Open-File Report 98-03

# ROCKS AND RUINS OF THE "UPPER GRAND"

## An Illustrated Trail Guide to the Geology and Historical Archeology of Lehigh Gorge State Park, Northeastern Pennsylvania

**Jon D. Inners**

Commonwealth of Pennsylvania
Department of Conservation and Natural Resources
Bureau of Topographic and Geologic Survey
1998

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by Jon D. Inners, Pennsylvania Geological Survey

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Aerial view of the great bend of the Lehigh River at Rockport, looking north. The extensive rock cuts along the rail trail (old grade of the Central Railroad of New Jersey) on the north side of the bend are in the Mauch Chunk Formation. Indian Run flows into the Lehigh in the left center. (Photo by John G. Waidner, 1981.)

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# DEDICATION

This trail guide is dedicated to the memory of John G. “Jack” Waidner (1932-1994), steelworker, teacher, scout leader, and lover of the outdoors. Over several decades and into the 1990’s, Jack led many educational and recreational field trips through the Lehigh Gorge, both on land and on water. He probably knew more about the hidden recesses and historical nuances of the “Upper Grand” than anyone. All of us who were lucky enough to know him will remember Jack Waidner as a man of blithe and unassuming courage who never let adversity get the upper hand.

# PREFACE

> The Lehigh…forms numerous short turns between the mountains, and affords frequent falls, as well as below the falls deep pools, which render this stream a most valuable one for mills of any kind.
>
> John James Audubon—written in 1829.
> (Audubon, 1960, p. 317)

John James Audubon, the great American painter and naturalist, sojourned along the upper Lehigh River for six weeks in the late summer and fall of 1829, at about the time that industrialization—in the form of innumerable saw mills—was just beginning there. In the above quote, he notes one of the important physical attributes of the river that led to its rapid nineteenth-century development. This trail guide is an imperfect attempt to catalogue further aspects of the geology and geography of the Lehigh Gorge that relate to its industrial and transportation history between White Haven and Jim Thorpe. Though preliminary in every sense of the word, I hope it will prove interesting and useful not only to bikers and hikers in the gorge but also to those charged with administering and developing recreational and educational opportunities in the gorge area.

Even though the Lehigh Gorge and the surrounding "Great Pine Swamp" were in large part wild and untamed country at the time of his visit, Audubon foresaw some of the harmful effects of unchecked exploitation, especially deforestation, which would soon mar the landscape. Within 20 years a host of tanneries joined the saw mills, a canal had been completed as far as White Haven, coal was being mined from many of the mountaintops west of the river, and steam railroads were probing down to the river from the nearby coal fields. For the next three-quarters of a century the gorge bustled with industry. But then a gradual decline set in, and in many ways the Lehigh River from White Haven down to Jim Thorpe is much like it was in Audubon's time—maybe even wilder and more secluded as there are now no saw mills and the forests have returned. Harking back to the brief period around the turn of the last century when the lower gorge was a famed tourist attraction, the entire length of the gorge is—with the creation of Lehigh Gorge State Park and the Delaware and Lehigh National Heritage Corridor—fast becoming one of Pennsylvania's great recreational assets.

CORRECTION: The currently active railroad through the gorge is the Reading, Blue Mountain, and Northern Railroad, not Conrail. The RBM&N, headquartered in Hamburg, PA, assumed ownership of trackage in the gorge on August 19, 1996.

# INTRODUCTION

The Lehigh Gorge is a winding, rocky gash cut by the Lehigh River through a broad upland between the eastern Anthracite region and the Pocono Plateau in northeastern Pennsylvania. It extends approximately 25 miles from White Haven in Luzerne County to Jim Thorpe (formerly Mauch Chunk) in Carbon County, most of it being included in Lehigh Gorge State Park (Figure 1). A major recreational component of the park is a 26-mile-long hiking-and-biking trail that follows the west bank of the river from Port Jenkins—a mile and a half north of White Haven—to Jim Thorpe. This mainly geological guide includes a detailed trail log from the northernmost park gate at Port Jenkins to the site of Lock No. 1 of the "Upper Grand Section" of the Lehigh Canal at Jim Thorpe, a total distance of 26.1 miles. Information on archeological and historical sites within and adjacent to the trail is given where it illustrates aspects of the historical geography of the gorge area.

**Geology**

The Lehigh Gorge exposes folded rocks ranging in age from Late Devonian to Late Mississippian (Plate 1, in pocket). These rocks, the Catskill through Mauch Chunk Formations, comprise thick sequences of resistant gray sandstones and conglomerates and less resistant red sandstones, siltstones, and mudstones (Figure 2). All of the rocks are fluvial in origin, having been deposited by ancient streams between 375 and 320 million years ago when the area that is now Pennsylvania lay in the tropics a little south of the equator (Figure 3). Structurally, the gorge is in the transition zone between the folded rocks of the Ridge and Valley to the west and the relatively flat-lying rocks of the Pocono Plateau to the east. Thus, folds that are well defined in

