VIRGINIA WATER RESOURCES RESEARCH CENTER

Development of
Aquatic Life Use Assessment Protocols
for
Class VII Waters in Virginia

Addendum to 2016 Report of the
Academic Advisory Committee
for
Virginia Department of Environmental Quality

SPECIAL REPORT

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DEVELOPMENT OF AQUATIC LIFE USE ASSESSMENT PROTOCOLS FOR CLASS VII WATERS IN VIRGINIA

Addendum to 2016 Report of the Academic Advisory Committee for Virginia Department of Environmental Quality

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Introduction

This report is an addendum to the fiscal year (FY) 2016 report to the Department of Environmental Quality (DEQ) by the Academic Advisory Committee (AAC) entitled: "Development of Aquatic Life Use Assessment Protocols for Class VII Waters in Virginia" (Garey *et al*. 2016). The addendum provides a description of nutrient concentration data (total nitrogen and total phosphorus) at blackwater swamp sites visited in 2016, as well as benthic macroinvertebrate assemblage data collected at a subset (11) of these sites.

Data Collection

Water samples were collected for analysis of total nitrogen and total phosphorus (TN and TP, respectively) at study sites during the field visits described in the FY 2016 report (Garey *et al*. 2016). A total of 25 sites were visited in FY 2016. These sites were selected from the 34 sites detailed in the FY 2015 report (Garey *et al*. 2015), excluding four sites that did not exhibit characteristics of Class VII waters and five sites, which were posted and for which landowner permission for access was not obtained. Nutrients were not analyzed from two sites (Otterdam and Cypress Swamps) because water samples ruptured in the laboratory freezer. Therefore, TN and TP were determined from a total of 23 study sites (Table 1). Water samples were placed on ice immediately after collection, and stored in a laboratory freezer until analysis. TN and TP were analyzed in each sample using a Scalar Segmented Flow Analyzer.

Macroinvertebrate data were collected from 11 study sites. Nine of the 11 macroinvertebrate collections were made in March 2016, and two collections were retrieved from the Virginia Commonwealth University (VCU) Interactive Stream Assessment Resource (INSTAR) database. The retrieved collections came from an unnamed tributary to Mill Swamp (K34009) and from Terrapin Swamp (K33005) and were taken on May 13, 2005 and May 17, 2005, respectively (Table 1, Figure 1).

Table 1: Swamp sites identified in the FY 2015 AAC report as exhibiting characteristics of Class VII blackwater swamps and their respective location, total nitrogen and phosphorus concentrations, and land-cover condition.*

Site Code	Name	Longitude	Latitude	TN (mg/L)	TP (mg/L)	Land-Cover Condition
K25002	Raccoon Creek	-77.28	36.81	0.20	0.01	Altered
K38008	UNT Chapel Swamp	-76.80	36.62	0.48	0.02	Altered
K23004	Galley Swamp	-77.40	36.96	0.48	0.01	Altered
K34007	Golden Hill Swamp	-76.82	37.10	0.57	0.02	Altered
K35001	Round Hill Swamp	-76.94	36.85	0.59	0.05	Altered
K38009	Mill Swamp	-76.78	36.55	0.61	0.02	Altered
K38001	UNT Summerton Creek	-76.73	36.55	0.68	0.01	Altered
K29007	UNT Mill Run	77.08	36.80	0.71	0.02	Altered
K36018	Kingsale Swamp	-76.79	36.69	1.40	0.03	Altered
K33011	Burnt Mills Swamp	-76.78	36.85	1.51	0.02	Altered
K33005	Terrapin Swamp	-76.87	36.98	2.11	0.02	Altered
K24005	Parker Run	-77.17	36.86	NA	NA	Altered
K32007	UNT Blackwater River	-77.11	37.08	0.19	0.02	Reference
K29001	Parker Branch	-77.11	36.95	0.35	0.02	Reference
K23015	UNT Joseph Swamp	-77.28	37.08	0.44	0.03	Reference
K32002	UNT Johnchecohunk Swamp	-76.97	37.10	0.79	0.02	Reference
K23010	Mush Pond Swamp	-77.35	36.96	NA	NA	Reference
K32220	Otterdam Swamp	-77.15	37.14	NA	NA	Reference
K31020	UNT Blackwater Swamp	-77.21	37.12	0.16	0.02	Intermediate
K33003	Tucker Swamp	-76.87	36.88	0.27	0.01	Intermediate
K23017	UNT Nottoway River	-77.88	36.99	0.34	0.02	Intermediate
K23012	Gosee Swamp	-77.35	37.02	0.37	0.01	Intermediate
K34009	UNT Mill Swamp	-76.81	37.08	0.43	0.02	Intermediate
K35004	UNT Seacock Swamp	-76.92	36.95	0.51	0.01	Intermediate
K23002	Arthur Swamp	-77.47	37.17	0.66	0.01	Intermediate
K23007	Jones Hole Swamp 2	-77.40	37.10	0.68	0.01	Intermediate
K23003	Jones Hole Swamp	-77.37	37.07	NA	NA	Intermediate
K23013	Joseph Swamp	-77.22	37.04	NA	NA	Intermediate
K24002	Anderson Branch	-77.29	36.93	NA	NA	Intermediate
K32205	Cypress Swamp 2	-76.97	37.15	NA	NA	Intermediate

