Report on Nutrient Synoptic Surveys in the Lower Patuxent Watershed, Calvert County, Maryland, April 2003 as part of the Watershed Restoration Action Strategy.

Maryland Department of Natural Resources
Watershed Services
Landscape and Watershed Analysis
Management Studies
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Acknowledgements

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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.

Significant field collection assistance was provided by Jennifer Rusko Rebecca Zeiber, Matt Evans, and Kevin R. Coyne of MD Dept of Natural Resources, Watershed Services, Landscape and Watershed Analysis, Management Studies.

Cover photo: Battle Creek 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 March, 2003 in selected Calvert County watersheds as part of the Lower Patuxent WRAS. Samples were collected at 40 sites with a focused in the Hall Creek, Island Creek, and Solomons Harbor watersheds, and additional less intense sampling in other county watersheds. Biological samples were collected at ten of the nutrient sites. Nitrate/nitrite concentrations were found to be high in one subwatershed, moderately elevated in eight others, and baseline in the remaining subwatersheds. Nitrate/nitrite yields were found to be excessive in four subwatersheds, high in four, moderately elevated in 8, and baseline in the remainder. Excessive concentration of orthophosphate were found in 6 subwatersheds, high concentrations in 5, moderate concentrations in 5, and the remainder below baseline. Orthophosphate yields were found to be moderate in two subwatersheds, and baseline in the remainder. The elevated nitrate/nitrite concentrations and/or yields appear to be associated with residential developments on well and septic. The elevated orthophosphate concentrations and yields appear to be associated with systems that had fine suspended sediment loads lingering in the water column several days after rain events. No anomalies were found in the insitu measurements of dissolved oxygen, pH, temperature, or conductivity. Benthic macroinvertebrate communities at the ten sites sampled ranged from fair to very poor. Fish communities at the four sites sampled would be considered poor. The degradation in the biotic community was attributed to degraded habitat associated with storm water flows.

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Introduction

The 2003 nutrient synoptic survey in the Lower Patuxent watershed concentrated sampling in the Hall Creek, Island Creek, and Solomons Harbor watersheds. Additional samples were collected at downstream sites on the remaining large tributaries to the Lower Patuxent in Calvert County.

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.

Benthic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected at the time of water chemistry samples during the spring to be within the MBSS spring index period. Macroinvertebrate collections were made over a $2m^2$ area of the best available habitat using a 0.3m wide dip net with a mesh size of 500 microns. The best available habitats include: gravel riffles, snags, submerged vegetation and root mats. Habitats were sampled in the proportion to their occurrence at the station. Samples were composited in a sieve bucket, fine sediments washed out, and large debris rinsed and discarded. The remaining sample was preserved in 70% ethanol and returned to the laboratory for subsampling. Subsampling was done using a gridded tray. Grids were chosen at random until the grid with the 100th organism had been completed. Organisms were identified to genus, recorded on a bench sheet, and archived for future reference. Insitu water quality data (dissolved oxygen, pH, conductivity, temperature) were collected during each sampling episode with a Hydrolab Surveyor II. A macroinvertebrate index of biotic integrity (IBI)(MD DNR, 1998) was calculated to facilitate ranking of site quality.

Fish Sampling
Fish were sampled during the summer to coincide with the MBSS index period for fish sampling. Backpack electroshockers were used for two passes through a 75 meter reach of stream with block nets at each end of the reach. All species were enumerated and weighed to obtain taxa richness and biomass estimates.

Results

The Lower Patuxent watershed in Calvert County was delineated into 41 subwatersheds based on road crossings and stream confluences. Station locations are noted in Table 2, and subwatersheds are shown in Figure 1. Grab samples for dissolved nutrient analysis were collected at all 41 of these sites, although one sample was lost in transit to the laboratory. Benthic samples were collected at a subset of 10 sites and fish at 4 sites.

Nutrient loads and yields within the Lower Patuxent watershed were generally low as shown in Table 3., and as compared to other watersheds around the state (Table 4). No subwatersheds were found to have excessive nitrate/nitrite concentrations, and only one was found to have a high concentration. Nine relatively small headwater streams had moderately elevated nitrate/nitrite concentrations (Figure 2). Excessive per hectare nitrate/nitrite yields were noted at four stations, high yields were noted at four stations, and moderate yields were noted at 8 stations (Figure 3). Excessive concentration of orthophosphate were found in 6 subwatersheds, high concentrations in 5, moderate concentrations in 5, and the remainder below baseline. Orthophosphate yields were found to be moderate in two subwatersheds, and baseline in the remainder (Figures 4 and 5).

In situ water quality parameters of temperature, pH, dissolved oxygen and specific conductivity were measured at 20 of the 41 sampling sites. No anomalous readings were noted at any of these sites (Table 5).

Analysis of macroinvertebrate samples collected at ten sites is shown in Table 6. Index of Biotic Integrity scores were fair at one site, poor at 5 sites, and very poor at the remaining four sites. Fish collection data from four of the macroinvertebrate sites also found depauperate communities (Table7).

