

## 3.21 Sycamore Creek Stream Restoration

### 3.21.1 Introduction

The Sycamore Creek subwatershed is within the larger Lower Rock Creek watershed (*Figure 3.23.1*). Much of the subwatershed was developed without any stormwater management controls in place to manage runoff. Restoration of this creek included stream restoration near Arctic Avenue and Bauer Drive in Aspen Hill, Maryland. Two vernal pool wetlands were created as a part of this restoration project and areas near the stream were reforested. This report represents monitoring results five years following restoration.

#### *Subwatershed facts*

**Subwatershed Drainage Area:** 992 acres, 1.6 square miles

**Subwatershed Imperviousness:** 22 percent

**Property Ownership:** Private and Maryland-National Capital Park and Planning Commission

#### *Project Facts*

**Project Length:** 6,400 feet

**Estimated Costs:** Structural (\$500,000);

Reforestation (\$74,000) Funded in part through the Federal Highway Administration TEA-21 Enhancement Program, administered by the Maryland State Highway Administration

**Project Completion Date:** December 2004

#### *Project Selection*

The Countywide Stream Protection Strategy, (CSPS 1998, updated 2003), published by the Department of Environmental Protection (DEP), evaluated biological, chemical, and habitat conditions of streams in the county, and identified impaired “priority” subwatersheds for restoration, including the Sycamore Creek subwatershed. Following the CSPS, the Rock Creek Watershed Feasibility Study (April 2001) evaluated more than 14 miles of Rock Creek and its tributaries to identify specific stream restoration and stormwater management opportunities. The study identified 23 priority stream restoration sites, including the Sycamore Creek tributary of Rock Creek (*Figure 3.21.5*).

#### *Pre-Restoration Conditions*

Much of the lower Rock Creek Watershed, including the Sycamore Creek subwatershed, was developed prior to regulations requiring stormwater management control and the watershed contains a high percentage of impervious surfaces. Uncontrolled stormwater runoff from highly impervious areas creates erosive, high velocity or “flashy” stormwater flows that cause damage to receiving streams. The Rock Creek Watershed Feasibility study identified several impaired conditions in Sycamore Creek. Uncontrolled stormwater created severe streambank erosion and unstable banks, undercut trees, and damage to private property (*Figure 3.21.1 and 3.21.3*). Undercut trees fell into the stream and created debris jams that blocked the stream and caused further bank erosion. Over time, the stream channel down-cut and became overwidened, which limited stream access to the original floodplain, exposed sewer lines to potential damage, and destroyed habitat necessary for diverse aquatic life. Sediment from eroded banks and road grit accumulated in the stream, further degrading stream habitat conditions. The lower end of the

project area, located on parkland, had better conditions, with numerous vernal pools, and a riparian buffer providing habitat and shade to help reduce stream water temperatures.

*Restoration Actions Taken*

The Sycamore Creek Project used in-stream restoration techniques and reforestation to help stabilize streambanks and enhance riparian habitat. Newly built in-stream structures included rock and log vanes, which direct water away from unstable streambanks and form downstream scour pools and provide good habitat for fish (*Figures 3.21.2 and 3.21.4*). Rock cross vanes were also installed and function as grade control, slowing the erosive process of stream down-cutting.



***Figure 3.21.1 – Sycamore Creek Prior to Restoration, Picturing Bank Erosion, Undercut Trees, and Overwidened Stream Channel***



***Figure 3.21.2 – Sycamore Creek Post Restoration, Picturing Stabilized Banks, and Normalized Channel Reach***



***Figure 3.21.3 – Sycamore Creek Prior to Installation of Log Vanes***



***Figure 3.21.4 – Sycamore Creek Post Restoration, Picturing Log Vanes to Stabilize Banks***

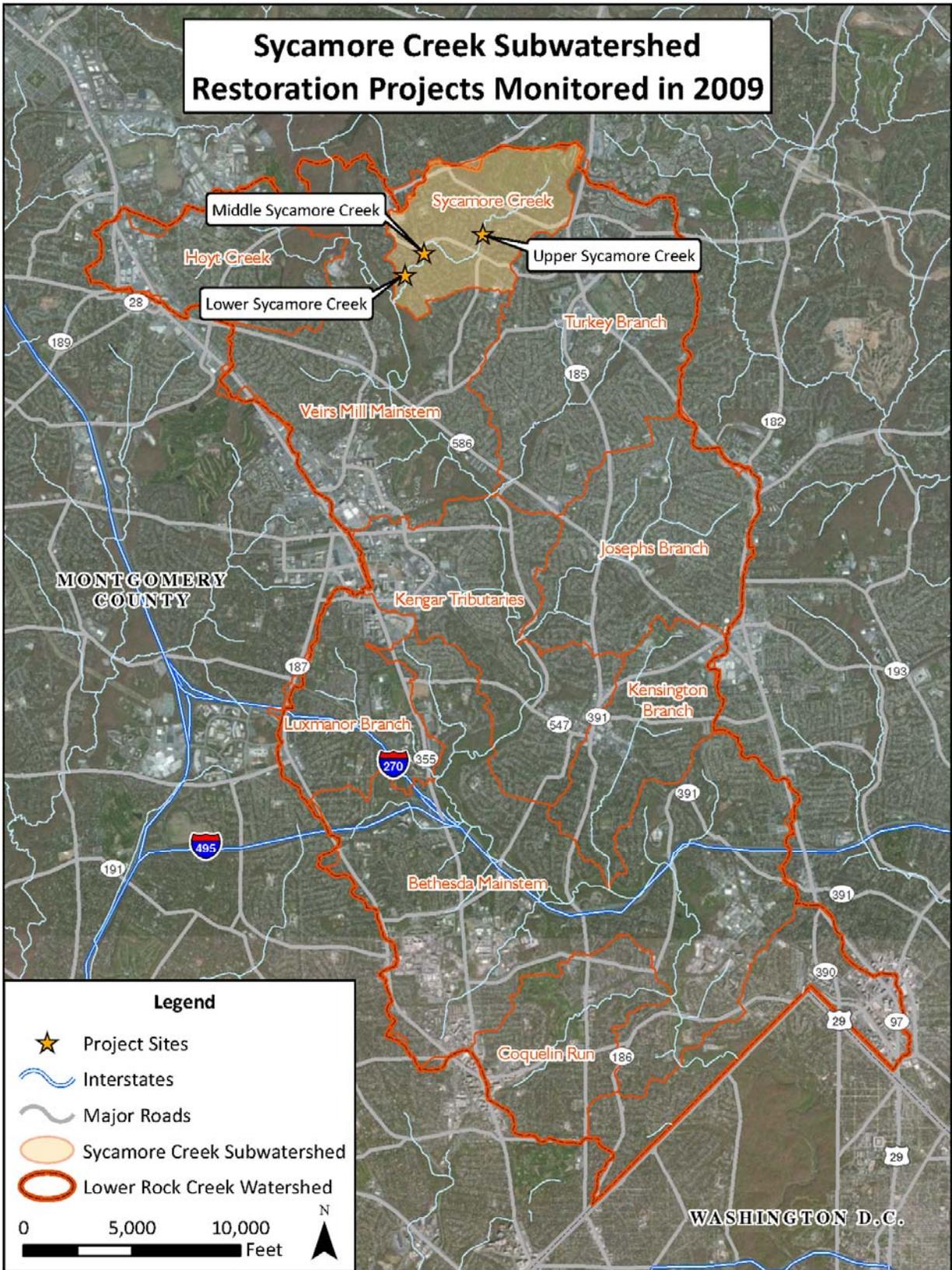


Figure 3.21.5 – Sycamore Creek Subwatershed Restoration Projects Monitored in 2009

### 3.21.2 Restoration Goals

The project’s primary goals were to stabilize eroding streambanks, re-establish a riparian buffer, protect sewer lines, improve fish passage, improve aquatic habitat conditions, and increase amphibian habitat by creating two shallow wetlands. **Table 3.21.1** provides a list of restoration goals, monitoring performed to evaluate the success of the goals, and when and where the monitoring occurred.

**Table 3.21.1 – Summary of Restoration Project Goals and Associated Monitoring**

<b>Why: Restoration Goals</b>	<b>What: Monitoring Done to Evaluate Goal</b>	<b>When: Years Monitored</b>	<b>Where: Station or Location Monitored</b>
<ul style="list-style-type: none"> <li>• Improve aquatic habitat conditions in Sycamore Creek</li> <li>• Improve water quality in the Sycamore Creek</li> </ul>	<ul style="list-style-type: none"> <li>• Aquatic Communities:               <ul style="list-style-type: none"> <li>▪ Benthic macroinvertebrates</li> <li>▪ Fish</li> </ul> </li> <li>• Qualitative Habitat</li> <li>• In-situ water Chemistry</li> </ul>	2002 and 2003 (pre) 2005, 2007, 2008, and 2009 (post)	LRSB101A, LRSB101B, LRSB101C
<ul style="list-style-type: none"> <li>• Reduce stream erosion and sedimentation</li> <li>• Reduce erosive stream flows</li> <li>• Improve stormwater management quantity control</li> </ul>	<ul style="list-style-type: none"> <li>• Quantitative habitat (stream morphology surveys)</li> </ul>	2002 (pre) 2005, 2007, 2010, 2011 <sup>1</sup> (post)	LRSB101A, LRSB101B, LRSB101C
<ul style="list-style-type: none"> <li>• Create wetlands</li> <li>• Create amphibian habitat</li> </ul>	<ul style="list-style-type: none"> <li>• Vernal pool or wetland</li> <li>• Wetland vegetation</li> </ul>	2005, 2006, 2009 (post)	LRSB101B
<ul style="list-style-type: none"> <li>• Reforest riparian zone</li> </ul>	<ul style="list-style-type: none"> <li>• Botanical survey</li> </ul>	2007 and 2009 (post)	LRSB101A, LRSB101B, LRSB101C

<sup>1</sup> Quantitative habitat surveys were scheduled for 2009, but were delayed at LRSB101A and LRSB101B due to missing benchmarks. These benchmarks were located and survey work was performed in 2010 and 2011. 2010 and 2011 reports will include updates for this monitoring for all three monitoring sites.

### 3.21.3 Methods to Measure Project Goals

The basic sampling design for most of the monitoring tasks was pre-restoration (before) and post-restoration (after) monitoring, located within the project area. Data were collected at three sites in the vicinity of this restoration project, LRSB101A, LRSB101B, and LRSB101C (**Figure 3.21.6**). Site LRSB101A is a County long-term monitoring site that has been sampled more often than the sites established only for restoration sampling. All the data collected at this site, prior to and after restoration, are presented and discussed below. At all three sites, the County monitored biological communities (benthic macroinvertebrates and fish), performed rapid habitat assessments (RHAB), and collected in-situ water chemistry to evaluate the aquatic habitat conditions and water quality during the pre- and post-restoration periods. Since restoration at site LRSB101B also included the creation of wetlands, the wetland vegetation planted for the project was monitored, as was the wetland habitat created for amphibians and other wetland fauna. A map showing the extent of the restoration and the location of the monitoring sites is

provided in *Figures 3.21.6 – 3.21.7*.

These data are presented in the results section below. For more information on how this monitoring is performed and used to measure stream health in the County, see the Methods section above (Section 2).