*Underlined sites are those for which macroinvertebrate samples were collected.

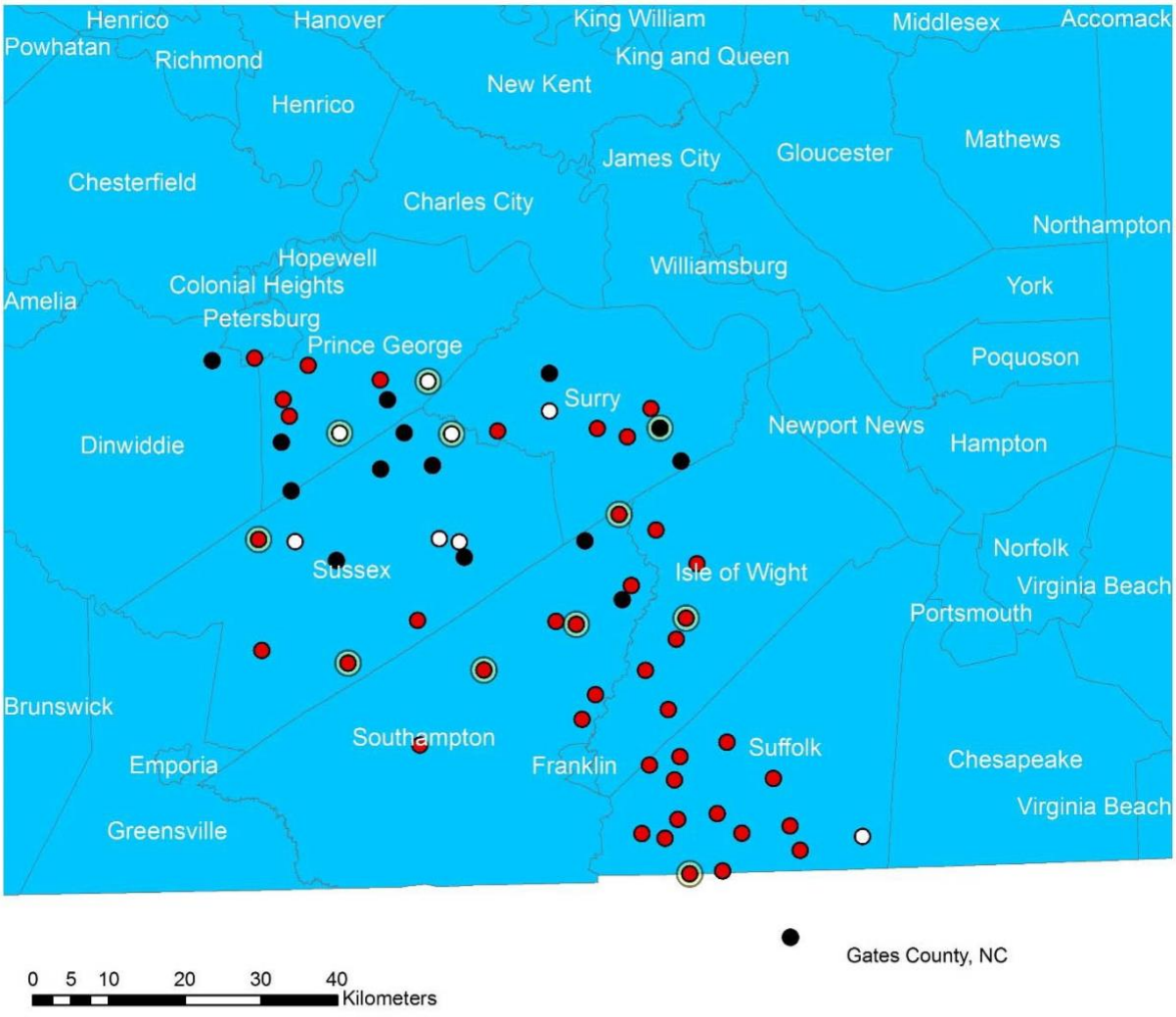

Figure 1: Blackwater swamp study site locations. Highlighted sites are those at which macroinvertebrate collections were made.

