NEW RIVER GORGE NATIONAL RIVER
GAULEY RIVER NATIONAL RECREATION AREA
BLUESTONE NATIONAL SCENIC RIVER
GEOLOGIC RESOURCES MANAGEMENT ISSUES
SCOPING SUMMARY

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Executive Summary

A Geologic Resource Evaluation scoping meeting for New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River was held at park headquarters in Glen Jean, West Virginia on July 13 and 15, 2004. The scoping meeting participants identified the following as the most significant geologic resources management issues.

1. Slope failure from both natural and human-induced sources is a significant issue.

2. The identification and inventorying of fossil localities and fossil resources is a high priority.

3. Coal mining has had a major impact on NERI, including water drainage from waste piles.

4. Park staff is interested in the study and interpretation of the New River as a significant geologic feature in terms of its age, coal mining, and use as a transport corridor.

Introduction

The National Park Service held a Geologic Resources Evaluation scoping meeting for New River Gorge National River (NERI) Gauley River National Recreation Area (GARI), and Bluestone National Scenic River (BLUE) at park headquarters on Tuesday, July 13, and Thursday, July 15, 2004. The purpose of the meeting was to discuss the status of geologic mapping in the park, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: (1) Digitized geologic maps covering NERI; (2) An updated and verified bibliography; (3) A scoping summary (this report); and (4) A Geologic Resources Evaluation Report which brings together all of these products.

New River Gorge National River was established on November 10, 1978, by Public Law 95-625. Total area of the park is about 72,189 acres (2004), of which over 45,000 acres is federal land. It extends about 53 miles along the New River from Hinton, WV on the south to Fayetteville, WV to the north. Gauley River National Recreation Area (GARI) was authorized on October 26, 1988, by Title II of the "West Virginia National Interest River Conservation Act of 1987." The NRA was established "to protect and preserve the scenic, recreational, <u>geological</u>, and fish and wildlife resources of the Gauley River and its tributary, the Meadow River [emphasis added]…" It includes 25 miles of the Gauley River and six miles of the Meadow River. Total area is 11,507 acres (2003) with only about 3,560 acres of federal land. Bluestone River National Scenic River was also authorized on October 26, 1988, by Title III of the above legislation. It contains about 10.5 miles of the lower Bluestone River. Total area is 4,310 acres (2003) of which over 3,000 acres are federal.

There are 16 quads of interest covering NERI, including one (north-south) row of quads to the east and one row to the west of the park. From east to west and north to south the quads are: Corliss, Winona, Fayetteville, Beckwith, Rainelle, Danese, Thurmond, Oak Hill, Meadow Bridge, Meadow Creek, Prince, Beckley, Talcott, Hinton, Shady Spring, and Crab Orchard.

Those quads of interest covering the Gauley River National Recreation Area to the north are: Summerville, Gilboa, Lockwood, Bentree, Mount Nebo, Summerville Dam, Ansted, and Gauley Bridge. Those for Bluestone National River to the south are: Forest Hill, Pipestem, Flat Top, Odd, Peterstown, Lerona, Athens, and Matoaka.

Physiography

New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River all lie in the Appalachian Plateau Physiographic Province. The province covers about two-thirds of western West Virginia. The rocks are relatively flat lying, except for folds and faulting toward the east side of the Province. The oldest rocks are located in these eastern fold sequences and range in age from late Ordovician through the Mississippian. The majority of the Appalachian Plateau is comprised of Pennsylvanian and Permian strata. All the minable coal is located in these rocks. The rocks exposed in the northern part of the Plateau, including the coal seams, are younger than those exposed in the southern part. Most of the natural gas (95% to 98%) and all the oil resources of West Virginia lie in the Plateau Province. The boundary between Appalachian Plateau and the Valley and Ridge provinces is the Allegheny Front, a complex and rather abrupt change in the topography, stratigraphy, and structure.

The New River and the Gauley River join to form the Kanawha River near the town of Gauley Bridge in south-central West Virginia. The Kanawha River drains into the Ohio River near Point Pleasant, WV. The combined Kanawha-New River Basin extends over West Virginia, Virginia, and North Carolina and encompasses an area of about 12,333 square miles (U.S. Department of the Interior, 1996). Although the New River flows through three physiographic provinces, the three subject park units all lie in the Appalachian Plateau Province.

