A Case Study: Calculating a Precipitation Frequency Curve Using L-Moment Statistics with Emphasis on the Uncertainties in the Analysis

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MOTIVATION
Rainfall-produced floods can overtop dams which result in dam failure if adequate releases through the spillways and outlets do not occur.
Three such significant disasters resulting from inaccurate forecasting of flood conveyance requirements include (Jansen 1983):
- South Fork (Johnstown), United States
- Oros, Brazil
- Panselt and Machchhu, India

BACKGROUND
OVERTOPPING ASSESSMENT
Initial Risk Assessment – If the dam can safely pass the current PMF without overtopping, then overtopping is not considered a failure option for that dam.

PMF – Probable Maximum Flood – The ‘maximum runoff condition resulting from the most severe combination of hydrologic and meteorological conditions considered reasonably possible for a drainage basin’ (USDOI 1987)

- If the dam does not safely pass the PMF – higher level study needed.

Rainfall-based statistics (i.e. precipitation frequency) and rainfall-runoff routines are needed as input for the method of analysis and modeling required to produce a Hydrologic Hazard Curve (HHC). An HHC is an estimated relationship of flood magnitudes (or volumes) to annual exceedance probabilities (AEPs) up to the PMF. From an HHC, flood peaks may be compared with spillway discharge capacities to determine the risk of overtopping.

INTRODUCTION
HYDROLOGIC HAZARD
The probability of failure during some hydrologic event due to an undersized spillway needs to be determined at East Park Dam, CA.

- Thick-arch concrete dam
- Structural height of 139 ft.
- Crest length of 266 ft.
- Reservoir with a capacity of 50,900 acre-ft
- Reservoir storage for irrigation

OBJECTIVE
Create a precipitation frequency curve for use as input into a rainfall-runoff model which will, in turn, be used to create a Hydrologic Hazard Curve. Flood peaks may then be compared with spillway discharge capacities to determine the risk of overtopping.

METHODOLOGY
Regional statistics calculated from the L-Moments method will be used to create the precipitation frequency curve. As a regional statistics method, this scheme allows space for time substitution (Hosking and Wallis 1997).

PRECIPITATION FREQUENCY
- Input – Annual maximum 1-day precipitation totals from the NWS COOP rain gauge network (determined from the NCDC Summary of the Day precipitation product)
- Region for statistical analysis – Area with similar climatological characteristics as that of the East Park watershed

STEPS TO COMPUTE PRECIPITATION FREQUENCY CURVE
1. The rain gauges with discordant data were removed to form a statistically homogeneous dataset.
   Total = 92 rain gauges, ~3,000 station-years of data
2. L-Moment ratios (L-Cv, L-skewness, L-kurtosis) were computed for the gauges in the dataset. These ratios were used to find a common set of distribution parameters, defining a single probability distribution function for the region (i.e. the regional growth curve).

   Generalized Logistic Distribution Parameters
   \[ \xi \quad \alpha \quad \beta \quad h \]

3. Scale the regional growth curve by a point precipitation value representative of East Park Dam to find the at-site growth curve. The areal average of the East Park watershed = 2.80" (the at-site growth curve for 24-hr precipitation)
4. The 24-hr at-site growth curve scaled to a 72-hr storm, based on historical record of extreme storms. Scale factor = 1.75 (Corrigan et al. 1999)
5. The 72-hr at-site growth curve scaled to the 100 mi² watershed. Scale factor = 90.25% (Corrigan et al. 1999)
6. The basin growth curve extrapolated from 3,000 years to the PMP.

REFERENCES


