CHAPTER 4

SUSTAINABILITY: CASE STUDIES

Particular locations along the C&O Canal have demonstrated a pronounced vulnerability to floods during its history. This vulnerability was a consequence of design choices made by the canal company, and the geography of certain locations along the Potomac. Two of the most notorious trouble spots are Widewater (between Great Falls and Old Angler's Inn), and a section of canal opposite Harpers Ferry, W.Va., at the confluence of the Shenandoah and Potomac Rivers. Historically, high water plagued the canal in these locations, and despite determined preventive action by the C&O Canal Company, the B&O Railroad, and the National Park Service, there only has been limited success in minimizing flood damage at both these places. They represent two of the greatest challenges in making the canal sustainable--locations where engineering has repeatedly failed to protect the canal from the river.

Widewater

Below Great Falls, Bear Island splits the Potomac River into two channels. Engineers designing the C&O Canal decided to avoid digging and blasting a path along the river by damming off the inactive northern channel, constructing a wall and towpath along the island and incorporating the channel into the canal. This solution saved money for the C&O Canal Company in the 1830s when it was plagued by overruns, lawsuits, and other problems. However, it cost the company and its successors dearly in the years that followed. Although the southern channel of the Potomac has the capacity to handle the entire flow from upstream in low or normal periods, during a flood the northern channel becomes an overflow path.

The vulnerability at Widewater first became apparent in the 1840s. During the flood of October 1847, William H. Bryan, the collector of tolls in Georgetown reported, "Mr Lambie was down today & I am told, & reports that there is already 150 or 200

feet of the high embankment below the log wall gone."[1] It was the largest breach ever seen of the C&O Canal to that date.[2]

Such breaks at Widewater occurred repeatedly because the embankment there was much taller and narrower than anywhere else on the canal, yet it had to hold in a large body of water. When flood waters suddenly increased the pressure on the embankment, particularly after years of neglect, it easily broke.[3]

The flood of 1847 convinced the C&O Canal Company that preventive measures were necessary at Widewater. Rather than reinforce the embankment, the solution of Chief Engineer Charles B. Fisk was to build a stop lock and guard bank above Lock 16 to divert the water rushing down to Widewater area back to the southern channel of the Potomac.[4]

The stop lock and guard bank at Widewater built in the late 1840s were a dismal failure. Two major breaches occurred at Widewater during the flood of April 1852, the first in the same location as the large break in 1847, except that it was 500 feet in length, rather than only 200 feet. The water rushing through this break washed the embankment all the way down to its bottom. The second break occurred 100 yards upstream from the first and was seventy-five feet long. After a flood where the total repair estimate came to $80,000, Charles Fisk indicated it would cost $10,000 to fix Widewater alone. With no better way to protect the canal near Bear Island, the canal company rebuilt the guard

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[1]William H. Bryan, Collector, Washington, D.C., to Charles B. Fisk, Chief Engineer, Georgetown, 9 October 1847, Chief Engineer's Incoming Correspondence, 1834-52. During the nineteenth century, Widewater was referred to as "log walls" or the "log wall level." According to Thomas L. Patterson, a former engineer and general superintendent of the canal, and his partner T. P. Kinsley, the area took its name from the construction of the towpath there. "The towpath lies along the rocky points of the island [Bear Island] ," they wrote, "and was probably, originally formed on a wharf or wall of logs bolted to the surface or face of the cliff. All trace of these logs has disappeared [by 1890] except the occasional bolt showing where they had been secured." See Report of T. L. Patterson and T. P. Kinsley, Civil Engineers, Exhibit "A," to the Maryland Receivers, 9 June 1890, Brown et al. Trustees v. Chesapeake and Ohio Canal Company.

[2]John Lambie, Superintendent, Georgetown, to James M. Coale, President, Frederick, 8 November 1847, C&O Incoming Correspondence, 1828-90.

[3]Sipes interview.