The New River originates in the Blue Ridge Mountains of North Carolina at an elevation of 3,800 feet and flows northward 250 miles before joining the Gauley. The mean discharge of the New over the last ten years as measured in the park at Thurmond is 8,798 cubic feet per second (cfs). Maximum discharge was 89,400 cfs and the minimum was 808 cfs. The topography is characterized by steep slopes (>20%) with flat-bottomed valleys and flat ridge tops. Average annual precipitation is 43.5 inches. (U.S. Department of the Interior, 1996)

The Gauley River originates in eastern West Virginia near the town of Slatyfork. It flows generally west-southwest for 107 miles to its junction with the New River. The drainage basin covers about 1,422 square miles. The Summerville Dam has controlled the flow since 1965. Mean discharge of the Gauley below the dam is 2,084 cfs with a maximum of 18,200 cfs (1979) and a minimum of 1.9 cfs (1967). The Meadow River is a major tributary, part of which his administered by the NPS (U.S. Department of the Interior, 1996).

The Bluestone River joins the New River at Bluestone Lake, a reservoir south of Hinton, WV. It originates 77 miles to the southwest, ten miles west of Bluefield, Virginia, near the Virginia-West Virginia border. The drainage basin covers only about 462 square miles since the Bluestone does not have any major tributaries. The mean discharge rate is 469 cfs, measured over a 41 year period (U.S. Department of the Interior, 1996). The maximum discharge rate recorded was 19,300 cfs (1977) and the minimum recorded was 7.0 cfs (1955).

Geologic History

The Appalachian Plateau Physiographic Province (also called the Allegheny Plateau) is made of relatively undeformed Paleozoic sedimentary rocks dissected by rivers forming steep-sided valleys with intervening ridges. The province is part of the Appalachian Mountain system which has a long and complex geologic history.

Proterozoic Era – In the mid-Proterozoic, a super continent formed which included most of the continental crust in existence at the time. Sedimentation and the subsequent, deformation, igneous intrusion, and volcanism associated with this event are manifested in the metamorphic gneisses in the core of the Blue Ridge Province (Harris et al., 1997). These rocks, deposited over a period of a 100 million years and more than a billion years old, form the basement upon which all other rocks of the Appalachians were deposited.

In the late Proterozoic, roughly 600 million years ago, tectonic rifting began which resulted in the break-up of the super-continent and the opening of a basin that eventually became the Iapetus Ocean. In this tensional environment, flood basalts and other igneous rocks such as diabase and rhyolite extruded through cracks in the granite gneisses of the Blue Ridge core. These flood basalts comprise the Catoctin Greenstone, a prominent geologic unit in the Blue Ridge province. At the same time, the Iapetus basin collected sediments that would eventually form the Appalachian Mountains.

Early Paleozoic Era – From Early Cambrian through Early Ordovician time, orogenic activity along the eastern margin of the continent began again. The Taconic orogeny (~440-420 Ma) in the central Appalachians was a volcanic arc – continent convergence. Oceanic crust and the volcanic arc from the Iapetus basin were thrust onto the eastern edge of the North American continent. The Taconic orogeny resulted in the closing of the Iapetus Ocean, subduction of oceanic crust beneath the continent, the creation of volcanic arcs, and the uplift of continental crust. In response to the overriding plate thrusting westward onto the continental margin of North America, the crust bowed downwards creating the deep Appalachian basin that filled with mud and sand eroded from the highlands to the east (Harris et al., 1997).

During the Late Ordovician, the oceanic sediments of the shrinking Iapetus Ocean were thrust westward onto other deepwater sediments of the western Piedmont. Sandstones, shales, siltstones, quartzites, and limestones were then deposited in the shallow marine to deltaic environment of the Appalachian basin. These rocks, now metamorphosed, currently underlie the Valley and Ridge province to the east.

This shallow marine to fluvial sedimentation continued for a period of about 200 My during the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian Periods. This resulted in thick piles of sediments. The source of these sediments was from the highlands that were rising to the east during the Taconian orogeny (Ordovician), and the Acadian orogeny (Devonian).

The Acadian orogeny (~360 Ma) continued the mountain building of the Taconic orogeny as the African continent approached North America (Harris et al., 1997). Similar to the preceding Taconic orogeny, the Acadian event involved land mass collision, mountain building, and regional metamorphism (Means 1995). This event was focused further north than central Virginia.