Discussion

The elevated nitrate/nitrite concentrations appear in subwatersheds that have significant residential development with individual septic systems. The excessive and high nitrate/nitrite yields also mirror these residential development areas. While this association of high nitrate/nitrite values with residential development appears significant, it is not universal, and would require additional investigation to confirm. The subwatersheds with excessive and high orthophosphate concentrations are also in areas of higher density residential development. As noted in the introduction, PO_4 generally travels bound to sediment. Moderate rains several days prior to sampling, coupled with active construction and abundant clay within the active channels, could produced fine sediments that persisted in the water column of the streams to create the elevated PO4

Table 2. Lower Patuxent WRAS Synoptic Survey, March 2003
Station Location

Station	Location	lat	long
0	Island Cr at Ross Rd	38.44892	-76.5542
1	UT to Patuxent at Cage Rd	38.41887	-76.5189
2	Island Cr at Ross property map34, grid 14 p 247	38.43675	-76.544
3	UT to Island Cr at Littleford prop map 34, grid 8 p 17	38.44035	-76.5413
4	UT to Island Cr at Littleford prop map 34, grid 8 p 17	38.44027	-76.5409
6	UT to Lake Lariat at Tomahawk Dr	38.37012	-76.416
7	Lake Lariat to Mill Cr at Hall rd	38.3545	-76.4268
9	Mill Cr at Gunsmake Tr	38.37683	-76.4238
10	UT to Mill Cr at Gunsmake Tr	38.376	-76.4196
12	Coles Cr at Hall Rd	38.33845	-76.4261
13	UT to St Johns off high school prop	38.35305	-76.4427
14	UT to St Johns off middle school	38.36218	-76.4407
15	UT to Hall Cr at Ward Rd		
16	Hall Cr at Rt 260		
17	UT to Hall Cr at Rt 260	38.74025	-76.6296
18	UT to Hall Cr at Leonard Prop map 3, grid 17, p 142	38.72947	-76.6344
19	Hall Cr at Spriggs prop map 3, grid 23 P 26	38.72583	-76.6217
21	UT to Hall Cr at Hicks prop map 3, grid 18, p 25	38.72892	-76.6332
23	Hall Cr at Chittams map 6, grid 8, p 390	38.70507	-76.6603
25	Fowlers Mill Br at Rt 4		
26	Fowlers Mill Br at Fowler Rd		
27	Hall Cr at Chesapeake Beach Rd		
28	Hall Cr at Rt 2		
29	Hall Cr at Rt 4		
30	Fridays Cr at Chaneyville Rd		
31	Chew Cr off Smokey Rd DNR prop	38.64417	-76.6644
32	Cocktown Cr at Huntingtown Rd		
33	Sewell Br at Rt 2/4	38.97807	-76.6096
34	Hunting Cr at Plum Pt Rd	38.97398	-76.6076
36	Battle Cr at Rt 506	38.49448	-76.595
37	UT to Battle Cr at Grays Rd	38.48927	-76.5899
38	Battle Cr at German Chapel Rd	38.51735	-76.5968
39	St leanards Cr at Ball Rd	38.46772	-76.517
40	St Leonards Cr at Parran Rd	38.44907	-76.4952
41	Quacker Swamp at Rt 2	38.44675	-76.4809
43	Helen Br at confluence w/ St Paul Cr at landfill prop	38.38362	-76.4577
44	St Paul Br at landfill prop	38.38353	-76.4569
45	UT to Helen Br at landfill rd	38.37768	-76.4559
46	UT to Island Cr at Dorshow prop map 34, grid 21, p 41	38.43045	-76.5305

