MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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2006 Bush River Shallow Water Monitoring Data Report

28 March 2008

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2006 Bush River
Shallow Water Monitoring Data Report

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Introduction

In 2006, The Maryland Department of Natural Resources (DNR) was contracted by Harford County, Maryland to conduct temporally intensive water quality monitoring on the Bush River.

Temporally Intensive Monitoring – The Continuous Monitoring Component of the Shallow Water Monitoring Program is designed to collect a temporal record of water quality data from fixed shallow water stations throughout the Chesapeake and Maryland Coastal Bays. Maryland DNR deployed and maintained YSI^{TM} 6600 EDS multiparameter datasondes at 46 Continuous Monitoring sites spread across 15 Chesapeake Bay tributaries/water bodies during 2006. Four Coastal Bay sites also were monitored. The following water quality data were collected at 15-minute intervals throughout the submerged aquatic vegetation (SAV) growing season (April - October): dissolved oxygen, turbidity (water clarity) fluorescence (used to estimate chlorophyll concentration), water temperature, salinity, and pH. The purpose of the monitoring project is to assess compliance with the new Chesapeake Bay ambient water quality criteria and to characterize water quality and habitat conditions.

Nutrient and Calibration Samples – Nutrient and calibration data were collected by DNR staff during deployment of the Continuous Monitoring sondes. Discrete whole water samples were collected to measure chlorophyll *a*, total suspended solids, and nutrients. Sondes were removed and replaced with freshly calibrated instruments on a biweekly basis. At the time of each instrument replacement, Secchi disk depth and photosynthetically active radiation (PAR) measurements were recorded for use in calculation of light attenuation (Kd) or water clarity.

Bush River Continuous Monitoring - Continuous Monitoring data were collected at two sites in the Bush River in 2006: Otter Point Creek (XJG7035) and Lauderick Creek (XJG4337) (Figure 1). The Otter Point Creek continuous monitor was fixed 0.3m above the bottom sediments and deployed from March 14th, 2006 through December 31st, 2006 (Figure 1). This site was funded through a cooperative agreement with the National Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve System (NERRS) Program. A second continuous monitor was deployed in Lauderick Creek. The equipment was suspended from a float, one meter below the water's surface, from March 28th through November 6th, 2006. The Harford County Government provided funding for the continuous monitoring equipment, nutrient analyses, and maintenance of the Lauderick Creek site.

Real-time 2006 data from the Lauderick Creek and Otter Point Creek continuous monitoring sites were made available through DNR's "Eyes on the Bay" website, www.eyesonthebay.net. Data were uploaded on an hourly basis for the full suite of physical parameters.

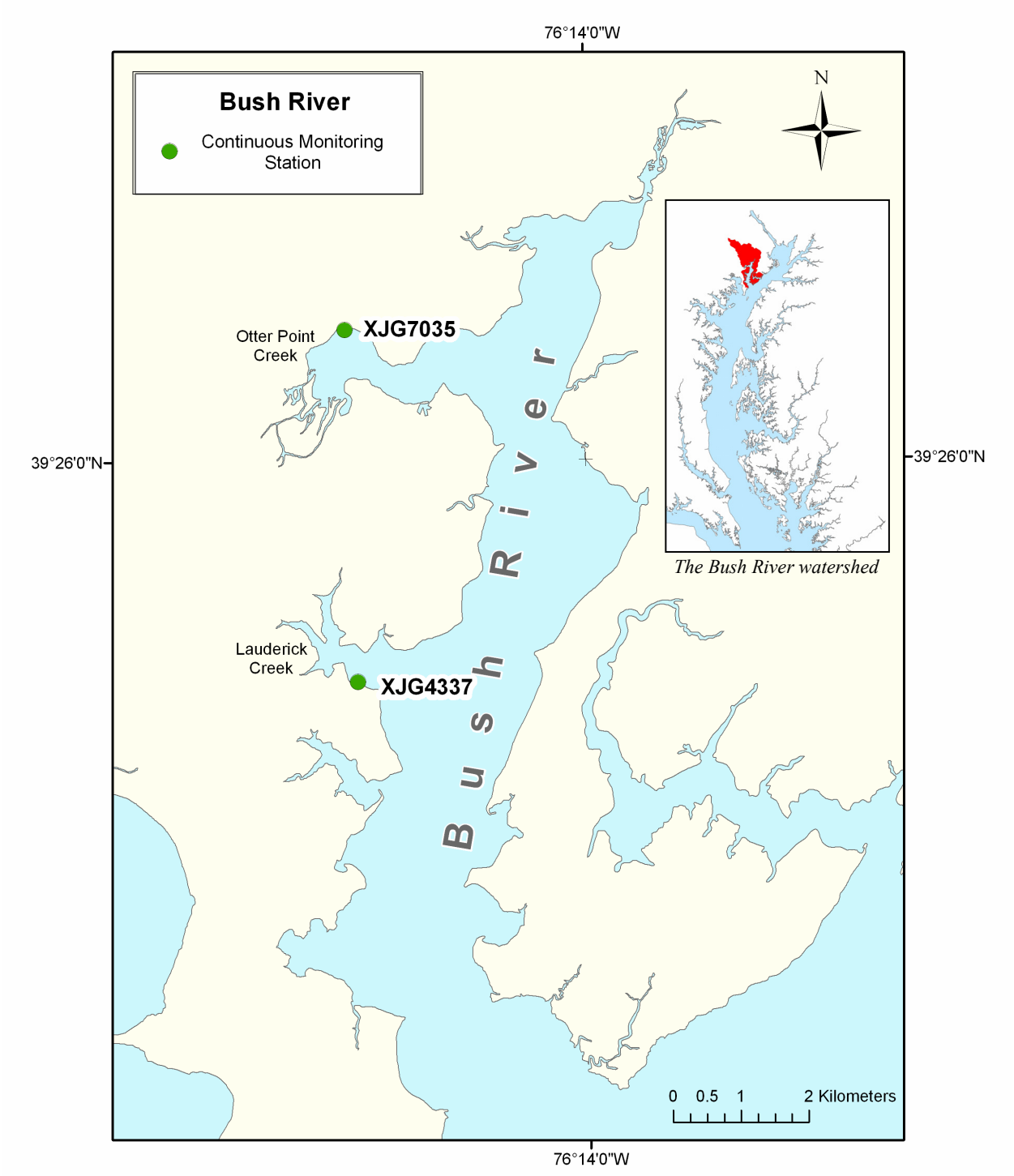

Figure 1. A map of the Bush River showing the 2006 Continuous Monitoring sites at Otter Point Creek and Lauderick Creek

Table 1. Total and average precipitation measured at the Baltimore/Washington International - Thurgood Marshall Airport (BWI) during 2006. www.bwiairport.com

