CHAPTER 6

STAGE (ELEVATION) - FREQUENCY ANALYSIS

6-1. Uses. Maximum stage-frequency relations are often required to evaluate inundation damage. Inundation can result from a flooding river, storm surges along a lake or ocean, wind driven waves (runup), a filling reservoir, or combinations of any of these. Minimum elevation-frequency curves are used to evaluate the recreation benefits at a lake or reservoir, to locate a water supply intake, to evaluate minimum depths available for navigation purposes, etc. (Stages are referenced to an arbitrary datum; whereas, elevations are generally referenced to mean sea level.)

6-2. Stage Data.

a. The USGS WATSTORE Peak Flow File has, in addition to annual peak flows, maximum annual stages at most sites. Also, some sites located near estuaries have only stage information because the flow is affected by varying backwater conditions.

b. River stages can be very sensitive to changes in the river channel and floodway. Therefore, the construction of levees, bridges, or channel modifications can result in stage data that is non-homogeneous with respect to time. For riverine situations, it is usually recommended that the flow-frequency curve (Figure 6-1) and a rating curve (stage versus

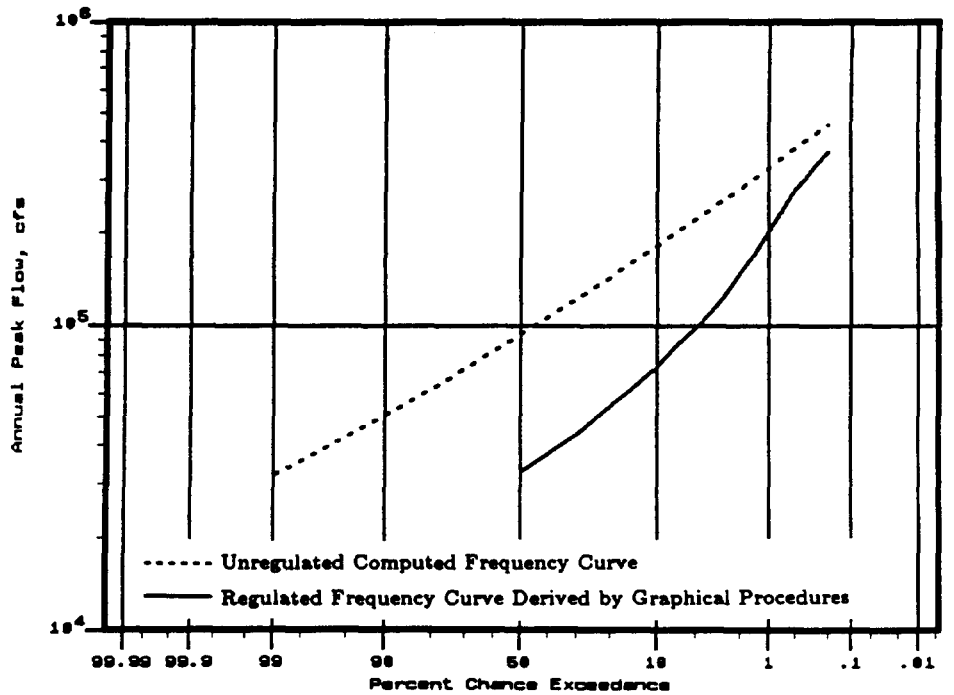

Figure 6-1. Flow Frequency Curve, Unregulated and Regulated Conditions.

flow, Figure 6-2) be used to derive a stage-frequency curve (Figure 6-3). A stage-frequency curve derived by indirect methods may not always represent the true relation if the site is subject to occasional backwater situations. Backwater conditions can be caused by an ice jam, a debris flow, a downstream reservoir, a high tide, a storm surge, or a downstream river. A coincident frequency analysis may be necessary to obtain an accurate estimate of the stage-frequency relationship (see Chapter 11).

c. Usually the annual extreme value is used to develop an annual series, but a seasonal series or a partial-duration series could be developed if needed. Caution must be used in selecting independent events. Independent events are not easily determined if the events are elevations of a large lake or reservoir; in fact even the annual events may be significantly correlated.

