North Fork of the Shenandoah River
Watershed Assessment
Virginia and West Virginia

June 2008

Rapid watershed assessments provide initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders. These assessments help landowners and local leaders set priorities and determine the best actions to achieve their goals.

U.S. Department of Agriculture
Natural Resources Conservation Service
Richmond, Virginia

North Fork of the Shenandoah River
Watershed Assessment
Virginia and West Virginia

Frederick, Page, Rockingham, Shenandoah and Warren
Counties, Virginia and Hardy County, West Virginia

Abstract

This watershed assessment involved the collection of data and information for the purpose of developing a watershed profile, including a description of the natural resource conditions and trends, issues, concerns and problems along with recommendations for local action. The information will assist decisionmakers to make informed decisions and facilitate the timely implementation of various conservation programs.

Authority

Prepared under the authority of the Conservation Technical Assistance Program, Soil Conservation and Domestic Allotment Act of 1935, as amended, Public Law 74-46, 16 U.S.C. (590a-f and 590q), 7 CFR Part 610 (CFDA 10.902).

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EXECUTIVE SUMMARY

The North Fork Shenandoah River Watershed is a dominantly agricultural region in the northwestern part of Virginia and eastern West Virginia. Part or all of five Virginia counties and part of one West Virginia county are located in this 661,821 acre watershed. The seven 10-digit subwatersheds were used as a basis for inventory and evaluation of the local resource concerns. The primary agricultural activities are livestock production, particularly chickens, turkeys and unconfined beef cattle, and hay and row crop production. Three of the counties in the watershed are in the top five counties in Virginia in value of agricultural products sold. The number of urban acres in the watershed has increased rapidly in the past 16 years with most of the converted acreage coming from agricultural land. About 94% of the agricultural land is considered to be Prime or Important farmland. Woodland covers about 62% of the watershed.

The primary concerns that have been identified in the watershed are the decline in water quality, the loss of agricultural land to urbanization, the projected inability to meet the future water quantity demand, and the perception that farmers are the primary source of water quality impairments.

There are 2,606 miles of perennial and intermittent streams in the watershed. Of these, 272.5 miles fail to meet their designated uses due to fecal coliform bacteria, temperature, pH, or benthic macroinvertebrate bioassessment impairments. Twenty-one TMDL studies have been done or are planned in the watershed. Since this watershed contributes to the drainage of the Chesapeake Bay, a Tributary Strategy Report has been developed to guide implementation of urban and agricultural water quality practices. The presence of nearly 1,800 sinkholes in the agricultural land contributes to the potential for pollution of the ground water.

Between 1992 and 2001, over 31,000 acres were developed for urban use. Most of this growth is occurring along I-81 which runs down the center of the watershed. Increased surface water flows have resulted from the increase in impervious surfaces. However, the demand for water is expected to exceed the available supply by 2025. Ground water resources are already declining. There are a number of citizens groups working with the local governments to address this issue.

Most of the farmers in the watershed are willing to work with NRCS, Soil and Water Conservation Districts, Cooperative Extension, and other conservation partners to install conservation practices on their land. However, it would take $56 million dollars to achieve the water quality improvements needed for the Chesapeake Bay. The landowner share would be $19 million. Additional money would be required to assist with installation of the urban BMPS that also need to be installed.

Resources should be targeted to provide the level of technical and financial assistance services needed to get accelerated implementation of conservation practices on the land. Based on the number of impaired stream miles and other criteria, priority should be given to the North Fork Shenandoah – Linville Creek, NFS-Narrow Passage Creek, Smith Creek, and Stony Creek subwatersheds. The first priority for practice installation should be buffers on perennial streams and open sinkholes.

There are many citizens groups in the watershed that attest to the willingness of the community to address the difficult problems that must be solved to improve water quality, manage urban growth and its needs, and to assist the farming and urban communities to be good stewards of the land.

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PURPOSE

Rapid Watershed Assessments are intended to provide an overview of current land use and natural resource conditions and trends. The overview also provides suggestions on which conservation investments might best address the concerns of landowners, the conservation districts, and other community organizations and stakeholders within the watershed. These assessments can help landowners and local government leaders set priorities and determine the best actions to achieve their natural resource goals.

INTRODUCTION

The North Fork of the Shenandoah River Watershed is a largely rural 661,821 acre basin (1,035 square miles) located in the Shenandoah Valley of northwest Virginia and eastern West Virginia (Figure 1). The watershed includes all of Shenandoah County, Virginia, and parts of Rockingham, Page, Warren, and Frederick Counties in Virginia, and Hardy County, West Virginia. A small portion of the largest city in the area, Harrisonburg, Virginia, is also in the watershed. The 8-digit river basin (02070006) is made up of seven 10-digit hydrologic units (subwatersheds) ranging in size from 67,335 acres to 141,608 acres. The subwatershed names, acreages and percent of the total watershed are listed in Table 1. A map of the watershed and the subwatersheds is shown in Figure 2.

Table 1. North Fork Shenandoah (NFS) River Hydrologic Units

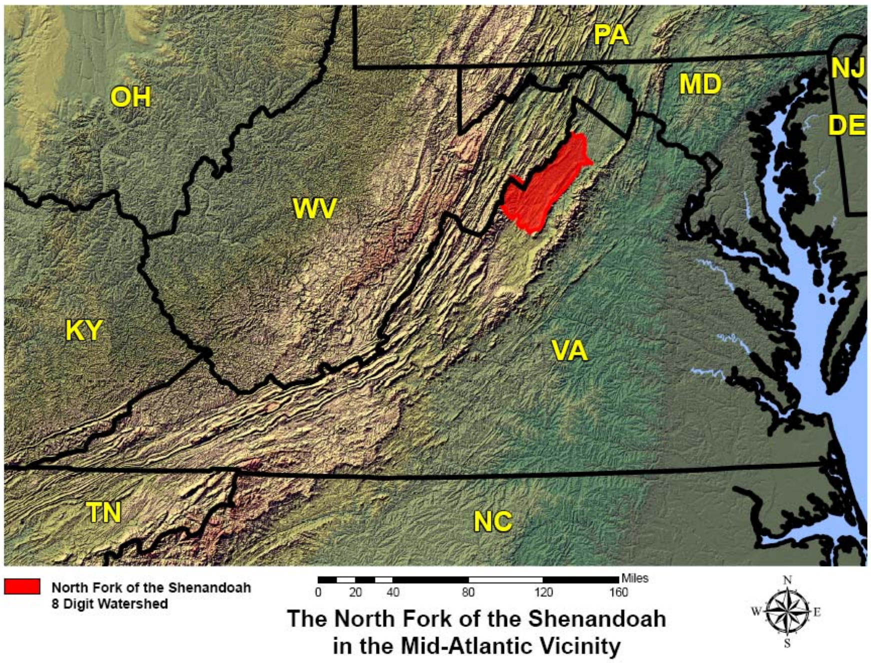
Hydrologic Unit Code	Hydrologic Unit Number	10-digit Hydrologic Unit Name	Hydrologic Unit Acres	% of the Total Watershed
PS-K	0207000601	NFS-Shoemaker River	133,158	20.1%
PS-L	0207000602	Smith Creek	67,335	10.2%
PS-M	0207000603	NFS-Linville Creek	141,608	21.4%
PS-N	0207000604	Stony Creek	72,560	11.0%
PS-O	0207000605	NFS-Narrow Passage Creek	78,373	11.8%
PS-P	0207000606	Cedar Creek	100,687	15.2%
PS-Q	0207000607	NFS-Passage Creek	68,099	10.3%
Potomac/ Shenandoah	02070006	Together the 7 subwatersheds constitute the North Fork Shenandoah River	Total Acres: 661,821	100%

Source: NWBD dataset for Virginia and West Virginia.

The river basin contains a very diverse and productive agricultural sector including a significant portion of Rockingham County which is ranked first in the State for market value of agricultural products sold. It also contains all of Shenandoah County which is ranked fifth. A portion of Page County, the fourth ranked agricultural county, is within the river basin as well. Poultry (mainly turkeys and broilers) and livestock (mainly dairy and beef) operations dominate agricultural enterprises in the area.

Water quality is a concern to a variety of people that includes individuals, community groups, county governments, and State and Federal agencies. Issues of concern to individuals include safety of drinking water supplies and impacts of regulation on farming activities. Community groups have been formed to address such issues as the needs of specific subwatersheds and the effects of fish kills in the Shenandoah River. At the State level, the Department of Environmental Quality (DEQ) has identified 272.48 miles of perennial and intermittent streams that are impaired to the point where aquatic organisms are harmed or where recreational use of the water is restricted. To address the identified impairments, Total Maximum Daily Load (TMDL) studies are planned for each impaired stream segment. On a larger scale, a multi-state initiative to improve water quality in the Chesapeake Bay has led to the development of a Tributary Strategy report which defines the broad changes needed within the watershed.

Figure 1. Location of North Fork Shenandoah River Watershed



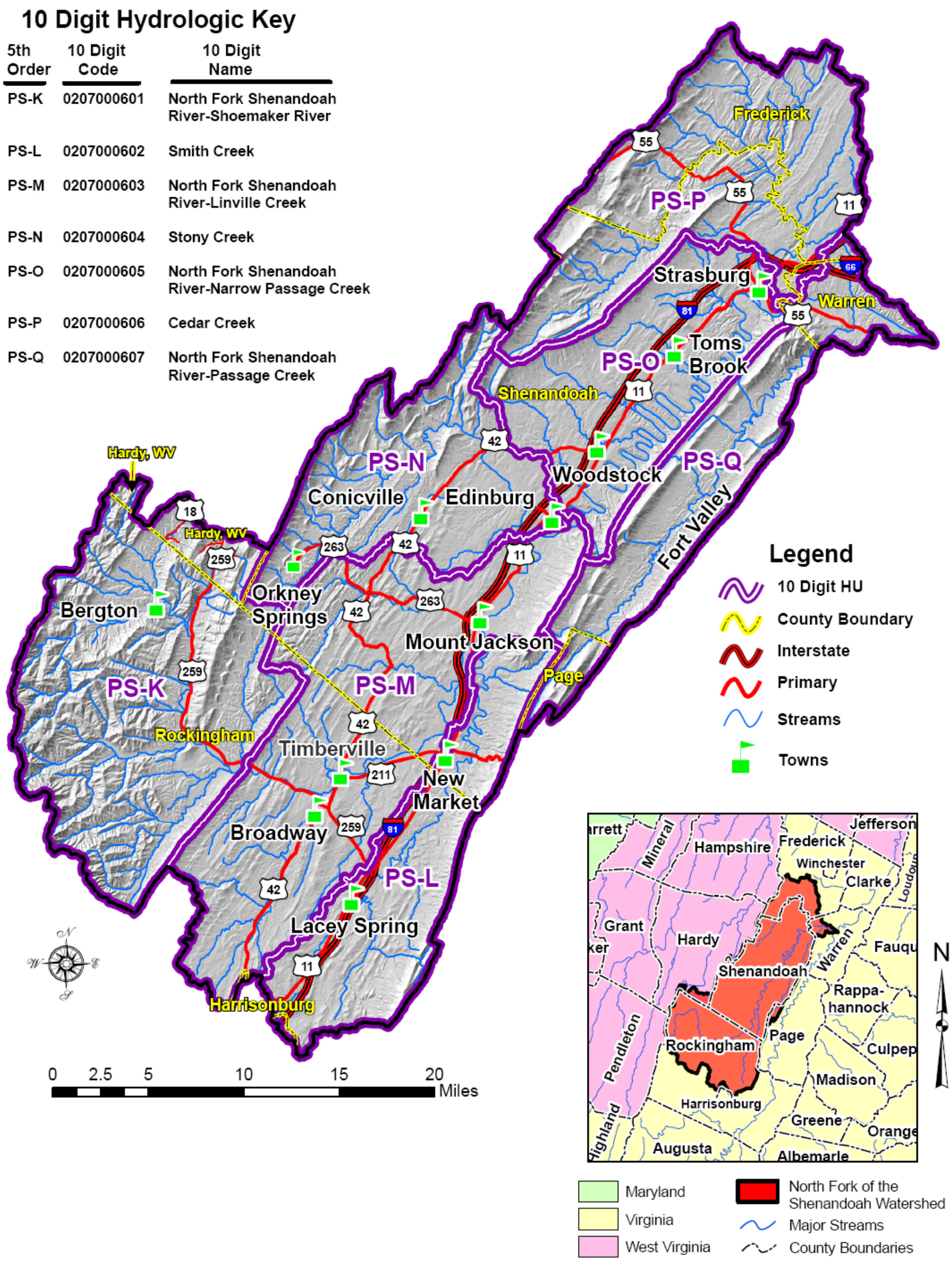
All map citations are in Appendix A.

Water quantity issues are also an increasing concern. U.S. Geological Survey (USGS) monitoring of the surface water suggests that the overall long-term trend for annual runoff is one of increasing volumes. The variance from one year to another also seems to be increasing. One possible cause of these changes is the increasing acres of urban land use. The drought conditions experienced in the past few years have led to an increased demand for ground water. Increases in well depths have led to concerns of ground water "mining."

The conversion of farmland to urban land is another major concern in the watershed. During the years between 1992 and 2001, nearly 60% of the acres converted to urban uses came from agriculture. Forest land and "Other" land represented about 20% each of the remaining land that was converted to urban uses. Related concerns include the increase in surface water runoff and its associated pollutants, the increase in septic system installation, the increase in water demand, and the irretrievable loss of prime and important farmlands.

To compound these major issues, there is the perception that farmers are the major culprits in the contamination of the water and land. Identification of pollutants and sources is a complex issue with multiple components. Although farming is a fairly visible occupation, it is not the only source of water quality problems and should not be addressed as such.

Figure 2. Watershed Map with 10-digit Subwatershed Boundaries



PHYSICAL DESCRIPTION

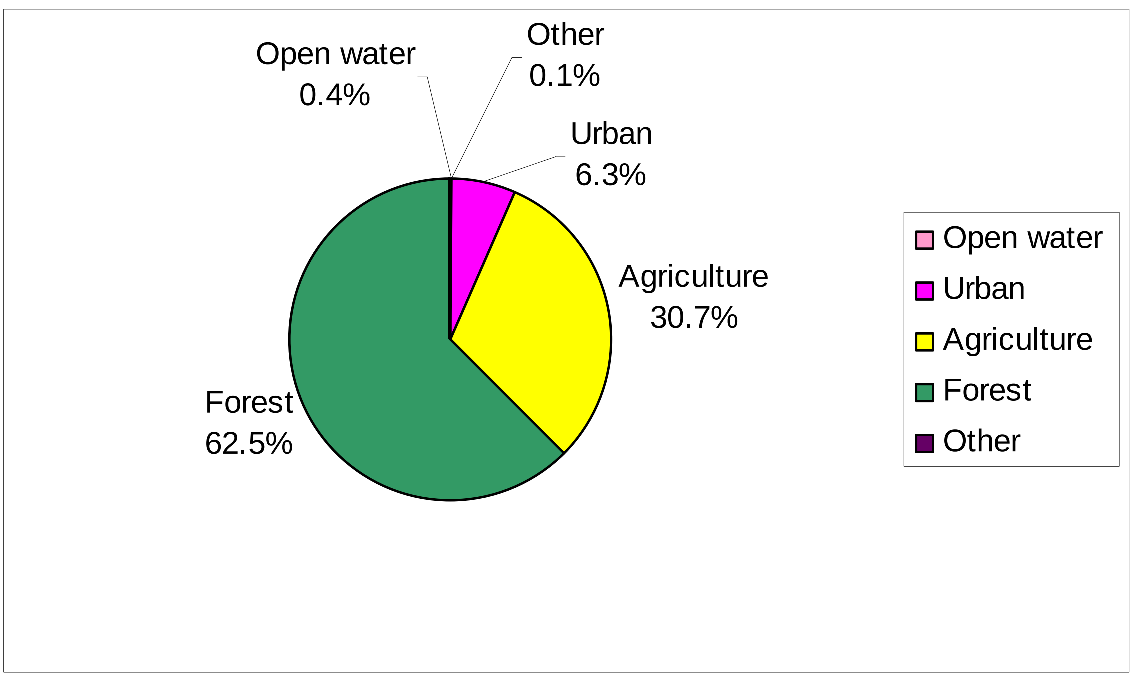
General Location and Description. The watershed is located along the northwestern border of Virginia. It is bounded by West Virginia to the west and Massanutten Mountain to the east. The South Fork of the Shenandoah River Watershed is immediately adjacent on the south and east sides of the watershed. A very small section of the City of Harrisonburg is included in the watershed. The communities of Broadway, Mount Jackson, Woodstock, Strasburg, Fort Valley, Toms Brook, Timberville, Edinburg, Bergton, Orkney Springs, New Market, and Columbia Furnace are also located in the watershed.

The watershed is bisected by Interstate 81 which passes in a north-south direction. At Strasburg, Interstate 66 intersects with I-81. Due to the topography, most of the primary roads are parallel to I-81.

The North Fork of the Shenandoah River runs north before turning east at Strasburg to its confluence with the South Fork of the Shenandoah at Front Royal to become the Shenandoah River. At Harpers Ferry, the Shenandoah River drains into the Potomac River which then continues to the Chesapeake Bay.

Land Cover. As of 2001, the watershed was about 62.5% wooded (413,368 acres), with an additional 30.7% in agricultural land (203,199 acres) and 6.3% in urban land (41,955 acres). Open water (0.4%) and Other (0.1%) made up the remainder (Figure 3).

Figure 3. 2001 Land Cover Data



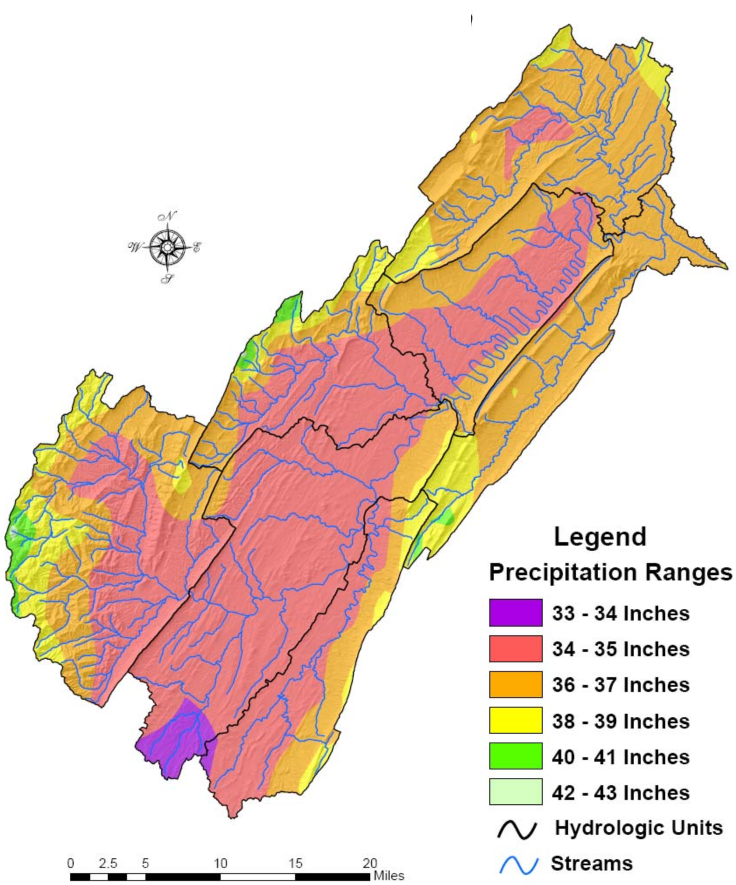
Source: USGS 2001 National Land Cover Data.

Climate and Precipitation. The watershed lies in the northern Valley and Ridge physiographic province. This province has a continental, humid, temperate climate, and is characterized by warm to hot summers and rather cold winters. The average annual temperature is 54 degrees Fahrenheit, with an average minimum temperature in winter of 24 degrees Fahrenheit and an average maximum temperature of 86 degrees Fahrenheit in the summer. The last frost of spring normally occurs in late April and the first frost in the fall occurs in mid-October. This provides a growing season of approximately 176 days.

The average annual precipitation is 37 inches, varying from about 33 inches in the driest years to about 40 inches in the wettest years (Figure 4). There is some variety of precipitation across the watershed due to the topography and the resulting rain shadows. For these same reasons, the Shenandoah Valley is one of the driest areas of the State. The precipitation is well distributed throughout the year with the highest monthly precipitation occurring in May through September. Snowfall averages about 23 inches annually, with appreciable snow cover on the ground an average of 17 days per year.

In the past several years, precipitation has been lower than average, resulting in drought conditions throughout the watershed. Effects of this can be seen in the increased demand for livestock water systems and the increased depths of newly constructed wells.

Figure 4. Average Annual Precipitation Ranges



Geology. The geology of the watershed primarily consists of sedimentary rock formations approximately 300 - 500 million years old (Figure 5). There are some minor intrusive igneous bodies throughout the watershed, but they are minor in extent. The bedrock in the western mountain areas is sandstone, shale and conglomerates. The Massanutten Mountain in the east is dominated by Silurian sandstone supported by Ordovician shale. The sandstone is folded into a syncline which outcrops at the ridge tops. Weathering of the underlying Martinsburg shale in some areas of the mountain has caused the sandstone to break and slide to form talus slopes.

The valley area of this watershed consists of Ordovician Carbonates (Limestone and Dolomite) and Shale. These sedimentary rocks are approximately 450 million years old and have been folded and fractured, causing the North Fork of the Shenandoah River to be very sinuous in some areas. The limestone and dolomite rock formations allowed the development of a karst landscape which is characterized by sinkholes, solution channels and caves created when mildly acidic water slowly dissolved the rock strata. There are 134 known caves in the watershed and nearly 1,800 sinkholes were observed during soil mapping. These karst features allow surface water to rapidly enter subsurface aquifers with none of the natural filtration that would occur if the water slowly percolated into the aquifer through the soil and the pore spaces in the rock. Slow percolation allows surface water contaminated with bacteria, chemicals and sediment to receive some natural cleansing. Surface water entering aquifers through karst features receives no such cleansing which results in the degradation of ground water and domestic water supplies.

Sinkholes are very distinct features of the physical geography in five of the seven subwatersheds. The observed sinkholes range from very noticeable in the Linville, Narrow Passage, Stony, and Cedar Creek subwatersheds to non-existent in the Passage Creek subwatershed and almost non-existent in the Shoemaker River subwatershed. Table 2 shows the numbers of sinkholes and caves in each subwatershed. Figures 24-30, in the subwatershed descriptions, show the approximate location of the known sinkholes.

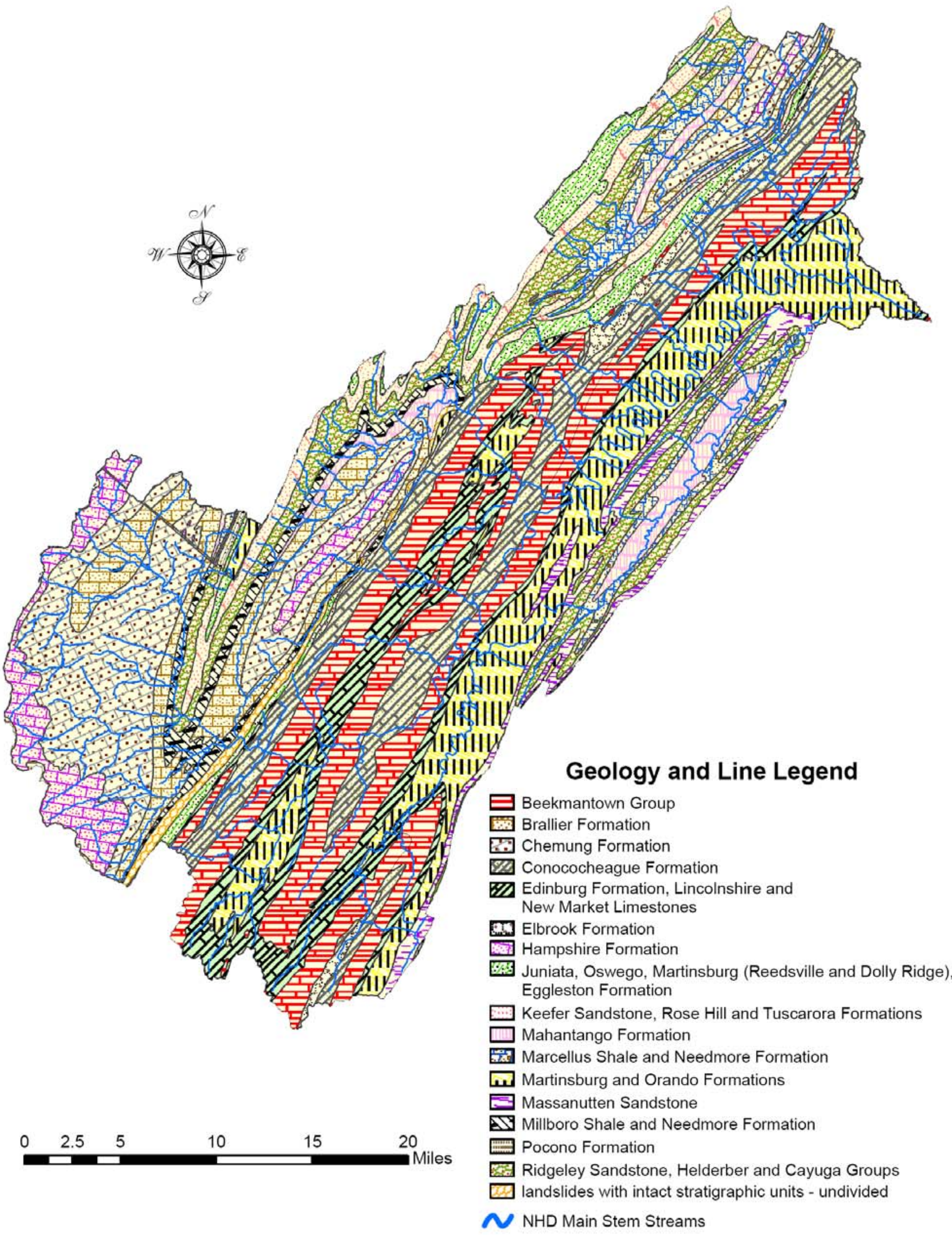
Table 2. Numbers of Observed Sinkholes and Known Caves

10 Digit HU Name	No. of Observed Sinkholes	No. of Known Caves
Shoemaker River	3	3
Smith Creek	329	35
Linville Creek	773	54
Stony Creek	187	14
Narrow Passage Creek	375	19
Cedar Creek	131	9
Passage Creek	0	0
Total:	**1,798**	**134**

Source: SSURGO Special Features Data.

The number of known caves ranges from zero in Passage Creek to 54 in Linville Creek. These known caves are significant in that they provide habitat for several species of bats and other cave-dwelling creatures.

Figure 5. Geology



Soils. The watershed consists of residual, colluvial and alluvial soils (Figure 6). The residual soils found in the western mountainous area are formed from sandstone, shale, and conglomerate. These soils are shallow to moderately deep, gently sloping to very steep, well drained or somewhat excessively drained with loamy subsoils. The residual soils found in the eastern section of the watershed, on Massanutten Mountain, are formed from sandstone and shale. These soils are moderately deep to deep, gently sloping to very steep, well drained or somewhat excessively drained with loamy or sandy subsoils. The residual soils found in the main valley are formed from limestone, dolomite and interbedded limestone and calcareous shale. These soils are moderately deep to very deep, gently sloping to steep, well drained with clayey subsoils.

The colluvial soils[1] found in the watershed formed from the materials of the residual soils and their respective bedrock types. These soils are very deep, gently sloping to very steep, somewhat poorly drained to well drained, with loamy or clayey subsoils.

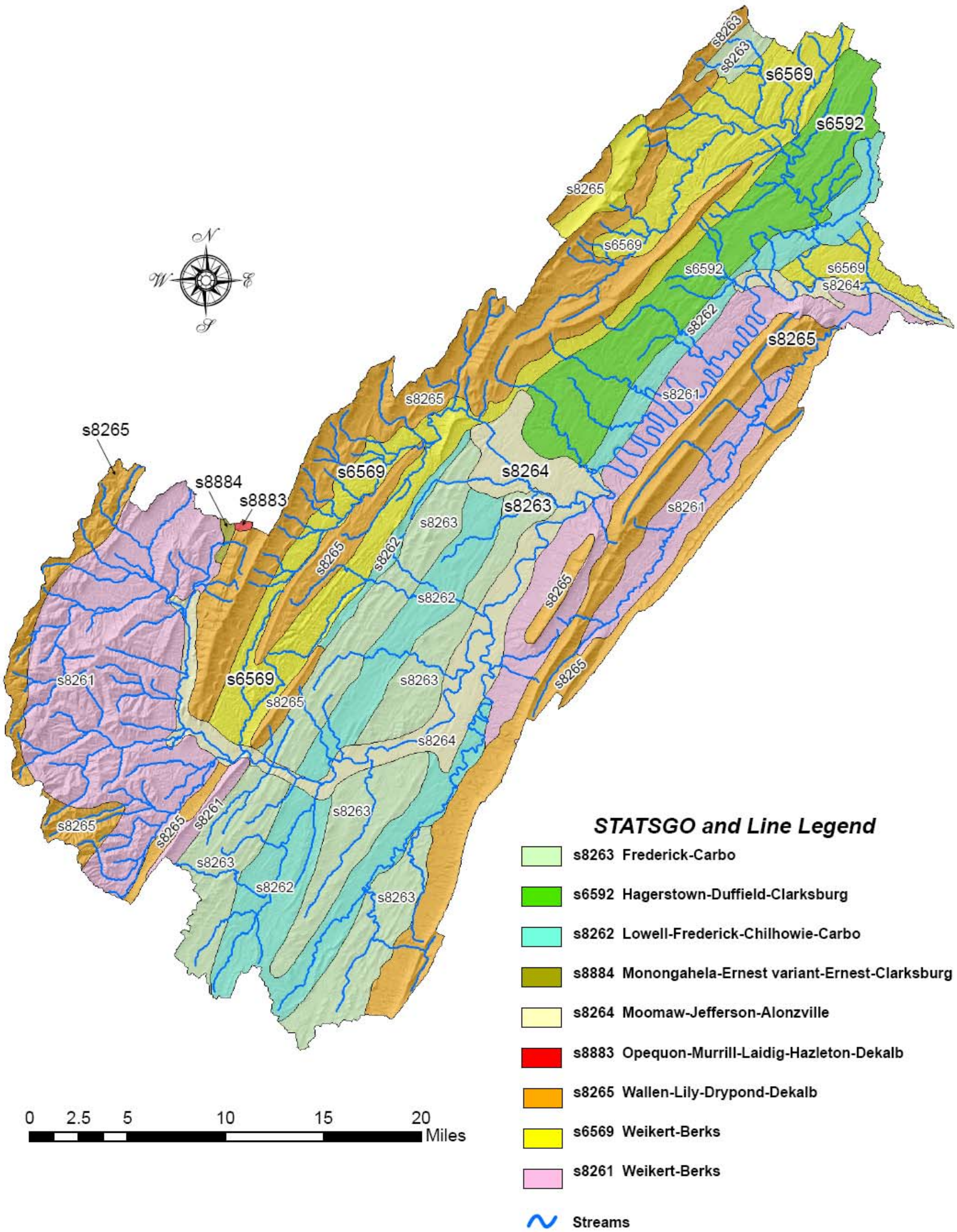
The terrace soils, which do not flood, formed from materials washed onto the alluvial areas from the uplands of the watershed. These soils are very deep, nearly level to moderately steep, moderately well to well drained, with loamy or clayey subsoils.

The floodplain soils, which have the potential for flooding, formed from materials washed onto the alluvial areas from the uplands of the watershed. These soils are very deep, nearly level, poorly to well drained, with loamy or clayey subsoils.

The mild acidity of the streams in this watershed is largely due to the low buffering capacity of the soils that comprise the perimeter of the drainage area. The parent materials of these soils consist of low pH sandstones and shale. Other factors, such as acid rain and the high organic surface material, also contribute to acidity of the water.

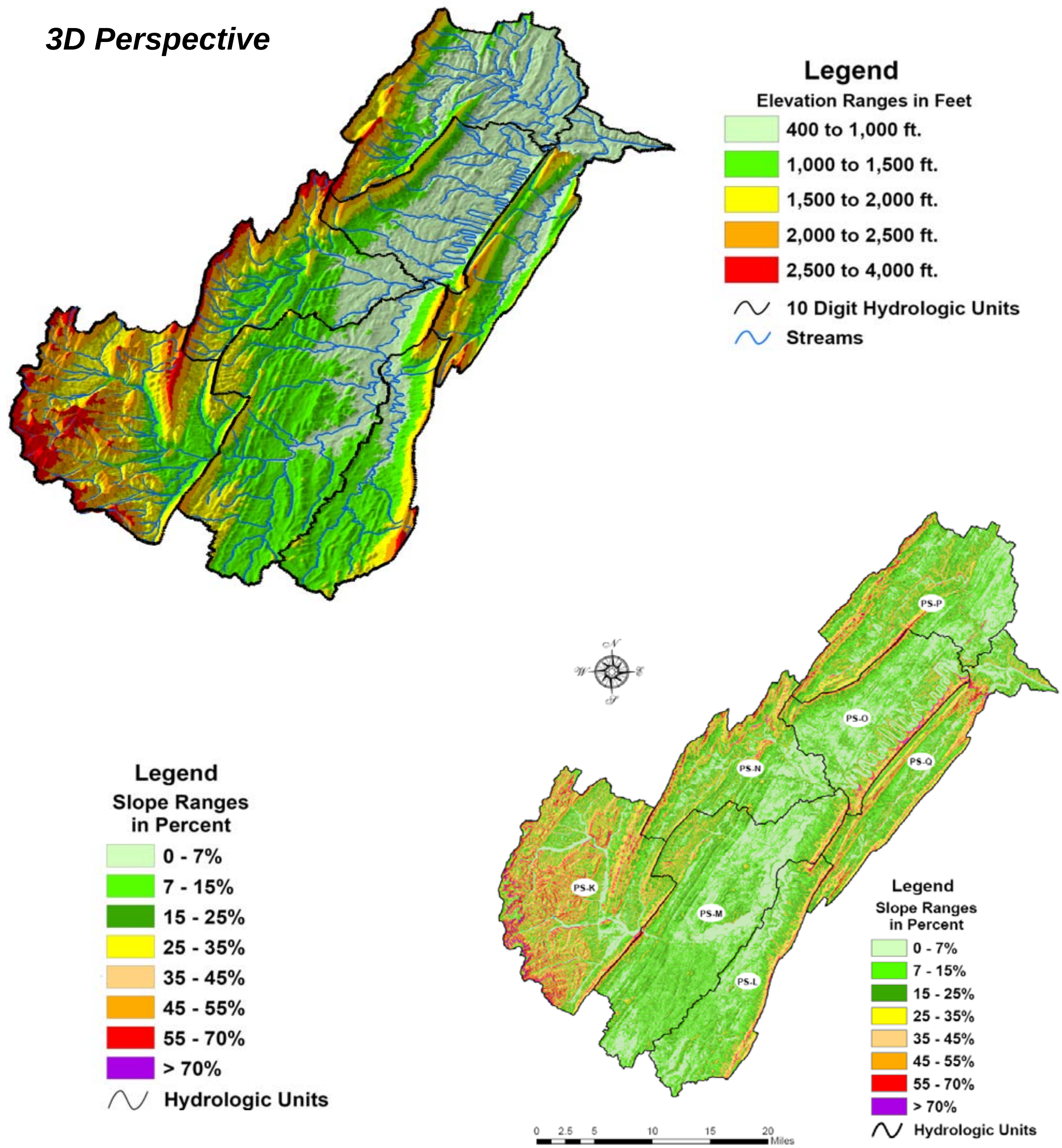
[1] Colluvial soils are soils that have developed as a result of being deposited/built-up by gravity at the base of steep sloping landscapes such as mountains. Typically these soils form into fan-shaped deposits.

Figure 6. STATSGO Soil Map Units



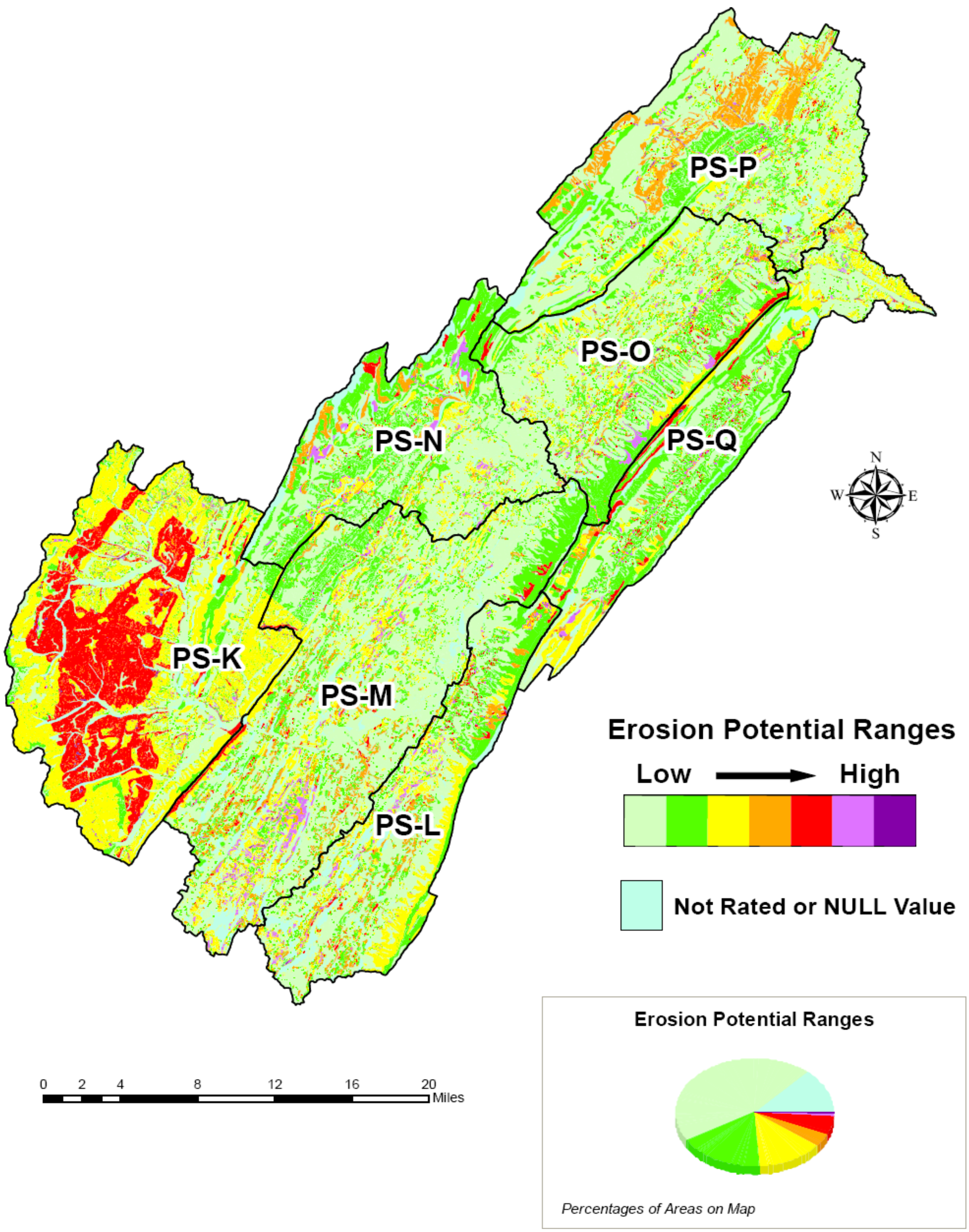
Elevation and Slope Ranges. Elevations in the watershed range from about 4,000 feet in the headwaters to a range of 1,500 to 300 feet in the valley floor (Figure 7). Slopes range from zero to 25% in the valley floor. The ridges and mountains have side slopes from 25% to more than 70%. The majority of these steep lands are wooded and in National Forest.

Figure 7. Elevation and Slope Ranges (10m data)



Erosion Potential. The soil erosion potential is low to moderate in the majority of the watershed. The ranges of erosion potential shown in Figure 8 were determined from the soil erodibility, runoff potential, slope, and existing land use. Much of the land shown in the higher risk categories is presently in woodland due to the slopes and soils. If the land use changes to something with less vegetation, the soil erosion will increase.

