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STREAMFLOW ESTIMATES FOR HUMPBACK CREEK, CORDOVA C-5 QUADRANGLE, ALASKA

By

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STREAMFLOW ESTIMATES FOR HUMPBACK CREEK, CORDOVA (C-5) QUADRANGLE, ALASKA

A Report Submitted to the Alaska Power Authority

by

The State of Alaska Department of Natural Resources
Division of Geological and Geophysical Surveys (DGGS)
Water Resources Section
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INTRODUCTION

Humpback Creek, a small stream five miles northeast of Cordova, Alaska, is being considered for a run-of-river hydroelectric project by the Cordova Electric Cooperative, Inc. and the Alaska Power Authority (APA). The Water Resources Section of DGGS was contracted by APA to analyze and estimate streamflow conditions for Humpback Creek; this information will be used to evaluate the hydrologic feasibility of the project and to aid in future system planning and design.

BACKGROUND

Humpback Creek flows four miles on a generally westward course to Orca Inlet northeast of Cordova. The drainage basin encompasses approximately 4.4 sq mi, with a basin high elevation of nearly 3500 ft and a low elevation at sea level. Two small snowfields are located in the basin along with two small lakes.

The U.S. Geological Survey gaged the creek 800 ft upstream of the mouth from October 1973 to September 1975 (U.S.G.S., 1974-75). These two years of record are the only published discharge data available, and are not necessarily indicative of long-term flow conditions.

Weather records for the Cordova area (AEIDC, 1985) are available for two stations, the Cordova airport, 10 mi southeast of town, and radio station KLAM, downtown. The airport averages 90 in. of precipitation a year, with September being the wettest month and January and June the driest months. In Cordova, yearly precipitation is almost double and averages 170 in., with October being the wettest month and June the driest month.

The Humpback Creek watershed should receive as much or more precipitation as downtown Cordova because of orographic effects, but no site specific data are available for the creek. However, runoff for Humpback Creek during the water year 1975 was 152 in. (USGS, 1975), and this figure can be used to back-calculate basin precipitation. Precipitation and streamflow were about 10 percent above normal for the 1975 water year; therefore, "normal" runoff might equal 137 in. a year. Add to runoff 20 in. of yearly evapotranspiration for Cordova (Patric and Black, 1968) and another 20 in. of estimated ground water, lake, and soil moisture losses, and that results in 177 in. of annual precipitation for the Humpback Creek watershed. This later precipitation estimate tends to confirm annual rain and snowfall amounts comparable with downtown Cordova, not the airport.

RESULTS

DGGS performed four tasks for this study after discussions with APA and Cordova Electric Cooperative staff. In addition, hydrologists Carrick and Long visited Humpback Creek on August 19, 1985, inspected the facilities sites, and took streamflow discharge measurements at three locations. The four tasks and findings follow.

Task 1: How representative is the discontinued USGS gaging station to the proposed intake weir site?

The old USGS gage station is located 0.5 mi downstream of the intake site, with a drainage basin area of 4.37 sq mi compared to 4.25 sq mi for the intake site. A bedrock gorge consisting of metasedimentary and metamorphic rocks separates the USGS station from the intake site. The bedrock, though exhibiting tight crenulations and cleavage, does not appear highly fractured or permeable.

The streambed at the intake site is made up of gravel and cobbles of undetermined thickness deposited behind an old log crib dam. This bed material is somewhat thicker than what normally might be the case because of sediment trapping by the dam. Downstream at the USGS station, the bed is composed of gravel, cobbles, some boulders, and bedrock.

Weather patterns at the two locations should be similar, if not the same, and no significant tributaries exist between the intake and USGS sites.

The above evidence suggests that streamflow at the proposed intake site and the USGS gaging station will be nearly the same. Some streamflow probably moves through the gravels behind the log crib dam, but reappears as surface flow immediately downstream of the structure. Discharge measurements taken on two different occasions this summer showed flows at both sites within 1-5 cfs of each other, i.e. discharges approximately equal considering allowable measurement limits of error. It is our opinion that streamflow data from the discontinued USGS gage station are representative of flow conditions at the upstream intake weir site.

Task 2: How indicative of Humpback Creek long term streamflow conditions are the two years of USGS gaging records?

The USGS (1985) has gaging data for three other small basins in the Cordova area: Power, Dick, and West Fork Olsen Bay Creeks. Streamflow in all three creeks was at record low levels, averaging 35 percent below normal, during water year 1974 (Oct. 73 - Sept. 74). The following water year 1975 (Oct. 74 - Sept. 75), streamflow was about typical, averaging 8 percent above normal. Cordova precipitation during the same periods was 35 percent below and 9 percent above normal, respectively. Based on the above information, we can say that USGS gaging records for water year 1974 would not be indicative of long term streamflow for Humpback Creek. But, area streamflow and precipitation during water year 1975 are so close to normal that it would be safe to conclude that USGS gaging data on Humpback Creek for the same year could be indicative of long term conditions.

