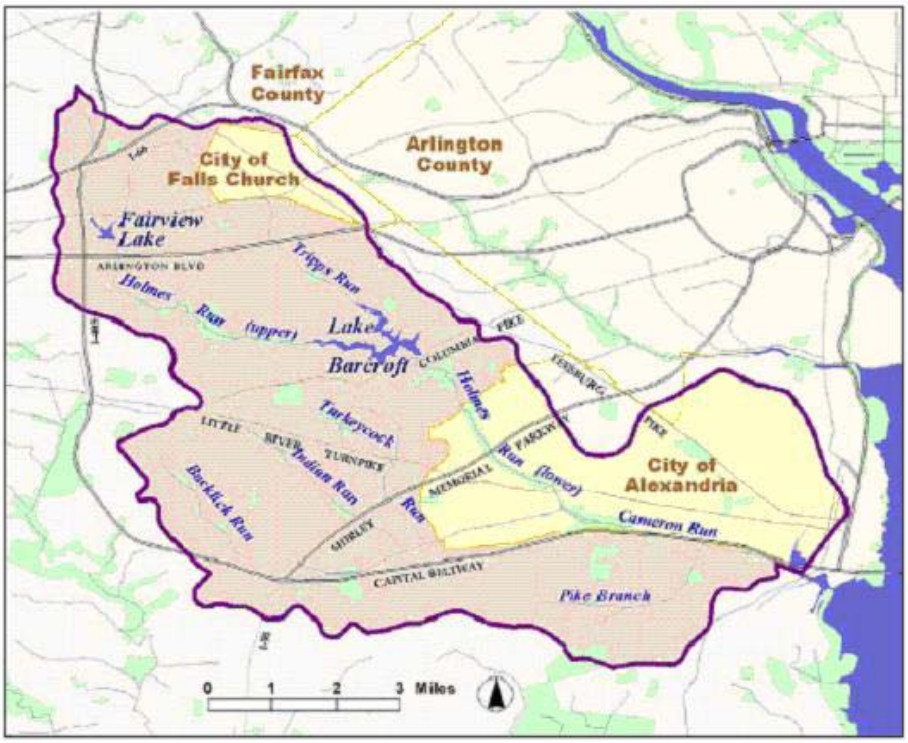
APPENDIX I

FLOOD FREQUENCY ANALYSIS REPORT

Flood Frequency Analysis

For Cameron Run at USGS Gaging Station 01653000 At Alexandria, Virginia



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December 6, 2006

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The Northern Virginia Regional Commission (NVRC) developed this analysis for the US Army Corps of Engineers, Baltimore District in coordination with Fairfax County and the City of Alexandria. The project manager and primary author of this report is William D Hicks (Bill), P.E. This analysis has been strengthened by contributions from the work of the Hydraulics and Hydrology Workgroup of the Cameron Run Feasibility Project. The author wishes to specifically acknowledge those members who participated in the development of this analysis.

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The Northern Virginia Regional Commission (NVRC) is an independent public agency chartered in 1969 to plan for the physical, social and economic development of the region. The Commission serves in an advisory capacity to local, state, and federal governments and as an advocate for Northern Virginia and its 1.9 millions residents. The Commission's policies and programs are established by a twenty-five member Board of Commissioners comprised of elected officials appointed by the governing bodies of Arlington, Fairfax, Loudoun and Prince William; the Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park, and the Towns of Dumfries, Herndon, Leesburg, Purcellville and Vienna.

Funding for this work was generously provided to the Northern Virginia Regional Commission from the US Army Corps of Engineers to assist with their ongoing feasibility study with Fairfax County and the City of Alexandria. Any assessments and conclusions contained in this report represent the results of the staff's technical investigations and do not represent policy positions of the Northern Virginia Regional Commission unless so stated in any adopted Resolutions of said Commission.

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Executive Summary

The purpose of this study is twofold. The primary purpose of this study is to perform a current flood flow frequency analysis for Cameron Run with existing stream gage data. This analysis follows the federally recommended guidelines described in Bulletin 17B, "*Guidelines for Determining Flood Flow Frequency*" by the Interagency Advisory Committee on Water Data. A secondary purpose of this study is to identify and consolidate earlier analyses of the Cameron Run stream gage data.

To meet the first objective, annual peak flow data collected at the US Geological Survey (USGS) gaging station (Station 01653000) on Cameron Run in Alexandria, Virginia were compiled for water years 1953 through 2006. Using the methodologies prescribed by Bulletin 17B, generally conforming to a Log Pearson Type III distribution, a frequency curve was developed with the data.

In finalizing this frequency curve, staff from the Northern Virginia Regional Commission (NVRC) met with the Cameron Run Hydrology and Hydraulics (H&H) Workgroup to discuss various concerns regarding the data set. Key issues included: intended use of the frequency data; validation of the June 25, 2006 flood event; gage placement; minor gaps in the data set; management of the Lake Barcroft dam; and urbanization of the watershed during the period of record.

Although the ultimate use of the published frequency curve can not be dictated by this document, the project's H&H workgroup agreed that understanding the existing and potential flood protection on Cameron Run should be the primary focus of this analysis. Therefore, the efforts to develop this analysis align with current Federal Emergency Management Agency (FEMA) requirements for such analyses and special attention was given to the magnitude of 100-year recurrence interval. The 100-year event, or the event with a one percent (1%) chance of occurring during any given year, is often used as a target when designing flood protection projects.

The final flow frequency relationship presented in Table 1 was generated using industry standard techniques including the statistical modeling package PeakFQ developed by the USGS and adhering to the guidelines of Bulletin 17B. The input and output files are included as an appendix to this document.

(1) Recurrence Interval [years]	(2) Probability	(4) 2006 Analysis 1956 – 2006 (cfs)
2	0.5	4,157
5	0.2	6,993
10	0.1	9,266
25	0.04	12,600
50	0.02	15,430
100	0.01	18,570
500	0.002	27,210

Table 1 2006 Flood Frequency Analysis Based on 1956 thru 2006 data set.

Also included in this report are results of earlier frequency analyses developed for various studies associated with Cameron Run during the last 35 years. Since 1971 the US Army Corps of Engineers (USACE), FEMA, and USGS have published frequency data for Cameron Run at various times. These studies predicted magnitudes of the 100-year event ranging from 12,000 to 30,000 cubic feet per second. The variability of these predictions stems from the various methodologies employed to determine the values and the length of records in the data set available at the time of analysis.

Background

Cameron Run is a direct tributary of the Potomac River (Hydrologic Unit Code (HUC) 02070010). Its 42 square mile watershed drains portions of Fairfax County and the cities of Falls Church and Alexandria as well as a very small portion of Arlington County. The Potomac River Basin cradles the Cameron Run watershed and ultimately carries its waters to the Chesapeake Bay.

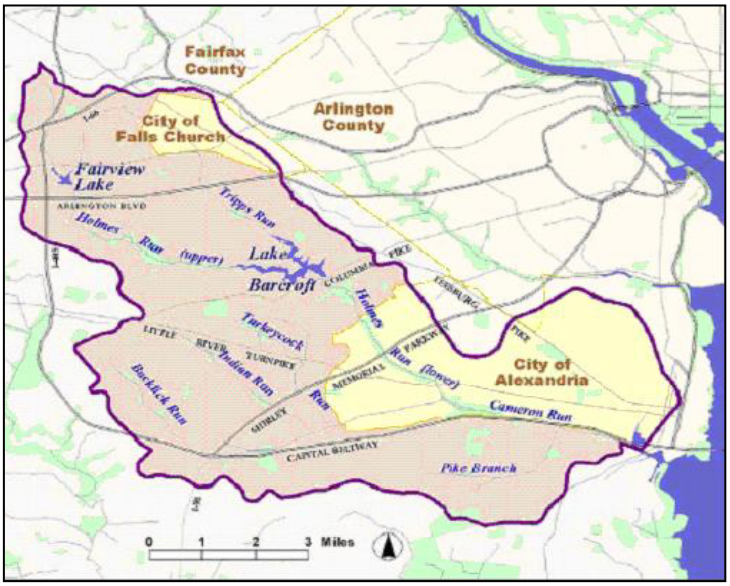

Figure 1. Cameron Run Watershed with Jurisdictional Boundaries

Cameron Run drains tributaries in Fairfax County, Falls Church and Alexandria including: Holmes Run, Tripps Run, Turkeycock Run, Indian Run, Backlick Run and Pike Branch. Water from the Cameron Run watershed generally flows in an eastward direction to the Potomac River. Cameron Run changes names to Great Hunting Creek just upstream of its confluence with the Potomac River.

The western portion of the watershed (west of the "Fall Line") is characterized by the Piedmont physiographic province; east of this division is described by the Coastal Plain physiographic province. Prior to European immigration to the area the watershed was primarily a forested landscape. During the 1600s and early 1700s farmers converted the forested landscape to agricultural uses that included tobacco, wheat, and corn crops. Since the 1700s, and primarily during the 20th century, the watershed has transformed into an "ultra-urban" state with no agricultural uses beyond that of a backyard or community garden.

The major tributaries of Cameron Run rise in Fairfax County and collect in the mainstems of Backlick Run and Tripps/Holmes Run. These streams flow through portions of Fairfax County and Falls Church before reaching Alexandria where they combine to form Cameron Run. Cameron Run's flood control channel carries water out of Alexandria and back into Fairfax County where it picks up the discharge from Pikes Branch and becomes Great Hunting Creek before discharging into the Potomac River. The lower portion of Cameron Run and the entire reach of Great Hunting Creek are tidally influenced.

USGS Gaging Station 0165300

Eight hundred feet downstream of the confluence of Backlick and Holmes Run, within the free flowing or alluvial section of Cameron Run, the USGS maintains a gaging station. The gage is located on the downstream side of the railroad bridge depicted in Figure 2. The gaging station captures stage (and flow) data from the 33.7 square mile sub-watershed draining to the gage location. This sub-basin represents approximately 80% of the entire watershed area that ultimately drains to the Potomac River.

