The Glade – Reaches 5 and 6

Fairfax County, Virginia

WSSI #20030, Task I2b

Biological Monitoring Report- Year 1 (Post-Construction)

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Executive Summary

As set forth in the "Northern Virginia Stream Restoration Bank Banking Instrument" (Banking Instrument), streams and drainage features within The Glade Watershed have been stabilized and restored. This stream restoration should result in a direct improvement of in-stream habitat.

In the first year following restoration, Wetland Studies and Solutions, Inc. (WSSI) conducted biological stream assessments along 7,165 linear feet of stream restoration in The Glade Design Reaches 5 and 6, as well as 1,175 linear feet of non-restored areas above and below Design Reach 6[1] (Exhibit 3). This monitoring was conducted pursuant to the maintenance and monitoring requirements defined in the Northern Virginia Stream Restoration Bank (NVSRB) Banking Instrument, Section VI.B.2.(i). This report summarizes the Year 1 monitoring (post-construction) in 2011, as compared to the baseline (pre-construction) conditions assessed from 2007-2009.

Biological stream monitoring was conducted along three[2] biological monitoring reaches using benthic macroinvertebrate and habitat data. Fieldwork was conducted on March 28, 2011. Benthic macroinvertebrate data was used to calculate a Stream Condition Index for Virginia Non-coastal Streams (VA-SCI) and habitat data was used to calculate the Total Habitat Score for each reach.

Our Year 1 post-restoration results indicate that on average the habitat quality of the stream has increased. However, benthic macroinvertebrate condition has decreased, which is expected, likely due to factors such as the short time since the initial disturbance from the restoration and stormwater runoff. It will take time for benthic macroinvertebrates to re-colonize these streams and in order to expedite colonization, water quality enhancements will need to be undertaken within the watershed (by others).

Introduction

As set forth in the "Northern Virginia Stream Restoration Bank Banking Instrument" (Banking Instrument), dated February 17, 2006 and prepared by Wetland Studies and Solutions, Inc. (WSSI), Northern Virginia Stream Restoration, L.C. will restore approximately 14 miles of streams and upland buffers, within portions of the Snakeden Branch, Colvin Run, and The Glade watersheds in Reston, Virginia. As required in Section VI.B.2. (i) of the Banking Instrument, biological monitoring will be conducted within restored streams within these watersheds. These stream restoration activities should result in a direct improvement of in-stream habitat. Using

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[1] *Approximately 800 linear feet of stream between Designs Reaches 5 and 6 was not restored. In addition, 50 linear feet within Design Reach 6 and 325 linear feet at the downstream end of Design Reach 6 were not restored.*

[2] *Note that biological monitoring reaches 1-D through 1-G, 2A and 3A were restored in 2010 and do not require monitoring in 2011.*

benthic macroinvertebrate and habitat data, this first post-construction monitoring report characterizes Design Reach 5 and 6 as well as portions non-restored stream in the Glade Watershed portion of the NVSRB in 2011, as compared to baseline conditions described in Biological Monitoring Reports #1 (dated December 8, 2008), #2 (dated December 17, 2008), and #3 (dated October 14, 2009). With this data, we propose to evaluate the effect of stream restoration on the condition of streams within The Glade Watershed portion of the NVSRB.[3]

Project Area

The study area includes approximately 7,164 linear feet of restored stream along Design Reaches 5 and 6 and 1,175 linear feet of non-restored stream in The Glade, as well as the adjacent riparian corridors. The study area is located north of Lawyers Road (Route 673) between Soapstone Drive and Twin Branches Road in Fairfax County, Virginia. Exhibit 1 is a vicinity map that depicts the approximate location of the study area.

The study area is covered mostly by mixed-deciduous forest. The Glade flows in an easterly direction through the study area. An asphalt recreational trail, which crosses The Glade multiple times, is located parallel to the stream. The study area is gently to moderately sloping. The topography can be seen in the excerpt from the Vienna, Virginia-Maryland 1994 USGS topographical quadrangle map included as Exhibit 2.