Late Paleozoic Era – Following the Acadian orogenic event, Iapetus Ocean was completely destroyed during the Late Paleozoic as the North American continent collided with the African continent. This formed the Appalachian mountain chain and the super continent Pangaea. This mountain building episode, called the Alleghanian orogeny (~325 – 265 Ma), was the last major orogenic event of the Appalachian Mountains. The deformation by folding and faulting produced the Sugarloaf Mountain anticlinorium and the Frederick Valley synclinorium in the western Piedmont, the Blue Ridge-South Mountain anticlinorium, and the folds of the Valley and Ridge province. During this orogeny, rocks of the Great Valley, Blue Ridge, and Piedmont provinces were transported as a massive block (Blue Ridge – Piedmont thrust sheet) westward onto younger rocks of the Valley and Ridge along the North Mountain fault. The amount of compression was extreme. Estimates are of 20-50 percent shortening which translates into 125–350 km (75-125 miles) of lateral translation (Harris et al., 1997).

Mesozoic Era – Following the Alleghenian orogeny, during the late Triassic (about 230-200 Ma), a period of rifting began as the joined continents began to break apart from. The super continent Pangaea was segmented into roughly the continents that persist today. This episode of rifting or crustal fracturing initiated the formation of the current Atlantic Ocean and caused many block-fault basins to develop with accompanying volcanism (Harris et al., 1997). Thick deposits of unconsolidated gravel, sand, and silt were shed from the eroded mountains and were deposited at the base of the mountains as alluvial fans and spread eastward forming part of the Atlantic Coastal Plain.

Cenozoic Era – Since the breakup of Pangaea and the uplift of the Appalachian Mountains, the North American plate has continued to drift toward the west. The isostatic adjustments that uplifted the continent after the Alleghenian orogeny continued at a subdued rate throughout the Cenozoic Period (Harris et al., 1997). Pleistocene age glaciers never reached the south-central West Virginia (the southern extent was in northeastern Pennsylvania),

Stratigraphy

The following stratigraphy was taken mostly from the West Virginia Geologic and Economic Survey website, “Geology of the New River Gorge.” Except for Quaternary alluvium, all the formations are Paleozoic. From youngest to oldest:

Alluvium (Quaternary): Unconsolidated boulders, gravel, sand, and silt, mostly along river banks, beds, and floodplains.

Pottsville Group (Pennsylvanian)

Kanawha Formation: About 900 feet of shale and siltstone with lesser amounts of siltstone; contains the Gilbert and Eagle coal seams

New River Formation: Maximum thickness, 900 feet; unconformably overlies the Pocahontas; coal-bearing sandstones, siltstones, and shales; capped by the Nuttall Sandstone Member; contains the Fire Creek, Beckley and Sewell coal seams; also contains plant fossils and invertebrates such as pelecypods, ostracodes and brachiopods (Englund, 1977).

Pocahontas Formation: 400 ft.; coal-bearing sandstone (~70%) with lesser amounts of siltstone, shale, and underclay (28%); contains the Pocahontas coal seams (Nos. 2, 3 and 6), plant fossils and fossil invertebrates; thins northwestward and pinches out (Englund, 1977)

Mauch Chunk Group (Upper Mississippian)

Bluestone Formation: 650 ft.; shale and siltstone with lesser amounts of sandstone and minor limestone and coal (McDowell and Schultz, 1990).

Pride Shale Member: 40-120 feet thick, consisting of dark-gray shale grading locally to silty shale or interlaminated siltstone and shale (Englund, 1977)

Gladys Fork sandstone member: Misidentified as a distinct member; now considered the Princeton Formation.

Princeton Formation: 60 ft.; coarse conglomerate grading into a sandstone (orthoquartzite to subgraywacke, McDowell and Schultz, 1990).

Hinton Formation: 1,100 ft. red, green, and gray, marine and freshwater shales and siltstones with lesser amounts of sandstone and limestone; includes the Stony Gap sandstone (an orthoquartzite) and Avis limestone.

Bluefield Formation: The part of the formation exposed in the park is dominantly non-marine sediments and paleosols.

Structure

Situated in the east-central part Appalachian Basin, the strata in the New River Gorge area are relatively flat-lying with a regional dip of less than 2° to the northwest. The dip increases to about 5° to the southeast in the Thurmond quadrangle on the western limb of the Mann Mountain anticline (Henry et al., 1977). In the southern part of the Gorge area the strata are gently folded, including the Lawton and Springdale synclines and three unnamed anticlines. Faulting is minor.