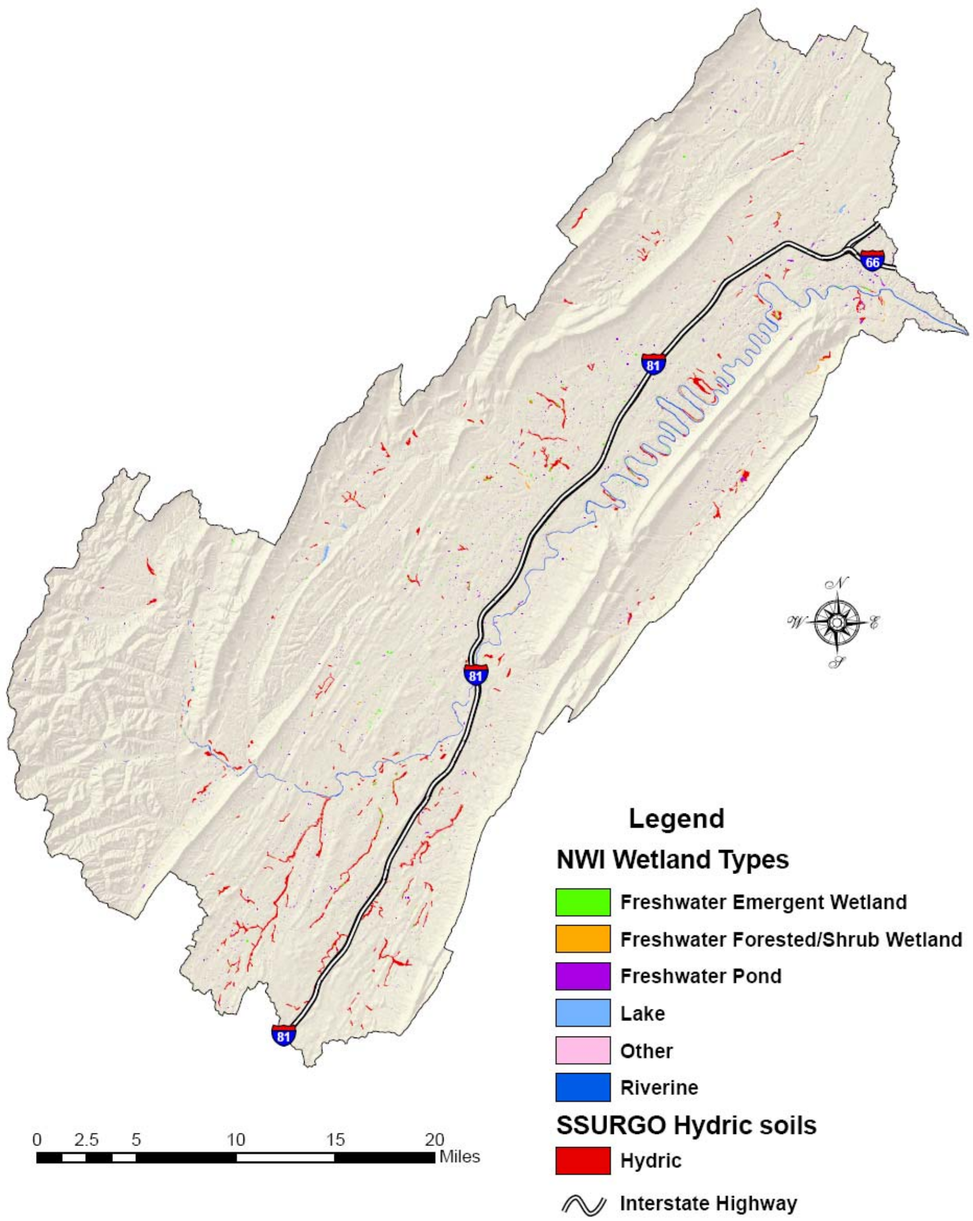
Figure 8. Soil Erosion Potential



Wetlands and Hydric Soils. Hydric soils are scattered throughout the North Fork drainage (Figure 9) and make up less than 1% of the total land area in the basin. The total acreage of hydric soils in the North Fork watershed is 5,650 acres. Hydric soils occur in all seven subwatersheds ranging from a high of 1,822 acres in the Linville Creek subwatershed to a low of 309 acres in the Cedar Creek subwatershed.

There are 3,719 acres of associated wetlands in the watershed. The Narrow Passage Creek subwatershed has the highest area of wetlands with 1,337 acres. The Shoemaker River subwatershed has the smallest total wetland area with 186 acres. The largest wetland type in the watershed is the riverine type which covers 1,806 acres (48.5%) of all wetland acres.

Figure 9. Hydric Soils and NWI Wetlands



Prime and Statewide Important Farmland. In 2003, the Virginia legislature passed a law requiring all State agencies to encourage the preservation of farm and forest land (Figure 10). Parcels of land with soils that have state or local importance, including prime, unique, and locally important farmland, are eligible for preservation because these soils are particularly well-suited for agricultural production. Under the Farm and Ranchland Protection Program (FRPP), the Natural Resources Conservation Service (NRCS) can fund up to 50% of the cost of an easement to protect the land from development as long as at least 50% of the land area is composed of prime, unique, or statewide or locally designated important soils (Figure 11, Table 3). Participation in the easement program is voluntary.

Figure 10. Prime and Statewide Important Farmland

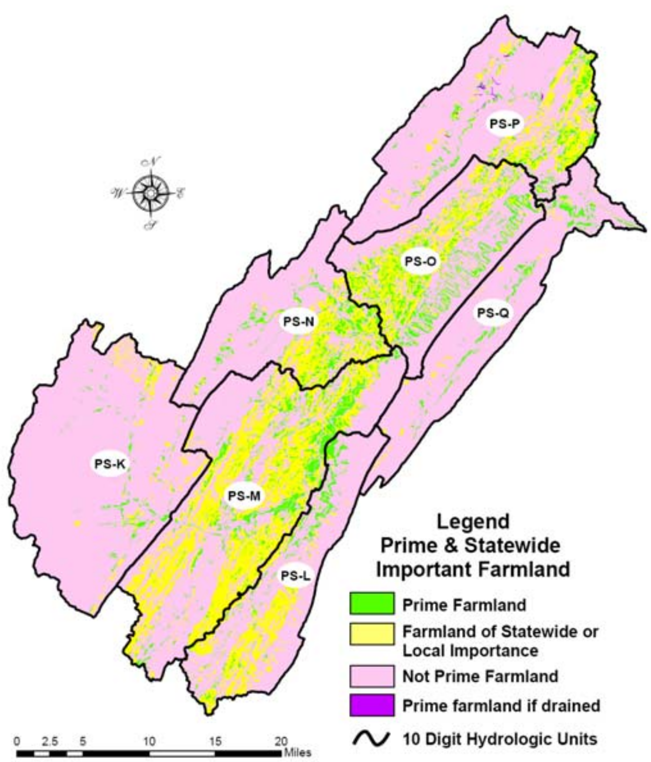


Figure 11. Prime Farmland and Important Farmland by Percent of Watershed

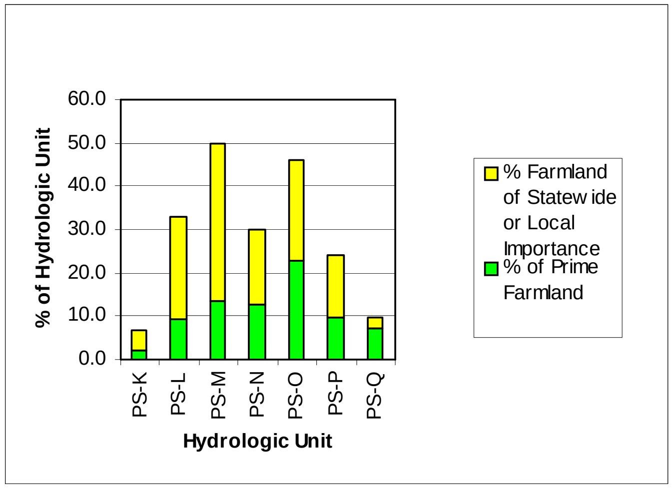


Table 3. Prime and Important Farmland in the Agricultural Land.

Hydrologic Unit	Prime Farmland acres	Important Farmland acres	% of Prime & Important Soils in the Ag. Land[a]
Shoemaker River (PS-K)	3,068	6,155	90.1
Smith Creek (PS-L)	6,273	16,031	75.9
Linville Creek (PS-M)	18,888	51,835	88.4
Stony Creek (PS-N)	9,077	12,702	100.0[b]
Narrow Passage Creek (PS-O)	17,972	18,181	100.0[b]
Cedar Creek (PS-P)	9,982	14,464	98.3
Passage Creek (PS-Q)	5,020	1,629	74.2
Totals	**70,280**	**120,997**	**94.1**

[a] Sources: USGS 2001 NLCD Database and USDA-NRCS Soil Database.

[b] Some Prime or Important soils are also found in Forest or Other land uses.

Surface Water Flows. In the watershed, there are an estimated 955 miles of perennial streams in the watershed[2]. Intermittent streams represent another 1,652 miles of surface water. Table 4 displays the perennial, intermittent, and total stream miles, by subwatershed. Lake Laura and Lake Birdhaven are lakes located in the headwaters of the Stony Creek subwatershed. There are seven other lakes in Shenandoah County.

Table 4. Miles of Perennial and Intermittent Streams by Subwatershed

Subwatershed Name	Miles of Perennial Streams	Miles of Intermittent Streams	Total Miles of Streams
NFS-Shoemaker River	196.7	332.5	529.2
Smith Creek	69.6	217.3	286.9
NFS-Linville Creek	186.7	363.9	550.6
Stony Creek	129.5	110.6	240.1
NFS-Narrow Passage Creek	118.6	186.0	304.6
Cedar Creek	143.3	203.2	346.5
NFS-Passage Creek	110.1	238.5	348.6
Totals:	954.5	1,652.0	2,606.5

Data Source: The National Hydrography Dataset from USGS.

Figure 12 shows the location of the eight USGS flow gauging stations in the North Fork Watershed. Figures 13, 14, and 15 illustrate mean annual flow data for three of the eight stations. Linville Creek, Mt. Jackson and Buckton gauging stations span the drainage and all three exhibit an increasing trend for the respective periods of record. This is true for all the stations except Cedar Creek #2 which shows a slight decreasing trend, but is only based on five years of data. The other recording stations in the watershed are Cootes Store on the North Fork Shenandoah River above the confluence with Linville Creek, Smith Creek near Broadway, the North Fork Shenandoah River near Strasburg, Cedar Creek #1 near Winchester, and Cedar Creek #2 near Middletown.

[2] Estimated by the NRCS using data from the National Hydrography Dataset (NHD) based upon the U.S. Geologic Survey Digital Line Graph (DLG) hydrography data integrated with stream reach data information from the U.S. Environmental Protection Agency Reach File Version 3 (RFV3) data.

Figure 12. Flow Gauging Stations and Ground Water Monitoring Site

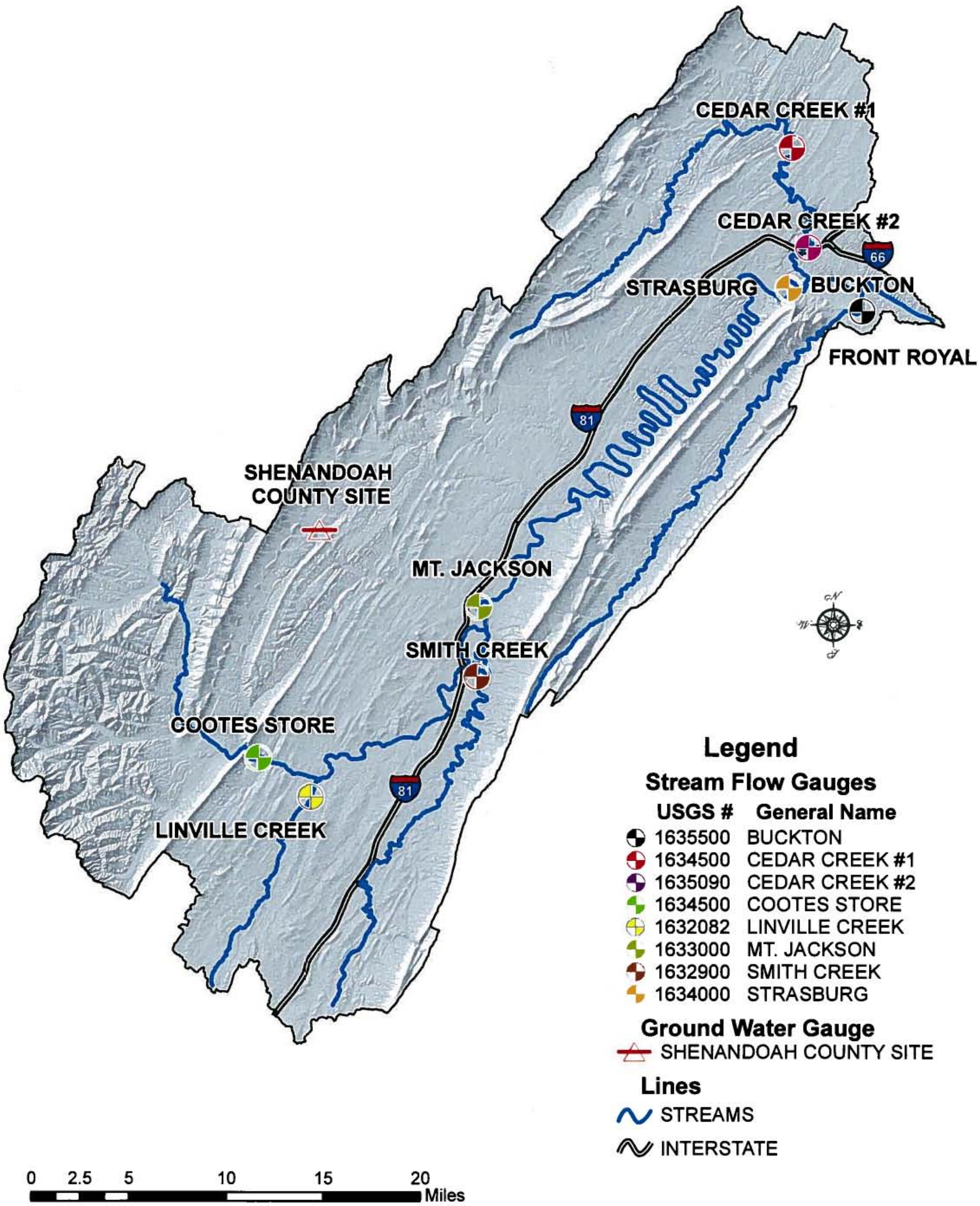
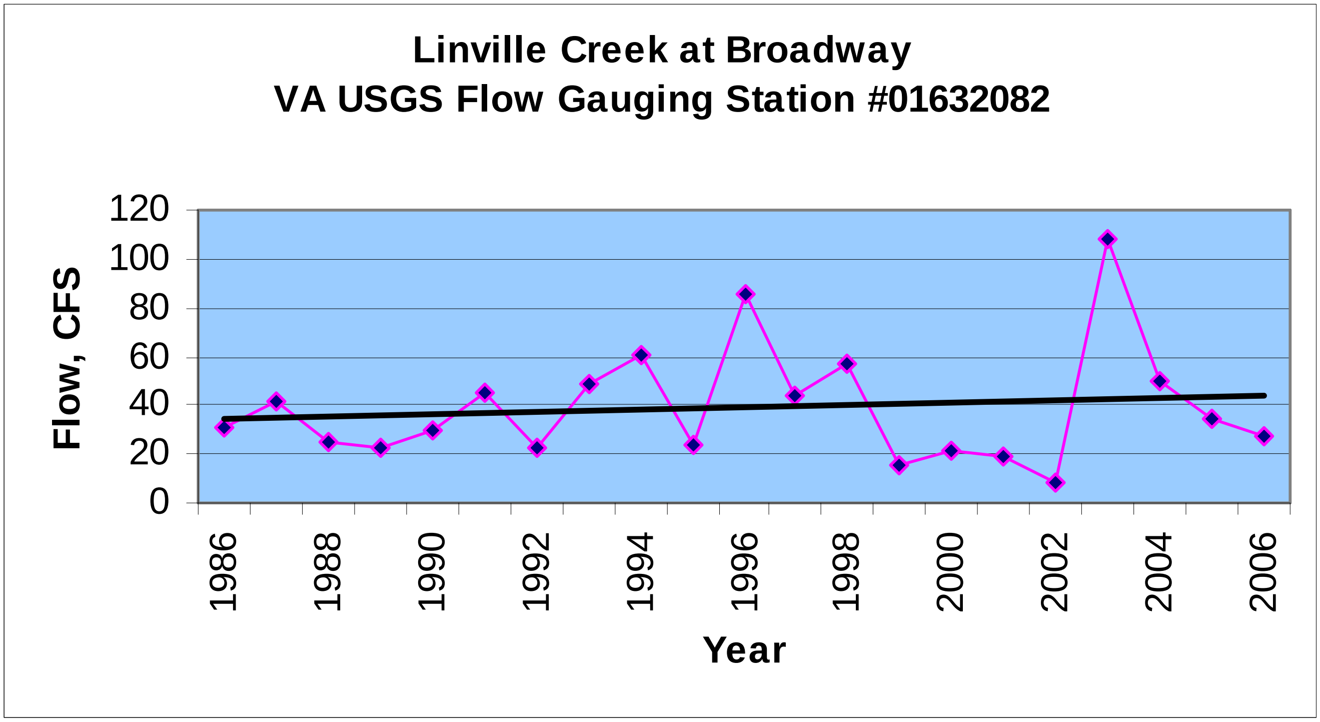
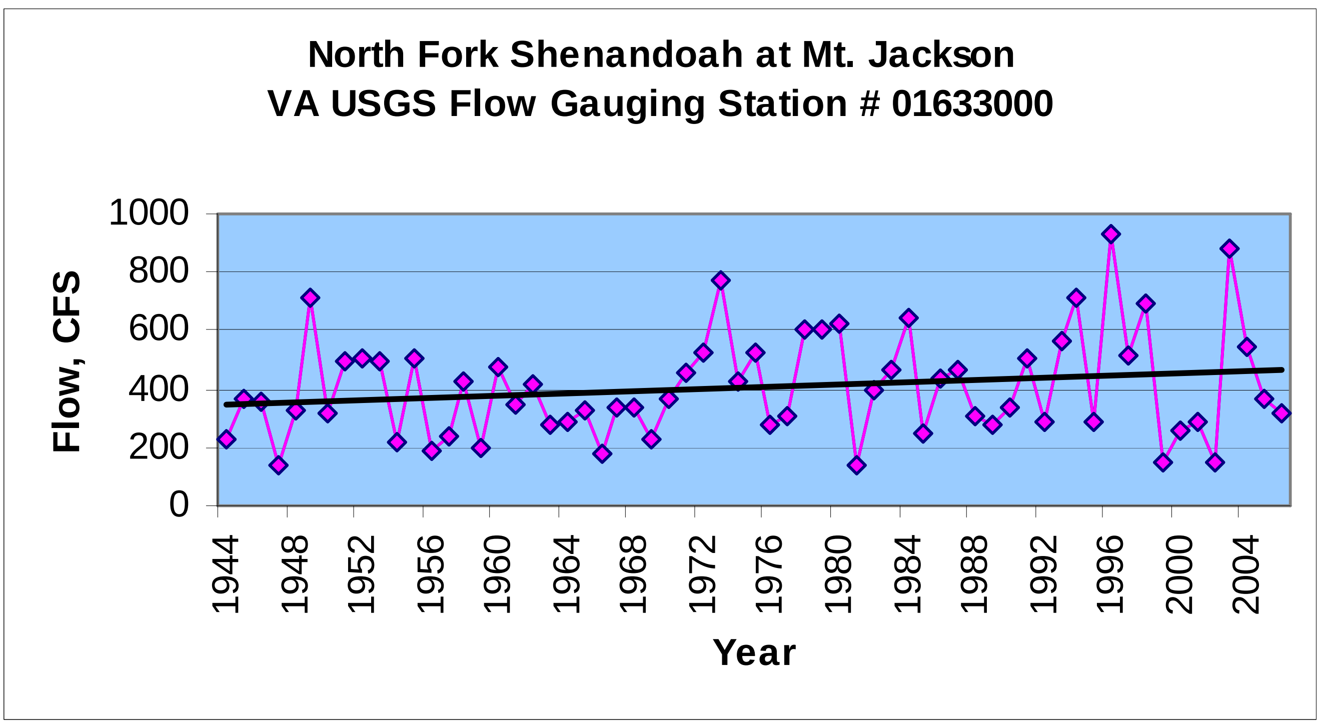


Figure 13. Flow Data for Linville Creek



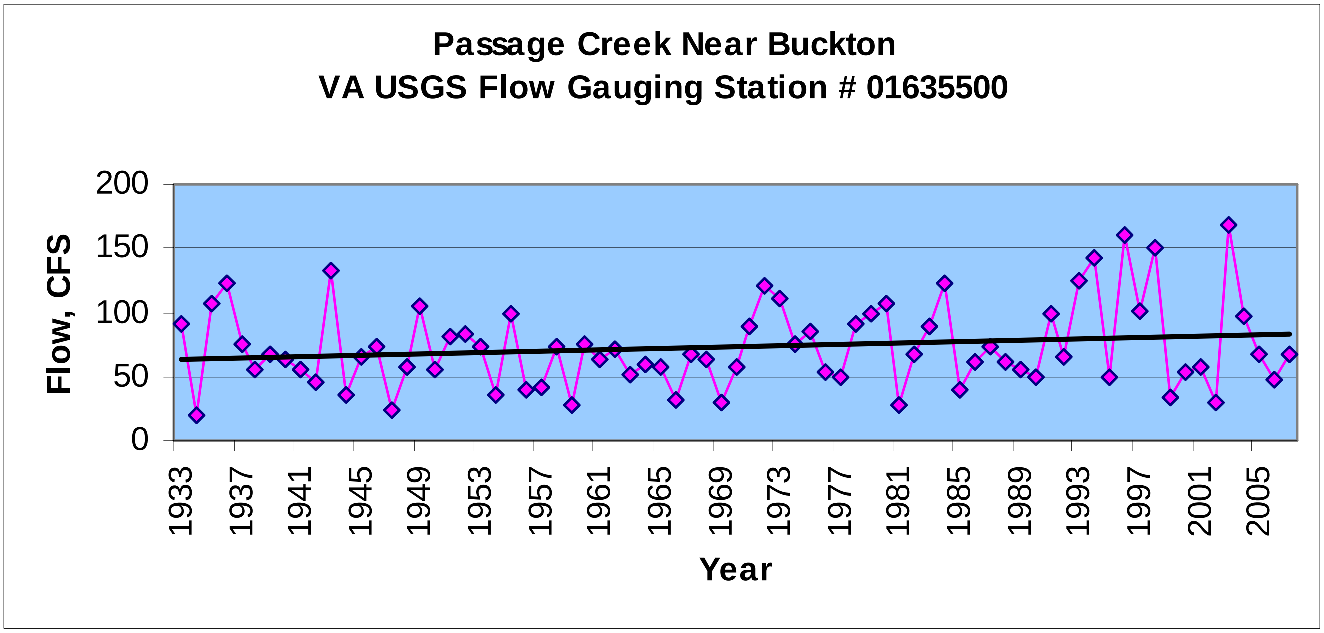
Source: USGS Real Time Water Data, National Water Information System, February 1, 2008.

Figure 14. Flow Data for North Fork Shenandoah River



Source: USGS Real Time Water Data, National Water Information System, February 1, 2008.

Figure 15. Flow Data for Passage Creek



Source: USGS Real Time Water Data, National Water Information System, February 1, 2008.

Flooding Concerns. Periodic flooding has been identified as a concern in Shenandoah County. Along the main stem of the river, the damage is primarily agricultural damage to relatively low valued crops. Most of the other observed areas of damage were located along tributary streams with limited numbers of impacted properties, roads, and bridges. The damaged areas are widely dispersed throughout the county. During a flood assessment in 2003, NRCS determined that it was not economically feasible to install flood control dams to prevent flooding. At the present time, Shenandoah County is systematically addressing flooding issues by promoting nonstructural measures such as floodplain zoning, relocation of homes, and low-impact development. Major recurrent flooding was not identified as a concern in the other counties in the watershed.

Ground Water Resources. The USGS has a ground water monitoring well in the western part of the river basin (Figure 12). Data are limited (2006 – 2007), and indicate seasonal fluctuations more than significant long term trends. A longer period of observations is required to draw further conclusions from this site.

Interviews with well drilling companies located in the Shenandoah Valley indicate that the typical well drilled in the Shenandoah Valley is about 360 feet deep and costs around $7,107 to drill, encase, grout and cap. This equates to about $19.70/LF. Cost per foot of depth ranged from $14.70 for routine jobs to $24.80 for more difficult installations in karst topography. The average depth of a drilled well 8-10 years ago is estimated to have been about 275 feet which is 85 feet shallower than today. This would suggest that the pumping of ground water in the Valley is effectively removing ground water at a rate that exceeds replenishment from rainfall and deep aquifer recharge. At the present time, the typical range of drilling depths varies from 60-1,000 feet. The well drillers also noted that karst areas are more problematic and expensive for drilling, encasing, and grouting wells. The limestone rock is harder than shale or sandstone areas and tends to cave-in much more, requiring encasing to deeper depths. They also agreed that limestone areas are more inconsistent with respect to depths required and water yields.

Water Withdrawals. Winchester, Timberville, Strasburg, Woodstock and Broadway take municipal water withdrawals from the North Fork Shenandoah River. Other major users include a food processing co-op, two ski resorts, and a State fish hatchery (Table 5). From 1997 to 2006, water withdrawals increased for every user except the Town of Woodstock. In the 2001 Shenandoah Valley Water Resources Strategic Plan, water use is expected to increase by 25 percent from 2000 to 2030. With this expected usage, the maximum daily demand for water from the North Fork Shenandoah River would exceed the supply of water provided by the mean low flow of record by 2025.

Table 5. Major Surface Water Withdrawals

Owner	System	Source	Annual Withdrawals, MG 1997	2006
City of Winchester	Winchester PWS*	North Fork. Shenandoah	2403.85	3040.09
Food Processors Water Coop.	Industrial & Commercial – COM**	North Fork Shenandoah	468.01	726.21
Town of Woodstock	Woodstock PWS	North Fork Shenandoah	255.31	243.37
Commonwealth of Virginia	Front Royal Fish Culture (Hatchery)	Passage Creek	278 (1999)	300.4
Town of Strasburg	Strasburg PWS	North Fork Shenandoah	220.16	279.47
Town of Broadway	Broadway PWS	North Fork Shenandoah	105.77	138.74
Bryce Resort	Bryce Resort - COM	Stony Creek	57.46	62.1
Town of Timberville	Timberville PWS	Spring	37.95	60.33
Shenvalee Lodge, Inc.	Shenvalee Lodge - COM	Smith Creek	20	41.3

Source: DEQ, 1997-2006 Water Withdrawals.
*PWS=Public Water Supply
**COM=Commercial

Irrigation. Information on trends in irrigated agriculture is available from 1997 and 2002 Census of Agricultural data (Table 6). This data indicates that the number of irrigated farms increased substantially for this time period in four of the six counties in the watershed while two counties experienced minor declines. Overall, the region experienced a 48% increase in the number of irrigated farms during this period. Four of the six counties have increases in the number of irrigated acres, while one county shows a minor decrease in irrigated acres. Overall the region has experienced a 29% increase in the number of irrigated acres, with Frederick County having the greatest increase.

Table 6. Agricultural Irrigation Statistics

Selected Characteristics	Frederick County, Virginia	Page County, Virginia	Rockingham County, Virginia	Shenandoah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Farms with irrigation -							
2002:	44	11	141	49	25	6	276
1997:	32	13	89	33	11	9	187
% change:	**+38%**	**-15%**	**+58%**	**+48%**	**+127%**	**-33%**	**+48%**
Acres irrigated -							
2002:	10,465	2,069	25,348	9,411	2,008	(D)	49,301
1997:	3,537	1,570	18,225	6,637	2,089	6,081	38,139
% change:	**+196%**	**+32%**	**+39%**	**+42%**	**-4%**	n/a	**+29%**

Source: 1997 and 2002 Census of Agriculture.
(D) = Data withheld to avoid disclosing information for individual farms.

Effects of Karst Topography. Because of the karst topography in the watershed, the surface waters and the ground water have the potential to continually intermix. Deep percolation of rainfall and surface runoff charges the ground water. In karst areas, much of the ground water re-emerges as surface waters through springs and seeps, subsurface connections between ground water and wetlands that discharge to the aquifer, or directly to the stream channels themselves. Ground water can also re-enter the surface flows when private, municipal, industrial and agricultural wells are used to pump water for application to the land. The surplus water from these uses contributes to the surface water. The base flow of the perennial streams is completely dependent upon ground water flows when no surface runoff occurs. This is a crucial aspect of both water quantity and quality concerns in the watershed.

Threatened and Endangered Species. The Virginia Fish & Wildlife Information Service was used to determine threatened and endangered species known or likely to occur within a two mile radius of five selected points in the watershed (Table 7 and Figure 17). These sites were selected to provide representative samples within the watershed.

Of the ten listed threatened and endangered species in the watershed, the Shenandoah Salamander, Plethodon shenandoah (Figure 16), is the only species that does not occur in all five selected locations. It occurs, or is likely to occur, in two of the five selected locations. The other nine species are likely to occur in all selected locations, and therefore, likely to occur throughout the watershed. There are confirmed observations of four of the species, the Brook Floater, the Wood Turtle, the Upland Sandpiper, and the Loggerhead Shrike, at several of the selected locations.

Table 7. Threatened and Endangered Species at Selected Points in Watershed

Status*	Tier**	Group & Common Name	Scientific Name	Confirmed
		Mammals		
FESE	I	Indiana Bat	Myotis sodalis	No
		Birds		
ST	I	Peregrine Falcon	Falco peregrinus	No
ST	I	Upland Sandpiper	Bartramia longicauda	Yes
ST	I	Loggerhead Shrike	Lanius ludovicianus	Yes
ST	I	Bald Eagle	Haliaeetus leucocephalus	No
FSST		Migrant Loggerhead Shrike	Lanius ludovicianus migrans	No
		Reptiles		
ST	I	Wood Turtle	Glyptemys insculpta	Yes
		Amphibians		
FESE	I	Shenandoah Salamander	Plethodon shenandoah	No
		Aquatic Mollusks		
FSSE	II	Brook Floater	Alismidonta varicosa	Yes
FSST	II	Green Floater	Lasmigona subviridis	No

Source: Virginia Fish and Wildlife Information Service

* Species status: FE = Federal Endangered; FT = Federal Threatened; SE = State Endangered; ST = State Threatened; FP = Federal Proposed; FC = Federal Candidate; FS = Federal Species of Concern; SC = State Candidate; CC = Collection Concern; SS = State Special Concern

** I = VA Wildlife Action Plan – Tier I – Critical Conservation Need; II = VA Wildlife Action Plan – Tier II – Very High Conservation Need.

Figure 16. Shenandoah Salamander, Plethodon shenandoah

Credit: Lester Via. USGS.

Coldwater/Trout Streams. Data from the Virginia Department of Game and Inland Fisheries (VDGIF) indicates that there are 169.5 miles of coldwater streams within the North Fork (Figure 17). Of the total miles of coldwater, 102.7 miles are reported to already support either wild or stocked Brook trout and 3.0 miles support wild Rainbow trout. About 63.8 miles of streams in the river basin are cold enough to support trout, but currently do not have resident or stocked put-and-take populations.

Fish and Wildlife. The watershed falls into the Northern Ridge and Valley Ecoregion (Figure 18). In the 2005 Comprehensive Wildlife Conservation Strategy, VDGIF listed 384 animal species of greatest conservation need in the Northern Ridge and Valley Ecoregion. Each of these species is allocated to one of four tiers. Tier I species are those with a critical conservation need having an extremely high risk of extinction. In the Northern Ridge and Valley Ecoregion, there are 55 Tier I Species. Of the seven Tier I species found in the watershed, four are state threatened (ST), and one is federally endangered, state endangered (FESE). Two other species, a bird and a butterfly, are state special concern (SS) and federal species of concern (FS), respectively. Figure 19 shows the relative density of Tier I Species in Virginia and in the watershed. This area is of significant importance to wildlife.

Several Federal species of concern (FS) and State special concern species (SS) are also found in the watershed. There are four mammal species: the Appalachian Cottontail, Sylvilagus obscurus; the Allegheny Woodrat, Neotoma magister; the Northern River Otter, Lontra canadensis lataxina; and the Eastern Small Footed Myotis, Myotis leibii. Bird species include the Cerulean Warbler, Dendroica cerulean; the Golden Winged Warbler, Vermivora chrysoptera; the Winter Wren, Troglodytes troglodytes; the Northern Harrier, Circus cyaneus; the Barn Owl, Tyto alba pratincola; the Brown Creeper, Certhia americana; the Dickcissel, Spiza americana; the Purple Finch, Carpodacus purpureus; the Alder Flycatcher, Empidonax alnorum; the Golden Crowned Kinglet, Regulus satrapa; the Common Moorhen, Gallinula chloropus cachinnans; the Red-breasted Nuthatch, Sitta canadensis; the Hermit Thrush, Catharus guttatus; and the Magnolia Warbler, Dendroica magnolia. There is also one reptile, the Timber Rattlesnake, Crotalus horridus; one amphibian, the Cow Knob Salamander, Plethodon punctatus; and one mollusk, the Tennessee Pigtoe, Fusconia barnesiana.

Figure 17. Threatened and Endangered Species Sample Sites and Coldwater Streams

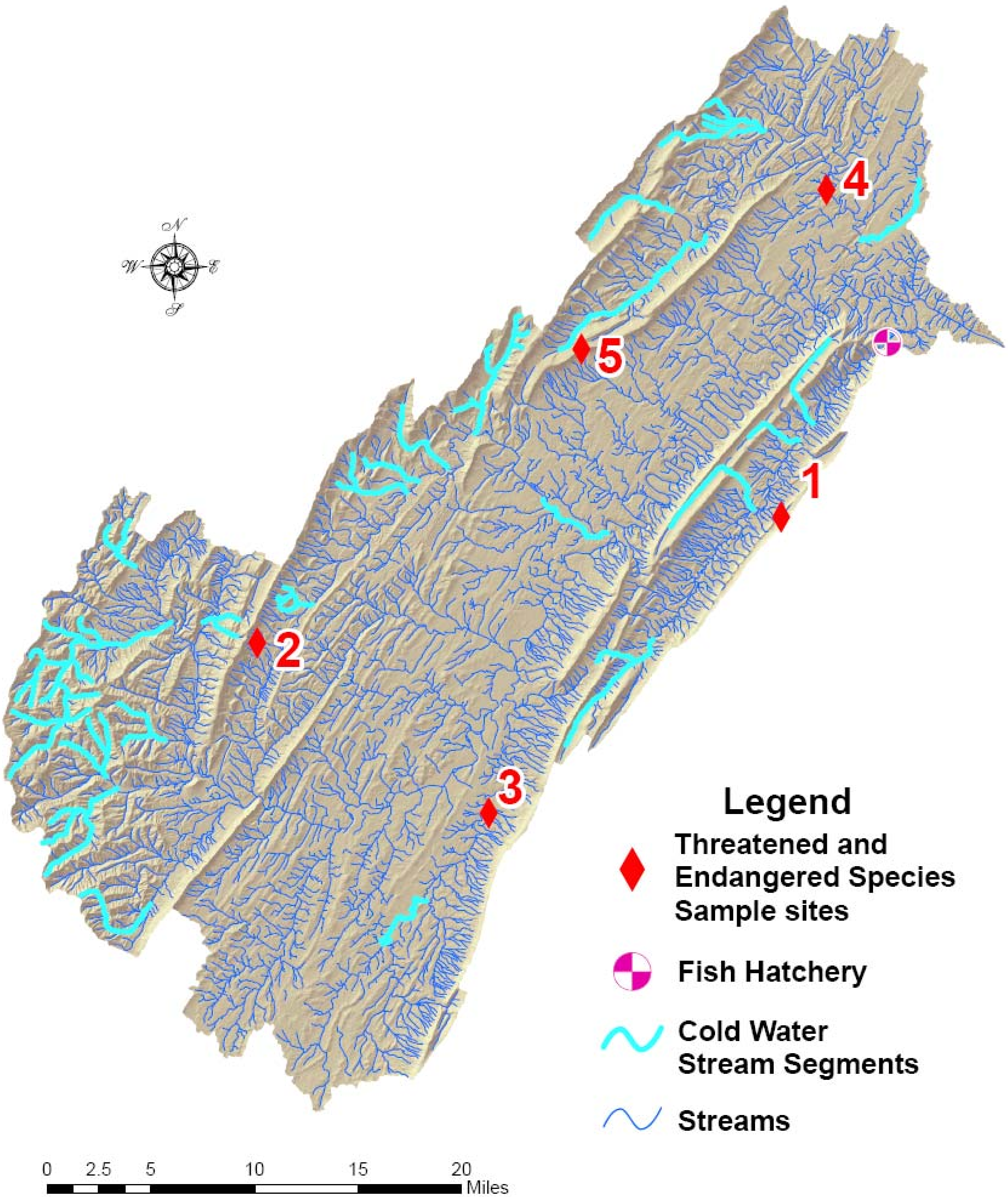


Figure 18. Bailey's Ecoregions

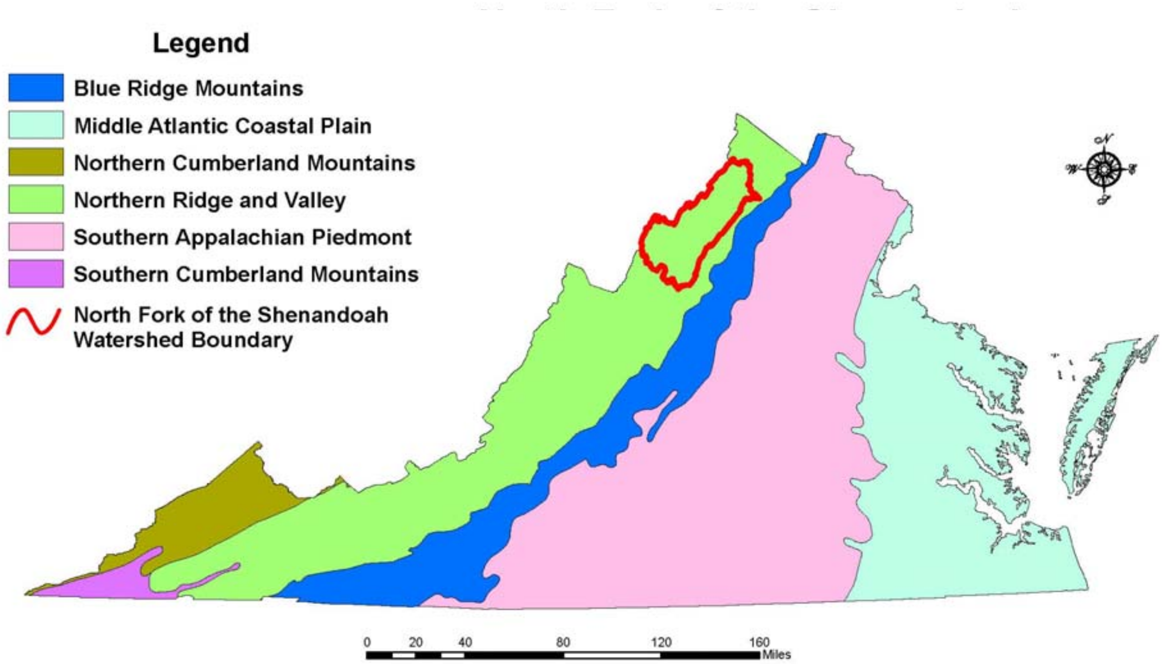
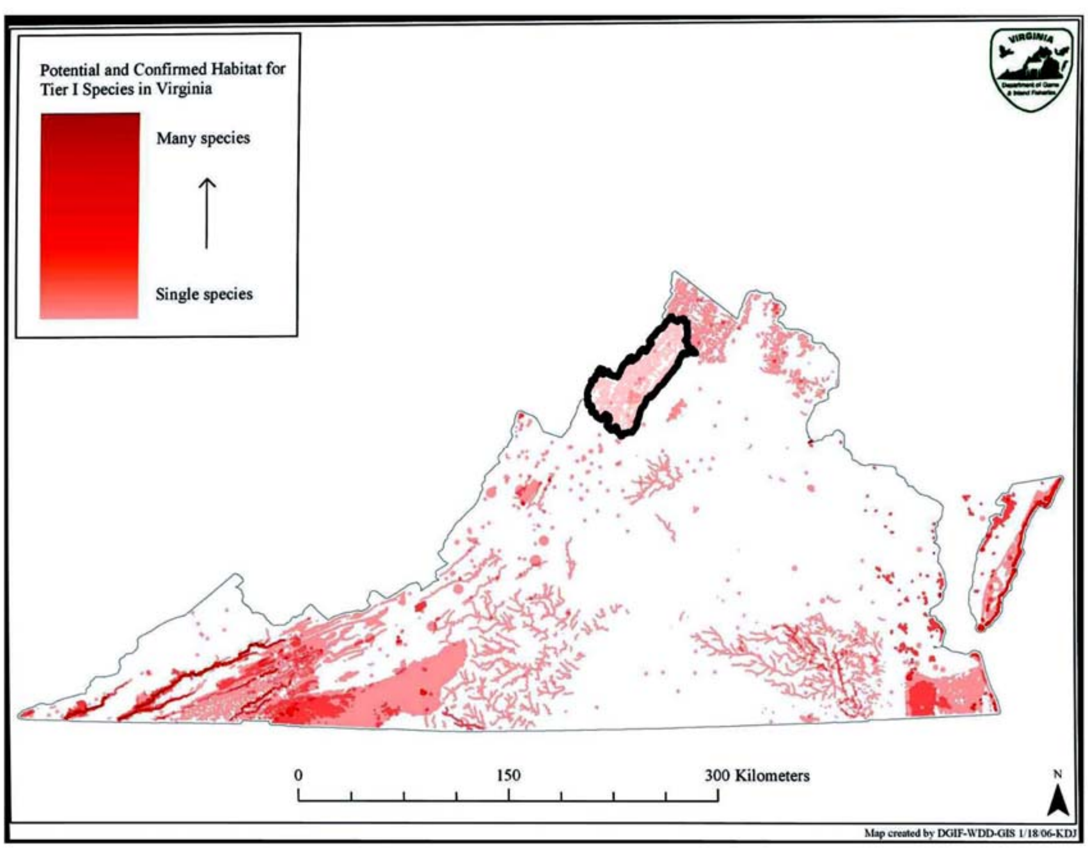


Figure 19. Potential and Confirmed Habitat for Tier 1 Species in Virginia



Subwatershed Descriptions. The seven 10-digit subwatersheds in the river basin have many features in common, such as types of water quality impairments and types of conservation activities and programs that are available. These common features are described in this section. The unique qualities of each subwatershed are noted in the individual subwatershed descriptions.