6-3. Frequency Distribution. Stage (elevation) data are usually not normally distributed (not a straight line on probability paper). Therefore, an analytical analysis should not be made without observing the fit to the plotted points (see Chapter 2). Usually, an arithmetic-probability plot is appropriate for stage or elevation data, but there may be situations where a logarithmic or some other appropriate transformation will make the plot more nearly linear. When drawing the curve, known constraints must be kept in mind. As an example, the bottom elevation, bankfull stage, levee heights, etc., would be important for a riverine site. The minimum pool, top of conservation pool, top of flood control pool, spillway elevation, operation criteria, etc., all influence the elevation-frequency relation for a reservoir, Figure 6-4. These constraints usually make these frequency relations very non-linear. Extrapolation of stage (elevation) frequency relations must be done very cautiously. Again, any constraints acting on the relations must be used as a guide in drawing the curves. Historical information can be incorporated into a graphical analysis of stage (elevation) data by use of the procedures in Appendix 6 of Bulletin 17B (ref 46). The statistical tests (Appendix 4, ref 46) to screen for outliers should not be applied unless the stage (elevation) data can be shown to nearly fit a normal distribution.

6-4. Expected Probability. The expected probability adjustment should not be made to frequency relations derived by graphical methods. The median plotting position formula corrects for the bias caused by small sample sizes. The expected probability adjustment should be made when an analytical method is used directly to derive the stage (elevation) frequency relation. The expected probability adjustment should be made to the flow-frequency curve when the stage (elevation) frequency relation is derived indirectly.

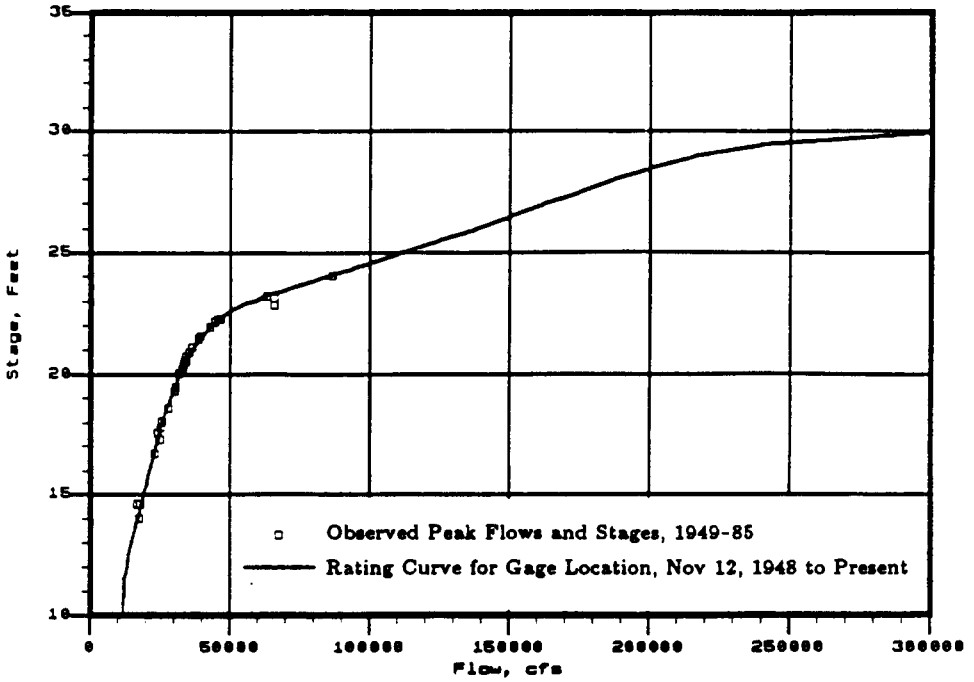

Figure 6-2. Rating Curve for Present Conditions.

