3.15 Piping Rock Drive Stormwater Pond

3.15.1 Introduction

The Piping Rock Drive stormwater pond was constructed in 2002. The pond is located in the headwaters of the Upper Good Hope subwatershed of the Paint Branch (***Figure 3.15.3***). The Good Hope tributary is classified as a Use III stream, cold water system, that supports a naturally reproducing brown trout population. Reducing the impacts from the uncontrolled stormwater runoff is critical to improving and maintaining the health of the Good Hope tributary and is one of the goals of this restoration project. The design for the stormwater pond included an in-stream diversion structure to capture the majority of the first flush of runoff (one-year extended detention) during a rain storm and divert the water into the pond. The water diverted into the stormwater pond is captured, filtered by the wetland vegetation, and slowly released back to the stream (***Figures 3.15.1 and 3.15.2***). The newly created wetland and native landscaping are also important features for filtering runoff and supporting a diverse and balanced community for amphibians, insects, fishes, birds, and other wildlife.

Figure 3.15.1 – Piping Rock Drive Stormwater Pond in 2009

Figure 3.15.2 – Piping Rock Drive Stormwater Pond in 2009

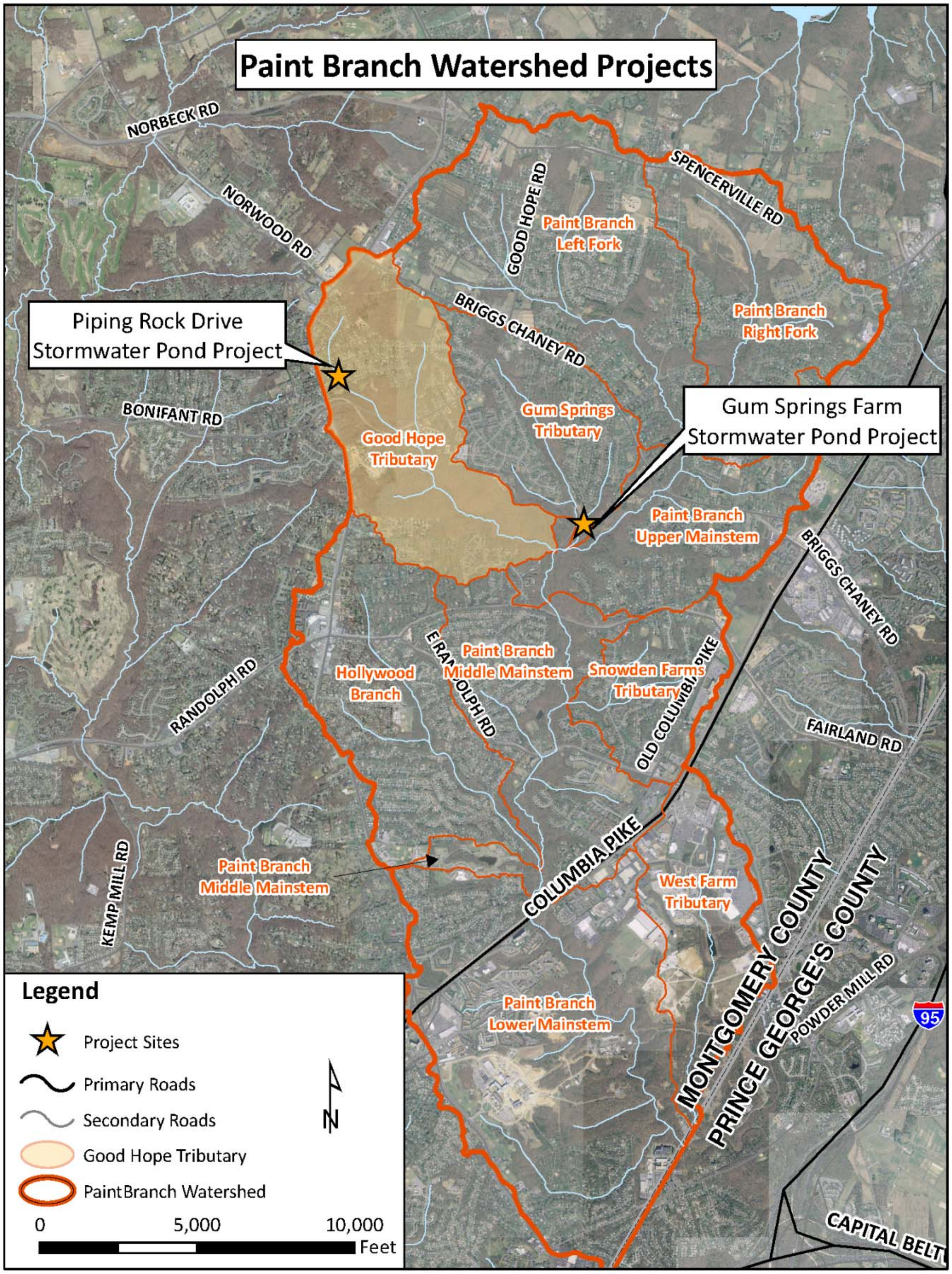


Figure 3.15.3 – Paint Branch Watershed Restoration Projects, Including Piping Rock Drive Stormwater Pond

Subwatershed facts

Subwatershed Drainage Area: 964 acres
Subwatershed Imperviousness: 26 percent

Project Facts

Project Area: The Piping Rock Drive stormwater pond provides stormwater management for 166 acres where none had previously existed, and created 0.5 acres of new wetlands. Of the 166 acres of drainage area, this pond captures stormwater runoff from 18 acres of impervious surfaces (rooftops, driveways, roads, etc.). Sixty-two percent of the project area is residential, 27 percent is grass/open space, and the remaining 11 percent is forest.

Costs: $571,732, funded in part by Maryland Department of the Environment

Completion Date: February 2002

Property Ownership: Maryland-National Capital Park and Planning Commission

Project Selection

In May 1997, Montgomery County conducted the Upper Paint Branch Watershed Stormwater Management/Stream Restoration Assessment. This watershed study evaluated and prioritized stormwater management and stream restoration projects throughout the Upper Paint Branch Watershed (MCDEP 1997). This watershed study identified the Piping Rock Drive stormwater pond as a priority project due to the lack of stormwater management upstream of Piping Rock Drive.

Pre-Restoration Conditions

The Upper Good Hope subwatershed has shown signs of slight deterioration in the past, due to the uncontrolled stormwater upstream of Piping Rock Drive. The uncontrolled stormwater runoff and excessive sediment from eroding streambanks has degraded the water quality of the Good Hope tributary. Encroachment upon the riparian stream buffers along portions of the Good Hope tributary by urban activities are also contributing thermal impacts, and increasing the degradation of streambanks.

Restoration Actions Taken

The extended detention pond is a traditional off-line pond with a weir structure intercepting stream flow, capturing the one-year storm event, and allowing all larger storm events to pass through. The project also included removal of an old farm culvert and stream restoration to prevent excessive streambank erosion.

3.15.2 Restoration Goals

Pre- and post-restoration monitoring was conducted within the stream, up and downstream of the pond, as well as within the Piping Rock Drive stormwater pond itself. ***Table 3.15.1*** below presents the restoration goals, monitoring performed to evaluate the success of the goals, and when and where the monitoring occurred.

Table 3.15.1 – Summary of Restoration Project Goals and Associated Monitoring

Why: Restoration Goals	What: Monitoring Done to Evaluate Goal	When: Years Monitored	Where: Station or Location Monitored
• Improve aquatic habitat conditions in the Good Hope • Improve water quality in the Good Hope	• Aquatic Communities: ▪ Benthic macroinvertebrates ▪ Fish • Qualitative Habitat • Water Chemistry	1995-2000 (pre) 2002-2009 (post)	PBGH108
• Avoid introduction of new thermal impacts in the Good Hope	• Stream temperature	2003, 2006, 2009	PBGH1002 PBGH1003
• Reduce stream erosion and sedimentation • Reduce erosive stream flows • Improve stormwater management quantity control	• Quantitative habitat (stream morphology surveys)	2006, 2010, 2011	PBGH100P Above PBGH100P Below
• Create wetlands • Create amphibian habitat	• Vernal pool or wetland • Wetland vegetation	2006, 2009	Piping Rock Drive stormwater pond wetland and surrounding habitat (PBGH100P)

3.15.3 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 upstream and downstream of the project. Data were collected at six sites in the vicinity of this restoration project, PBGH108, PBGH100P Above, PBGH100P Below, PBGH1002, PBGH1003, and the pond and surrounding habitat (PBGH100P) (***Figure 3.15.4***).

Site PBGH108 is a Montgomery County Department of Environmental Protection (MCDEP) Special Protection Area (SPA) long-term monitoring site that is regularly sampled. At this site, the County monitored biological communities (benthic macroinvertebrates and fish), performed rapid habitat assessments (RHAB), and collected water chemistry to evaluate the aquatic habitat conditions and water quality during the pre- and post-restoration periods. This site is located less than one mile downstream of the restoration site and has been sampled annually from 1995 to 2009, with the exception of 2001.

Sites PBGH1002, located upstream of the stormwater pond, and PBGH1003, located downstream of the stormwater pond (***Figure 3.15.4***), were established to monitor the temperature effects of the restoration (***Table. 3.15.1***). At these sites, temperature loggers were deployed to determine if the pond affected the stream temperature regime observed during the pre-restoration monitoring. At PBGH100P Above and PBGH100P Below, survey crews measured the shape of the stream profile and cross section and assessed channel bed materials to evaluate sediment transport and erosion. Crews also monitored the wetland habitat of the stormwater pond itself (PBGH100P) to evaluate the wetland vegetation planted by the County, as well as the habitat created for amphibians and other wetland fauna. A map showing the stormwater pond and monitoring locations is provided in ***Figure 3.15.4***. All data collected prior to 2002 are considered pre-restoration data and all subsequent data are considered post-restoration. 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 2***).

