WARM SPRINGS RUN
WATERSHED ASSESSMENT

Morgan County, West Virginia

December 2010

Warm Springs Watershed Association

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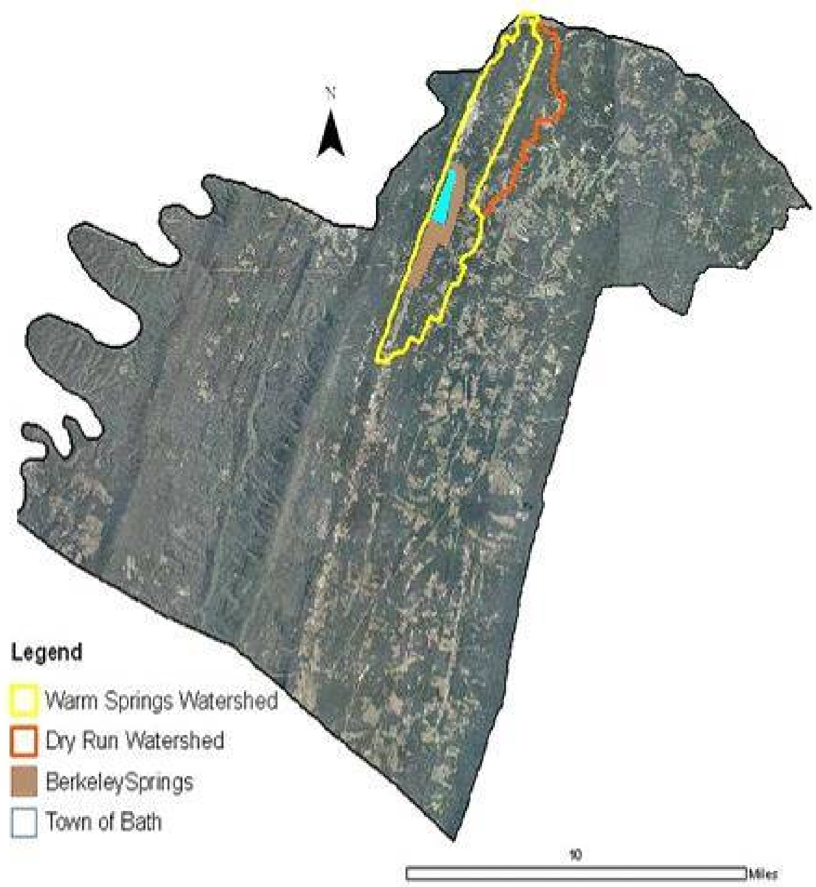
Introduction

Warm Springs Run is an 11.8 mile non-navigable stream located entirely in Morgan County in the Eastern Panhandle of West Virginia. The Run flows north to the Potomac River and ultimately to the Chesapeake Bay. Warm Springs Run has one large tributary, Dry Run, which enters it about 3000 feet upstream from the confluence with the Potomac River. (While some information will be provided, a detailed watershed analysis of Dry Run will likely be undertaken at a later time.)

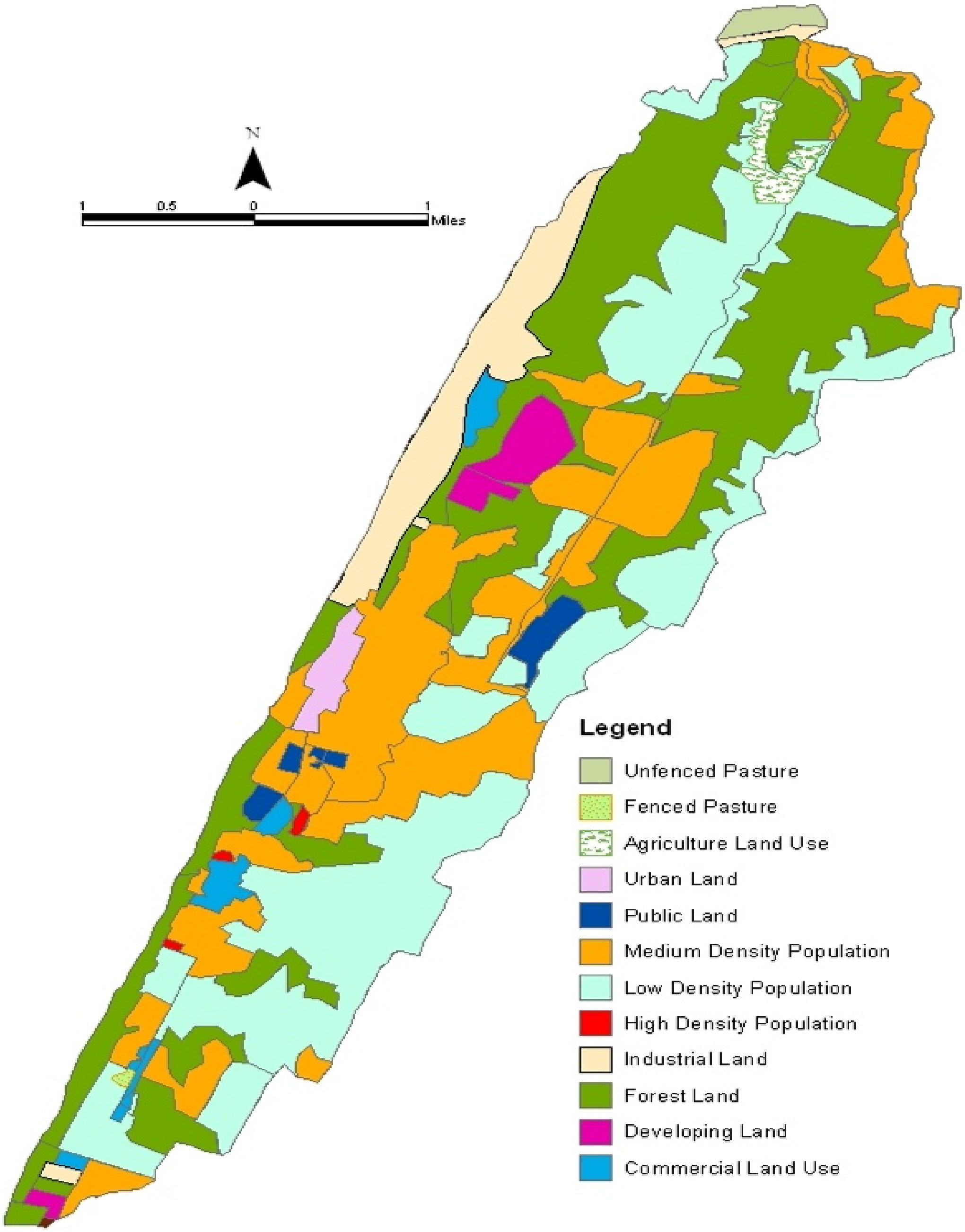
The total watershed area draining into Warm Springs Run is 9,682 acres: 7,178 acres drain directly into Warm Springs Run; there are 2,504 acres in the Dry Run sub-watershed area.

The topography of the watershed is mainly mountainous, with valleys throughout. Warm Springs Ridge forms the western boundary of the watershed. The eastern boundary of the entire Warm Springs Run Watershed, including the Dry Run Sub-watershed, is Pious Ridge. The eastern boundary of the Warm Springs watershed is Horse Ridge. Sleepy Creek Watershed is located to the south and east of the Warm Springs Watershed; the Sir John's Run Watershed, also known as the Cold Run Valley, is located to the west of Warm Springs Ridge.

The Town of Bath, the county seat, is located in the watershed. Established in 1776, the town now has a population of approximately 700 people. At the time the town was named, it was located in the Commonwealth of Virginia. Because an older town in the Commonwealth already had the name of Bath, the postal service called the new town Berkeley Springs. The designation has also come to apply to a larger area surrounding the Town of Bath. The population of Berkeley Springs is approximately 3000 people.



Map 1: Warm Springs Run watershed, located in Morgan County, WV

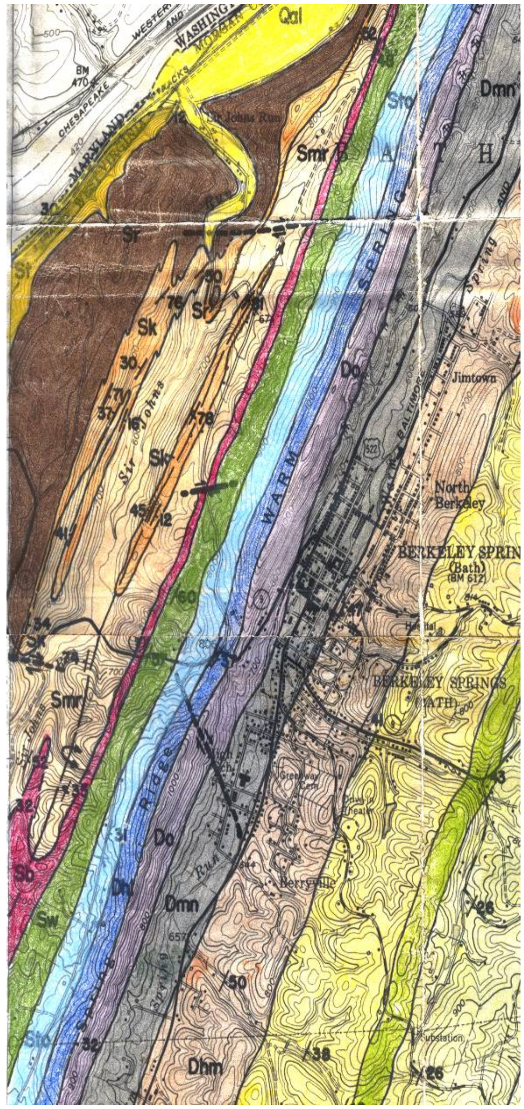


Map 2: Land Use Map of the Warm Springs Run Watershed

A little more than half (56%) of the watershed contains low or medium density residential development. The town of Bath is classified as a high-density housing area that occupies nearly 1% of the watershed area. A little more than a quarter of the watershed is perforated forest land (28%). In a perforated forest there are areas of human intervention where there are no trees.. These non-forested areas are a result of logging, roads, railroads, etc. A little less than 2% of the watershed is unfenced meadow, fenced pasture or agricultural land. Ten percent of the watershed is used for industrial or commercial purposes. Impervious surfaces cover 17% of the total watershed area.

Geology

The terrain of the Warm Springs Run Watershed is composed of mountains and valleys that lie in a southwest to northeast orientation, which is part of the Northern Appalachian Ridges and Valleys Physiographic Province. This province is characterized by a series of long, narrow mountains with caps made up of resistant sandstone and conglomerate, and valleys, made up of shale and a limited amount of carbonate rock.



Map 3: WV geological survey map of the Berkeley Springs recharge area.

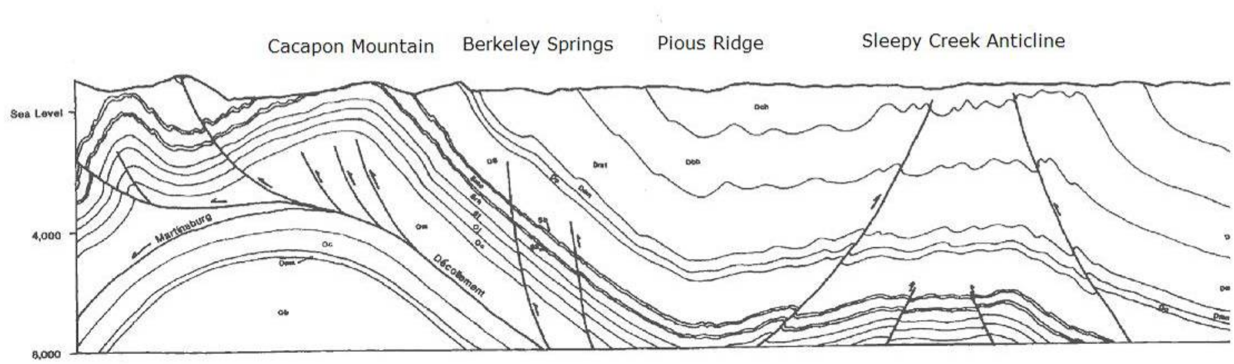
Land Forms

The landforms of the watershed clearly show the effects of uplift, folding, and geologic erosion. The valleys between the mountain ridges are underlain primarily by shale, which is relatively soft and easily eroded over time. The valleys are strongly dissected by small intermittent and perennial streams that form a trellis pattern. The ridge tops are usually broad and gently sloping to moderately steep. Side slopes are usually steep or very steep.