Significant Geologic Resource Management Issues at New River Gorge National River

1. Slope failure

Frequent landslide and hillslope movement present an on-going hazard in NERI. The strata in the area is mostly sandstone and shale. When the shale become saturated with water, the water lubricates the glide planes allowing slippage and slope failure. As the shale slopes fail the resistant sandstone above collapses creating large landslides. The undercutting of slopes for railroad tracks also induces slope failure. Material from the gorge walls fall into the rivers altering the steam profile, the bed load, as well as the characteristics of the rapids.

Only a few slides have been active in historical time, the largest being on the north side of the New River east of Thurmond (Davies and Ohlmacher, 1977). Other slides occur in thin deposits of weathered sandstone mixed with unsorted sand, clay and vegetation. These slides, which do not extend to bedrock, may be up to 30 feet thick underlying slopes of 30° to 45° and move slowly downhill (Davies and Ohlmacher, 1977).

There is a need for an inventory of the areas where slope failure has occurred as well as those areas that are susceptible to landsliding. Comparing aerial photographs from the present to a series from the past can show the amount of material moved and the sequence of slope failure. Check with CSX (coal company) for historical records. Other sources of information include: Landsat photos, although they lack the resolution required, county aerial photos, and note changes in vegetation cover and vegetation type (Contact: Jim Vanderhorst with Abies Ecology Inc. and the WVDNR).

2. Paleontological Resources

There is a distinct need to identify and inventory fossil localities. A first step is to review the literature. The cost of a complete data search was given to be about $4,000. There was some data gathered by Vince Santucci and Allison Koch (see, Reference: Gillespie, W.H., Clendeming, John, and Pfefferkon, Herman W., 1978, “Plant Fossils of West Virginia”). Also contact Greg McDonald as a source of information about fossil collection and curation. The West Virginia Geological and Economic Survey needs about $5,000 to continue the project (contact: E. Ray Garton). There is also a need to deploy a group of field investigators to find the localities and the identify the specific locations (check with Mitch Blake of the WVGES).

The park would also like to develop a “fossil dig” or quarry where visitors (especially children) hunt for fossils and dig them out. This would be a great educational resource available in the Avis Limestone and it would not result in the loss of valuable fossils. Fossil destruction from landsliding and flooding is also an issue. It is not known how many fossil areas have been impacted by these processes. All fossil areas, even those not exposed, are impacted by slope failure. If the fossils are lost and not collected, for all practicable purposes, they do not exist at all. The amount of loss of fossils through destruction or theft by visitors is not known.

3. Abandoned coal mines

Major coal seams occur in the Pocahontas (Pocahontas 3 and 6 seams), New River (Fire Creek, Beckley and Sewell coal seams), and Kanawha formations (Eagle, No. 2 Gas, Peerless, Cedar Grove, and Coalburg seams). Surface and underground coal mining has been a major extractive industry in the area for over a century. The completion of the Chesapeake and Ohio (C&O) in January 1873, opened up the link between the coal resources in West Virginia and the iron production in Virginia. From 1873 to 1878, A.A. Low, who had established the Low Moor iron mine in Virginia, shipped iron ore to Fayette County, West Virginia to be smelted using the newly available clean New River coal. The Kaymoor Mine was opened in 1899 and mining continued for the next 63 years.

Consequently, abandoned mines, acid mine drainage and slope instability are high priority issues with the parks. Through funding from the Office of Surface Mining (OSM) a five-year program (1987-1992) closed 161 portals in NERI. More recently the Geologic Resources Division has helped fund closures at the Kaymoor Mine, Eleverton Mine, Craig's Branch Mine, as well as the Ames Complex (Cloues and Geise, 1998). Although water from mine portals is generally potable, water from coal waste (gob piles) at production facilities has a low pH (~2.5) and can severely impact water quality down stream. Wastes piles (overburden) from surface mining are side-cast from the mines forming linear piles (e.g. 15+meters deep by ~50 meters wide by ~0.5 km long). Culverts in the park tend to pond water on some of the gob piles resulting in acid mine drainage from the oxidation of pyritic material (iron sulfide) in the coal.