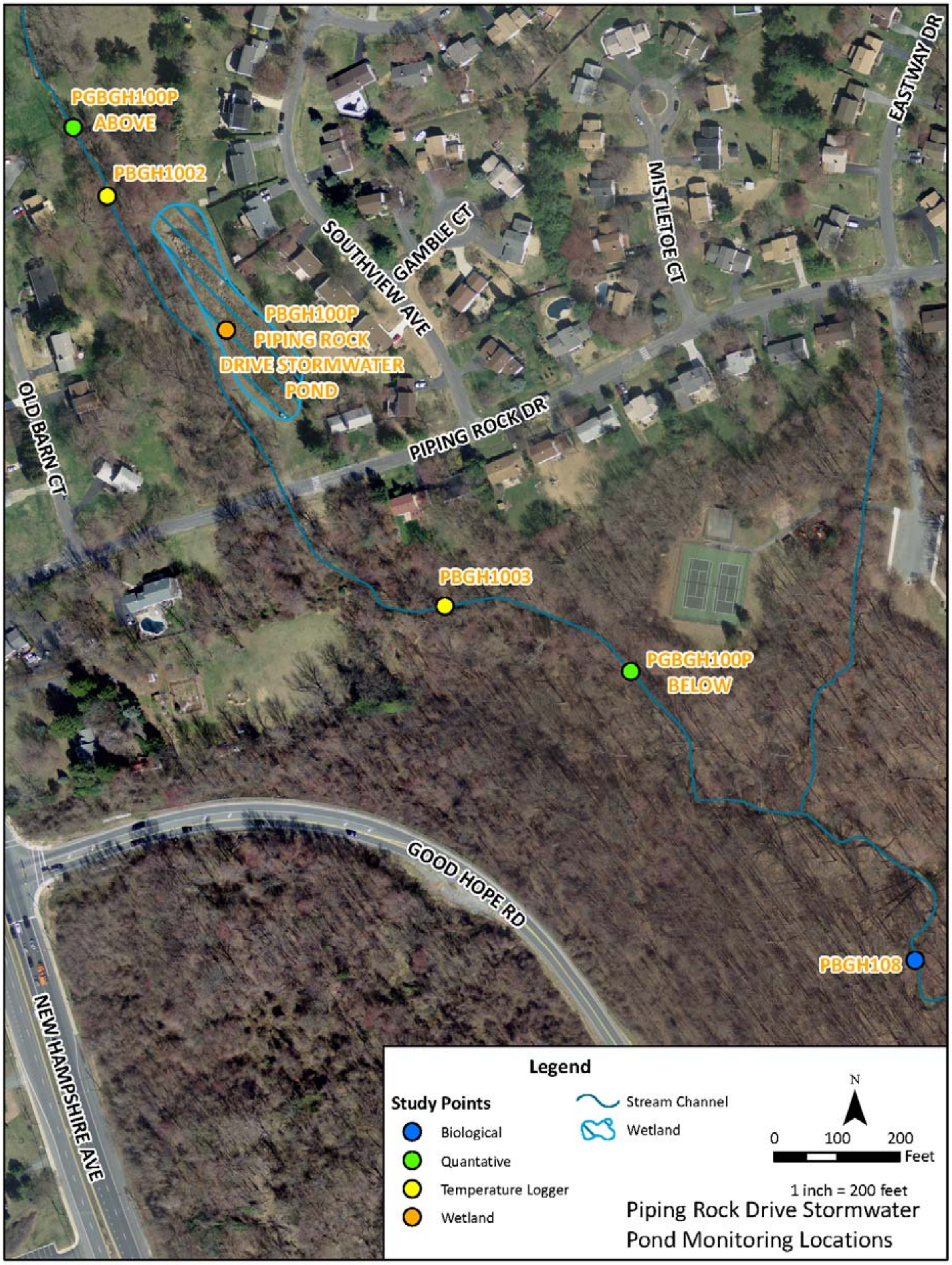


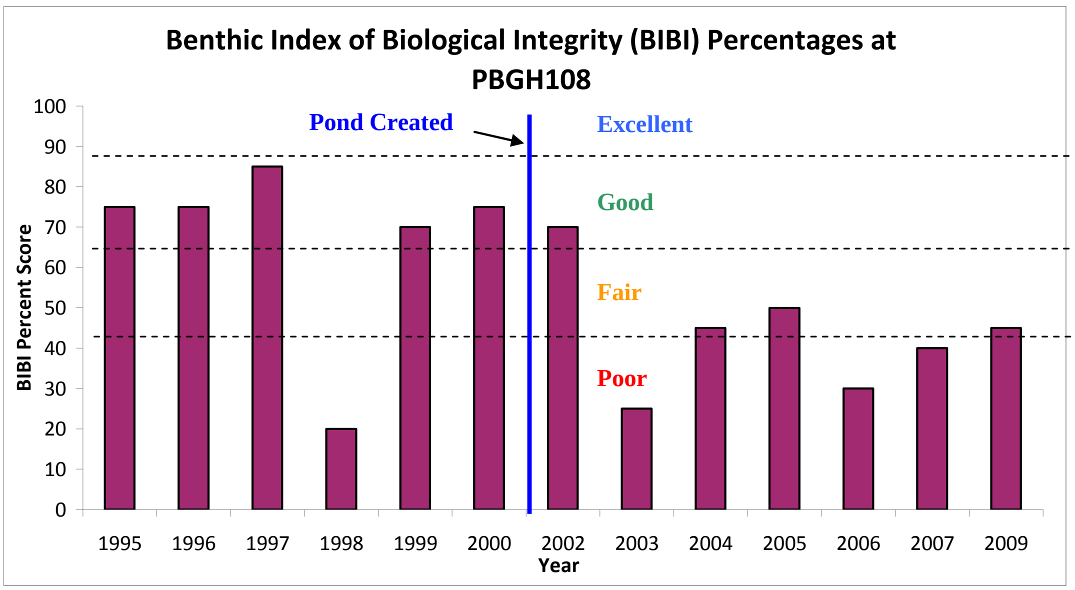
Figure 3.15.4 – Map of Monitoring Locations

3.15.4 Results and Analysis

Benthic Macroinvertebrates

BIBI (Benthic Index of Biological Integrity) Scores

Pre-restoration benthic macroinvertebrate assessments were conducted at site PBGH108 by MCDEP from 1995 through 2000. The Benthic Index of Biological Integrity (BIBI) percentages at this site were generally stable throughout the pre-restoration period with only one year, 1998, scoring below Good (***Figure 3.15.5***). The benthic community composition at site PBGH108 also remained similar during the pre-restoration monitoring period, except for the community collected in 1998.



Year	1995	1996	1997	1998	1999	2000	2002	2003	2004	2005	2006	2007	2009
BIBI Percentage	75	75	85	20	70	75	70	25	45	50	30	40	45
(Narrative Ranking)	(Good)	(Good)	(Good)	(Poor)	(Good)	(Good)	(Good)	(Poor)	(Fair)	(Fair)	(Poor)	(Poor)	(Fair)

Figure 3.15.5 – Pre- and Post-Restoration Benthic Index of Biological Integrity (BIBI) Percentages at PBGH108

The BIBI percentages were generally lower during the post-restoration period when compared to the pre-restoration data (***Figure 3.15.5***). The community was dominated by several sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa during the pre-restoration monitoring period. These taxa were either completely absent or present in reduced numbers during the post-restoration period. One of the most consistent declines in the benthic community was the increase in biotic index among years. The biotic index is a weighted measure of the tolerance values of the community. The lower the tolerance value, the less tolerant (more sensitive) a taxon is to degraded conditions, with zero being the least tolerant to degradation and nine being the most tolerant to degradation. The biotic index ranged from 2.3 to 7.1 prior to pond construction with most years having values near or below four. Post-restoration, the biotic index ranged from 4.6 to 8.3 with most years having values above six (***Figure 3.15.10***). Other patterns of individual benthic macroinvertebrate metrics were not constant over time. 2009 field data sheets for this task are included in ***Appendix D***.

Dominant Taxa

The pre-restoration benthic community was generally dominated by one genus of Plecoptera (stonefly), *Amphinemura* sp., one genus of Ephemeroptera (mayfly), *Ephemeralla* sp., and Chironomidae (midges). *Simulium* sp. and *Prosimulium* sp. (blackfly larvae) were also present in varying amounts throughout the pre-restoration period. In 1998, the community was heavily dominated by midges, and pollution sensitive orders such as Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa were completely absent. At the beginning of the post-restoration period, in 2002, the dominant taxa were relatively pollution intolerant *Amphinemura* sp. and midges. Between 2003 and 2009, the benthic macroinvertebrate community was dominated by pollution tolerant midges and Oligochaeta (aquatic worms).

Overall, during the pre-restoration period, the two most dominant taxa were midges followed by *Amphinemura* sp. Dominant taxa comprised 56 percent of the community at PBGH108 prior to the construction of the pond and 61 percent after pond construction. The first most dominant taxon in the post-restoration period was the same as the pre-restoration period (Chironomidae). However, during the post-restoration period, the second most dominant taxon was Naididae, a family of aquatic worm, one of the most pollution tolerant taxon at this site.

Tolerance Values

Tolerant taxa made up an average of 38 percent of the community during the pre-restoration period and decreased to 13 percent of the community post-restoration (***Figures 3.15.6 and 3.15.7***). The percentage of tolerant individuals increased from the pre-restoration period to the post-restoration period (from 38 percent to 69 percent), the percentage of sensitive individuals decreased (from 50 to 16 percent). Changes in tolerance values over time indicates a more degraded stream condition in the post-restoration period.