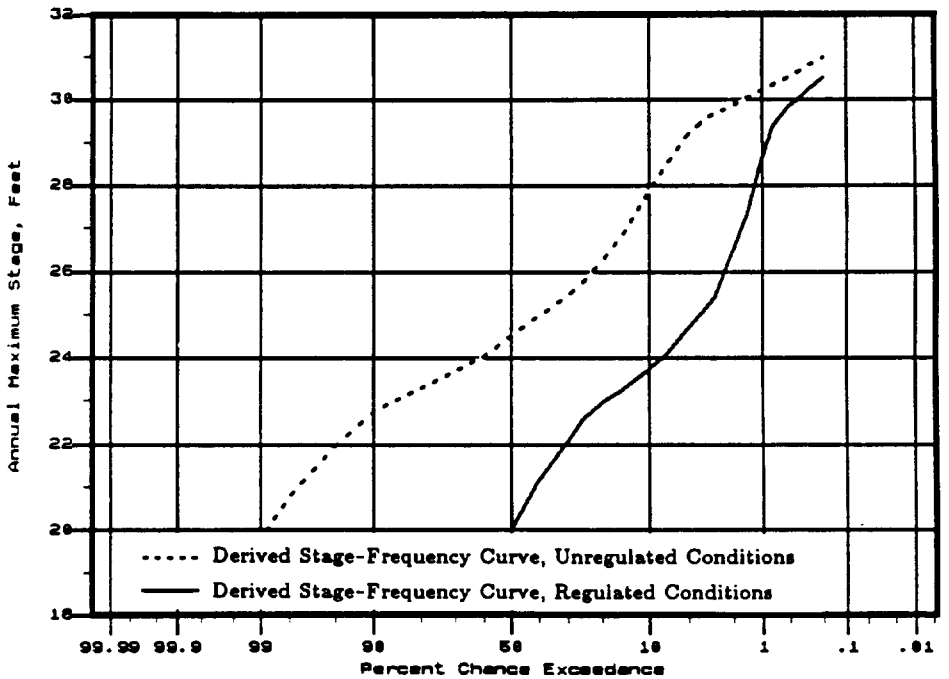

Figure 6-3. Derived Stage-Frequency Curves, Unregulated and Regulated Conditions

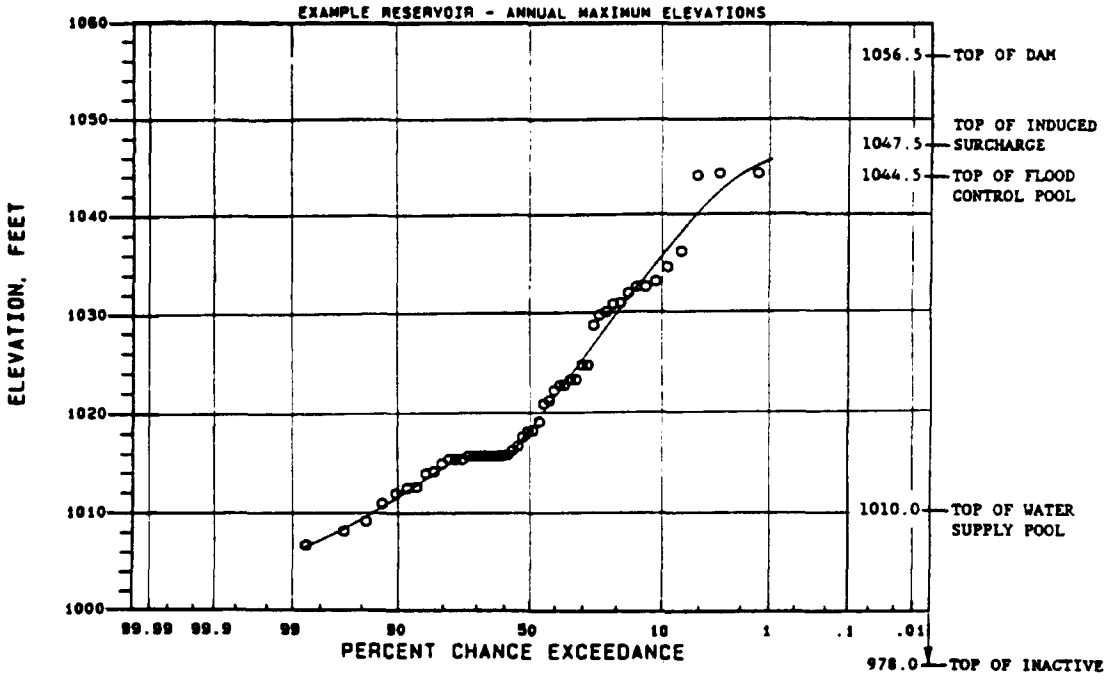

Figure 6-4. Maximum Reservoir Elevation-Frequency Curve.