Geomorphology, Vegetation, and Patowmack Canal Construction Problems: Great Falls Park, Potomac River, Virginia

Potomac River Gorge, Virginia
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Field Trip Guidebook T236

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COVER Photograph of the Great Falls of the Potomac River from the Visitors Center, Great Falls Park, Virginia.

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IGC FIELD TRIP T236:
GEOMORPHOLOGY, VEGETATION, AND PATOWMACK CANAL CONSTRUCTION PROBLEMS: GREAT FALLS PARK, POTOMAC RIVER, VIRGINIA

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The spectacular landscape of the Great Falls of the Potomac River, approximately 25 kilometers northwest of Washington, D.C., is the result of prolonged geological and biological processes. The slow downcutting of the resistant bedrock by the river, controlled in part by faults and jointing, the weathering of the rock, and the continuous growth of the forest have interacted to produce the present landscape. Superimposed on these long, continuous processes has been the effects of 200 years of human activity.

Great Falls lies near the eastern edge of the Piedmont physiographic province, which adjoins the Atlantic Coastal Plain province to the east (Figure 1). The boundary between these two provinces, commonly called "the Fall Line," extends approximately from New York City southwestward through Philadelphia, Baltimore, Washington, Richmond, and beyond. Each of these cities was founded at the upstream end of the navigable waters of a major river, where industries prospered by applying the hydrologic power of the falls.

The rocks underlying the Piedmont province at Great Falls are highly metamorphosed shale, muddy sandstone, and volcanic rocks forming schists, metagraywacke, and amphibolites of Cambrian age (Drake, 1987). Granite, lamprophyre, and quartz veins were intruded during the Acadian Orogeny. Slow uplift of the Piedmont and the Appalachian Mountains to the west beginning in the Miocene Epoch resulted in downcutting of rivers and deposition of sediments on the Coastal Plain to the east. As sea level lowered during the Pleistocene, the Potomac River eroded deeper into underlying bedrock. The configuration of the channels at Great Falls is the result of local differences in bedrock, the locations of joints and a major fault, and periodic river flooding. The effects of these local differences can be seen in active flood plains, bedrock terraces now rarely flooded, and rolling uplands. On some of the uplands, relict terrace deposits, including rounded boulders and gravel, are preserved.

Vegetation reflects the differences in the physical environment. Some tree and shrub species are widespread, but many grow only on selected types of terrain. Sycamore, silver maple, box elder, and green ash grow only on active flood plains. Chestnut oak, post oak, and red oak are found where bedrock is exposed on terraces. Pin oak, willow oak, swamp white oak, and red maple are present in swamps. Forests on rolling uplands near Great Falls have been repeatedly cut for firewood and lumber, some of the land has been cultivated, and much of the soil has been severely eroded. These upland sites support a large number of tree species, but yellow poplar, beech, white oak, and black oak are most common. Part of the bedrock terrace close to the old Patowmack Canal supports many introduced species of trees, vines, shrubs, and ornamental flowers.

The Patowmack Canal was conceived as a method of transporting people and materials around Great Falls, to provide the uninterrupted river travel from the Chesapeake Bay to the upper reaches of the Potomac River which would enable development of the west. The project required the confederated states of Maryland and Virginia to agree to free trade on the Potomac River. Use of the canal would require water from the river, which belonged to Maryland, to flow into Virginia. Negotiations fostered by the Patowmack Canal Company added an incentive for the adoption of the United States Constitution and the establishment of 13 United States in place of 13 independent states (Garrett, 1987).