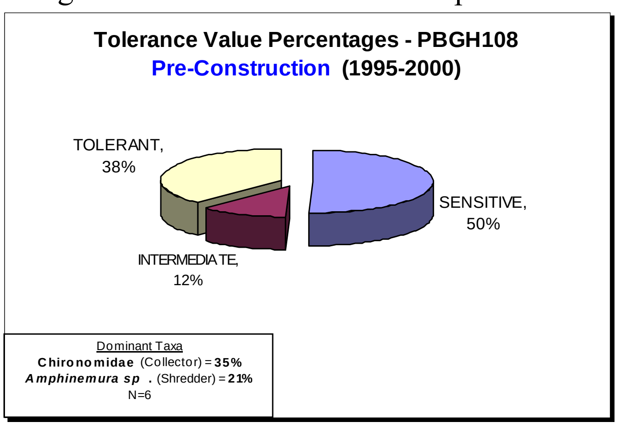


Figure 3.15.6 – Benthic Macroinvertebrate Tolerance Composition at PBGH108 Prior to Restoration of the Piping Rock Drive Stormwater Pond

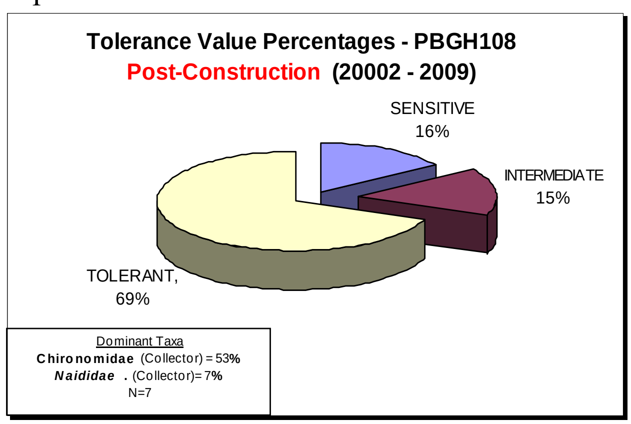


Figure 3.15.7 – Benthic Macroinvertebrate Tolerance Composition at PBGH108 After Restoration of the Piping Rock Drive Stormwater Pond

Functional Feeding Groups

Functional feeding groups of benthic macroinvertebrates are helpful in describing the condition, habitat, and food availability in a stream. Each functional feeding group has a specialized method of food acquisition and depends on certain in-stream conditions to feed effectively. More specialized feeders, including scrapers and shredders, often require less degraded stream conditions or specific habitat features. Benthic macroinvertebrates classified as generalist feeders, such as collectors and filterers, can often persist in more impacted streams (EPA 2010). Prior to construction at the Piping Rock Drive stormwater pond, collectors dominated the community at PBGH108. Collectors are generally more tolerant to in-stream stressors. The remaining functional feeding groups by decreasing order were shredders, filterers, scrapers, and predators. ***Figure 3.15.8*** shows the composition of functional feeding groups at PBGH108 prior to construction.

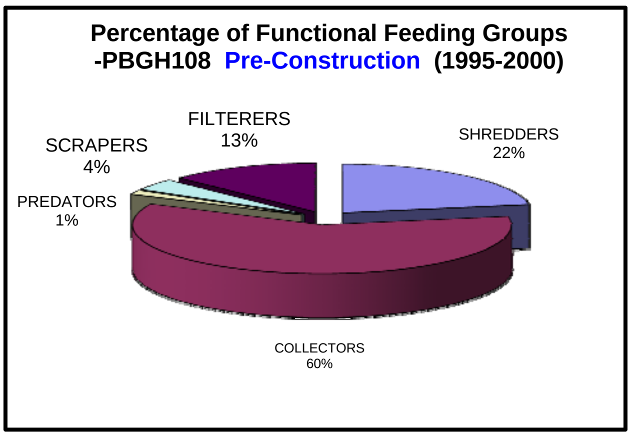


Figure 3.15.8 – Benthic Macroinvertebrate Functional Feeding Group Composition at PBGH108 Prior to Restoration of the Piping Rock Drive Stormwater Pond

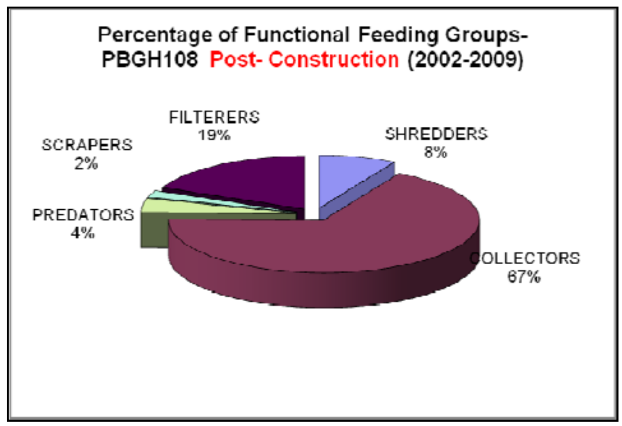


Figure 3.15.9 – Benthic Macroinvertebrate Functional Feeding Group Composition at PBGH108 After Restoration of the Piping Rock Drive Stormwater Pond

The composition of community functional feeding groups was similar after construction of the Piping Rock Drive stormwater pond and collectors remained the dominant feeding group (***Figure 3.15.9***). However, filterers became second-most dominant, followed by shredders, predators, and scrapers. The decrease in percentage of shredders and scrapers and increase in filterers is an indication of a shift to a community of less specialized functional feeding groups.

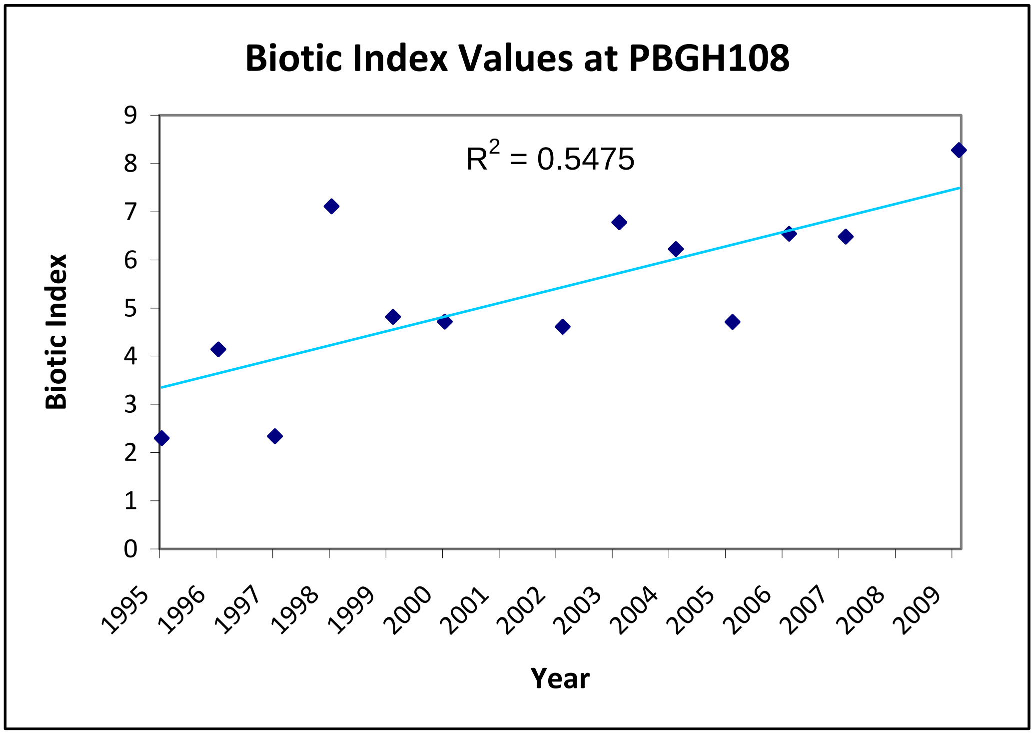


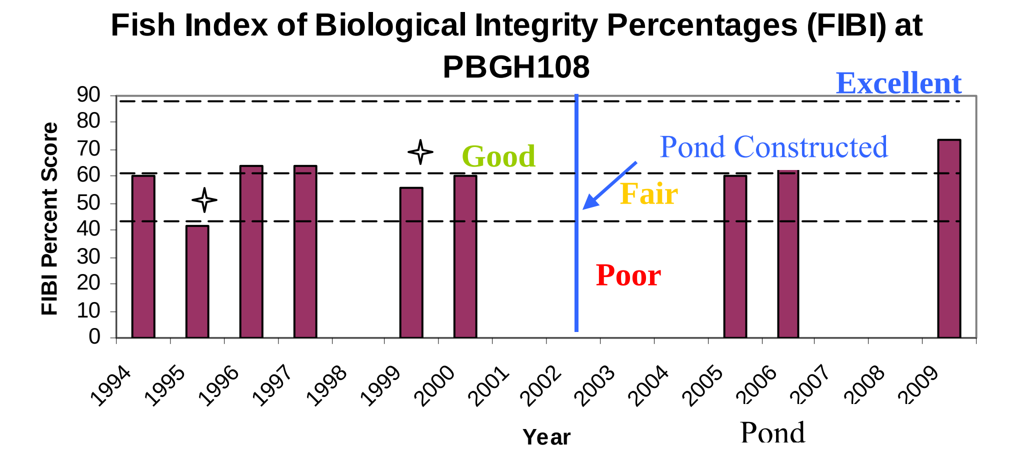
Figure 3.15.10 – Biotic Index values at PBGH108. Biotic Index = (number of individuals per taxa × Tolerance values for all taxa and total) / total number of organisms.

Fish

FIBI (Fish Index of Biological Integrity) Scores

The pre-restoration fish community, as assessed by the MCDEP Fish Index of Biological Integrity (FIBI), generally remained Fair from 1994 to 2000, with one intervening year (1995) scoring in the Poor range (***Figure 3.15.11***). Based on the Palmer Hydrological Drought Index (PHDI) data from the National Oceanic and Atmospheric Administration (NOAA), moderate to severe drought conditions existed in the area in March and April prior to the collection of fish in July, 1995 (NOAA 2009). *Salmo trotter* (brown trout) were only collected from 1994 through 1996. Historically, the Good Hope tributary of the Paint Branch has been the primary spawning ground for the naturally reproducing brown trout population. However, the brown trout fishery has experienced significant declines in the last few decades, especially within the upper portions of the Good Hope subwatershed.