Month	Total rainfall (inches)	Normal rainfall (inches)	Departure from Normal (inches)	Mean Rainfall (inches)
January	3.48	3.47	0.01	0.129
February	2.64	3.02	-0.38	0.110
March	0.18	3.93	-3.75	0.008
April	3.28	3	0.28	0.117
May	1.61	3.89	-2.28	0.062
June	7.32	3.43	3.89	0.261
July	1.86	3.85	-1.99	0.069
August	1.45	3.74	-2.29	0.052
September	7.56	3.98	3.58	0.315
October	5.75	3.16	2.59	0.213
November	6.25	2.12	4.13	0.231
December	1.88	3.35	-1.47	0.070

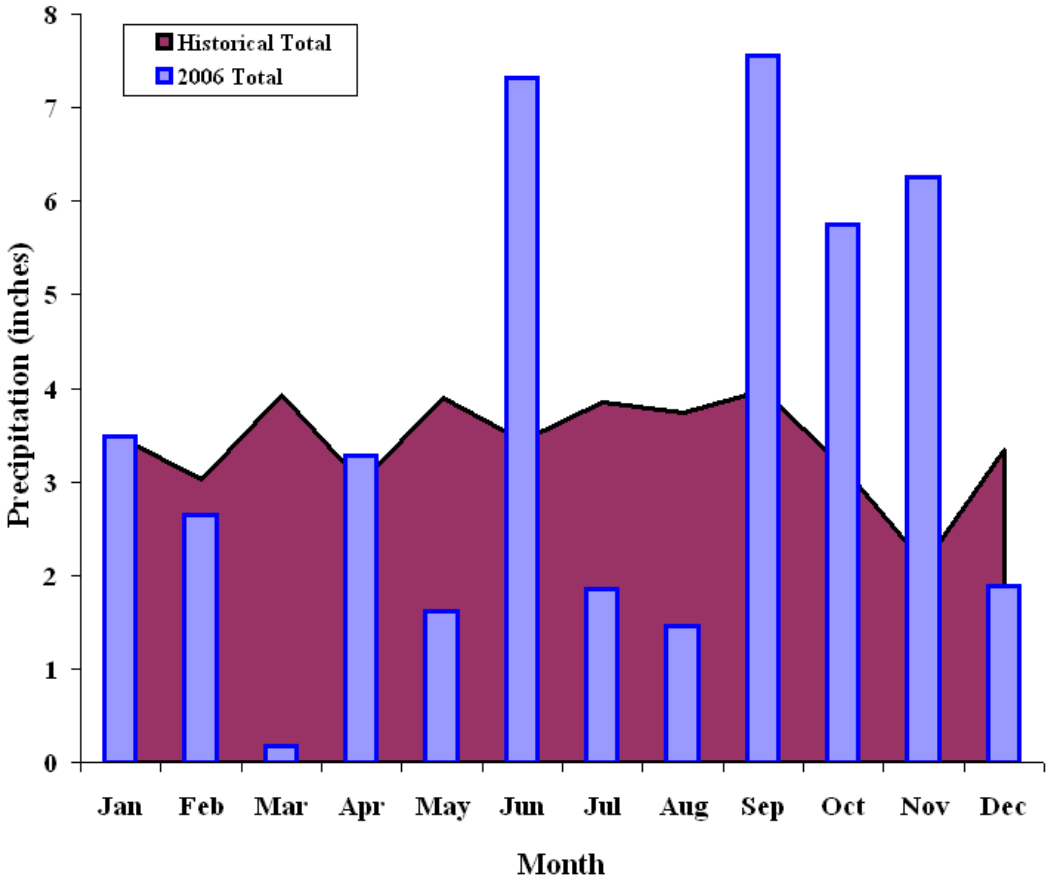

Figure 2. Comparison of the 2006 total monthly precipitation (inches) and the historical total monthly precipitation at Baltimore/Washington International - Thurgood Marshall Airport (BWI).

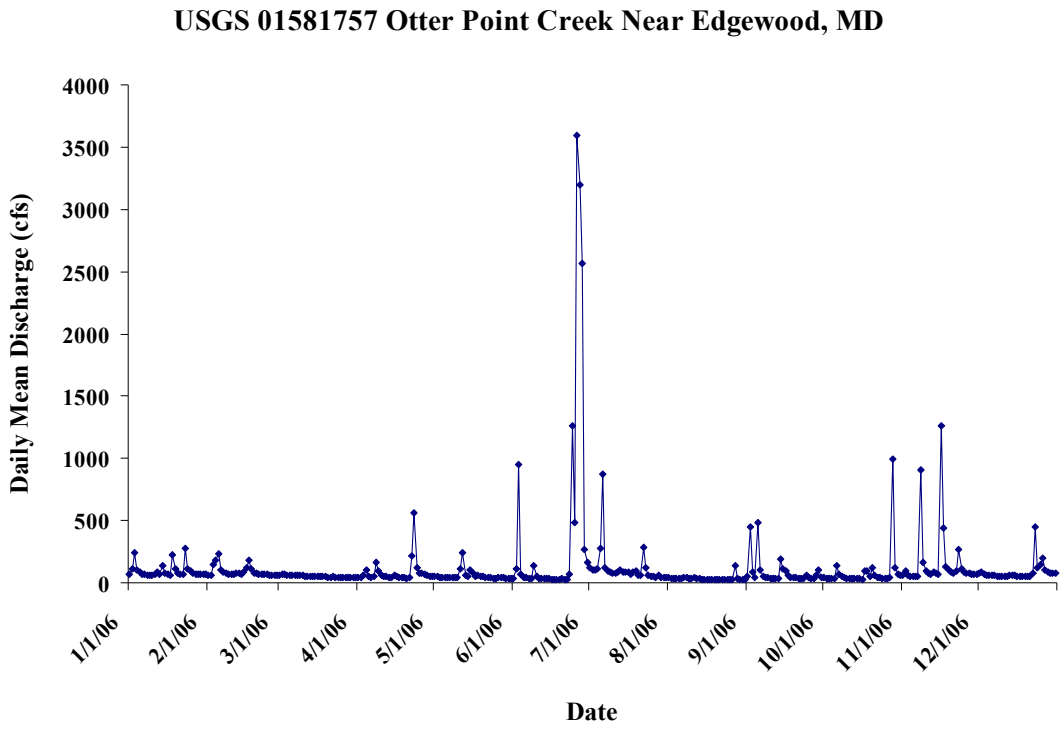

Figure 3. The daily mean discharge (Q) measured at the USGS Otter Point Creek Gage Station near Edgewood, Maryland in 2006. Measurements are reported in cubic feet per second (cfs). Data from USGS.gov