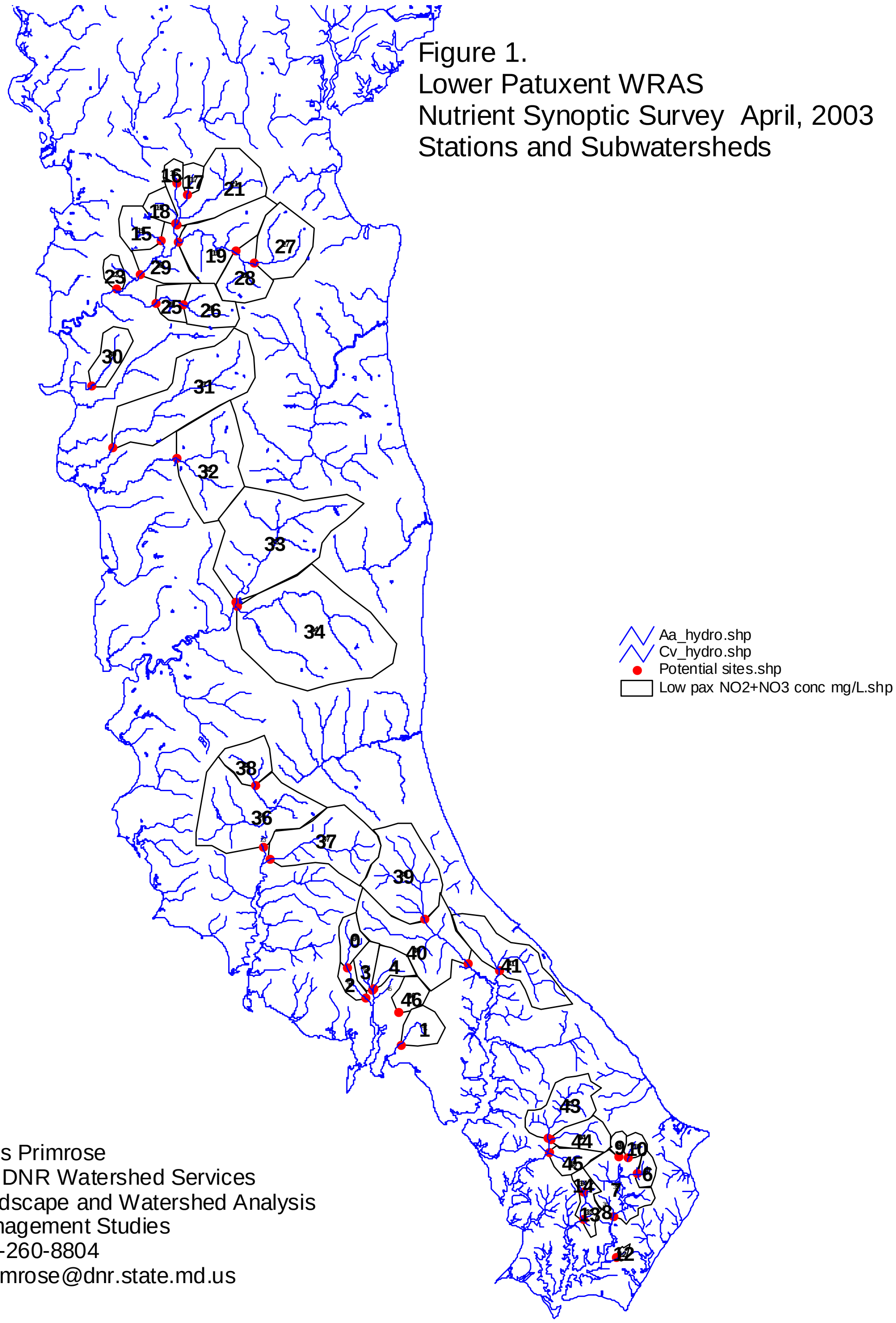


Figure 1.
Lower Patuxent WRAS
Nutrient Synoptic Survey April, 2003
Stations and Subwatersheds

Niles Primrose
MD DNR Watershed Services
Landscape and Watershed Analysis
Management Studies
410-260-8804
nprimrose@dnr.state.md.us

Table 3. Lower Patuxent WRAS Synoptic Survey, March 2003
Dissolved Nutrient Concentrations and Yields

Station	Date	Time	Area (Ha)	Discharge L/s	PO_4 mg/L	NO_2+NO_3 mg/L	PO_4 KG/H/D	NO_2+NO_3 KG/H/D
0	03/25/03	1430	176	33	0.007	0.330	0.000114	0.005391
1	03/25/03	1400	227	2	0.002	4.480	0.000001	0.002558
2	03/25/03	1200	286	63	0.005	0.080	0.000096	0.001529
3	03/25/03	1250	184	14	0.005	0.110	0.000032	0.000711
4	03/25/03	1300	141	39	0.011	1.160	0.000260	0.027459
6	04/01/03	1030	91	8	0.001	0.810	0.000007	0.005842
7	04/01/03	1000	748	105	0.001	0.680	0.000012	0.008235
9	04/01/03	1000	54	12	0.001	1.240	0.000020	0.024403
10	04/01/03	1020	79	23	0.001	0.600	0.000025	0.014833
12	04/01/03	900	24	6	0.000	0.000	0.000000	0.000000
13	04/01/03		188	22	0.001	0.390	0.000010	0.003861
14	04/01/03	1230	55	7	0.001	0.850	0.000011	0.009067
15	03/24/03	1345	271	72	0.018	1.030	0.000414	0.023682
16	03/26/03	1416	63	24	0.025	2.500	0.000821	0.082091
17	03/26/03	1115	91	19	0.020	1.160	0.000355	0.020570
18	04/03/03	1337	143	26	0.025	0.890	0.000391	0.013914
19	04/03/03	1100	1662	448	0.010	0.520	0.000233	0.012108
21	04/03/03	1320	780	214	0.011	0.500	0.000261	0.011865
23	04/03/03	1225	101	1	0.004	0.500	0.000003	0.000395
25	03/24/03	1250	501	175	0.017	1.050	0.000513	0.031686
26	03/24/03	1320	323	92	0.013	0.570	0.000321	0.014053
27	03/26/03	1140	555	217	0.007	0.570	0.000237	0.019279
28	03/24/03	1430	941	324	0.008	0.630	0.000238	0.018729
29	03/25/03	1451	3415	732	0.009	0.360	0.000167	0.006667
30	03/26/03	1155	258	15	0.061	1.420	0.000313	0.007283
31	03/26/03	1304	1369	371	0.007	0.400	0.000164	0.009372
32	03/26/03	1336	1027	250	0.014	0.670	0.000294	0.014080
33	04/01/03	1509	1739	468	0.002	0.190	0.000047	0.004421
34	04/01/03	1404	2279	875	0.002	0.040	0.000066	0.001327
36	04/02/03	1420	1531	148	0.002	0.030	0.000017	0.000251
37	03/27/03	1055	917	60	0.002	0.030	0.000011	0.000170
38	03/27/03	1155	296	22	0.002	0.190	0.000013	0.001232
39	03/27/03	1400	951	128	0.004	2.400	0.000046	0.027808
40	03/27/03	1235	1873	56	0.002	0.050	0.000005	0.000128
41	03/27/03	1324	711	91	0.003	0.030	0.000033	0.000333
43	04/02/03	945	485	63	0.001	0.120	0.000011	0.001357
44	04/02/03	1015	249	23	0.001	0.170	0.000008	0.001348
45	04/01/03	1315	169	49	0.003	0.400	0.000075	0.009963
46	04/02/03	1330	162	29	0.006	2.150	0.000092	0.032834