The fish community assessments conducted during the post-restoration period showed a steady increase in the FIBI score, from Fair to Good. In 2009, *Cottas caeruleomentum* (Blue Ridge sculpin) were collected for the first time at this site. Blue Ridge sculpin are considered an intolerant (pollution-sensitive) fish species and were the cause of the FIBI score increase in 2009. This was also the first time since 1996 that any intolerant species was found at PBGH108. Field data sheets from 2009 fish monitoring are included in ***Appendix D***.



Year	1994	1995	1996	1997	1999	2000	2005	2006	2009
FIBI Percentage	60	42	64	64	56	60	60	68	74
(Narrative Ranking)	(Fair)	(Poor)	(Fair)	(Fair)	(Fair)	(Fair)	(Fair)	(Fair)	(Good)

✧ *Indicates moderate to severe drought conditions in summer sampling period (NOAA 2011)*

Figure 3.15.11 – Pre- and Post-Restoration Fish Index of Biological Integrity (FIBI) Percentages at PBGH108

Dominant Species

The pre-restoration fish community was heavily dominated by *Rhinichthys atratulus* (blacknose dace), *Clinostomus funduloides* (rosyside dace), and *Semotilus atromaculatus* (creek chub). *Etheostoma olmstedi* (tessellated darter), *Catostomus commersoni* (white sucker), *Anguilla rostrata* (American eel), and *Rhinichthys cataractae* (longnose dace) were also collected in varying amounts throughout the pre-restoration period. Community composition remained substantially similar throughout the post-restoration period. However, a shift in species dominance occurred between 2005 and 2006, from an assemblage dominated by blacknose dace, to a more even community with almost equal numbers of blacknose dace and rosyside dace. Sampling completed in 2009 showed a community with rosyside dace as the most abundant fish species followed by blacknose dace and creek chub.

Over both the pre- and post-restoration monitoring periods, when the fish data were compiled for all sampled years, blacknose dace was the most dominant species, followed by rosyside dace. However, rosyside dace was the most dominant species collected in the final year of sampling, post-restoration. Blacknose dace made up an average of 58 percent of the community prior to restoration, and rosyside dace comprised an average of 20 percent during this time. After construction of the Piping Rock Drive stormwater pond, blacknose dace dominance decreased to 38 percent and rosyside dace dominance increased to 30 percent.

Functional Feeding Groups

The percentage of invertivores increased from the pre- to the post-restoration period and the percentage of omnivores decreased. Rosyside dace are invertivores, feeding primarily on invertebrates, while blacknose dace are omnivores, a more general functional feeding group. Invertivores are considered a specialized feeding group often associated with higher quality streams, and omnivores are less specialized and have a varied diet. ***Figures 3.15.12*** and ***3.15.13*** show the percentages of each functional feeding group for pre- and post-restoration monitoring periods, respectively.

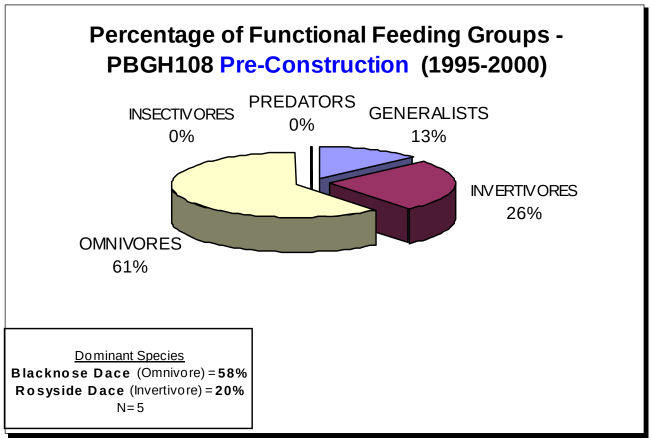


Figure 3.15.12 – Fish Functional Feeding Group Composition and Dominant Species at PBGH108 Prior to Restoration of the Piping Rock Drive Stormwater Pond

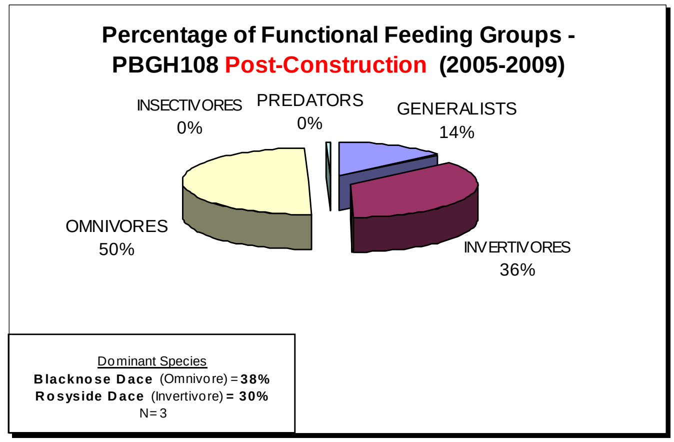


Figure 3.15.13 – Fish Functional Feeding Group Composition and Dominant Species at PBGH108 After Restoration of the Piping Rock Drive Stormwater Pond

Tolerance Values

The percentage of tolerant fish also declined from the pre-restoration period to the post-restoration period, from approximately 78 to 67 percent, respectively. One fish species considered to be sensitive, brown trout, was present in the pre-restoration period and a different species considered to be sensitive, Blue Ridge sculpin, was present in the post-restoration period. The percentage of intermediate individuals increased in the post-restoration period while the percentage of tolerant individuals decreased. This increase was due to the presence of rosyside dace in 2009, which is considered intermediate in sensitivity. ***Figures 3.15.14*** and ***3.15.15*** show the differences in tolerant fish species between pre- and post-restoration sampling periods.

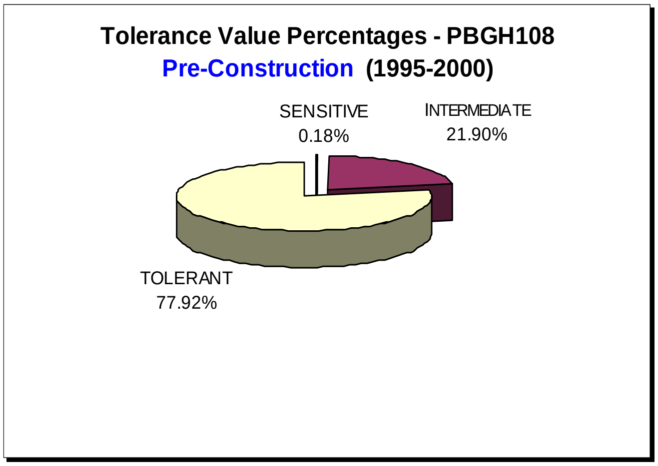


Figure 3.15.14 – Fish Tolerance Composition at PBGH108 Prior to Restoration of the Piping Rock Drive Stormwater Pond

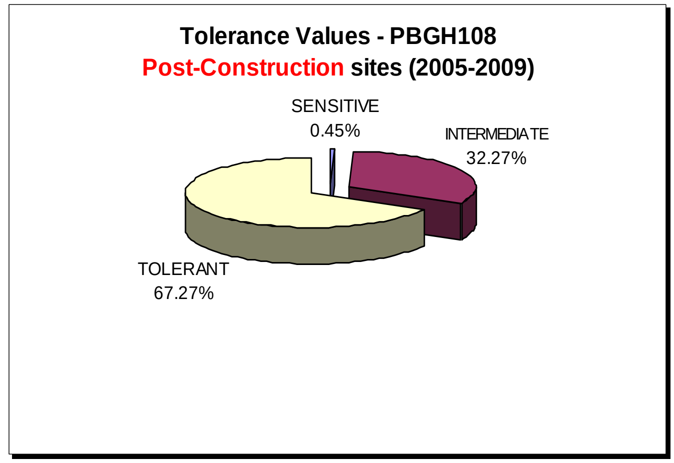
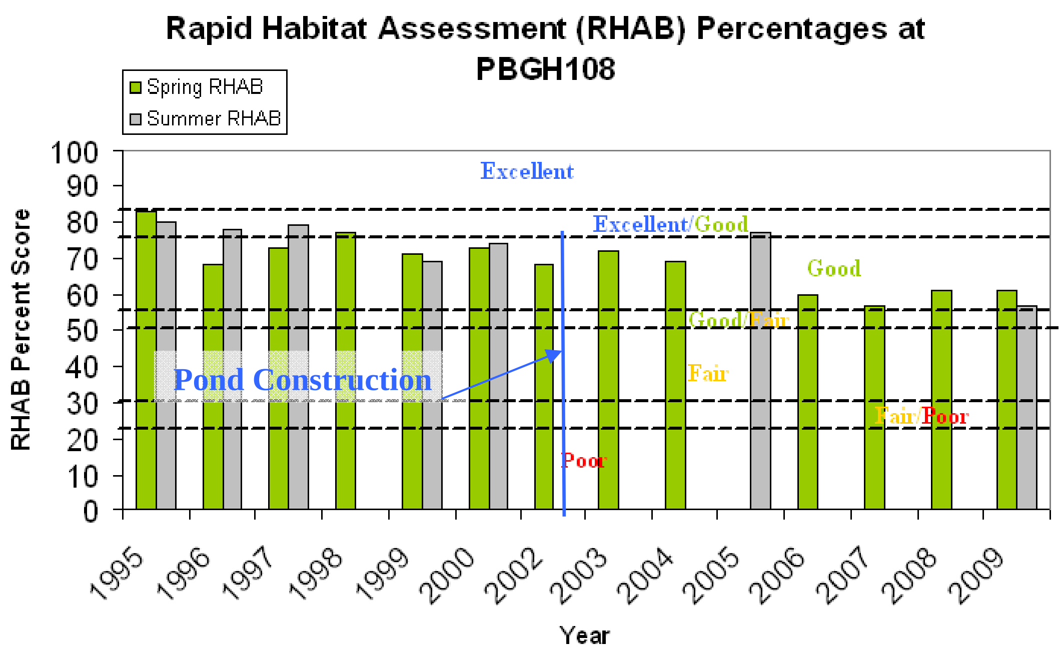


Figure 3.15.15 – Fish Tolerance Composition at PBGH108 After Restoration of the Piping Rock Drive Stormwater Pond

Qualitative Habitat

Aquatic habitat was evaluated at PBGH108 from 1995 to 2009, with the exception of 2001. Habitat quality showed gradual declines during the pre-restoration period (***Figure 3.15.16***). Epifaunal substrate and the frequency of riffles metrics experienced the clearest declines during the pre-restoration period. Sediment deposition and bank stability were generally rated lower than other individual habitat parameters throughout the pre-restoration period. Despite declines in individual habitat metrics, the overall aquatic conditions remained in the Good range.