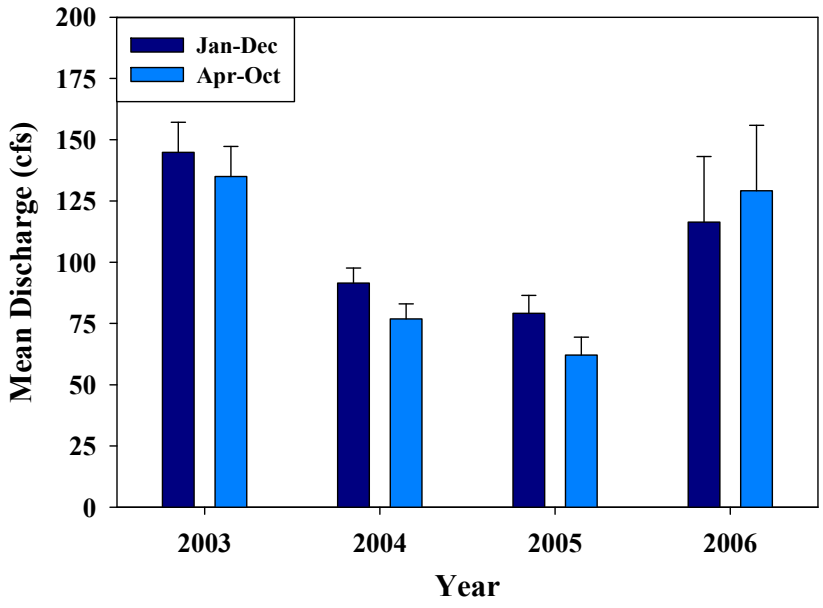

Figure 4. The yearly (Jan-Dec) and SAV growing season (Apr-Oct) mean discharge measured at the USGS Otter Point Creek Gage Station (01581757), 2003-2006. Measurements are reported in cubic feet per second (cfs). Data from USGS.gov

Salinity *(See Figure 5 for graph of data)*

Salinity levels for both the Otter Point Creek and Lauderick Creek stations were well within their normal annual ranges. Salinity values are lower for Otter Point Creek because it is located farther upriver. An extreme rain event occurred in the period June 24 – 28, 2006, where as much as 12 inches of precipitation fell in the upper Bush River watershed. Effects of this event were seen at both stations, as salinity levels approach zero due to the fresh water input (Figure 3). Approximately two months passed before salinity recovered to its previous level.

Dissolved Oxygen *(See Figure 5 for graph of data)*

Dissolved oxygen is an important measure of water quality. Values less than 5.0 mg/l are known to stress fish and other aquatic organisms. Dissolved oxygen graphs for both Lauderick Creek and Otter Point Creek exhibited expected declines during the summer months, due to warmer water temperatures and higher demand by algae. In general, the percent failure of dissolved oxygen thresholds (Table 2) was much less than the period of 2003 – 2005 for Otter Point Creek, but slightly higher for Lauderick Creek.

The daily variability observed in the dissolved oxygen data is due to the diel cycle of algae producing oxygen during daylight hours, while consuming it at night. This is compounded during periods of high algal concentration when significant amounts of oxygen are also consumed during the process of decomposing dead algae.

The greater magnitude of variability at Otter Point Creek suggests that area is more affected by excess nutrients and algae blooms than Lauderick Creek. The Otter Point Creek site is located in a bed of *Hydrilla verticillata*, an exotic underwater grass which also contributes oxygen to the system during the day.

Oxygen levels at Lauderick Creek were at their highest point during a spring phytoplankton bloom recorded in March and April. After the bloom dissipated at the end of April, dissolved oxygen was generally recorded between 5 and 8 mg/l for most of the summer months. The gap which exists in Lauderick Creek oxygen data in early July was due to a probe failure.

pH *(See Figure 6 for graph of data)*

pH is a measure of the acidity of the water, and is most useful as a surrogate for chlorophyll when algae communities are made up of cyanobacteria, also known as blue-green algae. Cyanobacteria do not fluoresce within the wavelength spectrum measured by the YSI 6025 chlorophyll probe. Elevated pH levels in low salinity waters, such as those in the the Bush River, often indicate high concentrations of cyanobacteria.

The extreme precipitation event at the end of June lowered the pH at Otter Point Creek for several days. Rainwater has pH of about 5.5, much less than the water in the creek, which ranged from approximately 6.5 – 9 during the month of June. The large influx of freshwater

caused the dramatic, but temporary, drop in pH. Lauderick Creek also exhibited a decline in pH during this time, although it is much less dramatic because it is farther downriver.

Water Temperature (*See Figure 6 for graph of data*)

Water temperature at both Bush River stations predictably rose as air temperatures increased during the summer months. Higher water temperatures create an environment that is more conducive to algae blooms. As water temperature increases, water also hold less dissolved oxygen. Notably, for the first time since intensive monitoring began in 2003, water temperatures exceeded 35°C at Otter Point Creek. The maximum temperatures for the year at each station were 35.96°C (96.7°F) at Otter Point Creek on July 31, and 33.18°C (91.7 °F) at Lauderick Creek on July 18.

Turbidity (*See Figure 7 for graph of data*)

Turbidity is a measure of water clarity that quantifies the degree to which the water loses its transparency due to the presence of suspended particulates. In 2006, several events caused turbidity levels to rise.

At Lauderick Creek, the spring phytoplankton bloom observed in March and April contributed to elevated turbidity levels during that time. The June rainfall event also caused turbidity to increase due to the influx of sediment-laden stormwater runoff. The effect of the June rains was more profound at Otter Point Creek, where turbidity temporarily approached 1000 NTU, a level that is near to the maximum detection limit of the sensor.

Examination of the percent failure of the estimated turbidity threshold for underwater grass growth (Table 2) shows that each station met the threshold less than 1% of the time sampled. This may explain, in part, why the acres of underwater grasses have been in decline over recent years.

Chlorophyll *(See Figure 7 for graph of data)*

Chlorophyll is a measure of algae in the water, and is calculated using values measured by a fluorescence probe. Most species of algae fluoresce within the spectrum of wavelengths emitted by the sensor. However, some species, such as many species of cyanobacteria, fluoresce outside this wavelength and are thus not detected.

At Lauderick Creek, the chlorophyll sensor recorded the spring phytoplankton bloom beginning in late March and extending into April. A short-lived increase was recorded in the end of May, and then chlorophyll levels remained relatively constant, hovering below 20 ug/l for most of the rest of the year. Comparing the Lauderick Creek data to the narrative chlorophyll criteria (Table 2) shows approximately one-third of the readings exceeded 15 ug/l, and 5.5 % were above 50 ug/l. Again, this is excluding any cyanobacteria that fluoresce outside the visible range of the sensor.

At Otter Point Creek, the spring bloom was also captured by the fluorescence sensor, which logged elevated chlorophyll levels in March and April. As with the Lauderick site, chlorophyll values declined following a spike in late May, and remained below 50 ug/l for the remainder of the sampling season. The baseline chlorophyll at Otter Point Creek is higher than that of Lauderick Creek. The percent failure for 15 ug/l chlorophyll (Table 2) was nearly 60%.