George Washington, general of the army and first president of the United States, had earlier surveyed the Potomac River basin and promoted a river trade route west into the Appalachian Mountains. He advocated the use of boats and a system of canals and lift locks to circumvent waterfalls. The

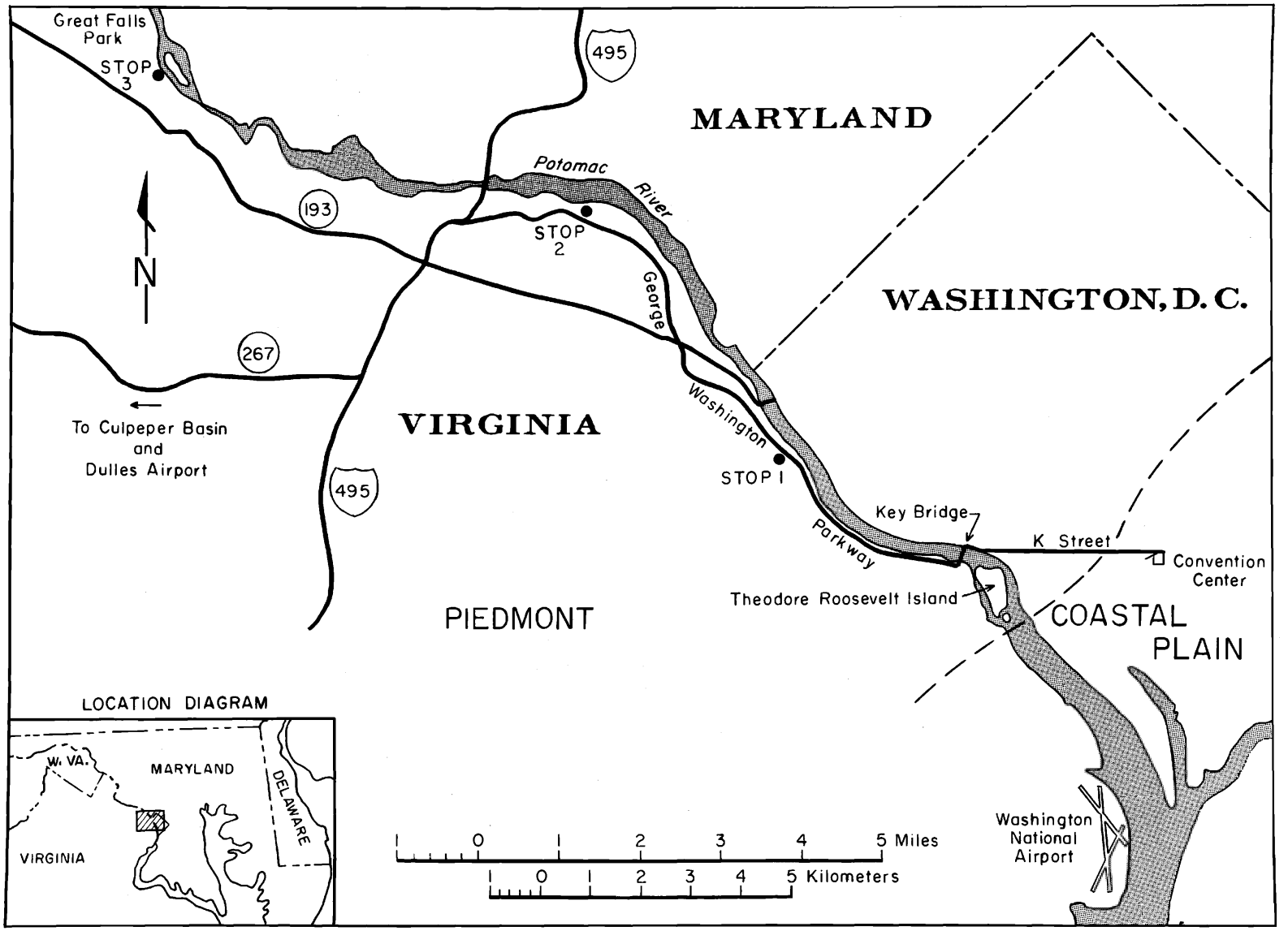

FIGURE 1 Map of the field trip area in northern Virginia with locations of stops 1-3.

Patowmack Canal at Great Falls was the most ambitious phase of his canal construction project. The canal was plagued with severe construction problems from the start in 1785 until completion in 1802. The problems were, in part, the result of insufficient site study prior to construction. The proposed canal route was selected by surveyers trapped within a cabin during a snow storm that completely obliterated the landscape. The route selected was the shortest in distance, but because of the geologic setting was difficult to develop. Had the swamp to the south and west of Glade Hill (Figure 2) been surveyed, the canal could possibly have been built in much less than 17 years and at a fraction of the cost. Operations of the canal ceased in 1828 when transportation was assumed by the continuous Chesapeake and Ohio Canal located across the river.