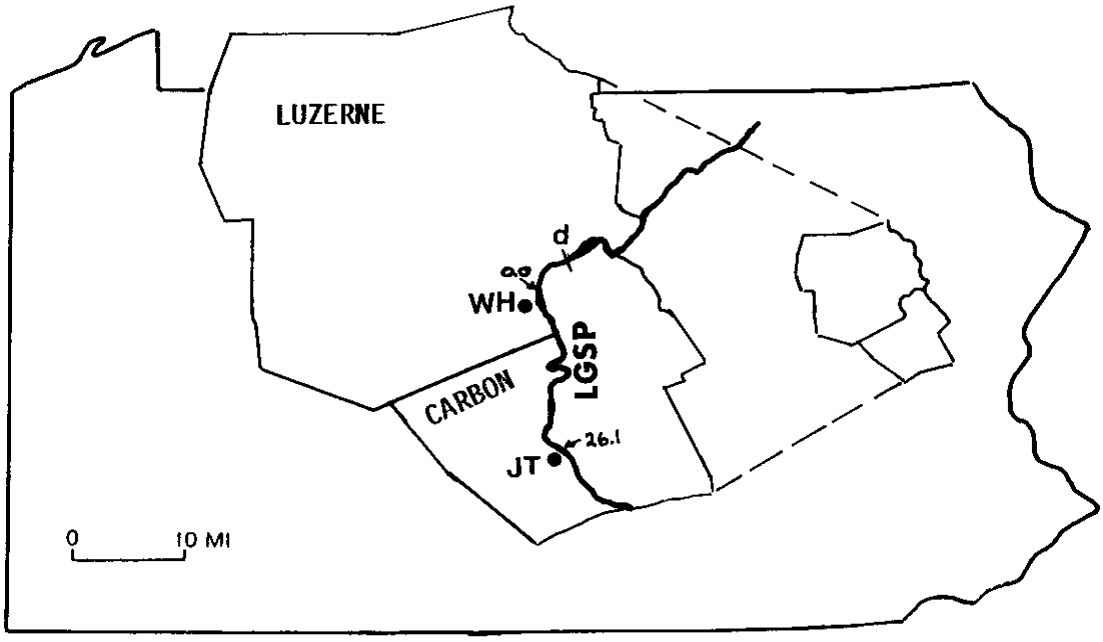
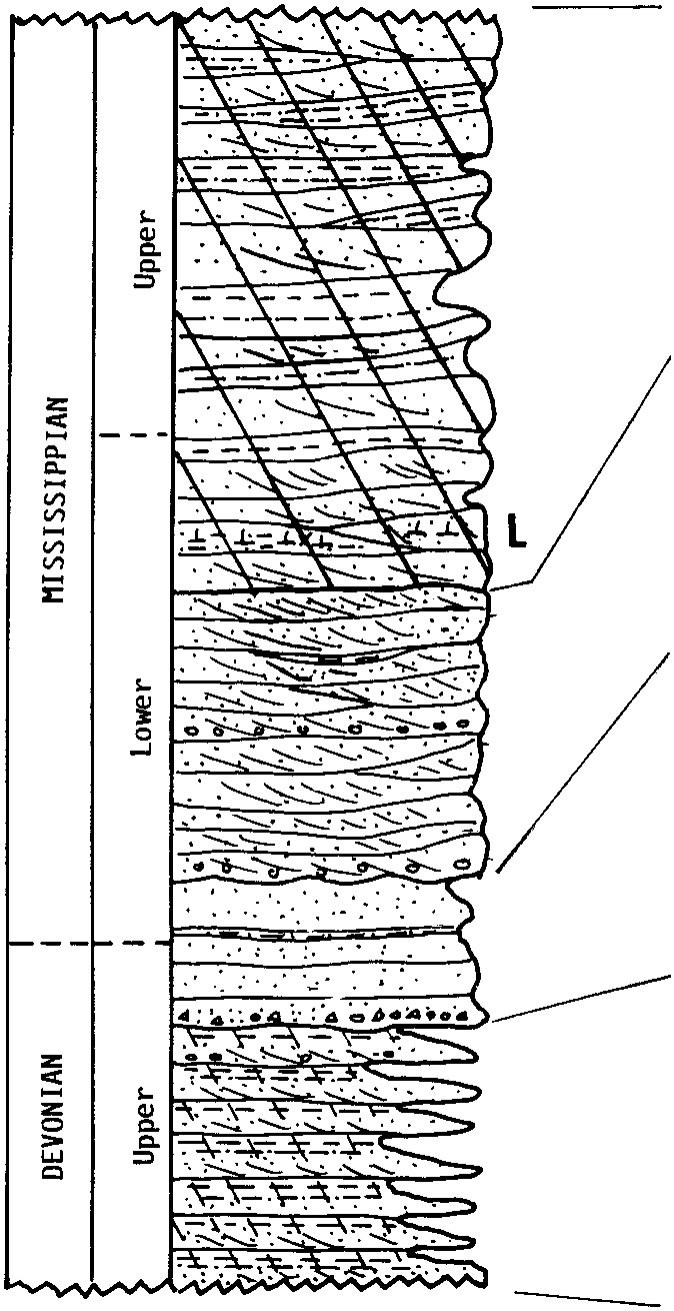



Figure 1. Location Map of Lehigh Gorge State Park. (LGSP = Lehigh Gorge State Park; WH = White Haven; JT = Jim Thorpe; d = Francis E. Walter Dam; 0.0 = start of trail log; 26.1 = end of trail log.)




**Mauch Chunk Formation**
Interbedded sandstone, siltstone, and mudstone, with some thick conglomerate units—especially in lower part. Typically grayish red, but containing some gray and greenish-gray sandstones and conglomerates. Interval of crossbedded, calcareous sandstone (L) about 200 feet above base.
1000± ft thick.

**Pocono Formation**
Dominantly gray, crossbedded, quartzitic sandstone, with thick conglomeratic intervals defining two members (Beckville, lower, and Mount Carbon, upper). Contains a few, thin lenticular gray and greenish-gray shale intervals. Plant stems and trunks occur locally.
Approximately 750 ft thick.

**Spechty Kopf Formation**
Mostly gray and olive-gray sandstone, with thin olive-gray shaly interbeds. Commonly at base is a distinctive diamictite composed of an unsorted mixture of clay, silt, sand, and pebbles, which grades up into olive-gray mudstone and laminated shale and sandstone.
Up to 375 ft thick.

**Catskill Formation**
**Duncannon Member**
Fining-upward cycles of sandstone (locally conglomeratic), siltstone, and mudstone. Sandstones are gray to grayish red, crossbedded. Siltstones and mudstones are mostly grayish red. Carbonized plant debris common locally. Exhibits uranium mineralization at Penn Haven Junction. Approximately 700 feet thick.

Figure 2. Rock units exposed in the Lehigh Gorge. (Diagonal lines = red color; L = limy sandstone strata probably equivalent to the Loyalhanna Formation of western Pennsylvania.)

