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Effective Discharges of Illinois Streams

by
David W. Crowder and H. Vernon Knapp

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Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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David W. Crowder and H. Vernon Knapp

Prepared by:
Illinois State Water Survey
Watershed Science Section
2204 Griffith Drive
Champaign, Illinois 61820-7495

A Division of the Illinois Department of Natural Resources

Prepared for the:
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

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Executive Summary

The hydrologic regime of a natural stream is usually highly complex and encompasses a wide range of discharges. The magnitudes and frequencies at which the various discharges occur play a key role in creating the channel's morphology. The concept of "dominant discharge" proposes that there exists a single steady discharge that, theoretically, if constantly maintained in a stream over a long period of time would form and maintain the same basic stable channel dimensions as those produced by the long-term natural hydrograph. This theoretical discharge is referred to as a stream's dominant discharge. If such a dominant discharge exists and can be accurately calculated, this discharge can be one of the tools that stream restoration personnel use to help design channels that are morphologically stable, i.e., not experiencing either excessive erosion or sediment deposition. There is no direct method to calculate a stream's dominant discharge, and stream researchers have commonly assumed that the dominant discharge can be equated with either the stream's bankfull discharge, a specific flood recurrence interval, or the stream's effective discharge. The purpose of this study is to analyze the available data and existing computational methods for the third approach, that being the estimation of effective discharges specific to Illinois streams.

The effective discharge of a stream is defined as the single discharge rate that carries the most sediment over time. Note that the effective discharge is not typically a discharge associated with the most extreme flood events, which may carry large amounts of sediment load but occur infrequently. Instead it is commonly considered to be a moderately high discharge having a more modest load, but occurring frequently enough that in the long-run it carries more sediment than the extreme flood events. To facilitate computations, the effective discharge is estimated as occurring within a discharge class or increment, rather than as a single discharge. Effective discharge can be estimated using data on suspended sediment load, bed load, bed material, or total sediment load, with the method of estimation depending on the sediment transport characteristics of the stream, available data, and, to some degree, the researcher's school of thought. For this study, estimates of effective discharges are based on the suspended sediment load, which is the dominant load in most Illinois streams.

Suspended sediment data collected at 88 gaging stations within Illinois were analyzed to determine which gaging stations in Illinois currently have sufficient suspended sediment data available to estimate effective discharges. A procedure was adapted from previous research and implemented to compute effective discharge values for each stream location having sufficient suspended sediment data. For each of those gaging stations, an estimate was made of the flow frequency at which the effective discharge was equaled or exceeded. For stations having adequate sediment data, flood recurrence intervals associated with effective discharge values were computed using annual maximum flow data. Correlation coefficients (r^2) for 12 linear regressions are presented to describe the relationship between six effective discharge parameters and channel slope and watershed area.

The data from 20 of the 88 gaging stations were deemed sufficient for computing effective discharge values. These 20 gaging stations were located on streams with watershed areas ranging from 244 to 6363 square miles (mi^2). The relatively large watershed areas allow use of mean daily discharge values in computing effective discharge values. The annual

maximum series analysis indicated that recurrence intervals associated with effective discharges found at these stations ranged from less than 1.01 years to 1.23 years. Such recurrence intervals are on the low end of the 1- to 3-year recurrence intervals commonly reported in other studies. However, these recurrence intervals are representative of Illinois' larger watersheds, and recurrence intervals of effective discharges in smaller Illinois watersheds could be quite different. Of the 20 qualified stations, 20 percent had effective discharge estimates that were less than the station's average mean daily discharge. Such low magnitude flow events are not usually associated with a stream's dominant discharge. Thus, geomorphic assessments and bankfull computations are required to further assess whether these and other effective discharge values are representative of the 20 individual streams' dominant discharges. Due to the small sample size, regression analyses relating specific effective discharge parameters to channel slope and watershed area were inconclusive.

Effective discharge computations are particularly sensitive to how the sediment rating curve used in the computation is developed and the number of discharge classes used in the computation. The sampling frequency and duration over which the sediment samples used to create sediment rating curves also may influence effective discharge computations significantly. Thus, while stream restoration personnel will likely continue to use these and other effective discharge values as part of several tools in hydraulic and channel design applications, uncertainties in their use should be acknowledged and undue weight should not be assigned these values, as they cannot yet be expected to yield fully reliable results in applications. Like previous researchers, we recommend more comprehensive investigations that compare effective discharge estimates to bankfull discharges in combination with a geomorphic assessment of each stream's characteristics to yield a better understanding of whether currently computed effective discharge values adequately represent dominant discharges in Illinois.

Suspended sediment represents the dominant sediment load in most Illinois streams. In some cases, effective discharge computations based on total loads or bed material loads may be more appropriate than using suspended sediment loads analyzed here. However, the bed load, bed material, bank material, local channel slope, and channel cross-section information required to perform these computations and analyses are almost nonexistent. While many of these data can be collected at selected stream locations, inherent difficulties in estimating bed loads in Illinois streams make this approach unfeasible. New technologies for sampling or estimating bed load most likely would need to be developed and tested.

This analysis presents a comprehensive assessment of effective discharges based on the available suspended sediment and flow data in Illinois. Long-term sediment data sets are needed at more stream locations to more fully estimate and understand effective and dominant discharges in Illinois streams. The greatest need for additional data is for smaller watersheds less than approximately 200 mi^2 because most potential applications of the effective discharge concept in stable channel design are for smaller watersheds. Smaller watersheds also may have significantly different geomorphic characteristics and effective discharges may behave differently than those in larger watersheds. The Illinois State Water Survey currently is measuring suspended sediment at gaging stations on 13 small watersheds, which could prove very useful in effective discharge analysis as longer data records become available at these sites.

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Glossary of Terms

The following terms are defined for the purposes of this report.

Bankfull discharge – A generic term for the full discharge that a stream can convey within its banks. Note that different researchers define what constitutes "bankfull" differently (Williams, 1978).

Discharge class (or bin) – One of the equally sized discharge increments into which a gaging station's flow range is subdivided during an effective discharge computation.

Discharge class value (or bin value) – The discharge value assigned to a particular bin or discharge class. The discharge value assigned is the average of the uppermost and lowermost discharges defining the bin.

Dominant discharge – A single steady discharge that if constantly maintained in a stream over a long period of time would form and maintain the same basic stable channel dimensions as those produced by the long-term natural hydrograph (see Inglis, 1949).

Effective discharge – The single discharge rate that carries the most sediment over time. Note that the effective discharge is not typically a discharge associated with the most extreme flood events, which may carry large amounts of sediment load but occur infrequently. Instead it commonly is considered to be a moderately high discharge having a more modest load, but occurring frequently enough that in the long-run it carries more sediment than the extreme flood events. To facilitate computations, the effective discharge is estimated as occurring within a discharge class or increment, rather than as a single discharge.

Larger streams – Streams or rivers for which it was judged that daily mean discharge data could be used to accurately determine flow frequency values (with watershed areas generally above 200 square miles).

Smaller streams – Streams or rivers for which it was judged that sub-daily discharge data would need to be used to accurately determine flow frequency values (with watershed areas generally below 200 square miles).

Stable channel – An alluvial or self-formed channel for which the characteristic dimensions and features do not change over engineering time scales (Thorne et al., 1996). This definition allows for channel evolution over long-term time scales; and for short-term fluctuations, such as those caused by a major flood or other events, that may interrupt channel stability and from which the channel has to recover. No excessive erosion or deposition occur in a stable channel, and these processes are generally in equilibrium (Watson et al., 1999), which allows the stream's morphological conditions to remain relatively constant over time.

Effective Discharges of Illinois Streams

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Introduction

The purpose of this study was to analyze the available data for estimating effective discharges in Illinois streams, and apply and adapt established computational methods for estimating effective discharges where sufficient data was available. The application of the dominant and effective discharge concepts is one of several tools in stream restoration that are still undergoing development, and it is expected that the analyses presented herein will be highly useful to stream restoration personnel in gaining a better understanding of the data needs and application issues associated with effective discharges. A review of some of the basic concepts associated with dominant and effective discharges are presented below. The scope of study does not include hydraulic and geomorphic assessments of sites needed to validate the appropriateness of these estimates with regard to stable channel design.

Channel Stability and Dominant Discharge

Stream engineers and geomorphologists define stable channels as dynamic entities. Thorne et al. (1996) define stable channels as either "dynamic" or "moribund," but the latter category is typically a stream where the channel is a relic formed by a prior hydrologic regime. According to Thorne et al. (1996), "a dynamically stable stream is one where the channel is alluvial, or self-formed, and where the characteristic dimensions and features of the channel do not change over engineering time scales." This definition allows for channel evolution over long-term time scales; as well as for short-term fluctuations, such as may be caused by a major flood or other events, that may interrupt channel stability and from which the channel has to recover. In a stable channel there is no excessive erosion or deposition and these processes are generally in equilibrium (Watson et al., 1999). Within this equilibrium, a stable channel has the potential to migrate laterally, creating erosion of one bank and deposition along the other.

Over the last few decades, the concept of dominant discharge and its use in evaluating channel stability has received much attention (e.g., Andrews, 1980; Ashmore and Day, 1988; and Castro and Jackson, 2001; Wolman and Miller, 1960). This concept assumes that a single steady discharge that if constantly maintained in a stream over a long period of time would form and maintain the same basic stable channel dimensions as those produced by the long-term natural hydrograph (FISRWG, 1998). Under this assumption, a channel designed to carry a stream's dominant discharge and pass the same amount of sediment that enters the reach under this discharge should be stable over time. Consequently, many believe that knowing a stream's dominant discharge is an important component of channel restoration work.

Three basic methods are available for estimating a stream's dominant discharge. The first method assumes that a stream's dominant discharge is equal to the discharge that the stream carries at bankfull conditions. Different researchers define and compute bankfull discharge differently. Williams (1978) describes various definitions of bankfull and approaches of estimating bankfull discharge. In this document, no specific definition of bankfull is used, nor are any bankfull discharges computed. Instead, bankfull discharge is discussed only in generic terms; full discussion of the application of bankull discharge and its relation and use in dominant discharge theory are beyond the scope of this report.

A second approach assumes that a stream's dominant discharge is the discharge within the stream having a specific recurrence interval. The exact recurrence interval used can be based upon recurrence intervals associated with bankfull and/or effective discharge values computed in streams similar to the one being studied or an average bankfull/effective discharge recurrence interval. Recurrence intervals for bankfull and effective discharges between one and two years are commonly reported (e.g., Castro and Jackson, 2001; Williams, 1978; and Wolman and Miller, 1960).

The third approach assumes that the stream's dominant discharge is equal to the discharge that, over the long term, carries the most sediment load within a stream. This discharge is referred to as the effective discharge. However, like bankfull discharge, different researchers compute a stream's effective discharge differently (e.g., Ashmore and Day, 1988; Andrews, 1980; and Biedenharn et al., 1999). A brief discussion of some of these approaches appears in the next section.

Considerable effort has been spent on comparing results and advantages of various methods used to compute dominant discharge. Andrews (1980) observed that effective and bankfull discharges were nearly the same for 15 gaging stations within the Yampa River basin of Wyoming and Colorado. However, other results (Benson and Thomas, 1966; and Pickup and Warner, 1976) indicate that bankfull and effective discharges may be significantly different. Research also has shown that recurrence intervals for effective and bankfull discharges can vary substantially from stream to stream (e.g., Williams, 1978; and Nash 1994). This variability suggests that using an average bankfull or effective discharge recurrence interval for dominant discharge may not always be appropriate (e.g., Williams, 1978; and Nash 1994). Moreover, watershed area, topography, and hydrologic regimes may influence bankfull and dominant discharges in specific ways (Ashmore and Day, 1988; and Castro and Jackson, 2001, among others). No current consensus exists on the relationships or differences between bankfull discharge, effective discharge, and specific recurrence intervals. Due to this lack of clarity, Copeland et al. (2000) recommend that, if possible, all three approaches of determining dominant discharge be computed at a particular stream location and that field indicators be used to determine which method seems most appropriate.

Using Dominant/Effective Discharge Estimates

Once a stream's dominant discharge has been estimated, many stream restoration personnel use this value to try to design a morphologically stable channel configuration.

Specifically, they can compute depths, velocities, shear stresses/tractive forces, and sediment transport rates within various channel configurations under the stream's estimated dominant discharge. Based on these results, the most stable channel configuration under dominant discharge conditions is selected for design. Consequently, if a poor estimate of the stream's dominant discharge is used, depths, velocities, and shear stresses within a specific stream may be under- or overestimated dramatically, leading to excessive erosion or deposition that affects the design reach, and possibly upstream and downstream reaches as well. Moreover, Simon and Darby (1999) argue that there are certain cases in which designing a channel based on a single dominant discharge cannot yield a stable channel configuration. It also should be noted that effective discharge should be computed at stable channel reaches and not within incised (unstable) streams (e.g., Biedenharn et al., 1999; and Simon and Darby, 1999). Unfortunately, many of the streams for which effective discharge values are needed are incised. For the above-mentioned reasons, design of channels using dominant discharge theory remains problematic and currently cannot be expected to yield reliable hydraulic design (Copeland, et al., 2000).

Effective Discharge Computations

Effective discharge is a specific application of the magnitude-frequency analysis described by Wolman and Miller (1960). In this analysis, two curves are generated: a sediment load curve describing the amount of sediment carried by various discharges within a stream, and a flow frequency curve describing the frequency of various flows within a stream. Multiplying the two curves yields a load histogram curve that quantifies the relative loads carried by different discharges over time. The discharge value or increment of discharge that carries the most sediment load over time (coinciding with the peak of the load histogram curve) is referred to as the effective discharge. The flow frequency, sediment load, and load histogram curves of a sample effective discharge computation are shown (Figure 1). Depending on the researcher, flow frequency, sediment load, and load histograms can be expressed in different units. In this report, flow frequency is expressed as the percentage of time (number of days that discharges occur within the various discharge classes divided by the total number of days for which mean daily discharge measurements were available). The sediment load curve is reported in tons/day. The load histogram is reported as percentage of load carried, which is computed by summing the total load carried by each discharge class and then dividing the amount of sediment carried by each discharge class by this value.

While computing effective discharge is conceptually simple, several methods exist to obtain and then multiply sediment and frequency curves. Differences among the methods include: how sediment load curves are developed, the time base used in establishing frequency and sediment rating curves, and how flow frequency and sediment load curves are multiplied together. Often, the method adopted depends on the specific stream being studied and discharge and sediment data available at that location. Differences in these methods have the potential to cause effective discharge values to be fundamentally different and incomparable with those of other researchers.

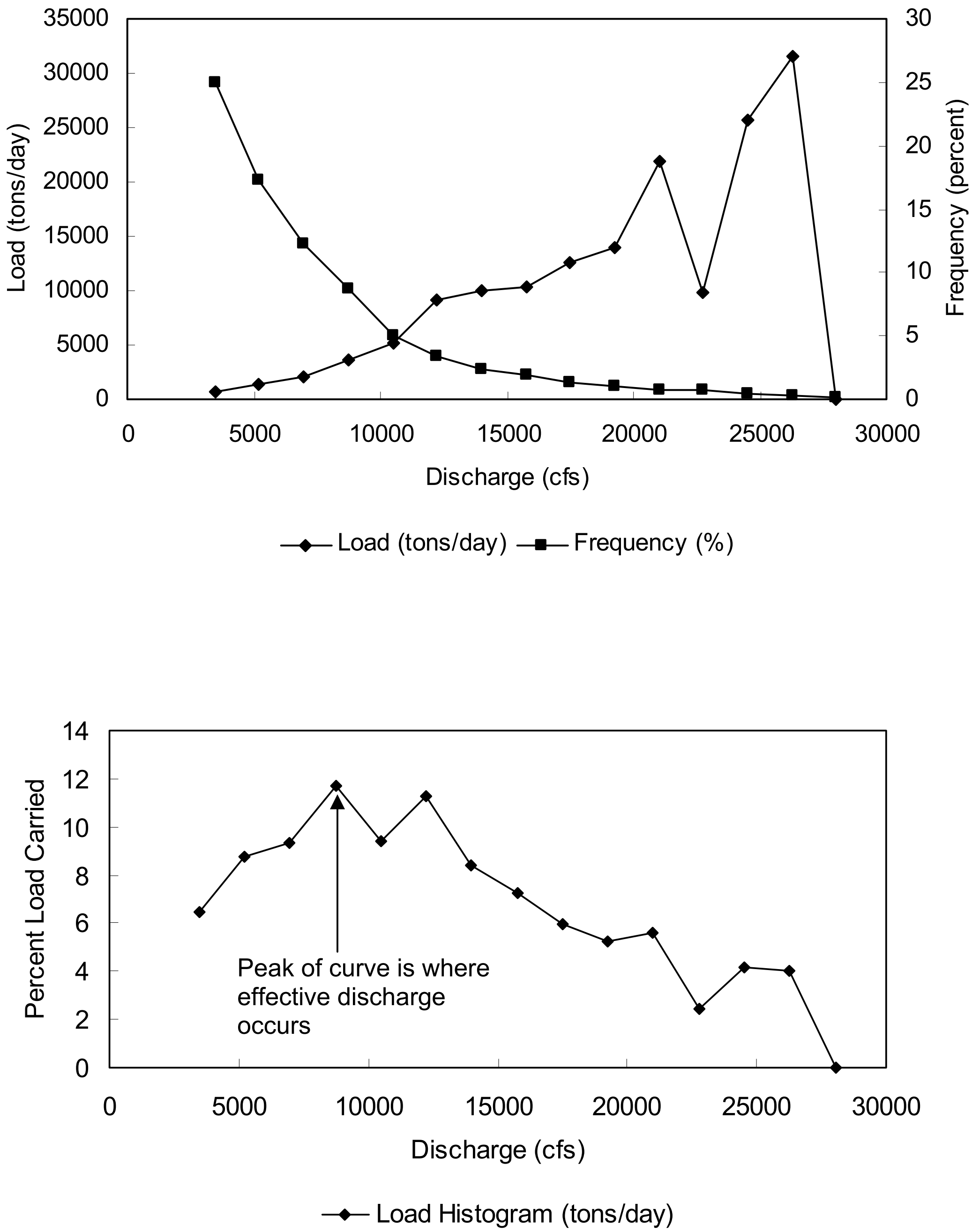

Figure 1. Sample effective discharge computation: flow frequency and sediment load curves (top) load histogram curve (bottom).

Sediment Load Curves

Different researchers often use fundamentally different sediment rating curves in computing effective discharge. Ashmore and Day (1988), among others, used suspended sediment loads. In contrast, Andrews (1980) used total load (bed load plus suspended load), while Pickup and Warner (1976) used bed load. Biedenharn et al. (1999) recommend using a bed material load, which consists of all bed load and the proportion of bed material that moves in suspension. Exactly how these different approaches compare to one another is not clear and may, in part, depend on the particular stream being analyzed.

Computational Time Base

Discharge and sediment data are developed from measurements that are typically collected instantaneously or over short time periods. These instantaneous measurements are typically processed to compute mean daily values, in which form the discharge and sediment data are often published. In effective discharge computations, discharge and sediment data need to be analyzed using methods that accurately sample and reflect the entire range of flows and sediment loads within a stream. When only mean daily values are available for analysis, variabilities that occur within any 24-hour period are lost. For larger streams, for example, the Kaskaskia and Rock Rivers in Illinois, the amount of variability within any 24 hours is expected to be relatively small. Consequently, flow frequency records based on mean daily discharge values combined with mean daily sediment load estimates adequately will characterize the range of discharges and sediment loads within these larger streams (Biedenharn et al., 1999). In contrast, storm hydrographs in smaller streams, such as those in watersheds draining less than 100 square miles (mi^2), may rise and fall within several hours. In such smaller streams, mean daily discharge values do not reflect the rise and fall in flow conditions or the variation in sediment loads associated with these flows. In these cases, instantaneous data or data based on short time intervals should be used to accurately represent the relationship between flow and sediment load. This can be accomplished by using 60-, 30-, 15-, or 5-minute discharge data to describe a stream's flow frequencies and instantaneous sediment load data to derive a sediment rating curve with a corresponding 60-, 30-, 15-, or 5-minute time base (Biedenharn et al., 1999). To date, most effective discharge computations have been based on flow frequency curves derived from mean daily discharge.

Creating Sediment Load Histograms

Effective discharge is computed by multipling the flow frequency curve by the sediment load curve to obtain a sediment load histogram. Two basic approaches exist for performing this computation. The first approach assumes that a stream has a log-normal flow frequency distribution and a sediment load curve that is well described by a power curve function. The two curves are multiplied analytically to obtain the sediment load histogram and its peak value. This procedure was conceptually outlined by Wolman and Miller (1960) and examined in detail by Nash (1994).

The second approach [used by Benson and Thomas (1966), among others] subdivides a stream's entire discharge record into a series of equal bins (or discharge classes) and computes the frequency of flow events within each bin. A sediment-discharge relationship is then established, typically, but not always, using a power curve function. Using the derived sediment-discharge relationship, the mean discharge value within each bin is assigned a sediment transport rate and multiplied by the frequency of discharges within that bin. The resulting load histogram graphs the relative amount of total sediment load carried within each bin over time, with the effective discharge associated with the bin carrying the most load.

Both methods have drawbacks. In the first approach, log-normal frequency distribution may not always be appropriate. Nash (1994) performed a chi-square analysis for 55 streams and found that the log-normal distribution generally fit the various streams' flow data well, but no comparisons were statistically significant at the 99 percent confidence level. Moreover, Ferguson (1987) points out that using a power curve to establish sediment rating curves creates a bias that results in underestimating sediment loads and ultimately a stream's sediment yield. As discussed later, the underestimation of sediment loads and sediment yields may influence stream restoration design significantly even though Nash (1994) points out that the power curve's bias will not affect the effective discharge value if the power curve fits the data well over the entire discharge range and sediment load hysteresis loops are symmetrical.

When a power curve is used to establish the sediment rating curve, the second approach, like the first approach, tends to underestimate sediment transport loads and long-term sediment yields. An additional problem with the second approach is choosing the number of discharge classes (bins) used to subdivide frequency and sediment rating curves. Sichingabula (1999) demonstrated that effective discharge values are particularly sensitive to the number of discharge classes used, and that no specific number of class discharge intervals can be used to define the effective discharge objectively. Subsequently, Sichingabula also recommended discontinuing this traditional means of computing effective discharge. Nevertheless, this approach continues to be the more standard one for computing effective discharge. Biedenharn et al. (1999), among others, recommended ways to reduce the subjective nature of determining class discharge size. Moreover, it is not necessary to assume that flow frequencies are log-normally distributed, or that the sediment-discharge rating curves follow a power curve when using this approach.