Aquatic habitat during the post-restoration monitoring period continued along a similar downward trajectory observed during the pre-restoration period. While several assessments rated the aquatic habitat similarly to the pre-restoration scores (i.e., spring of 2003 and summer of 2005), the majority of the post-restoration scores were below what was observed during the pre-restoration period (***Figure 3.15.16***). Generally, epifaunal substrate, riffle/run frequency, and bank stability scores continued to be rated lower than other individual habitat metrics and continued to decline during the post-restoration monitoring period. Aquatic habitat scores showed substantial declines after 2005.



Pre Construction							
Year	1995	1996	1997	1998	1999	2000	2002
RHAB % Spring (Narrative Ranking)	83 (Excellent)	68 (Good)	73 (Good)	77 (Excellent/Good)	71 (Good)	73 (Good)	68 (Good)
RHAB % Summer (Narrative Ranking)	80 (Excellent/Good)	78 (Excellent/Good)	79 (Excellent/Good)	NA	69 (Good)	74 (Good)	NA

Post Construction							
Year	2003	2004	2005	2006	2007	2008	2009
RHAB % Spring (Narrative Ranking)	72 (Good)	69 (Good)	NA	60 (Good)	57 (Good)	61 (Good)	61 (Good)
RHAB % Summer (Narrative Ranking)	NA	NA	77 (Good)	NA	NA	NA	57 (Good)

Figure 3.15.16 – Pre- and Post-Restoration Rapid Habitat Assessment (RHAB) Percentages at PBGH108

Quantitative Habitat

Quantitative monitoring was supposed to occur at sites PBGH100P Above and PBGH100P Below, but was delayed due to problems locating the benchmarks. Data were collected in 2010 and will be presented in the subsequent 2010 report.

Water Chemistry

Generally, in-situ water quality parameters were in compliance with COMAR standards (***Table 2.6***) for Use III streams during most of the pre-restoration period (***Table 3.15.2***). One dissolved oxygen reading, taken during the summer of 1999, was below the 5 mg/L instantaneous standard. One water temperature reading, taken during the summer of 1995, exceeded the 68ºF standard for Use III waters. Both 1995 and 1999 were drought years, according to NOAA's National Climatic Data Center, Historical Palmer Drought Index, which may explain these below-standard readings. The water temperature recorded during the summer of 2000 also approached the upper limit for Use III, Nontidal Cold Water.

Table 3.15.2 – Pre-Restoration in-situ Water Chemistry Data at PBGH108

Parameter	1995		1996		1997		1998	1999		2000	
	spring	summer	spring	summer	spring	summer	spring	spring	summer	spring	summer
Dissolved oxygen (mg/L)	-	7.47	10.56	10.04	10.36	6.58	13.02	13.28	4.01	11.00	7.18
Dissolved oxygen (% saturation)	-	83	97	91	95	68	104	125	89	102	77
pH	-	6.61	6.58	6.64	6.72	6.70	6.89	7.10	6.97	7.17	6.97
Conductivity (µmhos)	-	95	91	98	110	91	99	72	89	89	104
Water temperature (ºF)	57.2	69.3	53.6	52.3	53.2	69.9	43.9	54.5	65.7	55.0	67.8

In-situ water chemistry parameters measured within the post-restoration monitoring period were generally within state standards with the exception of two pH readings and one temperature reading (***Table 3.15.3***). pH levels were slightly lower than the Use III standard (6.5 – 8.5) in the spring of 2005 and 2009. One water temperature measurement in the summer of 2005 was above the 68ºF standard for Use III, Nontidal Cold Water.

Table 3.15.3 – Post-Restoration in-situ Water Chemistry – PBGH108

Parameter	2002	2003	2004	2005		2006		2007	2008	2009
	spring	spring	spring	spring	summer	spring	summer	spring	spring	spring
Dissolved oxygen (mg/L)	10.38	14.91	9.39	9.67	6.85	11.91	8.09	10.08	12.72	7.64
Dissolved oxygen (% saturation)	99	131	99	91	77	122	85	115	107	82
pH	6.77	7.00	6.75	6.33	6.63	6.71	6.83	7.16	7.74	6.18
Conductivity (µmhos)	75	129	130	118	113	102	115	136	157	143
Water temperature (ºF)	55.4	57.2	63.9	52.3	72.1	62.1	66.2	56.7	47.3	66.9

Stormwater Wetland

Prior to the restoration of the stormwater wetland at this site, the landscape consisted of a combination of open field and forested stream buffer (***Figure 3.15.17***). Since MCDEP floodplain species searches have indicated various wetland obligate species in the Paint Branch watershed stream valley, including *Lithobates sylvaticusi* (wood frog), *Ambystoma maculatum* (spotted salamander), and *Pseudacris crucifer crucifer* (spring peeper), the County was confident the restoration of a wetland would attract these various wetland- dependent species to this area.

Figure 3.15.17 – Vicinity of the Piping Rock Drive Stormwater Pond Prior to Restoration

The stormwater pond was constructed in 2002 and monitored post-restoration in 2006 and 2009. The restoration site is characterized by two open water areas that are surrounded by emergent wetland, and a scrub-shrub wetland that lies between the two open water pools. In 2006, the larger open water pool dimensions were estimated as 308 feet (ft) long, 72ft wide, and 24 inches (in) deep with emergent vegetation dominated by *Typha latifolia* (broadleaf cattail). One adult *Anaxyrus americanus* (Eastern American toad) was observed and three large Eastern American toad egg masses were observed in the pool complex in 2006.

In 2009, the stormwater pond was estimated as 420ft long, 95ft wide, and one foot deep. The water temperature at the time of the June 24, 2009 site visit was 86°F and the air temperature was 95°F. The pond supported submerged and emergent vegetation, trees, shrubs, and herbaceous vegetation dominated by cattail and *Impatiens capensis* (jewelweed). Four adult *Lithobates clamitans melanota* (northern green frog), and 22 juveniles were observed. One adult *Lithobates palustris* (pickerel frog), several unknown toad tadpoles of one type, and approximately four unknown tadpoles of a different type were also found in the deeper portion of the stormwater pond. *Hyla versicolor* (Gray treefrog) were heard calling during the 2009 monitoring. Several macroinvertebrate taxa were also observed, including Zygoptera (damselfly larvae), Coryixidae (backswimmers), and Gastropoda (snails). Field data sheets for wetland monitoring in 2009 are included in ***Appendix D***.

Wetland Vegetation

Pre-restoration wetland vegetation data were not available for this site, as the wetland was created as part of the restoration. ***Figure 3.15.17*** is an aerial photograph taken in 1998 and shows the vicinity of the Piping Rock Drive stormwater pond prior to its construction.

The Piping Rock Drive stormwater pond was monitored in 2006 and 2009 to evaluate the success of the planted wetland vegetation after construction. Methodologies differed between years; in 2006, 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. The results from 2006 indicated that this area was a wetland. There was some standing water in the center of the pond and the perimeter was planted with trees and shrubs. In 2006, the wetland vegetation was dense and tall, with *Salix nigra* (black willow) as the dominant canopy species. The understory was comprised of broadleaf cattail and *Leersia oryzoides* (rice cutgrass). Many other herbaceous wetland plants were also identified.

The vegetation monitoring in 2009 was based on three distinct wetland zones, one palustrine emergent wetland (PEM) (Area 1) that bordered the northernmost open-water pool, one palustrine scrub shrub (PSS) that extended between the two open-water areas (Area 2), and one PEM (Area 3) that fringed the larger and southernmost open-water. Each of these three wetland zones were monitored and scored separately**.** ***Figure 3.15.18*** shows the locations of the three monitored areas.

A total score for the entire site was calculated based on a weighting of the sub-scores determined by the area of each zone. The total score for the entire site was 90.25 out of a possible 100 (***Table 3.15.4***). All three areas within the site were determined to be wetlands based on vegetation, soils, and hydrology.

Table 3.15.4 – Post-restoration Vegetation Assessment (2009)

Area #	Area Score	Size of Sub-Area (sf)	Credit (sf)	Portion of Total Credit (based on Sub-Area)	Sub-Score
1	84.85	1,860	1,860	0.1	8.5
2	90.4	10,440	10,440	0.6	54
3	92.5	5,280	5,280	0.3	27.75
Total		17,580	17,580	1.0	90.25

Figure 3.15.18 – Locations of the 2009 Monitored Wetland Zones at the Piping Rock Drive Stormwater Pond

Hydrophytic vegetation was dominant throughout the site. However, it appeared that most of the planted emergent wetland vegetation within the site were not successful, as very few of the plants shown on the restoration project plans were observed during the site visit. The only emergent plants observed that were on the restoration project plans were *Sagittaria latifolia* (arrowhead) and *Pontederia cordata* (pickerelweed). *Acer rubrum* (red maple) and *Cornus amomum* (silky dogwood) saplings were the only woody species from the plant list observed. However, many trees and shrubs that appear to have been planted along the periphery of the wetland cells, particularly on the east side (Area 2), seemed to be surviving and growing. The only species that was found growing in this area (Area 2) that was on the restoration plans was silky dogwood.

