WRD RESOURCE ROOM

VAFO

QUALITATIVE EVALUATION OF THE EFFECTS OF CHANGING WATERSHED LAND USES ON THE HYDROLOGY, CHANNEL MORPHOLOGY AND HISTORICAL USES OF VALLEY CREEK, VALLEY FORGE NATIONAL HISTORICAL PARK, PENNSYLVANIA

William B. Reed

Technical Report NPS/NRWRD/NRTR-90/08

WATER RESOURCES DIVISION

National Park Service • Department of Interior
Fort Collins • Denver • Washington

U.S. Department of Interior • National Park Service

QUALITATIVE EVALUATION OF THE EFFECTS OF CHANGING WATERSHED LAND USES ON THE HYDROLOGY, CHANNEL MORPHOLOGY AND HISTORICAL USES OF VALLEY CREEK, VALLEY FORGE NATIONAL HISTORICAL PARK, PENNSYLVANIA

William B. Reed

Technical Report NPS/NRWRD/NRTR-90/08

October 1990

U.S. Department of Interior • National Park Service

Water Resources Division • 301 S. Howes Street • Fort Collins, Colorado 80521

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

The objective of this report is to provide a qualitative evaluation of the hydrology and geomorphology of Valley Creek necessary for developing effective bank stabilization strategies. Valley Creek flows for approximately 11,000 feet through Valley Forge National Historical Park to its confluence with the Schuylkill River. Valley Creek at Schuylkill River has a watershed of 23.25 square miles. The watershed has undergone extensive land use changes during the last 20 years resulting in changes in Valley Creek flow characteristics and associated fluvial processes.

Within the park, between the covered bridge and the upper forge site, Valley Creek once migrated back and forth within a very narrow valley. In recent times, the stream has been confined by alternative uses of the valley floor, and now threatens these uses as it continues to adjust to changes in watershed conditions. Of particular concern is the potential for the undermining of Route 252 and underlying forced sewer main.

In general, it appears that present-day changes in land use from agriculture to low-density residential areas and corporate centers may have less impact on the hydrology of Valley Creek than did the previous transition from agriculture to high-density residential areas and industrial parks. Therefore, if present-day changes in land use continue, the discharge characteristics of Valley Creek will deviate very little from existing conditions. However, channel geometry will continue to widen in response to previous changes in stream flow (especially flood peaks) caused by historic changes in watershed conditions.

Based upon these conclusions, slope protection and erosion control efforts should be designed for current streamflow conditions and will need to anticipate future changes in channel geometry. Conceptual slope protection and erosion control designs for the upper forge site *and* for the reach between the covered bridge and the upper forge site are presented in Appendix A.

ACKNOWLEDGEMENTS

The assistance provided to the author by Brian Lambert, Natural Resource Specialist, Valley Forge National Historical Park, contributed to the preparation of this report.

INTRODUCTION

Valley Creek flows through Valley Forge National Historical Park to its confluence with the Schuylkill River. The Valley Creek watershed has undergone extensive land use changes during the last 20 years resulting in changes in flow characteristics and associated fluvial processes.

Within the park, between the covered bridge and the upper forge site (a distance of approximately 2,000 feet), Valley Creek once migrated back and forth within a very narrow valley. In recent times, the stream has been confined by alternative uses of the valley floor, and now threatens these uses as it continues to adjust to changes in watershed conditions. Of particular concern is the potential for the undermining of Route 252 and underlying forced sewer main.

Most recently the failure of a wall, located between the stream and the road at the upper forge site, brought the attention of park and Pennsylvania Department of Transportation (PennDoT) staff to the problem of stream bank stability within the park. This report is prepared in response to a request from the Acting Park Superintendent for assistance in evaluating the cause of this problem and in developing possible solutions.

This report was specifically prepared as background information for use by the interdisciplinary team that is currently (1990) developing a stream bank stabilization design for Valley Creek between the covered bridge and the upper forge site. The objective of this report is to provide a qualitative evaluation of the hydrology and geomorphology of Valley Creek necessary for developing effective bank stabilization strategies. Field observations are summarized (Appendix B) and historical watershed conditions evaluated. An analysis of the probable effects of changing watershed conditions on the hydrology and morphology of Valley Creek is presented. Finally, conceptual slope protection and erosion control designs are offered in Appendix A.

DESCRIPTION OF VALLEY CREEK WATERSHED

Valley Creek watershed is located 20 miles west of Philadelphia, Pennsylvania. The watershed is located mainly in Chester County with a small portion (5 percent) in Montgomery County. Valley Creek flows for 11,000 feet through Valley Forge National Historical Park and is a perennial tributary to Schuylkill River. The mouth is near Washington's Headquarters within the park. At this confluence, the drainage area of the watershed is 23.25 square miles (Figure 1). Immediately upstream of the park, Valley Creek is crossed by the Pennsylvania Turnpike. One hundred feet upstream of this bridge, the creek is gaged by the U.S. Geological Survey (USGS). The drainage area of the watershed above this gaging station is reported as 20.8 square miles (Kolva, et al., 1989).

The watershed has a rectangular shape and is approximately 3 miles wide (north to south) and 8 miles long (west to east). The highest and lowest points in the watershed are 720 feet near Union Chapel (northwestern corner) and 70 feet (water surface elevation shown on USGS Valley Forge Quadrangle) at Schuylkill River (northeastern corner), respectively. Elevations are above National Geodetic Vertical Datum of 1929. Total channel length is 56,000 feet. Average channel slope is 1.2 percent. From highest

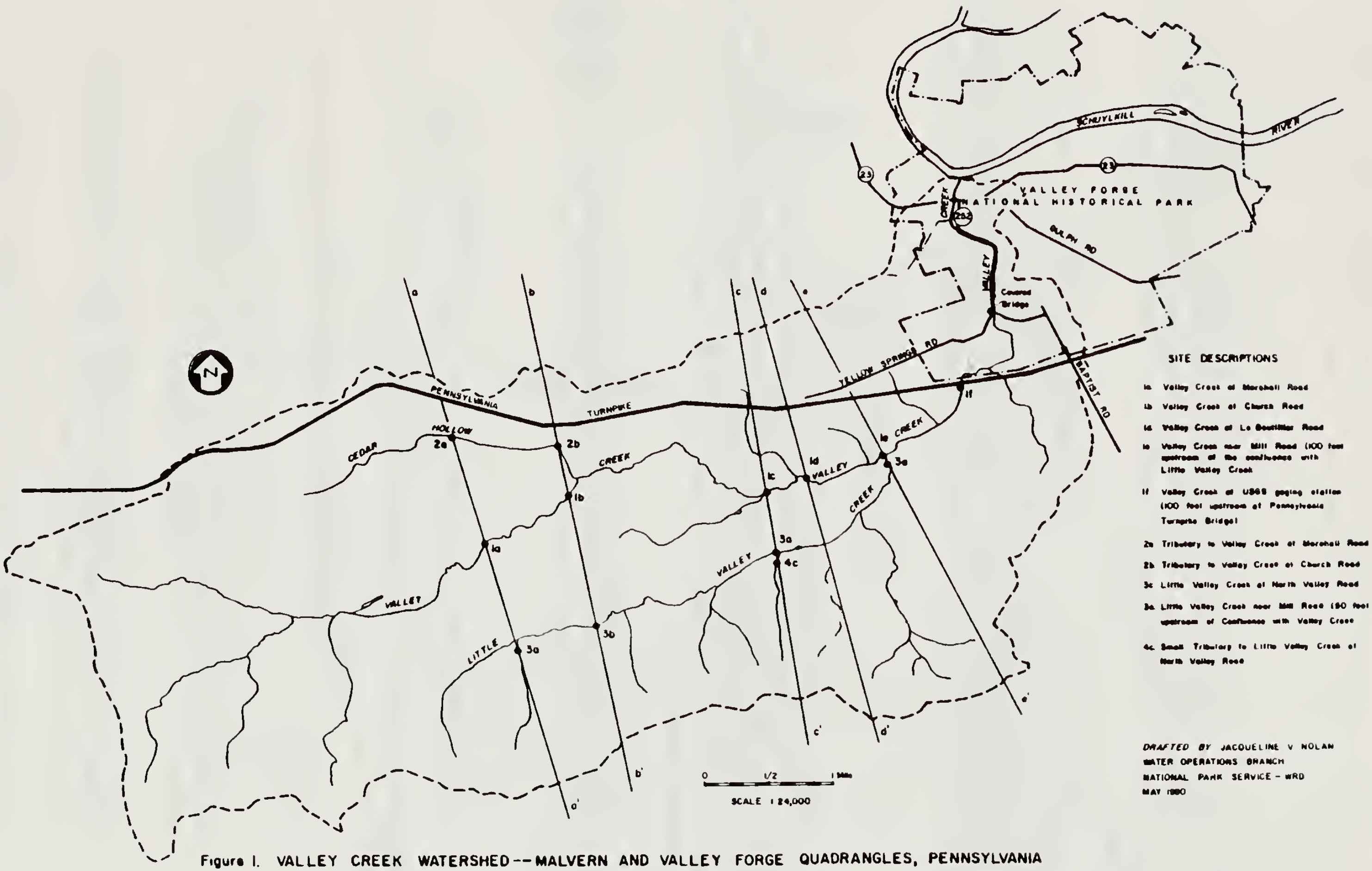

Figure I. VALLEY CREEK WATERSHED--MALVERN AND VALLEY FORGE QUADRANGLES, PENNSYLVANIA point in watershed to Church Road (a distance of 25,900 feet), average channel slope is 2.0 percent. From Church Road to mouth (a distance of 30,100 feet), average channel slope is 0.4 percent.

The watershed is located in the Piedmont physiographic province of southeastern Pennsylvania and is typical of the narrow limestone valleys and the low hills of this region. The geology of the watershed consists of Ordovician and Cambrian sedimentary (shale, limestone, dolomite, and sandstone) and metamorphic (schist, serpentine, gneiss, and quartzite) rocks (Willard, 1962). Limestone and dolomite are quarried within the watershed.

The soils within the watershed are predominately, moderately well-drained silt loams derived from weathered limestone, schist, gneiss, and quartzite (Commonwealth of Pennsylvania, 1973). The hydrologic soil group classification for these soils is Group B [U.S. Soil Conservation Service (SCS), 1986]. The runoff potential for an undeveloped watershed with soils of this classification is low to moderate (Van Haveren, 1986).

FIELD OBSERVATIONS

A reconnaissance of Valley Creek watershed was conducted on July 26-27, 1989, and March 27-28, 1990. During 1989, preliminary field observations were made at nine sites upstream of the park boundary (Figure 1) and at various locations within the park (Figure 2). During 1990, additional measurements were made and a few of the previous measurements verified. Detailed documentation of all measurements and observations is provided in Appendix B.

Although not thoroughly documented, the observed stream was remarkably different in 1990 than 1989. In 1990 the stream reach above the covered bridge, the reach within the narrow valley, and the reach near the mouth exhibited, in contrast to 1989, higher occurrences of bank erosion.