[4]Charles B. Fisk, Chief Engineer, Cumberland, to President and Directors, 25 April 1850 and 2 August 1849, C&O Incoming Correspondence, 1828-90.

bank and stop lock. However, they raised the stop lock above the level of the 1852 flood, and secured it to higher ground on the north and to the guard bank on the south.[5]

These structures did their job until November 1877. The great flood of that month exceeded the levels of 1852 and caused considerable harm at Widewater. Three hundred yards above the bottom of Widewater there was a break 192 feet long and twelve feet deep. Not only that, but the embankment from the break to the downstream end of Widewater appeared to be slipping slowly into the water. The flood damaged Lock 15, its flume, and the towpath below it. Lock 16 also suffered injury as well as the towpath between it and Lock 15. Still, the cost of damage in this area was less than in 1852, only $4,500.[6]

It is not known if any improvements were made to the stop lock and guard bank after the 1877 flood. In any case, the guard bank failed in 1889, when high water not only devastated Widewater yet again, but put the canal company out of business. The B&O trustees hired two engineers to survey the damage on the canal. Thomas L. Patterson, a former engineer and general superintendent of the canal, and his partner, T. P. Kinsley, reported that the failure of the guard bank had sent water rushing below Lock 15 into the widewater, causing two breaches. They wrote:

> The Canal here occupies a deep rocky gorge, formerly the inside channel of the river. This was cut off from the river by an embankment to the head of an island and another forty feet high from the foot of the Island to the mainland. It is through this latter bank that a breach has been made, not however to its full depth. . . . There is a second breach below the junction of the high embankment with the mainland, where the towpath is very high above the ordinary water level of the river opposite it.[7]

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[5]John Page, Georgetown, to "Dr Sir," 22 April 1852; Charles B. Fisk, Chief Engineer, Washington, D.C., to President and Directors, 29 April 1852, C&O Incoming Correspondence, 1828-90; Patterson and Kinsley, Exhibit "A," to the Maryland Receivers, 9 June 1890, Brown et al. Trustees v. Chesapeake and Ohio Canal Company.

[6]Benjamin Fawcett, Secretary, to President and Directors, c. December 1877, C&O Incoming Correspondence, 1828-90.

[7]Patterson and Kinsley, Exhibit "A," to the Maryland Receivers, 9 June 1890, Brown et al. Trustees v. Chesapeake and Ohio Canal Company.

Patterson's and Kinsley's account of the damage at Widewater in 1889 is supplemented by an earlier report of the officers of the C&O Canal Company to its stockholders. This account describes the break at the downstream end of Widewater as 150 feet long and thirty feet deep. In the second break, 920 feet of towpath was washed away. On the way to causing the two breaks the flood waters also "nearly destroyed" Lock 15.[8] The damage estimate submitted by the receivers of the C&O Canal Company put the cost of the repairs to the entire canal at $268,698. Of that figure, $37,057 was needed just to fix Widewater and the rest of the level below Lock 15.[9]

After the 1889 flood, a calm period on the Potomac spared Widewater significant damage until the flood of 1924. The trustees of the B&O Railroad did not submit damage reports for Widewater during May 1924 and March 1936, but the area certainly suffered during these floods because of the extensive repair work that was necessary there in the late 1930s.

The National Park Service rebuilt Widewater as part of its pre-World War II restoration of the canal between Georgetown and Seneca. NPS devoted a considerable portion of its resources to this area during the project. Of the $500,000 appropriated by Congress, one-fifth was spent at Widewater. In repairing Widewater, the Park Service designed the work specifically with sustainability in mind. Besides rebuilding the stop lock above Lock 16, the National Park Service, according to the Evening Star, had the contractor for Widewater "construct the retaining walls, dikes, cribbing, earth fill and riprap so that it will be easy for flood water to flow over the top of the embankment over a wide front, carrying away a few feet of easily replaced topping."[10] At points where flood waters had broken through in 1936, workers installed concrete capping to provide further reinforcement.[11]

Despite the improvements at Widewater, the flood of October 1942 devastated the area. After spending a large sum to renovate and improve this area, Congress refused to appropriate money for

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[8]The President and Directors to the Stockholders of the Chesapeake and Ohio Canal, 13 June 1889, Ibid.

[9]Report of the Maryland Receivers, 9 June 1890, Ibid.

[10]Evening Star (Washington, D.C.), 15 September 1939, B1.