Analysis

A total of 17 candidate macroinvertebrate metrics were evaluated. These metrics included all used by DEQ in either the Virginia Stream Condition Index or the Coastal Plain Macroinvertebrate Index, as well as Simpson's and Shannon's diversity indices, and evenness indices calculated by dividing each of the diversity indices by total taxa richness (Table 2).

Index construction and evaluation were conducted in the same manner as for the fish-based index described in the FY 2016 report (Garey *et al*. 2016). First, metrics for which raw values of zero occurred at five or more sites were excluded. Based on simple linear correlations between percent forest land cover and raw metric values, the response of each remaining metric to stress was determined (increase or decrease in metric values with increasing watershed disturbance). Metrics were then scaled as described by Blocksom (2003), and the final index was constructed by selecting the metric score combination (arithmetic mean of metric scores) that yielded the highest correlation with the percentage of forest cover within each watershed. To effectively achieve this result, a code script was developed using R, version 3.1 (R Core Team 2014), following the algorithm presented by Schoolmaster *et al*. (2013).

Table 2: The 17 candidate metrics evaluated and their response to stress (where stress is defined as a decrease in percent forest land cover within the watershed).*

Metric	Explanation	Response to stress
Top 2 dominant taxa	Proportion of sample comprised of 2 most numerically dominant taxa	Decrease
Top 5 dominant taxa	Proportion of sample comprised of 5 most numerically dominant taxa	Decrease
Proportion *Ephemeroptera*	Proportion of sample comprised of the order *Ephemeroptera*	Decrease
Proportion *Plecoptera* and *Trichoptera*	Proportion of sample comprised of Plecoptera and Trichoptera, excluding the Family Hydropsychidae	NA
Proportion *Chironomidae*	Proportion of sample comprised of the Family *Chironomidae*	Decrease
Proportion scrapers	Proportion of sample comprised of algae scrapers	Increase
Taxa Richness	Total taxa in sample	Increase
EPT richness	Total number of EPT taxa	Increase
Average pollution tolerance value	Average pollution tolerance value	Increase
Proportion intolerant	Proportion of taxa with tolerance value < 3.5	NA
Proportion tolerant	Proportion of taxa with tolerance value > 3.5	Decrease
Proportion shredders	Proportion of sample comprised of taxa that shred coarse organic matter	Increase
Proportion clingers	Proportion of sample comprised of taxa that cling to hard substrate	Increase
Shannon diversity	Shannon diversity index	Increase
Simpson diversity	Simpson diversity index	Decrease
Shannon evenness	Shannon index divided by richness	Decrease
Simpson evenness	Simpson index divided by richness	Decrease

* Underlined metrics were used in the final bioassessment index.
NA: metric was excluded because five or more sites received scores of zero.

Results

The level of anthropogenic alteration assumed at each site based on the land-cover analysis was not changed by the nutrient concentrations. No reference sites had concentrations that exceeded the reference thresholds of 1.5 mg/L for TN or 0.05 mg/L for TP. Only two sites assigned to the altered category based on land cover exhibited TN concentrations that exceeded the reference threshold, and no sites exceeded the phosphorus threshold (Table 1).

The most effective index selected by the algorithm (i.e., that showing the strongest correlation with forest watershed land cover) consisted of five metrics: (1) top two dominant taxa, (2) proportion of *Ephemeroptera*, (3) proportion of *Chironomidae*, (4) *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) richness, and (5) Simpson's diversity (Table 2). The five-metric index showed a strong, and statistically significant linear correlation with the percentage of forest land cover (r: 0.88; $p<0.05$; Figure 2). Index scores were higher at reference sites than at altered sites in all cases (100% correct site assignment based on the macroinvertebrate index).