DESCRIPTION OF HISTORICAL WATERSHED CONDITIONS

In general, the watershed has experienced five major phases of land use over the last 300 years:

1) heavily forested--prior to significant settlement of the area by colonists (pre-1700s);

2) the clearing of a small portion of the valley floor for agricultural use and village sites, approximately 4 to 20 percent of the watershed deforested--prior to the American Revolution (1700 to 1776);

3) the clearing of the valley floor, rolling hills and other mild slopes for additional agriculture use and growing village sites, approximately 40 to 50 percent of the watershed deforested, (1800s);

4) the clearing of additional land for and the conversion of marginal

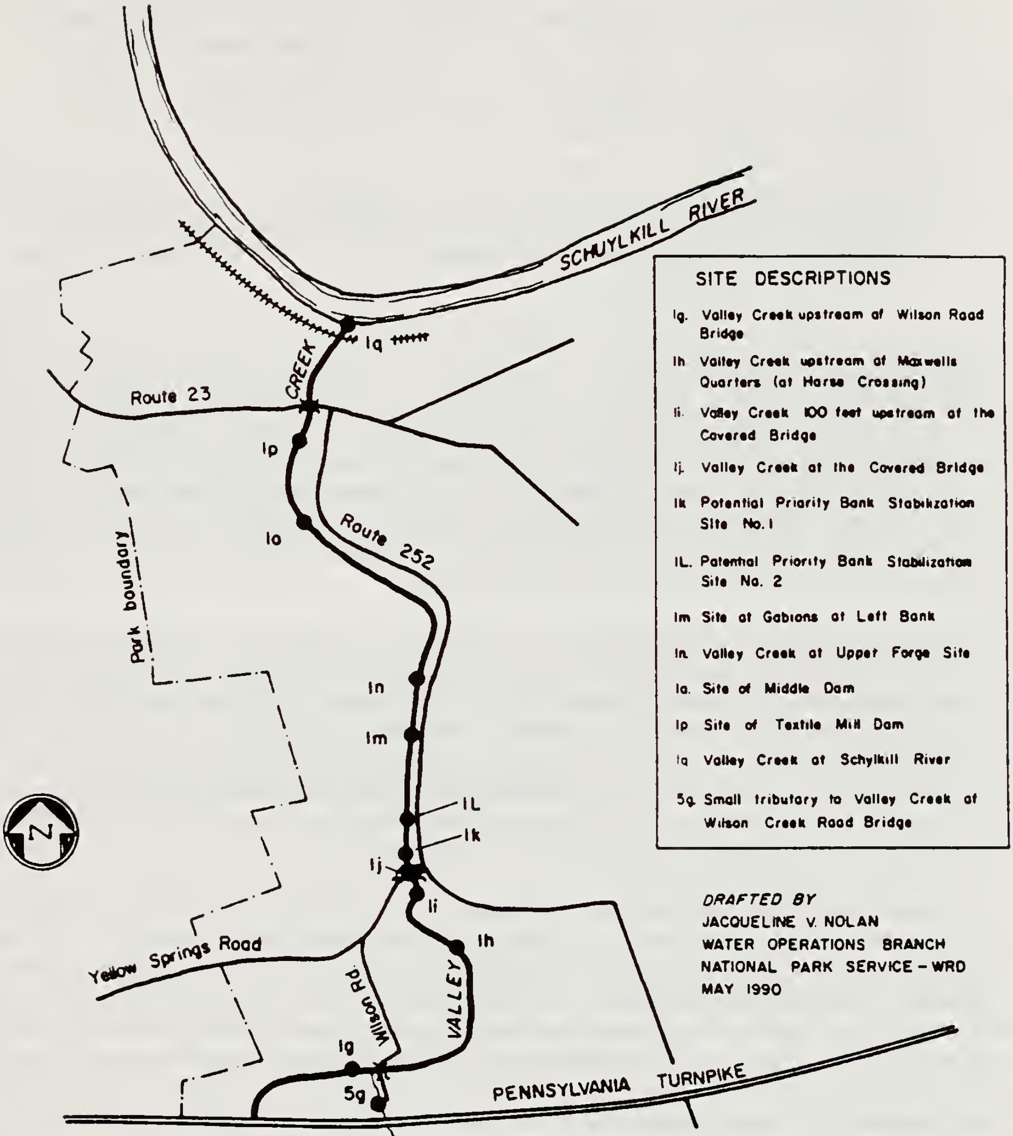

Figure 2. FIELD OBSERVATION SITES ALONG VALLEY CREEK WITHIN VALLEY FORGE NHP

agricultural lands to residential, commercial, and industrial areas, including planned communities (high-density residential areas), shopping centers, industrial parks, railroad yards, and quarries, approximately 60 percent of watershed deforested (1900 to 1985)--with accelerated development and major land use changes occurring essentially over a 15-year period from approximately 1970 to 1985; and

5) the conversion of marginal and prime agricultural lands to commercial parks and isolated estates (low-density residential areas), approximately 60 percent of the watershed deforested--this is the current trend (1985 to possibly the year 2000).

The above scenario is generalized; therefore, there may be numerous exceptions to the sequence and description of events. It is beyond the scope of this report to quantify the exact pattern of historical land use within the watershed. However, the above generalizations and the following qualitative narratives are used to approximate historic and projected watershed conditions; thereby, permitting a preliminary analysis of the effects of changing land uses on the hydrology, channel morphology, and historical uses of Valley Creek. Since there have been at least seven different dam sites between the covered bridge and the mouth of Valley Creek, the effects of the historical uses of Valley Creek on river morphology will also be considered.

Watershed condition, as defined in this report, is the health of the watershed compared to its natural state as measured in the terms of three characteristics (1) peak flows, (2) low flows, and (3) channel morphology. A watershed with characteristics typical of natural conditions is considered excellent. Whereas, a watershed with characteristics typical of moderately developed conditions (without stormwater management) is considered poor. Good and fair conditions exist between these two extremes with: good representing conditions that have only been slightly impacted by development, and fair representing conditions between good and poor.

Watershed condition for phase 1: excellent. When the watershed was heavily forested, the stream flow of Valley Creek was very different than it is today. Under these conditions, soil infiltration rates were high and watershed runoff was dominated by subsurface (interflow) processes. Overland flow, which conveys precipitation to stream channels more rapidly than subsurface flow, was likely, less common. Thus, peak discharges associated with precipitation were of lesser magnitude and severe flooding was less frequent than it is today. In contrast, the base flow of Valley Creek was greater, being fed by larger soil moisture and ground water reserves during dry seasons. Because the magnitude of peak flows associated with precipitation were smaller, the stream channel was presumably neither as deep nor as wide as it is today.

Watershed condition for phase 2: excellent to good. As the colonists moved into the watershed they cleared a small portion of the valley floor for agriculture. An estimate of this clearing may be as high as 20 percent (Brush, 1989) or as low as 4 percent (Defries, 1986) of all available land. Such a change in land use had a relatively mild impact upon watershed condition. This is because the areas cleared probably had very mild slopes and productive soils (well-drained, highly permeable loams), and were not major sources of runoff even after clearing. However, under the worst scenario, sediment loads (which were naturally low) may have been increased because of reduced vegetative cover.

Watershed condition for phase 3: good to fair. As deforestation continued over the next century, resulting in 40 to 50 percent of the watershed deforested (Defries, 1986), the hydrology and geomorphology of Valley Creek changed noticeably. For the first time, towns--as we know them--were founded (Chester County, 1982). The main factors causing the presumed change in the hydrology and geomorphology of Valley Creek was a significant loss in vegetative and soil cover. The reduced infiltration of impacted soils would favor overland flow. This change resulted in both a significant increase in peak flows and a significant decrease in base flows. Initially, severe flooding occurred more frequently. Eventually, the stream channel increased its capacity to convey larger flows by becoming wider and deeper. Sediment loads increased due to reduced cover and to an increase in the occurrence of overland flows. The sediment loads may have increased by as great as 3 to 8 times the pre-1700s' loads (Wolman, 1967).

During this phase (1800s), the two-story high textile mill dam (site 1p on Figure 2) was constructed upstream of present-day Route 23. This dam (the largest ever constructed on Valley Creek) pooled water as far upstream as the covered bridge (site 1j on Figure 2). Although, the pond behind such a dam would have been below the present-day elevation of Route 252, the middle dam and upper forge sites were inundated (Figure 3). The stream banks between site 1i and site 1p are composed of unconsolidated highly erodible sediments which were deposited behind this dam during this phase of high sediment loads.

Watershed condition for phase 4: fair to poor. During this phase, the effect of continued deforestation and the conversion of marginal agricultural lands to other purposes, began to severely threaten park natural and cultural resources. The amount of developed land in Chester County doubled from 1970 to 1985 (Chester County, 1988). At least one historically perennial tributary to Valley Creek lost its base flow due to the construction of a planned community outside of the park (see the description for site 5g in Appendix B). Such a severe response to changing land use occurs when a large percentage of the watershed becomes impervious. This change results in reduced infiltration and greater storm runoff. Also, peak flows associated with storms become larger than in the past as the watershed's response to rainfall becomes flashier due to a shorter time of concentration. Even for moderately developed watersheds, runoff volumes may be increased by more than 50 percent *and* time of concentrations may be decreased by as much as 50 percent--particularly if extensive drainage "improvements" are made (Schueler, 1987). However, towards the end of this phase, the sediment loads may have decreased to half the previous phase's loads (Wolman, 1967).

At the beginning of phase 4, the textile mill dam was destroyed, leaving the sediments that had deposited behind the dam exposed. These sediments had accumulated over approximately 90 years (from about 1830 to about 1920) and would have been deposited from the dam site to 100 feet upstream of the covered bridge (site 1i on Figure 2). After the dam was destroyed, the stream would have reestablished a channel by cutting down through these sediments. Because the sediments were unconsolidated, this process would have likely taken only a few years. This resulted in a reach with relatively high stream banks. As stated above, the present-day stream banks between site 1i and site 1p are highly erodible remnants of this era.

