APPENDIX F

Environmental Characteristics Influencing Service

Environmental characteristics can greatly affect the costs of water and wastewater service. Most of the environmental factors in Appalachia lead to higher costs, especially in the Highlands. Subsurface conditions often are hard rock, making installation and repair of pipes relatively expensive. Groundwater typically occurs in fractures of bedrock rather than in large, deep aquifers that are predictable in yield and depth, as are found in the unconsolidated and semi-consolidated sediments of the coastal plain. Frequently, soils are thin and unsuitable for onsite waste systems. Slopes are pervasive and often steep, sometimes requiring more and larger pumps and leading to a dispersed population, as settlements concentrate linearly along river bottoms.

Appalachian water quality suffers disproportionately from acid rain, especially of sulfates. The acid water can be buffered for drinking. However, it takes a toll on the region's aquatic life, which is costly both for subsistence fishing and for parts of the region that look to recreational angling as an economic asset.

Other airborne pollutants, such as mercury, are potentially more serious in the region than they are nationally. Further, there are areas of elevated, naturally occurring radio nuclides in the groundwater. The mercury, the radio nuclides, historically rapacious extractive industries, and widespread inadequacies in wastewater handling all contribute to significant water-quality problems in the region.

On the positive side of the ledger, the region receives ample precipitation, and as the headwaters area for the entire eastern United States, it has fewer problems with upstream contamination than do communities in the lower Piedmont, coastal plain, and Mississippi River corridor. The corollary of this fact, though, is that the quality of Appalachian waste treatment is linked directly to the costs and risks of surface water treatment downstream, in the rest of the eastern United States.

Another positive environmental factor is that the soils support an abundance—indeed, a huge diversity—of plant life, notably trees, both hardwoods and softwoods. Where the forest cover has been restored since its historic clearing from 1871 to 1930, or where it has expanded as a result of the reduction in grazing on ridges, the canopy and the riparian vegetation help stabilize soils and minimize suspended sediment in rivers and streams.

Topography, Geology, Soils, Precipitation, and Groundwater

The physiographic province map (Figure 1-2 in the report) includes shaded relief showing topography in Appalachia. The region includes all the mountain areas of the eastern United States south of New England. Also, it extends into piedmont terrain on the east and into interior plains on the west and the south. Topology, geology, soils, precipitation, and groundwater all are intimately related. Ultimately they are important to consideration of a region's comparative advantages, disadvantages, and costs in delivery of water and wastewater services. This appendix discusses these environmental factors in detail by physiographic province, except for precipitation.

Regarding precipitation, it suffices to say that the region as a whole receives an abundance. Average annual precipitation ranges from somewhat less than 36 inches in parts of Maryland, Pennsylvania, Virginia, and West Virginia to more than 80 inches in parts of southwestern North Carolina.[121] The high-precipitation

---

[121] Most of the information in this chapter on geology and its consequences for the water resources of Appalachia is extracted from Henry Trapp Jr. and Marilee A. Horn, *Atlas of the*

areas of the Blue Ridge Province in southwestern North Carolina are temperate rain forests, with annual precipitation exceeded in the mainland United States only by parts of the Pacific Northwest. These are the first mountainous areas to greet the warm moist air that blows in from the Gulf of Mexico, and that is why the rainfall is so high. Correspondingly, as one moves northward across the region in the rain shadows of the major ridges, there are areas of much lower precipitation. For example, the valley in which Asheville is located gets much less rain than the mountains just to Asheville's south and west.

There is a large gradient across Appalachia in the percentage of precipitation that falls as snow, from high-snowfall counties in western New York to a very low percentage of precipitation as snow south of North Carolina.

A similarly large gradient exists in the length of the growing period and the U.S. Department of Agriculture zone ratings for plant hardiness, which are based on average annual minimum temperatures. Appalachia runs from zone 4b through zone 7. Zone 4b includes a small area of Appalachia around Jasper, New York, which has an average annual minimum temperature of – 25°F to – 20°F. Zone 5 includes most of Pennsylvania's Appalachian region, with a further band running down the high mountains on the east side of West Virginia. This area has an average annual minimum temperature of – 20°F to – 10°F. Zone 6 includes the rest of the northern and central areas of Appalachia, as well as the North Carolina and Tennessee mountains down to north Georgia. Here the average annual minimum temperature is – 10°F to 0°F. Finally, Zone 7, encompassing

---

United States: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, West Virginia (Washington, D.C.: USGS, 1997) chapter 730-L (available on capp.water.usgs.gov/gwa/gwa.html), along with related information from other authors of the U.S. Geological Survey's atlases for the relevant physiographic regions, including chapter 730-K for the Appalachian Plateaus and chapter 730-G for the southern portions of the Appalachian Plateaus as well as the Atlantic and Interior Plains..

North Carolina's Piedmont, a small corner of upstate South Carolina, Georgia, the southernmost Tennessee mountains, and all of the Alabama and Mississippi Appalachian region, has average annual minimum temperatures of 0°F to 10°F.[122]

The Appalachian Plateaus

The Appalachian Plateaus province, especially in the Allegheny Mountain, Kanawha, Cumberland Plateau, and Cumberland Mountain sections, is characterized by high, sharp ridges, low mountains, and narrow valleys—in some places extremely narrow, where rivers have dissected the plateaus but remaining rock has resisted weathering and erosion. In the more southerly, Cumberland part of the province, folding, faulting, and uplift, followed by differential erosion, has produced long, steep ridges running parallel from southwest to northeast. Elevation of the Highlands ranges from 1,000 to 4,500 feet, with a few peaks higher, notably Spruce Knob (4,861 feet), the highest point in West Virginia. Local relief generally ranges from 1,000 to 2,500 feet. The bedrock, generally Devonian shale and siltstone, Mississippian carbonates and sandstones, and Pennsylvanian shale, sandstone, and coal, is overlaid by residuum, colluvium, and alluvial material.*]*Sandstone and some of the tougher carbonates hold up most of the upland portions; weaker carbonates and shale underlie most valleys.[123]

The Allegheny Mountain, Kanawha, and Cumberland Plateau sections are underlain by rocks that are continuous with those of the Valley and Ridge

---

[122] United States Department of Agriculture, *Plant Hardiness Map of the United States* (Washington, D.C.: USDA, 1990).

[123] Chapter 18 of *Ecological Subregions of the United States*, W. Henry McNab and Peter E. Avers, comps. (Washington, D.C.: U.S. Forest Service, 1994).

province, but in the plateaus the layered rocks are nearly flat-lying or gently tilted and warped, rather than intensively folded and faulted. The boundary between the two provinces is a prominent southeast-facing scarp called the Allegheny Front, or the Cumberland Escarpment in the southern part. The scarp faces the Valley and Ridge Province, and throughout most of the segment, the eastern edge of the Appalachian Plateaus Province is higher than the ridges in the Valley and Ridge.

Most of the precipitation that falls on the Plateaus moves quickly down the slopes, rather than sinking into the typically thin soils. Thus there is not as ample a bedrock aquifer as in the Valley and Ridge Province.

The chemical quality of water in the freshwater parts of the bedrock aquifers of the Appalachian Plateaus province is variable but usually satisfactory for municipal supplies and other purposes. Most of the water in the upper parts of the aquifers is not greatly mineralized and is suitable, or can be made suitable, for most uses. However, fresh groundwater generally circulates only to shallow depths in the Appalachian Plateaus province. In much of the area, saline water or brine is not far below the land surface, with only a thin transition zone between freshwater and saltwater. Around Pittsburgh, Pennsylvania, for example, wells drilled deeper than 100 feet below the level of the nearest major stream often yield saline water. West Virginia developed a salt industry in the eighteenth century based on its saltwater springs. Daniel Boone and other explorers and settlers in Kentucky sought the salt licks at the western edge of the Appalachian plateaus and on into the Bluegrass (for example, the Licking River).

