Water: WARSSS

Hydrologic Processes: Bankfull Discharge

The term **bankfull** was originally used to describe the incipient elevation on the bank where flooding begins. In many stream systems, the bankfull stage is associated with the flow that just fills the channel to the top of its banks and at a point where the water begins to overflow onto a floodplain (Leopold et al. 1964). The bankfull stage and its attendant discharge serve as consistent morphological indices which can be related to the formation, maintenance and dimensions of the channel as it exists under the modern climatic regime. The terms effective and/or dominant discharge are synonymous with bankfull discharge as used in this procedure; see the federal manual Stream Corridor Restoration: Principles, Processes and Practices (FISRWG 1999) (PDF) EXIT Disclaimer for a detailed discussion of these three related concepts. Stream dimensions, patterns and bed features associated with the longitudinal river profile are generally described as a function of channel width as measured at the bankfull stage. Since streams are self-formed and self-maintained, it is important to relate measurable features one can identify in the field to a corresponding bankfull discharge. This definition of bankfull, however, applies primarily to stream types that have an observable floodplain feature, no matter how wide. Floodplains can be quite small and inconspicuous in certain stream types, where they may be naturally indistinct or presently being developed. Streams that are deeply entrenched in the landform do not exhibit significant changes in channel width as flood flows increase. With increasing flood stage, stream depth generally increases at a more rapid rate than the corresponding channel width. Bankfull stage can be observed and determined within the entrenched stream types by using a series of common stage indicators that are generally located along the boundary of the active channel.

A commonly accepted and universally applicable definition of bankfull was provided by Dunne and Leopold (1978): "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work results in the average morphologic characteristics of channels."

It is this discharge, along with the range of flows that make up an annual hydrograph, which governs the shape and size of the active channel. Bankfull discharge is associated with a momentary maximum flow that has an average recurrence interval of 1.5 years as determined using a flood frequency analysis (Dunne and Leopold 1978). Although great erosion and enlargement of steep, incised channels may occur during extreme fluvial events, it is the modest flow regimes that transport the greatest quantity of sediment material over time, due to the higher frequency of occurrence for such events (Wolman and Miller 1960). An example of the relationship between flow magnitude and frequency of flow occurrence is shown in **Figure 52**.

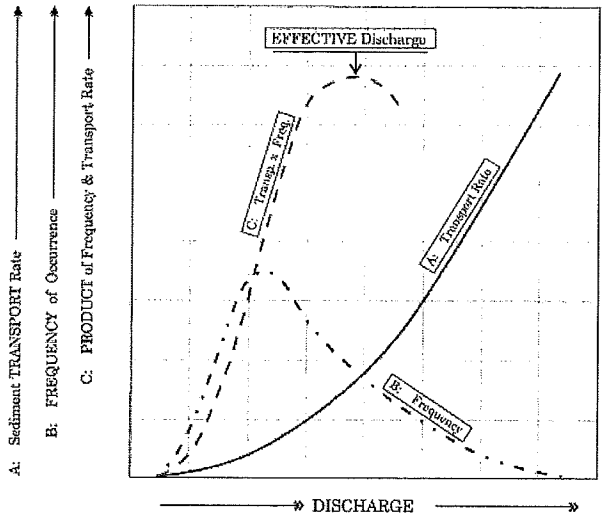

Figure 52. Relations between DISCHARGE, Sediment TRANSPORT Rate, FREQUENCY of Occurrence, and the PRODUCT of Frequency and Transport Rate (after Wolman and Miller 1960).

The dominant, effective or bankfull discharge is associated with the peak of cumulative sediment transport for a given streamflow magnitude and frequency of occurrence. The majority of work over time is accomplished at moderate flow rates as shown in **Figure 52**. The effectiveness of bankfull discharge and a discussion of dominant or effective discharge theory is summarized by Andrews (1980).

Recent analyses of peak flow data for gage stations on 47 rivers located in Ontario, Canada, indicated that their bankfull discharges have an average return interval of 1.6 years, with a range from 1.5 to 1.7 years (Annable 1995). There exists in the literature, however, a range of return periods for "bankfull discharge" from 1 to 25 years (Williams 1978). In the Williams study, however, there was not a clear distinction made by the author

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between the elevations of the low terrace and the active floodplain, which serves as the indicator of bankfull stage. The low terrace, by definition, is an abandoned floodplain. The flows necessary to over-top the low terrace bank must be associated with a flood of large magnitude, much larger than the actual bankfull discharge. A low terrace feature is often mistaken for an active floodplain by an untrained field observer.

An analysis of return periods related to field-determined bankfull discharge conducted by the author over the past 10 years and using data for gage stations located on rivers throughout North America indicates a range in return interval from 1.05 to 1.8 years. Exceptions to this finding appear to be associated with highly developed urban watersheds, where the return period of the bankfull discharge is closer to 1.1 year. Often, the U.S. Army Corps of Engineers field interpretation of "ordinary high water" and the bankfull stage are synonymous. Thus, one may conclude that the flow regime associated with bankfull discharge is a relatively frequent event.

Bankfull discharge is a key concept not only for properly classifying streams, but also to determine departure from reference conditions such as in the calculation of width/depth ratio. The width and mean depth measured for the width/depth ratio calculation are those dimensions at bankfull discharge.

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