Table 4. Annual & Spring Nutrient Concentration Averages from Other Nutrient Synoptic Surveys

Mg/L	Piney	German Br.	Pocomoke	**Lower Patuxent**	Breton Bay	Upper Patuxent	Choptank	Liberty
NO2+NO3 Spring	3.742	3.832	3.734	**.75**	0.223	0.439	2.892	3.410
NO2+NO3 Annual	4.823	4.704	2.384					
PO4 Spring	0.800	0.043	0.028	**0.007**	0.004	0.012	0.023	0.004
PO4 Annual	1.177	0.067	0.022					

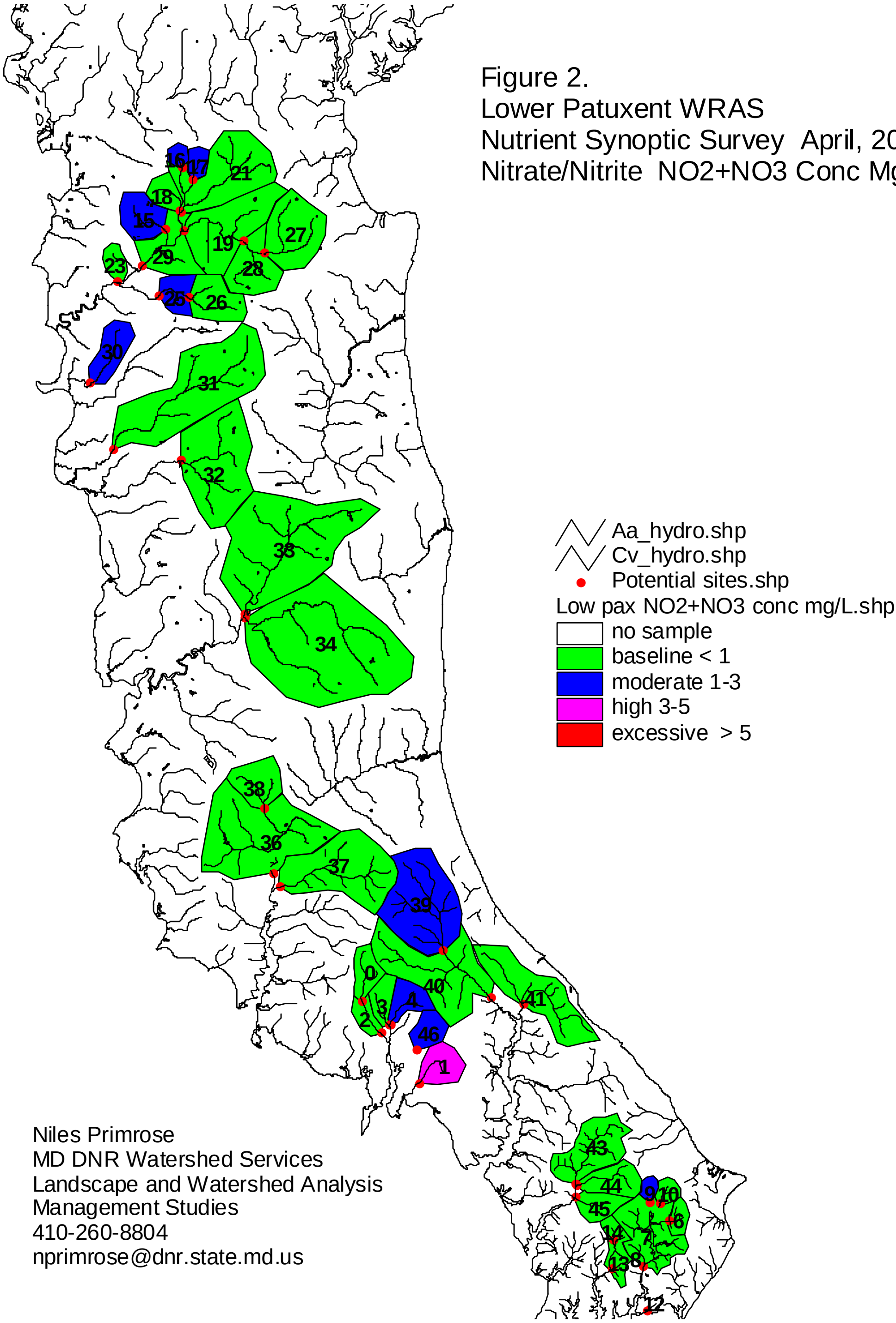
concentrations. One small headwater stream translated the excessive PO_4 concentration into a moderate yield. Again, further investigation would be needed to isolate significant sediment sources within the impacted watersheds.