The origin of the brine is uncertain. One explanation is that salt has leached from deposits of rock salt found in rocks underlying much of western Pennsylvania, Maryland, Virginia as well as West Virginia. In southwestern Pennsylvania the consolidated rocks nearest the surface are mostly

Pennsylvanian in age. Pennsylvanian rocks are the principal coal-bearing formations and consist of cyclic sequences of sandstone, shale, conglomerate, clay, coal, and minor limestone. The sandstones are the most productive aquifers, although coal beds and limestones also yield water. The limestones, however, are thin compared with those of the Valley and Ridge province.

The Appalachian Plateaus Province in Maryland is only in Garrett County (home of the Accident case study—see appendix E) and the adjoining western one-third of Allegany County. Rocks of Pennsylvanian age cover most of the Plateaus area, but Mississippian and Devonian rocks are exposed along the crests of northeast-trending anticlines and in some of the deeper valleys. The Pennsylvanian and upper Mississippian geologic formations and their water-yielding characteristics are similar to those of Pennsylvania. Yields of wells completed in Pennsylvanian rocks range from 20 to 430 gallons per minute, but yields of wells completed in Mississippian strata range only from 20 to 180 gallons per minute. Devonian rocks in Maryland yield only small quantities of water.

The water-yielding geologic units of West Virginia are similar to those of Pennsylvania, except that the sandstones of the Mauch Chunk Groupyield little water, and the Mississippian Greenbrier Limestone locally is a productive aquifer. The Greenbrier Limestone is exposed primarily in parts of Tucker, Randolph, Pocohontas, Greenbrier, and Monroe counties in the southeastern part of the state. Yields of wells completed in Permian and Pennsylvanian sandstones range from 5 to 400 gallons per minute. Yields from wells in the Greenbrier Limestone range only from 5 to 100 gallons per minute, but some springs that issue from the Greenbrier, as in the White Sulphur Springs area, discharge 1,000 gallons per minute or more.

The Appalachian Plateaus province in Virginia covers Buchanan and Dickenson counties and small parts of several adjoining counties in the southwestern corner of the state. The principal water-yielding geologic units are sandstones of the Harlan, the Wise, and the Lee formations of Pennsylvanian age, and the Mississippian Greenbrier Limestone. Water from these aquifers is used mainly for domestic supply because well yields are generally less than 12 gallons per minute from the Pennsylvanian aquifers and less than 50 gallons per minute from the Greenbrier Limestone. Many of the sandstone beds in the Pennsylvanian rocks are tightly cemented and are less permeable than the coal beds, which tend to be highly fractured and thus yield water. Some deep coal mines in this area are reported to be dry. This suggests that water-bearing fractures in all the rocks extend only a few hundred feet below the land surface.[124]

In the Appalachian Plateaus, active, underground mining of coal disturbs the natural system of groundwater flow. Mines use artificial drains to dispose of unwanted water. Mines can create new fractures and thus increase the permeability of the soil. When the drains are effective, they can lower the regional water table, and the directions of groundwater flow can change in some cases until flow moves across former groundwater divides into adjoining basins. Groundwater tends to flow toward mines, which usually have pumps removing water from them. Adverse effects of mine drainage on well yields are greatest where the mines are not much deeper than the bottoms of the wells and where vertical fractures connect the aquifers and the mines. Abandoned mines can collapse. This causes fracturing of the rocks that overlie the mine and also may leave a depression on the land surface.

---

[124] *Ibid.*

The Valley and Ridge Province

The Valley and Ridge province is a series of parallel, narrow valleys and mountain ranges (high ridges) trending southwest to northeast, created by differential erosion of tightly folded, intensely faulted bedrock. The Great Valley is its eastern edge, butting against the west side of the Blue Ridge province. On the west the province is bordered by the steep, high ridge of the Allegheny, Kanawha, and Cumberland escarpments. In the middle section, the alternating valleys and ridges trend northeastward from southwestern Virginia to east-central Pennsylvania and then eastward toward northern New Jersey. In the Tennessee section, the province extends southwestward through Tennessee into northern Georgia and Alabama. Elevation ranges from 300 to 4,000 feet. Local relief is 500 to 1,500 feet. As the result of repeated cycles of uplift and erosion, resistant layers of well-cemented sandstone and conglomerate form long, narrow mountain ridges and less-resistant, easily eroded layers of limestone, dolomite, and shale form valleys. The rocks of the province range in age from Cambrian to Pennsylvanian. Parts of this province from central Pennsylvania into New Jersey have been glaciated, and glacial deposits fill or partially fill some of the valleys.

The Great Valley itself is worth separate mention as the main historical pathway—from Native American times through the present—for humans through Appalachia from north to south. It is the most pronounced and persistent valley in the Valley and Ridge province, floored with easily eroded rock, such as shale, slate, and carbonate rocks. Generally it ranges from 10 to 20 miles wide, but it is much narrower in and near Roanoke County, Virginia. Part of the eastern boundary of the Great Valley is a zone of thrust faulting; crystalline rocks of the Blue Ridge province have been shoved northwestward tens of miles over Paleozoic sedimentary rocks in places. The western boundary of the valley is the first mountainous ridge of resistant sedimentary rock.

The part of the Valley and Ridge province northwest of the Great Valley consists of persistent mountain ridges underlain by resistant sandstone, conglomerate, and quartzite, which alternate with valleys floored with shale or slate and carbonate rocks. A relatively thick layer of soil has developed in this region, especially in the valleys. Drainage patterns generally follow the marked topography, which itself follows the pattern of resistant versus weak rocks, with a major stream down every valley. Such streams are called "subsequent streams." Major streams and their tributaries intersect at right angles to form a rectangular stream network called a "trellis drainage pattern."

For example, in the Shenandoah Valley, which is part of the Great Valley in Virginia and West Virginia, the Shenandoah River flows northward to join the Potomac River. The Shenandoah River follows a band of weak and soluble rocks as the course of least resistance, as do most of the other rivers in the Valley and Ridge province.

A few major rivers, however, such as the Lehigh and the Susquehanna rivers in Pennsylvania, the Delaware River between Pennsylvania and New Jersey, and part of the Potomac River in West Virginia, Maryland, and Virginia, cut directly across the ridges and valleys. Such streams are called "superimposed streams." The Susquehanna River, for example, crosses six major ridges within 50 miles upstream from Harrisburg, Pennsylvania.

The principal aquifers in the Valley and Ridge Province from Virginia through New Jersey are carbonate rocks (mostly limestone) and sandstones that range in age from early to late Paleozoic. The sedimentary formations of the Valley and Ridge Province are commonly thick and steeply tilted. Thus a water well usually penetrates only the consolidated rock formation exposed at the surface. Therefore, geologic maps are good guides to the type of rock from which a well can withdraw water. The Valley and Ridge Province is widest in Pennsylvania and contains more geologic units there. The Great Valley in Pennsylvania is floored with lower Paleozoic carbonate rocks and shale. Principal water-yielding geologic units are limestone and dolomitic limestone of the Waynesboro Formation through the St. Paul Group (Cambrian and Ordovician ages), with well yields reported to range from 25 to 210 gallons per minute. Yields from sandstone of the Martinsburg Formation, by contrast, range only from 10 to 30 gallons per minute. Northwest of the Great Valley, the uppermost Paleozoic rocks in central to northeastern Pennsylvania are coal-bearing beds of Pennsylvanian age mostly associated with the anthracite coal fields, where deeply infolded beds of coal were preserved from erosion. The processes of folding and deep burial drove off most of the volatile content of the bituminous coal in the more intensely folded areas and converted it to anthracite.

The Valley and Ridge Province extends through most of the Maryland Panhandle, but the Great Valley part is restricted to Washington County. The Great Valley in Maryland is floored with predominately carbonate rock and shale of Cambrian and Ordovician ages. The principal water-yielding units are the Tomstown Formation through the Beekmantown. Well yields commonly range from 25 to 400 gallons per minute. West of the Great Valley, sandstones of Ordovician to Devonian age are the principal aquifers but commonly yield less than 120 gallons per minute. Locally, yields of as much as 100 gallons per minute are reported for wells in limestone of late Silurian and early Devonian age.