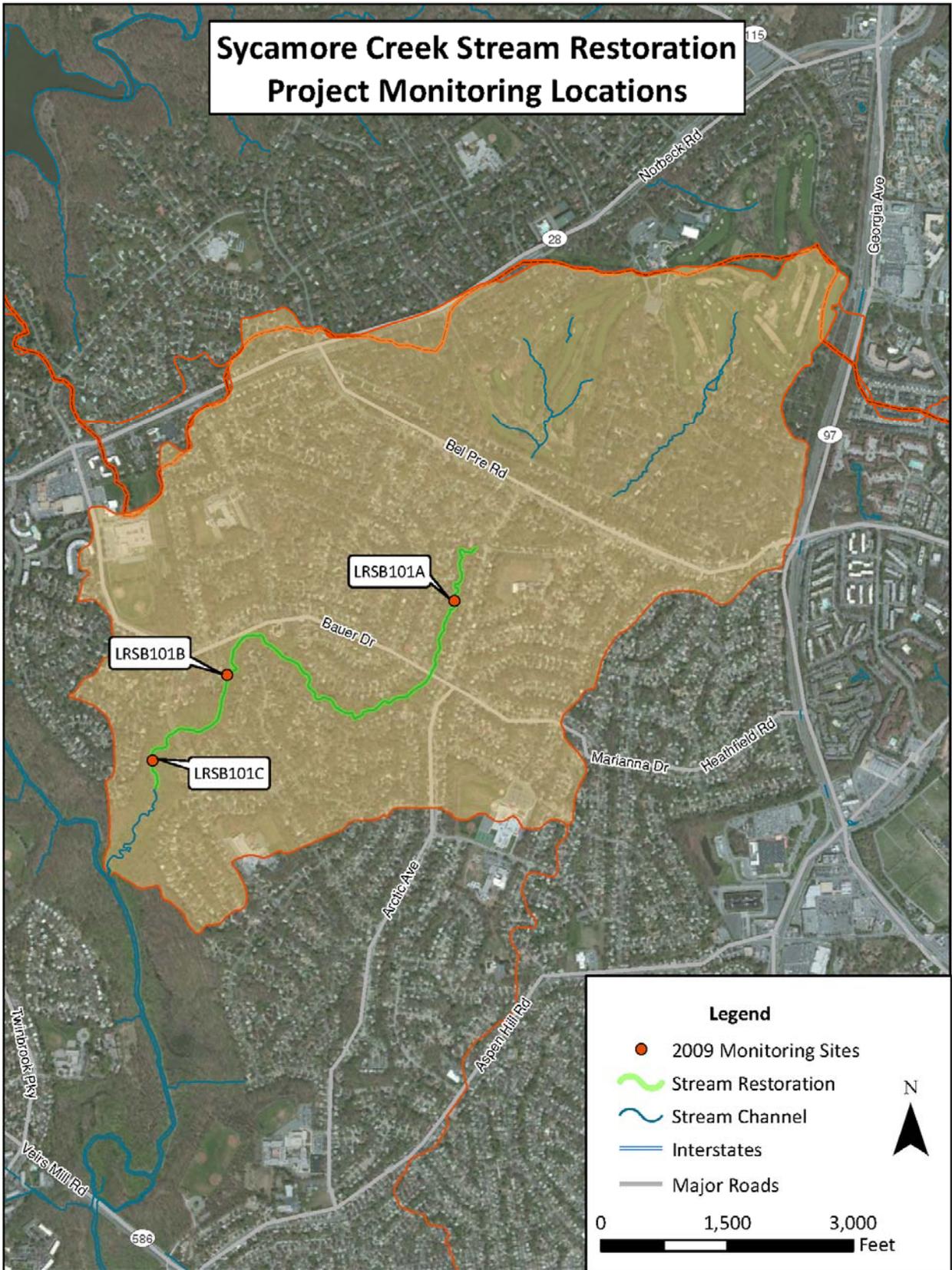


Figure 3.21.6 – Sycamore Creek Subwatershed Restoration Sites Monitored in 2009



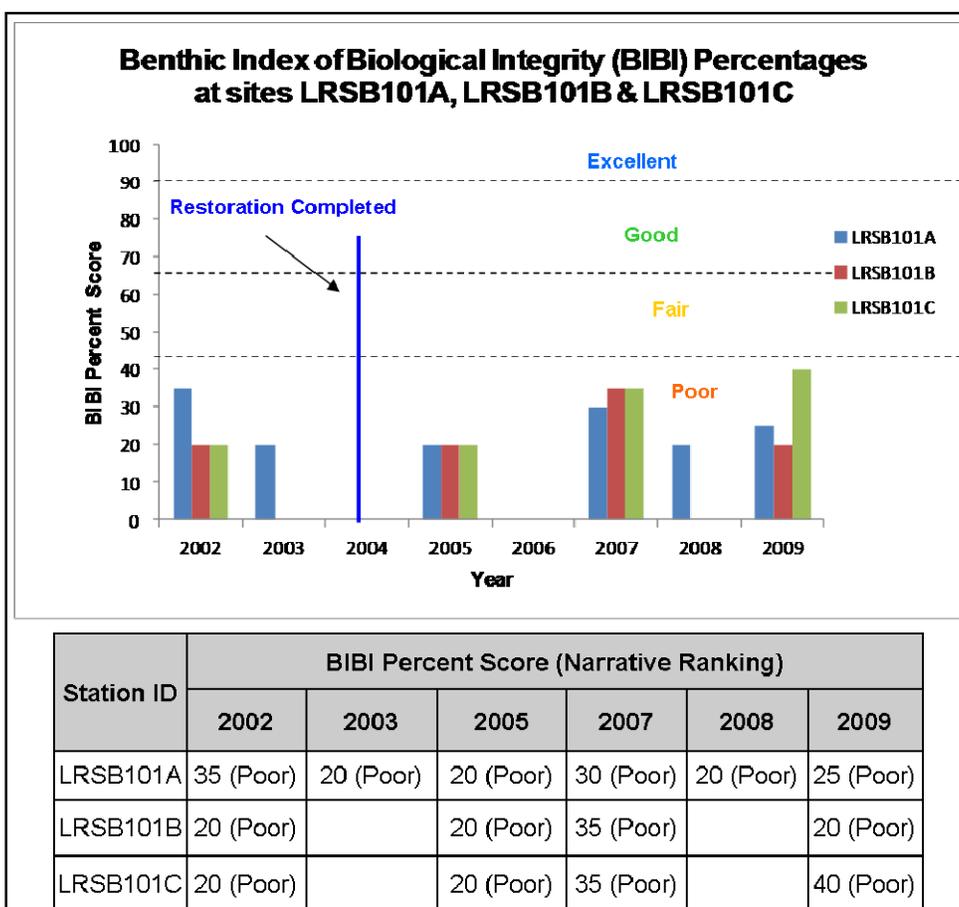
Figure 3.21.7 – Map of Monitoring Locations in Sycamore Creek

### 3.21.4 Results and Analysis

#### *Benthic Macroinvertebrates*

##### BIBI (Benthic Index of Biological Integrity) Scores

Pre-restoration benthic macroinvertebrate assessments were conducted at sites LRSB101A, LRSB101B, and LRSB101C in, 2002 and also at LRSB101A in 2003. Benthic macroinvertebrate communities consistently scored in the Poor Benthic Index of Biological Integrity (BIBI) range at all sites in the Sycamore Creek project area (**Figure 3.21.8**). Chironomidae (midges) dominated the community at each site. Amphipoda (scuds), Isopoda (sowbugs, pillbugs), and a few genera of Zygoptera (damselfly) were also present but in much lesser amounts. One genus of Ephemeroptera (mayfly), *Stenelmis*, was present at each site prior to construction and was the only taxa of the Ephemeroptera, Plecoptera, Trichoptera (EPT) group or taxa sensitive to disturbance collected at any of the sites during this time.



**Figure 3.21.8 - Pre- and Post-Restoration Benthic Index of Biological Integrity (BIBI) Percentages at LRSB101A, LRSB101B, and LRSB101C**

All benthic macroinvertebrate percent scores remained in the Poor range at the three Sycamore Creek sites after restoration. Each site showed an increase in BIBI percent score in 2007 but both LRSB101A and LRSB101B decreased in 2009, while the BIBI percent score at LRSB101C increased. Site LRSB101C showed a gradual improvement in BIBI percentage from 2005 to 2009. The increase in BIBI percentages in 2007 was due to the presence of one EPT taxon at

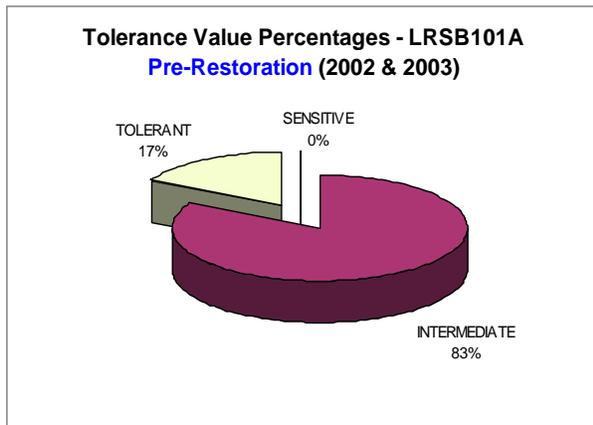
each site; no EPT taxa were collected in the project area in 2005 and only one was collected in 2009, at LRSB101C. All sites also had an increase in the ratio of scrapers to scrapers plus filter feeding collectors in 2007, contributing to the increase in BIBI scores in that year. Scrapers need periphyton to feed and are considered a more specialized functional feeding group than collectors and are therefore more sensitive to disturbance. Generally, these sites were comprised of macroinvertebrates that reflect a disturbed condition. An improvement in overall benthic community composition after restoration activities was only apparent at the downstream site, LRSB101C through 2009.

Dominant Taxa

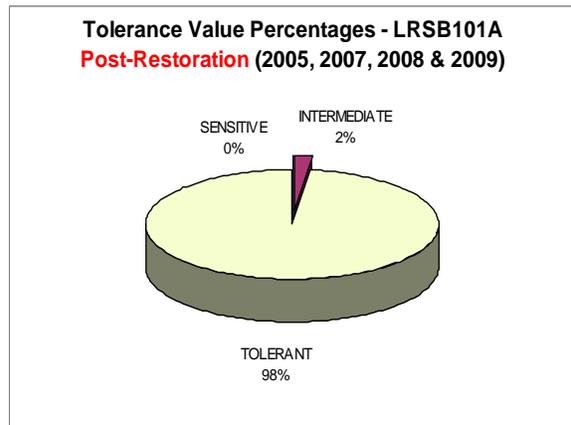
Prior to restoration, all sites were dominated by scuds and midges. These most dominant two taxa comprised from 73 to 94 percent of the communities prior to restoration. After restoration, the benthic macroinvertebrate community was dominated by midges and aquatic worms and the percentage of dominance of these two taxa ranged from 72 to 82 percent.

Tolerance Values

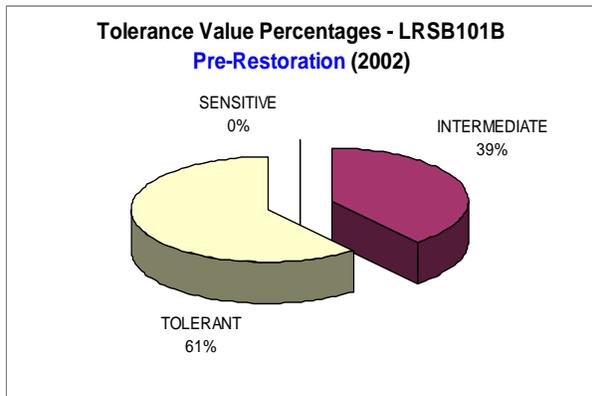
Tolerant benthic macroinvertebrate taxa comprised between 17 and 61 percent of the community in the pre-restoration period, and sensitive taxa were absent from all sites during this time. After restoration occurred, the percentages of tolerant individuals ranged from 94 to 97, increasing at all sites from the pre-restoration period. However, at LRSB101C a small percentage of sensitive individuals were present in the post-restoration period. *Figures 3.21.9 - 3.21.14* show the proportion of tolerances at all three sites prior to and after restoration.



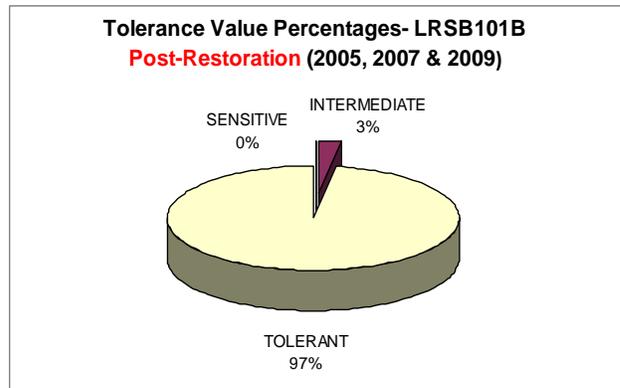
**Figure 3.21.9 – Benthic Macroinvertebrate Tolerance Composition at LRSB101A Prior to Restoration**



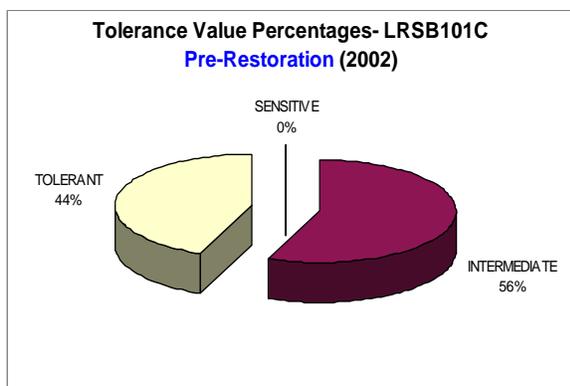
**Figure 3.21.10 – Benthic Macroinvertebrate Tolerance Composition at LRSB101A After Restoration**



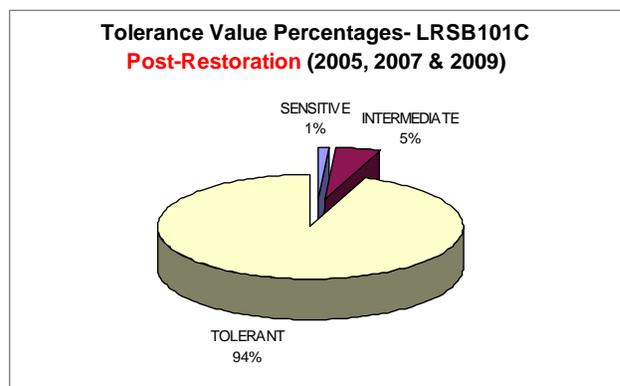
**Figure 3.21.11 – Benthic Macroinvertebrate Tolerance Composition at LRSB101B Prior to Restoration**



**Figure 3.21.12 – Benthic Macroinvertebrate Tolerance Composition at LRSB101B After Restoration**



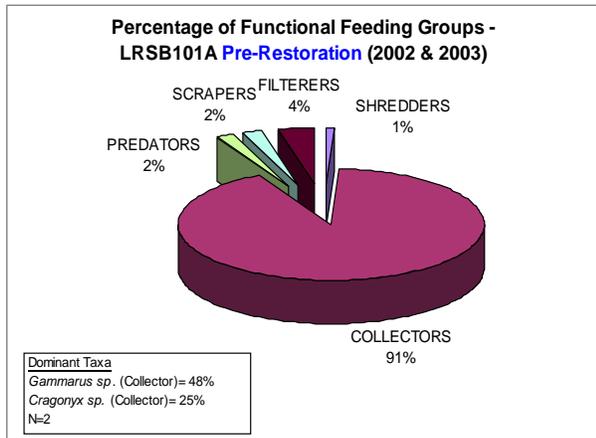
**Figure 3.21.13 – Benthic Macroinvertebrate Tolerance Composition at LRSB101C Prior to Restoration**