Table 2. Bush River Continuous Monitoring Percent Failure (2006)

		June - September		April - October		
Station Name	Station ID	Dissolved Oxygen Thresholds		Chlorophyll *a* Narrative Criteria		Turbidity Threshold
		<3.2 mg/L	<5.0 mg/L	>15 ug/L	>50ug/L	>8 NTU
Otter Point Creek	XJG7035	0.1%	9.0%	59.7%	1.6%	99.8%
Lauderick Creek	XJG4337	0.3%	6.5%	32.2%	5.5%	99.2%

The Dissolved Oxygen threshold of 3.2 mg/l is the EPA instantaneous minimum for the open water fish and shellfish designated use. 5.0 mg/l is Chesapeake Bay continuous concentration criteria for open water. (See www.chesapeakebay.net/content/publications/cbp_12138.pdf)

For Chlorophyll a*, values greater than 50 ug/l are generally considered algae bloom conditions. Values less than 15 mg/l generally represent healthy algae concentrations*

The turbidity threshold of 8 NTU is an estimation of the water clarity required for underwater grass growth.

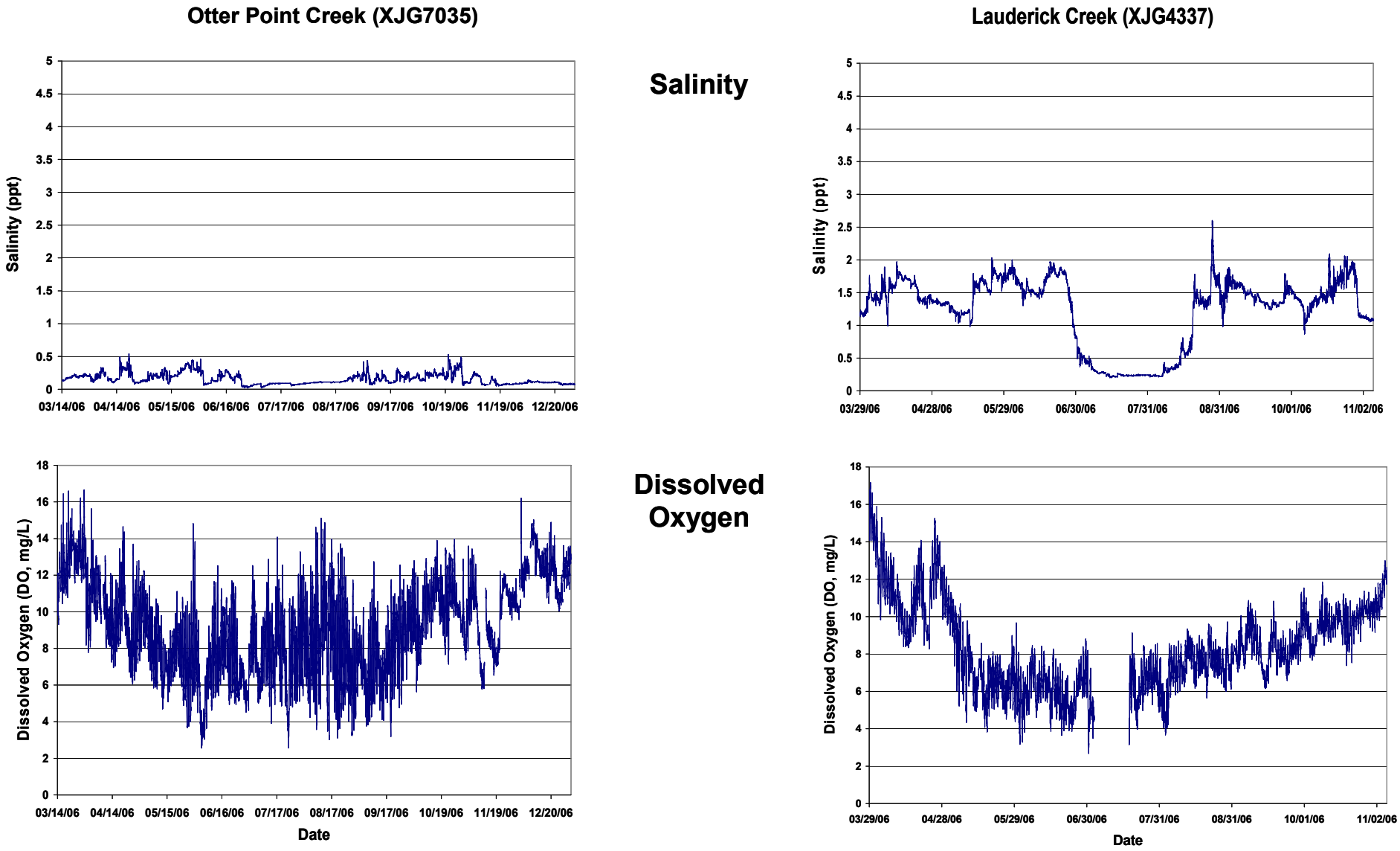

Figure 5. Continuous Monitoring sonde readings for salinity and dissolved oxygen at Otter Point Creek and Lauderick Creek, 2006.