In West Virginia the Great Valley part of the Valley and Ridge Province is only in Jefferson and Berkeley counties and is underlain mostly by carbonate rocks of Cambrian and Ordovician ages (Tomstown Dolomite through Black River Limestone) that typically yield about 35 gallons per minute to wells. Locally, wells completed in these rocks yield as much as 600 gallons per minute, however, and some springs that issue from the rocks discharge from 1,000 to 5,000 gallons per minute.

The Valley and Ridge Province in western Virginia extends from Clark and Frederick counties almost to the North Carolina state line. The Great Valley in Virginia is floored primarily by carbonate rocks and shale of Cambrian and Ordovician ages, with well yields commonly from 150 to 1,000 gallons per minute.

The carbonate rocks that are mostly in the valleys receive recharge from precipitation that falls directly on the valley floors, as well as from runoff from the adjacent ridges. Highly permeable solution zones that have developed by the enlargement of joints and other openings collect and channel the water. "Sinkholes," which are closed depressions in the land surface that form where part of the roof of a solution cavity has collapsed, form a direct connection from the land surface to a carbonate aquifer. Surface runoff can move directly into a sinkhole, as can groundwater in the soil that overlies the carbonate rocks. Recharge to the aquifer through sinkholes takes place very quickly, and any contaminants at or near the land surface can move directly into the aquifer. Surface water that is channeled into small streams in the valleys can leak downward through the streambed to recharge the aquifer in places where the water table of the aquifer is lower than the water level in the stream.

Along with sinkholes, the water and the carbonate rocks produce caves. The Southeast has about two-thirds of all U.S. caves that are more than 3 kilometers long, and many of them are in Appalachia. Mammoth Cave, mostly in Edmonson County, Kentucky, at the eastern edge of Appalachia, is the world's largest recorded cave system.[125]

---

[125] Peter White et al., *Environments of the Southeast* (Delray Beach, Fla: St. Lucie Press) (online).

Although springs issue from some of the aquifers in all the physiographic provinces of Appalachia, large springs are most characteristic of the Valley and Ridge Province. Flow is particularly large for springs that issue from the carbonate rocks. Three types of springs are common, and all result from groundwater movement driven by the force of gravity. “Contact springs” form where water-saturated permeable material overlies less-permeable material. The water comes to the land surface at the contact of the two types of material, and the springs might issue where the contact intersects a sloping land surface. Contact springs are common in the Valley and Ridge Province, but generally they discharge only small volumes of water.

“Impermeable-rock springs” are fed by fractures, joints, or bedding planes in rocks that have low intergranular permeability. Small springs of this type that issue where a vertical joint intersects a bedding plane and that generally discharge only small volumes of water are typical of parts of the Appalachian Plateaus Province but exist also in the Valley and Ridge province.

“Tubular springs” issue from solution channelsin carbonate rocks. These are typically the largest flow springs because they can have extensive networks of tributaries underground and the large openings transmit large quantities of water. For example, in Pennsylvania, 90 percent of the springs that discharge 100 gallons or more per minute issue from Ordovician and Cambrian limestones and dolomites. Most of those that discharge more than 2,000 gallons per minute issue from limestone.

Water in the aquifers from which the springs issue can be either confined or unconfined. Springs that issue from aquifers containing confined water are called “artesian springs.” Springs that issue from aquifers containing unconfined water are called “gravity springs.” Some of the springs in the Valley and Ridge Province discharge water that is distinctly warmer than the average air temperature. Most of the thermal springs in the eastern United States are in the Valley and Ridge Province. The spring waters have become naturally heated by deep circulation of the water to levels where the rocks are substantially warmer than the average surface temperature of Earth.

The chemical quality of water varies in the aquifers of the Valley and Ridge Province but is generally suitable for municipal supplies and other purposes. Most of the water in the upper parts of the aquifers is not greatly mineralized and is suitable for drinking and other uses. However, the deep parts of the aquifers contain saline water in many places, and brackish water has been reported locally from zones as shallow as 90 feet below the land surface in valleys near the West Branch of the Susquehanna River in Pennsylvania.

The Blue Ridge Province

The long series of ridges that make up the Blue Ridge province consists of very old crystalline rock (Precambrian in parts, dating in places to 1.2 billion years) that is relatively resistant to weathering and erosion. The subsurface of the Blue Ridge province varies greatly in mineral composition, but the hydraulic characteristics are similar across the area: there are almost no pore spaces in which water can accumulate, so groundwater exists mainly in joints and fractures of the rock.

The Blue Ridge Province includes a narrow belt of rounded, gentle knobs of diverse altitude slightly higher than the adjacent Piedmont province running through Virginia and Maryland to Pennsylvania and northern New Jersey. This northern area of the Blue Ridge lies outside Appalachia, however, so this report views the province as running south from the Roanoke Gap into northern Georgia. The eastern boundary of the Blue Ridge province is the Blue Ridge front, or escarpment, which is a single, abrupt slope, commonly marked by faulting. The Blue Ridge front rises more than 1,700 feet above the Piedmont surface near the North Carolina/Virginia state line and reaches a maximum height above the Piedmont of nearly 2,500 feet in central North Carolina. The Blue Ridge Province contains the tallest mountains, the highest altitudes (greater than 6,000 feet), and the most rugged topography in eastern North America. The southern part of the province has steep, forest-covered slopes cut by numerous stream valleys. The valleys of the major rivers include broad, gently rolling areas as well as narrow gorges. The province reaches a maximum width of 70 miles in North Carolina. The province as a whole includes more than forty-six peaks higher than 6,000 feet in elevation. About 80 percent of the province is made up of low mountains.[126] Kephart, in his classic 1913 narrative, estimated that mountains with slopes of 20 percent to 40 percent covered 90 percent of western North Carolina.[127]

The quality of water from aquifers in the different rock types of the Piedmont and Blue Ridge provinces is similar. The water generally is suitable for drinking and other uses, but iron, manganese, and sulfate occur locally in objectionable concentrations. Concentrations of dissolved solids in water from these aquifers average about 120 milligrams per liter. The water is soft; hardness averages about 63 milligrams per liter. Also, the water is slightly acidic; the median hydrogen ion concentration, which is measured in pH units, is 6.7 (on a scale of 1–14, 7 being neutral). The median iron concentration is 0.1 milligram per liter, but concentrations as large as 25 milligrams per liter have been reported. Large iron concentrations can be caused by corrosion or the action of iron-fixing

---

[126] Chapter 18 of *Ecological Subregions of the United States*.

[127] Horace Kephart, *Our Southern Highlanders: A Narrative of Adventure in the Southern Appalachians and a Study of Life among the Mountaineers* (1913; reprint, Knoxville, Tenn.: University of Tennessee Press, 1976), 28–29.

bacteria on iron and steel casings and well fittings. Some crystalline rocks and some sedimentary rocks in early Mesozoic basins contain minerals that, when weathered, can contribute iron and manganese to groundwater, particularly if the water is slightly acidic. Treatment of the water usually will cure problems of excess iron and manganese.

Groundwater recharge is highly variable in the Blue Ridge and Piedmont provinces because it is determined by local precipitation and runoff, which themselves are highly variable, influenced by topographic relief and the capacity of the land surface to accept infiltrating water. Most of the recharge in the Piedmont and the Blue Ridge provinces takes place between streams. Almost all recharge is from precipitation that enters the aquifers through the porous regolith. Much of the recharge water moves laterally through the regolith and discharges to a nearby stream or depression during or shortly after a storm or another kind of precipitation. Some of the water, however, moves downward through the regolith until it reaches the bedrock, where it enters fractures in crystalline rocks and sandstones, or solution openings in carbonate rocks.

Well yields for all types of crystalline rocks generally are small. A recent study reported an average yield of 18 gallons per minute for wells completed in these rocks in North Carolina. Only about three percent of wells encounter no fractures and are either dry or will not have a sustained yield. Where the rock is fractured only near the surface, wells will yield from 10 to 20 gallons per minute until—in a short time—the fractures are drained. Then well yield suddenly declines. Where several fractures connected to the regolith are penetrated by a well, moderate sustained yields are possible, whereas a well that encounters numerous closely spaced fractures is most likely to have a high sustained yield. Wells in valleys, draws, and depressions tend to have higher-than-average yields. Draws on the sides of the valleys of perennial streams where a thick blanket of regolith underlies the adjacent ridges are the best sites for wells with large yields. A statistical analysis that related well yield to topographic setting in the Piedmont and the Blue Ridge provinces of North Carolina indicated that wells drilled in valleys or draws have average yields three times those of wells located on hills or ridges.