Rock Systems

The highly folded and faulted rocks of the watershed are all sedimentary in origin and were formed during the Devonian, Silurian, and Mississippian periods. The youngest rocks in the watershed are the Pocono Group Sandstones, which are members of the Mississippian geologic period. The oldest rocks are the Tuscarora sandstones which are Silurian age rocks. The Tuscarora sandstones have been folded into a well defined anticline that forms Cacapon Mountain. Rocks of the Devonian system are the most extensive in the Warm Spring Run drainage area and are exposed in wide bands east and west of Sideling Hill. They include the shales, siltstones and fine-grained sandstones of the Hampshire, Chemung, Braillier and Mahantango Formations.

Figure 1: Cross section of rock strata in the area



Soils

Soils are formed from the effects of time, climate, and biological factors on bedrock or sediments deposited by floods or erosion. Each factor influences the expression of the others, although bedrock (also known as parent material) and landscape position have generally produced the major differences in this county.

Most of the soils in the Warm Springs Run Watershed are weathered from siltstone, shale, or sandstone and were formed in place. These are considered the oldest soils. So, too, biological and weathering processes have had the longest span to influence development;. However, the process may be hindered by steepness of slope, or by rock that is resistant to weathering. Consequently ,these soils may or may not show a high degree of development in the profile.

Figure 2: Weikert silt loam soil

Shale, siltstone and fine-grained sandstone are the predominate bedrock in the watershed. About 75% of its soils are formed on this type of residual material. These soils are shallow and acidic with a pH from 3.5 to 5.5. The Weikert Series, the most common soil type in the watershed, is less than 20 inches to bedrock. Weikert, Berks, Clearbrook, and Cavode all have low water holding capacity and usually contain many small fragments of shale. Clearbrook and Cavode soils have a perched water table 10 to 24 inches below the surface. These soils are in close proximity on the landscape, and without excavation it may be difficult to see the differences.

The soils on Warm Springs Ridge are loamy sands and allow unrestricted infiltration of precipitation. These soils belong to the Shaffenaker and Vanderlip Series with about 600 acres mapped in the watershed. They are extremely subject to erosion due to the unconsolidated nature of the texture and the steepness of Warm Springs Ridge. Removing the vegetative cover or increasing impervious cover on these soils create repercussions for the entire watershed. Theses soils tend to be shallow and strongly acid. Large rocks and boulders are part of the landscape.

Soils altered by construction make up about 8% of the watershed. Usually these areas have had topsoil stripped for construction activities or are the location of rock quarries. Both shale and sandstone are extracted from these locations. Reclamation is not typically required for shale pits in West Virginia.

Floodplain soils in the watershed have parent material washed from hillsides and footslopes and are acidic. The floodplain soils are the youngest soils because of the constant climatic activity of scouring and deposition that occurs in this active landscape position. They exhibit weakly developed profiles and can have a wide variation within the floodplain due to the presence of temporary channels formed during floods. In this watershed the Holly and Melvin soils found in the stream valley are considered hydric with a water table near the surface during the growing season. They are frequently flooded. Wetlands are common on these soils. Lindside soils are only occasionally flooded, but have a high water table. Coombs and Philo are well drained loamy soils that are occasionally flooded. The floodplain soils make up about 4 percent of the watershed, but much of it is covered by residential and commercial development.

Soils formed at the foot slopes of the mountains and near the head of drainageways are the result of erosion and gravity. This material is younger than the underlying bedrock, but still has existed long enough for complex horizons to form within the soil profile. Buchanan and Ernest soils are found in the landscape with Buchanan formed from eroded sandstone and Ernest formed from eroded shale. They exhibit a perched water table 16 to 24 inches below the surface and a higher percentage of clay than surrounding soils.

Soils react and respond differently to various uses. Soil properties influence agricultural and timber productivity as well as site selection and design of residential and commercial developments. Production of agricultural crops is related to chemical properties such as natural fertility, water holding capacity, and acidity as well as physical properties such as steepness of slope, amount of rocks, and the potential of topsoil for erosion. Soil properties affect building sites through properties such as soil wetness, flooding potential, corrosive potential to underground utility lines and pipelines, and permeability for waste water disposal or growth of plants.

A complete list of soils and the extent of each soil mapping unit in the watershed is found in Table 11in the Appendix.

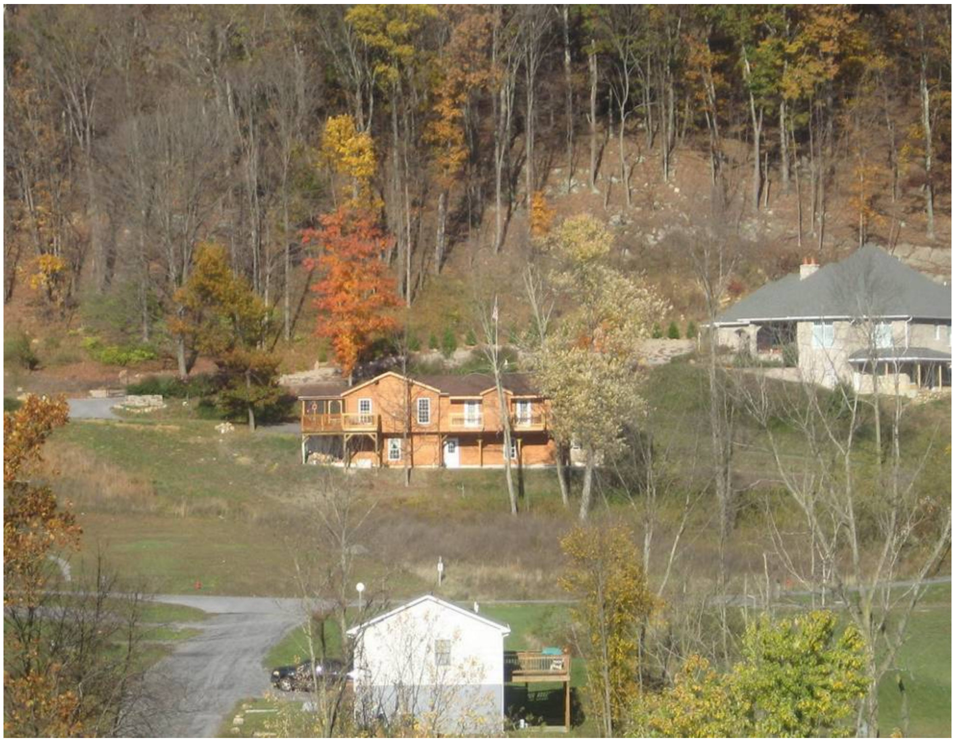


Figure 3: Removing the vegetative cover or increasing impervious cover on these soils create repercussions for the entire watershed.

Forests

The Warm Springs Run Watershed area contains 2,008 acres of forested land or about 16% of the total land use. Most of the forest-cover is relegated to Warm Springs Ridge. The forested land is composed of hardwood and pine species.

From the mid-19th century through the1950s Morgan County forests were heavily timbered. Even recently, the Warm Springs Run Watershed has had its share of timber harvesting. Over 410 acres were harvested on U.S. Silica property in 2005; 265 acres were clear cut. This harvesting was done for forestry management purposes. About 48% of the forestland in the watershed is actively managed through the WV Forest Stewardship Program or a similar land tax assessment program designed to encourage managed timberland. This high percentage is due to property in managed timberland U.S. Silica property.

Forest Decline

Throughout the years, several major threats have contributed to the decline of forest health in the watershed. Threats from disease, insects, and invasive plant species, complicated by severe weather, have caused large-scale changes in the watershed's forests. In the late 1800s a fungal disease (*Cryphonectria parasitic*) eliminated the chestnuts. In the mid 1950s, Dutch elm disease caused the death of elms in the area. Several other species, such as pitch pine, once timbered, have been unable to reestablish themselves.

In recent decades, infestations of the gypsy moth (*Lymantria dispar* L.), a voracious consumer of foliage in its larval stages, have been prevalent. While it attacks primarily oak trees, it will eat leaves from as many as 500 other hardwood species. The moth, a native of Europe and Asia, was introduced in Massachusetts in the late 1800s, as a potential silk producer. An aggressive insecticide spray program, underwritten by the WV Department of Agriculture, was relatively successful at keeping the insect attack at bay on private lands. The public land in the watershed, which did not benefit from the annual sprays, lost many large oaks through the combination of insect infestation and droughts that occurred simultaneously.

Recently the small hemlock wooly adelgid (*Adelges tsugae*) has invaded the area, attacking the small hemlock population found in shady coves along streams. The insect is believed to be a native of Asia and feeds at the base of needles. A heavy infestation can cause death of the host in about five years, especially if other environmental stress is present.

Figure 4: Emerald Ash Borer

The emerald ash borer (EAB) *Agrilus planipennis* is an introduced pest that has killed at least 40 million ash trees *(Fraxinus spp.)* in North America. Suppression and eradication efforts have largely been unsuccessful and this pest continues to spread. In 2008 it was discovered in Morgan County just beyond the headwaters of Warm Springs Run near Cacapon State Park. There are portions of Warm Springs Ridge that are 50% ash. This pest is a grave threat for the health of local forests.

Figure 5: Conifers frame the Castle in Berkeley Springs

Table 1: Common tree species in the watershed

Native tree species found in abundance:	**Other native tree species:**
Red oak (*Quercas rubra*)	Black locust (*Robinia pseudoacacia*)
Black oak (*Q. velutina*)	Black cherry (*Prunus serotina*)
White oak (*Q. alba*)	White ash (*Fraxinus americana*)
Chestnut oak (*Q. prinus*)	Sycamore (*Platanus americana*)
Scarlet oak (*Q. coccinea*)	Silver maple (*Acer saccharinum*)
Butternut hickory (*Carya cordiformis*)	Red maple (*A. rubrum*)
Pignut hickory (*C. glabra*)	Sugar Maple *(A. Saccharum)*
Shagbark hickory (*C. ovata*)	Sassafras (*Sassafras albidum*)
*t*Tulip poplar (*Liriodendron ulipifera*)	Black gum (*Nyssa sylvatica*)
	Dogwood *(Cornus florida)*
Common conifer species:	**Other less abundant conifer species:**
Virginia pine (*Pinus virginiana*)	Hemlock (*Tsuga canadensis)*
White pine (*P. strobus*)	Pitch pine (*Pinus rigida*)

Wildlife Habitat

Development in the watershed is classified as mostly residential and includes some commercial and some industrial uses. Thirty-two percent of the watershed is forested. Non-forested areas include mowed lawns, old fields, vacant lots, pastures, and even regenerating forest. This mosaic of human land use also supports a dynamic urban wildlife interface.