Pertinent streamflow data for Humpback Creek published by USGS (1975) for water year 1975 is as follows:

Mean Annual Flow - 48.9 cfs

Maximum Daily Flow - 416 cfs

Peak Flow - 638 cfs

Winter Minimum Daily Flow - 2 cfs

Summer Minimum Daily Flow - 17 cfs

Mean Annual Runoff - 152 in.

If it is assumed that streamflow in Humpback Creek was, like the other creeks, about 8 percent above normal for 1975, then an adjusted mean annual flow would be 45 cfs. Breakup on the creek occurs in April, while freezeup probably takes place in November or December. Power generation would therefore be done from May to November when mean monthly flow would be approximately 58 to 68 cfs based on the USGS records.

To complement and confirm the two years of published flow records, the USDA Forest Service Water Resources Atlas (1979) was used to estimate additional streamflow data. The Atlas provides numerous regression equations for use in estimating streamflow characteristics for ungaged watersheds in the Tongass and Chugach National Forests. Each equation contains easily obtained precipitation and physiographic variables that are significant for the particular streamflow characteristic. Each equation does have a certain amount of error unique to the calculation. For instance, average annual and some mean monthly flows have the lowest error, while low flow equations, especially winter low flow, have considerably greater error.

Table 1 lists various calculated flow characteristics for Humpback Creek. Because precipitation is one of the most significant variables used in the equations, two different mean annual precipitation amounts were utilized to account for any uncertainties in rain and snowfall estimations. The 140 in. figure is derived from precipitation maps in the Atlas, and the 170 in. figure is taken from previously described sources in the background section of this report. Other variables used to make the flow calculations are as follows:

Basin area - 4.25 sq mi (from the intake site upstream)

Proportion of basin above treeline - 60 percent

Proportion of basin in main channel lakes - 1 percent

Slope of main channel - 146.8 ft/1000 ft

Mean elevation of basin - 1237 ft

Miles south to Gulf of Alaska - 12 mi

Task 3: Construct a monthly streamflow hydrograph and flow duration curve to illustrate timing and magnitude of flows.

The U.S. Forest Service Water Resources Atlas and USGS gaging records were used to derive the graphs. See figure 1 and 2. The total flow represented by the hydrograph agrees with published records, though the timing of the flows may not. In particular, June would typically have a higher flow than July, and the flows in September and October would generally be higher than depicted.

Task 4: Calculate monthly and annual energy projections using measured and estimated flow figures.

The energy or power available is taken from the formula: Energy (Kilowatt hours or KWH) = Discharge (cfs) X Head (ft) X Generation System Efficiency X .0847 (Conversion Factor) X 24 hours. Table 2 gives the results of the calculations using the following variables taken from Loeffler and Denig-Chakroff (1985): Head = 175 ft, Efficiency = 80 %.

CONCLUSION

Inspection of USGS gaging records for Humpback Creek and other Cordova area streams indicates that data from water year 1975 represents near normal streamflow conditions. We believe that mean annual flow for the creek falls somewhere between 40 and 50 cfs, with discharge during the ice free generating months of May - November averaging 58 - 68 cfs. The energy projections given in Table 2 are estimates that don't take into account the design limitations of the turbine/penstock system. However, if we use a seven month average flow of 58 cfs (a lower rate than the Water Resources Atlas estimates but equivalent to the lowest USGS figures) then the total annual energy available would be 3.53 million KWH, a conservative amount that, nonetheless, should not render the project hydrologically unfeasible at this time.

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Table 1. Humpback Creek Flow Estimates. Based on U.S. Forest Service Water Resources Atlas Regression Equations.

	Using 140 in. mean annual PPT (cfs)	Using 170 in. mean annual PPT (cfs)
Mean Annual Flow	38.2	47.9
Mean JAN Flow	7.6	10.4
Mean FEB Flow	4.9	7.6
Mean MAR Flow	6.9	9.5
Mean APR Flow	13.9	15.7
Mean MAY Flow	87.4	109.7
Mean JUN Flow	61.6	85.7
Mean JUL Flow	88.9	106.8
Mean AUG Flow	54.8	68.2
Mean SEP Flow	53.8	65.8
Mean OCT Flow	54.1	68.8
Mean NOV Flow	32.8	43.1
Mean DEC Flow	12.4	18.3
MAY - NOV Mean	61.9	78.3
7 Day 10 Year Winter Low Flow	1.2	1.5
7 Day 10 Year Summer Low Flow	3.6	4.7
30 Day 10 Year Winter Low Flow	1.0	1.3
30 Day 10 Year Summer Low Flow	10.9	13.8
5 Year Peak Flow	850.5	1129.3
10 Year Peak Flow	1002.7	1315.9
100 Year Peak Flow	1496.0	1892.2

Table 2. Humpback Creek Energy Projections.