Groundwater discharge to a stream (base flow) is an indication of the maximum sustained groundwater yield. The percentage of stream flow composed of base flow is determined by the infiltration capacity of the soil and the capacity of the underlying aquifers to store and transmit water. In part of the Piedmont Province in southeastern Pennsylvania, base flow ranges from 57 percent to 66 percent of stream flow in drainage basins that are underlain predominately by crystalline rocks, and 77 percent in a typical basin that is underlain by carbonate rocks. It ranges from 33 percent to 67 percent of stream flow in three drainage basins that are underlain by crystalline rocks in the Piedmont and the Blue Ridge provinces of Maryland, and from 32 percent to 65 percent (average 44) in ten crystalline-rock drainage basins in the Piedmont of North Carolina.

The Piedmont Province

The Piedmont, literally “foot of the mountain,” rises from the eastern coastal plain gradually to the Blue Ridge Mountain front. It has much the same bedrock as the Blue Ridge province: metamorphic and igneous rocks ranging in age from Precambrian to Paleozoic that have been sheared, fractured, and folded—but there also are sedimentary basins—such as the Richmond basin and the Dan River–Danville basin—that formed along rifts in Earth’s crust and contain shale, sandstone, and conglomerate of early Mesozoic age, interbedded locally with basaltic lava flows and minor coal beds. The sedimentary rocks and basalt flows are intruded in places by diabase dikes and sills. Headward erosion by the streams draining to the east accounts for the area being in lower relief than the adjoining highlands. The eastern boundary of the Piedmont province, called the "fall line," where the harder crystalline bedrocks meet the semiconsolidated sediments of the coastal plain, is outside Appalachia. The western boundary ranges in altitude from 350 to 700 feet above sea level in Pennsylvania, rising to 700 or 800 feet above sea level in northern Virginia. Farther south, where Appalachia intersects the Piedmont near the Virginia/North Carolina line, it rises to about 1,500 feet above sea level.[128] In places, remnant structures have resisted erosion, leaving exposed granitic domes and outcroppings called "monadnocks." Examples are Hanging Rock, Sauratown Mountain, Pilot Mountain, Stone Mountain, Table Rock, along the eastern side of Linville Gorge in North Carolina, and Stone Mountain, in Georgia.

A general difference exists between Appalachian subsurface conditions from the Blue Ridge east and the entire eastern seaboard: fractured bedrock in the Highlands versus some sedimentary material in the Piedmont and extensive layers of sedimentary rock in the Coastal Plain. The harder, crystalline subsurface of Appalachia in the Blue Ridge is reflected in thinner soils, less certain availability of water for wells drilled in a given location, and greater complexity in assessing the source and the extent of contaminated groundwater .

The Atlantic Plain and Interior Plains Provinces

Part of Appalachia includes coastal plain topography: the southernmost Appalachian counties in Alabama and all the Appalachian counties in Mississippi. All but a portion of one county in Mississippi are classified as East

[128] Chapter 18, *Ecological Subregions of the United States*.

Gulf Coastal Plain physiography. The counties on the far west of Appalachia, going as far north as south-central Ohio, are in the Interior Plains province.

The subsurface geology of the Coastal Plain counties is conceptually like that of the Atlantic Coastal Plain. That is, unlike the Appalachian Highlands, the Coastal Plain counties lie on relatively flat sedimentary rocks that form layer-cake-like layers, most of which are more permeable than the rocks of the Highlands and thus can serve as productive aquifers. The Appalachian Plateau and Interior Plain areas of Alabama, Tennessee, Kentucky, and southern Ohio have a cap of resistant sandstone that creates the large, undissected mesas of the Cumberland Plateau and the Interior Low Plateaus. These are bounded at the interface with the Coastal Plain by steep slopes where erosion has removed the sandstone cap and weathering has exposed the underlying sedimentary strata.

The most productive aquifers across the Atlantic Plain and Interior Plains are limestone layers that lie beneath the sandstone and other Pennsylvanian-age rock cap, and that are exposed in the Interior Plains in wide valley floors. Gaps and cracks in the limestone are expanded by slightly acidic water, producing the cave systems, large springs, and often complex Karst topography. Wells in the limestone of the region produce reported flows as high as 4,000 gallons per minute. Wells in the remaining sandstone cap layers may be adequate for domestic consumption but are unlikely to produce flows greater than 200 gallons per minute.

The rock layers throughout the region, as well as into the Valley and Ridge province, are fairly continuous, but in the Valley and Ridge province they have been folded dramatically, changing the hydrology. Because the rock units are continuous across broad regions, the aquifers are not generally named, as they are in the western United States and on the Atlantic Coastal Plain, but the water-bearing characteristics of particular layers is reasonably well known. Across much of the area, there are confining shales beneath the productive limestone, with further water-bearing layers under the shale aquitard, but these lower layers often have brackish water. The groundwater quality in the higher water-bearing layers across the regions is variable, with much of the water suitable after treatment for domestic purposes, but with many areas having high concentrations of sulfur compounds and iron.

Topographic relief in the Atlantic Plain is low, with maximum elevations typically ranging from 150 to 450 feet above sea level. Elevation in the Interior Low Plateaus is typically 900–1,000 feet above sea level.

Land Use and Land Cover

The fecund forest of Appalachia has been noted since the days of the earliest European visitors. John Banister, Oxford graduate, early botanist, and founder of the College of William and Mary, wrote in 1680,

> This is a Country excellently well water'd & so fertile that it does or might be made yield anything that might conduce to the pleasure or necessity of life. But want of Peace, too much land & the great crops of Tobacco men strive to make hinder Virginia from improving.[129]

In 1797, Louis Philippe, who would become King of France in 1830, toured the region with his two brothers and noted,

> We rode through hilly, picturesque country in the foothills of the Montagnes Bleues, which run from southwest to northeast and are the first range in from the coast. They are not high. There is little or no bare rock to be seen.

---

[129] John Banister, Letter to Dr. Robert Morison, reprinted in *The Height of Our Mountains: Nature Writing from Virginia's Blue Ridge Mountains and Shenandoah Valley*, eds. Michael Branch and Daniel Philippon (Baltimore: Johns Hopkins Press, 1998).

> The slope is not precipitous, and the forest stretches uninterruptedly to the summits . . . The view from the far slopes of the Blue Ridge Mountains would be very beautiful if only the trees did not obscure it . . . The banks of the [Shenandoah] River are charming, and this whole region looks like Switzerland.[130]

As recently as 1902, James Wilson, a trained observer, noted that

> …remote from the railroads the forest on these mountains is generally unbroken from the tops of ridge and peak down to the brook in the valley below, and to-day it is in much the same condition as for centuries past . . . The lumberman attacked this forest several decades ago when he began to penetrate it in search of the rarer and more valuable trees, such as the walnut and cherry. Later, as the railroads entered the region to some extent, he added to his list of trees for cutting the mountain birch, locust, and tulip poplar, and successively other valuable species. During the past few years he has cut everything merchantable . . . In these operations there has naturally been no thought for the future . . . The hope and permanent interests of the lumberman are generally in another State or region, and his interest in these mountains begins and ends with the hope of profit. There is, however, no evidence that the native lumberman has in the past exhibited any different spirit.[131]

---

[130] Louis Phillipe, King of France, Diary of My Travels in America (1797), reprinted in *The Height of Our Mountains*.

[131] James Wilson, Report on the Forests and Forest Conditions of the Southern Appalachian Region (Washington, D.C.: Government Printing Office, 1902), reprinted in *The Height of Our Mountains*. Wilson was secretary of agriculture under Presidents McKinley, Roosevelt, and Taft. He personally visited the region and indicted the forestry practices then under way, in text and photographs.