Between 1936 and 1985 five major floods covered all or part of the Patowmack Canal. If the river had flooded during 1785-1828 as frequently, or to the levels, that it has in the last 50 years, construction might have been terminated before completion of the canal in 1802, or canal operations might have ended before 1828.

Topographic Maps: 1:24,000 scale ($7\frac{1}{2}$ minute quadrangles): Washington West, D.C., Falls Church, Va., Vienna, Va., Rockville, Md., Seneca, Md., Va. 1:100,000 scale: Washington West D.C.-Md.-Va., and Baltimore, Md.

En Route From the Convention Center to Stop 1.

The most impressive geologic features of Washington, D.C., result from widely differing bedrock. The eastern two-thirds of the area is within the Coastal Plain province, where poorly consolidated, nearly flat-lying gravel, sand, silt, and clay stratigraphically overlap an east-sloping basement of metamorphic and igneous rocks. The western third of Washington is on the Piedmont Plateau province, where the resistant metamorphic and igneous rocks are exposed.

The route from the Convention Center crosses Pleistocene gravel, sand, and silt deposits of the Coastal Plain province before ascending onto the Piedmont province. The route crosses the river upstream of Roosevelt Island, a Holocene terrace at the eastern edge of the Piedmont province.

From the Convention Center, travel west on K Street, follow signs to the Whitehurst Freeway, and cross the Potomac River on the Key Bridge. Immediately turn right (west) onto George Washington Parkway and proceed 4.5 kilometers (2.7 miles) to the second overlook.

Stop 1: Overlook on George Washington Parkway

The horizon directly across the river is the Piedmont province. Directly below is the modern flood plain, which consists of a thin layer of fine-grained alluvium deposited on resistant bedrock. The fine alluvium is present because minor, frequent floods, which normally would wash the alluvium downstream, have been diverted upstream of the bridge to the left by a diversion channel of the metropolitan water supply reservior. The diversion channel was cut into the bedrock under the Chesapeake and Ohio Canal on the Maryland side of the river. The flood plain downstream of the diversion channel floods an average of only once in 2 years, and water velocity is diminished by the high tides of the Chesapeake estuary. Upstream from the bridge, canal locks were built in the late 18th century as part of the Patowmack Canal system, another segment of which will be seen at Great Falls.

The route to stop 2 follows the older rock-cut terraces bordering the river channel and drops occasionally into narrow tributary valleys. Continue west on the Parkway 6.7 kilometers (4.0 miles) to the entrance to Turkey Run Park. Proceed to parking area C.

Stop 2: Turkey Run Recreation Area

The rolling hills in the picnic area are typical of the Piedmont. These knolls and locally gentle slopes are interspersed with narrow, steeply sloping valleys. A short distance to the north, the land drops steeply, more than 60 meters to the river. The underlying bedrock consists of Cambrian metamorphic rocks, metadiorite, gabbro, and amphibolite with numerous quartz veins (Drake, 1987).

The knolls and steeply sloping valleys precluded heavy agricultural land use in the past. The absence of gullies, which are common in even-sloping cultivated areas underlain by