Using estimated discharges from Table 1.

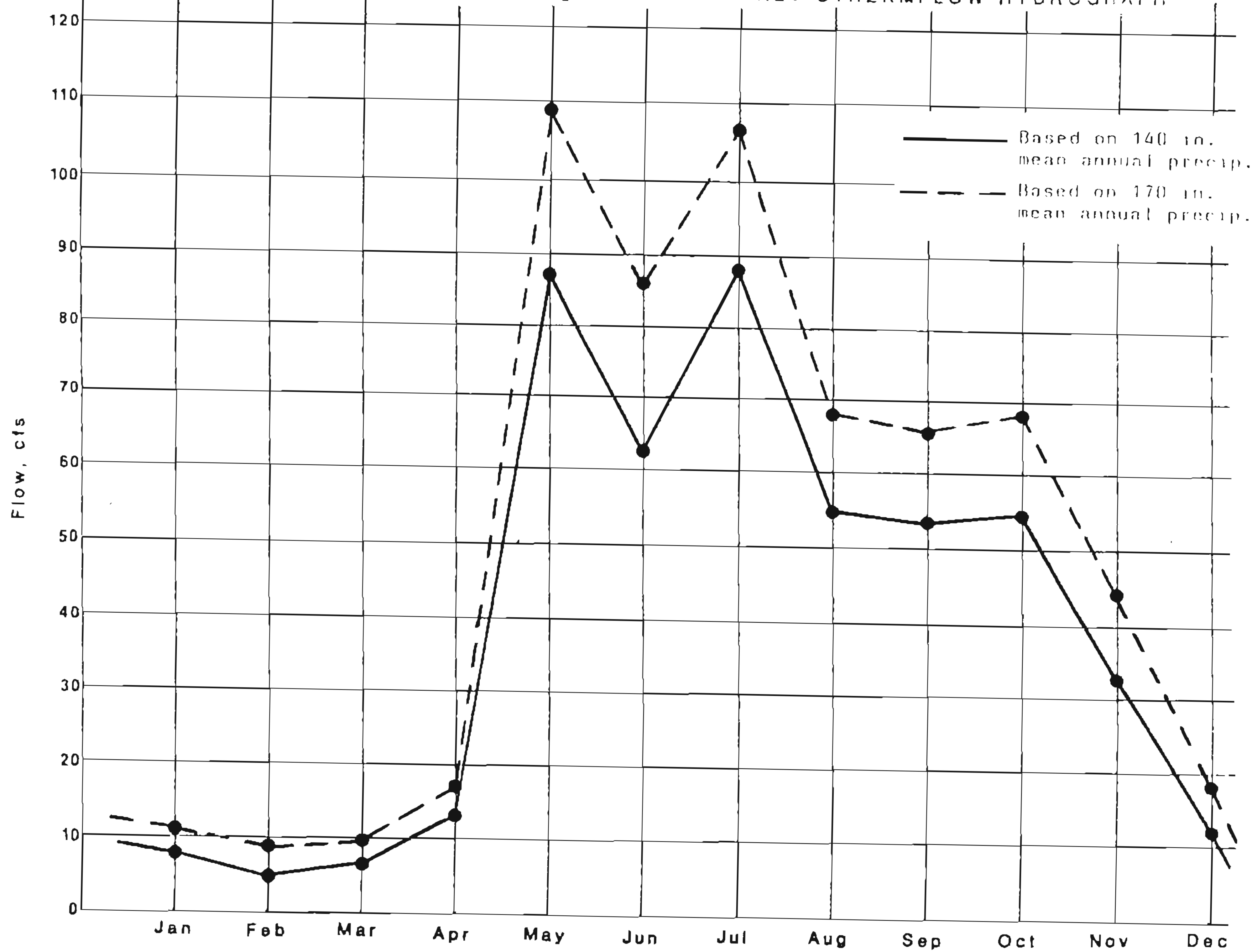
	140 in. Mean Annual PPT (KWH)	170 in. Mean Annual PPT (KWH)
Mean Annual Production (based on mean annual flow)	3,968,066	4,975,664
JAN Production	67,050	91,752
FEB Production	39,046	60,561
MAR Production	60,874	83,812
APR Production	118,675	134,043
MAY Production	771,074	967,812
JUN Production	525,926	731,686
JUL Production	784,307	942,227
AUG Production	483,465	601,684
SEP Production	459,331	561,785
OCT Production	477,289	606,978
NOV Production	280,038	367,977
DEC Production	109,397	161,449
MAY-NOV Production (based on monthly figures)	3,769,876	4,768,680