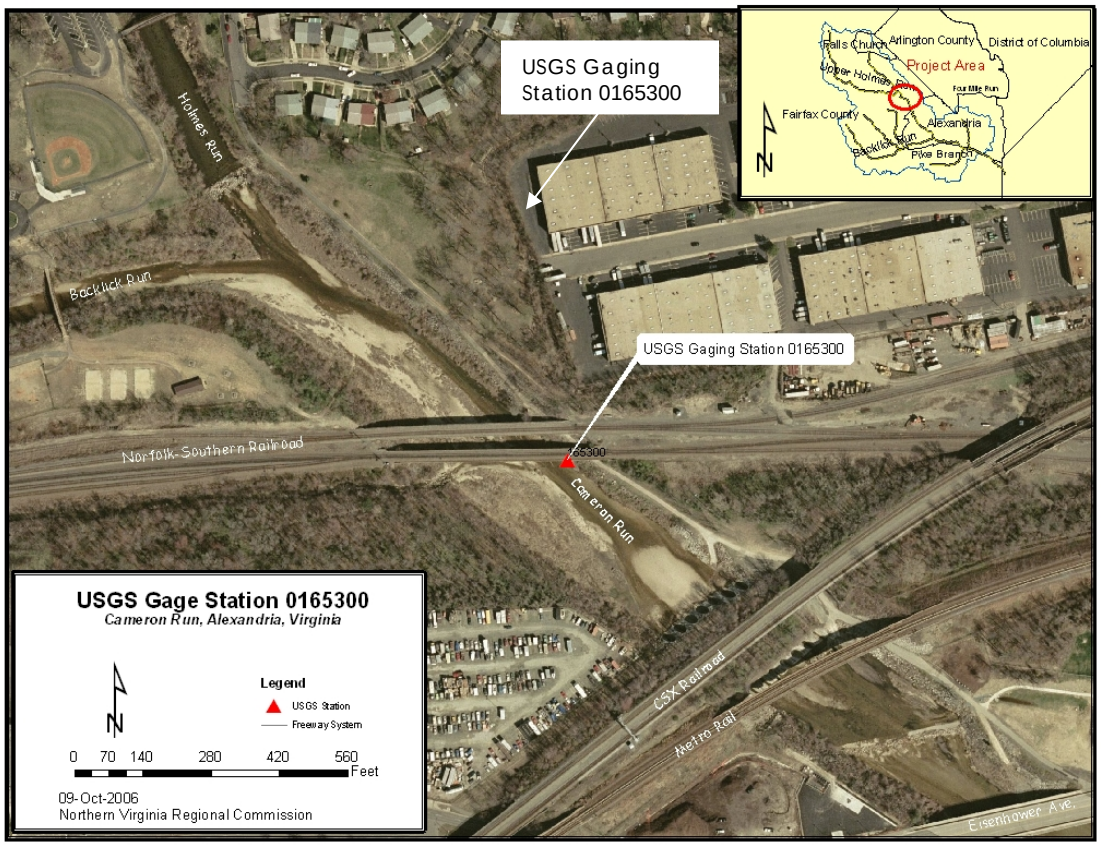

Figure 2. Photographic Map of USGS Gaging Station 0165300

The USGS gaging station on Cameron Run has collected flow data from 1956[1] through the present. The gage is sponsored by the City of Alexandria with maintenance and calibration services provided by the USGS. The gage records a stage measurement every 15 minutes. Each recorded value is digitally transferred to USGS and a corresponding discharge value is calculated from a site specific stage-discharge curve. These values are then uploaded to the station's website and provided to the public at: http://nwis.waterdata.usgs.gov/dc/nwis/uv?site_no=01653000 . All measurements and

[1] The USGS Annual Peak Data Set includes a historical stage measurement from 1953. The stage value represents a specific high event where stage data could be indirectly measured and was not used in this flow-based analysis.

related calculations preceding USGS publication of this data must conform to the applicable USGS standard protocol.

For each year the single highest peak flow measurement recorded at the station is incorporated into a list of annual peak values. Those records constitute the primary data set used to develop this flood frequency analysis. The annual peaks for the Cameron Run station recorded are included in Table 2. The values presented were extracted from data downloaded from the USGS website for the Cameron Run station in September 2006. Original USGS data for the 0165300 station was provided electronically in the standard USGS WATSTORE electronic data format.

Water Year	Date	Flow (cfs)	Gage Height
1953	05-May-1953		*11.9
1956	20-Jul-1956	3,950	8.62
1957	05-Apr-1957	865	5.5
1958	08-Jul-1958	2,600	7.93
1959	12-Jun-1959	2,900	7.93
1960	05-Apr-960	1,300	5.68
1961	26-Aug-1961	3,820	7.35
1962	12-Mar-1962	1,230	4.84
1963	20-Aug-1963	6,480	10.48
1964	13-May-64	2,550	5.78
1965	05-Mar-1965	3,330	6.92
1966	14-Sep-1966	9,300	14.14
1967	25-Aug-1967	6,950	12.72
1968	10-Sep-1968	4,780	10.65
1969	08-Sep-1969	4,030	9.66
1970	09-Jul-1970	6,910	13.11
1971	27-Aug-1971	4,320	9.32
1972	22-Jun-1972	19,900	18.14
1973	10-Jul-1973	4,730	9.94
1974	30-Aug-1974	3,860	8.39
1975	26-Sep-1975	14,900	16.73
1976	31-Dec-1975	3,700	8.1
1977	12-Jul-1977	5,040	8.2
1978	26-Jan-1978	6,200	8.93
1979	25-Feb-1979	4,300	7.3
1980	13-Mar-1980	1,900	4.74

ater ear	Date	Flow (cfs)	Gage Height
1981	04-Jul-1981	6,920	8.45
1982	30-May-82	3,720	5.95
1983	21-Jun-1983	5,710	9.03
1984	29-Mar-1984	4,460	6.95
1985	05-Nov-1984	3,950	6.4
1986	02-Aug-1986	3,630	6.04
1987	24-Dec-1986	3,890	6.84
1988	18-May-1988	2,980	5.33
1989	06-May-1989	6,960	9.5
1990	05-Jul-1990	3,510	5.67
1991	23-Oct-1990	4,800	7.34
1992	24-Jul-1992	3,570	6.15
1993	23-Nov-1992	2,650	4.94
1994	28-Nov-1993	5,900	8.5
1995	20-Jan-1995	2,130	5.02
1996	19-Jan-1996	5,870	8.73
1997	08-Nov-1996	3,760	6.82
1998	17-Feb-1998	3,230	6.28
1999	16-Sep-1999	2,820	5.83
2000	28-Jul-2000	7,020	9.64
2001	17-Dec-2000	5,410	8.34
2002	19-Jun-2002	1,420	4.07
2003	23-Sep-2003	9,330	11.29
2004	19-Nov-2003	4,220	7.27
2005	28-Mar-2005	4,770	7.78
2006	25-Jun-2006	16,500	17

* Historic Peak

Table 2. USGS Stream Gage Information for Station 1653000 Cameron Run, Virginia

There are fifty (50) records[2] available through the WATSTORE file, including an historical peak stage value for record-year 1953. (An historic record reflects a record that would

[2] The value for WY2006 (16,500 cfs) is a USGS-provided value recorded at the gage on June 25, 2006. This value was validated by the USGS in an e-mail to Bill Hicks dated November 30, 2006 and incorporated into the data set for inclusion in the statistical modeling contained herein.

have otherwise not been observed except for evidence indicating its unusual magnitude.) The series corresponds to "Water Years" where a water year is defined as the period between October 1st of one year and September 30th of the next. Flow data are presented in units of cubic feet per second (cfs) and stage data in feet above the station datum.

Examination of the Data Set

Table 3 annotates the same Cameron Run Peak Flow records to clarify the gaps or discrepancies in the data set.

The data for 1953 is based on a historic stage record. No flow values were recorded at the gaging station until 1956. The frequency analysis is based only on peak **flow** data; so consequently, the 1953 record is not used in frequency analysis. The flow values included in the data set begin at water year 1956.

The "Event of Record," or the highest recorded peak flow in the period of record, was recorded in 1972. Its recording coincided with Tropical Storm Agnes's presence in the area on July 22, 1972 and resulted in a recorded peak flow of 19,900 cfs.

During a period of bridge construction between 1977 and 1979 the gage was temporarily moved downstream of its present location (1,200 feet and 2,500 feet). Although the USGS was unable to confirm the exact positions the relocations the descriptions correspond to the Eisenhower Avenue Bridge and a grade control structure in the run, respectively. Neither location resulted in a location downstream of a major tributary to Cameron Run where the data recorded at these relocations would be substantially affected by increased flows. Furthermore, during this period the flow values recorded were of a relatively minor magnitude thereby having little effect on the large magnitude event predictions of concern. For this analysis no break in the record is acknowledged for this temporary relocation of the gage. The reasoning to overlook this minor relocation is based on three factors.

First, a similar USGS gaging station, 0165200, on Four Mile Run (another Potomac River tributary in Alexandria, Virginia immediately to the North) recorded consistent low magnitude events for Four Mile Run during the same timeframe. The consistent records for a neighboring stream support the assumption that no extraordinary event occurred during this period.

Second, no major tributaries enter Cameron Run between the permanent and temporary gage locations that could drastically alter the flows passing the gage.

The third factor follows the intended purpose of the analysis, flood protection – especially regarding the 100-year event. Any temporary relocation of the gage to a downstream location inherently builds a conservative bias (predicting larger magnitude events for a given frequency) into the data set because the drainage area for the downstream, temporary location is larger than the permanent one. This means that the recorded discharge magnitudes for any given storm during the three years the gage was located downstream were larger than would have been recorded at the permanent upstream location due to the increased drainage area.

A six month gap exists in the data set from April 1979 until September 1979. This gap in data will be considered a random disturbance in the data unrelated to any flood events, e.g., the gaging instruments were destroyed during an unusually large flood event, etc. No evidence exists from the neighboring Four Mile Run watershed/gage that a significant event was missed during this timeframe. Further suggesting a hydrologically unrelated cause is that the gap occurs during the end of the aforementioned relocation period possibly caused by the logistics of relocating the gage.

On June 25, 2006 a significant flood event (16,500 cfs) occurred along Cameron Run in Alexandria and Fairfax County. The H&H workgroup pursued the confirmation of this data point and its inclusion in this analysis. The USGS develop an indirect measurement from high water marks observed near the gage from this event to confirm this value for final publication in the annual USGS Water Resources Data Book. This USGS confirmed this value in an e-mail to Bill Hicks on November 30, 2006.

Some general concern exists that during large flow events the location of the gage allows for gage readings to be influenced from backwater conditions from the CSX railroad bridge just downstream of the gage location. Evaluation of the reality of this backwater condition is beyond the scope of this study. However, during a subsequent study to this analysis the USACE will be developing a computer model (HEC-RAS) for Cameron Run that should provide some insight into this issue.