Pasture is the dominant agricultural land use in this watershed, followed by hay and row crops. Corn is the main row crop, with approximately equal amounts harvested for silage and grain (Figure 20). Winter cover crops are used on a majority of the silage ground. Soybean acres have been increasing in recent years. Overall, minimum tillage is the most common on the row cropland. In 2007, a significant amount of land that had been in grass for the last 20 years was cropped due to higher commodity prices. No-till was the primary means for converting pasture and hay into cropland.

Figure 20. Corn Grown in the Shenandoah Valley

Credit: Cory Guilliams, NRCS, Harrisonburg, Virginia

Poultry and beef operations are the dominant type of animal operations in the river basin. The Linville Creek subwatershed is the number one producer of chickens followed by Shoemaker River, Smith Creek, and Stony Creek. The Smith Creek subwatershed is the number one producer of turkeys followed by Linville Creek, Stony Creek, and Shoemaker River. Most of these farmers have some storage facility for the litter/poultry waste generated on their farms. Many also have dead bird composting facilities (Figure 21). Disposal of poultry litter has become more difficult in recent years. The use of phosphorus-based nutrient management plans has resulted in a decrease in the total amount of manure/litter that can be spread on each field. With this change, many farmers have more manure than available land and disposal becomes a problem. In addition, poultry litter applied in quantities sufficient to meet the phosphorus need of the crop does not provide enough nitrogen to meet crop requirements. The purchase and application of supplemental nitrogen is required.

Figure 21. Example of a Dead Bird Composter

Credit: Cephas Hobbs, NRCS, Richmond, Virginia.

The Linville Creek subwatershed is also first in production of confined beef, followed by Narrow Passage Creek, Stony Creek, and Smith Creek. The dominant subwatershed for unconfined beef is the Linville Creek subwatershed. Smith Creek and Narrow Passage Creek are also big producers. Dairies are found in six of the seven subwatersheds in the river basin. Most of the dairy operations and some of the confined beef operations have some type of manure storage system. Application of cow manure has many of the same problems experienced with application of poultry manure.

Feed lots without manure collection systems often have denuded, muddy sacrifice areas (Figure 22). These areas are a significant source of pollutants, particularly if they drain to a stream. Pasture-based beef cattle are fed supplemental hay during the winter months. Limestone outcrops in the field are commonly used as feeding sites in the hope that the manure and wasted hay will decay and cover the rock outcrop. Since these outcrops are often associated with karst topography, this practice can contribute to the pollution of both the ground and surface water. Grassed feeding areas that are denuded of vegetation by continual use also can contribute nutrients, manure, and sediment to the water.

Figure 22. Sacrifice Lot

Credit: NRCS Field Office, Harrisonburg, Virginia.

Each subwatershed has at least one stream reach with a water quality impairment severe enough to restrict the designated uses of fishing, swimming, or aquatic habitat. There are also lesser impairments in many of the streams. The most common contaminants are sediment, nutrients, and fecal coliform bacteria. Sediment pollution can come from stream banks damaged by flooding and livestock access and from sheet and rill erosion on cropland and overgrazed pasture land. Where the land use is urban or is changing to urban, gully and sheet and rill erosion from roads, clearings, and other types of development can also contribute to the sediment loading. The “flashy” nature of some of the high gradient streams in the steeper areas of the watershed can contribute to stream bank erosion. The lack of adequate buffers along a majority of the streams allows sediment from overland sources to move directly into the streams.

There are a variety of potential sources of nutrient pollution. Point sources can include some of the smaller waste treatment plants, improperly stored animal manures, and concentrated beef or dairy feeding areas. To a lesser degree, failing septic systems and straight pipes may be a source of nutrients and bacteria. Nonpoint sources can include agricultural fields and urban lawns where fertilizers are applied in excess. Fields where animal manures are applied in amounts greater than the crop requirements are another potential source. Where animals have unrestricted access to a stream, some manure is deposited directly into the water. As with sediment, the lack of buffers can allow nutrients to be delivered directly to the streams.

Fecal coliform bacteria pollution is coming from livestock in and adjacent to the streams, wildlife, and improperly stored and utilized animal manures and animal mortality.

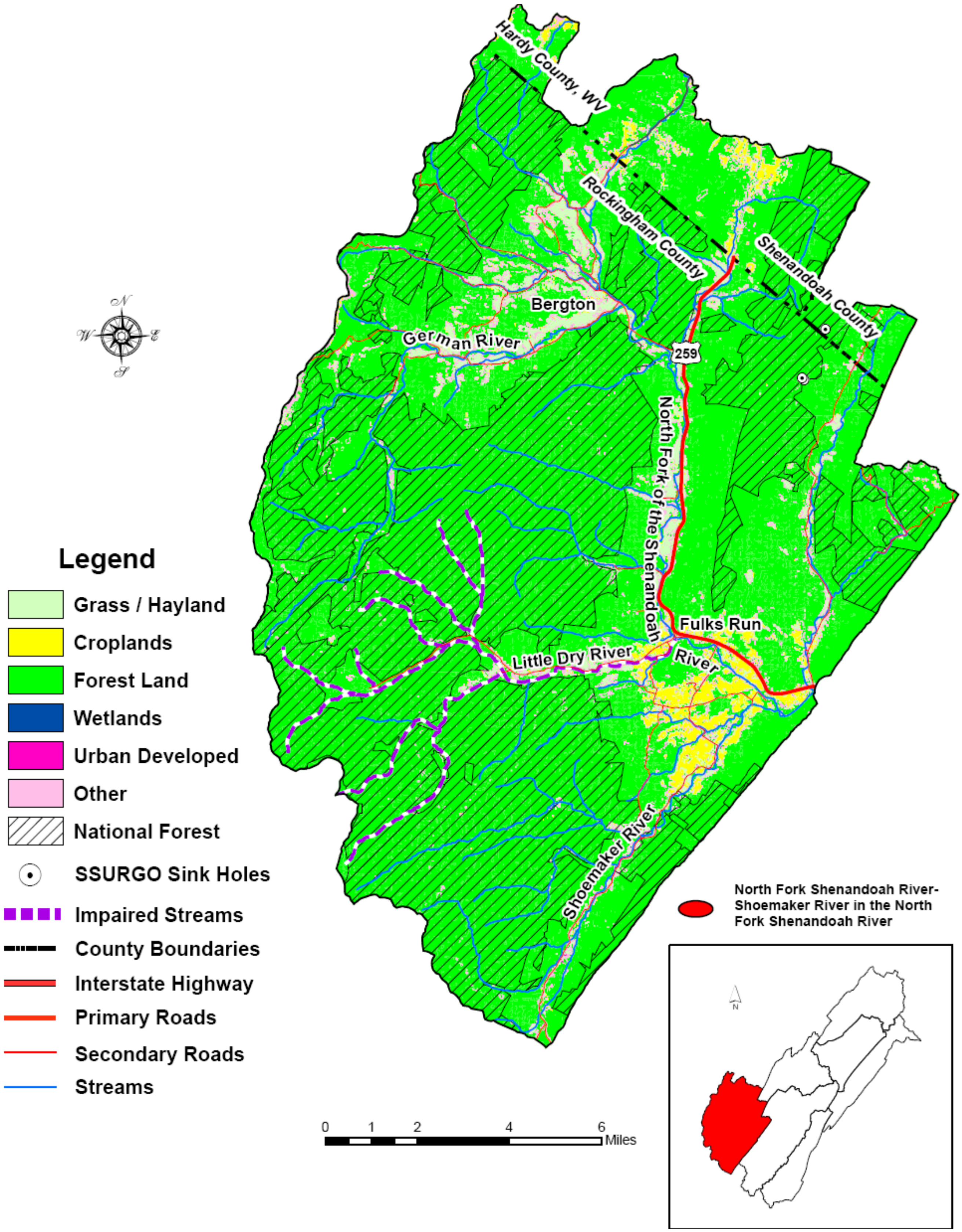
For the most part, the farmers and landowners in the watershed are receptive to participating in cost-share programs and also to receiving technical assistance. In the headwaters of the Linville Creek subwatershed, there are some farmers that prefer to only accept technical assistance. The Virginia Agricultural Best Management Practice (BMP) Program and the USDA Environmental Quality Incentive Program (EQIP) are used frequently for cropland conversion practices, stream bank protection practices, and waste management or utilization. In the Passage Creek subwatershed, participation in government programs and requests for technical assistance may be lower than average because there is less agriculture in the subwatershed.

In the Valley, there have been numerous EQIP projects to improve water quality. Typical projects address animal waste (litter storage sheds, winter feeding areas, etc.), grazing land concerns (livestock exclusion from streams, rotational grazing systems, alternative water systems, etc.), cropland concerns (long-term rotations including perennial forages, etc.), or forestry concerns (establishment of trees on marginal pasture land, etc). In particular, the Linville Creek and Stony Creek subwatersheds have had targeted EQIP projects to address these issues. Furthermore, there have been several producers who have completed Conservation Reserve Enhancement Program (CREP) projects to establish riparian buffers along pastures. Over the years, a great number of litter storage sheds, dead bird composting facilities, manure storage pits, rotational grazing systems, watering systems (Figure 23), stream exclusion, cropland conversion to pasture and hayland, and winter cover crops have been installed with assistance from the Virginia Agricultural BMP Program.

Figure 23. Frost-proof Trough for Livestock Water

Credit: NRCS Field Office, Harrisonburg, Virginia.

Figure 24. North Fork Shenandoah River - Shoemaker River (PS-K) – Land Use and Features



North Fork Shenandoah River - Shoemaker River PS-K

This subwatershed is mainly in Rockingham County, Virginia, with small portions of Shenandoah County, Virginia, and Hardy County, West Virginia (Figure 24). The Virginia portion of this watershed consists of 46 poultry operations, two Grade A dairy operations, two beef feedlots, and many pasture-based beef cattle operations (cow/calf and stocker). The average beef cattle herd size is 40 head or less. In recent years, the number of horse farms in the watershed has increased. There are also a few goat and sheep farms.

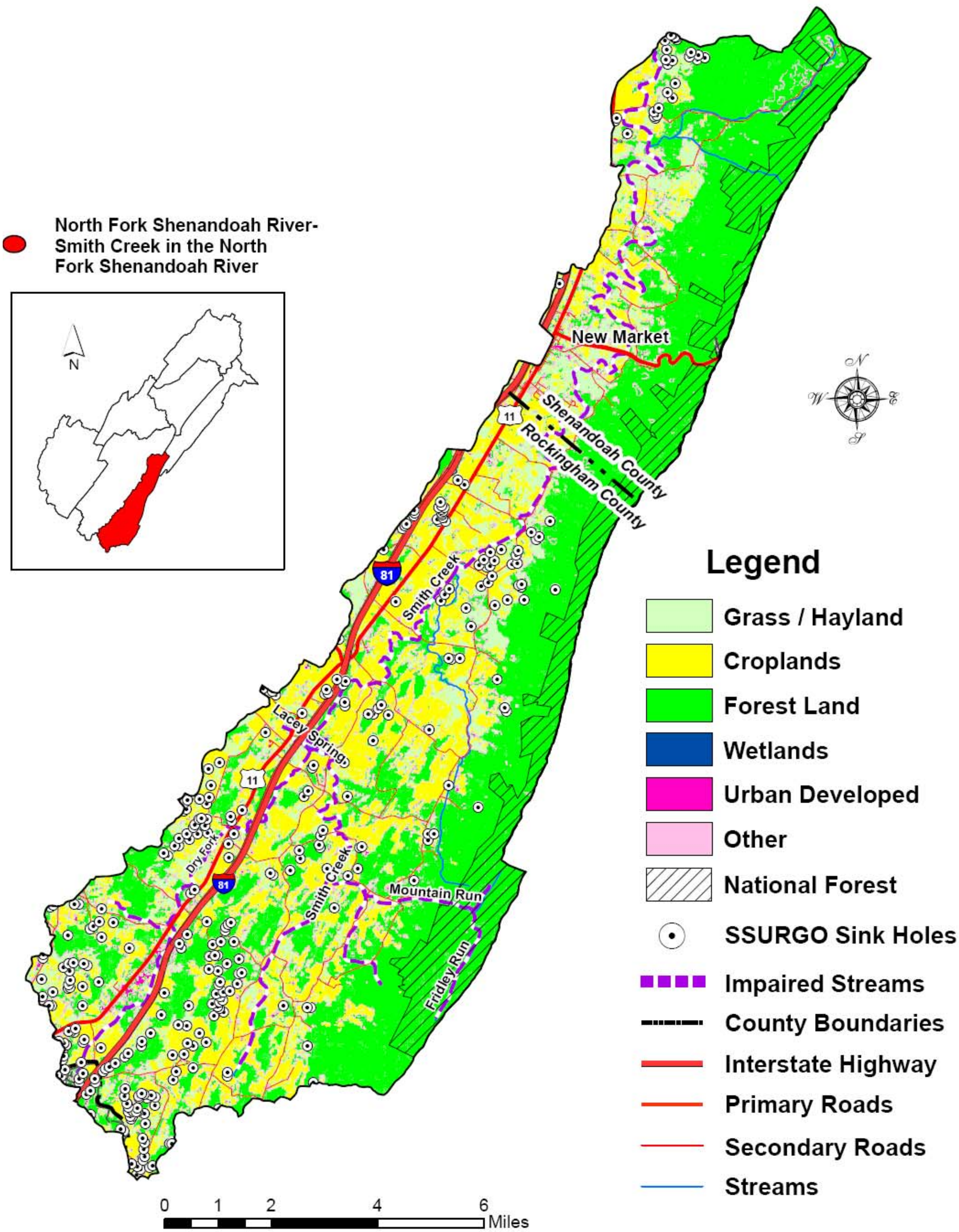
The Hardy County portion of this watershed has a number of commercial poultry operations as well as cow/calf operations (averaging an estimated 30-40 cow/calf pairs) and dairies. The beef and dairy cattle are over-wintered on pasture with feed delivered to different locations to minimize compaction and damage to the sod and to better distribute the animal waste. There are a few small fields used for annual crop production, but the majority of the agricultural land in Hardy County is in pasture or hayland. The Hardy County part of the watershed had six participants in the Potomac Headwaters Land Treatment Project (PL-534). Each participant build a litter shed and a dead bird composter.

The 10,230 acres of cropland, hayland, and pasture in the subwatershed are located primarily on bottomland and old stream terraces near larger streams. Most of the 119,773 acres of woodland are part of the George Washington and Jefferson National Forest. The main streams in this subwatershed are Bennett Run, German River, Little Dry River, Slate Lick Branch, Shoemaker River, Runion Creek, Sours Run, and the North Fork Shenandoah River. Crab Run and Capon Run begin in Hardy County and extend into Rockingham County. There are 196.7 miles of perennial streams and 332.5 miles of intermittent streams. Due to the shale, siltstone, and sandstone geology, there are only three caves and three sinkholes identified in this watershed.

Even in this relatively isolated area, land use conversion is a concern. Over 9,200 acres in the watershed have been identified as prime or important farmland. During the time period from 1992 to 2001, the Urban land use in this watershed increased from 453 acres to almost 3,000 acres. Most of this land was converted from woodland (1,376 acres), agriculture (443 acres), and Other (699 acres).

The Virginia DEQ has identified 34.74 miles of the Little Dry River as impaired by pH and fecal coliform which restricts use for aquatic life and recreation. The majority of these impaired sections are in the National Forest but pasture/hayland adjacent to the river may also make some contribution to the impairment.

Figure 25. Smith Creek (PS-L) – Land Use and Features



Smith Creek (PS-L)

The Smith Creek Watershed is mostly in Rockingham County with about a quarter of the area in Shenandoah County (Figure 25). There are 32 permitted commercial poultry operations (turkey and chickens) and several non-permitted (small) poultry operations, 18 Grade A dairy operations, about 30 beef feedlots, many pasture-based beef cattle operations (cow/calf, stocker, and feeder), some sheep and goat farms, and some small horse farms. The average dairy milks around 100 head. Most of the beef cattle farms average around 50 head.

The subwatershed has a large amount of cropland, both on bottomland and on upland. There is also a large amount of pasture and hayland. In recent years, a good bit of hayland and pasture have been converted to cropland because of high commodity prices. Some of the private woodland in this watershed is managed for timber production. Most of the mountainous woodland in this watershed is part of the George Washington and Jefferson National Forest. There is a 27-hole golf course in this watershed as well. The main streams in this watershed are Smith Creek, Dry Fork, War Branch, Mountain Run, and Fridley Run.

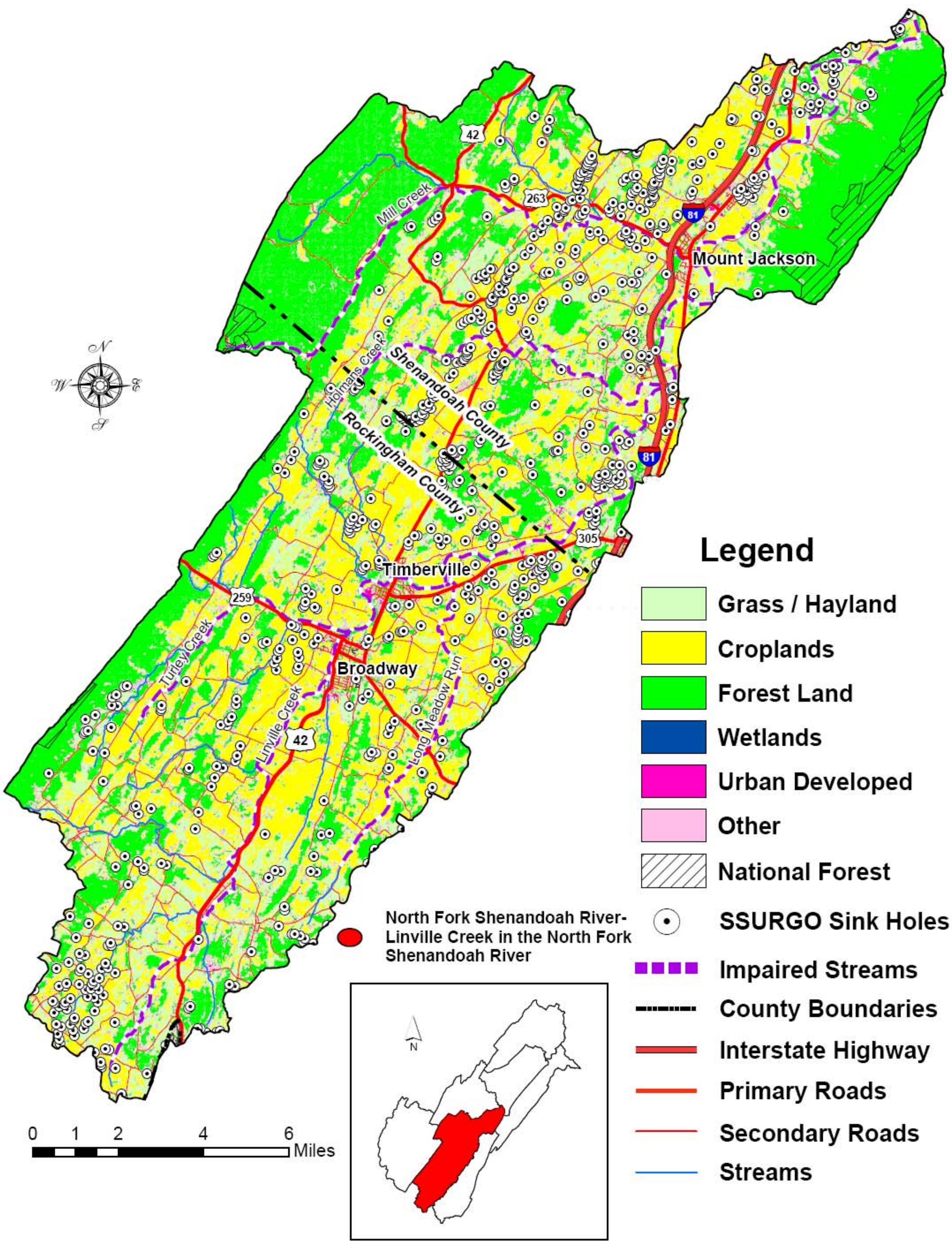
Over a third of the acres in the watershed are identified as prime or important farmland. Some of this was lost when almost 2,300 acres of agricultural land were converted to other uses between 1992 and 2001. About 500 acres of woodland and 900 acres of other land use have also been converted. There has been a corresponding increase of about 3,800 acres of Urban land. Since 2005, 160 acres of commercial fruit orchards (apple and peach) have been converted to row crop production. No commercial orchards remain in the subwatershed.

There are 329 identified sinkholes located primarily in the agricultural land. This is due to the dolomite limestone geology in the valley areas. This equates to about 7.2 sinkholes per square mile in agricultural land. The potential for water quality impairment is high due to the ease with which surface and ground water can be exchanged through these features. There are also 35 known caves.

Of the 286.9 miles of perennial and intermittent streams in the Smith Creek watershed, 52.54 miles are identified as impaired. Fridley Run, located in the National Forest, is impaired for aquatic life due to pH and benthic macroinvertebrate bioassessments. Mountain Run (5.98 miles) and Dry Fork (10.08 miles) are also impaired for the benthic macroinvertebrate bioassessments. Smith Creek (33.88 miles) and Lacey Spring (0.2 miles) are impaired but meet the TMDL requirements.

In 2006, two farmers from this watershed were selected to be in the Conservation Security Program (CSP) because of the amount of conservation that had been completed on their operations. A few tracts of land in this watershed have been protected from suburban development by placing them in conservation easements.

Figure 26. North Fork Shenandoah River - Linville Creek (PS-M) – Land Use and Features



North Fork Shenandoah River - Linville Creek (PS-M)

The Linville Creek subwatershed is about equally divided between Rockingham and Shenandoah Counties (Figure 26). Poultry (turkeys and broiler-type chickens) are a significant industry with approximately 170 poultry operations. There are approximately 30 grade A dairies with an average dairy herd size of around 125 head in Shenandoah County and around 100 head in Rockingham County.

Beef cattle are another major livestock enterprise in this subwatershed with cow/calf and stocker operations. The average herd size is around 50–60 head. Most of these animals are on pasture. There are also approximately 20 concentrated beef operations, ranging from a few managed feedlots to areas where large concentrations of cattle are fed for much of the year. Sheep, goats and horses are present and growing in total numbers, but generally are on small operations.

Cropland is located both on bottomland and upland sites. Along the North Fork of the Shenandoah River, some of the cropland is irrigated from the river and with treated waste water from the Towns of Broadway and Timberville. There are approximately 3,000 acres of apple and peach orchards that range from approximately 50 acres to 700 acres in size. Over the past five years, 600 acres of orchards in this watershed have been converted to cropland or other uses. Woodlands cover 34.5% of the land in Linville Creek. There are some small sections of National Forest around the perimeter of the subwatershed. Although some of the private woodland is managed for optimum timber production, the majority is unmanaged.

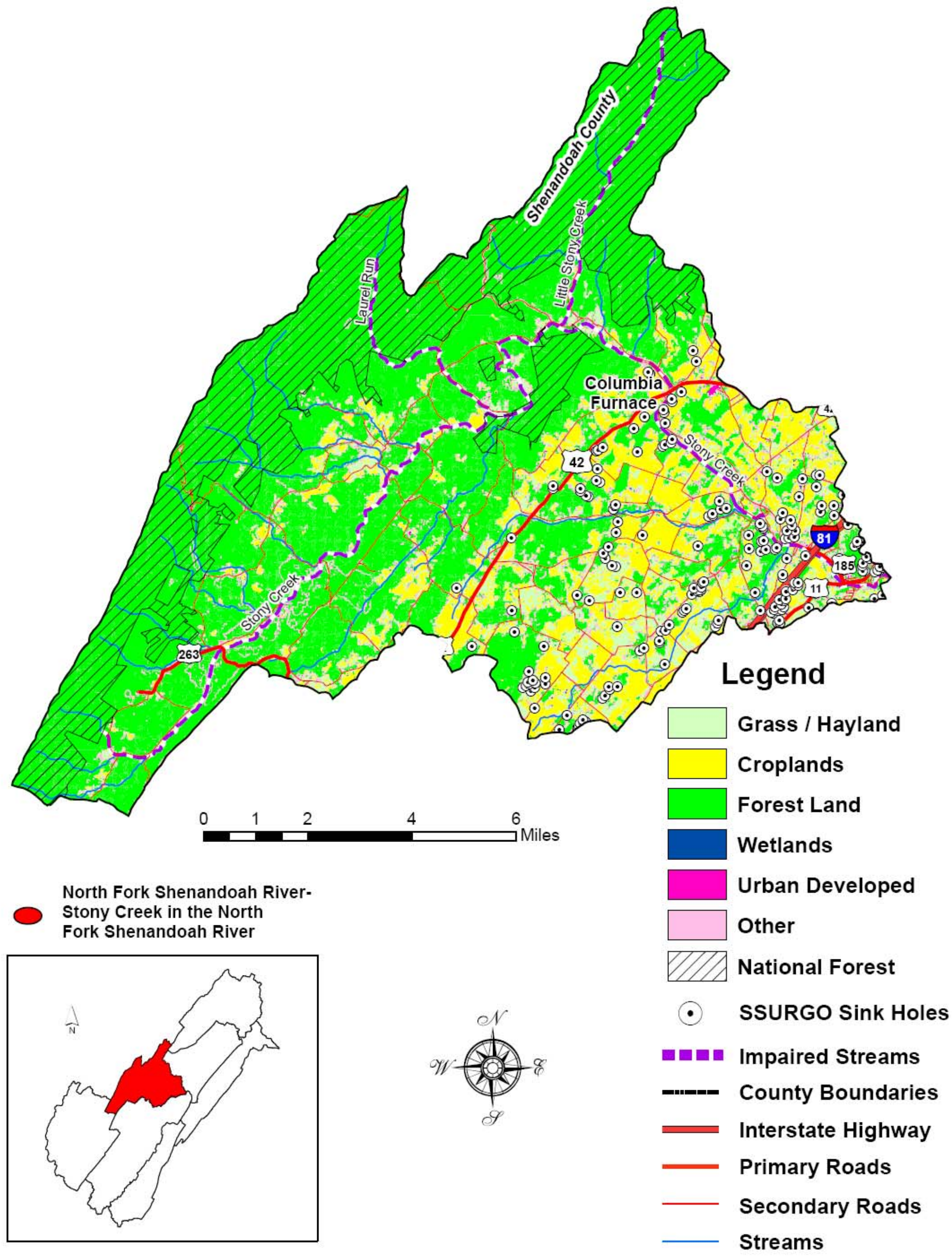
There are 733 identified sinkholes in Linville Creek. These sinkholes are primarily located in the agricultural land which is underlain by dolomitic limestone. The density of sinkholes is 6.18 per square mile within the agricultural land of the watershed. The relatively high sinkhole density promotes rapid exchanges of surface and ground water which increases the potential for water quality problems.

In the past 16 years, suburban development has substantially increased in the headwaters of this watershed around the City of Harrisonburg and in the center of the subwatershed around Broadway and Timberville. From 1992 to 2001, the acres of urban land in the watershed increased from 3,200 acres to over 12,000 acres. Most of the land that was developed was previously used for agricultural production, but there were also declines in the woodland and Other land use categories. In 2001, there were 70,723 acres of Prime and Important farmland acres in the subwatershed. This number represents 49.9% of the subwatershed.

The main streams within the Linville Creek Watershed are Long Meadow Creek, Holmans Creek, Cedar Run, Turley Creek, and the North Fork Shenandoah River. Of the 550.6 miles of perennial and intermittent streams in the watershed, 81.62 miles have been identified as impaired. With the exception of Mill Creek, all the impaired streams originate in agricultural land and have impairments that would affect the aquatic life in the streams.

The Holmans Creek subwatershed within the Linville Creek subwatershed, has received targeted EQIP, state BMP, two 319 grants and TMDL funds. In 2007, the Linville Creek Land Treatment Watershed Project (PL-534) was completed and closed out after 22 years. In 2006, two farmers from the Linville Creek subwatershed were selected to be in the CSP because of the amount of conservation that had been completed on their farms.

Figure 27. Stony Creek (PS-N) - Land Use and Features



Stony Creek (PS-N)

The Stony Creek subwatershed is entirely within Shenandoah County (Figure 27). Poultry (turkeys and broiler-type chickens) are a significant industry in this watershed. There are 16 permitted poultry operations, with an average of three poultry houses per farm. Most, if not all farms in the watershed, have some storage facility for the litter/poultry waste generated on their farms. Many also have dead bird composting facilities. There are three Grade A dairies in this watershed, with all having some type of waste storage system in place. The average dairy herd size is around 125 head.

Cow/calf and stocker cattle operations are common. The average herd size is around 50–60 head and grazing is the main means of feeding the cattle. There are several large feedlot operations. Sheep, goats and horses are present and growing in total numbers, but generally are on small operations and are a minor concern.

In 2001, there were 21,779 acres of Prime and Important farmland. Along the North Fork Shenandoah River, a good bit of cropland is irrigated directly from the river.

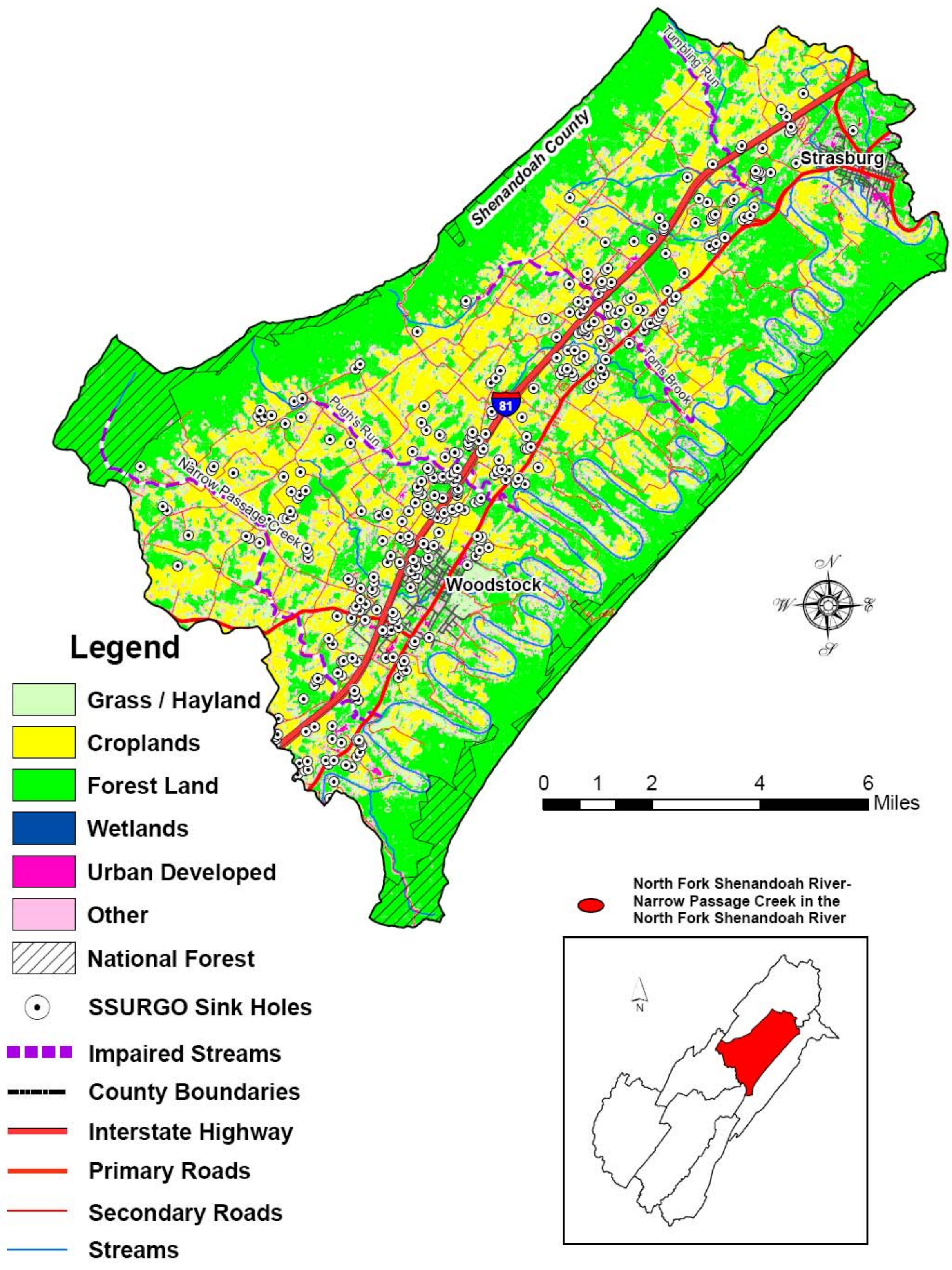
Woodlands cover 67.5% of the watershed. National Forest account for about half of the woodland acres. The private woodland is mostly unmanaged. However, some parcels are managed for timber production.

There are 187 identified sinkholes in Stony Creek. These sinkholes are primarily located in the agricultural land which is underlain by dolomitic limestone. Sinkhole density is 6.5 sinkholes per square mile in the agricultural land portion of the watershed. There is the potential for ground water contamination due to the topography.

From 1993 to 2001, the acres of urban land in the watershed increased from 1,200 to over 5,000 acres. Almost all of the land that has been developed was previously used for agricultural production, but there were also declines in the woodland and Other land use categories.

The main tributaries within this watershed are Painter Run, Swover Creek, Riles Run, Garlic Hollow Run, Little Stony Creek, and Laurel Fork. Stony Creek is impaired for both temperature (9.46 miles) and fecal coliform (17.03 miles). Approximately 6.5 miles of Little Stony Creek and 5.13 miles of Laurel Run are impaired for aquatic habitat. These three streams represent about 16% of the stream miles in the watershed.

Figure 28. North Fork Shenandoah River - Narrow Passage Creek (PS-O) – Land Use and Features



North Fork Shenandoah River - Narrow Passage Creek (PS-O)

The Narrow Passage Creek subwatershed is entirely within Shenandoah County (Figure 28). There are seven permitted poultry operations in this subwatershed. The three Grade A dairies in this watershed have an average herd size of around 125 head.

There are numerous cow/calf and stocker operations. The average herd size is 50–60 head. Pasture and supplemental hay are the predominant means of feeding. There are approximately 12 concentrated beef operations. Sheep, goats and horses are present and growing in total numbers, but generally are on small operations and are a minor concern.

Along the main stem of the North Fork Shenandoah River, there is a good bit of cropland that is irrigated from river withdrawals. Narrow Passage Creek has approximately 100 acres of apple and peach orchards.

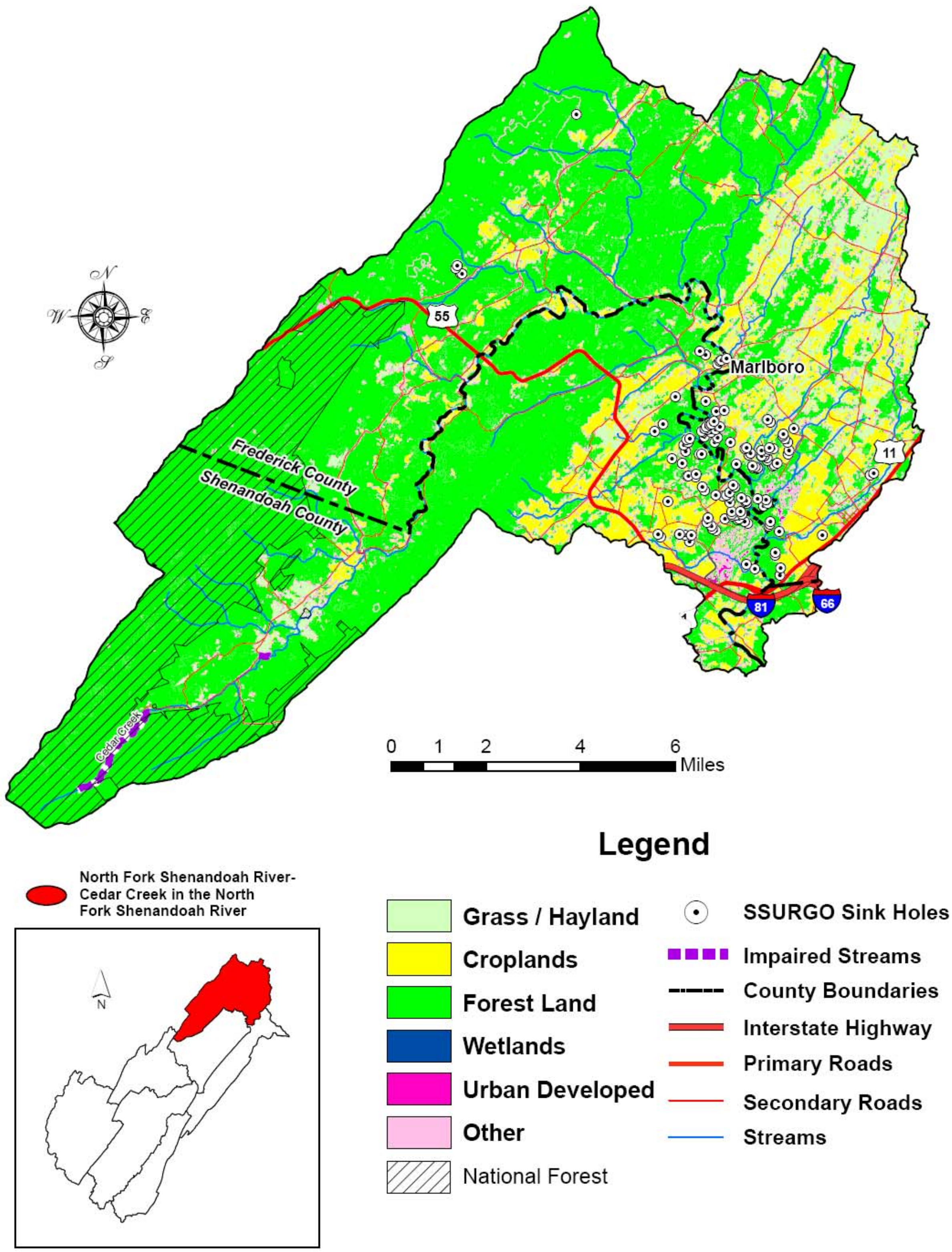
Woodlands cover 47.9% of the watershed. There are some sections of National Forest around the perimeter of the subwatershed. Some of the private woodland is managed for timber production but the majority is unmanaged.

There are 375 identified sinkholes in Narrow Passage Creek. These sinkholes are primarily located in the agricultural land which is underlain by dolomitic limestone. Sinkhole density is 7.64 sinkholes per square mile in the agricultural land portion of the watershed. The relatively high sinkhole density promotes rapid exchanges of surface and ground water which increases the potential for water quality problems.

From 1992 to 2001, the acres of urban land in the watershed increased from 3,400 to 8,200 acres. Almost all of the land that has been developed was previously used for agricultural production, but there were also declines in the woodland and Other land use categories. There were 36,153 acres of Prime and Important farmland in 2001.

Major tributaries in this watershed include Pugh’s Run, Toms Brook, Tumbling Run, Snapps Run and South Fork Run. Fecal coliform impairments have been identified on Narrow Passage Creek (10.77 miles), Pugh’s Run (5.86 miles), and Tumbling Run (4.15 miles). The North Fork Shenandoah River has 11.84 miles of fecal coliform impairment. Tom’s Brook (7.18 miles) and North Fork Shenandoah River (4.60 miles) also have some segments with impairments that are significant but do not require a TMDL study. A total of 44.40 miles, about 15%, of the 304.6 miles of perennial and intermittent stream in the subwatershed are impaired.