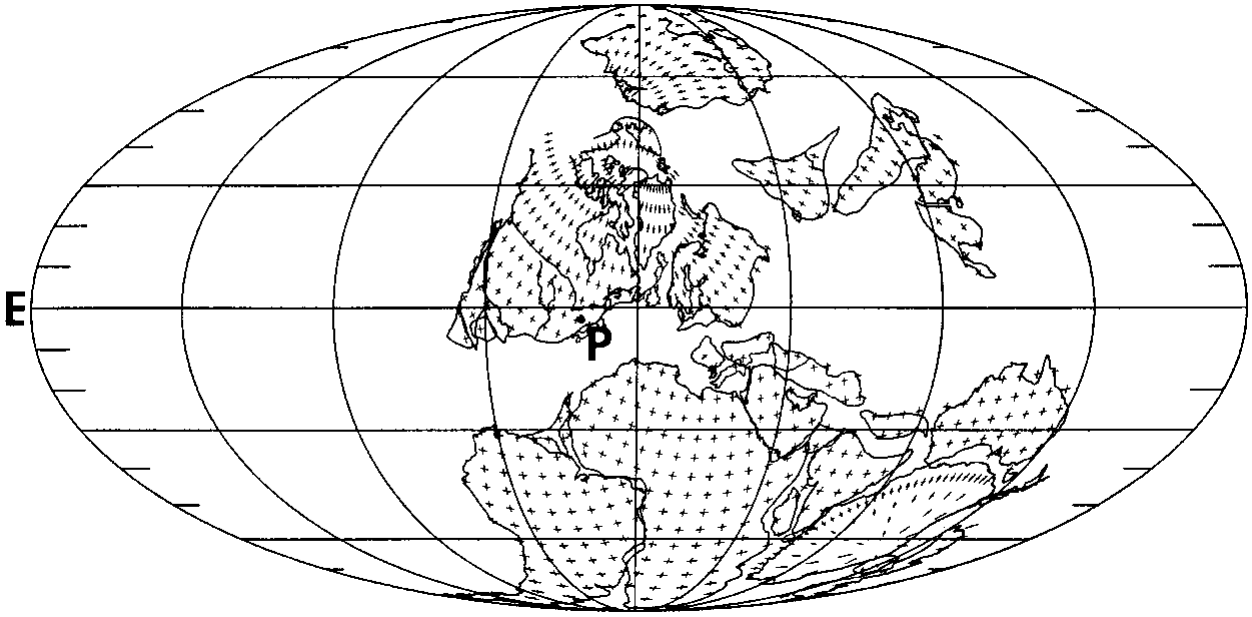



Figure 3. Mid-Mississippian (335 million years ago) paleogeographic map (Scotese and others, 1979, p. 264). Note that Pennsylvania (P) was situated south of the Equator (E) at that time.

the gorge flatten out and disappear within a few miles eastward (Plate 2, in pocket). This folding of the rock strata which is so evident in outcrops from one end of the gorge to the other took place approximately 250 million years ago when the African continental plate collided with the North American continental plate. Geologists refer to this mountain-building episode as the Alleghanian Orogeny. It affected a vast area of eastern North America stretching from Alabama to the Maritime Provinces of Canada. (See Barnes and Sevon, 1996, for an excellent discussion of the early geologic history of Pennsylvania.)

The Late Pleistocene (Wisconsinan) glacial border (about 20,000 years old) crosses the gorge about five miles south of White Haven near the Luzerne-Carbon County Line on the west side of the river and Hickory Run on the east side (Plate 3, in pocket). Upstream of this so-called "terminal moraine" deposits of stratified glacial sand-and-gravel are particularly well developed north and south of White Haven and just south of Tannery. Pocono Transcrete, Inc., operates a sizeable aggregate operation in these deposits 1.5 miles south of White Haven. Glacial striae on bedrock near Port Jenkins and Tannery trend S50E to S40W, indicating general southward movement of ice through the gorge (see Plate 3).

Several continental glaciations older than the Wisconsinan (now commonly referred to as Illinoian and Pre-Illinoian) extended into the gorge area between at least 850,000 years ago and 150,000 years ago. Deposits from these very ancient glacial events can be found scattered over the uplands bordering the gorge, but stream erosion and mass wasting have largely removed them from the gorge itself.

The extreme cold that held sway over northeastern Pennsylvania during the tens of thousands of years that each of these glaciations waxed and waned has had a profound influence on the

landscape. The resistant sandstones and conglomerates of the Pocono and Spechty Kopf Formations and the Duncannon Member of the Catskill Formation are susceptible to frost-splitting as water/ice freezes and expands in natural fractures of the rock. Over the last million years or so, physical breakdown of these rocks and gradual downslope movement of the resulting fragments has built up a mantle of subangular to rounded boulders and cobbles of native sandstone and conglomerate on slopes bordering the gorge. Thick sandy and silty deposits containing many resistant boulders and cobbles also clog many of the tributary ravines.

***Origin of the Gorge***. The Lehigh River has arrived at its present position as a result of downward and headward erosion that started relatively late in the erosional history of Pennsylvania (Figure 4). The gorge area was once covered by 3 or 4 miles of rock above the Mauch Chunk. This consisted of Pennsylvanian- and Permian(?)-age sedimentary strata and probably great sheets of older rocks emplaced by faults during the continental collision that folded the rock strata and produced the ancestral Appalachian mountains about 250 million years ago.