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1953	05-May-1953	11.9	
1956	20-Jul-1956	8.62	3,950
1957	05-Apr-1957	5.5	865
1958	08-Jul-1958	7.93	2,600
1959	12-Jun-1959	7.93	2,900
1960	05-Apr-960	5.68	1,300
1961	26-Aug-1961	7.35	3,820
1962	12-Mar-1962	4.84	1,230
1963	20-Aug-1963	10.48	6,480
1964	13-May-64	5.78	2,550
1965	05-Mar-1965	6.92	3,330
1966	14-Sep-1966	14.14	9,300
1967	25-Aug-1967	12.72	6,950
1968	10-Sep-1968	10.65	4,780
1969	08-Sep-1969	9.66	4,030
1970	09-Jul-1970	13.11	6,910
1971	27-Aug-1971	9.32	4,320
1972	22-Jun-1972	18.14	19,900
1973	10-Jul-1973	9.94	4,730
1974	30-Aug-1974	8.39	3,860
1975	26-Sep-1975	16.73	14,900
1976	31-Dec-1975	8.1	3,700
1977	12-Jul-1977	8.2	5,040
1978	26-Jan-1978	8.93	6,200
1979	25-Feb-1979	7.3	4,300
Gap from April 1979 until Sept 1979			
1980	13-Mar-1980	4.74	1,900
1981	04-Jul-1981	8.45	6,920
1982	30-May-82	5.95	3,720
1983	21-Jun-1983	9.03	5,710
1984	29-Mar-1984	6.95	4,460
1985	05-Nov-1984	6.4	3,950
1986	02-Aug-1986	6.04	3,630
1987	24-Dec-1986	6.84	3,890
1988	18-May-1988	5.33	2,980
1989	06-May-1989	9.5	6,960
1990	05-Jul-1990	5.67	3,510
1991	23-Oct-1990	7.34	4,800
1992	24-Jul-1992	6.15	3,570
1993	23-Nov-1992	4.94	2,650
1994	28-Nov-1993	8.5	5,900
1995	20-Jan-1995	5.02	2,130
1996	19-Jan-1996	8.73	5,870
1997	08-Nov-1996	6.82	3,760
1998	17-Feb-1998	6.28	3,230
1999	16-Sep-1999	5.83	2,820
2000	28-Jul-2000	9.64	7,020
2001	17-Dec-2000	8.34	5,410
2002	19-Jun-2002	4.07	1,420
2003	23-Sep-2003	11.29	9,330
2004	19-Nov-2003	7.27	4,220
2005	28-Mar-2005	7.78	4,770
2006	25-Jun-2006	17	16,500

- Incomplete Data
- Validated Data
- Present Location
- Downstream Location
- Missing Data

Table 3. USGS Stream Gage Information for Station 1653000 Cameron Run, Virginia

Plots of the Data Record

The following plots are included to better visualize the magnitude of individual data points (annual peaks) in relation to one another and to spot trends in the data. The chart in Figure 3 presents the annual peak events recorded at the USGS gage on Cameron Run. The 1972 event of 19,900 cfs marks the event of record.

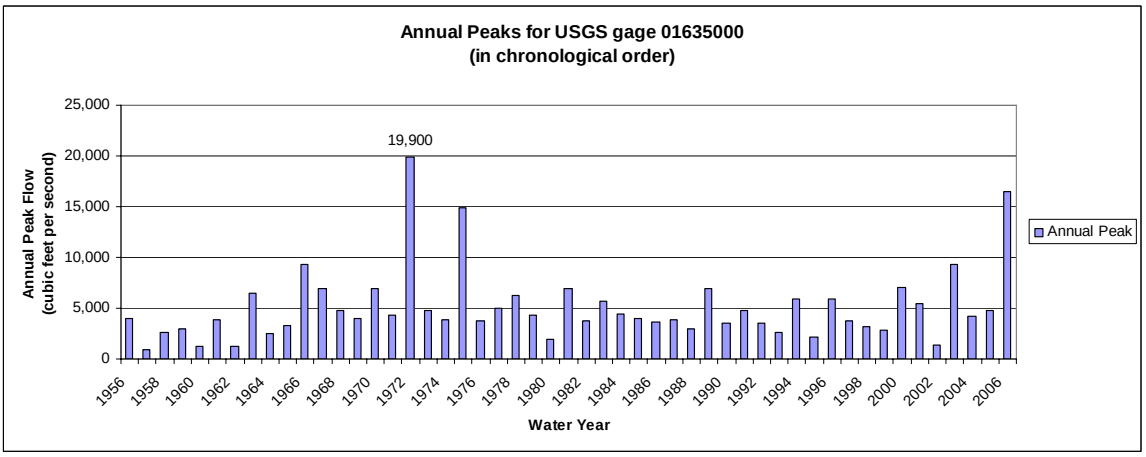

Figure 3. Annual Peak Flows in Chronological Order

The chart in Figure 4 presents the same event data in order of decreasing peak magnitude. This graphic shows that more than half of the annual peaks were of a magnitude of less than 5,000 cfs and only three events were greater than 10,000 cfs.

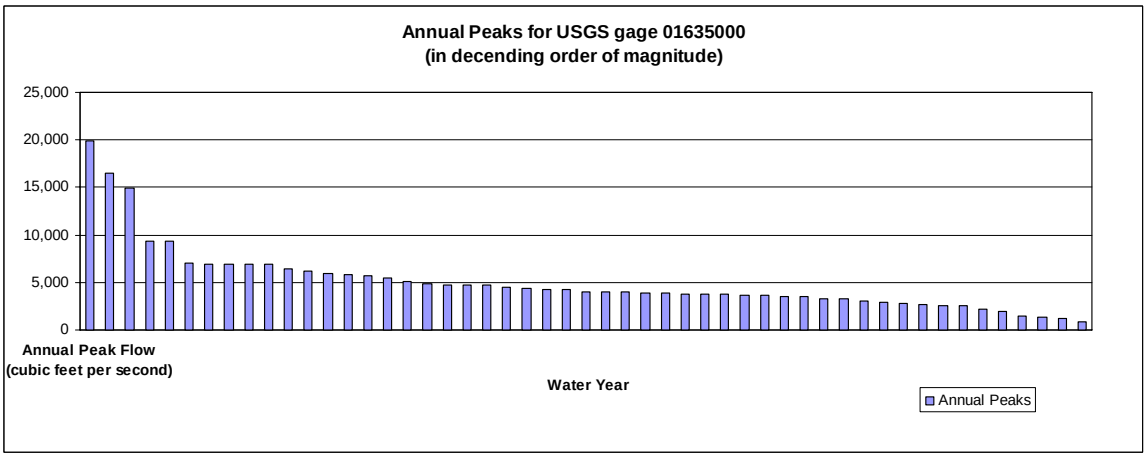

Figure 4. Annual Peaks in Descending Order

The following three scatter plots (Figures 5, 6, & 7) represent each annual peak flow with single a data point.

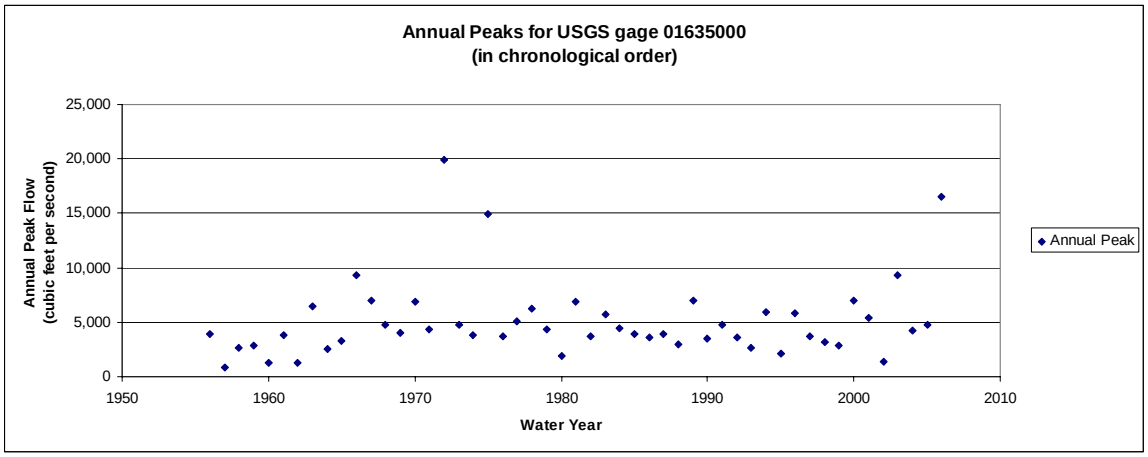

Figure 5 Annual Peak Events – Water Years 1956 thru 2006

The graph in Figure 6 includes a trend line developed from linear regression. A slight trend upward can be noticed on this graphic. This slope of this line is about 0.3% upward.

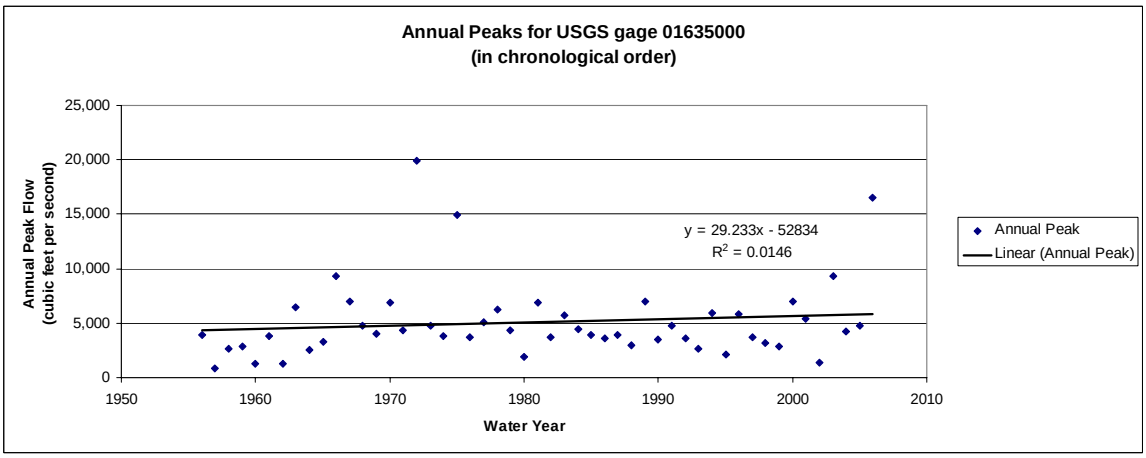

Figure 6 Annual Peak Events – Water Years 1953 thru 2006 overlain with a trend line

The scatter plot in Figure 7 includes the same data overlain with a line depicting the mean, or average, magnitude of annual peaks over the period of record. This value, at approximately 5,000 cfs, only provides a comparison for actual peak events.