4. Interpretation of New River Gorge as a significant geologic feature

There are several characteristics that make the New River Gorge and the New River unique.

a. The first is the claim that the New River is the second oldest river in the world (second to the Nile). The New River cuts across old structure of the Appalachians. However, recent data indicates that the Appalachians may have uplifted as recently as 50 million years ago and may still be rising.

b. The area is noted for its Upper Mississippian marine fossils and Lower Pennsylvanian fossils. There are Mississippian vertebrates in Vertisols of the Hinton Formation as well as possible Pleistocene organisms. The age span is about 6 million years (322 to 316 my, Hinton to Kanawha).

c. Several very economic coal seams occur: Castle, Sewell, Fire Creek, and Pocahontas #6 and #3.

d. The New River was part of a major transport corridor aiding in the early settlement of the interior of the United States. The corridor extends from the James River to the Greenbrier River, to the New River and to the Kanawha River. This route was originally followed by Native Americans prior to European settlement.

e. NERI contains the type locality of the Raleigh Formation and the New River Formation (named after gorge).

f. Kanawha Falls forms a migration barrier to small-mouth bass and other migratory fish species.

g. Rock falls in the area may have the largest boulders in the eastern United States (Steve Kite, WVU).

h. Some of shales weather uniquely into spheroidal shapes. This spheroidal weathering is an unusual feature found throughout the park occurring in very thinly bedded shales and siltstones of the Hinton Formation.

5. Other issues

Groundwater: There is little information on the water from the portals of abandoned coal mines. Thirteen sites have been sampled for metals such as Fe, Mn and Al as well as for pH. Outside the park measurement have shown a low pH (2.0) as well as high Fe and Al. Question: What is the groundwater chemistry of NERI?

Cave and karst: There are no major karst features in the area. The Greenbrier Limestone is not exposed in the park. The Avis Limestone in the Hinton Formation is the only named limestone member that outcrops in the park and is about 30 feet thick. The Avis can be very fossiliferous in some areas. Some unique features are: (1) Water trickling into fractures has created a columnar "City of Rocks-like" structure. These are located throughout the park usually located at or near the rim of the gorge; (2) There are small doline-like structures (sinkholes) that occur in the Nuttall sandstone, a massive sandstone formation that occurs at the top of the gorge.

Hazardous wastes: Hazardous wastes are associated mostly with abandoned mines and abandoned town sites. Petroleum products are leaking from underground storage tanks, Even after removal there are residual hydrocarbons left at the site, especially in the soil. Most of these sites are handled by the maintenance division (Contact: Jake Hoogland, Environmental Quality Division, Washington, D.C.; 202-513-7188). Gob piles left over from coal mining need to be located, sampled and monitored. Some are presently being monitored.

Soils: This is mostly being handled by Pete Biggam (NPS-GRD) and the National Conservation Resource Service (NCRS). There is an old soil survey available, apparently done in the 1940s. Swelling clays are an issue. Mica found in the Hinton Formation has some swelling characteristics. Also, phyllosilicates like mica have glide planes that can readily produce movement when saturated with water. Many shales in the area are thin-bedded and produce numerous planes of potential movement.

Wetlands: The park has the National Wetlands Inventory (NWI) Maps. However, there are very small wetlands that have developed from seeps which are too small to be on the NWI maps or to show up on aerial photos. Some of these are seasonal and are associated with mine portals. Therefore, there is a need for an inventory. Some artificial wetlands have been created by roads and trails and these also need to be inventoried.

Stream channel morphology: Stream flow and sediment load studies are needed for the three rivers, especially the New River. The deepest part of the channel is believed to be about 100 feet deep. The New River channel has a profile near the New River Gorge Bridge and there has been some local mapping of the channel. LIDAR would be useful for river channel studies and for profiles of the New River Gorge. However, terrestrial LIDAR is quite expensive. There are flow monitoring stations on the New River at Thurmond and Hinton, on the Bluestone River and two stations on the Gauley River.

Human Activity: NERI, GARI, and BLUE all have great amounts of nonfederal lands (in the case of GARI about 72% is non-federal). This means that there are many private residences in and surrounding the parks presenting a problem in waste disposal. Many local residents pump their sewage directly into the rivers. Also, many failing septic systems leak into the rivers. Campers along the river dump their wastes directly into the river. Boaters and rafters also dump there garbage and human wastes into the rivers. There are numerous roads throughout the parks. The locals not only want to keep these roads open, but create more roads to allow greater access for fishing. All of this creates an influx of fecal coliform into the river waters. Other sources of pollutants include urban runoff (Beckley WV), auto wastes (oil, tires), and various chemical products from local businesses. The NPS Water Resources Division is working with Jesse Purvis, park aquatic biologist, to quantify the water quality.