Wilson's observations were prescient: with the coming of the railroads from 1870 to 1930, the forests of the region were nearly all cut. Ronald Eller, Ronald Lewis, and John Alexander Williams have written histories of the deforestation of Appalachia.[132] This clear-cutting of the region had profound negative effects on water quality and quantity—namely, huge losses of already rare topsoil, and devastating floods.

Woody cover across the region may be increasing. However, some experts believe that forest cover peaked in the 1960s and now is declining because of changes in the frequency of fires and the aging and demise of old-field pine that colonized many abandoned farms across the region in the mid and late nineteenth century.[133] Timber is both a source of economic opportunity for many in the region and an integral component of the region's water-quality system.

Ambient Water Quality

The adage "What goes in, comes out" has enormous public health repercussions in the context of the quality of water used for drinking water. The connection between wastewater services and water quality is equally strong. In most cases the quality of bodies of water receiving discharge is the primary factor that dictates wastewater treatment requirements. Some of the highest-quality and

[132] See Ronald D. Eller, *Miners, Millhands, and Mountaineers: Industrialization of the Appalachian South, 1880-1882* (Knoxville: University of Tennessee Press, 1982); Ronald L. Lewis, *Transforming the Appalchian Countryside* (Chapel Hill: University of North Carolina Press, 1998); Ronald L. Lewis, "Railroads, Deforestation, and the Transformation of Agriculture in the West Virginia Back Counties, 1880-1920," in *Appalachia in the Making: The Mountain South in the Nineteenth Century*, eds. Mary Beth Pudup, Dwight B. Billings, and Altina L. Waller (Chapel Hill: University of North Carolina Press, 1995), 297–320; John Alexander Williams, *Appalachia: A History* (Chapel Hill: University of North Carolina Press, 2002), 246–259.

[133] White et al., *Environments*.

most outstanding resource waters in the eastern United States are in Appalachia. This is not surprising, given the abundant precipitation, the remaining forest cover, and the headwaters location of most Appalachian streams. Fly fishing in Virginia's highlands dates back at least to 1851.[134] The New River and its tributaries have world-class fishing for smallmouth bass. Recreational paddlers also revere Appalachian waters, including the Youghiogheny, the Cheat, the Gauley, the Pigeon, the Obed-Emory system, the Ocoee (site of the 1996 Summer Olympics whitewater venue), the Nantahala, the Chattooga, and the New River gorge itself, a national park. Steep creek headwaters draw the sport's elite and deranged. The Greenbrier and New rivers provide experiences that are extremely rare in the eastern United States: multi-day raft trips with excellent float fishing. Commercial guides and companies renting recreational equipment, as well as people able and willing to offer shuttles and advice, have benefited from this water-centered market. The outdoor-adventure business is the biggest employer in several jurisdictions in the region.

High-quality, high-quantity water also is reflected in the diversity of water-dependent species, both amphibians and fish. "The southern Appalachians are a world center of diversity for salamanders and have 68 species of a unique group of lungless salamanders that evolved in this region of well-oxygenated streams and high rainfall," writes Peter White and colleagues.[135] Appalachia is a major contributor to the southeastern United States' status as the richest region for

---

[134] See Philip Pendleton Kennedy, *The Blackwater Chronicle* (1853; 2d ed., Morgantown, W.Va.: West Virginia University Press, 2002). The Blackwater River, now in West Virginia, was the site of a fishing expedition in 1851 by Kennedy, David Hunter Strother, and other anglers.

[135] White et al, *Environments*

.

diversity of freshwater fish of any temperate area of comparable size in the world. [136]

However, as White and his colleagues point out, this diversity is largely attributable to the numerous narrowly restricted endemic species in a lot of the headwater streams. Many of these species depend on very good water quality and are accordingly threatened by changes in the environment that might not be as significant in ecologies involving larger, downstream bodies of water. Thus White and his colleagues find a much higher percentage of species endangered or threatened in Appalachia than in other parts of the Southeast (see Table F-1).

Table F-1. Endangered or Threatened Species, by Region

Faunal Region	Percent of Species Endangered or Threatened
Southern Appalachians	18.3
Interior Plateau	11.4
Atlantic Slope	7.1
Lower Appalachicola River basin	6.3
Lower Mississippi River	6.0
Lower Mobile River basin	4.9
Peninsular Florida	4.1

Source: Peter White et al., *Environments of the Southeast* (Delray Beach, Fla.: St. Lucie Press).

Some writers, Harry M. Caudill among them, have viewed Appalachia's abundance and high quality of water as great assets.[137]Federal policy makers

---

[136] Peter White et al., *Environments of the Southeast* (Delray Beach, Fla: St. Lucie Press), available on biology.usgs.gov/s+t/SNT/noframe/se130.htm..

[137] See Harry M. Caudill, *The Watches of the Night* (Boston: Little, Brown, 1976), 253–54, on water as the future of the region.

should realize that Appalachia is home to the headwaters of almost all the important rivers of the eastern United States and thus whatever happens for better or worse to Appalachian waters has major consequences for the nation as a whole.

Appalachia also is home to some serious problems with ambient water quality. Recent reports submitted by the Appalachian states to the Environmental Protection Agency (EPA), as required by Section 305(b) of the Clean Water Act of 1972, contain lists [required by the Section 303(d)] of water segments in each state that are too polluted to attain their designated use (swimming, fish consumption, drinking, aquatic life, and other purposes). The Section 303(d) list is updated in even years. The lists and their associated narratives in the Section 305(b) reports give a snapshot of ambient water quality in the Appalachians at the start of the twenty-first century. Most states in the United States began assessing their stream quality by or before the 1950s, but the evaluations were not systematic in method or universal in coverage. The Section 305(b) reports have serious limitations, but given that the United States has no real national accounting of the extent and the costs of water pollution, they are a reasonable second-best assessment.

Some particularly important qualifications regarding the Section 305(b) reports are that (1) they provide a snapshot only of waters actually sampled during a certain period of record; (2) the sampling in every state is far from being any kind of full monitoring system; (3) states differ in how they interpret "impairment" of waters; (4) states in the region rarely do much biological monitoring in the uppermost reaches, the ones that are most characteristic of Appalachia and provide much of the habitat for threatened and endangered species; and (5) the ephemeral and intermittent segments, and the remaining wetlands, which contribute disproportionately to ultimate, downstream water quality, are rarely assessed or discussed in these reports.

There also has been criticism of recent state assessments of impaired waters because the stakes have changed for the states in light of EPA's and the courts' recent push for development of total maximum daily loads (TMDLs) for impaired waters. Some critics claim that the need to generate TMDLs is leading states to undercount their impaired waters. Undoubtedly, TMDL development is a difficult, resource-intensive effort for each of the states in Appalachia, one that poses real administrative challenges for the its water-quality regulators. The requirement to develop TMDLs has not generally been coupled with a significant commitment of new resources. Undoubtedly also, states exercise much discretion in how they use attainment determinations. Sampling locations and times; the actual standards; the approach to biological, metals, and other types of testing; and accounting for drought and other unusual conditions all differ somewhat across the states. Thus it is not possible to make a meaningful comparison of the number of stream miles considered impaired in one state versus the number considered impaired in another state, and this report does not attempt such a comparison.

Nonetheless, the Section 305(b) reports constitute the best extant data sets across all the states in Appalachia for assessing ambient water quality. If a state deems a water body to be impaired and includes it in its Section 303(d) list, that water body certainly has some significant water-quality problems.

The physiographic subregions of Appalachia correspond in most ways to the major divisions between river basins. By grouping the U.S. Geological Survey's hydrologic unit classifications at the fairly general four-digit level, one can begin to see how the river systems of the region map onto the physiographic regions.

Water Quality of the Appalachian Plateaus and Interior Plains

All the river basins in West Virginia are in Appalachia, and they drain the Appalachian Plateaus province, except for rivers on the eastern and northern borders of the state, such as the Upper James and the Upper Potomac. West Virginia's 2004 Section 303(d) list identifies 878 impaired streams, covering about 6,170 stream miles. This is an increase from the 2002 list (667 streams, covering 4,374 miles), due in large part to increased monitoring.