In 2007, the Purple Loosestrife Task Force (now the Warm Springs Watershed Association) commissioned a stream corridor assessment to document invasive plants, physical impacts, and natural features along the Run. Wildlife species encountered during the survey were also documented. (Table 2) These wildlife observations suggest that the stream supports a functioning, albeit impaired, ecosystem. (O'Malley 2007)

Wildlife observations from the Warm Springs Run Watershed have contributed to large-scale assessments (countywide and statewide). From 1984-89, the first West Virginia Breeding Bird Atlas (BBA) reported 80 bird species in the vicinity of the Warm Springs Run (at nearby Cacapon State Park). Observers with the second Breeding Bird Atlas (2009-2014) have recorded 67 species thus far in the vicinity of the watershed (also at Cacapon State Park). In 2010, BBA observations from the town of Berkeley Springs included early successional, forest interior, and wading species. (Table 3) BBA survey efforts in the watershed are ongoing through 2014. (WVDNR 2010)

Table 2: Wildlife species recorded during 2007 stream corridor assessment

Taxa	Common Name	Scientific Name
	Wood turtle	*Glyptemys insculpta*
Reptiles	Common snapping turtle	*Chelydra serpentina*
	Common water snake	*Nerodia sipedon*
	Garter Snake	*Thamnophis sirtalis*
	Beaver	*Castor canadensis*
Mammals	Deer	*Odocoileus virginiana*
	Fox squirrel	*Sciurus niger*
	Raccoon	*Procyon lotor*
	Green frog	*Rana clamitans*
	Grey tree frog	*Hyla versicolor*
Amphibians	Spring peeper	*Pseudacris crucifer*
	American toad	*Bufo americanus*
	Pickerel frog	*Rana palustris*
	Great blue heron	*Ardea herodias*
	Green heron	*Butorides virescens*
	Wood duck	*Aix sponsa*
Birds	Belted kingfisher	*Ceryle alcyon*
	Eastern towhee	*Pipilo erythrophthalmus*
	Carolina wren	*Thryothorus ludovicianus*
	Northern cardinal	*Cardinalis cardinalis*

Table 3: 2010 Breeding Bird Observations in Berkeley Springs

Habitat	Common Name	Scientific Name
Riparian	Green heron	*Butorides virescens*
	killdeer	*Charadrius vociferus*
	Song sparrow	*Melospiza melodia*
	Black-capped chickadee	*Poecile atricapillus*
	Indigo bunting	*Passerina cyanea*
	Common grackle	*Quiscalus quiscula*
Early Succession	Gray catbird	*Dumetella carolinensis*
	American robin	*Turdus migratorius*
	American goldfinch	*Carduelis tristis*
	American crow	*Corvus brachyrhyncos*
	Eastern towhee	*Pipilo erythrophthalmus*
	Tufted titmouse	*Baeolophus bicolor*
	Ovenbird	*Seiurus aurocapillus*
Forest Interior	Wood thrush	*Hylocichla mustelina*
	Scarlet tanager	*Piranga olivacea*

From 2005 through 2009, the West Virginia Odonate Atlas project documented 56 species in Morgan County. Five voucher specimens (including one county record) were collected from Warm Springs Run itself. Eight voucher specimens (and two county records) were collected from a wetland within the watershed. (Table 4, WVDNR 2009)

Table 4: Odonates Collected in the Warm Springs Run Watershed (2005-2009)

Site	Location	Common Name	Scientific Name	County Record
Warm Springs Run at airport	0.5 mi E on CR1 from U.S. Route 522 to bridge over Warm Springs Run	Variable dancer	*Argia fumipennis*	
		Blue-tipped dancer	*Argia tibialis*	yes
		Familiar bluet	*Enallagma civile*	
		Powdered dancer	*Argia moesta*	
		Powdered dancer	*Argia moesta*	
River Road swamp	1.0 mi E on CR1 from U.S. Route 522 to swamp on south side of road	Slender spreadwing	*Lestes rectangularis*	yes
		Blue dasher	*Pachydiplax longipennis*	
		Blue dasher	*Pachydiplax longipennis*	
		Twelve-spotted skimmer	*Libellula pulchella*	
		Slaty skimmer	*Libellula incesta*	yes

Figure 6: : Slender spreadwing

Figure 7: Blue-tipped dancer

Warm Springs Run is not managed for a sport fishery therefore, WVDNR biologists have not formally surveyed the fish population. However, in August of 2009, a fish kill occurred in the vicinity of Berkeley Springs State Park. The resulting investigation identified six fish species (large mouth bass, blacknose dace, stoneroller, creek chub, bluntnose minnow, cutlips minnow) in the Run (WVDNR fishery biologists consider the species identified in the fish kill as typical for a warm water stream of this size in the Eastern Panhandle (WVDNR 2009). The cause of the kill was determined to be caused when park employees improperly drained the town swimming pool.

The West Virginia Natural Heritage Program maintains a database of rare, threatened, and endangered species occurrences in West Virginia. Three rare species have been documented in Warm Springs Run. The wood turtle was encountered during the 2007 Stream Corridor Assessment. Habitat for wood turtles remains suitable throughout much of the watershed. The Eastern mole was documented in 1895 and the Earleaf false foxglove was recorded in 1938; their habitat has very likely been negatively impacted since that time.

Table 5: Rare species occurrences in Warm Springs watershed

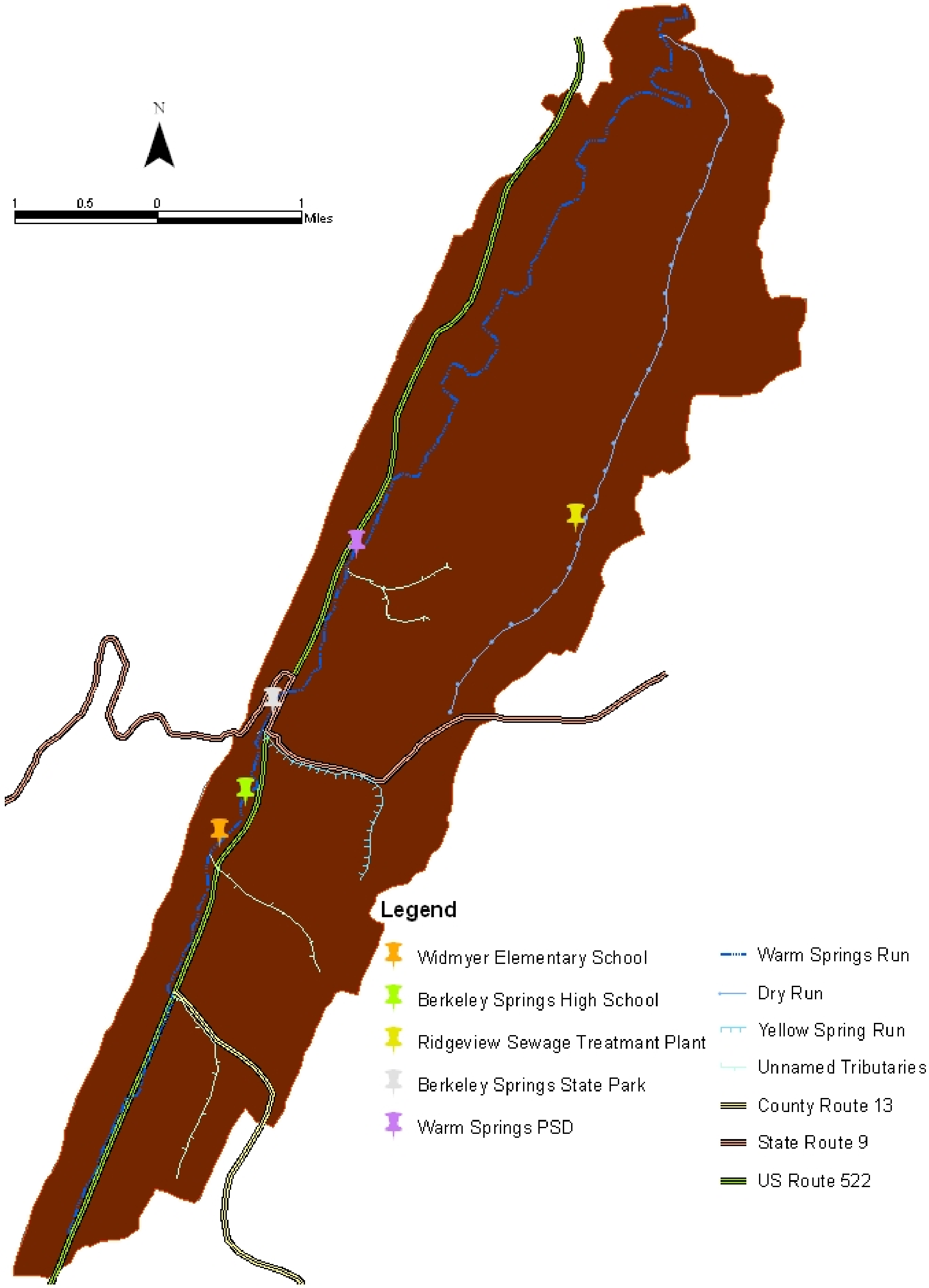
Common name	Scientific Name	# Occurrences
Wood turtle	*Glyptemys inscultpa*	1
*Earleaf False foxglove	*Agalinis auriculata*	1
**Eastern mole	*Scalopus aquaticus*	1

*The Earleaf false foxglove record is from 1938 and is not considered current.
**The Eastern mole record is from 1895 and not considered current.

Figure 8: Earleaf false foxglove

Figure 9: Wood turtle

Figure 10: Eastern mole.



Map 4: Locations map

1954 Watershed Assessment

The first watershed assessment was done in 1954 in response to regular flooding, which had become an economic problem for residents of the watershed. Leading citizens of Morgan County reported to Flood Control Flood Survey Office the USDA Soil Conservation Service (SCS), now Natural Resources Conservation Service (NRCS) that Warm Springs Run had out-of-bank flows once or twice every year.

Many of the homes and businesses in the floodplain reported water in their basements. Stores in the main part of town used sand bags or other temporary dikes to keep water out of their first floors. Particular attention was given to the situation at the Park View Inn (now known as the Country Inn), where water flooded the basement and heating plant on several occasions. Considerable damage was also done to the Inn's lawn, flowers and shrubbery.

Figure 11: 1939 flooding in Berkeley Springs State Park

It was also noted that north of the Inn, the town park (now Berkeley Springs State Park), had been covered with silt. The community swimming pool, located just west of the Run, had been damaged during flood events. The town's water supply, taken from the warm springs located in the Park, was contaminated during floods. Roadways were made impassible, and at times were completely washed out.

Figure 12: Flooding on Fairfax Street, Berkeley Springs

The report estimated that the annual costs incurred due to flooding were $50,000. In today's dollars that figure would be $475,000 annually. The damages done by the 1936 flood were estimated to be $219,948 or calculated to be about $3 million dollars today.

The initial assessment concluded that while there were some homes in the floodplain, "the bottomland area is largely unoccupied by residential developments, or is in a semi-abandoned condition because of the frequency of floods and imperfect to poorly drained soil conditions."

Land use conditions and possible solutions to address resource problems were suggested.

Flood Control Dams

In response to regular flooding of Warm Springs Run, SCS designed a Flood Prevention and Watershed Protection Program. Local sponsorship was provided by the Town of Bath and the Eastern Panhandle Conservation District. This project was the first watershed project (P.L. 534) for the Potomac River Basin in West Virginia.

The project was to include 2,198 acres of land treatment measures and nine flood control dams designed to hold back and safely pass the 100-year frequency storm. The land treatment measures gave special emphasis on such water holding measures as liming, fertilizer, and seeding of pastures; tree planning on eroded areas; proper cutting of farm woodlands; plowing and planting crops in strips on the level; diversion ditches and contour sub-soiling to slow down and reduce flood water running off land.

Dams were designed to provide flood protection to the property and people living below them. The dams were designed with permanent pools covering one-half to one acre. During periods of hard rains, flood waters would cover two to six acres at each site and then be safely released over a period of time.