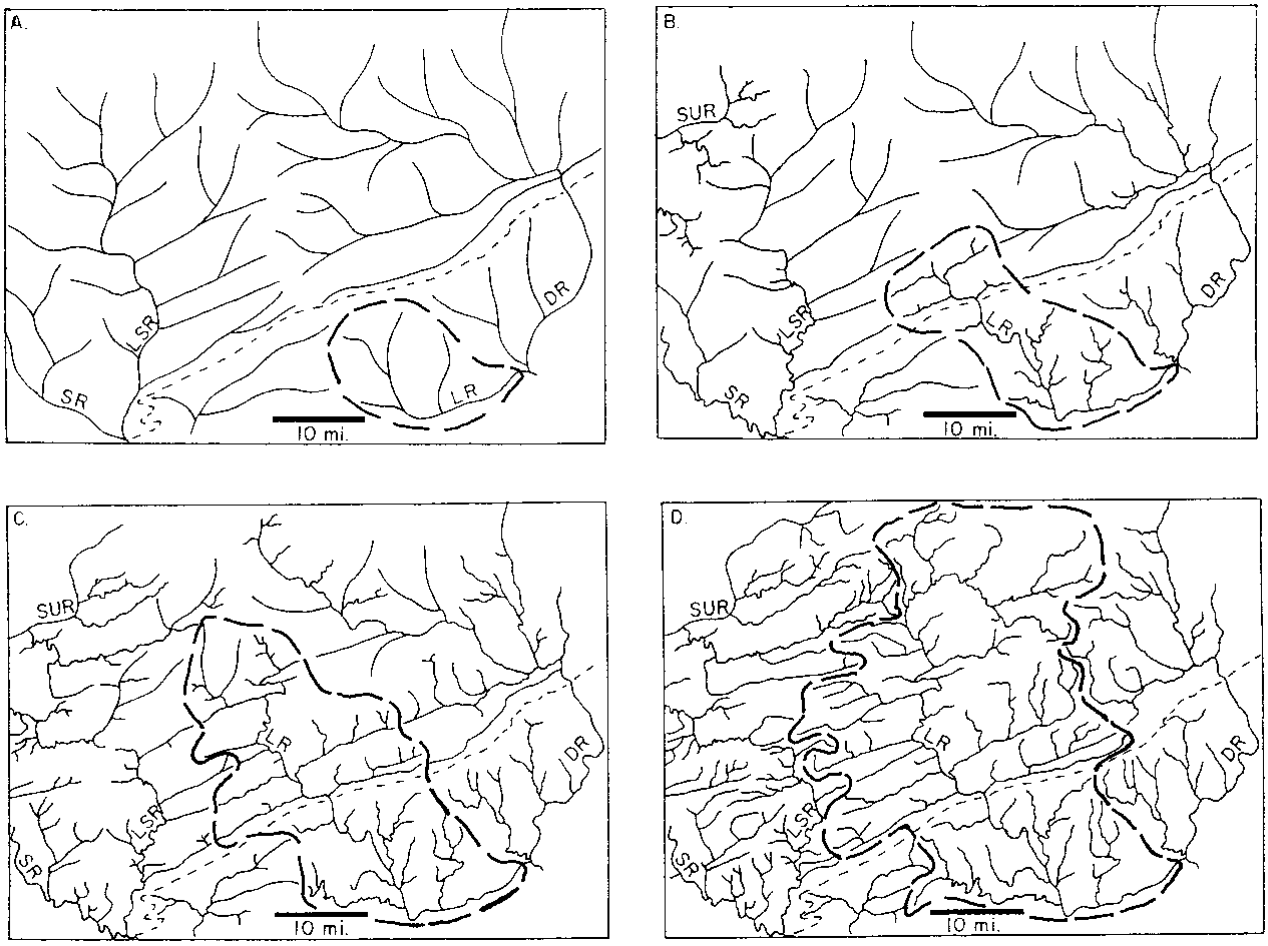



Figure 4. Hypothetical development of the Lehigh River drainage basin. A. Middle to Late Jurassic (135 million years ago); B. Early Cretaceous (110 million years ago); C. Late Cretaceous-Early Tertiary (65 million years ago); D. Present. (DR = Delaware River; LR = Lehigh River; LSR = Little Schuylkill River; SR = Schuylkill River; SUR = Susquehanna River; Short-dash line = present crest of Blue Mountain; long-dash line = approximate limits of Lehigh River drainage basin. (Sevon, in Inners and others, 1994).

Some of this overlying rock was eroded by tributaries of the ancestral Schuylkill and Delaware Rivers during the middle part of the Mesozoic era when the Lehigh was only a minor branch of the Delaware. By the time that most or all of the rock sheets emplaced by faulting had been eroded (perhaps 100 million years ago), a youthful Lehigh River eroded headward in the area between the two larger drainages. That the river in the gorge originated by headward erosion rather than downcutting through the relatively "flat-lying" fault sheets (superposition) is strongly suggested by the striking adjustment to bedrock structure of many of its reaches (see Plate 2, in pocket, and the discussions in the Trail Log from Tannery to Rockport and Rockport to Penn Haven Junction.)

**History**

The Lehigh Gorge enters recorded history at about the same time as does a young, energetic and creative entrepreneur from Philadelphia named Josiah White (1782-1850). In the years immediately following the War of 1812, White, who operated a wire-nail mill on the Schuylkill River, became convinced of the economic potential of northeastern Pennsylvania anthracite, or "stone coal," which was just beginning to reach markets on the east coast. In 1818, after reconnoitering the gorge all the way to Stoddartsville in what is now Luzerne County, White and a partner obtained a twenty-year lease on coal lands near Mauch Chunk (at the eastern end of the today's Southern Anthracite field) and formed the Lehigh Coal Company and the Lehigh Navigation Company. (The two were combined into the Lehigh Coal and Navigation Company [LCNC] in 1821.)

Before the end of 1818 White began construction of "descending navigation" below Mauch Chunk, using dams and "bear-trap locks" of his own design to form temporary floods on which arks could pass over the rocky shoals in the river. By 1823 over a thousand tons of anthracite, along with large tonnages of timber and farm products, reached Philadelphia from the Lehigh Region.

The next year the LCNC purchased rich timber holdings in the area around what is now Rockport, and built four sawmills along Indian Run, Laurel Run, and Leslie Run. Over the ensuing decades, many sawmills—and grist mills—sprang up on other tributary streams in the gorge. White Haven, settled in 1824, became the major lumber-shipping center. Bark from the logs provided tannin for curing leather, and by the 1860's, numerous tanneries were operating along the river, particularly around Tannery, a mile and a half south of White Haven (Young, 1991; Petrillo, 1998).

***The Canal.*** Between 1825 and 1829, White and the LCNC built the Lehigh Canal between Easton on the Delaware River and Mauch Chunk, a distance of 46 miles. The wild river course farther upstream, however, remained untamed. It wasn't until June of 1836 that work began on extending the canal another 26 miles north to the vicinity of the recently founded village of White Haven. In only two years the "Upper Grand Section" of the canal—an impressive engineering achievement consisting of 26 miles of navigable water, 20 dams, and 29 "high-lift" locks—was completed, overcoming an elevation difference of more than 600 feet (Plate 4, in pocket; Table 1). (A descending navigation system with three dams and three "bear-trap locks" connected the upper end of the canal proper with Stoddartsville, 12 miles farther upstream.)