Overall Methodology

Per maintenance and monitoring requirements defined in the Banking Instrument, Section VI.B.2. (i), biological stream assessment reaches are to be established for every 2,000 linear feet of stream restoration along samplable streams at the NVSRB[4]. Once established, these reaches are to be monitored prior to stream restoration, then in years 1, 5, and 10. The following methods are to be employed:

- Biological Reconnaissance (BioRecon), following guidance established in the U.S. Environmental Protection Agency's "Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers" (EPA's RBP; Barbour et al. 1999.)[5]
- Biological stream assessment for Calculating the Stream Condition Index for Virginia Non-coastal Streams (VA-SCI), following guidance established in "A Stream Condition Index for Virginia Non-Coastal Streams" (Tetra Tech 2003) and "Using Probabilistic Monitoring Data to Validate the Non-Coastal Virginia Stream Condition Index" (DEQ 2006).[6]

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3 *Note that monitoring reports for the Snakeden Branch and Colvin Run watershed portions of the NVSRB are provided under separate cover.*

4 *Assessment reaches were established for every 2,000 linear feet of samplable streams, which includes perennial and intermittent streams containing enough flowing water to sample in the spring.*

5 *Note that the BioRecon was used to aid in the selection of permanent monitoring reaches during the first year of pre-construction monitoring and is not required in subsequent monitoring years. The results of the BioRecon are described in "Biological Monitoring Report #1, Pre-construction Monitoring, Northern Virginia Stream Restoration Bank, The Glade Watershed", dated December 8, 2008.*

6 *This method is to be used in all monitoring years and is accompanied by a habitat assessment, following guidance established Virginia Department of Environmental Quality's (DEQ) standard operating procedures for stream habitat assessment.*

Biological Stream Monitoring

Biological Stream Monitoring Methodology. The biological stream monitoring consisted of two components: 1) Stream habitat assessment and 2) benthic macroinvertebrate assessment. The stream habitat assessment was conducted using guidance established in the DEQ SOPs for stream habitat assessment (DEQ 2008) [7] and the U.S. Environmental Protection Agency's Rapid Bioasssessment Protocol for habitat (Barbour et al. 1999). The benthic macroinvertebrate assessment field work was conducted using guidance established in the SOPs for multi-habitat benthic macroinvertebrate sampling (DEQ 2008). [8]

WSSI assessed three 300 linear foot reaches that were selected in Biological Monitoring Report #1 (Reach 1-A through 1-C). [9] The locations of these three sampling reaches relative to Design Reaches 5 and 6 are depicted in the Biological Stream Monitoring Map (Exhibit 3). The assessed reaches were selected to be representative of the condition of The Glade and unnamed tributaries of The Glade. However, these biological monitoring reaches were selected before the restoration plans were designed for Design Reaches 5 and 6, and during the public review process, it was determined that portions of Design Reaches 5 and 6 need not be restored. These portions include a beaver save area, located between Design Reaches 5 and 6, a small stretch of stream within Design Reach 6, and the downstream end of The Glade (Design Reach 6), before it crosses under Twin Branches Road. The non-restored area downstream from Design Reach 6 contains biological monitoring Reach 1-A, approximately 10% of which was restored. Biological monitoring Reach 1-B is located at the upstream end of Design Reach 6 and approximately 50% of this reach was restored with portions of the biological monitoring reach located within the beaver save area. Since the biological monitoring reaches had already been established, WSSI decided not to shift the biological monitoring locations to completely restored areas to prevent a skew in the data so these areas could be used as reference data points. Photographs, Habitat and Benthic Macroinvertebrate Field Data Sheets are included in Exhibit 4 for each reach. Benthic macroinvertebrate sampling and habitat assessment field work was conducted by WSSI environmental scientists Benjamin Rosner, PWS, PWD, CT, CE,[10] Alison St.Onge, CT,[11] and Matthew Brennan on March 28, 2011.

