# THE DEVELOPMENT OF BANKFULL HYDRAULIC GEOMETRY RELATIONSHIPS FOR STREAMS OF THE GEORGIA COASTAL PLAIN

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**Abstract.** Bankfull hydraulic geometry relationships, also known as regional curves, relate bankfull stream channel dimensions to watershed drainage area. Established regional curves are important to channel assessment and stream restoration efforts as they can confirm identification of bankfull stage and channel dimension in ungaged watersheds and help estimate the appropriate bankfull dimension and discharge for natural channel designs. In Georgia, stream restoration for mitigation purposes relies heavily on the use of natural channel design. This paper describes results of bankfull hydraulic geometry relationships developed for streams of Georgia's Coastal Plain and how the curve is being used for stream restoration purposes within Georgia. The relationships based on Georgia streams will be compared to relations from other Southeastern State coastal plains, in an effort to compliment and extend regional relationships. Results of this study will be discussed with particular attention to issues relevant to coastal stream restoration processes in the state of Georgia.

KEY TERMS: Natural Channel Design, Surface Water Hydrology, Fluvial Processes, Geomorphology, Regional Curves, Coastal Plain

## INTRODUCTION

The purpose of this study was to develop a regional curve for streams of the Georgia Coastal Plain. Regional curves relate bankfull channel dimensions to drainage area (Dunne and Leopold, 1978). Regional curves are used to identify bankfull stage and dimension in un-gaged watersheds and to help estimate bankfull dimension and discharge for natural channel designs.

## SITE SELECTION CRITERIA

After completion of an inventory of USGS gage sites and potential reference reaches, a field evaluation was conducted to locate sites eligible for the analysis. Site eligibility criteria were as follows:

1. Streams must be a single thread channel
2. Beaver activity, including dams, must not hydrologically impact the site
3. Stream channel must be free to naturally adjust its dimension, e.g. not armored by riprap
4. Streams could not have been recently dredged
5. Stream banks could not have recently undergone vegetation removal
6. Bank height ratios (lowest bank height divided by the bankfull maximum depth) must be less than 1.5 for gage stations and 1.2 for reference reaches
7. Gage station sites must have accurate, identifiable reference marks and gage plates
8. Discontinued crest gage stations must have verifiable reference marks
9. Land use is not rapidly changing (especially important for reference reaches).

A total of 105 USGS gages and 50 un-gaged streams were visited during the field assessment portion of the project. Most sites were rejected due to factors such as braided channels or incised streams that limited identification of the bankfull stage and corresponding descriptions of bankfull dimension.

## METHODOLOGY

To develop a statistically significant dataset twenty stable stream reaches were surveyed. Ten U.S. Geological Survey gage stations were selected with at least ten years of continuous or peak discharge measurements, no major impoundments, no significant change in land use over the past ten years, and less than 10% impervious cover over the watershed area. To supplement data collected in gaged watersheds, ten stable reference reaches in ungaged watersheds were also selected. These reaches also had no major impoundments, no significant change in land use over the past ten years, and less than 10% impervious cover over the watershed area.

Many stream restoration projects occur in small watersheds less than 26 square kilometers ($km^2$). However, most of the gage stations in Georgia are greater than 130 $km^2$. In addition, many gauged channels are impacted from road crossings and channel modification. Therefore, reference reach streams were included in the study. Rosgen (1994) defines a reference reach as a portion of a stream that represents a stable channel within particular valley morphology. For this study, we further defined the reference reach as a Rosgen C or E stream type with bank height ratios less than 1.2. The bank height ratio is defined as the lowest bank height divided by the bankfull maximum depth. A bank height ratio of 1.2 was used as a selection criteria to ensure that potentially incised streams were not included. Analyses were conducted on gauged and reference reach streams to determine channel dimension, pattern, profile, Rosgen stream type, stream characterization, and bankfull discharge.

A series of field measurements was conducted at each selected stream in order to classify the stream and determine key features for development of the regional curve. Cross-sectional and longitudinal surveys were conducted at each stream to determine the channel dimension, pattern, and profile for each stream. Bed material analyses were conducted to assist in stream classification and characterization after Bunte and Abt (2001). In addition, bankfull discharge was estimated for each reach following the methods described in USGS Bulletin #17B, "guidelines for Determining Flood Flow Frequency (USGS, 1982).