Although the "Upper Grand" did a lively business transporting anthracite mined at Buck Mountain, Hazleton, and Wilkes-Barre, it could never free itself from the unrelenting dictates of nature. Although merely a portent of worse to come, the flood of 1841 halted operations for

# TABLE 1. Locks and Dams of the Lehigh Canal ("Upper Grand")

| Lock No. | Dam No. | Miles from Jim Thorpe | Lift of Lock (ft) | Length of Dam (ft) | Height of Dam (ft) | Width of Dam at Base (ft) | Condition of Lock |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.68 | 15.3 | 200 | 20 | | Fair |
| Guard | | 1.04 | | | | | Excellent |
| 2 | | 1.49 | 17 | | | | Excellent |
| 3 | 2 | 2.47 | 20 | 187 | 25 | 63 | -- (Gone) |
| 4 | | 3.25 | 14 | | | | Fair |
| 5 | 3 | 3.48 | 10 | 262 | 16 | 45 | Poor |
| 6 | | 3.83 | 21 | | | | Fair |
| 7 | 4 | 4.51 | 20 | 194 | 27 | 65 | Poor |
| 8 | | 5.39 | 21 | | | | Fair |
| 9 | 5 | 5.96 | 20 | 240 | 32 | 80 | -- |
| 10 | | 7.49 | 16 | | | | Poor |
| 11 | 6 | 8.03 | 13 | 209 | 24 | 63 | -- |
| 12 | | 8.8 | 21 | | | | -- |
| 13 | 7 | 9.44 | 22 | 180 | 29 | 80 | -- |
| 14 | | 10.46 | 18 | | | | -- |
| 15 | 8 | 10.58 | 20 | 190 | 58 | 120 | -- |
| 16 | 9 | 11.57 | 21 | 220 | 27 | 76 | -- |
| 17 | 10 | 12.46 | 22 | 235 | 32 | 80 | -- |
| 18 | 11 | 13.79 | 25 | 212 | 35 | 81 | -- |
| 19 | 12 | 15.08 | 25.5 | 210 | 32 | 80 | -- |
| 20 | 13 | 16.02 | 25 | 205 | 34 | 86 | -- |
| 21 | 14 | 16.96 | 25 | 189 | 35 | 107 | Fair |
| 22 | | 18.02 | 20 | | | | Excellent |
| 23 | 15 | 18.59 | 20 | 300 | 26 | 75 | Poor |
| 24 | 16 | 19.5 | 28 | 190 | 45 | 110 | Excellent |
| 25 | | 20.97 | 20 | | | | Excellent |
| 26 | 17 | 21.57 | 25 | 257 | 35 | 80 | -- |
| 27 | 18 | 23.01 | 30 | 306 | 36 | 96 | Poor |
| 28 | 19 | 23.94 | 22 | 295 | 27 | 75 | Excellent |
| 29 | 20 | 24.85 | 25 | 375 | 28 | 75 | Fair |
| | | Total Lift | 601.8 ft | | | | |

almost two years. And then, in June of 1862, a great "freshet" brought on by 30 hours of continuous rainfall broke numerous tributary mill dams, as well as the big log booms on the Lehigh at White Haven, releasing several hundreds of thousands of logs that wrecked irreparable damage on the canal. Less than a year later, the state legislature allowed abandonment of the "Upper Grand Section" and the construction of a railroad from Mauch Chunk to White Haven.

***The Railroads.*** Plate 5 (in pocket) summarizes the complex railroad network that developed in the gorge over a period of seventy-five years. The earliest railroads did not compete with the canal, rather they complemented it. Over a period of nearly twenty years, Josiah White himself engineered four ingenious rail systems to get anthracite from the mines to the canal: the Summit Hill Gravity-Railroad at Mauch Chunk (1827), the Buck Mountain Railroad from Buck Mountain to Rockport (1840), the original Lehigh and Susquehanna Railroad (L&S) (with its "Ashley Planes") from White Haven to Wilkes-Barre (1841), and the "Switchback Railroad," replacing the "gravity-road" at Mauch Chunk. Even the Beaver Meadow Railroad, its original line completed in 1836 from Beaver Meadow(s) in the Eastern Middle Anthracite field to Penn Haven on the Lehigh, trans-shipped its coal on the canal until 1855, when the line was extended along the west bank of the river to Mauch Chunk in direct competition with the LCNC.

The eventual chief competition of the canal was the Lehigh Valley Railroad (LVRR). Construction of the Lehigh Valley (originally the Delaware, Lehigh, Schuylkill and Susquehanna Railroad) between Mauch Chunk and Easton began in 185l and was completed under the management of Asa Packer in 1855 The railroad extended its line northward through the gorge mainly by acquisition of previously existing "shortlines," such as the Beaver Meadow, and in 1867 reached Wilkes-Barre. Although competition between the LVRR and the LCNC was intense, each was able to carve out an economic niche for itself. (The canal below Mauch Chunk continued to operate until 1942.)

After abandonment of the "Upper Grand Section" in 1862, the LCNC pushed the Lehigh and Susquehanna Railroad down the gorge from White Haven, reaching Mauch Chunk in 1868. The narrow gorge now boasted two competing railroads, generally on opposite sides of the river, except from Penn Haven south. In 1871, the Central Railroad of New Jersey (CNJ) leased the Lehigh and Susquehanna and thus acquired direct access to the burgeoning traffic in anthracite.

After World War I a gradual decline in the anthracite trade helped to bring on a decline in the region's railroads. In 1965 the CNJ and the LVRR consolidated their lines along the Lehigh River and abandoned much of the Central's trackage. (The hiking-and-biking trail in Lehigh Gorge State Park mostly follows this old CNJ right-of-way.) In 1972 the Lehigh Valley took over all of the Central's operations in Pennsylvania; and in 1976 that railroad's properties were, in turn, taken over by Conrail.

***Tunnels.*** Between White Haven and Jim Thorpe the rugged topography of the gorge forced the various railroad companies to blast out three hard rock tunnels. Oldest (and by far smallest) is that of the Buck Mountain Gravity Railroad at the village of Rockport, completed sometime between 1838 and 1840. Second, both in terms of age and length, is the long-abandoned Glen Onoko Tunnel (L&S, later CNJ) on the east side of the Lehigh about two miles northwest of Jim Thorpe, completed in 1868. The most recently completed (1884) and longest is the still active Rockport Tunnel (LVRR, now Conrail) , located about one mile east of Rockport.

In addition to these subterranean excavations, millions of cubic yards of rock had to be blasted away to squeeze the various railroad rights-of-way into the narrow corridor bounded by the walls of the gorge on one side and the river or canal on the other.