[11]Washington Post, 14 November 1942, 5B.

its maintenance. There was no one around to install the boards in the stop lock and flood waters proceeded without impediment into Widewater, where they overwhelmed the concrete capping.[12] According to the Washington Post, "water washed under and around the capping, then crumbled it, as it did at another natural outlet point farther down."[13]

The considerable expense of repairing Widewater meant it was last area of the canal downstream from Seneca repaired after the 1942 flood. The estimated expense of restoring the canal from Lock 5 to Seneca after the 1942 flood was $140,000. About 75 percent of that amount, or $105,000 would have been needed just to repair Widewater.[14] Hence, instead of restoring Widewater after World War II, the Park Service opted instead to repair the rest of the canal above and below. They used the stop lock to divert canal water from Dam 2 back to the river, and built a dike at the bottom of Widewater to prevent water on the Lock 14 level from flowing back into the area. The Corps of Engineers supplied surplus water from the Washington aqueduct to fill the canal from the bottom of Widewater to Lock 5.[15] Not until 1954 did the Park Service finally start to rebuild Widewater, and job was not finished until 1957. Even then, a section of towpath remained unrepaired below Lock 15, leaving a rocky, barely passable trail for hikers.[16]

After the repairs were finished, NPS management was not optimistic the work would survive. The new towpath embankment showed signs of slippage soon after its completion. Harry T. Thompson, associate superintendent of National Capital Parks, did not think the slippage was a problem unless a flood appeared.

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[12]Baumann, Widewater, 60.

[13]Washington Post, 14 November 1942, 5B.

[14]Horne to Thompson, 1 December 1953, Administration, Protection and Maintenance File 1460/C&O-5.

[15]P. E. Smith, Chief, Engineering Division, to H. T. Thompson, 29 August 1945; E. A. Schmitt, Chief Water Supply Division, U.S. Engineers Office, Irving C. Root, Superintendent, National Capital Parks, Washington, D.C., 2 October 1945; National Capital Parks Press Release, 1 February 1946, Ibid.

[16]Baumann, Widewater, 12.

"In which case," he added, "I doubt if anything would save the Widewater fill in the future any more than it has in the past.[17]

NPS launched a more ambitious restoration of Widewater in 1970. The aim was to repair the towpath and eliminate the rocky section impassible to bicycles. However, to make the area accessible to heavy trucks workers cut down trees and turned the towpath into a road, complete with turnabouts. This approach angered the environmental community, and public pressure forced the abandonment of the towpath restoration project before its completion. Environmentalists, objecting to damage to geological resources and to inadequate compliance with preservation laws, also stopped construction of a temporary foot bridge over the rocky gap below Lock 15 in 1976.[18]

The flood Thompson had feared finally came in 1972, when flood waters again devastated Widewater. With the stop lock inoperative (from wear and neglect), there was nothing to divert the flood away from this area and it tore two holes in the embankment, the first eighty feet long and seventeen feet deep and the second 195 feet long and twenty-one feet deep.[19]

The C&O Canal Restoration Team, led by Richard G. Huber, planned and supervised the repairs at Widewater after the 1972 flood. Contractors working under the restoration team made the stop lock functional and rebuilt the 900-foot guard wall that funnelled the diverted water down to the southern channel of the Potomac River. According to NPS historian Merrill J. Mattes, work on the guard wall consisted of:

> . . . a complete reconstruction of 450 feet . . . and patch repairs of the remaining 450 feet using hand placed riprap. Both wing walls on the berm side as well as the guard wall were restored. Mortared and dry-laid walls adjacent to the stop lock parapet wall that carried the towpath were also restored, and the towpath was regraded for 200 feet downstream. The earth ramp built under the previous contract would now impede the diversion of flood waters, so

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[17]Harry T. Thompson, Associate Superintendent, National Capital Parks, to Chief, Maintenance Branch, 1 February 1954; Harry T. Thompson, Assistant to the Director, to Irving Brant, Washington, D.C., 7 November 1957, Administration, Protection and Maintenance File 1460/C&O-5.

[18]Baumann, Widewater, 13-20.

[19]Mattes, Landmarks of Liberty, 19.

it was removed and replaced by a wooden stairway that would be washed clear in a flood.[20]

As previously indicated, the restoration team gave the embankments in Widewater extra stability by placing gabion baskets in them as reinforcement, much as steel bars give greater strength to concrete. As Mattes described the work:

> . . . gabion baskets were wired together to form a core of rock nine feet wide at its base, three feet wide at its top, and 18 feet high. As the gabion core was constructed, the towpath embankment was laid down in 6-inch layers and compacted. Eight-inch filter pipes were laid parallel to the rock core and relieved to the river side of the fill. Because the largest break occurred at a curve, a core of gabions 80 feet long by 12 feet wide was placed on the embankment at the waterline to reduce erosion of the fill from wave action.[21]