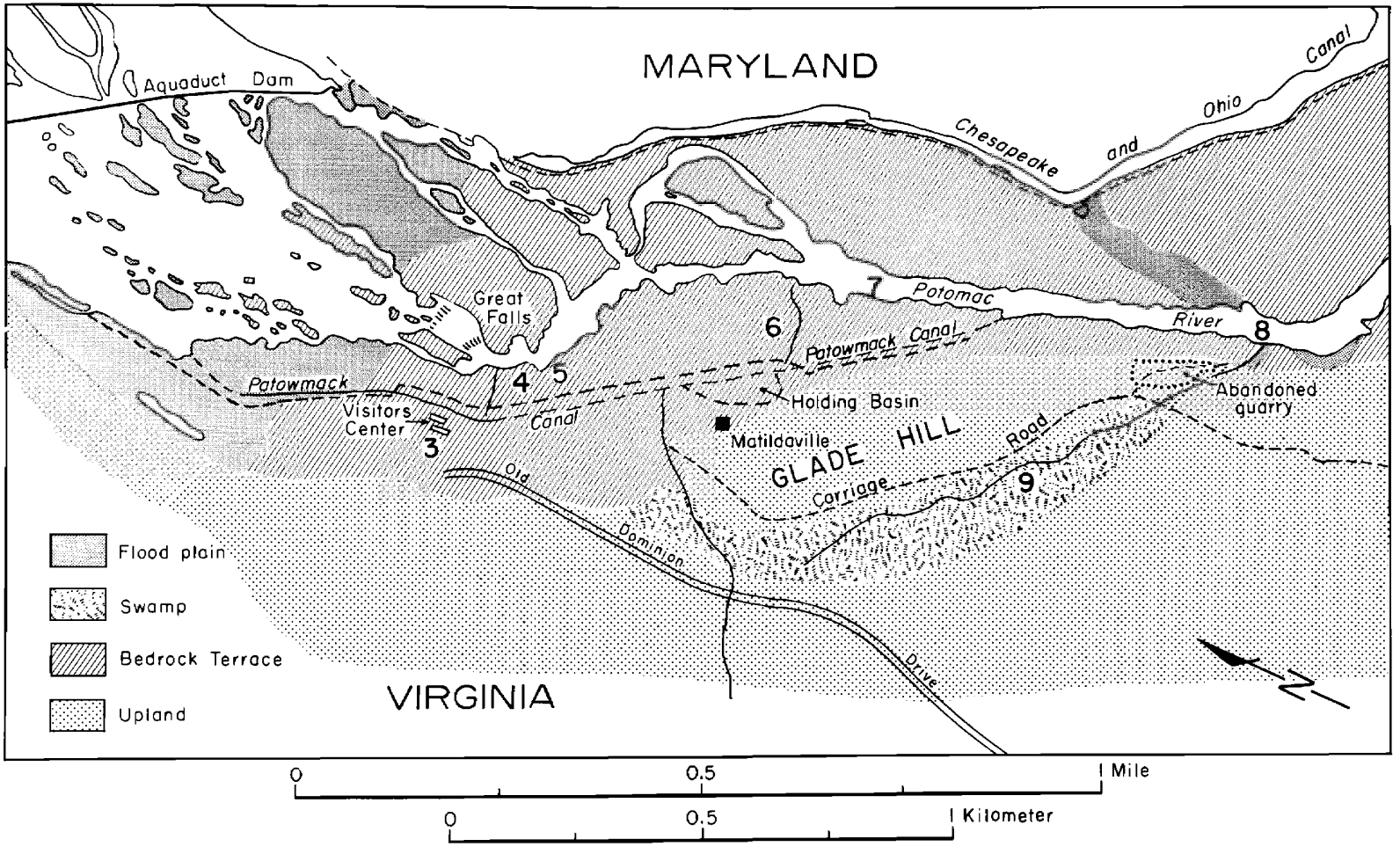

FIGURE 2 Detail of a portion of Great Falls Park showing field trip stops 3-9.

thick saprolite, indicates that cultivation of crops probably never occurred here. Early forests, however, were cut at least periodically for lumber and firewood. Today, much of the forest is made up of yellow poplar, a high-demand lumber source. Commonly yellow poplar grows more abundantly after fall and early winter logging if some trees have been spared and can provide a seed source. Scattered throughout the forest are heavily branched trees that grew originally in open areas. These trees probably were to small to have been cut profitably for lumber and, thus, grew in a newly opened area and developed broad, spreading crowns. These abundant seed producers established the current stand of trees. Large white and red oaks, beech, and bitternut hickory, scattered in the forest on steeper valley walls, were not readily accessible for lumbering.