***Floods.*** From Josiah White's day down to the present time, floods have been the scourge of the Lehigh Gorge (Table 2). The mountainous terrain promotes rapid runoff, and the tight constriction of the valley walls provides little room for flood waters to spread out. Clear cutting of timber and the domino-like failure of many small mill dams on the Lehigh's tributaries exacerbated the floods of the mid-nineteenth century. When the local dam failures were combined with the washing out of the log booms at White Haven, as happened in 1862, pure havoc reigned in the valley of the Lehigh. Wrote a resident of Mauch Chunk of the 1862 flood:

> *Along the front at Mauch Chunk you couldn't see nothing but the coal chutes; Everything else was under water. Loaded boasts had been swamped and sunk to the bottom. Folks up toward White Haven had left their homes for higher ground before their cabins floated away. Seemed like the flood was tearing everything loose. Uprooted trees, smashed cabins, drowned cattle, chicken coops, outhouses--everything was being swept down river. There ain't been nothing like it since.*

At least 150 people died.

Several severe floods have since struck the upper Lehigh, but none have matched the fury of the 1862 flood. After the last great flood on the Lehigh—the one spawned by Hurricane "Diane" in 1955, the U.S. Army Corps of Engineers built the Francis E. Walter Dam about six miles upstream of White Haven (Figure 5). Completed for flood control in 1961, and subsequently modified for recreation and water supply, the dam controls a drainage area of 288 $mi^2$ and has helped to prevent serious flood damage on the Lehigh for more than 30 years. At maximum pool elevation, the Walter-dam reservoir extends more than 5 miles upstream to the Falls of the Lehigh at Stoddartsville (Figure 6). Periodic, controlled water releases from the dam allow for whitewater rafting on the upper Lehigh even during periods of low water.

Figure 5. View of the Francis E. Walter Dam from the left (south) abutment, showing rip-rap lined earthen banks, control tower for outlet conduit, and ledges of Mississippian-age Pocono sandstone in pool area to right.

# TABLE 2. Major Historic Floods of the Lehigh River.

(Compiled by John S. Koehler, Weatherly, PA.)

| | |
|---|---|
| Jan. 1841 | Winter flood destroyed all the bridges and washed out sections of railroad track south of Penn Haven. The "Upper Grand" was so crippled that it took three years to restore complete canal service. |
| Sept. 1850 | Fall flood wrecked large sections of the railroads along the river. |
| June 4-5, 1862 | "Freshet" destroyed the whole "Upper Grand Section" of the Lehigh Canal. Railroad bridges, dams, and locks were completely wrecked. As a result, the canal was abandoned above Mauch Chunk. |
| Aug. 24, 1901 | Flash Flood caused heavy damage to railroad property of the Lehigh Valley and Central Railroad of New Jersey along the river. |
| Dec. 13-14, 1901 | Heavy rainfall spawned floods that washed out many sections of roadbed and several bridges on both the Lehigh Valley and Jersey Central. Particularly heavy damage was suffered by the southbound Lehigh Valley bridge at Penn Haven. |
| Feb. 28, 1902 | Unprecedented floods destroyed bridges between White Haven and Mauch Chunk. A bridge at White Haven collapsed, and the two Lehigh Valley bridges at Penn Haven were completely wrecked, one span being carried a half mile downstream. |
| May 22-23, 1942 | Heavy downpours in the upper Lehigh drainage caused great flood damage to both railroads from above White Haven to Easton. Tracks were completely washed out at Rockport, and swollen streams and rills off the mountains undercut the tracks at many other places. Locks, towpaths, and locktenders' houses on the canal below Mauch Chunk were extensively wrecked. At Hickory Run State Park, nearly 8 inches of rain were recorded between 10 AM on May 20 and 7 AM on May 23. |
| June 7, 1942 | An evening cloudburst dumped about 7 inches of rain on the area around Rockport. Resulting flash floods caused severe damage in the valley between Rockport and Penn Haven. |
| Aug. 18-19, 1955 | Flood waters spawned by Hurricane "Diana" destroyed large sections of track in the Lehigh Gorge. The river entered the north portal of the Lehigh Valley Railroad's Rockport Tunnel, damaging the bore and digging out a large cavity at the south portal. |

Figure 6. The Falls of the Lehigh at Stoddartsville. The Lehigh River here plunges about 25 feet over well jointed ledges of Devonian-age Duncannon sandstone.

# TRAIL LOG

(**Site 1**, etc. = sites of special interest shown on Plate 1; Bd = bedding attitude.)

*PORT JENKINS-TO-WHITE HAVEN ACCESS AREA SECTION*

Between Port Jenkins and the White Haven Access Area, the trail passes through glaciated terrain underlain by sandstones of the Early Mississippian-age Pocono Formation from about mile 0.4 to just south of mile 1.5 and dominantly red conglomerates, sandstones and shales of the Late Mississippian-age Mauch Chunk Formation for the remainder of the route. The mile-wide belt of Pocono rocks just south of Port Jenkins reflects a broad, westward-plunging anticline, the main axis of which appears to cross the trail at about mile 1.0. (A small anticline on the north limb of the main fold crops out at mile 0.4.) About 3 miles to the northeast, gently folded Pocono strata on the north limb of this fold form the foundation rock of Francis E. Walter Dam and crop out extensively along the north shore of the reservoir (see Figure 5 and Sevon, 1975a).

Evidence of fairly recent glaciation (i.e., late Wisconsinan, or about 20,000 years ago) along this section of the trail includes a gravel deposit at mile 0.1 and a polished and striated quartzitic sandstone ledge at mile 0.85. The gravel is part of an extensive area of ice-contact stratified drift up to a hundred feet thick that lies on the inside of a broad jog in the river at Port Jenkins.

Ruins of the northernmost stone lock (No. 29) on the Lehigh Canal and the contiguous remains of the right (west abutment) of the White Haven Dam (No. 20) occur at miles 1.5. The dam, uppermost and largest on the canal, was the only one to survive the great freshet of 1862.

White Haven, founded by and named for Josiah White in the 1820's, became the northern terminus of two-way navigation along the Lehigh River with the completion of the "Upper Grand Section" of the Lehigh Canal in 1838. The town became an important trans-shipment point for anthracite hauled over the mountains from Wilkes-Barre on the Ashley Planes. During the latter part of the 19$^{th}$ century and well into the 20$^{th}$, White Haven was an important depot stop for both the Lehigh Valley and Central Railroad of New Jersey. The most geologically significant local industry is Wilmot Engineering (mile 1.75), designers and manufacturers of mining and environmental equipment.

MILEAGE

0.0 Gate at Port Jenkins, just south of SR 40041. Scattered in the wooded, somewhat hummocky terrain to the left are picturesque jumbles of large, red sandstone boulders and blocks, the largest of which is 15 feet in maximum dimension. They are probably weathered from local Mauch Chunk bedrock, but some may have been transported a short distance and dropped by the late Wisconsinan glacier.