Discharge and Sediment Data Needs

The flow frequency data required to compute effective discharge values often are computed from discharge data collected at streamgaging stations. In many cases, gaging stations have relatively long discharge records (> 10 years). However, until recently, most discharge data have been recorded and made available in terms of mean daily discharge values. Consequently, most discharge records are more suitable for computing effective discharge values for streams in relatively large, nonflashy watersheds.

Of the rather large number of gaging stations collecting discharge data, only a few also collect suspended sediment samples. Suspended sediment data and discharge records from those stations often can be used to compute effective discharge values (based on suspended sediment rating curves) for stream locations at or near the gaging location. Unfortunately, very few stations also monitor bed load transport rates. Consequently, to compute effective discharge using bed load, total load, or bed material rating curves, one cannot use gage data alone. Instead, empirical bed load transport equations such as those described in standard sediment transport books (e.g., ASCE, 1975) must be used to help estimate bed load transport rates and develop the desired sediment rating curve.

The accuracy of effective discharge computations using streamgaging data will depend, in part, upon the type and amount of data collected at a particular station. Often the amount and type of data used to compute effective discharge differs between researchers. For example, Andrews (1980) assumed that 5 or more years of discharge data were sufficient to develop the flow frequency values needed to compute effective discharge, whereas Biendenharn et al. (1999) recommend using at least 10 years of discharge data. Biedenharn et al. (1999) also recommend using care in computing frequency curves based on discharge records longer than 25 years to avoid hydrologic changes (due to watershed development, etc.) within the discharge record.

The amount of sediment data used by researchers to derive sediment rating curves also differs. Andrews (1980) evaluated total load using gaging stations with 25 or more suspended sediment samples and empirical bed load values to compute effective discharge values. In contrast, Ashmore and Day (1988) evaluated suspended sediment using daily suspended sediment records up to 21 years in length in their computations. Unfortunately, such information does not specifically address how frequency, duration, and range of discharges of sediment samples collected at a gaging station influence sediment rating curves and concomitant effective discharge computations.

The frequency and duration over which suspended sediment samples collected at a gaging station will influence the accuracy of quantifying loads carried by various discharges within a stream. The longer the sample duration, the greater the likelihood of sampling more extreme events. More frequent sampling increases the likelihood of sampling sediment loads characteristic of short-duration storm events and capturing the natural variability of sediment concentrations that occur at similar discharges. Hence, sampling suspended sediment concentration once a week over five years may generate a significantly different sediment rating curve than sampling once a week and periodically throughout storm events over the same time period. The authors are unaware of any guidelines for determining how frequently and over what duration of time sediment samples should be collected at a particular gaging station in order to accurately compute effective discharge. Hence, subjective determinations, on a site by site basis, are necessary to assess whether a station has sufficient sediment data to capture the range of discharges and sediment transport variability within a stream before computing an effective discharge.

The sediment rating curves used in computing effective discharge, depending on the available data, may be derived strictly from actual sediment sample data or from sediment sample data and estimates based on an interpolation procedure such as that used by Ashmore and Day (1988) to create continuous daily suspended sediment records. In both methods, sampling frequency and duration may influence the resulting sediment rating curves and effective discharge computation. For this reason, a 1-year mean daily sediment load record (365 points) that employed linear interpolation to estimate load values for most days may be quite different than a 7-year record of actual sediment samples taken once a week (364 samples). Therefore, rating curves developed with the same number of data points, but collected or estimated in different fashions, also may be significantly different.

Study Objectives

The major objectives of this study follow:

- Based on currently available suspended sediment concentration and discharge records, apply and adapt existing procedures to estimate effective discharges for Illinois streams.
- Estimate effective discharge values for Illinois gaging stations having sufficient sediment and flow data.
- If possible, use computed effective discharge results to propose a potential method of estimating effective discharges at ungaged locations within Illinois.
- Determine additional monitoring necessary to better estimate effective discharge values for various regions and types of streams within Illinois.

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Other ISWS staff assisted in the preparation of this report. Technical comments and guidance provided by Mike Demissie, head of the ISWS Watershed Science Section, and Laura Keefer were helpful in defining key issues regarding effective discharge. Karla Andrew provided database management and computer programming support. Eva Kingston edited the report. Finally, the efforts of Don Roseboom, formerly of the ISWS, who proposed the idea of studying effective discharge in Illinois, are appreciated.

Suspended sediment records used in the analyses were collected and provided by the U.S. Geological Survey (USGS) and the ISWS Benchmark Sediment Monitoring Program. David Soong, USGS, graciously provided annual maximum series estimates used for computing effective discharge recurrence intervals of Illinois streams.

Any opinions, findings, and conclusion or recommendations expressed in this report are those of the authors and do not necessarily reflect those of the IEPA or the ISWS.

Study Methodology

Available Data

Discharge and suspended sediment data used in this project originally were collected by the U.S. Geological Survey (USGS) or the Illinois State Water Survey (ISWS). When these data are combined, discharge frequency and sediment rating curve data exist for 88 different sites throughout Illinois. Thirteen additional ISWS gaging sites currently are collecting discharge and sediment data that also may be suitable for computing effective discharges in the future. The 1- to 2-year discharge and sediment records currently available for these stations are not sufficient for analysis, and thus were not included in the study.

The estimation of effective discharges in this analysis was based on two basic assumptions. It was assumed that suspended sediment load (versus total, bed load, or bed material load) can be used to compute effective discharge for these 88 stations. It also was assumed that the streams have been morphologically stable over the entire period of the discharge record. As will be discussed later, much of the available data are from streams with watersheds areas greater than 500 mi^2, which are commonly but not always stable in Illinois. However, the scope of work does not include the validation of either of these assumptions.

The amount and types of discharge and suspended sediment data collected at the different gaging stations varied greatly, depending on the agency involved in collecting the data and underlying stream monitoring programs. In most cases, the suspended sediment sample data available at a gaging station were collected over a much shorter period than that over which discharge data were collected. A discussion of some additional differences in the types and amounts of data available follows.

Mean Daily and Instantaneous Data

The USGS discharge data are based on stage records collected every 60, 30, 15, or 5 minutes, depending on the variability of flows. From these records, mean daily discharge values are estimated and reported by the USGS. For many years, USGS monitoring stations reported only mean daily discharge. However, unit stage values collected at gages and their corresponding unit (or instantaneous) discharge estimates also are now readily available for the past seven years of record, since Water Year 1994. Mean daily flows must be used for analysis of periods prior to 1994.

Consistent with the recording of mean daily discharges, the USGS reports suspended sediment load data as mean daily loads. Instantaneous suspended sediment concentrations used in estimating USGS mean daily loads are not readily available, particularly for older records. The manner in which a mean daily load is estimated or computed may differ, depending on the stream and flow events being sampled. On days that a stream's discharge is not changing significantly, a single unit (or instantaneous) suspended sediment concentration sample and its corresponding unit discharge may be used to estimate the mean daily suspended sediment load. During some storm events, several instantaneous suspended sediment concentration samples may be used to estimate mean daily suspended sediment load. Yet, on other days, no actual sediment sample may be collected, and the mean daily sediment load will be estimated based on sediment measurements taken on days other than the day for which the estimate is being made. To our knowledge, there are no studies to estimate the accuracy of USGS mean daily loads based on these methods. Such an evaluation was beyond the scope of this study and may not be feasible using only Illinois data.

Discharge Data

The USGS reports mean daily discharge for each of the 88 Illinois streamgaging stations at which suspended sediment samples also have been collected. Unit value discharge records are available for the last 7 years at 73 gaging stations; the remaining 15 stations were discontinued prior to 1994. The 88 gaging stations in this study represent streams having watershed areas from 2.4 mi^2 to 26,743 mi^2. As previously discussed, mean daily discharge records are best suited for describing flow frequencies of large streams where discharge values are not likely to change significantly within a day. For the purposes of this study, the size threshold between larger watersheds and smaller watersheds is considered to be 200 mi^2. As discussed later, this threshold is consistent with the watershed size above which flow frequency curves based on mean daily flows and unit discharge values are essentially identical.

Smaller watersheds in this study are likely to have flows that vary diurnally during runoff events, and mean daily discharge values are not likely to accurately describe their flow frequencies. Hence, the USGS unit discharge records are probably a more suitable means of obtaining flow frequencies for smaller streams. These records are typically less than seven years in length and are not available for every station. For stations that have both unit discharge records and a relatively long mean daily discharge record, a technique discussed later ("Extending Gage Discharge Data" section) has been developed to better estimate the long-term expected flow frequencies in smaller watersheds.

Suspended Sediment Data

The USGS measured suspended sediment concentrations at or near 42 of the 88 gaging stations being analyzed. To create sediment-discharge relationships for each of these 42 stations, mean daily sediment concentrations were matched with mean daily discharges on the date for which each mean daily sediment concentration was estimated. A mean daily load for that day then was computed such that each pair of mean daily sediment concentration and mean daily discharge provides a single data point that can be used in establishing a mean daily sediment load curve. As discussed later ("Sediment Rating Curves" section), three different approaches were used to develop load curves based on these data points. The three resulting sediment-discharge relationships based on mean daily discharge and load values are applicable for determining effective discharges of larger streams.

The ISWS measured suspended sediment concentrations at 58 USGS streamgages. Unlike the USGS sediment data, the ISWS sediment data were available and were used in original unit or instantaneous formats. In this format, instantaneous suspended sediment concentrations are matched with the concurrent instantaneous flow, as measured by the ISWS at the USGS gage site. An instantaneous load was then computed such that each pair of instantaneous suspended sediment concentration and discharge provides a single data point that can be used in establishing an instantaneous sediment load curve. As with the USGS data, three different load curves were established based upon data points provided at each gaging station. Sediment load curves based on instantaneous data can be used for effective discharge computations using any specified time base of interest (daily, hourly, etc.). Thus, unlike the USGS mean daily data, effective discharge values for both small and large streams can be computed using ISWS data.

Two additional differences exist between the ISWS and USGS suspended sediment concentration data. The frequency and duration of sample collection is the first difference. The ISWS suspended sediment sample data sets were obtained by taking a single suspended sediment concentration measurement every week or two. The USGS data were collected at irregular intervals and throughout occasional storm events. The second difference is that all ISWS sediment discharge data points used to derive sediment discharge rating curves are actual sample values, whereas a large number of the USGS sediment discharge data points are interpolated estimates. Hence, in a typical year, the USGS will provide 365 sediment discharge data points (many interpolated estimates) for a gaging station, whereas the ISWS will provide between 26 and 52 sediment data points (no interpolated estimates). The two sampling and reporting strategies may be quite different in their ability to collect data that can be used to describe sediment discharge relations adequately. Determining whether these differences in sampling frequency are significant and how they influence effective discharge computations was beyond the scope of this study. Consequently, caution should be taken in aggregating effective discharge results obtained from the two data sets. It is probably more appropriate to analyze and interpret the results of the ISWS and USGS data separately, as was done in this study.

Overall, the USGS data provide both flow frequency and suspended sediment data necessary to compute effective discharges at 30 stations. The USGS flow frequency data and the ISWS suspended sediment data combined provide the data necessary to compute effective discharges at 46 stations. Finally, 12 stations had USGS flow frequency data for use with either USGS sediment data or ISWS sediment data. For these 12 stations, two estimates of the streams' effective discharge can be made: one based on instantaneous sediment concentrations, the other on mean daily sediment concentrations.

The amount of suspended sediment and discharge data for computing effective discharge values in Illinois is summarized (Table 1). Specifically, the periods of time over which suspended sediment and discharge data were collected at each USGS gaging station are presented. The total number of suspended sediment data points available from this sampling period and subsequently used to estimate suspended sediment rating curves in the effective discharge computations also are shown. Similarly, the number of water years (corresponding to the entire discharge monitoring period) used in computing flow frequency curves at each gaging station also is tabulated. Stations for which USGS mean daily suspended sediment data were available are presented first, followed by stations for which ISWS instantaneous suspended sediment data were available.

Table 1. Summary of Available Suspended Sediment and Discharge Data for USGS Stations

USGS station		*Suspended sediment data record*			*Mean daily discharge*	
Number	*Name*	*Sampling period(s)*	*Water Years*	*Data points*	*Sampling period(s)*	*Water Years*
Stations with USGS mean daily suspended sediment data						
5419000	Apple River near Hanover	1995-1997	3	1096	1935-2000	66
5570350	Big Creek at St. David	1972-1980	9	1459	1972-1986	15
5570370	Big Creek near Bryant	1972-1986	15	3744	1972-1992	21
5599500	Big Muddy River at Murphysboro	1980-1997	18	6362	1933-1933, 1996-2000	6
3382170	Brushy Creek near Harco	1980-1981	2	608	1968-1983	16
5532500	Des Plaines River at Riverside	1979-1982	4	1279	1944-2000	57
5466500	Edwards River near New Boston	1979-1981	3	1004	1935-2000	66
5548500	Fox River at Johnsburg	1998-1999	2	547	1998-1999	2
5447500	Green River near Geneseo	1978-1981	4	1287	1936-2000	65
5584685	Grindstone Creek near Birmingham	1981	1	365	1981-1981	1
5584680	Grindstone Creek near Industry	1981	1	365	1981-1981	1
5469000	Henderson Creek near Oquawka	1978-1981	4	1279	1935-1996, 1998-2000	65
5559600	Illinois River at Chillicothe*	1993-2000	8	2231	1982-2000	19
5563800	Illinois River at Pekin*	1995-1997	3	1096	1940-1956, 1988 -2000	30
5586100	Illinois River at Valley City	1980-2000	21	7535	1939-2000	62
5568800	Indian Creek near Wyoming	1981	1	364	1960-2000	41
5525000	Iroquois River at Iroquois	1979-1980, 1993-1996	6	1826	1945-2000	56
5526000	Iroquois River near Chebanse	1979-1981, 1993-1996	7	2190	1923-1998, 2000 -2000	77
5520500	Kankakee River at Momence	1979-1981, 1993-1996	7	2191	1905-1906, 1915 -2000	88
5527500	Kankakee River near Wilmington	1979-1982, 1993-1996	8	2556	1915-1933, 1935 -2000	85
5591200	Kaskaskia River at Cooks Mills	1979-1997	19	6848	1970-2000	31
5594100	Kaskaskia River near Venedy Station	1980-1997	18	6362	1970-2000	31
5440000	Kishwaukee River near Perryville	1979-1981	3	914	1940-2000	61
5585000	LaMoine River at Ripley	1981, 1995-1997	4	1461	1921-2000	80
3378900	Little Wabash River at Louisville	1977-1981	5	1666	1965-1983	19
3384450	Lusk Creek near Eddyville	1980-1981	2	639	1968-2000	33
5567510	Mackinaw River below Congerville	1983-1986	4	1096	1984-1986	3
5568000	Mackinaw River below Green Valley*	1995-1997	3	1096	1921-1956, 1988-2000	49

Table 1. (Continued)

USGS station		*Suspended sediment data record*			*Mean daily discharge*	
Number	*Name*	*Sampling period(s)*	*Water Years*	*Data points*	*Sampling period(s)*	*Water Years*
Stations with USGS mean daily suspended sediment data						
5548105	Nippersink above Wonder Lake	1994-1997	4	1198	1994-1997, 1999-2000	6
5548110	Nippersink below Wonder Lake	1994-1997	4	1106	1994-1997	4
5548280	Nippersink Creek near Spring Grove	1998-1999	2	547	1967-2000	34
5536000	North Branch Chicago River at Niles	1985-1986	2	720	1951-2000	50
5420100	Plum River at Savanna	1995-1997	3	1096	1995-1997	3
5446500	Rock River near Joslin	1975-1982	8	1034	1940-2000	61
5583000	Sangamon River near Oakford	1981, 1983-1986, 1995-1997	8	2322	1910-1911, 1915-1919, 1922, 1929-1933, 1940-2000	74
5570380	Slug Run near Bryant	1976-1980	5	1461	1975-1992	18
5439000	South Branch Kishwaukee River at DeKalb	1980-1981	2	731	1926-1933, 1980-2000	29
3382100	South Fork Saline River near Carrier Mills	1980-1981	2	731	1966-2000	35
5570000	Spoon River at Seville	1981, 1995-1997	4	1461	1915-2000	86
5437630	Spring Creek at McFarland Road near Rockford	1979-1981	3	842	1979-1982	4
5437632	Spring Creek at Rock Valley College at Rockford	1979-1981	3	841	1979-1982	4
5555300	Vermilion River near Lenore	1980-1981	2	487	1931-1931, 1972-2000	30
Stations with ISWS Instantaneous Suspended Sediment Data						
5419000	Apple River near Elizabeth*	1981-1982	2	61	—	—
5495500	Bear Creek near Marcelline	1981	1	221	1944-2000	57
5556500	Big Bureau Creek at Princeton	1981-1990	10	528	1936-2000	65
5597000	Big Muddy River at Plumfield	1981-1982	2	64	1908-2000	93
3612000	Cache River at Forman	1981-2000	20	1315	1923-2000	78
5597500	Crab Orchard Creek near Marion	1981	1	22	1952-2000, 1994-2000	56
5593520	Crooked Creek near Hoffman	1981	1	161	1975-1998	24
5529000	Des Plaines River near Des Plaines	1981	1	26	1941-2000	60
5540500	DuPage River at Shorewood	1981	1	221	1941-2000	60
5566500	East Branch Panther Creek at El Paso	1981-1982	2	30	1950-1983	34
5466000	Edwards River near Orion	1981-1982	2	58	1941-2000	60
5444000	Elkhorn Creek near Penrose	1981	1	175	1940-2000	61
3345500	Embarras River at Ste. Marie	1981-1988	8	378	1908-1908, 1910-2000	92
3344000	Embarras River near Diona	1981-1982	2	218	1939-1940, 1944 -1947, 1971 -1983	19
5551200	Ferson Creek near St. Charles	1981-1982	2	71	1961-2000	40

Table 1. (Continued)

USGS station		Suspended sediment data record			Mean daily discharge	
Number	*Name*	*Sampling period(s)*	*Water Years*	*Data points*	*Sampling periods(s)*	*Water Years*
Stations with ISWS Instantaneous Suspended Sediment Data						
5550000	Fox River at Algonquin	1981-1982	2	222	1916-2000	85
5552500	Fox River at Dayton	1981	1	34	1915-2000	86
5447500	Green River near Geneseo	1982-1983	0	31	1936-2000	65
5469000	Henderson Creek near Oquawka	1983-1988	6	202	1935-1996, 1998 -2000	65
5539000	Hickory Creek at Joliet	1981	1	29	1945-2000	56
5592800	Hurrican Creek near Mulberry Grove	1981	1	85	1971-2000	30
5525000	Iroquois River at Iroquois	1981-1982	2	492	1945-2000	56
5526000	Iroquois River near Chebanse	1982-1983	2	357	1923-1998, 2000 -2000	77
5520500	Kankakee River at Momence	1982-1985, 1988-1990, 1993-2000	15	615	1905-1906, 1915-2000	88
5527500	Kankakee River near Wilmington	1983-2000	18	856	1915-1933, 1935-2000	85
5592500	Kaskaskia River at Vandalia	1981-2000	20	975	1908-2000	93
5592100	Kaskaskia River near Cowden	1981	1	159	1970-2000	31
5438500	Kishwaukee River near Belvidere	1981-1982	2	71	1940-2000	61
5440000	Kishwaukee River near Perryville	1983-1990	8	288	1940-2000-	61
5584500	LaMoine River at Colmar	1981-1988, 1993-2000	16	782	1945-2000	56
5585000	LaMoine River at Ripley	1983-1990, 1993-2000	16	631	1921-2000	80
3379600	Little Wabash River at Blood	1981-1982	2	59	1914-2000	87
3381500	Little Wabash River at Carmi*	1981-1985,1993-2000	13	560	1940-2000	61
5567510	Mackinaw River below Congerville	1981-1982	2	30	1984-1986	3
5568000	Mackinaw River below Green Valley*	1981	1	55	1921-1956, 1988-2000	49
5587000	Macoupin Creek near Kane	1981	1	144	1921-1933, 1941-2000	73
5542000	Mazon River near Coal City	1981-2000	20	800	1940-1996, 1999-2000	59
5564400	Money Creek near Towanda	1981	1	27	1958-1983	26
3346000	North Fork Embarras River near Oblong	1981-1982	2	79	1941-2000	60
5435500	Pecatonica River at Freeport	1981-2000	20	726	1914-2000	87
5467000	Pope Creek near Keithsburg	1981	1	177	1935-1996, 1998-2000	65
5437500	Rock River at Rockton	1981-2000	20	1052	1903-1909, 1914-1919, 1940-2000	74
5446500	Rock River near Joslin	1982-1983	2	32	1940-2000	61
3336900	Salt Fork River near St. Joseph	1981-1982	2	250	1959-1991	33
5582000	Salt Creek near Greenview	1981-1983	3	92	1942-2000	59

Table 1. (Concluded)

USGS station		Suspended sediment data record			Mean daily discharge	
Number	*Name*	*Sampling period(s)*	*Water Years*	*Data points*	*Sampling period(s)*	*Water Years*
Stations with ISWS Instantaneous Suspended Sediment Data						
5578500	Salt Creek near Rowell	1981-1983	3	293	1943-2000	58
5572000	Sangamon River at Monticello	1981-2000	20	646	1908-1912, 1914-2000	92
5576500	Sangamon River at Riverton	1981-1983	3	316	1909-1912, 1915-1956,1986 -2000	61
5594000	Shoal Creek near Breese	1981-1982	2	167	1910-1915, 1946 -2000	61
5594800	Silver Creek near Freeburg	1981-2000	20	869	1971-2000	30
3380500	Skillet Fork at Wayne City	1981	1	24	1909-1912, 1915-1921, 1929-2000	83
5439500	South Branch Kishwaukee River near Fairdale	1981-1982	2	250	1940-2000	61
5576022	South Fork Sangamon River below Rochester*	1981-1982	2	251	1950-2000	51
5569500	Spoon River at London Mills	1981-1987, 1994-2000	14	762	1943-2000	58
5525500	Sugar Creek at Milford	1981-1983	3	200	1949-2000	52
5554490	Vermilion River at McDowell*	1981-1982	2	30	1943-2000	58
3339000	Vermilion River near Danville*	1981, 2000-2000	2	23	1915-1921, 1929-2000	79
5555300	Vermilion River near Lenore	1984-2000	17	710	1931-1931, 1972-2000	30

Note:
*Both sediment and discharge data were not available at the station. Sediment and/or discharge data from nearby stations were manipulated and used to compute effective discharge values.