After the textile mill dam was destroyed, archeological investigations of the upper forge site began (1920s). During these investigations, the sediments were dredged to create a

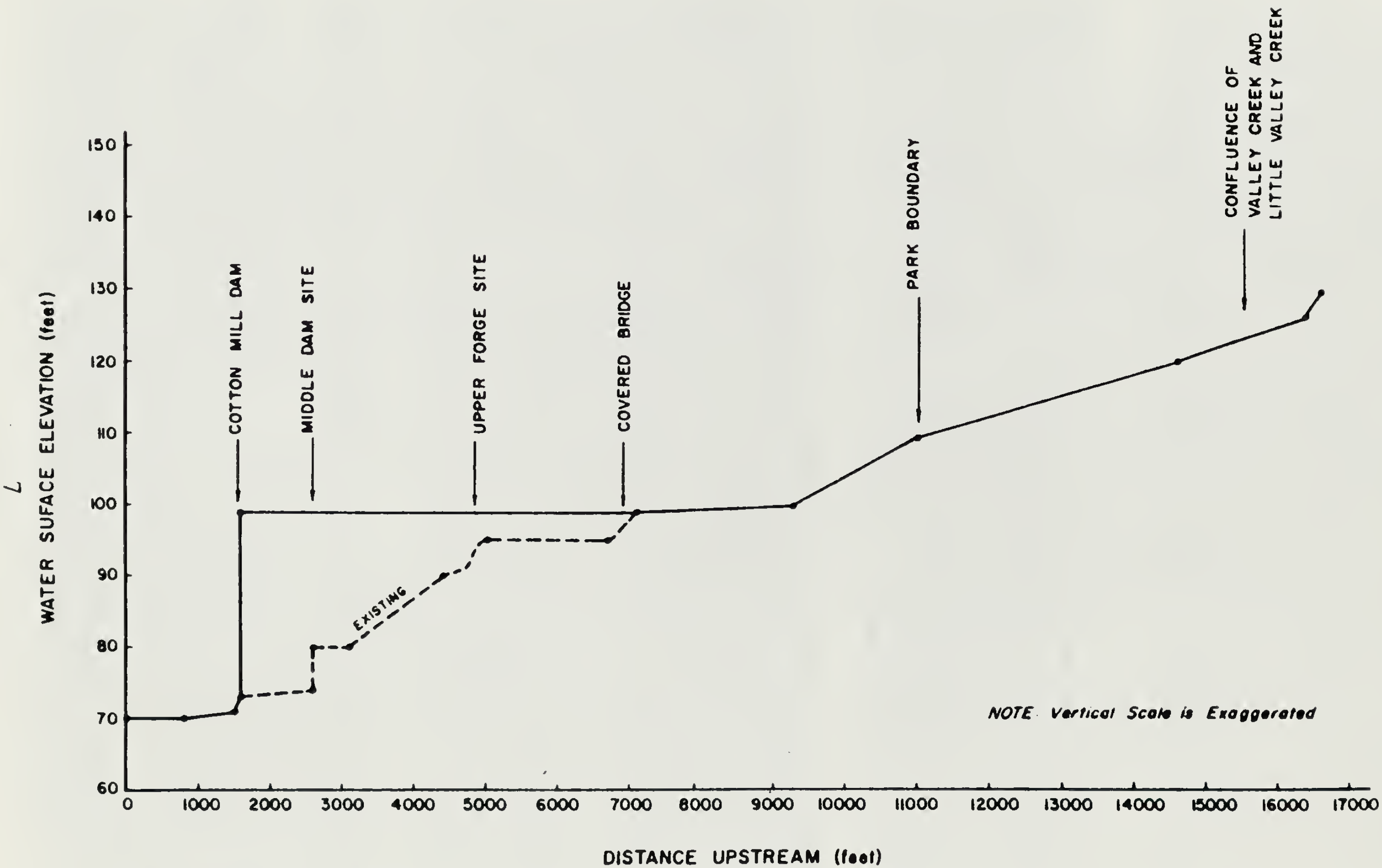

Figure 3. WATER SURFACE PROFILE--1800s to 1920, VALLEY FORGE CREEK, VALLEY FORGE NHP

COMPILED BY WILLIAM B REED 11/27/89
DRAFTED BY JACQUELINE V NOLAN

channel away from the upper forge site. Later, in 1931, the middle dam was reconstructed. This dam, although small by comparison with the former textile mill dam, does provide base control, i.e., it is a structurally controlled break in the water surface profile (Figure 4).

Watershed condition for phase 5: presently poor; potential for fair. In general, only the least productive soils and steeper slopes are still forested (Chester County, 1982). Although agriculture and woodlands are the two largest land use categories in Chester County, these land uses have decreased the most since 1970 (Chester County, 1988). The conversion of marginal and prime agricultural lands to corporate parks and isolated estates may actually improve the previous watershed condition by reducing peak flows and sediment loads through best management practices. However, the watershed condition's best potential will likely only be achieved through the establishment of a watershed committee or advisory board. Without proper stormwater management, peak discharges will increase as the impervious area within the watershed increases (Sloto, 1988).

Whereas, during this phase hydrologic conditions may improve (assuming that stormwater runoff will be better managed), channel conditions (unless otherwise altered) will decline. This decline is because the stream channel is still adjusting to previous changes in watershed conditions, i.e., is just beginning to respond to increased flows resulting from changes which occurred during the previous phase. At the end of this phase, if the entire area has been developed, the sediment loads may decline to the phase 2 levels (Wolman, 1969). Essentially, this improvement in sediment loads occurs because: (1) erodible surfaces no longer exist (no new sources of sediments exist) and (2) in-channel sources of sediments have been depleted.

SIMULATED STREAM HYDROLOGY FOR SELECTED WATERSHED CONDITIONS

Stream hydrology was simulated for future and representative historical conditions using the SCS unit hydrograph method (SCS, 1986). Specifically, the SCS TR-55 (Urban Hydrology for Small Watersheds) graphical method was used to calculate the peak discharges for 24-hour single-event rainfalls with the following return periods: 1, 2, 5, 10, 25, 50, and 100 years. Flows were calculated for Valley Creek at Schuylkill River. The following years were subjectively selected as representative of the five major phases of land use in recent history and near future: 1685, 1776, 1885, 1985, and 1995. The rainfall amount for each storm was provided by the TR-55 computer program (from file COUNTY.RF), using a county and state combination of Montgomery County and Commonwealth of Pennsylvania. For these events, I selected a Type III rainfall distribution which is representative of Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts.

TR-55 subroutines (TCTT and RCN) were used to calculate time of concentration and runoff curve numbers. These values were then used by the graphical method. Limitations of the graphical method is that only *one* time of concentration and *one* curve number can be used to describe the watershed for each simulated condition, i.e., assumes that land use, soils, and cover are distributed uniformly throughout the watershed. However, the *one* curve number is determined by dividing the watershed into separate land uses by cover description, e.g, to determine the curve number for 1985, 11 cover descriptions were used. For each cover description, the associated

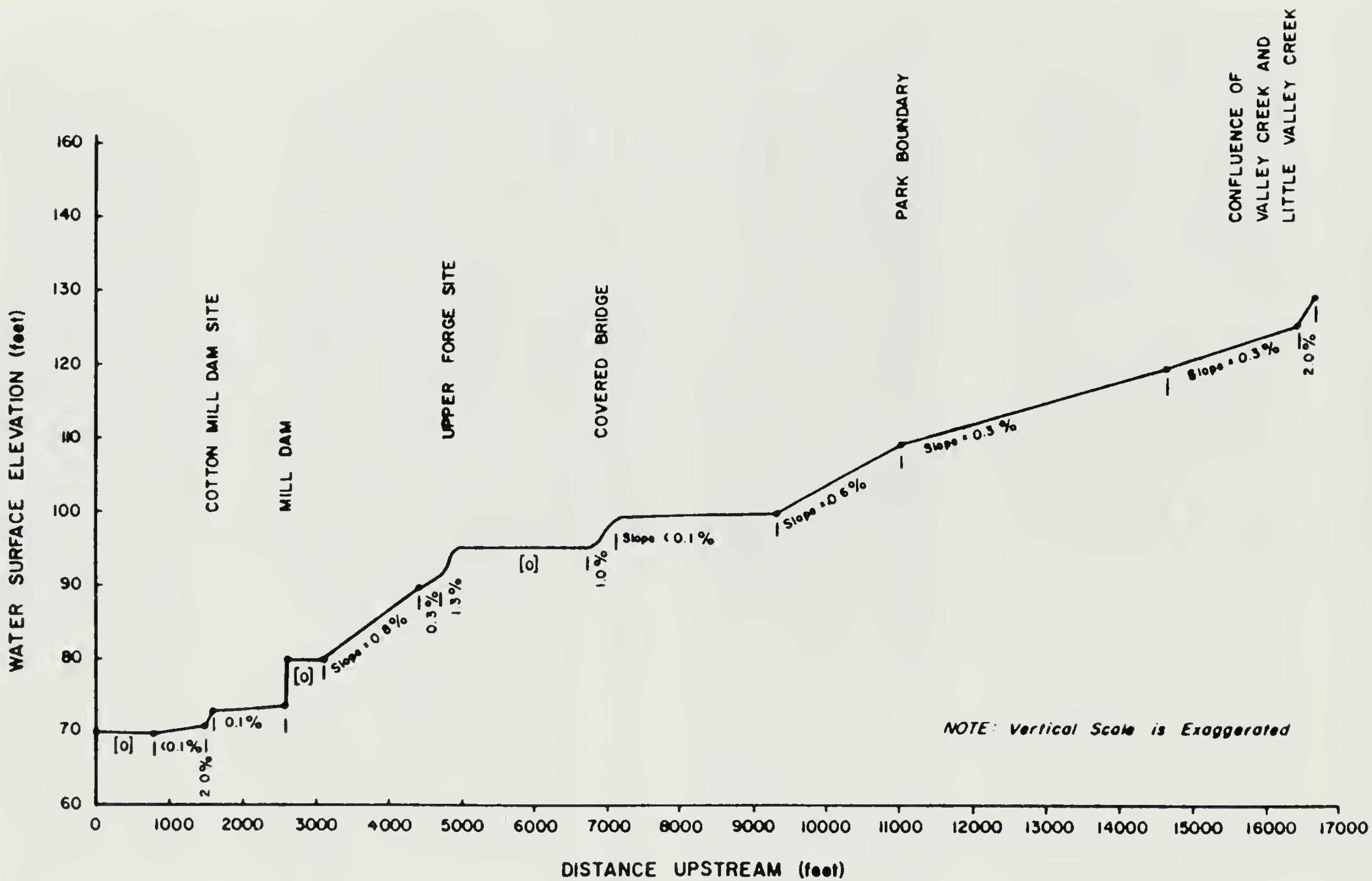

Figure 4. WATER SURFACE PROFILE--EXISTING CONDITIONS, VALLEY CREEK, VALLEY FORGE NHP

COMPILED BY WILLIAM B REED 11/27/89
DRAFTED BY JACQUELINE V. NOLAN

curve number has been predefined in the software. Because of the qualitative nature of this report, I considered these limitations acceptable.

Time of concentrations ranged from 4.21 hours (1685 and 1776) to 3.2 hours (1885, 1985, and 1995). For each simulated year, the input data (type of flows, length of flows, surface codes, etc.) used to obtain the time of concentrations are presented in Appendix C.

The curve numbers used were 55 (1685), 56 (1776), 60 (1885), 67 (1985), and 66 (1995). For each simulation, the input data (cover descriptions, their areas, and their software assigned curve numbers) used to obtain the weighted curved number for the watershed are presented in Appendix C. In general:

> For 1685, the entire watershed was assumed wooded.
>
> For 1776, the watershed was assumed described by three agricultural cover descriptions including woods.
>
> For 1885, the watershed was assumed described by four agricultural cover descriptions including woods and farmsteads.
>
> For 1985, the watershed was described by 11 cover descriptions including urban and agricultural land uses. This land use pattern was obtained from USGS Valley Forge and Malvern Quadrangles that were photo revised in 1981 and 1983, respectively. Therefore, the full extent of urbanization in 1985 may not have been completely realized.
>
> For 1995, the watershed was described by 9 cover descriptions including urban and agricultural land uses. However, I assumed that all cultivated agricultural lands that remained in 1985 had since been converted to corporate parks and isolated estates. Additionally, I assumed that all farmsteads that remained in 1985 had since been either converted to parks (urban open space) or subdivided and subsequently converted to planned estates.

EFFECTS OF CHANGING LAND USES ON THE HYDROLOGY OF VALLEY CREEK WITHIN VALLEY FORGE NATIONAL HISTORICAL PARK

Peak flows: The complete hydrologic output data of the TR-55 computer simulations are presented in Appendix C. Table 1 presents the calculated peak discharges for the 2- and 100-year 24-hour rainfall and estimates of the 500-year peak discharges. These values are in cubic feet per second (cfs).

