Comprehensive Watershed Based Management Plan for Warm Springs Run

A Potomac Direct Drains Watershed

Morgan County, WV

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By

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Cover photo - Warm Springs Run as it passes through Berkeley Springs State Park. (Note well-developed limestone gravel point bar just upstream from the foot bridge.) Credits **-** Robert K. Denton Jr., April 2012

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Preface

The Warm Springs Run is the outfall channel of the largest thermal spring in the Potomac Highlands Region, a unique environmental feature of both historic and natural significance. The reputed therapeutic quality of the spring waters attracted the Native American people to the site. Subsequently, the first spa in the American colonies sprang up around the springs named after the town of Bath, England.

Although the springs were highly valued, and thus conserved and protected from contamination, the Warm Springs Run itself did not merit such regard. Used as an open sewer and waste dump for various historic industries in the Town of Bath, the stream became significantly polluted. Thankfully, in recent decades there has been a concerted effort to reverse the environmental impacts to the Run. The historic industries closed down many years ago. The construction of a sanitary sewer main, installed from 1976 – 1979, extending the length of the stream, now prevents the discharge of waste directly into the channel. However, despite these improvements, the stretch of the Warm Springs Run south of the Town of Bath, upstream from the historic springs, is still utilized by many as little more than a drainage ditch. Currently, this upstream section of the Run still suffers the greatest number of impacts from contemporary development, while the section downstream from the Town of Bath to near the confluence with the Potomac River remains in a relatively undisturbed, natural state.

It is our hope that this management plan will aid the Warm Springs Run Watershed Association, Morgan County, and the State of West Virginia to manage the negative impacts to this important little stream. In doing so, the larger goal of protecting the Chesapeake Bay will be contributed to as well.

Introduction and Description of Warm Springs Run Watershed

The purpose of this document is to provide a Comprehensive Watershed Management Plan for the US Environmental Protection Agency, the Warm Springs Watershed Association, and the stakeholders of the Warm Springs Run (WSR) watershed, to guide future non-point source project proposals for funding through the Clean Water Act Section 319 and other sources.

In 2012 the Warm Springs Watershed Association was awarded a FY11 Chesapeake Bay Regulatory and Accountability grant to be used in the creation of a Comprehensive Watershed Management Plan for the Warm Springs Run (WSR) and its tributaries. This management plan is intended to provide guidance for stream bank restoration and contaminant mitigation activities with the goal of helping West Virginia achieve Total Maximum Daily Load (TMDL) requirements.

The scope of services as outlined in the grant proposal is as follows:

1. Consultant(s) will synthesize information reported in existing reports and documents provided by the client (e.g. Warm Springs Run Watershed Assessment, etc.)

2. Consultant(s) will provide engineering and geological assessment support to analyze soils, geology, hydrology and geomorphology that contribute to non-point and point source pollution in the WSR.

3. Consultant(s) will document the load reductions needed from the WSR watershed to help West Virginia achieve TMDL goals. Consultant(s) will propose a suite of practices to achieve point and non-point source reductions. Also considered will be practices in the non-regulated developed lands section of the Comprehensive Watershed Management Plan (e.g. residential fertilizer and runoff reduction practices).

4. Consultant(s) will:
    a. investigate sources of stream quality impacts relative to their respective negative effect on the Run;
    b. present recommendations on a cost-benefit basis, prioritizing which would which would provide the most benefits from a financial and/or acceptability of implementation basis;
    c. categorize recommendations on the basis of funding source availability (e.g. 319 non-point source reduction; Chesapeake Bay Fund, etc.).
    d. regardless of what recommendations for action that are listed in the management document, the consultant will list next steps to deliver the highest-priority implementation actions. The proposed plans for implementation will include, where possible, education-based as well as engineering-based interventions.

5. Consultant(s) will prepare cost estimates and determine entities to provide technical assistance and remedial activity implementation for all proposed actions.

6. Consultant(s) will deliver a Comprehensive Watershed Based Management Plan to the WSR Watershed Association.

Physical Setting

The WSR watershed is located in north central Morgan County West Virginia, and is the principle surface drainage of the valley formed by Warm Springs Ridge to the west and Horse Ridge, to the east.

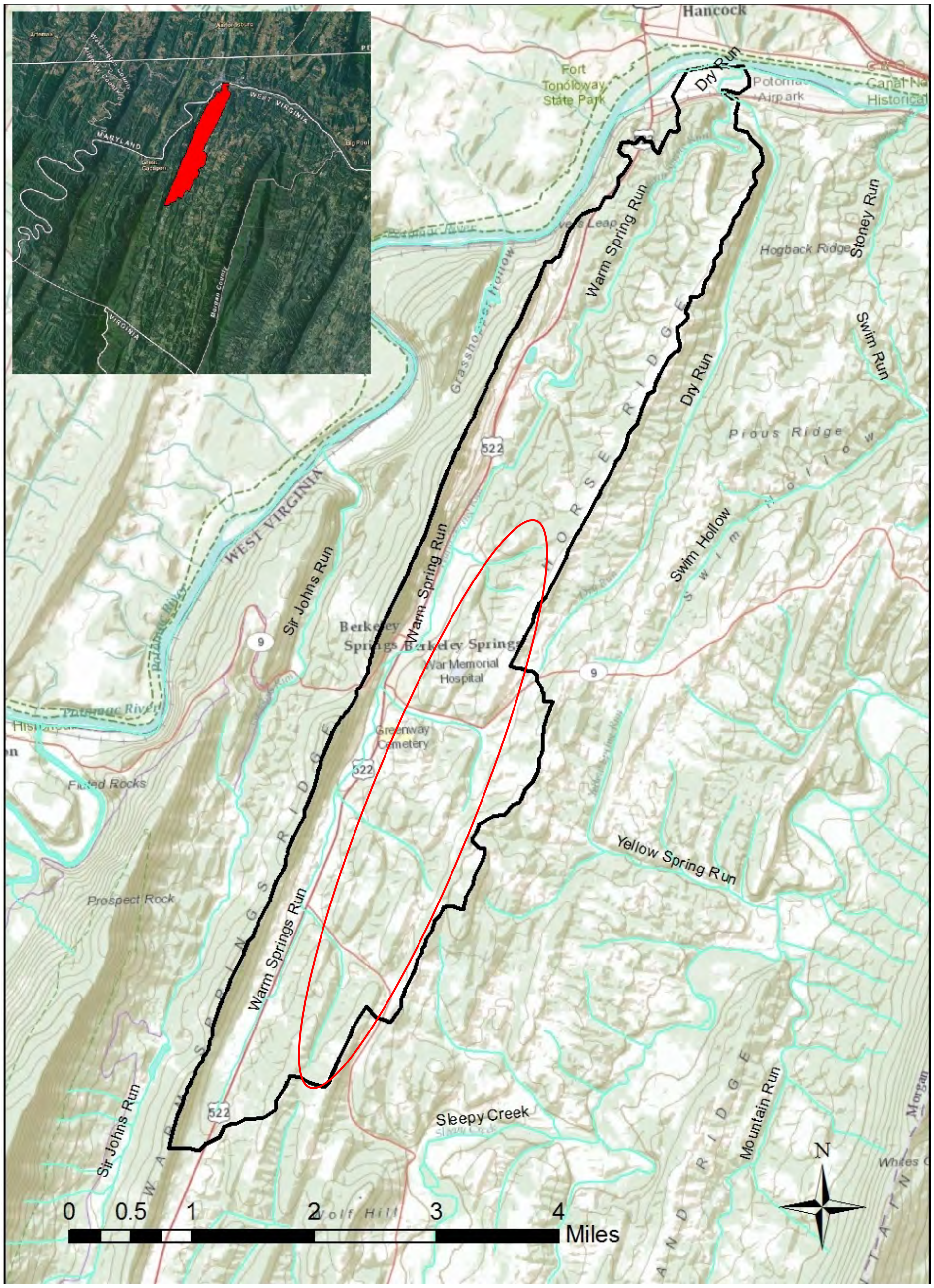


Figure 1. Location of the Warm Springs Run watershed (black outline) in Morgan County, WV. The eastern tributaries are within the red oval.

The WSR is approximately 11.8 miles in total length, and is a non-navigable stream throughout (see Figure 1). The total watershed catchment of the WSR has been estimated at approximately 7,178 acres (not including the Dry Run Watershed to the east); however, the USGS reports the watershed as 7,084 acres (Wiley, et al., 1996). There are five (5) eastern tributaries to the WSR originating in the upland to the east of the main stem's valley, from north to south, respectively: 1) an (unnamed) stream running along Jimstown Road, 2) Yellow Spring Run, 3) an unnamed stream running through Sugar Hollow, 4) Kate's Run, which parallels Winchester Grade Road, and 5) the Dry Run.

Topography and Geology

The topography of the WSR is typical of the drainages located in the eastern Potomac Highlands section of the Ridge and Valley Physiographic Province. The stream's main stem follows along the eastern edge of the Cacapon Mountain Anticlinorium (a broad, generally upward folded area of bedrock), where relatively soft, erosion-prone shale contacts the hard, erosion-resistant Oriskany sandstone forming Warm Springs Ridge. Warm Springs Ridge is the eastern "hogback" of Cacapon Mountain, and extends parallel with the axis of the Cacapon Mountain Anticline (see Figure 2).

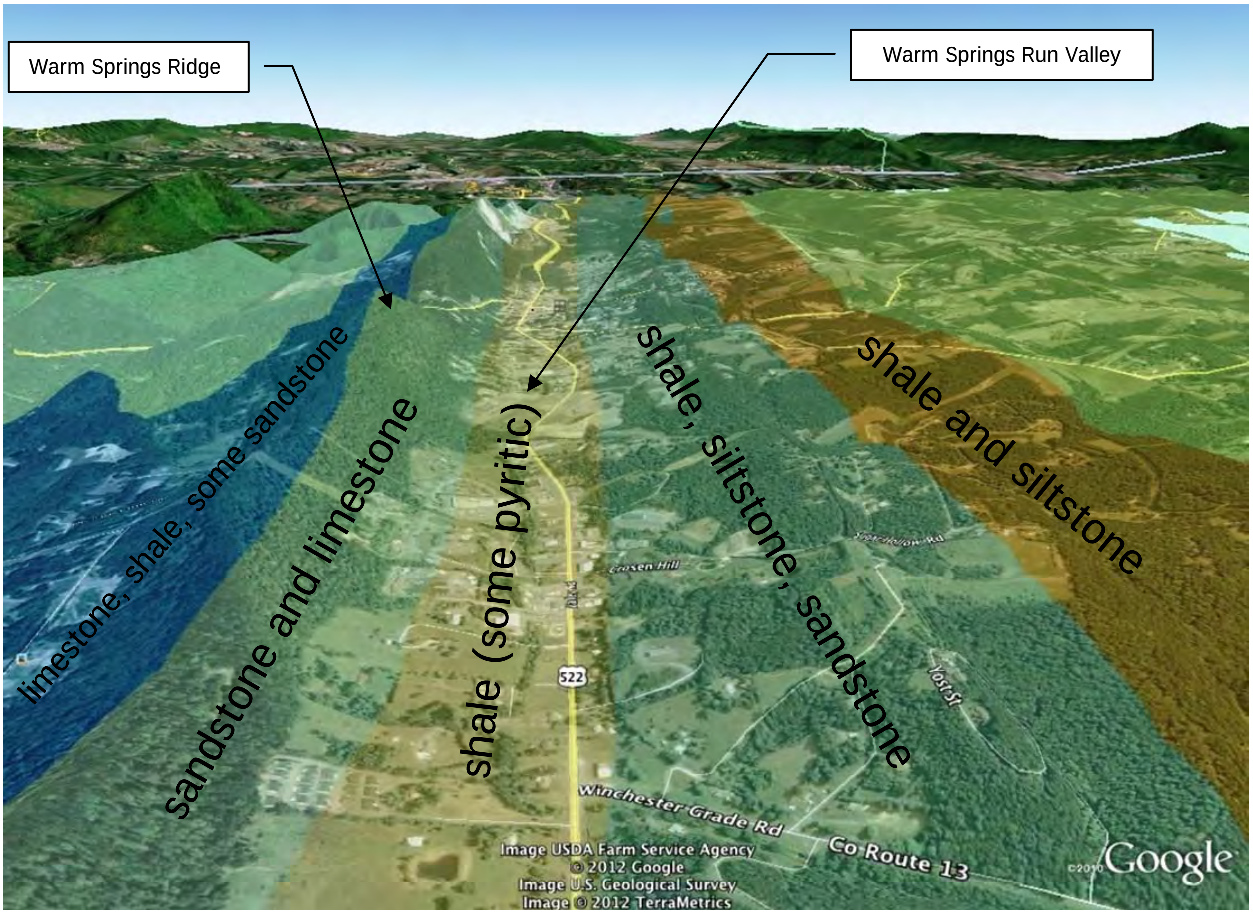


Figure 2. Topographic setting and generalized rock types of the Warm Springs Run Valley.

The WSR valley is underlain entirely by the shale, siltstone and sandstone of the Marcellus, Needmore, and Mahantango Formations, all dating from the Devonian geologic period 415 to 355 mya[1]. The southern (upstream) section flows along the contact of the two units, and is probably controlled by the underlying rocks' lithology and structure. The central section is underlain by the Marcellus and Needmore shales, but the stream wanders back onto the Mahantango in its northern (downstream) reach.

The subordinate, eastern tributaries of the WSR are all underlain by the Brallier and Chemung Formations, composed of clastic rocks (shale, siltstone, and sandstone) also dating to the Devonian geologic period. The plan view of the regional geology is shown on Figure 3, and a cross section is shown on Figure 4.

[1] million years ago

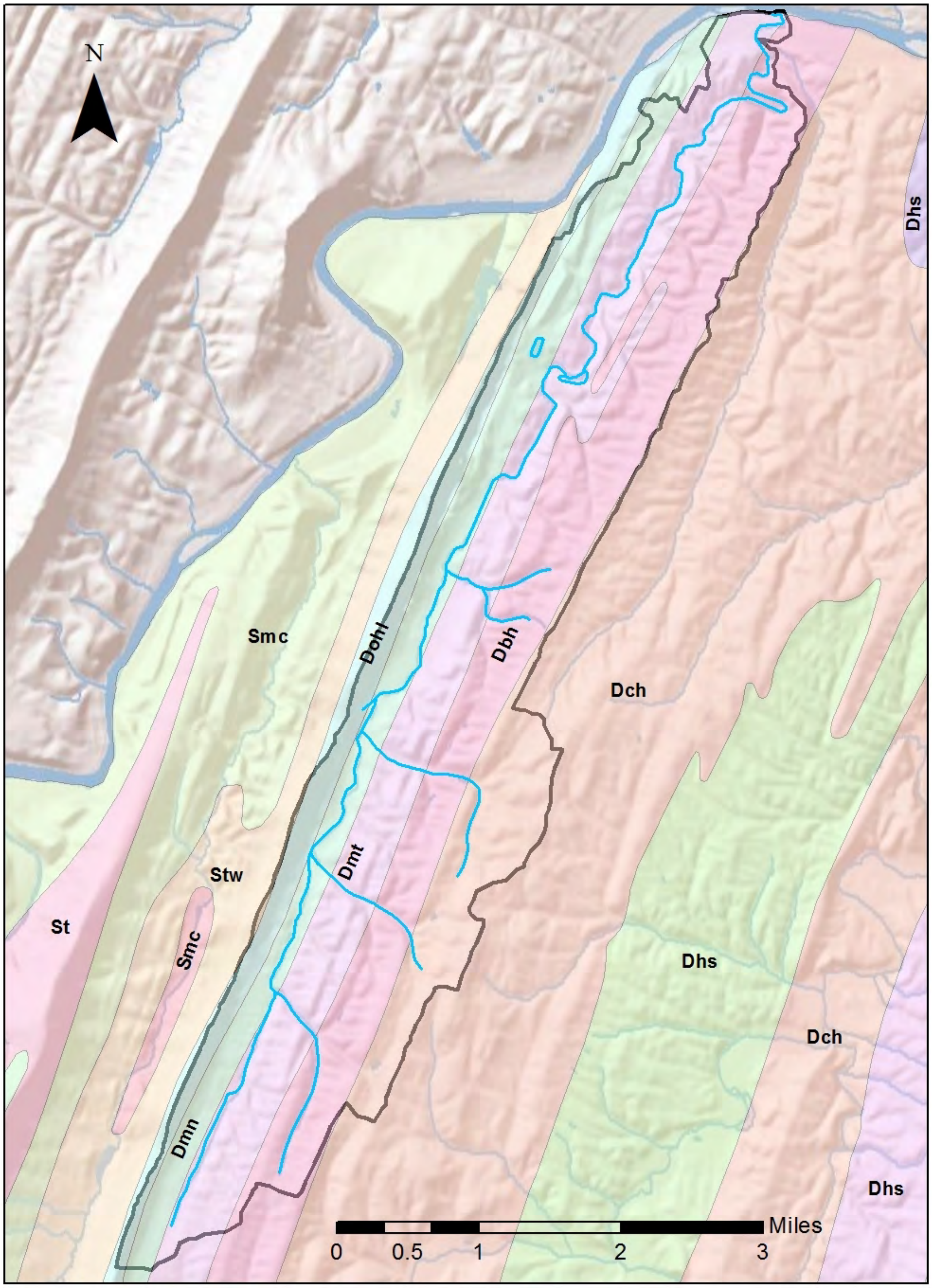


Figure 3. Areal bedrock geology map of the WSR Watershed. (Abbreviations Key: St = Tuscarora Formation; Smc = Mackenzie Group; Stw = Tonoloway and Wills Creek Formations; Dohl = Oriskany Sandstone and Helderberg Limestone; Dmn = Marcellus/Needmore Formations; Dmt = Mahantango Formation; Dbh = Brallier Formation; Dch = Chemung Formation; Dhs = Hampshire Formation)

Key to Geological Codes

(Devonian Period)
Dha – Hampshire Fm.
Dch – Chemung Fm.
Dbh – Brallier Fm.
Dmt – Mahantango Fm.
DMn – Marcellus & Needmore Fms.
Do – Oriskany Group
DS – Early Devonian & Late Silurian Carbonates (includes Helderberg, Tnoloway and Wills Creek Fms.)

(Silurian Period)
Sb – Bloomsburg Fm.
Smc – Mackenzie Group
Srh – Rose Hill Fm.

(Ordovician Period)
Oj – Juniata Fm.
Oo – Oswego Fm.
Om – Martinsburg Fm.
Oc – Conococheague Fm.
Otbr – Trenton & Black River Group Carbonates
Ob – Beekmantown Fm.

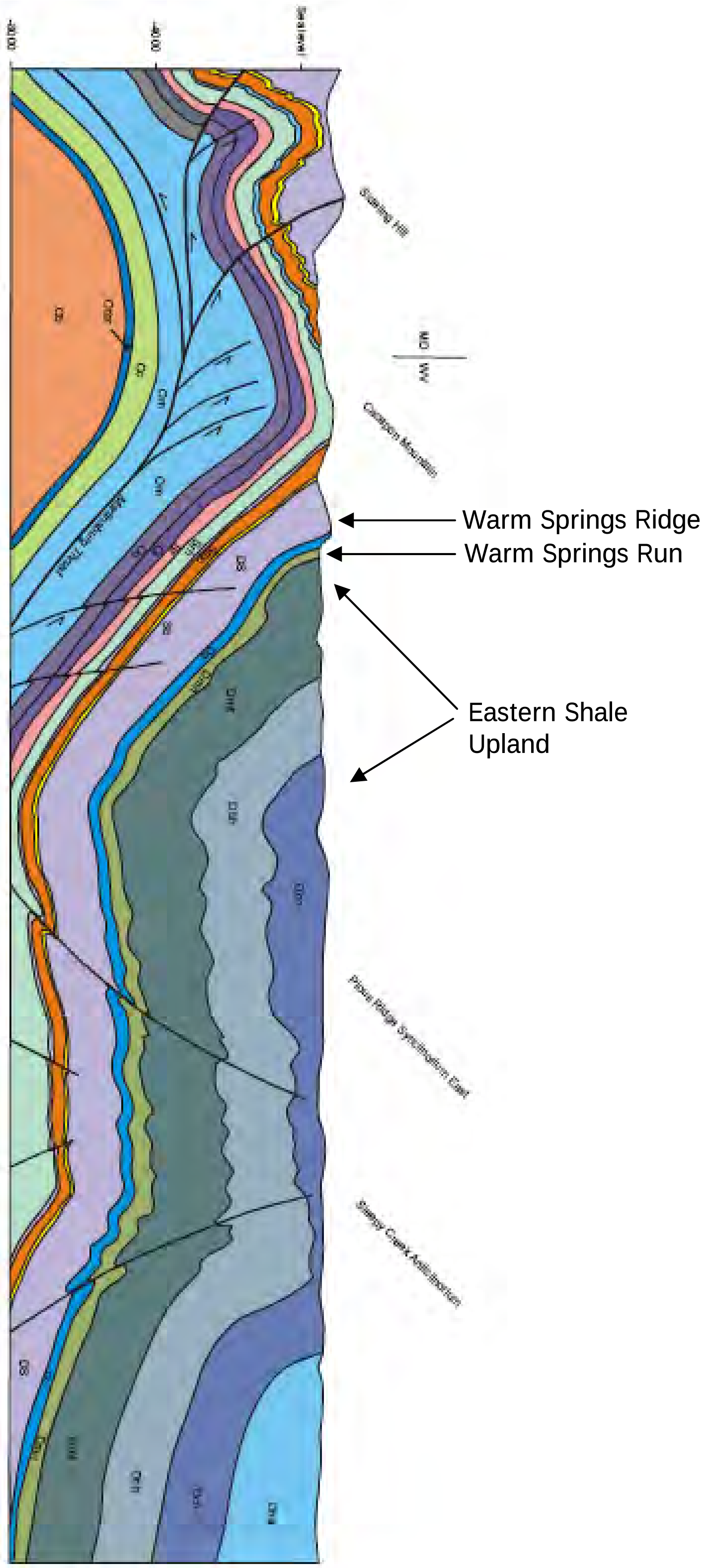


Figure 4. Cross section of the regional geology of the WSR watershed (Donovan et al, 2006).