Visual Basic Program for Computing Effective Discharge

Computing effective discharge estimates at 88 gaging stations requires manipulating a large amount of data and performing repetitive computations. A Visual Basic computer program was developed to facilitate this process and allows a user to compute estimates of the effective discharge for a gaging station using a methodology similar to that described by Biedenharn et al. (1999). The program computes the range of discharge values for a specific gaging station and divides this range into a specified number of arithmetic bins (discharge classes) of equal size. The proportion of flow events within each discharge class is then computed. Available suspended sediment data are used to estimate the amount of sediment that each discharge class transports. Each discharge class's sediment load is then multiplied by the proportion of flow events within that discharge class. The resulting load histogram depicts the long-term sediment load that each bin transports. The median discharge (the average of the lowest and highest discharges defining a discharge class) of the bin carrying the greatest load is the effective discharge.

Sediment Rating Curves

A number of ways exist to compute the amount of sediment that each bin transports. A commonly used method creates a log-log plot of sediment load versus discharge and uses linear regression to fit a line through the data (e.g., Biedenharn et al., 1999). This regression line (on an arithmetic scale) is plotted as a power curve of the form $Q_s = aQ^x$, where Q_s is the suspended sediment load, a and x are constants determined from the linear regression, and Q is the discharge class's median discharge. The resulting power function is then evaluated at the Q value of each bin (the average of the lowest and highest discharges defining a discharge class). The sediment loads corresponding to the median discharge of each bin represent sediment loads of individual bins.

Unfortunately, this power function formulation is known to underestimate sediment load values (Ferguson, 1987). Biedenharn et al. (1999) suggest overcoming this problem by using two sediment curves: one describing lower discharges and one describing higher discharges. However, if both curves are power curves, the load estimates still will be underestimated due to the reasons put forth by Ferguson (1987). Applying such an approach systematically and consistently for 88 stations is also problematic. Hence, an alternative approach was adopted and evaluated in which suspended sediment data available for a station are divided into the same discharge classes as those used to compute flow frequency estimates. Suspended sediment loads of all sediment data points having discharges within a specific discharge class are averaged and assigned to be the discharge class' sediment transport rate. Alternatively, the median suspended sediment load of data points within a discharge class can be assigned to represent the sediment transport rate of the discharge class. To investigate the effect of the various means of assigning sediment transport rates to discharge classes on effective discharge computations, the program computes effective discharge values using the traditional power function formulation, and the alternative mean and median formulations. Ultimately, the mean approach was adopted for reasons described in the "Sensitivity of Effective Discharge Computations" section.

Flow Frequency Curves

Flow frequencies of all active USGS gaging stations in Illinois were computed for 1994-2000 using both daily and sub-daily (15-minute or hourly) time increments. The frequency distribution of sub-daily flow values was almost identical to the frequency distribution for mean daily flows for Illinois streams in watersheds greater than 200 mi^2. Based on this analysis, it was concluded that flow frequencies based on mean daily discharge are sufficient and appropriate for use in calculating effective discharges for streams with drainage areas in excess of 200 mi^2. For Illinois streams in smaller watersheds, use of flow frequencies based on sub-daily time increments is generally recommended unless it can be demonstrated that the frequency of mean daily and sub-daily values are essentially equivalent.

Extending Gage Discharge Data

For consistency in the computation of effective discharges, it is important that the estimates of flow frequency reflect the expected long-term flow conditions for each stream. A flow frequency analysis based on a short discharge record, only a few years of record, may significantly overestimate or underestimate the occurrence of flows over the long term, thus biasing the effective discharge estimate. This is especially likely when the period of record occurs during an excessively wet sequence of years or during a drought. Biedenharn et al. (1999) recommend basing effective discharge computations on at least 10-20 years of discharge data. For Illinois, estimates of long-term flow frequency often are made using base periods of at least 30-50 years.

When a gage has a short record, long-term flow frequency usually can be estimated if there is a long-term record available from another gage within the same general hydrologic region that has similar watershed characteristics. This long-term gage, or index gage, essentially is used to describe the variability in the streamflow quantity over time. It is also essential that watersheds and hydrologic processes at the short-term gage and the long-term index gage have similar hydrologic characteristics.

Assume that the gage of interest, or secondary gage, has a short-term record running from year *b* to year *c*, and the index gage has a long-term record running from year *a* to year *d* that includes the period from year *b* to year *c*. Let QS represent the series of flows recorded at the short-term secondary gage and QI the series of flows recorded at the long-term index gage. The flow duration relationship, or flow frequency distribution, for the short-term gage can be defined by computing the probability, P, that the flow at the gage exceeds any given flow value, q_x. The probability of exceedence is represented by the following function:

$$P\ (QS_{bc} > q_x) \qquad (1)$$

where QS_{bc} represents the flow frequency distribution as computed over the years *b* to *c*. A similar flow frequency distribution for the index gage can be computed for the concurrent period, years *b* to *c*:

$$P\ (QI_{bc} > q_x) \qquad (2)$$

and also for the index gage for its entire period of record, years *a* to *d*, which represents the expected long-term flow conditions at that gage:

$$P\ (QI_{ad} > q_x) \qquad (3)$$

The proposed methodology for estimating the long-term flow conditions at the secondary gage is based on a frequency adjustment procedure originally developed by Knapp et al. (1985). This procedure uses the difference in flow frequency between the long-term (years *a* to *d*) and short-term (years *b* to *c*) flow records at the index gage to compute a frequency shift, which is then applied to the secondary gage.

To compute the long-term flow frequency at the secondary gage for the flow value q_z , the first step is to determine the flow frequency associated with the flow q_z over its short-term record, years *b* to *c*. The corresponding flow value q_y at the index gage is determine such that:

$$P\ (QS_{bc} > q_z) = P\ (QI_{bc} > q_y) \qquad (4)$$

The difference in the flow frequency for flow q_y at the index gage between the short-term and long-term records, $P\ (QI_{ad} > q_y) - P\ (QI_{bc} > q_y)$, is then used to compute the long-term probability of exceedence of q_z at the secondary gage, as follows:

$$P\ (QS_{ad} > q_z) = P\ (QS_{bc} > q_z) + P\ (QI_{ad} > q_y) - P\ (QI_{bc} > q_y) \qquad (5)$$

When Equations 4 and 5 are combined, the result becomes:

$$P\ (QS_{ad} > q_z) = P\ (QI_{ad} > q_y) \qquad (6)$$

The entire long-term flow duration relationship at the secondary gage can be computed by applying Equations 4-6 over the entire range of flow conditions at that gage.

The above relationships can be used to estimate the long-term flow frequency corresponding to 15-minute or hourly readings. Specifically, for gages in smaller watersheds, the flow frequency should be defined using instantaneous data recorded in increments of one hour or less (usually 15 minutes), rather than the mean daily flows computed for all stations. Although the mean daily flow records cover the entire period of gaging, which often exceeds 30 years, the 15-minute readings (or gage values) are readily available for only the past 7 years, since 1994. However, the long-term flow frequency for the 15-minute readings can be estimated using the same process defined above for extending gage discharge data. In this process, the mean daily flows for the period of record at a particular gage can be treated as the index station (QI flows), and the 7-years of 15-minute gage values for that same gage can be treated as the secondary station (QS flows), with the short-term record, years *b-c*, representing the 7 years of concurrent 15-minute and daily data, and the long-term record, years *a-d*, representing daily data for the entire period of record.

Computation Time Base

The effective discharge program was developed first to compute effective discharge values based on mean daily discharge frequencies and either USGS mean daily sediment concentrations or ISWS instantaneous sediment concentrations. Later the program was expanded to implement the extension algorithm described in the "Extending Gage Discharge Data" section. However, due to a lack of sediment-discharge data on small watersheds, the extension algorithm was not used or completely tested within this study. Consequently, all effective discharge results presented in this report are based upon mean daily discharge frequencies (computed over the gage's entire discharge record) and either USGS mean daily sediment concentrations or ISWS instantaneous sediment concentrations, depending on the suspended sediment data available at a particular station. For stations having both USGS and ISWS suspended sediment data, two computations were performed: one using the USGS data and the other using ISWS data. When instantaneous suspended sediment data for a particular location are used, it is inherently assumed that discharge and suspended-sediment loads change little throughout a day.

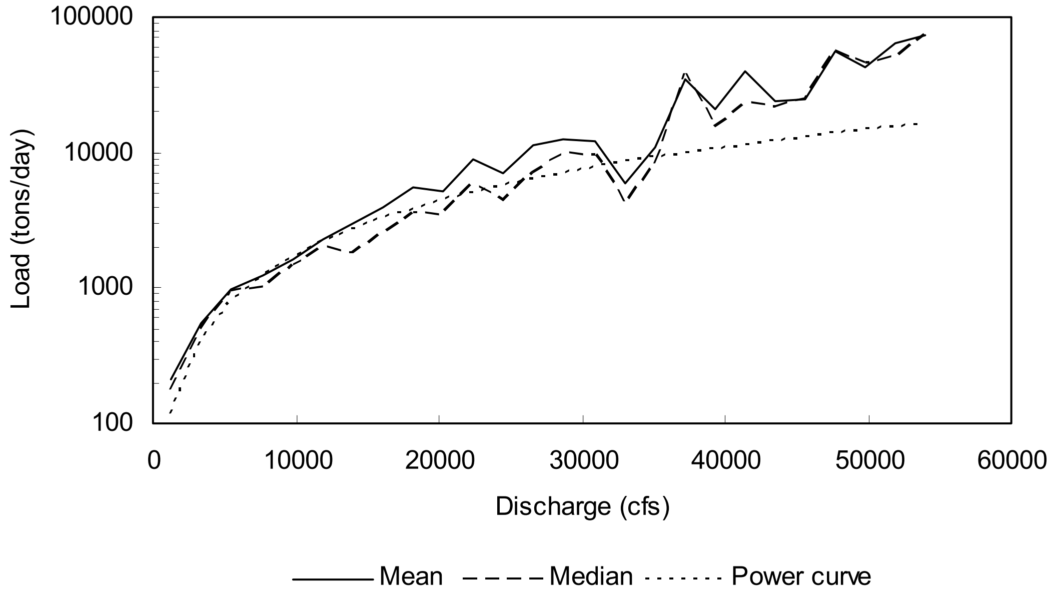
Sensitivity of Effective Discharge Computations

It was known in advance that not all 88 stations had sufficient data to adequately estimate an effective discharge value. However, the Visual Basic program was used to compute effective discharge values for all 88 gaging stations, following the guidelines of Biedenharn et al. (1999). The resulting computations provided a means of analyzing and comparing how the various suspended sediment and discharge records and other variables influenced effective discharge computations.

Three basic comparisons were made. First, comparisons were made to determine which sediment-discharge relationship appears to provide the most reliable effective discharge estimates. Second, observations were made on how the total number of suspended sediment samples collected at a gaging station influence effective discharge computations. Third, calculations were made to determine qualitatively how the range of discharges over which suspended sediment samples were collected influenced effective discharge computations. The results of these comparisons provide, in part, the basis for the methodology ultimately adopted to estimate effective discharges at qualified and partially qualified stations. The results of these comparisons are briefly described below.

Effects of Different Sediment Rating Curves

The method in which sediment transport rates are assigned to discharge size classes can influence effective discharge computations significantly. An example of how the power curve, mean, or median sediment rating curves affect the effective discharge estimate is shown (Figure 2). Specifically, the sediment-discharge relationships (top of Figure 2) and load histograms (bottom of Figure 2) are shown for each of the three sediment discharge formulations. At discharges less than 6000 cubic feet per second (cfs), the power curve formulation predicts the lowest sediment transport rates, while the mean formulation predicts the



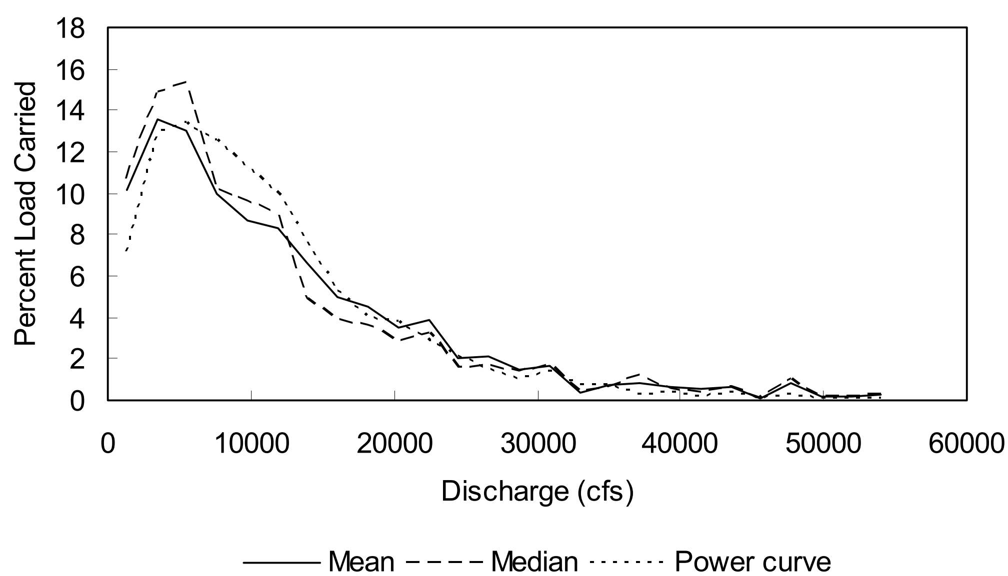


Figure 2. Differences between power curve, mean, and median approaches to estimate sediment loads: sediment load or transport rates (top), and load histograms (bottom).

highest sediment transport rates. This produces load histograms similar in shape that lay on top of each other at the lower discharges (bottom of Figure 2). While the three different sediment rating methods can assign significantly different sediment transport rates, all three methods can, in certain cases, estimate similar or the same effective discharge values for a station. In other cases, all three methods may yield significantly different effective discharge values. Overall, it was concluded that the mean approach predicted higher sediment yields than either the power curve or median approach. As Ferguson (1987) demonstrated that the power curve generally underestimates sediment transport rates and sediment yields within a stream, these results suggest the use of the mean sediment discharge rating curve approach for computing effective discharges.

Effects of Sample and Bin Size

The amount of sediment data collected at a station directly influences the ability to estimate effective discharges in a number of ways. Primarily, the amount of data determines the accuracy and completeness of the sediment-discharge relationship needed to compute effective discharge. The graph shown in Figure 3 depicts the power curves generated with 1, 2, 3, 5, 10, 15, and 19 years of data collected at the USGS gaging station on the Kaskaskia River, near Cooks Mills, Illinois. The sediment load predicted with one year of data (1979) at 3488 cfs is 280 percent greater than that predicted based on 19 years of data. Results from other years in the record may also be expected to produce significantly variable estimates of the effective discharge. Such large differences in sediment load estimates have the potential to affect a stream’s effective discharge estimate depending on the exact magnitude of the difference and the underlying flow frequencies of the stream. Moreover, if the sediment load that is determined to be carried by the effective discharge is to be used in helping determine stable channel geometry in stream restoration projects, then large errors in the sediment discharge rating curve could adversely influence channel design.

When using the mean or median approach to derive sediment discharge rating curves, the amount of data for a site significantly influences the ability and ease of identifying the effective discharge within a load histogram. The longer and more representative the sediment record, the greater the likelihood of obtaining several sediment samples in each discharge class. Obtaining several suspended sediment samples in a bin is important because the greater the number of samples in a bin, the better the estimate of the average/median sediment load being transported within that bin. In contrast, the shorter and less representative the suspended sediment record, the fewer the number of samples one is likely to obtain in each discharge class. When only a few samples (or even a single sample) are in each bin, the average or median suspended sediment load carried by each bin is estimated poorly, and the sediment rating curve can oscillate widely (due to the variability in sediment transport rates that occur within discharge classes). Moreover, it is possible that no sediment samples will occur within a bin, causing the bin to incorrectly carry no load. When such oscillations occur, insufficient suspended sediment data exist and effective discharge cannot be estimated reliably. Additionally, as the size of the bins used in an effective discharge computation will determine the number of sediment samples within each discharge class, the number of discharge classes used in a computation can dramatically influence a load histogram and the resulting effective discharge value.

Flow frequencies associated with a load histogram's bins can also cause histograms to oscillate. These oscillations may be due to the actual nature of flow frequencies within a stream, the assignment of a specific number of bins (which influences how many flow events occur within a bin), or sampling variability. Discharge classes at the extreme high end of the load histogram are particularly susceptible to oscillations created by sample variability as only a few discharge measurements may exist for the highest discharges. Discharge classes at the highest discharges may therefore have no flow events or only one or two flow events occurring within them.

Histograms were generated (with 15 and 30 bins) for two gaging stations: one with 1052 sediment samples and one with 218 samples. Load histograms produced by the mean, median, and power curve approach for the station with 1052 samples are shown (Figure 4a). Using 15 bins, the mean approach creates a smooth load histogram with a single well-defined peak. All but the highest discharge classes are carrying some load, indicating that sediment samples and flow events fall within these discharge classes. The same approach using 30 bins creates a slightly sinuous histogram with an effective discharge value of about 1575 cfs less than was computed with 15 bins. Load histograms produced by the mean, median, and power curve approach for the station with 218 samples also are shown (Figure 4b). Using 15 bins, the mean approach produces a slightly sinuous load histogram with discharge classes greater than 8000 cfs carrying no load because no sediment samples fell within these bins. Using 30 bins, the mean approach produces a far more sinuous histogram and an effective discharge only 268 cfs larger. However, discharges between 3759 and 4832 cfs are shown as carrying no load because no sediment samples fell within the two bins covering this range of discharges. Because these discharges are fairly moderate in nature, the sediment data are insufficient for computing effective discharge at this station.

The load histograms shown in Figure 4 demonstrate that load histograms and effective discharge are sensitive to both available data and the number of bins used in the computation. An analysis of the power curve histograms in Figure 4 and the sediment rating curve results in Figure 3 reveals that sediment data and discharge class size also influence effective discharge computations based on the power curve approach. Consequently, establishing how much sediment data and how many bins should be used in an effective discharge computation becomes subjective. How bin sizes ultimately were assigned for this project is discussed in the section entitled "Assigning Discharge Class Size (Number of Bins)". Criteria used to determine whether a station had sufficient sediment data are discussed in the "Identifying Qualified Gaging Stations" section.

Effects of Sampling Range

While the total number of sediment samples collected is important in obtaining a good sediment-discharge relationship, sediment samples need to be collected over the entire range of discharges within a stream. If sediment samples are collected only during relatively low flows, the effective discharge estimate may occur in the last discharge bin that contains sediment data (Figure 5). The effective discharge for Big Creek at St. David (USGS 05570350), as estimated by the mean approach, is 549 cfs and carries 28.3 percent of the stream's total load. However, as

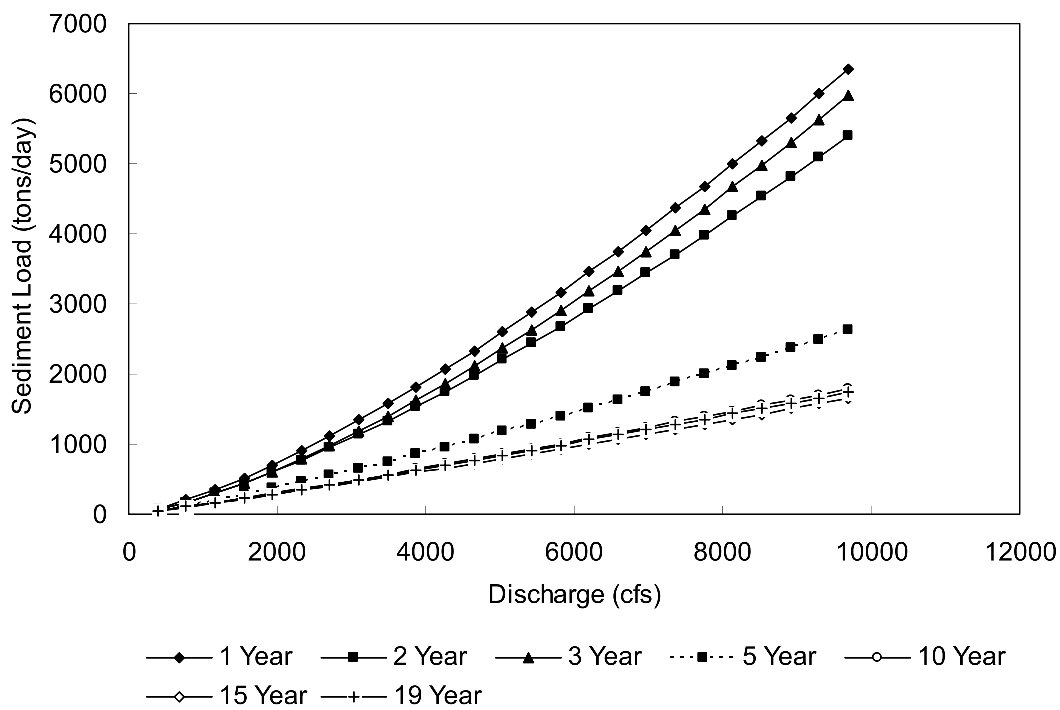
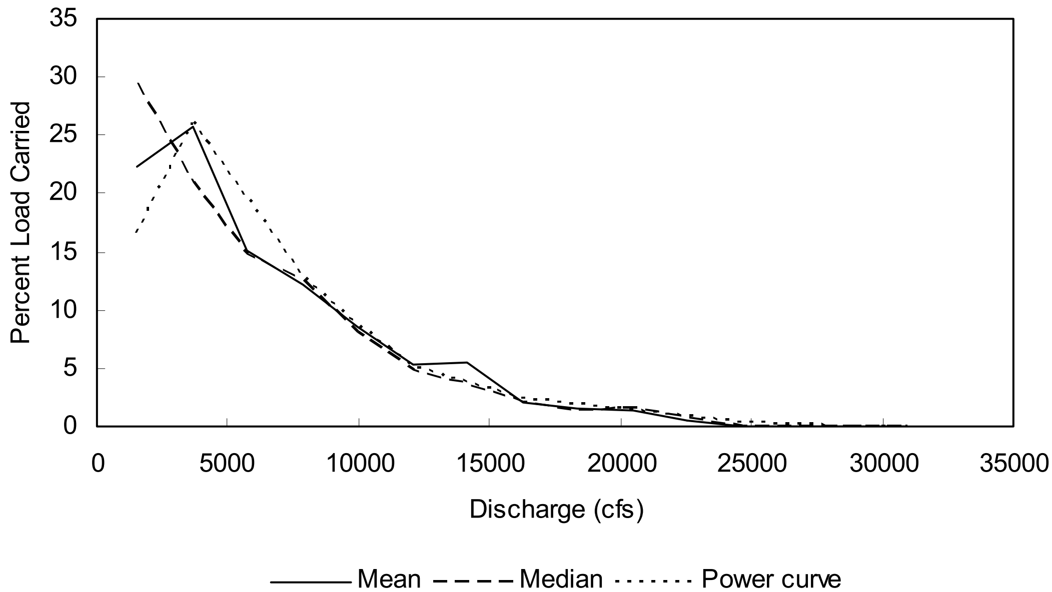


Figure 3. An example of the effect of sediment record length (or total number of samples) on estimating sediment-discharge relationships (using a power curve approach).

no sediment samples were collected at a discharge of greater than 580 cfs, no sediment samples have discharges within the next higher discharge class, and the load histogram at 671 cfs (the next higher discharge class) has no load associated with it. In reality, this discharge carries a load, but the amount is unknown due to lack of sampling (or extrapolated if a power curve is adopted). Consequently, if additional data were collected at higher discharges, the peak in the load histogram could actually occur in the 671 cfs bin or in a bin with even higher discharges. Moreover, the estimates for the percent load carried by each discharge would improve as the sediment loads of the higher discharge classes are sampled and contribute to the station's total sediment yield. The discharge of 620 cfs corresponds to the 1.25-year flood, which further suggests that more data should be collected at higher flows, because effective discharges with flows equivalent to the 1.5-year flood are commonly reported. Therefore, one should not accept 549 cfs as the stream's effective discharge.