The restoration team also had an inoperative waste weir, that could drain excess water from Widewater, stabilized and restored to functional use. Reconstructing the stop lock and guard bank, restoring Widewater proper, and repairing Locks 15 and 16 cost the Park Service $789,000 of the $14 million it expended in post-1972 restoration of the canal.[22]

The costly repairs after the 1972 flood of Widewater, however, did yield some positive results. In October 1976, about a year after the work at Widewater had ended, the Potomac River experienced a moderate flood. When news of the impending high water reached the chief of maintenance, Dale Sipes, he ordered the foreman in the Palisades District, Don Foster, to have his crew install the planks in the stop lock above Lock 16. The stop lock worked. While the flood washed out the Catoctin Creek foot bridge, Widewater was spared appreciable damage.[23] Likewise,

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[20]Ibid., 20-21.

[21]Ibid., 19. Dale Sipes, the chief of maintenance during the 1972 was critical of using gabions to reinforce the embankment at Widewater, believing they were ineffective for that purpose. "Gabions don't stabilize a structure or a foundation," he told the author. "What they're intended for is to eliminate or reduce the erosion effects on a stream bed." See Sipes interview.

[22]Ibid., 19-21; 1975 Annual Park Report, vii.

[23]Sipes interview.

the stop gate functioned in 1985, during a much higher flood than in 1976. There was some damage at Widewater, but no gaping breaches as in 1972.[24]

Whether the preventive measures at Widewater would work in a flood of truly massive proportions, however, is still at best uncertain. The ruin of Widewater after the floods of 1847, 1852, 1877, 1889, 1924, 1936, 1942, and 1972 does not engender optimism in the ability of human ingenuity to prevent flood damage there. However, as the experience of 1976 and 1985 shows, flood prevention at Widewater is not an entirely hopeless task. The measures taken there after 1972 minimized damage in 1976 and 1985, the latter flood being of sizable proportions. Likewise, in 1942 and 1972, when the stop lock was not operative, major damage occurred at Widewater.

The Harpers Ferry Area

Like Widewater, the C&O Canal experienced severe flooding problems at the confluence of the Shenandoah and Potomac Rivers, across from Harpers Ferry, W.Va. However, the flood danger resulted not from taking away a river channel for the canal, but from geography and hydrology. A report to Congress on the flood danger to the proposed C&O Canal Parkway, aptly summarized the threat. "The gradient of the river at this point," the report stated, "is relatively steep and immediately below the confluence with the Shenandoah River the valley is reduced to a narrow gorge where it passes through the Blue Ridge Mountains. Excessive discharge from either the Shenandoah or the Potomac Rivers is impeded at this point causing local floods in this area." Hence, not only severe floods hurt the canal around confluence, but smaller floods did damage as well. The parkway report stated, "Records kept since 1889 show that on an average of every two years the elevation of this high water has equaled that of the towpath and has exceeded the towpath level by five feet on an average of every five years."[25]

The C&O Canal Company realized the flood problem in the vicinity of Harpers Ferry early. In March 1834, Charles Fisk recommended the construction of waste weirs "above the head of

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[24]Young interview.

[25]Chesapeake and Ohio Canal Report, House Document No. 687., 8.

Harpers Ferry Falls."[26] At some later point, probably in the 1830s, the canal company also built a protection wall of masonry and riprap, five feet in height, along the route of the canal in the Harpers Ferry area to protect it from the river.[27]

Like the rest of the canal, however, little if any damage occurred in this area during the 1830s. While the Shenandoah River made a significant contribution to the flood of 1836, there was only minor damage to the C&O Canal there, although water covered the area.[28]

The luck of Harpers Ferry changed for the worse in the 1840s. The flood of February 1840, which affected the unfinished portion of the canal most greatly, caused four breaches between Lock 31 and Dam 3. One of the breaks at the head of Lock 36 was fifty-five feet long and went down to the bottom of the embankment.[29] Waters overran the canal at Lock 33 in April 1843.[30] The river rose even higher in the Harpers Ferry area in September 1843. A resident wrote the canal company, "The Shanandoah [sic] Locks are gone the river higher than ever known, the bank of the Canal here under water."[31] The flood caused

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[26]Charles B. Fisk, Engineer, Washington, D.C., to the President and Directors, 18 March 1834, C&O Incoming Correspondence, 1828-90.

[27]Chesapeake and Ohio Canal Report, House Document No. 687., 8.