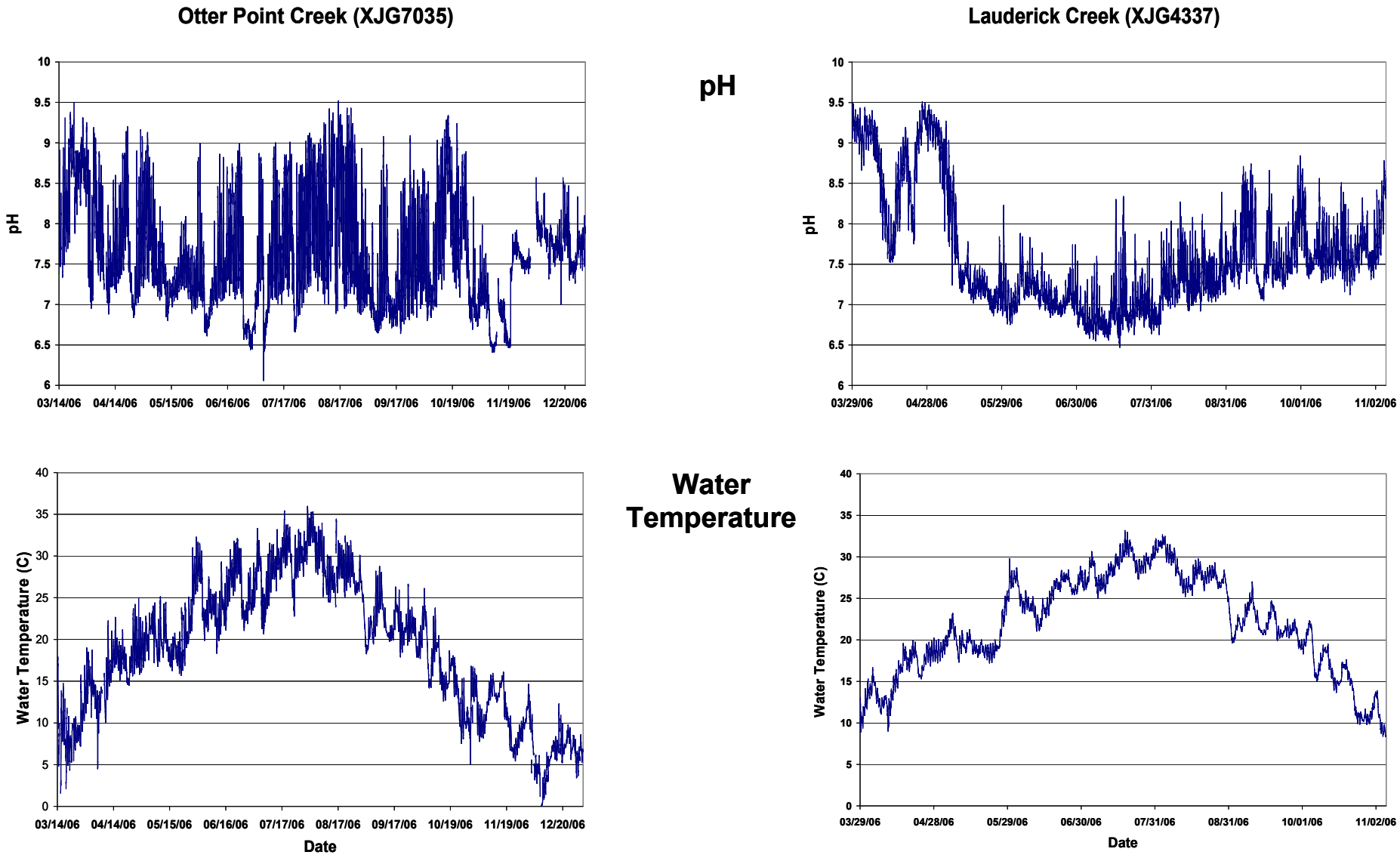

Figure 6. Continuous Monitoring sonde readings for pH and water temperature at Otter Point Creek and Lauderick Creek, 2006.

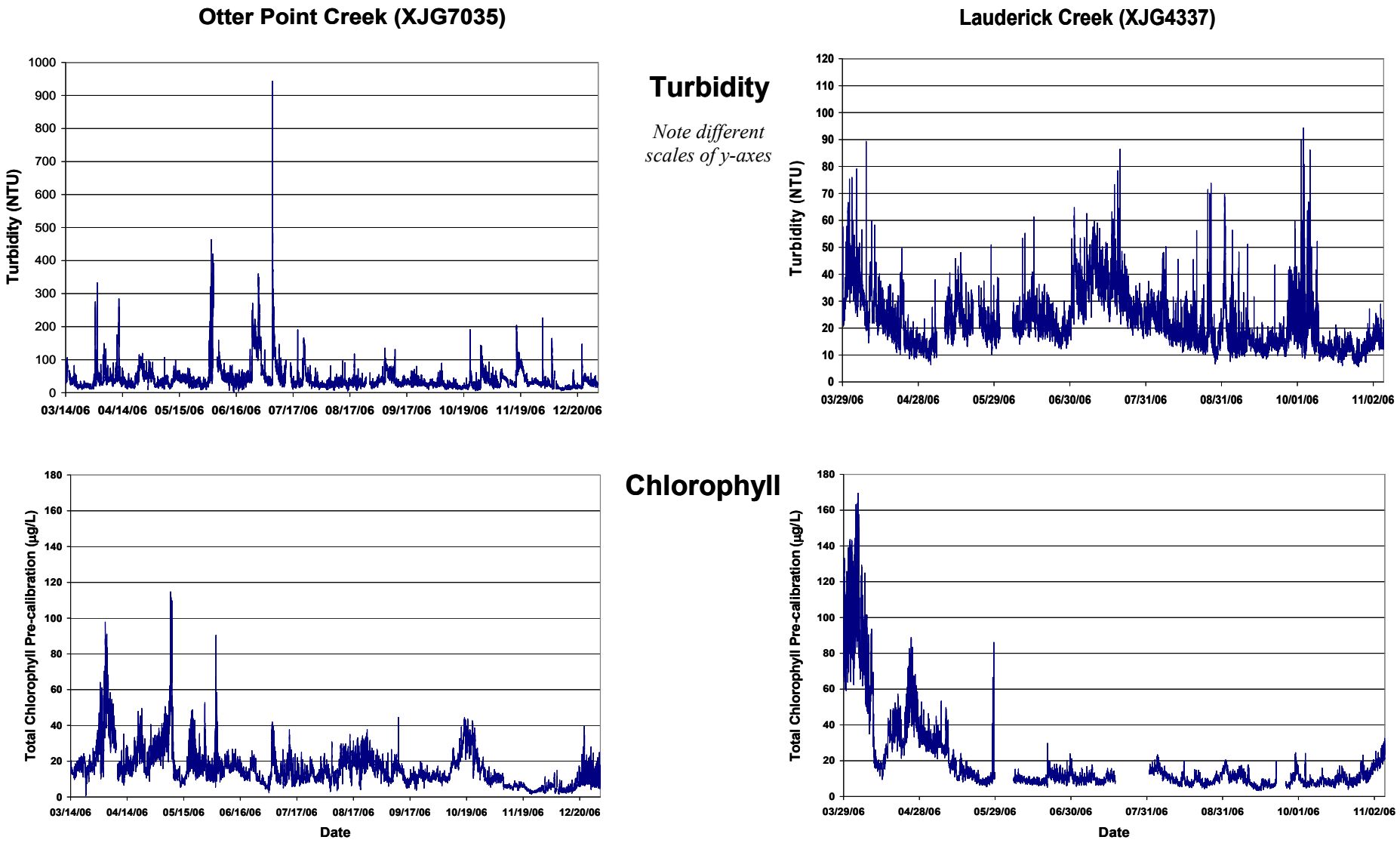

Figure 7. Continuous Monitoring sonde readings for turbidity and total chlorophyll at Otter Point Creek and Lauderick Creek, 2006.

Pigment and Nutrient Data

Bi-weekly grab samples of water were taken at each of the two Continuous Monitoring stations on the Bush River. Secchi depth, a measure of water clarity, was also recorded at the time of the grab sample. The water was processed using vacuum filtration, and the resulting particulate and filtrate samples delivered to laboratories for analysis. Chlorophyll *a* and pheophytin were analyzed by the Maryland Department of Health and Mental Hygiene (DHMH) Environmental Chemistry Division. Suspended solids and nutrient samples were analyzed at the University of Maryland's Chesapeake Biological Laboratory (CBL) Nutrient Analytical Services Laboratory (NASL). For details on methods, procedures, analysis and detection limits, refer to the Quality Assurance Project Plan (QAPP) for the Shallow Water Monitoring Program. This document can be found at http://mddnr.chesapeakebay.net/eyesonthebay/documents/swm_qapp_2006.pdf.