The most common numeric water-quality criteria impairments still are those related to mine drainage, bacterial contamination, and acid rain. As with streams in Kentucky, Pennsylvania, and Virginia, there are substantial water-quality problems with legacy mine-drainage-impaired in West Virginia. Mine-drainage streams often are impaired by acidity (low pH) and/or elevated concentrations of metals, including iron, aluminum, and manganese. Many of these streams also fail tests of biological integrity (ability to support aquatic life). West Virginia's 1998 Section 303(d) list included 488 streams affected by mine drainage, and the 2002 list contained 128. TMDLs have been developed for streams impaired by mine drainage in the Cheat River, the Tygart Valley River, Paint Creek, the Elk River, the Buckhannon River, Ten Mile Creek, the Monongahela River, Dunloup Creek, the Tug Fork River, the West Fork River, Guyandotte and Stony River watersheds. West Virginia plans to address the remaining mine-drainage impairments from the 1998 list with a TMDL before March 30, 2008. The 2004 list contains only 80 of the streams listed as impaired by mine drainage on the 1998 list. The 80 streams cover approximately 373 miles.

Pennsylvania has estimated the costs (in 2004) necessary to address the environmental impacts of acid mine drainage in Pennsylvania alone at $16 billion.[138] Most of these impaired waters are in Appalachia. This is a good example of a major water problem in Appalachia for which the costs do not make their way into most water and wastewater needs assessments.

Of its stream miles assessed for purposes of the latest Section 305(b) report, approximately half of which are in the Appalachian Plateaus and half in the Valley and Ridge province, Pennsylvania considers 84 percent to be attaining their designated uses for fish and aquatic life.[139] This means that the biological integrity of the stream and critical chemical parameters such as dissolved oxygen seem adequate for a healthy stream. It does not mean that the water is safe for human recreational contact, because these stream miles still could suffer from fecal coliform or other bacteriological impairments. It also does not take account of problems with contaminated fish tissue. Like most states, Pennsylvania issues advisories on consumption of freshwater fish, mostly because of mercury. Of the 10,762 miles (16 percent) of assessed and impaired stream miles, where causes are known, the major causes of impairment are drainage from abandoned mines, agriculture, and urban runoff. Pennsylvania's 2004 report shows few stream miles assessed for support of recreational use (140 miles) and human health use (1,944 miles).

Many Appalachian waters contain elevated levels of fecal coliform bacteria. Contributors to the problem include leaking or overflowing sewage collection systems, illegal sewage discharges by homeowners through straight pipes or failing septic systems, and runoff from urban or residential areas and agricultural lands. In its 305b report, West Virginia notes that its Section 303(d) list for waters impaired by fecal coliform almost certainly underestimates the number of

[138] State of Pennsylvania, *2004 Integrated 305(b) Report (Draft), Part I (Executive Summary)*.

[139] *Ibid*.

streams with this problem because intensive monitoring (especially of smaller waters higher in the watersheds) has only recently become a priority. This recent targeting effort has increased the number of fecal coliform listings from 29 on the 2002 Section 303(d) list to 185 on the 2004 list. The combined length of waters identified as impaired relative to the fecal coliform is approximately 1,490 miles. This underestimation of fecal coliform contamination is likely true of all the streams in Appalachia.

The headwater sections of many Appalachian Plateau waters are acidic, and this impairs the aquatic community. The impairment is most prevalent in watersheds with soils of low buffering capacity. Usually it is caused by acid precipitation. Some states, such as West Virginia, add limestone to impaired stream segments. This treatment has, in many instances, restored fisheries to some extent.

The following discussion of major river basins in the northern Appalachian Plateaus and their impairment status is based on West Virginia, Pennsylvania, Ohio, and New York Section 305(b) draft reports for 2004.

The Delaware River

Pennsylvania lists several of the Delaware River watersheds in its northeastern corner as impaired by PCBs, mercury, and siltation.

The Susquehanna River

New York's southern tier of counties in Appalachia includes part of the Susquehanna River basin. Broome County has Susquehanna waters impaired by nutrients (Whitney Point Lake) as well as for pathogens (Park Creek and its tributaries). The main stem of the river in Broome, Tioga, Otsego, and Chenango counties is listed as impaired by mercury. White Birch Lake and Beaver Lake in

Broome County are listed as possibly impaired by phosphorus from onsite wastewater systems.[140]

The Guyandotte River

Both the Upper Guyandotte (above the confluence of Island Creek) and the Lower Guyandotte watersheds are impaired by total iron and fecal coliform. The Upper Guyandotte watershed also is impaired by dissolved aluminum and biologically. Numerous Guyandotte River tributaries are affected by pollutants related to mine drainage.

The Kanawha River and Its Major Tributaries (the Gauley, Elk, Coal, New, and Greenbrier Rivers)

The main stem of the Upper Kanawha River (extending upstream to the confluence of the New and Gauley rivers) is impaired by dissolved aluminum. The Gauley River from its mouth to river mile 98.0, the Lower New River from its mouth to river mile 68.2, and the entire length of the Greenbrier River also are impaired by dissolved aluminum. The Lower New River is listed for fecal coliform impairment from river mile 1.2 upstream to river mile 58.2 (near Sandstone Falls, W.Va.), and the Bluestone River is impaired by fecal coliform for its entire length in West Virginia.

The Lower Kanawha River, downstream to its confluence with the Ohio River at Point Pleasant, is impaired by fecal coliform, as are the main stems of the Coal and Elk rivers. A TMDL for dioxin for the Lower Kanawha was completed in 2000.

---

[140] State of New York, *2004 Integrated 305(b) List (Draft)*.

The Monongahela River and Its Major Tributaries (the Cheat, Tygart Valley, and West Fork Rivers)

The main stem of the Monongahela River is impaired for total aluminum, total iron, total manganese, and pH. The entire length of the Monongahela River in West Virginia remains on the 2004 Section 303(d) list for violations of the fecal coliform criteria.

The three major tributaries of the Monongahela River—the Cheat, Tygart Valley, and West Fork rivers—all have undergone TMDL development for total iron, total aluminum, total manganese, and pH. Additionally a section of the Tygart Valley River is impaired by fecal coliform. Finally the main stem of the West Fork River is listed for biological and fecal coliform impairments from its mouth upstream to the Stonewall Jackson Lake tailwater.

Maryland's three counties in Appalachia—Garrett, Allegany, and Washington (Hagerstown)—have some water-quality problems, although perhaps no more, or none of higher priority, than in the more urbanized, downstream areas of the state. Garrett County and a part of Allegany County drain into the Monongahela River basin. The Youghiogheny River has some segments with excessive coliform. There are segments of the Little Youghiogheny impaired for fecal coliform and nutrients, and many of the tributaries in the "Yak" basin fail to meet tests of biological integrity. Some areas of Deep Creek Lake and the surrounding waters still suffer from acid mine drainage.

The Little Kanawha River

A TMDL was finalized in 2000 for the main stem of the Little Kanawha River and several tributaries, for total aluminum and total iron. A small headwater section of the river is impaired relative to pH. The impaired segment begins at river mile 162.1 and extends upstream to the headwaters.

The Ohio River

TMDLs for dioxin and PCB impairments in the Ohio River were developed in 2000 and 2002, respectively, by West Virginia. The 277 miles of the Ohio River passing through West Virginia are impaired from a variety of sources. For the Ohio River as a whole, the Ohio River Valley Water Sanitation Commission has encouraged consistent approaches to Sections 305(b) and 303(d) by jurisdictions with water-quality authority.

The Tug Fork River

A TMDL for main stem of the Tug Fork River was finalized in 2002 for total aluminum and total iron. Additionally, TMDL development for total iron, total aluminum, total manganese, and pH was finalized in 2002 for numerous tributaries of the Tug Fork River affected by mine drainage. The Tug Fork River remains on the Section 303(d) list for biological impairment from mile point 54.2 to its headwaters.