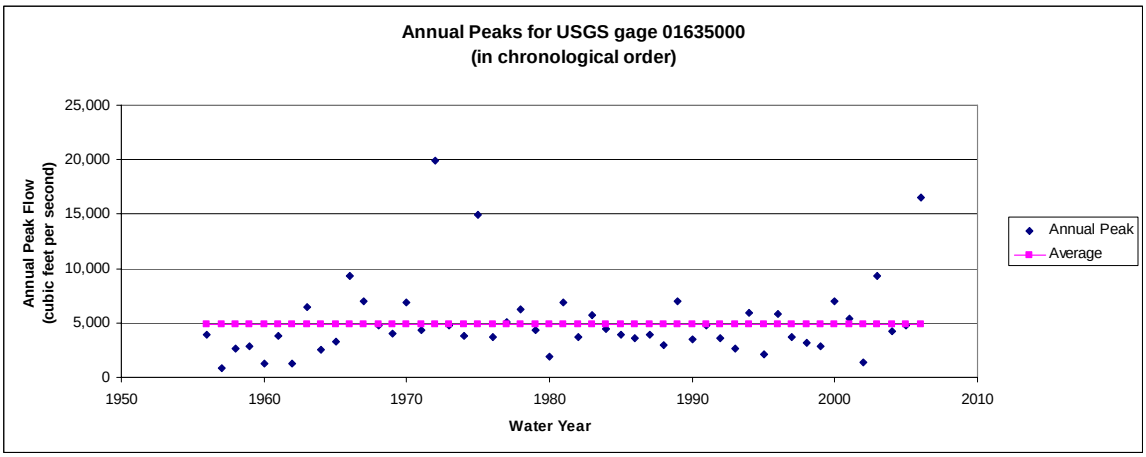

Figure 7 **Annual Peak Events – Water Years 1953 thru 2006 overlain with a mean (average) line**

Rainfall Data and Its Effects on the Data Set

This analysis compiles hourly precipitation records for the National Weather Service (NWS) station at Washington Reagan National Airport (DCA) (448906) to compare rainfall trends to annual flow peaks recorded at the Cameron Run gaging station. The weather station at DCA is located at 38° 51' N / 77°02'W, only 4.6 miles northeast of the stream gaging station as depicted in Figure 8. For this discussion it is assumed that the proximity of the DCA NWS station to the Cameron Run watershed allows recording of rainfall data similar to rainfall actually occurring in the Cameron Run watershed.

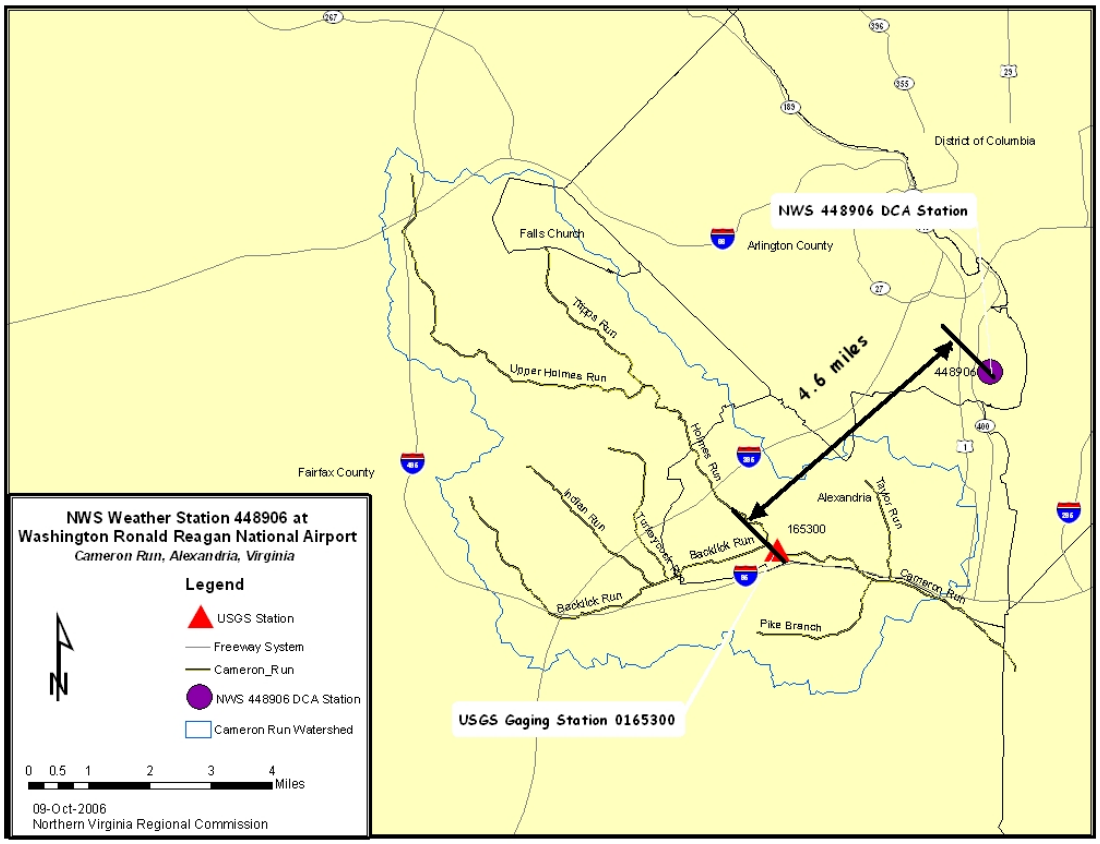

Figure 8 Location of DCA National Weather Service Station 448906

The rainfall records at the DCA station dates back to 1952. Hourly precipitation data is served on the web at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20027254. This analysis calculated annual rainfall totals for each water year and counted the number of days during each water year that experience rain. Counting days receiving rainfall was used as a simplistic proxy for counting actual storm events[3]. Figure 9 graphically depicts both annual rainfall

[3] The rainfall analysis uses a time unit (24-hours - one calendar day) to parse storm events not a true break in the storm event. Storms spanning multiple calendar days and separate storms occurring on the same calendar day are divided or lumped together, respectively.

volumes and annual days of precipitation. These scatter plots are overlain with trend lines calculated by linear regression.

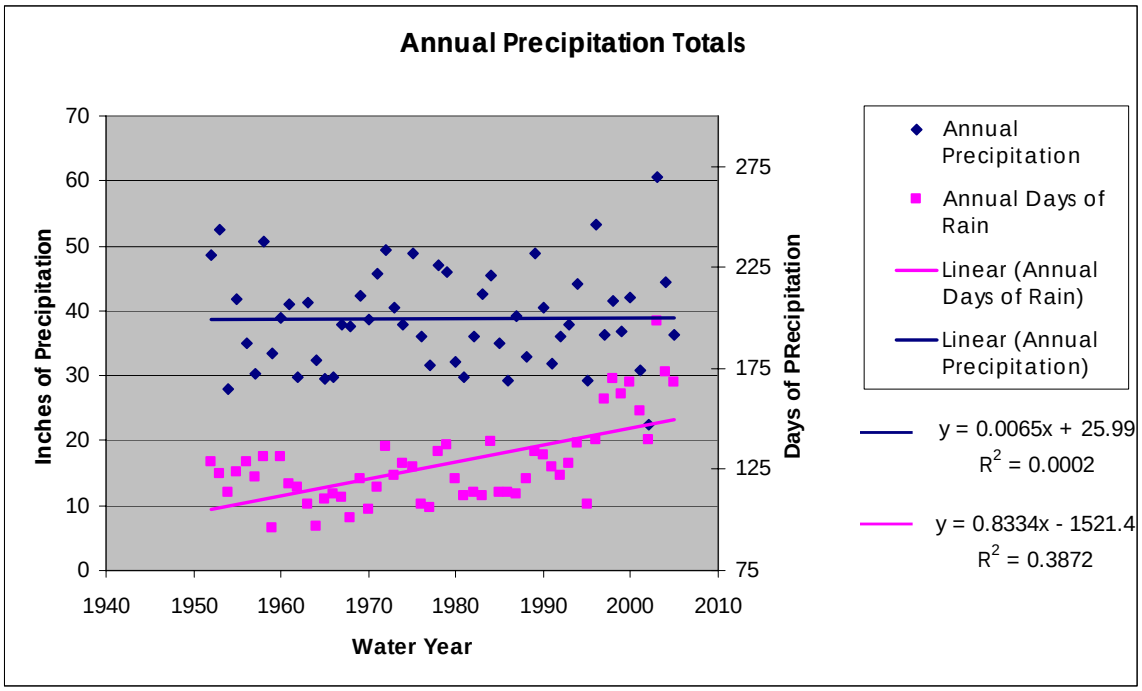

Figure 9 **Scatter Plot of Annual Rainfall Totals and Annual Days of Precipitation Recorded at the DCA Weather Station**

The trend line for annual rainfall shows that average annual rainfall recorded at the DCA station is just less than 40 inches per year. Although the totals vary from year to year the average has remained constant through the period of record. This is contrary to the number days each year that rain has been recorded which is trending upward. Because annual rainfall has stayed roughly constant and the number of rain events has increased the typical rain event has been getting smaller (by about 0.8 inches/year).

In Figure 10 the annual rainfall totals are graphed along with the annual peak flows recorded at the Cameron Run gaging station. These data are also overlain with trend lines (by linear regression). The constant annual rainfall total is contrasted by the slight upward trend of maximum flow peaks recorded on Cameron Run.