[28]J. Y. Young, Superintendent, Georgetown, to J. P. Ingle, Clerk,, Washington, D.C., 1 June 1836; James O'Reilly, Georgetown, to John P. Ingle, Clerk; W. S. Elgin, Superintendent, to President and Directors, 6 June 1836; W. S. Elgin, Superintendent, Harpers Ferry, to G. C. Washington, President, Washington, D.C., 13 June 1836, C&O Incoming Correspondence, 1828-90.

[29]W. S. Elgin, Superintendent, Harpers Ferry, to Francis Thomas, President, 11 February 1840; G. W. Rodgers, Superintendent, Canal Line, to John P. Ingle, Clerk, 13 February 1840, Ibid.

[30]W. S. Elgin, Superintendent, Harpers Ferry, to Charles B. Fisk, Chief Engineer, 15 April 1843, 12 noon, Chief Engineer's Incoming Correspondence, 1834-52.

[31]J. G. Cobb, Harpers Ferry, to James M. Coale, President, 16 September 1843, C&O Incoming Correspondence, 1828-90.

severe erosion in the embankments around the Shenandoah River Lock, and tore one of the lock gates out.[32]

It appears that the canal company raised the level of the embankments at Harpers Ferry, as at other vulnerable locations on the canal, because of the September 1843 flood. After the July 1846 freshet, which came within fourteen inches of the September 1843 height, Superintendent W. S. Elgin wrote, "the improvement done at the Shenandoah inlet Lock has saved the canal at this point and there is no damage for 20 miles Below this point." According to Elgin, the damage was not even one-fourth as much of that of the previous flood.[33]

The Harpers Ferry area appears to have escaped serious damage in the flood of October 1847, but it was not so lucky in April 1852. The Shenandoah River inundated both the town of Harpers Ferry and the C&O Canal. There was a breach eighty feet long in the Maryland abutment of Dam 3. While the damage estimate for the entire canal was $80,000, between Lock 32 and Dam 3 it was $5,000 alone. After the flood, W. S. Elgin proposed running a guard bank from Dam 3 to Lock 36.[34]

The worst flood to that date in the Harpers Ferry area, the "Great Freshet in the Shenandoah," started September 30, 1870. According to Harlan Unrau, "The most significant damage to the waterway occurred between Sandy Hook and Lock No. 33 at Harpers Ferry. Here a breach 850 feet in length was opened in the canal embankment, and the protective wall which supported the towpath was greatly undermined."[35]

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[32]Unrau, The Major Floods, 7.

[33]W. S. Elgin, Superintendent, Point of Rocks, to James M. Coale, President, Frederick, 8 July 1846, C&O Incoming Correspondence, 1828-90.

[34]W. S. Elgin, Superintendent, Harpers Ferry, to Charles B. Fisk, Chief Engineer, 25 April 1852, Chief Engineer's Incoming Correspondence, 1834-52.; Charles B. Fisk, Chief Engineer, Washington, D.C., to President and Directors, 29 April 1852, C&O Incoming Correspondence, 1828-90; Charles Fisk, Chief Engineer, Washington, D.C., to W. S. Elgin, Superintendent, 5 May 1852, Drafts of Chief Engineer's Outgoing Correspondence, 1836-38, 1846-52.

[35]Unrau, The Major Floods, 25; Forty-Third Annual Report of the President and Directors of the Chesapeake & Ohio Canal Company to the Stockholders, June 5th, 1871 (Hagerstown, Md.: A. G. & M. W. Boyd, Printers, 1871), 8.

However, the injury to the canal in 1870 palled in comparison to the flood of November 1877. "It looked to me as if the canal was gone forever at Harpers Ferry," a coal company officer later testified. [36] A C&O Canal Company committee was more descriptive about the disaster. It stated, "at Harpers Ferry . . . for a distance of more than two thousand feet the Entire guard wall at the inlet lock at the Shenendoah [sic] was swept away and the canal filled with the wash from the Potomac . . ."[37] After the 1877 flood, crews excavated the debris and rebuilt the guard wall higher than before.[38]

The area around Harpers Ferry also suffered in the flood of 1886, but detailed records describing the damage were not found. It was necessary, however, to add stone to Dam 3 afterward and to clean out its feeder, suggesting a relatively mild freshet.[39]

The 1889 flood devastated Harpers Ferry to a greater extent than the horrendous flood of 1877. The canal company reported to its stockholders soon after the waters receded that from Lock 32 to the Harpers Ferry bridge, "the Towpath, and heavy river walls for the distance of a Mile are nearly destroyed, the river and Canal being one for nearly all the distance." The flood also badly damaged Locks 34, 35, and 36. The B&O trustees, who took over the canal company in 1890, believed it would cost $22,503 to restore the canal from Lock 32 to 36--over 8 percent of the repair estimate for the entire canal.[40]

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[36]A. P. Gorman, President, Annapolis, to the Directors, 12 December 1877, C&O Incoming Correspondence, 1828-90.