Table 1. Valley Creek at Schuylkill River: Peak Discharges for Selected Watershed Conditions.

Year	2-year peak	100-year peak	500-year peak
1685	350 cfs	4,200 cfs	5,900 cfs **
1776	400 cfs	4,600 cfs	6,500 cfs **
1885	800 cfs	6,600 cfs	9,300 cfs **
1977	---	7,100 cfs *	10,000 cfs *
1985	1,450 cfs	8,300 cfs	11,700 cfs **
1995	1,350 cfs	8,100 cfs	11,400 cfs **

* These values were obtained from U.S. Army Corps of Engineers, 1981.
** These values were estimated using the ratio of 500-year flow to 100-year flow established for 1977.

The 100-year peak discharge values for 1985 and 1995, although conservative, are not as high as comparable estimates made by others (Heister, 1989; Commonwealth of Pennsylvania, 1973).

Conversely, the 2-year peak discharge values for 1985 and 1995 may be high. This is because I did not take into consideration the possible cumulative effect of the small dams--throughout the watershed--on the peak flows of small floods. If these dams had any available storage prior to such events, then the resulting peak discharges would likely be less than the values presented in Table 1.

The effects of changing land uses on the flood hydrology of Valley Creek at Schuylkill River has been to increase the magnitude of floods, e.g., the magnitude of the 100-year flood increased from 4,200 cfs to 6,600 cfs over the 200-year period from 1685 to 1885. Another way to interpret this hydrologic trend, is that a given magnitude flow now has a more frequent (smaller) recurrence interval and thus, a higher probability of occurring. For example, a flow with a magnitude of 6,600 cfs would have been a flood with a recurrence interval (or return period) slightly greater than the 500-year flood in 1776, but would have been only a 100-year flood in 1885. And if a flood of this magnitude was to occur today, it would be only a 50-year flood (Appendix C). One result of this trend is that although the covered bridge may have been designed (by chance or on purpose) for the 100-year flood at the time of its construction (1851), that it now has a conveyance (below low steel) roughly equal to the 50-year flood.

In general, over the 300-year period from 1685 to 1985, the peak discharges were doubled. This is typical of changes in stream hydrology for a moderately developed watershed, i.e., Increased peak discharges about 2 to 5 times higher than pre-development conditions (Schueler, 1987). Essentially, half of the increase occurred over the 100-year period from 1785 to 1885 and half occurred over the 100-year period from 1885 to 1985. Most of this latter increase has occured since 1970. As modeled, the present trend in land use changes may actually cause a slight decrease in current (1985) peak discharges (Figure 5). This is because I assumed that in the future stormwater runoff would be better managed, i.e., I assumed that future land uses would have a lower curve number than the current land uses they replaced.

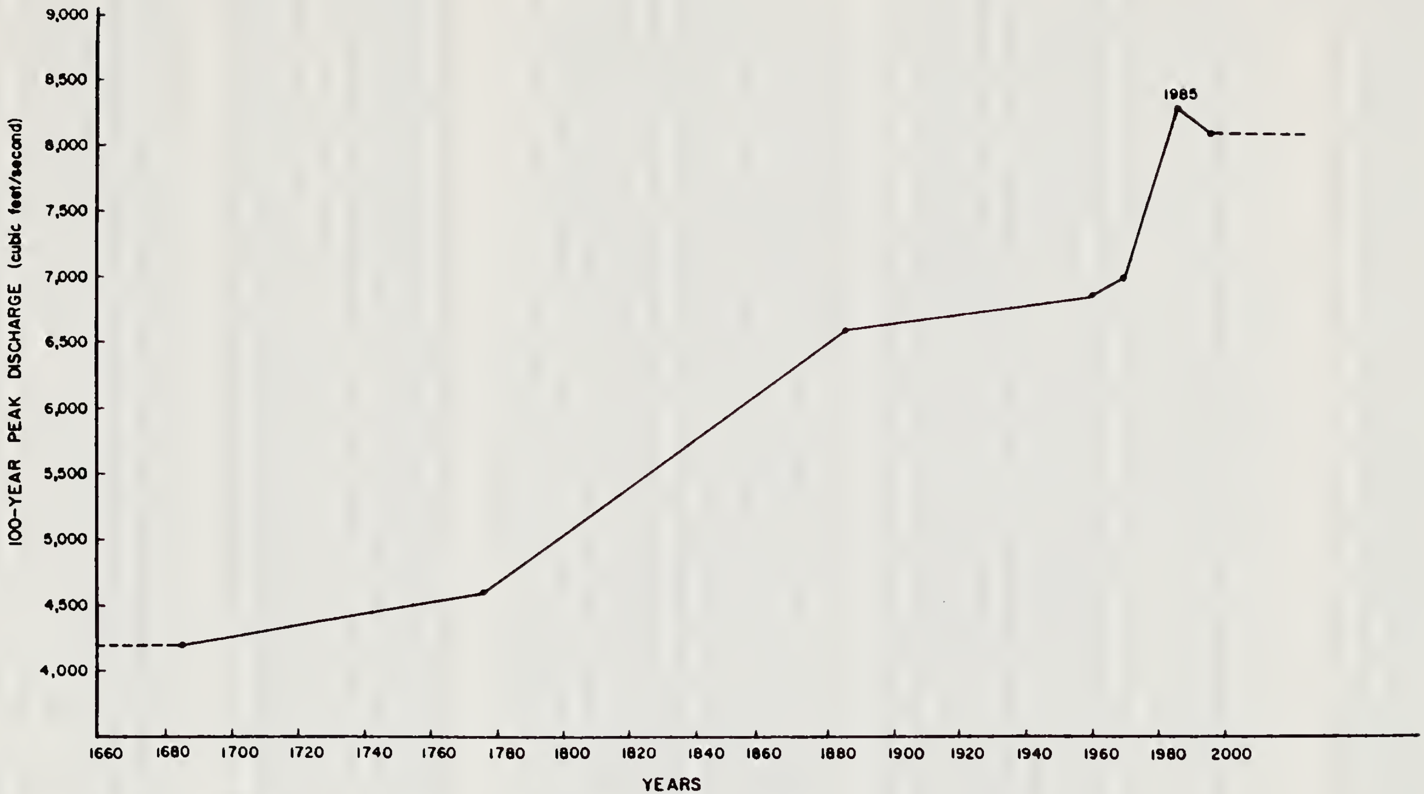

Figure 5. 100-YEAR PEAK DISCHARGES -- 1685 to 1995, VALLEY CREEK at SCHUYLKILL RIVER, VALLEY FORGE NHP

COMPILED BY WILLIAM B REED 2/04/1989
DRAFTED BY JACQUELINE V NOLAN

An analysis using the storage routine for the TR-55 computer program indicates that even for relatively small events (e.g., the 2-year storm), the amount of storage required to reduce peak flows from projected 1995 peaks to modeled 1885 conditions would be considerable. Reducing the discharge of the 2-year event (24-hour rainfall of 3.2 inches) from 1,350 cfs to 800 cfs would require a detention basin storage volume of 205 acre-feet.

Base flow: Over the 300-year period from 1685 to 1985, the base flow of Valley Creek within Valley Forge National Historical Park has presumably decreased. Although data have not been presented to support this supposition, it is made based upon the observation that at least one formerly perennial tributary to Valley Creek no longer flows continuously during the summer. The observed drying up of the smaller stream, and the speculated reduced Valley Creek base flow, agrees well with the changes to stream hydrology expected within a moderately developed watershed (Schueler, 1987). However, the permitted discharge from the limestone quarry (site 2b on Figure 2) may have offset any decrease that would have occurred in recent years. Additionally, the growth of public water and sewer systems has resulted in significant interbasin transfers out of the Valley Creek watershed (Sloto, 1987). Sloto (1987) estimates that the net loss of water in 1984 was 630 million gallons. Such a loss could contribute to a reduction in base flow, but would likely not cause a noticeable change.

EFFECTS OF CHANGING LAND USES ON THE CHANNEL MORPHOLOGY OF VALLEY CREEK WITHIN VALLEY FORGE NATIONAL HISTORICAL PARK

Whereas the hydrologic response to land use changes is almost immediate, the morphologic response may occur over several decades. Indeed, since recent land use changes within Valley Creek watershed have occurred relatively rapidly (Figure 5), it seems likely that river morphology is still adjusting--and if left unaltered--may continue to do so for at least another decade. The primary channel response to increased storm flows is through widening. For a moderately developed watershed, the increased channel width may be 2 to 4 times the pre-development width (Schueler, 1987). This may mean that at the park boundary the 1685 channel width of Valley Creek was only 20 feet--instead of the 40 feet it is today.

The spans of three 19th century bridges in the study area seem to indicate that the width of Valley Creek has changed very little since 1882 (the date of the bridge for Valley Creek at Mill Road; see the description for site 1e in Appendix B). Assuming that channel depth and grade have remained the same, primary channel adjustments to the recent increases in storm flows have been decreases in channel roughness. This would provide a more efficient conveyance of flows through an increase in flow velocities. A few ways in which a decrease in roughness may have occurred are: (1) a change in bed material, (2) a reduction in bank vegetation, and (3) a reduction in bank irregularities.

For particular stream reaches, the channel gradient could have increased through channel straightening. However, this would not have been the case for the reach between the covered bridge and the upper forge site. The straightness of this reach is consistent with its very low slope. Therefore, although the stream has been confined by other uses of the valley floor, the stream pattern of this reach has likely not been recently modified. Indeed, the channel geometry for this reach has probably been the same since shortly after the textile mill dam was destroyed, approximately 70 years ago.

However, observations made during 1990 seem to suggest that the previously observed hiatus between changes in land use and changes in channel geometry has now ended. Either the flow velocities have now increased enough to permit bank erosion, or there has finally been a large enough event to initiate the erosion process. Bank erosion seemed to be especially prevalent where the slope of the channel is less than 0.3 percent.

EFFECTS OF CHANGING LAND USES ON THE HISTORICAL USES OF VALLEY CREEK

Historically, the lower reach of Valley Creek has been used for milling and industrial waterpower by the construction of several dams at various locations. These dams would have been of different heights--determined by the power requirements of the purpose for which they were constructed. Originally, the dams would have been very low because of the modest horsepower requirements of iron forges (a type of water mill). However, the textile mill (an industrial factory requiring the distribution of waterpower) would have required a much larger dam. The typical medium-scale cotton mill of this era occupied a building 150 to 200 feet long, 40 to 50 feet wide, and 4 or 5 stories high above the basement, where the waterwheel was usually located (Hunter, 1979).

The effects of changing land uses between 1685 and 1885 on the hydrology and geomorphology of Valley Creek may have complemented the changes in the historical uses of the stream. Inadvertently, the smaller, gentler stream of the colonial era was gradually changed to the larger, powerful stream of the industrial era. However, the effects of changing land uses since 1970 on the hydrology and geomorphology of Valley Creek have resulted in an impaired fluvial system that may not yet be in equilibrium with existing watershed conditions. Ultimately, in the East, urbanization without effective stormwater management results in streams with hydrology and appearances more common to the desert Southwest.