Kentucky Rivers

The main river basins in the Appalachian region of Kentucky are, from north to south, the upper Ohio River, the Little Sandy River–Tygart's Creek, the Big Sandy River, the upper Licking River, the upper Kentucky River, and the Upper Cumberland River. All of them drain the Appalachian Plateaus and the Interior Low Plateaus. Having moved in the mid-1990s to a watershed-based approach to water-quality assessment and issuance of permits, Kentucky completed its first round of systematic monitoring of all its watersheds in 2002, giving a snapshot of the conditions in the wadable streams of the Kentucky highlands. However, the assessment data for the Little Sandy–Tygart's Creek basin was not compiled in time for the 2004 Section 303(d) list.

In the Big Sandy River basin, entirely in Appalachia, Beaver Creek in Floyd County; Levisa Fork in Lawrence, Johnson, and Floyd counties; and the Tug Fork River all are impaired streams of first priority, with more than 128 miles that fail or partially fail to support aquatic life and are unsuitable for swimming. Causes include pathogens from septic systems and straight pipes, siltation, mining, lead, and municipal point-source disposal. In the Little Sandy River–Tygart's Creek basin, also entirely in Appalachian and not fully cataloged (as noted earlier), at least four top-priority streams do not support aquatic life: Hood Creek and the East Fork of the Little Sandy River in Boyd County, Newcombe Creek in Elliot County, and White Oak Creek in Greenup County. TMDLs are in place for the East Fork of the Little Sandy River and for Newcombe Creek.

In the Appalachian portion of the Licking River basin, major portions of the upper Licking River and its tributaries, as well as Fleming Creek do not support aquatic life or swimming. Seriously impaired streams include Burning Fork of the Licking River in Magoffin County, for pathogens from waste; Elk Fork of the Licking River in Morgan County, for siltation and turbidity from logging and mining; Flat Creek of the Licking River in Bath County, for pathogens; the Middle Fork of the Licking River in Magoffin County, for pathogens; Fleming Creek of the Licking River in Fleming and Nicholas counties, for pathogens and excess phosphorus from intensive animal feeding operations and grazing; Fox Creek of the Licking River in Fleming County, for siltation and low dissolved oxygen from logging; Hinkston Creek of the South Fork of the Licking River in Bath and Montgomery counties, for siltation and low dissolved oxygen; Johnson Creek of the Licking River in Magoffin County, for pathogens; Puncheon Camp Creek of the Licking River in Magoffin County, for pathogens; Slate Creek of the Licking River in Bath County, for pathogens; Triplett Creek of the Licking River in Rowan County, for pathogens and excess nutrients; and the Licking River of the Ohio River itself in Magoffin County, for siltation from logging and mining.

In the Fleming Creek basin, Allison Creek, Cassidy Creek, Craintown Branch, Doty Creek, Logan Run, Poplar Creek, Sleepy Run, Town Branch, Wilson Run, and other (unnamed) tributaries all are seriously impaired for pathogens and other pollutants. Little Stoner Creek of Stoner Creek in Clark County, Prickly Ash of Slate Creek in Bath County, Straight Creek and Williams Creek of Elk Fork in Morgan County, and Williams Creek of Elk Fork in Morgan County round out the list of high-priority, seriously impaired Appalachian waters in the upper Licking River basin.

In the upper reaches of the Kentucky River and its tributaries, more than 420 miles of streams are classed as first-priority waters not attaining their designated uses, including the entire 162.6 miles of the North Fork of the Kentucky River through Letcher, Perry, Breathitt, Wolfe, and Lee counties, none of which is safe for swimming because of pathogens from straight piping and other wastewater problems.

Similarly, many miles of the Upper Cumberland River and its tributaries, in Harlan, McCreary, Whitley, Knox, Rockcastle, Bell, Wayne, Cumberland, Laurel, and Pulaski (where mercury from acid rain threatens a federally listed species) counties, are polluted to the point of formal listing as top-priority streams not attaining their designated uses.

In short, every single river basin (and nearly every county) in the Appalachian area of Kentucky has some serious water-quality problems.

Tennessee Rivers Draining the Appalachian Plateaus

All of east Tennessee and a portion of central Tennessee lie in Appalachia, so many of the state's river basins, including the watershed management areas centered in Johnson City, Knoxville, Cookeville, and Chattanooga, are Appalachian waters. However, Tennessee watersheds are not organized by river basins that correspond to the physiographic regions of Appalachia.

From a physiographic point of view, Tennessee rivers divide into those draining the Appalachian Plateaus, those in the Tennessee Valley (which is in the Valley and Ridge province—see the next section), and a small group of upper watersheds in the Blue Ridge province (see Water Quality in the Blue Ridge Province). There are numerous miles of impaired Appalachian streams in each of these regions.

Regarding the basins draining the Appalachian Plateaus, in the Upper Cumberland River basin, Pine Creek and its tributaries, Bear Creek and Roaring Paunch Creek in Scott County, all are impaired by pathogens, metals, and/or silt. To the west, in the Obey River basin, mining and abandoned mines have impaired streams in Clay, Overton, Cumberland, and Putnam counties, and municipal sources have impaired waters in Fentress and Pickett counties. Warren, Coffee, Grundy, and Sequatchie counties share impaired waters in the Collins River watershed, most often from sediment associated with grazing and other changes in riparian cover and use. Similar problems exist in the Smith, DeKalb, Van Buren, White, Bledsoe, Cumberland, and Warren county watersheds of the Caney Fork River.

Despite all these problems, the volume of water-quality problems in the Appalachian region of Tennessee probably is lower than in the urbanized areas, especially around Nashville.

Water Quality in the Valley and Ridge Province

The Tennessee Valley

Still in Tennessee but moving east to the Valley and Ridge province, there are even more substantial water-quality impairments than in the Appalachian Plateaus, as one would expect with the longer, more industrialized history of the Tennessee Valley. In the North and South forks of the Holston River, in Sullivan and Hawkins counties, the impairments vary from mercury historically discharged from industrial sources to sedimentation caused by stream-bank erosion related to grazing and bacteria from animal waste. The impaired stretches of the upper Clinch River in Hancock, Hawkins, and Campbell counties are similarly varied, from pathogens to excess nutrients and unknown toxins. The lower Clinch River, along with the Lower Tennessee River, is contaminated with almost all known pollutants. The Obed-Emory watersheds are greatly impaired by drainage from abandoned mines. The Watauga River basin, in Washington, Carter, and Johnson counties, has a variety of stream segments impaired by agricultural uses. In the Holston River basin, in Knox, Jefferson, Grainger, Hawkins, and Hamblen counties, there are waters impaired by pathogens, silt, and metals. The primary water problems in the Upper French Broad River basin of Cocke County are pathogens, although residents also complain about occasional color from the Blue Ridge (formerly Champion) paper mill upstream on the Pigeon River in North Carolina. Pathogens also mar many stream miles in the lower French Broad River basin of Sevier County. Impaired sections of the Nolichucky River basin in Cocke, Greene, Washington, and Unicoi counties are primarily polluted by siltation from agricultural uses. In Roane, Rhea, and Meigs counties, the main stem of the Tennessee River and some of its tributaries are impaired by contaminated sediments that have PCB, chlordane, hexavalent chrome, mercury, and a variety of other industrial-chemical legacies. The Ocoee River, despite its popularity as a recreational destination, is highly polluted with mill and mine tailings and contaminated sediments. Elsewhere in southeast Tennessee, the problems caused by livestock grazing in streams and breaking down stream banks are widespread.

Virginia Waters

Virginia waters in Appalachia span the Appalachian Plateaus, the Valley and Ridge province, and the Blue Ridge province, but the main region by area is the Valley and Ridge province. The Appalachian waters of Virginia have higher dissolved oxygen than the downstream waters do, but also relatively frequent problems with fecal coliform contamination.

The Potomac River and Its Tributaries (the Cacapon River, the South Branch, Opequon Creek, and the Shenandoah River)

In West Virginia's part of the Valley and Ridge province, several major tributaries are listed in 2004 for dissolved-aluminum violations, including the Cacapon River, the South Branch of the Potomac River, Opequon Creek, and the Shenandoah River. Each of these tributaries is listed for its entire length in West Virginia. In addition, Opequon Creek continues to be listed for impairments of the water-quality criteria for fecal coliform and biological integrity. A new segment of the South Branch of the Potomac River also is listed for fecal coliform, from mile point 14.2 to mile point 54.9. Fecal coliform impairment in segments and tributaries upstream of mile point 54.9 were addressed by a TMDL developed in 1998.