Between 1955 and 1961, eight of the nine dams originally proposed for this project were built. The dams control runoff from 1,271 acres upstream from the Town of Bath. In total, the structures can hold back 278 acre-feet of water (90 millions gallons) and protect about 97 acres.

Although the Warm Springs Run Watershed Flood Prevention Dams are fifty years old, they have been well maintained. The structures are reviewed and evaluated twice a year for safety and future program operations by the USDA NRCS, WV Conservation Agency, Eastern Panhandle Conservation District and local project sponsors.

Figure 13: Flood control structure

Present Day Flooding

Flooding in the watershed is still a problem for Berkeley Springs and the Town of Bath. The steep hillsides transmit stormwater quickly into the stream. Major damages have been mitigated by the flood control dams, but clean-up costs, damage to roadways and streambank walls is still significant. In 1991 a supplemental study to the original 1954 report by the USDA Soil Conservation Service proposed additional flood channels be constructed through the Town of Bath. The project was justified by the amount and occurrence of damage to structures in the watershed that had been built since the time of the original study and since less than 20% of the watershed was controlled by the Warm Springs flood prevention dams. The funding for the proposed project was never sought.

After extensive flooding in 1996 Morgan County used Federal Emergency Management grants to purchase and demolish three frequently flooded structures at three sites along the Run.

Figure 14: 2009 flooding in Berkeley Springs State Park

Figure 15: 2009 flooding on Williams Street

Figure 16: 2009 flooding on Williams Street

Tributaries to the Run

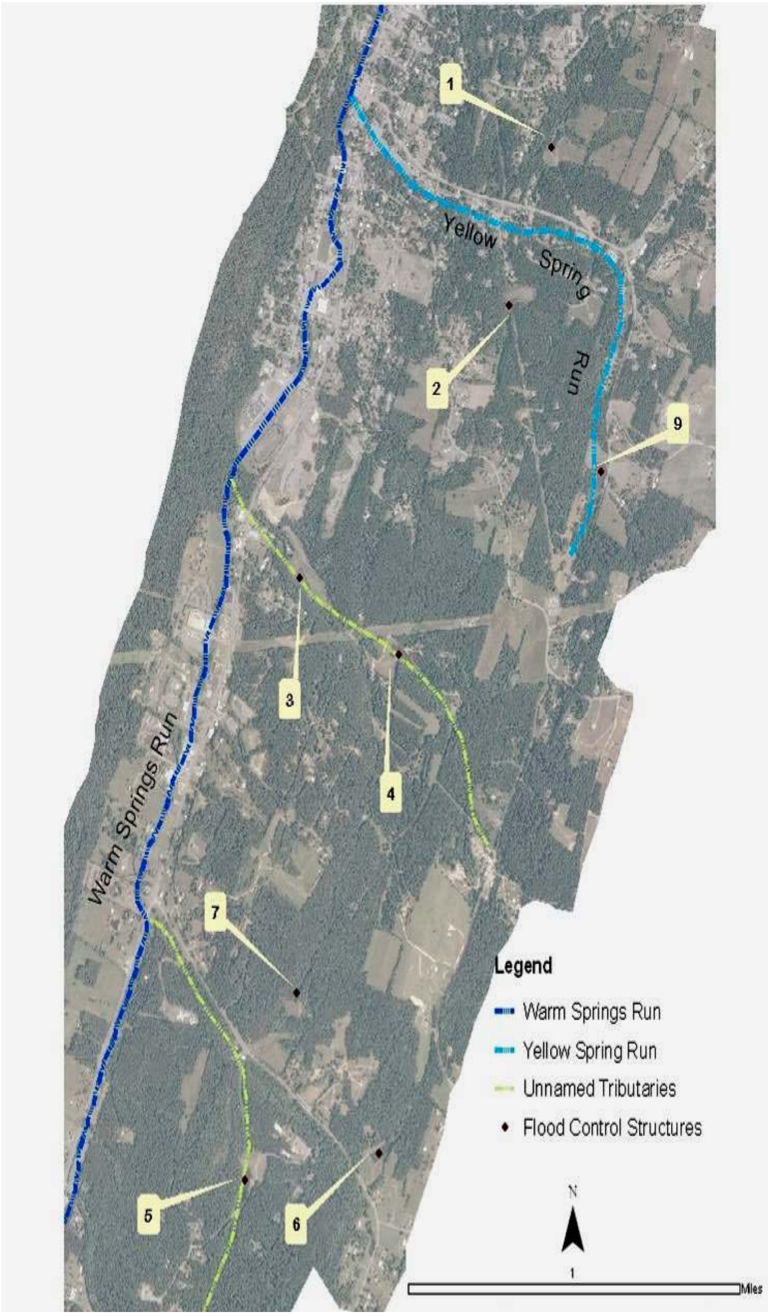
Dry Run is the only major tributary to Warm Springs Run. Dry Run is a small, intermittent stream. The streambed and associated riparian buffer are largely undisturbed.

The first watershed assessment reported that there were several small, unnamed tributaries draining into the Run from the east. After the dams were installed, water draining from them fed these tributaries.

Water drains from dams 1, 2 and 9 into Yellow Run. This stream flows along WV Route 9 and empties into Warm Springs Run just south of the Country Inn. Water from dams 3 and 4 enters into a small tributary that flows along Sugar Hollow Road, and empties into Warm Springs Run just south of Widmyer Elementary School. Water drains from dams 5, 6 and 7 into a small, unnamed tributary that flows along Winchester Grade Road (CR 13). This tributary joins the Run at the intersection of that road and U.S. Route 522.

The Warm Springs, located in Berkeley Springs State Park, contribute significant base-flow to Warm Springs Run. Long before the first European-Americans discovered them, the Warm Springs of this area were already a famous health mecca attracting indigenous peoples from the Great Lakes to the Carolinas. The first settlers, who came to the region in 1730, learned the uses and value of the springs from the Indians and began spreading the word of its benefits throughout the settlements of the east.

Perhaps the most notable and influential advocate of the curative powers of the springs was George Washington, who, at 16, visited them as a member of a party surveying the western limits of Thomas Lord Fairfax's lands. On March 18, 1784, young Washington noted in his diary that “We this day called to see Ye Fam'd Warm Springs."



Map 3: Dams and tributaries to the Run

Developed Land

Land use in the watershed area north of the Town of Bath has remained unchanged since 1990 as a large percentage of the land is owned by U.S. Silica Corporation. In the rest of the watershed, population growth has driven land use from agriculture and forest to residential and commercial. Extensive residential development has taken place along the eastern and southern portions of the watershed. This increased development has caused a significant amount of sedimentation in the stream corridor.

Figure 17: Construction in the watershed

Section 10.8 of Morgan County's "Ordinance Regulating the Establishment of Real Estate Subdivisions" outlines the regulations that deal with protecting water quality. If roads are included in the subdivision plan, the developer must submit an erosion control plan that meets the standards and specifications of the Eastern Panhandle Soil Conservation District.

Section 10.5 of the code deals with flood-prone areas. This section requires that proposed subdivisions within the 100-year flood plain shall be required to demonstrate conclusively that the building footprint will be located outside the 100-year flood plain. Any fill within this flood plain is conditioned on the applicant obtaining Letter of Map Revision, per FEMA requirements. In 2009 an ordinance went into effect that prohibits the placement of wells and septic systems within the 100-year flood plain.

Morgan County also has an ordinance for stormwater management in areas with more than 3,000 square feet of impervious surface. Minimum control requirements state that both the volume and rate of runoff shall be controlled, so that post-development levels of 24-hour, 2-year, and 10-year frequency storms are at levels equal to or less than pre-development levels for the same frequency storms. In addition, the runoff must safely pass the 24-hour, 100-year frequency storm without damaging stormwater management facilities. The ordinance does not require water quality control measures for runoff.

Subdivisions and Single Family Homes

The primary area for residential growth has been in the eastern sections of the watershed, on shale soils (primarily Hydrologic Group C/D soils). Once vegetation is removed in the development process, these soils contribute a significant amount of storm runoff. The typical soil characteristics of low fertility, strong acidity, limited water holding capacity, and shallowness make it particularly difficult to re-establish vegetation once it has been removed. Limited development has taken place on Warm Springs Ridge. This area is extremely prone to erosion due to the sandy nature of the soils (Hydrologic Group A). Once developed, this area loses its capacity to infiltrate precipitation. During construction, these soils are extremely vulnerable to erosion, even when typical erosion control methods are applied.

Commercial Development

Most commercial development has taken place south of the Town of Bath, along the U.S. Route 522 corridor. There has been construction close to the stream, immediately adjacent to the FEMA-designated floodway (the stream and adjacent 100-year frequency floodplain). This placement of buildings has had a profound effect on the steam corridor and its resilience to outside forces.

Figure 18: Construction in the watershed

Commercial areas typically have been filled and paved over or buildings have been constructed. Few of these areas have any stormwater controls because they do not meet the size requirement or because the requirement was waived due to the location next to the Run. These practices result in increased degradation of the stream, from raised water temperature, as well as increased contaminants from runoff. None of the businesses constructed in this region of the watershed in the last two decades have done anything to improve the condition of the stream.

Potable Water

Most homes and businesses in the watershed receive their drinking water from the Town of Bath Water Works. The water is drawn from the Warm Springs located in the State Park. The water, which is remarkably pure, is thought to originate from Cold Run Valley, the watershed to the west of Warm Springs. No land use safeguards have been enacted to protect this area of significant recharge. The water which supplies the springs is thought to be old and from deep groundwater due to its constant temperature of 74°F. However, it has been observed to relate to severe drought conditions by an 18-month lag time.

Table 6: Estimated flow of Warm Springs Run at Morgan County Courthouse

	Gallons per Minute	Gallons per Day	Cubic Feet per Second	Approximate Drainage Area (Sq. Mi.)
Warm Springs Production	1,200	1,728,000		
Town of Bath Water Works Extraction	750	1,080,000		
Available	450	648,000	1.00	
WSR at Waste Water Treatment Plant (Does not account for Springs)	444	639,809	0.99	6.7
WSR at U.S. Route 522 Culvert (65% of watershed at Waste Water Treatment plant) 444 gallons/min X 65% = approx 290 g/m	740		1.65	4.4

Areas of legacy pollution, which is defined as long-lived pollutants from earlier land uses, are more likely to be found in an urban watershed. (Walsh) In the Warm Springs Run Watershed, there are several areas of legacy pollution. The area adjacent to the train depot on Williams Street is undergoing remediation to eliminate arsenic from the soil. A few yards away on the banks of the Run, there is an area where the Victor Products Company had a refrigeration manufacturing plant. Traditionally, fluorocarbons, especially chlorofluorocarbons were used as refrigerants. Although these chemicals are being phased out due to their ozone depletion properties, residue still remains. Old tanks from many small filling stations in the watershed have not yet been removed. As these tanks decompose, petroleum products find their way to the streams.

Figure 19: Legacy pollution in the watershed

The water yields of aquifers outside the area served by the Water Works can be quite low, with a range of about 3 to 15 gallons per minute recharge common. Well drillers are certified by the WV Office of Environmental Health Services, Environmental Engineering Division, with well permits for individual wells being issued by the Morgan County Health Department. Table 6 provides some estimated flow rates at various areas of the watershed. Some of the chemicals found in the watershed, listed in Table 7 have the potential to contaminate ground water.