Mapped Soils

The soils mapped within the WSR Watershed have been discussed in detail in the 2010 WSR Watershed Assessment (WSWA, 2010); however, they can be divided into four (4) broad categories:

1. **Residual soils formed by weathering from shale, siltstone and fine grained sandstone** comprise the majority of the soils in the WSR Valley and the eastern upland area. The predominant soil in the watershed, the Weikert Series, underlies over 65% of the entire area, with lesser amounts of Clearbrook and Cavode soils. These soils are very shallow, averaging only 20 to 40 inches before reaching weathered (paralithic) bedrock, and 36 to 48 inches before reaching hard, lithic bedrock. These soils can have perched water tables, ranging from 10 to 24 inches below the surface. The Weikert series soils have severe erosion potential, while the Clearbrook and Cavode soils have slight to moderate erosion potential. The Weikert Series soils have moderately low to high permeability (0.06 to 6.00 in/hr). They are generally considered very limited for the construction of septic drain fields due to seasonally elevated water tables, shallow bedrock, and high permeability. These soils can have a low pH due to the presence of acid sulfate derived from pyrite present in the parent material (pyritic shale).

2. **Residual soils formed from sandstone on the slopes of Warm Springs Ridge** comprise the second most common soil type in the watershed, dominated by the Shaffenaker and Vanderlip series. These soils are granular, poorly consolidated loamy sands that have severe erosion potential when their vegetative cover has been removed. These soils have been heavily denuded of fines (eluviated), with what little content of fines being transported downhill to the footslope soils. These soils have moderately high to extremely high permeability (0.6 to 19.98 in/hr).

3. **Floodplain soils,** which are composed of transported colluvium and alluvium that have been deposited in the stream valley bottomlands, include the Holly, Melvin, Coombs and Philo series. These soils have been covered or obliterated by development in much of the upstream reach (south of Berkeley Springs) of the WSR watershed. These soils have slight to moderate erosion potential. The floodplain soils have moderately high to high permeability (0.6 to 2.0 in/hr), are frequently flooded, and can have high seasonal water tables. Two of the soils (the Holly silt loam and Melvin silt loam) are considered hydric soils. Hydric soils are characterized by an abundance of moisture and reduced oxygen levels to the extent that the soil supports only water tolerant vegetation. Hydric soils are generally associated with wetland areas.

4. **Footslope soils** are formed by a combination of in-place weathering and the transport of fine soil components from higher elevations, and consist primarily of the Buchanan and Ernest series. These soils are higher in clay content than most of the other soils in the WSR watershed, and often have perched water tables ranging from 16 to 24 inches below the surface. These soils have moderately low to moderately high permeability (0.06 to 0.6 in/hr).

A custom soil report for the WSR watershed was obtained from the USDA-NRCS on May 16, 2012, and is included as Appendix A. A comprehensive comparison of the mapped soils to observed soils was beyond the scope of this management plan; however, during the field work for the plan development all of the observed soils compared favorably with their equivalent mapped units.

Hydrology

The Warm Springs Run is a perennial stream, with a "trellice" pattern typical of the Potomac Direct Drain system of the eastern Potomac Highlands section of the Ridge and Valley Geophysical Province. The stream's overall course is controlled by the structure of the bedrock over which it flows, as discussed in the previous section on geology. The stream originates at a head spring at an elevation (EL) of approximately 818 feet above mean sea level (AMSL). The stream declines in elevation gradually as it flows northward, and enters the Potomac River at EL 397, just to the east of Hancock, Maryland and approximately 5-miles north of the Town of Bath. There are no sudden drops in elevation, so accordingly there are no significant waterfalls or cascades along the main branch of the WSR. The summit of Warm Springs Ridge to the west of the WSR ranges from 200 to over 400 feet above the valley floor. The highest point of the Ridge is just north of the Town of Bath, at approximately EL 1,060. The shale upland to the east of the mainstem valley ranges from EL 600 to EL 900, with an average elevation of 800 feet AMSL.

Figure 5. Map showing the upstream tributaries and flood control dam locations. The dams are assigned unique identifiers based on the original proposed number of nine (9) dams. Dam #8 was never constructed.

As is typical of the surface streams in the rugged Potomac Highlands, the WSR has a modest perennial base flow[2], but is prone to severe flash flooding after major rainfall events, rapid snowmelt, or a combination of the two. In an effort to control the flash flooding of the main valley nine (9) dams were proposed for the upstream portion of the watershed. Between 1955 and 1961, eight (8) of the nine proposed dams were constructed on various tributary streams throughout the watershed (see Figure 5).

[2] The stream base flow of Morgan County has not been measured as of this report's date.

The dams control runoff from approximately 1,271-acres, and are designed to detain 278 acre-feet (90 million gallons) of water.

The flood control dams managed to mitigate the catastrophic flash flooding that has occurred along the main branch of the WSR since historic times; nevertheless, the WSR is still prone to flooding after major surface flow events. The flood control dams moderate less than 20% of the stream's flow, and rapid runoff as a result of both tropical storms and combined snowmelt/rainfall since that time has continued to cause flooding in Berkeley Springs and the Town of Bath. Storm events greater than 1-inch of rain can cause sheet flow off the steep ridge to the west of town, and the upland to the east; this flow is exacerbated by the fact that these events often occur after the regional soils have been saturated by prior rain or snowmelt. Under such conditions, even permeable soils will shed the water, and the WSR then becomes the primary drain for the valley and its environs.

Stream Channel Modification - Examination of historical topographic maps (Hancock, 1901 – surveyed 1899) suggests that the course of the Warm Springs Run and its tributaries has changed little over the past century. An excerpt of the historic topographic map is included as Figure 6.

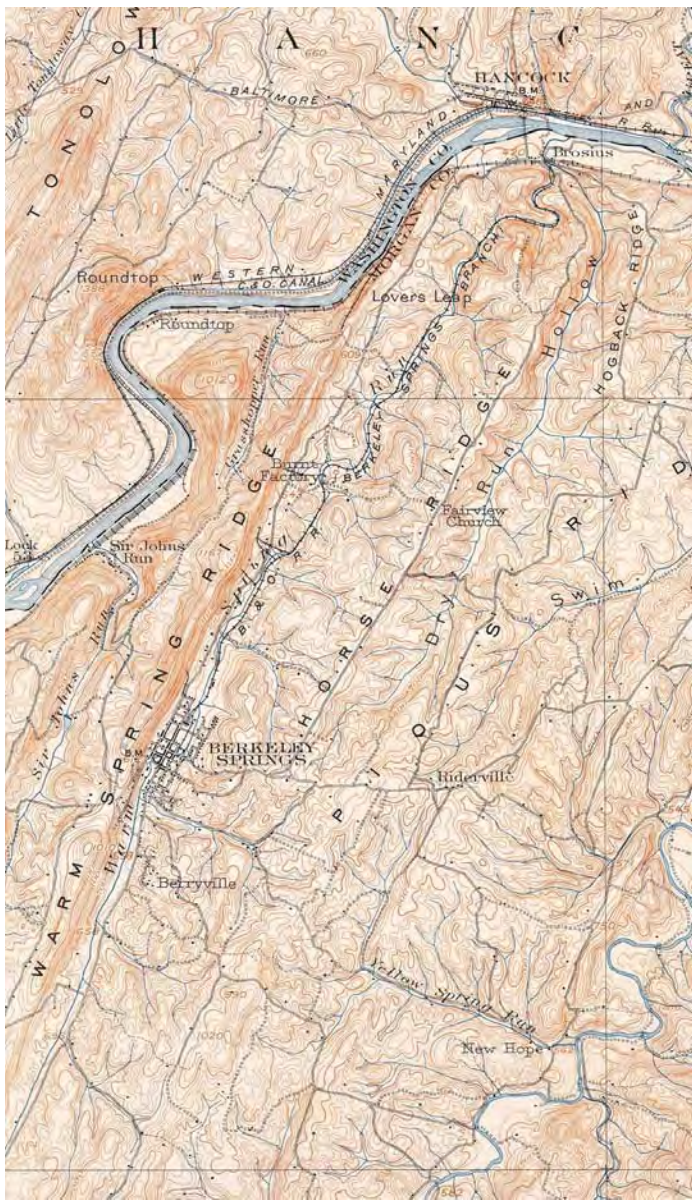


Figure 6. Excerpt of the 1901 Hancock Topographic Quadrangle.

Groundwater - The WSR derives its groundwater base flow from two very different sources, these being: 1) a series of headwaters springs located entirely within the Devonian shale formations, and 2) the Warm Springs themselves, which arise from the Oriskany Sandstone at the east-central base of the Warm Springs Ridge.

The headwater springs are nearly all diffuse rises without a discernable "throat" or discreet opening from the subsurface. Many appear as marshy or swampy wet "areas", and are not readily recognizable as "springs", per se. These springs are recharged by small water-bearing fractures in the bedrock. Water which initially collects in a shallow aquifer that reposes in the soil and weathered rock overburden layer diffuses slowly into the underlying bedrock aquifer through a myriad of tiny cracks and openings. The springs generally rise where there is a contact between different lithologies in the bedrock, often where a less permeable rock type (solid shale, siltstone) contacts a more permeable rock (fractured shale, sandstone, etc.), or where there are small faults or disconformities in the bedrock stratum. It is of note that as it percolates through the strata on its journey to the springs the groundwater picks up various minerals and metals that are present in the bedrock, resulting in the occurrence of "chalybeate" (iron bearing) springs which are often mistaken as sources of contamination due to reddish "slimes" and discoloration coming from the spring rise. These slimes and sheens are due to the presence of naturally occurring iron and sulfur fixing bacteria, which utilize the dissolved iron in their metabolisms. The reddish colors around the spring heads are the result of the iron being oxidized as it comes into contact with the atmosphere.

The eastern tributaries have a low base flow. While this flow has not been measured to date; our field observations did not show any flow greater than 20 to 30 gallons per minute (gpm) during April 2012 in any of the tributaries. The WSWA measured various stream parameters, including flow, during the period of April through June, 2010. Locations of the WSWA monitoring points are shown on Figure 7.

The greatest contributors to the base flow of the WSR are the Warm Springs located in Berkeley Springs State Park. The springs arise from five (5) discreet conduits in the Oriskany Sandstone, at the base of the eastern face of Warm Springs Ridge. The combined flow of the springs is variable, but nominally is reported as averaging 1,000 gpm. The springs were monitored in a groundwater study from November 2005 through March 2006, and the combined flow from the Ladies Spring and Lord Fairfax Spring (two of the five spring rises) varied from a high of 1,930 gpm to a low of 538 gpm (Donovan, et al., 2006). It is interesting to note that the flow at the Warm Springs varied in concert with the flow of Tonoloway Spring (also called the Suburban Bottling Spring), located in the Cold Spring Valley on the western side of Warm Springs Ridge.

Over the years there have been several attempts by hydrologists to locate the recharge area of the Warm Springs; however, the exact location of the recharge area has yet to be established. A study by the USGS in 1994 proposed that 2/3 of the recharge occurred along and on the Warm Spring Ridge, extending at least 11 miles south of the Town of Bath (Lessing and Hobba, 1994). This study also concluded that the temperature of the springs (averaging 74.5^{o} F) suggests the water circulates to a minimum depth of 1,825-feet below the surface. Tritium isotope analysis of the Warm Springs indicates that the majority of the water is at least 30 years old.

In contrast, the 2006 study (Donovan, et al., 2006) examined the geochemistry of the Warm Springs, as well as the flow rates in a series of springs located west of Warm Springs Ridge. This study established that the water chemistry of the Warm Springs more closely matched springs arising from carbonate (limestone/dolostone) aquifers, in particular the karst Helderberg Limestone and Tonoloway Formation, lying between Warm Springs Ridge and Cacapon Mountain. The Warm Spring differed significantly from the springs originating in regional clastic rock (sandstone, shale, etc.) aquifers. The Warm Springs' flow rate also varied in parallel with the carbonate springs, in particular the aforementioned Tonoloway Spring. These data suggest that the Warm Springs must have a recharge zone that extends beyond the Warm Spring Ridge, and may stretch as far as the eastern slope of Cacapon Mountain (see Figure 4).

Figure 7. Level 1 Stream Survey sampling and observations points being monitored by the Warm Springs Run Watershed Association, with discharge rates measured during the late Spring and Summer of 2010.

Section A - Sources of Impairment in the Warm Springs Run Watershed

Along with all of the other jurisdictions with waters flowing into the Chesapeake Bay, West Virginia has been assigned a Cap Load. The combined Cap Load for all of the jurisdictions represents an overall pollution "diet" that the Chesapeake Bay requires to become healthy again. WV's Cap Load is a "calorie limit" for nitrogen, phosphorus, and sediment limits for WV's portion of the Potomac Basin. For each of these pollutants WV must develop a strategy to reduce the current pollutant load down to the level of the Cap Load as well as derive a strategy on how that Cap Load will be maintained. To do this, we must first know what the current load is, what the future loads will be, and which pollutant sources are responsible for generating those loads (WV-WIP, 2012).

The Chesapeake Bay Program has determined that many of the actions West Virginia is taking to attain the nitrogen and phosphorus Cap Loads will also reduce sediment pollution in West Virginia's rivers and streams sufficiently to achieve the sediment Cap Load for the Bay. Therefore, West Virginia WIP strategies are provided only for nitrogen and phosphorus.

Current and future pollutant load estimates are generated by the Chesapeake Bay Watershed Model (CBWM) and broken down into land uses (sources) and locations. Examples of land use are pasture and developed land. Each of these land uses has a pollution load associated with it (Figure 8). The location part of the equation can best be thought of as a watershed, or all the land area that drains to a particular body of water.

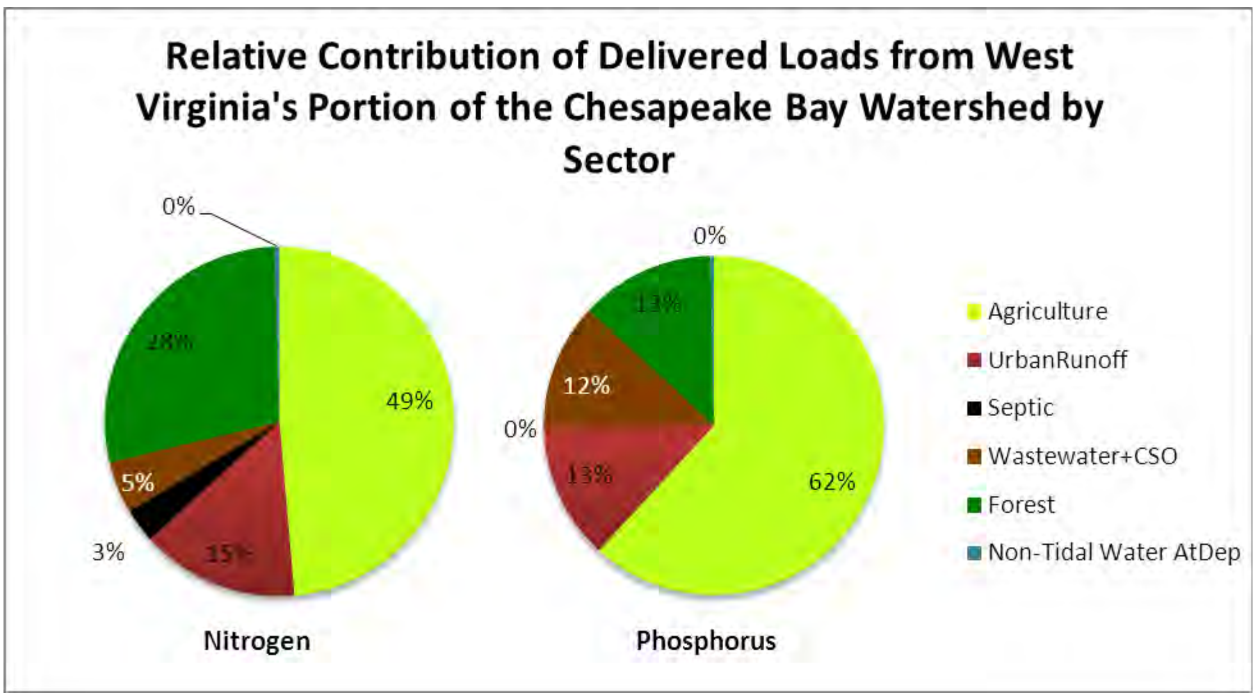


Figure 8. Delivered nitrogen and phosphorus loads from major load sectors in West Virginia. Estimates are generated by the Chesapeake Bay Watershed Model. (WV-WIP, 2012)

The pollutant sources which are responsible for generating loads are grouped into "sectors". The major load sectors in West Virginia are Wastewater, Developed Lands and Industrial (sometimes called "Urban Runoff"), Agriculture, Forest, and Other. Sources within sectors may be regulated or unregulated. Typically, point sources are regulated by National Pollutant Discharge Elimination System (NPDES) permits and non-point sources are unregulated. However, certain functionally similar sources are alternatively classified as point and non-point sources. One example is the subset of animal feeding operations identified as Concentrated Animal Feeding Operations (CAFOs) that require NPDES permits, and the subset of animal feeding operations that do not meet the CAFO size threshold and, therefore, do not require permits. Another example is permitted urban areas that have been designated as municipal separate storm sewer system (MS4) sources based on population density, and non-permitted urban areas that do not meet the population density threshold for MS4 designation. TMDLs must establish “wasteload allocations” for point sources and “load allocations” for non-point sources and background loads. Total nitrogen and phosphorus loadings used in the Chesapeake Bay Model have been calculated for the WSR and Dry Run watersheds as shown in Figures 9 and 10, however, it should be noted that these loadings were based on the land use categories shown on Figure 8, broken down specifically for the WSR Watershed.

The CBWM categorizes loads into “edge-of-stream” and “delivered” loads. An edge-of-stream load, as the term suggests, is the amount of pollutant that enters the stream in the locality of the pollutant source. A delivered load is the proportion of the edge-of-stream load that ultimately reaches the Chesapeake Bay. For nitrogen, the delivered load decreases as you get farther away from the Bay due to in-stream biological processes that convert available nitrogen to gaseous elemental nitrogen. Thus, one pound of edge-of-stream load from Jefferson County, which is closer to Chesapeake Bay, has a much greater impact to downstream tidal waters than a pound of edge-of-stream load from Morgan County, which is further away. The difference between edge-of-stream and delivered loads affects the overall cost and efficiency of implementing pollution reductions.

Based on the CBWM, the load reductions (lbs/acre) of nitrogen, total suspended solids and phosphorus needed to meet the 2025 Chesapeake Bay Initiative goals were estimated by WVDEP for the WSR watershed as shown on Table 1.