There are gas wells in the parks (especially, NERI and GARI). An inventory in the Gauley River NRA conducted by the park in 2001/2002 located 28 gas wells believed to be inside the park (Pugh, 2003). One abandoned gas well at a trailhead in NERI is leaking gas. This and two other abandoned wells are near an area of high visitor use. A communications relay tower for the oil and gas producers should be put under the 36 CFR 9B regulations. Railroad activity through the park is also a problem in that there are leaks, spills, derailments and other accidents associated with rail transport.

Scoping Meeting Participants

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Michael Hohn	Geologist	WV Geologic and Economic Survey
Stephen Schindler	Geologist	U.S. Geological Survey
Steve Kite	Geologist	West Virginia University

References

Cloues, Philip, and Gese, Diann, 1998, New River Gorge National River abandoned mine land field trip, March 17-18, 1998, National Park Service, Geologic Resources Division, 21p.

Davies, W.E., and Ohlmacher, G.C., 1977, Map of landslides, New River Gorge area, Fayette, Raleigh, and Summers Counties, West Virginia, U.S. Geological Survey Open-File Report OF 77-76, Map K, scale 1:50,000.

Englund, Kenneth J., and Thomas, Roger E., 1990, Late Paleozoic depositional trends in the Central Appalachian Basin, U.S. Geological Survey Bulletin 1839-F, p.F1-F19.

Englund, Kenneth J., and others, 1977, Mineral resource, geological, and geophysical maps of the New River Gorge area, Fayette, Raleigh, and Summers Counties, West Virginia, U.S. Geological Survey Open-File Report OF-77-76, Maps A-L.

Granger, Darryl E., Kirchner, James W., and Finkel, Robert C., 1997, Quaternary downcutting rate of the New River, Virginia, measured from differential decay of cosmogenic ^{26}Al and ^{10}Be in cave-deposited alluvium, *Geology*, v.25, no.2 (Feb.), p.107-110.

Harris, A.G., Tuttle, E., Tuttle, S.D., 1997, *Geology of National Parks*, Kendall/Hunt Publishing Company, 759 p.

Henry, T.W., Warlow, R.C., Windolph, J.F., Meissner, C.R., Jr., Englund, K.J., and Arndt, H.H., 1977, Structure contour map of the coal bearing rocks of the New River Gorge area, Fayette, Raleigh, and Simmers Counties, West Virginia, U.S. Geological Survey Open-File Report OF 77-76, Map B, scale 1:50,000.

Lessing, Peter, 1996, West Virginia Geology: Physiographic Provinces, West Virginia Geologic Survey, http://www.wvgs.wvnet.edu/www/geology/geolphyp.htm (accessed April 19, 2005).

McDowell, Robert C., and Schultz, Arthur P., 1990, Structural and stratigraphic framework of the Giles County area, a part of the Appalachian Basin of Virginia and West Virginia, U.S. Geological Survey Bulletin 1839-E, p.1-E24, Plate 1, Geologic map, scale 1:125,000.

Meissner, Charles R. Jr., 1981, Geologic Map of the Shady Spring Quadrangle, Raleigh and Summers Counties, West Virginia, U.S. Geological Survey Geologic Quadrangle Map GQ-1546.

Pugh, Sammy, 2003, Gas well inventory, Gauley River National Recreation Area, unpub. NPS report, 3p.

Rast, Nicholas, 1989, The evolution of the Appalachian Chain, *in* Bally, A.W., and Palmer, A.R., (eds.), The Geology of North America – An overview, Geological Society of America, The Geology of North America, v. A, p.323-348.