In Maryland many Casselman River basin waters are biologically impaired, as are parts of the Upper North Branch of the Potomac River. The Lower North Branch of the Potomac River is impaired by elevated fecal coliforms. Also, there are the usual mercury problems in fish tissue in Maryland headwater streams, resulting from acid rain.

The Pennsylvania Portion of the Valley and Ridge Province

The northern terminus of the Valley and Ridge province is the original heartland of the United States' coal mining industry. Thus many of the streams in the region are impaired by drainage problems from abandoned mines. Hazle Creek, Nesquehoning Creek, Buck Mountain Creek, Black Creek, the Lehigh River, and the Schuylkill and Little Schuylkill rivers are examples of Pennsylvania's estimated 4,036 miles of streams impaired by drainage from abandoned mines.[141]

Water Quality in the Blue Ridge Province

North Carolina has responsibility for the vast majority of Appalachian waters in the Blue Ridge province. North Carolina's water-quality program, in both issuance of permits and assessment, is based on a five-year cycle for each of the state's seventeen major river basins. This five-year, basinwide approach has been adopted recently by other states in the Appalachian area, but North Carolina has been following it since the late 1980s. Thus, although an integrated Section 305(b) and Section 303(d) report is available as of March 2004, the Appalachian river basins were not scheduled for intensive biological testing until summer 2004, and the 2004 report does not present the very latest findings on ambient water quality in the Appalachian region of North Carolina.

The Appalachian area covers all the rivers draining North Carolina to the west and the north, including the New, the Watauga, the French Broad, the Little Tennessee, and the Hiwassee, as well as the small portion of the Savannah River

---

[141] State of Pennsylvania, *2004 Integrated 305(b) Report, Narrative Summary*.

basin in North Carolina. The Appalachian area also covers portions of the Broad, Catawba, and Yadkin river basins, all draining to the Atlantic in South Carolina. Finally the Appalachian area of North Carolina includes a small portion (the Dan River and its tributaries in Stokes County) of the Roanoke River basin.

North Carolina, following recent EPA guidance, has ceased to list its impaired waters as high, medium, or low priorities. Instead it will reflect its prioritization for impaired waters in the TMDL schedule. Few stream segments in the Appalachian area of North Carolina are listed for near-term TMDL development. A substantial number of stream segments are included in category 6, meaning that they are considered to be impaired biologically but the cause of the biological impairment is not currently known. Without knowing the cause, North Carolina cannot develop a TMDL. Thus North Carolina intends to focus its efforts in the next several years on sorting out the causes of impairments in these category 6 waters.

Water Quality in the Piedmont

North Carolina, South Carolina, and Georgia share responsibility for water quality in the Piedmont part of Appalachia. The river basins of most interest in the Piedmont are the Roanoke, the Yadkin–Pee Dee, the Catawba, and the Broad.

South Carolina’s waters in Appalachia include small portions of the Savannah, Saluda, and Broad river basins in the upstate region. Through the long-term, Herculean efforts of Tommy Wyche, an attorney in Greenville, and his friends and associates, substantial parts of upstate South Carolina have been put into conservation-easement status for protection of views and watersheds. Perhaps in part as a result, the Highlands areas of South Carolina generally have fewer water-quality problems than do downstream reaches in the state, which tend to be more heavily affected by urbanization and discharger. Nonetheless, even in the area around Greenville, serious contamination problems exist, especially in sediments that have collected historical industrial discharges. This problem is pervasive in the Piedmont.

Georgia waters in Appalachia include the Tennessee, Coosa, and Tallapoosa river basins, along with parts of the Chattahoochee, Savannah, and Oconee river basins. Like Alabama, Georgia spans four physiographic regions in Appalachia.

There are impaired waters in the Appalachian area of Georgia, such as many Coosa River basin waters still affected by historic PCB contamination from a General Electric facility in Rome (Floyd County), PCB contamination of the Conassauga River in Murray and Gordon counties, and contaminated runoff into the Elijay and Etowah rivers in Gilmer and Bartow counties, respectively. However, the waters of upstate Georgia are relatively clean and apparently attain their designated uses in comparison with waters in more urban and downstream parts of the state.

The Atlantic Plain and the Southern Ends of the Highlands

Much of Alabama is located in Appalachia. River basins in this region include the Black Warrior, the Tennessee, the Coosa, and the Talipoosa. There also are several major lake systems: Wilson Lake, Wheeler Lake, Guntersville Lake, Lewis Smith Lake, Weiss Lake, Lake Martin, Lake Jordan, Mitchell Lake, and Logan Martin Lake. There are waters in all the Alabama river basins in Appalachia that do not support use: pathogen, nutrient, industrial, and abandoned mine pollutants in the Black Warrior, which includes Birmingham; contaminated sediments and urban runoff in the Coosa; pathogens, metals, and sediments in the Talipoosa; and pathogens, toxics, urban runoff, and sediments in the Tennessee.

Mississippi

Mississippi's basins wholly or partly within Appalachia are the North Independent Streams, the Tennessee River, the Tombigbee River, and small headwater segments of the Yazoo–Upper Mississippi rivers.

In the North Independent Streams basin, TMDLs are in effect for a significant part of the drainage. Other segments show impairment as a result of a mixture of pollutants, including nutrients, pesticides, sediment, and pathogens.

The Tennessee River basin in Mississippi is relatively unproblematic, although Seven Mile and Chambers creeks in Alcorn and Tishomingo counties are impaired by pathogens and for aquatic life support, and Bear, Chambers, Indian, and Little Yellow creeks fail tests for aquatic life support because of some combination of nutrients, low dissolved oxygen, pesticides, and sedimentation.

Many waters in the Tombigbee River basin are unsuitable for swimming because of pathogens. Many others are impaired for aquatic life support. There are similar problems in the Appalachian area of the Yazoo River basin, but in general, the water-quality problems in Mississippi's part of Appalachia are no greater and probably are lesser in magnitude than problems lower down in the Yazoo River basin and in the coastal and Mississippi delta areas.

The Mercury Problem

Mercury deserves special mention. Aerial deposition of mercury is a national problem, but one with special significance for Appalachia. Mercury contamination in fish tissue at levels above health standards is found in every state, and a recent EPA study found detectable levels in every single fish sample taken from a broad national sampling effort.[142] All the Appalachian states have

[142] See EPA's study website for updated information at www.epa.gov/waterscience/fishstudy. The first two years of data are analyzed by the U.S. Public Interest Research Group in U.S. PIRG,

issued fish consumption advisories for mercury, especially for pregnant women and for children.

One of the major sources of this pollution is combustion of coal—hence the special significance for Appalachia, especially its coal-producing areas. The Appalachian states collectively accounted for 44 percent of the United States' reported atmospheric emissions of mercury and mercury compounds in 2002. Of the top 100 electric utilities emitting airborne mercury, 28 were in Appalachia. The total reported emissions of mercury from these 28 sources in 2002 equaled 15,643.6 pounds.[143]

Conclusion

As with everything else about Appalachia, simple generalizations about water quality are impossibly misleading. There are areas of high-quality water and water uses in the eastern United States, and there are areas so contaminated by decades of uncontrolled discharges that the prospect for cleanup at any foreseeable time looks grim.

What is perhaps most important to an understanding of water and wastewater funding in the region is that most expressed needs for capital spending account minimally, if at all, for the costs of watershed restoration. If Appalachia is ever to attain Harry Caudill's vision of a region that use its water to draw urbanites and their money from all over the eastern United States, much more funding will have to be found to improve ambient water quality.

Reel Danger: Power Plant Mercury Pollution and the Fish We Eat (August 20004), available on cta.policy.net/reports/reel_danger/reel_danger_report.pdf

[143] Analysis of data from EPA's Toxics Release Inventory 2002, available at www.epa.gov/tri/tridata/tri02/, by University of North Carolina, Environmental Finance Center, July 2004.

[This page intentionally left blank]