3.3 Hydrology and Flood History

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Introduction

The water that flows through the Broadstreet Hollow stream into the Esopus Creek reflects the integrated net effect of all the watershed characteristics that influence the hydrologic cycle. Such characteristics include the climate of the drainage basin (type and distribution patterns of precipitation), the geology (permeable or impermeable surfaces affecting timing and amount of runoff), and the vegetation (uptake of water by plants as well as protection against erosion). All these factors affect the timing and amount of streamflow in the stream. This variable timing and amount is referred to as the stream's hydrologic regime. Understanding the hydrology of a drainage basin is important to the stream manager, since stream flow patterns affect aquatic habitat, flood behavior, recreational use, and water supply.

<u>BSH Stream Statistics:</u> The streams in BSH are perennial streams, that is, they flow year-round except in extreme drought conditions. The drainage pattern in the watershed is dendritic (branching tree-like form), typical of the Catskill Mountain watersheds.

The BSH streams form a system of streams that can be classified by stream order. A stream order identifies the position in a hierarchy of tributaries occupied by a stream segment. Any clearly defined channel without tributaries is designated as a 1st order channel. Where two 1st order channels join they form a 2nd order channel; where two 2nd order channels join, a 3rd order channel is formed, and so on (Strahler, 1968). Most of the BSH watershed drains into small headwater 1st order channels. The main Broadstreet Hollow and Jay Hand Hollow are 2nd order streams, below their confluence is a 3rd order stream.

<u>Streamflow</u>

Streams flow at many different levels from a small trickle during a dry summer to a raging torrent during rapid thaw of a thick snowpack. Streamflow varies on several time scales. Over the course of a year we can watch the stream swell and shrink with the seasons. Over the course of a summer storm (hours to days) or a spring thaw (days to weeks) we can also watch the stream swell and shrink. Hydrologists use a hydrograph of a stream, a graphical representation of the streamflow over some period of time, to characterize the relationship between flow and timing. An active stream gage is necessary to monitor stream discharge and develop a hydrograph. Unfortunately BSH does not have a suitable gage to prepare a hydrograph for the stream. For illustrative purposes we can consider hydrographs for the adjacent basin of Stony Clove (Figure 1).

There are essentially two basic types of streamflow: storm flow and base flow. Storm flow appears in the channel in direct response to precipitation and/or snowmelt, whereas base flow sustains streamflow during interstorm or subfreezing periods. The annual hydrograph shows the peaks and "valleys" of streamflow over the course of the year (see Figure 1). The "rise and fall" of the peaks are associated with storm flows and the lows are generally associated with base flow conditions. A review of the hydrograph reveals that the 1998/1999 winter was a particularly wet period. Streamflows are also higher during this period since the vegetation is no longer taking up much of the flow as can be seen to occur during the summer months. The insert graph in Figure 1 is a close-up of one of the storm flow events in the Stony Clove watershed. At the end of June 1999 there was a small rainfall event that brought the streamflow up from the summer baseflow conditions. Storm flow receded back toward base flow conditions prior to the July 4, 1999 rain storm. The response of the streamflow to the July 4, 1999 rainstorm is rapid, presumably due to antecedent conditions from the previous rainfall, rising to approximately 80 cubic feet per second (cfs). Minor rains followed but eventually the landscape drained and the streamflow returned to summer base flow conditions, approximately 8 cfs.