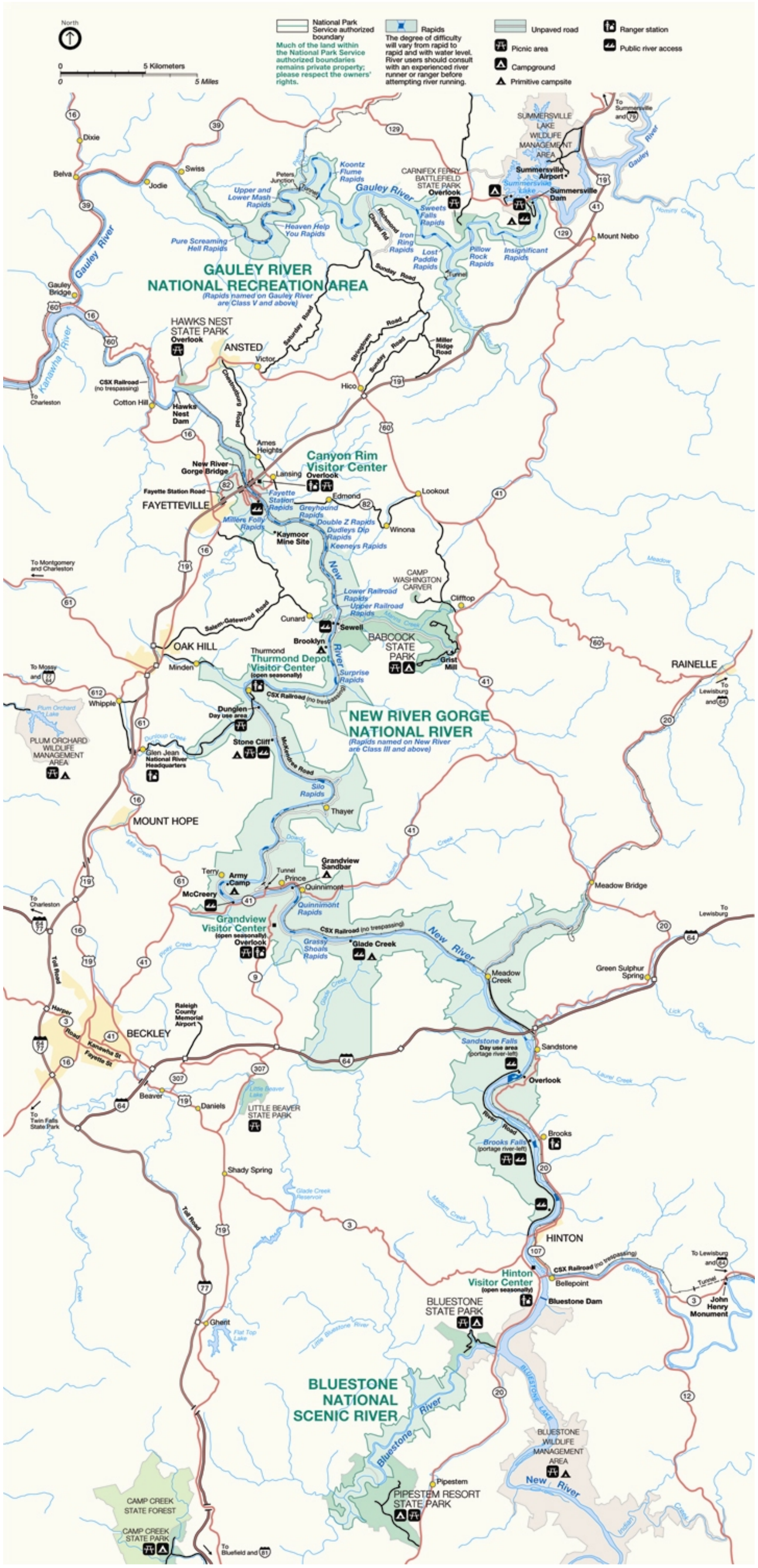
United States Department of the Interior, 1996, New River Gorge National Recreation Area, Gauley River National Recreation Area, and Bluestone National Scenic River, West Virginia: Water Resource Scoping Report, National Park Service, New River Gorge National River and National Park Service Water Resources Division Technical Report NPS/NRWRS/NRTR-96-76, 25p.

United States Environmental Protection Agency, 1980, Supplemental Information Document to the Areawide Environmental Assessment for Issuing New Source NPDES Permits on coal mines on coal mines in the Coal/Kanaha River Basin, West Virginia, Chapter 2, Existing Conditions, p.2-259 – 2-299.

West Virginia Geological and Economic Survey, 2005, Geology of the New River Gorge, West Virginia Geology: Earth Science Studies, http://www.wvgs.wvnet.edu/www/geology/geoles01.htm (accessed April 22, 2005).