[37]P. Harriell and John Humbird, Baltimore, to the President and Directors, 12 December 1878, Ibid.

[38]Ibid.; Testimony of Frederick Mertens, Boat Builder in Cumberland, 4 March 1880, in Report of the Joint Standing Committee, 93-94.

[39]Fifty-Ninth Annual Report, 15-18.

[40]The President and Directors to the Stockholders of the Chesapeake and Ohio Canal, 13 June 1889; Report of the Maryland Receivers, 9 June 1890, Brown et al. Trustees v. Chesapeake and Ohio Canal Company. Patterson and Kinsley, the engineers left a more explicit description of the damage to the canal around Harpers Ferry. See Report of T. L. Patterson and T. P. Kinsley, Civil Engineers, Exhibit "A," to the Maryland Receivers, 9 June 1890, Ibid.

As might be expected, the C&O Canal at Harpers Ferry suffered greatly during the great floods of 1924, but no detailed records of that damage were found in the course of research. In 1936, the canal in Harpers Ferry suffered extensive damage from Lock 32 all the way up to Dam 3.[41] The greatest flood in the history of the lower Shenandoah River occurred in October 1942. Water levels for that flood exceeded the great flood of 1870 on the Shenandoah and approached those of March 1936 flood on the Potomac. Like 1936, no documents have been found describing the damage to the canal around Harpers Ferry as a result of the 1942 flood.[42] The lack of records for the area beginning in 1924 reflects the neglect of the B&O Railroad afforded the canal after that year.

Unlike Widewater, the C&O Canal opposite Harpers Ferry was not restored before World War II. Indeed, the canal in this area received little maintenance after navigation ended in 1924 either by the B&O Trustees or by the National Park Service, and by the early 1950s the canal there was in ruins. The lack of maintenance and repeated floods took their toll. Henry G. Weeden, the Park Service engineer who surveyed the location around 1950 for the proposed C&O Canal Parkway, remarked in his report that the old protective wall had been "practically obliterated in many places."[43]

The poor state of the canal in the Harpers Ferry area impressed Weeden. While apparently downplaying the flood threat at other locations on the canal to advance the cause of the parkway, Weeden was frank about the vicinity of Harpers Ferry. He warned:

> The terrain at Harper's Ferry, the confluence of the Potomac and the Shenandoah Rivers, is such that the parkway would be exposed to the full force of all future floods. Because of the steep clifts [sic] along the Maryland side of the river it will be impossible to change the alignment to any extent and some study should be made as to the advisability of a by-pass of this difficult condition. Interruption in the use of the parkway in this area may be expected every year or so if the present alignment and grade of the canal is followed unless substantial erosion control and flood

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[41]Unrau, The Major Floods, 42.

[42]Potomac River and Tributaries, House Document No. 622, 23, 26.

[43]Weeden, "A Study of the Potomac River," 9.

protection walls are constructed similar to the original canal protection.[44]

The flood of June 1972, as many floods before it, caused great damage at Harpers Ferry. Although damage on the canal extended all the way up to Hancock in 1972, it was greater below Harpers Ferry where the swollen Shenandoah River added its waters to the Potomac.[45] The flood rendered the towpath impassible, caused a sixty-foot washout at Lock 34 and a 100-foot washout of the guard bank of Dam 3, as well as causing more general damage in the mile of the canal downstream of the dam.[46] Rather than repair the break at Lock 34, the Park Service built a foot bridge to span the gap, restoring towpath continuity, while leaving the hole as an escape valve for future flood waters.[47] Richard G. Huber's restoration team after 1972 also repaired many of the culverts in the Harpers Ferry area and restored the towpath.[48] Still, Harpers Ferry suffered in the November 1985 flood. A large washout occurred between Lock 33 and the Shenandoah River Lock, "exposing the Canal prism to the river."[49]

Despite extensive and repeated damage to the canal in the Harpers Ferry area, it did not become an expensive problem like Widewater. The high visitation at Widewater and its location in the rewatered section of the canal between Georgetown and Seneca made it important to repair that location completely after each major flood, despite the great expense. At Harpers Ferry, however, it was possible to leave some damage where it did not make sense financially to repair in the face of future floods.