En Route to Great Falls

The field trip route northwestward continues to parallel rock-cut terraces that border the river. Continue west on the Parkway, follow signs to Interstate 495, Virginia, and take the first exit off I-495, north on Route 193. From I-495 westward, the route is along an older road that crosses three larger tributary streams. Many water-powered mills, built approximately 150 years ago, took advantage of the steep gradient of these streams.

About 6 kilometers (4.1 miles) from I-495, our route turns north into Great Falls Park, an area maintained as a natural, historic site by the U.S. National Park Service. The road into the park follows an old rail-line bed that orginally ran from near downtown Washington to the Falls. Proceed to the parking lot beyond the visitor's center.

Stop 3: Visitor's Center, Great Falls Park, Diorama

On the second floor of the visitor's center, a three dimensional model of the park shows physiographic and cultural features of the area. Notice the location of the Patowmack Canal and the topography of the adjacent swamps and uplands.

Proceed to the overlook just downstream from the visitor's center.

Stop 4: Closeup of the Falls

The total drop of the river here is about 12 meters, and the lower cascade is about 5 meters high. The rock is Cambrian metagraywacke. The falls and surrounding area can be viewed in the stereo-pair aerial photographs shown in Figure 3.

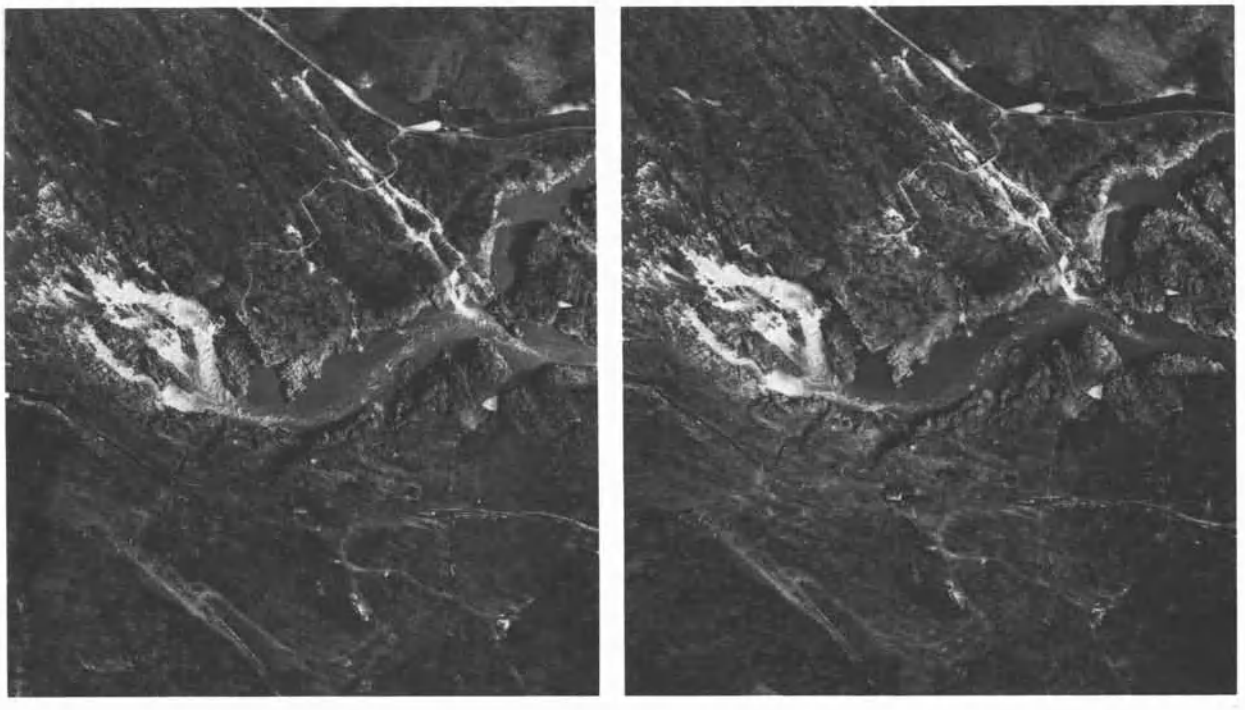

FIGURE 3 Stereo aerial photographs of the Potomac River Gorge at Great Falls Park.