* * * * * *

Using USGS Gaging Records:

Mean Annual Production (based on 45 cfs mean annual flow)	4,674,424 KWH
MAY-NOV Production (based on 63 cfs average)	3,836,869 KWH

Figure 1. MONTHLY STREAMFLOW HYDROGRAPH



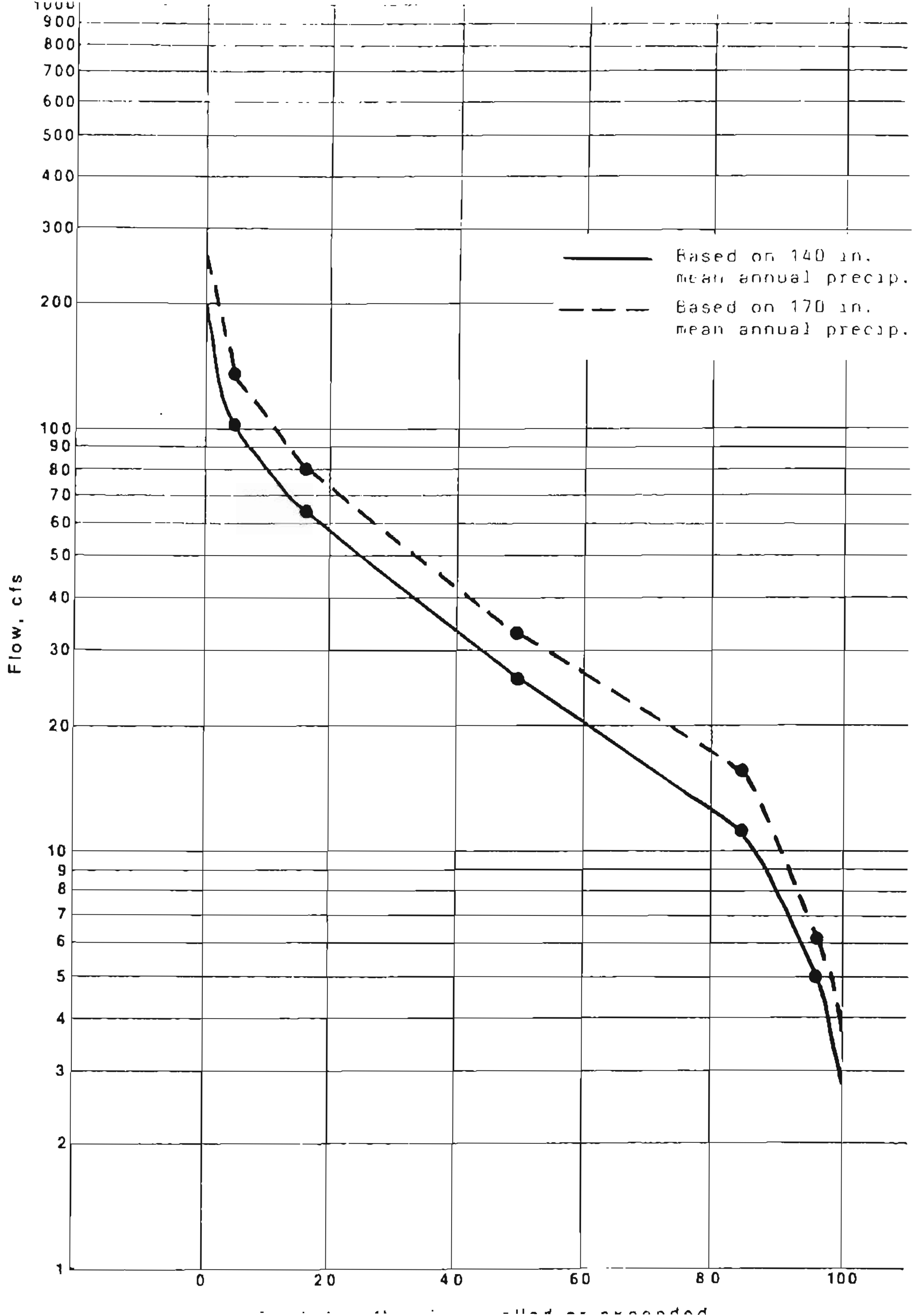


Figure 2. FLOW DURATION CURVE