Table 1. Projected Load Reductions to meet the 2025 Goals

Total 2010NA Loads	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	19.23	789.94	1.26
Pasture	17.97	790.50	1.77
Residential	18.01	327.05	1.19
2025 Goals	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	15.74	649.53	1.09
Pasture	13.94	512.16	1.28
Residential	17.99	320.51	1.19
Reduction Needed	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	3.50	140.41	0.18
Pasture	4.03	278.35	0.49
Residential	0.03	6.54	0.01
Note – All values in lbs/acre			

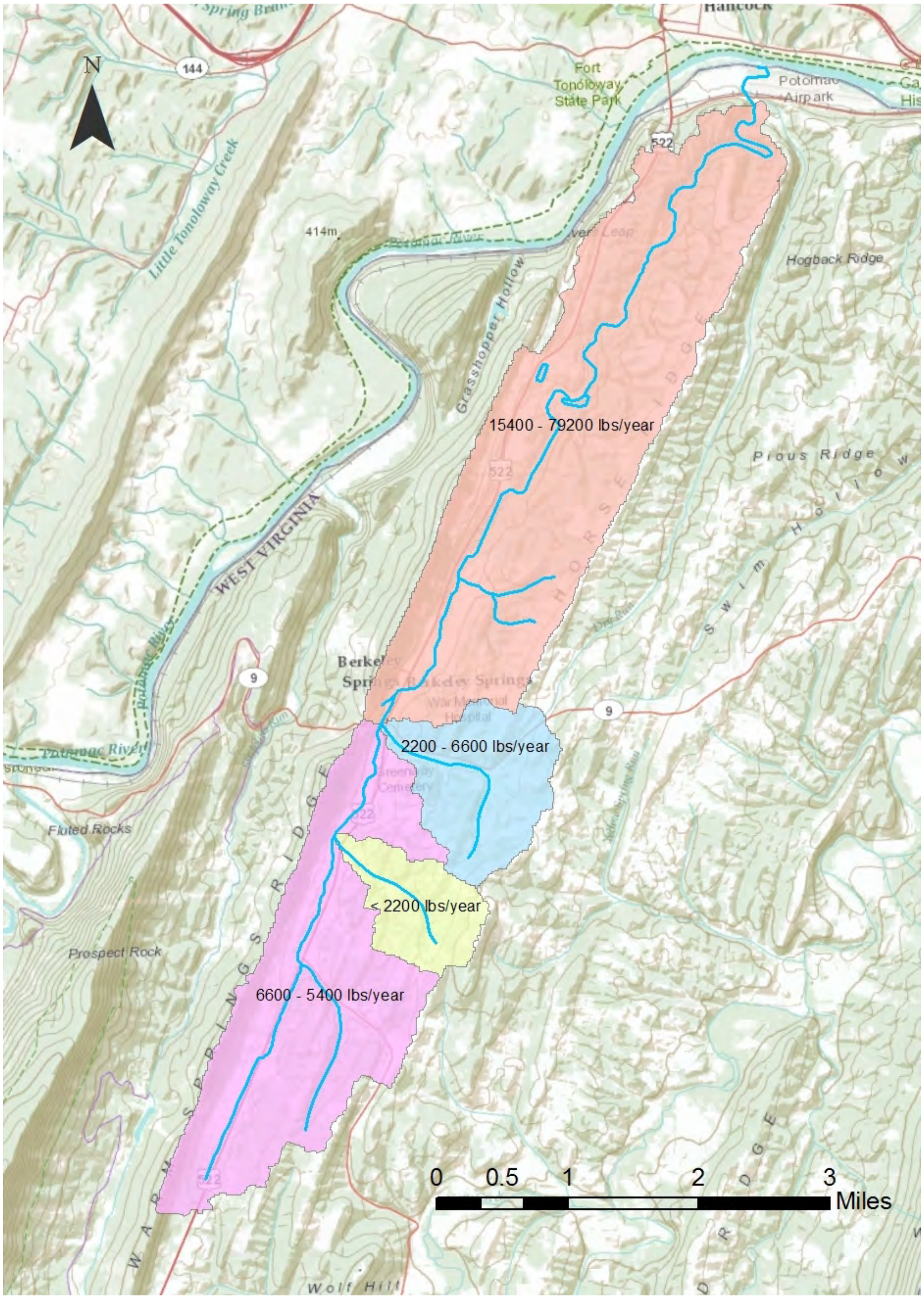


Figure 9. Nitrogen loads (per annum) estimated for the WSR Watershed based on the Chesapeake Bay Model. Individual catchment area load data were derived from the USGS Sparrow Surface Water Quality Model.

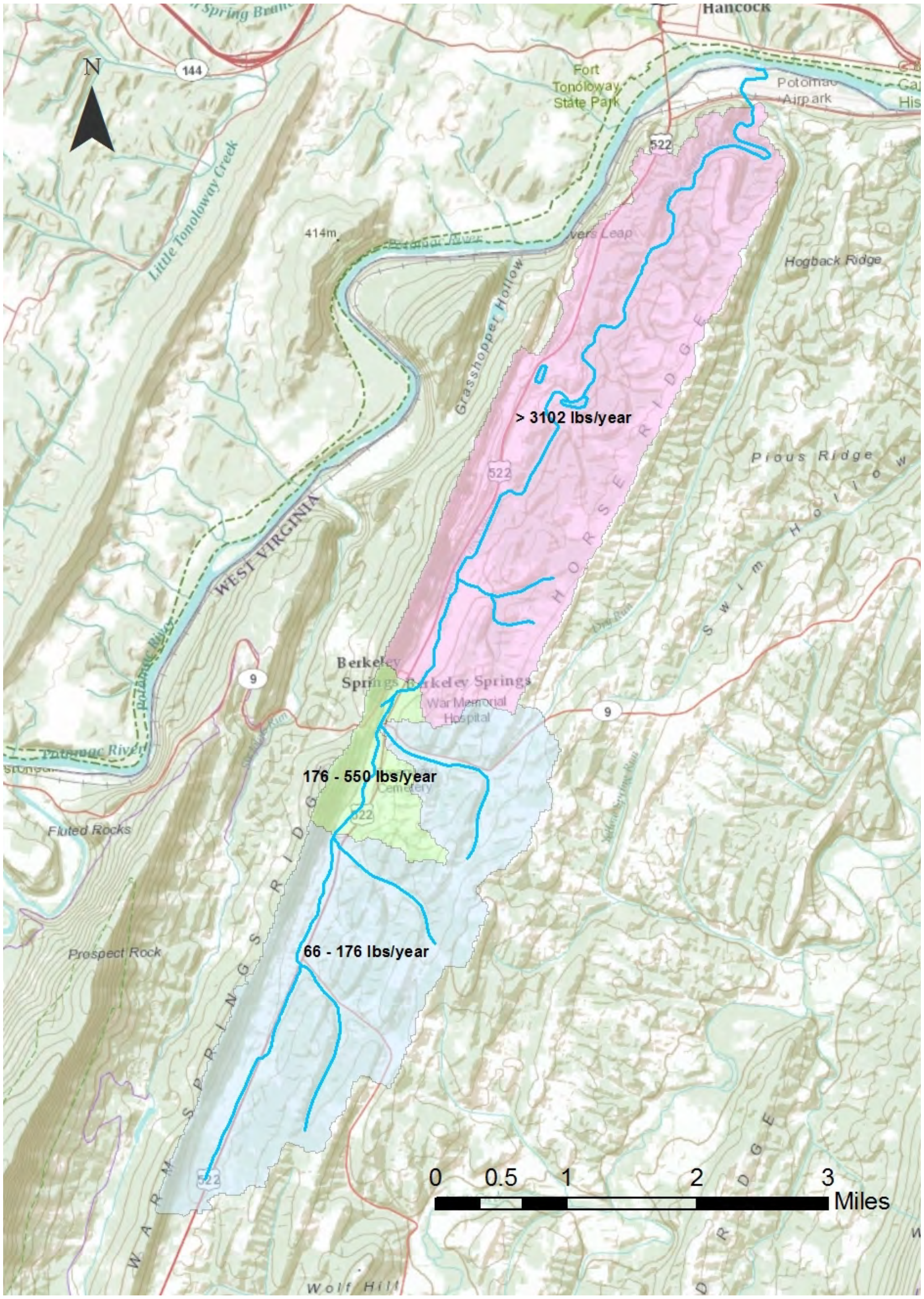


Figure 10. Phosphorus loads (per annum) estimated for the WSR Watershed based on the Chesapeake Bay Model. Individual catchment area load data were derived from the USGS Sparrow Surface Water Quality Model.

Measured Land Use – 2010 WSR Watershed Assessment

A summary of land use categories within the WSR watershed is shown on Figures 11 and 12. The majority (83.4%) of the WSR watershed is comprised of forested land and low to medium density population areas.

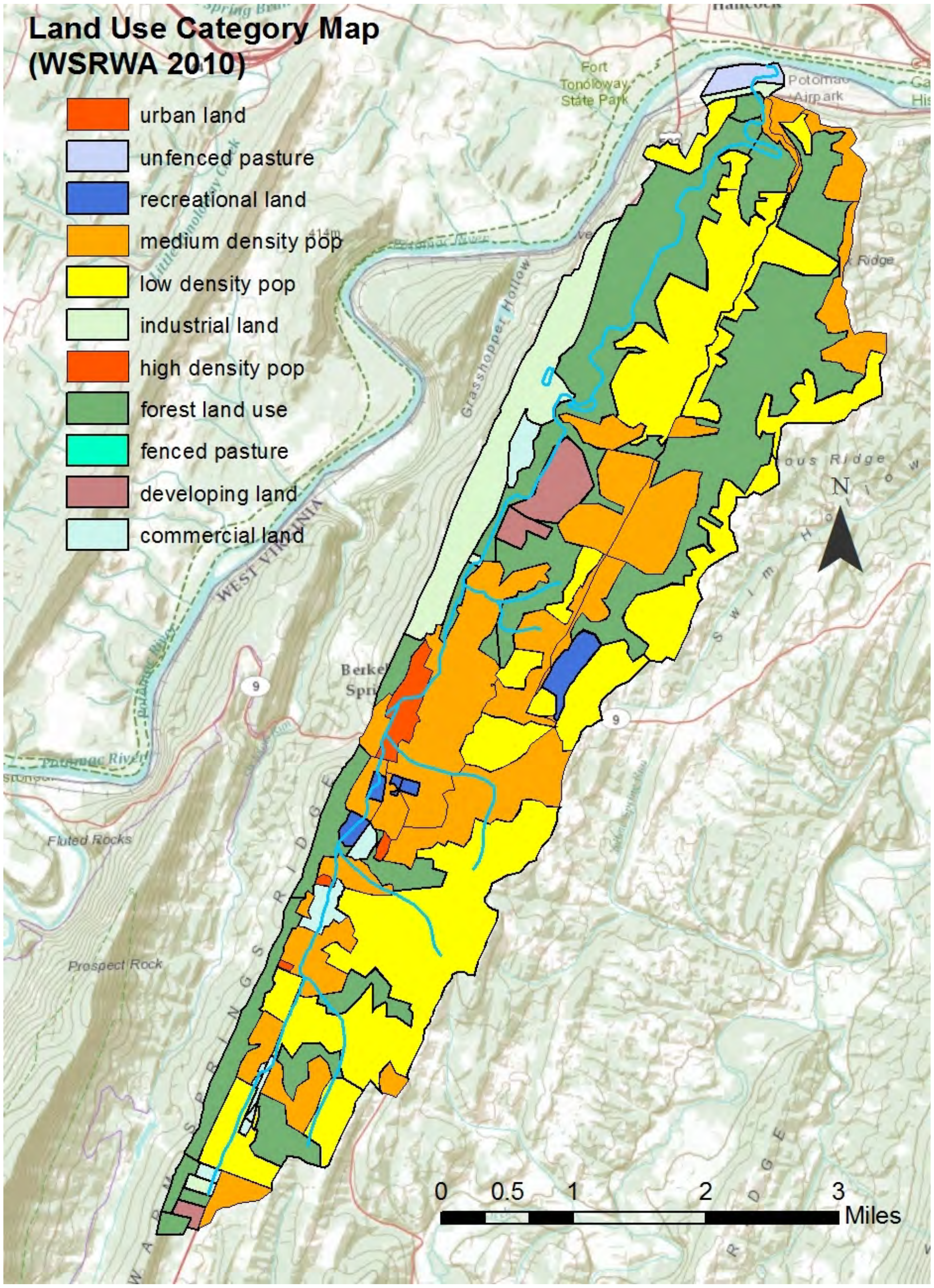


Figure 11. Land use map for the Warm Springs Run and Dry Run watersheds based on categories established in the 2010 Warm Springs Run Watershed Assessment.

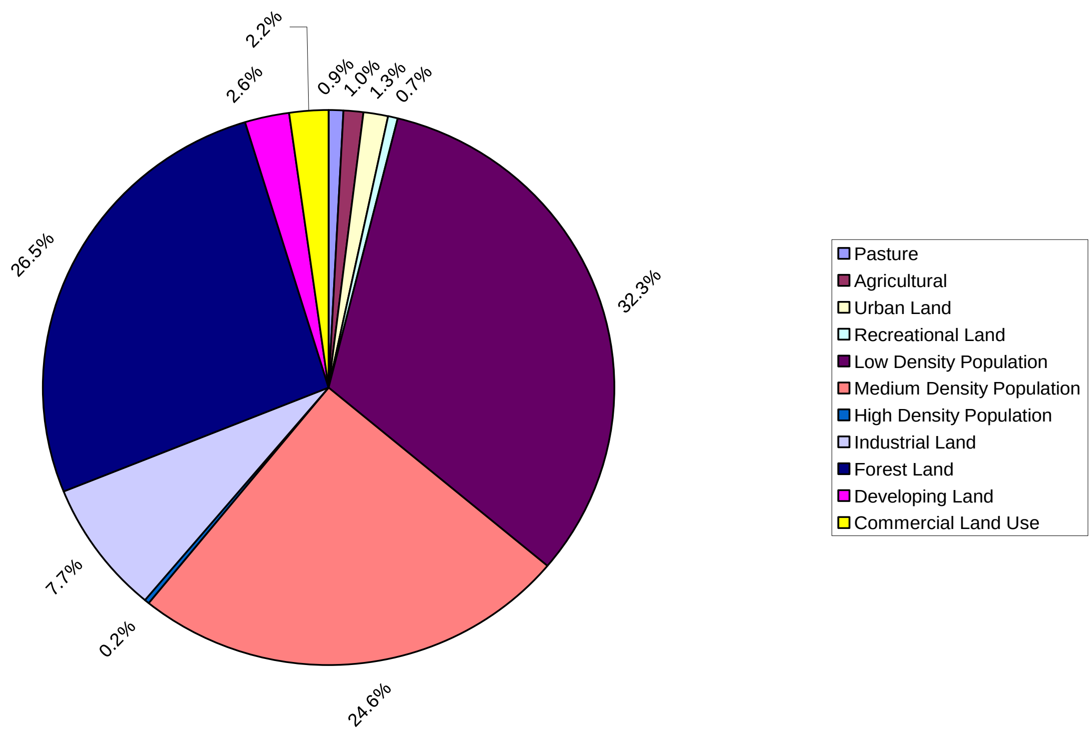


Figure 12. Pie chart showing relative percentages of major land use categories within the WSR Watershed (does not include the Dry Run watershed).

The majority of the industrial land use is occupied by what was formerly known as the US Silica mines and production facility (locally known as the "sand mine") located north of the Town of Bath. This area comprises approximately 7.7% of the watershed. The remaining land uses (commercial, urban land, etc.) comprise less than 10% of the watershed. Agricultural lands (open pasture, livestock and row crop) comprise only 1.9% of the WSR watershed land use acreage. Thus, the WSR watershed is unique by West Virginia standards, and can be classified more accurately as an "urban/subsurban" watershed, than as one dominated by agricultural land use.

Comparison of the CBWM land use category percentages to the results of the 2010 WSR Assessment shows some significant differences, as shown on Table 2.

Table 2. Land Use Category Comparison

	CBWM (acres)	**2010 WSR WA** (acres)
Background	6,278	3,123
Construction	89	198
Crop	518	59
Extractive	336	584
Pasture	355	85
Residential/Urban	2,254	5,375

Referencing Table 1, the reductions in N, P and TSS loads are based on a significant contribution of crop and pasture to the WSR watershed's total load; however the land use data collected during the 2010 WSR watershed assessment, and verified during the field investigation stage of this report, suggests that any reduction to loads from these sectors within the WSR watershed would probably be inconsequential in helping West Virginia achieve TMDL goals. Nevertheless, water quality and benthic assessments of the WSR have demonstrated that there are significant sources of impairment that are affecting the stream and its watershed.

Based on the estimates of land use acreage derived from the 2010 WSR Watershed Assessment data, the reductions for total N, P, and TSS were recalculated as shown on Table 3.

Table 3. Recalculated Load Reductions to Meet the 2025 Goals Based on the 2010 WSR WA Land Use Acreage Summary

Total 2010NA Loads	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	168.85	6,933.06	11.11
Pasture	75.06	3,300.79	7.4
Residential	7.56	137.15	0.5
2025 Goals	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	137.62	5,681.01	9.5
Pasture	56.51	2,075.79	5.18
Residential	7.84	139.7	0.52
Reduction Needed	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	31.23	1,252.05	1.62
Pasture	18.55	1,225.00	2.21
Residential	-0.28	-2.55	-0.01
Note – All values in lbs/acre			

As can be seen by comparison with Table 1, the loads per acre are significantly higher for all three land uses, because of the difference in acreage within the watershed in comparison with the estimated acreage used as an input for the CBWM. Nevertheless, the baseline for individual non-regulated agriculture operations, inclusive of manure transport, is 21% N and 29% P edge-of-stream reduction from 2010NA loadings. The specified reduction rates were determined by the average reduction from 2010 NA prescribed for the agriculture sector exclusive of the CFO land use in the final Phase II WIP 2025 model scenario. Therefore, the actual reduction necessary to comply with the WV WIP 2025 goals will need to be recalculated based on input of the revised land use acreage determined in the 2010 WSR WA.

Impairment of the WSR Watershed

Referencing the West Virginia 2012 Draft Section 303(d) List prepared by the West Virginia Department of Environmental Protection (WVDEP), the Warm Springs Run[3] (identified as WVP-10) is listed as an impaired stream within the Potomac Direct Drains Watershed (HUC# 02070004). Figure 12 shows the sampling points at which impairment parameters were measured by WVDEP.

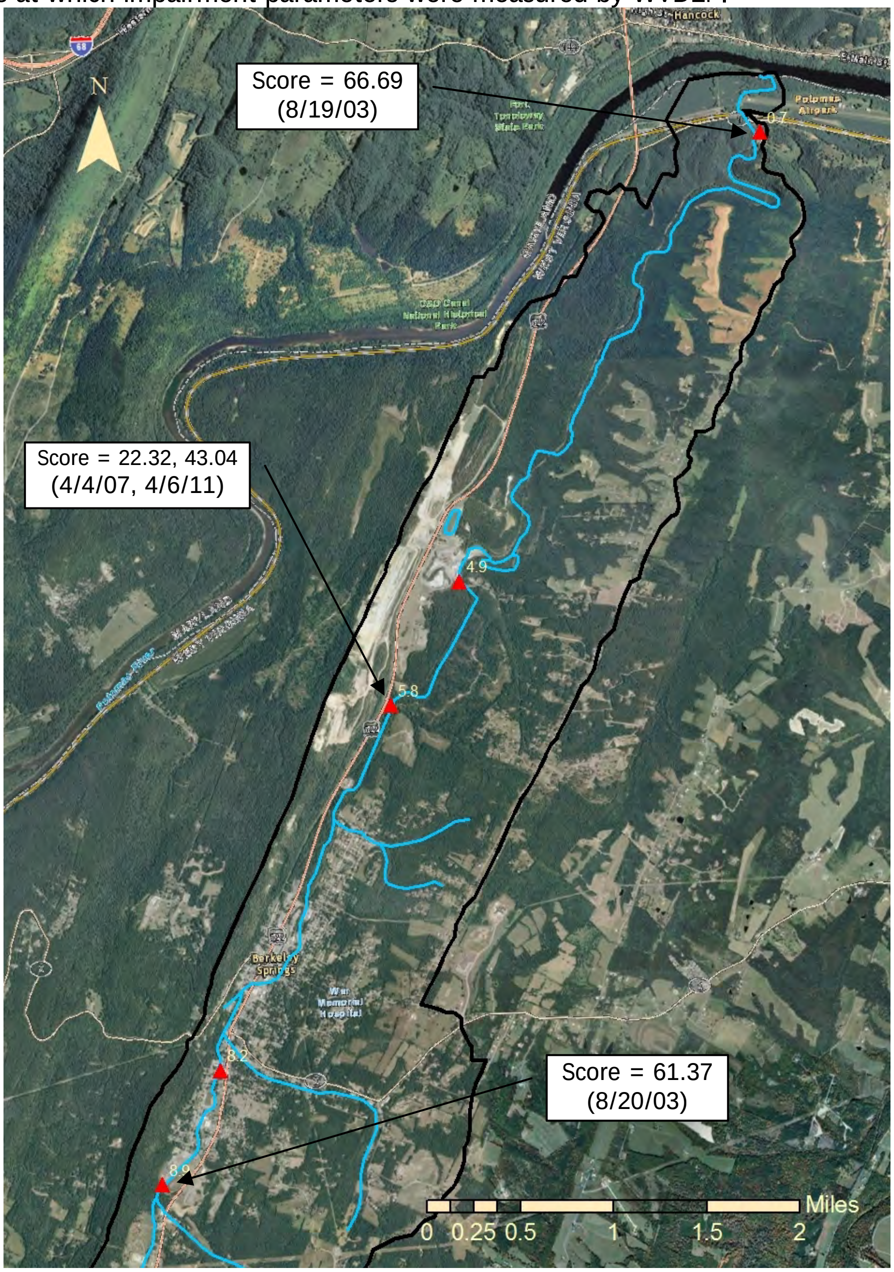


Figure 12. WVDEP Sampling Points along the Warm Springs Run, with benthic evaluation scores and sampling dates when the scores were developed. Any score above 50 is considered indicative of a healthy aquatic benthos. Sampling locations are labeled with their mile points.