Failing to collect suspended sediment samples at the lower discharges within a stream is also undesirable because over time rather large amounts of sediment can be transported at lower discharges and have significant impacts on sediment load histogram values. Load histograms for the Rock River at Rockton (USGS 5437500) were plotted using sediment data covering the entire range of flow events within the stream (top of Figure 6) and with sediment data covering the upper 80 percent of the flow events (bottom of Figure 6). When all data are present, the load histogram's peak is well defined and the first bin carries about 6 percent of the stream's entire



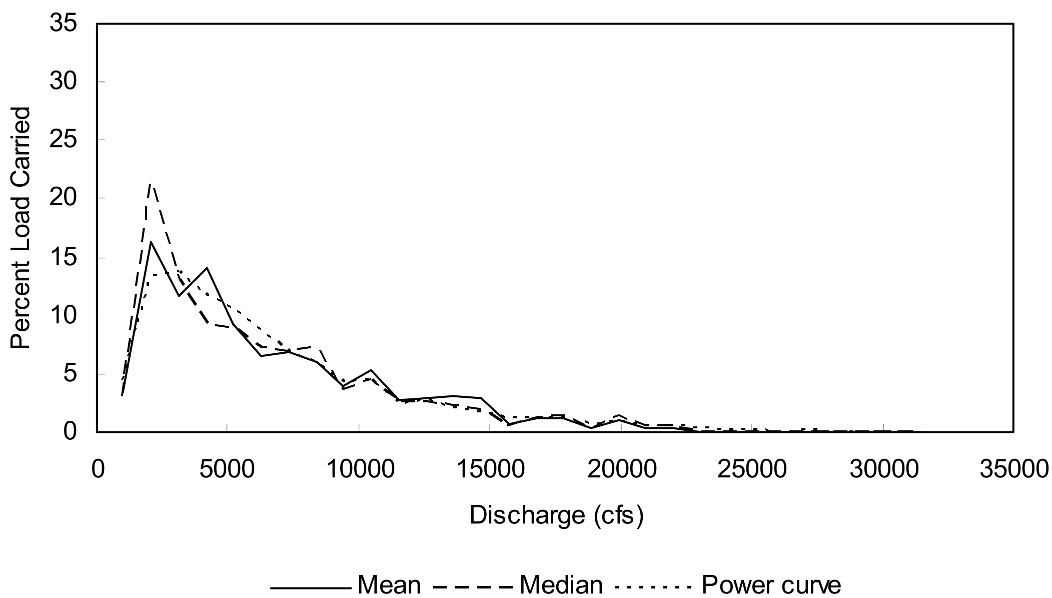
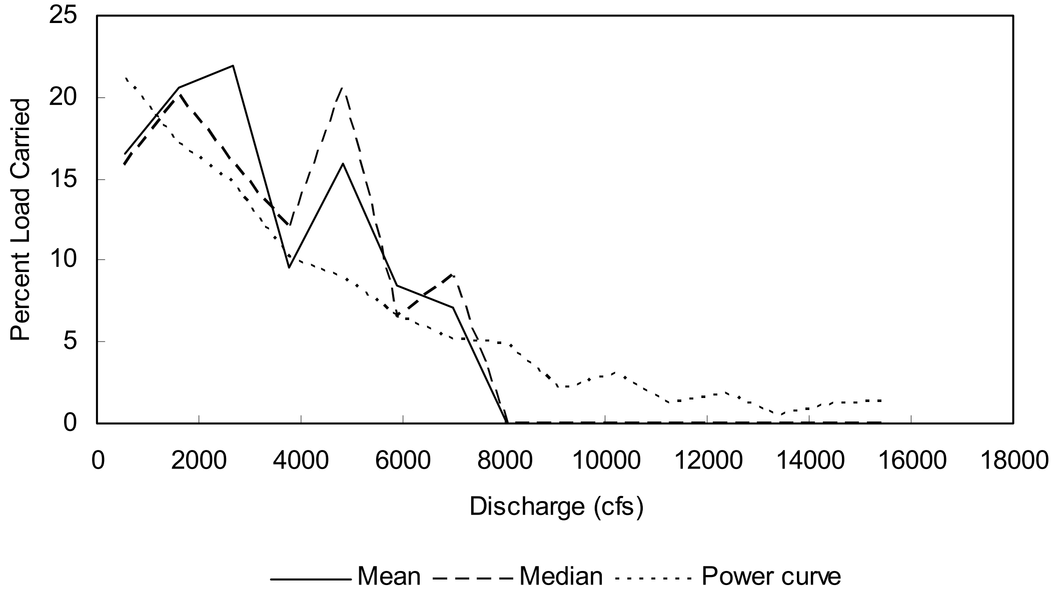


Figure 4a. Load histograms from a station with 1052 sediment samples: 15 bins (top) and 30 bins (bottom).



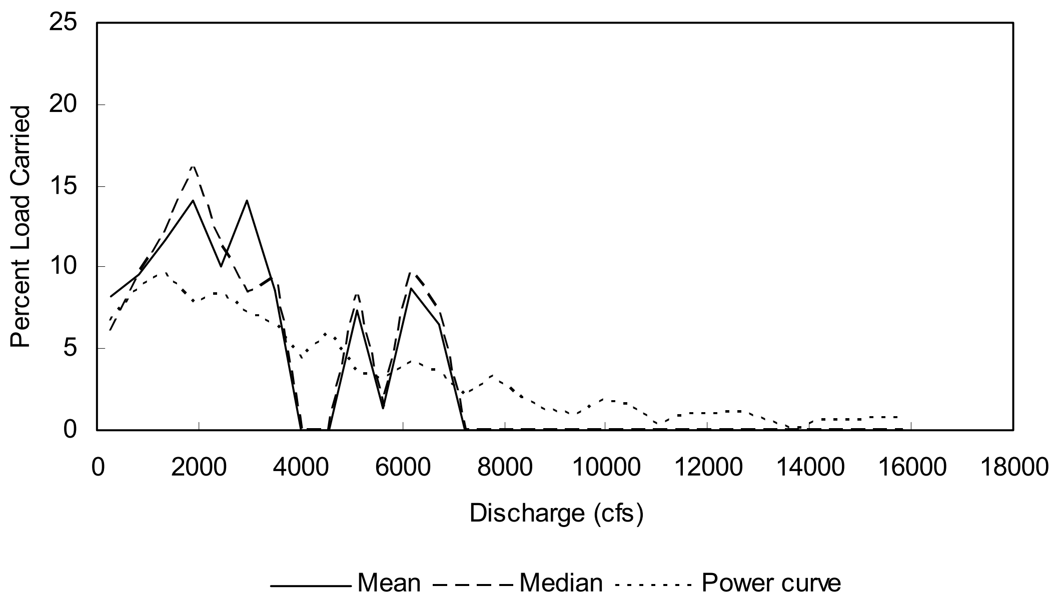


Figure 4b. Load histograms from a station with 218 sediment samples:
15 bins (top) and 30 bins (bottom).

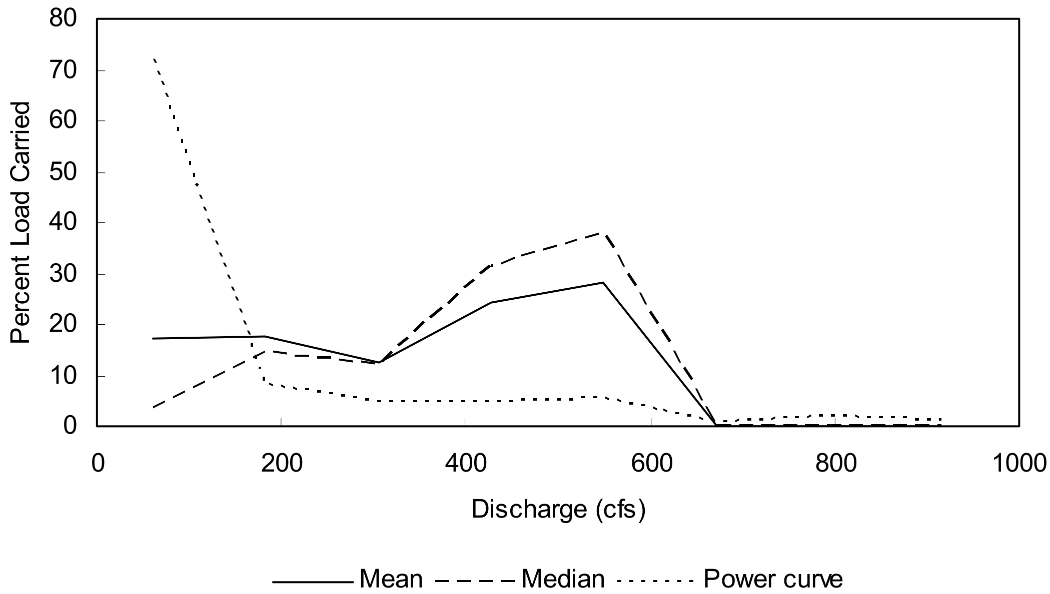
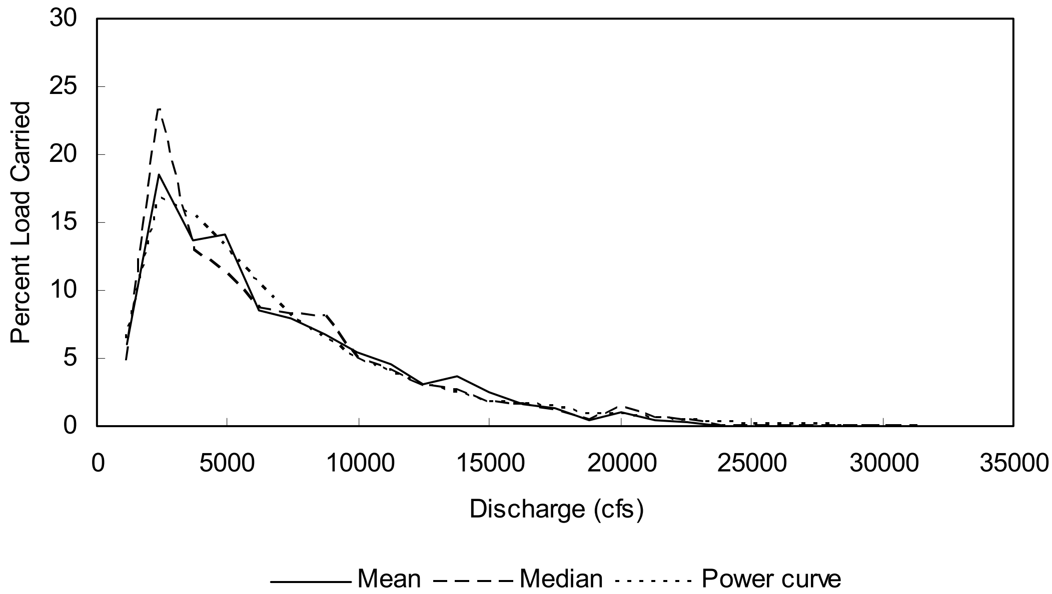


Figure 5. Mean and median load histograms which have the effective discharge occur in the last bin containing sediment samples.

load. However, with the lower 20 percent of the sediment data omitted, the load histogram indicates that no sediment is being transported within the first bin. If even a larger percentage of the lower discharge range is not sampled, one runs the risk of not even sampling sediment transport rates at flows representative of the effective discharge.

Identifying Qualified Gaging Stations

The preliminary effective discharge estimates used to evaluate the influence of various rating curves and other variables on effective discharge values also were used to determine gaging stations with sufficient discharge and sediment data to estimate effective discharge. Specifically, statistics were analyzed summarizing each station's discharge and sediment data, along with the sediment load histogram resulting from the mean sediment discharge rating curve. A subjective decision then was made regarding the reliability of the suspended sediment and discharge data to estimate an effective discharge for that station. A description of how this decision was made follows.



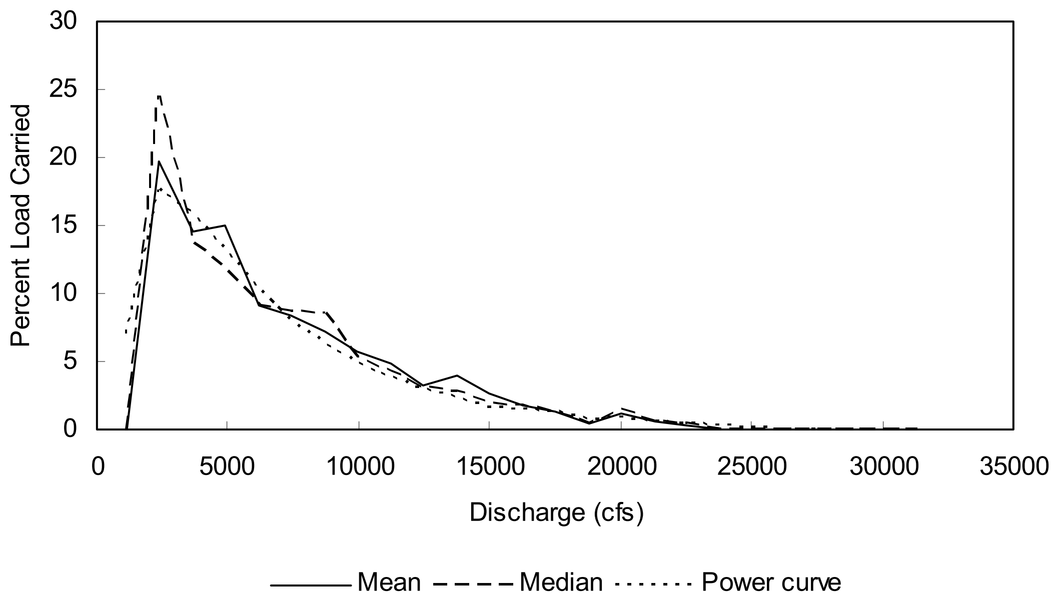


Figure 6. Load histograms with sediment samples representing the entire discharge range (top) and the upper 80 percent of the discharge range (bottom).

Biedenharn et al. (1999) state that effective discharge estimates can vary significantly, depending on the discharge classes chosen, and that selecting the number of bins to use is subjective. Consequently, even determining effective discharge values for streams having substantial data is not always straightforward. However, a number of the guidelines that Biedenharn et al. (1999) suggest for helping compute effective discharge also can be used to help determine if sufficient data exist at a station. For example,

- The effective discharge computation should be based on at least 10 – 20 years of discharge data.
- The resulting load histogram should be a smooth, continuous curve with a single peak.
- If the effective discharge occurs in the first discharge class, the number of discharge classes should be increased until the effective discharge occurs in the second bin.
- The effective discharge should be stable over a number of different bin sizes.
- The effective discharge should be between the 1- and 3- year flood events.

Additionally, if a reliable effective discharge is to be made, samples used to derive the sediment-discharge relationship should cover discharges somewhat larger than the effective discharge.

Based on these guidelines, the following criteria were used to determine stations with sufficient data:

- The station had at least 10 years of mean daily discharge values.
- Sediment data were collected at least up to discharges corresponding to the 1.25-year annual mean series flood for that station.
- Sediment-discharge relationships covered at least 90 percent of the entire range of flows recorded at the station.
- The effective discharge did not occur in the last discharge class in which sediment data were available.
- The resulting load histogram had a reasonably smooth trend from which a peak load could be identified (curve was not too noisy).
- The effective discharge did not appear to change significantly with moderate changes in bin size.

As this process is subjective in nature (particularly with regard to the last two criteria), it was further decided to classify each gaging station as qualified, partially qualified, or disqualified. Gaging stations that met the criteria listed above were classified as qualified stations. Stations that could not be considered qualified for a specific reason, such as not having suspended samples covering 90 percent of the entire range of discharges, but had substantially better suspended sediment and discharge data than other stations were classified as a partially qualified stations Stations that clearly contained insufficient data to create an adequate sediment-discharge relationship were disqualified.

It is recognized that some of these criteria are subjective, but the authors currently are not aware of any more objective criteria available to determine what constitutes sufficient data to compute effective discharge values. A more thorough examination of this topic is warranted in the future.

Assigning Discharge Class Size (Number of Bins)

When computing the preliminary effective discharge values used to identify qualified gaging stations, effective discharge values were estimated using several different bin sizes at each gaging station. Varying the bin sizes allowed evaluation of whether the sediment load histogram and effective discharge values at a particular gaging site changed significantly with the number of bins (or discharge class sizes) used in the computation. This analysis revealed that effective discharge values were almost always sensitive to changes in bin size, even for those stations with the best sediment and discharge data. This finding is consistent with research by Sichingabula (1999) and others. It was noted that between 20 and 25 discharge classes worked well in many computations. However, some computations required 45 or more discharge classes so that the effective discharge did not occur in the first discharge class as recommended by Biedenharn et al. (1999). In contrast, using 45 bins, in some cases, created oscillating load histograms with no clear maximum value to represent the effective discharge. Consequently, using a consistent number of bins for each computation was not feasible.

Because the same number of bins could not be used in every computation, efforts were taken to make sure that the final effective discharge estimates (for qualified and partially qualified stations) were computed in a consistent fashion that assured an effective discharge did not fall into the first discharge class or create unreasonably noisy load histograms. Specifically, the number of bins used to compute the effective discharge at a particular gaging station was determined using the flow chart shown in Figure 7. In the first iteration of the computation, 25 bins were assumed. A check then was made to determine if at least one flow event from the gaging station's flow record fell into each bin. If every bin did not contain at least one flow event, the number of bins was reduced slowly to find the maximum number of bins that could be used in the computation and still have at least one flow event in each bin. An evaluation was then made to make sure that the peak of the load histogram did not occur within the first bin. If the peak did not occur within the first bin, then the mean discharge of the bin containing the peak of the histogram was used as the effective discharge. If the peak of the load histogram occurred within the first bin, then the number of bins was increased iteratively to find the minimum number of bins that could produce a load histogram without its peak occurring in the first bin. (Note: this may result in a histogram without a flow event in every bin). The mean discharge of the bin containing the peak of the load histogram then was used as the effective discharge.

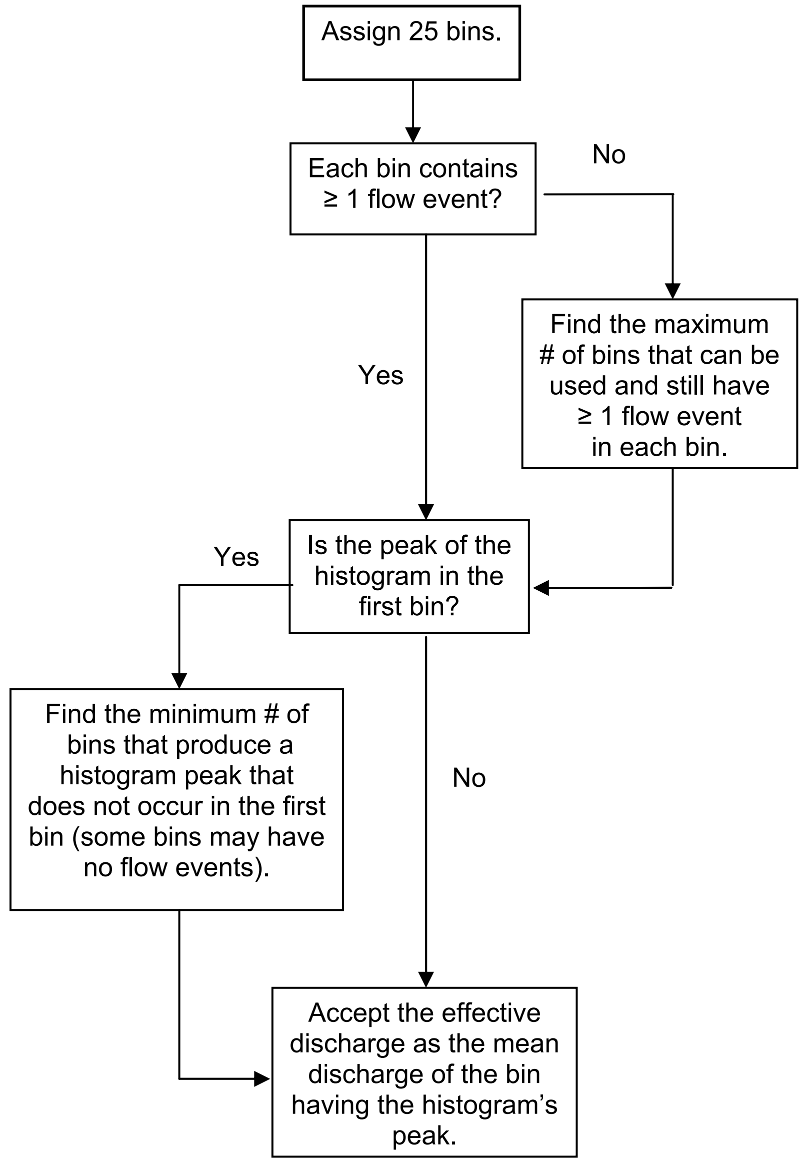


Figure 7. Flow chart used to determine the number of bins or discharge classes.