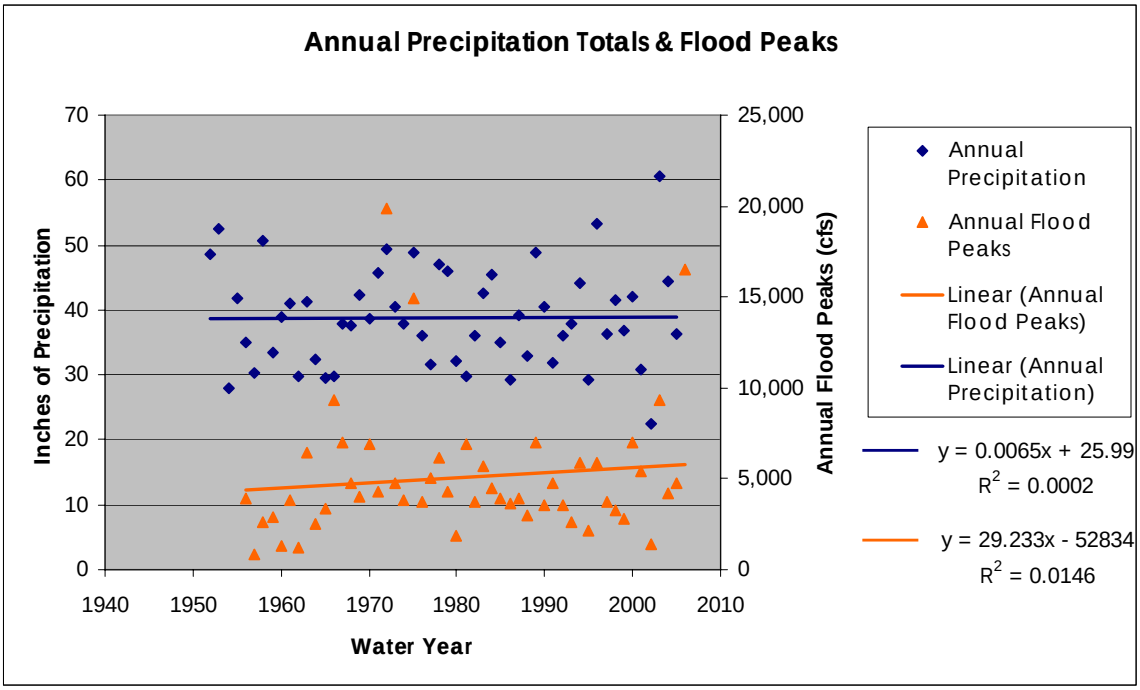

Figure 10 **Scatter Plot of Peak Flow Events Cameron Run Superimposed on Annual Precipitation Totals from the DCA Weather Station**

The annual flood peak has trended higher (29cfs/year) creating a total change in magnitude of annual peak flows across the period of record (as calculated from the trend line) of 1,450 cfs. Because the typical rain event has trended lower (Figure 9) and the typical annual peak flood event has trended higher (Figure 10) it appears that rainfall has had a negative correlation to the annual peak flow data set for Cameron Run[4].

Urbanization Effects on the Data Set

The degree of imperviousness of a watershed typically increases as the watershed becomes more developed or urbanized due to the greater percentage of area covered by impervious structures, i.e., roadways, rooftops, sidewalks, parking lots, etc. These impervious areas create higher peak flows and lower base flows in the watershed tributaries. These effects are most evident in the higher frequency, lower magnitude rain/flood events and diminish as the range of magnitudes increases because the initial abstractions (infiltration, interception, and surface storage) become less significant when measured against rainfall for a large event, e.g. a 100-year rainfall event.

Estimates of imperviousness of the Cameron Run watershed range between 23% and 41%. Although the imperviousness of the Cameron Run watershed has increased since 1956 (the period of record) this increase likely has had only a small effect on the higher

[4] This negative correlation will be discussed in the next section, **Urbanization Effects on the Data Set.**

magnitude recorded peaks. The USGS published a paper in 1970 by Daniel G. Anderson entitled "Effects of Urban Development on Floods in Northern Virginia" (Anderson, 1970). In that paper Anderson states that "impervious surface has a decreasing effect upon larger floods and has an insignificant effect upon the 100-year flood."

Historic annual aerial photography or other data providing a method to adjust the record values for the temporal development of the watershed is not readily available. However, the focus of this analysis is the 100-year flood event where Anderson states that the degree of watershed development would have a minor or negligible effect on the 100-year flood event or greater. And any increased values in the higher frequency, lower magnitude events due to increased development in the watershed only act to build a conservative bias (predicting larger magnitude events for a given frequency) into the analysis. Thus, using the data set without any adjustments for development will have a negligible affect on the 100-year event prediction and will work to create a more conservative bias in the higher frequency portion of the curve.

Lake Barcroft Effects on the Data Set

Lake Barcroft is a 135 acre manmade lake on Holmes Run in Fairfax County. Its creation in the early 1900's served the water supply needs for the City of Alexandria. No longer serving that capacity the amenity continues to exist accepting waters from the 14.5 square miles draining to it.

Typically the water level in the lake is maintained automatically at 208.5 feet elevation. Thus, the discharge from Lake Barcroft equals the inflow into the lake negating the lake's impact on the Cameron Run gage readings. However, in 1972 during the peak event for that year there was a small breach in the dam. The breach was not a catastrophic dam failure and only added a small amount of flow to Holmes and Cameron Run. The breach occurred at roughly the same time as the peak was recorded at the gaging station downstream. Given the travel time of any wave of water from the small breach at Lake Barcroft such a wave of water would only affect the recession limb of the hydrograph recorded at the gage – not the peak.

During research to develop this study, NVRC discovered a study describing uncertainty about the 1972 value (19,900 cfs) and FEMA requested that the data be excised from that analysis. To understand the effect of including or excluding the 1972 value in the analysis, NVRC ran the Log Pearson analysis both ways and developed preliminary frequency curves including and excluding the 1972 value. As expected, the removal of the 1972 event from the data set resulted in a curve significantly lower than the analysis that included the value. The magnitude of the 100-year event in the lower curve was 13,020 cfs meaning that both the actual 1972 and 1975 events would be considered well above a 100-year event magnitude under this frequency curve developed without the 1972 event.

When comparing the1972 and 1975 events on Cameron Run with similar data for Four Mile Run and its frequency curve it appears unreasonable to remove the 1972 event from the Cameron Run data set. The Four Mile Run gage, since 1951, shows no events approaching a 100-year event. So it is very unlikely that Cameron Run, only a few miles

away, would have multiple events exceeding the 100-year frequency. If the value for this event has been artificially increased due to the small dam failure at the Lake Barcroft dam then it only serves to make the resulting curve more conservative (greater magnitudes for a given frequency).

Additionally some evidence indicates that some "excess" discharge from Lake Barcroft due to operator error during the 1975 event. Discussion with the H&H workgroup discounted this possibility as a random error that may or may not occur during any historic, or future, event. The USGS annual peak flow table provides no evidence of this 1975 excess. Further, any such increased values will work to make the analysis more conservative as described above.

Assumptions Regarding the Data Record

In order to develop the flood frequency analysis for this study certain assumptions were incorporated into the analysis. All of these assumptions have been discussed previously but are included here for easy reference. These assumptions relate to the intended use of the data, the completeness and cleanliness of the data provided by USGS, and to watershed characteristics affecting the data set. Those assumptions are listed below:

- The focus of this analysis is for flood protection. The predicted 100-year event is typically considered the industry standard target for protection levels.

- The six month gap in the data set during water year 1979 was the result of relocating the gage back to its original and current location or a funding shortage. As such, the gap is independent of flood levels and does not affect the record, i.e., the gage was not damaged during an elevated event and did not record, thereby skewing the data either significantly upward.

- All necessary evaluation of the raw data through WY2005 was performed by the USGS prior to posting the data in the WATSTORE format to ensure that all peak events are accurate and representative of independent events. No effort was made through this analysis to review the raw data used for creating the WATSTORE file for the period of record.

- The operation of the dam on Lake Barcroft and the minor dam breach in 1972 has not affected the annual peak values for the Cameron Run gage.

Method of Analysis

Data analysis adheres to the statistical methodology described in the 1982 edition of the Guidelines for Determining Flood Flow Frequency, Bulletin 17B, developed by the Hydrology Subcommittee for the Interagency Advisory Committee on Water Data (published under USGS cover). In summary, the methodology outlined in Bulletin 17B requires log transformation of the annual peak flow data to fit to the Pearson Type III distribution (log-Pearson Type III) for development of the annual flood series (Bulletin 17B). The method of moments is employed to develop the statistical parameters

(mean, standard deviation, and skew) of the distribution from the station data (Bulletin 17B).

Bulletin 17B follows the December 1967 Bulletin 15 "A Uniform Technique for Determining Flood Flow Frequencies," issued by the Hydrology Committee of the Water Resources Council. Its general purpose was to provide a "consistent approach to flood-flow frequency determinations." Bulletin 17 (March, 1976), Bulletin 17A (June, 1977), and Bulletin 17B (issued 1981 and reissued 1982) were expansions on the 1967 publication (Bulletin 17B).

FEMA recommends specific computer software for flood frequency analyses (FEMA Website, September 2006, http://www.fema.gov/plan/prevent/fhm/en_stat.shtm). The USGS-developed PeakFQ computer program is listed by FEMA as an acceptable statistical model for determining Flood Frequency Analysis consistent with Bulletin 17B. The accepted USGS PeakFQ computer program was employed for this study.

Data was inputted into the PEAKFQ computer program through the WATSTORE ASCII text file. The output from the PEAKFQ program produces both a graphical plot of the calculated frequency curve with the observed peaks and confidence bands and an ASCII text file detailing the input data and the calculated probabilities with their associated confidence bands. Plots and text outputs for use in this study are included in the appendices.

Results

The frequency relationship developed in this study is presented below in Table 4. It was developed using the aforementioned methodology, gage records from 1956 thru 2006 and various assumptions regarding the data. The plots depicted in Figure 11 (log-log scale) and Figure 12 (normal scale) includes the best fit frequency curve and the upper and lower 95% confidence limits.