The listed impairment parameters are CNA-Biological[4] (aquatic life impairment) and fecal coliform. The impaired reach is listed as encompassing 10.3-miles, reportedly the entire length of the stream[5]. The

[3] It should be noted that in the referenced report, the stream is referred to as the Warm "Spring" Run.

[4] CNA = Conditions Not Acceptable

[5] The WSR Watershed Assessment considers the length of the stream to be 11.8 miles, not 10.3 miles.

WSR was listed as impaired for CNA-Biological on the 2010 Section 303(d) List, but not for fecal coliform, which was added to the 2012 list. Sources of both impairment factors (i.e. CNA-Biological and fecal coliform) are referenced in the 2012 List as "unknown". Total Maximum Daily Load Values for the WSR have not been established yet, and are projected to be developed no later than 2021.

It is of note that the most heavily impaired sampling station measured by WVDEP was located at Mile Point 4.9, approximately 4-miles downstream from the Town of Bath, and approximately 1.3 miles downstream from the Warm Springs Public Service District Water Treatment Plant. Water quality parameters were also measured at the other mile points, but benthic scoring was not performed for any but the sites indicated as scored on Figure 12.

Fecal coliform colony counts were determined at all five sampling points, and selected results or equivalent (comparable) dates are shown on Table 4.

Table 4. Selected Fecal Coliform Results for WVDEP Mile Point Stations

Sample ID	Mile Point	Sampling Date	Value (colonies/100 ml)
33708	**0.7**	**4/3/07**	**500**
34346	0.7	6/26/07	168
34660	**0.7**	**7/24/07**	**420**
35196	**0.7**	**8/16/07**	**2,400**
36137	**0.7**	**9/27/07**	**1,000**
36149	0.7	10/17/07	320
47703	**0.7**	**10/27/09**	**1,100**
33709	**4.9**	**4/3/07**	**500**
34347	**4.9**	**6/26/07**	**600**
34661	4.9	7/24/07	220
35197	**4.9**	**8/16/07**	**2,400**
35425	4.9	9/6/07	350
36138	4.9	9/27/07	172
36150	**4.9**	**10/17/07**	**550**
47708	4.9	10/27/09	60
33710	5.8	4/3/07	300
34348	**5.8**	**6/26/07**	**1,950**
34662	5.8	7/24/07	270
35198	**5.8**	**8/16/07**	**>60,000**
36139	5.8	9/27/07	300
36151	**5.8**	**10/17/07**	**2,700**
47713	5.8	10/27/09	113
33711	8.2	4/3/07	100
34349	**8.2**	**6/27/07**	**4,400**
34663	**8.2**	**7/24/07**	**1,250**
35119	**8.2**	**8/16/07**	**>60,000**
35427	**8.2**	**9/6/07**	**440**
36140	8.2	9/27/07	230
36152	8.2	10/17/07	320
47703	**8.2**	**10/27/09**	**1,100**
Note – Samples in **bold** exceed the West Virginia Water Quality Standard of 400 colonies/100 ml			

As can be seen from the data shown on Table 4, wide variation in values for fecal coliform colonies was observed throughout the sampling period. The data for August 16, 2007 showed a consistent high spike in the coliform data, starting well upstream at Mile Point 8.2, and extending along the entire length of the run. Historical meteorological data records show there was approximately 0.5 inches of rain the day the samples were collected; however, it is unknown whether this may have affected the reported fecal coliform test result.

Similarly, the WVDEP study showed that elevated levels of total N, P, and TSS were observed during the water quality analysis phase of the impairment evaluation, as shown on Table 5.

Table 5. WVDEP WQ Sampling Events - Total N, Total P and TSS

Sample ID	**Mile Point**	**Sampling Date**	**Total N** (mg/liter)	**Total P** (mg/liter)	**TSS** (mg/liter)
47703	0.7	10/27/09	0.72	0.12	<2
47705	4.9	9/1/09	0.69	NA	<2
47706	4.9	9/8/09	0.84	0.07	NA
47708	4.9	10/27/09	0.83	0.35	<2
47710	5.8	9/1/09	0.86	0.57	3
47718	8.2	10/27/09	0.86	<0.01	<2

The actual load delivered to the Potomac River from the WSR can be inferred from the 10/27/09 data point (Sample ID 47703) shown on Table 4 above. These data were collected when the stream was at normal flow conditions, based on regional climatic records. Discharge rate of the WSR at this sampling point during base flow conditions was measured by the WSR Watershed Association at approximately 14.5 cfs, so the delivered loads of N and P can be calculated as follows:

Total Nitrogen delivered load on 10/27/09 @ mile point 0.7
0.72 mg/l x 14.5 cfs = 292 mg/sec (conversion = 28 liters/cf)
292 mg/sec x 60 = 17.52 g/min
((17.52 x 60) x 24) x 365 = 9,208 kg/year (or) **20,300 lbs/year**

Total Phosphorus delivered load on 10/27/09 @ mile point 0.7
0.12 mg/l x 14.5 cfs = 48.7 mg/sec
48.7 mg/sec x 60 = 2.92 g/min
((2.92 x 60) x 24) x 365) = 1,534 kg/year (or) **3,381 lbs/year**

These loads are much lower than the values which have been inferred for the WSR based on the land use category breakdown in the CBWM. Nevertheless, a significant load of both nitrogen and phosphorus is being delivered annually by the WSR to the Potomac River, and contributes to the TMDL for West Virginia in general. In addition, the WSR has been shown to have significant impairment due to the presence of elevated levels of fecal coliform bacteria, and CNA-biological (due to organic enrichment and sedimentation).

Probable Origin of Measured Impairments

Fecal Coliform – Like many communities in the Potomac Highlands region, only a portion of the residential and commercial properties within the WSR watershed are served by a municipal sewer system. The WSR watershed area is served currently by the Warm Springs Public Service District (WSPSD), and the extent of municipal sewer coverage is shown on Figure 13.

Structures not served by the WSPSD were estimated based on evaluation of recent aerial photography, cross-referenced with the USGS 7.5-minute Topographic Quadrangles (Bath, WV; Hancock, MD-WV). Based on these data, there are approximately 308 structures not currently served by the municipal sewer system. The location of these structures is shown on Figure 13.

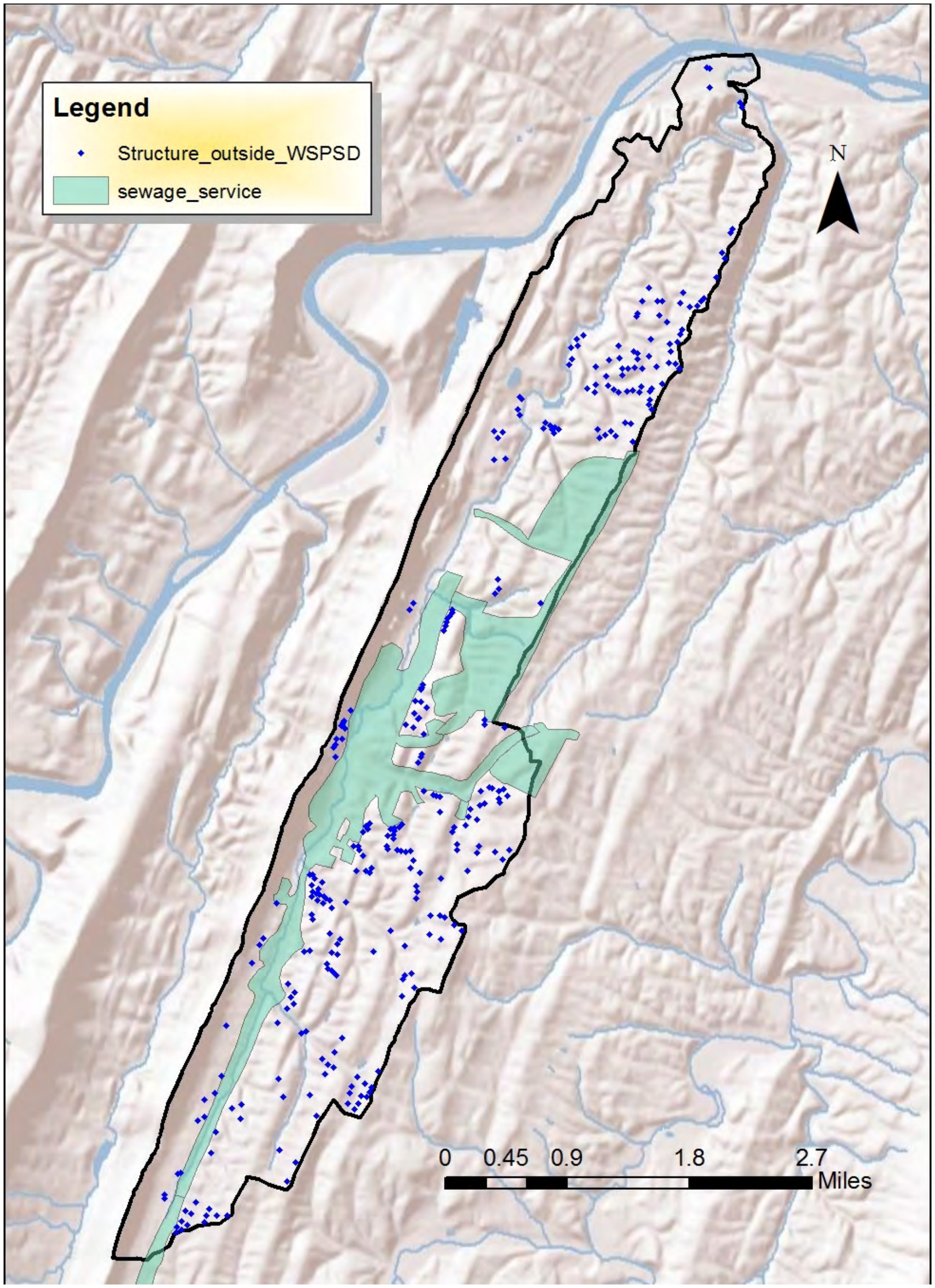


Figure 13. Coverage area of the WSPSD sewer system and locations of structures (blue diamonds) inferred to be served by private sewage disposal systems (i.e. septic drainfields).

It is of note that typically, 1% to 5% of any septic system fail within the first year of operation (USEPA, 1993). Our assessment has revealed that 85% of the septic systems in the WSR watershed are more than 30 years old, which suggests that nominally at least 30% to 50% of these systems (even under ideal conditions) have failed or are failing. In addition, based on USDA-NRCS soil survey data (Appendix A), all of the soils within the WSR watershed are considered of limited suitability due to seasonal high water tables, shallow bedrock, low cation exchange capacity and seepage from the base soil layer.

One of the characteristics of the shale residual soils that dominate the WSR watershed is the occurrence of numerous ephemeral "wet weather" springs. These ephemeral springs become active only after rainfall or snowmelt events, when water that collects just above the lithic (hard) bedrock stratum finds pathways to the surface through high permeability substrata within the residual soils. Rainfall events of 1-inch or less can activate these springs, and if there has been an extended period of higher than normal precipitation with soil saturation even seemingly insignificant rainfall quantities (<0.25 inches) can cause them to begin flowing. The majority of the ephemeral springs are located along the various tributary valleys, and even in "dry" swales that form the trellis of catchments leading to the tributary reaches. It is notable then, that many of the roads in the WSR utilized the tributary valleys and swales as convenient routes to ascend onto the shale uplands to the east of the WSR's main stem. Accordingly, many homes were built along these roads, especially in the tributary valleys and swales south of the Town of Bath. Thus, any sewage effluent which percolates rapidly through the marginal soils would be expected to collect in the weathered bedrock stratum and would be flushed out after rainfall events as the ephemeral springs become active. This may account for the unusually high fecal coliform counts seen in the upper half of the WSR, during the 0.5 inch rainfall event that occurred during the DEP sampling event of 8/16/07 (Table 4). Similarly, relatively high total N values were seen far upstream on the WSR during the 10/27/09 sampling event shown on Table 4. Thus, at least some of the distribution of nutrient loads and pathogens seen in the WSR can probably be attributed to private sewage disposal systems, and the physical and hydrological properties of the soils in which these systems are located.

In summary, even under the best of conditions a fully functional conventional septic system can only be expected to remove 28% total N, 57% total P, and 72% total suspended solids (TSS), respectively (USEPA, 1993). Thus, if a large percentage of the septic systems within the WSR watershed are failing or have failed, or have been installed in unsuitable soils, then their contribution to nutrient loading and fecal coliform counts may be significant. It is not unreasonable to assume that nearly all of the conventional septic systems within the WSR watershed are failing, or have failed, based on the USDA-NRCS soil survey data.

Sediment – Sedimentation of the WSR and its tributaries is probably the major factor contributing to the CNA-Biological impairment observed in the benthic assessment conducted by WVDEP. It is interesting to note that the reduction of sediment load within a watershed also results in accordant reduction in both total N and P loads (WIP, 2012; Simpson and Weammert, 2009). Thus, any strategy to reduce sediment load will help to reduce nutrient loads as well.

Four major sources of sedimentation have been identified in the WSR watershed:

1) Streambank Erosion – The 2007 WSR Stream Corridor Assessment and the subsequent 2010 WSR Watershed Assessment both identified significant areas of stream bank erosion. Many of these areas are located in the reach of the WSR's main stem located upstream from the Town of Bath, and are associated with areas where there is insufficient vegetated buffers and/or direct impact on stream flow by infrastructure objects (e.g. bridges, culverts, manholes, etc.) placed in or adjacent to the stream channel. Removal of stream bank vegetation also contributes significantly to erosion and transport of sediment.

2) Uncontrolled Stormwater Runoff – Urban and developed area runoff increases flow velocity in the stream, by "dumping" stormwater directly into the channel. The Berkeley Springs area does not have a centralized storm sewer system, and all stormwater either drains as sheet flow from impervious surfaces such as paved parking lots, roofs, and roads, or is collected by drop inlets and dumped into the WSR via drain pipes. In many cases, even the so-called "pervious" areas such as gravel parking lots function as impervious surfaces due to compaction of the soil and overlying gravel layers. It is not surprising that there is a close association of impervious surfaces and reaches of the WSR where the stream has become deeply incised or "entrenched" and disconnected from its flood plain (Figures 14 and 15).

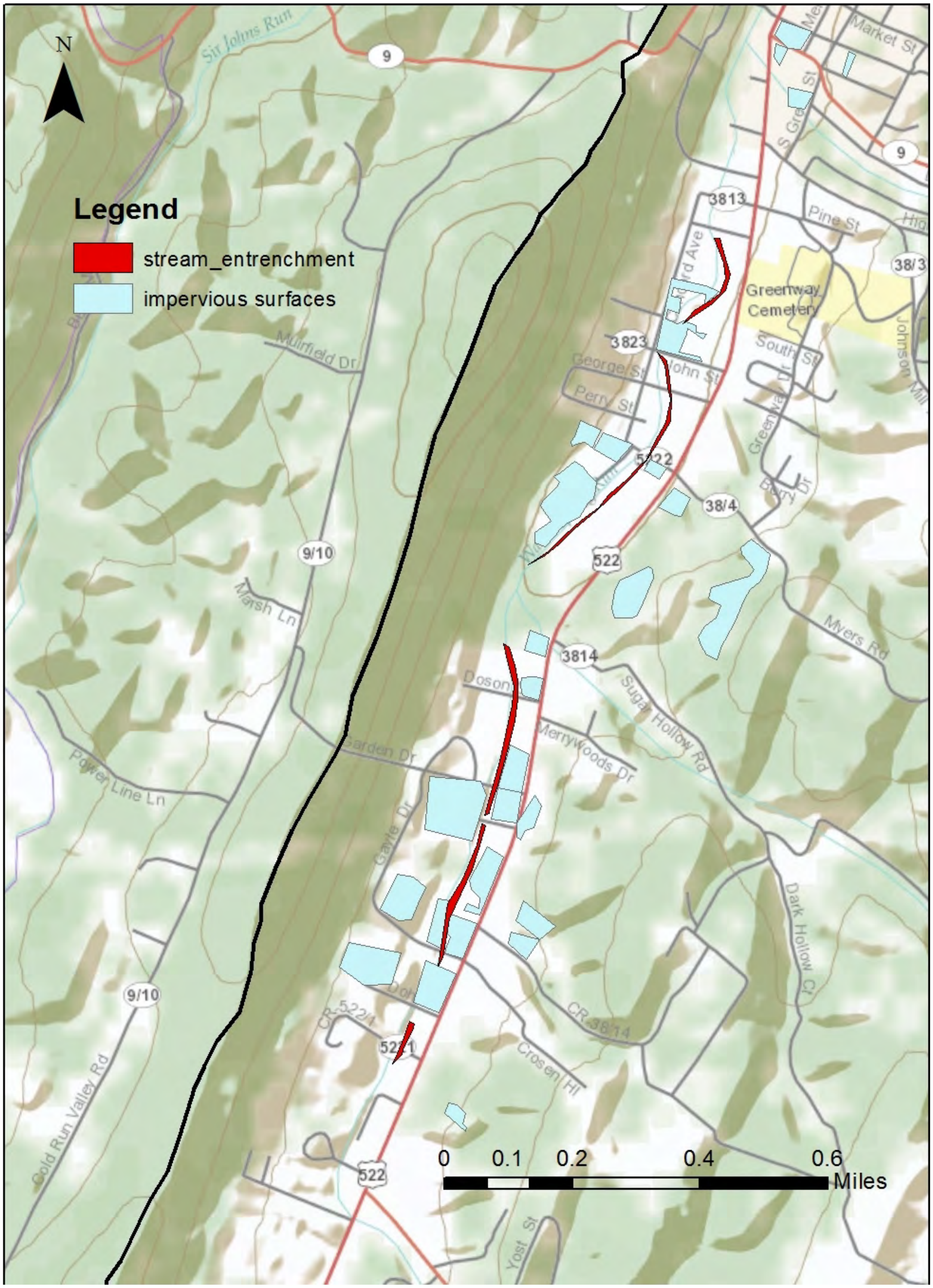


Figure 14. Map showing areas of stream entrenchment (incision) occurring along the WSR channel upstream (south) from the Town of Bath. Relative entrenchment was determined by examination of digital elevation models and verified in the field. Note the association of areas with impervious surfaces and the adjacent stream entrenchment.