The macroinvertebrate and fish communities appear to be responding to the poor instream habitat conditions found at most of the sampling sites. Streams were generally devoid of gravel riffles and depauperate in large woody debris. Although riparian habitat was generally good, being dominated by trees and shrubs, the instream habitat was dominated by shifting sand or hardpan clay substrate that provided little good quality habitat. The metric and IBI scores for the ten macroinvertebrate samples are shown in Table 6. As noted, only site four could be considered "good" with a score of 3, with the remaining classified as "poor" or "very poor". Historic macroinvertebrate sampling on Hunting Creek, Sewell Branch and St. Leonards Creek showed similarly impacted communities. An overview of the fish sampling results is provided in Table 7. The presence of killifish and striped bass at site 2 indicated free access to tidewater. The overwhelming presence of brook lamprey at site 44 was indicative of the very sandy substrate within the sample reach. The predominance of bluegill and bullheads in the fish community at site 9 was due to recruitment from the pond immediately upstream. The fish community at site 14 was probably more typical of the remainder of the watershed.

Conclusions

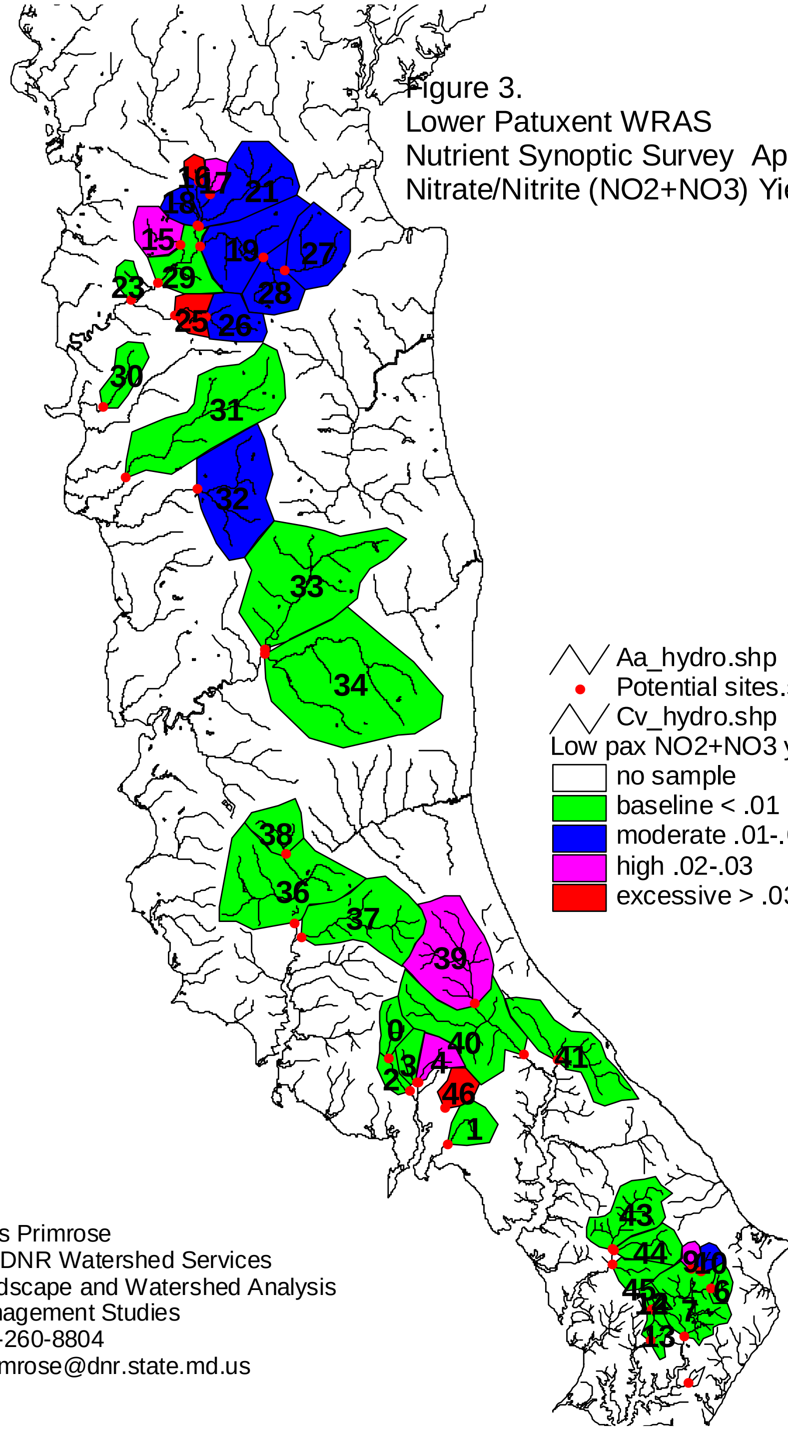
The apparent association of high dissolved nitrate/nitrite and suburban subdivisions should be investigated further to determine if there is an actual cause and effect. The poor macroinvertebrate and fish communities were not associated with any known water quality problems, but resulted from degraded habitat. The habitat degradation is associated with storm water flows from roads and other concentrations of impervious surface. The prevalent topography of the county, ridges with deep adjacent stream valleys, is very prone to damage from storm water. Even communities with low impact features, such no curb and gutter and grass swales, can be important contributors to the problem due to the erosive effect of relatively small volumes of water moving through significant elevation changes from development site to stream valley. Further investigations, especially in older communities that predate significant storm water control measures, may be required to begin to target restoration efforts.