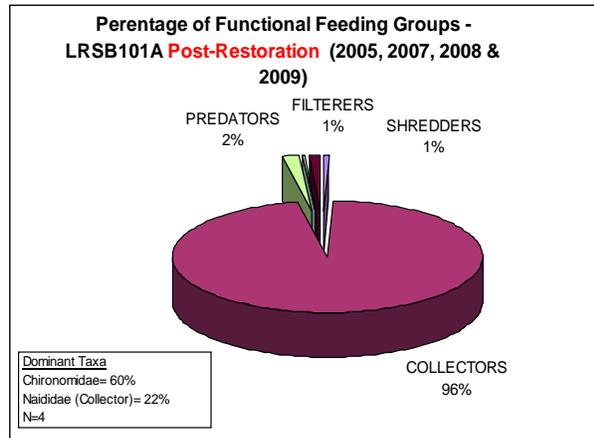
**Figure 3.21.14 – Benthic Macroinvertebrate Tolerance Composition at LRSB101C After Restoration**

### Functional Feeding Groups

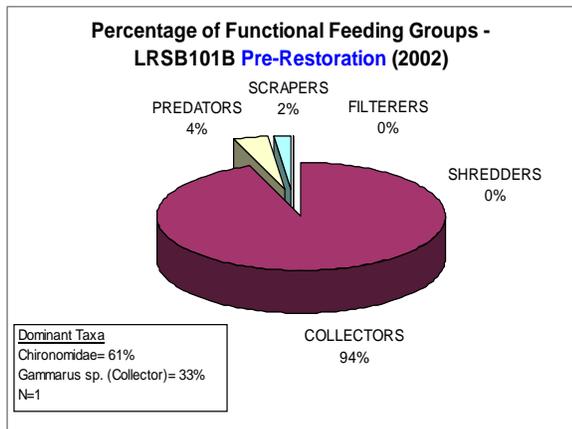
At all sites, collectors were the most dominant feeding group both prior to and after restoration. The proportion of collectors increased from the pre- to the post-restoration period at LRSB101A, but decreased slightly at the other two sites. Additionally, most of the specialized feeding groups that were present in only minor amounts prior to restoration declined to even lower proportions after restoration at all sites, except LRSB101C which had a slight increase in the percentage of shredders, rising from zero to one percent. However, the percentage of scrapers declined from eight to three percent at this site. **Figures 3.21.15 – 3.21.20** show the proportions of functional feeding groups at all Sycamore Creek sites prior to and after restoration activities occurred.



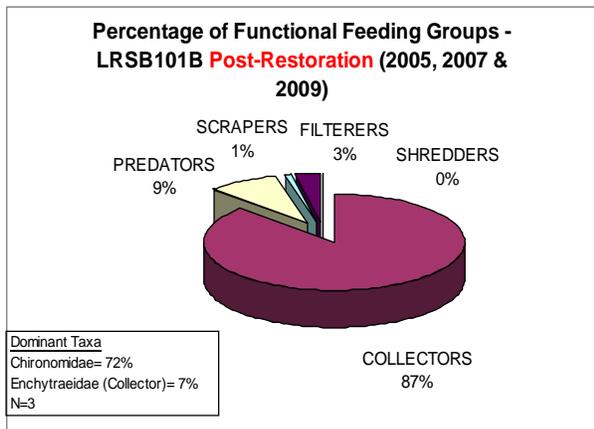
**Figure 3.21.15 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101A Pre-Restoration**



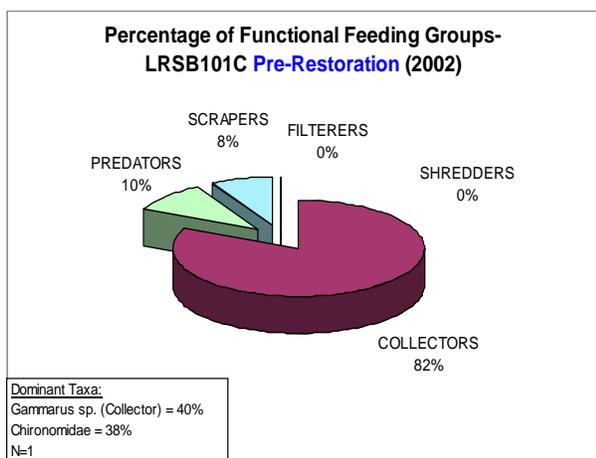
**Figure 3.21.16 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101A Post-Restoration**



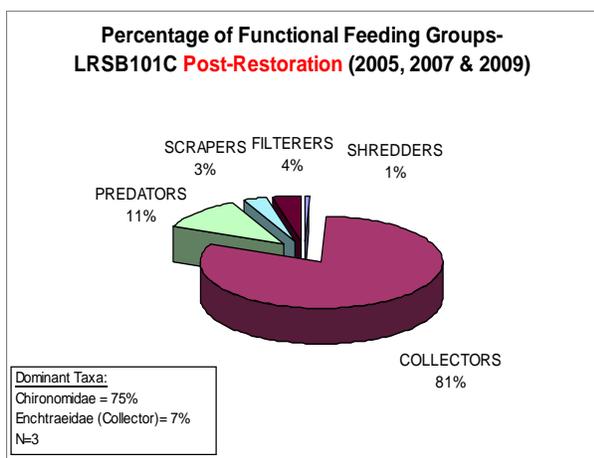
**Figure 3.21.17 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101B Pre-Restoration**



**Figure 3.21.18 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101B Post-Restoration**



**Figure 3.21.19 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101C Pre-Restoration**



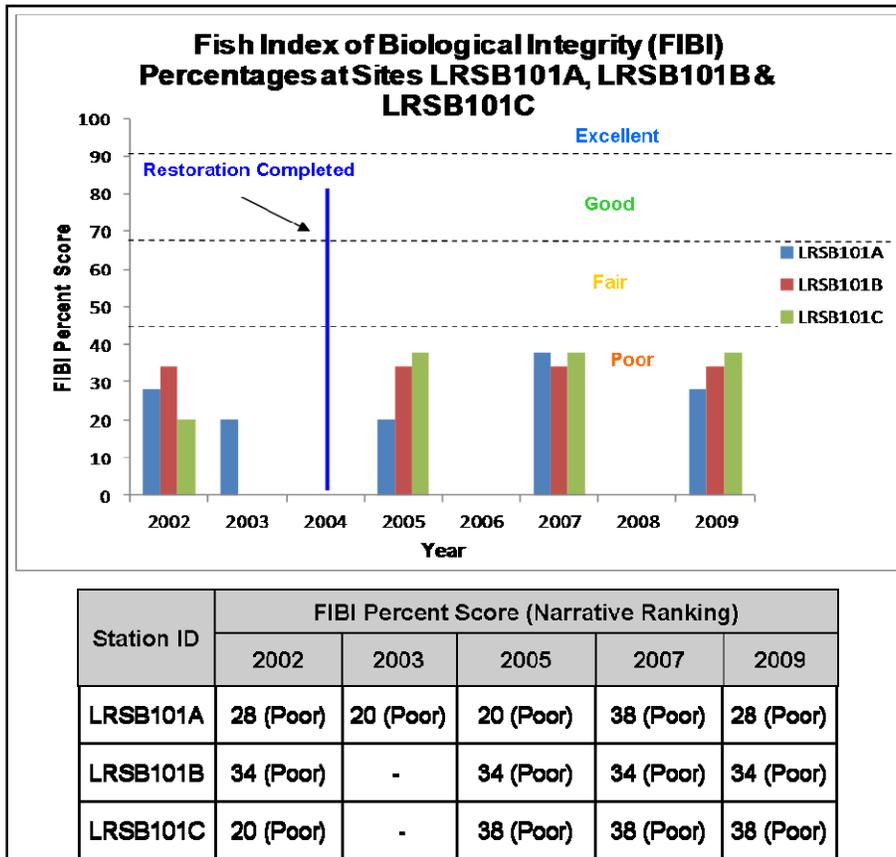
**Figure 3.21.20 – Benthic Macroinvertebrate Feeding Group Composition at LRSB101C Post-Restoration**

*Fish*

FIBI (Fish Index of Biological Integrity) Scores

Fish IBI scores were in the Poor range at all sites prior to restoration at Sycamore Creek (**Figure 3.21.21**). *Rhinichthys atratulus* (blacknose dace) was the most dominant species collected at all sites and the only species found at LRSB101A in 2002 and 2003. Two other fish species were collected at LRSB101B and three others were collected at LRSB101C, prior to restoration. Fish tolerant to urban conditions comprised the fish community at Sycamore Creek prior to restoration activities.

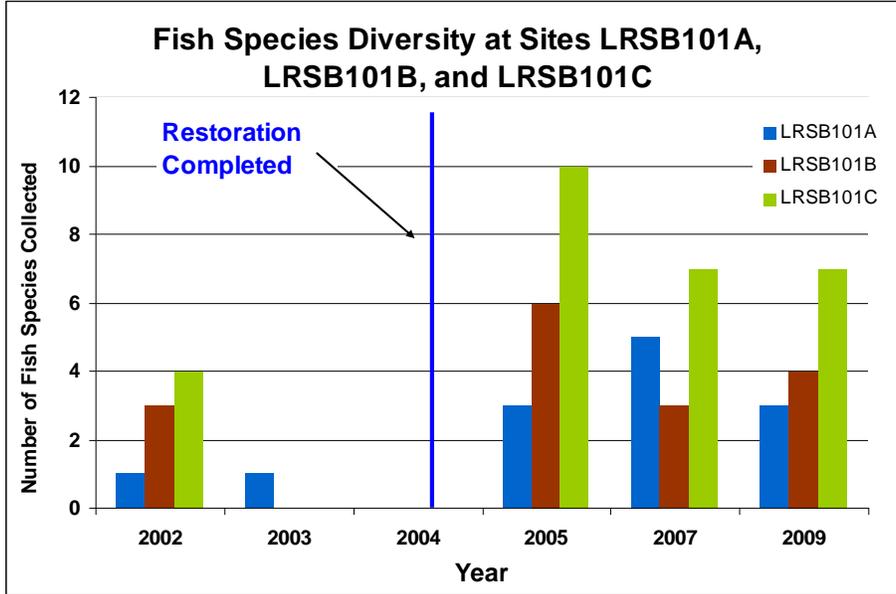
Fish IBI scores were also in the Poor range at all three Sycamore Creek sites post-restoration. Similar to pre-restoration assessments, blacknose dace dominated the community at all three sites. However, fish species diversity increased after restoration at all three sites from baseline fish species diversity values (**Figure 3.21.22**). American eel, a migratory species, was also collected at LRSB101C in all three post-restoration years and was not found at this site prior to construction. Also, the percent of non-pioneer fish (averaged between all three sites) increased from less than one percent pre-restoration to an average of eight percent following restoration (**Figure 3.21.23**). Generally, Fish IBI scores and community composition were similar pre- and post-restoration, however, species diversity increased slightly at all sites post-construction.



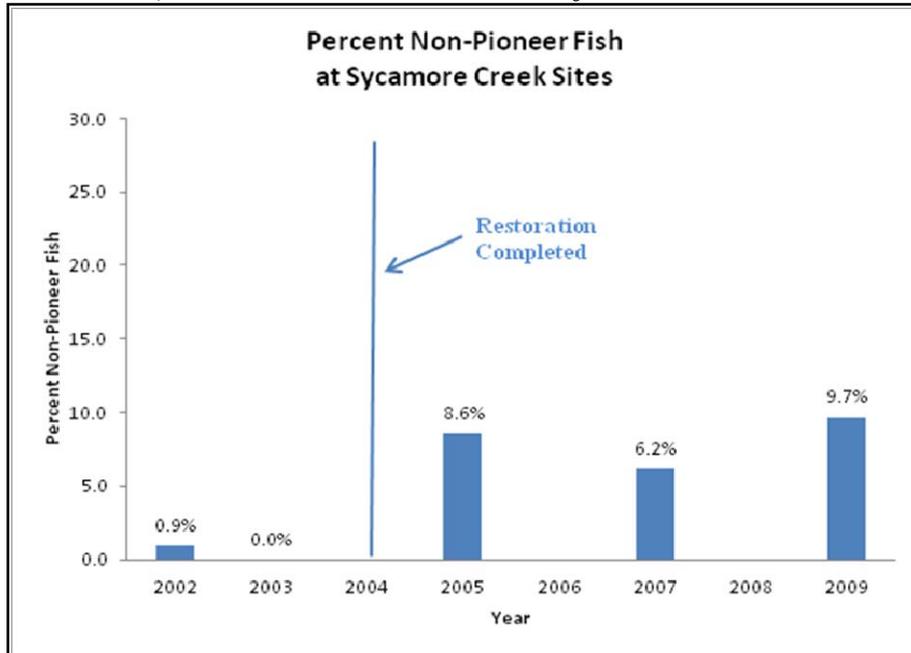
**Figure 3.21.21 – Pre- and Post-Restoration Fish Index of Biological Integrity (FIBI) Percentages at LRSB101A, LRSB101B, and LRSB101C**

### Dominant Taxa

Blacknose dace dominated all sites in all years in the Sycamore Creek project area. They comprised from 75 to 100 percent of the communities prior to restoration and from 60 to 84 percent after restoration. *Semotilus atromaculatus* (creek chub) was second most dominant in the post-restoration period at all sites and was second most dominant at LRSB101C prior to restoration.