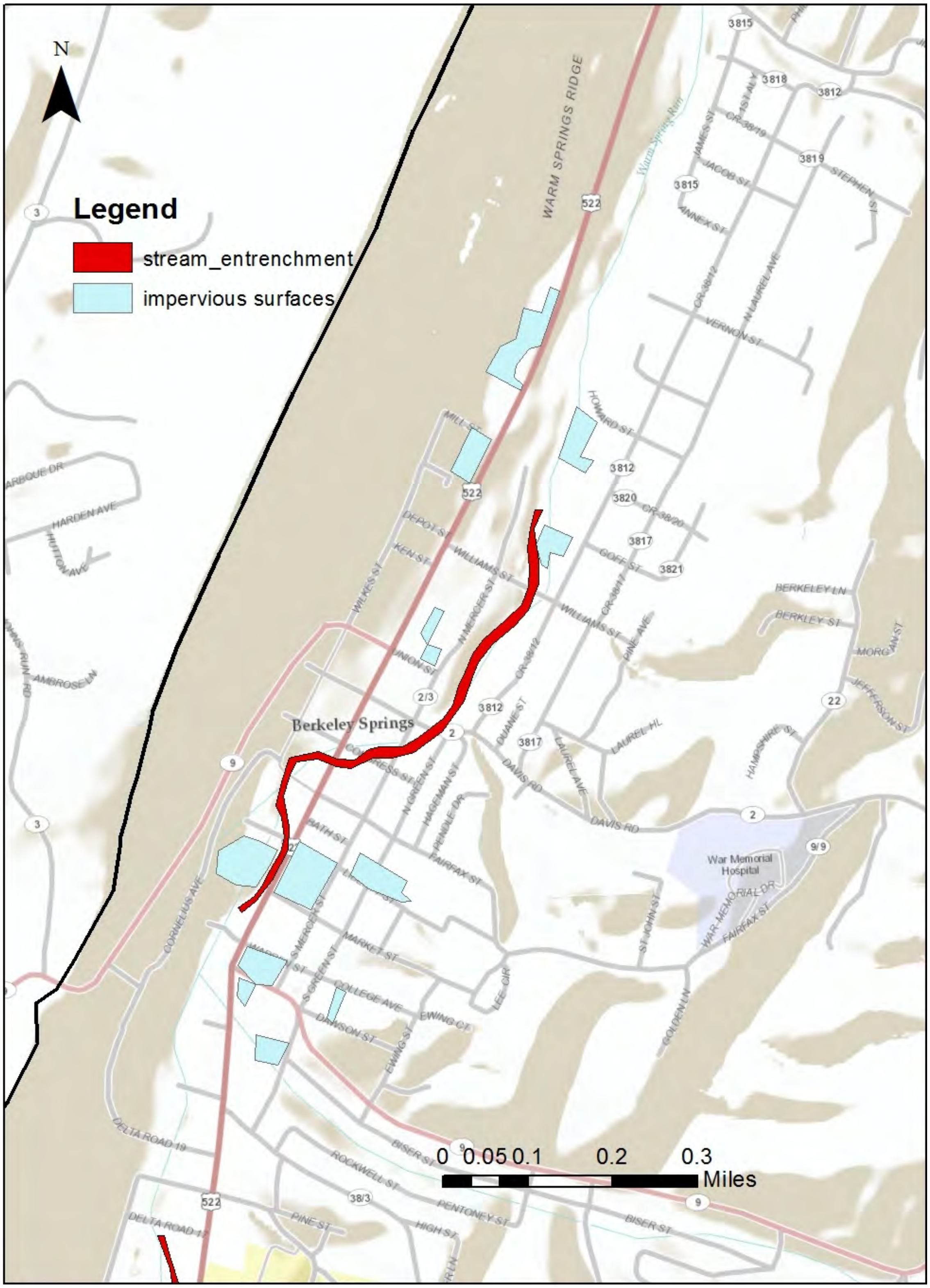


Figure 15. The route of the deeply entrenched WSR as it passes through the central and northern part of the Town of Bath.

It is of note that the WSR north (downstream) from the Town of Bath enters a primarily forested reach, and continues within this forested area nearly to its confluence with the Potomac River. Along this entire stretch there is little evidence of deep entrenchment and/or stream bank erosion, except where infrastructure (mainly roadway bridges) crosses the stream. In many ways, this area probably represents the condition of the entire WSR prior to historical development. It's also of note that although the flood control dams located on the eastern tributaries have helped mitigate the catastrophic flooding the Town of Bath experienced prior to their construction, nevertheless the reduction in flooding has contributed to the stream entrenchment and erosion seen in the WSR's main stem. During flash flood events an undisturbed stream tends to spread out into its floodplain, distributing much of the transported sediment along the floodplain's surface where it enriches the existing soil and nourishes plant life. What sediment is deposited on the stream's bed is usually flushed out and/or incorporated into the streambed's existing structure.

When a catchment area has been modified by both detention structures (such as the flood control dams) and the addition of impervious surfaces and uncontrolled stormwater disposal, the stream channel begins to "detach" itself from its floodplain and becomes entrenched. Thus, the entire sediment load that is disgorged from upstream is carried along the channel, and either is flushed out as suspended solids into the receiving water body (in this case the Potomac River), or settles to the bottom of the channel. This excessive quantity of sediment (which ordinarily would be deposited on the floodplain) results in unnatural conditions on the stream bed, negatively impacting the health of the stream's benthic community. Finally, stormwater that flows into the stream either as sheet flow or from piping, carries with it sediment, chemical contaminants (e.g. oil, grease, salts, etc.), turf grass fertilizer overspread, animal feces, and organic trash that accumulates on the impervious surfaces, further compromising the benthos as it destroys the stream's natural ecological balance and contributes to the nutrient loads.

3) Disturbed Land - Development of land for industrial, commercial, or residential usage includes activities such as clearing and grading of vegetated land. The removal of vegetation and disturbance of soil from development and construction leave soil particles exposed and susceptible to erosion by wind and water. Nitrogen and phosphorus may also be transported from development sites via adsorption to eroded soil particles or dissolution in runoff from exposed areas. Erosion and sediment control practices protect water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

The relatively steep hillsides fronting onto US Route 522 within the WSR watershed have resulted in significant cut banks being developed to make room for building footprints. In many cases, these cut banks are left denuded of vegetation due to the difficulty in establishing new plant growth. The subsoil that occurs in the residual soils of the watershed is low in fertility. In addition, the presence of pyritic shale in some areas (specifically in soils derived from the Marcellus and Needmore Formations) tends to produce acid sulfate soils in which aluminum is present in a form that is toxic to most plant life. This creates a vicious cycle, where as erosion proceeds, the lighter sediments are transported downgradient, and the weathered shale subsoil continues to erode and oxidize, thus producing more acid sulfate which inhibits plant growth on the already nutrient deficient soil. The sediment thus continues to be transported to downstream water bodies, along with the accompanying nutrients that become bound to the sediment particles.

4) Gravel and Dirt Roads – One of the most poorly understood factors contributing to stream sedimentation is runoff from dirt and gravel roads. Data is unavailable to determine the exact portion of sediment carried off dirt and gravel roads during the beginning or "first flush" of a precipitation event; however, research from other land uses suggests that first flush volumes carry the majority of sediment load in the runoff. First flush is related to factors such as the distribution of intensities during a storm, percent impervious cover, the number of dry days, and watershed area (Klimkos, et al., 2009)..

Gravel and dirt roads, parking lot and paths in the WSR watershed are typically surfaced with unwashed crusher run limestone and/or locally quarried crushed shale and sandstone. Many of these gravel roads and paths act as drainages for water flowing off of the upland areas to the east of the Run. Examination of the channel adjacent to these areas during field work for this plan revealed considerable quantities of limestone gravel and finely divided lime "dust" which had become incorporated into the channel base.

Limestone gravel was also observed as scattered point bars along the course of the Run, especially in the Town of Bath (see cover photograph).

Areas that are surfaced with locally quarried shale and sandstone can yield large amounts of sediment due to the fact that the relatively soft rock fragments are being crushed and powdered by the repeated passage of vehicles over the surface. Shale surfaced roads are the most prone to generation of transportable sediment particles, and water bodies adjacent to the regional dirt roads show high levels of turbidity following storm events as a result. Much of the shale can be reduced to particles that are so small that they become part of the suspended solid load.

Finally, roadside drainage ditches can become "traps" for sediment during light rain events. Once this sediment load is accumulated, and if the ditch is not cleaned out, during heavy rain events (>0.5 inch per hour) these ditches will disgorge their sediment load which is then transported downhill towards the stream channel.

Proposed Reductions of Measured Impairments

As mentioned previously, TMDLs will not be established for the WSR watershed until 2021; therefore, baseline and allocated loads and the reductions needed to comply with the TMDL requirements are currently undetermined. However, using a "worst case" scenario, the maximum daily load delivered to the Potomac River can be extrapolated from the data of the WVDEP benthic assessment as follows:

Table 6. Worst Case Scenario Daily Loads

Stressor	**Sample ID**	**Date**	**Daily Load Delivered**
Fecal Coliform	35196	8/16/10	5.8×10^{12} counts
Sediment (as TSS)	47710	9/1/09	8.0 tons

It should be kept in mind that these values are based on the highest numbers for each stressor observed during the benthic assessment study's water quality data collection events. They are probably not representative of the average daily loads, which will be determined at a future date.

It is of note that at no time during the benthic assessment sampling was TSS observed near the mouth of the WSR at levels higher than trace (i.e. < 2 mg/l). Thus, the worst case value for TSS was necessarily derived from a sample collected approximately 5.8 miles upstream from the WSR's confluence with the Potomac River. The fecal coliform sample was collected approximately 0.7 miles upstream from the confluence, and is probably more representative of the delivered load (on that date, exclusively). The lack of suspended sediment near the WSR's mouth is somewhat surprising, but implies that much of the sediment is coagulating and settling out prior to arriving at the mouth of the stream. This is not surprising, as the water arriving in the Run from the Warm Spring is highly charged with ionic calcium, which can act as a coagulant for colloidal clay particles that probably make up the bulk of the suspended sediment. It is also symptomatic that the worst benthic scores for the WSR were observed at a station near the center of the Run (mile point 5.8), but not at the 0.7 mile station just upstream from the confluence with the Potomac.

Final load reductions will not be established until 2021; however, based on the reductions called for in the Potomac Direct Drains for which TMDLs have been established (e.g. Opequon Creek, Mill Creek, Sleepy Creek, Elks Run etc.) target reductions can be inferred.

Table 7. Inferred Reductions

Source	**Reduction Needed**
Fecal Coliform (all sources)	100%
Sediment – (all sources)	30%

Without the benefit of baseline and allocated loads having been determined, the metrics for reduction and the relative success of the management strategies recommended herein will necessarily be derived from periodic stream monitoring. Motoring protocols and schedule are discussed in Section I.

Section B/C - BMPs or "Non-point Source Measures" Proposed to Achieve Load Reductions

The following measures and proposed Best Management Practices (BMPs) are derived from the West Virginia 2012 Watershed Implementation Plan, Phase II; the University of Maryland/Mid Atlantic Water Program Final BMP Report (Simpson and Weimert, 2009); WVDEP Stormwater Guidance Document; the Eastern Panhandle Conservation District and WV Conservation Agency; the USDA-NRCS conservation practice documents; the Chesapeake Stormwater Network Design Specifications and Technical Bulletin No.9; and the West Virginia Water Research Institute.

To Achieve Fecal Coliform Reductions From On-site Waste Treatment (Septic) Systems

Nearly all of the soils types present in the WSR watershed are classified by the USDA-NRCS soils survey as of limited suitability for septic drainfields; therefore, it can be assumed that many, if not all of the existing systems are failing or in the process of failing. Thus, the following management steps are recommended to reduce the quantity of untreated effluent that may be migrating into the shallow aquifer and subsequently to the WSR.

1) Identification and Characterization – An effort should be made to locate all private on-site treatment systems within the WSR watershed by reviewing permit data at the Morgan County Health Department. Once these systems have been located, testing should be conducted to determine if the systems are leaking or functioning properly. Two field screening techniques capable of identifying the locations of failing septic systems are the brightener test and color infrared (CIR) aerial photography. The first uses specific phosphorus-based elements found in many laundry products. Often called brighteners, they indicate the presence of failing on-site wastewater systems (Lalor et al., 1999; TWRI, 1997). The second technique uses color infrared (CIR) aerial photography to characterize septic system performance (Sagona, 1988). This method quickly and cost-effectively assesses the potential effects of failing systems. It uses variations in vegetative growth or stress patterns over septic system field lines to identify potentially malfunctioning systems. A detailed on-site visual and physical inspection will confirm if the system has failed and determine the extent of the repairs needed. County health departments or other authorized personnel may carry out such inspections.

2) Upgrade and Repair – If a system is shown to be leaking, failing or failed, then steps must be taken to repair it. If a drainfield is undersized, it may need to be expanded to a Class II drainfield, which encompasses a larger area for absorption. The services of a licensed septic installer should be engage to evaluate any systems that show signs of failure, and recommend remedial measures that will be necessary.

3) Pumpout and Maintenance – Even properly functioning septic systems can become compromised over time. A septic system management program of scheduled pumpouts and regular maintenance is the best way to reduce the possibility of failure for currently operating systems. A number of local agencies have taken on the responsibility for managing septic systems. We recommend that the local Health Department send residents a 5-year notification for pump-out requirements. The County may contract to have pumpout performed if the owner does not comply with the 5-year requirement and can fine or back-charge the owner for the costs of maintenance.

4) Connection to Sanitary Sewer – The Warm Springs PSD and Health Department should investigate the costs related to connecting residences that are currently served by on-site systems to the municipal sewer system. This may involve the construction of sewerage lift stations, grinders, or other infrastructure to facilitate the transport of sewerage that cannot be gravity fed to the sanitary main.

5) Non-Conventional On-Site Systems – There will inevitably be failing or failed septic systems that either cannot be repaired, or were located in soils that are not amenable to either Class I or II drainfield construction. In these cases, the use of non-conventional systems such as mounds, intermittent or recirculating sand filters, or denitrifying systems may be recommended. In addition, sites that are close together can be "clustered" and may use a centralized wastewater treatment system. Recirculating sand filters systems are recommended for this purpose, as they are ranked as having the highest efficiency in reduction of N, P, TSS and fecal coliform bacteria.

To Achieve Fecal Coliform Reductions from Pasture Sources

There is a single, 6.1-acre fenced cattle pasture located along the west side of Route 522, just south of Weber Lane and approximately 4,300-feet north of the headwater springs of the WSR. The WSR runs through the eastern portion of the cattle pasture, and the animals are allowed to move freely through and into the stream. The cattle are rotated to other sites on a regular basis.

We recommended that a fence be constructed to prevent the cattle from entering the stream. Alternative water sources should be provided to supply the livestock with necessary drinking water. In addition, a vegetated buffer strip should be established between the banks of the Run and the fenced cattle pasture. The combination of fencing and a riparian buffer has the potential to reduce fecal coliform transport to the stream by over 70% (WVCA, 2007).

To Achieve Fecal Coliform Reductions from Cropland Sources

There are two areas of cropland occurring within the WSR watershed: a 59-acre tract of row crop cultivation located just north (downstream) from Airport Lane, on both sides of the WSR; and a 79-acre tract located along the western flank of Horse Ridge on Fairview Lane, approximately 1-mile south of the intersection of Fairview Lane and River Road. Both of the crop areas have sufficient vegetated buffers in place to remove up to 50% of all fecal coliform.

The farm operators should be encouraged to develop nutrient management plans that minimize the use of nutrient sources of fecal coliform (e.g. sewage sludge, manure), while ensuring maximum yield and minimal nutrient loss.

Fecal Coliform Reductions by Wetlands

Due to financial challenges, and/or voluntary non-compliance on the part of septic system owners, it may be impossible to completely mitigate the source of fecal coliform entering the shallow groundwater aquifer supplying the WSR. It is interesting to note that one of the most effective means of reducing fecal coliform and nutrient loads from groundwater is through the protection and maintenance of wetland areas at spring rises, seeps, and tributary channels. Wetlands can reduce N, BOD, and TSS by 90%, 80%, and 80%, respectively; and pathogens by 4 Logs or 99.99% (USEPA, 2003).

Referencing the USFWS National Wetland Inventory, there are 71 jurisdictional wetlands within the WSR watershed encompassing approximately 31-acres. The majority of the wetlands are farm ponds, small impoundments, and pools lying along the WSR and its various tributaries. The flood control dam reservoirs have been sufficiently naturalized to be included as part of the wetland inventory for the watershed. In fact, these reservoir wetlands may serve to significantly reduce both fecal coliform and nutrients loads being discharged with groundwater that emerges from the tributary headsprings.

A putative wetland area that has yet to be delineated and included in the jurisdictional inventory is located at the headwater reach of the WSR's main stem. The following section describes the proposed management plan for this wetland area.

Headwaters Wetland Management Plan

Purpose and Need - The purpose of this wetland management plan is to appropriately characterize and restore to pre-alteration conditions the headwater wetland and intermittent stream system of Warm Springs Run for the purposes of improving water quality downstream. The quality of this wetland area, which is the origin o f the WSR, has an influence on the water quality of the surrounding area, including the Warm Springs Run watershed and the receiving waters of the Potomac River. Therefore, there is a need for a wetland management plan to allocate restoration resources appropriately for the headwater wetland as well as within the watershed.

Topography and Landscape Position - The headwater system of Warm Springs Run is located south of the town of Berkeley Springs, West Virginia. Valley Road (US Route 522) borders this wetland feature to the east. A steeply sloped, forested hillside forms the western border of this depressional feature. This system drains approximately 78 acres, consisting of the surrounding foothills and valley (Figure 16).

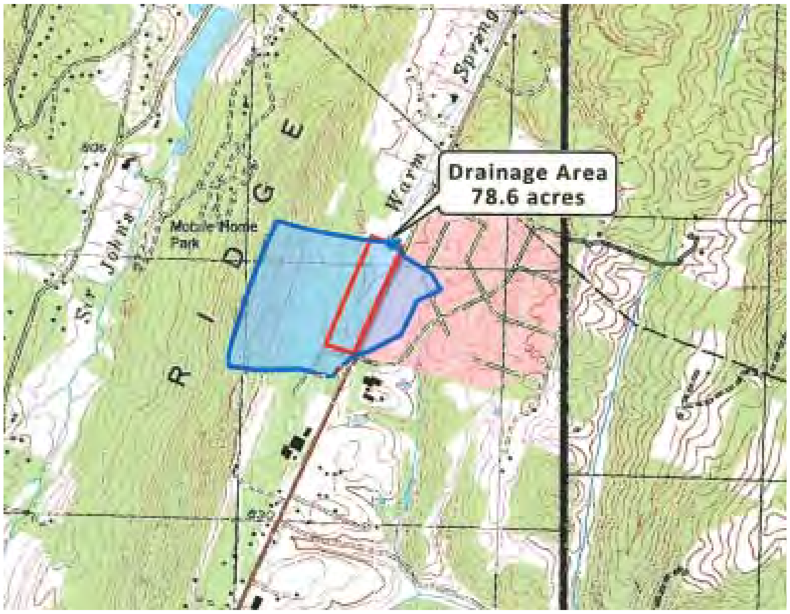


Figure 16. U.S.G.S. Quadrangle-Great Cacapon, WV-MD 2001 depicting the drainage area of the headwater system of Warm Springs Run.

Wetland Condition - Headwater wetland and stream systems perform important ecosystem services and functions and are the piping network for the transportation of pollutants downstream. As the source of streams, these wetlands have a considerable impact on the health and integrity of the downstream reaches. Restoration of this headwater system will improve water quality throughout Warm Springs Run. Table 7 provides the ecosystem services and functions of headwater wetland and stream systems.

Table 8. Ecosystem Services and Functions Provided by Headwater Wetlands
Ecosystem Services and Functions
Source of streams through groundwater discharge
Surface water retention
Stream flow control and maintenance
Nutrient cycling
Carbon sequestration
Habitat for native flora and fauna

Prior to the recent alterations to this feature, the headwater wetland of Warm Springs Run was a palustrine forested (PFO) wetland, as can be seen in the remnant PFO wetland immediately downslope and in the West Virginia Statewide Addressing and Mapping Board (SAMB) Spring 2003 Natural Color Imagery (Figure 16). The present wetland consists of scrub/shrub vegetation and is dominated by invasive species such as broad-leaf cattails (*Typha latifolia)* and Nepal microstegium (*Eulalia viminea)*. This alteration can be seen in the National Agricultural Imagery Program (NAIP) Summer 2011 Natural Color Imagery (Figure 17). A remnant PFO wetland is located immediately downslope of the altered wetland, providing evidence of what the unaltered wetland system may have looked like. Figures 17 and 19 provide a visual description of the wetland conditions on site.

Figure 16. Spring 2003 West Virginia Statewide Addressing and Mapping Board (SAMB) Natural Color Imagery. This aerial image depicts the forested study area that includes the headwater wetland of Warm Springs Run.

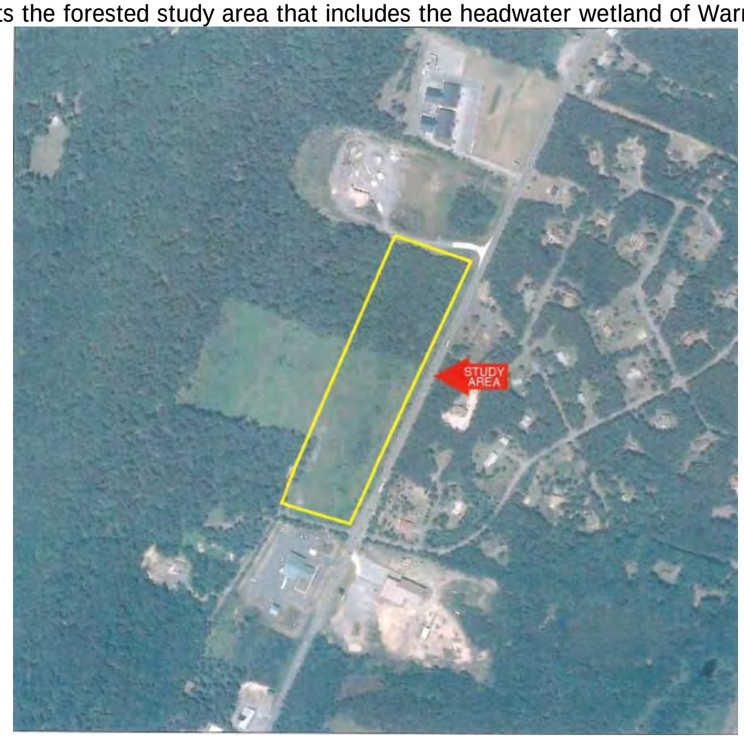


Figure 17. Summer 2011 National Agricultural Imagery Program (NAIP) Natural Color Imagery. This aerial image depicts the altered portion of the headwater wetland of Warm Springs Run. Note that the northern portion of the study area remains a PFO wetland remnant.