Figure 2.
Lower Patuxent WRAS
Nutrient Synoptic Survey April, 2003
Nitrate/Nitrite NO2+NO3 Conc Mg/L



Niles Primrose
MD DNR Watershed Services
Landscape and Watershed Analysis
Management Studies
410-260-8804
nprimrose@dnr.state.md.us

Figure 3.
Lower Patuxent WRAS
Nutrient Synoptic Survey April, 2003
Nitrate/Nitrite (NO2+NO3) Yield (KG/H/D)



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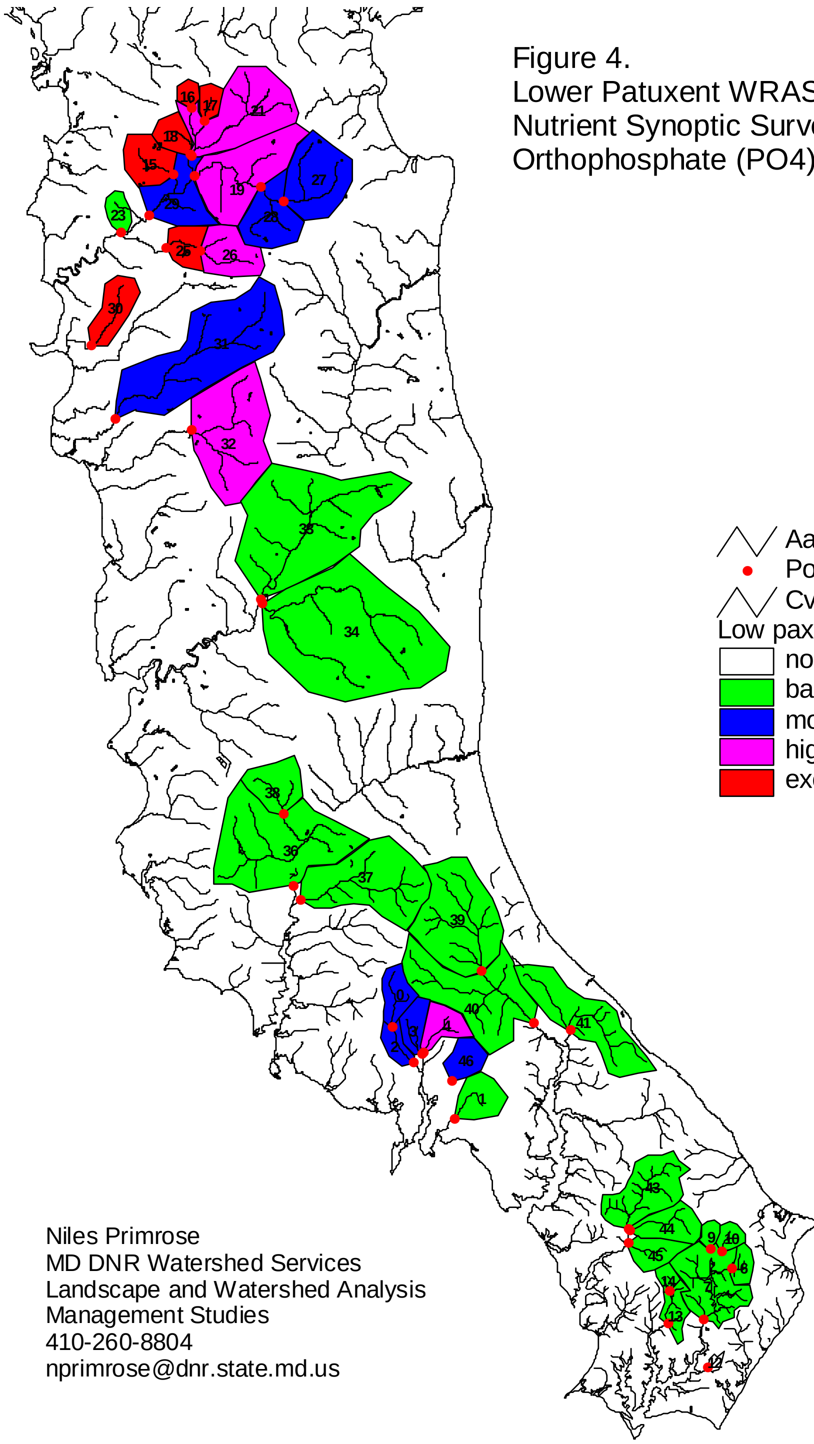
410-260-8804
nprimrose@dnr.state.md.us