Assessing Effective Discharge Recurrence Intervals and Regional Variability

Effective discharge recurrence intervals of qualified gaging stations were computed to assess the regional variability of effective discharges within Illinois. Linear regression analyses then were performed to determine specific geographic trends in effective discharge. Specifically, relationships were examined between effective discharge and watershed area, channel slope, effective discharge, effective discharge recurrence interval, physiographic units, percent flows exceeding effective discharge, and total load transported by flows less than or equal to effective discharge. Regression analyses performed and their results are discussed in the "Results" section of this report.

Results

Qualified, Partially Qualified, and Disqualified Gaging Stations

A list of gaging stations for which suspended sediment and discharge data were available for computing effective discharge is shown (Table 2). Associated with each gaging station is its watershed, its USGS station number, and its qualification status. Similarly, Table 3 lists gaging stations that currently collect suspended sediment data on smaller watersheds. However, the discharge and suspended sediment data for these stations are not currently available, and records are too short to compute effective discharge.

The total number of qualified stations is 20. Three stations qualified based on both the USGS and ISWS sediment data. These 20 stations represent stations on streams with watershed areas between 244 mi^2 and 6363 mi^2. An additional 18 stations are partially qualified either through USGS or ISWS sediment data. Three stations originally were classified as qualified (Stations 5586100, 5563800, and 5559600). However, as effective discharge values are to be computed for streams not undergoing significant change in their watersheds and flow regimes, it was decided to disqualify these three gaging stations on the Illinois River and list them as partially qualified due to the river's altered condition, including many human-made navigational structures and significant streamflow modifications occurring within this river's watershed. A similar argument could be made for other streams with qualified gaging stations, but the Illinois River is probably the most severely affected of the rivers with qualified gaging stations.

Effective Discharge Results (Qualified and Partially Qualified Stations)

Detailed results of the effective discharge computations are tabulated and graphed for qualified and partially qualified stations (Appendices A-D). There are two categories of stations within the qualified stations: those that use USGS mean daily suspended sediment load data (Appendix A) and those that use ISWS instantaneous suspended sediment data (Appendix B). Likewise, the partially qualified results are categorized according to the type of suspended sediment data used to compute the effective discharge values: USGS (Appendix C) or ISWS (Appendix D). Within each of these categories, tables and graphs are presented in alphabetical order according to the streamgage name.

Description of Effective Discharge Tables

Five tables and one graph present the effective discharge results for individual stations. The tables and graph for USGS# 03612000 (Cache River at Forman) are an example of the type of data found in each appendix (Figure 8).

1) The first table, upper left, summarizes the mean daily discharge records of an individual station by showing the number of discharge records (days) over the period of record, the range of daily discharges over the period of record, and the average and median values of the observed discharges at that station.

Table 2. List of Qualified, Partially Qualified, and Disqualified Stations

USGS ID	*USGS station name*	*River basin*	*Watershed area (mi^2)*	*Sediment data used*
		Qualified Stations		
3612000	Cache River at Forman	CACHE	244	ISWS
5466500	Edwards River near New Boston	MISSISSIPPI	445	USGS
5525000	Iroquois River at Iroquois	KANKAKEE	686	USGS
5526000	Iroquois River near Chebanse	KANKAKEE	2091	USGS
5520500	Kankakee River at Momence	KANKAKEE	2294	ISWS and USGS
5527500	Kankakee River near Wilmington	KANKAKEE	5150	ISWS and USGS
5591200	Kaskaskia River at Cooks Mills	KASKASKIA	473	USGS
5592500	Kaskaskia River at Vandalia	KASKASKIA	1904	ISWS
5594100	Kaskaskia River near Venedy Station	KASKASKIA	4393	USGS
5584500	LaMoine River at Colmar	LAMOINE	655	ISWS
5585000	LaMoine River at Ripley	LAMOINE	1293	ISWS and USGS
3381500	Little Wabash River at Carmi	LITTLE WABASH	3102	ISWS
3378900	Little Wabash River at Louisville	LITTLE WABASH	745	USGS
5568000	Mackinaw River below Green Valley	MACKINAW	1073	USGS
5435500	Pecatonica River at Freeport	ROCK	1326	ISWS
5437500	Rock River at Rockton	ROCK	6363	ISWS
5572000	Sangamon River at Monticello	SANGAMON	550	ISWS
5583000	Sangamon River near Oakford	SANGAMON	5093	USGS
5594800	Silver Creek near Freeburg	KASKASKIA	464	ISWS
5570000	Spoon River at Seville	SPOON	1636	USGS
		Partially Qualified Stations		
5419000	Apple River near Hanover	MISSISSIPPI	247	USGS
5532500	Des Plaines River at Riverside	DES PLAINES	630	USGS
3345500	Embarras River at Ste. Marie	EMBARRAS	1516	ISWS
5550000	Fox River at Algonquin	FOX	1403	ISWS
5447500	Green River near Geneseo	ROCK	1003	USGS
5469000	Henderson Creek near Oquawka	MISSISSIPPI	432	USGS
5559600	Illinois River at Chillicothe	ILLINOIS	13543	USGS
5563800	Illinois River at Pekin	ILLINOIS	14585	USGS
5586100	Illinois River at Valley City	ILLINOIS	26743	USGS
5525000	Iroquois River at Iroquois	KANKAKEE	686	ISWS
5526000	Iroquois River near Chebanse	KANKAKEE	2091	ISWS
5440000	Kishwaukee River near Perryville	ROCK	1099	USGS
5446500	Rock River near Joslin	ROCK	9549	USGS
5578500	Salt Creek near Rowell	SANGAMON	335	ISWS

Table 2. (Continued)

USGS ID	*USGS station name*	*River basin*	*Watershed area (mi^2)*	*Sediment data used*
	Partially Qualified Stations (concluded)			
5576500	Sangamon River at Riverton	SANGAMON	2618	ISWS
5576022	South Fork Sangamon River below Rochester	SANGAMON	870	ISWS
5569500	Spoon River at London Mills	SPOON	1072	ISWS
5555300	Vermilion River near Lenore	VERMILION	1251	ISWS
	Disqualified Stations			
5419000	Apple River near Elizabeth	MISSISSIPPI	207	ISWS
5495500	Bear Creek near Marcelline	MISSISSIPPI	349	ISWS
5556500	Big Bureau Creek at Princeton	BUREAU	196	ISWS
5570350	Big Creek at St. David	SPOON	28	USGS
5570370	Big Creek near Bryant	SPOON	41.2	USGS
5599500	Big Muddy River at Murphysboro	BIG MUDDY	2169	USGS
5597000	Big Muddy River at Plumfield	BIG MUDDY	794	ISWS
3382170	Brushy Creek near Harco	OHIO	13.3	USGS
5597500	Crab Orchard Creek near Marion	BIG MUDDY	31.7	ISWS
5593520	Crooked Creek near Hoffman	KASKASKIA	254	ISWS
5529000	Des Plaines River near Des Plaines	DES PLAINES	360	ISWS
5540500	DuPage River at Shorewood	DUPAGE	324	ISWS
5566500	East Branch Panther Creek at El Paso	MACKINAW	30.5	ISWS
5466000	Edwards River near Orion	MISSISSIPPI	155	ISWS
5444000	Elkhorn Creek near Penrose	ROCK	146	ISWS
3344000	Embarras River near Diona	EMBARRAS	919	ISWS
5551200	Ferson Creek near St. Charles	FOX	51.7	ISWS
5552500	Fox River at Dayton	FOX	2642	ISWS
5548500	Fox River at Johnsburg	FOX	1205	USGS
5584685	Grindstone Creek near Birmingham	LAMOINE	45.4	USGS
5584680	Grindstone Creek near Industry	LAMOINE	35.5	USGS
5539000	Hickory Creek at Joliet	DES PLAINES	107	ISWS
5592800	Hurricane Creek near Mulberry Grove	KASKASKIA	152	ISWS
5568800	Indian Creek near Wyoming	SPOON	62.7	USGS
5592100	Kaskaskia River near Cowden	KASKASKIA	1330	ISWS
5438500	Kishwaukee River near Belvidere	ROCK	538	ISWS
3379600	Little Wabash River at Blood	LITTLE WABASH	1387	ISWS
3384450	Lusk Creek near Eddyville	OHIO	42.9	USGS
5567510	Mackinaw River below Congerville	MACKINAW	776	USGS and USGS

Table 2. (Concluded)

USGS ID	*USGS station name*	*River basin*	*Watershed area (mi^2)*	*Sediment data used*
		Disqualified Stations (concluded)		
5587000	Macoupin Creek near Kane	MACOUPIN	868	ISWS
5542000	Mazon River near Coal City	MAZON	455	ISWS
5564400	Money Creek near Towanda	MACKINAW	49	ISWS
5548105	Nippersink Creek above Wonder Lake	FOX	84.5	USGS
5548110	Nippersink Creek below Wonder Lake	FOX	97.3	USGS
5548280	Nippersink Creek near Spring Grove	FOX	192	USGS
5536000	North Branch Chicago River at Niles	CHICAGO	100	USGS
3346000	North Fork Embarras River near Oblong	EMBARRAS	318	ISWS
5420100	Plum River at Savanna	MISSISSIPPI	273	USGS
5467000	Pope Creek near Keithsburg	MISSISSIPPI	174	ISWS
3336900	Salt Creek (or Salt Fork R.?) near St. Joseph	WABASH	134	ISWS
5582000	Salt Creek near Greenview	SANGAMON	1804	ISWS
5594000	Shoal Creek near Breese	KASKASKIA	735	ISWS
3380500	Skillet Fork at Wayne City	LITTLE WABASH	464	ISWS
5570380	Slug Run near Bryant	SPOON	7.1	USGS
5439000	South Branch Kishwaukee River at DeKalb	ROCK	77.7	USGS
5439500	South Branch Kishwaukee River near Fairdale	ROCK	387	ISWS
3382100	South Fork Saline River near Carrier Mills	OHIO	147	USGS
5437630	Spring Creek at McFarland Road near Rockford	ROCK	2.4	USGS
5437632	Spring Creek at Rock Valley College at Rockford	ROCK	2.8	USGS
5525500	Sugar Creek at Milford	KANKAKEE	446	ISWS
5554490	Vermilion River at McDowell	VERMILION	551	ISWS
3339000	Vermilion River near Danville	WABASH	1290	ISWS

Table 3. Additional Stations Collecting Sediment and Discharge Data

USGS ID	*ISWS ID*	*USGS station name*	*River basin*	*Watershed area (mi²)*	*Sediment data used*
	500	Big Creek near Dongola (Union)	CACHE	8	ISWS
	513	Cache River at Ulin	CACHE	164	ISWS
	301	Court Creek near Appleton	SPOON	44	ISWS
	202	Cox Creek near Newmansville	SANGAMON	9	ISWS
	503	Cypress Creek near Cypress	CACHE	24	ISWS
	303	Haw Creek near Maquon	SPOON	55	ISWS
	602	Hurricane Creek near Hutton (Union Center)	EMBARRAS	33	ISWS
	601	Hurricane Creek near Timothy (county line)	EMBARRAS	47	ISWS
5588720		Judy's Branch at Glen Carbon	MISSISSIPPI	N/A	USGS
5588700		Judy's Branch at Oak Lawn Estates	MISSISSIPPI	N/A	USGS
5588710		Judy's Branch Tributary at Glen Carbon	MISSISSIPPI	N/A	USGS
	603	Kickapoo Creek near Charleston	EMBARRAS	27	ISWS
	401	Lake Branch near Albers	KASKASKIA	18	ISWS
	701	Little Vermilion River near Sidell	WABASH	N/A	ISWS
	402	Lost Creek near Hoffman	KASKASKIA	78	ISWS
	302	North Creek near Oak Run	SPOON	27	ISWS
	201	Panther Creek at Site M	SANGAMON	15	ISWS
	500	Big Creek near Dongola (Union)	CACHE	8	ISWS

Note: N/A = not applicable

Cache River at Forman: USGS # 03612000

Discharge record	Mean daily discharge (cfs)
Records	28387
Min.	0.00
Max.	8780.00
Mean	297.33
Median	55.00

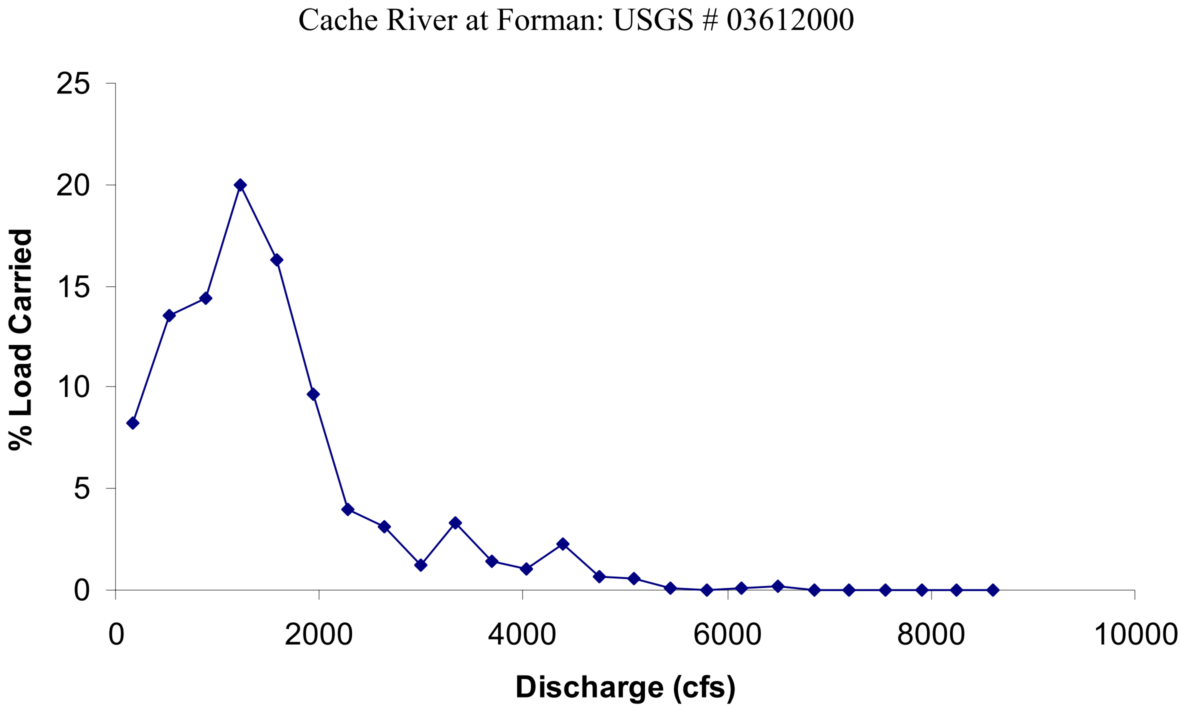
Suspended sediment record	Discharge (cfs)	Load (tons/day)
Records	1315	1315
Min.	0.10	0.0029
Max.	6328.00	16928.7494
Mean	421.89	385.5902
Median	102.50	15.1313
< (%)	0.9406	
> (%)	0.1268	
r^2	0.9178	

Effective discharge results	Mean approach
Bins	25
Bin size (cfs)	351.20
Discharge (cfs)	1229.20
Exceedance (%)	5.90
Cumulative load (%)	56.18

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	253	0	0.008913	0.0000
0.0 - 351.2	21532	894	0.758516	25.7149
351.2 - 702.4	2955	152	0.104097	308.6673
702.4 - 1053.6	1579	92	0.055624	611.2524
1053.6 - 1404.8	786	58	0.027689	1711.8022
1404.8 - 1756.0	447	52	0.015747	2445.1214
1756.0 - 2107.2	276	29	0.009723	2347.8716
2107.2 - 2458.4	139	11	0.004897	1921.0373
2458.4 - 2809.6	95	9	0.003347	2202.8636
2809.6 - 3160.8	68	4	0.002395	1240.6169
3160.8 - 3512.0	56	2	0.001973	3961.5096
3512.0 - 3863.2	33	1	0.001163	2926.4532
3863.2 - 4214.4	33	2	0.001163	2078.7150
4214.4 - 4565.6	19	2	0.000669	7950.5744
4565.6 - 4916.8	23	3	0.000810	1918.7425
4916.8 - 5268.0	22	1	0.000775	1676.9589
5268.0 - 5619.2	12	1	0.000423	785.3891
5619.2 - 5970.4	10	0	0.000352	0.0000
5970.4 - 6321.6	13	1	0.000458	439.5105
6321.6 - 6672.8	11	1	0.000388	904.4791
6672.8 - 7024.0	10	0	0.000352	0.0000
7024.0 - 7375.2	5	0	0.000176	0.0000
7375.2 - 7726.4	3	0	0.000106	0.0000
7726.4 - 8077.6	4	0	0.000141	0.0000
8077.6 - 8428.8	1	0	0.000035	0.0000
8428.8 - 8780.0	2	0	0.000070	0.0000
>8780.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
176	8.2367
527	13.5685
878	14.3577
1229	20.0152
1580	16.2589
1932	9.6398
2283	3.9722
2634	3.1131
2985	1.2550
3336	3.3001
3688	1.4366
4039	1.0205
4390	2.2472
4741	0.6565
5092	0.5488
5444	0.1402
5795	0.0000
6146	0.0850
6497	0.1480
6848	0.0000
7200	0.0000
7551	0.0000
7902	0.0000
8253	0.0000
8604	0.0000
0	0.0000

Figure 8a. Examples of tables used in appendices to present effective discharge output.



Load histogram curve using mean approach.

Figure 8b. An example of graphs used in the appendices to present effective discharge output.

2) The second table, top center, summarizes the suspended sediment data for that particular station. For stations using USGS mean daily suspended sediment load data (Appendices A and C), the number of records represents the number of days for which mean daily suspended sediment has been estimated. Also shown are the minimum, maximum, mean, and median discharges over which suspended sediment loads were estimated, and the minimum, maximum, mean, and median values of all the daily load estimates. The percent of flow events over the entire period of record with discharges lower than the lowest discharge at which a suspended sediment sample was measured is indicated as "< Min (%)," while "> Max (%)" reports the percent of flow events with discharges higher than the highest discharge at which suspended sediment samples were collected. The r^2 value, the square of the correlation coefficient for the power curve passing through the underlying sediment-discharge relationship of the station, also is provided and shows the proportion of total variation in load that can be explained by differences in discharge.

For stations using ISWS instantaneous suspended sediment data (Appendices B and D), the number of records represents the number of instantaneous suspended sediment measurements. The statistics for the instantaneous suspended sediment data are the same as described in the previous paragraph.

3) The third table, upper right, gives the number of bins used in the effective discharge computation, bin size, and estimated effective discharge "Discharge (cfs)" for the station. The percent flow exceedance associated with the effective discharge value "Exceedance (%)" and the cumulative percentage of suspended sediment transported by flows less than and equal to the effective discharge "Cumulative Load (%)" are included in this table as well.

4) The fourth table, lower left, shows individual class intervals (bins) used in the effective discharge estimation. Also shown are the number of flow events associated with each bin, the number of sediment samples within each bin, the cumulative frequency of occurrence (or proportion of flow events) within the bin, and the mean suspended sediment load for each bin. If more than 25 bins were used for the computation, only results from the first 25 bins are shown.

5) The fifth table, lower right, gives the mean discharge value or bin value for each bin (cfs) and the percent of total suspended sediment load carried by flows in that bin.

Description of Effective Discharge Graphs

The load histogram for each station is shown on the page following the tables. This graph shows the same information as the fifth table, i.e., discharge class intervals versus percentage of total suspended sediment load carried within the discharge intervals (bins). In cases where more than 25 bins were used in the effective discharge computation, the graph shows the percentage of total suspended sediment load carried for all discharge class intervals.

Summary Tables

In addition to the detailed information in Appendices A-D, the names of qualified and partially qualified stations and computed effective discharge values are presented (Tables 4-5). Watershed areas of the individual stations also are provided in these tables. Note that effective discharges for some stations can be computed with either USGS mean daily data or ISWS instantaneous data, and that the effective discharge estimates using these two sets of data are not necessarily similar.

Flood Recurrence Intervals

The recurrence intervals for effective discharge values were computed in accordance with the guidelines outlined by the Interagency Advisory Committee on Water Data (1982). The USGS (David Soong, personal communication, 2002) provided the mean, standard deviation, and skew coefficients of the maximum annual discharges data used in these computations for each qualified gaging station. Recurrence intervals for qualified gaging stations for which USGS mean daily suspended sediment data were available are shown (Table 6). Recurrence intervals for qualified gaging stations for which ISWS instantaneous suspended sediment data were available are shown (Table 7). The 1.25- and 2.0-year flood recurrence intervals associated with each qualified station also are shown (Tables 6 and 7).

Table 4. Effective Discharges of Qualified Stations

Station description	*Watershed area (mi^2)*	*Effective discharge (cfs)*
Based on USGS mean daily sediment data		
Edwards River near New Boston: USGS # 05466500	445	956
Iroquois River at Iroquois: USGS # 05525000	686	670
Iroquois River near Chebanse: USGS # 05526000	2091	2709
Kankakee River at Momence: USGS # 05520500	2294	1703
Kankakee River near Wilmington: USGS # 05527500	5150	7929
Kaskaskia River at Cooks Mills: USGS # 05591200	473	661
Kaskaskia River near Venedy Station: USGS # 05594100	4393	4920
LaMoine River at Ripley: USGS # 05585000	1293	3753
Little Wabash River at Louisville: USGS # 03378900	745	2864
Mackinaw River below Green Valley: USGS # 05568000	1073	4210
Sangamon River near Oakford: USGS # 05583000	5093	12041
Spoon River at Seville: USGS # 05570000	1636	5745
Based on ISWS instantaneous sediment data		
Cache River at Forman: USGS # 03612000	244	1229
Kankakee River at Momence: USGS # 05520500	2294	1703
Kankakee River near Wilmington: USGS # 05527500	5150	3541
Kaskaskia River at Vandalia: USGS # 05592500	1904	5909
LaMoine River at Colmar: USGS # 05584500	655	1187
LaMoine River at Ripley: USGS # 05585000	1293	3753
Little Wabash River at Carmi: USGS # 03381500	3102	5308
Pecatonica River at Freeport: USGS # 05435500	1326	1131
Rock River at Rockton: USGS # 05437500	6363	2391
Sangamon River at Monticello: USGS # 05572000	550	584
Silver Creek near Freeburg: USGS # 05594800	464	1250

Table 5. Effective Discharges of Partially Qualified Stations

Station description	*Watershed area (mi^2)*	*Effective discharge (cfs)*
Based on USGS mean daily sediment data		
Apple River near Hanover: USGS # 05419000	247	2067
Des Plaines River at Riverside: USGS # 05532500	630	1148
Green River near Geneseo: USGS # 05447500	1003	1030
Henderson Creek near Oquawka: USGS # 05469000	432	1844
Illinois River at Chillicothe: USGS # 05559600	13543	12936
Illinois River at Pekin: USGS # 05563800	14585	20158
Illinois River at Valley City: USGS # 05586100	26743	32964
Kishwaukee River near Perryville: USGS # 05440000	1099	1048
Rock River near Joslin: USGS # 05446500	9549	8730
Based on ISWS instantaneous sediment data		
Embarras River at Ste. Marie: USGS # 03345500	1516	2388
Fox River at Algonquin: USGS # 05550000	1403	408
Iroquois River at Iroquois: USGS # 05525000	686	1067
Iroquois River near Chebanse: USGS # 05526000	2091	1456
Salt Creek near Rowell: USGS # 05578500	335	506
Sangamon River at Riverton: USGS # 05576500	2618	4577
South Fork Sangamon River below Rochester: USGS # 05576022	870	838
Spoon River at London Mills: USGS # 05569500	1072	1648
Vermilion River near Lenore: USGS # 05555300	1251	6565

Recurrence interval estimates for all qualified stations ranged from less than 1.01 to 1.23 years. Sixty percent, 12 of the 20 effective discharges reported in Tables 6 and 7, had recurrence intervals less than or equal to 1.01 years. Only 3, 15 percent, of the stations had effective discharges greater than 1.10 years. These relatively small recurrence intervals do not necessarily represent flood events, and are more indicative of common high-flow conditions. On average, a river's annual maximum discharge should equal or exceed the 1.01-year flow event 99 percent of the time (99 years of a 100-year record). Likewise, a river's annual maximum discharge should equal or exceed the 1.25-year flow event for 80 years of a 100-year record.