Figure 18. Looking south at the altered headwater wetland of Warm Springs Run. The dominant species in this area include broad-leaf cattails, Nepal microstegium, and black willow. Note that this area is dominated by invasive species and noxious weeds.

Figure 19. Looking north-northwest at the remnant PFO wetland located immediately downslope of the altered headwater wetland. This area characterizes what the original site conditions may have looked like.

The sources of hydrology for this wetland include, but are not limited to, surface water runoff, groundwater discharge, and precipitation. Indicators of wetland hydrology include saturation in the upper 12 inches of soil, redoximorphic features present in the soil, and drainage patterns.

Soils in the existing wetland are typically dark gray to gray with soil mottles, a color and condition indicative of hydric soils. The mapped soils for the surrounding area include Clearbrook-Cavode silt loams, Buchanan loam, and Berks-Weikert Channery silt loam. These soils were formed in place from shale, siltstone, and fine-grained sandstone. Although the soils in the surrounding area are not hydric, they are poorly drained and do contain hydric inclusions. This is consistent with what was observed during field work, as groundwater discharge has led to pockets of wetlands in the surrounding area.

The vegetation in this area is predominantly hydrophytic and adapted to wetland environments. A partial list of the plant species documented in the surrounding area at the time of the reconnaissance field work, along with the corresponding wetland indicator status, are listed in Table 9.

Table 9. Partial Plant Species List in Warm Springs Run Headwater System

Plant Species	**Wetland Indicator Status**
Acer negundo (box elder)	FAC
A. rubrum (red maple)	FAC
Amelanchier canadensis (serviceberry)	FAC
Cornus amomum (silky dogwood)	FACW
Dichanthelium clandestinum (deer-tongue witchgrass)	FAC
Eleocharis obtusa (blunt spikerush)	OBL
Eulalia viminea (Nepal microstegium) *	FAC
Fraxinus pennsylvanica (green ash)	FACW
Impatiens capensis (spotted touch-me-not)	OBL
Juncus effusus (soft rush)	FACW
Lonicera japonica (Japanese honeysuckle) *	FAC
Ludwigia palustris (marsh seedbox)	OBL
Platanus occidentalis (American sycamore)	FACW
Poa palustris (fowl bluegrass)	FACW
Quercus bicolor (swamp white oak)	FACW
Q. palustris (pin oak)	FACW
Rosa multiflora (multiflora rose)	FACU
Rubus argutus (serrate-leaf blackberry)	FACU
Salix nigra (black willow)	FACW
Sambucus canadensis (elderberry)	FACW
Scirpus cyperinus (wool grass)	FACW
Smilax rotundifolia (common greenbrier)	FAC
Typha latifolia (broad-leaf cattail)*	OBL
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands	
*: These species are considered noxious weeds or are non-native invasive species.	

Stream Condition **-** A reconnaissance of the surrounding area found that the remnant PFO wetland contained braided channels and vernal pools, as can be seen in Figure 20.

Figure 20. Looking north-northeast at the shallow stream channels present in the PFO wetland located downslope of the altered wetland.

The stream channels present within this portion of the wetland are shallow, allowing for the overflow of the stream bank and settling of water in the wetland. These channels primarily provide drainage in high-flow situations, and do not become perennial until further downstream. Vernal pools are also present within this system, allowing for surface water detention as well as habitat for wildlife.

Wetland Management Design Concept

Habitat Types - The altered wetland can be restored to a forested condition in order to restore the original habitat in this area. Wetland hydrology and soils are currently present in this wetland; however, the vegetation needs to be enhanced. Scrub-shrub species will be included in the planting plan to encourage a three tiered forest canopy throughout the wetland. Existing upland habitat lacking hydric soils should be preserved and enhanced to create a 100 feet buffer surrounding the headwater wetland of Warm Springs Run.

Approach - It is suggested that planting within the headwater wetland and surrounding riparian area be conducted. However, to increase the success rate of these plantings there needs to be an invasive species management component to the planting process. Prior to planting, a preliminary treatment of invasive species should be conducted, consisting of spot applications to targeted species with a 2% solution of Rodeo, a DOW AgroSciences product with the active ingredient glyphosate. This solution will consist of three gallons of water, eight ounces of herbicide, and two ounces Methylated Seed Oil (MSO) surfactant, which is added to the solution to facilitate absorption of the product into the foliage. The targeted species for this treatment include multiflora rose, broad-leaf cattails, and Nepal microstegium.

Planting should be conducted to restore the existing wetland to a forested state as well as to enhance the existing riparian buffer. One gallon container plants should be planted at a minimum density of 400 stems per acre. Proposed species for planting are listed in Table 10.

Table 10. Proposed Species for Restoration Planting

Plant Species	Growth Habit	Wetland Indicator Status
PALUSTRINE FORESTED WETLAND		
Acer negundo (box elder)	Tree	FAC

Table 10. Proposed Species for Restoration Planting		
Plant Species	**Growth Habit**	**Wetland Indicator Status**
Amelanchier arborea (serviceberry)	Shrub	FAC
Alnus serrulata (brookside alder)	Shrub	OBL
Betula nigra (river birch)	Tree	FACW
Cornus amomum (silky dogwood)	Shrub	FACW
Platanus occidentalis (American sycamore)	Tree	FACW
Quercus palustris (pin oak)	Tree	FACW
Q. phellos (willow oak)	Tree	FAC
Sambucus Canadensis (elderberry)	Shrub	FACW
Salix nigra (black willow)	Shrub	FACW
Viburnum dentatum (southern arrowwood)	Shrub	FAC
FORESTED RIPARIAN BUFFER		
Acer rubrum (red maple)	Tree	FAC
Carya glabra (sweet pignut hickory)	Tree	FACU
C. tomentosa (mockernut hickory)	Tree	NI
Cercis canadensis (eastern redbud)	Shrub	FACU
Cornus florida (flowering dogwood)	Shrub	FACU
Ilex opaca (American holly)	Shrub	FACU
Quercus alba (white oak)	Tree	FACU
Q. prinus (chestnut oak)	Tree	UPL
Q. rubra (red oak)	Tree	FACU
Viburnum prunifolium (black-haw)	Shrub	FACU
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands NI: No Indicator; insufficient information available to determine wetland indicator status		

As previously stated, to reach the goal of a restored forested wetland area, both shrub and tree species will be planted to create a three-tiered forested wetland, similar to the system immediately downslope. In addition, existing upland habitat lacking hydric soils will be preserved and enhanced to create a 100 feet buffer surrounding the headwater wetland of Warm Springs Run. Wetland and riparian seed mixes shall be dispersed in the appropriate areas for immediate ground cover after invasive species removal has taken place.

Regulatory Requirements - As much of this area is included in the jurisdictional waters of the US, consultation with the US Army Corps of Engineers and the West Virginia Department of Environmental Protection should occur prior to any work or replanting taking place. Additionally, the property owner must agree with proposed work as this area appears to be on private property. Furthermore, we recommend that a conservation easement be recorded to protect this system in perpetuity to ensure long term protection of this valuable resource. This will also require the permission of the landowner.

To Achieve Fecal Coliform Reductions from Miscellaneous Sources

Two sources of fecal coliform that can contribute significantly to loads are:

1) Improperly disposed animal fecal waste;
2) Illegal dumping of carcasses.

Animal feces (dogs, cats) can be a significant contributor to fecal coliform and nutrient loads in the urban setting. Fecal material that is left on streets, gutters and sidewalks in the Town of Bath will be washed directly into the WSR via the storm sewers. BMPs for reducing domestic animal waste will be discussed in the subsequent section on sediment reduction from impervious areas.

A second, less recognized source of fecal coliform (and other pathogens) results from the illegal or improper disposal of animal carcasses, primarily the Virginia White Tailed Deer (*Odocoileus virginianus*).

Deer carcasses and "gut bags" (the removed peritoneal sac and organs from a butchered deer) are often disposed of in forested areas, out of sight and at night. One of the places these carcasses are often easily disposed of is areas adjacent to roadways, or forested declivities such as stream bottoms. The remains of several deer carcasses were found in the forested area between the former concrete plant, and the Potomac Edison facility on Route 522, near the headwaters springs of the WSR. In semi-rural areas such as the WSR watershed, a surprisingly large number of deer carcasses are disposed of in this way every autumn, often in the same area.

The best way to reduce this source of fecal coliform is public education and outreach regarding proper disposal methods for animal remains, combined with strict enforcement of local and state codes regarding illegal dumping of carcasses.

To Achieve Sediment Reductions from Stream Erosion Sources

The dimension, pattern, and profile of stream channels adjust in response to changes in the contributing watershed. This can be due to an increase in runoff rates and volumes resulting from an increase in impervious area. Streams also adjust from more direct impacts, such as culverts, bridges, roads, and other infrastructure placed in or adjacent to the channels, or as a result of the removal of streamside vegetation. All of the above have played a role in contributing to the instability of sections of Warm Springs Run.

However, instability of urban stream channels can be corrected to return them to a stable condition. If the primary cause of the degradation is related to an increase in stormwater runoff, steps can be taken to reduce runoff through the provision of enhanced stormwater management (including both traditional stormwater management facilities as well as through the use of Low Impact Development (LID) techniques). Even if it were feasible to provide the necessary level of runoff reduction (which is often very difficult to achieve, especially in large watersheds), some level of stream channel restoration would likely still be required. Thus, the remaining alternative is to restore the stream channel to enable it to withstand the current flow regime and to accommodate the in-stream alterations (culverts, bridges, etc.). Various techniques are available and have been successfully employed in urban streams to return long-term stability. A discussion of these techniques is provided below.

Raising the Stream Invert

In instances where channel incision is the primary source of the instability (either as a result of in-stream impacts, such as the installation of a culvert or other infrastructure that instigates the development of a head-cut, or as a result of an increase in runoff rates or volumes), stability can be restored by raising the stream invert with a reinforced bed material that is sized to accommodate the existing shear stress. This technique, which is most often employed in conjunction with other techniques (discussed below), reconnects the stream to its floodplain. Enabling flood flows to have access to a larger cross-sectional area reduces shear stresses on the channel bed and banks and results in a healthier, more stable riparian habitat.

Figure 21 A/B - Snakeden Branch, Reston, VA. Invert raised to reconnect to the floodplain.

Cross-Vanes, J-Hooks

Cross-vanes, J-hooks, and other in-stream rock/wood structures provide grade control, direct flows away from stream banks, dissipate energy, and improve in-stream habitat. When properly designed and constructed, these structures are very effective in returning long-term stability to the stream channel.

Figure 22A/B - Tributary to Snakeden Branch, Reston, VA. Double-Step Cross-Vane, design and in

Step-Pools

Step-pools are also constructed from large boulders and are typically used to provide transition into and out of culverts in order to dissipate energy and to provide a means for dropping elevation in a controlled and stable manner over a relatively short distance. This is of particular use in conjunction with raising the invert in streams where existing culvert crossings at lower elevations must be maintained.

Figure 23 - Fort Belvoir, VA. Newly constructed step pools.

Imbricated Rock Walls

This practice is very useful in providing permanent stabilization of the bank in areas where the stream channel must remain at a lower elevation and grading of the bank is not feasible. This is often associated with culvert crossings or in instance where infrastructure must be protected. Imbricated rock walls perform better than gabions as these can fail over time. They are also more aesthetically pleasing in a more natural environment.

Figure 24 - The Glade, Reston VA. Newly constructed imbricated rock wall to protect trail.

Grading to Provide a Bankfull Bench

In instances when channel instability is due to increased flow rates (i.e. a larger channel cross-section is needed), this can be provided through grading of the banks. If the channel is currently incised and raising the invert is not feasible, a bankfull bench can be graded at the lower elevation in order to provide the necessary cross-sectional area. This can require a significant amount of disturbance depending on the existing conditions and required channel size, and thus can be problematic in forested areas or when utilities or other infrastructure is located adjacent to the channel.

Figure 25 - Snakeden Branch, Reston VA. Newly constructed bankfull bench at lower elevation.

Heavy Planting Densities

Regardless of the selected restoration technique, the planting of heavy densities of native trees, shrubs, and herbaceous materials is an essential element to achieving long term stability. This is often overlooked or the quantity of plants is reduced in order to save money – often at the expense of a failed project.

Figure 26 A/B - The Glade, Reston, VA. Planting of newly restored channel and 1 year later.

To Achieve Sediment Reductions from Gravel and Dirt Roads

Practices are under development by the University of Maryland (UMD) Center for Dirt and Gravel Road Studies to help reduce the amount of sediment runoff from dirt and gravel roads. These techniques, termed environmentally sensitive road maintenance practices (ESMPs) are:

1. Driving Surface Aggregate(DSA): durable and erosion resistant road surface;
2. Raising the Profile: raising road elevation to restore natural drainage patterns;
3. Grade Breaks: elongated humps in the road surface designed to shed water;
4. Additional Drainage Outlets: creating new outlets in ditchline to reduce channelized flow; and
5. Berm Removal: Removing unnecessary berm and ditch on downhill side of road to encourage sheet flow.

Effectiveness of these ESMPs to reduce TSS is shown on Table 11 as follows:

Tabel 11. ESMP Efficacy at TSS Reduction

Technique	TSS Effectiveness Estimate
Driving Surface Aggregate - Limestone	50%
Driving Surface Aggregate - Sandstone	55%
Raising the Road Profile	45%
Grade Breaks	30%
Additional Drainage Outlets	15%
Berm Removal	35%
Note – Reduction estimates based on total ESMP efficacy adjusted by first-flush factor (UMD, 2009)	

Description/Definition of BMP and Effectiveness Estimate:

Driving Surface Aggregate (Preferred Method)

DSA is a specific gradation of crushed stone developed by the Center for Dirt and Gravel Road Studies specifically for use as a surface wearing course for unpaved roads. DSA achieves sediment reductions by decreasing erosion and transport of fine material from the road surface. Due its relatively high efficacy in reducing TSS, we recommend this method for controlling sediment runoff from the dirt and grave roads within the WSR Watershed. We are recommending that an initial 1-mile of road be used as a demonstration project to evaluate the efficacy of this method in reducing sediment loss. Based on the results of this project, decisions can be made regarding moving forward aggressively on a gravel and dirt road DSA resurfacing effort county-wide.

Raising the Road Profile

Raising the road profile involves importing material to raise the elevation of an unpaved road. It is typically practiced on roads that have become entrenched (lower than surrounding terrain). Raising the elevation of the road is designed to restore natural drainage patterns by eliminating the down-slope ditch and providing cover for pipes to drain the up-slope ditch. Removing the down-slope ditch will eliminate concentrated flow conveyed in the ditch and will create sheet flow. Raising the Road Profile achieves sediment reduction by controlling and reducing the volume of road runoff. Raising the road profile involves importing fill material to raise the elevation of the roadway up to the elevation of the surrounding terrain. The road is filled to a sufficient depth as to eliminate the ditch on the down-slope side of the road and encourage sheet flow. Shale and gravel are the most common fill materials for roads. Other potential recycled fill materials include ground glass, waste sand, automobile tires, clean concrete rubble, etc.

Grade Breaks

Grade breaks are an intentional increase in road elevation on a downhill grade which causes water to flow off of the road surface. It is designed to reduce erosion on the road surface by forcing water into the ditches or surrounding terrain. Erosion of the road surface is reduced by forcing runoff laterally off the road. In some cases, grade breaks are used to force water off the road entirely, serving as an additional drainage outlet. Sites where water is not forced off the road entirely convey the water into a roadside ditch. The Center's report forced water into the roadside ditch.

Additional Drainage Outlets
Drainage outlets are designed to capture water flowing in the roadside ditch and force it to leave the road area. There are two major types of drainage outlets. Turnouts (also called bleeders or cutouts) outlet water from the down-slope road ditch. They usually consist of relatively simple cuts in the down-slope road bank to funnel road drainage away from the road. Drainage that is carried by the up-slope road ditch is usually outletted under the roadway by the use of a crosspipe (also called culvert, sluice pipe, or tile drain). Installing additional drainage outlets reduces concentrated flow, peak flow discharges and sediment transport and delivery from unpaved roads and ditches into streams, and can increase infiltration. It does not affect sediment generation from the road surface or deliver in the up-slope ditch, thus all data on sediment reductions in the report is only for down-slope ditch unless otherwise noted. Drainage outlets are to be placed in locations that have the least likelihood of reaching streams. If a newly added outlet conveys sediment to the stream, little, if any, sediment reductions will be obtained.

Berm Removal
A berm is a mound of earthen material that runs parallel to the road on the downslope side. Berms can be formed by maintenance practices and road erosion that lowers the road elevation over time. In many cases, the berm is unnecessary and creates a ditch on the downslope side of the road. This berm can be removed to encourage sheet flow into surrounding land instead of concentrated flow in an unnecessary ditch. Restoring sheet flow results in decreased runoff and sediment transport along the roadway, increase infiltration, and reduced maintenance associated with the road drainage system.

Nutrient Removal **-** Total Nitrogen (TN) and Total Phosphorous (TP) removal is minimal with dirt and gravel road erosion and sediment control. One reason is that dirt and gravel roads are not fertilized. The other is that the environmental benefit association with dirt roads is such that nitrogen (N) and phosphorus (P) reductions are not anticipated; nutrient reductions are not a component of the average function of dirt and gravel roads. If N and P reductions are associated with dirt and gravel roads they should track sediment reductions.

One situation where nutrient reductions could be associated with dirt and gravel roads is on farm lanes where the road was used as a conduit to the stream. If projects remove that mechanism so water is dispersed out onto the field, then the nutrient removal is proportional to the amount of water reduced from discharging directly to the stream.

To Achieve Sediment Reductions from Disturbed Areas

There are many areas of exposed weathered shale in the landscape and in road side ditches within the Warm Springs Run watershed. Exposed and weathered shale is a source of sediment and runoff to the watershed. Therefore, there is a need for a weathered shale management plan that will appropriately characterize and provide potential restoration techniques for these areas.

Areas of exposed weathered shale are located throughout the Warm Springs Run watershed in locations of previous development activities as shown in Figures 27 - 29.

Figure 27. Exposed weathered shale along roadside with minimal vegetative growth after many years.

Figure 28. Exposed weathered shale behind shopping center. Slope devoid of vegetation.

Figure 29. Weathered shale adjacent to commercial development. Minimal vegetative growth after several years.

These exposed weathered shale areas in their current condition increase runoff and sediment supply into the channels and streams within the Warm Springs watershed. Additionally, these areas have the potential to negatively affect water chemistry if these shales have sulfides in them and are acid-forming. Restoration of these areas will improve water quality throughout Warm Springs Run.

Management Strategy

As these areas are potential acid sulfate soils, the following protocol should be used in determining the reclamation of these areas, as recommended by Professor W. Lee Daniels, PhD, Department of Crop and Soil Environmental Sciences, Virginia Tech (http://www.landrehab.org/content.aspx?ContentID=1384):

1. Field investigate area, including the collection of soil and drainage samples.

2. Laboratory analyses including pH, Potential Peroxide Acidity test, and other relevant characterization tests are completed.

3. A reclamation prescription can then be developed based on the laboratory results and the site specific conditions. The prescription shall include a lime recommendation, emphasizing that the lime must be thoroughly incorporated into the top 6 inches of soil. Fertilization needs shall also addressed, and incorporation of organic amendments or topsoil covers are typically recommended but not always essential for reclamation success. After incorporating these amendments, seeding should be completed only during established planting dates in the fall or spring.

We recommend seeding and planting be conducted to restore the areas to a vegetated state. In all areas we recommend a temporary erosion and sediment control cover crop (annual ryegrass and foxtail millet) coupled with a native seed mix including herbs, grasses, and woody species. In areas other than roadside ditches we recommend one gallon container plants trees and shrubs should be planted at a minimum density of 400 stems per acre. Proposed species for planting are listed in Table 12.