In the most recent Upper Western Shore Basin Summary, DNR characterized the relative status of total phosphorus in Bush River as good, with an improving trend. Total nitrogen was classified as fair, also with an improving trend. Chlorophyll *a* status, however, was classified as poor, although it did show an improving linear trend. (http://www.dnr.state.md.us/bay/tribstrat/upper_west/uw_status_trends.html)

Table 3. Discrete Continuous Monitoring Data for Chlorophyll-*a*, Pheophytin, Dissolved Organic Carbon, Total Suspended Solids, Volatile Suspended Solids, and Secchi Disk Depth for Otter Point Creek (XJG7035) in 2006.

Date	Sample Depth (m)	Replicate Number	Chlorophyll-a (µg/L)	Pheophytin (µg/L)	Dissolved Organic Carbon (mg/L)	Total Suspended Solids (mg/L)	Volatile Suspended Solids (mg/L)	Secchi Depth (m)
03/14/06	0.6	1	23.92	2.77		66.0	9.0	0.3
03/28/06	0.5	1	29.90	3.07		16.5	8.5	0.4
03/28/06	0.5	2	29.16	1.98		16.0	8.5	
04/11/06	0.2	1	31.77	6.82	3.90	85.0	15.0	0.1
04/25/06	0.3	1	29.16	2.77	6.63	71.0	12.0	0.2
04/25/06	0.3	2	32.15	2.39		61.0	11.0	
05/09/06	0.2	1	26.17	7.33	3.87	35.0	12.0	0.1
05/23/06	0.1	1	15.89	0.47	3.57	25.0	8.8	0.3
05/23/06	0.1	2	14.02	0.37		22.5	7.5	
06/06/06	0.1	1	7.48	4.95	6.54	68.8	12.5	
06/20/06	0.1	1	28.41	6.65	4.38	32.0	15.0	0.2
06/20/06	0.1	2	14.20	6.21		27.0	10.0	
07/03/06	0.1	1	38.13	0.60	3.89	39.0	11.0	0.3
07/18/06	0.2	1	29.16	4.34	5.90	2.4	19.0	0.3
07/18/06	0.2	2	26.91	5.01		26.0	8.0	
08/01/06	0.3	1	37.38	10.37	5.11	31.3	13.7	0.2
08/15/06	0.3	1	35.88	7.55	4.32	26.0	10.0	0.3
08/28/06	0.5	1	44.86	15.85	4.95	40.0	13.0	0.3
08/28/06	0.5	2	34.39	10.62		22.0	11.0	
09/11/06	0.2	1	38.88	4.04	4.72	27.0	10.0	
09/26/06	0.2	1	35.88	4.93	4.20	80.0	18.0	0.3
09/26/06	0.2	2	25.42	3.89		41.0	14.0	
10/10/06	0.3	1	17.94	1.94	4.04	18.0	7.0	0.4
10/24/06	0.1	1	31.90	2.99	4.39	8.0	6.7	0.4
10/24/06	0.1	2	29.41	4.09		13.3	6.7	
11/06/06	0.3	1	11.46	4.59	5.30	25.3		0.3
11/20/06	0.2	1	4.49	0.75		42.0		0.1
11/20/06	0.2	2	4.49	0.75				
12/19/06	0.2	1	20.93	3.49		14.7	6.0	0.3
12/19/06	0.2	2	19.94	2.39				0.3

Table 4. Discrete Continuous Monitoring Data for Chlorophyll-*a*, Pheophytin, Dissolved Organic Carbon, Total Suspended Solids, Volatile Suspended Solids, and Secchi Disk Depth for Lauderick Creek (XJG4337) in 2006.

Date	Sample Depth (m)	Chlorophyll-a (μg/L)	Pheophytin (μg/L)	Dissolved Organic Carbon (mg/L)	Total Suspended Solids (mg/L)	Volatile Suspended Solids (mg/L)	Secchi Depth (m)
04/11/06	1	20.93	10.47	3.34	36.0	10.0	0.2
04/25/06	1	49.34	5.08	4.55	26.0	10.7	0.6
05/09/06	1	24.67	7.78	4.40	27.0	10.0	0.2
05/23/06	1	11.96	3.74	3.56	33.0	9.0	0.3
06/06/06	1	13.46	3.29	3.54	37.0	10.0	
06/20/06	1	26.91	6.58	3.26	28.0	8.0	0.3
07/03/06	1	10.47	4.19	5.97	33.0	8.0	0.2
07/18/06	1	12.71	9.27	5.24	34.0	8.0	0.3
08/01/06	1	18.69	5.91	5.60	26.0	9.0	0.4
08/15/06	1	19.94	4.83	5.14	25.3	6.0	0.5
08/28/06	1	17.44	4.54	4.50	16.0	6.0	0.6
09/11/06	1	23.42	4.14	4.58	28.0	8.7	
09/26/06	1			4.25	21.0	11.0	0.3
10/10/06	1	19.81	3.22	4.07	17.5	5.5	0.5
10/24/06	1	13.95	3.49	3.93	12.7	4.7	0.6
11/06/06	1	22.05	5.94	4.03	25.0		0.5

Table 5. Discrete Continuous Monitoring Nutrient Data for Otter Point Creek (XJG7035) in 2006: ammonium (NH_4), nitrite (NO_2), nitrite + nitrate (NO23), dissolved inorganic nitrogen (DIN), particulate nitrogen (PN), total dissolved nitrogen (TDP), total nitrogen (TN), orthophosphate (PO_4), particulate phosphorus (PP), total dissolved phosphorus (TDP), total phosphorus (TP), particulate carbon (PC), and silicate (SiO_2).