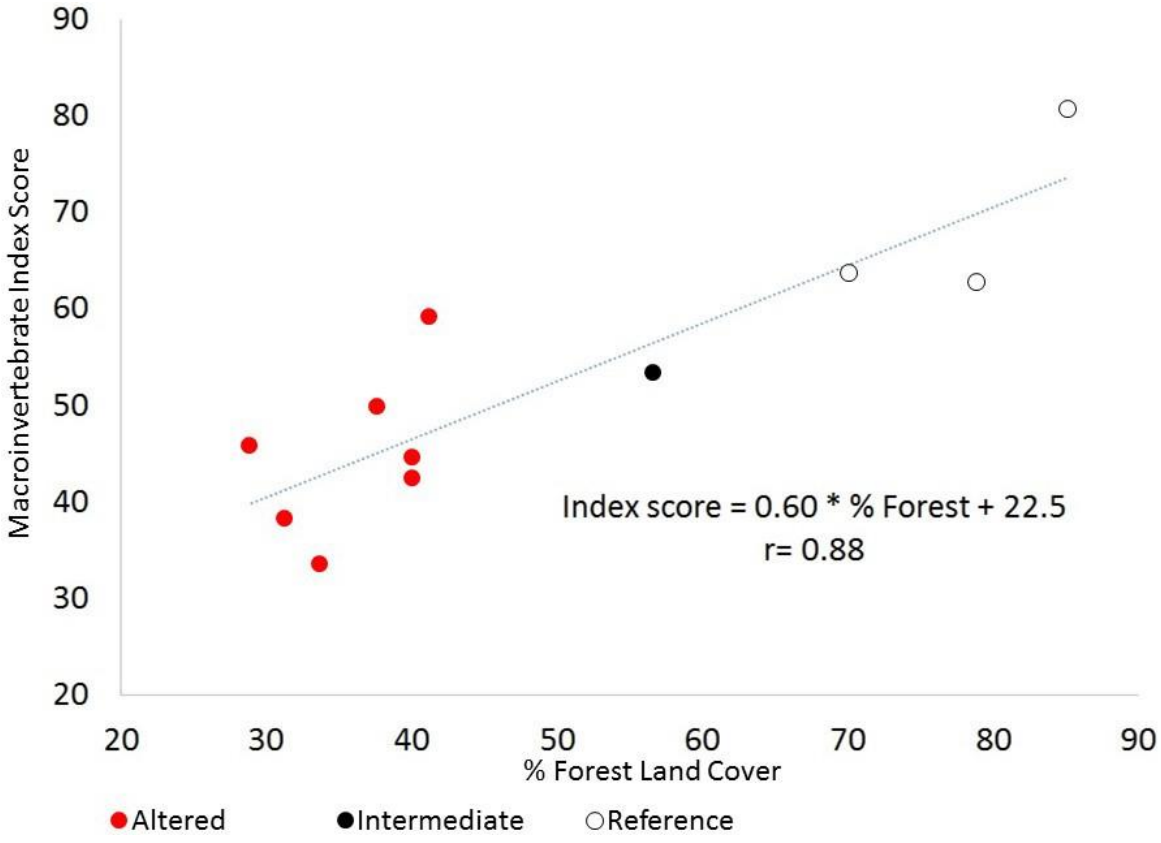

Figure 2: Correlation of macroinvertebrate index scores with percent forest land cover at 11 study sites.

Conclusions

Based on the observed nutrient concentrations and current reference thresholds (1.5 mg/L and 0.05 mg/L for TN and TP respectively), no changes to the assumed alteration status of each site are needed. None of the reference sites exhibited nutrient concentrations that exceed the reference thresholds. In most cases (all but for TN concentrations at two sites), sites with substantially altered watersheds exhibited nutrient concentrations below reference thresholds. Therefore the AAC should discuss the potential for lowering the thresholds in order to better characterize site conditions.

The macroinvertebrate index developed here was slightly more effective at distinguishing watershed land-cover alteration (correlation with forested land cover: 0.88 and percent correct assignment: 100%) than the fish-based index developed for the FY 2016 report (correlation with forested land cover: 0.73 and percent correct assignment: 97%; Garey *et al*. 2016). It should be noted, however, that the macroinvertebrate index was developed using only 11 study sites and was not validated with independent data, whereas the fish index was developed with 41 sites and validated with data from an additional 26 sites.

This analysis provides preliminary evidence that a macroinvertebrate-based index may provide an effective tool for assessment of Class VII waters. Further study should be conducted to more thoroughly evaluate this potential and compare fish and macroinvertebrate metrics in Class VII swamp waters in the Chowan River Basin.

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