FLOOD FREQUENCY OF LARGE RIVERS IN SOUTHERN ARIZONA

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Report of Group 3 (Time Series)

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INTRODUCTION

Our group interpreted our assignment rather broadly. We discussed the availability and dependability of long-term rainfall and runoff records, circulation patterns, the variability of "fall" storms, climatic fluctuations versus climatic trends, the similarities between the 1926 and 1983 record runoff-producing storms on the San Pedro and Santa Cruz, respectively, and regionalization of flood frequencies in the Southwest.

RECOMMENDATIONS

(1) That there is a firm committment by the USGS, with strong support from other interested agencies, to continue the existing runoff-measuring stations in the Southwest, and to reestablish the Tucson station on the Santa Cruz River.

(2) That supplemental peak records be collected at appropriate ungaged sites in other streams and rivers in the Southwest to augment the records from existing stations. Such additional data would be helpful in estimating regional flood peak frequencies. In no case, however, should supplementary stations be operated at the expense of the existing stream-gaging networks.

(3) That NOAA representatives from the Salt Lake City Flood Forecast Center and the Hydrometeorological Branch, in Silver Spring, MD, be included in any future efforts of this group.

(4) That there will be a concerted effort by all governmental agencies involved in collecting hydrologic and meteorologic data to make the data available in compatible and easily accessible form.

(5) That we support the effort of Larry Hendersen, Federal Highway Administration, to organize a regional effort in estimating regional flood frequencies in the Southwest.

DISCUSSION

Precipitation

One of the principle problems in identifying possible effects of rainfall trends or fluctuations in runoff is that our longest rainfall records correspond to the period of migration of people and cattle into the Southwest. Some rangelands changed radically during this early period, and significant changes are still occurring in many; land that was once dominated by grass species has become brush-dominated. Gullies have replaced swales and meandering streams. Various researchers have ascribed the changes to such factors as overgrazing, the reduction of range fires, climatic change, and a combination of the three.

There are a dozen or so published long-term (over 100-yr) rainfall records for Arizona and New Mexico. However, only a few of these can be considered relatively error free, and only one (Ft. Bayard, NM) has been located in essentially the same location for the fall period of record. For the most part, long-term records are the result of combining two or more stations from different, but hopefully not too far removed, locations. Several of these combine the rainfall records from older military outposts with nearby stations in populated areas. In some cases, such as the University of Arizona and Las Cruces, such combined records may be fairly reliable. However, in most cases, the combined records are from stations that are too far removed, and/or have significantly different elevations.

The problem is that we cannot rely on rainfall records to confirm trends or climatic fluctuations affecting runoff, because almost all reliable rainfall records began well after man had begun to change the range and forest environment in the Southwest. Reliable shorter-duration rainfall records do not confirm or reject hypotheses for either rainfall trends or climatic fluctuations in the Southwest.

We identified "fall" storms as dominating flood frequencies in the Southwest, but we were unable to say if these storms were following a recognizable pattern, region-wide, or whether or not we could identify a trend in the occurrence and/or magnitude.

Fall Storms

We discussed the occurrence of major runoff-producing floods on the San Perdro and Santa Cruz Rivers. Both rivers are basically north flowing, with relatively narrow drainage basins. Flood peaks could be expected to develop similarly on each basin, since there are no major storage reservoirs on either drainage. In our discussion, we concentrated on the peak records from Charleston, on the San Pedro, and Tucson, on the Santa Cruz.

Flood frequencies on the San Pedro are dominated by peaks recorded between 1914 and 1932, including the record flood peak in late September, 1926. This period of above-average maximum annual flood peaks corresponds to an above-average period of rainfall at Tombstone, Arizona. Since 1932, the only major fall flood peak occurred in October, 1977. Major summer flood peaks were recorded in 1940 and 1954.

On the other hand, there were no major flood peaks recorded on the Santa Cruz from December, 1914 to 1930 (corresponding to the period of excessive runoff on the San Pedro), as well as 1930 through 1960. Since 1960, there have been six significant flood peaks on the Santa Cruz, including the record flood of late September/early October, 1983. The rainfall records from all Santa Cruz Basin stations indicate an increase in the magnitude (and possibly the incidence) of major September/October storms in the last 25 years.

There has been a documented change in the Santa Cruz drainage since records have been kept, and there is a strong suggestion of an upward trend in

flood peaks on the Santa Cruz. A corresponding increase in fall storm rainfall, however, clouds the issue (See later section on trends).