In accordance with the SOPs, habitat conditions were assessed by qualitatively rating ten habitat parameters, including Epifaunal Substrate/Available Cover, Embeddedness, Velocity/Depth Regime, Sediment Deposition, Channel Flow Status, Channel Alteration, Frequency of Riffles, Bank Stability, Vegetative Protection, and Riparian Vegetative Zone Width. The overall habitat quality of each reach was determined by adding together the individual metric scores to provide a Total Habitat Score at each reach, with a maximum of 200 points possible. Each reach was then assigned a narrative rating according to the total habitat score, where "Optimal" is 200-160, "Sub-optimal" is 159-107, "Marginal" is 106-54, and "Poor"

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7 *Note that the DEQ has revised their SOP for habitat. Thus, starting in 2010, WSSI is using the latest SOP for habitat (DEQ 2008).*

8 *Note that the DEQ has revised their SOP for benthic macroinvertebrates. Thus, starting in 2010, WSSI is using the latest SOP for benthic macroinvertebrates (DEQ 2008).*

9 *Note that biological monitoring reaches 1-D through 1-G, 2-A and 3-A were restored in 2010 and do not need to be assessed in post-construction Year 2.*

10 *Professional Wetland Scientist #1766, Society of Wetland Scientists Certification Program, Inc. VA Certified Professional Wetland Delineator #3402-000080; North American Benthological Society (NABS) Certified Level 1 Taxonomist: All Phyla; Certified Ecologist, Ecological Society of America.*

11 *North American Benthological Society (NABS) Certified Level 1 Taxonomist: All Phyla; ISA Certified Arborist MA-5179A.*

is 53-0. Stream habitat data was recorded on the WSSI Benthic Macroinvertebrate and Habitat Field Data Sheets (Exhibit 4 for each reach).

To assess benthic macroinvertebrate condition, 60 linear feet of best-available habitat in each reach was sampled using a D-Framed Net. Habitat types sampled include cobble/gravel, snags/leafpacks, root-wads, and submerged vegetation. Benthic field data was recorded on WSSI Benthic Macroinvertebrate and Field Data Sheets (Exhibit 4 for each reach).

The benthic macroinvertebrate samples were processed and subsampled by WSSI staff using guidance from the SOPs. Specifically, a fixed-count method was used, where organisms were randomly picked from a gridded (numbered) tray and the organisms were identified to the family level (if possible) using a dissecting microscope. Each individual (containing a head) found in a sample was recorded and enumerated on a WSSI Benthic Macroinvertebrate Bench Sheet (Exhibit 4 for each reach).

Benthic macroinvertebrate data were analyzed by calculating the Stream Condition Index for Virginia Non-coastal Streams (VA-SCI), following guidance established in "A Stream Condition Index for Virginia Non-Coastal Streams" (Tetra Tech 2003) and "Using Probabilistic Monitoring Data to Validate the Non-Coastal Virginia Stream Condition Index" (DEQ 2006). The VA-SCI is a multi-metric Index of Biotic Integrity developed for the DEQ to assess Streams of the Commonwealth. The VA-SCI uses seven biotic metrics and one biotic index including Total Taxa, EPT Taxa, Percent Ephemeroptera, Percent Plecoptera + Trichoptera (Excluding Hydropsychidae), Percent Scrapers, Percent Chironomidae, Percent Top Two Dominant Taxa, and Hilsenhoff Biotic Index. The individual metrics and index used are defined and described as follows:

- Total Taxa Richness. Total Taxa Richness represents the total number of taxa in a sample. Total Taxa Richness is expected to be relatively high in undisturbed streams and is expected to decrease in response to environmental disturbance. Total Taxa Richness can range from 0-22 for the VA-SCI.

- EPT Taxa Richness. EPT Taxa Richness represents the number of taxa from the aquatic insect orders Ephemeroptera, Plecoptera, and Trichoptera. EPT taxa are generally very sensitive to pollution. Total EPT Taxa Richness is expected to be relatively high in undisturbed streams, and it is expected to decrease in response to environmental disturbance. EPT Taxa Richness can range from 0-11 for the VA-SCI.