Areas 1 and 2 had fairly low plant diversity. Area 1 was dominated by broadleaf cattail and rice cutgrass and Area 2 was dominated by volunteer black willow. Area 3 had a higher diversity of planned wetland plant species and was dominated by broadleaf cattail, pickerelweed, and arrowhead. Invasive plant species were mostly absent from the wetland, although *Arthraxon hispidus* (small carpgrass) was observed in Areas 2 and 3. The site had hydric soils and most of the planned wetland area had suitable wetland hydrology to support wetland vegetation. The wetland complex was determined to provide several biological, hydrologic, and water quality functions, including 1) providing habitat for reptiles, amphibians, and other wetland dependent wildlife, 2) filtering sediments, pollutants, and toxins, 3) furnishing organic material to aquatic food webs, 4) floodwater and headwater storage, and 5) several other important wetland functions. Overall, this restoration site appears to support highly functioning wetlands (***Figure 3.15.19***). 2009 field data sheets for this task are included in ***Appendix D***.

Figure 3.15.19 – PBGH100P in 2009, dominated by broadleaf cattail, pickerelweed, and arrowhead

Temperature

Pre-restoration stream temperature was monitored downstream of the future location of the Piping Rock Drive stormwater pond at PBGH108 in 1998 and 2000 using continuous data loggers (***Figure 3.15.4***). In 1998, the average temperature at PBGH108 was 65.7^{o}F, with 28 percent of all readings exceeding the 68^{o}F Use III temperature standard. In 2000, the average temperature was 64.4^{o}F, with 11 percent of the readings exceeding 68^{o}F (***Table 3.15.5***).

Table 3.15.5 –Average Stream Temperatures at PBGH108 in 1998 and 2000

Date	1998	2000
Average Temperature (^oF)	65.7	64.4
Percentage of readings exceeding Use III standard (68 ^oF)	28	11

Stream temperatures were monitored upstream (PBGH1002) and downstream (PBGH1003) of the pond after its restoration, in 2003, 2006, and 2009 (***Figure 3.15.20***). ***Table 3.15.6*** shows the minimum, maximum, and average temperature at each site, and the differences between these values at the up and downstream sites per year. It also shows the percentage of readings that exceeded the Use III temperature standard. In 2003, temperatures above and below the pond were similar, with the average temperature above the pond exceeding the average below the pond by 0.1^{o}F. In 2006 and 2009, temperatures were higher below the pond by 0.8 and 1.2^{o}F, respectively. However, the downstream logger locations in 2006 and 2009 were below a pipe outfall carrying road runoff from Piping Rock Drive; whereas in 2003, the downstream logger was placed above this outfall. Therefore in the later years, the data collected at the downstream stations had the confounded influence of runoff from the road and therefore do not accurately portray the affects of the pond on stream temperature.

Table 3.51.6 – Min, Max, and Average Stream Temperatures at PBGH1002(US) and PBGH1003(DS)

Date	2003			2006			2009		
Location	US	DS	Δ*	US	DS	Δ	US	DS	Δ
Min Temperature (^oF)	54.4	55.9	1.5	57.1	55.2	-1.9	57.3	56.7	-0.6
Max Temperature (^oF)	77.4	74.4	-3.0	76.4	87.1	10.7	75.3	84.4	9.1
Average Temperature (^oF)	67.2	67.1	-0.1	67.5	68.3	0.8	66.5	67.7	1.2
Percentage of readings exceeding Use III standard (68 ^oF)	50.4	52.1	1.7	51.3	57.2	5.9	40.3	43.9	3.6

* the delta symbol (Δ) is used to represent change in temperature from upstream to downstream

Although average temperatures between the upstream and downstream sites only differed by a little more than one degree, the percentage of readings above 68^{o}F was higher at the site downstream of the pond. In addition, a paired t-test performed on the 2009 data, comparing means between the upstream and downstream site, yielded a highly significant difference (p value <0.0001) between temperatures upstream and downstream of the pond. On average, downstream temperatures were 1.04 degrees warmer than upstream temperatures. Post-restoration temperature profiles from all years are plotted for each site and presented below (***Figures 3.15.20*** and ***3.15.21***).

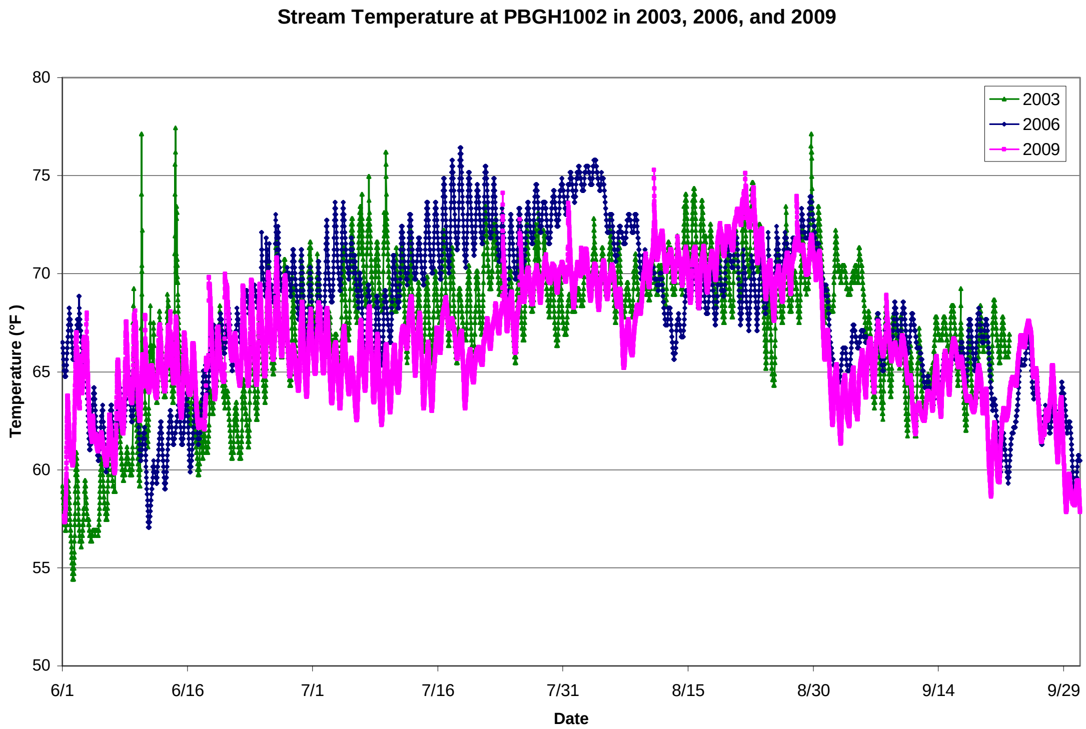


Figure 3.15.20 – Stream Temperature Upstream of the Piping Rock Drive Stormwater Pond in 2003, 2006, and 2009

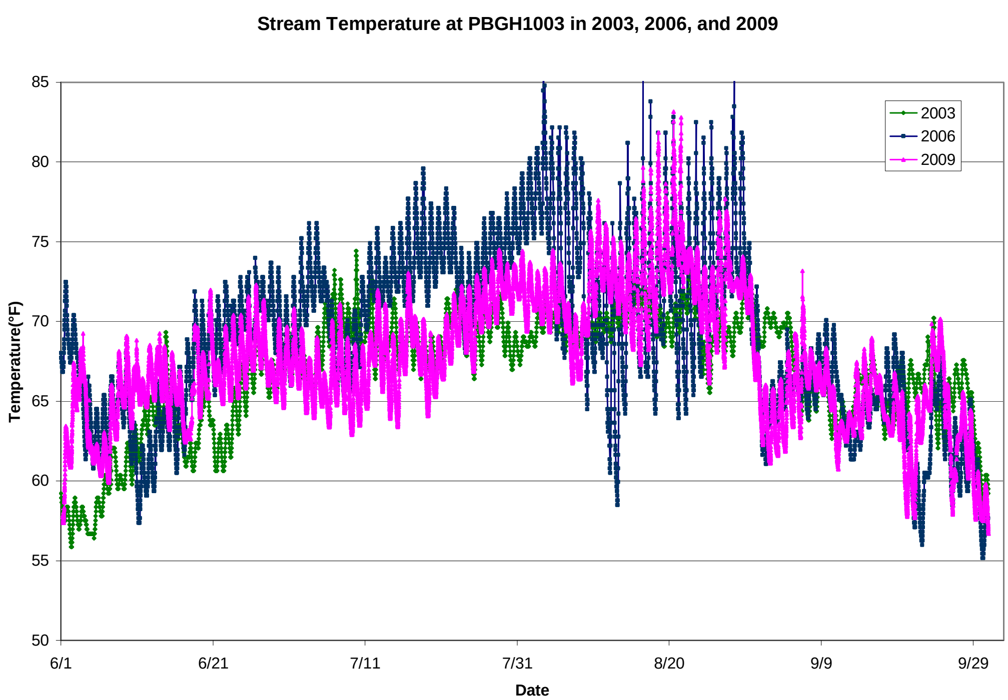


Figure 3.15.21 – Stream Temperature Downstream of the Piping Rock Drive Stormwater Pond in 2003, 2006, and 2009

In addition to average temperatures over the summer sampling period, two storm events were analyzed to determine the impact of the stormwater pond on the downstream receiving waters. Based on the most recent Atlas 14 Intensity-Density-Frequency (IDF) data for the area, the one-year storm event occurs with a 24 hour rainfall event of 2.61 inches. IDF data were obtained from the National Oceanographic and Atmospheric Administration (NOAA) National Weather Service (NWS). The Piping Rock Drive stormwater pond was constructed to capture the majority of storm flows up to the one-year extended detention. The effectiveness of the pond to prevent an increase in thermal inputs into the Good Hope has been assessed using two of the largest rainfall events in 2009. No storm events greater than the one-year flow occurred during the summer sampling period in 2009. However, the two largest storm events, occurring on June 3rd and August 28th, were evaluated. Rainfall on June 3, 2009 totaled 1.35 inches, with another 0.49 inches falling on June 4, 2009. On August 28, 2009, 2.20 inches of rain fell and on August 29, 2009, another 0.27 inches of rain fell. Rainfall data were obtained from the Weather Underground KMDSILVE11 weather station located in Calverton, MD, approximately six miles from the Piping Rock Drive stormwater pond. For each storm event, stream temperature readings at both sites were plotted together. Air temperature and precipitation were also plotted, including one day prior to the storm period where no rainfall occurred, through the day of the storm, and the following day. This plot allowed normal diurnal temperature fluctuations to be compared with storm event temperatures.