Figure 29. Cedar Creek (PS-P) – Land Use and Features



Cedar Creek (PS – P)

The Shenandoah County portion of this watershed is mostly forested, with a majority of the woodland managed by the U. S. Forest Service (Figure 29). The open land is predominantly pasture and hayland. Cropland acreage in the watershed is around 500 acres and is generally in a rotation. There are several herds of cattle (cow/calf and stocker). Average herd size is about 50 head. There are approximately 300 acres of orchard. One trout farm is present along a spring branch draining to Cedar Creek. The main streams draining into Cedar Creek from Shenandoah County are Mulberry Run and Turkey Run.

The Frederick County portion of this watershed is approximately 60% forested, most of which is privately owned and generally unmanaged. Open land is mostly used for pasture and hay production and row crops grown in rotation. Cattle can be found throughout this portion of the watershed. Herd size is generally 60 to 80 head in cow/calf and stocker operations. A few confined beef operations exist but are generally small. There is one dairy of approximately 100 head. Two horse operations of approximately 20 head each are present in the watershed and farmettes, with a few horses each, are scattered throughout the county. One goat operation has approximately 50 head. Approximately 100 acres of vegetables are produced and there are about 400 acres of orchard. Some farms have been lost to development in the Frederick County portion, though the watershed remains largely rural and agrarian. The main streams draining into Cedar Creek from Frederick County are Buffalo Marsh Run, Meadow Brook, and Fawcett Run.

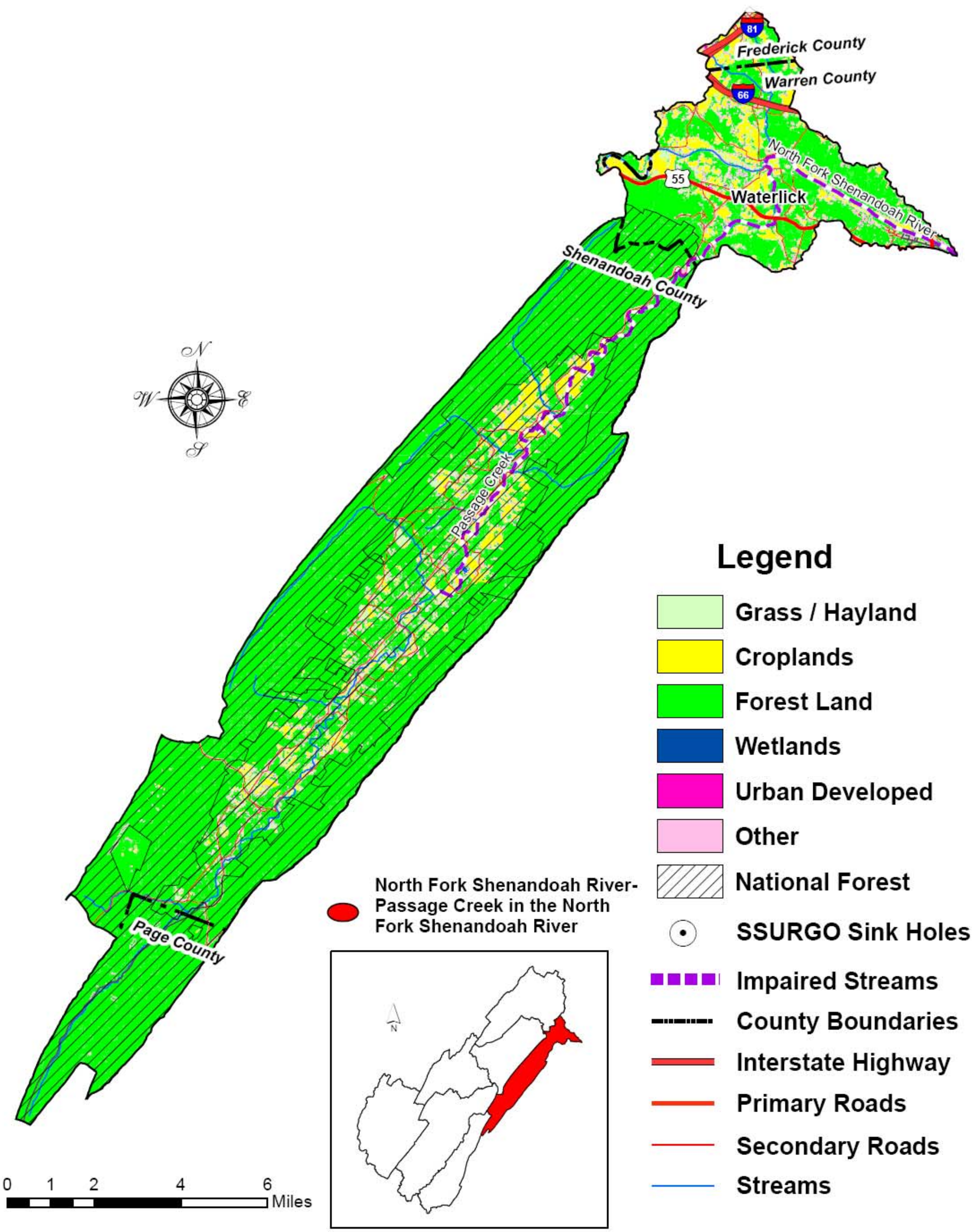
Almost a quarter of the land in the Cedar Creek subwatershed is categorized as Prime or Important Farmland. Land use conversion is an increasing concern in this watershed. In 1992, 305 acres were identified as Urban. In 2001, this number had increased to 4,970 acres. Forested land acres decreased by 3,310 acres and agricultural land decreased by 544 acres in this same time period.

Nine caves and 131 sinkholes have been identified in this subwatershed. These are located primarily in the agricultural areas on the east side of the watershed where the soils are underlain by limestone formations. Sinkhole density is 1.46 sinkholes/square mile of agricultural land. This density is much lower than for the Linville Creek, Smith Creek, Stony Creek, and Narrow Passage subwatersheds. However, the potential for water quality impacts is still present.

Overall, the quality of water in the Cedar Creek watershed is good. It ranks low on agricultural sediment and nutrient loading. Of the 346.5 miles of perennial and intermittent streams in the subwatershed, only 2.53 miles have been identified as impaired. This small headwater segment of Cedar Creek is located in the George Washington and Jefferson National Forest and does not support benthic macroinvertebrates.

In the Cedar Creek subwatershed, participation in government programs and requests for technical assistance is comparatively lower in the Shenandoah County portion, though increased interest has been seen in the recent years in the State BMP and NRCS EQIP programs. The Frederick County portion of the watershed has a higher rate of program participation and requests for technical assistance.

Figure 30. North Fork Shenandoah River - Passage Creek (PS-Q) – Land Use and Features



North Fork Shenandoah River - Passage Creek (PS–Q)

Passage Creek is an isolated watershed contained within the confines of the Massanutten Synclinorium[3] (Figure 30). The geology here is unique compared to the other subwatersheds in that sandstones predominate and there is a complete absence of sinkholes and known caves. Above the stream valley, there are steep mountain slopes covered in hardwood forest. Much of this forestland is owned by the U. S. Forest Service. Practically all of the activity, agricultural and otherwise, in this watershed occurs on the valley floor, relatively near the stream. Cropland is scarce in this watershed, with most of the open land used for low intensity pasture or hay production. Cattle operations are generally small in nature (10 to 30 head) and consist of cow/calf and stocker. A few small sheep and goat operations exist. There is one significant horse facility (approximately 30 horses) in the watershed. Agricultural enterprises are generally small. The Virginia Department of Game and Inland Fisheries operates a fish hatchery toward the lower end of this watershed. The main streams in this watershed are Passage Creek, Mine Run, and Peters Mill Run.

Approximately 9.8% of the Passage Creek subwatershed is Prime or Important Farmland. Land use conversion is a concern since the urban acreage increased from 952 acres in 1992 to 3,585 acres in 2001. During that same time period, agriculture acres declined by over 2,200 acres and “Other” land uses declined by about 1,000 acres.

Overall, the quality of water in the Passage Creek watershed is good. It ranks low on agricultural sediment and nutrient loading. However, fecal coliform contamination restricts the recreational use of 18.5 miles at the lower end of Passage Creek. Approximately 3.5 miles of the North Fork Shenandoah River were removed (delisted) from the list of impaired waters due to improvements in water quality. Several years ago, there was a move to designate Passage Creek as Tier 1 in EPA’s ranking of streams due to the creek’s very good water quality and low levels of contamination. However, opposition of local residents, fearful of possible government intervention, led to cessation of this effort.

[3] A syncline is a geologic term for a mountain land feature characterized by a fold that has a concave upward shape. A synclinorium is a large syncline on which minor folds are superimposed due to displacement and upturning. This makes the Massanutten Mountain a unique feature of the Shenandoah Valley.

RESOURCE CONDITIONS AND TRENDS

Development. Interstate 81 traverses the entire length of the watershed. Interstate 66 enters the northern portion of the basin from the east and permits rapid access to the nation's capitol. The mid-Atlantic location close to major metropolitan areas of the east coast, including Washington, D.C., makes the area an attractive location for manufacturing, warehouses, and product distribution centers. The northern part of the watershed is also attracting overflow growth from the Washington, D.C. suburbs. These combined characteristics have resulted in significant growth of the area's population centers along the I-81 corridor.

According to the Shenandoah County Building Inspection/Code Enforcement Department, certificates of occupancy were issued for 1,495 for new residential properties and 32 new commercial/industrial properties from January of 2005 through March 31st of 2008. About 65.6% of the new residence permits were for single family residences. The residential certificates include 521 in 2005, 476 in 2006, 424 in 2007 and 74 from January of 2008 through the end of March, 2008. The rate was highest in 2005 at a little over 43 certificates issued/month. Reflecting the general downturn on housing in the USA, the number of certificates issued in 2006 declined to almost 40/month. It declined further to a rate of 35/month in 2007 and, so far in 2008, certificates for residential properties have averaged about 25/month. Certificates of occupancy for new construction of commercial/industrial properties averaged 0.83/month in 2005, 1/month in 2006, 0.75/month in 2007, and 0.33/month up to the end of March, 2008, in Shenandoah County.[4]

Data collected from the Rockingham County Community Development Department indicates that a total of 4,345 certificates of occupancy were issued by the County during a five year period from January of 2003 through December of 2007 (an average of 869/year). Of these, 3,603 (82.9%) were for new residential properties (721/year). The remaining 17.1% were issued for commercial properties (148.4/year). The residential numbers ranged between a low of 47/month in 2007 and a high of 76/month in 2004. The issuance of residential certificates of occupancy peaked in 2004 with a total of 913 and decreased every year since then. The monthly rate of residential property certificates was 76.1 in 2004. The commercial certificates issued ranged between a low of 10.2/month in 2003 and a high of 15.8/month in 2007. The total number of commercial certificates of occupancy in 2007 was 189. Commercial permits increased steadily every year from 2003 onward. The residential numbers reflect the general downturn in housing in the USA, but the commercial certificates issued go against this trend and suggest that Rockingham County has been an attractive place for businesses to start up or to expand existing operations.

Well permit and septic system permit data collected from the State of Virginia Regional Health Department office for Rockingham County indicates that 1,352 permits for wells and 1,420 permits for septic systems were issued by Rockingham County from January 1st, 2003 through April 30, 2008. Annual data was not available. An average of 257.5 well permits and 270.5 septic system permits per year were issued from 2003 through April of 2008. According to the Regional Health Department office, 938 (66.1%) of the 1,420 septic system permits were conventional tanks with drain-fields and 482 (33.9%) were for alternative and more expensive septic systems. This is because the good sites

[4] These numbers were more difficult to establish due to the fact that the County lists these by specific use instead of commercial or industrial property classes and has them listed with all permits which include renovations and additions to existing structures. Permits for renovations and additions were not included because they are not reflective of new growth.

have for the most part already been developed. Increasingly, alternative septic systems have to be installed due to marginal sites.

Well permit and septic system permit data collected from Shenandoah County indicates that 408 permits for wells and 413 permits for septic systems were issued by the County from January 1st, 2005 through March, 2008. The 408 well permits include 170 in 2005, 115 in 2006, 97 in 2007 and 26 from January of 2008 through the end of March, 2008. The 413 septic system permits for Shenandoah County include 184 in 2005, 112 in 2006, 92 in 2007, and 25 from January of 2008 through the end of March, 2008. The septic system and well permit numbers correlate with each other very closely. Both categories of permits range from a low of about 8/month (2007) to a high of 14-15/month (2005).

Land Cover Changes. The increase in development has caused significant changes in the land cover. In 1992, only 1.6% of the watershed was in urban land (Table 8). As of 2001, 6.3% of the watershed was in urban land (Table 9). Decreases in woodland, agricultural land, and Other land uses account for this increase (Table 10). In particular, agricultural land decreased by over 18,000 acres during those years.

Figures 31 and 32 show the changes that occurred in the urban and agricultural land uses between 1992 and 2001, by hydrologic unit. Without exception, every hydrologic unit experienced increases in urban acres and decreases in agricultural acres. Figure 33 shows the overall change in land use for these years. Passage Creek was the only watershed that had an increase in forest acres rather than a decrease. The acreage of Other uses declined throughout the watershed. In particular, the Linville Creek Watershed had an increase in urban land of nearly 9,000 acres. This very large increase may be due to the fact that the City of Harrisonburg is located along the southern border of the watershed. Interstate Highway 81 passes through the Linville Creek, Smith Creek, Stony Creek, Narrow Passage Creek, and Cedar Creek watersheds. This has contributed to the development of this area. Increases in urban acreage ranged from around 3,830 each in Smith Creek and Stony Creek to about 4,760 each for Narrow Passage Creek and Cedar Creek. Shoemaker River and Passage Creek each had about 2,590 acres of new urban development.

In the Linville Creek subwatershed, 82% of the land converted to urban came from land previously in agriculture. Between 60% and 70% of the new urban acres came from agricultural land in Smith Creek, Stony Creek, Narrow Passage Creek, and Passage Creek. Cedar Creek and Shoemaker River converted 11.7% and 17.4% from agriculture to urban, respectively. In these two watersheds, the majority of the land converted to urban was forested or Other use.

Table 8. Land Use Changes in the Watershed by Percent Change

Land Use Category	1992 Land Cover, acres	2001 Land Cover, acres	Difference, acres	Percent of 1992 Value as of 2001
Urban	10,751.0	41,955.1	31,204.1	390
Agricultural	221,330.0	203,199.3	-18,130.7	92
Forest	420,091.0	413,367.8	-6,723.2	98
Open water	2,786.8	2,786.8	0.0	100
Other	6,861.7	511.7	-6,350.0	7
Total	661,820.5	-	-	-

Source: USGS 1992 and 2001 NLCD Database.

Table 9. Increase in Urban Acres from 1992 to 2001

Subwatershed	Urban Acres, 1992	Urban Acres, 2001	Increase, Acres	% Increase in acreage from 1992 to 2001
Shoemaker River (PS-K)	453.9	2,998.5	2,544.6	660.6
Smith Creek (PS-L)	1,290.1	5,069.9	3,779.8	393.0
Linville Creek (PS-M)	3,175.6	12,013.7	8,838.2	378.3
Stony Creek (PS-N)	1,209.6	5,089.7	3,880.1	420.8
Narrow Passage Creek (PS-O)	3,364.4	8,227.9	4,863.5	244.6
Cedar Creek (PS-P)	305.1	4,969.8	4,664.7	1,628.9
Passage Creek (PS-Q)	952.3	3,585.4	2,633.1	376.5
Total Acres	10,751.0	41,955.1	31,204.1	390.2

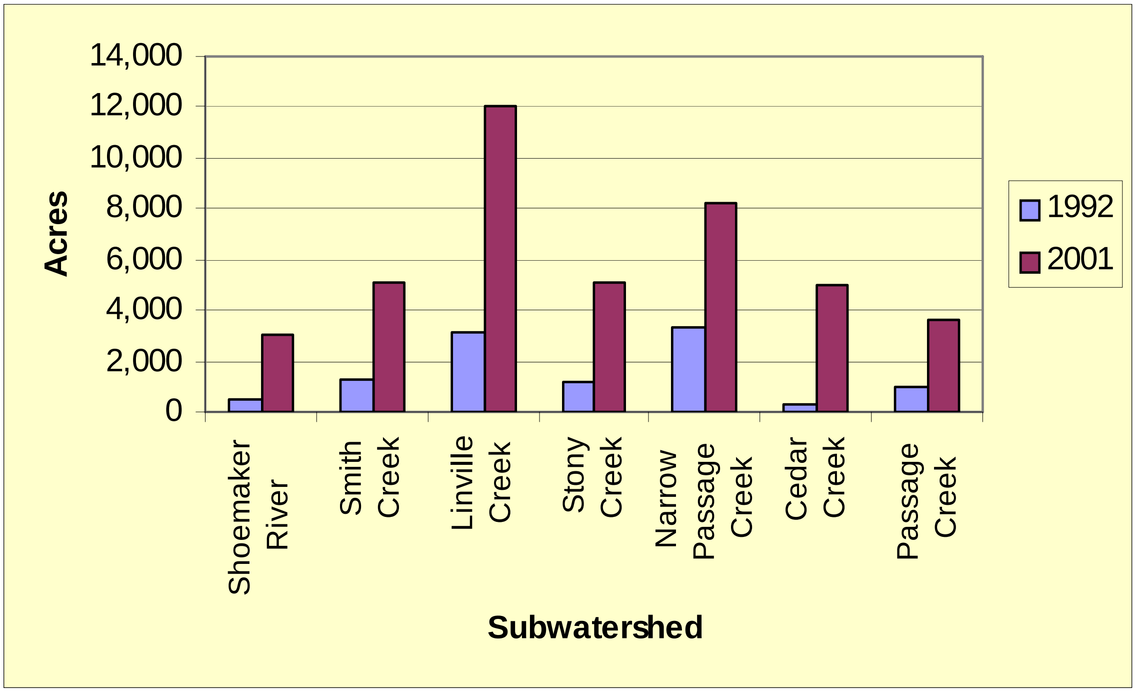
Source: USGS 1992 and 2001 NLCD Database.

Table 10. Land Converted from Other Uses to Urban Usage

Subwatershed	From Agriculture		From Forest		From Other	
	%	acres	%	acres	%	acres
Shoemaker River (PS-K)	17.43	444	54.08	1,376	28.48	725
Smith Creek (PS-L)	60.21	2,276	14.96	536	24.83	938
Linville Creek (PS-M)	82.06	7,253	4.44	392	13.50	1,193
Stony Creek (PS-N)	62.25	2,415	25.13	951	12.62	490
Narrow Passage Creek (PS-O)	61.37	2,985	14.91	725	23.72	1,154
Cedar Creek (PS-P)	11.67	544	70.96	3,310	17.38	811
Passage Creek (PS-Q)	69.19	1,822	0.00	0	30.86	812

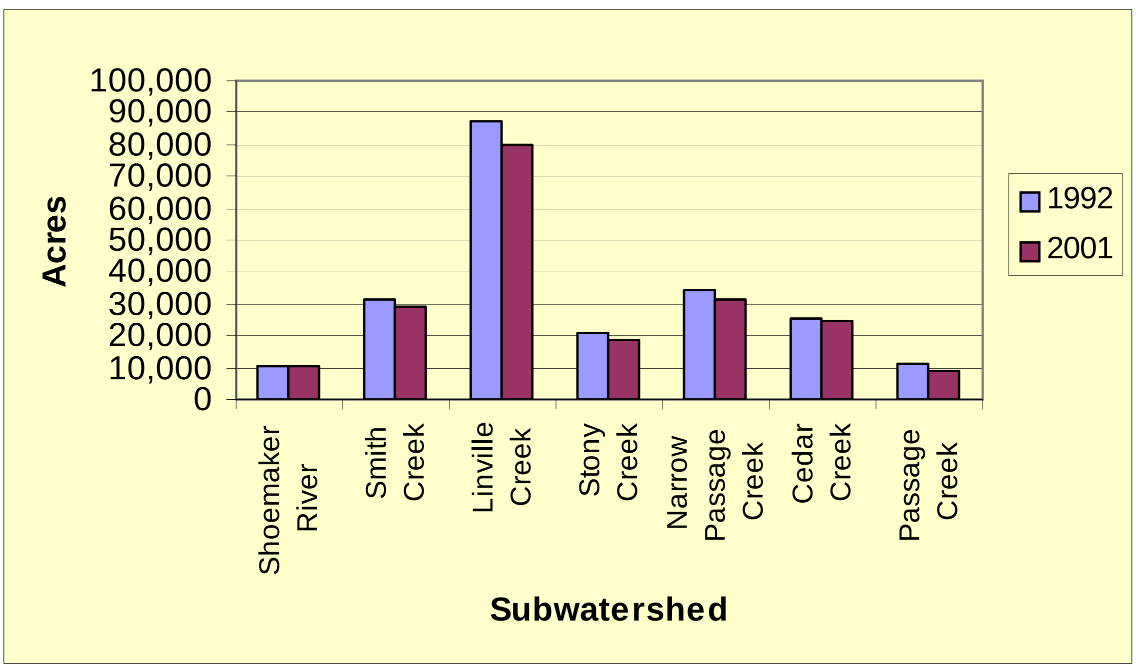
Source: USGS 1992 and 2001 NLCD Database.

Figure 31. Change in Acreage of Urban Land 1992-2001



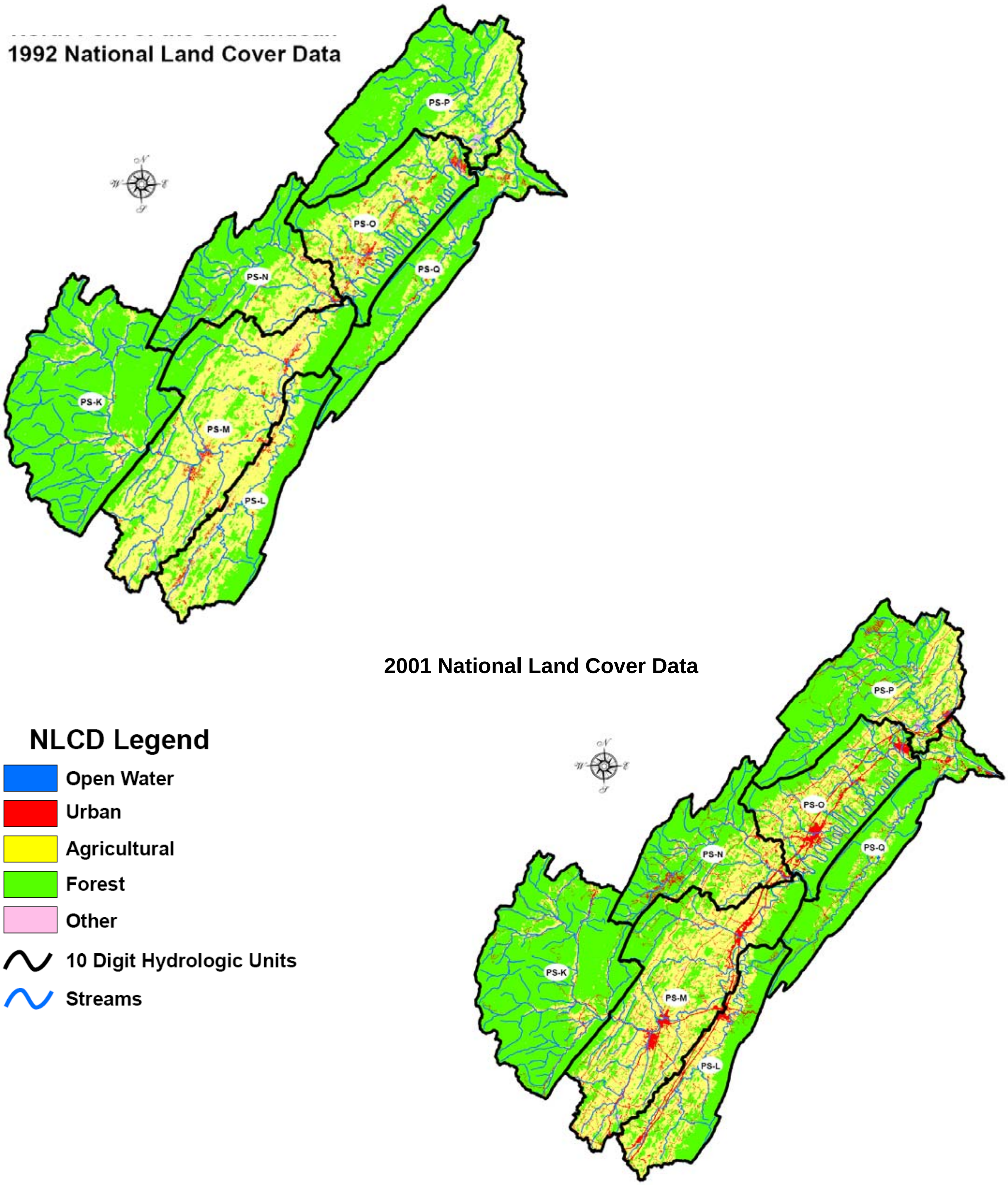
Source: USGS 1992 and 2001 NLCD Database.

Figure 32. Change in Acreage of Agricultural Land 1992-2001



Source: USGS 1992 and 2001 NLCD Database.

Figure 33. Land Cover in 1992 and 2001 by NLCD Data Classes



Forest Resources. The total forested acres in the watershed is 437,938 acres, which is 66% of the total land area (excluding urban forests). The Shoemaker River Watershed has the highest total forest cover at 120,870 acres, or 90% of the area, while the Smith Creek Watershed has the lowest total forest cover at 35,453 acres, or 52.7% of the area. On a percentage basis, Linville Creek Watershed has the lowest overall percentage of forest cover at 39.2%. For this section, the RESAC (Regional Earth Science Application Center) data was used because it provides a more detailed analysis than the NLCD data.

Forest land is divided into three forest types; deciduous forest, evergreen or coniferous forest, and mixed deciduous forest. Total deciduous forest throughout the watershed is 346,889 acres. Total coniferous forest is 76,293 acres, and total mixed deciduous forest occupies 14,756 acres.

Land ownership data are listed by county. Table 11 lists forest land ownership by percentages of total county forest land.

Table 11. County Forest Land Ownership as a Percentage of Total Forest Land

Ownership	Frederick	Page	Rockingham	Shenandoah	Warren	Hardy
Total Acreage	128,921	81,722	253,579	184,362	64,311	299,400
National Forest	3.3%	32.7%	49.1%	36.4%	7.9%	19.4%
Other Federal	---	---	---	---	2.7%	---
State	>1%	>1%	>1%	>1%	>1%	2.1%
County/ Municipal	>1%	>1%	>1%	>1%	1.0%	---
Forest Industry	>1%	>1%	>1%	>1%	>1%	2.0%
Private/ Farmer	34.1%	29%	7.5%	9.7%	28.9%	10.9%
Private/ Corporate	12.4%	---	11.2%	9.7%	14.4%	18.3%
Private/ Individual	49.6%	37%	31.7%	43.8%	43.4%	47.3%

Source: Forest Statistics for Virginia, 1992, USDA, Southeastern Forest Experimental Station, Tony G. Johnson.

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Surface Water Quality. Surface water quality is a concern at the regional, State, and local levels. Regionally, the North Fork Shenandoah River drainage is about 7% (1,034 square miles) of the drainage of the Chesapeake Bay. Nutrients, particularly phosphorus, and sediment are major contributors to the decline of the water quality in the Bay. Algal blooms caused by excess nutrients block the light needed by the aquatic vegetation. When these plants then die, the resulting decay depletes the oxygen in the water. This decrease in dissolved oxygen kills the fish and other aquatic species. Under the Chesapeake Bay Agreement, Virginia is committed to reduce the pollutants that come from Virginia watersheds. The 2005 Potomac-Shenandoah Tributary Strategy identifies pollutant reduction goals and strategies to achieve them. These goals are based on a broad overview of each watershed. Application of these goals is done at the local level.

The Virginia DEQ monitors the health of the streams in the watershed. Water quality data is gathered for both perennial and intermittent streams. The intermittent stream segments were sampled by DEQ during periods of flow and were determined to exceed pollution standards for one or more pollutants using the same criteria applied to analysis of the perennial sections. Much of the data used by DEQ is gathered by local citizen groups.

Section 303(d) of the Clean Water Act states that water bodies that are not meeting their designated uses (fishing, swimming, and aquatic habitat) due to pollutants must be placed on the Impaired Waters List (Table 12). This list is updated every two years. Virginia is required to develop TMDLs for water bodies on the list where normal permitting and BMPs have not achieved water quality standards and restored designated uses. Figure 34 displays the impaired streams and monitoring stations in the watershed.

Definitions: The 305(b)/303(d) 2006 Integrated List of Waters in the North Fork of the Shenandoah River basin places the following stream segments in their respective assessment categories.

Category 2A – Waters are supporting one or more designated uses. Waters are attaining all of the designated uses for which they are monitored, but there is insufficient data to document the attainment of all uses.

Category 2B – Waters are supporting one or more designated uses. Waters are of concern to the State but no Water Quality Standard exists for a specific pollutant, or the water exceeds a state screening value. These waters are considered fully supporting with observed effects.

Category 3A – Waters needing additional information. No data are available within the data window of the current assessment to determine if any designated use is attained and the water was not previously listed as impaired.

Category 4A – Waters are impaired or threatened but a TMDL is not needed. Impaired or threatened for one or more designated uses but does not require a TMDL because the TMDL for specific pollutants is complete and USEPA approved.

Category 5A – Waters are impaired and a TMDL is needed. The Water Quality Standard is not attained. The assessment unit (stream segment) is impaired or threatened for one or more designated uses by a pollutant (s) and requires a TMDL (303d list).

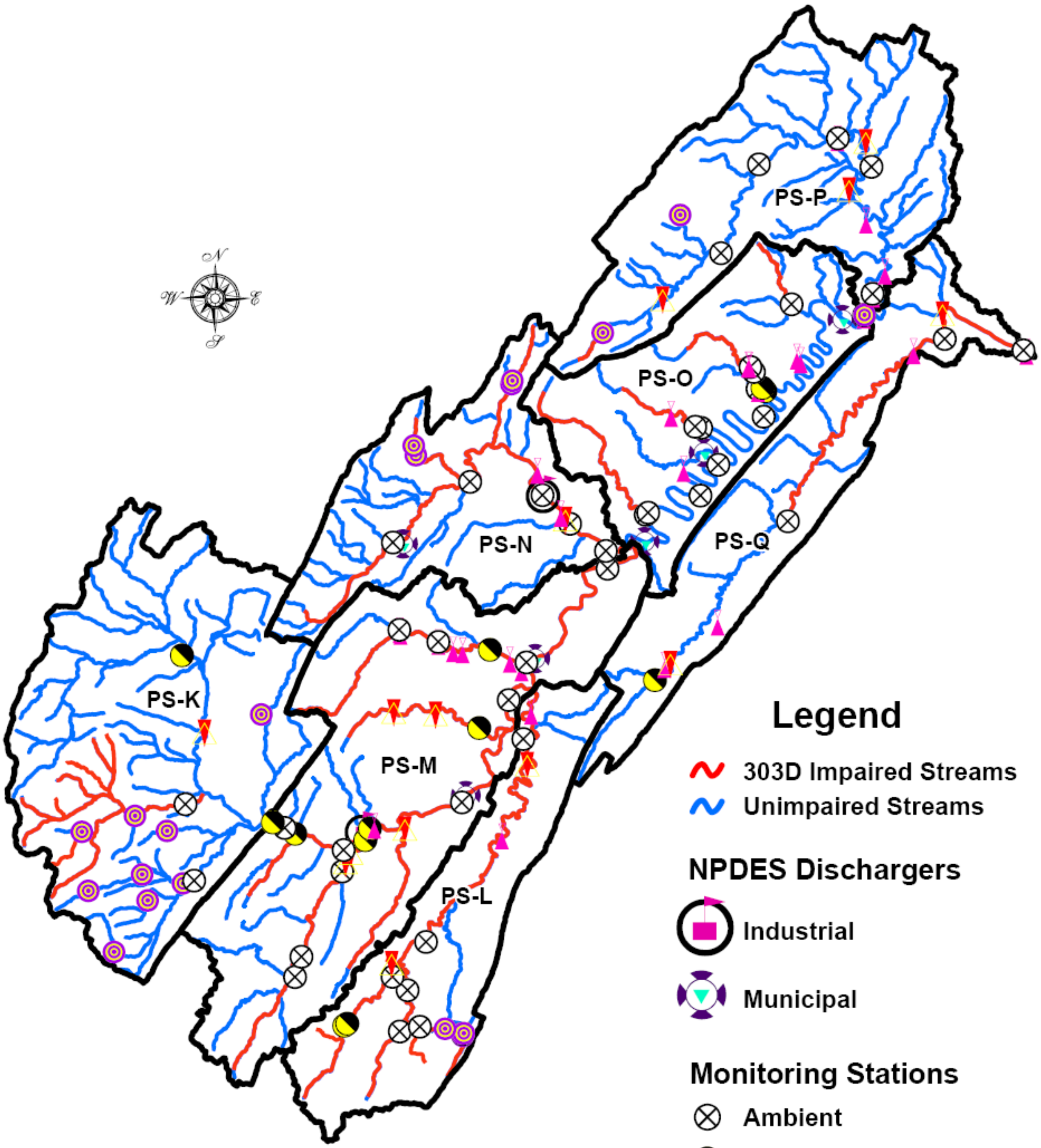
Category 5D – The Water Quality Standard is not attained where TMDLs for a pollutant have been developed but one or more pollutants remain requiring (additional) TMDL development.

Table 12. Impaired Stream Segments by Miles and Impairments

Hydrologic Unit	Assessment Category						
Stream Name	2A miles	2B miles	3A miles	4A miles	5A miles & impairment	5D miles & impairment	Waters Identified for Delisting since 2004
North Fork Shenandoah River - Shoemaker River (PS-K)							
Little Dry River	-	-	-	-	34.74 pH 34.74 FC	-	-
German River	-	33.55	-	-	-	-	-
North Fork Shenandoah River	-	21.9	-	-	-	-	-
Smith Creek (PS-L)							
Dry Fork	-	-	-	-	-	10.08 Benthic	-
Fridley Run	-	-	-	-	2.40 Benthic 2.40 pH	-	-
Lacey Spring	-	-	-	0.20	-	-	-
Mountain Run	-	-	-	-	-	5.98 Benthic	-
Smith Creek	-	-	-	33.88	-	-	-
North Fork Shenandoah River - Linville Creek (PS-M)							
Holmans Creek	-	-	-	10.41	-	-	-
Linville Creek	-	-	-	13.55	-	-	-
Long Meadow Run	-	-	-	-	8.56 Benthic	10.08 Temp	-
Mill Creek	-	-	-	-	14.99 Benthic 14.99 FC	-	-
Turley Creek	-	-	-	-	4.02 Benthic	-	-
North Fork Shenandoah River	-	34.15*	-	-	20.01 FC	-	-
Stony Creek (PS-N)							
Laurel Run	-	-	2.07	-	5.13 Benthic	-	-
Little Stony Creek	-	-	-	-	6.53 Benthic	-	-
Stony Creek	-	-	-	-	17.03 FC 9.46 Temp	-	-
North Fork Shenandoah River - Narrow Passage Creek (PS-O)							
Narrow Passage Creek	-	-	-	-	10.77 FC	-	-
Pugh's Run	-	-	-	-	5.86 FC	-	-
Tom's Brook	-	-	-	7.18	-	-	-
Tumbling Run	0.90	-	-	-	4.15 FC	-	-
North Fork Shenandoah River	-	18.36*	-	4.60	11.84 FC	-	17.03
Cedar Creek (PS-P)							
Cedar Creek	3.68	32.74	0.76	-	2.53 Benthic	-	18.93
North Fork Shenandoah River - Passage Creek (PS-Q)							
Passage Creek	16.96	-	-	-	18.50 FC	-	-
North Fork Shenandoah River	-	-	-	-	-	-	3.54
Total Miles of Designated Waters	21.54	140.70	2.83	69.82	176.52	26.14	39.50

FC = Fecal Coliform; Benthic = Benthic Macroinvertebrate Bioassessment; Temp = Temperature.
* Multiple discreet segments.
Source: 2006 305(b)/303(d) Integrated Water Quality Assessment and Impaired Stream Listing, Virginia Department of Environmental Quality

Figure 34. Impaired Streams, Monitoring Stations, and NPDES Discharge Points



The 2006 DEQ data indicate that a total of 272.48 miles of perennial or intermittent streams are impaired within the watershed (Table 12). The Smith and Linville Creek subwatersheds have the highest percentage of miles impaired. The Cedar Creek subwatershed has the smallest percentage of impaired perennial water miles. Overall, 25% of the perennial stream miles are impaired.

There are six municipal wastewater treatment plants in the watershed, five of which are located along the mainstem of the North Fork Shenandoah (Figure 34). There are also two industrial facility dischargers in the watershed, one of which is involved in chicken processing. With the exception of a reclamation and reuse facility, all of these facilities discharge permitted loadings of nitrogen and phosphorus.

Figure 35. The North Fork Shenandoah River at Red Banks in Shenandoah County

Credit: Cory Guilliams, NRCS, Harrisonburg, Virginia.

Water Quality Trend Analysis. The Virginia DEQ maintains 17 water quality trend analysis stations in the Shenandoah River Basin. Eight of these stations are located in the North Fork watershed. The water quality parameters monitored at these stations for trend analysis are Bacteria (FC), Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Oxidized Nitrogen (nitrate + nitrite = NOx), pH (PH), Temperature (Temp), and Total Kjeldahl Nitrogen (TKN).

Trends are measured as long term (20 year trends 1985-2004) and Mid-Term (most recent 10 years). The long term trends and mid-term trends for these parameters in the Potomac Shenandoah Basin are shown in Figures 36 - 44. For all parameters except Dissolved Oxygen and pH, increasing trends indicate a decline in water quality and decreasing trends indicate an improvement in water quality. For Dissolved Oxygen and pH, increasing trends indicate improving water quality and decreasing trends indicate a decline.

Figure 36. Water Quality Trends for Bacteria. The trend is toward improved water quality.

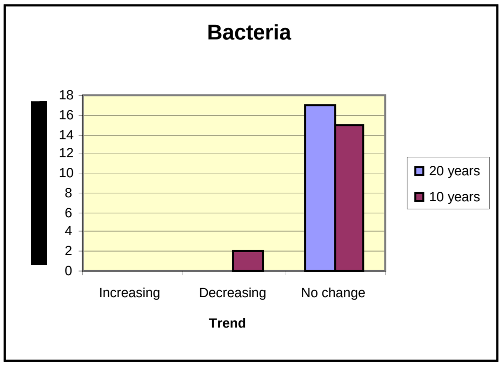


Figure 37. Water Quality Trends for Total Nitrogen. The overall tread is toward improved water quality.

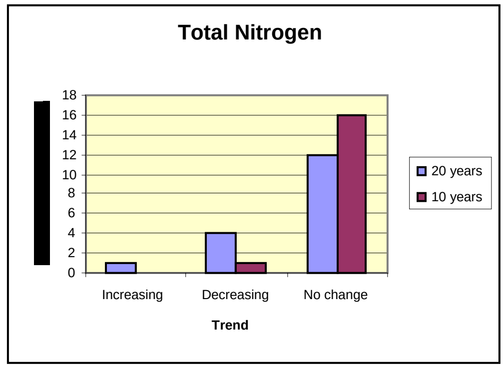


Figure 38. Water Quality Trends for Total Phosphorus. The trend for Total Phosphorus is toward some improvement in water quality.

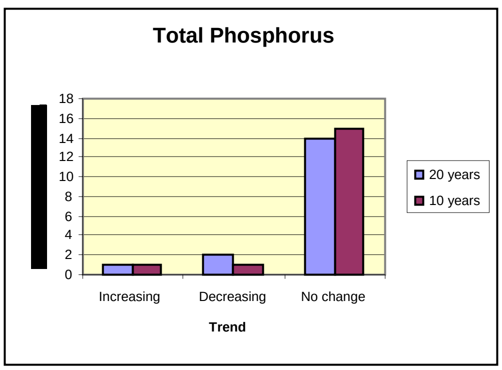


Figure 39. Water Quality Trends for Total Suspended Solids. The water quality is trending toward a slight improvement.

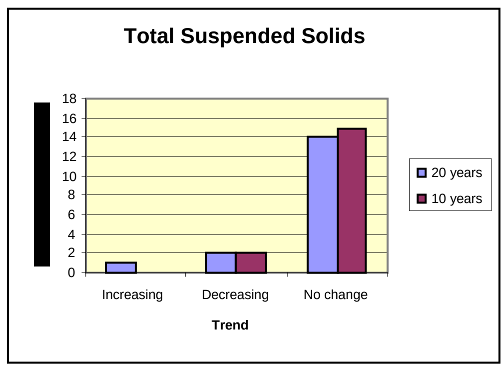


Figure 40. Water Quality Trends for Dissolved Oxygen. There is a slight declining trend for this parameter.