- Percent Ephemeroptera. The Percent Ephemeroptera represents the ratio of members of the aquatic insect order Ephemeroptera (mayflies) to the total number of individuals in a sample. Mayflies are generally very sensitive to pollution, thus Percent Ephemeroptera is expected to decrease in response to environmental disturbance. Percent Ephemeroptera can range from 0-61.3 for the VA-SCI.

- Percent Plecoptera + Trichoptera (Excluding Hydropsychidae). The Percent Plecoptera + Trichoptera (Excluding Hydropsychidae) represents the ratio of members of the aquatic insect orders Plecoptera (stoneflies) and Trichoptera (caddisflies) (excluding those in the pollution tolerant family Hydropsychidae) to the total number of individuals in a sample. Percent Plecoptera + Trichoptera (Excluding Hydropsychidae) is expected to decrease in response to environmental disturbance. Percent Plecoptera + Trichoptera (Excluding Hydropsychidae) can range from 0-35.6 for the VA-SCI.

- Percent Scrapers. The Percent Scrapers represents the ratio of taxa adapted primarily for scraping food from a substrate to the total number of individuals in a sample. Percent Scrapers is expected to decrease in response to environmental disturbance. Percent Scrapers can range from 0-51.6 for the VA-SCI.

- Percent Chironomidae. The Percent Chironomidae represents the ratio of members of the aquatic insect family Chironomidae (non-biting midges) to the total number of individuals in a sample. Because chironomids are generally tolerant to pollution, Percent Chironomidae is expected to increase in response to environmental disturbance. Percent Chrionomidae can range from 0-100 for the VA-SCI.

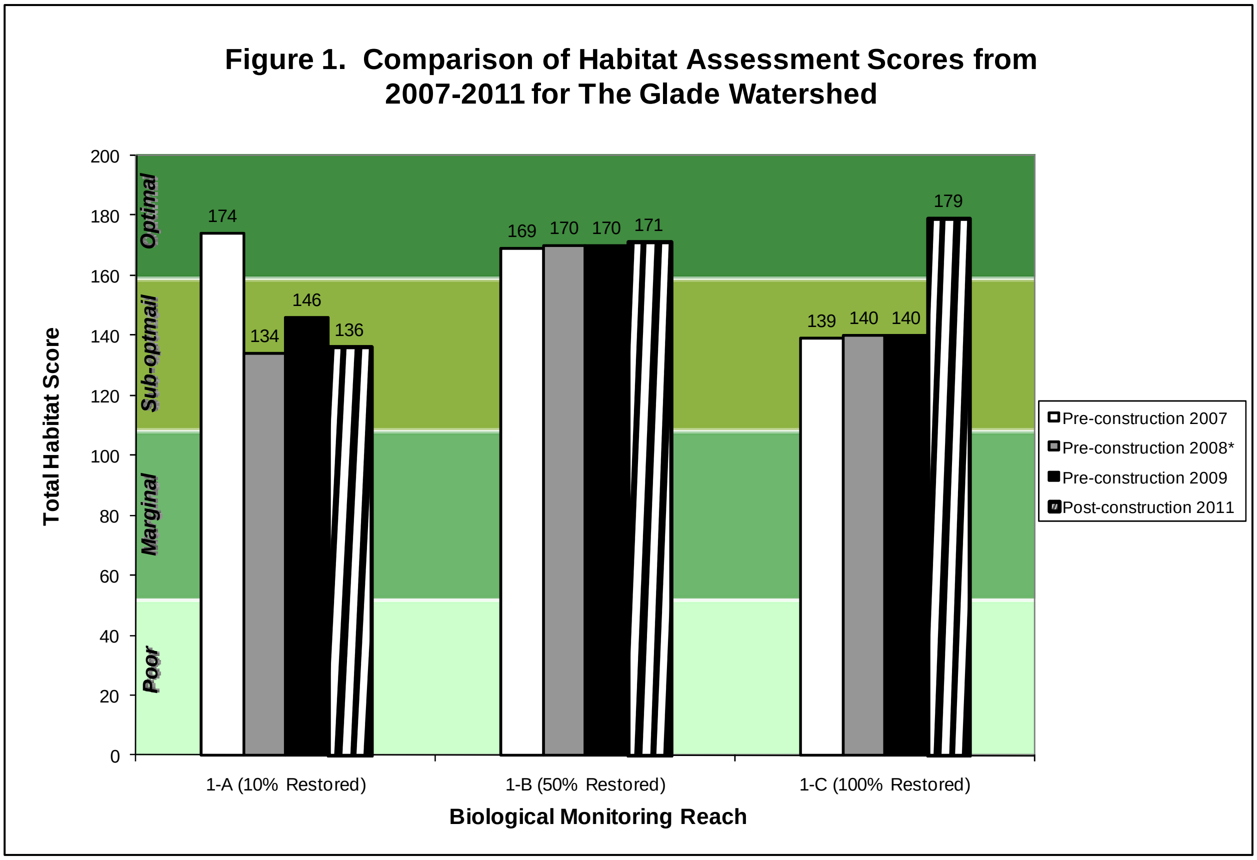
- Percent Top Two Dominant. The Percent Top Two Dominant is the ratio of the top two most abundant taxa in a sample to the total number of individuals in a sample. Percent Top Two Dominant is expected to increase in response to environmental disturbance. Percent Top Two Dominant can range from 30.8-100 for the VA-SCI.
- Hilsenhoff Biotic Index (HBI). The Hilsenhoff Biotic Index is the abundance-weighted average tolerance of assemblage of organisms (Family taxonomic level). The HBI is expected to increase in response to environmental disturbance. The HBI can range from 3.2-10 for the VA-SCI.