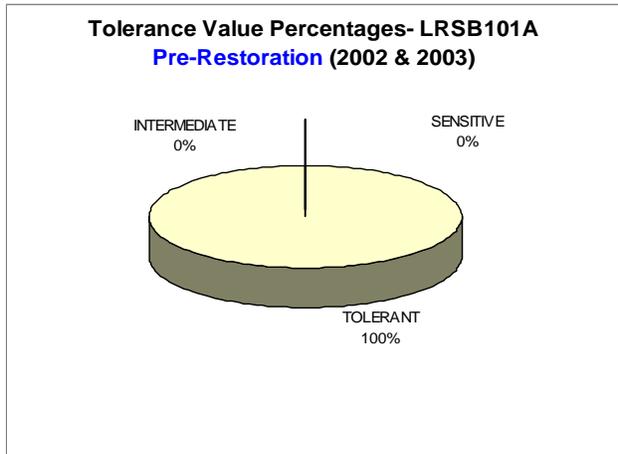
**Figure 3.21.22 – Diversity of Fish Species Collected at LRSB101A, LRSB101B, and LRSB101C Prior to and After Restoration**



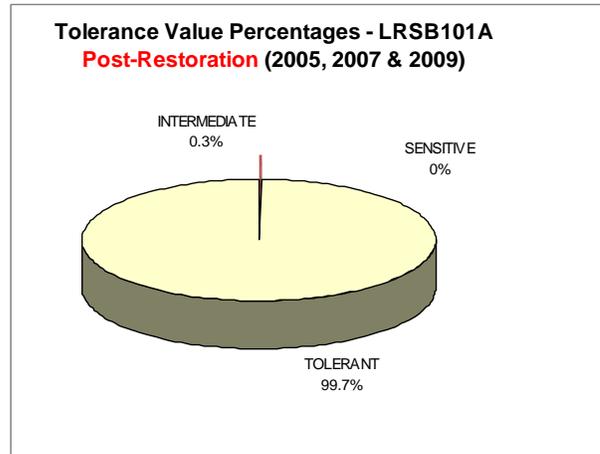
**Figure 3.21.23 – Percent Non-Pioneer Fish Collected at Sycamore Creek Sites (LRSB101A, LRSB101B, and LRSB101C), Prior to and After Restoration**

## Tolerance Values

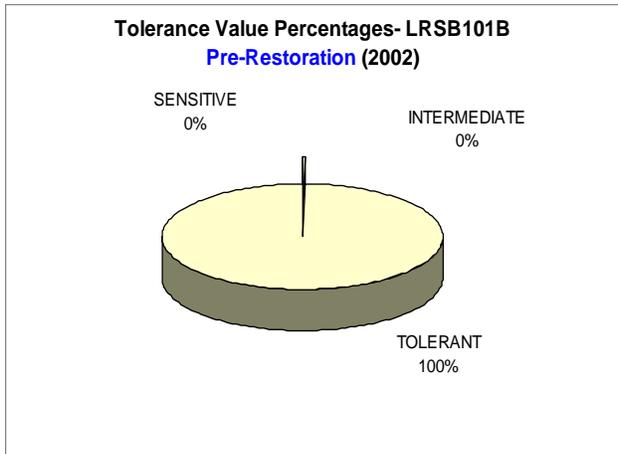
Tolerant fish species comprised more than 95 percent of the sampled community at all sites in all years. All sites, however, showed an increase in the proportion of fish intermediate in sensitivity in the post-restoration years, with LRSB101A occupied by 0.3 percent intermediate individuals, and LRSB101B and LRSB101C having two and four percent of the community represented by intermediate individuals, respectively. *Figures 3.21.24- 3.21.29* show the proportion of tolerances at all three sites prior to and after restoration.



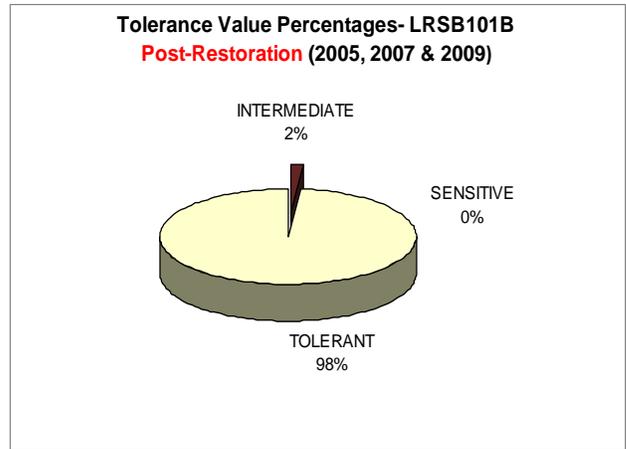
*Figure 3.21.24 – Fish Tolerance Composition at LRSB101A Prior to Restoration*



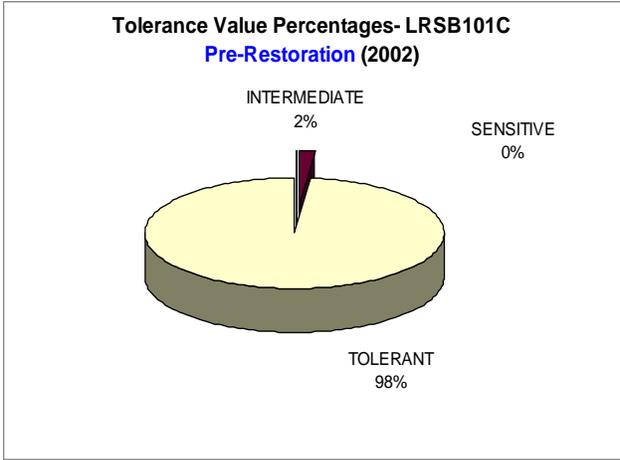
*Figure 3.21.25– Fish Tolerance Composition at LRSB101A After Restoration*



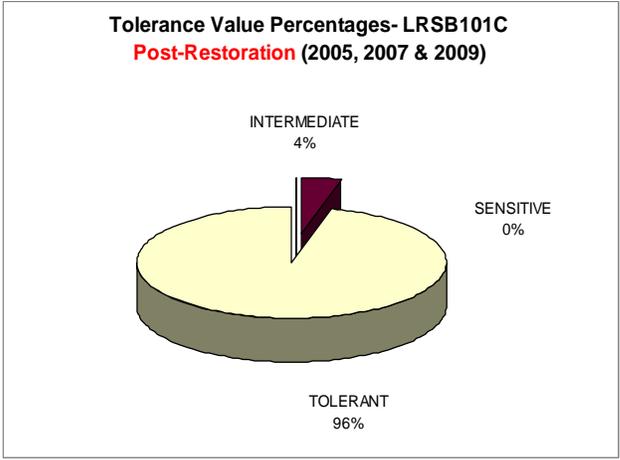
*Figure 3.21.26 – Fish Tolerance Composition at LRSB203B Prior to Restoration*



*Figure 3.21.27 – Fish Tolerance Composition at LRSB101B After Restoration*



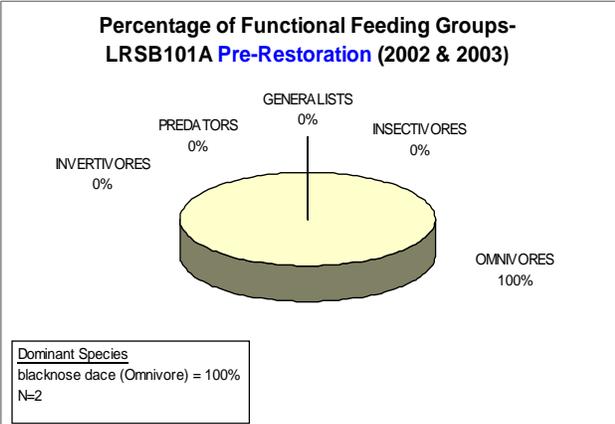
**Figure 3.21.28 – Fish Tolerance Composition at LRSB101C Prior to Restoration**



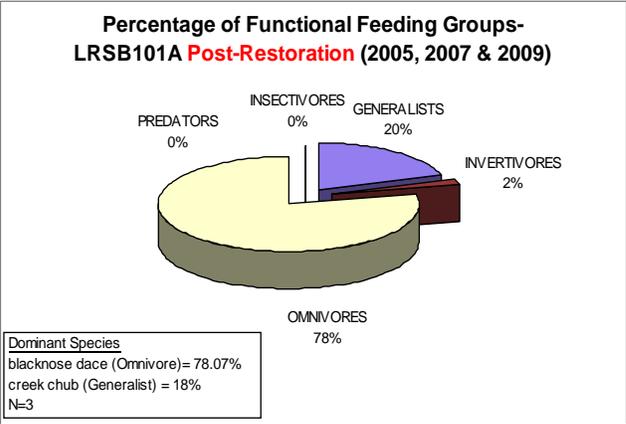
**Figure 3.21.29 – Fish Tolerance Composition at LRSB101C After Restoration**

Functional Feeding Groups

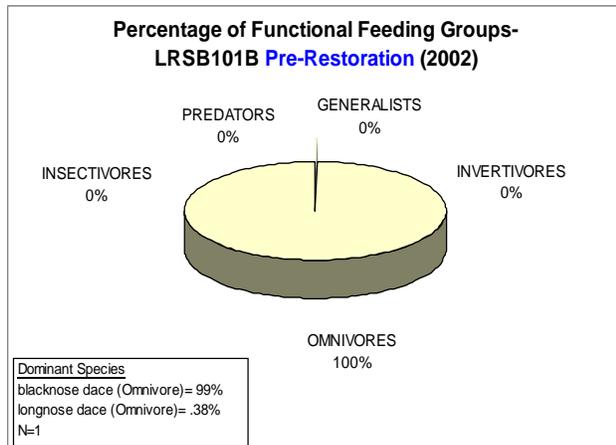
Omnivore and generalist fish feeding groups dominated the communities in all years and were the only two feeding groups represented prior to restoration. Invertivores were collected after restoration, comprising one percent of the community at LRSB101B and LRSB101C, and two percent of the community at LRSB101A. *Figures 3.21.30 – 3.21.35* show the proportions of functional feeding groups at all Sycamore Creek sites prior to and after restoration activities occurred.



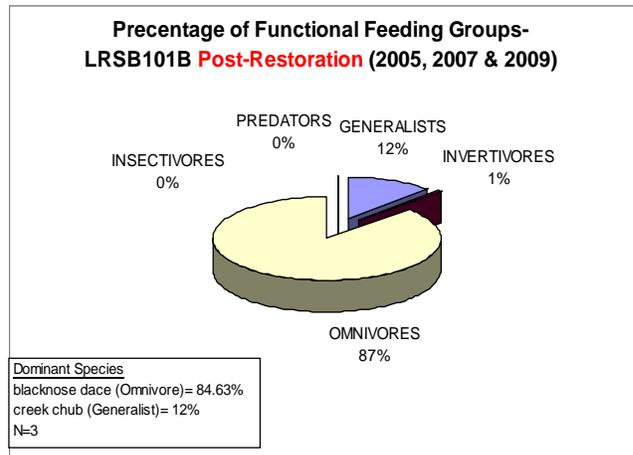
**Figure 3.21.30 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101A Prior to Restoration**



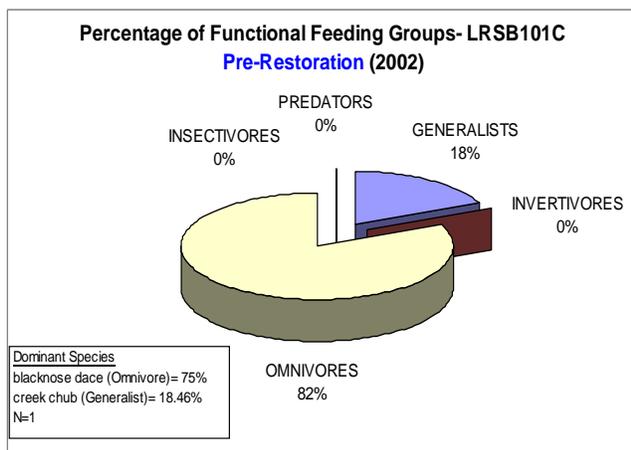
**Figure 3.21.31 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101A After Restoration**



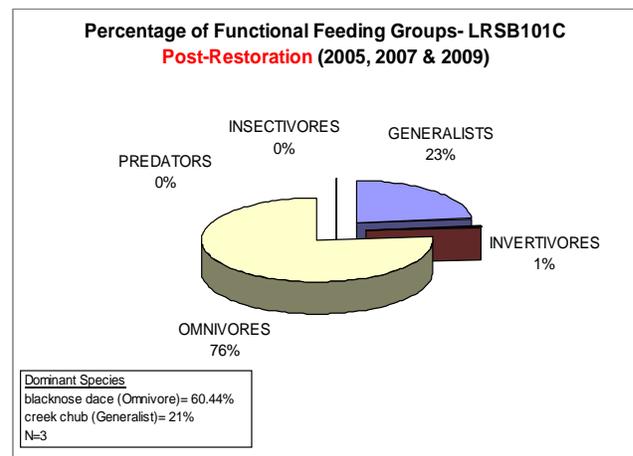
**Figure 3.21.32 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101B Prior to Restoration**