Although flow events larger than a stream's effective discharge may occur relatively frequently within these streams, effective discharge values are also typically larger than the river's mean daily discharge. The effective discharges in Table 6 are 0.822 to 5.205 times that of

Table 6. Recurrence Intervals of Effective Discharge Values at Gaging Stations Having USGS Suspended Sediment Data

USGS station name	*USGS #*	*Physiographic unit*	*Watershed area (mi^2)*	*Slope (ft/ft)*	*Mean discharge (cfs)*	*Effective discharge (cfs)*	*1.25-year flow event* (cfs)*	*2.0-year flow event* (cfs)*	*Effective discharge recurrence interval (years)*	*Flows in effective discharge bin (%)*	*Flows exceeding effective discharge (%)*	*Total suspended load (%)*
Kaskaskia River at Cooks Mills	5591200	Bloomington Ridged Plain	473	0.00029	456	661	3590	5350	< 1.01	12.68	20.87	26.43
Edwards River near New Boston	5466500	Galesburg Plain	445	0.00051	302	956	2600	4170	1.01	6.91	7.80	44.32
La Moine River at Ripley	5585000	Galesburg Plain	1293	0.00035	841	3753	5740	9530	1.07	2.15	5.78	59.79
Spoon River at Seville	5570000	Galesburg Plain	1636	0.00038	1104	5745	8030	12600	1.08	1.46	3.48	63.40
Iroquois River near Chebanse	5526000	Kankakee Plain	2091	0.00013	1737	2709	8880	13200	< 1.01	7.49	20.07	24.80
Iroquois River at Iroquois	5525000	Kankakee Plain	686	0.00021	588	670	2670	3910	< 1.01	15.66	28.64	33.21
Kankakee River at Momence	5520500	Kankakee Plain	2294	0.00017	2073	1703	4920	6740	< 1.01	26.32	48.45	27.87
Kankakee River near Wilmington	5527500	Kankakee Plain	5150	0.00024	4447	7929	15540	24700	1.02	7.41	16.61	32.63
Kaskaskia River near Venedy Station	5594100	Springfield Plain	4393	–	3731	4920	13100	22600	1.02	12.01	26.37	40.03
Little Wabash River at Louisville	3378900	Springfield Plain	745	0.00050	580	2864	6890	11200	< 1.01	4.68	6.39	60.37
Mackinaw River near Green Valley	5568000	Springfield Plain	1073	0.00047	712	4210	4830	8330	1.17	1.99	7.11	63.53
Sangamon River near Oakford	5583000	Springfield Plain	5093	0.00024	3451	12041	12500	22500	1.23	8.33	7.44	71.69

Note:
Total suspended load (column 13) is the percentage moved by flows less than or equal to the effective discharge.
*Values are from Soong et al. (in preparation).

Table 7. Recurrence Intervals of the Effective Discharge Values at Gaging Stations Having ISWS Suspended Sediment Data

USGS station name	*USGS #*	*Physiographic unit*	*Watershed area (mi^2)*	*Slope (ft/ft)*	*Mean discharge (cfs)*	*Effective discharge (cfs)*	*1.25-year flow event* (cfs)*	*2.0-year flow event* (cfs)*	*Effective discharge recurrence interval (years)*	*Flows in effective discharge bin (%)*	*Flows exceeding effective discharge (%)*	*Total suspended load (%)*
Sangamon River at Monticello	5572000	Bloomington Ridged Plain	550	0.00052	420	584	3190	5400	< 1.01	13.97	21.58	37.67
La Moine River at Colmar	5584500	Galesburg Plain	655	0.00070	460	1187	4350	8490	1.01	6.71	3.28	36.03
La Moine River at Ripley	5585000	Galesburg Plain	1293	0.00035	841	3753	5740	9530	1.07	2.15	3.88	58.39
Kankakee River at Momence	5520500	Kankakee Plain	2294	0.00017	2073	1703	4920	6740	< 1.01	26.32	48.45	34.18
Kankakee River near Wilmington	5527500	Kankakee Plain	5150	0.00024	4447	3541	15540	24700	< 1.01	22.34	43.34	24.54
Little Wabash River at Carmi	3381500	Mt. Vernon Hill Country	3102	0.00022	2753	5308	10340	15600	1.02	11.70	20.11	49.85
Pecatonica River at Freeport	5435500	Rock River Hill Country	1326	0.00030	948	1131	3400	5470	< 1.01	25.34	69.59	66.94
Rock River at Rockton	5437500	Rock River Hill Country	6363	0.00016	4316	2391	10200	14700	< 1.01	27.01	66.58	24.57
Cache River at Forman	3612000	Shawnee Hills Section	244	0.00051	297	1229	2210	3640	1.04	2.77	5.90	56.18
Kaskaskia River at Vandalia	5592500	Springfield Plain	1904	0.00026	1515	5909	7650	12700	1.11	3.68	19.55	79.92
Silver Creek near Freeburg	5594800	Springfield Plain	464	0.00044	367	1250	2670	5220	1.05	7.52	9.12	71.63

Note:
Total suspended load (column II) is the percentage moved by flows less than or equal to the effective discharge.
*Values are from Soong et al. (in preparation).

the river's mean daily discharge. Only one station, Kankakee River at Momence (USGS# 5520500), has an effective discharge value less than the river's mean daily discharge. Effective discharges in Table 7 are 0.554 to 4.461 times the river's mean daily discharge   Stations 5520500, 5527500, and 5437500 (Table 7), however, all have effective discharge values less than the river's mean daily discharge.

These results indicate that over time the largest fraction of suspended sediment transported within these streams is typically by relatively frequent flow events that have magnitudes less than or slightly greater than the smallest recorded maximum annual discharge but larger than the mean daily discharge. For example, for the station on the Kankakee River near Wilmington (USGS# 05527500), the river has a relatively small mean daily discharge (4447 cfs) compared to its effective discharge of 7929 cfs, which has a return period of 1.02. Thus, the river's annual maximum discharge equals or exceeds the effective discharge value, on average, 98 out of every 100 years, but the effective discharge is 1.78 times that of the river's mean daily discharge.

Biedenharn et al. (1999) suggest that most effective discharges should have recurrence intervals between 1.0 and 3.0 years. Here, most (85%) of the recurrence intervals were found within a narrow range of recurrence intervals (between 1.000 and 1.100). However, other researchers have found that the recurrence intervals for effective discharges can vary by orders of magnitude (less than one year to several tens of years), and that recurrence intervals of effective discharge estimates may depend on geographical and hydrologic characteristics found within the streams being studied (e.g., Nash, 1994; and Ashmore and Day, 1988). Nash (1994) and Ashmore and Day (1988) also concluded that no single recurrence interval can be used to represent effective discharge values. Due to the limited data in this study, it is unclear whether the narrow range of recurrence intervals reported was due to regional trends within Illinois or other factors. Moreover, a comparison of each qualified station's effective discharge, 1.25-year flow event, and 2.0-year flow event, demonstrates that small differences in recurrence intervals (e.g., between 1.01, 1.25, and 2.00 years) may represent large changes in discharge. In this study, the 1.25-year flow events are 1.04 to 5.46 times larger than the effective discharge, while the 2.0-year flow events are 1.87 to 9.25 times larger than the effective discharge. Consequently, assuming a stream's dominant discharge to be equal to the effective discharge versus a commonly accepted recurrence interval such as 1.5 years may result in a significantly different dominant discharge estimate.

Geographic Variations in Effective Discharge within Illinois

Eleven regression analyses are performed to help assess any physiographic or regional trends in effective discharge within Illinois. The first five regressions plot effective discharge, effective discharge recurrence interval, percent of flows in effective discharge bin, percent of flows exceeding effective discharge, and cumulative percent of suspended sediment load carried by discharges less than or equal to effective discharge against slope.   These regressions help quantify how channel slope affects effective discharge.   The remaining six regressions plot effective discharge, effective discharge return period, channel slope, percent of flows in effective discharge bin, percent of flows exceeding effective discharge, and cumulative percent of suspended sediment load carried by discharges less than or equal to effective discharge against watershed area. These analyses help determine watershed area influences on effective discharge values. As the type of suspended sediment data collected at a gaging station influences effective discharge values, these 11 regression analyses were performed for stations in Table 6 and Table 7. Regression analyses also were performed on all data collectively. Additionally, the predominant physiographic region through which a particular stream flowed prior to reaching each qualified gaging station was identified using Illinois physiographic regions defined by Leighton et al. (1948). Thus, each gaging station and its effective discharge are directly associated with a physiographic region to help determine the influence of specific physiographic regions on effective discharge values. Physiographic units associated with each station are shown in Table 6 and Table 7. Color marker codes also were used to identify the physiographic region associated with each data point in the regression analyses.

Slope values assigned to each station in Tables 6 and 7 were from Curtis (1987). However, a slope value for USGS station 5594100 was not available. Consequently, all slope regression analyses for Table 6 are based on 11 data points, whereas watershed area regression analyses are based on 12 data points. The 11 regressions calculated using the Table 7 data each contain 11 data points.

Correlation coefficients (r^2) for the various regressions were tabulated (Table 8). Regression analysis trends statistically significant at the 95 percent confidence level using the Student's **t-**distribution also are indicated. Only the regression plotting percent flows exceeding effective discharge against channel slope was statistically significant for the ISWS, USGS, and ISWS and USGS combined data sets.

The regression trend between effective discharge and watershed area was statistically significant when using USGS data, but not when using ISWS data. Conversely, the regression analysis plotting the percent of flows occurring within the effective discharge bin versus watershed area was statistically significant for ISWS data, but not USGS data. These results suggest that the amount and type of suspended data used in computing effective discharge may influence regression analysis results. However, more data would be needed to show conclusively that such differences are caused by the different data types used to compute effective discharge. Regression lines obtained by plotting percent of flows exceeding effective discharge against watershed area (using USGS data, ISWS data, and combined USGS and ISWS data) are shown (Figure 9).

It is not clear from these results whether any of the six effective discharge parameters correlate closely with channel slope or watershed area. Likewise, no relationships between the physiographic characteristics of a stream and effective discharges could be detected visually within various plots. Before such relationships can be identified, effective discharge results from many more gaging locations need to be available. This is particularly true for streams with watershed areas smaller than 244 mi^2 because none were included in these analyses.

Table 8. Correlation Coefficients for Linear Regression Analyses

	X - axis variables					
	USGS data in Table 6		*ISWS data in Table 7*		*USGS and ISWS Data*	
Y-axis variables	*Slope (ft/ft)*	*Watershed area (mi^2)*	*Slope (ft/ft)*	*Watershed area (mi^2)*	*Slope (ft/ft)*	*Watershed area (mi^2)*
Q_{eff} (cfs)	0.0141	0.6691*	0.2856	0.1461	0.0779	0.3586*
Return period (years)	0.0212	0.1094	0.0006	0.1066	0.0037	0.0103
Slope (ft/ft)	-	0.2203	-	0.5181*	-	0.368*
Flows in Q_{eff} bin (%)	0.3537	0.0097	0.3319	0.3959*	0.2708*	0.1561
Flows Exceeding Q_{eff} (%)	0.4529*	0.0136	0.434*	0.4004*	0.3347*	0.1795*
Cumulative Load (% carried by flows ≤ Q_{eff})	0.3487	0.0021	0.0087	0.336	0.0952	0.0825

Note: An asterisk (*) indicates regression trends that are significant at the 95 percent confident level using the Student's **t**-distribution.

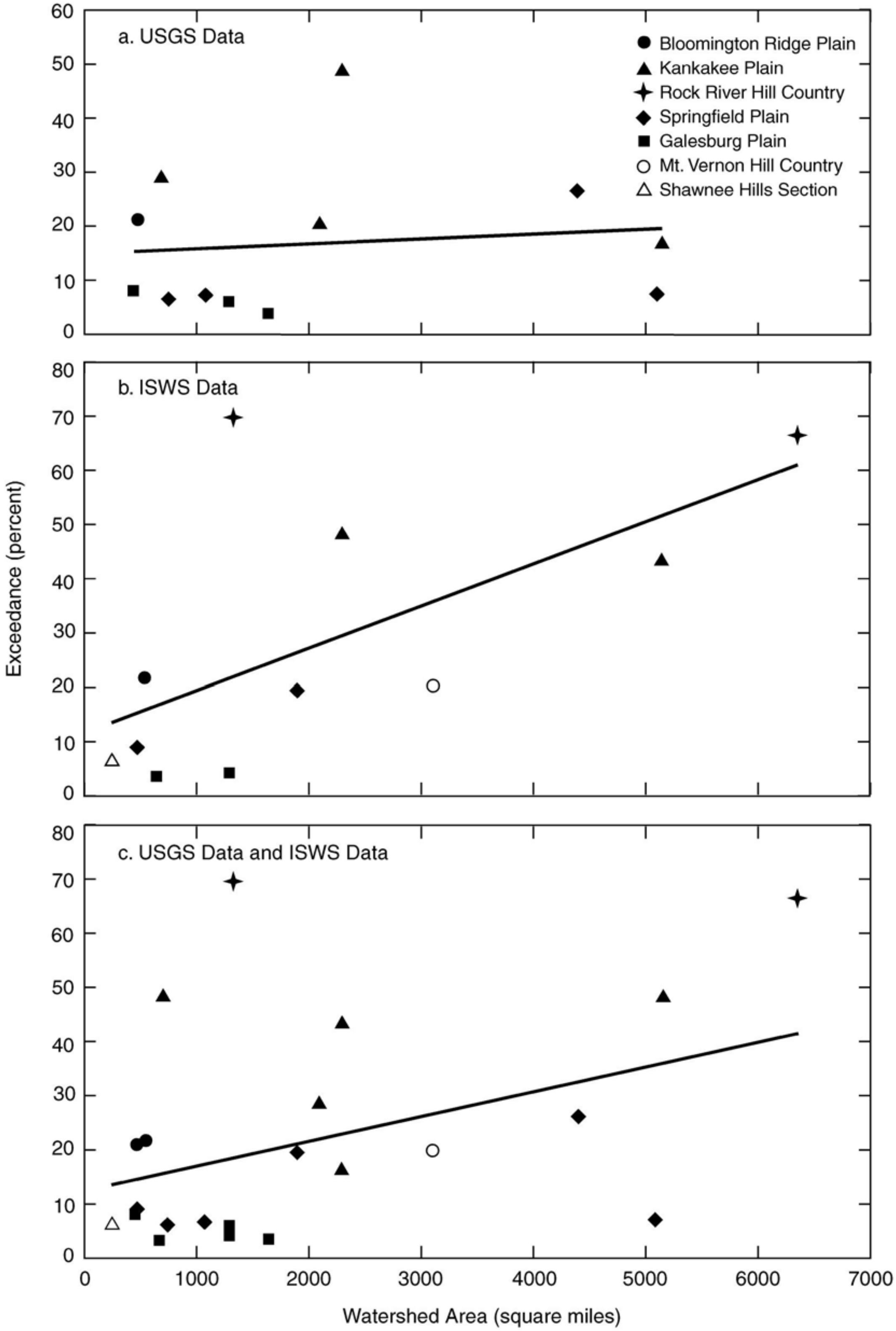


Figure 9. Plots of the percentage of flows exceeding effective discharge versus watershed area: a) USGS data, b) ISWS data, and c) USGS and ISWS data.

Discussion and Conclusions

Overall Project Assessment

Suspended sediment and discharge records for 88 Illinois gaging stations were examined for use in estimating effective discharges. It was determined that only 20 of these stations had sufficient suspended sediment and discharge data to compute effective discharge values. In each case, it was assumed that these sites were morphologically stable and that their flow regimes had not changed significantly over the entire mean daily discharge period of record due to stream or watershed modifications. Although there is insufficient information available to validate this assumption, most of the 20 qualified stations in this analysis are on streams with watershed areas in excess of 500 mi^2, which are commonly but not always stable streams in Illinois. A computational procedure was developed to compute effective discharge values at these stations. Flow frequencies and flood recurrence intervals associated with effective discharge values of these 20 stations also were computed.

Linear regression analyses were performed in an attempt to determine how various attributes of effective discharge correlated with slope and watershed area of the gaged streams. Originally, it was hoped that sufficient data would be available to compute effective discharge values at a large number of stations representative of various types and sizes of streams within Illinois. With such data, it would be possible to investigate potential methods to identify effective discharge trends and estimate effective discharge values at ungaged stations throughout Illinois. Currently, insufficient data are available to predict geographic variations in effective discharges or thus estimate effective discharge values at ungaged locations.

Despite this lack of data, study results provide valuable information regarding the data and knowledge necessary to accomplish this objective and better quantify effective discharge values in the future. The following sections briefly summarize the process of estimating effective discharges within Illinois, effective discharge values and effective discharge recurrence interval values obtained for qualified gaging stations, monitoring needs to improve effective discharge computations, and the need for validating current and future effective discharge estimates.

Computing Effective Discharge

Computing effective discharge is conceptually and mathematically simple. However, effective discharge values are particularly sensitive to the method and underlying data used to create sediment rating curves and the number of discharge classes used in the computation. In this study, a stream's suspended sediment load was used in computing effective discharges. Sufficient data to create bed load, total load, and bed material loads simply did not exist for these 88 stations. Consequently, the impact of using different sediment loads on effective discharge estimates in Illinois streams remains unknown. A separate evaluation needs to determine which loads are most important in determining effective discharges within Illinois streams, so that they can be properly incorporated into future effective discharge computations.

The method used to estimate sediment load values for a particular discharge class can influence effective discharge values significantly. Based on load histogram curve results and theoretical arguments put forth by Ferguson (1986), it was determined that estimating sediment loads using a power curve had a tendency to underestimate sediment transport rates and sediment yields. Consequently, an alternative method was used to assign the amount of sediment each discharge class carries. Specifically, sediment load data available for a station were divided into the same discharge classes as those used to compute flow frequency estimates. Suspended sediment loads for discharges falling within a specific discharge class were then averaged and assigned to be the discharge class' sediment transport rate.

It is not yet possible to clearly define the amount of sediment and discharge data needed to compute effective discharge. Simple examples demonstrate that the amount of suspended sediment data collected and the range of discharges over which samples are collected can influence effective discharge results. Determining the number of discharge classes to be used in an effective discharge computation is subjective. Specific guidelines were developed to determine what constituted sufficient data and the number of discharge classes used in a computation. While these criteria provide a consistent means of analyzing current data, these guidelines are still subjective. It is difficult, if not impossible, to determine the computational uncertainty associated with using varying amounts of sediment data and discharge classes.

Geographic Variations in Effective Discharge

Of the 20 qualified gaging stations, 9 of these stations were considered qualified using USGS daily suspended sediment concentration data, while 8 of these stations were considered qualified using ISWS instantaneous suspended sediment concentration data. The remaining three stations were qualified using either USGS or ISWS data. Significant differences exist between USGS daily sediment estimates and the ISWS instantaneous sediment measurements. These differences may influence effective discharge results. Consequently, pooling ISWS and USGS data results is probably not appropriate. However, two of the three gaging stations that were qualified using either USGS or ISWS data yielded similar effective discharge values for both ISWS and USGS data.

Most effective discharge values for qualified stations represent high-flow events, but typically not flood events. Recurrence intervals for the 20 effective discharge estimates ranged from less than 1.01 to 1.231 years. More than half of these estimates were similar to or less than the station's minimum recorded annual peak discharge, or typically not as great as the base flood event for the stream. Effective discharge values were typically greater than the station's mean discharge value; however, the effective discharge at four stations was less than the river's mean discharge. Consequently, effective discharges at qualified gaging stations are often fairly frequent flow events, at least for qualified stations that are located in large watersheds. It is possible, although not necessarily the case, that effective discharge estimates from smaller watersheds could represent more typical flood events.

It is not known how effective discharges compare with bankfull discharge estimates, which like effective discharge estimates, often are associated with a stream's dominant discharge. Additionally, on site geomorphic assessments of streams conditions are necessary to determine whether or not the calculated effective discharge reasonably can be associated with a river's dominant discharge or bankfull discharge, especially for stations having effective disharges less than the stream's mean flow.

Although the effective discharge values have a narrow range of recurrence intervals, using this range of values to estimate effective discharge at ungaged sites or to identify how effective discharge varies with slope or watershed area is not recommended. All stations are within relatively large watersheds (244 – 6363 mi^2 in area). Thus, effective discharge values of stream locations within smaller watersheds are not represented. Obtaining information on streams in smaller watersheds may be particularly important as prior researchers have suggested that effective discharge recurrence intervals tend to increase with a decrease in watershed area (Wolman and Miller, 1960; and Ashmore and Day, 1988).

Methods have been proposed for computing effective discharge at locations that lack sediment data (e.g., Biedenharn et al., 1999). None of these methods were used in this study, and it is not known how well such methods would work for Illinois streams.