- The VA-SCI was calculated by taking the weighted average of the individual metric (and index) scores, with an VA-SCI range of 0-100. The weighting is as follows:

    - Total Taxa: Score = 100 x (X/22), where X = Metric Value
    - EPT Taxa: Score = 100 x (X/11), where X = Metric Value
    - Percent Ephemeroptera: Score = 100 x (X/61.3), where X = Metric Value
    - Percent Plecoptera + Trichoptera less Hydropsychidae: Score = 100 x (X/35.6), where X = Metric Value
    - Percent Scrapers: Score = 100 x (X/51.6), where X = Metric Value
    - Percent Chironomidae: Score = 100 x [(100-X) (100-0)], where X = Metric Value
    - Percent Top 2 Dominant: Score = 100 x [(100-X) (100-30.8)], where X = Metric Value
    - Hilsenhoff Biotic Index: Score = 100 x [(100-X) (100-3.2)], where X = Metric Value

Each reach was then assigned a narrative rating according to the calculated VA-SCI, where "Excellent" is >73, "Good" is 60-72, "Stress" is 43-59, and "Severe Stress" is <42.

Biological Stream Monitoring Results and Discussion. Habitat results for Year 1 show that Reach 1-A, 90% of which was not restored, scored a "Sub-optimal" habitat condition rating. Reach 1-B is 50% restored, with the upstream portion within the non-restored beaver save area, and scored in the "Optimal" category. Reach 1-C was the only fully restored reach in Design Reaches 5 and 6 and scored in the "Optimal" category (Figure 1 and Exhibit 4 for each reach). The average habitat assessment score for all restored stream reaches assessed in 2011 is 162 out of 200 following restoration which falls in the "Optimal" category. These results show improved habitat conditions following restoration, with scores exceeding the pre-restoration scores with the exception of Reach 1-A which was not fully restored. Improved habitat assessment scores relate to the success of the well vegetated and stabilized banks, with little erosion or depositional zones present throughout the restored reaches. It is expected that this trend will continue over time as the density of the reforested riparian zone increases.