**Figure 3.21.33 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101B After Restoration**



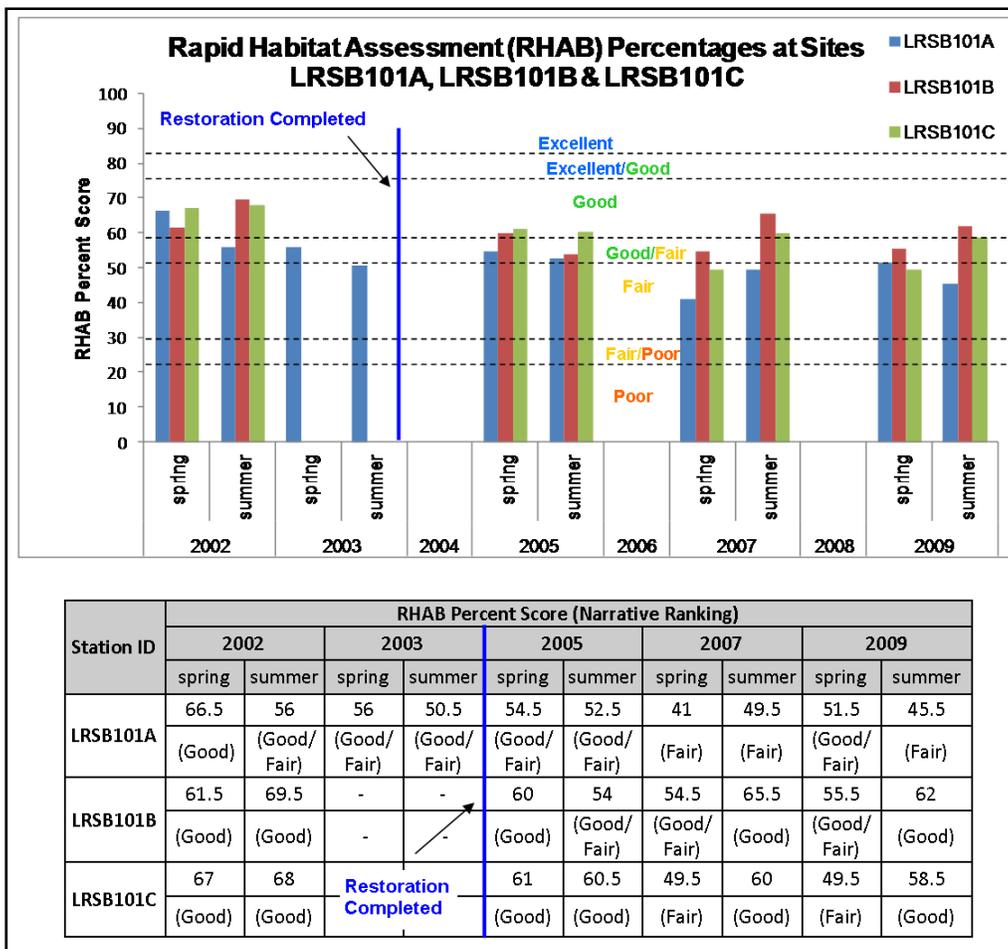
**Figure 3.21.34 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101C Prior to Restoration**



**Figure 3.21.35 – Fish Functional Feeding Group Composition and Dominant Species at LRSB101C After Restoration**

### Qualitative Habitat

Pre-restoration qualitative habitat was evaluated at LRB101A, LRSB101B, and LRSB101C in the spring and summer of 2002, and also at LRSB101C in the spring and summer of 2003. Scores prior to restoration were mostly in the Good range at all Sycamore Creek sites, with LRSB101A scoring a little lower than others during the summer of 2002 (**Figure 3.21.36**). In-stream cover, the habitat category associated with fish habitat, was generally assessed as having “adequate habitat for maintenance of populations”. Benthic macroinvertebrate habitat was generally rated as suboptimal, with the two sites lower in the watershed, LRSB101B and LRSB101C scoring slightly higher. Riffles occurred fairly frequently at all sites, and sediment deposition was rated as minor to moderate, with LRSB101B being less affected by sediment deposition. The streambanks in the project area were moderately stable to moderately unstable and the vegetated buffer at LRSB101A and LRSB101B were moderately impacted by human activities.



**Figure 3.21.36 – Pre- and Post-Restoration Rapid Habitat Assessment (RHAB) Percentages at LRSB101A, LRSB101B, and LRSB101C**

Post-construction qualitative habitat scores declined slightly from pre-restoration conditions and were generally in the Good, Good/Fair, and Fair ranges at the three Sycamore Creek sites. In-stream cover and epifaunal substrate rankings for fish and benthic macroinvertebrate habitat were mostly in the lower suboptimal and upper marginal ranges at LRSB101A, a decline from the pre-construction period. At LRSB101B epifaunal substrate scores were also in the lower suboptimal and upper marginal ranges, also declining from the pre-restoration period. However, in-stream cover scores were slightly higher at LRSB101B than they were in the pre-restoration period. LRSB101C had higher epifaunal substrate and in-stream cover scores than the other two sites on Sycamore Creek, mostly in the suboptimal range; assessed as providing adequate habitat for fish and having riffles with an abundance of cobble. Occurrence of riffles declined from the pre-construction period at all sites after construction, while sediment deposition increased with moderate to heavy sediment deposition noted at LRSB101A and LRSB101C. Site LRSB101B had slightly better sediment deposition scores but was still assessed as having moderate deposition and more than was assessed prior to restoration. Channel flow status was fairly consistent among sites with approximately 75 percent of the channel being filled with water. Streambanks at all three Sycamore Creek sites were moderately stable. Vegetation covered approximately 50 to 70 percent of the banks at all sites and patches of bare soil were apparent. Overall, post-restoration qualitative habitat scores were slightly lower than pre-restoration

scores. No one aquatic habitat parameter declined consistently post-restoration, and declines were not consistent among the three Sycamore Creek sites. Declines at LRSB101A were primarily due to lower scores for in-stream cover and channel alteration. Lower post-restoration scores at LRSB101B were due to declines in epifaunal substrate and bank vegetative protection and LRSB101C declined the most in the channel alteration and embeddedness parameters. Channel alteration did occur within all of these sites; however, alteration was associated with restoration and necessary stabilization. Some of the techniques used for restoration/stabilization on this project may have impaired aquatic habitat since they were done before the new natural channel design approach and therefore the aquatic habitat may have been degraded. Whenever possible, the County uses the new natural channel design approach; the goal of this design approach is to stabilize the stream in coordination with enhancing the aquatic habitat.

#### *Water Chemistry*

Except for the pH value collected at LRSB101A (8.63) in the spring of 2002, all in-situ water chemistry readings were in compliance with the COMAR standards at the three Sycamore Creek sites. The pH value at LRSB101B, the next closest downstream site, was 8.40, which was also notably higher than typical pH readings at this site, but was still acceptable according to the State's standard. *Tables 3.21.2 – 3.21.4* show the in-situ water chemistry readings at all three sites in the Sycamore Creek project area.

**Table 3.21.2 – In-situ Water Chemistry – Site LRSB101A**

Parameter	2002		2003		2005		2007		2008	2009	
	spring	summer	spring	summer	spring	summer	spring	summer	spring	spring	summer
Dissolved Oxygen (mg/L)	18.2	-	12.5	7.25	12.75	13.59	15.73	9.2	10.71	-	6.9
Dissolved Oxygen (% Saturation)	-	70	111	80	119	153	142	111	105	-	81
pH	8.63	7.01	7.23	6.88	7.76	7.9	8.25	8.07	7.67	7.78	7.59
Conductivity (µmhos)	300	311	324	286	348	369	346	402	333	354	380
Water Temperature (°F)	53.6	76.3	50	68.5	54.1	70	51.3	76.5	57.6	63.7	72

**Table 3.21.3 – In-situ Water Chemistry – Site LRSB101B**

Parameter	2002		2005		2007		2009	
	spring	summer	spring	summer	spring	summer	spring	summer
Dissolved Oxygen (mg/L)	14.9	8.28	12.76	11.61	19.38	9.43	5.93	6.52
Dissolved Oxygen (% Saturation)	-	99	117	127	174	108	66.9	70
pH	8.40	7.25	7.70	8.29	8.10	7.98	7.38	7.36
Conductivity (µmhos)	303	282	365	368	432	384	430	354
Water Temperature (°F)	57.2	80	52.3	68	51.1	72.1	62.4	66.4

**Table 3.21.4 – In-situ Water Chemistry – Site LRSB101C**

Parameter	2002		2005		2007		2009	
	spring	summer	spring	summer	spring	summer	spring	summer
Dissolved Oxygen (mg/L)	12.2	5.14	11.49	9.25	16.85	9.57	9.03	6.8
Dissolved Oxygen (% Saturation)	116	60	103	99	-	108	87	69
pH	7.62	6.90	7.57	7.75	8.03	7.99	7.83	7.62
Conductivity (µmhos)	333	152	389	390	405	379	395	418
Water Temperature (°F)	55.4	75.9	50.9	65.7	50.2	70.5	59.9	70

*Vernal Pools*

Two vernal pools were created at LRSB101B as part of the restoration project at Sycamore Creek and were both monitored in May of 2005 and 2007, and in April of 2009. Vernal Pool 1 lies upstream of Vernal Pool 2 (**Figure 3.21.37**). In 2005, *Lithobates catesbeianus* (American bullfrog) tadpoles were found in this vernal pool as well as three unidentified frog tadpoles. In 2007, *Lithobates sylvaticus* (wood frog) tadpoles were observed in the vernal pool as were Gerridae (water striders). In April 2009, the vernal pool was approximately 75 feet by 40 feet, a little over half a foot deep, and the temperature in the vernal pool was 55°F. Emergent, herbaceous vegetation was found growing within the vernal pool in 2009, including *Schoenoplectus tabernaemontani* (softstem bulrush), *Nymphaea sp.* (waterlily), and algae. Herbaceous vegetation surrounded the vernal pool as well, and was dominated by *Juncus effusus* (common rush), grasses, and *Ranunculus ficaria* (fig buttercup or lesser celandine), a non-native ground cover. Additionally, trees planted around the perimeter of the pool were healthy. In 2009, *Anaxyrus americanus* (Eastern American toad) was the only species of amphibian found in Vernal Pool 1. No adults were found, but one egg mass and approximately 25 Eastern American toad tadpoles were observed in the pool.



**Figure 3.21.37 – Vernal Pool 1 at LRSB101B in April 2009, showing lesser celandine surrounding the vernal pool and algae within**

In 2005, wood frog tadpoles were observed in Vernal Pool 2 and in 2007, American bullfrog tadpoles were found. At the time of monitoring in April 2009, Vernal Pool 2 was approximately

65 feet long by 26 feet wide. Emergent, herbaceous vegetation was found growing, primarily at the downstream end of the vernal pool and included softstem bulrush, and water lily or *Sagittaria sp.* (arrowhead) (**Figure 3.21.38**). Common rush and lesser celandine were found growing on the banks. Logs and a few smaller tree limbs were also observed in the vernal pool and were noted as potential attachment sites for egg masses. Three *Ambystoma maculatum* (spotted salamander) egg masses were found within the pool (**Figure 3.21.39**). *Pseudacris crucifer crucifer* (spring peepers) were heard calling from the pool and one adult was observed outside the pool. Two *Plethodon cinereus* (Eastern red-backed salamanders), in the leadback phase, were found under logs during the search around the perimeter of the vernal pool (**Figure 3.21.40**).



**Figure 3.21.38 – Vernal Pool 2 at LRSB101B in 2009, showing lesser celandine and softstem bulrush**



**Figure 3.21.39 – Vernal Pool 2 at LRSB101B showing spotted salamander egg mass**



**Figure 3.21.40 – Perimeter of Vernal Pool 2 at LRSB101B, showing Eastern red-backed salamander in lead-back phase**

#### *Wetland Vegetation*

Pre-restoration wetland vegetation data were not available for this site, as the wetlands were created as part of the restoration. The wetlands at LRSB101B were monitored in 2005, 2007, and 2009 to evaluate the success of the planted wetland vegetation after restoration. Wetland 1 is the same area described above as Vernal Pool 1 and Wetland 2 is the same as Vernal Pool 2. The vernal pool herpetofauna monitoring was performed in the spring, and the wetland

vegetation monitoring was performed in the summer or fall. Monitoring methodologies differed among years; in 2005 and 2007, a point-intercept sampling procedure (Federal Interagency Committee for Wetland Delineation 1989) was performed and in 2009, the *MDE Mitigation Site Scoring Method* (2007) was used.

In 2005, the most prevalent plant species found at both Wetland 1 and 2 included common rush and softstem bulrush. In 2007, it appears that only Wetland 2 was monitored. The dominant plant species observed at this time included *Microstegium vimineum* (Nepalese browntop), *Dichanthelium clandestinum* (deertongue grass), and common rush. Monitoring results in 2007 indicated this area was a wetland. In 2009, both wetlands were monitored at LRSB101B. Each wetland was monitored separately and was given a total score out of 100 points based on vegetation, soils, hydrology, and wetland functional gains (*Table 3.21.5*).

**Table 3.21.5 – Post-restoration Wetland Vegetation Assessment (2009)**

Area	Vegetation Score (out of 30)	Soil Score (out of 20)	Hydrology Score (out of 30)	Wetland Functional Gains Score (out of 20)	Area Total Score (out of 100)
Wetland 1	17.5	12	22	15	66.5
Wetland 2	21.25	12	22	18	73.25

Wetland 1 is a palustrine emergent wetland and lies upstream of Wetland 2. On the day of the assessment in October 2009, 40 percent of the wetland area was inundated with approximately four inches of water and 60 percent of the area was saturated. Dominant emergent species observed were softstem bulrush, common rush, and *Leersia oryzoides* (rice cutgrass) (*Figure 3.21.41*). None of the planted species appear to have survived, however a few volunteer trees and shrubs were found growing around the edge of the wetland, including: *Asimina triloba* (pawpaw), *Betula nigra* (river birch), and *Cephalanthus occidentalis* (common buttonbush). Four of the six river birch were found dead and had *Polygonum perfoliatum* (Asiatic tearthumb) climbing on them, and one *Hamamelis virginiana* (American witchhazel) was found dead. Asiatic tearthumb and Nepalese browntop occupied approximately two percent of the wetland area and may be a concern for the future success of this wetland. The density of wetland plant species was fairly low, at 25 percent. The expected growth of the existing vegetation was also low due to stress caused by invasive species and deep water that limits potential habitat. Overall, Wetland 1 scored 66.5 out of 100. Soils in the wetland were determined to be hydric; however, they were thin, sandy, and underlain by solid rock. These conditions were not optimal for plant growth. Wetland functional gains were also determined to be low, with the wetland providing only minor wetland functions.