The record San Pedro and Santa Cruz floods appear very similar, although much more information is available for the 1983 storm (For one thing, we have had satellites to track tropical storms only since the mid 1960's). There was up to 12 inches of rainfall on the upper San Pedro drainage in the 1926 storm, with most of the rainfall concentrated in a 48-hr period. On the same dates, the Santa Cruz drainage recorded from 3 to 5.5 inches. The similarities suggest a similar flow pattern bringing moist tropical air into the region, but with the flow slightly displaced for the two events. The similar volume of rainfall in 1926 also suggests that fragments of a tropical storm may have been caught up in the circulation of moist air into southeastern Arizona.

We discussed the possibility of shifts in the flow patterns for major fall storms. Such a shift might be explained by some meteorological pattern of highs, lows, and tropical storm occurrence, along with changes in ocean surface temperature. These thoughts led to the recommendation that NOAA professionals should be included in future efforts of this group in any regional effort to estimate regional flood frequencies.

NOAA (or former NOAA) candidates who have been involved in hydrometeorological studies in the Southwest include Dr. Gerald Williams, Chief, Salt Lake City Flood Forecast Center, and E. M. Hansen, F. K. Schwarz, I. S. Brenner, J. E. Hales, R. J. Renard, and W. N. Bowman.

Trend Analysis

If all storms are included, there is a significant negative trend in the magnitude of annual maximum flood peaks on the San Pedro River at Charleston,

and a significant positive trend in the magnitude of annual maximum flood peaks on the Santa Cruz River at Tucson. If the 1926 storm is eliminated from the San Pedro record, there is still a slight, but statistically insignificant, negative trend in the annual maximum peaks. If the 1983 storm is eliminated from the Santa Cruz, there is still a significant positive trend in maximum annual peaks.

We agreed that we could not reach a definite conclusion, but we did agree that indications of a trend were stronger for the Santa Cruz than for the San Pedro. The San Pedro analysis also applies to the flood peak record on Whitewater Draw. The Whitewater Draw record is also dominated by the 1926 event and other flood peaks early in the record.

We concluded that we needed to maintain all existing runoff-measuring stations in the Southwest, and that the Tucson station on the Santa Cruz should be reopened. Also, flood peaks and volumes should be estimated by the USGS for the missing years of record.

Time Series Analysis

We spent some time discussing the relative merits of time series analysis and deterministic modeling. The two methods are, in some sense, supportive. Time series analysis is essential for frequency estimates, and deterministic modeling is particularly useful to estimate the effect of changing watershed characteristics and different input distributions. For example, a deterministic model might be very useful on an urbanizing watershed. Time series analyses would indicate flood frequencies for a stationary process, and the deterministic model could aid in estimating possible increases or decreases, for example, in the 100-yr flood if the process is not stationary (as may be the case on many drainage basins in the Southwest).

Again, we concluded that we need longer rainfall and runoff records, along with other geomorphic and topographic data, to verify or satisfy the various hypotheses that have been suggested for apparent changes in rainfall-runoff relationships in the Southwest.

Regionalization of Flood Frequencies

There was some discussion on the relative merits of the "index" method of regionalizing flood peak frequencies. Although there were proponents of each method, the concensus was that this was a less important problem than the uncertainty in the available data that has been used for regionalization. The concensus also was that regionalization is certainly worth considering, and may be the preferred method of the future for estimating flood peak frequencies in the Southwest. There was some sentiment for establishing one method of analysis, one distribution, etc. However, it was pointed out that designating Log Pearson Type 3 as the official governmental distribution did not convince anyone that it was the "best" distribution, either for general or specific cases. Stating a preferred method or distribution might be an option.

Regional Effort

Larry Hendersen (Federal Highway Administration) discussed the possibility of a regional research team effort to establish flood frequencies in the Southwest. He felt such an effort should extend across state and agency lines and include private concerns. It should not be restricted to a state-by-state analysis, but should be regional in nature. Such an effort would include state and federal agencies in California, Arizona, New Mexico, Nevada and, possibly, Utah. He admitted that there were difficulties in putting such a team together, but he felt the outcome would justify the effort. He said that

the current approach to research on flood peak freequencies in the Southwest had not been entirely satisfactory, and that a regional effort would be worthwhile.