CONCLUSIONS

* In general, it appears that present-day changes in land use from agriculture to low-density residential areas and corporate centers may have less impact on the hydrology of Valley Creek than did the previous transition from agriculture to high-density residential areas and industrial parks.

* If the current trend continues, then Valley Creek streamflow characteristics will deviate very little from existing conditions. Therefore, slope protection and erosion control efforts should be designed for current streamflow conditions.

* The hiatus between changes in land use and changes in channel geometry has ended. Unless altered, the channel will continue to widen in response to previous increases in stream flow (especially flood peaks) caused by historic changes in watershed conditions. Therefore, slope protection and erosion control efforts will need to anticipate future changes in channel geometry.

* Based upon the above conclusions, conceptual slope protection and erosion control designs for the upper forge site *and* for the reach between the covered bridge and the upper forge site are presented in Appendix A. If implemented properly, these efforts should be sustainable over time.

ADDITIONAL STUDIES

Additional studies which may be conducted in the future to more thoroughly examine the effects of changing land uses on the hydrology and morphology of Valley Creek include:

* a more detailed investigation of the land-use history of Valley Creek watershed, possibly using stratigraphic pollen analysis;

* a more thorough examination of the morphology of Valley Creek, possibly including an evaluation of historical photographs of selected sites, and geobotanical indicators;

* a more thorough examination of the effects of changing land uses on the hydrology of Valley Creek, possibly using a more detailed description of watershed characteristics for selected historic periods; and

* a statistical evaluation of the hydrologic record for the Valley Creek gaging station, after 10 to 15 years of data collection, to determine the present-day flood frequency distribution.

REFERENCES CITED

Brush, G.S. 1989. Abstract: a History of Sediment and Metal Influxes in some Mid-Atlantic, USA Estuaries. Eos, October 24.

Chester County. 1982. Chester County Open Space and Recreation Study. Chester County Planning Commission and Chester County Parks & Recreation Department, West Chester.

Chester County. 1988. Chester County Land Use Plan. Chester County Planning Commission, West Chester.

Commonwealth of Pennsylvania. 1973. Hydrologic Study of Valley Creek at Valley Forge State Park. Department of Environmental Resources, Harrisburg.

Defries, R.S. 1986. Effects of Land-use History on Sedimentation in the Potomac Estuary, Maryland: A Water-quality Study of The Tidal Potomac River and Estuary. U.S. Geological Survey Water-Supply Paper 2234-K.

Heister, R.D. 1989. Impact of Urbanization on a Small Stream. Conestoga High School, Berwyn.

Hunter, L.C. 1979. A History of Industrial Power in the United States, 1780-1930, Volume One: Waterpower in The Century of the Steam Engine. University Press of Virginia, Charlottesville.

Kolva, J.R., et al. 1989. Water Resources Data, Pennsylvania, Water Year 1988, Volume 1. Delaware River Basin. U.S. Geological Survey Water-Data Report PA-88-1.

Mason, T.R. 1984. Erosion and Sediment Control Plan for Valley Forge National Park: Valley Creek Streambank Stabilization. U.S. Soil Conservation Service, Norristown.

Schueler, T.R. 1987. Controlling Urban Runoff: a Practical Manual for Planning and Designing Urban BMPS. Metropolitan Washington Council of Governments, Washington, D.C.

Sloto, R.A. 1987. Effects of Urbanization on the Water Resources of Eastern Chester County, Pennsylvania. U.S. Geological Survey Water-Resources Investigations Report 87-4098.

Sloto, R.A. 1988. Effects of Urbanization on Storm-Runoff Volume and Peak Discharge of Valley Creek, Eastern Chester County, Pennsylvania. U.S. Geological Survey Water-Resources Investigations Report 87-4196.

REFERENCES CITED (CONTINUED)

U.S. Army Corps of Engineers. 1981. Flood Preparedness Plan Outline, George Washington's Headquarters, Valley Forge National Historical Park.

U.S. Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds. Technical Release 55.

Van Haveren, B.P. 1986. Water Resources Measurements, a Handbook for Hydrologists and Engineers. American Water Works Association, Denver.

Willard, B. 1962. Pennsylvania Geology Summarized. Pennsylvania Geological Survey Educational Series No. 4.

Wolman, G. 1967. A Cycle of Sedimentation and Erosion in Urban River Channels. Geografiska Annaler, vol. 49A, No. 2-4.

APPENDIX A

VALLEY CREEK STREAM RESTORATION PROJECT: CONCEPTUAL DESIGNS FOR SLOPE PROTECTION AND EROSION CONTROL

By William B. Reed

INTRODUCTION

Valley Creek flows for approximately 11,000 feet through Valley Forge National Historical Park to its confluence with the Schuylkill River. Valley Creek at Schuylkill River has a watershed of 23.25 square miles. The watershed has undergone extensive land use changes during the last 20 years resulting in changes in Valley Creek streamflow characteristics and associated fluvial processes.

THE UPPER FORGE SITE REVISITED

Background: The Village of Valley Forge received its name from the iron forge built along Valley Creek in the 1740s. This forge was destroyed by the British in 1777 prior to the arrival of George Washington's army. The upper forge site may be the ruins of this historic forge.

At this site, stone masonry walls were constructed (circa 1945) to protect the buried ruins and Route 252. However, the walls constrict the flow of Valley Creek, gradually reducing the channel width from 42.6 to 31.3 feet. This channel configuration and changing watershed conditions have resulted in: (1) a lowering of the stream channel (which had already been dredged during archeological investigations), (2) an undermining of the right-bank wall, and recently (3) a collapsing of a segment of the right-bank wall into the stream.

Several solutions for providing bank stabilization at the site have been proposed. My understanding is that the current thinking is to replace the right-bank wall with a reinforced concrete, cantilevered wall that is faced with salvaged stone from the previous structure (proposed by the Federal Highway Administration). Construction is planned to begin this Autumn (Brian Lambert, personal communication). Whereas, I support this treatment for the right-bank slope, I also believe that the opposite wall downstream of the footbridge needs to be lowered from a height of 7-1/2 feet to a height of 3 feet *and* the span of the footbridge needs to be increased from 34 feet to a minimum span of 43 feet.

Discussion: I conducted an analysis of Valley Creek at the upper forge site using the U.S. Army Corps of Engineers' HEC-2 (Water Surface Profiles) computer program (U.S. Army Corps of Engineers, 1982). The analysis indicates that although the left-bank wall may have been designed (by chance or on purpose) for the 50-year flood at the time of its construction (circa 1945), that it now has a conveyance roughly equal to the 25-year flood, i.e., the peak flow rate for which the structure was designed (5,000 cfs) now has a more frequent (smaller) recurrence interval and, thus, a higher probability of occurring. Assuming supercritical flow, the preliminary analysis indicates that the left-bank wall needs only to be 3 feet high to provide sufficient conveyance for the 2-year flow (1,350 cfs). It is generally accepted that the 1.5- to 2-year flow is the bank-full flow for natural channels, i.e., for natural channels the 1.5- to 2-year flow is the dominate channel-forming flow. If the left-bank wall is lowered to a height of 3 feet, then the area behind the structure will serve as a floodplain. This area is sufficiently wide enough that flood velocities will remain low, i.e., the area will not be subject to scour. Indeed, for large events (events greater than the 25-year flood) the velocities (and thus, potential for erosion) during peak flows will remain the same.

At the upper forge site, a footbridge spans the creek upstream of the right-bank wall. Upstream and downstream of the bridge the width of the stream channel is 46.7 feet and 42.6 feet, respectively. However, the span of the bridge is only 34 feet. The preliminary analysis indicates that the conveyance under the bridge (the conveyance below low steel) is roughly equal to the 5-year event (2,700 cfs). The analysis also indicates that flood velocities are relatively high under the bridge. These accelerated velocities are due to the constriction of flows and have caused scouring under the bridge. Unless corrected, this situation will ultimately result in the left-bank wall and the right-bank bridge abutment being completely undermined.

Conceptual design: A design for slope protection and erosion control at the upper forge site is described by the following five steps. This design is a modification of the design I presented in the attachment to my July 1989 trip report (dated August 8, 1989) and could be implemented as part of the Federal Highway Administration's proposed efforts.

Step 1: Restore the fallen stone masonry wall or provide a similar treatment for the right bank. If necessary, reinforce the wall below the water surface and behind the wall at its base. If possible, move the wall back (towards the road) to gain additional cross-section area.

Step 2: Starting downstream of the footbridge, lower the left-bank wall by approximately 4-1/2 feet (from a height of approximately 7-1/2 feet to a height of 3 feet). This action will provide a more stable channel and floodplain geometry and will reduce the erosional force of flood events with recurrence intervals between the 2-year event (bank full after restoration) and the 25-year event (bank full prior to restoration); thus, providing long-term protection for the right-bank wall, Route 252, and the upper forge site.

Step 3: Connect the floodplain behind the lowered left-bank wall with the existing floodplain that is 200 feet downstream of the upper forge site. This would require that the mound that lies between the upper forge site and the downstream floodplain be removed. This mound is likely an artifact of archeological investigations during the 1920s. This step will allow continuity of overbank flow during floods and, thereby, provide additional protection for the right-bank wall, Route 252, and the upper forge site.

Step 4: Cover the upper forge site behind the left-bank wall with a thin layer of soil and reestablish floodplain vegetation. The soil recovered during the previous step could be used to cover this site to a height equal in elevation to the lowered left-bank wall. Reestablishing floodplain vegetation will provide protection for the upper forge site by further reducing flood velocities. However, the effect of their roots on the buried ruins should be considered prior to planting.

Step 5: Move the footbridge's right-bank abutment towards the road to increase the bridge span from 34 feet to a minimum span of 43 feet. This step will ameliorate the threat (of bridge and left-bank wall failure) by treating the cause rather than the symptom.

FROM THE COVERED BRIDGE TO THE UPPER FORGE SITE

Background: Within the park, between the covered bridge and the upper forge site (a distance of approximately 2,000 feet), Valley Creek once migrated back and forth within a very narrow valley. In recent times, the stream has been confined by alternative uses of the valley floor and now threatens these uses as it continues to adjust to changes in watershed conditions. Of particular concern is the potential for the undermining of Route 252 and underlying forced sewer main.

Discussion: The stream channel for Valley Creek is still adjusting in response to increased flows caused by previous changes in watershed conditions. This conclusion is based upon measurements of channel geometry made during a reconnaissance of changing land uses and existing conditions conducted with the assistance of Brian Lambert, Natural Resource Specialist, Valley Forge National Historical Park, on July 26-27, 1989 and March 27-28, 1990.

The channel slope for Valley Creek within the park varies from 0 to 2 percent. The flat reach of 0 percent slope is essentially the reach between the covered bridge and the upper forge site. Therefore, this reach is dominated by subcritical flow. Calculations using HEC-2 indicate that the depth of flow for the 2-year event along this reach is 3.5 to 4.5 feet. However, upstream of the covered bridge and downstream of the upper forge site (for reaches with similar slopes--slopes less than 0.3 percent) the stream appears to be establishing, through erosion, banks approximately 2 to 3 feet high. I assume that this difference is because the channel geometry is adjusting to the 1.5-year flow (estimated at 880 cfs) rather than the 2-year flow (1,350 cfs).