June 3, 2009 Storm Event

As shown in ***Table 3.15.7***, average stream temperatures associated with this storm event were higher below the pond than above. On June 3, 2009, the day of the major storm event, stream temperatures were almost one degree warmer below the pond than above. On June 4, 2009, when 0.49 inches of rain fell, the average temperature downstream was slightly lower than the previous day, but still 0.78°F higher than above the pond. On the day of the major rainfall, the maximum temperature measured from below the pond was 6.50°F higher than above the pond. As shown in ***Figure 3.15.22***, the stream temperatures on all three days generally followed similar patterns upstream and downstream of the pond. However, the temperatures measured downstream of the pond were almost always slightly warmer. The downstream warming trends seen throughout the summer sampling period appear to be exacerbated during storm events, possibly due to the impact of warm water detained by the pond or from runoff from Piping Rock Drive flowing into the stream due to the influx of new rainwater.

Table 3.15.7 – Min, Max, and Average Stream Temperatures June 3, 2009 Storm

Date	**June 2, 2009**			**June 3, 2009**			**June 4, 2009**		
Rainfall (in)	0.00			1.35			0.49		
Location	US	DS	Δ*	US	DS	Δ	US	DS	Δ
Min Temp (°F)	60.2	60.2	0.0	63.1	63.2	0.1	61.4	61.0	-0.4
Max Temp (°F)	67.0	67.4	0.4	68.0	74.5	6.5	66.0	67.0	1.0
Average Temp (°F)	63.0	63.2	0.2	65.3	66.3	1.0	62.5	63.3	0.8

* the delta symbol (Δ) is used to represent change in temperature from upstream to downstream

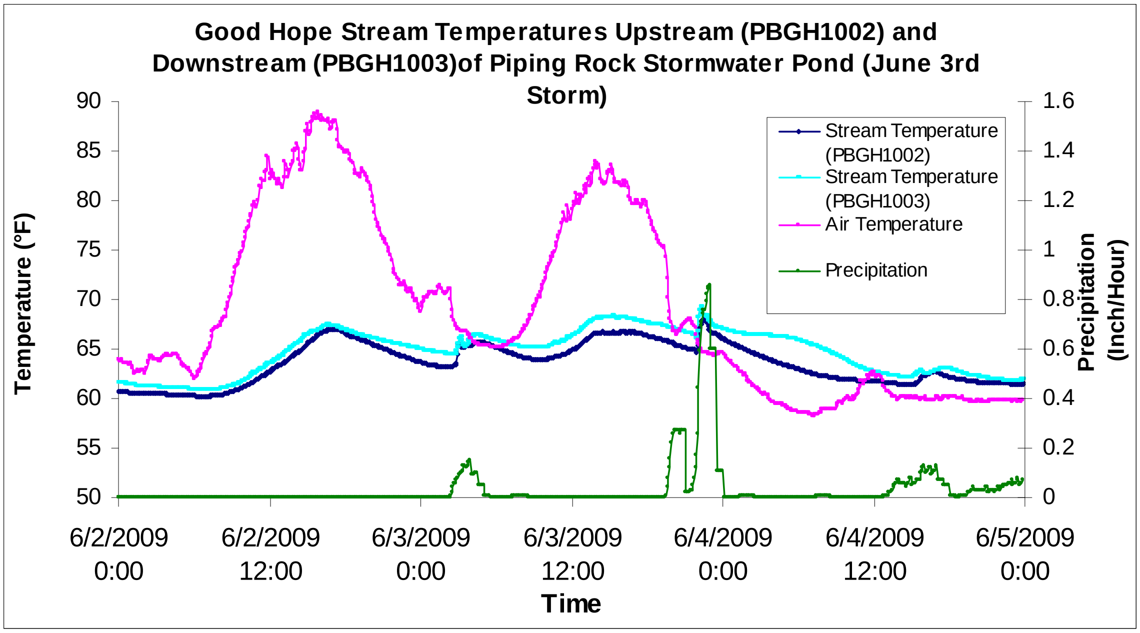


Figure 3.15.22 – Precipitation, Air, and Stream Temperatures, Upstream (PBGH1002) and Downstream (PBGH1003) of the Piping Rock Drive Stormwater Pond during the June 3rd Storm

August 28, 2009 Storm Event

As shown in ***Table 3.15.8*** below, average, minimum, and maximum stream temperatures above and below the pond for the August 28, 2009 event, were much higher than those observed during the June 3, 2009 storm event (***Figure 3.15.23***). The general temperature increase from June to August is typical as stream temperature trends typically reflect summer air temperature trends. This general trend in climbing temperatures can be seen in Figures 13.4.15 and 13.4.16.

On the days preceding and following the storm event, average stream temperatures below the pond were much higher, 1.8°F and 1.7°F, than the average stream temperatures above the pond. This indicates that as the ambient air temperatures increase over the summer, the water inside the Piping Rock Drive stormwater pond is warming and increasing the temperature of the stream. On the day of the storm, stream temperatures remained higher below the pond than above (1.0°F), but the difference between the stations above and below was less than before or after the storm event. So while the influence of the pond runoff may confound the data somewhat it does not explain the long-term observation of higher temps below.

Table 3.15.8 - Min, Max, and Average Stream Temperatures August 28, 2009 Storm

Date	**August 27, 2009**			**August 28, 2009**			**August 29, 2009**		
Rainfall (in)	0.00			2.20			0.27		
Location	US	DS	Δ*	US	DS	Δ	US	DS	Δ
Min Temp (°F)	69.0	67.1	-1.9	70.5	71.9	1.4	69.9	71.5	1.6
Max Temp (°F)	71.8	77.7	5.9	73.9	73.8	-0.1	72.0	74.1	2.1
Average Temp (°F)	70.5	72.3	1.8	71.5	72.5	1.0	70.8	72.5	1.7

* the delta symbol (Δ) is used to represent change in temperature from upstream to downstream

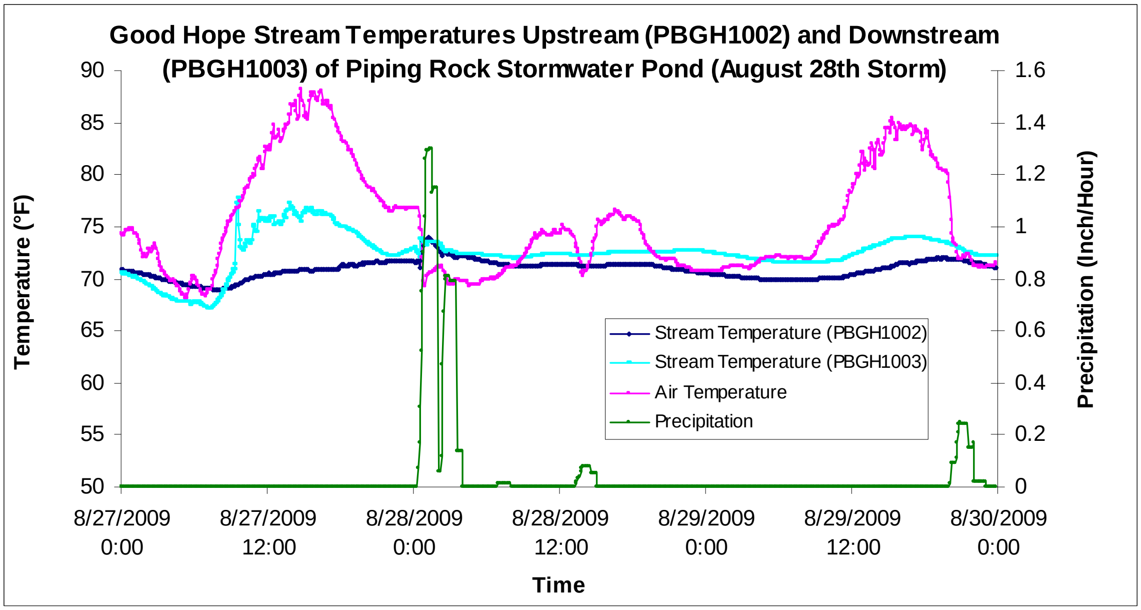


Figure 3.15.23 – Precipitation, Air, and Stream Temperatures Upstream (PBGH1002) and Downstream (PBGH1003) of the Piping Rock Drive Stormwater Pond during the August 28th Storm

In addition to warmer downstream water temperatures compared to upstream during post-restoration monitoring, the average post-restoration water temperatures and Use III standard exceedances below the pond were higher than those observed during the pre-restoration period. During the pre-restoration period in 1998 and 2000, average temperatures were 65.7°F and 64.4°F, respectively. During the post-restoration period in 2003, 2006, and 2009, average temperatures were 67.1°F, 68.3°F, and 67.7°F, respectively. During the pre-restoration period in 1998 and 2000, the percentage of readings exceeding the Use III standard were 28 and 11, respectively. During the post-restoration period in 2003, 2006 and 2009, the percentage of readings exceeding the Use III standard were 52, 57.2, and 43, respectively. Again, it is important to note that in 2006 and 2009 the downstream logger was placed below the outfall of a storm drain capturing road runoff from Piping Rock Drive whereas in 2003 the downstream logger was placed above this outfall. Therefore the data collected in 2006 and 2009 should be compared carefully to the pre-restoration data. However, the placement of the loggers below the road outfall in 2006 and 2009 does not completely explain the downstream temperature increases, as these higher temperatures were noted to exist prior to storm events as well as during and after when road runoff would be expected to have the greatest influence.