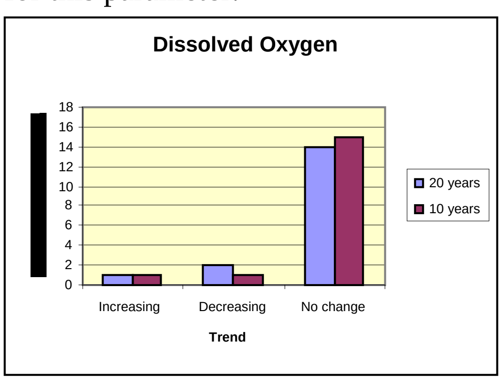


Figure 41. Water Quality Trends for Oxidized Nitrogen. The overall trend is for improving water quality.

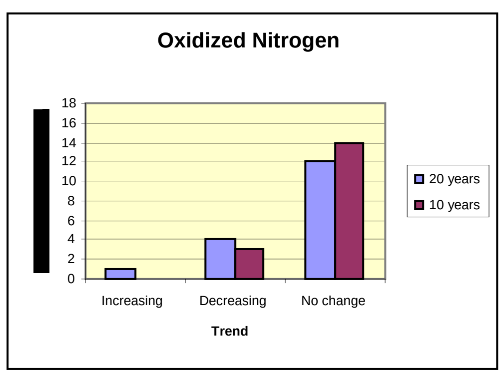


Figure 42. Water Quality Trends for pH. Water quality has declined slightly over the mid-term and long-term period of analysis.

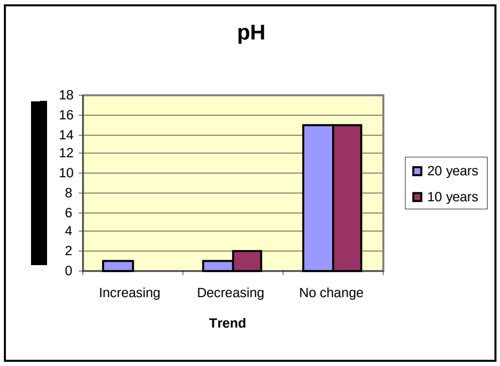


Figure 43. Water Quality Trends for Temperature. Water temperature is increasing over time.

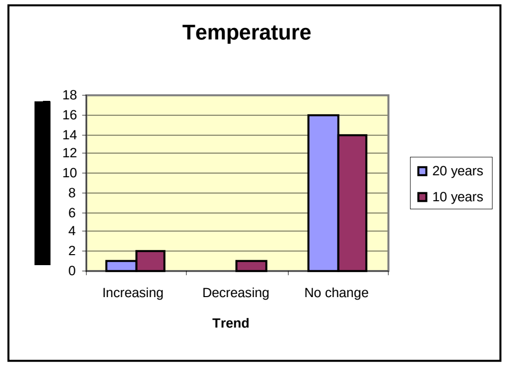
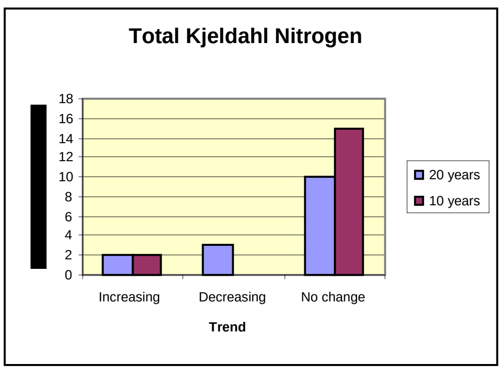


Figure 44. Water Quality Trends for Total Kjeldahl Nitrogen. Existing water quality has declined slightly.



Source: Figures 36-44 are derived from Virginia DEQ water quality trend analysis stations in the Shenandoah River Basin for 1985-2004.

Shenandoah River Fish Kills. The North Fork Shenandoah River experienced what is termed a "chronic" fish kill in 2004 and again in 2006 concentrated downstream of Woodstock. The 2004 kill appears to follow a geographic pattern that originated in the South Branch of the Potomac in 2002, the North Fork Shenandoah in 2004, and finally, the South Fork Shenandoah in 2005. Between April and July 2005, it is estimated that 80% of the adult smallmouth bass and redbreast sunfish populations died. Juvenile bass and sunfish were only lightly affected, if at all. Kill areas occurred throughout the entire length of these rivers with no clear upstream or downstream boundaries.

Fish pathologists at Virginia Tech and the U.S. Fish & Wildlife Service consider the primary cause of death to be stress from an undetermined factor(s) with secondary bacterial skin lesions forming prior to mortality. Also, a condition known as fish intersex has been observed. Male smallmouth bass have been found to take on female characteristics and carry developing eggs in their testes, which may possibly be attributed to estrogen-like compounds being discharged to surface waters.

Due to these events, a Shenandoah River Fish Kill Task Force was formed in July 2005. The Task Force is comprised of federal and state agency personnel, agriculture, industry, streamside landowners, anglers, academia, industry, and citizen environmental groups. The Task Force has met monthly since

July 2005 and has identified a number of possible causes for the kills, along with strategies for investigating these possible causes. Recommendations from a Fish Kill Conference in October 2005 resulted in the following actions:

- DEQ initiated a 4 month water sampling plan on the Shenandoah River in March 2006 to include daily sampling at 9-10 stations and several times daily during storm events to catch the effects of storm runoff. Samples were tested for nutrients, ammonia, temperature, dissolved oxygen and other parameters to determine the reactions of fish health to changes in environmental conditions.
- Scientists from the USGS Fish Disease Lab in Lamar, PA, in cooperation with VDGIF, have been conducting a comprehensive evaluation of fish health in the Shenandoah River.
- The USGS Office of Water Resources in Richmond initiated a 24 hour monitoring effort at two sites on the North and South Forks of the Shenandoah in April 2006. This was a real-time monitoring of ammonia (hourly), as well as pH, dissolved oxygen, temperature, conductivity, turbidity, and flow.
- DEQ has modified fish tissue sampling to identify chemicals not usually included in fish tissue analyses. Members of the Task Force are participating in sample collection.
- Several university studies addressing climatological and ecological assessments were conducted during the summer of 2006. These included Genomic DNA Pathogen Evaluation by Virginia Commonwealth University, Climatological and Hydrologic Data Assessment by James Madison University, and Benthic Invertebrate Sentinel Indicator Study by Virginia Tech.

In 2007, USGS, in cooperation with the Friends of the North Fork of the Shenandoah River (FNFSR), conducted water quality sampling for anthropogenic organic compounds (AOCs) at two flow gauging stations: Pugh’s Run near the town of Woodstock, and at Mount Jackson near Red Banks. Review of 2007 water quality data has indicated the presence of several classes of toxic chemicals and hormonal activity. Polycyclic aromatic hydrocarbons (PAHs) are carcinogenic compounds derived from combustion. Several of these, including fluoranthene, pyrene, phenanthrene, and substituted naphthalenes were detected in low concentrations typical of rural settings with low urbanization and industry.

Phenanthrene had the highest concentration of the identified PAHs at 760 picograms per liter (pg/l). The only organochlorine pesticide in reportable concentrations was trifluralin at 10 pg/l. Atrazine and simazine were the most commonly detected agricultural pesticides at both sites. Atrazine concentrations ranged from 68 to 650 nanograms per liter (ng/l) over the course of two sampling periods at the two stations. Simazine concentrations ranged from 5.5 to 24 ng/l. The atrazine metabolite desethylatrazine was detected at both sites in concentrations ranging from 6.9 to 21 ng/l. Carbaryl or Sevin was also identified at low concentrations. PCBs were not detected in significant concentrations at either site. Several waste indicator chemicals such as para-cresol, a wood preservative, DEET mosquito repellant, and caffeine were detected at low levels, indicating a minor influence from wastewater treatment plants and septic systems.

The most common pharmaceutical detected at both stations during both sampling events was Venlafaxine, an antidepressant, at concentrations of 1.2 to 10 ng/POCIS (polar organic chemical integrative sampler). Codeine and carbamazepine, an anticonvulsant drug, were detected in single samples at both stations, and caffeine was also detected in significant concentrations in three samples.

Four steroidal hormones were targeted for detection in this study, but only 17 alpha-ethynylestradiol was detected, and not in significant concentration.

A Yeast Estrogen Screen (YES) was used to determine the potential estrogenicity of chemicals sampled by semipermeable membrane devices (SPMDs) and polar organic chemical integrative samplers (POCIS). Estradiol equivalent factors (EEQs) were calculated to provide a relative measure of estrogenicity. The EEQ levels observed in the SPMD samples was close to background levels whereas the POCIS estimates were much greater. The conclusion is that the chemicals responsible for causing an estrogenic response (in fish) are more water soluble (polar or hydrophilic) and less likely to bioaccumulate in fish and other aquatic organisms. They may, however, produce fish intersex responses because of their continued supply and availability.

Citizen Monitoring. The Friends of the North Fork of the Shenandoah River have conducted water quality sampling since 1988. Sampling is accomplished by volunteer citizen monitors who are trained through State grant funds. Monitors take samples on a biweekly basis at 17 designated sampling sites throughout the watershed (Figure 34). Samples are analyzed at the Friends of the Shenandoah River (FOSR) laboratory and results are provided to the Virginia DEQ.

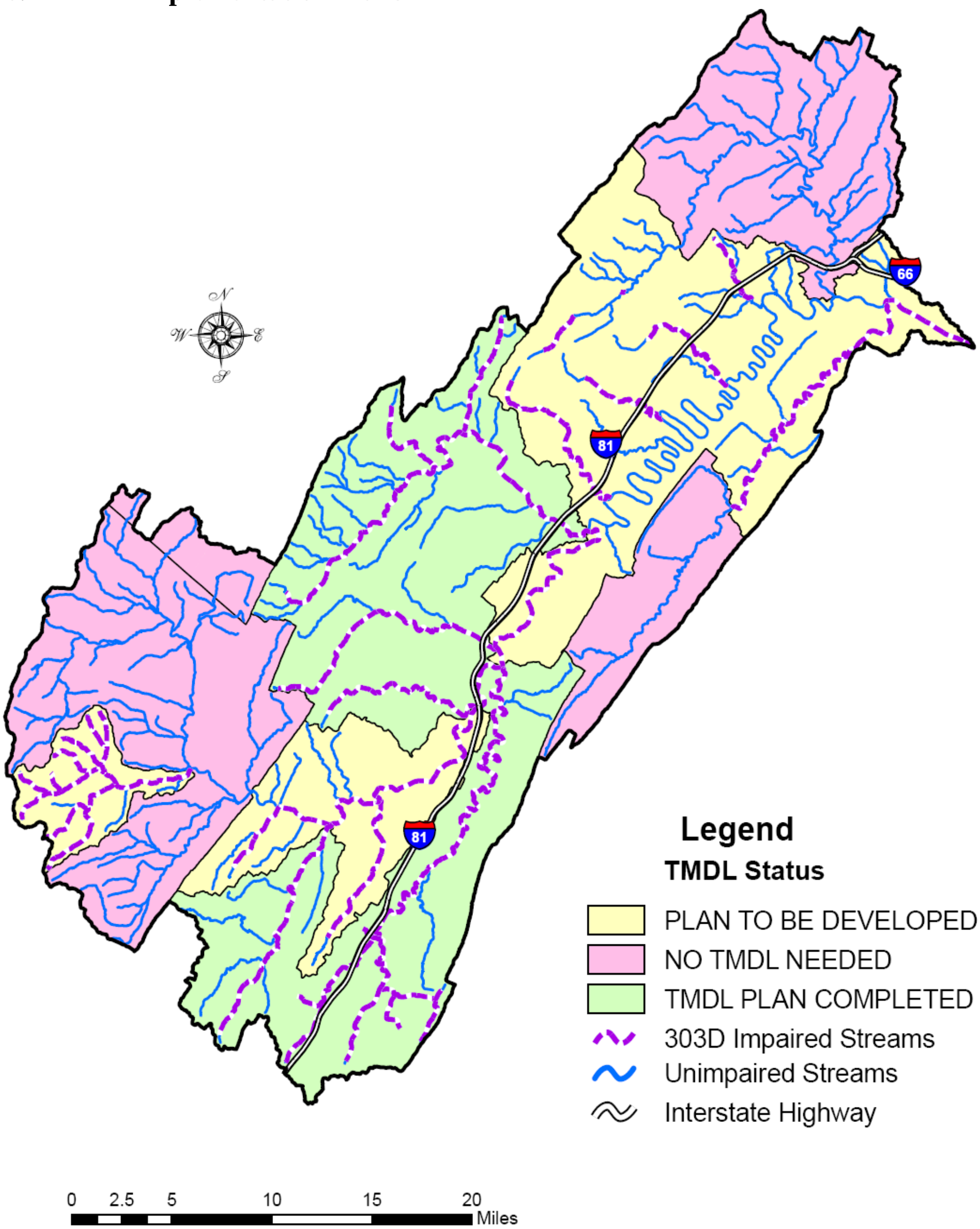
Since 1998, DEQ has provided grant funds in the range of $1,000-$5,000 to citizen volunteer groups. Typically, these funds are used to purchase monitoring equipment and laboratory supplies, provide personnel training, and conduct sample analysis.

Figure 45. Citizen Monitoring

Credit: EJ Fanning, NRCS, Richmond, Virginia.

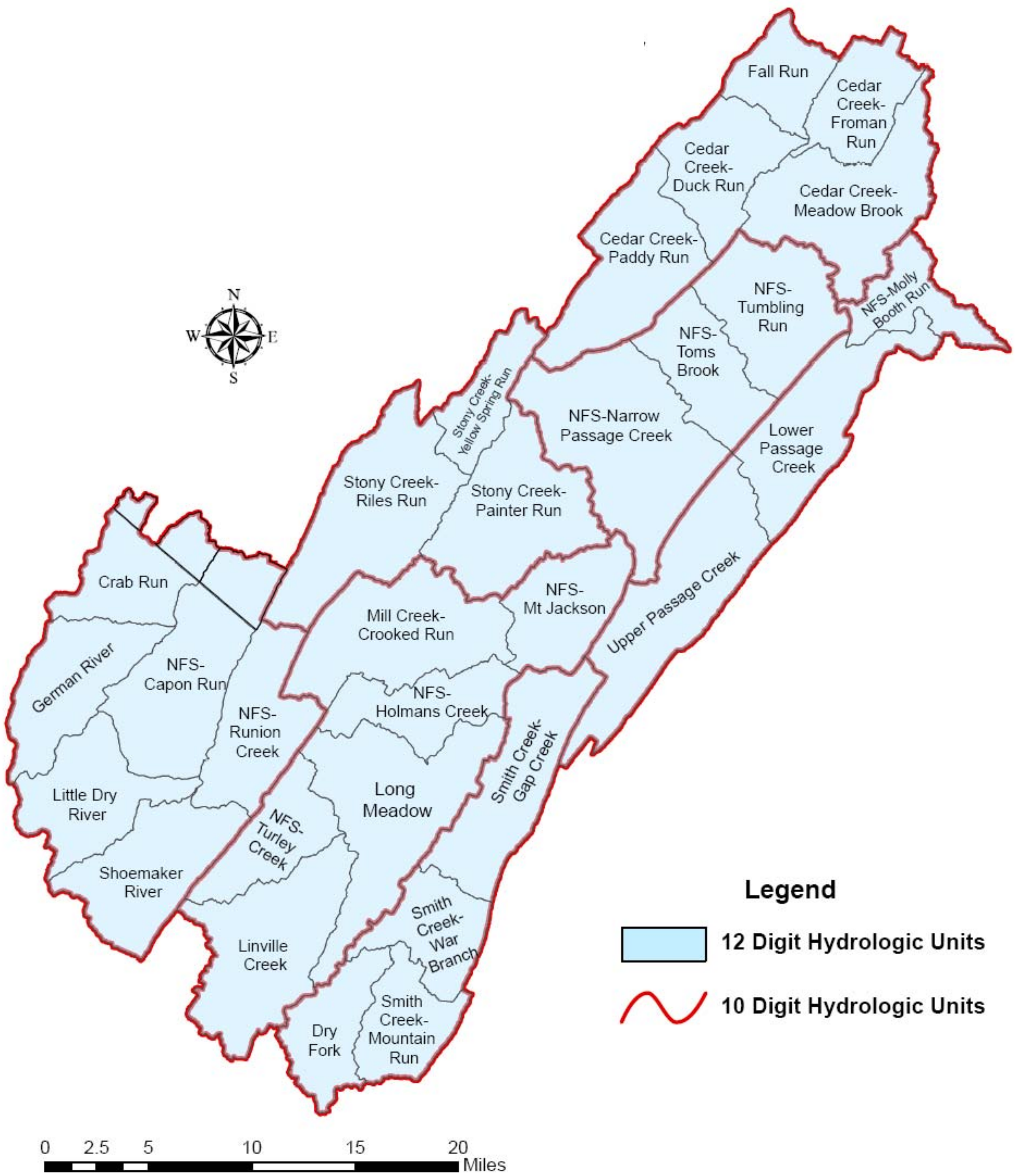
TMDL Studies and Implementation Plans. The Virginia DEQ has designated 272.48 miles of the streams in the watershed as impaired. To deal with the identified impairments, the DEQ has led the development of Total Maximum Daily Load (TMDL) studies for the subwatersheds with impaired streams (Figure 46). The development of a TMDL study is the first phase in a three step process. The next step is to develop a plan to implement actions that will result in meeting the pollutant allocations established by the study. The final step is to implement the plan. Five TMDL studies have already been developed and one is in the process of implementation. Sixteen more studies are to be developed. In addition, three of the previously developed plans will be revised to include TMDLs for additional pollutants. All TMDL studies are scheduled to be completed by 2018.

Figure 46. TMDL Implementation Plans



Animal Numbers and Distribution in the Watershed. Within each of the seven 10-digit subwatersheds, there are smaller subdivisions called 12-digit hydrologic units (HUs) that are named for the creeks in the area (Figure 47). Since the types and numbers of animals vary within a subwatershed, the animal numbers are shown by the 12-digit HUs in Figures 48-53. This will also allow correlation with local knowledge.

Figure 47. 12-Digit Hydrologic Units within the Watershed



Poultry. The greatest concentrations of confined chickens during a cycle (6 cycles or flocks per year) are found in the Linville Creek and Long Meadow HUs, with bird numbers in the range of 2.2 – 3.5 million (Figure 48). The Shoemaker River, North Fork Shenandoah-Turley Creek, and Mill Creek-Crooked Run HUs have the next lowest concentrations with 1.1-1.3 million birds per cycle. The HUs with essentially no confined chickens include Fall Run, Cedar Creek-Froman Run, Cedar Creek-Duck Run, Cedar Creek-Meadow Brook, and North Fork Shenandoah-Molly Booth Run. The remaining HUs have confined chickens in ranging in numbers from 7,000 to 711,500 birds.

The Dry Fork of Smith Creek, Smith Creek-Mountain Run, Smith Creek-Gap Creek, and Long Meadow HUs have the greatest concentrations of confined turkeys in the watershed with a range of 224,500-608,400 birds per cycle (3 cycles or flocks per year) (Figure 49). The Linville Creek, Mill Creek-Crooked Run, North Fork Shenandoah-Mt. Jackson, and the North Fork Shenandoah-Holmans Creek HUs have the next lowest range of confined turkeys at 161,500 – 209,900 birds. The HUs with no confined turkeys include all of the Cedar Creek subwatershed, all of the North Fork Shenandoah-Passage Creek subwatershed, Stony Creek-Yellow Springs Run, and North Fork Shenandoah-Tumbling Run. All other HUs have some concentration of confined turkeys ranging from 7,500 to 132,000 birds.

Figure 48. Animal Feeding Operations – Confined Chickens During a Cycle

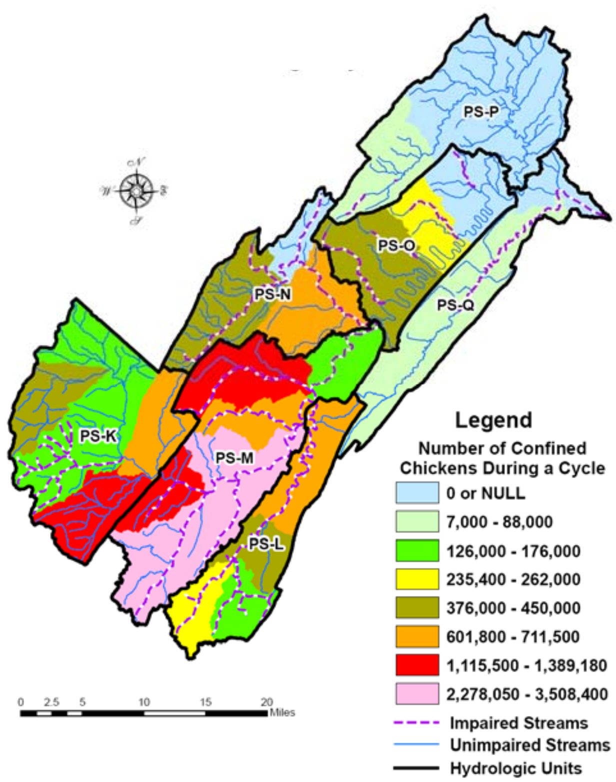
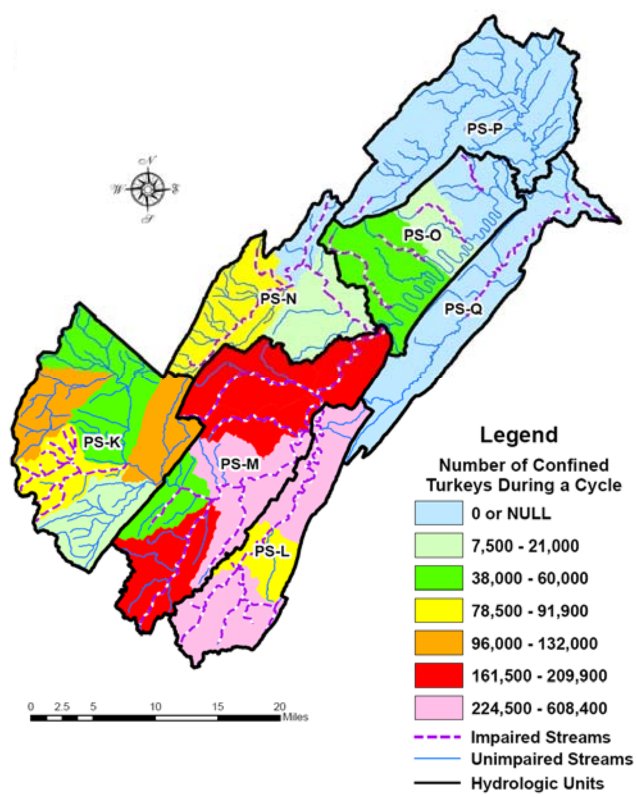


Figure 49. Animal Feeding Operations - Confined Turkeys During a Cycle



Confined Beef. Animal feeding operations (AFOs) are defined as a lot or facility where animals are confined for a total of 45 days or more in any 12 month period, and crops or vegetative growth are not maintained during the normal growing season over the lot or facility. The greatest concentration of confined beef feeding operations is in the North Fork Shenandoah-Narrow Passage Creek HU and Long Meadow HU where 715 – 813 beef are confined during a cycle (Figure 50). The next largest concentration of confined beef occurs in the Stony Creek-Painter Run HU and in the North Fork Shenandoah-Mt. Jackson HU where 389-444 beef may be confined during a cycle. The Holmans Creek, Smith Creek-Gap Creek, Dry Fork, and Cedar Creek-Meadow Brook HUs have the next largest concentrations of confined beef, ranging from 50 – 175 animals per cycle. The remaining areas of the watershed do not have confined beef feeding areas.

Unconfined or pastured beef occur in the highest numbers (540-965) in the Dry Fork, Long Meadow and North Fork Shenandoah-Turley Creek HUs (Figure 51). The next largest numbers (295-535) of unconfined beef are found in the Linville Creek, Mill Creek-Crooked Run, and North Fork Shenandoah-Mt. Jackson HUs. Pastured beef do not occur in any significant numbers in the Little Dry River, Shoemaker River, North Fork Shenandoah-Capon Run, North Fork Shenandoah-Runion Creek, Stony Creek-Riles Run, Stony Creek-Yellow Springs Run, and North Fork Shenandoah-Tumbling Run HUs. There are few pastured beef in the Cedar Creek and Passage Creek subwatersheds. Pastured beef are found in numbers ranging from 35 – 535 in all other HUs in the watershed.

Figure 50. Animal Feeding Operations - Confined Beef

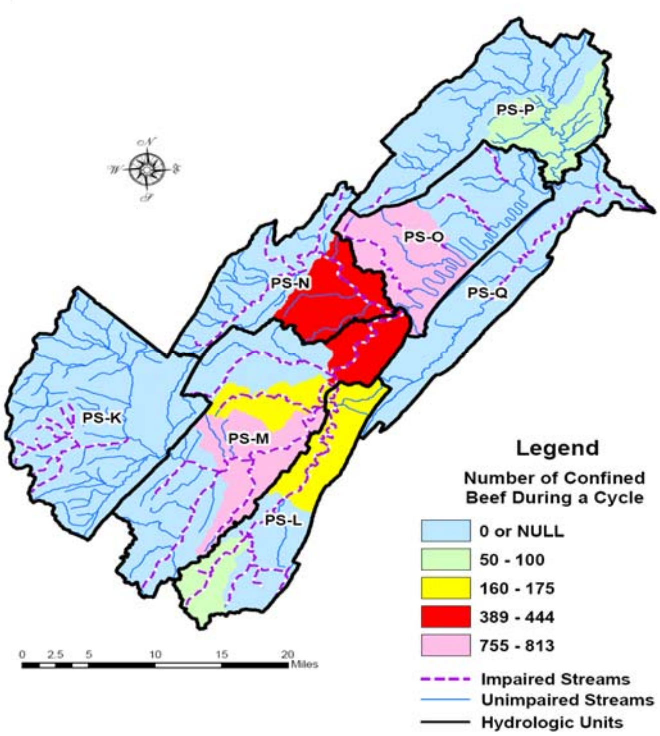
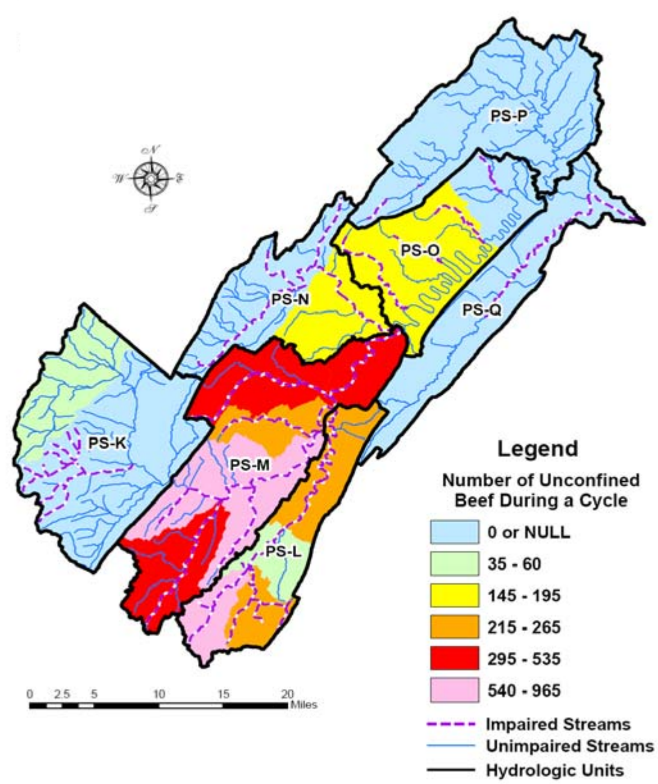


Figure 51. Animal Feeding Operations - Unconfined Beef



Dairies. The largest confined dairy herd in the watershed is found in the Long Meadow HU at 247 cows (Figure 52). The next largest herds are found in the Dry Fork, Smith Creek-War Branch, Mill Creek-Crooked Run, and North Fork Shenandoah-Narrow Passage Creek HUs, with a range of 140-160 cows. Areas of the watershed having no confined dairy cows are the Cedar Creek subwatershed and the North Fork Shenandoah-Passage Creek, North Fork Shenandoah-Tumbling Run, North Fork Shenandoah-Toms Brook, Stony Creek-Yellow Springs Run, Stony Creek-Riles Run, North Fork Shenandoah-Holmans Creek, North Fork Shenandoah-Runion Creek, Little Dry River, German River, and Crab Run HUs. The remaining HUs have numbers of confined dairy cows ranging from 50 – 125.

A majority of the watershed has no dairy loafing lots (Figure 53). The HUs that do have loafing lots include Linville Creek with six lots, Long Meadow and Smith Creek-Mountain Run with four lots in each area, Smith Creek-War Branch, Smith Creek-Gap Creek and North Fork Shenandoah-Narrow Passage Creek with three lots each, Stony Creek-Painter Run and Mill Creek-Crooked Run with two each, and North Fork Shenandoah-Mt. Jackson, Dry Fork, North Fork Shenandoah-Capon Run and Shoemaker River HUs with one each.

Figure 52. Animal Feeding Operations - Confined Dairy Cattle

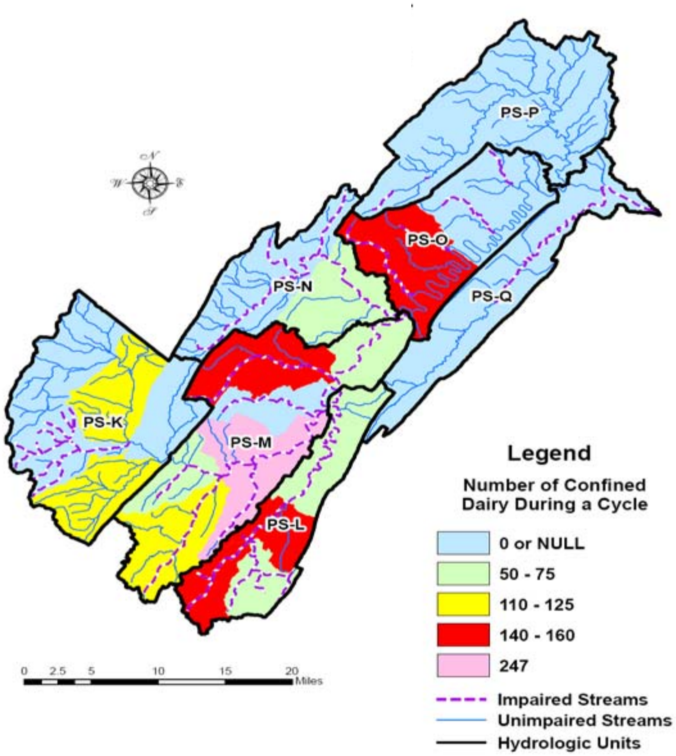
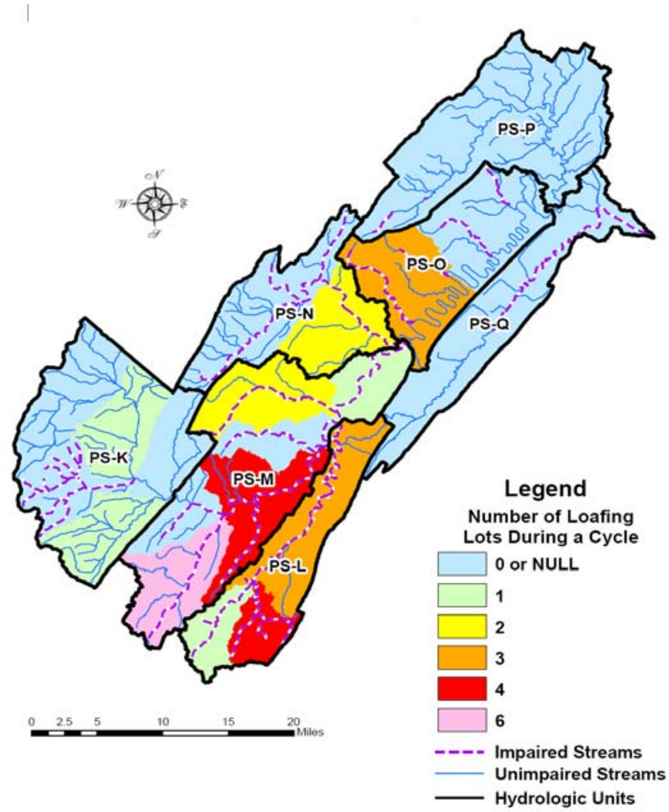


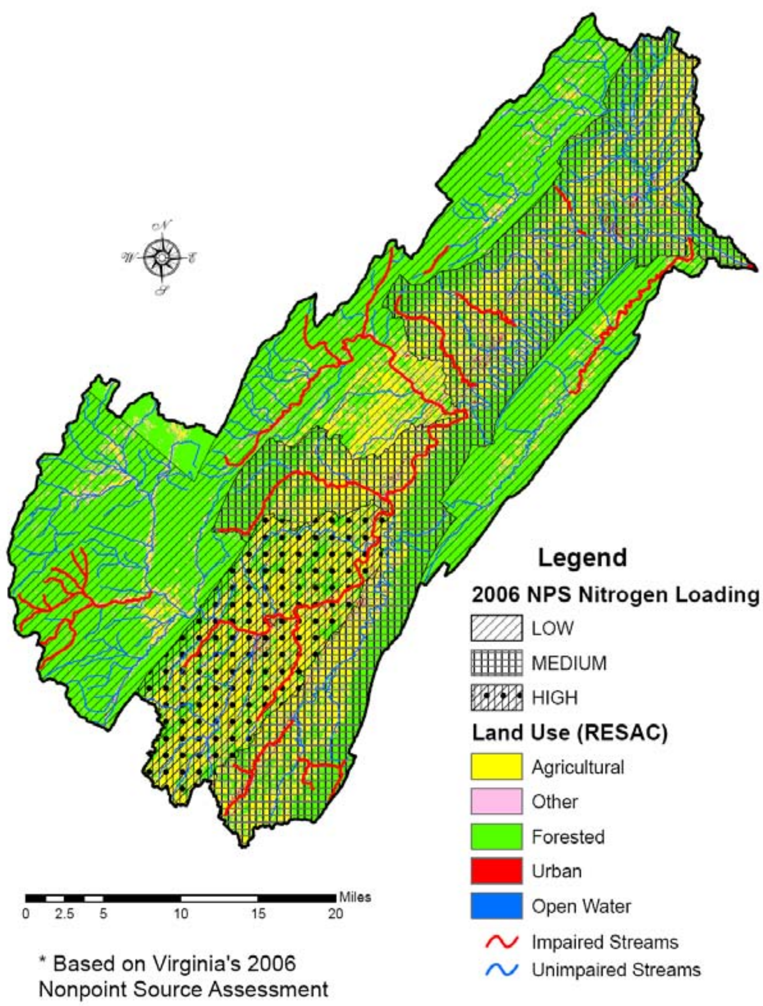
Figure 53. Animal Feeding Operations – Loafing Lots



Agricultural Pollutant Loadings. The pollutants of most concern in the watershed are nitrogen, phosphorus, and sediment. Nitrogen is water soluble and easily runs off into the streams. Ammonia gas can be generated from soluble nitrogen and is toxic to fish and aquatic life. Phosphorus is usually attached to the sediment and is carried into the water by eroded sediment. Soluble phosphorus triggers algal blooms which reduce sunlight transmission to underwater plants. When these plants die, they consume the dissolved oxygen in the water, which may cause fish kills. Sediment eroded into the stream inhibits fish reproduction by smothering the eggs. Excess sediment accumulated in lakes and ponds reduces the available water storage.

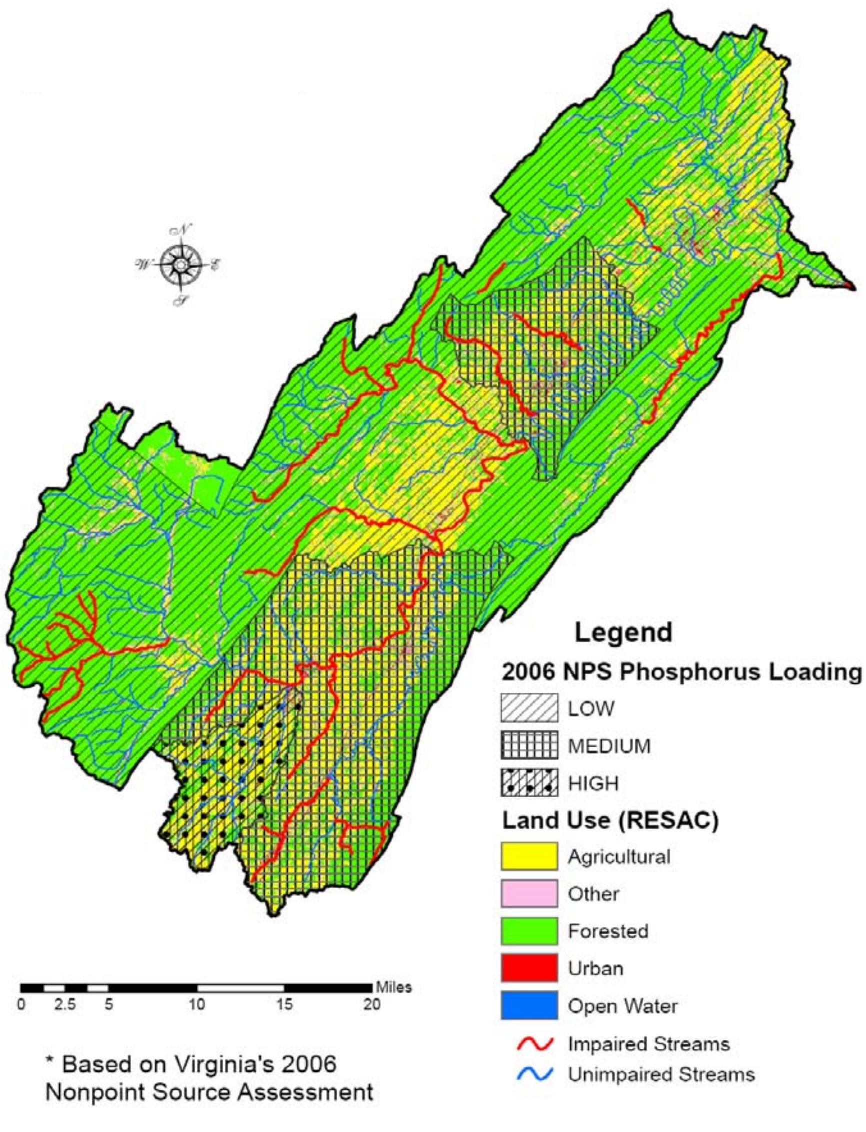
Nitrogen. The highest nonpoint source (NPS) nitrogen loadings in the North Fork watershed come from the Linville Creek subwatershed (Figure 54). Medium NPS loadings originate from the Smith Creek subwatershed and follow that pattern throughout the central part of the watershed, except for lower Stony Creek, which is rated as a low contributor of NPS nitrogen. Passage Creek and the northwesterly margins of the watershed are rated as low contributors of NPS nitrogen. It should be noted that the Linville Creek subwatershed has some of the highest concentrations of confined chickens, turkeys, beef (confined and pastured), and dairy cows in the watershed. From 1985 to 2002, agricultural sources of nitrogen delivered to the Chesapeake Bay from the Shenandoah-Potomac drainage declined from 36% to 31%. It is projected to drop to 23% by 2010.

Figure 54. Nonpoint Source Nitrogen Loading



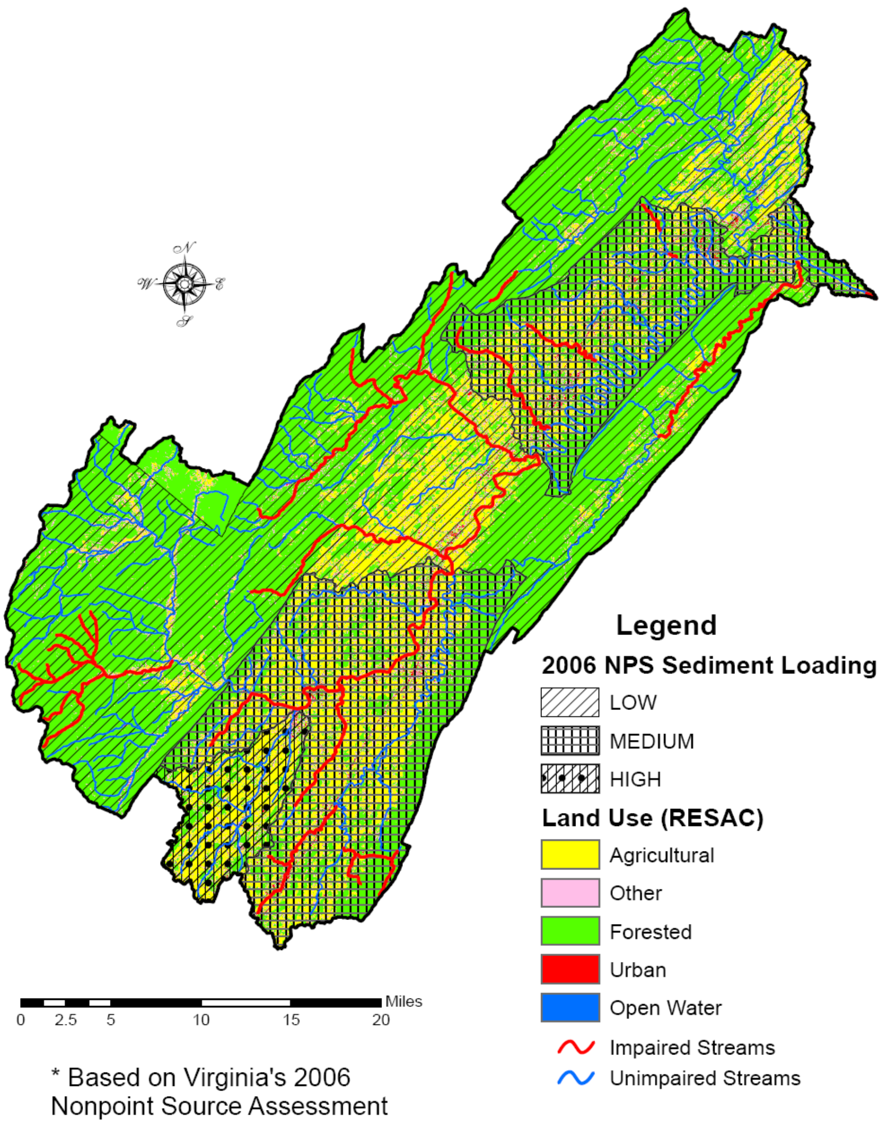
Phosphorus. The NPS phosphorus loading for the watershed follows a similar pattern as the nitrogen loadings, except that the areas of high and medium loadings are less extensive (Figure 55). The upper half of Linville Creek is rated as contributing a high phosphorus loading, while the lower half of Linville Creek, Smith Creek and Narrow Passage Creek are rated as contributing a medium phosphorus loading. As with nitrogen loading, Passage Creek, Stony Creek and the northwesterly margins of the watershed are considered to be low contributing areas of NPS phosphorus. Agricultural contribution of phosphorus to the Chesapeake Bay from the Shenandoah-Potomac drainage in 1985 and 2002 were 53% and 51%, respectively. The projected loading for 2010 is 45%.