The 1.5-year flow has a 66 percent chance of being equaled or exceeded at least once in any given year and a 96 percent chance of being equaled or exceeded at least once in 3 years. Other ways to express this concept are (1) on the average the 1.5-year event will be equaled or exceeded at least once every 1.5 years and (2) on the average the 1.5-year event will be equaled or exceeded at least once, 2 years out of every 3 years.

As stated above, the stream channel is still adjusting to increased flows. The primary adjustment is through a widening of the stream channel. Measurements of stream geometry made at various sites within the park suggest that for a channel slope less than 0.3 percent that stable channel widths range from approximately 39 to 47 feet. These widths are stable for present-day watershed conditions if (1) the channel width is not encroached upon by fallen trees or flood debris *and* (2) an area for overbank flow exists adjacent to the channel at a height ranging from 2 to 3 feet above the streambed.

Conceptual Design: To provide slope protection and erosion control for this reach of Valley Creek, the following conceptual design is offered. This approach could be implemented in phases over the next 5 to 10 years. However, it is recommended that Phase 1 be accomplished as soon as possible to provide protection for the road and eliminate the need for additional temporary solutions.

Phase 1: Provide slope protection for the right bank using soil bioengineering techniques where possible.

Phase 2: Remove the gabions that were placed to protect the footpath (left bank). This site is approximately 600 feet upstream of the upper forge site. After removing the gabions, widen the channel to a minimum width of 43 feet *and* lower the footpath to a height approximately 3 feet above the streambed. The widened channel and sculptured left bank will provide a more stable channel and floodplain geometry--while resembling more natural conditions. To further enhance natural values, soil bioengineering techniques should be considered for providing slope protection at the sculptured left bank.

Phase 3: Widen the channel *and* lower the footpath for other stream segments between the covered bridge and the upper forge site. Although the height of the sculptured left bank (the height of the footpath) can be a uniformed 3 feet above the streambed for the entire reach, the width of the stream should be varied from a minimum width of 39 feet to a maximum width of 47 feet. This variability is suggested to: (1) provide a more natural appearance than that provided by a uniformed width and (2) allow flexibility in dealing with site specific constraints. For each segment the local channel pattern should be preserved and soil bioengineering techniques considered for providing slope protection. These segments could be selected on a priority basis, or the restoration efforts could be accomplished by working from downstream (the upper forge site) to upstream (the covered bridge site).

SUMMARY

Valley Creek within Valley Forge National Park is exhibiting changes in hydrology and channel geometry that are typical of streams within moderately developed watersheds. For example, the stream is actively widening its channel in response to increased peak flows. However, if the above-described slope protection and erosion control measures are implemented, then a more stable channel configuration will be established. The goal of the proposed restoration is to establish a new channel in harmony with existing and future watershed conditions *and* in harmony with existing uses of the valley floor.

The conceptual designs are very similar. Both designs include lowering the left bank and establishing an area for overbank flow. The primary difference is that at the upper forge site the stream, during normal flows, remains confined between two walls, thus, preventing the channel from undermining the road or moving onto the ruins.

REFERENCES CITED

Lambert B. 1990. Personal Communication. Natural Resource Specialist, Valley Forge National Historical Park.

U.S. Army Corps of Engineers, 1982. HEC-2, Water Surfaces Profiles, Users Manual.

APPENDIX B

RECONNAISSANCE OF VALLEY CREEK WATERSHED

by William B. Reed

INTRODUCTION

A reconnaissance of Valley Creek watershed was conducted on July 26-27, 1989, and March 27-28, 1990. During 1989, preliminary field observations were made at nine sites upstream of the park boundary (Figure 1) and at various locations within the park (Figure 2). During 1990, additional measurements were made and a few of the previous measurements verified.

Each site will be described, in sequence, moving from upstream to downstream in the basin. Unless noted otherwise, reported widths, depths, and flows were estimated.

SITE DESCRIPTIONS

1a. Valley Creek at Morehall Road (East Whiteland Township Park): East of Morehall Road, the flow was 30 cubic feet per second (cfs) within East Whiteland Township Park. The water was clear in appearance. The Valley Creek floodplain within this local park is a mosaic of forested and cleared areas. Stream length from the highest point in the watershed to this site is 4.0 miles.

2a. Tributary to Valley Creek at Morehall Road (Upstream of Quarry): West of Morehall Road, the flow was 0.01 cfs (5 gallons per minute) where this tributary flows adjacent to an abandoned railroad line.

2b. Tributary to Valley Creek at Church Road (Downstream of Quarry): The flow was 33 cfs. The water was milky in appearance. This site is approximately 400 feet south of where this tributary may have once flowed under Church Road. The increase in flow between sites 2a and 2b is partially caused by dewatering of the quarry that lies between these sites. Such dewatering may result in a lowering of the local ground water table. The quarry has a discharge permit for 3 to 5 million gallons per day. The point of discharge is a controlled outlet from the quarry's settling ponds. The distance between sites 2a and 2b is approximately 1.9 miles.

1b. Valley Creek at Church Road (Upstream of Confluence With Tributary): The flow was not recorded for this site. The water was clear in appearance. Stream length from the highest point in the watershed to this site is 4.9 miles.

4c. Small Tributary to Little Valley Creek at North Valley Road: The flow was not recorded for this site. The small channel is incised. A possible cause of the entrenchment may be increased stormwater runoff from Highway 202 and the Paoli railroad yard.

3c. Little Valley Creek at North Valley Road (Upstream of Confluence With Small Tributary): The flow was 8 cfs. The channel for Little Valley Creek is approximately 8 feet wide (heights of banks were not noted). The stream meanders across a meadow (possibly abandoned cleared land). Channel bottom is sandy. Stream length from highest point in Little Valley Creek watershed to this site is 3.7 miles.

1d. Valley Creek at Le Boutillier Road: The flow was 63 cfs. The water was milky in appearance. The channel for Valley Creek is approximately 25 feet wide (heights of banks were not noted). Channel bottom is silty. Stream length from highest point in watershed to this site is 7.0 miles.

1e. Valley Creek Near Mill Road (100 Feet Upstream of the Confluence With Little Valley Creek): The flow was 65 cfs. The water was very milky in appearance. A reason for the water being milkier here than at site 1d may be related to the break in channel slope that occurs at Mill Road. The reach immediately upstream of Mill Road has a channel slope of 2.0 percent (with a bedrock channel bottom) and the reach immediately downstream of Mill Road has a channel slope of 0.3 percent (with a silty sand channel bottom).

At site 1e, the channel for Valley Creek is 30 feet wide with banks approximately 3 feet high. Approximately 500 feet upstream of this site is a dam that can be seen from Mill Road. The dam, which pools Valley Creek, is about 5 feet high. The pond behind the dam does not appear on the USGS Valley Forge Quadrangle (1966: photo revised 1981) and, therefore, is either very small or relatively new (built or enlarged during the last 8 years). Whereas the span of the bridge across Valley Creek is 35 feet, the width of the channel under the bridge is only 30 feet. The height of the bottom of the bridge (low steel) is 11 feet above the streambed. These measurements (bridge span, channel width under the bridge, and height of low steel) were made with park staff on March 28, 1990. The date of this structure is 1882. Upstream, between Mill Road and the dam, the stream channel is 35 feet wide and seemed exceptionally shallow. Stream length from highest point in watershed to site 1e (100 feet upstream of the confluence with Little Valley Creek) is 7.6 miles.

3e. Little Valley Creek Near Mill Road (50 Feet Upstream of Confluence With Valley Creek): The flow was 10 cfs. The water was clear in appearance. The channel for Little Valley Creek is approximately 25 feet wide with banks approximately 3 feet high. This area (sites 1e and 3e) is posted with a warning of the possible health risk associated with the eating of contaminated fish (PCBs from former dust control measures at the Paoli railroad yards, Little Valley Creek watershed, have entered the aquatic environment). However, the riparian community appeared healthy and the floodplain appeared active (appeared to be periodically inundated). Channel bottom is sand and gravel. Stream length from highest point in Little Valley Creek watershed to this site is 5.0 miles.

Whereas the span of the stone arch bridge across Little Valley Creek at Mill Road is 28 feet, the width of the channel under the bridge is only 22 feet. The height of the crown is 7.5 feet above streambed. These measurements were made with park staff on March 28, 1990. The date of this structure is 1912.

1f. Valley Creek at USGS Gaging Station (100 Feet Upstream of Pennsylvania Turnpike Bridge): The flow was 75 cfs. The water was milky in appearance. This site is 0.9 miles downstream of the confluence of Valley Creek and Little Valley Creek. The channel for Valley Creek is approximately 40 feet wide with banks approximately 3.5 feet high. The slope of the stream channel is 0.3 percent. Upstream of this gaging station, throughout the watershed, there are several small dams on Valley Creek and its tributaries. Stream length from the highest point in the watershed to this site is 8.5 miles.

1g. Valley Creek Upstream of Wilson Road Bridge (and Upstream of Confluence With Small Tributary): Approximately, the left stream bank is 2 feet high, the right bank is 4 feet high, and channel width is 40 feet. Channel slope is 0.3 percent and channel bottom is sandy. Upstream of this site, channel slope increases to 0.6 percent and at one point the channel width decreases to 30 feet. However, downstream of this site, the span of Wilson Road Bridge is 60 feet and the width of the channel under the bridge is 40 feet. The height of the bottom of the bridge (low steel) is 6 feet above the streambed. I made these measurements (bridge span, channel width under the bridge, and height of low steel) on March 27, 1990. The date of this structure is 1886. Stream length from the highest point in the watershed to this site is 8.7 miles.

5g. Small Tributary to Valley Creek Upstream of Wilson Road Bridge: This tributary which originates in Chesterbrook has been heavily impacted by urbanization. The stream which is shown as perennial on the USGS Valley Forge Quadrangle (1966: photo revised 1981) was not flowing. It is assumed that urbanization of this small watershed has caused this former perennial stream to become seasonally dry. The channel for this stream is entrenched and has a "blown out" appearance. The concrete-lined arch conduit that coveys this stream under the Pennsylvania Turnpike is 14 feet wide at its base and 8 feet high at its crown. Upstream of the Pennsylvania Turnpike, debris dams were observed across the dry channel of this small tributary.

1h. Valley Creek Upstream of Maxwell's Quarters (at Horse Crossing): The channel geometry here was similar to the USGS gaging station site; the channel is approximately 40 feet wide with banks approximately 3.5 feet high. Channel bottom is bedrock. Channel slope is less than 0.1 percent.

1i. Valley Creek 100 Feet Upstream of the Covered Bridge: Downstream of this point, Valley Creek becomes entrenched as it flows through a narrow V-shaped valley between Mounts MIsery and Joy. It is reported by park staff that at one time Valley Creek could have been pooled to this point by a large, textile mill dam. The dam was located approximately 1.0 miles downstream (site 1p). Therefore, the stream banks between site 1l and site 1p are composed of unconsolidated highly erodible sediments deposited behind the dam.