3.15.5 Discussion

Table 3.15.9 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, three were partially successfully, and two project goals were not met by restoration actions.

Table 3.15.9 – Summary of Project Goal Results

Goal	Result
Improving aquatic habitat conditions in the Good Hope	Unsuccessful – continued declines in aquatic habitat within the Good Hope tributary
Improving water quality in the Good Hope	Partially successful – general declining trend in the benthic macroinvertebrate community, increasing trend in the fish community
Avoiding introduction of new thermal impacts in the Good Hope	Unable to determine – observed thermal impacts downstream of the Piping Rock Drive stormwater pond, but 2 years of post-restoration data included runoff from road – need further temperature analysis
Reducing stream erosion and sedimentation	Unable to determine – physical data from 2010 will suggest if these goals have been met
Reducing erosive stream flows	Unable to determine – physical data from 2010 will suggest if these goals have been met
Creating wetlands	Successful - open water, emergent and forested wetlands now exist in the restoration area that was previously open field
Creating amphibian habitat	Successful – several species of amphibians were observed in and around the pond
Riparian reforestation	Successful – trees have been planted and allowed to grow in the restoration area that was previously open field

Successful – Wetlands, Amphibian Habitat, and Riparian Reforestation

The Piping Rock Drive stormwater pond appears to have met several of the project goals including creating amphibian habitat, creating wetlands, and reforestation (***Figures 3.15.24 and 3.15.25***). The wetlands created in the restoration area were determined to be highly functioning. They provide several biological, hydrologic, and water quality functions such as habitat for amphibians, and other wetland dependent wildlife; filtering sediments, pollutants, and toxins; furnishing organic material to aquatic food webs; floodwater and headwater storage; and several other important wetland functions. Several amphibian species were documented living within and around the pond complex. However, no obligate vernal pool species were observed, and fish were also present in the largest of the pools, indicating the stormwater facility probably functions as a wetland rather than a vernal pool. The stormwater pond does provide habitat for a variety of amphibians, birds, invertebrates, and fish.

The goal of reforestation also appears to have been met at the Piping Rock Drive stormwater pond. The restoration site has been replanted with native grasses, shrubs, and trees. The trees that were planted within the wetland, dominated by black willow, are surviving. Trees planted along the periphery of the entire restoration site, including alder, silky dogwood, redbud, oak, and green ash are thriving.

Figure 3.15.24 – Piping Rock Drive Stormwater Pond 2009 (dominated by broadleaf cattail, pickerelweed, and arrowhead)

Figure 3.15.25 – Piping Rock Drive Stormwater Pond 2009 (dominated by black willow)

Partially Successful – Water Quality

According to the results at PBGH108 downstream of the Piping Rock Drive stormwater pond, the goal of improving water quality has had mixed results. The benthic macroinvertebrate community experienced a general declining trend during the post-restoration period. In particular, the diversity of the benthic macroinvertebrate community has declined, especially sensitive taxa. The proportion of midges in the samples has predictably increased as habitat conditions have declined. Over time, the proportion of clingers and sprawlers, those organisms that need clean, sediment-free substrates, has declined sharply. This correlates with the increased sedimentation and embeddedness seen in the habitat trends as well as the degraded conditions seen on-site. The benthic macroinvertebrate community has experienced declines in the proportion of shredders, those organisms that require leaf litter, and scrapers, those organisms that feed on periphyton. The decline in the proportion of scrapers correlates well with the amount of sedimentation and embeddedness found during the on-site assessment. Periphyton cannot establish where the substrate is occluded by fine sands and sediments. Active areas of erosion were present at the long-term monitoring site, likely supplying the riffles and pools with the fine sediments.

Conversely, after the construction of the stormwater pond, the fish community downstream has remained similar to pre-restoration conditions, with a trend of slight improvement. Generally, fish species composition was similar pre- and post-restoration. However, the distribution of dominance has shifted since the installation of the pond, with blacknose dace heavily dominating the community from 1994 to 2005, to a more balanced community in subsequent years. Rosyside dace and blacknose dace were equally dominant in later years, with rosyside dace dominating in 2009. More specialized fish species and species less tolerant to urbanization have also increased in abundance since the Piping Rock Drive stormwater pond construction. The first record of Blue Ridge sculpin occurred in 2009. This was also the first pollution-sensitive species collected at this site since 1996. This shift in community assemblage and presence of a sensitive fish species may indicate that the pond is meeting its goal of improving water quality to support a relatively healthy fish community.

Unsuccessful – Aquatic Habitat

In general, aquatic habitat conditions downstream of the restoration declined from the Excellent/Good range to the lower end of the Good range from 1994 to 2009. The individual habitat parameters that remained consistent over time included channel alteration and riparian buffer width, which would not be expected to change without a major change in land use or development directly adjacent to the site. The most notable degradation in habitat was due to the increase in bar formation and erosion, and the decrease in channel flow status, embeddedness, bank stability, and epifaunal substrate (***Figure 3.15.26***). The overall aquatic habitat conditions continued to decline after the construction of the Piping Rock Drive stormwater pond in 2002. The declines in aquatic habitat over time, despite the restoration activities, may have an influence on the project meeting its other goals of improving stormwater quantity control, reducing stream erosion and sedimentation, and improving water quality. The decline in aquatic habitat conditions and the benthic macroinvertebrate community may be due to other factors in the overall watershed, such as increased imperviousness and urbanization. However, the data collected downstream of the pond seem to indicate this project has been unsuccessful at improving aquatic habitat.

Figure 3.15.26 – PBGH108, below the Piping Rock Drive Stormwater Pond (example of the degraded habitat including an eroded bank and dewatered roots providing little habitat that look to be previously watered)

Unable to Determine – Thermal Impacts

In two of the three post-restoration monitoring years, stream temperatures measured downstream of the pond were higher than those measured upstream of the pond. However, in both of these years, 2006 and 2009, the downstream loggers were placed below the outfall of the Piping Rock Drive storm drain thus confounding the influence of the pond on stream temperatures. Additionally, the first year post-restoration, the logger was placed above the Piping Rock Drive outfall and temperatures were slightly lower below the pond than above. Therefore, the increase in temperature below the pond cannot be directly and only attributed to the pond. The goal of avoiding introduction of new thermal impacts to the Good Hope tributary cannot be determined at this time. Continuing to monitoring temperatures in the Good Hope tributary is recommended at this site to determine the influence of the pond on downstream waters. Upstream and downstream logger deployment is recommended, however the downstream loggers should be placed above the Piping Rock Drive outfall to isolate the influence of the Piping Rock stormwater pond. If temperatures remain significantly higher below the pond, then remediation measures may be advisable.

3.15.6 Conclusions

Overall, the Piping Rock Drive stormwater pond restoration has met or partially met many of the project goals. The restoration has created wetlands and amphibian habitat as well as helped reforest the stream buffer in an area once dominated by herbaceous vegetation. Although most of the wetland plantings do not appear to be surviving, volunteer hydrophytic vegetation is successfully growing in the wetland. Black willow saplings have taken over part of the site even though they were not originally planted there. In the future, it could save the county money up front by not installing containerized tree and shrub plantings, but rather just over seeding with a native seed mix. The site could then be monitored to see how well woody volunteer and seeded species are colonizing the site. If successful, no augmenting would be necessary with containerized plants. If unsuccessful, then perhaps some containerized plantings would be needed. However, if the volunteers and seeded species are not growing, then soils or hydrology could be assessed at the site to make sure that these are appropriate for vegetation to become established.

At this time, it cannot be determined if the goal of avoiding introduction of new thermal inputs to the Good Hope tributary has been met. In 2003, one year after the construction of the pond, there were no thermal impacts detected in the Good Hope when the discharge of the pond was monitored in isolation from the Piping Rock Drive road runoff. In 2006 and 2009, although temperatures were higher below the pond than above, it is impossible to determine if the increases were a result of the pond or the road runoff since the downstream loggers were placed below the outfall of the Piping Rock Drive storm drain. A future temperature study is recommended to isolate the effluent of the pond from the road runoff to determine if this goal has been met. If this study does indicate that the pond is contributing heated water to the Good Hope tributary, this goal may be better achieved by reducing mowing and trimming around the pond and allowing trees, shrubs, and pond-side vegetation to grow uninhibited to provide better pond shading. Concerns have been raised about greater plant growth potentially causing blockage of the pond outlet and riser with debris from the vegetation. However, without greater shading, it is unlikely that thermal impacts can be easily remediated. Possible structural changes to the existing pond design to address thermal impacts, such as reducing detention time to reduce potential warming, could increase downstream discharges and erosion. Consequently, more invasive structural changes are not currently recommended without a comprehensive engineering analysis.

Other project goals, including the improvement in water quality and reduction in erosive forces and sedimentation in the stream below the pond, may not be attainable within the scope of this restoration project because of increased urbanization in the watershed. The Piping Rock Drive stormwater retrofit appears to be controlling some of the stormwater runoff in the area, but the quantity of stormwater inputs and the presence of upstream stormwater sources may limit the ability of one such retrofit to maintain high quality stream resources as found downstream in the Good Hope tributary. Searching for other opportunities to control stormwater and remediate the effect of non-point source runoff in the subwatershed without creating new thermal impacts is likely required to prevent further declines in aquatic habitat, benthic macroinvertebrate communities, erosive flows, and sedimentation.