0.05 Railroad Milepost 144.

0.1 North-dipping, thick-bedded Mauch Chunk conglomeratic sandstone exposed in shallow cut to left. Cobbly, late Wisconsinan-age "kame" gravel can be seen at the north end of the cut. Mauch Chunk conglomerate and conglomeratic sandstone

cropping out on the adjacent railroad right-of-way contains abundant red-shale clasts 0.5 to 5 inches in diameter.

0.2 Down over the bank to left are more displace blocks of Mauch Chunk sandstone. One tower-like block is about 20 feet high.

0.4 Cliff to right exposes a gentle anticline in thick-bedded, gray Pocono sandstone.

0.85 (**Site 1**) Low ledge of glacially smoothed and striated, gray Pocono sandstone in shallow cut to left. Azimuth of the striae is S52E, indicating that the basal ice of the glacier moved in that direction at this point.

Just beyond is a culvert under the railroad and trail that directs water to a beautiful little waterfall over gently north-dipping, crossbedded Pocono sandstone at the top of the bank to left.

0.9 (**Site 2**) Prominent ledge of north-dipping, crossbedded Pocono sandstone to right. The thicker beds exfoliate and weather to distinctive smooth and bulbous projections.

1.0 Sandstone-block retaining wall to right.

1.2 To right is south-dipping, thick-bedded Pocono sandstone. (More Pocono is exposed in a railroad cut above the trail, but these beds are mostly hackly and spheroidally weathered, medium-dark-gray siltstone.)

When the leaves are off the trees, the great flat formed by deposition behind the old White Haven Dam (see mile 1.5) can be seen in the valley to left.

1.35 Another sandstone-block retaining wall to right.

1.45 Prominent cut though south-dipping (Bd N85W/19S) Pocono sandstone extending south to trail gate at mile 1.5. At the south end, the sandstone is coarse grained and pinkish weathering.

1.5 North gate at White Haven.

(**Site 3**) Path to left (east) of the gate leads to extensive Lehigh-Canal ruins near the river. A large stone lift-lock (No. 29) is partially filled in with blocks that have fallen from the walls, only the upper 10 to 12 feet of which are exposed. (No arch is visible at the south end, as in well preserved locks along the canal.) Many iron tie-rods are still in place. Attached to the lock is the massive (stone) right abutment of the stone-and-timber White Haven Dam, functional from 1838 until it was destroyed by the Army Corps of Engineers (as unsafe) in 1951. The island and alluvial flats upstream from the dam site are formed of the bottom deposits of the lake behind the dam.

1.6 Turn left onto Main Street just past parking lot.

1.75 Stop sign. Turn left onto Berwick Street, then almost immediately right into parking lot of White Haven Shopping Center. Historic Marker on north side of Berwick Street here reads:

> WHITE HAVEN. Named for Josiah White (1781-1850) whose Lehigh Navigation system was vital to coal and lumber transport. This was the northern limit, 1837-1862, of the two-way navigation from Easton. Here it met White's 20-mile railroad to Wilkes-Barre with its inclined "Ashley Planes."

On Berwick Street just east of the railroad is the plant of Wilmot Engineering, a long-time manufacturer of equipment for the anthracite-mining industry.

1.9 Bear left onto unpaved trail (which leads into abandoned railroad grade) at south end of lot.

2.0 Gently south-dipping Mauch Chunk red sandstone (and minor red silty clay shale) to right.

2.15 Pass under twin bridges carrying I-80 over the Lehigh River.

2.25 To right of the White Haven Access Area and along the active Conrail tracks above is a deep terraced cut in gently north-dipping, red Mauch Chunk sandstone.

*WHITE HAVEN ACCESS AREA-TO-ROCKPORT SECTION*

Between White Haven and Rockport, two Mississippian-age bedrock units—the Pocono and Mauch Chunk Formations—are alternately exposed for nearly nine miles in steep man-made cuts along the old railroad grade and in water-worn ledges in the bed of the Lehigh. (Excellent exposures are also visible in railroad cuts on the east side of the river.) For much of this distance, the Lehigh flows at right angles across a succession of broad folds (see Plate 2) which commonly are warped into smaller folds, as at Tannery (mile 3.4), in the vicinity of "Lunch Rock" (mile 5.5 to 5.6), and at mile 6.7. From mile 8.3 at Mud Run to mile 10.3 just north of Rockport, the river and parallel trail follow along the "strike," or bedding trend, of the Pocono Formation on the north limb of the Summer Mountain anticline. Other spots of particular geologic interest along this section of the trail are a glacially striated Pocono sandstone ledges (mile 3.6) at Tannery, a broad expanse of folded and crossbedded Pocono sandstone at Lunch Rock (mile 5.5), a quartz-crystal locality in fractured and mineralized Pocono sandstone at mile 5.7, an old red sandstone quarry from which stone for various structures on the canal and railroad was obtained (mile 6.1), and picturesque potholes in ledges of Pocono sandstone along the west bank of the river just downstream of Mud Run (mile 8.3).

This section of the trail exhibits the best preserved and most extensive canal and dam ruins along the "Upper Grand." Ruins of seven locks (Nos. 28, 27, 25, 24, 23, 22, and 21) and abutments or other remains of four dams (Nos. 19, 18, 17, and 16) (see Table 1) are readily evident between miles 2.5 and 9.4. Two of these locks—Nos. 27 and 24—had the highest lifts on the canal, 30 and 28 feet, respectively.

Other interesting structures and structural remains on this section include the stone foundation ruins of the large tannery on the east bank of the Lehigh at Tannery (opposite mile 3.5), the concrete abutments and piers of the high railroad bridge on the Hays Creek Branch of

the Lehigh Valley Railroad (mile 4.7), the concrete foundation of the Leslie Run Hotel (mile 7.3), the extant stone-arch railroad bridge across Mud Run (opposite mile 8.3), and the north portal of the active Rockport Railroad Tunnel (opposite mile 10.1).

Mud Run is also the site of the most tragic event in the history of the Lehigh Gorge, the great train accident which killed 66 people in the Fall of 1888.