Figure 55. Nonpoint Source Phosphorus Loading



Sediment. Nonpoint source sediment loading closely follows the patterns of NPS phosphorus loading intensities, except that the North Fork Shenandoah-Tumbling Run HU and the North Fork Shenandoah-Molly Booth HU are listed as medium sediment contributors (Figure 56). Otherwise, upper Linville Creek is the highest sediment loading contributor, and Smith Creek and the central area of the watershed, except for Stony Creek, are considered medium contributors to sediment loading. The remaining areas of the watershed are considered low sediment contributors. Agricultural contribution of sediment to the Chesapeake Bay from the Shenandoah-Potomac drainage were 78% and 72% for 1985 and 2002, respectively, and are expected to drop to 54% by 2010.

Figure 56. Nonpoint Source Sediment Loading



SOCIO-ECONOMIC DATA

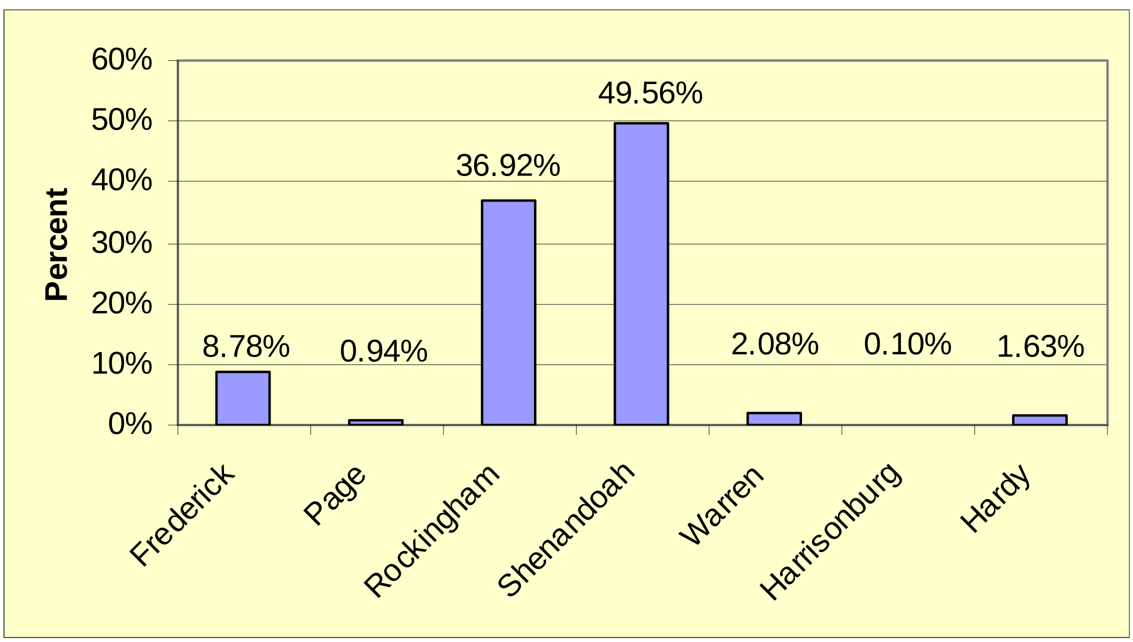
Introduction. The 2000 Census of the general population and 2002 Census of Agriculture are the latest national data sets available for all localities within the North Fork Shenandoah River watershed. Although some Census data estimates for 2006 are available for select localities, only Census data from 2000 will be used in order to be consistent across all localities. Since this data is not allocated to specific watersheds by either Census, the social and economics data are addressed at the County level. Table 13 and Figure 57 show how much of each county lies in the watershed.

Table 13. Area and Percent of Area of each County/Locality within the Watershed

County/Locality	Acres of each County contained within the watershed	Total Acres contained within each County/Locality	Percent of each County lying within the watershed	Percent of the watershed contained within each County/Locality
Frederick County	58,096	266,136	21.8%	8.78%
Page County	6,210	201,079	3.1%	0.94%
Rockingham County	244,313	546,020	44.7%	36.9%
Shenandoah County	328,024	328,024	100.0%	49.6%
Warren County	13,737	138,561	9.9%	2.08%
Harrisonburg (City)	655	11,301	5.8%	0.10%
Hardy County, WV	10,785	374,097	2.9%	1.63%
Total:	661,821	1,865,218	---	100.00%

Source: U.S. Census County Boundaries and the Hydrologic Unit Boundaries for VA and WV.

Figure 57. Acres of each Locality contained within the North Fork



Source: U.S. Census County Boundaries and the Hydrologic Unit Boundaries for VA and WV.

From this data, Shenandoah, Rockingham and Frederick Counties are shown to be the most significant counties within the watershed. Together, they constitute 630,433 acres (95.3%) of the 661,821 acre watershed. The natural resource conditions and trends and land management in these counties determine the productivity of the agricultural economy within the watershed and have a significant impact on the quality of the area's surface and ground water.

Population and Demographics. The Weldon Cooper Center for Public Service at the University of Virginia (Demographics and Workforce Section) is currently projecting 6.7% and 15.5% increases in the populations of the Central Shenandoah Valley and Northern Shenandoah Valley regions, respectively. These increases are based on projections through July 1, 2007 and represent change over the seven year period since the 2000 Census data was released. The northern part of the Valley is under greater development pressure due to closer proximity to the Washington, D.C. populace. Frederick, Shenandoah and Warren Counties are estimated to have grown the most during this time period with increases of 23.2%, 16.1%, and 13.4%, respectively. The Central Shenandoah Planning District Commission projects that the region will grow by 31.4% by 2030. Table 14 and Figure 58 show the demographics of the population in each of the six counties that are part of the watershed. Table 15 shows the population in selected towns and cities in the watershed.

Nearly 23% of the region's increase in total population is expected to come from the Hispanic population, which is forecasted to replace the black population as the region's largest minority by 2030. The Census Bureau has projections for Virginia through 2006 indicating that the Hispanic population of the state as a whole had increased from 329,540 in 2000 to 470,871 in 2006. This represents an increase of 42.9% with Hispanics rising from 4.7% of the overall population to 6.2%. This trend is consistent at the national level.

Table 14. Population and Age

Selected Characteristics	Fred-erick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Population:	59,209	23,177	67,725	35,075	31,584	12,669	246,256
Median Age:	36.7	39.0	37.5	40.9	37.1	38.9	n/a
Under 5:	3,825	1,286	4,246	1,948	2,100	755	14,160
18 or older:	43,606	17,854	51,046	27,264	23,501	9,715	172,986
Over 65:	6,303	3,644	9,431	6,083	3,893	1,884	31,238

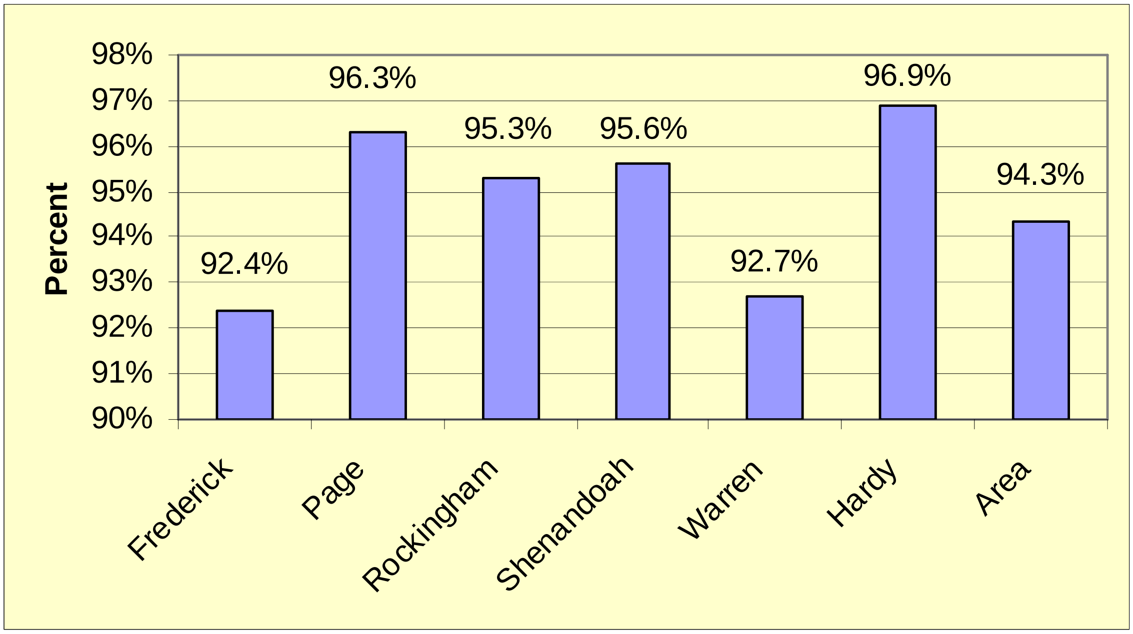
Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

Table 15. Population of Cities and Towns

Cities and Towns	Population
Broadway	2,192
Harrisonburg	40,468
Mount Jackson	1,664
New Market	1,637
Strasburg	4,017
Timberville	1,739
Toms Brook	255
Woodstock	3,952

Source: U.S. Census Bureau, 2000 Census.

Figure 58. Percent of White Race, by County



Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

Education. Educational achievement, as reflected in the 2000 Census of the general population, lags behind the state and national statistics for both percent who are high school graduates or higher and for those with a bachelor's degree or higher (Table 16). This is surprising given the level of economic activity in the Shenandoah Valley and the proximity of the northern part of the valley to Washington D.C.

Table 16. Education

Location	High School Graduates	Bachelor's Degree	Graduate or Professional Degree	% High School Graduate or Higher	% Bachelor's Degree or Higher
Frederick County, VA	14,025	4,899	2,392	78.6%	18.6%
Page County, VA	6,386	951	621	64.8%	9.8%
Rockingham County, VA	15,934	5,083	2,870	72.4%	17.6%
Shenandoah County, VA	9,572	2,461	1,200	75.3%	14.7%
Warren County, VA	7,964	2,184	990	75.5%	15.0%
Hardy County, WV	3,909	495	331	70.3%	9.4%
Estimate for the Region	57,790	16,073	8,404	n/a	n/a
Virginia	-	-	-	81.5%	29.5%
United States	-	-	-	80.4%	24.4%

Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

Employment. Manufacturing is the largest employer in the area (Table 17). Unemployment rates are lower than the state and national averages as are the percentages of families and individuals below the poverty level excepting Page County, Virginia and Hardy County West, Virginia.[5] The poverty levels in Page and Hardy counties are both higher than the state and national figures.

Table 17. Labor Force, Employment, Unemployment and Poverty

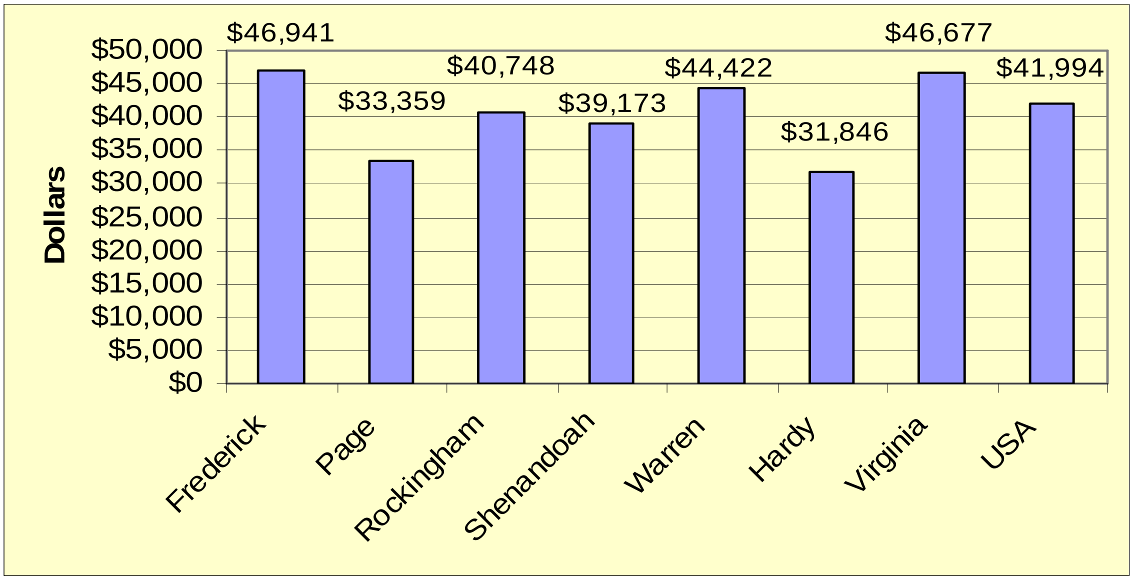
Location	In Labor Force (16 yrs. old and over)	Em-ployed	Un-employed	Sector of the Economy with the Largest Employment	Employ-ment in Agri-culture, Fishing, Forestry and Mining	Percent of families living below the poverty level	Percent of individ-uals living below the poverty level
Frederick County, VA	31,720	30,930	790 (2.5%)	Manufacturing (5,679, 18.4%)	650 (2.1%)	4.0%	6.4%
Page County, VA	11,511	11,061	450 (3.9%)	Manufacturing (2,979, 26.9%)	440 (4.0%)	10.1%	12.5%
Rockingham County, VA	35,853	34,650	1,203 (3.3%)	Manufacturing (8,334, 24.1%)	2,140 (6.2%)	5.3%	8.2%
Shenandoah County, VA	18,204	17,710	494 (2.7%)	Manufacturing (3,870, 21.9%)	684 (3.9%)	5.8%	8.2%
Warren County, VA	16,245	15,687	558 (3.4%)	Education, health and social services (2,707, 17.3%)	173 (1.1%)	6.0%	8.5%
Hardy County, WV	6,353	6,129	224 (3.5%)	Manufacturing (1,945, 31.7%)	305 (5.0%)	10.5%	13.1%
Estimate for the Region	119,886	116,167	3,719 (3.1%)	Manufacturing (22,807, 19.6%)	4,392 (3.8%)	-	-
Virginia	-	-	4.2%	Education, health and social services (18.3%)	43,425 (1.3%)	7.0%	9.6%
United States	-	-	5.8%	Education, health and social services (19.9%)	2.43 million (1.9%)	9.2%	12.4%

Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

[5] An income level below which an individual or family is considered poor. The U.S. Census Bureau defines poverty level based on a set of money income thresholds that vary by family size and composition. If a family's total income is less than that family's threshold, then that family, and every individual in it, is considered poor. The Census Bureau updates its poverty thresholds annually. In 2000, a family of two adults and two children with total income below $17,463 was considered below the poverty level.

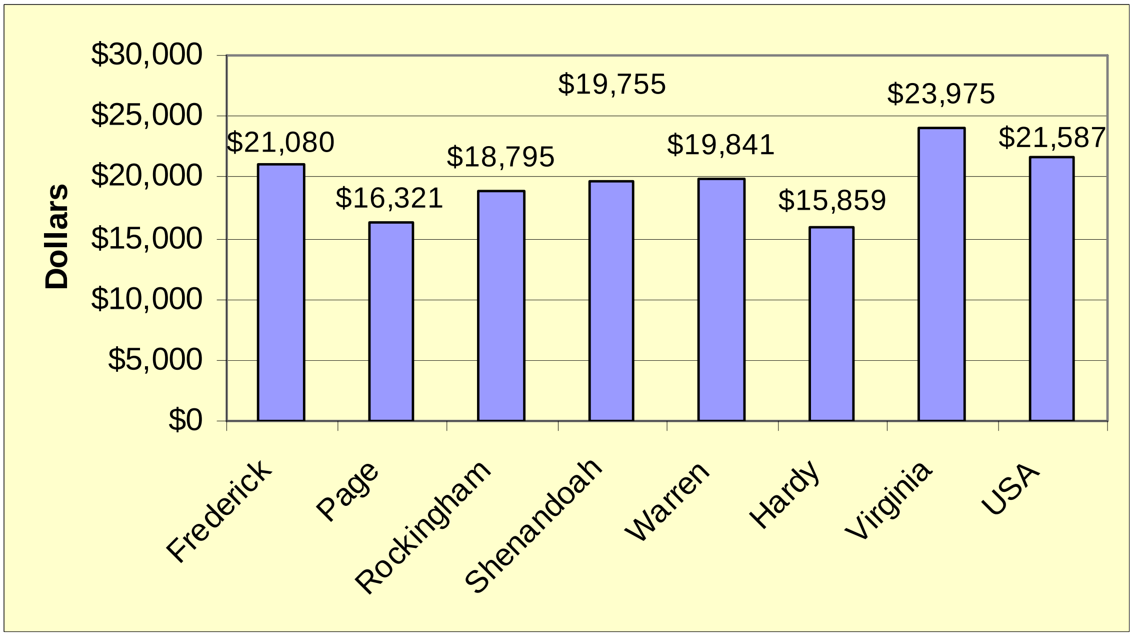
Income. Median household income includes income from the householder as well as all others living in each house, related or not (Figure 59). Given that many households are occupied by single individuals, household incomes are slightly lower than family incomes. With the exception of Frederick County, the median household income for the counties in the watershed is lower than the income for the State. Per capita income is the same as income per person or per resident of a given population. Per capita income in these counties is substantially lower than the State or National average (Figure 60).

Figure 59. Median Household Income



Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

Figure 60. Per Capita Income



Source: U.S. Census Bureau, American Community Survey, American Fact Finder, 2000 Census.

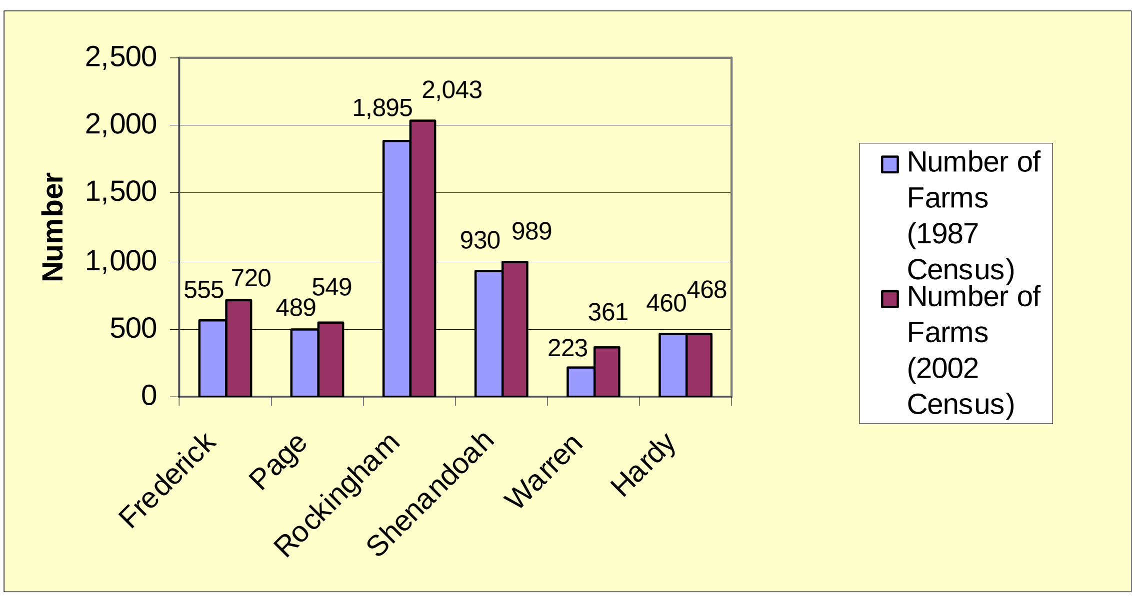
2002 Agricultural Census Data. Information about the farms in the watershed is only available at the county level. Table 18 lists general farm statistics for the six counties that are in the watershed. Figures 61 and 62 show how the number of farms and the acres of land in farms have changed from 1987 to 2002. The average farm size is shown in Figure 63.

Table 18. General Farm Statistics

Selected Character-istics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Number of farms: 2002:	720	549	2,043	989	361	468	5,130
1997:	568	541	1,834	841	259	467	4,510
1992:	536	521	1,864	832	207	486	4,446
1987:	555	489	1,895	930	223	460	4,552
Land in farms (acres) – 2002:	112,675	64,045	248,578	133,032	48,940	128,425	735,695
1997:	99,926	67,829	230,409	126,844	44,784	142,940	712,732
1992:	98,142	64,856	236,074	125,394	38,967	141,742	705,175
1987:	111,116	67,250	242,224	138,883	40,901	147,646	748,020
Average farm size:	156	117	122	135	136	274	n/a
Ave. value of land and bldgs/farm:	$489,205	$407,298	$498,534	$481,467	$545,878	$431,143	n/a

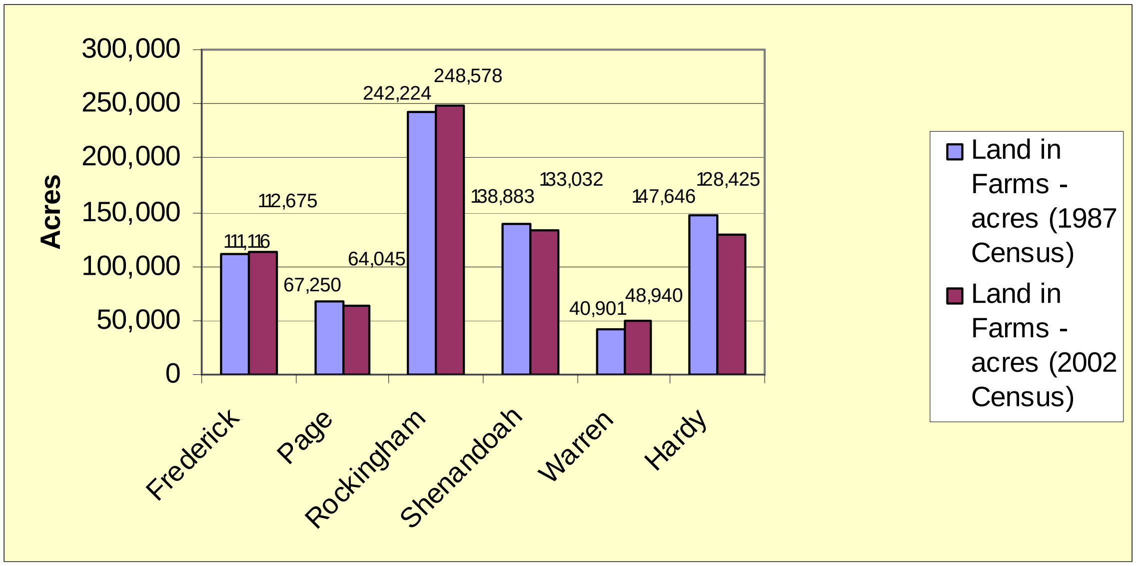
Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 61. Changes in the Number of Farms from 1987 to 2002



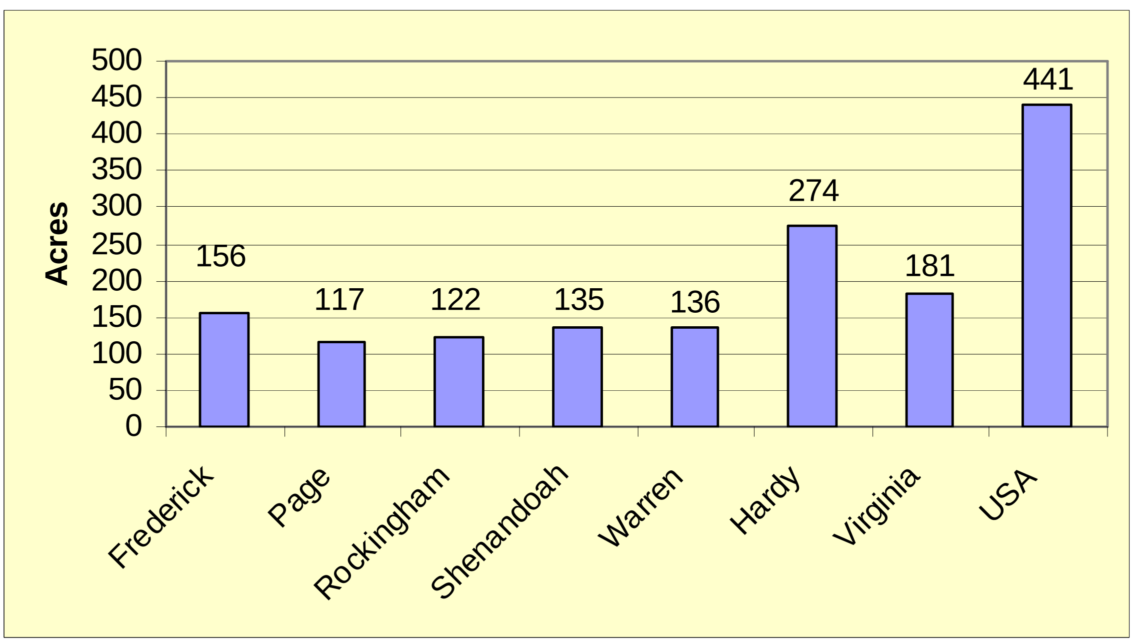
Source: 1987 and 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 62. Land in Farms



Source: 1987 and 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 63. Average Farm Size



Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

The five Virginia counties have average farm sizes well below the Virginia and national averages (Figure 63). However, the intensity of agricultural land use is quite high. This is especially true among the poultry and dairy operations in Rockingham, Shenandoah, and Page Counties in Virginia and Hardy County in West Virginia (Table 19). Many dairies and poultry operations in the Valley are intensively farmed on relatively small acreages. Many of these operators do not have adequate land to appropriately apply the wastes generated by their animals or birds. This constraint limits the options for improving environmental conditions on the farm.

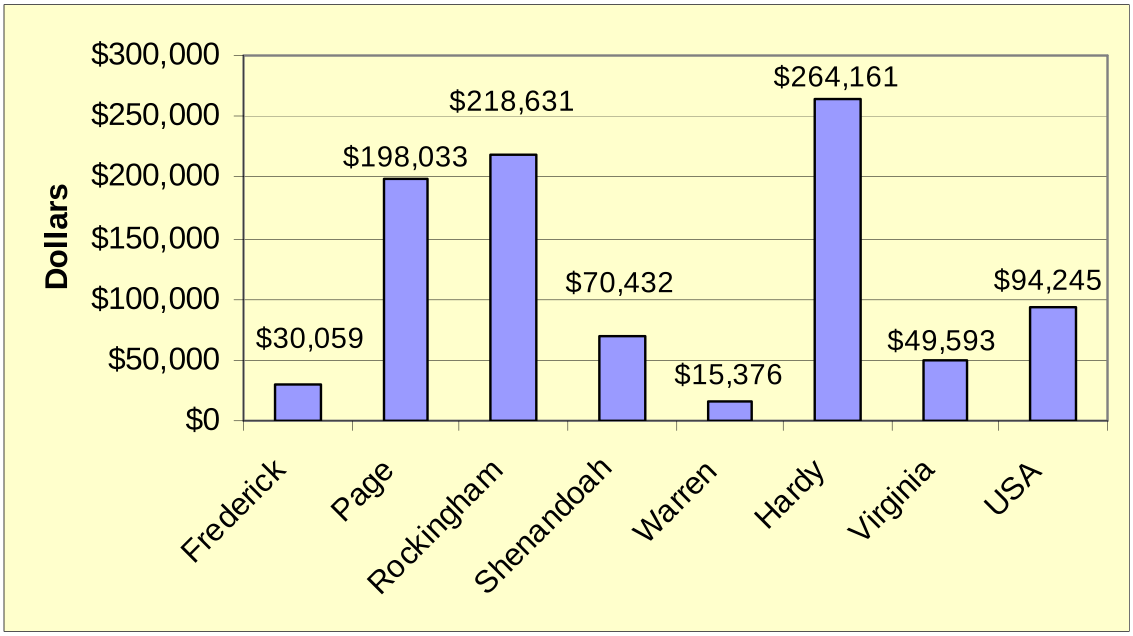
Table 19. Farm Size and Market Value of Production

Selected Character-istics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Farms by size, **1-9 acres**	51	67	241	59	19	43	421
Farms by size, **10-49 acres**	231	188	591	349	140	96	1,246
Farms by size, **50-179 acres**	260	191	823	370	129	147	1,550
Farms by size, **180-499 acres**	138	81	309	166	55	118	701
Farms by size, **500-999 acres**	28	17	60	34	14	40	159
Farms by size, greater than or equal to **1,000 acres**	12	5	19	11	4	24	64
Cropland acres	59,312	33,178	148,173	70,324	23,536	39,811	304,010
Inventory of cattle	20,113	23,418	119,938	38,317	8,788	21,535	193,792
Market value of agricultural products sold	$21.64 million	$108.72 million	$446.66 million	$69.66 million	$5.55 million	$123.63 million	$706.20 million
Market value of agricultural products sold - ave./farm	$30,059	$198,033	$218,631	$70,432	$15,376	$264,161	n/a

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Rockingham County ranks first in the state in terms of market value of agricultural products sold ($446,663,000 vs. $143,914,000 for the second ranked agricultural county – Augusta County and $109,133,000 for the third ranked county, Accomack County) (Figure 64). Page County ranks fourth in the state in terms of market value of agricultural products sold ($108,720,000). Shenandoah County ranks fifth ($69,658,000), Frederick County ranks 30th ($21,642,000) and Warren County ranks 76th ($5,551,000). Hardy County, WV, has an annual market value of agricultural products sold of $123,630,000. Tables 20-22 give more information about the farming operations.

Figure 64. Market Value of Agricultural Products Sold – average/farm



Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Table 20. Types and Numbers of Farming Operations

Selected Character istics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	Estimate for the Region
Farms by North American Industry Classification							
Beef cattle farming	315	221	694	537	176	155	2,098
Cattle feedlots	31	25	57	68	12	11	204
Dairies	6	10	262	19	0	3	300
Poultry/egg production	8	147	523	64	6	151	899
Hay farming & all other crop farming	130	56	179	126	64	67	622
Hog/pig farms	9	5	8	3	0	13	38
Sheep/goat farms	20	22	64	24	5	27	162
Oilseed & grain farms	16	10	53	39	6	4	128
Vegetable & melon farms	7	3	19	7	0	0	36
Fruit & tree nut farms	39	2	26	28	15	3	113
Greenhouse, nursery & floriculture	36	10	43	22	15	7	133
Other animal agriculture including aquaculture	103	38	115	52	62	27	397

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Table 21. Poultry Farms and Inventory

Selected Characteristics	Frederick County, Virginia	Page County, Virginia	Rockingham County, Virginia	Shenandoah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Poultry – farms	40	127	433	71	13	140	824
Poultry – inventory number	(D)	43.18 million	105.79 million	19.61 million	(D)	42.37 million	210.95 million

Note: Includes layers 20 weeks old or older, broilers and other meat-type chickens.
(D) Data withheld to avoid disclosing data for individual farms.
Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Table 22. Cattle and Horse Operations

Selected Characteristics	Frederick County, Virginia	Page County, Virginia	Rockingham County, Virginia	Shenandoah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Cattle and Calves inventory, milk cows – farms	8	15	321	35	3	6	388
Cattle and Calves inventory, milk cows – number	693	252	30,084	2,256	3	213	33,501
Cattle and Calves inventory, beef cows – farms	330	300	806	578	165	231	2,410
Cattle and Calves inventory, beef cows – number	9,985	10,783	25,906	15,916	3,976	8,748	75,314
Horses and ponies inventory, number	1,388	675	2,541	954	587	564	6,709

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Pasture and Woodland. The 258,610 acres of land used for pasturing livestock within the five Virginia counties represents 7.8% of the total pastureland in the state. Feed corn is grown for silage or green-chop (Table 23).

Table 23. Inventory of Cropland and Pastureland

Selected Characteris-tics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Crops harvested, corn for silage or green-chop - acres	1,138	1,778	25,748	3,847	92	2,383	34,986
Pastureland, all types – acres	45,981	30,067	105,690	55,081	21,791	60,858	319,468
Pastureland excluding cropland and woodland used for grazing – acres	20,056	14,809	51,057	28,584	6,825	25,497	146,828

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

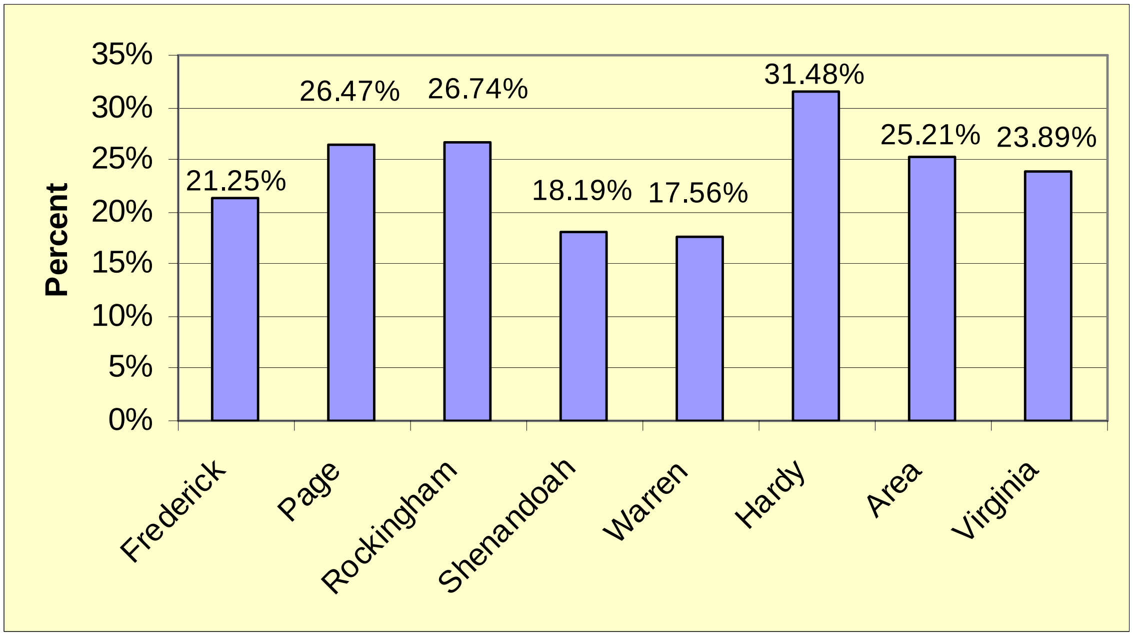
Grazing cattle in wooded areas can reduce the productivity of the site and accelerate erosion, sediment, and nutrient transport, and delivery of these pollutants to receiving waterways (Table 24, Figure 65). If these areas are simply used for shade, then less environmental damage is likely to occur. If inadequate forage is available, then the cows will browse among the trees and their hooves will cause damage to the surface roots of trees. In addition, livestock typically access these areas by trails which can concentrate runoff and cause accelerated erosion. Adequate forage and supplemental feed is important for minimizing the negative effects of grazing livestock in wooded areas.

Table 24. Grazed and Total Woodland Acres on Farms

Selected Characteris-tics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	General Estimate for the Region
Grazed Woodlands – acres	5,671	3,164	10,296	5,447	2,842	18,305	45,725
Total Woodland – farms	409	274	971	538	226	337	2,755
Total Private Woodland – acres	26,682	11,955	38,507	29,944	16,183	58,139	181,410

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 65. Grazed Woodland as a Percent of Total Private Woodlands



Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Cropland. The main crops in the North Fork Shenandoah river basin are corn for silage and, to a lesser extent, corn for grain; hay, including alfalfa but mainly consisting of fescue and mixed fescue and clover hay; and soybeans (Table 25). Vegetable crops are a relatively minor agricultural enterprise within the Shenandoah Valley but are increasing in acreage and market value.

Table 25. Cropland Farms and Acreage

Selected Characteris-tics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	Estimate for the Region
Cropland, farms	578	427	1,656	853	281	367	4,162
Cropland, total acres	59,312	33,178	148,173	70,324	23,536	39,811	374,334
Cropland, total acres harvested	37,344	20,254	99,399	46,177	10,470	21,684	235,328

Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Status of Bee Colonies. Rockingham County, which is first in the state in terms of market value of agricultural products sold, ranks second in the state in number of bee colonies, behind only Clarke County where apple orchards are commercially important. Frederick County is first in apple production in the state and also ranks high in the total number of bee colonies. Page County had only two farms with bee colonies. Shenandoah County has several apple orchard acres but not many bee colonies. Warren County was not listed as having any honey bee colonies. Hardy County had only four farms with 88 colonies of bees as of 2002. Agricultural enterprises such as poultry operations are not directly dependent upon pollinators, but the feed they use is wind and pollinator dependent.

It should be noted that this data is probably out of date given the age of the reported data and the recent news about "Colony Collapse Disorder" (CCD). A survey of bee colony health released in May, 2008 by the Apiary Inspectors of America indicates that 36.1% of the commercial beehives were lost due to CCD in 2007. This is negatively compounded on top of surveyed losses of 32% in 2006. The onset of CCD led the Apiary inspectors of America to begin this survey in 2006 to estimate colony deaths. The data is insufficient to show a long-term trend, but they are very troubling and indicate that farming might increasingly have to depend upon native pollinators for this environmental service.

The many small fields in the Valley are conducive to allowing natural pollinators to provide pollination. However, on larger fields (60 acres or more), natural pollinators can't be depended upon to make sure that pollination is not constraining productivity. One alternative is to have commercial suppliers contracted to bring honey bees in where and when they are needed.

The importance of honey bees and other pollinators is well documented. The fact that only Rockingham County has a significant number of bee colonies, albeit on a relatively small number of farms, raises the concern of whether or not lack of good pollination is limiting agricultural productivity and economic growth. According to the 2002 Census of Agriculture, Virginia has 39 counties/localities with five or fewer farms with bee colonies. Overall, honey production significantly increased from 1997 to 2002 which means that the on-farm colonies were getting larger. However, there are several counties in the watershed with very few or no on-farm bee colonies.

Table 26. Status of Bee Colonies

Selected Characteristics	Frederick County, Virginia	Page County, Virginia	Rockingham County, Virginia	Shenandoah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	Estimate for the Region
Total number of farms with bee colonies	13	2	21	6	0	4	46
Total number of bee colonies	437	(D)	1,315	21	0	88	1,861

(D) Data withheld to avoid disclosing data for individual farms.
Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 66. Apple Orchard

Credit: Cephas Hobbs, NRCS, Richmond, Virginia.