1j. Valley Creek at the Covered Bridge: This covered bridge, commonly referred to as the Knox Covered Bridge, was constructed at the head of the mill pond for the textile mill that existed at the time of construction (see site 1p). The bridge was built in 1851. After the bridge washed away in 1865, it was rebuilt. Then in 1960 it was repaired and strengthened with steel girders after a fire. (The Denver Post, Sunday, November 19, 1989, pages 6T and 7T.) The span of this bridge is 50.4 feet. Low steel at the center of the bridge is 10.5 feet above the streambed. Bridge dimensions were measured with park staff. Riprap at left bank, immediately downstream of the bridge, reduces the effective cross section area under the bridge by approximately 20 percent. (The riprap appeared relatively new, i.e., this stabilization work protecting the footpath and a stormwater outfall may have been accomplished within the last 5 years.) A rough estimate of the channel conveyance underneath this bridge is 6,600 cfs (assuming: (1) a cross section area of 400 square feet, (2) a hydraulic radius of 6 feet, (3) a roughness coefficient of 0.030, and (4) a water surface slope of 0.01 feet/feet). The channel bottom under the bridge is bedrock. Stream length from the highest point in the watershed to this site is 9.3 miles.

1k. Potential Priority Bank Stabilization Site #1: This site is from 100 feet to 350 feet downstream of the covered bridge, assuming bank stabilization (right bank) will be done along a 250 foot reach. At the upstream end of this reach (100 downstream of covered bridge) the channel is 38.0 feet wide; at the mid-point (225 feet downstream of covered bridge) the channel is 50.2 feet wide (widths measured by park staff).

1l. Potential Priority Bank Stabilization Site #2: This site is from 525 feet to 725 feet downstream of the covered bridge, assuming bank stabilization (right bank) will be done along a 300 foot reach. At the upstream end, the channel is 37.1 feet wide; near the downstream end, the channel is 38.9 feet wide (widths measured by park staff).

1m. Site of Gabions at Left Bank: In 1985, gabions were placed at this site by park staff to protect the footpath. This work was recommended by the SCS (Mason, 1984). The width of the stream channel adjacent to the gabions at the upstream and downstream end is 39 feet and 32 feet, respectively. Approximately 100 feet upstream and downstream of the gabions, the stream width is 41 feet and 38 feet, respectively. The overall height of the structure is 9 feet (3 tiers of baskets, each basket 3 feet high). The width of the structure is 5.5 feet (the baskets are stacked almost completely vertical without any offset). These measurements were made with park staff on March 28, 1990. The site is approximately 600 feet upstream of the upper forge site (site 1n). Stream length from the highest point in the watershed to this site is approximately 9.6 miles.

1n. Valley Creek at Upper Forge Site (Site of Foot Bridge, Failed Wall at Right Bank, and Proposed Bank Stabilization by the Federal Highway Administration): Flow was 60 cfs (this estimate was made on 7/27; all other flow estimates were made on 7/26). At this site a foot bridge crosses Valley Creek to provide access to the upper forge site from Route 252. The span of the foot bridge is 34.0 feet. The length of the bridge is 10.6 feet. Low steel at left bank and at center of the stream is 7.1 feet above the streambed. Low steel at the right bridge support is 5.0 feet above streambed. It was noted that the right bridge support is being undermined. A rough estimate of the channel conveyance underneath this foot bridge is 3,050 cfs (assuming: (1) a cross section area of 225 square feet, (2) a hydraulic radius of 4.7 feet, (3) a roughness coefficient of 0.035, and (4) a water surface slope of 0.013 feet/feet).

At the left bank a stone masonry wall has been constructed to protect the upper forge site during high flows. The left bank wall begins 39.7 feet upstream of the foot bridge and extends to 122.3 feet downstream of the bridge; total length of wall is 172.6 feet. The height of the left bank wall above the streambed is 5.7 feet upstream of the foot bridge and 7.5 feet downstream of the bridge. The maximum width of the area between the wall and the footpath (the width of the protected upper forge site) is 67 feet.

At the right bank downstream of the foot bridge there is another stone masonry wall across from the one described above. Although it is currently not as long, this wall is higher than the left bank wall and extends further downstream. The recent failure of a section of this wall may allow severe bank erosion during high flows. Such erosion would threaten Route 252 above (and behind) the wall. Route 252 at this point is approximately 15 to 20 feet above the streambed. Four causes of the collapse of this wall segment have been previously suggested: (1) general decline due to the age of the wall, (2) hydrostatic pressure behind the wall during an unusually wet winter/spring, (3) undermining of the wall at its base, and (4) a combination of these conditions.

Between my first (July 1989) and second (March 1990) visits to the site, a portion of the wall that was partially collapsed, fell completely into the stream. As a temporary measure, the exposed slope is now protected with riprap. Permanent slope protection and erosion control designs for the upper forge site *and* for the reach between the covered bridge and the upper forge site are presented in Appendix A.

Over a stream distance of 122.3 feet, the stream width is constricted from 46.7 feet upstream of the foot bridge to 31.3 feet at the downstream end of the left bank wall. At the upstream end of right bank wall, 43.9 feet downstream of foot bridge, the stream is 42.6 feet wide. At the upstream end of wall failure, 78.3 feet downstream of the foot bridge, the stream is 36.6 feet wide. Low flows are initially constricted at the foot bridge that has a span of 34 feet. These constrictions may be the cause of two distinct channel features: (1) a scour pool underneath the foot bridge and (2) a break in channel slope (a nickpoint) downstream of the foot bridge near the upstream end of wall failure. However, since this general area was once the site of a forge, it was also once the site of a natural drop in the stream channel that was increased (or accentuated) by the construction of a dam. The bridge, walls, and stream dimensions were measured with park staff. The channel bottom (from upstream of the foot bridge to downstream of the right bank wall) is a thin layer of rubble lying on bedrock. The stream length from the highest point in the watershed to this site is 9.7 miles.

Approximately 200 feet downstream of the upper forge site is a site that has a well developed floodplain adjacent to the stream channel. The height of the right bank is 8 feet, the height of the left bank is 1 to 3 feet, and the width of the channel is 40 feet. The width of the area for overbank flow (left bank) is 41 feet. These measurements were made with park staff on March 28, 1990. Between this floodplain and the upper forge site is a mound that is likely an artifact of archaeological investigations during the 1920s.

1o. Site of Middle Dam: This dam, originally built prior to the American Revolution, was rebuilt in 1931. The sediments behind the dam are believed to have high PCB concentrations. The area below the dam is posted: "No Swimming." The drop over the dam is 6 feet. The structure is a nickpoint that causes a break in the water surface profile (Figure 4). The removal of the dam would likely result in a lowering of the channel upstream as the profile adjusted to a new base level. To allow fish migration, an alternative to breaching the dam may be to construct a fish ladder. Channel bottom underneath the dam is believed to be bedrock. Stream length from the highest point in the watershed to this site is 10.1 miles.

1p. Site of Textile Mill Dam: This dam built in the 1800s is reported to have pooled water as far upstream as the covered bridge (see sites 1i and 1j above) and was breached about 1920. To have pooled water that far upstream, the dam would have had to have been approximately 25 feet high, approximately the height of a two-story building (Figure 3). This height agrees well with the observed height of the remains of the dam--exposed at the left bank of Valley Creek. The pond behind such a dam would have been below the present-day elevation of Route 252 (right bank). The site is approximately 250 feet upstream of the bridge for Route 23. It is interesting to note that the bridge for Route 23 has two stone arches: the left arch was for Valley Creek and the right arch was for the tailrace from the textile mill. The textile mill was located adjacent to Route 252 at the dam. Downstream of Route 23, the flooding of Valley Creek is partially determined by the Schuylkill River that can cause backwater conditions during high flows. The channel bottom at the dam site is bedrock. Stream length from the highest point in the watershed to this site is 10.3 miles.

1q. Valley Creek at Schuylkill River: Valley Creek is 45 feet wide where it flows into the Schuylkill River. This width is partially controlled by a large stone arch over Valley Creek that is also 45 feet wide at its base. This railroad bridge arch is located approximately 100 feet upstream of the mouth of Valley Creek. Valley Creek approaches the stone arch from the left at an angle. In 1990, the right bank was observed to be rapidly eroding immediately upstream of the arch. Stream length from the highest point in the watershed to this site is 10.6 miles.

OTHER OBSERVATIONS

Although not thoroughly documented, the observed stream was remarkably different in 1990 than 1989. In 1990 the stream reach above the covered bridge, the reach within the narrow valley, and the reach near the mouth exhibited, in contrast to 1989, higher occurrences of bank erosion.

APPENDIX C

TR-55 GRAPHICAL DISCHARGE METHOD VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: ______ Date: ________
Subtitle : Year 1685 at Valley Forge

Data : Drainage Area : 23.3 * Sq Mi
: Runoff Curve Number : 55 *
: Time of Concentration : 4.21 * Hours
: Rainfall Type : III
: Pond and Swamp Area :

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.6	3.2	4.2	5.1	5.6	6.3	7.2
Ia/P Ratio	0.63	0.51	0.39	0.32	0.29	0.26	0.23
Used	0.50	0.50	0.39	0.32	0.29	0.26	0.23
Runoff (in)	0.10	0.25	0.61	1.03	1.29	1.69	2.25
Unit Peak Discharge (cfs/sqmi/in)	81	81	95	103	107	109	111
Pond and Swamp Factor 5.0% Ponds Used	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Peak Discharge (cfs)	139	343	977	1784	2311	3095	4209

* - Value(s) provided from TR-55 system routines

TR-55 CURVE NUMBER COMPUTATION VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: _____ Date: ________
Subtitle : Year 1685 at Valley Forge

Cover Description		Hydrologic Soil Group A Sq miles (CN)	B	C	D
OTHER AGRICULTURAL LANDS					
Woods	good	-	23.3(55)	-	-
Total Area (by Hydrologic Soil Group)			23.3		

TOTAL DRAINAGE AREA: 23.3 Sq miles WEIGHTED CURVE NUMBER: 55*

* - Generated for use by GRAPHIC method

TR-55 Tc and Tt THRU SUBAREA COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1685 at Valley Forge

State: PA

User: WBR
Checked: ____

Date: 11-28-89
Date: _______

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	300	0.04	H				0.653
Shallow Concent'd		1200	0.1	U				0.065
Open Channel		24400	0.02		.04025		16.5	0.975
Open Channel		30100	.004		.04550		25	2.515
					Time of Concentration =			4.21*

SHEET FLOW SURFACE CODES

A Smooth Surface
B Fallow (No. Res.)
C Cultivated < 20% Res.
D Cultivated > 20% Res.
E Grass-Range, Short

F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

SHALLOW CONCENTRATED SURFACE CODES

P Paved

U Unpaved

* - Generated for use by GRAPHIC method

TR-55 GRAPHICAL DISCHARGE METHOD

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1776 at Valley Forge (6%)

State: PA

User: WBR
Checked: ______

Date: 11-28-89
Date: ________

Data : Drainage Area : 23.3 * Sq Mi
: Runoff Curve Number : 56 *
: Time of Concentration : 4.21 * Hours
: Rainfall Type : III
: Pond and Swamp Area :

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.6	3.2	4.2	5.1	5.6	6.3	7.2
Ia/P Ratio	0.60	0.49	0.37	0.31	0.28	0.25	0.22
Used	0.50	0.49	0.37	0.31	0.28	0.25	0.22
Runoff (in)	0.12	0.28	0.66	1.09	1.37	1.78	2.35
Unit Peak Discharge (cfs/sqmi/in)	81	83	97	105	107	110	112
Pond and Swamp Factor 3.0% Ponds Used	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Peak Discharge (cfs)	169	404	1115	2004	2563	3407	4602