**Note that the habitat score for Reach 1-A decreased dramatically in 2008. This drop was due to blockage of the Twin Branches culvert, located at the downstream end of the Glade, which caused sediment deposition and increased embeddedness of the substrate, a decrease in the velocity and depth regime, and a decrease in the frequency of riffles within Reach 1-A. This blockage has since been removed.*

Benthic macroinvertebrate results show that individuals from 9 taxa[12] were collected from all three reaches collectively (Table 1, Exhibit 4) during the 2011 post-construction benthic macroinvertebrate monitoring. Of all taxa collected, non-biting midge larvae (Chironomidae) and aquatic worms (Oligochaeta) comprised the majority of individuals in the reaches.

[12] *Although 10 taxa are listed in Table 2, Oligochaeta were not included as part of the total taxa collected within the study area because individuals were not identified to the family-level.*

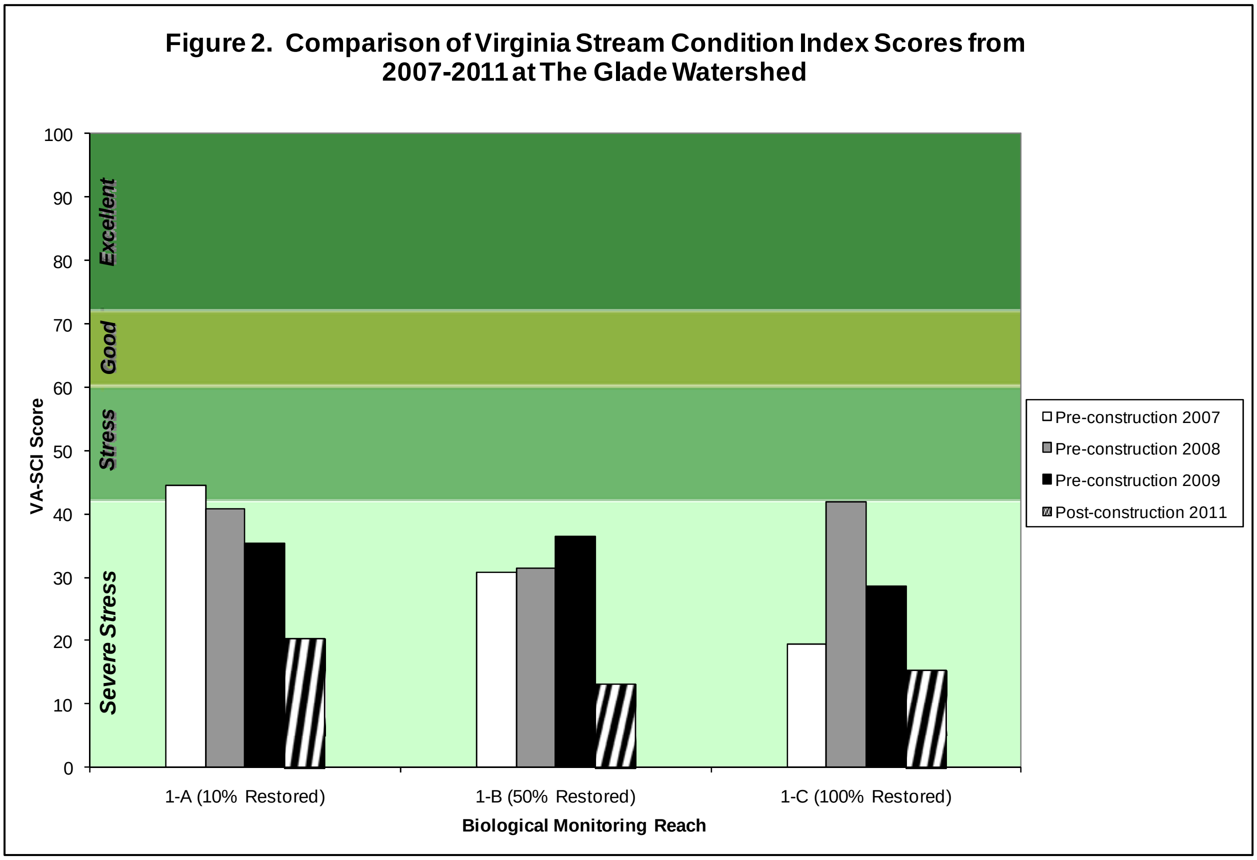
Table 1. The Glade Raw Data				
TAXA	REACH			
	1-A (10% Restored)	1-B (50% Restored)	1-C (100% Restored)	Total
Chironomidae	85	103	87	275
Coenagrionidae	2			2
Dryopidae	1			1
Elmidae	4		1	5
Gomphidae	1			1
Hydropsychidae	5	1	3	9
Oligochaeta	6	9	9	24
Saldidae			1	1
Sphaeriidae	1	1		2
Tipulidae	1			1
Total	**106**	**114**	**101**	**322**