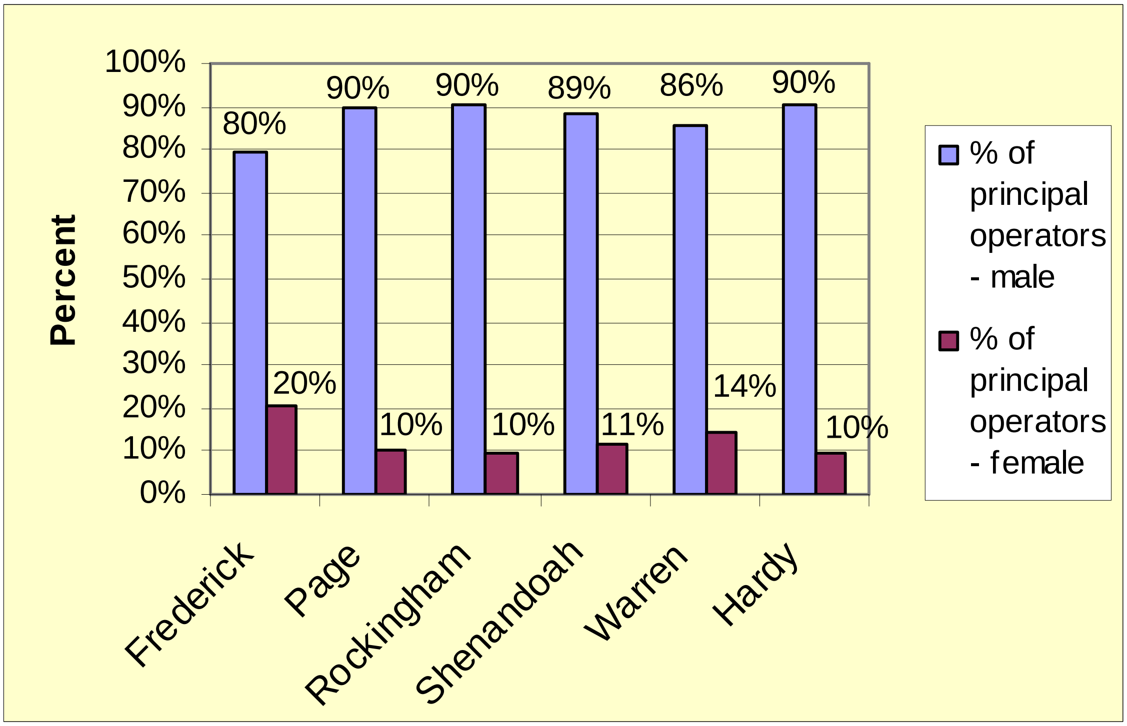
Farmer Profile. Information about the farmers in the watershed is only available at the county level. Table 27 lists general farmer statistics for the six counties that are in the watershed. Figures 67 and 68 also show some of the farmer characteristics.

Table 27. Farmer Profile

Selected Character-istics	Frederick County, Virginia	Page County, Virginia	Rocking-ham County, Virginia	Shenan-doah County, Virginia	Warren County, Virginia	Hardy County, West Virginia	Estimate for the Region
Total number of farm operators	1,119	849	3,219	1,476	487	734	7,884
Male operators	732 (65.4%)	606 (71.4%)	2,331 (72.4%)	1,093 (74.0%)	349 (71.7%)	535 (72.9%)	5,646 (71.6%)
Female operators	387 (34.6%)	243 (28.6%)	888 (27.6%)	383 (26.0%)	138 (28.3%)	199 (27.1%)	2,238 (28.4%)
Total number of principal operators, male	573	492	1,843	876	310	423	4,517
Total number of principal operators, female	147	57	200	113	51	45	613
Primary occupation of principal operator:							
Farming	373	325	1,285	549	167	300	2,999
Other Occupations	347	224	758	440	194	168	2,131
Principal operator, average age - years	56.7	57.0	53.6	57.5	58.9	54.9	n/a

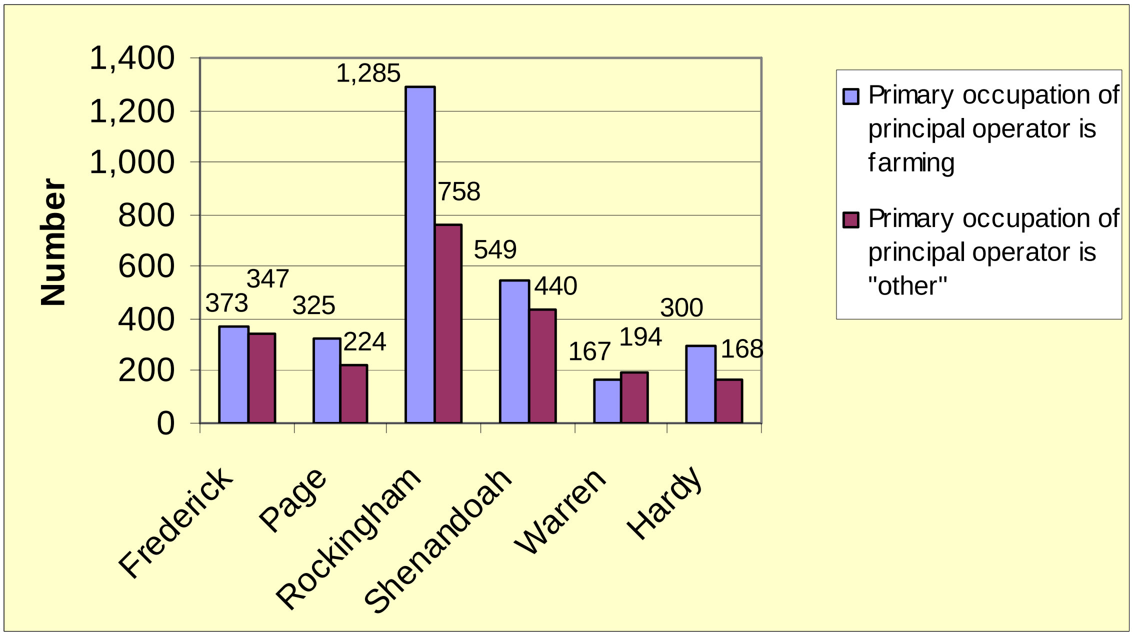
Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 67. Comparison of Number of Male and Female Operators



Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

Figure 68. Primary Occupation of Principal Operator



Source: 2002 Census of Agriculture, USDA/National Agricultural Statistics Service.

STAKEHOLDERS: ISSUES, CONCERNS AND OPPORTUNITIES

There are many stakeholder groups concerned about water quality in the watershed. The identified stakeholder groups include, but are not limited to the following: farmers; conservation, water quality and land protection groups; waste management coalitions; state and federal agencies; landowners; and residents. In addition, several stakeholder groups have been formally organized and play an important role in TMDL planning activities.

To capture the stakeholder input for this watershed, information was compiled from Shenandoah Tributary Strategy meeting minutes, TMDL meeting minutes, questionnaires, locally developed publications, agency handouts, news articles, and personal conversations. Since water quality issues have been thoroughly discussed in the Shenandoah River watershed, these sources were used to identify major issues rather than holding additional meetings. (See References for citations of information sources.) Based on this information, general perceptions and concerns from the farming community are highlighted below. Table 28 further details common themes expressed by stakeholders.

Farmer perceptions include:

- The belief that farmers are unfairly blamed for water quality problems. This includes their perceptions that the public and policymakers exaggerate water quality problems and ignore other significant causes of water degradation.
- The belief that producers get little public credit for their positive contributions to environmental sustainability and water quality improvement.
- A lack of trust sometimes mentioned by farmers regarding state and federal programs and those who promote them.
- That there is too much red tape, excessive bureaucracy, paperwork, and program inconsistency regarding cost-share programs.
- That key BMPs have restrictive guidelines. Nutrient Management Plans, stream buffers and fencing garnered numerous citizen comments.
  - Buffers: Because of the relatively small size of farming operations in the Valley, farmers said 35-foot buffers take too much acreage out of production.
  - Nutrient Management Plans: With the shift to phosphorus-based plans, producers perceive they will be able to spread less manure/litter on their land, increasing costs of commercial nitrogen for their farming operations. There is not enough technical assistance to help them write complex plans.
  - Fencing is expensive to install and maintain, especially in flood-prone areas.
- General belief by farmers that trust and agricultural background are the two main necessities for working with agencies that assist farmers to implement conservation programs. Trust between farmers and state and federal agency representatives is key to encouraging farmers to implement conservation practices which improve water quality.
- The need for more conservation education and outreach. Farmers prefer face-to-face education in small groups/small workshops and one-on-one contact.
- The importance of observing first-hand the various practices in action on working farms. Farmers trust other farmers. Seeing BMPs on other farms and hearing why they were placed there and what they accomplish will help educate others.

- That whole farm management is a benefit to farmers when delivered by visits from experts who could advise them on a variety of issues including finances, nutrient balance, environmental concerns, etc.

Additional resource pressures on the watershed. In addition to comments related to agriculture, there are numerous other major pressures on this watershed that people responded to with specific comments related to water quality. Top concerns include:

- Growth pressures/sprawl-related loss of farmland, forest, and open space contribute to negative water quality (Figure 69).
- The need for more focus on the urban stresses on the watershed due to rapid development of residential and industrial areas.
- General air, water and natural resource quality concerns, including "fish kills" in the watershed.
- Little to no funding available for water quality monitoring and research, including citizen monitoring.

Figure 69. Agricultural and Residential Land Use in the Valley

Credit: Cephas Hobbs, NRCS, Richmond, Virginia.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input

Conversion of farmland, forestland, and open space through development pressures results in sprawl and negative impacts on water quality.	
Resource Concerns	***Opportunities***
• There are only a few economically viable alternatives to conversion and development, such as Purchase of Development Rights Programs or Transfer of Development Rights. Many farmers rely on selling their land as their retirement plan. • Potential economic benefits to landowners derived from recreation opportunities in stream corridors from wildlife habitat, walking trails, fishing, etc., have not been well documented. • There is a need for coordination in Virginia to facilitate other major planning initiatives that affect water quality goals, including the Chesapeake Bay Agreement. For example: the proposed expansion of I-81. • Land use planning should be more fully considered at the local level in terms of water quality because of the connection between land use and water quality.	• Fully address urban nutrient management, cluster development, and managing sewage through integration of watershed planning and land use planning at the local level. • Strengthen the relationship between county comprehensive plan goals and development allowed under Future Land Use Maps, zoning, and subdivision ordinances to more positively address water quality concerns. • Consider strengthening and expanding permanent and temporary land protection options at the local level such as agricultural/forestal districts and agricultural overlays. • Improve water quality by modeling successful watershed planning such as what has occurred in Smith Creek as a result of private landowner action and support from various program sources. • Identify and work with private landowners to protect their land and water resources while sustaining farms, forests, and community culture. • Identify all potential sources for technical and financial support for more initiatives in watersheds where landowners spearhead action. • Identify, develop, and market potential sources of income for interested landowners from clean water. Examples are recreational opportunities through restoration of a native brook trout fishery and fishing on private land.

Sources: See References.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

Farmers are unable or unwilling to install sufficient conservation practices to significantly improve water quality.	
Resource Concerns	***Opportunities***
• There is a lack of willingness in landowners to give up agricultural land to a nonproducing buffer. • There is the perception by local landowners that "what I do won't matter." • The riparian buffer area could become a source for undesirable species, i.e. multi-flora rose, autumn olive, thistles, etc.. • There is frustration with the time and trouble it takes to deal with paperwork to enroll. • There is also frustration with lag time and red tape in obtaining and working with contractors, when needed. • Off-stream watering systems can cause annoyance and risk of loss of water supply from a well or other non-stream source. A permanent stream always has water and is convenient. • There is the perception that landowners take the position that, "I won't do anything until I have to." • There is the belief that standards and specifications for installing BMPs can be inflexible and deter potential participants. • Ways of tracking and crediting BMPs that are implemented outside of an incentive program, including livestock exclusion and cover crops, are limited. • Staff levels for organizations that administer BMP programs are not adequate to sustain high levels of implementation. • There is a lack of sufficient cost-share money and assistance for low income groups. • Absentee landowners/tenant lease arrangements decrease opportunity to establish and maintain BMPs.	• Work on fitting BMPs to the landscape. Utilize all conservation practices and be flexible with layout and installation. For example, water quality can be improved through riparian forest buffer, riparian herbaceous cover, filter strips, field borders, critical area treatment, etc. • Develop and implement a method of tracking non-cost-shared BMPs. In addition, getting credit for BMPs not currently recognized by the Bay Program is necessary. • Use stream monitoring, rather than emphasizing computer models, to measure water quality successes. • Promote strategies for government actions on public lands and employ a lead-by-example strategy. • Recognize and quantify potential roadblocks to implementing BMPs. • Establish additional incentives for installing BMPs such as adjusting property values where riparian buffers have been placed. • Utilize the Agriculture Stewardship Act to require landowners to stop polluting streams. There is reluctance to use the Act to submit complaints on neighbors. • Utilize opportunities for market-based nutrient and carbon trading opportunities for landowners in the watershed. Additional information and outreach will be required. • Build public support for adoption of BMPs through better marketing and advertising.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

State and Federal agricultural cost-share programs need to be more flexible.	
Resource Concerns	***Opportunities***
• Landowners are unwilling to pay the 25% cost-share for fencing and off-stream watering. • Landowners are reluctant to incur financial responsibility for fencing maintenance. • There is dissatisfaction with lag time between upfront finance cost and reimbursement. • Effective outreach strategies for non-participants are limited.	• Increase cost-share funding and payments to landowners. • Target cost-share to the most cost-effective practices for both farmers and conservation organizations. • Use a sliding scale based on income level to determine cost-share amounts. This may increase participation by low income groups. • Consider other incentives agencies can offer in addition to cost-share. For example: soil testing, well testing, etc. • Explore alternative methods to help landowners out with their portion of the cost-share funds if they are low income. Utilize farmer's labor for in-kind credit. • Explore alternatives that will help landowners come up with their portion of the BMP cost (they would benefit if they did not have to pay all costs upfront and then be reimbursed). • Catalog some of the less expensive practices that produce water quality benefits and distribute information to landowners and other organizations. • Establish realistic cost estimates for the non-point source BMPs to include life cycle costs, reduction effectiveness, and efficiency of reductions considering cost, maintenance and how soon reductions are realized. This is critical to compare point source programs to nonpoint source programs.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

Livestock access to streams and water quality impacts are a concern.	
Resource Concerns	***Opportunities***
• There is a lack of flexibility in State and Federal cost-share programs to work with farmers who are willing to exclude livestock from waterways and install alternative water systems but don't want a specific setback. • State and Federal programs should have sliding scale cost-share for fencing or water based on stream exclusion. For example: 5', 10', 15', or 20' from the stream. • State and Federal program requirements can an obstacle to implementation of livestock exclusion practices. • Limited information is available on maintenance costs associated with replacing fencing after flood events. • There is a lack of effective educational strategies to convince livestock operators of the health benefits to livestock of off-stream watering systems and fencing out of streams. • A tax credit that is currently offered to farmers who install alternative water without fencing has not proven to be a sufficient incentive due to average farm income and existing tax breaks. • There is a perceived lack of flexibility for cost-share of flash grazing under drought conditions. Options for grazing under drought conditions have been identified as a concern by farmers considering the practice.	• Make use of state and federal cost-share programs administered through SWCDs and NRCS that provide up to 75% cost-share for buffer practices with a minimum 35 ft. width. • Provide technical assistance to farmers who wish to install buffers that do not meet minimum widths required to receive cost-share. • Consider new models such as in Rockingham and Augusta Counties. Farmers who want to install fencing and alternative water with less than a 35 ft setback have the option to receive financial assistance through a pilot livestock exclusion project funded privately for three years. Livestock must be excluded for five years with top of stream bank requirement as a minimum pilot program requirement. Monitoring will be part of the project through a separate grant. • Provide customized assistance to farmers using DCR and VA Tech publication showing some of the benefits of livestock exclusion to the farmer in 2007. Additional data showing the economic benefits of livestock exclusion and justification of associated costs is needed to share with farmers. • Develop promotional materials that will provide a cost-benefit analysis of practices including rotational grazing and improving pasture management.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

Excess animal manure and associated management of stored and excess manure have effects on water quality.	
Resource Concerns	***Opportunities***
• Excess animal manure and poultry litter from intensive animal agriculture creates implications for water quality. • There is an inadequate supply of litter available for purchase on the open market. Farmers rely on established networks to move litter between farms. • End users of manure that are not required to have a Nutrient Management Plan have no restrictions on their use of animal manure. • There is inadequate tracking of the movement of poultry litter in and out of watersheds.	• Continue to offer BMPs that are cost-shared through state and federal programs. • Promote continuous funding that has been made available for riparian buffers through NRCS, VA DOF, VA DCR and the SWCDs. • Reinforce current activities to further cooperative education and outreach efforts that highlight the economic benefits of non-structural nutrient management practices. • Promote the use of the recently initiated state poultry litter transport program and EQIP-offered incentives for transport from farms producing litter to those that can use it to fulfill crop nutrient requirements. • Promote research findings and educational activities from the recently formed Waste Solutions Forum (WSF) to work on solving problems related to excess animal manure and water quality impacts in Shenandoah Valley. • Promote ongoing efforts to improve demand and markets for manure-based products. • Promote ongoing efforts to create alternative methods for processing manure and end uses for manure, including waste to energy options. • Promote ongoing policy and educational efforts to help ensure funding for excess nutrient issues and other associated goals.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

Point sources have an impact on local water quality that needs to be addressed, including small wastewater treatment plants, ailing septic systems, and straight pipes that may be discharging bacteria and nutrients into streams.	
Resource Concerns	***Opportunities***
• There is a lack of homeowner education with respect to septic system care and maintenance. • Since there is a limited capacity to expand sewer lines to accommodate increased development in rural areas, septic systems continue to be built in new subdivisions. • Time limitations and difficulty in locating straight pipes have resulted in an inability to enforce the existing ban on them in Virginia. • There is fear of legal and/or social consequences if homeowners request assistance and/or report on neighbors despite the offer of financial assistance in replacing straight pipes. • Impact of smaller wastewater treatment plants (discharges less than 500,000 gpd) are not considered significant and, therefore, are not addressed in TMDL concept proposals. These smaller facilities should be addressed from a local perspective and their individual impact on local streams determined.	• Implement educational activities for more homeowner education regarding septic system care and maintenance. More funds could be available to help with the cost of pump-outs. • Consider developing a set of disincentives for installing septic systems. There is the potential for inclusion of septic denitrification as a planning tool to focus growth where appropriate infrastructure exists, and to minimize/reduce the conversion of agricultural land to residential land use. • Develop a wastewater treatment plant operator training and technical assistance program and a monitoring and reporting initiative for small wastewater treatment facilities.
Causes of fill kills need to be identified.	
Resource Concerns	***Opportunities***
• Reduction of an estimated 80 percent of the adult smallmouth bass and redbreast sunfish population occurred in more than 100 miles of the South Fork Shenandoah River in Virginia between April and July 2005. A nearly identical fish kill was observed in the North Fork Shenandoah River in 2004. • Limited funding for intensive sampling and needed research to further pinpoint the causes of the fish kills and associated water quality problems has not been readily available.	• Utilize the Fish Kill Task Force to conduct research as funding and time is available to determine the causes of the fish kills. • Implement continuous monitoring of the chemical makeup of agricultural waste streams in the watershed. Past evaluations of river water has focused specifically on nutrients and ammonia. A plan is under development for expanded, comprehensive testing of waste streams and sources connected with agricultural land uses, with assistance from DCR. That information will be compared with chemicals found in fish tissue, sediments and water in the fish kill areas. • There is an opportunity to further raise public awareness about the importance of water quality and multiple stressors on water resources through attention to the fish kills.

Table 28. Water Quality Resource Concerns and Opportunities as Expressed in Public Input (continued)

TMDL identification, Tributary Strategies, and implementation processes in the watershed are not well understood.	
Resource Concerns	***Opportunities***
• There is a lack of awareness from the general public about water quality issues and how TMDL implementation can help address those issues on an ongoing basis. • Pre-existing misconceptions about regulatory requirements associated with TMDL studies and implementation plans weaken public support in the planning process. • TMDL implementation plans are not watershed-specific enough and do not include specialized solutions for water quality impairments in different communities. • There is a lack of knowledge and understanding by the public about how the Tributary Strategy can work to improve water quality. • Limited coordination of funding programs in TMDL watersheds has reduced the effectiveness of implementation efforts. • Contradictory requirements to water quality goals by state and federal programs should be resolved.	• Integrate TMDL Implementation Plans and watershed management more efficiently into local Comprehensive Plans. • Target active partners that can act as “sparkplugs” in the community and could help overcome obstacles in getting the public involved in the TMDL Implementation process. • Increase outreach activities to publicize and clearly explain the implementation process and its benefits. • Provide incentives to participate in the implementation program such as well testing. This will help bring people in to the urban and residential programs. • Consider splitting large TMDL watersheds in order to better concentrate efforts on implementation. This would include splitting funding and staff. • Consider targeting the sectors that benefit most from TMDL reductions and the sectors that contribute the most to pollutant loads when determining how additional reductions could be achieved. • Look to the results from the last Tributary Strategy initiative and quantify benefits achieved from the expenditure of those funds. Utilize this information to set priorities for targeting future funds.

Natural Resource Considerations and Strategy Options. Although there is a wide variety of resource concerns addressed in Table 28, many of them can be addressed using a consistent strategy. Some can be addressed at the subwatershed level. Others need a regional or whole watershed approach. The basic strategy is to identify the issues, inventory the existing resources, analyze the information and determine solutions, and develop a plan for implementation of the selected solution.

When the topic is water quality, an inventory of the natural resources and land use is needed in order to critically analyze pollutants types and sources. Understanding the various pathways the pollutants can take, and the land use conditions that cause them, is crucial. The following list of natural resource considerations and strategy options is provided to assist the local working groups to address their land use and water quality problems.

1) Inventory all farming operations within a given stream subwatershed in order to identify natural resource and land use issues, concerns, perceptions, and problems. Also, identify other activities in the subwatershed and their land use issues, concerns, perceptions, and problems.

2) Utilize tools such as the Index of Biotic Indicators (IBI) type assessments of the fish and macro-invertebrates to further define the current conditions of perennial streams.

3) Utilize the NRCS Stream Visual Assessment Protocol, or similar approaches, to inventory and characterize local streambanks and channel conditions and to identify specific problem areas.

4) Identify which pollutants are natural and which are man-induced. There are background levels of pollutants in all natural resource systems. Examples of this are fecal coliform from wildlife or heavy metal erosion and transport from exposed geologic layers.

5) Management practices should be favored over structural practices because they tend to be much less expensive and more cost effective in achieving desired on-farm and water quality goals.

6) Structural practices, such as grassed waterways, rock riprap toes, and grade stabilization structures, may be needed at selected points in the agricultural landscape to prevent major erosion/pollution from occurring and to cope with problems caused by major storm events.

7) Promote practices that build soil quality as modeled by the NRCS Soil Condition Index. Enhanced soil quality increases the on-site farm productivity, and at the same time, improves environmental performance of the farm with respect to on-site and off-site soil, water, air, animal and plant resources.

8) Establish long-term monitoring and analysis to determine program impacts. There are time-lags in most natural resource systems between the time when land use improvements occur and when observable changes/improvements in water quality will occur. These time lags can be quite long in some natural systems.

9) Focus local implementation efforts on identified natural resource and land use issues, concerns, perceptions and problems. Examples of this would be perennial stream segments, sinkholes with open holes, and lands within one mile of the streams where impairments are already documented or where current conditions and trends in land use are a cause for concern. Identification of the most vulnerable

lands within the watershed and corresponding land users is a vital component of the planning and implementation efforts.

10) Work in areas where there are both stretches of impaired waters and farmers that are receptive to work with public agencies and/or private organizations.

11) Temperature, nutrient content (mainly nitrogen levels) and pH are crucial for protecting and/or extending the areas where high-valued cold water fish, such as trout, can live. Forested riparian buffers should be established along these streams so the buffering and shading will enhance survivability.

12) Promote the establishment of permanent native vegetation in buffer areas along perennial stream segments and sinkholes. Promote protection of sensitive landscape features such as closed-basin sinkholes, caves, springs, wetlands and seeps by establishing permanent native vegetation around them.

13) Encourage use of purchase of development rights programs to conserve prime farmlands and maintain green-space around and near historic communities.

Appendix B lists additional strategies that can be used.

Figure 70. A recently established Riparian Forested Buffer on Long Meadow Run in Rockingham County

Credit: NRCS Field Office, Harrisonburg, Virginia.

CONSERVATION ACTIVITIES IN THE WATERSHED

Conservation Organizations. The following list describes some of the existing water and land conservation organizations that exist in the Shenandoah Valley and their activities and interests in the watershed. This list is not all inclusive.

The **Friends of the Shenandoah River** (FOSR) is a non-profit, volunteer organization dedicated to the preservation and improvement of the Shenandoah River and its tributaries. Information on their many activities is available at: http://www.fosr.org/

The **Interstate Commission on the Potomac River Basin (ICPRB)** is an interstate compact commission established by Congress in 1940 to help the Potomac basin states and the federal government to enhance, protect and conserve the water and associated land resources of the Potomac River basin through regional and interstate cooperation. The ICPRB is represented by appointed commissioners from Maryland, Pennsylvania, Virginia, West Virginia, the District of Columbia, and the federal government. Their website is: http://www.potomacriver.org

The **Potomac Conservancy** is a land trust organization focused on land preservation and associated water quality protection of the waters of the Potomac River. The organization also focuses on protecting river health and water quality, preserving the scenic beauty of "the world's wildest urban river," and encouraging responsible recreation. Their website is: http://www.potomac.org

The **Poultry Litter Transport Program** is available via the NRCS EQIP program to transport poultry litter out of Page and Rockingham Counties. The Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, has a similar program.

A **Regional Water Resources Policy Committee (RWRPC)** was formed in 2002 to discuss water resource issues of the Shenandoah River. The RWRPC includes elected representatives and citizen stakeholders from all counties and municipalities within the watershed. The RWRPC is currently leading efforts to address water quantity and quality issues within the Shenandoah River Watershed. The main goal of the RWRPC is to create a regional Shenandoah Valley Water Resources Strategic Plan that will be adopted and observed by municipalities throughout the region. This plan would also meet a state mandate requiring the development of local or regional water supply plans between 2008 and 2011.

The **Shenandoah County Water Resources Advisory Committee (WRAC)** was chartered by the County in 1999 and reports periodically to the county Board of Supervisors. The WRAC was formed in order "to study the water resources of the county and provide recommendations to the Board of Supervisors concerning these resources, including water quality and quantity.

The **Shenandoah Forum** is a grassroots citizen's organization that was created in response to the potential expansion of Interstate 81 and has since taken on growth and development issues. Their primary concern is conservation of open space (agricultural and historical areas) and environmentally sound/low impact growth decisions. Their website is http://www.shenandoahforum.org

The **Shenandoah Resource Conservation and Development Council (RC&D)** focuses on sponsoring and promoting programs that improve the quality of life and sustainable use of natural resources by providing volunteer leadership, technical resources, and financial assistance. The RC&D program is a sponsored by the U.S. Department of Agriculture and is managed by the NRCS. Their website is http://shenandoahrcd.org

The **Shenandoah Riverkeeper** was created to address the continuing decline of water quality in the Shenandoah River, signified most prominently by multiple fish kills of large fish populations throughout the Shenandoah River since 2004. The Shenandoah Riverkeeper organization is affiliated with the national nonprofit organization known as Waterkeeper Alliance. Waterkeepers advocate for compliance with environmental laws, respond to citizen complaints, identify problems which affect the program's identified body of water, and devise appropriate remedies to address the problems. The Shenandoah Riverkeeper is currently actively tracking permit infractions by point source polluters and reports of fish kills and other pollution accounts throughout the watershed. Strong advocacy, utilization of Virginia's Agricultural Stewardship Act, and litigation, when necessary, are the major tools used by the Shenandoah Riverkeeper to protect water quality within the Shenandoah River. Their website is http://www.potomacriverkeeper.org/

The **Shenandoah Valley Network (SVN)** is a coordinating organization that provides technical and hands-on assistance to Network members in the areas of transportation and land use planning, grassroots organizing, media outreach and capacity building of county level citizen organizations. Their goal is to promote the growth designs and economic development that honor the natural resources, culture, and lifestyle valued in the Shenandoah Valley. Their website is http://www.shenandoahvalleynetwork.org

The **Shenandoah Valley Pure Water Forum** is a DCR sponsored community improvement forum that addresses water quality issues and environmental education in the Shenandoah Valley. The group works through networking, education, and specific actions including special projects. This group represents a broad coalition of public and private interests and is coordinated through James Madison University. Their web-site is: http://www.purewaterforum.org/

The **Smith Creek Watershed Partnership** began as an extension of the Smith Creek Citizens Watershed Committee in 2007. This group is made up of citizens, local and state government representatives, academics, and water and land conservation groups. The goal of this group is to develop and implement a citizen-led TMDL implementation plan for Smith Creek which will result in its removal from Virginia's impaired streams list and the restoration of native trout to Smith Creek.

The **Valley Conservation Council (VCC)** is a land trust organization with over 1,000 members throughout the Shenandoah Valley. The VCC works with land owners Valley wide to educate and promote the use of conservation easements to preserve open space in an effort to "conserve rural heritage, protect our waters, and save resources for the future in Virginia." The VCC holds conservation easements and also facilitates the easement of land through the Virginia Outdoors Foundation, a state land conservation program. Their website is http://valleyconservation.org

The **Waste Solutions Forum (WSF)** is a broad based community effort coordinated by the Shenandoah RC&D Council. The WSF engages farmers, policy makers, researchers, industry representatives and government officials in forums for utilizing excess animal waste in the Shenandoah Valley. The web-site is: http://www.shenandoahrcd.org/ProjWasteSolutions.htm

Activities in the Watershed. Several land treatment projects have been implemented in the watershed or are planned for implementation.

The **Holmans Creek** Hydrologic Unit, in the Linville Creek subwatershed, has received conservation funding from multiple sources over the last 12 years. In 1996, the watershed was targeted under the Environmental Quality Incentive Program (EQIP). Twelve contracts were written and five were completed. From 1997–2000, two Section 319 grants were obtained. A coordinator was hired to work with farmers in the watershed during this four year period. Many contracts and demonstration projects were completed. In 2004, a TMDL plan was implemented. After four years, Holmans Creek still remains impaired due to a lack of participation in the conservation programs. However, the homeowner part of the plan exceeded goals for septic tank pump outs and replacements of failed septic systems.

In 2007, the **Linville Creek Land Treatment Watershed Project (PL-534)** was completed and closed out after 22 years of low-level funding (about $52,000/year). A total estimated $1,615,000 was expended under this program ($1,153,000 from the NRCS and $462,000 from the farmers themselves). As a result of this effort, 22 animal waste storage facilities, 38 alternative watering facilities, over 101,000 feet of fencing, 16.5 acres of grassed waterways, 81 acres of strip-cropping, and 1,053 acres of improved pasture and hay planting were installed. The waste storage facilities included litter storage sheds, dead bird composting facilities, and manure storage pits. The fencing facilitated rotational grazing systems and livestock exclusion from streams. Some cropland was converted to pasture and hayland, and winter cover crops were introduced with assistance from the Virginia Agricultural Best Management Practices Program.

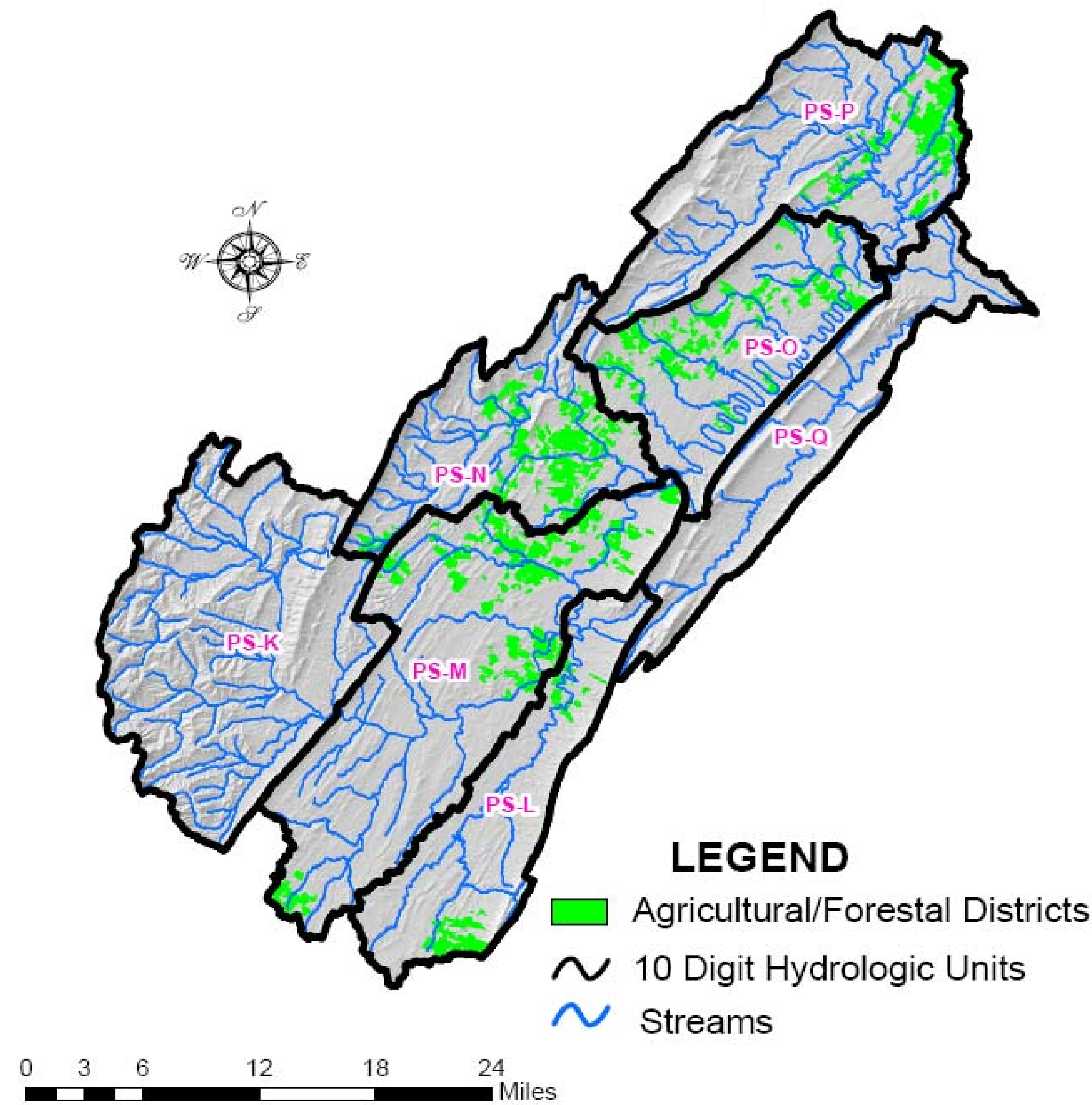
The Hardy County, WV, part of the Shoemaker River subwatershed had six participants in the **Potomac Headwaters Land Treatment Project (PL-534)**. This program began in 1998 and was used to build litter sheds for proper manure handling and storage and composters for proper disposal of animal mortality.

In 2006, the North Fork of the Shenandoah River was one of 60 watersheds nationwide selected for implementation of the **Conservation Security Program (CSP)**. This program rewards farmers who are doing an outstanding job taking care of the natural resources on the land that they have in agricultural production. Thirty-eight farmers in the watershed applied for CSP. Of these, the 15 who were accomplishing the highest level of conservation were accepted into the program. Together, these 15 contracts cover about 4,000 acres in the watershed. Over the next 10 years, these farmers will receive annual incentive payments to maintain the existing level of conservation on their farms and additional incentive payments if they carry out practices to further the level of conservation.

"Community Decisions Support for Integrated, On-the-ground Nutrient Reduction Strategies for Watershed Nutrient Planning and Management" is a recently funded USDA/CSREES National Integrated Water Quality Program to be implemented by Virginia Tech. The project will be carried out within a subwatershed within the North Fork of the Shenandoah with a scheduled end date in 2010. The goal of this effort is to develop a flexible, practical decision support tool and public participation process that can be utilized to aid planning and management of nutrients in the Mid-Atlantic states. This project will be coordinated through the local Waste Solutions Forum currently supported by the NRCS Resource Conservation and Development Council, the Extension Service, the Virginia Department of Conservation and Recreation and the local NRCS and SWCD offices.

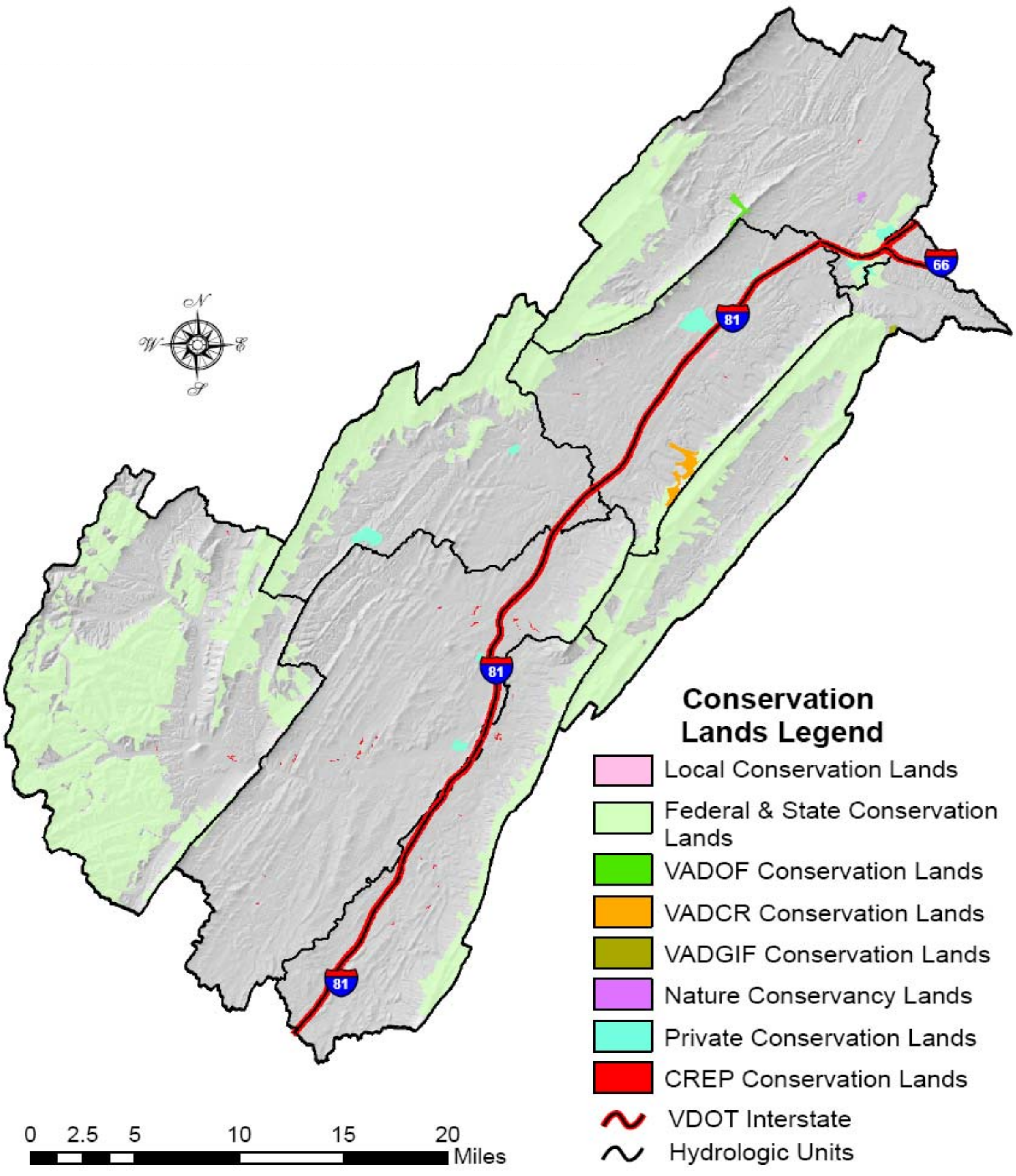
Agricultural/Forestal Districts. The establishment of Agricultural/Forestal Districts in a county is a way to preserve agriculture and forestry as industries, encourage maintenance of adequate open space area for expanding county populations, and promote land use planning and orderly development of real estate. Voluntary placement of land in one of these Districts means that the land is taxed based on the actual use of the land rather than its market value. Contracts are usually for a period of ten years and may be renewed for additional years. Since the minimum size of a new District is 200 contiguous acres, it is also a way to reduce defragmentation of wildlife habitat. Five of the seven hydrologic units in the watershed have Agricultural/Forestal Districts (Figure 71).