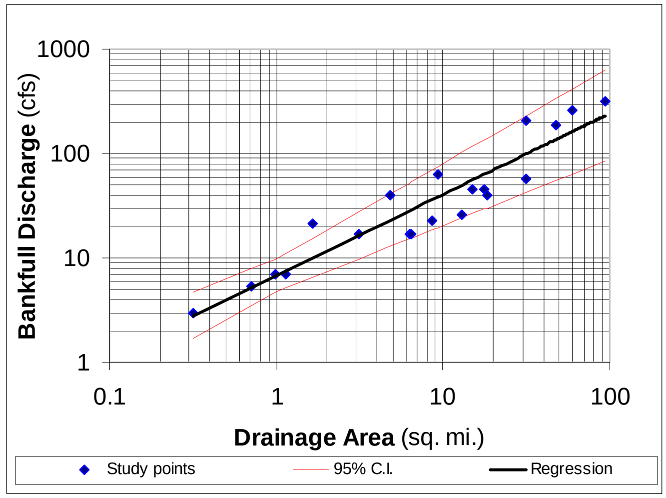
## RESULTS

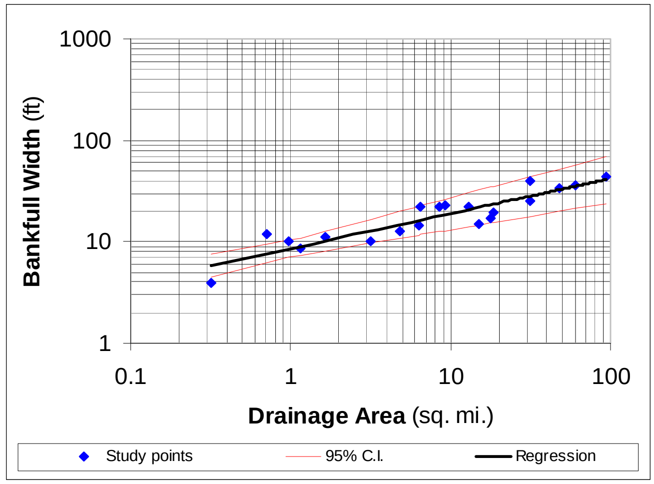
The relationships for bankfull discharge, cross-sectional area, width, and mean depth as functions of watershed area for the rural Coastal Plain of Georgia are shown below. These relationships were found to be linear on a log scale; therefore, a power function was utilized on the raw data. The 95% confidence intervals were also calculated for the regression equations and are shown in the figures below.

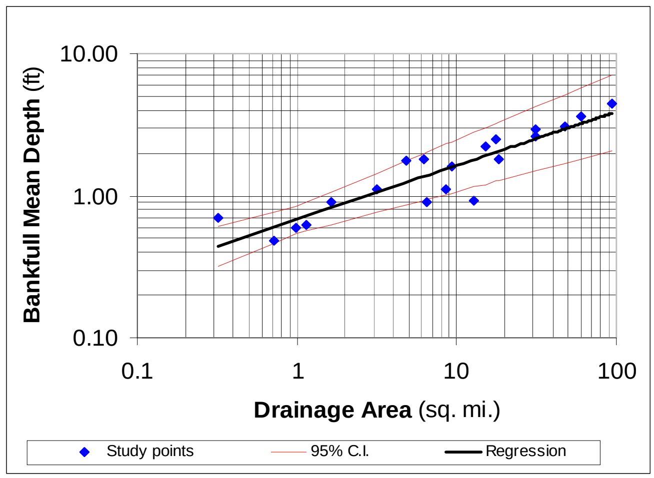
The power function regression equations and corresponding coefficients of determination for the regional curves are:

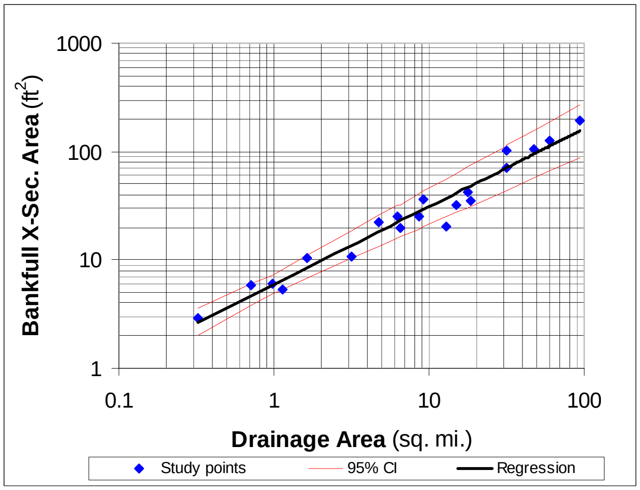
| | |
|---|---|
| Qbkf = 6.80 Aw0.78 | r2 = 0.88 |
| Abkf = 5.93 Aw0.72 | r2 = 0.96 |
| Wbkf = 8.59 Aw0.34 | r2 = 0.84 |
| Dbkf = 0.68 Aw0.38 | r2 = 0.83 |

Where Qbkf = bankfull discharge in cubic feet per second (cfs), Aw = watershed drainage area in square miles (sq. mi.), Abkf = bankfull cross-sectional area in square feet (ft2), Wbkf = bankfull width in feet (ft), and Dbkf = bankfull mean depth cross-sectional area in feet (ft).






CONCLUSIONS

This study found a strong relationship between bankfull relationships for area, width, mean depth, discharge, and drainage area in the rural Coastal Plain of Georgia. When used with appropriate caution and supported by other data, these regional curves can support stream assessment and restoration design.

Bankfull relationships of channel dimension developed in the upper and lower Coastal Plain are not significantly different. However, streams in the upper Coastal Plain demonstrated a significantly higher bankfull discharge than streams in the lower Coastal Plain.

Compared to streams in the North Carolina Piedmont and Mountains, streams in the rural Georgia Coastal Plain have relatively low bankfull discharge and area (Harman et al., 2000). This appears to agree with data from the North Carolina Coastal Plain (Doll et al., 2000). Return intervals for bankfull events are relatively short, on the order of one year.

It is possible that the streams in this study are single-threaded due to past land use and channel modification, and they are now evolving back to multi-channel systems. This theory is supported by the low bankfull stream powers, cross-sectional areas, discharge, and frequent return intervals (Schumann 1989). These results match well with research that describes Coastal Plain channels as aggradational with ample floodplain storage and infrequent avulsions. Since stream power is so low, the evolution from C and E to DA stream types will likely take centuries to complete. Nevertheless, this research provides a guide for designers to create Coastal Plain streams that will improve in function over time.

Further work is necessary to reduce the variability and improve the statistical strength of the regional curves. The twenty study sites fall within two physiographic regions and cover almost 77,700 km2. Clearly, additional data points would be useful in identifying possible local variability within the Coastal Plain. More discharge data are needed, especially in the lower Coastal Plain. Additional data may help to describe the channel evolution process from a C or E stream type to a DA stream type.

ACKNOWLEDGEMNTS

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