Table 12. Partial Plant Species List for Reforestation of Weathered Shale reas	
Plant Species	**Wetland Indicator Status**
Juniperus virginiana (eastern red cedar)	FACU
Cercis canadensis (eastern redbud)	FACU-
Viburnum prunifolium (black haw)	FACU
Cornus florida (flowering dogwood)	FACU-
Acer rubrum (red maple)	FAC
Quercus rubra (red oak)	FACU-
Quercus phellos (willow oak)	FAC+
Quercus alba (white oak)	FACU-
Hamamelis virginiana (witch hazel)	FAC-
Nyssa sylvatica (black gum)	FAC
Ulmus rubra (slippery elm)	FAC
Ilex opaca (American holly)	FACU+
Diospyros virginiana (persimmon)	FAC-
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands	

In conclusion, restoration of the weathered shale areas of Warm Springs Run will benefit water quality downstream and the entire watershed by decreasing runoff, reducing sediment deposition, and potentially reduce acid sulfides from entering the streams. In order to return the area from its currently altered state, some laboratory analyses must be conducted prior to restoration of the area, as each area may require a different method to restore the area. We recommend that a 1-acre plot of disturbed land be chosen as a demonstration project to evaluate the efficacy of the above described management practice for revegetation and stabilization.

To Achieve Sediment Reductions from Uncontrolled Stormwater Runoff

The WSR watershed area has three primary sources for uncontrolled stormwater runoff:

1) Paved streets and roads, in particular in the Town of Bath, Route 522, and along the eastern tributaries;

2) Roof drains, which channel water directly into the stream via downspouts that empty into disposal pipes;

3) Sheet flow from impervious areas (e.g. parking lots).

We propose the following methods to manage and reduce sediment load from these targeted areas:

Street Sweeping

Streets, roads, highways and parking lots accumulate significant amounts of pollutants that contribute to stormwater pollutant runoff to surface waters. Pollutants, including sediment, debris, trash, road salt, and trace metals can be minimized by street sweeping. Street sweeping can also improve the aesthetics of municipal roadways, control dust and decrease the accumulation of pollutants in catch basins. An effective municipal street sweeping program can meet regulatory requirements, assess street sweeping effectiveness, and minimize pollutants in roadways.

Street sweeping is practiced in most urban areas, often as an aesthetic practice to remove trash, sediment buildup, and large debris from curb gutters. Effective street sweeping programs can remove several tons of debris a year from city streets minimizing pollutants in stormwater runoff. In colder climates, street sweeping can be used during the spring snowmelt to reduce pollutants in stormwater runoff from road salt, sand and grit.

Municipalities can choose between the three different types of street sweepers (mechanical, regenerative air and vacuum filter) keeping in mind the targeted pollutants, pollutant type (large debris to particles less than 10 microns in diameter (PM10)), types of surfaces, travel distances, noise ordnances, and costs. Municipals often find it useful to have a compliment of each type of street sweeper in their fleet (CASQA, 2003).

Each type of street sweeper has it advantages and disadvantages concerning pollutant removal effectiveness, traveling speed, and noise generated by the street sweeper. With the different types of modern street sweepers capable of removing PM10 particles, price and personal preference are the primary selection criteria for most users. No definitive independent studies have yet been staged to determine "the best" sweeping system. Anecdotal data has also been inconclusive.

Implementation - An effective municipal street sweeping program should address at a minimum the following components:

Street Sweeping Schedule: Designing and maintaining a street sweeping schedule can increase the efficiency of a program. A successful program will need to be flexible to accommodate climate conditions and areas of concern. Areas of concern should be based on traffic volume, land use, field observations of sediment and trash accumulation and proximity to surface waters (CASQA, 2003). Street sweeping in these areas may need to be increased and the schedule amended. It is recommended that schedules include minimum street sweeping frequencies of at least once a year. In cold climates prone to snowfall the Connecticut Department of Environmental Protection recommends that municipalities conduct street sweeping as soon as possible after the snow melts (McCarthy, 2005). Removal of the accumulated sand, grit, and debris from roads after the snow melts reduces the amount of pollutants entering surface waters.

To evaluate the effectiveness of a street sweeping program, municipalities should maintain accurate logs of the number of curb-miles swept and the amount of waste collected (CASQA, 2003). Monthly or yearly intakes (per ton) can be measured per district, road, season, or mile. This information can be used to develop a written plan, schedule, and periodic re-evaluation for street sweeping that would target the following:

- those roadways with contributing land uses (high level of imperviousness, high level of industrial activity) that would be expected to show high pollutant concentrations and
- those roadways that have consistently accumulated proportionately greater amounts of materials (pounds per mile swept) between currently scheduled sweeps (Curtis, 2002).

Gross intake amounts can be presented to regulatory agencies and to finance directors to measure performance. The City of Dana Point, California reported that when sweeping was conducted twice a month, the monthly debris intake was 23 tons. Dana Point then increased street sweeping frequency to a weekly basis and the monthly total increased to 46 tons of debris (City of Dana Point, 2003).

Street Sweepings Storage and Disposal: Street sweeping material often includes sand, salt, leaves, and debris removed from roads. Often the collected sweepings contain pollutants and must be tested prior to disposal to determine if the material is hazardous. Municipals should adhere to all federal and state regulations that apply to the disposal and reuse of sweepings.

Municipalities are encouraged to develop comprehensive management plans for the handling of sweepings. A critical aspect of a management plan is selecting a location for storing and processing street sweepings (McCarthy, 2005). Storage locations should be equipped with secondary containment and possibly overhead coverage to prevent stormwater runoff from contacting the piles of sweepings. It is also recommended to cover the piles of sweepings with tarps to prevent the generation of excessive dust. Storage locations should be sized accordingly to completely contain the volume of the disposed

sweepings. To estimate the size of the storage location, estimate the volume of sweepings either on a ton-per-street mile or on pounds-per-capita basis (McCarthy, 2005). An average figure for urban areas is 20.25 tons-per street-mile (McCarthy, 2005).
Street Sweepings Reuse Practices: Although sweepings may contain pollutants, federal and state regulations may allow the reuse of sweepings for general fill, parks, road shoulders and other applications as long as the material is not a threat to surface waters. Prior to reuse, trash, leaves, and other debris from sweepings should be removed by screening or other methods (MPCA, 1997). Trash and debris removed should be disposed of by recycling or sent to a landfill (MPCA, 1997).

Parking Policy: Established parking policies increases the effectiveness of a street sweeping program. Parking policies can be established as city ordinance and incorporate the following:

1) Institute a parking policy to restrict parking in problematic areas during periods of street sweeping.
2) Post permanent street sweeping signs in problematic areas; use temporary signs if installation of permanent signs is not possible.
3) Develop and distribute flyers notifying residents of street sweeping schedules (CASQA, 2003).

Operation and Maintenance Program: A municipality should dedicate time for daily and weekly equipment maintenance. Regular maintenance and daily start up inspections insures that street sweepers are kept in good working condition (City of Greeley, 1998). It is vital for municipals to inventory and properly stock parts to prevent downtime and decrease productivity. Old sweepers should be replaced with new technologically-advanced sweepers, preferably modern sweepers that maximize pollutant removal (CASQA, 2003).

Manufactured Products for Stormwater Inlets

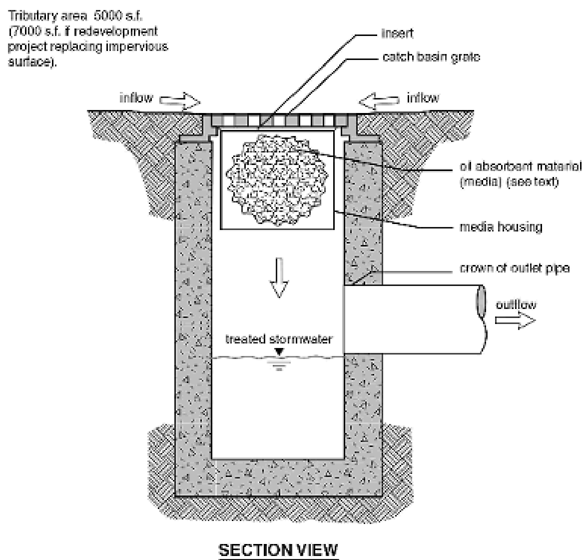
A variety of products called swirl separators or hydrodynamic structures have been widely applied to stormwater inlets in recent years. Swirl separators are modifications of traditional oil-grit separators. They contain an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. The concept behind these designs is that sediments settle out as stormwater moves in this swirling path, and additional compartments or chambers are sometimes present to trap oil and other floatables (see Figure 30). There are several different types of proprietary separators, each incorporating slightly different design variations, such as off-line application.

Swirl separators are best installed on highly impervious sites. Because little data are available on their performance (independently conducted studies suggest marginal pollutant removal), swirl separators should not be used as a stand-alone practice for new development. The best application for these products is as pretreatment to another stormwater device or, when space is limited, as a retrofit.

Siting and Design - The design of swirl concentrators is specified in the manufacturer's product literature. For the most part, swirl concentrators are rate-based designs. That is, their size is based on the peak flow of a specific storm event. This design contrasts with most other stormwater management practices, which are sized based on the capture, storage or treatment of a specific volume. Sizing based on flow rate allows the practice to provide treatment within a much smaller area than other stormwater management practices.

Maintenance - Swirl concentrators require frequent, typically quarterly, maintenance. Maintenance is performed using a vacuum truck, as is used for catch basins (see Catch Basin). In some regions, it may be difficult to find environmentally acceptable disposal methods. Due to hazardous waste, pretreatment, or groundwater regulations, sediments may sometimes be barred from landfills, from land applications, and from introduction into sanitary sewer systems.

Efficacy - While manufacturers' literature typically reports removal rates for swirl separators, there is little independent data to evaluate the effectiveness of these products. Two studies investigated one of these products. Both studies reported moderate pollutant removal, but while the product outperforms oil/grit separators, which have virtually no pollutant removal (Schueler, 1997), the removal rates are not substantially different from the standard catch basin. One long-term advantage of these products over catch basins is that if they incorporate an off-line design, trapped sediment will not become resuspended. Data from the two studies are presented below. Both studies are summarized in a Claytor (1999).



The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Figure 30. Example Hydrodynamic Structure

Table 13. Effectiveness of Manufactured Products for Stormwater Inlets		
Study	Greb et al., 1998	Labatiuk et al., 1997
Notes	Investigated 45 precipitation events over a 9-month period. Percent removal rates reflect overall efficiency, accounting for pollutants in bypassed flows.	Data represent the mean percent removal rate for four storm events.
TSS[a]	21	51.5
TDS[a]	-21	-
TP[a]	17	-
DP[a]	17	-
Pb[a]	24	51.2
Zn[a]	17	39.1
Cu[a]	-	21.5
PAH[a]	32	-
NO_2+NO_3[a]	5	-

[a] TSS=total suspended solids; TDS=total dissolved solids; TP=total phosphorus; DP=dissolved phosphorus; Pb=lead; Zn=zinc; Cu=copper; PAH=polynuclear aromatic hydrocarbons; NO_2+NO_3=nitrite+nitrate-nitrogen

Low Impact Development (LID) Retrofit Practices

Urban development significantly alters the natural features and hydrology of a landscape. Development and redevelopment usually creates impervious surfaces like concrete sidewalks and asphalt roadways, commercial and residential buildings, and earth compacted by construction activities. Prevented from soaking into the ground, rainwater runs across parking lots and streets, collecting used motor oil, pesticides, fertilizers, and other pollutants.

In most cities, a complex system of piping usually feeds contaminated stormwater flows directly into streams and coastal waters. More recently, stormwater control structures like dry extended detention ponds or wet retention ponds have been installed, most in new development, to intercept stormwater on its way to surface waters.

Historically, the goal of stormwater planning has been to prevent localized flooding by moving large amounts of water offsite as quickly as possible. However, experience has shown that traditional stormwater management has many limitations.

Expensive, ever-expanding storm sewer systems strain municipal budgets. Fast moving stormwater discharges cause downstream flooding, erode stream banks, and contribute to water quality violations. Bacteria and other pathogens carried in stormwater contaminate coastal waters, often requiring beach closures. Rainwater diverted or otherwise unable to soak into the soil cannot recharge aquifers. This reduces stream base flows, which can cause streams to dry-up for extended periods of time. Stormwater that collects in detention basins or flows over impervious surfaces is often much warmer than the streams into which it flows. This is a problem because a temperature increase of just one or two degrees can stress fish and other aquatic organisms.

Management Techniques - Like other alternative development strategies, LID seeks to control stormwater at its source. Rather than moving stormwater offsite though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb stormwater.

LID retrofitting integrates small-scale measures scattered throughout the development site. Constructed green spaces, native landscaping, and a variety of innovative bioretention and infiltration techniques capture and manage stormwater on-site. LID reduces peak runoff by allowing rainwater to soak into the ground, evaporate into the air, or collect in storage receptacles for irrigation and other beneficial uses. In areas with slow drainage or infiltration, LID captures the first flush before excess stormwater is diverted into traditional storm conveyance systems. The result is development that more closely maintains pre-development hydrology. Furthermore, LID has been shown to be cost effective, and in some cases, cheaper than using traditional stormwater management techniques.

The following are the techniques for LID retrofits that are feasible for the WSR watershed, in particular the Town of Bath and developed areas with impervious surfaces:

- **Bioretention Cells** – Commonly known as rain gardens, bioretention cells are relatively small-scale, landscaped depressions containing plants and a soil mixture that absorbs and filters runoff.
- **Cisterns and Rain Barrels** – Used to harvest and store rainwater collected from roofs. By storing and diverting runoff, these devices help reduce the flooding and erosion caused by stormwater runoff. And because they contain no salts or sediment, they can provide "soft" chemical-free water for garden or lawn irrigation, reducing water bills and conserving municipal water supplies.
- **Green Roofs** – These are roofs partially or completely covered with plants. Used for decades in Europe, green roofs help mitigate the urban "heat island" effect and reduce peak stormwater flows. The vegetated cover also protects and insulates the roof, extending its life and reducing energy costs.
- **Permeable and Porous Pavements** – These BMPs reduce stormwater runoff by allowing water to soak through the paved surface into the ground beneath. Permeable pavement encompasses a variety of mediums, from porous concrete and asphalt, to plastic grid systems and interlocking paving bricks suitable for driveways and pedestrian malls. Permeable pavement helps reduce runoff volumes at a considerably smaller cost than traditional storm drain systems.
- **Vegetated Filter Strips** – Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter

strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

- **Grass Swales** – These are broad, open channels sown with erosion resistant and flood tolerant grasses. Used alongside roadways for years primarily as stormwater conveyances, swales can slow stormwater runoff, filter it, and allow it to soak into the ground. Swales and other biofiltration devices like vegetated filter-strips improve water quality and reduce in-stream erosion by slowing the velocity of stormwater runoff before it enters the stream. They also cost less to install than curbs, storm drain inlets, and piping systems.

Efficacy of LID Retrofits to Reduce Loads – Various studies have been conducted to document the efficiency of the aforementioned LID methods to reduce contaminant loads. These data are summarized on Table 14 as follows:

Table 14. LID Load Reductions (Yu et al., 1992)

	Bio-Retention*	Porous Pavement	Grass Swales	75' Filter** Strip	150' Filter Strip
Total N	49%	35% - 75%	38%	-27	40%
Total P	65% - 87%	42% - 65%	29%	-25	20%
TSS	85%	71% - 99%	81%	54%	64%

*includes rain gardens, rain barrels, and green roofs

** To date, only one study (Yu et al., 1992) has investigated the effectiveness of a grassed filter strip to treat runoff from a large parking lot. The study found that the pollutant removal varied depending on the length of flow in the filter strip. The narrower (75-foot) filter strip had moderate removal for some pollutants and actually appeared to export lead, phosphorus, and nutrients.

In summary, LID retrofits can help reduce flow rates delivered to the receiving water body, as well as TSS and sedimentation in general. The reduction of nutrient loads varies, however, by the method being employed. Nevertheless, the reduction in stormwater quantity delivered to the WSR will inevitably assist in reducing streambank erosion that is related to uncontrolled stormwater runoff from impervious areas.

To Achieve Load Reductions by Conservation of the Lower Run

As was stated previously, the results of the WVDEP Benthic Assessment and Water Quality sampling have demonstrated that some of the best overall benthic scores were observed at mile station 0.7, just upstream from the WSR's confluence with the Potomac River. Similarly, the result for fecal coliform at this mile station was an order of magnitude lower than the upstream stations during the monitoring event of August 16, 2007, at which time unusually high levels of fecal coliform were observed along the entire length of the Run. Although there have been variations in the values throughout the water quality monitoring events, the overall high benthic scores reflect the general positive effect on the WSR's condition as it passes through the downstream reach.

There are few sources of impairment to the WSR north (downstream) from the Town of Bath, the most significant being the Warm Springs Public Service District water treatment plant, and the discharges from the (former) U.S. Silica facility north of the Town of Bath. It is our understanding that both of these facilities are in compliance with their discharge requirements. The WSPSD plant typically discharges 500,000 gallons of treated water to the Run daily (0.77 cfs), and 1,550,000 gallons per day after a 1-inch rain. This increase is attributed to sump pumps and/or residential drain systems that are channeled into the municipal sanitary sewer system. Based on their NPDES permit information, the sand mine operates five outlets that collectively discharge an average of 2.2 million gallons per day (3.4 cfs) to the Run.

It is of note that nearly the entire lower 4-mile reach of the WSR passes through a forested area, with little residential development of any kind. The few agricultural areas are buffered by vegetated strips as described in the previous sections on load reductions from cropland and pasture sources. Thus, this section has the benefit of a significant (greater than 150-feet) forested riparian buffer through nearly its entire reach. There are no sections of the stream throughout the lower 4-miles where there is significant erosion or stream channel incision, with the exception of a small area just downstream from the CSX yard located along River Road. We suspect that the uncontrolled discharged of stormwater from the CSX yard may have accelerated erosion and incision along this section, as the yard's stormwater flows downhill towards Airport Lane, and from there directly into the Run.

We recommend that Morgan County and the Eastern Panhandle Conservation District enter into discussion with the owners of this section of the Run to possibly create a conservation easement along the stream. Ideally, this easement would allow for the protection of a 150-foot wide forested riparian buffer along the stream (at the minimum) and ideally as wide as is feasible. Within this easement, the forest should be managed and protected from timbering and/or residential or commercial development. This would also allow the County to develop the area as public space, with considerable resources for outdoor recreation (i.e. hiking, bicycling, and fishing) and conservation education and interpretation.

To Reduce Flooding in the Town of Bath

The BMPs described in the prior sections of this report will help achieve reductions in both nutrient and sediment loads delivered to the Potomac River, and ultimately to the Chesapeake Bay; but there is a side benefit to encouraging onsite absorption in the upstream section of the WSR south of the Town of Bath, and that is helping to control catastrophic flooding.

It is of note that when the flood control dams were constructed along the eastern tributaries and the drainage swales feeding into them, the historic flash flooding seen in the Town of Bath was reduced considerably. There were several reasons for this.

1) It should be understood that in their undisturbed natural state, streams in mountainous regions on steep grades collect water that sheets off the hillsides. The unrestricted flow of water downhill carries along with it rocks, brush, leaves, and other debris that collects at "pinch points" in the channel. The water becomes dammed up temporarily behind these "dams", which then break suddenly, releasing a torrent which collects more debris, and the process repeats itself at the next pinch point. By the time the water reaches the main stem it is moving with destructive depth and velocity, carrying with it logs, rocks, and enormous quantities of sediment. The effects of this type of flash flooding on developed areas can be devastating. The 1985 flood along forks of the South Branch of the Potomac River in Pendleton County WV bears testament to the destructive power of these types of flash flooding events. Thus, the flood control dams helped to mitigate the contribution of the eastern tributries to the catastrophic flooding events seen in the Town of Bath by mitigating the type of stream behavior during flooding described above.

2) When the flood control dams were constructed, there was little commercial development along the reach (the main stem) of the WSR that parallels US Route 522 south of the Town of Bath. Thus, much of the water sheeting off the east slope of Warm Springs Ridge was absorbed by the relatively permeable soils along the pediment of the ridge and in the floodplain of the main stem. This upstream absorption, combined with the mitigating effects of the flood control dams was able to bring about a significant reduction in the catastrophic historic flooding seen in the Town of Bath since the 18th Century.