Stop 5: Flood levels and another look at the Falls

Continue downstream along the path to the flood gauge on the left. The 1936 flood, highest on records that date from 1895, may have been equalled in 1889. The high water of these floods might have flowed into the swamp (stop 7), but it certainly backed up the valley from near Sandy Landing (stop 6) to inundate much of the valley.

The bedrock terrace, here and across the river, extends upriver, where it is continuous with the present flood plain. A low dam just above the falls feeds a reservoir for the metropolitan area water supply.

The channels in the river follow the weakened, closely spaced joints in the metagraywacke bedrock. The joints are visible in the rock face across the river.

Continue along the path downstream.

En Route to Stop 6

The gravel foot trail is bordered by a shallow trench that was once the Patowmack Canal. The trench extends to a large holding basin, beyond which canal locks enabled boats to be raised or lowered through the bedrock terrace.

The nearly level, grassy surface beyond the trail is underlain by shallow bedrock, but it is moist and poorly drained. Except during occasional flooding, low stream velocity causes much of the sediment load to be deposited here. The few tree species, swamp white and willow oaks and red maple, are characteristic of local swamp environments. Trees characteristic of the bedrock terrace, scarlet, post, chestnut, and red oaks, are located on scattered, rocky outcrops.

The field trip route continues along the gravel foot trail. The large outcrop along the trail and those in the forest between the trail and the river are mica schist, a resistant, massive rock. This bedrock probably dictated the location of the holding basin from here toward Glade Hill beyond the forest (Figure 2). The basin held water required to operate the locks and was a place for barges to wait to be locked downriver. The basin became filled with sediment from flood waters after the canal operation ended in 1828. The first-generation trees here are typical of moist flood-plain and bedrock-terrace surfaces. These are yellow poplar, chestnut oak, green ash, sycamore, box elder, river birch, and hackberry.

Stop 6: Narrow Channel

The small channel to the left was dug during the construction of the canal as an overflow channel from the holding basin. Drill holes can be seen in the rock walls. The channel to the right was naturally eroded along a series of lamprophyre dikes. The trees found in the major valley toward the river, sycamore, blue beech, box elder, and American elm, are common on local flood plains.

Stop 7: Lamprophyre Dikes and the Gorge

The top of the cliff is 20 meters above the normal (8 m) river level. Across the river are three lamprophyre dikes offset about 25 meters upstream from those on the Virginia side. A fault extends from the islands at the falls to the distant hill to the right. The easily eroded rocks along the fault produced the deep, straight gorge. Down the trail are many outcrops of river-rounded schist.

On the left is a twin-trunked ash tree. The basal trunk is inclined downstream and from it grow two vertical trunks. The inclined trunk was once vertical but was felled, probably by a flood, resulting in the growth of two vertical sprouts--sprouts like those that grow from a cut stump. A count of the number of annual rings in the trunks indicates that the sprouts started to grow in 1889, the year of the flood that probably equalled the 1936 flood. Farther along the trail, many smaller trees that were felled by more recent floods (1972 or 1985) have produced vertical sprouts.

The field trip route returns to the canal and crosses one of the liftlocks. The lock walls were built chiefly of "Seneca sandstone," which was quarried from the Triassic-Jurassic Culpeper Basin located more than 13 kilometers upstream, and was floated downstream on barges.

Here the construction problems were magnified by the resistance of the bedrock. Excavation was accomplished by blasting the mica schist with black powder. Holes were made by hand, and according to records, if the workers did not drill 6 feet per day, they were deprived of their daily whiskey ration. Along the trail is a twin-

trunked white oak tree. These two trunks started to grow from a stump that was cut in 1818, probably for use as lumber in the canal construction.

Along the trail are many pot-holes formed when the river was flowing at this level. Many rounded pebbles, cobbles, and boulders were deposited at this time. Sand and small freshwater shells, present in depressions behind outcrops that parallel the river, were deposited by modern floods. The shells are of the same species that live on aquatic plants in quiet water above the falls.