(1) Recurrence Interval [years]	(2) Probability	(4) 2006 Analysis 1956 – 2006 (cfs)
2	0.5	4,157
5	0.2	6,993
10	0.1	9,266
25	0.04	12,600
50	0.02	15,430
100	0.01	18,570
500	0.002	27,210

Table 4 Frequency vs. Flow Relationship for Cameron Run Gage Data (September 2006)

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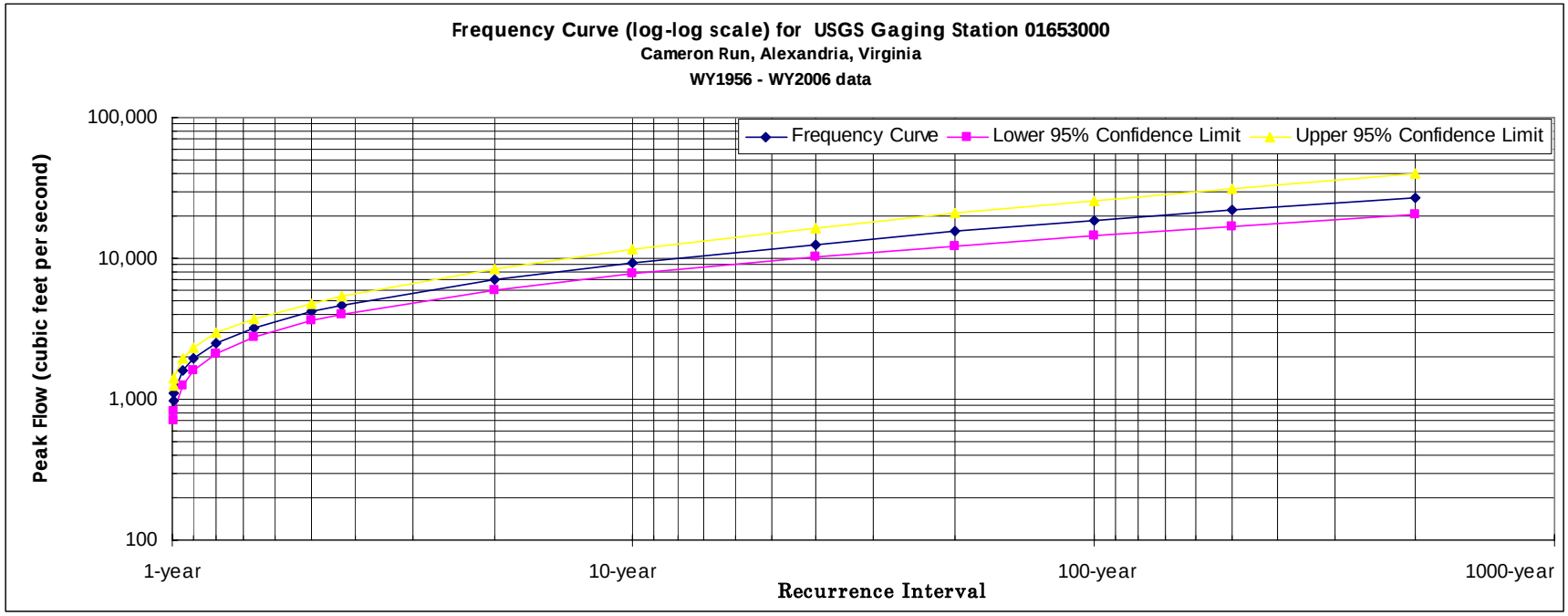

Figure 11 Frequency Curve (log-log scale) for USGS Gaging Station 01653000

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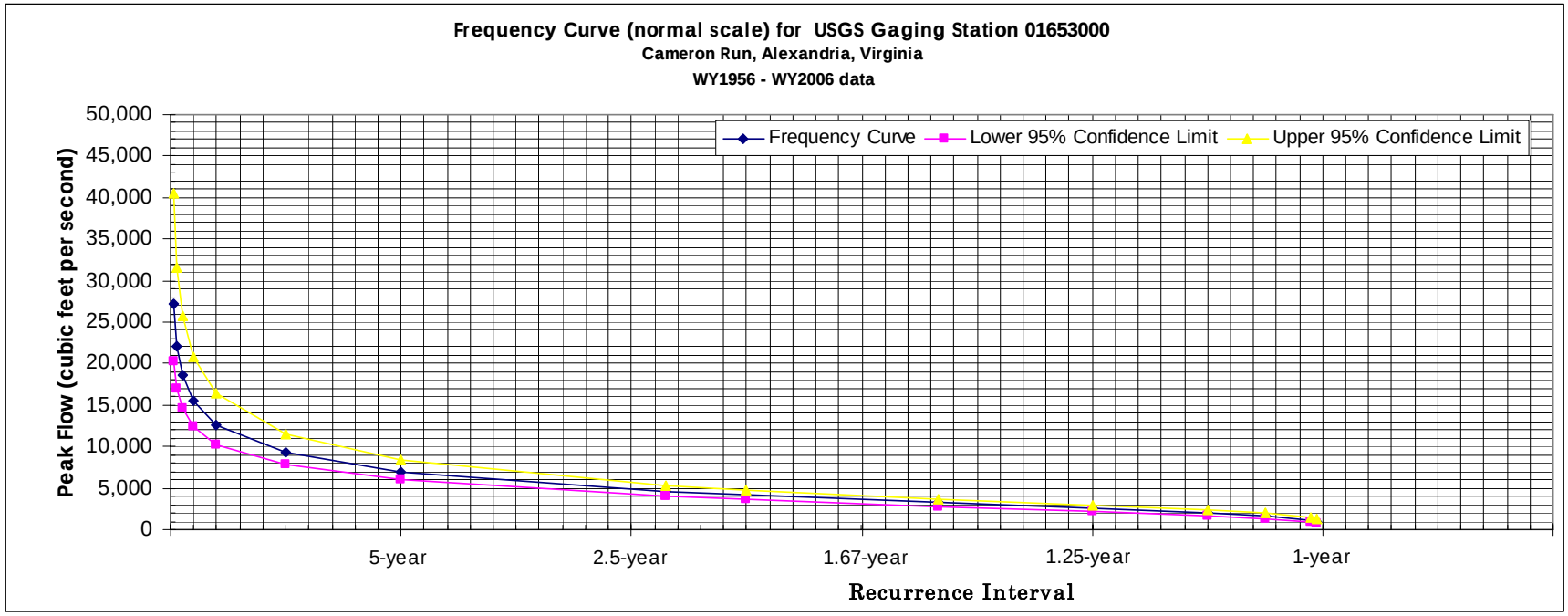

Figure 12 Frequency Curve (normal scale) for USGS Gaging Station 01653000

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Other Cameron Run Frequency Studies

Table 5 summarizes several previous flood frequency analyses performed to develop frequency data for Cameron Run at the gage site. The data presented ranges in completeness but all studies included show values for 100-year recurrence intervals. The 100-year predictions vary from 12,315 cfs to 30,000 cfs. The studies included differ on two key characteristics: methodology employed and the data set used.

For example, the 1971 USACE study closely aligns with the statistical methodologies employed with the current (2006) analysis but differs in the length of the period of record available for the analysis. In the 2001 FEMA/URS study URS employed three different methodologies for determining the magnitude of the 100-year event that varied from 12,000 cfs to nearly 23,000 cfs.

The Anderson method for determining frequency data has been employed for several studies for Cameron Run. When determining frequency data at the gage location, using the Anderson methodology in lieu of the industry standard, Log Pearson Type III analysis, adds uncertainly to the analysis. The Cameron Run gage data and analysis was one of the included gaging stations Anderson used to develop the Northern Virginia regression analysis.

With the variability in approaches to analyses it is difficult to draw relationships between these frequency predictions.

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Flood Probability		Recurrence Interval	1971 (1) (cfs)	1976 (2) (cfs)	1989 (3) (cfs)	1994 (4) (cfs)	1995 (5) (cfs)	1995 (6) (cfs)	2001 (7) (cfs)	2001 (8) (cfs)	2001 (9) (cfs)	2006 (10) (cfs)
0.5	50%	2-year	3,200					4,020				4,157
0.2	20%	5-year	6,400					6,720				6,993
0.1	10%	10-year	9,300					8,800		6,524	14,239	9,266
0.04	4%	25-year	11,200	13,400				1,170				12,600
0.02	2%	50-year	22,000	16,500				14,200		10,391	19,998	15,430
0.01	1%	100-year	30,000	19,500	19,400	25,600	12,927	16,800	18,000	12,315	22,931	18,570
0.002	0.2%	500-year	56,000					23,600		16,200	28,750	27,210

Table 5 Summary Table of Frequency Analyses for Cameron Run

Study
(1) 1971 USACE Flood Control Study
(2) 1976 USGS Floodplain Delineation
(3) 1989 USACE letter to FEMA
(4) 1994 Cameron Station Military Installation Flood Damage Reduction Study
(5) 1995 FEMA Flood Insurance Study (URS study)
(6) 1995 USGS Report 94-4148
(7) 2001 URS Log Pearson (avg. of 15,000 and 21,000 cfs)
(8) 2001 URS Anderson Method
(9) 2001 URS TR-20 Method
(10) 2006 NVRC Log Pearson Period of Record 1953 - 2006

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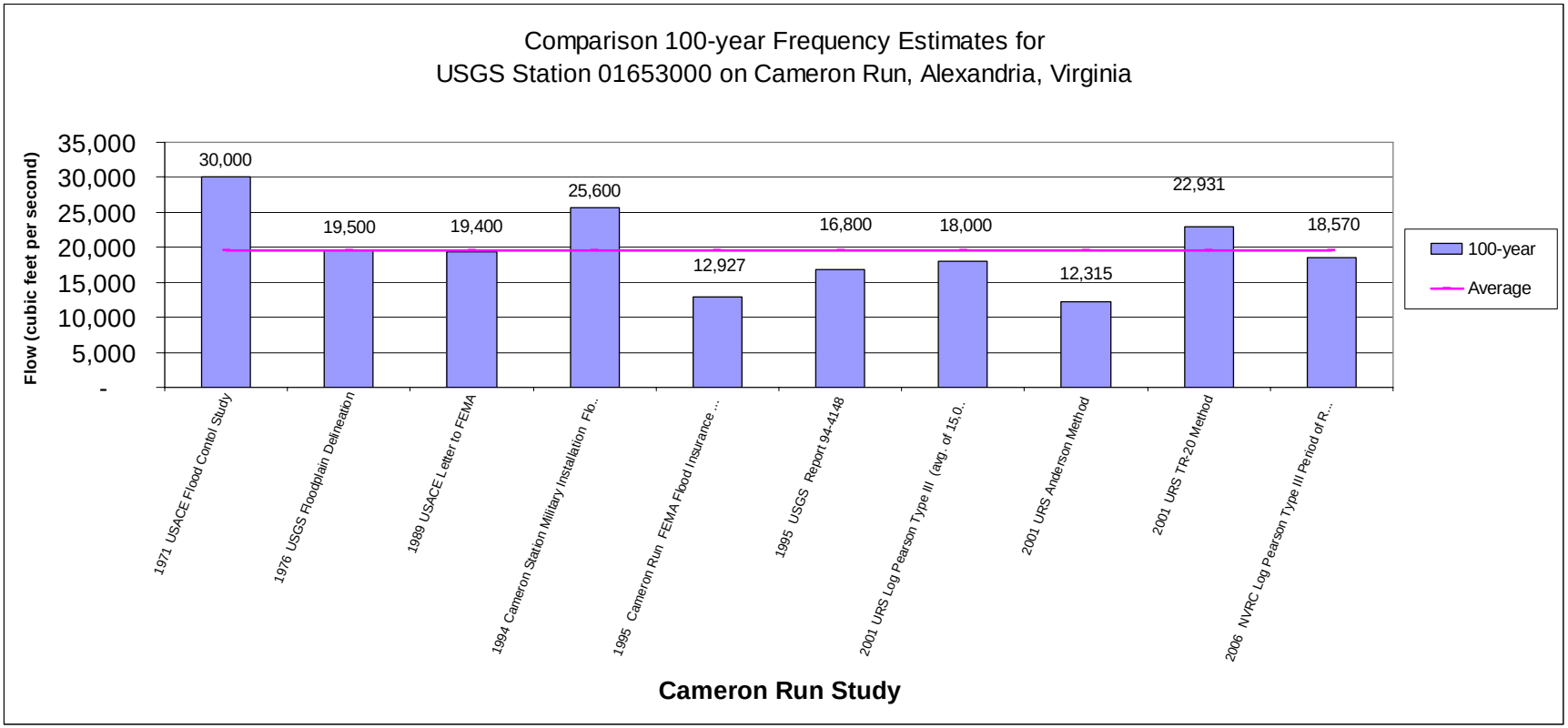
Comparison 100-year Frequency Estimates for
USGS Station 01653000 on Cameron Run, Alexandria, Virginia
Flow (cubic feet per second)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
30,000
19,500
19,400
25,600
12,927
16,800
18,000
12,315
22,931
18,570
1971 USACE Flood Contol Study
1976 USGS Floodplain Delineation
1989 USACE Letter to FEMA
1994 Cameron Station Military Installation Flo..
1995 Cameron Run FEMA Flood Insurance ...
1995 USGS Report 94-4148
2001 URS Log Pearson Type III (avg. of 15,0..
2001 URS Anderson Method
2001 URS TR-20 Method
2006 NVRC Log Pearson Type III Period of R...
100-year
Average
Cameron Run Study