Table 7: Chemicals found in watershed

Source	**Associated Chemicals Threat to Ground Water**	**Threat level**
Funeral services and crematories	M, MP, SOC, HM, VOC	Moderate
Gas stations	PH, M, VOC, SOC	High
Laundromats	VOC, SOC	Low
Leaking underground storage tanks	PH, VOC	High
Parking lots	VOC, PH	Low
Underground storage tanks	PH, VOC	High
Car dealerships	PH, VOC	High
Car washes	PH, VOC	Low
Material stockpiles (coal, metallic ores, phosphorus.	M, HM, T	High
Mines: abandoned	M, T	High
Schools	SOC, D, VOC, PH	Low
Sewer lines	M, VOC, MP, TO	High
Swimming pools	Chlorine	
Drinking water treatment plants	D	Low
Fire Stations	PH, VOC	Low

Index to Associated Chemicals are as follows:

MP Microbiological Pathogens: Total/Fecal Coliform, Viruses, Protozoa
NN Nitrate/Nitrite
VOC Volatile Organic Compounds
HM Heavy Metals
M Metals
SOC Synthetic Organic Compounds
T Turbidity
TO Taste and Odor precursors
R Radionuclides
PH Petroleum Hydrocarbons
D Disinfection byproducts

A Watershed Association is Born

The stream is in better shape than in days past when raw sewage and industrial waste were dumped directly into it. However, the West Virginia Department of Environmental Protection (WVDEP) placed the Run on the 303(d) list of impaired streams in 2003. In addition, samples collected by the WVDEP in 2008 indicated occasions of unacceptably high fecal coliform levels in the Run both above and below the sewage treatment plant. (See chart on page 30 for further information.)

For the past 10 or more years, many people have feared that the potential for rapid growth in the watershed poses a threat to the health of the Run. The *2007 Morgan County Comprehensive Plan* states in section LU5:

> (Morgan, Berkeley and Jefferson Counties), unlike the rest of the State, have experienced significant increases in growth over the past 50 years, due in large part to the automobile-driven development pressures from the growing metropolitan areas of Baltimore and Washington to the east. It has also experienced recent pressures from the spreading Winchester area in Virginia, to the south.

In 2002 Morgan County experienced its first year of issuing more than 100 permits for new homes. In 2005 this number approached 300. The 2007 comprehensive plan stated: "It appears from submission of major residential subdivision development plans…that permit activity will not decrease significantly in the near future." (Section LU-6)

This prediction did not prove to be true in light of the recent economic downturn. Should the trend of earlier years continue, unchecked development on the steep slopes of the watershed will have a very negative impact on the Run.

Figure 20: Eradicating invasive plants

Concern was heightened in 2004, when purple loosestrife (*Lythrum salicaria*) was discovered growing in the Run. Purple loosestrife is a highly aggressive non-native plant that invades wetland and riparian ecosystems. In addition to the possibility of out-competing native plants in the Run, purple loosestrife also threatens rare plants growing in adjacent watersheds. The Warm Springs Run Watershed is located in between the Cacapon River and Sleepy Creek, both of which contain the federally-endangered plant harperella (*Ptilimnium nodosum*). Harperella can also be found in Back Creek in neighboring Berkeley County, West Virginia. Outside of West Virginia, harperella is found in only ten other locations in the world.

In 2007 the Morgan County Purple Loosestrife Task Force commissioned a stream corridor assessment of Warm Springs Run. Armed with a better understanding of the condition of the Run, efforts intensified to establish a watershed association to restore protect and preserve the Run.

With help from the Morgan County Purple Loosestrife Task Force, Sleepy Creek Watershed Association, the Eastern Panhandle Conservation District, and Potomac Headwaters RC&D, the Warm Springs Watershed Association (WSWA) was formed in July of 2008.

In 2009 the WSWA was recognized by the WV Department of Environmental Protection for its work to build coalitions with other civic and governmental organizations in the town and county. In 2010, the organization was again recognized, this time for accomplishments achieved as a new watershed association.

Figure 21: Organizational meeting of the WSWA

Figure 22 : Repairing the riparian buffer

In February of 2010, members of the WSWA met to establish a three-year strategic plan. The following areas were deemed to be of highest concern:

From its headwaters to the mouth, there is a loss of native trees and plants in the riparian buffers along the Run. This condition results in excessive sedimentation and pollution inputs as well as increased water temperatures in the Run. So far, the WSWA has planted native trees and shrubs by Widmyer Elementary School and in a floodplain area on U.S. Route 522.

There is also concern that the health of the aquatic habitat is impaired due to bacterial and other biological factors. In 2010, monitoring was done to establish the baseline condition of the Run.

Finally, work continues to be done to control the rapid spread of invasive species that impact native plants in the Run.

Figure 23: Monitoring aquatic habitat

Impervious Surfaces

An impervious surface is a hard surface area that either prevents or retards the entry of water into the soil. Examples include but are not limited to buildings, roofs, patios, driveways, carports, parking lots or storage areas. Concrete or asphalt paving, sidewalks and soil surface areas compacted by construction operations, as well as oiled or macadam surfaces are also considered to be impervious.

Figure 24: Impervious surfaces in the watershed

Impervious surfaces collect particulate matter from the atmosphere, nitrogen oxides from car exhaust, rubber particles from tires, debris from brake systems, phosphates from residential and agricultural fertilizers, and dozens of other pollutants. On a parking lot, for example, one would find buildups of hydrocarbons, bacterial contamination, metals from wearing brake linings, and spilled antifreeze.

On a road of open-graded aggregate (stone), much of that material would seep down into the pavement and soil. The community of microorganisms living there would begin a rapid breakdown process. Because contaminants can't penetrate an impervious surface, and because water flows over them more rapidly, runoff from impervious surfaces means these pollutants end up in the water.

Impervious surfaces such as roads, parking lots and roofs, cover 17% of the area of the Warm Springs Run Watershed.

An Urban Watershed

The Center for Watershed Protection defines an urban watershed as "any watershed with more than 10% total impervious cover."(Manual 1, page 3)

Land Use	Estimated Percentage Impervious Surface by Land use	Acres in Watershed	Estimated Impervious Area (acres)
Impervious Surfaces	98%	64.2	62.9
Commercial Land	85%	164.8	140.1
Industrial Land	72%	251	180.7
Urban (Mixed	72%	101.4	73.0
High Density Residential	65%	18.8	0.9
Public (Open) Land	5%	51.3	33.3
Medium Density Residential	20%	798.5	519.0
Low Density Residential	12%	3251.7	159.7
Forest Land	0%	2340	0.0
Agricultural Land	Trace	138.1	89.8
Total Area		7179.8	1259.5
Percent Impervious Area			17.5%

Urban watersheds are also characterized by the presence of wastewater treatment plants, and significant alterations in the stream channel. (Martinet**)**

Figure 25: Outfall pipe from the WSPD sewage treatment plant into the Run

Urban Stream Syndrome

Urban stream syndrome describes the consistently observed ecological degradation of streams draining urban land. Water quality, hydrology, geomorphology, and biota all show signs of this degradation. (Walsh)

Factors Affecting Water Quality in Warm Springs Run

Water quality refers to the physical, chemical and biological characteristics of water. One obvious source of water quality degradation in an urban area is inadequately treated discharge of effluent from wastewater treatment plants. Effluent can introduce nutrient pollutants such as nitrogen and phosphorus.

The Warm Springs Public Service District's (WSPSD) sewage treatment plant, located on U.S. Route 522 discharged effluent into Warm Springs Run.

Figure9: WVDEP monitoring results by date for Warm Springs Run.

Sample Date	Range of Fecal Coliform Colonies/100mL	
	Low	High
8/20/2003	60	160
4/3/2007	100	3400
6/26/2007	168	4400
7/24/2007	220	1250
8/16/2007	2400	60000
9/6/2007	146	1750
10/17/2007	45	2700
8/11/2009	110	390
8/26/2009	200	1700
9/1/2009	310	560
9/8/2009	170	1800
10/5/2009	100	570
10/27/2009	20	1100

The following charts show dates, locations and the range of fecal coliform contamination in the Run between 2003 and 2009.

The first sewage treatment plant for the area went online April 1, 1980. DEP records show that in 2008, unacceptably high levels of fecal coliforms were found both above and below the sewage treatment plant. It has yet to be determined what might be the sources of fecal contamination south of the treatment plant.

The current plant was expanded, and went online in phases between October of 2007 and May of 2008. Since that time, the plant has been in compliance with DEP standards. There were times when fecal coliform levels were still high, as is indicated in charts. In 2009 the WVDEP presented an award to the WSPSD as one of the most improved treatment plants in the state.

Figure 10: WVDEP monitoring locations results.

Mile Point From Mouth	Map Location	Range of Fecal Coliform Colonies/100mL	
		Low	High*
0.7	Near mouth north of Berkeley Springs	146	2400
5.8	Downstream of WWTP and upstream silica plant north of Berkeley Springs	113	2700
8.2	Upstream sewer lines in Berkeley Springs	100	4400
0.1	Near mouth north of Berkeley Springs	45	3400
0.28	Upstream of unnamed tributary, northeast of Berkeley Springs	20	560

*Readings of 60,000 occurred once after a rain event, but were omitted here as an anomaly.

Excess nitrogen and phosphorus cause significant water quality problems, including an overgrowth of harmful algae, which in turn can lead to a reduction in dissolved oxygen (DO) in the water. Many species of aquatic life, such as trout and other active fish, require high levels of DO in the water. Even treated effluent has been linked to the presence of chemicals that can cause illness in wildlife and people.

Recently, there has been concern about high levels of pharmaceutical products in water that may be involved in reproductive problems for fish living in the water. So, too, there is concern that reproductive problems might occur among humans who drink even adequately treated water taken from a stream or river containing this form of pollution. (See *Mortality of Centrarchid Fishes in Potomac Drainage: Survey Results and Overview of Potential Contributing Factors*. V.S. Blazer, L.R. Iwanowicz, C.E. Starliper, D.D. Burkhardt, and J. Kelble. *Journal of Aquatic Animal Health* 22:190-281, 2010.)

Figure26: Treatment basins at WSPSD wastewater treatment plant

On October 21, 2010, Alana Hartman, of the WVDEP pointed out to the County Commission that “the Warm Springs Public Service District’s sewer plant along U.S. Route 522 will not meet proposed standards for phosphorous discharge…” (*Morgan Messenger* 29, 2010) The plant however, is well under the standards for nitrogen discharge.

While a large portion of households in the watershed are served by the Warm Springs Public Service District, there are areas where homes have private septic systems.

Prior to upgrades to the WSPSD system, there was extensive infiltration of the wastewater collection system during storms. Large storms would overwhelm the capabilities of the sewage treatment plant causing untreated effluent to flow into the Run. Recent upgrades have corrected most of the problems in the Town of Bath.

Stormwater System in the Town of Bath

The antiquated stormwater system in the Town of Bath carries stormwater runoff directly into the Run in most cases. The system is poorly mapped and rarely maintained. The collection pipes and inlet boxes are severely compromised. Untreated storm runoff may carry excess nitrogen and phosphorus from over-fertilized lawns and gardens, and from pet waste that has not been picked up and properly disposed. Some homes on the Run drain water from washing machines directly into the Run. The phosphorus in laundry detergent pollutes the water of the Run.