* - Value(s) provided from TR-55 system routines

TR-55 CURVE NUMBER COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1776 at Valley Forge (6%)

State: PA

User: WBR
Checked: ______

Date: 11-28-89
Date: ______

Cover Description		Hydrologic Soil Group A (Sq miles (CN))	B	C	D
CULTIVATED AGRICULTURAL LANDS					
Small grain C&T + Crop residue	good	-	0.94(69)	-	-
Close-seeded Cont & terraced legumes or rotation meadow	good	-	0.46(67)	-	-
OTHER AGRICULTURAL LANDS					
Woods	good	-	21.9(55)	-	-
Total Area (by Hydrologic Soil Group)			23.3		

TOTAL DRAINAGE AREA: 23.3 Sq miles WEIGHTED CURVE NUMBER: 56*

* - Generated for use by GRAPHIC method

TR-55 Tc and Tt THRU SUBAREA COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1776 at Valley Forge (6%)

State: PA

User: WBR
Checked: ____

Date: 11-28-89
Date: ______

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	300	0.04	H				0.653
Shallow Concent'd		1200	0.1	U				0.065
Open Channel		24400	0.02		.04025		16.5	0.975
Open Channel		30100	.004		.04550		25	2.515
					Time of Concentration =			4.21*

SHEET FLOW SURFACE CODES

A Smooth Surface
B Fallow (No. Res.)
C Cultivated < 20% Res.
D Cultivated > 20% Res.
E Grass-Range, Short

F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

SHALLOW CONCENTRATED SURFACE CODES

P Paved

U Unpaved

* - Generated for use by GRAPHIC method

TR-55 GRAPHICAL DISCHARGE METHOD

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1885 at Valley Forge (36%)

State: PA

User: WBR
Checked: ______

Date: 11-28-89
Date: ______

Data : Drainage Area : 23.3 * Sq Mi
: Runoff Curve Number : 60 *
: Time of Concentration : 3.20 * Hours
: Rainfall Type : III
: Pond and Swamp Area :

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.6	3.2	4.2	5.1	5.6	6.3	7.2
Ia/P Ratio	0.51	0.42	0.32	0.26	0.24	0.21	0.19
Used	0.50	0.42	0.32	0.26	0.24	0.21	0.19
Runoff (in)	0.20	0.41	0.86	1.36	1.67	2.12	2.75
Unit Peak Discharge (cfs/sqmi/in)	93	108	124	131	133	136	139
Pond and Swamp Factor 3.0% Ponds Used	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Peak Discharge (cfs)	328	770	1867	3110	3877	5035	6649

* - Value(s) provided from TR-55 system routines

TR-55 CURVE NUMBER COMPUTATION VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: ______ Date: ________
Subtitle : Year 1885 at Valley Forge (36%)

Cover Description		A	B	C	D
		Hydrologic Soil Group, Sq miles (CN)			
CULTIVATED AGRICULTURAL LANDS					
Small grain C&T + Crop residue	good	-	7.09(69)	-	-
Close-seeded Cont & terraced legumes or rotation meadow	good	-	0.46(67)	-	-
OTHER AGRICULTURAL LANDS					
Woods	good	-	14.9(55)	-	-
Farmsteads	—	-	0.85(74)	-	-
Total Area (by Hydrologic Soil Group)			23.3		

TOTAL DRAINAGE AREA: 23.3 Sq miles WEIGHTED CURVE NUMBER: 60*

* - Generated for use by GRAPHIC method

TR-55 Tc and Tt THRU SUBAREA COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: ____ Date: _______
Subtitle : Year 1885 at Valley Forge (36%)

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	300	0.04	H				0.653
Shallow Concent'd		1200	0.1	U				0.065
Open Channel		24400	0.02		.045100		33.0	0.691
Open Channel		30100	.004		.048180		49	1.789
					Time of Concentration =			3.20*

SHEET FLOW SURFACE CODES

A Smooth Surface
B Fallow (No. Res.)
C Cultivated < 20% Res.
D Cultivated > 20% Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

SHALLOW CONCENTRATED SURFACE CODES

P Paved
U Unpaved

* - Generated for use by GRAPHIC method

TR-55 GRAPHICAL DISCHARGE METHOD VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: ______ Date: ________
Subtitle : Year 1985 at Valley Forge (60%)

Data : Drainage Area : 23.3 * Sq Mi
: Runoff Curve Number : 67 *
: Time of Concentration : 3.20 * Hours
: Rainfall Type : III
: Pond and Swamp Area :

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (in)	2.6	3.2	4.2	5.1	5.6	6.3	7.2
Ia/P Ratio	0.38	0.31	0.23	0.19	0.18	0.16	0.14
Runoff (in)	0.40	0.69	1.27	1.87	2.23	2.76	3.47
Unit Peak Discharge (cfs/sqmi/in)	114	126	134	138	139	141	143
Pond and Swamp Factor 3.0% Ponds Used	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Peak Discharge (cfs)	762	1448	2846	4328	5224	6546	8342

* - Value(s) provided from TR-55 system routines

TR-55 Tc and Tt THRU SUBAREA COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: ____ Date: ______
Subtitle : Year 1985 at Valley Forge (60%)

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	300	0.04	H				0.653
Shallow Concent'd		1200	0.1	U				0.065
Open Channel		24400	0.02		.045100		33.0	0.691
Open Channel		30100	.004		.048180		49	1.789
					Time of Concentration =			3.20*

SHEET FLOW SURFACE CODES

A Smooth Surface
B Fallow (No. Res.)
C Cultivated < 20% Res.
D Cultivated > 20% Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

SHALLOW CONCENTRATED SURFACE CODES

P Paved
U Unpaved

* - Generated for use by GRAPHIC method

TR-55 CURVE NUMBER COMPUTATION VERSION 1.11

Project : Valley Creek at Schuylkill R. User: WBR Date: 11-28-89
County : Montgomery State: PA Checked: _____ Date: _______
Subtitle : Year 1985 at Valley Forge (60%)

Cover Description		Hydrologic Soil Group A	B	C	D
		Sq miles (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)					
Open space (Lawn, parks, etc.)					
Good condition; grass cover > 75%		-	0.6(61)	-	-
Impervious Areas					
Paved parking lots, roofs, driveways		-	0.5(98)	-	-
Streets and roads					
Paved: curbs and storm sewers		-	0.5(98)	-	-
Urban Districts	Avg % imperv				
Commercial & business	85	-	1.60(92)	-	-
Industrial	72	-	1.05(88)	-	-
Residential districts	Avg % imperv				
(by average lot size)					
1/8 acre (town houses)	65	-	1.05(85)	-	-
1 acre	20	-	3.65(68)	-	-
2 acres	12	-	1.05(65)	-	-
CULTIVATED AGRICULTURAL LANDS					
Small grain C&T + Crop residue	good	-	3.13(69)	-	-

YEAR 1985 (CONTINUED)

OTHER AGRICULTURAL LANDS					
Woods	good	-	9.32(55)	-	-
Farmsteads	—	-	0.85(74)	-	-
Total Area (by Hydrologic Soil Group)			23.3		

TOTAL DRAINAGE AREA: 23.3 Sq miles WEIGHTED CURVE NUMBER: 67*

* - Generated for use by GRAPHIC method

TR-55 GRAPHICAL DISCHARGE METHOD

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1995 at Valley Forge (60%)

State: PA

User: WBR
Checked: _____

Date: 11-28-89
Date: ________

Data : Drainage Area : 23.3 * Sq Mi
: Runoff Curve Number : 66 *
: Time of Concentration : 3.20 * Hours
: Rainfall Type : III
: Pond and Swamp Area :

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	1	2	5	10	25	50	100
24-Hr Rainfall (In)	2.6	3.2	4.2	5.1	5.6	6.3	7.2
Ia/P Ratio	0.40	0.32	0.25	0.20	0.18	0.16	0.14
Runoff (In)	0.37	0.64	1.21	1.80	2.15	2.66	3.36
Unit Peak Discharge (cfs/sqmi/in)	111	123	133	137	139	141	143
Pond and Swamp Factor 5.0% Ponds Used	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Peak Discharge (cfs)	684	1329	2684	4124	4997	6291	8054

* - Value(s) provided from TR-55 system routines

TR-55 CURVE NUMBER COMPUTATION — VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery — State: PA
Subtitle : Year 1995 at Valley Forge (60%)

User: WBR — Date: 11-28-89
Checked: ____ — Date: ________

Cover Description		Hydrologic Soil Group A (Sq miles (CN))	B	C	D
FULLY DEVELOPED URBAN AREAS (Veg Estab.)					
Open space (Lawn, parks, etc.)					
Good condition; grass cover > 75%		-	4.58(61)	-	-
Impervious Areas					
Paved parking lots, roofs, driveways		-	0.5(98)	-	-
Streets and roads					
Paved: curbs and storm sewers		-	0.5(98)	-	-
Urban Districts	Avg % Imperv				
Commercial & business	85	-	1.60(92)	-	-
Industrial	72	-	1.05(88)	-	-
Residential districts	Avg % Imperv				
(by average lot size)					
1/8 acre (town houses)	65	-	1.05(85)	-	-
1 acre	20	-	3.65(68)	-	-
2 acres	12	-	1.05(65)	-	-
OTHER AGRICULTURAL LANDS					
Woods	good	-	9.32(55)	-	-

YEAR 1995 (CONTINUED)

Total Area (by Hydrologic Soil Group)	23.3
TOTAL DRAINAGE AREA: 23.3 Sq miles	WEIGHTED CURVE NUMBER: 66*

* - Generated for use by GRAPHIC method

TR-55 Tc and Tt THRU SUBAREA COMPUTATION

VERSION 1.11

Project : Valley Creek at Schuylkill R.
County : Montgomery
Subtitle : Year 1995 at Valley Forge (60%)

State: PA

User: WBR
Checked: ____

Date: 11-28-89
Date: ______

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	300	0.04	H				0.653
Shallow Concent'd		1200	0.1	U				0.065
Open Channel		24400	0.02		.045100		33.0	0.691
Open Channel		30100	.004		.048180		49	1.789
					Time of Concentration =			3.20*

SHEET FLOW SURFACE CODES

A Smooth Surface
B Fallow (No. Res.)
C Cultivated < 20% Res.
D Cultivated > 20% Res.
E Grass-Range, Short

F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

SHALLOW CONCENTRATED SURFACE CODES

P Paved

U Unpaved

* - Generated for use by GRAPHIC method

The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, applied research, training and operational support to units of the National Park Service. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies and aquatic ecology.

Use of trade names does not constitute or imply U.S. Government endorsement of commercial products.

Copies of this report are available from the following:

Computer Assistant (303) 221-8330
National Park Service
Water Resources Division
301 S. Howes Street
Fort Collins, CO 80521

Technical Information Center (303) 969-2130
Denver Service Center
P.O. Box 25287
Denver, CO 80225-0287

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The mission of the Water Resources Division is to preserve and protect National Park Service water resources and water dependent environments. This mission is accomplished through a watershed management program based on needs at the park, Region, and National levels.

NPS D-17 October 1990