Date	Depth (m)	Replicate	NH_4 (mg/L)	NO_2 (mg/L)	NO23 (mg/L)	DIN (mg/L)	PN (mg/L)	TDN (mg/L)	TN (mg/L)	PO_4 (mg/L)	PP (mg/L)	TDP (mg/L)	TP (mg/L)	PC (mg/L)	SiO_2 (mg/L)
03/14/06	0.6	1	0.014	0.016	1.810	1.824		2.420		0.0024		0.076			
03/28/06	0.5	1	0.012	0.016	0.980	0.992		1.860		0.0023		0.072			
03/28/06	0.5	2	0.007	0.012	1.040	1.047				0.0027					
04/11/06	0.2	1	0.043	0.015	1.230	1.273	0.753	1.500	2.253	0.0033	0.110	0.017	0.127	5.16	3.36
04/25/06	0.3	1	0.171	0.018	1.050	1.221	0.543	1.660	2.203	0.0069	0.109	0.028	0.137	3.97	2.02
04/25/06	0.3	2	0.168	0.019	1.020	1.188				0.0033					
05/09/06	0.2	1	0.035	0.019	0.590	0.625	0.808	1.120	1.928	0.0046	0.062	0.019	0.082	5.91	3.20
05/23/06	0.1	1	0.031	0.007	0.259	0.290	0.528	0.690	1.218	0.0035	0.039	0.013	0.052	3.11	3.96
05/23/06	0.1	2	0.023	0.005	0.264	0.287				0.0034					
06/06/06	0.1	1	0.299	0.024	0.481	0.780	0.412	1.700	2.112	0.0046	0.112	0.030	0.143	3.13	3.55
06/20/06	0.1	1	0.065	0.022	0.649	0.714	0.584	1.180	1.764	0.0038	0.074	0.017	0.091	3.49	4.57
06/20/06	0.1	2	0.054	0.020	0.638	0.692				0.0042					
07/03/06	0.1	1	0.028	0.017	1.253	1.281	0.474	1.730	2.204	0.0043	0.064	0.022	0.086	2.83	6.14
07/18/06	0.2	1	0.028	0.018	0.866	0.894	0.567	1.290	1.857	0.0076	0.097	0.022	0.120	3.43	5.02
07/18/06	0.2	2	0.023	0.017	0.849	0.872				0.0031					
08/01/06	0.3	1	0.037	0.013	0.311	0.348	0.662	0.750	1.412	0.0038	0.069	0.017	0.085	4.15	5.06
08/15/06	0.3	1	0.043	0.028	0.694	0.737	0.515	1.120	1.635	0.0033	0.059	0.024	0.083	3.20	5.01
08/28/06	0.5	1	0.054	0.021	0.518	0.572	0.635	1.260	1.895	0.0032	0.088	0.022	0.110	3.63	4.36
08/28/06	0.5	2	0.036	0.022	0.465	0.501				0.0025					
09/11/06	0.2	1	0.019	0.015	0.621	0.640	0.519	1.090	1.609	0.0068	0.046	0.017	0.062	3.91	4.09
09/26/06	0.2	1	0.014	0.010	0.696	0.710	0.622	1.140	1.762	0.0077	0.100	0.016	0.115	5.53	3.96
09/26/06	0.2	2	0.003	0.010	0.658	0.661				0.0070					
10/10/06	0.3	1	0.023	0.007	0.677	0.700	0.376	0.900	1.276	0.0040	0.031	0.015	0.046	2.85	3.84
10/24/06	0.1	1	0.009	0.007	0.478	0.487	0.442	0.810	1.252	0.0041	0.040	0.014	0.054	2.97	3.93
10/24/06	0.1	2	0.008	0.007	0.449	0.457				0.0041				.	.
11/06/06	0.3	1	0.060	0.006	0.535	0.595	0.301	0.930	1.231	0.0057	0.044	0.016	0.059	2.07	3.49
11/20/06	0.2	1	0.070	0.006	0.784	0.854				0.0087					
11/20/06	0.2	2	0.074	0.007	0.812	0.886				0.0089					
12/19/06	0.2	1	0.004	0.008	1.920	1.924		2.440		0.0019		0.051			
12/19/06	0.2	2	0.004	0.007	1.950	1.924				0.0017					

Table 6. Discrete Continuous Monitoring Nutrient Data for Lauderick Creek (XJG4337) in 2006: ammonium (NH_4), nitrite (NO_2), nitrite + nitrate (NO23), dissolved inorganic nitrogen (DIN), particulate nitrogen (PN), total dissolved nitrogen (TDP), total nitrogen (TN), orthophosphate (PO_4), particulate phosphorus (PP), total dissolved phosphorus (TDP), total phosphorus (TP), particulate carbon (PC), and silicate (SiO_2).

Date	Depth (m)	NH_4 (mg/L)	NO_2 (mg/L)	NO23 (mg/L)	DIN (mg/L)	PN (mg/L)	TDN (mg/L)	TN (mg/L)	PO_4 (mg/L)	PP (mg/L)	TDP (mg/L)	TP (mg/L)	PC (mg/L)	SiO_2 (mg/L)
04/11/06	1	0.036	0.007	0.412	0.448	0.743	1.080	1.823	0.0036	0.067	0.023	0.090	4.47	0.36
04/25/06	1	0.011	0.002	0.014	0.025	0.703	0.780	1.483	0.0046	0.064	0.021	0.085	5.25	0.03
05/09/06	1	0.010	0.001	0.054	0.064	0.498	0.370	0.868	0.0028	0.064	0.016	0.080	3.62	0.35
05/23/06	1	0.046	0.001	0.016	0.062	0.482	0.530	1.012	0.0027	0.070	0.016	0.087	3.17	2.48
06/06/06	1	0.019	0.002	0.005	0.024	0.455	0.490	0.945	0.0028	0.052	0.022	0.075	3.07	3.88
06/20/06	1	0.025	0.003	0.015	0.040	0.406	0.370	0.776	0.0027	0.062	0.018	0.080	2.42	3.38
07/03/06	1	0.031	0.001	0.091	0.122	0.274	0.580	0.854	0.0056	0.049	0.025	0.073	1.95	4.36
07/18/06	1	0.085	0.002	0.081	0.166	0.322	0.810	1.132	0.0234	0.050	0.048	0.098	2.22	4.77
08/01/06	1	0.086	0.002	0.017	0.103	0.327	0.630	0.957	0.0086	0.046	0.029	0.074	2.07	4.58
08/15/06	1	0.008	0.002	0.009	0.017	0.332	0.650	0.982	0.0057	0.046	0.036	0.082	2.17	2.19
08/28/06	1	0.013	0.013	0.076	0.089	0.290	0.650	0.940	0.0059	0.036	0.031	0.067	1.73	0.92
09/11/06	1	0.003	0.000	0.003	0.006	0.423	0.420	0.843	0.0057	0.058	0.018	0.076	3.12	1.10
09/26/06	1	0.003	0.001	0.003	0.006	0.273	0.420	0.693	0.0051	0.035	0.012	0.047	2.52	1.40
10/10/06	1	0.023	0.003	0.123	0.146	0.363	0.590	0.953	0.0056	0.039	0.017	0.056	2.33	2.09
10/24/06	1	0.029	0.003	0.083	0.112	0.256	0.460	0.716	0.0039	0.025	0.014	0.039	1.74	1.59
11/06/06	1	0.016	0.004	0.097	0.113	0.343	0.560	0.903	0.0039	0.043	0.012	0.055	2.47	1.62

Submerged Aquatic Vegetation in the Bush River

Submerged aquatic vegetation (SAV) or underwater grasses are an important component of estuarine ecosystems. They provide habitat for juvenile fish and shellfish, supply food for waterfowl, oxygenate the water, and help stabilize bottom sediments. Little information is available regarding the historical distribution of SAV in the Bush River. According to aerial photographs taken by the Virginia Institute of Marine Science (VIMS), this segment of the Chesapeake Bay did not support SAV from 1989 to 1995. Patches of underwater grasses totaling <100 acres were observed in the Bush River in 1996 and 1997, but disappeared in 1998 and 1999. Underwater grasses reappeared in the Bush River in 2000 and maintained a constant presence in the river through 2006.