It is interesting then, that severe flooding in the Town of Bath has been on the increase in recent decades. Particularly notable was the flooding that occurred in January 1996, caused by the rapid snowmelt of over 30-inches of snow, combined with six inches of rain and unseasonably warm weather. Hurricane Fran in September of that same year dropped 5-inches of rain on the Potomac Highlands and caused further severe flooding. These severe flooding events are now occurring on a regular basis, most frequently caused by tropical systems or unusually heavy late winter/spring storms. We propose that these flooding events are being exacerbated by the loss of upstream absorption areas along the main stem of the WSR due to rapid commercial development and the resulting introduction of extensive areas of impervious surfaces, much of which has occurred within the last three decades. Removal of the forest cover along large stretches of the WSR upstream from the Town of Bath has also added to the problem. It is of note that the US Forest Service (USDA-USFS) has estimated that a forest canopy of one acre can collect as much as 4-inches of rain from a storm, reducing the contribution to the receiving water body by over 100,000 gallons per acre.

In summary, reducing runoff volume using green infrastructure has benefits beyond just removing pollutants. It also recharges groundwater, provides better protection of sensitive aquatic resources, and reduces the size and cost of hard infrastructure that would otherwise need to be constructed to prevent serious flooding. Therefore, in addition to the upstream absorption practices described in the previous sections of this plan, we would encourage Morgan County to pursue an aggressive policy of reforestation and urban tree planting wherever feasible along the WSR. The planting of trees in the commercial downtown section of the Town of Bath is strongly recommended as well.

(Note – One challenge with this approach has been how to account for the runoff reduction provided by green infrastructure in rainfall/runoff models commonly used by engineers. A runoff reduction calculation guideline has been developed by the USFS, and is included as Appendix C to this report.)

Section D – Technical and Financial Assistance Needed

The following section describes costs and financial assistance needed to implement the proposed management measures described in Section B/C. These costs are based on existing management plans for the Potomac Direct Drains, regional pricing structures for standard practices such as wetland and streambank restoration, and data derived from the USDA-NRCS, Chesapeake Stormwater Network, and USEPA menus of stormwater BMPs. Actual costs may vary depending on a number of site specific factors.

Table 15. Estimated Costs of Implementing Management Measures in the WSR Watershed

Onsite Treatment Systems (Septic Systems)

Practice	Planned Units	Cost per Unit	Total Cost
Field Assessment of Failed Systems	300	$750	$225,000
Repair & Upgrade of Failed Systems*	255	$6,500	$1,657,500
De-nitrification System Installs**	42	$12,000	$504,000
Subtotal			**$2,386,500**
*assuming an 85% failure rate **assuming 85% failure rate of priority systems located adjacent to tributary streams			

Fenced Pasture

Practice	Planned Units	Cost per Unit	Total Cost
Stream Fencing	1,336 feet	$2.50/foot	$3,340
Watering Station	1	$17,000/station	$17,000
Stream Crossing	2	$3,400	$6,800
Grass Buffer (agricultural)	1 acre	$230/acre	$230
Nutrient Management Plan	72 man hours	$85/hour	$6,120
Subtotal			**$33,490**

Cropland

Practice	Planned Units	Cost per Unit	Total Cost
Nutrient Management Plan	72 man hours	$85/hour	$6,120
Subtotal			**$6,120**

Misc. Fecal Coliform Reduction

Practice	Planned Units	Cost per Unit	Total Cost
Wetland Restoration	7.8 acres	$5,000/acre	$39,000
Pet Waste Reduction Campaign	1	$25,000	$25,000
Carcass Dumping Education Campaign	1	$25,000	$25,000
Subtotal			**$89,000**

Stream Erosion and Exposed Soil Repair

Practice	Planned Units	Cost per Unit	Total Cost
Design, oversight and construction	7,487 linear feet	$250/foot	$1,871,750
Road BMPs and Culvert Improvements	20	$10,000	$200,000
Exposed Soil Repair	1 acre	$13,500	$13,500
Subtotal			**$1,887,250**

(Table 15, continued)

Stormwater BMPs and Sediment Control

Practice	Planned Units	Cost per Unit	Total Cost
Rain Garden Installation	25	$500	$10,000
Green Roof Installation	$20/SF	225,000SF	$4,500,000
Vegetated Buffers at Impervious Sites	11.25 acres	$20,000	$225,000
Rain Barrel Workshops (15 barrels ea.)	5	$1,200	$6,000
Rain Garden Demonstrations	3	$20,000	$60,000
Street Sweeping (O&M Only)	12 miles-weekly	$30/mile	$18,720
Manufactured Sediment Traps	8	$20,000 ea.	$160,000
DSA Resurfacing Demonstration Project*	1 mile	$105,000	$105,000
Shale Bank Demonstration Project**	1 acre	$7,500	$13,000
Subtotal			**$5,097,720**
*Includes design, grading, equipment and materials, and testing **includes testing, liming and compost, native species planting, plus oversight			

Stream Sampling

Practice	Planned Units	Cost per Unit	Total Cost
Preparation of Sampling QAPP	1	$4,000	$4,000
ToN/ToP	35 per year*	$44	$1,540
Dissolved Nitrate plus nitrite as N	35 per year*	$20	$700
Dissolved Ammonia as N	35 per year*	$20	$700
Total Suspended Solids	35 per year*	$10	$350
Dissolved Ortho-phosphorus as P	35 per year*	$10	$350
Total Suspended Sediment	35 per year*	$20	$700
Fecal Coliform	35 per year*	$20	$700
Sand-fine split	3 per year	N/A	N/A
Subtotal			**$9,040**
*one (1) normal flow sample per 5 stations on a quarterly basis, and 3 “peak flow” samples per station per year			

Grand Total			**$9,509,120**

Specific sources of funding will be explored by establishing partnerships with various regional, state and private organizations and entities. Among which are the entities shown on the following list. (Organizations the WSWA has worked with in the past are shown in **bold**).

Morgan County

Morgan County Arts Council
Morgan County Board of Education
Morgan County Commission
Morgan County Department of Health
Morgan County Economic Development Authority
Morgan County Planning Commission
Morgan County Solid Waste Authority
Morgan County Extension Office, including the Morgan County Master Gardeners
Morgan County Chamber of Commerce

Town of Bath

Town of Bath
Town of Bath Tree Board
Warm Springs Public Service District

State and Federal Agencies

Berkeley Springs State Park
WV Department of Highways
WV Department of Environmental Protection
WV Division of Natural Resources
WV Division of Forestry
Chesapeake Bay Watershed Forester
WV Division of Fish and Wildlife
The Eastern Panhandle Regional Planning and Development Council
US EPA District 9

Private Entities

Streetscape Committee
The Museum of Berkeley Springs
Travel Berkeley Springs
Morgan County Rotary Club
Morgan County Lions Club

Section E – Information/Education Campaign

The Roles of the Warm Springs Run Watershed Association and its Partners (provided by Kate Lehman, President WSWA)

The Warm Springs Watershed Association (WSWA) was founded in 2008 and is currently is the process of becoming a 501(c)(3) organization. The mission of the WSWA is to restore, protect and preserve the Warm Springs Run and its watershed through education and the establishment of partnerships with concerned citizens, civic organizations, and governmental agencies.

From its inception the WSWA has engaged in various projects designed to restore, protect and preserve the Run. We have:

- completed corridor and watershed assessments;
- cleaned trash and debris from the Run on a regular basis;
- planted riparian buffers in various locations;
- trained volunteers to monitor the Run and test for fecal coliforms;
- monitored 10 sites for water chemistry, benthic organisms and fecal coliforms;
- engaged in efforts to control invasive species including purple loosestrife, mile-a-minute plant and Japanese knotweed.

We have done extensive work to educate the community about the existence of the Run, issues resulting in its impairment, and the role of individuals and organizations to help restore, protect and preserve the Run. Over the past three years we have made Power Point presentations to nearly every civic or governmental agency in the watershed. So, too, we have mailed brochures to every household in the watershed and published articles in the *Morgan Messenger,* the local paper, about our efforts and accomplishments. Each year at the Morgan County Fair we sponsor an interactive display designed to educate participants about the presence and significance of benthic macroinvertebrates in the Run.

Our efforts to establish partnerships with various organizations were recognized by the West Virginia Watershed Network in 2009 and 2011. The following is a partial list of some of the organizations with whom we've formed partnerships:

- Town of Bath Council;
- Morgan County Commission;
- Morgan County Planning Commission;
- Morgan County Department of Health;
- Morgan County Economic Development Authority;
- Morgan County Board of Education;
- Eastern Panhandle Conservation District;
- WV Extension Office;
- Morgan County Master Gardeners;
- Berkeley Springs State Park;
- The Museum of the Berkeley Springs;
- Potomac Valley Audubon Society watershed education program;
- WV DEP;
- US Division of Fish and Wildlife;
- WV DNR.

Members of the Warm Springs Watershed Association are proud of what we have accomplished over the past four years. Our efforts have been recognized by other organizations, including the WV Watershed Network, which named us an outstanding new watershed association in 2010.

Despite our many successes, at the Strategic Planning Session held in February 2011, we recognized that such piecemeal projects are not sufficient in and of themselves to bring water quality closer to the proposed TMDLs for the Phase 2 Plan for the Chesapeake Bay Initiative. Thus it is that we applied for and were awarded a grant to establish a Comprehensive Watershed Management Plan. We believe that the experience gained through the aforementioned projects and the partnerships formed with concerned citizens, civic organizations, and governmental agencies put the WSWA in an excellent position to implement this plan.

Morgan County Arts Council

The Morgan County Arts Council owns the Ice House, which is located at the corners of Independence and Mercer Streets in the Town of Bath. In the 19th century the building now known as the Ice House was a tannery which dumped waste from the tanning process directly into the nearby Warm Springs Run.

The WSWA plans to work with the MAC, the **Morgan County Historic Society** and the **Museum of the Berkeley Springs** to develop an exhibit on the historic industrial base of the Town of Bath and the subsequent degradation of Warm Springs Run as well as the long-term implication of some of the processes involved in, for example, tanning leather.

The WSWA and the MAC will provide public education programs to highlight how the current placement of the Ice House continues to impact upon the Run, specifically in terms of storm water management issues. Grants will be sought to implement best management practices to reduce the amount of stormwater runoff into the Run, including the installation of blue or green roofs, rain barrels and raised rain gardens adjacent to the Ice House and a rain garden at the edge of the Ice House Parking lot, which abuts the Run

Morgan County Board of Education

Berkeley Springs High School is built in the floodplain of the Warm Springs Run. Flooding, always an issue has become worse in recent years due to increased sediment depositions. During flooding, sediment deposits in the floodplain have become so deep as to bury gutter down spouts.

Fieldwork done as part of the Comprehensive Watershed Management Plan revealed two sources of increased sedimentation and thus flooding. The area upstream, especially around Morgan Square, has a very high percentage of impervious surfaces, which increases the volume and quantity of runoff into the Run. The result is incised or entrenched stream beds in the portion of the Run flowing past Widmyer Elementary School, which accounts for the increased sediment load deposited downstream at the High School. Interestingly, the installation of the raised sewer manholes in the bed of the stream exacerbated the sedimentation problem significantly, based on comments from school officials.

Members of the WSWA have already met with the Superintendent of Schools, the Treasurer/CSBO, and Superintendent of Maintenance to explore a partnership to seek funding from the **WV Conservation Agency** for natural stream bank restoration in front of Widmyer Elementary School. There was also discussion of working together to secure funds to implement non-engineering stormwater management practices at Widmyer and the High School, including green or blue roofs, rain barrels, and rain gardens so as to reduce the quantity and volume of stormwater entering the Run.

A workshop would be held for parents to encourage them to use these BMPs where applicable at their homes.

Merchants in Morgan Square

The WSWA will hold education programs for the merchants upstream from Widmyer as to non-engineering BMPs for reducing stormwater runoff in this area, which has a very high percentage of impervious surfaces. The WSWA will seek grants to assist merchants in purchasing and installing such devises.

Dollar General / Reed's Pharmacy

During recent construction on the area across from Widmyer Elementary School, a significant portion of a shale hill was denuded, which also increases runoff into WSR. The WSWA will partner with the merchants who own this property to do a demonstration shale bank reclamation and replanting project.

Morgan County Commission

The WSWA and the Eastern Panhandle Conservation District have already gained permission from the County Commission to install a rain garden in the area between the county employee parking lot and the Run. At this point we are waiting to determine what portion of that area will be used to access the intake valve where water is taken from the Run to use in the geo-thermal heating/cooling system for the Courthouse.

The WSWA will also explore non-engineering BMPs for the County Courthouse and Sheriff's headquarters.

The WSWA will also meet with appropriate parties, including the County Commission to discuss regularly scheduled street sweeping, including cost and implementation.

Morgan County Department of Health

The WSWA will form a partnership with the Morgan County Department of Health to determine the location and age of on-site sewage treatment systems in the watershed.

The WSWA will partner with WVDEP Non-Point Source team to secure a grant to be used to reach out to homeowners with on-site sewage treatment systems, including a first class mailing as well as newspaper articles and public meetings. Homeowners will be given information on how to recognize problems with an on-site sewage treatment system as well as information about available financial assistance to pump out functioning systems and replace failing systems. Finally, we will educate homeowners as to the proper ongoing care and maintenance of on-site sewage treatment systems.

Morgan County Planning Commission

On June 26 and WSWA and Matthew Pennington, Region 9, are making an hour-long presentation to the Planning Commission on the basic principles of stormwater management.

The Planning Commission is in the process of upgrading (not sure that's the right word) the County's existing stormwater management ordinances. The WSWA will work with the PC to insure encourage the adoption of practices that will help to reduce stormwater runoff into Warm Springs Run. The WSWA will also partner with the PC and the Chamber of Commerce to hold a workshop for local merchants on what non-engineering BMPs can be used, as well as seek grant money to help merchants improve their stormwater practices.

The WSWA, the County Commission and the Planning Commission will work together to seek landowner permission to delineate the wetland at the headwaters of the WSR, and submit delineation to the US Army Corps of Engineers for designation as a jurisdictional wetland.

Once that designation has taken place, these three organizations will form a partnership to restore the headwaters wetland.

Morgan County Extension Office, including the Morgan County Master Gardeners

The WSWA and Extension Office will hold a workshop of ways that homeowners can reduce runoff, including soil amendment, raised beds, rain barrels and rain gardens.

Town of Bath

The WSWA will meet with the Town of Bath Council to discuss the benefits of regularly scheduled street sweeping in the town, including cost and implementation.

WSWA, and Town of Bath, and Streetscapes will partner to seek grants for the installation of manufactured sediment traps in the Town of Bath to reduce stormwater runoff into the Run.

Town of Bath Tree Board

The WSWA will continue to partner with the Town of Bath Tree Board as well as the **Lions Club** to plant more trees in town, and where possible, to improve the riparian buffer of the Run as it flows through the town.

Warm Springs Public Service District

The WSWA will work with the WSPSD to explore the benefits of installing engineered structures to direct flow away from the raised manholes in the Run, thus reducing scouring around these surfaces. The WSPSD should be invited to be a partner in seeking funding for manufactured sediment traps so as to reduce the volume of stormwater that ends up in the Run. In addition, the WSWA should work with WSPSD to explore the possibility of sealing the raised manholes to prevent possible infiltration of water into the sanitary sewer main during flooding events.

Eastern Panhandle Conservation District

The WSWA and EPCD will work with the farmer in the watershed whose livestock has direct access to the run. We will seeks grants to help pay for fencing to keep the cattle out of the Run, as well as the installation of an alternative source of water for the herd.

Section F, G, & H – Schedule for Implementing Non-point Source (NPS) Management Measures, Description of Milestones, and Measurable Goals

- Submit WSR Comprehensive Watershed Management Plan to U.S. Environmental Protection Agency and WVDEP.
- Develop and submit proposal for funding assistance for baseline load sampling to be performed by WSWA.
- Hold meeting with Morgan County Commission and Public Works Department to discuss street sweeping schedule, costs and implementation.
- Hold public meeting(s) with owners of individual treatment (septic) systems regarding low-interest loan program, proper septic maintenance and methods for evaluating failing or failed septic systems.
- Identify and list specific on-site treatment systems throughout the WSR watershed using publicly available data (health department records, building permits, etc.)
- Field verify septic system records, and perform on-site inspections for evidence of failed or failing systems.
- Upgrade, pump and/or account for the failing or failed septic systems throughout the watershed.
- Hold three (3) Rain Barrel workshops (15 barrels each).
- Hold Rain Garden workshops, including the installation of two (2) to three (3) demonstration rain gardens at specific sites in the Town of Bath.
- Hold two (2) workshops with stakeholders regarding non-engineering stormwater BMPs for on-site bioretention and treatment of stormwater, and grant funding available for such efforts.
- Hold workshop with regional stakeholders regarding the use of washed crushed limestone (vs. crusher run) to reduce sediment loads to the WSR.
- Outreach to regional farmers regarding nutrient management and sediment control. Discuss fencing and alternate water supply options for cattle pasture area(s).
- Commence Natural Stream Design streambank erosion mitigation and prevention projects.
- Obtain permission from landowner to delineate the wetland at the headwaters of the WSR, and submit delineation to U.S. Army Corps of Engineers for designation as a jurisdictional wetland.
- Commence restoration of the headwaters wetlands.
- Determine appropriate 1-acre demonstration plot for shale bank reclamation and replanting.
- Commence shale bank demonstration project. Evaluate success after 1-year
- Determine appropriate 1-mile stretch of dirt/gravel road for DSA demonstration project.
- Commence DSA demonstration project. Evaluate results after 1-year.

- Submit annual reports to WVDEP and USEPA summarizing water quality and benthic quarterly monitoring.

- Prepare revised WSR Comprehensive Watershed Management Plan upon establishment of TMDLs for the WSR in 2021.

Section I – Monitoring Program

Sampling by WSWA - In order to determine the efficacy of the NPS management actions, specific parameters will need to be measured and tracked. We recommend that sampling should include the State TMDL variables (i.e. total nitrogen, total phosphorus and total suspended solids). In addition, the majority of the Potomac Direct Drains for which TMDLs have been established are tracking fecal coliform and (in some cases) sediment loads. The Draft 2012 Impaired Stream List for WV describes the WSR as being impaired by fecal coliform and CNA-biological (due to sedimentation). Thus, the proposed WSR monitoring program should also track these two parameters as well.

We recommend that volunteers from the WSR Watershed Association be trained in the proper methods for collecting grab samples, recording the chain of custody, and delivering the samples to the selected laboratory within the appropriate hold time.

Sampling Protocol – Recommended tests are based on the Chesapeake Bay Water-Quality Monitoring Program, Potomac River Nontidal Nutrient and Sediment Sampling Quality Assurance Project Plan, Section B.4 – Analytical Methods (WVDEP, 2005).

Samples should be collected at locations identical to the mile points at which the WVDEP is conducting benthic and water quality assessments, namely at mile points 0.7, 4.9, 5.8, 8.2 and 8.9 respectively. The samples should be analyzed for the following parameters:

1. Total Nitrogen
2. Total Phosphorus
3. Total Suspended Solids
4. Fecal coliform
5. Dissolved Nitrate + Nitrite as N
6. Dissolved Ammonia as N
7. Dissolved Ortho-Phosphate as P
8. Total Suspended Sediment

The selected laboratory should be certified by the State of West Virginia for the analysis of the target parameters.

Samples should be collected quarterly, during times of normal flow. Normal flow will be defined as any period in which there has not been a significant (>0.25-inch) rainfall or snowmelt water equivalent within 7 days of the sampling event. In addition, samples should be collected during or within 24 hours of a significant precipitation event (as defined above) above to monitor peak flow effects on the measured parameters. The number of samples collected during peak flow events may be up to (but not exceeding) four per year.

It is our understanding that the WSWA has the capability to monitor the following parameters in the field:

- Dissolved Oxygen
- Temperature
- pH
- nitrate
- discharge rate

Storm samples should also be tested for sand equivalent value (also known as sand/fine split). This test is performed in the field, and requires only a standard sieve screen. WSWA volunteers will be trained to run the test.

These data should be collected concurrent with the sample collection at each sampling event.

Certificates of analyses along with chain of custody documentation should be retained and kept in a secure repository by the WSWA for the duration of the testing. Annual data summaries should be shared with WVDEP and EPA Region 9.

A quality assurance project plan (QAPP) should be prepared prior to the commencement of any testing. We recommend using the West Virginia Potomac River Nontidal Monitoring Program QAPP document (Appendix B) as a model for the WSR sampling QAPP. The QAPP should be submitted to WVDEP and USEPA District 9 for approval prior to the commencement of testing.

Sampling by WVDEP – It is assumed that WVDEP will continue its ongoing 5-year cycle sampling in the Potomac Direct Drains watershed. These data will then be used to augment and act as a comparison to data collected by the WSWA for the same mile point stations. Collectively, these data will be used to establish the TMDL base load allocations and reductions necessary within the WSR watershed to meet state and watershed specific reduction goals.

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