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[44]Ibid., 9.

[45]Sipes interview.

[46]Jack Hobbs, Safety Officer, to Chief, Division of Safety Management, 3 July 1972, National Capital Region Records, 79-770003, National Park Service, Washington National Records Center, Suitland, Md.; Office of Cooperative Activities, National Capital Parks, National Park Service, General Plan: Chesapeake an Ohio Canal National Historical Park, (Washington, D.C.: National Park Service, 1975), 48.

[47]Mattes, Landmarks of Liberty, 23.

[48]Huber interview.

[49]Stanton, "The Flood of '85," C&O Canal Flood File.

CONCLUSION

The Flood History Study reveals the organizations who controlled the C&O Canal, at best, experienced only limited success in protecting it from the flooding of the Potomac River. In the case of both the C&O Canal Company and the National Park Service, their failure to build a sustainable canal was not from lack of effort. The C&O Canal Company's expenditures on flood repairs, renovations, and preventive activity helped financially ruin the organization. Likewise, since 1938, NPS has spent tens of millions of dollars repairing and protecting the canal. It has had some success with these expenditures, such as the bulkheads on Dams 4 and 5. However, the devastation of the C&O Canal NHP after the 1985 and 1996 floods show the river is still winning the battle. Yet the neglect of the canal by the B&O Railroad demonstrates the consequences of too little maintenance or flood damage prevention. As a result of the B&O's inaction between 1924 and 1938, flooding reduced the C&O Canal during those years from a functional waterway to an unsightly wreck. Hence, while history does not provide much encouragement because of the lack of success in building a sustainable canal, the past also demonstrates the folly of abandoning this effort if this valuable historic resource is to be preserved.

It must be admitted that the Flood History Study is not, nor should be, the last word on the history of flooding on the C&O Canal. The study was unable to utilize all the documentation existing on the canal, particularly outside of the Washington, D.C. metropolitan area. These sources include the personal papers of two presidents of the C&O Canal Company: those of Alfred Spates (1861-65, 1867-69) at the University of Virginia in Charlotte and Arthur P. Gorman (1872-82) in the Southern Historical Collection at the University of North Carolina at Chapel Hill. It might also be worthwhile to examine the papers of Daniel Van Slyke, an engineer who worked on the canal during the 1830s (at the New York Public Library) and Alexander B. McFarlan, an inspector of masonry during the construction of the waterway (at the Western Reserve Historical Society in Cleveland, Ohio). For floods in more recent decades, a large collection of records of the C&O Canal Association, a private organization devoted to preserving the canal, have recently opened at George Washington University in Washington, D.C. The association's canal walkers regularly reported on conditions throughout the park, and a systematic examination these reports could yield valuable information not only on major floods, but on the many minor episodes of flooding. The C&O Canal NHP also should systematically gather together its flood related records. There was a disappointing lack of records on flooding available from the park, particularly for the 1985. In any case, the C&O Canal NHP must continue oral interviews of former park personnel

involved in flood repairs. Such individuals interviewed for this report had many practical suggestions, based on years of experience, in minimizing flood damage. However, the Flood History Study was only able to make a start in tapping the wisdom of former and current employees in flood damage prevention.

History has much to tell that can help preserve the C&O Canal NHP. However, it is imperative that those persons who read this report do not stop with it, but go back and examine the primary sources available on flooding, especially the electronic notes and C&O Canal Flood File. They provide the most direct, detailed, and unfiltered information on flooding. This report can only provide an interpretation and analysis of the aforementioned resources. It is meant to provide insight and perspective. Intensive study of original documents, combined with a sense of how they fit into the larger picture hopefully will help readers avoid repeating the mistakes of the past, while recapturing old wisdom and assisting them in thinking of new approaches to the problem of the sustainability of the C&O Canal NHP.