**Figure 3.21.41 – Wetland Vegetation at Wetland 1, LRSB101B, common rush pictured**

Wetland 2 is a smaller palustrine emergent wetland located downstream of Wetland 1. On the day of the 2009 assessment, Wetland 2 was 90 percent inundated with approximately three inches of water and ten percent saturated. Dominant emergent species included: common rush, rice cutgrass, Nepalese browntop, softstem bulrush, and *Pontederia cordata* (pickerelweed) (**Figure 3.21.42**). Seventy-five percent of the vegetated cover was comprised of native wetland vegetation and seven percent was occupied by Nepalese browntop. Several healthy river birches planted by DEP were found growing on the wetland edge. Hydric soils were evident in the wetland, although no redoximorphic features were present in the profile. Very little mineral soil existed within the profile, which was underlain with rock. A sandy clay layer appeared to be creating a perched wetland condition at Wetland 2.

The total score for Wetland 2 was 73.25 out of 100. This site scored higher than Wetland 1 because it had a higher percent cover of emergent vegetation, which created a more habitable condition for obligate vernal pool species and other wildlife.



**Figure 3.21.42 – Wetland Vegetation at Wetland 2, LRSB101B, common rush, rice cutgrass, Nepalese browntop, and duckweed (light green floating vegetation) pictured**

### *Botanical Reforestation*

Botanical reforestation was performed at all three sites in this restoration project. Each site was split into planting zones that contained several planting areas. **Figure 3.21.7** shows the location of all botanical zones where planting success was evaluated. Original plantings for the project occurred in 2005 and repair plantings were performed in 2009, because many of the original plantings died due to deer browse/rub, natural stream migration, invasive plant competition, drought impacts, and other human disturbances.

Overall, 38 percent of the plantings survived to the 2009 survey. Planted trees survived much better than planted shrubs. Trees that had the greatest survival percentage at all Sycamore Creek sites included *Carpinus caroliniana* (ironwood) and *Platanus occidentalis* (American sycamore). The trees that had the worst survival percentages were *Kalmia latifolia* (mountain laurel) and *Quercus alba* (white oak). American sycamore and *Acer rubrum* (red maple) plantings had the highest growth rates site-wide and *Cercis canadensis* (Eastern redbud) was most often observed as a volunteer. The trees that were found growing at these sites generally ranged from 0.5 to 1.75 inch caliper, with one site having a few trees that were 2.5 inches. All of the planted trees ranged from 0.5 to one inch caliper. Based on these findings, tree growth has occurred at most zones, although it has not been substantial. However, many of the surviving plantings were only planted five months prior to being monitored, therefore it is not expected that these trees would have grown substantially, if at all, in that time-frame. Any increase in caliper size may be an indication that some of the plantings have become well established. The following sections will describe the success of the plantings at each zone in more detail.

#### LRSB101A

Monitoring site LRSB101A extends along Sycamore Creek for about a third of a mile from Dabney Drive south to Bauer Drive. Zone 1 (planting areas 25.2-25.9) is located at the upstream limit of the site (**Table 3.21.6**). Overall, planting survival was poor in this zone, as only nine percent of the plantings survived. Ironwood and American sycamore had the highest survival rates. Survival percentages of red maple, *Asimina triloba* (pawpaw), and *Amelanchier canadensis* (Canadian serviceberry) were lower, and several other planted species were present in minor amounts. Three species were found growing in Zone 1 that were not on the planting plan, including *Ilex opaca* (American holly), *Betula nigra* (river birch), and *Cercis canadensis* (Eastern redbud). These species are volunteers that are colonizing the site and contributing to the goal of riparian reforestation. Of the surviving plants, about 74 percent of the trees observed in 2009 appeared healthy, while only three percent were dead at the time of the vegetation survey. Additionally, all of the live trees that were counted in 2009 appeared to have grown since being planted. Most trees were approximately 0.5 to one inch caliper when planted. The caliper range of the trees counted in 2009 was between 0.5 and 1.75 inches, with American sycamore showing the largest increase in caliper size of all planted trees in this area. A few tree species did not appear to grow, including American hornbeam and Canadian serviceberry.

Four species of planted shrubs, including mountain laurel, *Viburnum prunifolium* (blackhaw), *Euonymus americanus* (strawberry bush), and *Rhododendron periclymenoides* (pink azalea) were observed within Zone 1, but only six individuals were present. Of these shrubs, about 83 percent appeared healthy, while 17 percent were dead at the time of the survey. Invasive plants such as Nepalese browntop, Asiatic tearthumb, and *Rubus phoenicolasius* (wineberry) were present, but not widespread. Deer browse was evident, but not pervasive within Zone 1.

**Table 3.21.6 – 2009 Botanical Reforestation Summary for Zone 1 (Site LRSB101A)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	26	2	3	11
<i>Amelanchier canadensis</i>	Canadian serviceberry	19	0	2	11
<i>Asimina triloba</i>	pawpaw	19	10	3	11
<i>Carpinus caroliniana</i>	ironwood	18	8	8	31
<i>Cornus florida</i>	flowering dogwood	14	0	0	0
<i>Euonymus americanus</i>	strawberry bush	42	0	1	2
<i>Fagus grandifolia</i>	American beech	40	0	2	5
<i>Kalmia latifolia</i>	mountain laurel	12	0	1	8
<i>Lindera benzoin</i>	northern spicebush	2	13	0	0
<i>Ostrya virginiana</i>	hophornbeam	12	0	0	0
<i>Platanus occidentalis</i>	American sycamore	43	0	10	23
<i>Populus deltoides</i>	cottonwood	2	0	0	0
<i>Quercus alba</i>	white oak	40	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	32	0	1	3
<i>Sassafras albidum</i>	sassafras	30	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	12	0	0	0
<i>Viburnum dentatum</i>	southern arrowwood	4	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	61	0	1	2
<b>Total</b>		<b>428</b>	<b>33</b>	<b>40</b>	<b>9</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Overall, only two percent of the plantings in Zone 2 (planting areas 24.1-24.3 and 24.5-24.8) survived; no trees were alive at the time of the survey. Eleven individual shrubs representing three species were present, including blackhaw, strawberry bush, and mountain laurel (**Table 3.21.7**). Approximately 64 percent of these were considered healthy, while 18 percent were dead. The remaining 18 percent, including only mountain laurel, were alive, but not considered healthy. The stressed individuals were resprouting, but appeared to be browsed by deer.

**Table 3.21.7 – 2009 Botanical Reforestation Summary for Zone 2 (Site LRSB101A)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	34	15	0	0
<i>Amelanchier canadensis</i>	Canadian serviceberry	10	0	0	0
<i>Asimina triloba</i>	pawpaw	9	37	0	0
<i>Betula nigra</i>	river birch	0	2	0	0
<i>Carpinus caroliniana</i>	ironwood	18	7	0	0
<i>Cercis canadensis</i>	eastern redbud	6	7	0	0

**Table 3.21.7 – 2009 Botanical Reforestation Summary for Zone 2 (Site LRSB101A)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Cornus florida</i>	flowering dogwood	18	0	0	0
<i>Euonymus americanus</i>	strawberry bush	41	0	3	7
<i>Fagus grandifolia</i>	American beech	22	0	0	0
<i>Hamamelis virginiana</i>	common witchhazel	7	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	10	0	2	20
<i>Lindera benzoin</i>	spicebush	0	1	0	0
<i>Ilex opaca</i>	American holly	1	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	6	0	0	0
<i>Platanus occidentalis</i>	American sycamore	12	15	0	0
<i>Populus deltoides</i>	cottonwood	3	0	0	0
<i>Prunus serotina</i>	black cherry	5	0	0	0
<i>Quercus alba</i>	white oak	22	0	0	0
<i>Quercus rubra</i>	northern red oak	0	2	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	27	0	0	0
<i>Sassafras albidum</i>	sassafras	28	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	35	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	37	0	4	11
<b>Total</b>		<b>351</b>	<b>86</b>	<b>7</b>	<b>2</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Zone 3 (planting areas 23.9-23.11) was characterized by much better survival than Zones 1 and 2, with 27 percent of all woody plantings surviving into 2009 (**Table 3.21.8**). Eighty-three percent of the woody plants observed in 2009 were considered healthy. More pawpaw and river birch trees were observed than originally planted, indicating these species are colonizing the site and contributing to the goal of riparian reforestation. Additionally, most tree species that were found in 2009 were noted to be larger than the size of the planted material; river birch and American sycamore have grown the most since being planted, increasing from 0.5 inch caliper to between 0.75 and 1.5 inch caliper. *Ostrya virginiana* (hophornbeam), white oak, and *Cornus florida* (flowering dogwood) did not survive, but no evidence of dead trees was present during the site visit. Shrubs fared poorly in Zone 3, with only 28 percent of the observed individuals appearing healthy compared to 44 percent appearing dead. The remaining 28 percent were alive, but were not considered healthy. Shrub species observed included mountain laurel, strawberry bush, mapleleaf viburnum, pink azalea, and *Lindera benzoin* (spicebush). These individuals do not appear to have grown much since being planted. Many of these were re-sprouting as a result of recent browsing by deer. Invasive plants were marginally present in Zone 3; only wineberry was observed.

**Table 3.21.8 – 2009 Botanical Reforestation Summary for Zone 3 (Site LRSB101A)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	11	5	3	19
<i>Amelanchier canadensis</i>	Canadian serviceberry	10	0	0	0
<i>Asimina triloba</i>	pawpaw	3	6	13	144
<i>Betula nigra</i>	river birch	0	3	4	133
<i>Carpinus caroliniana</i>	ironwood	5	5	2	20
<i>Cephalanthus occidentalis</i>	buttonbush	0	2	0	0
<i>Cercis canadensis</i>	eastern redbud	0	3	3	100
<i>Cornus florida</i>	flowering dogwood	17	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	2	67
<i>Fagus grandifolia</i>	American beech	6	0	1	17
<i>Kalmia latifolia</i>	mountain laurel	5	0	0	0
<i>Lindera benzoin</i>	spicebush	4	0	3	75
<i>Ostrya virginiana</i>	hophornbeam	3	0	0	0
<i>Platanus occidentalis</i>	American sycamore	9	12	4	19
<i>Quercus alba</i>	white oak	11	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	8	0	1	13
<i>Viburnum acerifolium</i>	mapleleaf viburnum	3	0	1	33
<i>Viburnum dentatum</i>	southern arrowwood	2	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	3	0	0	0
<b>Total</b>		<b>103</b>	<b>36</b>	<b>37</b>	<b>27</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Overall, planting survival in Zone 4 (planting areas 23.1-23.8) was fair; 11 percent of the original plantings were observed in 2009 (**Table 3.21.9**). Five species of mostly healthy trees were observed, including ironwood, American sycamore, river birch, red maple, and eastern redbud. Ninety-six percent of the observed individuals appeared healthy, while only one tree was dead. Of the 23 species that were planted in this zone, eastern redbud, strawberry bush, and river birch had the greatest percentages of survival. Eastern redbud was present in greater numbers than originally planted, suggesting this species is colonizing the site and contributing to the goal of riparian reforestation. Red maple and eastern redbud was the most successful in terms of growth, increasing in caliper size from approximately 0.5 inches to between one and 1.25 inches. Planted shrubs in Zone 4 are currently in poor condition, as none of the remaining plants appeared healthy at the time of the vegetation survey. Strawberry bush was the only shrub that has survived. Mountain laurel was also observed, but all individuals of this species were dead. Deer browse may account for poor survival of the shrubs, since the aforementioned trees were protected from deer by caging. Invasive plants were present, but not widespread in Zone 4. These included Nepalese browntop and Japanese honeysuckle.

