitu measurements of temperature and dissolved oxygen did not reveal any significant anomalies. Measurements of pH and specific conductivity did highlight both expected and unexpected anomalies. Streams flowing through areas dominated by karst geology almost invariably have elevated pH and specific conductivity. Glade Creek is the best example of this in the Upper Monocacy. A number of other subwatersheds, generally near the Monocacy mainstem, appeared to fall in to this category.

A number of streams had elevated pH values without elevated specific conductivity, but with elevated dissolved oxygen levels. Heavy algal growth in these streams drives the dissolved oxygen up, which in turn elevates the pH. Algal growth in streams is generally highest in the early spring prior to shading from leaf out of riparian vegetation. All of the streams with this condition were associated with row and forage crop agriculture where soil amendments such as lime would be prevalent to counteract naturally acidic conditions.

The upper portion of the Fishing Creek watershed had both very low pH and specific conductivity values. These depressed values are considered a natural condition, and indicate streams that are poorly buffered against the impacts of acid precipitation. Acidic precipitation events can lower stream pH to levels that can be directly or indirectly toxic to fish, herpetofauna, and aquatic invertebrates.

Subwatersheds number 97 and 98 were a special case with extremely high specific conductivity, combined with elevated nitrate/nitrite concentrations. Specific conductivity readings of 500 to 700 micromohs/cm are not uncommon in streams strongly influenced by limestone such as Glade Creek. Urban areas with dense road networks can also have moderately elevated specific due to infiltration of road salts.

Elevated nitrate/nitrite concentrations are rare in urban land uses because there are generally no significant sources such as agricultural activity or septic drain fields. The high conductivity, in conjunction with moderate to high nitrate/nitrite concentrations, points to possible infiltration from a sanitary sewer system. Both of these watersheds drain sewered portions of Fort Deitrich and the City of Frederick. Additional testing for optical brighteners (a detergent additive) and fluoride (a drinking water additive) were not definitive in indicating domestic waste water as the cause of the noted anomalies. Another potential cause of the high conductivity could be shallow ground water contaminated by dissolved road salts from the locally intense road network through these two watersheds. Testing for chloride will be the one of the next step towards source identification.

Conclusions

The synoptic survey highlighted a number of water quality issues in the upper Monocacy watershed. Subwatersheds with high or excessive nitrate/nitrite concentrations were almost exclusively associated with limestone influenced streams. The high number of subwatersheds with high and excessive nitrate/nitrite yields was associated with high groundwater recharge to streams in agricultural areas. Orthophosphate concentrations and yields also tracked agricultural areas. Specific conductivity was dependent on underlying geology. PH was influenced by geology as well as biological activity within the stream. The two small subwatersheds draining Frederick and Fort Deitrich will require further investigations to determine the cause(s) of the specific conductivity and nitrate/nitrite anomalies found in them. Part of this further investigation will be sampling for bacteria.

Literature Cited

Frink, Charles R.. 1991. *Estimating Nutrient Exports to Estuaries*. Journal of Environmental Quality. 20:717-724.