From 2002 to 2004, the SAV acreage in the Bush River steadily increased from 350 acres to 1,024 acres (figure 5). During this time period, SAV beds were concentrated in the upper reaches of Church Creek, Otter Point Creek, and Dove Cove. SAV coverage expanded by 164% between 2003 and 2004 and additional beds were observed along the main stem of the Bush River from Church Creek to Abbey Point and in Redmon and Towner Coves. During these three years, SAV beds were diverse, with as many as ten species of underwater grasses observed in a single year, and of moderate to high density.

SAV reached its highest level in the Bush River in 2004 (1,024 acres) and then declined during 2005 and 2006. The number of species of SAV observed in the river dropped from ten species in 2004 to the following four core species in 2006 (table 7): Coontail (*Ceratophyllum demersum*), Hydrilla (*Hydrilla verticillata*), Eurasian Watermilfoil (*Myriophyllum spicatum*), and Wild Celery (*Vallisneria americana*). The decline in SAV during the past three years coincided with the Bush River failing to meet several important SAV habitat criteria. From 2004 to 2006, the Bush River failed to meet the criteria for water clarity and chlorophyll (algae) and only met borderline conditions for total suspended solids (TSS). The Bush River did, however, meet the SAV habitat requirement for phosphorus, which is the only nutrient with habitat requirements in low-salinity portions of the Chesapeake Bay.
(www.dnr.state.md.us/bay/pdfs/UWSBasinSum8505FINAL07.pdf)

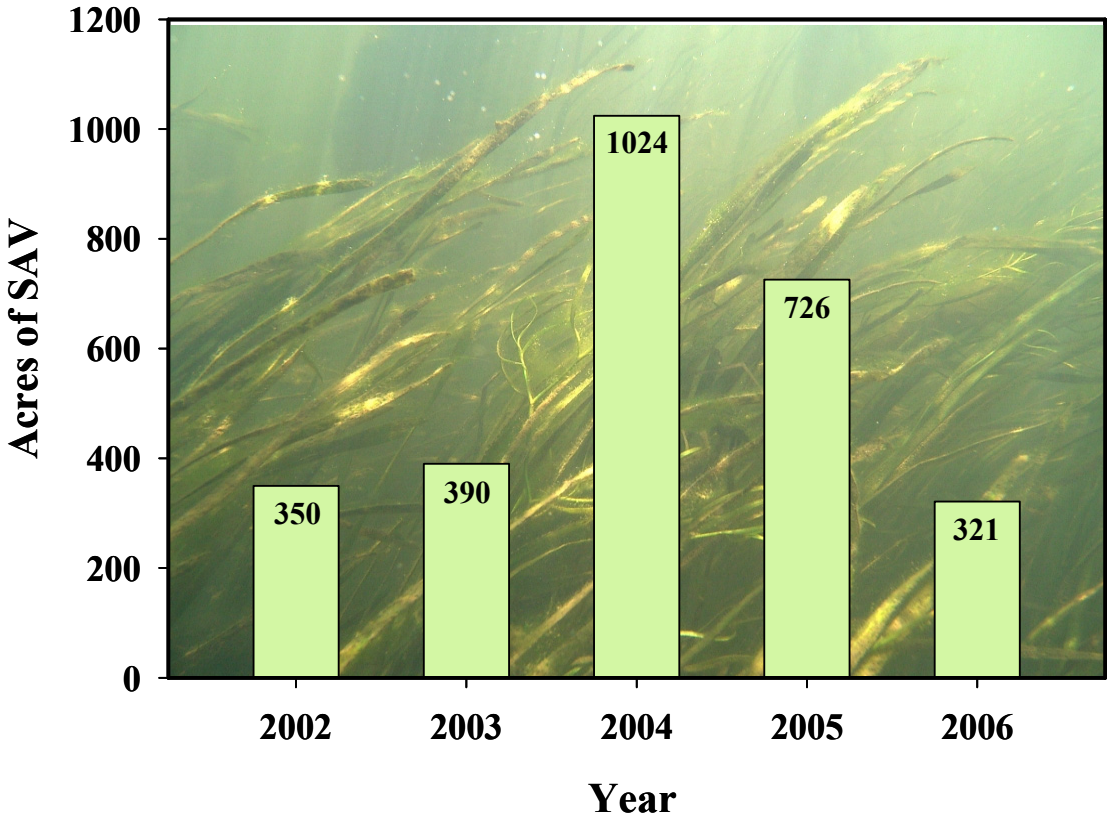

Figure 8. The number of acres of submerged aquatic vegetation (SAV) in the Bush River from 2002 through 2006. The background shows a bed of Wild Celery (*Vallisneria americana*).

Table 7. Recent Distribution of Submerged Aquatic Vegetation (SAV) in the Bush River.

Year	Acres of SAV	Percent change from previous year	SAV Density Class	SAV Density Class Distribution (% of total)	Number of species	Species Present
2002	349.83	+80%	0-10%	1.04%	9	Cd, Ec, Hd, Hv, Ms, Pcr, Ppu, Va, Zp
			10-40%	44.28%		
			40-70%	11.58%		
			70-100%	43.09%		
2003	390.15	+12%	0-10%	1.45%	10	Cd, Ec, Hd, Hv, Ms, Nm, Pcr, Ppu, Va, Zp
			10-40%	35.08%		
			40-70%	63.48%		
			70-100%	0.00%		
2004	1024.20	+164%	0-10%	6.41%	10	Cd, Ec, Hd, Hv, Ms, Ngu, Nm, Pp, Va, Zp
			10-40%	42.40%		
			40-70%	2.64%		
			70-100%	48.55%		
2005	725.53	-29%	0-10%	11.20%	8	Cd, Ec, Hv, Ms, Ngu, Nm, Pp, Va
			10-40%	33.21%		
			40-70%	11.43%		
			70-100%	44.16%		
2006	321.09	-56%	0-10%	NA	4	Cd, Hv, Ms, Va
			10-40%	NA		
			40-70%	NA		
			70-100%	NA		

Species key:

Cd - *Ceratophyllum demersum* (coontail)
Ec - *Elodea canadensis* (common elodea)
Hd - *Heteranthera dubia* (water stargrass)
Hv - *Hydrilla verticillata* (hydrilla)
Ms - *Myriophyllum spicatum* (Eurasian watermilfoil)
Ngu - *Najas guadalupensis* (southern naiad)
Nm - *Najas minor* (spiny naiad)
Pcr - Potamogeton crispus (curly pondweed)
Ppu - Potamogeton pusillus (slender pondweed)
Va - *Vallisneria americana* (wild celery)
Zp - *Zannichellia palustris* (horned pondweed)