2.3 RR overpass and south gate at White Haven. Overpass bridge is built of Pocono sandstone blocks.

2.4 Bridge over stream.

2.5 (**Site 4**) To left, between the old railroad grade and the river is Lock No. 28 of the Lehigh Canal. Faced with large (1.5±-foot) rectangular blocks of Pocono and Mauch Chunk sandstone, the lock is in excellent condition. Many vertical wood beams are still in place and outlet-arch of the water in-flow conduit is well preserved at the southwest end. Midway along the riverward side of the east wall is a rectangular stone buttress. At the northeast end is the massive, stepped abutment of Dam No. 19, with stony rubble from the old stone-and-timber cribbing extending outward toward the river.

A perfectly preserved stone culvert (constructed of Mauch Chunk red sandstone and conglomerate) near the south end of the lock carries the flow of a large stream beneath the old railroad grade. The keystone of the arch on the east wall is inscribed "CRR"—denoting the Central Railroad (of New Jersey). North-dipping red siltstone and sandsilt laminite of the Mauch Chunk Formation is exposed at the mouth of this culvert. A little to the south is a stone waste-weir that at one time carried the water from the stream through the canal.

About 125 feet north of the lock at the west edge of the canal bed is an 8-foot (±), glacially striated boulder red quartzitic sandstone that has probably not been moved far from its initial resting place.

2.55 Long cut in north-dipping Mauch Chunk red sandstone exposed for some distance to right. (This cut is largely obscured by trees in the summer months.) The rapids in the river below are bedrock controlled.

2.8 Partially hidden in the rhododendron thicket to right are more ledges of Mauch Chunk sandstone and claystone, still north dipping.

3.0 Concrete wall with weep holes to right. Just beyond are north-dipping, overhanging ledges of thick-bedded Mauch Chunk red sandstone that form shallow rock shelters.

3.1 (**Site 5**) To right is a small waterfall over north-dipping sandstone ledges. The culvert at the base of the cascade is clogged by material eroded from the cliff.

3.25 Yet another massive cliff of north-dipping Mauch Chunk sandstone to right.

3.4 To left in the woods are the ruins of Lock No. 27. Little but rubble piles remains of this structure. **Site 6**: Across the river from here adjacent to an old bridge(?) abutment, sandstone beds of the Pocono Formation are deformed into an anticlinal (up) fold. Dip (inclination) of bedding on the north limb of the fold is about $10^{o}$ NW and on the south limb about $30^{o}$ SE. A little farther south on the river bank just downstream of the east abutment of the SR 2046 bridge—is a well exposed synclinal (down) fold in slightly younger (higher) Pocono sandstone beds (Figure 7). (These two folds form a "couple," the north limb of the syncline being the south limb of the anticline.)

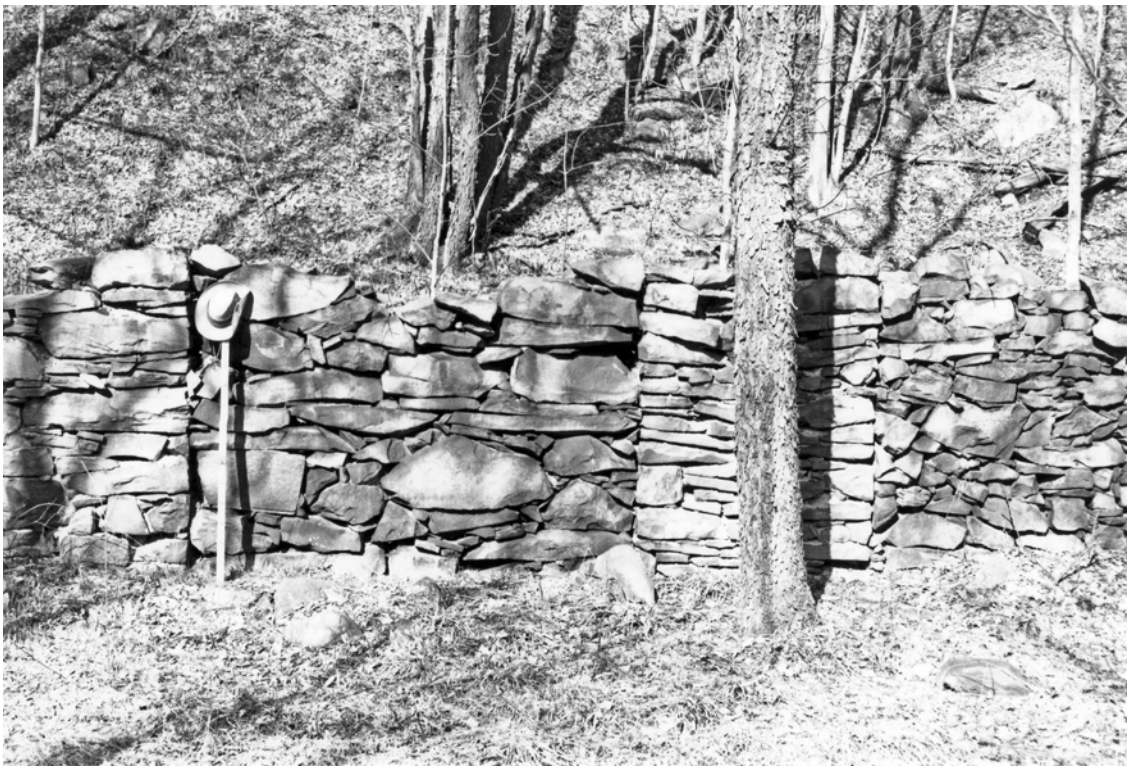
3.45 North gate at Tannery. Cross SR 2046 to parking lot.

3.5 Parking lot at south gate. **Site 7**: Directly opposite this point are the stone ruins of the old Lehigh Tannery, which extended about 600 feet south along the east bank of river. This tannery (one of several in the vicinity) was built by Thomas Small and Co. in 1860 and was at the time the largest in the United States (Petrillo, 1997). About 80,000 hides a year were processed here. The tannery was destroyed by fire in 1875. Plate 6 is a "tape and compass" map of the ruins; labeled features, such as pictured in Figures 8A and B, are entirely speculative.

Pass through south gate.

Figure 7. Syncline in the Pocono sandstone on the east side of the Lehigh River at Tannery (**Site 7**). An arrow marks the axis of the fold. Ruins of the old Lehigh Tannery are visible in the right background.

A.



B.

Figure 8. Stone ruins of the Lehigh Tannery (**Site 7**). A. Foundation of tanning vats at north end. B. Part of foundation wall in long drying or storage building at south end.