Wiley, Jeffrey B., 1993, Simulated flow and solute transport, and mitigation of hypothetical soluble-contaminant spill for the New River in the New River Gorge National River, West Virginia, U.S. Geological Survey Water-Resources Investigations Report 93-4105, 39p.

Wiley, Jeffrey B., and Cunningham, M.K., 1994, Flood characteristics for the New River in the New River Gorge National River, West Virginia, U.S. Geological Survey Open-File Report OF 93-007, 96p.



North
0 5 Kilometers
0 5 Miles
National Park Service authorized boundary
Much of the land within the National Park Service authorized boundaries remains private property; please respect the owners' rights.
Rapids
The degree of difficulty will vary from rapid to rapid and with water level. River users should consult with an experienced river runner or ranger before attempting river running.
Unpaved road
Picnic area
Campground
Primitive campsite
Ranger station
Public river access
GAULEY RIVER NATIONAL RECREATION AREA
(Rapids named on Gauley River are Class V and above)
SUMMERSVILLE LAKE WILDLIFE MANAGEMENT AREA
Summersville Airport
Summersville Lake
Summersville Dam
Mount Nebo
CARNIFEX FERRY BATTLEFIELD STATE PARK
Overlook
Koontz Flume Rapids
Gauley River
Sweets Falls Rapids
Iron Ring Rapids
Lost Paddle Rapids
Pillow Rock Rapids
Insignificant Rapids
Upper and Lower Mash Rapids
Heaven Help You Rapids
Pure Screaming Hell Rapids
Peters Junction
Dixie
Swiss
Belva
Jodie
Gauley Bridge
Kanawha River
HAWKS NEST STATE PARK
ANSTED
Victor
Hico
Sunday Road
Saturday Road
Miller Ridge Road
CSX Railroad (no trespassing)
To Charleston
Cotton Hill
Hawks Nest Dam
Ames Heights
Canyon Rim Visitor Center
Lansing
New River Gorge Bridge
Fayette Station Road
FAYETTEVILLE
Fayette Station Rapids
Greyhound Rapids
Edmond
Lookout
Millers Folly Rapids
Double Z Rapids
Dudleys Dip Rapids
Keeneys Rapids
Winona
Kaymoor Mine Site
To Montgomery and Charleston
CAMP WASHINGTON CARVER
Lower Railroad Rapids
Upper Railroad Rapids
Clifftop
Salem-Gatewood Road
Cunard
Sewell
Brooklyn
BABCOCK STATE PARK
Grist Mill
OAK HILL
Thurmond
Thurmond Depot Visitor Center
(open seasonally)
Minden
Surprise Rapids
RAINELLE
To Lewisburg and 64
To Mossy and 19
Whipple
Dunglen Day use area
CSX Railroad (no trespassing)
NEW RIVER GORGE NATIONAL RIVER
(Rapids named on New River are Class III and above)
PLUM ORCHARD WILDLIFE MANAGEMENT AREA
Plum Orchard Lake
Glen Jean National River Headquarters
Stone Cliff
McKendree Road
Silo Rapids
Thayer
MOUNT HOPE
Grandview Sandbar
Terry
Army Camp
Tunnel
Prince
Quinnimont
McCreery
Quinnimont Rapids
Meadow Bridge
To Lewisburg
Grandview Visitor Center
(open seasonally)
Overlook
Grassy Shoals Rapids
Glade Creek
New River
Meadow Creek
Green Sulphur Spring
To Charleston
Toll Road
Harper Road
Kanawha St
Fayette St
BECKLEY
Raleigh County Memorial Airport
Sandstone Falls Day use area (portage river-left)
Sandstone
Overlook
Beaver
Daniels
LITTLE BEAVER STATE PARK
To Twin Falls State Park
River Road
Brooks
Brooks Falls (portage river-left)
Shady Spring
Glade Creek Reservoir
HINTON
CSX Railroad (no trespassing)
To Lewisburg and 64
Tunnel
Hinton Visitor Center
(open seasonally)
Bellepoint
Bluestone Dam
John Henry Monument
BLUESTONE STATE PARK
Ghent
Flat Top Lake
Little Bluestone River
BLUESTONE NATIONAL SCENIC RIVER
Bluestone River
Bluestone Lake
BLUESTONE WILDLIFE MANAGEMENT AREA
New River
Pipestem
PIPESTEM RESORT STATE PARK
CAMP CREEK STATE FOREST
CAMP CREEK STATE PARK
To Bluefield and 81