The above data collected for each reach were used to calculate the biotic metrics as shown in Table 2. The VA-SCI requires that these metrics be weighted to determine the VA-SCI, as shown in Table 3. The results of our data analysis indicate that the benthic macroinvertebrate communities at all three stream reaches (Reaches 1-A through 1-C) were in "Severe Stress" in 2011 following stream restoration activities, based on their VA-SCI scores. The average VA-SCI numerical score for all reaches assessed in 2011 is 16.31 ("Severe Stress"). These scores are the result of the low number of total taxa, low number of total EPT taxa, low percentage of Plecoptera and Trichoptera (excluding Hydropsychidae), low percentage of Scraper taxa, high percentage of Chironomidae, high percentage of top two dominant taxa, and high HBI found within the reaches assessed.

Table 2. The Glade Biotic Metric Scores								
Reach	Total Taxa	Total EPT Taxa	Percent Ephemeroptera	Percent Plecoptera + Trichoptera (Excluding Hydropsychidae)	Percent Scrapers	Percent Chironomidae	Percent Top Two Dominant	HBI
1-A (10% Restored)	9	1	0.00	0.00	3.77	80.19	86.00	5.53
1-B (50% Restored)	4	1	0.00	0.00	0.00	90.35	98.00	5.54
1-C (100% Restored)	5	1	0.00	0.00	0.99	86.14	95.00	5.36

Table 3. 2011 Biotic Metric and Index Weighting and VA-SCI at The Glade.			
WEIGHTED METRIC	**BIOLOGICAL MONITORING REACH**		
	1-A (10% Restored)	**1-B (50% Restored)**	**1-C (100% Restored)**
Total Taxa	40.91	18.18	22.73
EPT Taxa	9.09	9.09	9.09
Percent Ephemeroptera	0.00	0.00	0.00
Percent Plecoptera + Trichoptera (Excluding Hydropsychidae)	0.00	0.00	0.00
Percent Scrapers	7.31	0.00	1.92
Percent Chironomidae	19.81	9.65	13.86
Percent Top Two Dominant	20.45	2.54	7.15
HBI	65.76	65.66	68.29
VA-SCI Numerical Score	20.42	13.14	15.38
VA-SCI Narrative Score	Severe Stress	Severe Stress	Severe Stress
Average VA-SCI Numerical Score	**16.31**		
Average VA-SCI Narrative Score	**Severe Stress**		

These results are similar to the 2007-2009 monitoring, where the benthic macroinvertebrate community at all three reaches was also in "Severe Stress" (Figure 2). It is expected that the VA-SCI scores in 2011 would not improve immediately following restoration efforts due to disturbance from construction. Such disturbances can temporarily reduce benthic condition, and recovery of the benthic community can be slow (Muatka 2002). WSSI noticed a similar decrease in the benthic community in the Snakeden Watershed immediately following restoration, however, recent data (2011) has shown a continual increase in the average SCI score, indicating that the benthic community may be starting to recover. Future data will show whether or not this is a trend. In Reach 1-A and 1-B, where portions of the biological monitoring sites were not disturbed by restoration, the SCI score still went down. Reach 1-A was impacted at the upstream end by the restoration, which may have caused temporary sedimentation to occur in the lower portion which would have a temporary adverse effect on the macroinvertebrate colony. Reach 1-B, which is 50% restored, also decreased in score mainly due to disturbance of the stream from restoration activities.