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APPENDIX A

DAMAGE TO THE C&O CANAL FROM MAJOR FLOODS

Flood or Flood Sequence	Areas With Major Damage	Damage Estimate ($)
June 1836	Little Falls to Seneca, Harper Ferry, Dam 4, below the Cacapon River	Unknown
April 1843	Georgetown to Edwards Ferry, with lesser damage between Dam 4 and Dam 6	$20,000
September 1843	Georgetown to Dam	$30,000
March 1846	Dam 4 to Dam 5	$21,327.76[1]
July 1846	Georgetown to Dam 6, water highest from Williamsport to Dam 6	$21,327.76[1]
October 1847	Georgetown to Dam 6, heavier in certain areas below Dam 5.	$48,201.56[2]
April 1852	Town Creek to Georgetown, with the greatest damage below Seneca	$100,000[3]
February to June 1857	Dam 4 and 5	$90,000
Summer 1860 to Summer 1862	Various locations, but principally at Dams 4 and 5	$50,000
September 1870	Sandy Hook to Harpers Ferry, Seneca to Georgetown	$22,520.42

DAMAGE TO THE C&O CANAL FROM MAJOR FLOODS

[1]Combined damages from the March and July 1846 freshets.

[2]Damage estimate includes the follow-up flood of November 1847.

[3]Figure includes the cost of post-flood improvements.

(Continued)

Flood or Flood Sequence	Areas With Major Damage	Damage Estimate ($)
August 1873	Antietam and Monocacy Divisions	$25,000
November 1877	The entire canal, with the worst damage in the in the middle section.	$238,500.21
April-May 1886 at Dam 6.	The entire canal, with worst damage at Dam 6	$82,000
May-June 1889	The entire canal, with worst damage below Harpers Ferry	$430,764.43
March-April 1924	Williamsport, Hancock, and Cumberland and some damage at Dam 1	$30,000
May 1924	The entire canal, with worst damage below Harpers Ferry	Unknown
March 1936	The entire canal.	$25,406.05[4]
October 1942	Worst damage below Harpers Ferry	$250,000[5]
June 1972	Georgetown to Hancock, with the worst damage below Harpers Ferry	$14,000,000
February 1984	The entire canal.	$580,000
November 1985	South Branch to Georgetown	Unknown

[4]Figure reflects only the repair of the canal at and below Little Falls.

[5]Figure reflects only the repair estimate from Georgetown to Great Falls.

APPENDIX B

DOCUMENTED FLOODS ON THE POTOMAC RIVER, 1828-1996

July/August 1829
February 1831
January 1832
February 1832
April 1832
November 1832
January 1834
April 1834
June 1834
August 1834
June 1836
November 1836
March 1838
January 1840
February 1840
May 1840
January 1841
August 1842
April 1843
August 1843
September 1843
March 1845
March 1846
May 1846
July 1846
November 1846
March 1847
October 1847
November 1847
December 1847
January 1849
April 1852
September 1852
June 1855
August 1855
February 1857
May 1857
June 1857
May/June 1858
April 1859
September 1859
January 1860
Summer 1860
November 1860
April 1861

DOCUMENTED FLOODS ON THE POTOMAC RIVER, 1828-1996
(continued)

July 1861
November 1861
April 1862
June 1862
April 1863
July 1863
December 1863
April/May 1864
March 1865
May 1865
October 1866
February 1867
October/November 1867
Winter 1868
May 1868
October 1868
September 1870
August 1872
February 1873
May 1873
June/July 1873
July 1873
August 1873
August 1874
January 1874
April 1874
March 1875
July/August 1875
September 1876
January 1877
November 1877
January 1879
June 1884
March/April 1886
May 1887
July 1887
May/June 1889
April 1891
October 1896
February 1897
April 1901
February 1902
June 1910
July 1912
Spring 1913
June 1915

DOCUMENTED FLOODS ON THE POTOMAC RIVER, 1828-1996
(continued)

August 1915
June 1916
March 1917
February 1918
December 1918
January 1919
May 1921
March/April 1924
May 1924
February 1925
November 1925
August 1926
September 1926
September 1927
April/May 1928
June 1928
April/May 1929
October 1929
July 1931
May 1932
April 1933
August 1933
December 1934
March 1936
January 1937
April 1937
May 1942
October 1942
September 1945
May 1947
April 1948
December 1948
June 1949
November 1952
October 1954
July 1955
August 1955
July 1956
January 1958
May 1958
April 1960
February 1961
March 1963
March 1967
June 1971
June 1972

DOCUMENTED FLOODS ON THE POTOMAC RIVER, 1828-1996
(continued)

October 1976
February 1979
February 1984
February 1985
November 1985
January 1996
September 1996