From the edge of the cliff, evidence of the effects of flooding on the distribution of lower plants (mosses and lichens) can be seen in the cliff across the river. Large, gray, warty lichens, Umbilicaria, occur near or at the cliff tops, where flooding is rarest. Several other lichen species are present. About 6 to 9 meters below the cliff edge are dark olive-green patches of a moss commonly found in the southern Great Smoky Mountains. The yellowish cast on the rocks, 3 to 6 meters above the normal river level, marks the location of a crustose lichen. Each group of plants occurs at a distinct flooding level of the river.

Stop 8: Sandy Landing

The improved road, presently used when needed by rescue personnel, and Sandy Landing date from the time of canal construction. Products to be carried downriver were unloaded above the falls onto wagons and hauled to Sandy Landing, where they were reloaded onto barges to complete the journey.

The cliff in the distance, downriver from Sandy Landing, rises about 40 meters above the river. George Washington travelled upriver, surveying the location of the canal. Because this cliff would have been insurmountable for a man on a horse, he could not have adequately surveyed the area.

The field trip route continues up the road and crosses an abandoned quarry whose history is obscure. Rock from the quarry possibly was used in the 1853 construction of the low dam upriver from the falls, seen at stop 2.

The stream on the left occupies a lowland extending northward west of Glade Hill (Figure 2). The road from the left is an old carriage road used for travel between Great Falls and Matildaville before construction of a rail line which became the alignment of the present entrance road.

The flood of 1936 (stop 3) was about 20 meters above river level where it was recorded at the visitors center and probably did not flow directly through the swamp. However, along the stream from the swamp to Sandy Landing, the 1936 flood waters probably backed up to the vicinity of the carriage road.

Stop 9: Swamp

The cleared embankment covers a sewer conduit that carries domestic and industrial refuse to a large sewer across the Potomac River. From here the refuse is piped to the Blue Plains processing facility, downriver from Washington, D.C.

The swamp occupies part of a lowland that extends northward through the picnic area south of the visitor's center to the river beyond. The lowland is an abandoned river channel. After the river ceased flowing in this valley, fine sediments from runoff accumulated slowly. Deposits in a few sampled places are 2 meters thick. At the bottom, resting on bedrock, is a thin layer of stream-laid sand and rounded gravel. Above, a poorly drained peat deposit has a C-14 age of about 9,500 years (Isabel Griffith, written commun., 1975). The ground in the swamp is poorly drained, and water stands, or is within a few centimeters of the surface.

The forest of the swamp is composed of pin, swamp white, and willow oaks, red maple, and sour gum. The shrubs, spicebush, southern arrowwood, poison sumac, and alder, are common. Skunk cabbage, a conspicuous, broad-leafed herbaceous plant, grows only in the wettest parts of the swamp. Skunk cabbage is the first plant in the swamp to bloom each year, often in January or early February.

The carriage road parallels the swamp at the base of Glade Hill northward. The road separates from the lowland at the north end and crosses a low bedrock terrace. Proceed back to the visitor's center.

TABLE 1. Common and scientific names of plants mentioned in this report.

sycamore	Platanus occidentalis
silver maple	Acer saccharinum
box elder	Acer negundo
red maple	Acer rubrum
green ash	Fraxinus pennslyvanica
chestnut oak	Quercus prinus
post oak	Quercus stellata
red oak	Quercus rubra
pin oak	Quercus palustris
willow oak	Quercus phellos
swamp white oak	Quercus bicolor
white oak	Quercus alba
black oak	Quercus velutina
yellow poplar	Liriodendron tulipifera
beech	Fagus grandifolia
white ash	Fraxinus americana
butternut hickory	Carya cordiformis
hackberry	Celtis occidentalis
American elm	Ulmus americana
sour gum	Nyssa sylvatica
spicebush	Lindera benzoin
arrowwood	Viburnum dentatum
poison sumac	Rhus vernix
alder	Alnus sp.
skunk cabbage	Symplocarpus foetidus

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arrowwood	Viburnum dentatum
poison sumac	Rhus vernix
alder	Alnus sp.
skunk cabbage	Symplocarpus foetidus

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