Future Monitoring Needs

To more fully estimate effective discharge values representative of different stream types within Illinois, additional stream monitoring needs to be conducted. These monitoring needs fall into three basic categories: 1) monitoring streams within small watersheds, 2) collecting additional suspended sediment samples at existing gaging stations, and 3) collecting types of sediment data not currently being monitored at existing gaging stations. An exact strategy for collecting/sampling various types of data is not described or proposed here. Instead, there is a brief discussion on how additional monitoring in these areas would contribute to a better understanding of effective discharge and trends within Illinois streams. Additional work would have to be done to develop an appropriate strategy for collecting and analyzing such data.

Monitoring Small Watersheds

Currently, no effective discharge values have been computed for streams in watersheds having areas less than 244 mi^2. The ISWS currently is measuring suspended sediment at gaging stations on 14 small watersheds. However, sediment and discharge data for these locations has become available only recently and is only a few years in duration. A thorough investigation of the effective discharge values obtained at these and similar locations is important for two reasons. First, this would provide the data needed to better estimate when mean daily discharge and sediment load values can be used to compute effective discharge and when instantaneous suspended sediment data and either 60-, 30-, or 15-minute data are needed to determine effective discharge. Second, smaller watersheds may have significantly different geomorphologic characteristics than larger watersheds. Slopes, bed material, and transport mechanisms may be significantly different and cause effective discharge values to behave differently than those in larger watersheds.

Additional Suspended Sediment Sampling at Existing Gaging Stations

A crucial component of computing effective discharges is developing appropriate sediment rating curves by sampling sediment loads across the full range of discharges in a stream. Some suspended sediment gaging stations evaluated in this study did not have sediment data representative of a large enough range of discharges to estimate effective discharge adequately. Consequently, these stations were labeled either partially qualified or disqualified and were not used to estimate effective discharge recurrence intervals. If collected appropriately, additional suspended sediment samples from active sediment gaging stations could provide the necessary extra data to establish sediment load curves covering the entire discharge ranges at these discarded stations.

In addition to collecting suspended sediment data across the entire range of flows within a river, samples need to be sufficient to account for the variability in sediment loads at different discharges. Otherwise, the sediment rating curve can still be poorly defined even if all discharge ranges have been sampled. In several partially qualified and disqualified stations, it appeared that numerous sediment samples had been collected at lower discharge ranges but only a few at higher discharges. In the effective discharge computation, this can cause loads carried by smaller discharges to be estimated more accurately than loads carried by larger discharges. Having inaccurate or poor load estimates for larger, but not extreme flow events, is undesirable as these discharges represent the range of flows where effective discharge is likely to exist. Additional storm sampling at sediment gaging stations would allow more accurate qualification of loads carried by higher discharges and lead to better estimates of effective discharge.

Types of Data Not Currently Monitored

Another important aspect in developing appropriate sediment rating curves is the type of sediment data used. In some cases, a load curve based on suspended sediment load may be sufficient. However, in other cases, it may be more appropriate to develop total sediment load curves or bed material transport curves. Creating these load curves requires information on bed load transport rates and suspended sediment transport rates within a stream. Unfortunately, very little actual bed load transport data are available in Illinois. This paucity of data probably reflects the difficulty of measuring bed load transport in Illinois streams.

Bhowmik et al. (1980) concluded that bed load samplers were incapable of adequately sampling sandy rivers common in Illinois. Indirect methods of estimating bed load transport rates through empirical equations are also problematic. Graf (1983) examined bed load transport in nine Illinois streams and found that three commonly used empirical equations provided estimates that varied by several orders of magnitude. Several different types of information need to be collected at a gaging site to use empirical bed load transport equations. These data include, but are not limited to, bed material composition, stream cross-sectional geometry, channel slope, and stage-discharge relationships at the cross section surveyed. This type of data also is not routinely available at Illinois gaging stations. Hence, an investigation of the role that bed load plays in effective discharge values in Illinois would be quite difficult to pursue. New technologies for sampling or estimating bed load may need to be tested and developed. Similarly, substantial care likely would have to be spent on developing appropriate and meaningful methods of collecting and interpreting bed load data.

Validation of Effective Discharge Values

Effective discharges computed at the 20 qualified gaging stations provide initial information on the discharges within Illinois that carry most suspended sediment over time. In estimating these values, it was assumed that both channel morphology and hydrologic characteristics of the stream were stable over the entire period for which discharge data were available. This allowed better estimates of long-term flow frequencies. Biedenharn et al. (1999) caution that discharge records longer than 20 years should be evaluated to make sure that watershed development or other activities were not influencing or altering flow frequency and sediment rating curve estimates during the period of record. Unfortunately, determining if a stream's hydrology and morphology are stable over the period of record is a difficult task requiring field observations and data analysis. Such an analysis was beyond the scope of this work. Hence, care should be taken to evaluate whether or not current effective discharge values meet these criteria.

Another crucial issue is to validate the physical significance of effective discharge values. It is often assumed that a stream's effective discharge is equal to its dominant discharge, which often is used to design channels. However, evidence suggests that this is not always the case. Wolman and Miller (1960) cite an example where some streams carry most of their sediment load in the winter at relatively low discharges, but a larger, less frequent discharge is responsible for determining the maximum bank height and floodplain of the river. The lower of these two discharges is the effective discharge. However, the larger discharge responsible for determining bank and floodplain height may more accurately represent the dominant discharge for which a channel should be designed. Ashmore and Day (1988) also suggest that the dominant discharge may not always be the same as the effective discharge for suspended sediment. Computing the bankfull discharge at gaging locations is therefore recommended. Additionally, a geomorphic assessment of stream stability should be made to better evaluate the physical significance of the effective discharge and how it compares to bankfull discharge estimates and discharges associated with recurrence intervals commonly used to represent dominant discharge.

Summary of Significant Findings and Recommendations

- As noted by Nash (1994), Sichingabula (1999), and others, effective discharge computations are sensitive to how sediment rating curves and discharge frequency are developed, along with the number of discharge classes used in their computation. As such, these estimates can be prone to large uncertainties. However, stream restoration personnel likely will continue to use these and other effective discharge values to help design and restore channels. As suggested by Copeland et al. (2000), uncertainties in their use should be acknowledged and undue weight should not be assigned these values, as they cannot yet be expected to yield fully reliable results in applications.

- Moreover, as recommended by Copeland et al. (2000), effective discharge values should be weighed and validated against other estimates of dominant discharge on particular streams, such as bankfull discharges and the discharges of specific recurrence intervals. Estimates of dominant discharge should also be evaluated in conjunction with knowledge gained by on-site geomorphic, hydraulic, and sediment transport analyses (Copeland et al., 2000). Future assessments also will be required to evaluate the ability of the dominant discharge to define channel stability in Illinois streams.

- A lack of consensus still exists about many aspects of computing effective discharge and how it relates to dominant discharge theory. Different types of data and methods used by individual researchers compute effective discharge/dominant discharge often make research values fundamentally different and incomparable with those of other researchers.

- Knowledge gained from comprehensive analysis of effective discharge values representative of Illinois streams is a first step in understanding effective discharges in Illinois. It also adds to the collective body of data describing effective discharge values, particularly for Illinois streams with watershed areas between 244 and 6363 mi^2.

- Twenty of 88 Illinois gaging stations have sufficient suspended sediment data to compute effective discharge values. Many hundreds of sediment data values were associated with each of these qualified stations.

- For qualified gaging stations, effective discharge values, computed using suspended sediment load curves, are typically relatively frequent high-flow events of magnitudes less than the 1.10-year flood, but greater than the river's mean discharge.

- Data are insufficient to compute effective discharge values for streams in smaller watersheds (< 244 mi^2). When data on smaller watersheds become available, the effective discharges should be computed based on flow frequencies derived on sub-daily time increments and instantaneous suspended sediment data.

- Due to a lack of data, computed correlations between effective discharge, watershed area, and channel slope are inconclusive. Before regional and physiographic relationships in effective discharges can be identified, data must be available for many more gaging locations.

- Suspended sediment represents the dominant sediment load in most Illinois streams. In some cases, effective discharge computations based on total loads or bed material loads may be more appropriate than using suspended sediment loads analyzed here. However, a paucity of bed load data and inherent difficulties in sampling and estimating bed loads in Illinois make comparing different approaches problematic now and in the near future.

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APPENDIX A

Effective Discharge Results for Qualified Stations that Use USGS Suspended Sediment Data

Notation for tables in Appendix A:

< (%) The percent of flow events less than the minimum discharge at which suspended sediment samples were collected

> (%) The percent of flow events greater than the maximum discharge at which suspended sediment samples were collected

Exceedance (%) The percent of flows exceeding the magnitude of the station's effective discharge

Cumulative load (%)* The percent of suspended sediment load carried by flows less than or equal to the effective discharge

% load carried* The percent of suspended sediment load carried by a discharge class.

Bin value (cfs) The average of the uppermost and lowest discharge values in a discharge class

Note:
* Values are based on the mean approach which assigns zero sediment load to discharge classes that having no sediment samples falling within them. Assuming or extrapolating sediment loads for these discharge classes would result in different percentage values.

Edwards River near New Boston: USGS # 05466500

Discharge record	
	Mean daily discharge (cfs)
Records	24107
Min.	1.30
Max.	14000.00
Mean	302.32
Median	131.00

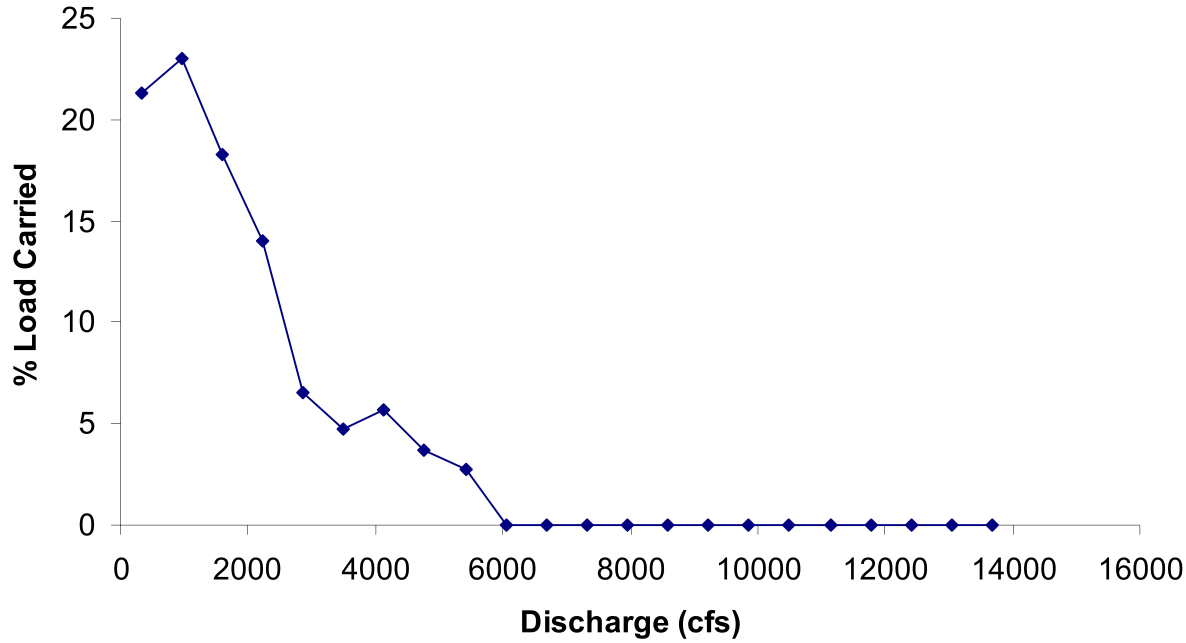
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1004	1004
Min.	11.00	1.4024
Max.	5330.00	75753.3366
Avg.	361.30	1327.6133
Median	158.00	65.8031
< (%)	3.0987	
> (%)	0.1161	
r^2	0.8621	

Effective discharge results	
Mean approach	
Bins	22
Bin size (cfs)	636.30
Discharge (cfs)	955.76
Exceedance (%)	7.80
Cumulative load (%)	44.32

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 1.3	0	0	0.000000	0.0000
1.3 - 637.604	21394	876	0.887460	242.3636
637.604 - 1273.909	1665	69	0.069067	3352.8634
1273.909 - 1910.214	492	24	0.020409	9012.9326
1910.214 - 2546.518	250	11	0.010370	13604.0210
2546.518 - 3182.823	114	7	0.004729	13918.0082
3182.823 - 3819.127	60	7	0.002489	19338.1763
3819.127 - 4455.432	62	5	0.002572	22137.5491
4455.432 - 5091.736	32	3	0.001327	28319.6739
5091.736 - 5728.041	14	2	0.000581	47435.5055
5728.041 - 6364.345	17	0	0.000705	0.0000
6364.345 - 7000.65	3	0	0.000124	0.0000
7000.65 - 7636.955	1	0	0.000041	0.0000
7636.955 - 8273.259	1	0	0.000041	0.0000
8273.259 - 8909.564	1	0	0.000041	0.0000
8909.564 - 9545.868	0	0	0.000000	0.0000
9545.868 - 10182.173	0	0	0.000000	0.0000
10182.173 - 10818.477	0	0	0.000000	0.0000
10818.477 - 11454.782	0	0	0.000000	0.0000
11454.782 - 12091.086	0	0	0.000000	0.0000
12091.086 - 12727.391	0	0	0.000000	0.0000
12727.391 - 13363.696	0	0	0.000000	0.0000
13363.696 - 14000.0	1	0	0.000041	0.0000
> 14000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
319	21.3443
956	22.9801
1592	18.2538
2228	14.0000
2865	6.5314
3501	4.7763
4137	5.6499
4774	3.7304
5410	2.7337
6046	0.0000
6682	0.0000
7319	0.0000
7955	0.0000
8591	0.0000
9228	0.0000
9864	0.0000
10500	0.0000
11137	0.0000
11773	0.0000
12409	0.0000
13046	0.0000
13682	0.0000
0	0.0000

Edwards River near New Boston: USGS # 05466500



Load histogram curve using the mean approach.

Iroquois River at Iroquois: USGS # 05525000

Discharge record	
	Mean daily discharge (cfs)
Records	20454
Min.	5.50
Max.	10200.00
Mean	587.87
Median	267.00

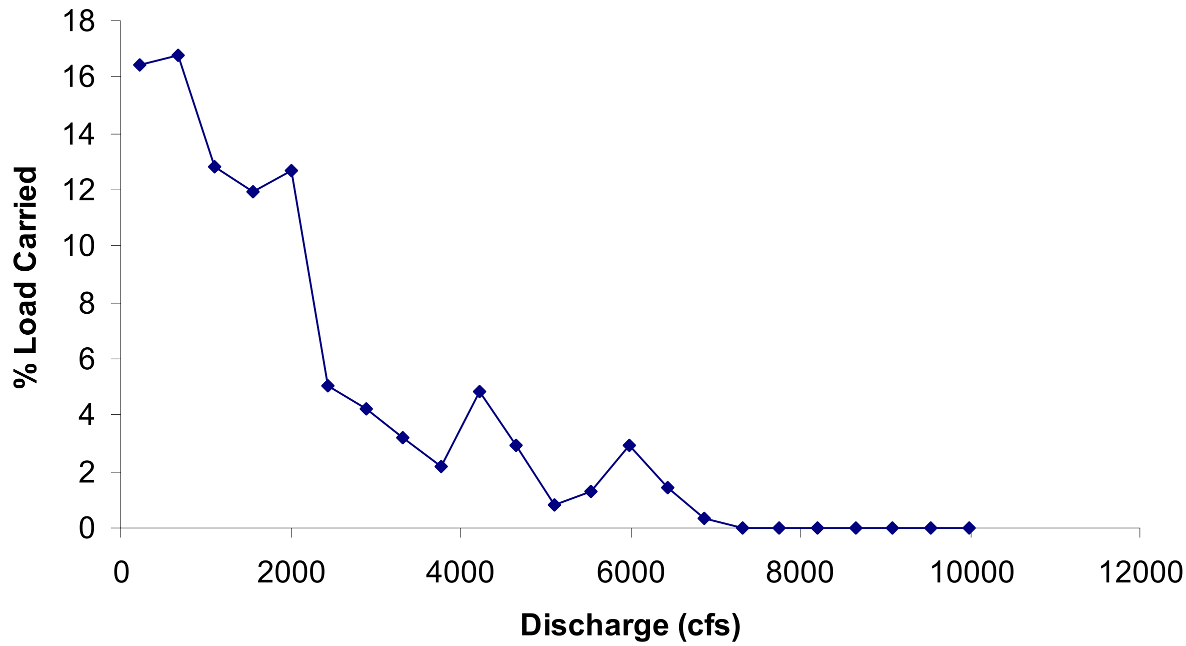
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1826	1826
Min.	22.00	0.4531
Max.	6770.00	12406.5722
Mean	754.52	156.4431
Median	339.50	46.5507
< (%)	4.5468	
> (%)	0.0244	
r^2	0.7004	

Effective discharge results	
Mean approach	
Bins	23
Bin size (cfs)	443.24
Discharge (cfs)	670.36
Exceedance %	28.64
Cumulative load (%)	33.21

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 5.5	0	0	0.000000	0.0000
5.5 - 448.739	12994	1055	0.635279	30.8908
448.739 - 891.978	3204	254	0.156644	128.3040
891.978 - 1335.217	1574	137	0.076953	199.2260
1335.217 - 1778.456	953	127	0.046592	306.0937
1778.456 - 2221.696	680	113	0.033245	456.4981
2221.696 - 2664.935	368	49	0.017992	335.4572
2664.935 - 3108.174	204	24	0.009974	509.8425
3108.174 - 3551.413	152	18	0.007431	520.9495
3551.413 - 3994.652	95	11	0.004645	555.1643
3994.652 - 4437.891	81	15	0.003960	1470.7083
4437.891 - 4881.13	64	7	0.003129	1131.9314
4881.13 - 5324.37	31	6	0.001516	652.8018
5324.37 - 5767.609	31	7	0.001516	1032.8308
5767.609 - 6210.848	12	1	0.000587	5912.5660
6210.848 - 6654.087	5	1	0.000244	6968.6511
6654.087 - 7097.326	2	1	0.000098	4564.4125
7097.326 - 7540.565	0	0	0.000000	0.0000
7540.565 - 7983.804	0	0	0.000000	0.0000
7983.804 - 8427.044	1	0	0.000049	0.0000
8427.044 - 8870.283	0	0	0.000000	0.0000
8870.283 - 9313.522	1	0	0.000049	0.0000
9313.522 - 9756.761	1	0	0.000049	0.0000
9756.761 - 10200.0	1	0	0.000049	0.0000
> 10200.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
227	16.4081
670	16.8043
1114	12.8185
1557	11.9243
2000	12.6892
2443	5.0463
2887	4.2516
3330	3.2369
3773	2.1559
4216	4.8697
4660	2.9613
5103	0.8272
5546	1.3088
5989	2.9003
6432	1.4243
6876	0.3732
7319	0.0000
7762	0.0000
8205	0.0000
8649	0.0000
9092	0.0000
9535	0.0000
9978	0.0000
0	0.0000

Iroquois River at Iroquois: USGS # 05525000



Load histogram curve using the mean approach.

Iroquois River near Chebanse: USGS # 05526000

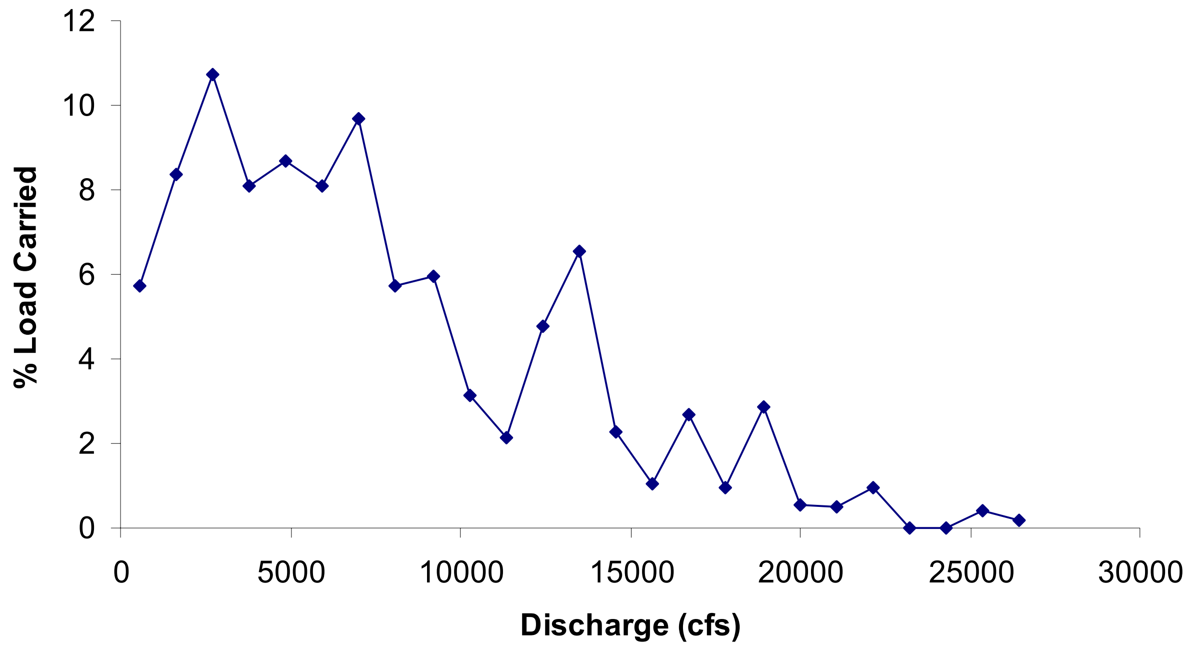
Discharge record	
	Mean daily discharge (cfs)
Records	27931
Min.	10.00
Max.	27000.00
Mean	1737.49
Median	735.00

Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	2190	2190
Min.	60.00	3.1526
Max.	27000.00	56957.3960
Mean	2425.96	1000.2232
Median	1040.00	125.7232
< (%)	6.4946	
> (%)	0.0000	
r^2	0.8287	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1079.60
Discharge (cfs)	2709.00
% Exceedance	20.07
Cumulative load (%)	24.80

Bin values (Mean approach)					Effective discharge histogram (Mean approach)	
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)	Bin value (cfs)	% Load carried
≤ 10.0	0	0	0.000000	0.0000	—	—
10.0 - 1089.6	16728	1123	0.598904	61.4123	550	5.7129
1089.6 - 2169.2	4552	365	0.162973	330.2248	1629	8.3592
2169.2 - 3248.8	2093	167	0.074935	922.0331	2709	10.7317
3248.8 - 4328.4	1357	125	0.048584	1069.9339	3789	8.0740
4328.4 - 5408.0	917	96	0.032831	1698.8985	4868	8.6634
5408.0 - 6487.6	604	71	0.021625	2408.9935	5948	8.0914
6487.6 - 7567.2	473	66	0.016935	3688.3212	7027	9.7016
7567.2 - 8646.8	333	50	0.011922	3089.1561	8107	5.7206
8646.8 - 9726.4	203	22	0.007268	5292.2734	9187	5.9744
9726.4 - 10806.0	156	29	0.005585	3620.4227	10266	3.1408
10806.0 - 11885.6	116	17	0.004153	3346.3918	11346	2.1587
11885.6 - 12965.2	113	11	0.004046	7615.1970	12425	4.7853
12965.2 - 14044.8	83	8	0.002972	14163.7126	13505	6.5375
14044.8 - 15124.4	51	11	0.001826	7960.4894	14585	2.2577
15124.4 - 16204.0	39	7	0.001396	4728.1477	15664	1.0254
16204.0 - 17283.6	20	4	0.000716	23918.3307	16744	2.6602
17283.6 - 18363.2	29	3	0.001038	5834.1948	17823	0.9409
18363.2 - 19442.8	21	5	0.000752	24547.6323	18903	2.8667
19442.8 - 20522.4	12	2	0.000430	8206.0141	19983	0.5476
20522.4 - 21602.0	13	4	0.000465	6857.9853	21062	0.4958
21602.0 - 22681.6	7	1	0.000251	24983.7469	22142	0.9725
22681.6 - 23761.2	3	0	0.000107	0.0000	23221	0.0000
23761.2 - 24840.8	4	0	0.000143	0.0000	24301	0.0000
24840.8 - 25920.4	3	2	0.000107	24136.7753	25381	0.4027
25920.4 - 27000.0	1	1	0.000036	32184.1649	26460	0.1790
> 27000.0	0	0	0.000000	0.0000	0	0.0000

Iroquois River near Chebanse: USGS # 05526000



Load histogram curve using the mean approach.