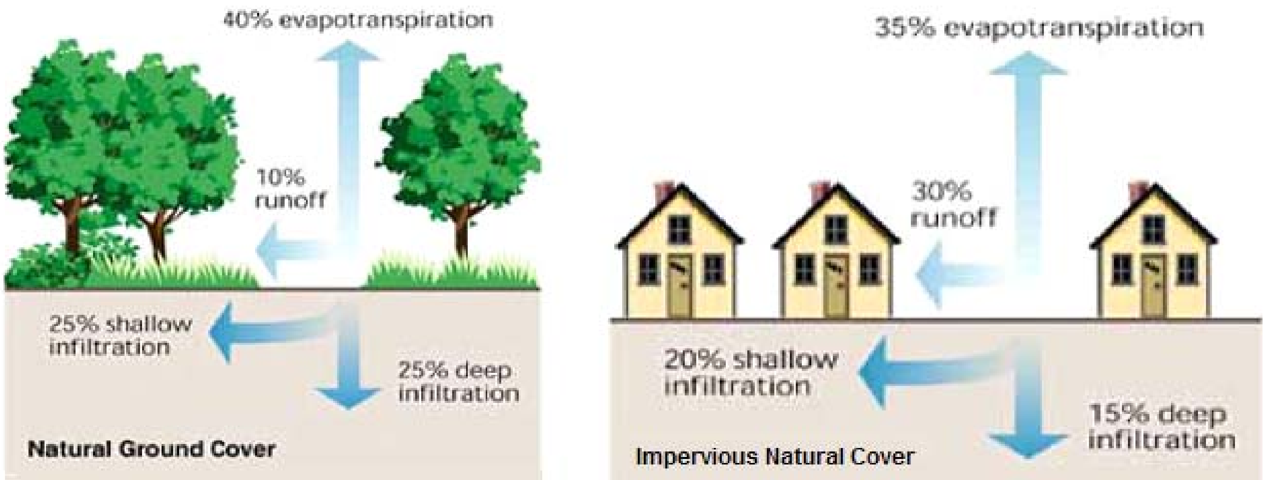
Factors Influencing the Hydrology of Warm Springs Run

Hydrology is the scientific study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, and on or below the land surface.

Generally, not all precipitation that falls on the earth can infiltrate the surface. A larger percentage of moisture can be absorbed by undisturbed surfaces than into ground that has been altered by compaction or removal of vegetative cover. Typically about 90% of precipitation infiltrates natural surfaces compared with only 45% in highly urbanized areas.

Of the precipitation that enters the soil, about 34 to 40% evaporates or is taken up by plants for transpiration. This moisture is released back into the atmosphere. About 25% (10 percent in urban areas) of the soil moisture is released into streams and small ephemeral drainageways. Depending on the conditions of the soil and the geology of an area, only 5 to 25 percent of the precipitation infiltrates deeply enough to recharge groundwater.

Figure 27: More precipitation is infiltrated into natural than into impervious surfaces.



When precipitation falls on an impervious surface in an urban area, it rapidly flows to the lowest point and ultimately into a stream. This rapid introduction of precipitation into the stream rather than being absorbed into the soil makes urban stream systems more prone to flash flooding than in areas with adequate plant cover. In the process, the rushing stormwater picks up contaminants and debris. Stormwater carries many types of pollutants from streets, parking lots, and roofs. (See Table 7 for a list of common pollutants found in the Warm Springs Run Watershed.)

The riparian buffer of the Warm Springs Run Watershed is highly impaired. In the section running from Winchester Grade Road to Jimstown Road, for example, there are virtually no areas where the banks of the Run are protected by stands of native trees and shrubs. There are more parking lots than lawns in this portion of the watershed, and where there are grassy areas they are almost always mowed right to the edge of the stream. In some areas, asphalt parking lots end right at the banks of the Run. In other places the Run is channelized, or lined with riprap, both of which destroy the riparian buffer.

Figure 28: Grass mowed to the edge of the Run

Figure 29: Parking lots paved to the edge of the Run

Figure 30: The Run channelized on one side, lined with riprap on the other side

Factors Influencing the Geomorphology of Warm Springs Run

Geomorphology is the scientific study of landforms and the processes that shape them. These processes will take place with or without human intervention. When there is human intervention, there are always unintended and negative consequences.

In streams, dynamic systems constantly adjust in an attempt to maintain equilibrium in terms of flow and sediment load. Stream channels maintain equilibrium by changing their width, depth, slope and sinuosity. (The sinuosity of a stream is the way the stream maintains a constant slope; the more sinuous a stream, the more gentle the slope.)

A change in a stream's flow or sediment will lead to the formation of new channel dimensions in predictable ways. Changes in an urban stream are less predictable due to the compounding variables that exist, but always result in degradation of the stream, streambank, and aquatic life unless mitigation is applied to counteract the alterations.

In urban watersheds, at least two factors influence the geomorphology of a stream. The first factor is structures such as bridges, culverts, railways and dams in the stream corridor, and changes on the streambank such as walls or riprap. These structures can interrupt the stream corridor, alter local stream hydrology and impact bank stability.

Figure 31: Structures in or near the Run affect its geomorphology

The second factor is development in the watershed without adequate stormwater or sediment controls. If erosion and sediment are not effectively controlled, land exposed during clearing and grading can deliver large volumes of sediment to the stream as runoff during storms. Research has shown that uncontrolled construction sites can export 20 to 2,000 times more sediment than other land uses. (Dreher and Merz-Erwin, 1991; Brown, 1998) Given the slopes and soils types in the Warm Springs Watershed, this factor is even more pronounced than it might be in other areas. (See Map 6 on page 51)

Excess sediment gradually accumulates in the channel, first filling pools and then depositing in runs and riffles, to the detriment of the creatures living on the bottom of the stream. The eggs of those aquatic species that deposit eggs on the stream bottom can be smothered by the sediment. Sediment deposition gradually raises the elevation of a streambed, a process known as channel aggradation. Aggradation is normally accompanied by widening as the channel expands its cross-section to accommodate stormwater flows, which have not diminished. The result is a stream channel that is shallower, wider and straighter than before. Such a stream is more likely to flood, and to flood more rapidly, than one that is deeper, narrower, and more sinuous.

Within the Warm Springs Run Watershed, a very fine example of these features of geomorphology can be seen in the area of the Run that flows past Berkeley Springs High School.

Figure 32: Closed culvert increases the sediment load, exacerbating flooding

The situation at Berkeley Springs High School is exacerbated by several features. The first is the pronounced lack of a riparian buffer upstream by Widmyer Elementary School. As stated earlier, riparian buffers filter and slow the introduction of sediment into a stream. Second, the lack of a riparian buffer causes erosion of the streambank itself, which also increases sediment load in the Run. Third, sediment is scoured from the streambed where there are raised manholes, culverts, or bridges; this sediment is then deposited downstream.

Finally, there is a long, closed culvert that runs under the parking lot of the high school. As with any contained culvert, and especially a long one, water builds up in velocity as it flows through the relatively narrow culvert. When the water exits the culvert, it deposits the load of sediment collected upstream. The deposited sediment further reduces the depth of the Run, exacerbating an already bad situation in terms of flooding.

Other kinds of channel modification found in the watershed include manholes and risers from the old sewage treatment system, bank armoring with rip-rap, gabions and walls on the sides of the Run. There are many places in the flood plain where parking lots are paved right to the edge of the streambank. While it was once thought that rip-rap, gabions, walls, and culverts stabilized the banks of a body of water, in fact they exacerbate problems of bank erosion on streambanks without this armor. It is more productive to solve problems at their source, and allow the stream corridor to maintain its dynamic equilibrium in terms of flow and sediment load.

Factors Influencing the Plant Biota of Warm Springs Run

Biota is defined as the combined flora (plants) and fauna (animals) or a region. **Biotic integrity** is “the ability to support and maintain a balanced, integrated, adaptive community of organisms having a composition, diversity and functional organization comparable to that in the natural habitats of the region.” *Invasive species* was officially defined on February 3, 1999 in Executive Order 13112:

> Invasive species means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

In this section we highlight some of the invasive species found in the watershed and explore how Urban Stream Syndrome contributes to changes in the biota. In general, streambanks with impaired or missing riparian buffers are more prone to erosion. A lack of canopy cover causes the temperature of the water to rise, thus reducing the amount of oxygen available to aquatic life. This factor, along with altered stream channels, leads to a loss of biotic richness, with increased dominance of tolerant and invasive species.

In the Forestry Section of this report, there is additional information about various species of invasive insects and infestations of tree species from Asia, such as tree of heaven (*Ailanthus altissima*).

Figure 33: Invasive species such as tree of heaven crowd out plants that are native to the watershed. Tree of heaven can also crack foundations.

As areas are timbered, nutrients are not recycled back into the soil. Natural soil fertility, typically low in this watershed, is further reduced from erosion and the reduction of soil organic matter from the oxidation of carbon. Increased air pollutants, such as nitrous and sulfuric oxides, further weaken trees, resulting in lowered resistance to common diseases. Rainfall in the region is more acidic than in previous centuries. Acid rain and the limited buffering capacity of the soils in the watershed also affect soil productivity in forest areas. Many invasive plants are adept at thriving on poorer sites and in spreading their populations through means assisted by humans. Once the cycle of infestation is started, colonization by invasive species can rapidly increase.

Figure 34: Field of Japanese knotweed.

Other invasive plants in the watershed include purple loosestrife, mile-a-minute vine and Japanese knotweed. The presence of Japanese knotweed illustrates the dynamic interaction between hydrology, geomorphology and biota in an urban watershed.

Japanese knotweed is found in moist, open- to partially-shaded habitats. It grows well in a variety of types of soils and soil pHs, and is especially likely to spread in disturbed areas. It can tolerate adverse conditions such as high temperatures, high salinity, drought and floods. Spreading rapidly through rhizomes and seeds, knotweed forms dense, nearly pure stands, which crowd out native plants. Japanese knotweed can also infiltrate tiny cracks in concrete culverts, bridge abutments, and septic tanks, causing damage to these structures.
By eliminating whatever grasses and other native plants might grow along the stream, knotweed causes the banks to become less stable and more likely to shear off during flooding. This process greatly increases the presence of sediment in the Run. Thick stands of knotweed can cause floodwaters to back up in the stream. When the water eventually breaks through the wall of knotweed, the creek banks are scoured. This process puts more sediment into the water, and facilitates the spread of knotweed into the disturbed soil.

In the Warm Springs Run Watershed, the vast majority of the stands of knotweed are found along the streambanks where there has been a disturbance of the riparian buffer. For example, there is very little knotweed found in the section of the Run from the headwaters to Winchester Grade Road, where there is less disturbance of the stream channel.

Figure 35: Mile-a-minute vine

Most of the mile-a-minute vine found in the watershed is located by the mouth of the Run. David Dick, WVDA, has released into this area weevils that destroy mile-a-minute plant and then move on to the next infestation.
Purple loosestrife, already mentioned in this report, has the ability to spread over acres of wetland areas, forcing out native species that had previously grown there.

Figure 36: Purple loosestrife can spread like wildfire if left uncontrolled.

Factors Influencing the Aquatic Biota of Warm Springs Run

Within the stream itself, populations of benthic macroinvertebrates also reveal symptoms of Urban Stream Syndrome.

Figure 37: Stonefly larvae

Freshwater benthic macroinvertebrates, or “macros,” are animals without backbones that are larger than the size of a pencil dot. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. The macros include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms, and the immature forms of aquatic insects, such as stonefly and mayfly nymphs.

Various species of macros possess a wide range of responses to stressors such as organic pollutants, sediments, and toxicants. For this reason, benthic macroinvertebrates have been used extensively in assessing the chemical, physical and biological health of watersheds and in assessing cumulative effects. Unlike fish, macros cannot move around much so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Their long life cycles make it possible to study declines in environmental quality or past pollution events such as pesticide spills and illegal dumping.

Figure 38: Caddisfly larvae

Mayflies, stoneflies, and caddisflies generally have little tolerance for pollution. If a large number of these insect types are collected in a sample, the water quality in the stream is likely to be good.

If only pollution-tolerant organisms such as non-biting midges and worms are found, the water is likely to be polluted. So, too, the presence or absence of certain feeding groups (such as scrapers and filterers) may indicate a disturbance in the food supply of the benthic animals in the stream and the possible effects of toxic chemicals.
Some of the factors seen in Urban Stream Syndrome which affect the aquatic biota found in the Run are excess sedimentation, effluent from the sewage treatment plant, and stormwater runoff. As noted in the section on stream monitoring:

> Overall, we found that the water quality deteriorated as we moved downstream from site1 to site5. We came away from site 1 thinking that the Run may not be as impaired as was thought, based on the benthic macroinvertebrates found. However, this impression changed significantly after surveying the other four sites – each one worse than the previous.