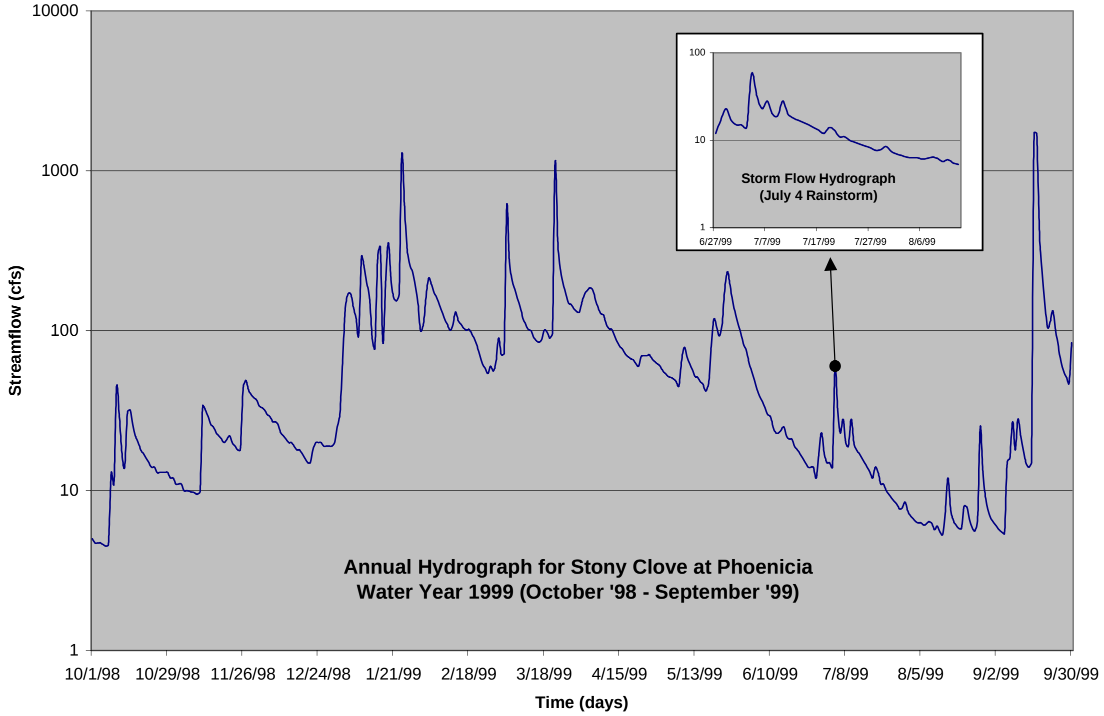

Figure 1. Annual Hydrograph for the Stony Clove at Phoenicia, NY, water year 1999.

Storm flow reaches the channel as channel interception, overland flow, or subsurface storm flow. Channel interception is simply the precipitation that falls directly into the water that is already in a stream channel. It shows up on the storm water hydrograph right away and disappears as soon as the event is over. In a small watershed like BSH, it is a minor component of the streamflow. Overland flow, or surface runoff, is the portion of precipitation or snow-melt that runs off over the surface after the infiltrative capacity of the surface has been exceeded. Overland flow is generated more consistently on some parts of a watershed and at some times rather than at others. Relatively impermeable areas (exposed bedrock, frozen ground, clayey-soils) will generate more runoff to the stream than relatively permeable areas (deep, coarse soils) or well-vegetated areas. The role of overland flow in the BSH watershed is variable, depending upon the time of year and location. Overland flow appears on the hydrograph pretty quickly and ends soon after the storm flow event. In the examples above overland flow and channel interception

account for most of the sharp peaks. Subsurface storm flow, or interflow, comes from rain or snow melt that infiltrates the soil. It either flows rapidly through highly permeable portions of the soil or displaces existing water into a channel. Subsurface storm flow shows up on the hydrograph after the other two components and lags after as the flow in the stream declines back to base flow conditions. The distinction between base flow and subsurface storm flow is transitional.
The "bankfull discharge" is an important streamflow associated with storm flow events. This flow and its significance are discussed in greater detail in Section 3.1.2.

Base flow is the water that drains from the land to sustain streamflow during dry periods and between storm flows. The source is groundwater that flows through the unsaturated and saturated soils and bedrock adjacent to the stream.

BSH Flood History

The flows that exceed stream channel capacity are called floods. Floods can range from minor overbank events to the raging torrents that wipe out bridges and carve new channels. Since there have been no historic stream discharge gages installed on the Broadstreet Hollow stream, we cannot report the specifics of major flood events in the basin. However, by evaluating the gage records at two nearby gages, and interviewing knowledgeable individuals from the area, we can describe some major flood events and draw conclusions as to the nature of flooding in the valley.

The two nearby gages that have a sufficiently long record to evaluate flood frequency and occurrence are the Esopus Creek at Allaben gage and the Bushnellsville Creek at Shandaken gage. Table 1. lists the floods recorded at these gages that exceed the 5-year recurrence interval, i.e. these are stream discharges that statistically could occur once every five years. A review of the dates shows that the recurrence interval concept can be misleading. During the 80's four floods exceeding the "five year event" occurred within a seven-year span on the Esopus, while there were no five year, or greater, events during the entire decade of the 70's. Another way to refer to these flood events is the likelihood of occurrence in any given year. A 5 year recurrence interval is the same as saying 20% of the years would have a 5-year flood. Thus there can be a cluster of years with large flood events and then a long period with only moderate flood events.