**Table 3.21.9 – 2009 Botanical Reforestation Summary for Zone 4 (Site LRSB101A)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	22	0	3	14
<i>Alnus serrulata</i>	hazel alder	0	3	0	0
<i>Amelanchier canadensis</i>	Canadian serviceberry	15	0	0	0
<i>Asimina triloba</i>	pawpaw	5	0	0	0
<i>Betula nigra</i>	river birch	0	14	6	43
<i>Carpinus caroliniana</i>	ironwood	15	0	0	0
<i>Cephalanthus occidentalis</i>	buttonbush	0	1	0	0
<i>Cercis canadensis</i>	eastern redbud	0	2	3	150
<i>Cornus florida</i>	flowering dogwood	11	0	0	0
<i>Euonymus americanus</i>	strawberry bush	8	0	4	50
<i>Fagus grandifolia</i>	American beech	13	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	15	0	0	0
<i>Lindera benzoin</i>	spicebush	15	0	0	0
<i>Ilex opaca</i>	American holly	4	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	7	0	0	0
<i>Platanus occidentalis</i>	American sycamore	14	0	3	21
<i>Populus deltoides</i>	cottonwood	2	0	0	0
<i>Quercus alba</i>	white oak	19	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	18	0	0	0
<i>Sassafras albidum</i>	sassafras	6	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	17	5	0	0
<i>Viburnum dentatum</i>	southern arrowwood	6	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	15	0	0	0
<b>Total</b>		<b>227</b>	<b>37</b>	<b>19</b>	<b>11</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Monitoring site LRSB101B is located immediately downstream of LRSB101A along Sycamore Creek. The site extends for about a mile from Bauer Drive across Russett Road to just downstream of the Russett Road bridge crossing. Zone 5 (planting areas 22.3-22.7, 22.9, 22.11) is located at the upstream limit of the site. Overall, 28 percent of the plantings were observed in 2009 (**Table 3.21.10**). Planted trees observed included red maple, ironwood, eastern redbud, pawpaw, American holly, and American sycamore. Two species of volunteer trees, American holly and eastern redbud were also observed. About 84 percent of individuals representing these species were healthy, only four percent were dead, and the remaining 12 percent were alive, but not considered healthy. The species with the greatest survival were pawpaw, ironwood, red maple, and American sycamore; these represent the only species of the original 18 planted species observed in 2009. Caliper sizes of most of the planted trees have not increased much,

but were fairly consistent among species, ranging from 0.5 to 1.25, which are not much bigger than those planted (0.5 to one inch caliper). No planted shrubs were found alive in this planting zone; only two dead mountain laurels were present during the vegetation survey. Very few shrubs were planted in this area and may have been browsed by deer prior to the 2009 monitoring. Japanese honeysuckle was only a minor constituent of the plant community in Zone 5.

**Table 3.21.10 – 2009 Botanical Reforestation Summary for Zone 5 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	5	4	4	44
<i>Amelanchier canadensis</i>	Canadian serviceberry	5	0	0	0
<i>Asimina triloba</i>	pawpaw	6	8	25	179
<i>Carpinus caroliniana</i>	ironwood	5	3	5	63
<i>Cornus florida</i>	flowering dogwood	5	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	0	0
<i>Fagus grandifolia</i>	American beech	3	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	10	0	0	0
<i>Lindera benzoin</i>	spicebush	3	4	0	0
<i>Ostrya virginiana</i>	hophornbeam	5	0	0	0
<i>Platanus occidentalis</i>	American sycamore	3	7	4	40
<i>Quercus alba</i>	white oak	4	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	3	0	0	0
<i>Sassafras albidum</i>	sassafras	13	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	1	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	8	0	0	0
<b>Total</b>		<b>82</b>	<b>64</b>	<b>38</b>	<b>28</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Overall, planting survival was good in Zone 6 (planting areas 22.2 and 22.10), with 71 percent of the plantings observed in 2009 (**Table 3.21.11**). More ironwood and pawpaw individuals were observed in Zone 6 than were planted, which indicates these species are colonizing the site and contributing to the goal of riparian reforestation. Health of observed trees was good within Zone 6; 93 percent were healthy in 2009 and seven percent were dead. Species observed included ironwood, red maple, American beech, American sycamore, and pawpaw. White oak was the only planted tree species not observed in 2009. The trees that were counted in 2009 ranged from 0.75 to 1.25 inch caliper. None of the species appeared to have grown much from their planting size of between 0.5 to one inch caliper.

Three species of shrubs were observed in Zone 6, including strawberry bush, spicebush, and mountain laurel; 55 percent of these species were found alive in 2009. However, only spicebush appeared healthy. Deer browse was noted at this site, but not deemed as inhibiting the growth of the remaining plants. Invasive species were also observed in Zone 6 and included Nepalese browntop, wineberry, and multiflora rose, but these invasives did not appear to be affecting the

growth of the plantings.

**Table 3.21.11– 2009 Botanical Reforestation Summary for Zone 6 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	4	1	4	80
<i>Amelanchier canadensis</i>	Canadian serviceberry	1	0	0	0
<i>Asimina triloba</i>	pawpaw	0	4	4	100
<i>Carpinus caroliniana</i>	ironwood	0	4	15	375
<i>Cornus florida</i>	flowering dogwood	1	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	3	100
<i>Fagus grandifolia</i>	American beech	6	0	3	50
<i>Kalmia latifolia</i>	mountain laurel	2	0	0	0
<i>Lindera benzoin</i>	spicebush	0	3	1	33
<i>Platanus occidentalis</i>	American sycamore	5	6	10	91
<i>Quercus alba</i>	white oak	7	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	4	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	1	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	4	0	0	0
<b>Total</b>		<b>38</b>	<b>18</b>	<b>40</b>	<b>71</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Overall, eight percent of the plantings were observed in Zone 7 (planting areas 21.3 and 22.1). Four species and 11 individuals were identified (**Table 3.21.12**). Those observed included pawpaw, red maple, spicebush, and American sycamore. All but one tree appeared healthy at the time of the vegetation survey; the other tree was dead. Trees ranged from 0.5 to 1.25 inch caliper in 2009. The sizes of these trees did not differ much from those planted. Fifteen other tree and shrub species were planted in Zone 7 but were not observed in 2009. Neither deer browse nor invasive plants were determined to be affecting the observed trees and shrubs within this zone.

**Table 3.21.12 – 2009 Botanical Reforestation Summary for Zone 7 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	5	5	1	9
<i>Amelanchier canadensis</i>	Canadian serviceberry	8	0	0	0
<i>Asimina triloba</i>	pawpaw	4	0	4	100
<i>Carpinus caroliniana</i>	ironwood	4	20	0	0
<i>Cornus florida</i>	flowering dogwood	4	0	0	0
<i>Euonymus americanus</i>	strawberry bush	4	0	0	0
<i>Fagus grandifolia</i>	American beech	6	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	15	0	0	0

**Table 3.21.12 – 2009 Botanical Reforestation Summary for Zone 7 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Lindera benzoin</i>	spicebush	1	6	3	43
<i>Ilex opaca</i>	American holly	1	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	5	0	0	0
<i>Platanus occidentalis</i>	American sycamore	6	11	3	17
<i>Populus deltoides</i>	cottonwood	2	0	0	0
<i>Quercus alba</i>	white oak	3	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	6	0	0	0
<i>Sassafras albidum</i>	sassafras	8	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	5	0	0	0
<i>Viburnum dentatum</i>	southern arrowwood	1	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	4	0	0	0
<b>Total</b>		<b>92</b>	<b>42</b>	<b>11</b>	<b>8</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Fourteen percent of the trees survived within Zone 8 (planting areas 21.2 - 21.2, 21.10-21.11) (**Table 3.21.13**), including American sycamore, pawpaw, ironwood, and red maple. Trees ranged from 0.5 to 1.5 inch caliper in 2009. The sizes of these trees did not differ much from those planted. None of the shrubs that were planted in 2005 survived. Of the 19 species planted, 13 of the species did not survive, which may be related to the known deer population issue within this stream corridor in addition to the droughts that this region has faced over the monitoring period.

**Table 3.21.13– 2009 Botanical Reforestation Summary for Zone 8 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	8	4	3	25
<i>Amelanchier canadensis</i>	Canadian serviceberry	1	0	0	0
<i>Asimina triloba</i>	pawpaw	8	18	7	27
<i>Carpinus caroliniana</i>	ironwood	6	2	3	38
<i>Cercis canadensis</i>	eastern redbud	0	5	0	0
<i>Cornus florida</i>	flowering dogwood	7	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	0	0
<i>Fagus grandifolia</i>	American beech	10	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	20	0	0	0
<i>Lindera benzoin</i>	spicebush	1	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	10	0	0	0
<i>Platanus occidentalis</i>	American sycamore	3	5	7	88
<i>Quercus alba</i>	white oak	2	0	0	0
<i>Rhododendron</i>	pink azalea	6	0	0	0

**Table 3.21.13– 2009 Botanical Reforestation Summary for Zone 8 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>periclymenoides</i>					
<i>Sassafras albidum</i>	sassafras	12	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	6	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	10	0	0	0
<b>Total</b>		<b>113</b>	<b>34</b>	<b>20</b>	<b>14</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

Eighteen percent of the plantings in Zone 9 (planting areas 20.6-20.7, 20.9) survived. This zone contained four species of planted trees, including American sycamore, river birch, pawpaw, and eastern redbud and one volunteer species, pawpaw (**Table 3.21.14**). Sixty-nine percent of the counted individuals were healthy and the remaining 31 percent were considered stressed. The caliper sizes of the individuals counted in 2009 ranged from 0.5 to 1.5 inches, which did not differ much from the stock that was planted (0.5 to one inch caliper). Thirteen of the planted species were not present in 2009. Rubbing by deer was evident on some of the trees, particularly river birch, but did not kill the trees. Similarly to Zone 8, no shrubs survived from the 2005 reforestation planting. Asiatic tearthumb, a non-native invasive plant, was present and may have out-competed the planted shrubs.

**Table 3.21.14 – 2009 Botanical Reforestation Summary for Zone 9 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	3	3	0	0
<i>Amelanchier canadensis</i>	Canadian serviceberry	2	0	0	0
<i>Betula nigra</i>	river birch	0	9	5	56
<i>Carpinus caroliniana</i>	ironwood	1	10	0	0
<i>Cercis canadensis</i>	eastern redbud	0	6	1	17
<i>Cornus florida</i>	flowering dogwood	2	0	0	0
<i>Euonymus americanus</i>	strawberry bush	6	0	0	0
<i>Fagus grandifolia</i>	American beech	3	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	10	0	0	0
<i>Platanus occidentalis</i>	American sycamore	4	4	1	13
<i>Populus deltoides</i>	cottonwood	1	0	0	0
<i>Quercus alba</i>	white oak	2	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	5	0	0	0
<i>Sassafras albidum</i>	sassafras	8	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	5	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	4	0	0	0
<b>Total</b>		<b>56</b>	<b>32</b>	<b>7</b>	<b>18</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

The survival rate of planted trees in Zone 10 (20.1-20.5, 20.8) was 23 percent (**Figure 3.21.43**). All of the shrubs planted in this zone died. Six species of trees were found growing in this zone and accounted for a total of 30 trees, with survival rates for these six species ranging from 40 to 100 percent (**Table 3.21.15**). One volunteer redbud tree was also observed. Eleven percent of the observed trees were dead at the time of the vegetation survey, 43 percent appeared healthy, and the remaining 46 percent were alive, but were not considered healthy. The range of caliper size of the trees counted in 2009 was between 0.5 and 1.25 inches. The trees planted for the project ranged from 0.5 to one inch caliper, suggesting that the growth of these trees has not been substantial. Browsing and rubbing by deer significantly affected some of the trees, and Nepalese browntop was present throughout much of the zone. Fifteen tree and shrub species that were planted were not encountered in 2009.

**Table 3.21.15 – 2009 Botanical Reforestation Summary for Zone 10 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	2	3	5	100
<i>Amelanchier canadensis</i>	Canadian serviceberry	1	0	0	0
<i>Asimina triloba</i>	pawpaw	10	5	6	40
<i>Betula nigra</i>	river birch	0	4	2	50
<i>Carpinus caroliniana</i>	ironwood	4	4	7	88
<i>Cephalanthus occidentalis</i>	buttonbush	0	3	0	0
<i>Cercis canadensis</i>	eastern redbud	0	3	4	133
<i>Cornus florida</i>	flowering dogwood	5	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	0	0
<i>Fagus grandifolia</i>	American beech	8	0	0	0
<i>Kalmia latifolia</i>	mountain laurel	23	0	0	0
<i>Lindera benzoin</i>	spicebush	2	5	0	0
<i>Ilex opaca</i>	American holly	2	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	8	0	0	0
<i>Platanus occidentalis</i>	American sycamore	6	3	7	78
<i>Populus deltoides</i>	cottonwood	2	0	0	0
<i>Quercus alba</i>	white oak	3	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	4	0	0	0
<i>Sassafras albidum</i>	sassafras	7	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	4	0	0	0
<i>Viburnum dentatum</i>	southern arrowwood	1	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	8	0	0	0
<b>Total</b>		<b>103</b>	<b>27</b>	<b>31</b>	<b>23</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100



**Figure 3.21.43 – Botanical Reforestation at LRSB101B, Planting Zone 10, showing American sycamore plantings**

Both trees and shrubs within Zone 11 (planting areas 19.4-19.8) experienced good survival, with 41 percent of those planted surviving at the time of the 2009 monitoring visit and many other volunteer trees and shrubs also present (**Table 3.21.16**). Woody plants were rather numerous and diverse within this zone, with 111 individuals representing nine species observed during the survey. Planted trees observed included eastern redbud, red maple, pawpaw, American sycamore, ironwood, northern red oak, American beech, and dogwood. However, only 39 percent of these were considered healthy, nine percent were dead, and the remaining 52 percent were alive but not considered to be healthy. The caliper size of the trees counted during the 2009 monitoring was between 0.5 and 2.5 inches, with only American beech representing individuals larger than 1.5 inches. The trees planted at this site were between 0.5 and one inch caliper.

Rubbing by deer and invasive species such as Asiatic tearthumb and *Ampelopsis brevipedunculata* (porcelainberry) may have contributed to the relatively low percentage of healthy trees. Colonization of Zone 11 by woody volunteers was significant, with seven different species accounting for 84 stems. Four shrub species were observed, including strawberry bush, blackhaw, mountain laurel, and spicebush. However, only nine individuals were counted and only four of these were healthy. Seven tree and shrub species originally planted were not observed in 2009.