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Considering High Frequency Events

The intent of this analysis was to develop a frequency curve useful in preparing for infrastructure improvements for large magnitude, low frequency flood events, e.g., the 100-year flood. However, with the current emphasis on more holistic approaches to watershed and stream management it is likely that the frequency data for the high frequency events will be used for channel improvements.

As discussed previously in this report, increased development in the watershed may have had only a minor effect on low frequency events. However, this is likely not the case for the higher frequency events, including events through the 5-year event. One factor in particular that supports this theory is the increased efficiency of neighborhood storm drain networks both above ground with the increased impervious surface coverage, and underground with expanded storm drain piping.

As development increases in a watershed the storm drain network will grow. The expanded network will usually be developed through the creation of neighborhood scale improvements not necessarily the replacement of large trunk lines or open channel sections that are typically designed for higher capacities. The drainage systems in these neighborhood areas will be designed under a dual requirement. First, these systems must adequately convey the 10-year storm event. Second, drainage pipes must meet a minimum size requirement, typically 15-inches in diameter.

Due to the smaller collection basins in a neighborhood system a 15-inch diameter storm drain will often have the capacity to carry significantly more flow from the basin area than a 10-year storm event will produce. Consequently, the higher frequency flows will have a more efficient conduit to reach the lower portions of the watershed. This efficiency of conveyance added to the combining of flows as they move to the lower portions of the watershed will work to distort the hydrograph and is likely one of the causes of higher peak flows for the lower magnitude events.

When considering why this effect cannot be extrapolated to the higher magnitude events it is important to realize that much of the storm flows associated with the higher magnitude events are not necessarily contained within the storm drain network where they can readily be carried to the downstream portions of the watershed. The stormwater in excess of the capacity of the storm drain network will contribute to localized flooding and thereby be stored, or detained, awaiting downstream capacity.

By using the Log Pearson Type III analysis the issue of stormdrain conveyance is negated. The flows analyzed represent the actual flows recorded.

In Conclusion

The data and analysis presented offer some understanding and statistical prediction derived from the actual flow data recorded at the USGS gage. Neither the data nor the analysis presented describes all of the factors acting on the watershed or the flood corridor

sufficiently to allow a reader to draw definitive conclusions about flow predictions at any location beyond that of the USGS gaging station location. A thorough examination of precipitation is not presented here, nor are factors such as existing channel capacity or sediment transport included in any manner in this study. Such items, and others, are crucial to a thorough understanding of the hydrology and hydraulics of Cameron Run.

It should be noted that 20% of the land draining the Cameron Run/Great Hunting Creek confluence with the Potomac River enters the stream downstream of the USGS gage and is therefore not recorded by the gage. The magnitude of flood waves downstream must be examined through deterministic models of the watershed and hydraulic corridor.

Even so, this flood flow frequency analysis does offer the reader and decision-makers a current understanding of what flow magnitudes can be expected in Cameron Run at the gaging station. Because the methodology used in this study subscribes to industry-standard techniques (Bulletin #17B) its results can easily be used by decision-makers for meaningful discussion and application in the broader hydrology and hydraulics context.

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Appendices

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WATSTORE INPUT FILE

for

WY1956 – WY2006 Data

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```
Z01653000                       USGS
H01653000       38482307706360051515 10SW0207001033.70         31.74
N01653000       CAMERON RUN AT ALEXANDRIA, VA
Y01653000
301653000       19530505                      11.90
301653000       19560720   3950                8.62
301653000       19570405    865                5.50
301653000       19580708   2600                7.93
301653000       19590612   2900                7.93
301653000       19600405   1300                5.68
301653000       19610826   3820                7.35
301653000       19620312   1230                4.84
301653000       19630820   6480               10.48
301653000       19640513   2550                5.78
301653000       19650305   3330                6.92
301653000       19660914   9300               14.14
301653000       19670825   6950               12.72
301653000       19680910   4780               10.65
301653000       19690908   4030                9.66
301653000       19700709   6910               13.11
301653000       19710827   4320                9.32
301653000       19720622  199005              18.14
301653000       19730710   4730                9.94
301653000       19740830   3860                8.39
301653000       19750926  14900               16.73
301653000       19751231   3700                8.10
301653000       19770712   5040                8.20
301653000       19780126   6200                8.93
301653000       19790225   4300                7.30
301653000       19800313   1900                4.74
301653000       19810704   6920                8.45
301653000       19820530   3720                5.95
301653000       19830621   5710                9.03
301653000       19840329   4460                6.95
301653000       19841105   3950                6.40
301653000       19860802   3630                6.04
301653000       19861224   3890                6.84
301653000       19880518   2980                5.33
301653000       19890506   6960                9.50
301653000       19900705   3510                5.67
301653000       19901023   4800                7.34
301653000       19920724   3570                6.15
301653000       19921123   2650                4.94
301653000       19931128   5900                8.50
301653000       19950120   2130                5.02
301653000       19960119   5870                8.73
301653000       19961108   3760                6.82
301653000       19980217   3230                6.28
301653000       19990916   2820                5.83
301653000       20000728   7020                9.64
301653000       20001217   5410                8.34
301653000       20020619   1420                4.07
301653000       20030923   9330               11.29
301653000       20031119   4220                7.27
301653000       20050328   4770                7.78
301653000       20060625  16500               17.00
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PeakFQ OUTPUT PLOT

for

WY1956 – WY2006 Data

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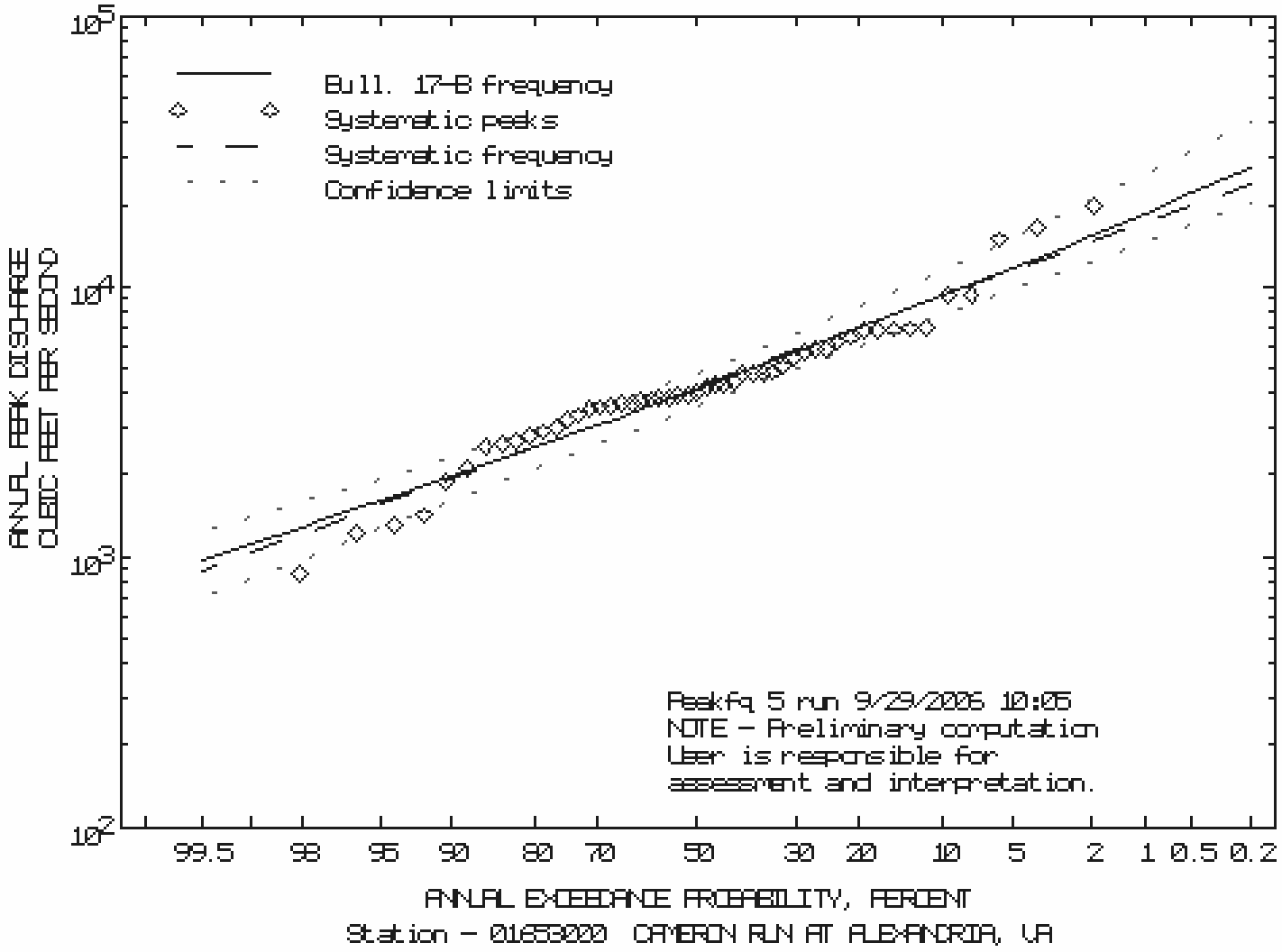

Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA

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PeakFQ OUTPUT FILE

for

WY1956 – WY2006 Data

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```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
  05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = WATSTORE
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\BHICKS\MY
DOCUMENTS\CAMERON RUN\FLOOD FREQUENCY ANALYS
                         specifications - PKFQWPSF.TMP
                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\BHICKS\MY
DOCUMENTS\CAMERON RUN\FLOOD FREQUENCY ANALYS
                         bcd  - WASTORE FILE WITH WY2006.BCD

1
```

```
Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
 Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
 05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

              Station - 01653000  CAMERON RUN AT ALEXANDRIA, VA


                   I N P U T   D A T A   S U M M A R Y

               Number of peaks in record           =       52
               Peaks not used in analysis          =        1
               Systematic peaks in analysis        =       51
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.683
                    Standard error                 =    0.550
                    Mean Square error              =    0.303
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   51
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            789.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     22638.9
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1
```

```
Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
 Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
 05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05

              Station - 01653000  CAMERON RUN AT ALEXANDRIA, VA


          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                       FLOOD BASE                   LOGARITHMIC
                 ----------------------  -------------------------------
                            EXCEEDANCE                STANDARD
                  DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                 -------------------------------------------------------
SYSTEMATIC RECORD       0.0     1.0000     3.6260      0.2627     -0.009
BULL.17B ESTIMATE       0.0     1.0000     3.6260      0.2627      0.165


   ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

     ANNUAL                                 'EXPECTED   95-PCT CONFIDENCE LIMITS
  EXCEEDANCE     BULL.17B    SYSTEMATIC PROBABILITY'  FOR BULL. 17B ESTIMATES
  PROBABILITY    ESTIMATE      RECORD     ESTIMATE        LOWER        UPPER

     0.9950        977.6        885.7        914.6        705.8       1248.0
     0.9900       1114.0       1031.0       1057.0        822.9       1401.0
     0.9500       1609.0       1561.0       1568.0       1262.0       1944.0
     0.9000       1969.0       1946.0       1937.0       1592.0       2335.0
     0.8000       2530.0       2541.0       2507.0       2113.0       2944.0
     0.6667       3214.0       3260.0       3202.0       2749.0       3701.0
     0.5000       4157.0       4231.0       4157.0       3607.0       4785.0
     0.4292       4632.0       4713.0       4639.0       4029.0       5353.0
     0.2000       6993.0       7034.0       7061.0       6013.0       8363.0
     0.1000       9266.0       9170.0       9448.0       7802.0      11500.0
     0.0400      12600.0      12160.0      13060.0      10290.0      16390.0
     0.0200      15430.0      14600.0      16240.0      12330.0      20760.0
     0.0100      18570.0      17190.0      19890.0      14510.0      25790.0
     0.0050      22040.0      19970.0      24100.0      16880.0      31560.0
     0.0020      27210.0      23940.0      30670.0      20290.0      40470.0
1
```

```
Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.003
 Ver. 5.0 Beta 8     Annual peak flow frequency analysis      Run Date / Time
 05/06/2005          following Bulletin 17-B Guidelines       09/29/2006 10:05
```

Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1953	-8888.0		1981	6920.0	
1956	3950.0		1982	3720.0	
1957	865.0		1983	5710.0	
1958	2600.0		1984	4460.0	
1959	2900.0		1985	3950.0	
1960	1300.0		1986	3630.0	
1961	3820.0		1987	3890.0	
1962	1230.0		1988	2980.0	
1963	6480.0		1989	6960.0	
1964	2550.0		1990	3510.0	
1965	3330.0		1991	4800.0	
1966	9300.0		1992	3570.0	
1967	6950.0		1993	2650.0	
1968	4780.0		1994	5900.0	
1969	4030.0		1995	2130.0	
1970	6910.0		1996	5870.0	
1971	4320.0		1997	3760.0	
1972	19900.0		1998	3230.0	
1973	4730.0		1999	2820.0	
1974	3860.0		2000	7020.0	
1975	14900.0		2001	5410.0	
1976	3700.0		2002	1420.0	
1977	5040.0		2003	9330.0	
1978	6200.0		2004	4220.0	
1979	4300.0		2005	4770.0	
1980	1900.0		2006	16500.0	

Explanation of peak discharge qualification codes

PEAKFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date / Time
05/06/2005 following Bulletin 17-B Guidelines 09/29/2006 10:05

Station - 01653000 CAMERON RUN AT ALEXANDRIA, VA

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	19900.0	0.0192	0.0192
2006	16500.0	0.0385	0.0385
1975	14900.0	0.0577	0.0577
2003	9330.0	0.0769	0.0769
1966	9300.0	0.0962	0.0962
2000	7020.0	0.1154	0.1154
1989	6960.0	0.1346	0.1346
1967	6950.0	0.1538	0.1538
1981	6920.0	0.1731	0.1731
1970	6910.0	0.1923	0.1923
1963	6480.0	0.2115	0.2115
1978	6200.0	0.2308	0.2308
1994	5900.0	0.2500	0.2500
1996	5870.0	0.2692	0.2692
1983	5710.0	0.2885	0.2885
2001	5410.0	0.3077	0.3077
1977	5040.0	0.3269	0.3269
1991	4800.0	0.3462	0.3462
1968	4780.0	0.3654	0.3654
2005	4770.0	0.3846	0.3846
1973	4730.0	0.4038	0.4038
1984	4460.0	0.4231	0.4231
1971	4320.0	0.4423	0.4423
1979	4300.0	0.4615	0.4615
2004	4220.0	0.4808	0.4808
1969	4030.0	0.5000	0.5000
1956	3950.0	0.5192	0.5192
1985	3950.0	0.5385	0.5385
1987	3890.0	0.5577	0.5577
1974	3860.0	0.5769	0.5769
1961	3820.0	0.5962	0.5962
1997	3760.0	0.6154	0.6154
1982	3720.0	0.6346	0.6346
1976	3700.0	0.6538	0.6538
1986	3630.0	0.6731	0.6731
1992	3570.0	0.6923	0.6923
1990	3510.0	0.7115	0.7115
1965	3330.0	0.7308	0.7308
1998	3230.0	0.7500	0.7500
1988	2980.0	0.7692	0.7692
1959	2900.0	0.7885	0.7885

```
       1999         2820.0         0.8077         0.8077
       1993         2650.0         0.8269         0.8269
       1958         2600.0         0.8462         0.8462
       1964         2550.0         0.8654         0.8654
       1995         2130.0         0.8846         0.8846
       1980         1900.0         0.9038         0.9038
       2002         1420.0         0.9231         0.9231
       1960         1300.0         0.9423         0.9423
       1962         1230.0         0.9615         0.9615
       1957          865.0         0.9808         0.9808
       1953        -8888.0           --             --
1


 End PEAKFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      52


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01653000       USGS CAMERON RUN AT ALEXANDRIA, VA


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
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USGS Data

For

Station 01653000 on Cameron Run

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Peak Streamflow for Virginia

USGS 01653000 CAMERON RUN AT ALEXANDRIA, VA

Alexandria City, Virginia
Hydrologic Unit Code 02070010
Latitude 38°48'23", Longitude 77°06'36" NAD27
Drainage area 33.70 square miles
Gage datum 31.74 feet above sea level NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1953	May 05, 1953	11.90		1980	Mar. 13, 1980	4.74	1,900
1956	Jul. 20, 1956	8.62	3,950	1981	Jul. 04, 1981	8.45	6,920
1957	Apr. 05, 1957	5.50	865	1982	May 30, 1982	5.95	3,720
1958	Jul. 08, 1958	7.93	2,600	1983	Jun. 21, 1983	9.03	5,710
1959	Jun. 12, 1959	7.93	2,900	1984	Mar. 29, 1984	6.95	4,460
1960	Apr. 05, 1960	5.68	1,300	1985	Nov. 05, 1984	6.40	3,950
1961	Aug. 26, 1961	7.35	3,820	1986	Aug. 02, 1986	6.04	3,630
1962	Mar. 12, 1962	4.84	1,230	1987	Dec. 24, 1986	6.84	3,890
1963	Aug. 20, 1963	10.48	6,480	1988	May 18, 1988	5.33	2,980
1964	May 13, 1964	5.78	2,550	1989	May 06, 1989	9.50	6,960
1965	Mar. 05, 1965	6.92	3,330	1990	Jul. 05, 1990	5.67	3,510
1966	Sep. 14, 1966	14.14	9,300	1991	Oct. 23, 1990	7.34	4,800
1967	Aug. 25, 1967	12.72	6,950	1992	Jul. 24, 1992	6.15	3,570
1968	Sep. 10, 1968	10.65	4,780	1993	Nov. 23, 1992	4.94	2,650
1969	Sep. 08, 1969	9.66	4,030	1994	Nov. 28, 1993	8.50	5,900
1970	Jul. 09, 1970	13.11	6,910	1995	Jan. 20, 1995	5.02	2,130
1971	Aug. 27, 1971	9.32	4,320	1996	Jan. 19, 1996	8.73	5,870
1972	Jun. 22, 1972	18.14	19,900[5]	1997	Nov. 08, 1996	6.82	3,760
1973	Jul. 10, 1973	9.94	4,730	1998	Feb. 17, 1998	6.28	3,230
1974	Aug. 30, 1974	8.39	3,860	1999	Sep. 16, 1999	5.83	2,820
1975	Sep. 26, 1975	16.73	14,900	2000	Jul. 28, 2000	9.64	7,020
1976	Dec. 31, 1975	8.10	3,700	2001	Dec. 17, 2000	8.34	5,410
1977	Jul. 12, 1977	8.20	5,040	2002	Jun. 19, 2002	4.07	1,420
1978	Jan. 26, 1978	8.93	6,200	2003	Sep. 23, 2003	11.29	9,330
1979	Feb. 25, 1979	7.30	4,300	2004	Nov. 19, 2003	7.27	4,220
				2005	Mar. 28, 2005	7.78	4,770

Peak Streamflow Qualification Codes.
5 -- Discharge affected to unknown degree by Regulation or Diversion

Table 6 **Peak Streamflow for Virginia USGS 01653000 CAMERON RUN AT ALEXANDRIA, VA**