Figure 4.
Lower Patuxent WRAS
Nutrient Synoptic Survey April, 2003
Orthophosphate (PO4) Concentration (mg/L)



Aa_hydro.shp
Potential sites.shp
Cv_hydro.shp
Low pax PO4 conc mg/L.shp
no sample
baseline < .005
moderate .005-.01
high .01-.015
excessive > .015

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nprimrose@dnr.state.md.us

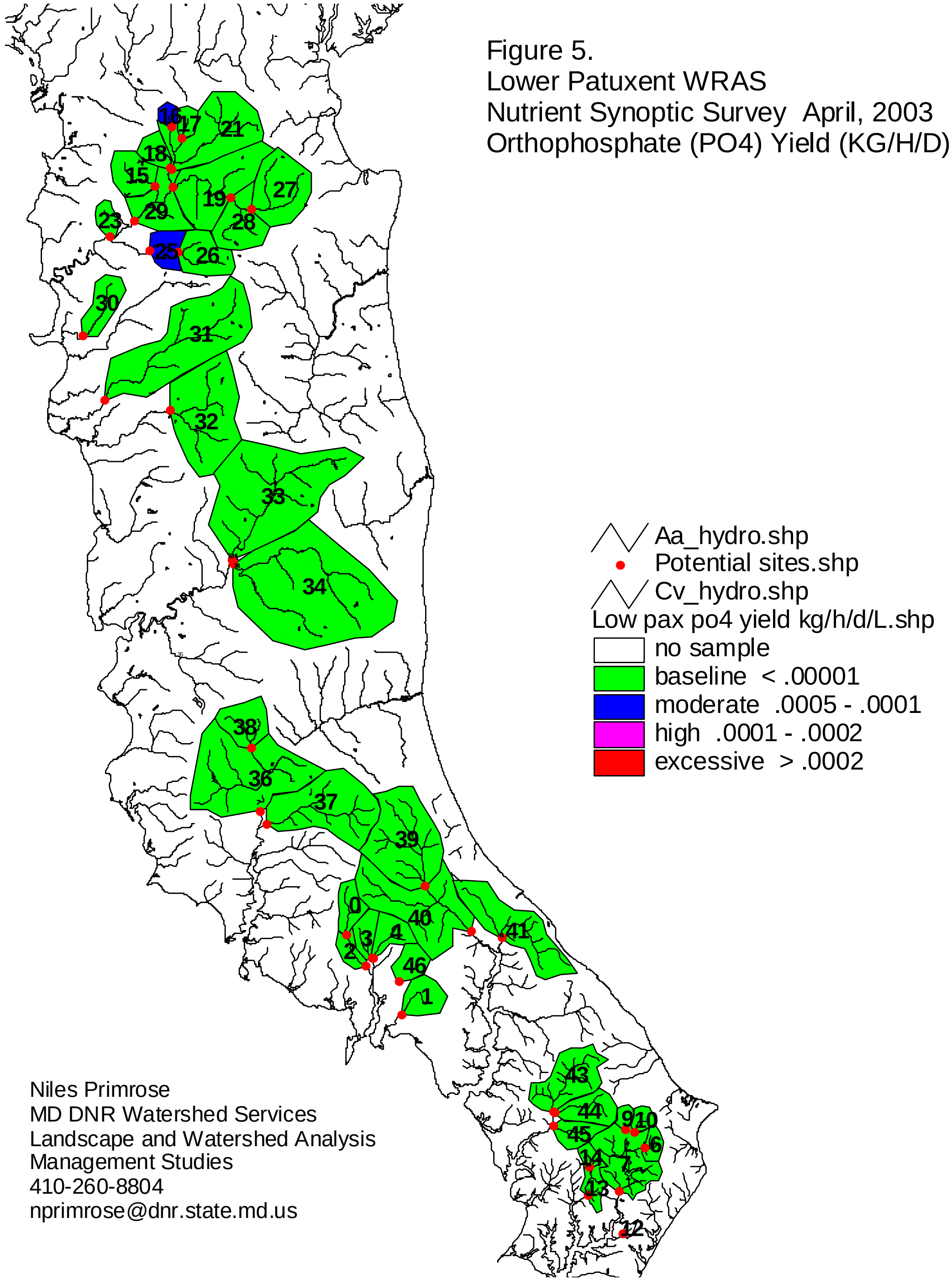
Figure 5.
Lower Patuxent WRAS
Nutrient Synoptic Survey April, 2003
Orthophosphate (PO4) Yield (KG/H/D)
Aa_hydro.shp
Potential sites.shp
Cv_hydro.shp
Low pax po4 yield kg/h/d/L.shp
no sample
baseline < .00001
moderate .0005 - .0001
high .0001 - .0002
excessive > .0002
Niles Primrose
MD DNR Watershed Services
Landscape and Watershed Analysis
Management Studies
410-260-8804
nprimrose@dnr.state.md.us