**Table 3.21.16 – 2009 Botanical Reforestation Summary for Zone 11 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	4	0	15	375
<i>Asimina triloba</i>	pawpaw	1	1	51	2550
<i>Carpinus caroliniana</i>	ironwood	2	0	9	450
<i>Cercis canadensis</i>	eastern redbud	0	2	5	250
<i>Cornus florida</i>	flowering dogwood	3	0	0	0
<i>Euonymus americanus</i>	strawberry bush	3	0	4	133

**Table 3.21.16 – 2009 Botanical Reforestation Summary for Zone 11 (Site LRSB101B)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Fagus grandifolia</i>	American beech	5	0	10	200
<i>Kalmia latifolia</i>	mountain laurel	14	0	0	0
<i>Lindera benzoin</i>	spicebush	3	0	1	33
<i>Ostrya virginiana</i>	hophornbeam	4	0	0	0
<i>Platanus occidentalis</i>	American sycamore	3	2	13	240
<i>Quercus alba</i>	white oak	3	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	4	0	0	0
<i>Sassafras albidum</i>	sassafras	4	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	3	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	5	0	3	60
<b>Total</b>		<b>61</b>	<b>5</b>	<b>111</b>	<b>170</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

LRSB101C

Site LRSB101C is immediately downstream of LRSB101B, and extends for only about 0.1 mile south from just below Russett Road to the Rock Creek Trail bridge crossing. Only one zone, Planting Zone 12 (planting areas 19.1-19.3) occupied this site. Overall survivability was good at this site, with 73 percent of the planted species surviving into 2009, including several volunteer trees and shrubs that contributed to this percentage (*Table 3.21.17*). Of the species that were observed in 2009, most had more individuals present than were planted, indicating colonization by volunteers is occurring. Four species of trees were present, including American beech, red maple, pawpaw, and sassafras. Forty-three stems were counted, of which only four percent were dead, 83 percent were healthy, and the remaining 13 percent were alive, but not considered healthy. Trees did not appear to have grown substantially since being planted. Most individuals ranged from three to four feet tall, which was the same size range that was planted.

Shrub plantings were relatively successful compared to other sites along the restored reach. Thirty-five individuals representing three species were observed, including strawberry bush, spicebush, and blackhaw. However, most of the surviving shrubs within Planting Zone 12 were generally in poor health; only 31 percent of stems counted were considered healthy, 19 percent were dead at the time of the vegetation survey, and the remaining 50 percent were alive, but not considered healthy. Evidence of deer browse was apparent throughout the zone and seemed to be mostly affecting strawberry bush and American beech. Invasive plants found within the zone included Asiatic tearthumb and multiflora rose; however, these species did not appear to be affecting the growth of the plantings.

**Table 3.21.17 – 2009 Botanical Reforestation Summary for Zone 12 (Site LRSB101C)**

Scientific Name	Common Name	Number Planted (2005)	Number Planted (2009)	Number Living (2009)	Percent Survival <sup>1</sup>
<i>Acer rubrum</i>	red maple	1	3	2	50
<i>Amelanchier canadensis</i>	Canadian serviceberry	4	0	0	0
<i>Asimina triloba</i>	pawpaw	9	1	26	260
<i>Betula nigra</i>	river birch	0	2	0	0
<i>Carpinus caroliniana</i>	ironwood	7	8	0	0
<i>Cercis canadensis</i>	eastern redbud	0	3	0	0
<i>Cornus florida</i>	flowering dogwood	2	0	0	0
<i>Euonymus americanus</i>	strawberry bush	1	0	18	1800
<i>Fagus grandifolia</i>	American beech	8	0	15	188
<i>Kalmia latifolia</i>	mountain laurel	6	0	0	0
<i>Lindera benzoin</i>	spicebush	4	0	13	325
<i>Ilex opaca</i>	American holly	5	0	0	0
<i>Ostrya virginiana</i>	hophornbeam	8	0	0	0
<i>Platanus occidentalis</i>	American sycamore	8	9	0	0
<i>Populus deltoides</i>	cottonwood	1	0	0	0
<i>Quercus alba</i>	white oak	3	0	0	0
<i>Rhododendron periclymenoides</i>	pink azalea	2	0	0	0
<i>Sassafras albidum</i>	sassafras	2	0	0	0
<i>Viburnum acerifolium</i>	mapleleaf viburnum	2	0	0	0
<i>Viburnum dentatum</i>	southern arrowwood	3	0	0	0
<i>Viburnum prunifolium</i>	blackhaw	5	0	4	80
<b>Total</b>		<b>81</b>	<b>26</b>	<b>78</b>	<b>73</b>

<sup>1</sup>Percent survival = (number observed + number of volunteers observed/total number planted (2005+2009))\*100

### 3.21.5 Discussion

**Table 3.21.18** below provides a summary of project goals, the results of post-restoration monitoring, and whether each project goal has been met by the restoration actions. Three of the project goals were successfully met, one was partially successful, and one project goal was not met by restoration actions.

**Table 3.21.18 – Summary of Project Goal Results**

Goal	Result
Improving aquatic habitat conditions in Sycamore Creek	Unsuccessful – increases in sedimentation at all sites, other declines in aquatic habitat were not consistent at all sites but all declined to some degree after restoration
Improving water quality in Sycamore Creek	Partially successful – no distinct trend in the benthic macroinvertebrate community; mostly stayed the same, but improved slightly at LRSB101C. Increasing trend in

	the fish community with most improvements at LRSB101C.
Reducing stream erosion, sedimentation, and erosive stream flows	Unable to determine – physical data from 2010 will determine if these goals have been met
Creating wetlands	Successful – both creation areas were determined to be wetlands, however one of the wetlands had low wetland plant density, was occupied by invasive plants, had thin and sandy soils not optimal for plant growth, and was assessed as providing only minor wetland functions. The other wetland had a greater percentage of wetland plants and scored higher.
Creating amphibian habitat	Successful – at Vernal Pool 2, two obligate vernal pool species were found and two other amphibian species were either heard calling from the pool or found in its periphery. At Vernal Pool 1, Eastern American toad tadpoles and eggs were found
Riparian reforestation	Partially successful – trees have been planted and allowed to grow in the restoration area that was previously open field; although a majority of the plantings have died

*Unsuccessful – Aquatic Habitat*

Overall, post-restoration qualitative habitat scores were similar or slightly lower than pre-restoration scores. Except for an increase in sedimentation at all sites, no one aquatic habitat parameter declined consistently post-restoration, and declines were not consistent among the three Sycamore Creek sites. Declines at LRSB101A were primarily due to lower scores for in-stream cover and channel alteration. Lower post-restoration scores at LRSB101B were due to declines in epifaunal substrate and bank vegetative protection, and LRSB101C declined the most in the channel alteration and embeddedness parameters. Channel alteration did occur within all of these sites; however, alteration was associated with restoration activities and therefore may not reflect a more degraded stream condition. The channel alteration parameter typically relates to detrimental channel alteration such as straightening, or lining in gabion baskets, large rip rap, or concrete that would reduce habitat quality for benthic macroinvertebrates and/or fish. Stream restoration, especially natural channel design restoration, is intended to improve aquatic habitat and is therefore typically given a higher score. However, the Sycamore Creek stream restoration project was designed and constructed prior to the adoption of natural channel design, and many of the restoration techniques had more of an emphasis on protecting streambanks and stabilizing the channel than it did for improving aquatic habitat. Large rip rap was placed in-stream and along banks, reducing habitat quality. Natural channel design attempts to provide stability, while also restoring and improving aquatic habitat. Despite lack of natural channel design, the project did provide some subtle improvements to aquatic in-stream habitat, as indicated by the slight improvement in the fish community.

### *Partially Successful – Water Quality*

Although FIBI scores remained in the Poor range in both the pre- and post-restoration periods, some of the individual metrics and more subtle fish community measures reflect an improvement in the community in the Sycamore Creek project area after restoration. Site LRSB101C was the only site that consistently increased in FIBI score after restoration. At all sites, the percentages of dominant species occupying the communities decreased after restoration and species diversity increased, both suggesting an improvement in the fish community. Also, the pre-restoration fish community (averaged among all three sites) consisted of nearly 100 percent pioneer species that are adept at surviving in degraded and transient conditions. After restoration, a community of non-pioneer species emerged, comprising approximately eight percent of the overall community. This increase in the percentage of non-pioneer fish species after restoration could indicate that more stable habitat is present to support a non-pioneer fish community. Even though species sensitive to disturbance were absent from the fish communities, the percentage of species intermediate in sensitivity increased at all sites and the percentage of tolerant species declined in the post-restoration period. Additionally, the proportion of invertivores, a more specialized feeding group often reflecting a less degraded system, were present at all sites after restoration where they before had been absent. These subtle improvements may be partially due to post-restoration improvements in the in-stream habitat noted in the qualitative habitat surveys. The combination of these improvements may suggest an overall improvement in the fish community at Sycamore Creek.

Overall, assessments of benthic macroinvertebrate communities did not show notable changes. Subtle improvements in BIBI and other community measures were similar to those that occurred within the fish communities, especially at LRSB101C. This site showed the most improvements in the benthic macroinvertebrate community post-restoration. A small percentage of taxa sensitive to disturbance were present at this site after restoration, as was the feeding group shredders, while they were absent prior to restoration. Site LRSB101A showed very little change in the benthic macroinvertebrate communities between monitoring periods; in fact, it showed a slight decline. Site LRSB101B showed only a slight increase in the BIBI score in 2007, but a subsequent decline in 2009 to the range observed in the pre-restoration period. Overall, LRSB101C appeared to be the only site to show discernible biological improvement after restoration. The lack of notable improvements at these sites may in part be due to the lack of improvement in the benthic macroinvertebrate habitat as observed in the post-restoration qualitative habitat surveys. Another possible explanation is the physical limitation to recolonization, since benthic macroinvertebrates are less mobile than fish and predominantly recolonize aquatically from short distances upstream, or over short distances from flying adults.

All in-situ water chemistry readings were in compliance with COMAR standard after restoration. However, this is an urban stream with high impervious cover that could be experiencing water quality issues that are missed with instantaneous readings, but are potentially being reflected in the poorly rated biological communities.

### *Successful – Wetlands and Amphibian Habitat*

Two wetlands were created as a part of this restoration project. Both were determined to be wetlands in the fifth year of monitoring. However, Wetland 1, the larger wetland, had invasive plants growing within it, including Nepalese browntop and Asiatic tearthumb, and only 25 percent of the wetland was occupied by native wetland vegetation. Overall, the wetland was determined to provide minor wetland functional gains. Two species of amphibian were found in

this wetland after construction, Eastern American toad and wood frog.

Wetland 2 had a higher wetland score than Wetland 1, because it was occupied by a greater percentage of native wetland plants and because it was determined to provide better/more wetland functional gains. Two species of obligate (spotted salamander and wood frog) and one facultative (spring peeper) vernal pool amphibian species were either seen or heard calling from the wetland. One additional amphibian species, Eastern red-backed salamander, was found in its periphery. Nepalese browntop, an invasive plant, occupied seven percent of the wetland, and is a concern for its future success. It is advised that both wetlands continue to be monitored in the future to ensure that native wetland vegetation is not taken over by invasive plant species.

#### *Partially Successful – Riparian Reforestation*

Overall, reforestation of the riparian zone of Sycamore Creek was only partially successful; approximately 24 percent of the plantings survived to 2009. With the addition of volunteer trees and shrubs to the survival percentage, the overall planting success was 40 percent. There was a high amount of variability among planting zones and among the three sites. Average survival rates, which included the presence of volunteers, were low overall among trees and shrubs and site-wide, ranging from two to greater than 100 percent.

The success of woody plantings within the Sycamore Creek stream restoration project area is a function of overall survival as well as the condition of persisting vegetation. Some species failed site-wide or had very poor survivability, including white oak, hophornbeam, flowering dogwood, and sassafras. Other species had much higher survivability, most notably pawpaw, American sycamore, red maple, and ironwood. These trees, which constitute the majority of living stems observed, were found to be in good condition during the 2009 survey. Of the surviving plantings, the overall average percentage of healthy trees was 68 percent, while only 39 percent of shrubs were healthy.

The trees that were found growing at these sites generally ranged in size from 0.5 to 1.75 inches, with one site having a few trees that were 2.5 inches. At the time of planting all of the planted trees ranged from 0.5 to one inch caliper; indicating that some level of tree growth has occurred at most zones, although it has not been substantial. Most of the surviving plantings were only planted five months prior to being monitored; therefore it is not expected that these trees should have grown substantially. Any increase in caliper size may be an indication of well established plantings.

The overall survivability at this site may have been limited by deer, and although evidence of deer was not apparent at all sites, many plantings were affected. Many trees and shrubs that were planted were not observed at all, which may have been due to browsing by deer shortly after being planted. The trees that were planted in 2005 were fairly small (0.5 inch caliper) and may have been entirely eaten by deer or too small to withstand other common stressors such as seasonal drought or competition by invasive species. It is recommended to plant more trees and shrubs at this site since the survival rates were so low. If more trees and shrubs are planted, it is also recommended that larger trees that are able to withstand some of the common stressors are planted and protected from deer browse with caging. Any new strawberry bush plantings must also be caged to protect them from deer browse. It is recommended to not plant mountain laurel as the survivability was extremely low.

### **3.21.6 Conclusions**

Overall, the Sycamore Creek restoration project has met or partially met most of the project goals five years after restoration. The project has created wetlands and habitat for amphibians, including obligate vernal pool species; it has also helped reforest the riparian zone, improved the fish communities, and showed very subtle benthic macroinvertebrate community improvements within Sycamore Creek. The goal of improving aquatic habitat was not met and may be due to other factors in the overall watershed, such as high imperviousness and urbanization.