An analysis of land use within the watershed of each stream reach indicates that each watershed is highly developed, with all reaches having 15 percent impervious land cover as depicted in the Land Cover Map (Exhibit 5), and Table 4. It has been documented that increases in watershed imperviousness reduce macroinvertebrate diversity, such that when imperviousness exceeds 10 to 15 percent, macroinvertebrate diversity becomes low (Klein 1979). Runoff from the highly impervious land within these watersheds typically produces a high volume and velocity of flowing water and sediment in the stream channels during storm events. As a result, epifaunal substrate/available cover within these streams becomes highly mobile and benthic macrofauna cannot easily colonize the available substrate (Debrey and Lockwood 1990) or they can be buried and killed by high sediment deposition (Wood and Armitage 1997). However, because the restored streams within our study area have been engineered to accommodate high volume flows, future habitat degradation should be minimized in the areas that were restored.

Table 4. Impervious Land Cover for Each Reach

REACH	Watershed Acres	Percent Impervious
1-A (10% Restored)	780	15
1-B (50% Restored)	668	15
1-C (100% Restored)	618	15

Nutrients, pesticides, and other chemical pollutants that enter the streams through runoff can also have a negative effect on the macroinvertebrate community (Wright et al 1995; O'Halloran et al. 1996; Kiffney and Clements 1994). Sources for such pollutants within the streams we assessed likely include residential lawns, roads, wildlife, and faulty sewer lines. High amounts of such pollutants into streams inevitably result in a shift in macroinvertebrate community composition, where pollutant tolerant taxa such as non-biting midge larvae and oligochaete worms out-compete sensitive taxa such as EPT (Shueler 1994).

Thus, given the factors listed above, it is not a surprise that our benthic macroinvertebrate data show low VA-SCI scores and pollution-tolerant taxa such as non-biting midges and aquatic worms as the dominant taxa. However, restoration has improved in-stream habitat, thus providing a stable substrate for colonization of benthic macroinvertebrates. It will take time for benthic macroinvertebrates to re-colonize these reaches and in order to enhance colonization, water quality enhancing measures will need to be undertaken in the watershed (by others).

Conclusions

The above results indicate that the habitat of Design Reaches 5 and 6 of The Glade on average is "Optimal" and the benthic macroinvertebrate community of the streams is still in "Severe Stress". Improved habitat assessment scores following restoration relate to the success of the well vegetated and stabilized banks (in the restored portions of the monitoring reaches), with little erosion or depositional zones present throughout the restored reaches as well as the continued stability of the non-restored portions of the Glade. As the density of the riparian vegetation increases over time, habitat conditions should improve for all of the reaches. The low VA-SCI are likely due to several abiotic factors, including highly impervious land cover, high nutrient, toxicant and sediment input from adjacent land use, as well as recent disturbance from restoration. It will take time for benthic macroinvertebrates to re-colonize these reaches and in order to enhance colonization, water quality enhancing measures will need to be undertaken in the watershed (by others).

Limitations

This study is based on examination of the conditions on the site at the time of our review and does not address conditions in the future. Such conditions may change over time and will be addressed in subsequent monitoring reports. Our biological monitoring report has been prepared in accordance with generally accepted guidelines for the conduct of such evaluations. We make no other warranties, either expressed or implied, and our report is not a recommendation to buy, sell or develop the property.

We offer no opinion and do not purport to opine on the possible application of various building codes, zoning ordinances, other land use or platting regulations, environmental or health laws and other similar statutes, laws, ordinances, code and regulations affecting the possible use and occupancy of the property for the purpose for which it is being used, except as specifically provided above. The opinions set forth above are rendered only and exclusively for the benefit of the addressees, the COE, the DEQ, and no other parties, successors or assigns. The foregoing opinions are based on applicable laws, ordinances, and regulations in effect as of the date hereof and should not be construed to be an opinion as to the matters set out herein should such laws, ordinances or regulations be modified, repealed or amended.

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