Table 5. Lower Patuxent WRAS Synoptic Survey, March 2003
Insitu Water Quality Parameters

Station	Time	Temp ^{O}C	Dissolved O_2 mg/L	pH	Specific Conductivity mmohs/cm
0	1430	17.05	10	6.84	173
1	1400	17.59	9.7	6.64	200
2	1200	15.21	12.29	7.16	172
3	1250	19.27	8.08	7.08	
4	1300	18.42	8.38	7.28	
6	1030	12.98	9.5	6.66	94
7	930	13.07	10.9	6.7	119
9	1000	13.59	10.27	6.49	134
10	1020	12.57	11.3	6.73	85
12	900	9.93	10.9	6.9	219
13					
14	1230				
15	1345				
16	1416				
17	1115				
18	1337	18.6	9.6	6.66	183
19	1100	13.48	9.76	6.94	185
21	1320	18.6	11.1	6.8	189
23	1225	17.2	9.7	6.35	249
25	1250				
26	1320				
27	1140				
28	1430				
29	1451				
30	1155				
31	1304	16.7	11.6	6.7	195
32	1336				
33	1509				
34	1404				
36	1420	17.3	12.44	7.16	116
37	1055	12.94	11.5	6.32	112
38	1155	14.98	10.4	6.6	123
39	1400	17.98	8.84	7.04	139
40	1235	16.3	12.5	6.77	134
41	1324	18.7	9.21	6.74	200
43	945	14.1	10.7	6.85	115
44	1015	15.6	10.1	6.55	148
45	1315				
45	1315				
46	1330	17.7	9.6	6.97	186

Table 6.Lower Patuxent WRAS Synoptic Survey, March 2003
Macroinvertebrate Index of Biotic Integrity

Station	# of Taxa	# of EPT	% Ephemoptera	% Tanytarsini of Chironomids	Becks Index	# of Scrapers	% Clingers	IBI Calc***	IBI Score
2	8*/1**	1/1	0/1	10/3	0/1	0/1	0/1	9/7	1.3
3	14/3	6/3	4/3	12/3	7/3	1/1	0/1	17/7	2.4
4	17/3	7/5	9/3	8/3	7/3	2/3	7/1	21/7	3
9	11/3	2/1	0/1	8/1	3/1	0/1	0/1	9/7	1.3
13	12/3	4/3	0/1	7/1	6/3	0/1	1/1	13/7	1.9
14	14/3	4/3	12/5	13/3	6/3	1/1	4/1	19/7	2.7
23	16/3	6/3	1/1	16/3	7/3	0/1	0/1	15/7	2.1
31	10/1	3/1	1/1	7/1	5/3	0/1	0/1	9/7	1.3
36	17/3	4/3	2/1	8/1	5/3	1/1	0/1	13/7	1.9
44	21/3	4/3	1/1	13/3	7/3	1/1	5/1	15/7	2.1

* value
** score
***Total score/ # of metrics

Table 7. Lower Patuxent WRAS, Summer 2003
Fish Species totals by site

Common name	Genus	species	Calvert 2	Calvert44	Calvert 9	Calvert14
Leastbrook lamprey	*Lampetra*	*aepyptera*	-	403	5	-
Sea lamprey	*Petromyzon*	*marinus*	-	2	-	-
American eel	*Anguilla*	*rostrata*	10	6	3	13
Blacknose dace	*Rhinichthys*	*atratulus*	1	-	-	-
Banded killifish	*Fundulus*	*diaphanus*	51	-	-	-
Eastern mudminnow	*Umbra*	*pygmaea*	-	4	1	12
Yellow bullhead	*Ameiurus*	*natalis*	-	-	1	-
Brown bullhead	*Ameiurus*	*nebulosus*	-	-	102	-
Creek Chubsucker	*Erimyzon*	*oblongus*	-	2	-	-
Striped bass	*Morone*	*saxitalis*	1	-	-	-
Pumpkinseed	*Lepomis*	*gibbosus*	3	-	12	2
Bluegill	*Lepomis*	*macrochirus*	-	-	178	1

Literature Cited

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