Figure 39: Leech

Particular mention should be made of the presence of the Asian clam (*Corbicula fluminea*). The Asian clam is a native of temperate and tropical Asia. The first record of this species in the United States is from 1938 in the Columbia River in Washington. Currently, the Asian clam occurs in 38 states and the District of Columbia. These mollusks are filter feeders that remove particles from the water column. They can be found at the sediment surface or slightly buried. Their ability to reproduce rapidly coupled with low tolerance of cold temperatures, can produce wild population swings. Densities of several thousand clams per square meter have been documented.

Figure 40: Black fly larvae

Figure 41: Biting midge

High concentrations of Asian clams have been known to clog water intake pipes used in power and water plants, causing millions of dollars worth of damage. This species also alters benthic substrates and competes with native mollusks for limited food and space resources. The 2007 Stream Corridor Assessment documented Asian clams from the mouth of Warm Springs Run upstream to the U.S. Silica plant (but not upstream of the low head dam at the plant).

Figure 42: Asian clam

Baseline Findings from Stream Monitoring Surveys

In preparation for the stream monitoring associated with this assessment, several members of the Warm Springs Watershed Association completed a WSWA-sponsored Stream Monitoring Workshop in April 2010. Two of the members took the course to maintain their certification status. The workshop was conducted by Tim Craddock, Coordinator of the Save Our Streams Program for the West Virginia Department of Environmental Protection (WVDEP). Following the workshop, attendees could elect to take a certification examination. As a result, two additional WSWA members received Level 1 certification as Volunteer Stream Monitors for West Virginia.

Figure 43: WSWA members test the waters of the Run

In June of 2010, the WSWA also sponsored a second stream monitoring workshop, Testing Our Waters. This workshop focused on teaching the correct protocol for monitoring water for bacteria, including fecal coliforms. While participants were not able to be certified, the course did provide a better understanding of bacterial monitoring procedures. Baseline data can be used to justify further testing, if warranted by findings.

Monitoring of Warm Springs Run began on April 21, 2010. Over the course of the next three months, stream surveys were conducted by teams of three or four certified monitors (at least one of whom was certified at level 3) in five separate locations along the Run. The information collected was recorded and the originals and summary documents submitted to Tim Craddock at WVDEP. The results of these surveys are summarized in the following paragraphs. Tabular data from the surveys, in summary chart format, and the summary survey documents submitted to WVDEP are appended to this assessment.

Survey Results:

Habitat and Physical Condition of the Run

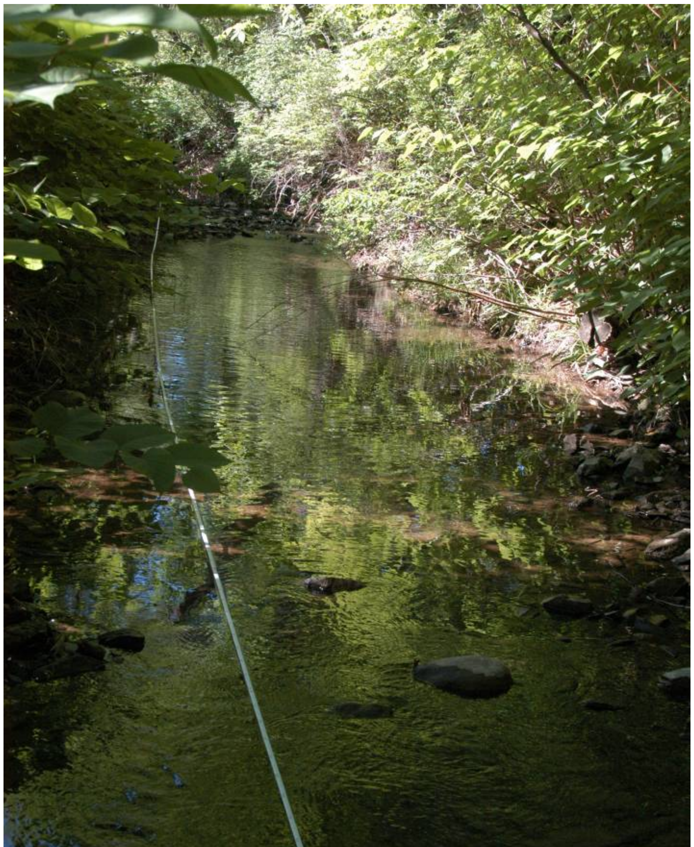


Figure 44: Site 1

Site1 is located at the intersection of U.S. Route 522 and Winchester Grade Road, Berkeley Springs, WV. The GPS Coordinates are N39° 35.873,' W78° 14.588.'

The reach started approximately 50 feet from U.S Route 522, a heavily traveled, paved, two -lane highway, with very significant commercial tractor trailer traffic. Above the reach, the Run extended under U.S. Route 522 to the east side, where it was joined by a significant tributary. This juncture occurred at a point where the Run made a 90° turn to the west, after having followed the highway for some distance. A small culvert entered the Run about 10 meters upstream of the reach. No discharge or odor was present. The streambed in the reach was mostly shale, with sand in the pools. There were occasional moderate to large trees along the streambanks, particularly on the east side.

Site 2 is located west of US Route 522, south of Widmyer Elementary, Berkeley Springs, WV. The GPS Coordinates are N39° 35.873,' W78° 14.588.'

The reach was in a mostly wooded area, with some large trees. The streambed contained a lot of fine sediment and the banks were moderately stable, with evidence of erosion from previous heavy flows.

Figure 45: Site 2

Site 3 is located south of the Country Inn, Berkeley Springs, WV. The GPS Coordinates are N39° 37.514,' W78° 13.733.'

The reach was bordered by U. S. Route 522 on the east side and the parking area of the Country Inn on the west side. The habitat is hardened and channelized by a rock wall on both sides in the area of the reach directly in front of the Inn. This section encompasses approximately 80% of the reach. There was a slimy algae coating on greater than 90% of the rocks in the streambed – the coating is a mix of algae, sediment, and organic matter. There are a couple of moderate-sized trees at the upstream end of the reach but no significant vegetation along the 80% that is hardened.

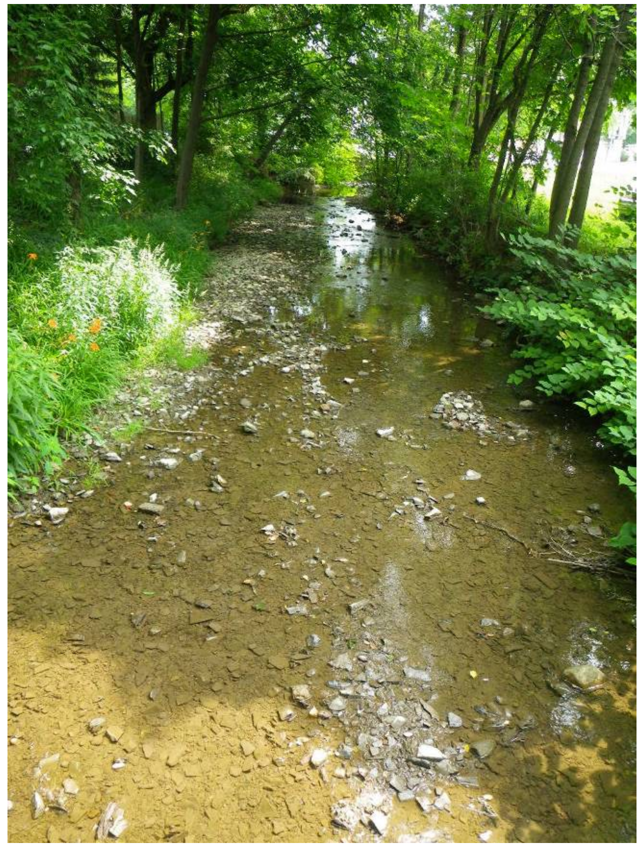


Figure 46: Site 3

Site 4 is located at North Berkeley Park, Berkeley Springs, WV. The GPS Coordinates are N39° 37.820,' W78° 13.389.'

The reach started at the north end of the park, adjacent to a small, chain link-fence. The water level in the reach was higher than normal, due to moderately heavy rain the previous evening. There were wildflowers on the west side of the reach and mostly grass on the east side. The upper 50 meters of the reach bank on the east side was hardened by a concrete wall. Two 8-9 inch diameter plastic drainpipes were seen extending from the concrete wall, but no drainage or odor was noted from either pipe. There were only a few trees and these were on the east side of the reach. A 25 foot long, metal and wood pedestrian bridge was located 82 meters upstream from the start of the reach. A double-lane concrete bridge was located approximately 100 feet above the upper end of the reach; the paved road received moderate, mostly residential traffic.

Figure 47: Site 4

Site 5 is located at Airport Road, Hancock, WV. The GPS Coordinates are N39° 41.602,' W78° 10.528.'

The reach is located near a small CSX railroad yard that services the U.S. Silica plant north of the Town of Bath. Cornfields were seen within 10-30 meters of the streambanks, on both sides of the reach, below the bridge. The Run flowed under an old single lane concrete bridge, located in approximately the center of the reach. Vehicle traffic on the bridge, which is used to access a local airport, is limited, as the bridge has a locked gate. The water in the reach was higher than expected considering the lack of rain the previous two months; this may be due to the fact that it is located several miles below the Warm Springs Public Service District waste-water treatment facility. There were a few large trees at the upper end of the reach, but the streambanks on the remainder of the reach contained mostly shrubs and flowering plants, including some purple loosestrife and a significant amount of Japanese knotweed on the west streambank, both above and below the bridge. The streambanks above the bridge showed evidence of significant erosion, based on the level of tree root exposure.

Figure 48: Site 5

Summary of Survey Findings

Keeping in mind that the five sites were surveyed over a several month span in the late spring through summer, it was surprising to see the great diversity of results among the sites. Overall, we found that the water quality deteriorated as we moved downstream from site1 to site5. We came away from site 1 thinking that the Run may not be as impaired as was thought, based on the benthic macroinvertebrates found; however, this impression changed significantly after surveying the other four sites – each one worse than the previous.

The WSWA anticipates re-surveying these same sites over the next few years as one means of determining whether or not our stream projects and educational efforts are having a positive effect on the Run. Since 2010 was a drought year in this area, even though we started out with a much greater than normal snowpack, we are hopeful that 2011 will bring a more normal pattern of precipitation. In any case, it will be interesting to see how the results compare.

