LTRC

Special Studies

TECHNICAL SUMMARY

SUMMARY OF REPORT NUMBER 229

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Prediction of Flood Quantiles at Ungaged Watersheds in Louisiana

INTRODUCTION

There are many instances in the construction of highway drainage facilities where discharges must be estimated for sites at which stream gage records are not available. It is unlikely that a gage will be located at the precise site where a bridge or culvert is to be placed. In addition, discharge estimates are sometimes required at existing bridge sites where no records are available. The present method for obtaining discharge estimates at ungaged sites utilizes general regression relationships developed for Louisiana by the U.S. Geological Survey. These equations are known to contain a fair degree of error and have not been compared to alternate techniques. The purpose of this study was to formulate two alternate methods for obtaining discharge estimates at ungaged sites based upon the latest scientific information and to compare these methods with the USGS regression equations and the method recommended by the U.S. Water Resources Council. Based upon statistical comparison indices of descriptive capabilities, the superior method was chosen and formulated in such a way that it can be conveniently used by LADOTD engineers.

STUDY OBJECTIVES

The objectives of this study were:

1. To determine hydrologically and physiographically homogeneous regions within Louisiana.
2. Based upon observed streamflow data in each region, to select the superior regional flood frequency method from among the two component extreme values (TCEV), the generalized extreme value (GEV) and regionalized log Pearson Type 3 (LP3) distributions.
3. To formulate the selected method into a procedure which can be applied at ungaged sites.
4. To compare the procedure formulated in (3) with the current method used by LADOTD.
5. To verify the procedure using data not used in its derivation and formulation.

RESEARCH APPROACH

The state of Louisiana was divided into four homogeneous regions based upon topographical, geological, soil and climatic data. These regions were essentially delineated by the alluvia of the Mississippi and Red River systems. Since watersheds within homogeneous regions contain similar topographical features, soil characteristics and climatic variability, it can be assumed that the runoff responses of these watersheds would also be similar. Next, the streamflow records were collected for all long-term gages (more than 20 years) within these regions. These records were screened for anomalies and inconsistencies, particularly with regard to upstream diversions or regulation and lack of channel control. A total of 85 gage records remained after the screening process. An average of about 27 records remained in each homogeneous region, except for one region which was composed entirely of Mississippi alluvium and thus demonstrated very small relief and consequently a lack of channel control. Only 5 long-term gages were located in this region.

Regional frequency analyses were performed on the streamflow records for each region using the TCEV, GEV and LP3 as base distributions. The TCEV parameters were estimated using the maximum entropy procedure. The GEV was fitted by probability-weighted moments and indexed using the mean at each station. The LP3 was fitted using ordinary moments and a regional skew value estimated as the mean of the station skews in the region. The performance of each method was statistically evaluated using standardized root mean square error (SRMSE).

FINDINGS AND CONCLUSIONS

No one method demonstrated clear superiority in all regions based upon SRMSE. Each method was clearly inferior in one region, superior in one region and performed about equally well elsewhere. However, regionalization by the index method is considerably easier than the other methods. Based upon this criterion, the GEV index method was chosen as the base method of frequency analysis. In this method, a nondimensional regional distribution is derived and regional quantiles are generated from it. These quantiles are then converted to site-specific values by multiplying by the at-site mean. Thus, once the regional distribution is derived, it is only necessary to know the mean flood at the site of interest in order to derive all quantiles.

In order to apply the procedure at ungaged sites, a relationship between mean of the flood series and drainage area was developed for each region. This relationship is presented both in the form of equations and graphically. Thus, in order to determine the flood quantiles at any site, only the drainage area of the watershed is needed. Given this information, the mean flood at the site can be derived from the mean-drainage area relationship for that region and then all flood quantiles can be developed from the regional distribution. The procedure was compared to the USGS regression equations and demonstrated considerable improvement in terms of SRMSE. The method was also verified on 16 short-term gage records not used in its derivation and demonstrated SRMSE results as good or better than the original comparison to the data used in its derivation.

RECOMMENDATIONS

Based upon the successful results obtained from this study, it is recommended that LADOTD adopt the GEV index method for estimating flood quantiles at ungaged sites in the state. At the very least, it should be used as a check and comparison with the current procedure in design and analysis situations. However, it is important not to use this method outside of the regions for which it was developed. Principally, regions not suitable for its use are the coastal wetland areas and the regions comprised totally of Mississippi alluvium, particularly in the south-central area of the state. It is also not suitable for use on very small (less than 10 mi^2) drainage basins.