Table 1. Flood Flows at Nearby Gages that Exceed Five Year Recurrence Intervals[3]

Esopus Creek at Allaben, NY (USGS Gage Number)	
Date	**Flood Discharge (cfs)**
3/30/51	20,000
7/28/69	7,870
3/21/80	15,900
2/20/81	6,540
4/5/84	8,470
4/4/87	16,100
1/19/96	15,000
Bushnellsville Creek at Shandaken, NY (USGS Gage Number)	
Date	**Flood Discharge (cfs)**
11/25/50	1,350
10/15/55	1,830
3/21/80	845
4/5/84	896
4/4/87	1,000
1/19/96	996

Flooding occurs in response to excessive runoff associated with spring snowmelt, summer thunderstorms, fall hurricanes, and winter rain-on-snow events. Five of the seven major floods recorded at the Esopus Creek at Allaben station occurred in late winter/early spring and are presumably associated with major snow melt events from either spring thaw or rain-on-snow events. The largest recorded flood is a spring runoff event. A summer flood in 1969 and the flood of January 1996 are the two other large floods recorded at the gage. Three of the six major floods recorded at the Bushnellsville gage occurred during the spring and are coincident with three of the Esopus events.

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[3] Flood frequency statistics based on recorded peak flows through 1997.
Esopus Creek at Allaben, NY
5 yr RI flood: ~6,500 cfs
10 yr RI flood: ~9,500 cfs

Bushnellsville Creek at Shandaken, NY
5 yr RI flood: ~800 cfs
10 yr RI flood: ~1,000 cfs

Two of the events (the two largest) are late fall events in the fifties and are associated with large tropical storms/hurricanes. The January 1996 flood was approximately a 10 year RI flood on the Bushnellsville Creek. There have been many other floods that exceed the bankfull discharge event but are less than the 5 year recurrence interval (RI) flood.
A little less than half of all recorded flood events occur in the Spring. Approximately 10% of the flood events occur in the summer. The remainder of thef loods is evenly split between winter and fall flood events.

From review of the available data we can surmise that most of the events that are bankfull and greater will occur in the late winter/spring as the result of thaws and major rain-on-snow events. This is in large part due to the storage of available water as snow on the landscape, reduced infiltration capacity if the ground is still frozen (or partially so), and the fact that evapotranspiration from vegetation is not actively routing water back into the atmosphere. The major floods of the 1980s all occurred in this time period (late February – early April) most likely associated with considerable snow packs. For example, the largest of these floods occurred on April 4, 1987. Applications for stream disturbance permits typically peak following floods, as landowners attempt to repair the damage caused by the floods.

The 1990s were a time of moderate flood events in the vicinity of Broadstreet Hollow with the exception of the winter flood of January 19, 1996, which was similar in scale to the April 1987. The Tropical Storm Floyd flood of September 1999 was typical of tropical storm events and the sometimes uneven distribution of precipitation associated with those storms. While the flooding in the Esopus drainages was typically less than a 5 year event, several drainages in the bordering Schoharie system had over a foot of precipitation in 24 hours with flooding that exceeded the 10 year event discharge. Summer thunderstorms are even more unevenly distributed across the Catskill Mountain landscape. The July 4, 1999 storm presented in Figure 1 only affected sub-regions of the Catskills. Flash flooding may be occurring in response to a sustained storm cell in some of the drainages that feed the Esopus Creek (e.g. Broadstreet Hollow), while only steady, lighter rainfall along the boundary of the storm results in a moderate increase in stream flow occurs elsewhere along the Esopus system.

The years 2000 – 2002 have been characterized by droughty conditions with intervening wet conditions. High water events have typically been limited to bankfull events. It is hard to predict when the next 5-year (or greater) flood will occur in the Broadstreet Hollow – the probability for a large flood is the same each year – though weather and storm patterns can be used to anticipate conditions for a few months out. The last large flood was in winter 1996, and it can be expected that when the next flood occurs, late winter/early spring during the snowmelt/rainy season will be prime time.