Figure 71. Agricultural and Forestal Districts



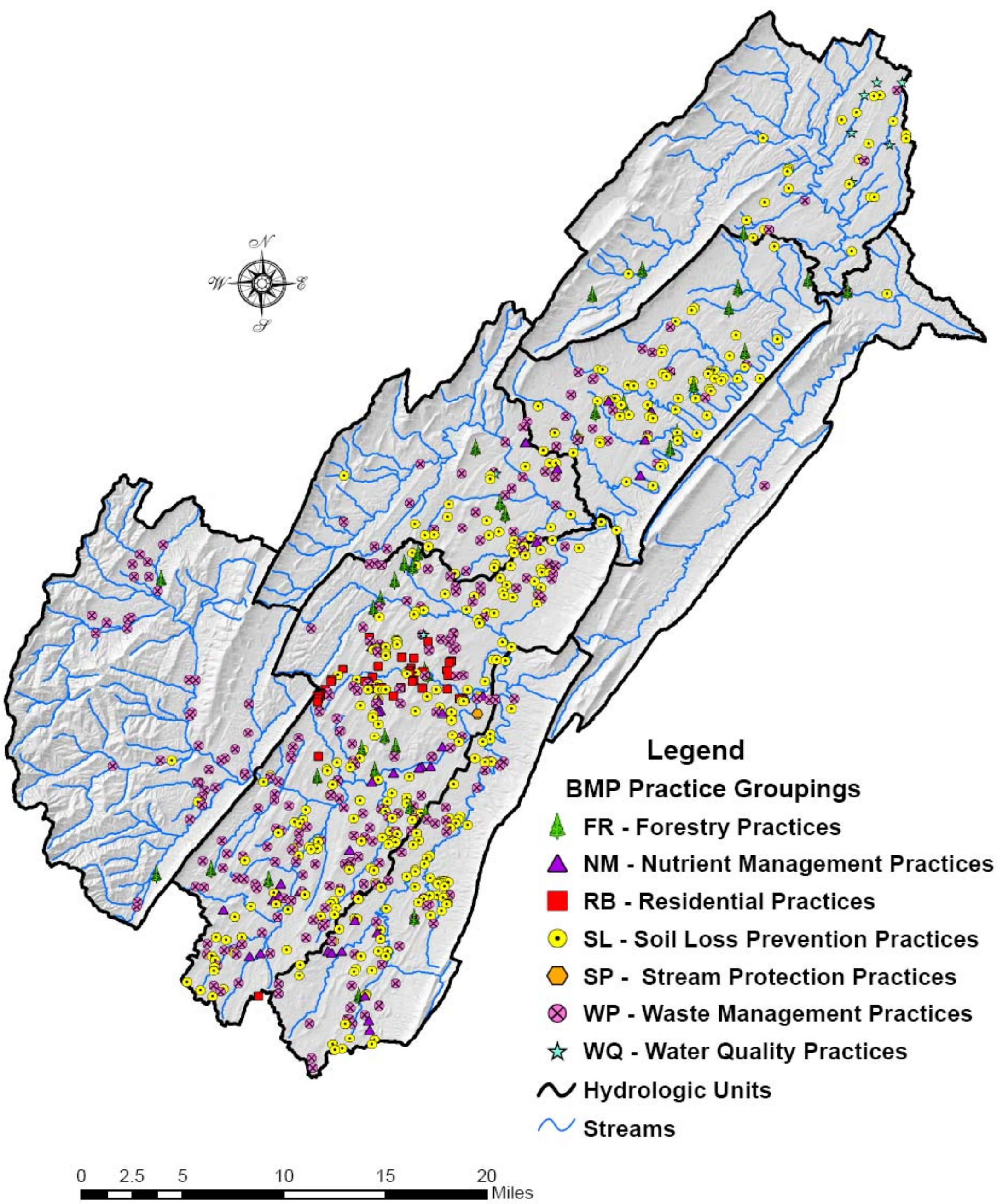
Conservation Lands and CREP. Separate from the Agricultural/Forestal Districts, there is land that is under some type of conservation program. Figure 72 shows some of the different entities that are involved with land conservation. Under many of these programs, the land is permanently protected from development.

Figure 72. Conservation Lands and CREP



Conservation Practice Installation. Conservation practices were installed on many farms in the watershed using approximately 30 different State BMP practices (from 1989 to 2006) and 41 different NRCS practices (from 2004 to 2007). State and NRCS cost-share programs were used to provide technical and financial assistance on many of these farms. Practices installed with technical assistance only and practices installed independent of government assistance account for some of the conservation activity in the watershed. Figure 73 shows the State BMP practices that were installed between 1989 and 2006.

Figure 73. Locations of State BMPs



CURRENT AND FUTURE CONDITIONS

A summary estimate of the general magnitude of expenditures made, based on the amounts of key practice reported installed between 2004 and 2007 for NRCS assisted practices and from 2002 through 2006 for State Cost-Share assisted practices, is shown in Table 29.

Because the Shenandoah River is in the Chesapeake Bay Watershed, it is an integral component of mid-Atlantic regional water quality planning and conservation initiatives. In March 2005, Virginia issued a Tributary Strategy for the Shenandoah and Potomac River Basins that sets ambitious goals for reducing nutrient and sediment inputs. Implementation of the Tributary Strategy is an essential first step to achieving nonpoint source reduction goals called for in the Chesapeake Bay Agreement of 2000.

The Chesapeake Bay Tributary Strategy identified broad goals for implementation of BMPs in the watershed. The Future Conditions table (Table 30) lists the key agricultural BMPs evaluated in the Tributary Strategy. It also estimates the quantities of BMPs that need to be installed to achieve the stated goals. These numbers are general planning numbers over a large scale. They do not account for structural practices, regularly used annual and management practices that were installed prior to the implementation of the Tributary Strategy, or practices implemented without State or Federal assistance.

Comparing the Current Conditions table with the Future Conditions table indicates that a large gap still exists between what has been implemented and what was projected to be implemented to meet the Tributary Strategy goals. Although precise figures for the total amounts of practices and costs expended within the river basin do not exist, a general estimate of about 5,355 acres of practices and approximately $855,000 ($160/acre) in expenditures (incentive payments plus farmer contributions) per year has been the rate of practice installation and expenditures on conservation practices since 2002.

Under the general planning assumptions used here, implementation of the Tributary Strategy would require the expenditure of approximately $28,090,000 each year on approximately 88,900 acres ($316/acre for each acre treated) for the next 2 years in order to achieve the planned completion date of 2010. It should noted that the level of planning and estimation of practice needs made at the level of a Tributary Strategy is very general and offers a “ball-park” idea of treatment needs. The level of planning applied with a Rapid Watershed Assessment for a river basin the size of the North Fork Shenandoah River is also of a general nature.

Table 29. Current Conditions - Best Management Practices Installed, Estimated Acres Benefited and Costs[6]

BMP Category	Units	Amount Installed	Acres Benefited	Total Estimated Cost	Estimated Cost-share Payments	Estimated Landowner Cost
Riparian buffers and filter strips	Acres	580	580	$353,400	$265,050	$88,350
Nutrient management	Acres	18,162	18,162	$136,600	$136,600	$0
Permanent Vegetative Cover (pasture, crop, hay)	Acres	1,300	1,300	$246,800	$185,100	$61,700
Grazing land protection						
Stream Protection (fencing of paddocks)	Linear Feet	56,113	2,943	$127,700	$63,850	$63,850
Prescribed Grazing (plan development)	Acres	9,510	9,510	$71,200	$0	$71,200
Cover crops (average annual)	Acres	2,514	2,514	$96,900	$61,100	$35,800
Stream protection with fencing (livestock exclusion)	Linear Feet	8,150	117	$18,600	$9,300	$9,300
Streambank Stabilization/Restoration	LF	7,140	n/a	$701,500	$350,750	$350,750
Waste Management	Systems	120	no data	$3,869,000	$2,818,000	$1,051,000
Wetland Restoration and/or Enhancement	Acres	103	103	$178,300	$89,150	$89,150
Conservation Tillage (average annual)	Acres	2,253	2,253	$132,450	$60,950	$71,500
Septic Connections (installation of new or replacement of old failing)	Systems	4	no data	$44,200	$25,800	$18,400
Septic Tank Pump-outs and disposal	Systems	41	no data	$9,400	$9,400	$0
Totals:	Acres	34,422	37,482	$5,986,050	$4,075,050	$1,911,000

Source: Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for the Shenandoah and Potomac River Basins, March 2005.

[6] The costs represent estimates calculated from actual costs (State Cost-Share practices) and average costs (NRCS and FSA practices) used in the various programs used to deliver technical and financial assistance for implementing conservation practices. Distinct incentive payments are paid by VA/DCR, NRCS, and FSA for implementing riparian forest buffers under State Cost-Share, EQIP, and CREP respectively. Incentive payments and annual rental payments under CREP are not included in these estimates.

Table 30. Future Conditions - Best Management Practices to be Installed, Estimated Acres Benefited and Costs[7]

BMP Category	Units	Amount Needed	Acres Bene-fited	Total Estimated Cost	Estimated Cost-share Payments	Estimated Landowner Cost
Riparian buffers and filter strips	Acres	33,531	33,531	$20,430,200	$15,322,700	$5,107,500
Nutrient management	Acres	72,752	72,752	$547,300	$547,300	$0
Permanent Vegetative Cover (pasture, crop, hay)	Acres	This goal has already been met.		$0	$0	$0
Grazing land protection: Stream Protection via fencing of paddocks	Linear Feet	This measure is not a goaled item in the Tributary Strategy		$0	$0	$0
Prescribed Grazing (plan development)	Acres	This goal has already been met.		$0	$0	$0
Cover crops (average annual)	Acres	31,949	31,949	$1,231,900	$776,100	$455,800
Stream protection with fencing (livestock exclusion)	Linear Feet	54,524	31.3	$124,050	$62,025	$62,025
Streambank Stabilization/Restoration	Linear Feet	2,860	1.6	$281,000	$140,500	$140,500
Waste Management	Systems	44	no data	$1,755,200	$1,301,800	$453,400
Wetland Restoration and/or Enhancement	Acres	8,386	8,386	$14,515,200	$7,257,600	$7,257,600
Conservation Tillage (average annual)	Acres	31,153	31,153	$1,831,300	$842,700	$988,600
Septic Connections (installation of new or replacement of old failing)	Systems	1,081	no data	$11,943,200	$6,967,500	$4,975,700
Septic Tank Pump-outs and disposal	Systems	15,419	no data	$3,521,700	$3,521,700	$0
Totals:	Acres	177,771	177,804	$56,181,050	$36,739,925	$19,441,125

Source: Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for the Shenandoah and Potomac River Basins, March 2005.

[7] Estimates based on projections from actual costs (State Cost-Share payments) and average costs from the 2007 NRCS/VA Average Cost list indexed to present values using the USDA/Producer Prices Paid Index.

SUMMARY

The North Fork of the Shenandoah River watershed is one of the most agriculturally significant areas of Virginia. Rockingham, Page, and Shenandoah Counties are among the top five counties in the State for market value of agricultural products sold. This is in spite of having average farm sizes that are 43-57% smaller than the average farm in the State. Poultry, beef, and dairy operations are the dominant farm type. Hay and row crops are also important. The highly fertile soils in the watershed have contributed greatly to this success. Over 94% of the agricultural land is designated as having Prime or Important soils.

The watershed is also rich in other resources. There are about 955 miles of perennial streams and 1,652 miles of intermittent streams. The area has a wide variety of wildlife, including a number of Threatened and Endangered species. Of the 169.5 miles of coldwater streams, over 100 miles support either native or stocked trout. National Forest is present in each of the seven subwatersheds. In the Shoemaker River (PS-K) and Passage Creek (PS-Q) subwatersheds, most of the woodland is federally owned.

As of 2001, agriculture accounted for about 30% (203,199 acres) of the land use in the watershed. Forest cover, with 413,368 acres, accounted for another 62%. Other land uses in the watershed are urban, with 41,955 acres (6.3%), Other (512 acres, 0.08%), and Open Water (2,787 acres, 0.4%). Based on the 1992 and 2001 NLCD data, the amount of urban land is rapidly increasing. About 60% of the new urban land is land that was once in agriculture. Forest and Other land uses each represent about 20% of the acres converted to urban. This change in land use is expected to continue since the population of the area is forecasted to increase by 31.4% by the year 2030. Preservation of the rural lifestyle, loss of family farms, increases in runoff and erosion, and water quality/quantity issues are a few of the concerns brought about by these changes.

Water quality issues exist for the watershed on regional, state, and local levels. At the regional level, the North Fork of the Shenandoah River represents about 7% (1,034 square miles) of the Chesapeake Bay drainage. One component of the effort to improve water quality in the Bay is the development of Tributary Strategy reports for each of the major drainage basins of the Bay watershed. These reports give broad overviews of measures that should be taken to reduce nutrient and sediment loadings. The North Fork of the Shenandoah River basin represents about 18% of Virginia's total contribution to the Bay drainage.

At the State level, the DEQ has identified 272.48 miles of stream with impairments that prevent attainment of all the designated uses of the water. About half of the impairments are related to fecal coliform contamination. Temperature, pH, and benthic macroinvertebrate bioassessments account for the remainder. There are 21 TMDLs studies that have either been completed or will be completed by 2018. These reports will be used to direct the implementation of practices to remove the designated impairment.

Local residents are also concerned about water quality. Recent fish kills in the Shenandoah River and the search for the cause have raised awareness of the many potential sources of water quality impairments. Many of the chemicals found in the water originate from industrial discharges and waste water. More common pollutants, such as sediment and nutrients, come from farming, urban construction and runoff, and streambank erosion. Ground water contamination is also occurring. There are nearly 1,800 observed sinkholes in the central part of the watershed. Many of the activities that cause surface water pollution can also affect ground water when pollutants are washed into sinkholes by overland flow. Local citizen groups have been formed to assist with water quality monitoring, increase environmental awareness and education, and to identify solutions to point and nonpoint source pollution problems.

Water quantity is also a major concern. From projections made by Shenandoah County planners, there will be insufficient surface water to meet the needs of the area by 2025. Also, the depth to water for drilled wells has increased by about 85 feet in the last 8-10 years indicating that the ground water is being removed faster than recharge can occur.

There is a perception that farming activities are the major causes of the water quality problems in the watershed and in the Chesapeake Bay drainage. However, the changes in land use and the increase in population are indicators that there are multiple activities within the watershed that could have impacts on water quality.

Figure 74. North Fork Shenandoah River Watershed – Looking towards Massanutten Mountain

Credit: Cory Guilliams, NRCS, Harrisonburg, Virginia.

CONCLUSIONS

Just as there are multiple issues of concern in the North Fork Shenandoah watershed, there are multiple ways of addressing these concerns. Identification of solutions to these issues must begin with an identification of the possible sources of the problems. Locally, the key issues and concerns have been identified as water quality, water quantity, conversion of agricultural land to urban uses, and the perception that farmers are the only group responsible for water quality impairments. An objective assessment of the problems, an acknowledgement that everyone in the watershed contributes to the problems in some way, a willingness to accept responsibility for individual contributions, and a commitment to the common goal of solving the problems will go a long way toward improving water quality.

The protection of natural resources and the implementation of conservation practices to improve water quality must be done at a local level. However, since the North Fork Shenandoah River is a contributing drainage to the Chesapeake Bay, there is a State obligation to encourage installation of urban and agricultural Best Management Practices to improve the quality of the water draining to the Bay.

On the regional and State level, Virginia has committed to reduce the nutrient and sediment loading coming from its watersheds. To do this, large amounts of both technical and financial resources must be committed by the State. However, commitment of resources at the State level does not translate to commitment of resources at a local level. Although a vast majority of the farmers and landowners in the North Fork Shenandoah River watershed are willing to work with the NRCS, Soil and Water Conservation Districts, Cooperative Extension, and others interested in agriculture and water quality to get conservation on the ground, the estimated landowner cost of over $19 million dollars is a deterrent to attainment of the Tributary Strategy goals.

The Tributary Strategy goals were determined by using a very broad-scale assessment of the water quality problems and possible solutions. This has resulted in the establishment of goals that may be substantially larger, in some cases, than the actual need. Refining the goals to more accurately reflect the current conditions and needs of the watershed may be a necessary first step to achieving the desired reductions. Information from the TMDL studies and local knowledge could be used in this process.

At the local level, farmers and many small urban landusers are not required to install nutrient and sediment reduction practices unless an activity is in violation of a State law. Installation of BMPs is voluntary. Cost-share and other economic incentives are commonly used to encourage installation of BMPs on agricultural land. However, many farmers and landowners do not want to follow the NRCS standards and specifications or State cost-share program rules and requirements that must be met in order to receive payments.

Another obstacle is the upfront cost of conservation practice installation. The farmer must pay for installation of the practice and then apply for reimbursement of the cost-share portion. This particularly represents a challenge for limited resource farmers who may not have the cash to pay upfront and, therefore, cannot take advantage of the financial assistance offered to them. There are also some farmers and landowners who do not want to work with any level of government or take cost-share funds from any agency or private organization for various religious and social reasons. In addition, some farmers and landowners do not know about NRCS, Soil and Water Conservation Districts, or other sources of assistance, and what can provided by them in the way of technical and financial assistance.

Efforts to achieve the water quality goals set in the TMDL plans have also encountered many of the same obstacles seen with the Tributary Strategy. At the present time, none of the conservation partnership organizations have adequate human and financial resources to achieve full implementation of the nonpoint and point source goals of either program.

Isolated efforts to install BMPs will not be sufficient to achieve improvements in water quality. Only concerted, targeted efforts to deal with all sources of nonpoint source pollution will make a difference. It is important to recognize that the gains in reducing agricultural nonpoint source pollution can be negated by other events. Uncontrolled sources of pollutants from commercial, industrial, residential and transportation developments can significantly impact water quality and offset gains made in other areas. This is in contrast to the perception that nonpoint source pollution comes only from agricultural sources and that farmers are the only people with responsibilities for water quality improvements.

Progress is being made, however. From 1985 to 2002, the contribution of nitrogen to the Chesapeake Bay from agricultural sources in the Shenandoah-Potomac drainage basin declined from 36% to 31%. It is projected to drop to 23% by 2010. Agricultural contribution of phosphorus in 1985, 2002, and 2010 is 53%, 51%, and 45%, respectively. Agricultural contribution of sediment for those same years is 78%, 72%, and 54%. These long term projections are partly due to land use conversion to developed uses, but also reflect that progress in the treatment of nonpoint source pollution from agriculture within the drainage area is being made.

Most of the farm operations in the river basin are located on prime farmland. The area’s rapid development means that prime farmlands are lost to agriculture forever. It also further complicates the area’s water resource flows and water quality conditions. Development causes an increase in the amount of impervious surface on a site. This leads to decreases in infiltration and ground water recharge and increases in the amount of runoff and pollutants that enter surface water. The additional runoff causes erosion of the stream banks and channels and can lead to destabilized sections in the streams. Other concerns with urbanization include loss of the family farms and the benefits of rural life, fragmentation of wildlife habitat, and infrastructure needs of a growing population. As with water quality problems, these issues require community input and a willingness to work together to find solutions.

The anticipated lack of sufficient water to meet the growing demand is another issue in the watershed. Ground water supplies have declined and none of the existing lakes in the watershed were built for water supply. Community involvement, a commitment of resource dollars, and the willingness of local governments to establish and enforce sound water use policies are some components of the needed solutions.

There are many components of the solutions. For some parts of the problem, there are tried-and-true solutions that can be used. In this case, lack of technical and financial resources to implement the solutions may be the roadblock. Other problems require new technology, a willingness to try new things, or both. Education and outreach programs, along with pilot projects, demonstrations, and field trials, are needed. Another commonly mentioned factor was the need for trust of the people who are providing technical assistance. Well-trained, knowledgeable staff are a necessity.

RECOMMENDATIONS

There is not a one-size-fits-all solution to the problems and concerns in the North Fork Shenandoah watershed. However, the general approach is the same: identify the stakeholders and work together to find solutions. The number of existing community organizations interested in resource protection attests to the value of this approach.

There are a number of practices that can be used to protect water quality. The establishment of vegetated riparian buffers adjacent to streams and waterbodies should be among the first practices implemented in any subwatershed. Riparian buffers provide a filter between activities on the land and the surface water. Perennial stream segments without buffers should be protected before intermittent stream segments because perennial segments receive and move pollutants all year long. In addition, the perennial segments also tend to be in landscapes more conducive to agricultural production and, therefore, have a greater potential for nonpoint source pollution transport and delivery.

Establishment of vegetated buffers around open sinkholes should also be a high priority, particularly in the four subwatersheds that have sinkhole densities of over six sinkholes per square mile of agricultural land. Sinkholes with open inlets are direct conduits to ground water.

Installation of buffers and other vegetated areas will increase the amount of water that infiltrates the soil and decrease the amount that runs off into the surface water. This contributes to ground water recharge, which in turn, increases the base flow of the streams. Vegetation also filters nutrients and sediment out of surface water through plant uptake.

Provision of one-on-one assistance to landowners will help to gain their trust and encourage them to implement needed conservation measures on their land.

The need for financial and technical assistance to install conservation practices in the watershed is greater than can be provided by the available resources. In order to achieve the greatest gains in water quality, these resources should be increased substantially and allocated to high priority subwatersheds. Table 31 lists five categories that rank various factors that affect water quality. The miles of Impaired Streams, the acres of Prime or Important Farmland and Land Converted to Urban Usage, and the number of Sinkholes are shown by the quantity of that category found in each subwatershed. A rank was determined for each subwatershed by sorting the values from largest to smallest. A value of “1” was assigned to the largest number in each category, a value of “2” was assigned to the next largest, and so on. The maps shown in Figures 48-53 were used to estimate the animal numbers in each subwatershed. The number of animals in each category was sorted from largest to smallest and the subwatersheds were ranked from one to seven accordingly. The ranked value from each category was summed by subwatershed. The smallest sum of ranked values represents the largest number of animals. The rankings from the five categories shown in Table 31 were summed to identify the subwatersheds with the highest priorities for implementation of conservation activities.

Future technical and financial assistance services and resources should be directed to the subwatersheds in the following priority order: 1) North Fork Shenandoah - Linville Creek; 2) North Fork Shenandoah - Narrow Passage Creek; 3) Smith Creek; 4) Stony Creek; 5) Cedar Creek; 6) North Fork Shenandoah – Shoemaker River; and 7) Passage Creek. Within these subwatersheds, the work can be further refined to address the most important sources of pollutants first. There may also be strategically placed sites within the landscape that are key to reducing in nonpoint source loadings. A local watershed working group would be able to assist with identification of these sources and sites.

Table 31. Ranking of Subwatersheds

Subwatershed, by overall rank		Impaired Streams		Prime or Important Farmland Land		Land Converted to Urban Usage		Sinkholes		Animals (composite ranking of animal numbers)
Rank	Name	Miles	Rank	Acres	Rank	Acres	Rank	Number	Rank	Rank
1	NFS-Linville Creek	81.62	1	70,723	1	8,838	1	773	1	1
2	NFS- Narrow Passage Creek	44.40	3	36,153	2	4,864	2	375	2	3-tie
3	Smith Creek	52.54	2	22,304	4	3,780	5	329	3	2
4	Stony Creek	38.15	4	21,779	5	3,880	4	187	4	4
5	Cedar Creek	2.53	7	24,446	3	4,665	3	131	5	5
6	NFS – Shoemaker River	34.74	5	9,223	6	2,555	7	3	6	3-tie
7	NFS – Passage Creek	18.50	6	6,649	7	2,633	6	0	7	6

Scientific investigations and analyses are needed for monitoring and evaluating water quality conditions or to better understand cause and effect relationships among land use and water quality variables. For example, Virginia Tech has recently embarked upon a series of replicated plot experiments to evaluate the efficacy of injecting liquid animal wastes such as from dairies. Depending upon the results, this may develop into an innovative practice that could be used to apply dairy waste more efficiently and in a more timely manner. The costs of the involved technologies appear to be prohibitive for a single farmer, but they might make economic sense for some custom applicators.

Although some of the loss of agricultural land can be prevented by the use of conservation easement programs, it is inevitable that this change will occur. Planned growth, point and nonpoint source erosion control, and stormwater management are a few of the ways to reduce the potential for adverse effects on the environment. The increased demand for water is also a component of the changing landscape in the watershed. The direct involvement of local governments with citizens groups is critical to balance growth and development with environmental stewardship.

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7/30/07	Meeting minutes, Holmans Creek
12/24/06	Meeting minutes, TMDL Implementation Workshop: Valley Region, Frontier Culture Museum, Staunton
9/26/06	Draft Meeting minutes, SCIP Committee
2/21/06	Meeting notes, Mill Creek: Sediment TMDL for a Benthic Impairment, Shenandoah County, Virginia
4/7/04	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market
2/4/04	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market Rescue Squad
2/4/04	Draft Input Decks, Shenandoah Tributary Strategy Meeting, New Market
2/4/04	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market
1/13/04	Meeting minutes, Tom's Brook Final TMDL Public Meeting, Tom's Brook Fire Volunteer Department
1/7/04	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market
11/12/03	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market Rescue Squad
11/12/03	Working Group Reports, Shenandoah Tributary Strategy Meeting, New Market
10/15/03	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market Rescue Squad
10/15/03	Meeting minutes, Shenandoah Tributary Strategy Meeting, New Market
8/27/03	Meeting minutes, Smith Creek TMDL First Public Meeting, Arthur L Hildreth Municipal Building, New Market
3/5/03	Meeting minutes, Linville Creek Public Meeting

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The North Fork of the Shenandoah Rapid Watershed Assessment was prepared by the NRCS Staff in Virginia and West Virginia. The draft report was reviewed by several partners and members of the local watershed workgroup and their comments were incorporated as deemed appropriate.

The following table identifies and lists the experience and qualifications of those individuals who were directly responsible for providing significant input into the preparation of the Watershed Assessment. Appreciation is extended to many other individuals, agencies and organizations for their input, assistance and consultation, without which this document would not have been possible.

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APPENDIX A

MAP SOURCES

MAP SOURCES

All of the Following maps were projected in UTM-Zone 17, with NAD83 DATUM and the GRS80 Spheroid.

Figure 1. Location of North Fork Shenandoah River Watershed. The North America Shaded Relief data were derived from the GTOPO30 elevation data. GTOPO30 is a global digital elevation model (DEM) with a horizontal grid spacing of 30 arc seconds (approximately 1 kilometer). GTOPO30 was derived from several raster and vector sources of topographic information. It was developed between 1993 and 1996 through a collaborative effort led by staff at the U.S. Geological Survey's EROS Data Center (EDC). The Shaded Relief image was developed to portray the terrain of North America. It is intended for visual purposes only.

Figure 2. Watershed Map with 10-digit Subwatershed Boundaries. The Hydrologic Units for this map, and all of the following maps were extracted from the NWBD dataset for Virginia and West Virginia. The Virginia Boundaries were compiled and digitized by the VA-DCR Division of Soil and Water Conservation. The West Virginia portion was digitized by the USDA-NRCS. The roads are from VDOT and WVDOT. The Streams were extracted from the "National Hydrography Dataset." The Hillshade in the background was produced from spatial analysis of the USGS Seamless elevation data with 10m resolution.

Figure 4. Average Annual Precipitation Ranges. The average precipitation was extracted from the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system developed by Dr. Christopher Daly, PRISM Group director. PRISM is a unique knowledge-based system that uses point measurements of precipitation. These are derived from the Virginia and West Virginia dataset.

Figure 5. Geology. The Virginia Geology was extracted from the Virginia PUB 174. from the Virginia Department of Mines, Mineral and Energy. The West Virginia Geology was provided by West Virginia Geological and Economic Survey.

Figure 6. Soils by STATSGO Map Units. The data was extracted from the STATSGO (State Soil Geographic Database) data. This data set is a digital general soil association map developed by the National Cooperative Soil Survey and distributed by the Natural Resources Conservation Service (formerly Soil Conservation Service) of the U.S. Department of Agriculture. It consists of a broad-based inventory of soils and nonsoil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The soil maps for STATSGO are compiled by generalizing more detailed soil survey maps.

Figure 7. Elevation Ranges (10m Data). The data was extracted from the USGS - NED (National Elevation Dataset). This data ranges from 90 to 10 meter resolution. The 10 meter data was used for analysis because it was the highest resolution data available for this region. The 3D rendition was derived from analysis with 3d analyst in the ESRI – ArcScene 9.2 extension. **Slope Ranges (10m Data).** The data was extracted from the USGS - NED (National Elevation Dataset). This information was derived from the 1/3 Arc Second Dataset. The slope ranges were created with surface analysis in the

ESRI –ArcGIS 9.2 spatial analyst extension. Slopes were created in percent slope as opposed to measurement of slope in degrees.

Figure 8. Soil Erosion Potential. ("North Fork of the Shenandoah Erosion Potential Ranges Based on Soils and Land Cover") This map is based on the K factor, Hydrologic Runoff group and Representative Slope for each of the soils considered. They were then overlaid with RESAC Land Cover groups that were susceptible to erosion. Them theme is based on calculated ranges derived from these factors.

Figure 9. Hydric Soils and NWI Wetlands. The Hydric soils were extracted from the SSURGO data for the six counties in this study area. The NWI (National Wetlands Inventory) data was derived from the data provided by the U.S. Fish and Wildlife Service.

Figure 10. Prime and Statewide Important Farmland. The data was extracted from the SSURGO (Soil Survey Geographic Database) data. This interpretation is based on Farmland Classification of the soils. The theme was produced for the six counties in the watershed, and then merged and dissolved on the farmland classes. Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. Farmland classification identifies the location and extent of the most suitable land for producing food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the Federal Register, Vol. 43, No. 21, January 31, 1978.

Figure 12. Flow Gauging Stations and Ground Water Monitoring Site. The data points on this map were derived from the USGS "Real-Time Water Data for the Nation" website. The URL for this site is http://waterdata.usgs.gov/va/nwis/rt .

Figure 17. Threatened and Endangered Species Sample Sites and Coldwater Streams. Threatened and Endangered Species information is from the Virginia Fish and Wildlife Information Service. The Cold Water Fisheries was extracted from the Virginia Department of Game and Inland Fisheries GIS website.

Figure 18. Bailey's Ecoregions. Bailey's Ecoregions, National Atlas of the United States, 2008.

Figure 19. Potential and Confirmed Habitat for Tier 1 Species in Virginia. Virginia's Comprehensive Wildlife Conservation Strategy, 2005. Virginia Department of Game & Inland Fisheries, Richmond, VA.

Figures 24-30. 10 digit Subwatershed Maps – Land Use and Features. The data used to produce the seven Sub watershed maps has the same sources. The titles of the maps are:

1. North Fork Shenandoah River - Shoemaker River (PS-K) Land Use and Features
2. Smith Creek Land (PS-L) Use and Features
3. North Fork Shenandoah River - Linville Creek (PS-M) Land Use and Features
4. Stony Creek (PS-N) - Land Use and Features
5. North Fork Shenandoah River - Narrow Passage Creek (PS-O) - Land Use and Features
6. Cedar Creek (PS-P) - Land Use and Features
7. North Fork Shenandoah River - Passage Creek (PS-Q) - Land Use and Features

Digital Data Sources:

The Land Use/ Land Cover was extracted from the RESAC dataset for Virginia. The Mid-Atlantic Regional Earth Science Applications Center (RESAC) is one of 7 regional centers funded by NASA's Earth Science Applications Program. The Mid-Atlantic RESAC leverages the UMD Geography Department's expertise in satellite remote sensing and the work of a diverse consortium of 36 partners in Government, Academia, Industry and NGOs to address applications of regional significance.

This 30 meter dataset was acquired by classification of pixels from Landsat 7. The 2001 NLCD was used in addition with other remote sensing techniques to produce this layer. The original classes were grouped for the maps. The Sinkholes were extracted from the SSURGO special features data for each county. They were clipped by the North Fork of the Shenandoah Watershed. These are a representation of the observations made while mapping the soils. The impaired streams are from the VA-DEQ’s 303D 2006 Non-point source assessment. The non-impaired streams are from the National Hydrography Dataset. The National Forest Boundary was provided by the USDA-Forest Service. The transportation is from the VDOT 2008 centerline transportation data.

Figure 33. National Land Cover Data 1992. The data was extracted from the USGS – Seamless Data Distribution Site. The data was then clipped for the North Fork of the Shenandoah Boundary and Projected to UTMS – Zone 17, GRS80 Spheroid/NAD83 DATUM. NLCD 1992 was the first land-cover mapping project with a national (conterminous) scope. No other national land-cover mapping program had ever been undertaken despite the existence of Landsat TM since 1984. NLCD 1992 provides 21 different land cover classes at the native 30-meter resolution of Landsat TM for the lower 48 states. The target scene acquisition date was 1992, although cloud cover and other factors forced use of scenes from other years because of a lack of useable information. Mapping was based on unsupervised clustering and logical modeling using a suite of ancillary data. **National Land Cover Data 2001.** The data was extracted from the USGS – Seamless Data Distribution Site. The data was then clipped for the North Fork of the Shenandoah Boundary and Projected to UTMS – Zone 17, GRS80 Spheroid/NAD83 DATUM. Thirty – Meter Landsat TM was used to produce this dataset. The NLCD 2001 improves upon NLCD 1992 in three important ways. Whereas NLCD 1992 was simply a land-cover data set, NLCD 2001 is a land-cover database comprised of three elements: land cover, impervious surface and canopy density. Second, NLCD 2001 used improved classification algorithms, which have resulted in data with more precise rendering of spatial boundaries between the 16 classes (an additional nine classes are available in coastal areas and another four classes in Alaska only). Third, NLCD 2001 also includes Alaska, Hawaii, and Puerto Rico. NLCD 1992 was restricted to the conterminous United States.

Figure 34. Impaired Streams, Monitoring Stations and NPDES Discharge Points. The data was extracted from the 2006 305(b)/303(d) Water Quality Assessment Integrated Report posted by the Virginia Department of Environmental Quality. This data includes point and line features. These were clipped with the North Fork of the Shenandoah Watershed. See Section in this report on 2006 305(b)/303(d) Water Quality Assessment.

Figure 46. TMDL Status. The Hydrologic Unit boundaries were classified using the TMDL status report from the VA Division of Soil and Water Conservation and the VA Division of Environmental Quality.

Figure 47. 12-Digit Hydrologic Units within the Watershed. The Hydrologic Units were extracted from the Virginia NWBD database.

Figure 48. Animal Feeding Operations – Confined Chickens During a Cycle
Figure 49. Animal Feeding Operations – Confined Turkeys During a Cycle
Figure 50. Animal Feeding Operations – Confined Beef
Figure 51. Animal Feeding Operations – Unconfined Beef
Figure 52. Animal Feeding Operations – Confined Dairy Cattle
Figure 53. Animal Feeding Operations – Loafing Lots
These maps were produced using the 12 digit HU boundaries for Virginia. The data for classifying these maps was extracted from the the AFO database developed VADCR-DSWC. This data contains the numbers by type of confined and, where available, unconfined farm animals by hydrologic unit. It can be queried by animal type (dairy, beef, swine, sheep, chickens, turkeys and horses), geographic area (jurisdiction, hydrologic unit, river basin, etc.) or both measures. A link to the AFO metadata is on the AFO database web page. The AFO database is currently on an annual update schedule.

Figure 54. Agricultural Nitrogen Loading
Figure 55. Agricultural Phosphorus Loading
Figure 56. Agricultural Sediment Loading. The Hydrologic Unit boundaries were classified using the TMDL status report from the VA Division of Soil and Water Conservation and the VA Division of Environmental Quality. Nonpoint source loadings are from the Virginia 2006 Nonpoint Assessment.

Figure 71. Agricultural/Forestal Districts. The data for this map was supplied by the Valley Conservation Council, and all of the County GIS Specialists in the North Fork of the Shenandoah Watershed.

Figure 72. Conservation Lands and CREP. The CREP data was extracted from the USDA-Farm Service Agencies Common Land Unit database. The Conservation Lands polygons were extracted from the Virginia Conservation Lands database – VADCR-Natural Heritage Program.

Figure 73. Locations of State BMPs. The BMP data was provided by the VADCR-Division of Soil and Water Conservation. Many of these features coincide with BMP sites sponsored by the State and USDA-NRCS.

APPENDIX B

SOCIOLOGICAL/COMMUNITY CONSIDERATIONS AND STRATEGY OPTIONS

SOCIOLOGICAL/COMMUNITY CONSIDERATIONS AND STRATEGY OPTIONS

Planning and implementation of water quality programs requires a collaborative team approach across all public and private sector agencies and interests to optimize limited human and financial resources. Winning the confidence and collaboration of the local land users is absolutely essential. Unless the local landowners stand to gain from implementing conservation practices, they will not participate in local programs and the water quality goals will not be met. The importance of a public/private partnership approach and local ownership by the farmers themselves can't be overemphasized.

Each subwatershed needs to be segmented into identifiable communities and groups of farmers based on their shared characteristics and links to the sources of the natural resource problems. Once the potential clients are well understood and the work needed to enlist their participation is known, then the distinct groups and communities can address the specific tasks needed to target specific changes in land use which will result in improvements in the environmental performance of the natural resources in the watershed. The following list of sociological/community considerations and strategy options are provided to assist the local working groups to solve their land use and water quality problems:

1) Consider using perspective from the agricultural adoption/diffusion model research to identify how to contact/enroll local land users, especially farmers who are leaders in their communities[8].

2) Recent increases in energy, transportation, fertilizer, concrete and steel costs, and other cost categories significantly add to the difficulty, complexity and uncertainty that agricultural land users face. Future efforts, such as with TMDL implementation, will likely be met with heightened scrutiny, resentment and opposition. Sensitivity to these concerns and flexibility to adjust project actions to better meet client needs is essential. If technical and financial assistance can be targeted to practices which improve on-farm efficiency, productivity and profitability in addition to environmental performance, then the farming communities will be much more willing to collaborate with the conservation partnership. Rotational grazing (prescribed grazing plans, fencing, and alternative watering facilities) and continuous no-till/no fallow farming offer such potential. Other practices, such as waste storage and management or riparian buffers needed for environmental performance improvements, may have to be promoted based on cost/share inventive payments available and cost-effectiveness for meeting environmental regulations and stewardship goals.

3) As a general principle, use limited program funds to help pay for the next increment of conservation that will further improve on-farm operations and off-farm environmental performance rather than for actions that have already been implemented. Beneficial practices and management actions that farmers are already taking or tending towards, and are likely to continue on their own, should simply be allowed to happen.

4) Single agency leads/all others support approach – Clearly, a single agency in the leadership, and preferably a technical agency, is most effective in leading the planning and implementation process among collaborating agencies and private interests. A single project coordinator works best for any

[8] The adoption/diffusion model provides an overview of how and who adopts innovations and then how the innovations spread to the rest of the population over time and how to use this understanding to shorten the adoption process. See "Human Considerations in Conservation Planning and Implementation" by Gail Brant, East Region Sociologist, USDA/NRCS, March 2008.

project of significant size and complexity and this person should not also be the technical staff. Coordination and management activities are very distinct from analytical, technical analysis and assistance skills and work activities.

5) Long-term funding and commitment is essential. The corollary to long-term funding is long-term commitment from the farmers. Long-term funding (3-10 year contracts), with flexible reimbursement terms, allows farmers to have a stability in what they can expect from their public partners.

6) Consider the point sources in each subwatershed and the private and public activities that give rise to these sources of pollutants. Opportunities to work with them can complement non-point source pollution efforts on farms.

7) Pre-tests of potential cooperator knowledge and attitudes can be very helpful. Such instruments can also be used to identify the information sources and processes that local farmers rely on and/or prefer for making land use and management decisions. The TMDL processes already conducted, with more to come, have done a lot to gauge farmer attitudes. More information is needed to assess where the potential cooperators are in terms of their management practices and knowledge of non-point source pollution transport and delivery/fate processes and how they would prefer to be educated on these matters. No matter which information sources a farmer uses, the information a project shares must be made available and ultimately delivered in timely, inexpensive, easily accessible and understandable formats and forums.

8) Post-implementation evaluations should be standard operating procedure. For them to be meaningful, there must also be detailed data and analysis of the “before project” natural resource and land use conditions.

9) There is no substitute for direct assistance. One-on-one planning and implementation assistance is essential for customizing the planning process and treatment to the site specific conditions of each farm operation.

10) Group meetings are part of the necessary public participation, information and education process that any project should entail. Group meetings complement one-on-one assistance by getting general information out to many but they do not substitute for one-on-one assistance.

11) Field days, demonstration projects, and farm tours are indispensible for promoting adoption of conservation practices, technology, and management knowledge. Some of these should target specific farmer client groups, such as small farmers, new farmers, and limited resource farmers. Producers typically share specific characteristics within their groups and may benefit from targeted outreach as opposed to the one-size-fits-all approach. This is because some practices and/or scale of practice implementation better fit small grower’s situations than large commercial grower’s. Conversely, larger growers may need demonstrations that highlight a different set of practices or systems. Not all farmer groups need the same mix of assistance packages.

12) Photographic records for before and after treatment conditions should be carefully taken and archived. Photos are extremely useful for communicating and documenting a project’s characteristics

and beneficial effects. This can greatly aid the adoption/diffusion of conservation practices, management knowledge and technology.

13) There is a tendency to attempt to do too much. It is far better to stay focused, under-commit and then over-deliver with our private land user clients. The same can be said about oversight groups. Establishing priority areas and priority worksheets are very helpful for determining who will get technical and financial assistance first. Getting the input of the intended customers and communicating back to them the final results for prioritization schemes is essential.

14) Voluntary programs and projects have a disadvantage. Some of the worst polluters may refuse to participate.

15) Flexibility in project administration and assistance services encourages greater participation. Technical assistance agencies can collect data, evaluate, plan and coordinate forever, but only a high level of cooperator participation will ensure the success of a project. Flexibility in implementation can greatly aid implementation. People participate or don’t participate for their own reasons: to avoid regulation or to comply with regulations; because others are doing it; for economic, aesthetic, environmental or philosophical reasons, etc. They may participate reluctantly, wholeheartedly or somewhere in between, but they will not participate blindly, without knowing why nor without realizing some kind of benefit.