Warm Springs Watershed Association

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Work Plan: Minor Watershed, Warm Springs Run, Morgan County, West Virginia of the Potomac River Basin, 1954

Figure 49: View of Warm Spring Ridge as seen from the East

Table 11: Soils and soil mapping unit

Soil Type	Map Unit Symbol	Soil Series	Acres in the Watershed	Percent in the Watershed
Residual Soils Formed on Shale	WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	2218.7	30.9%
	WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	1669.4	23.3%
	WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	814.7	11.4%
	WaC	Weikert channery silt loam, 8 to 15 percent slopes	351.1	4.9%
	BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	213.8	3.0%
	CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	74.2	1.0%
	BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	48.5	0.7%
	WaB	Weikert channery silt loam, 3 to 8 percent slopes	25.2	0.4%
		Total	**5415.6**	**75.5%**
Residual Soils formed on Sandstone	SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	244.0	3.4%
	Qo	Quarry, sandstone	152.3	2.1%
	SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	123.7	1.7%
	SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	39.7	0.6%
	SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	30.6	0.4%
	ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	7.5	0.1%
		Total	**597.8**	**8.3%**
Altered Soils	Ua	Udorthents, smoothed	368.8	5.1%
	Uu	Urban land-Udorthents complex, 0 to 25 percent slopes	206.0	2.9%
		Total	**574.8**	**8.0%**
Floodplain Soils	Ho	Holly silt loam	138.4	1.9%
	Ln	Lindside silt loam	68.0	0.9%
	Pg	Philo gravelly loam	42.6	0.6%
	Cz	Combs fine sandy loam	42.2	0.6%
	Ph	Philo silt loam	10.9	0.2%
	Me	Melvin silt loam	4.1	0.1%
			306.2	**4.3%**
Soils on Footslopes	BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	91.9	1.3%
	BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	43.3	0.6%
	BuC	Buchanan gravelly loam, 8 to 15 percent slopes	34.2	0.5%
	ErC	Ernest silt loam, 8 to 15 percent slopes	12.4	0.2%
	ErB	Ernest silt loam, 3 to 8 percent slopes	10.2	0.1%
	BuB	Buchanan gravelly loam, 3 to 8 percent slopes	7.0	0.1%
		Total	**199.0**	**2.8%**

Stream Survey Results

Table 12: Water chemistry	Test results				
	Site #1	Site #2	Site #3	Site #4	Site #5
Temperature	17 °C	23°C	20 °C	23 °C	22 °C
pH	7.5	7.0	7.5	6-6.5	7.5
Dissolved O_2	144% ?	140% ?	70%	75%	75%
Nitrate	1 ppm	ND	0 ppm	0 ppm	0-1 ppm
Turbidity	0 JTU	0 JTU	0 JTU	10 JTU	0 JTU
Iron	ND	ND	0 ppm	<0.5 ppm	0 ppm

°C = degrees Centigrade; ? = results in question; ND = not done; ppm = parts/million;
JTU = Jackson Turbidity Units

Table 13: Physical conditions	Results/Observations				
	Site #1	Site #2	Site #3	Site #4	Site #5
Avg width of run	16 ft	10 ft	10.5 ft	18 ft	15 ft
Avg depth of run	8 in	3 in	9 in	9 in	12 in
Avg riffle width	13 ft	ND	9 ft	18 ft	6-12 ft
Avg riffle depth	3.5 in	ND	2.5 in	4.25 in	3.5-5 in
Discharge rate	1.2 cfs	0.7 cfs	0.38 cfs	1.2 cfs	14.5 cfs ?
Water level	Normal	Normal	Low	Mod high	Low
Water clarity	Clear	Clear	Clear	Brown	Clear
Water color	None	Brown	None	None	None
Water odor	None	Musky	None	None	None
Sediment odor	None	ND	None	None	None
Streambed color	Brown	Brown	Brown	Brown	Brown
Surface foam	None	None	None	None	Slight
Algae color	Brown	Light green	Dark green/brown	Brn/dk green	Brown
Algae abundance	Moderate	Scattered	Heavy	Moderate	Moderate
Algae texture	Even coating	Matted	Even coating	Hairy	Hairy
Channel shade	>80%	60-80%	<40%	<40%	~ 15%

ft = feet; in = inches; cfs = cubic feet per second; ND = not done; ? = results in question

Table 14: Streambed composition	Percent of streambed				
	Site #1	Site #2	Site #3	Site #4	Site #5
Silt/clay	4	0	0	0	1
Sand	6	20	13	10	8
Gravel	55	58	71	54	63
Cobble	19	15	10	14	20
Boulder	1	7	4	9	4
Bedrock	15	0	0	11	3
Woody debris	0	0	2	2	1
Totals	100	100	100	100	100

Note: numbers are actual counts, not estimates

Table 15: Streambed compositions	Observations				
	Site #1	Site #2	Site #3	Site #4	Site #5
Sediment deposition	Suboptimal	Marginal	Marginal	Optimal	Optimal
Embeddedness	Suboptimal	Marginal	Optimal	Optimal	Optimal
Bank stability: Right	Optimal	Marginal	Optimal	Optimal	Optimal
Left	Suboptimal	Marginal	Optimal	Optimal	Suboptimal
Riparian buffer width: Right	Poor	Suboptimal	Poor	Poor	Poor
Left	Marginal	Suboptimal	Poor	Poor	Marginal

S = streamside at the site; M = within a ¼ mile of the reach site; W = within watershed
Level of activity/disturbance indicated by: 1-slight; 2-moderate; or 3-high

Table 16: Land uses		Location and level of activity/disturbance			
	Site #1	Site #2	Site #3	Site #4	Site #5
Active construction	-	M2	-	M1	-
Mountaintop mining	-	-	-	-	-
Deep mining	-	-	-	-	-
Abandoned mining	-	-	-	-	-
Logging	W1	W1	W1	W1	W1
Oil and gas wells	-	-	-	-	-
Recreation (parks, trails)	-	W1	S3	S1	-
Pastureland	M1	W2	W2	W2	W2
Cropland	-	-	-	-	S3
Intensive feedlots	-	-	-	-	-
Unpaved roads, parking areas	M1	W1	-	S1	M1
Trash dumps	-	-	-	-	-
Landfills	-	-	-	-	-
Industrial /commercial areas	M2	W1	W1	M1	W1
Single family homes	S1	M2	M1	M2	-
Suburban development	W1	W1	S3	M1	W1
Parking lots, strip malls, etc.)	M2	W1	S3	S2	W1
Paved roads	S1	M3	S3	M2	S1
Bridges	S1	M1	S2	S1	S1
Railroad yard	W1	W1	W1	W1	M1

Table 17: Benthic macroinvertebrates		Distribution			
	Site #1	Site #2	Site #3	Site #4	Site #5
Mayflies (*Ephemeroptera*)	50	4	6	10	2
Stoneflies (*Plecoptera*)	58	1	-	-	-
Case-building caddis (*Trichoptera*)	-	-	-	-	-
Net-spinning caddis (*Trichoptera*)	1	14	-	14	58
Common netspinner (*Hydropsychidae*)	-	13	25	64	21
Dragonflies (*Anisoptera*)	1	14	40	-	-
Damselflies (*Zygoptera*)	-	1	-	-	-
Riffle beetles (*Elmidae*)	-	11	14	2	6
Water pennies (*Psephenidae*)	1	43	91	11	18
Other beetles (*Coleoptera*)	1	2	-	-	-
Hellgrammites/Fishflies (*Corydalidae*)	-	-	-	2	-
Alderflies (*Sialidae*)	-	-	-	-	-
Non-biting midges (*Chironomidae*)	2	2	-	1	1
Black flies (*Simulidae*)	-	-	-	-	-
Crane flies (*Tipulidae*)	1	7	3	3	-
Watersnipe flies (*Athericidae*)	-	-	-	1	-
Other true flies (*Diptera*)	-	-	-	-	-
True bugs (*Hemiptera*)	-	2	-	-	-
Crayfish (*Decapoda*)	3	5	2	2	2
Scuds/Sideswimmers (*Amphipoda*)	1	2	1	-	>50
Aquatic sowbugs (*Isopoda*)	-	-	-	1	2
Clams (*Veneroida*)	-	-	-	2	-
Mussels (*Unionidae*)	-	-	-	-	-
Operculate snails (*Prosobranchia*)	-	-	-	-	-
Non-operculate snails (*Pulmonata*)	1	-	-	-	-
Aquatic worms (*Oligochaeta*)	3	-	-	14	1
Leeches (*Hirudinea*)	-	4	-	-	-
Flatworms (*Turbellaria*)	1	-	-	-	>50
Salamanders (*Caudata/Urodela*)	1	5	3	-	-

Note: specimens were collected in a kick net at 2-3 locations on each reach

Map 6: steep slopes in the watershed.

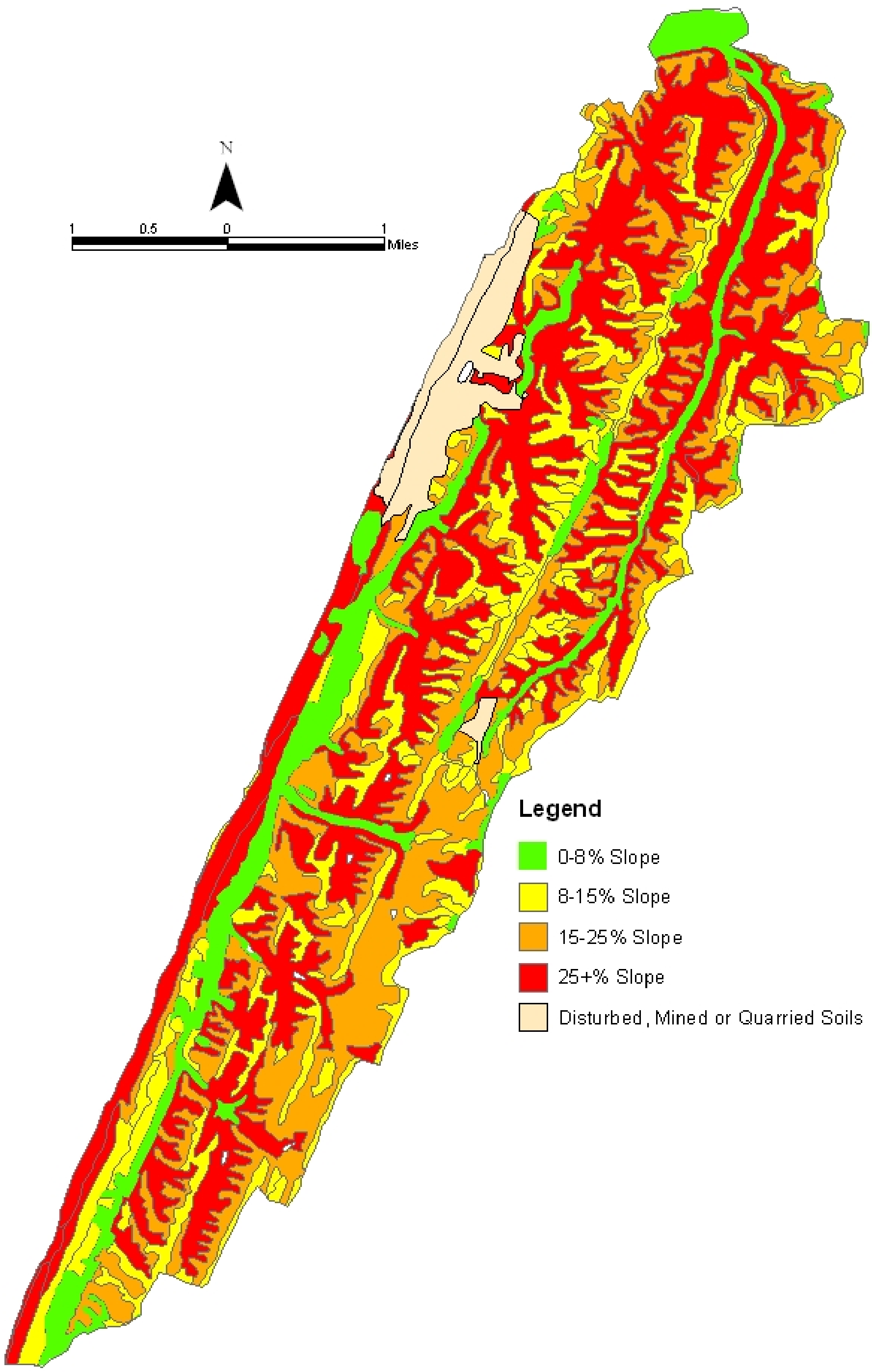

Figure 50: View of Warm Springs Ridge, western boundary of the Warm Springs Run Watershed. In the center of the photo stands the new Morgan County Courthouse built to replace the Courthouse destroyed by fire in 2006.

Warm Springs Watershed Association