Kankakee River at Momence: USGS # 05520500

Discharge record	
	Mean daily discharge (cfs)
Records	31795
Min.	248.00
Max.	14800.00
Mean	2072.56
Median	1580.00

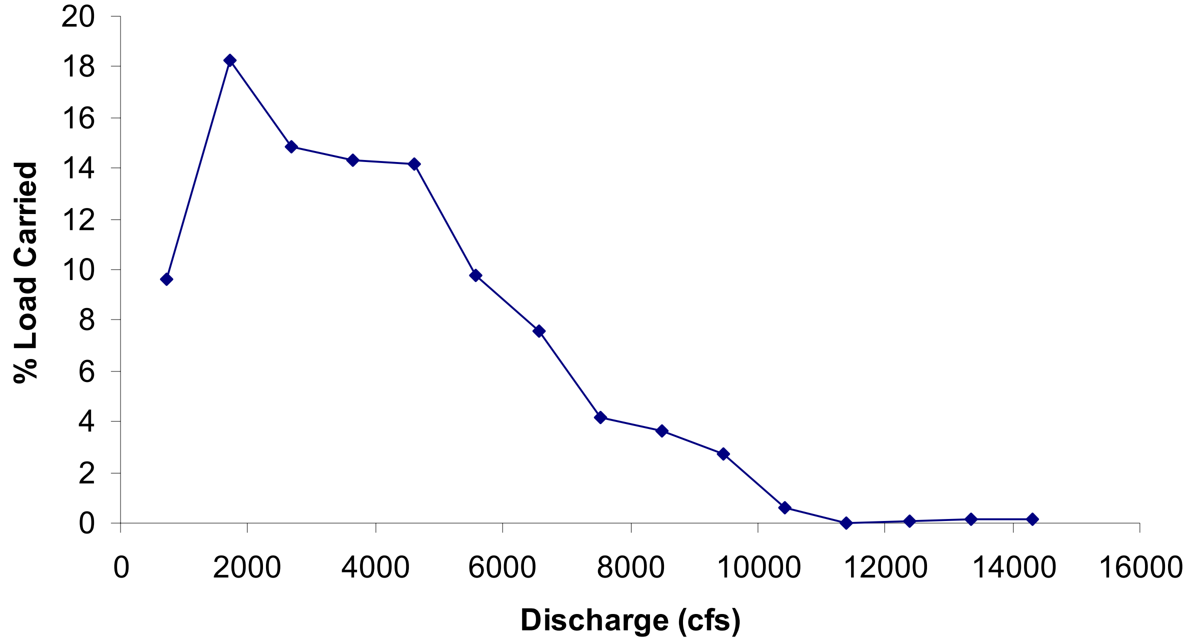
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	2191	2191
Min.	577.00	22.6211
Max.	14800.00	30579.5413
Mean	2649.65	496.0620
Median	2240.00	230.2770
< (%)	5.6361	
> (%)	0.0000	
r^2	0.6239	

Effective discharge results	
Mean approach	
Bins	15
Bin size (cfs)	970.13
Discharge (cfs)	1703.20
Exceedance (%)	48.45
Cumulative load (%)	27.87

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 248.0	0	0	0.000000	0.0000
248.0 - 1218.133	12207	518	0.383928	85.9735
1218.133 - 2188.267	8369	549	0.263217	237.5979
2188.267 - 3158.4	4650	411	0.146249	348.6242
3158.4 - 4128.533	2956	286	0.092971	526.6995
4128.533 - 5098.667	1934	216	0.060827	800.0469
5098.667 - 6068.8	974	109	0.030634	1090.2000
6068.8 - 7038.933	431	65	0.013556	1916.3197
7038.933 - 8009.067	165	22	0.005190	2753.4791
8009.067 - 8979.2	66	5	0.002076	5976.7780
8979.2 - 9949.333	28	6	0.000881	10524.4988
9949.333 - 10919.467	11	1	0.000346	5946.5463
10919.467 - 11889.6	1	0	0.000031	0.0000
11889.6 - 12859.733	1	1	0.000031	9061.4039
12859.733 - 13829.867	1	1	0.000031	14997.1628
13829.867 - 14800.0	1	1	0.000031	18160.5637
> 14800.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
733	9.6263
1703	18.2391
2673	14.8696
3643	14.2809
4614	14.1925
5584	9.7399
6554	7.5759
7524	4.1673
8494	3.6183
9464	2.7030
10434	0.6000
11405	0.0000
12375	0.0831
13345	0.1376
14315	0.1666
0	0.0000

Kankakee River at Momence: USGS # 05520500



Load histogram curve using the mean approach.

Kankakee River near Wilmington: USGS # 05527500

Discharge record	
	Mean daily discharge (cfs)
Records	30824
Min.	250.00
Max.	55100.00
Mean	4446.59
Median	2800.00

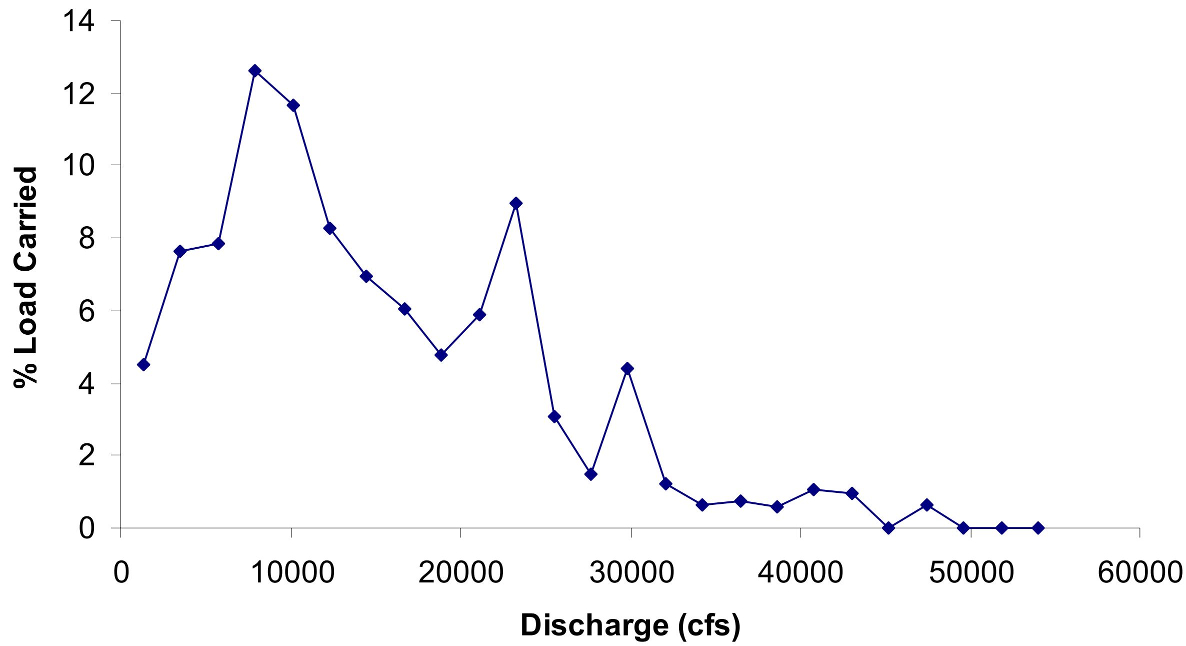
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	2556	2556
Min.	643.00	11.6478
Max.	48000.00	172258.3670
Mean	6278.39	2196.6401
Median	4160.00	385.0781
< (%)	4.1948	
> (%)	0.0130	
r^2	0.7938	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	2194.00
Discharge (cfs)	7929.00
Exceedance (%)	16.61
Cumulative load (%)	32.63

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 250.0	0	0	0.000000	0.0000
250.0 - 2444.0	14023	757	0.454938	118.0531
2444.0 - 4638.0	6886	646	0.223397	406.5444
4638.0 - 6832.0	3655	374	0.118576	788.6668
6832.0 - 9026.0	2285	210	0.074131	2020.1653
9026.0 - 11220.0	1455	149	0.047203	2933.5624
11220.0 - 13414.0	916	132	0.029717	3314.0764
13414.0 - 15608.0	533	73	0.017292	4788.0917
15608.0 - 17802.0	347	61	0.011257	6356.6476
17802.0 - 19996.0	201	44	0.006521	8652.8809
19996.0 - 22190.0	167	32	0.005418	12863.7230
22190.0 - 24384.0	121	25	0.003926	27193.1767
24384.0 - 26578.0	64	12	0.002076	17592.3089
26578.0 - 28772.0	50	5	0.001622	11043.8827
28772.0 - 30966.0	37	11	0.001200	43442.8220
30966.0 - 33160.0	27	9	0.000876	16655.6826
33160.0 - 35354.0	16	2	0.000519	14883.2211
35354.0 - 37548.0	10	5	0.000324	26956.1610
37548.0 - 39742.0	7	3	0.000227	30786.2996
39742.0 - 41936.0	8	4	0.000260	49726.4766
41936.0 - 44130.0	7	1	0.000227	48888.4315
44130.0 - 46324.0	2	0	0.000065	0.0000
46324.0 - 48518.0	4	1	0.000130	60581.9575
48518.0 - 50712.0	1	0	0.000032	0.0000
50712.0 - 52906.0	1	0	0.000032	0.0000
52906.0 - 55100.0	1	0	0.000032	0.0000
> 55100.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
1347	4.5189
3541	7.6417
5735	7.8686
7929	12.6005
10123	11.6513
12317	8.2865
14511	6.9663
16705	6.0211
18899	4.7476
21093	5.8641
23287	8.9817
25481	3.0734
27675	1.5073
29869	4.3877
32063	1.2276
34257	0.6500
36451	0.7358
38645	0.5883
40839	1.0859
43033	0.9342
45227	0.0000
47421	0.6615
49615	0.0000
51809	0.0000
54003	0.0000
0	0.0000

Kankakee River near Wilmington: USGS # 05527500



Load histogram curve using the mean approach.

Kaskaskia River at Cooks Mills: USGS # 05591200

Discharge record	
	Mean daily discharge (cfs)
Records	10971
Min.	0.00
Max.	9690.00
Mean	455.78
Median	176.00

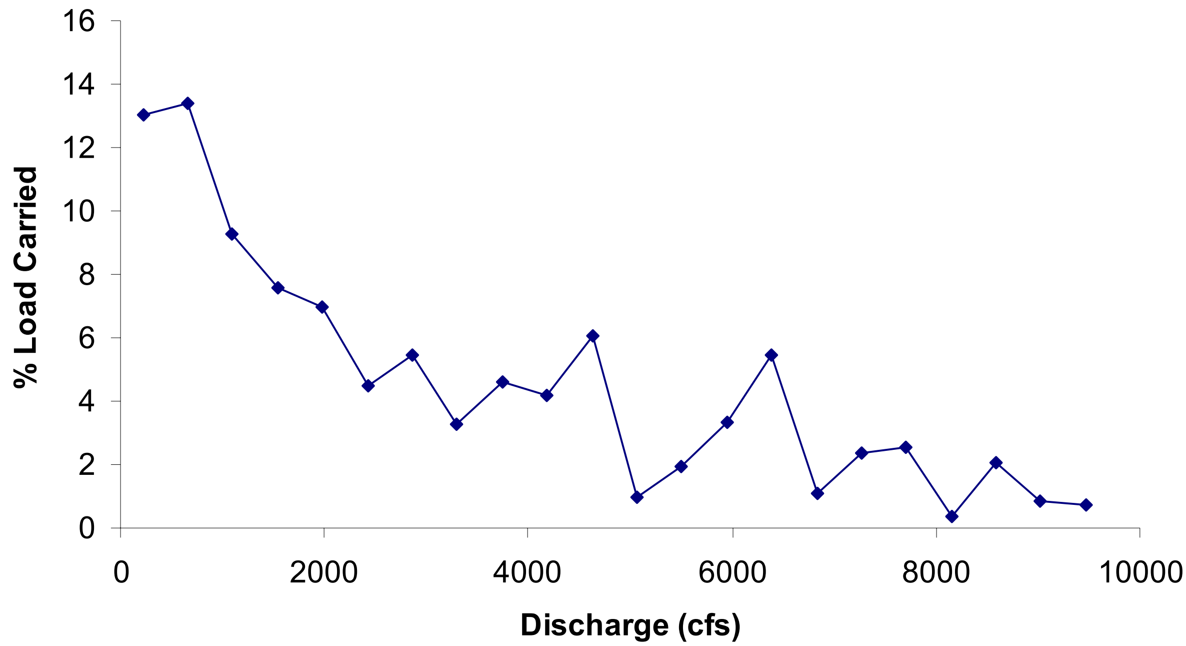
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	6848	6848
Min.	0.00	0.0000
Max.	9690.00	26091.9889
Avg.	458.09	132.5487
Median	172.00	18.7701
< (%)	0.0000	
> (%)	0.0000	
r^2	0.7812	

Effective discharge results	
Mean approach	
Bins	22
Bin size (cfs)	440.45
Discharge (cfs)	660.68
Exceedance (%)	20.87
Cumulative load (%)	26.43

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	1	1	0.000091	0.0000
0.0 - 440.455	7986	5017	0.727919	22.4182
440.455 - 880.909	1391	845	0.126789	131.9458
880.909 - 1321.364	609	379	0.055510	209.0222
1321.364 - 1761.818	343	200	0.031264	303.0207
1761.818 - 2202.273	239	154	0.021785	401.6807
2202.273 - 2642.727	122	71	0.011120	504.7083
2642.727 - 3083.182	94	57	0.008568	794.9663
3083.182 - 3523.636	53	30	0.004831	844.6396
3523.636 - 3964.091	35	21	0.003190	1800.2032
3964.091 - 4404.546	22	13	0.002005	2598.5429
4404.546 - 4845.0	19	12	0.001732	4375.5572
4845.0 - 5285.455	9	8	0.000820	1487.2433
5285.455 - 5725.909	8	7	0.000729	3308.9698
5725.909 - 6166.364	9	6	0.000820	5096.3439
6166.364 - 6606.818	10	7	0.000911	7490.9571
6606.818 - 7047.273	4	3	0.000365	3674.3391
7047.273 - 7487.727	5	5	0.000456	6534.0311
7487.727 - 7928.182	6	6	0.000547	5772.7202
7928.182 - 8368.636	1	1	0.000091	5295.8836
8368.636 - 8809.091	3	3	0.000273	9412.6295
8809.091 - 9249.546	1	1	0.000091	11453.4258
9249.546 - 9690.0	1	1	0.000091	10074.0562
> 9690.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
220	13.0501
661	13.3785
1101	9.2789
1542	7.5762
1982	6.9978
2423	4.4883
2863	5.4471
3303	3.2631
3744	4.5928
4184	4.1671
4625	6.0600
5065	0.9757
5506	1.9296
5946	3.3434
6387	5.4604
6827	1.0713
7268	2.3814
7708	2.5247
8148	0.3860
8589	2.0583
9029	0.8349
9470	0.7343
0	0.0000

Kaskaskia River at Cooks Mills: USGS # 05591200



Load histogram curve using the mean approach.

Kaskaskia River near Venedy Station: USGS # 05594100

Discharge record	
	Mean daily discharge (cfs)
Records	11323
Min.	56.00
Max.	48700.00
Mean	3731.26
Median	1950.00

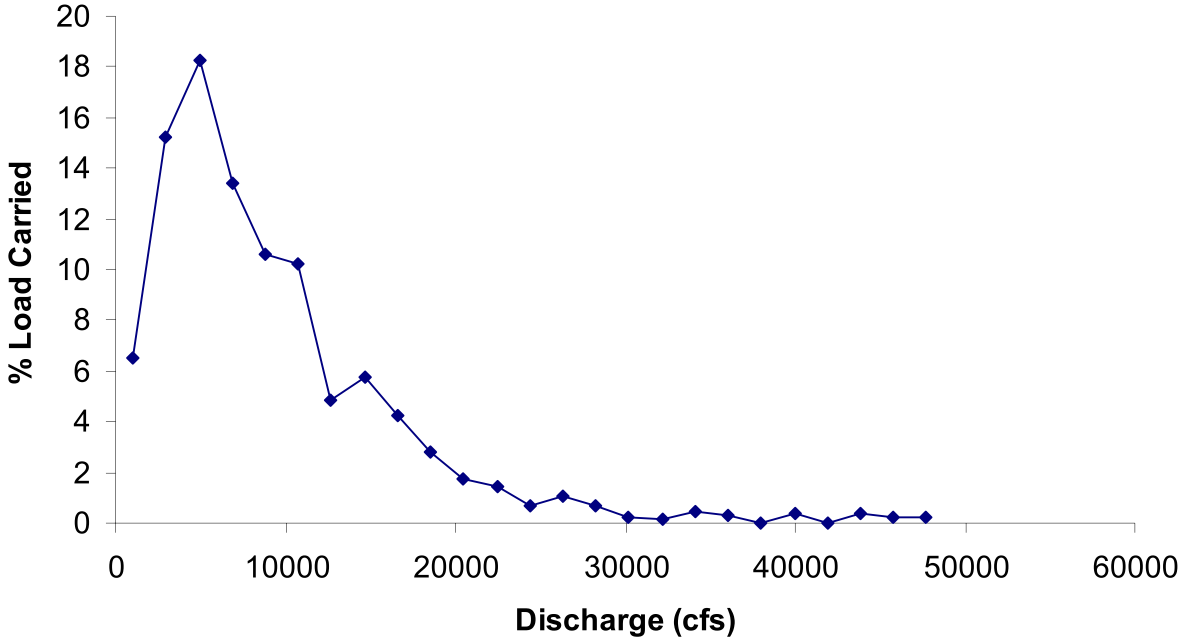
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	6362	6362
Min.	72.00	1.9067
Max.	48700.00	46588.8306
Avg.	3859.62	1536.0324
Median	1900.00	463.1734
< (%)	0.4327	
> (%)	0.0000	
r^2	0.8693	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1945.76
Discharge (cfs)	4920.40
Exceedance (%)	26.37
Cumulative load (%)	40.03

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 56.0	0	0	0.000000	0.0000
56.0 - 2001.76	5748	3243	0.507639	193.4708
2001.76 - 3947.52	1910	1096	0.168683	1360.6976
3947.52 - 5893.28	1360	683	0.120110	2285.0067
5893.28 - 7839.04	624	335	0.055109	3650.3547
7839.04 - 9784.8	446	220	0.039389	4060.8686
9784.8 - 11730.56	443	273	0.039124	3940.4563
11730.56 - 13676.32	223	141	0.019694	3719.6096
13676.32 - 15622.08	200	127	0.017663	4921.2594
15622.08 - 17567.84	144	98	0.012717	5020.0036
17567.84 - 19513.6	82	51	0.007242	5789.6093
19513.6 - 21459.36	41	18	0.003621	7238.1245
21459.36 - 23405.12	29	21	0.002561	8234.0321
23405.12 - 25350.88	12	7	0.001060	10008.0972
25350.88 - 27296.64	16	13	0.001413	11294.9647
27296.64 - 29242.4	13	12	0.001148	8969.6498
29242.4 - 31188.16	4	3	0.000353	8411.8370
31188.16 - 33133.92	4	1	0.000353	7455.2701
33133.92 - 35079.68	6	5	0.000530	13482.7584
35079.68 - 37025.44	4	3	0.000353	14342.0089
37025.44 - 38971.2	1	1	0.000088	5017.7902
38971.2 - 40916.96	6	4	0.000530	9816.9524
40916.96 - 42862.72	1	1	0.000088	6074.6465
42862.72 - 44808.48	3	3	0.000265	22972.4478
44808.48 - 46754.24	2	2	0.000177	18530.0316
46754.24 - 48700.0	1	1	0.000088	36931.8012
> 48700.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
1029	6.5292
2975	15.2590
4920	18.2455
6866	13.3736
8812	10.6337
10758	10.2490
12703	4.8700
14649	5.7788
16595	4.2442
18541	2.7874
20486	1.7424
22432	1.4020
24378	0.7051
26324	1.0610
28270	0.6846
30215	0.1976
32161	0.1751
34107	0.4750
36053	0.3368
37998	0.0295
39944	0.3458
41890	0.0357
43836	0.4046
45781	0.2176
47727	0.2168
0	0.0000

Kaskaskia River near Venedy Station: USGS # 05594100



Load histogram curve using the mean approach.

LaMoine River at Ripley: USGS # 05585000

Discharge record	
	Mean daily discharge (cfs)
Records	29058
Min.	0.96
Max.	26800.00
Mean	841.17
Median	235.00

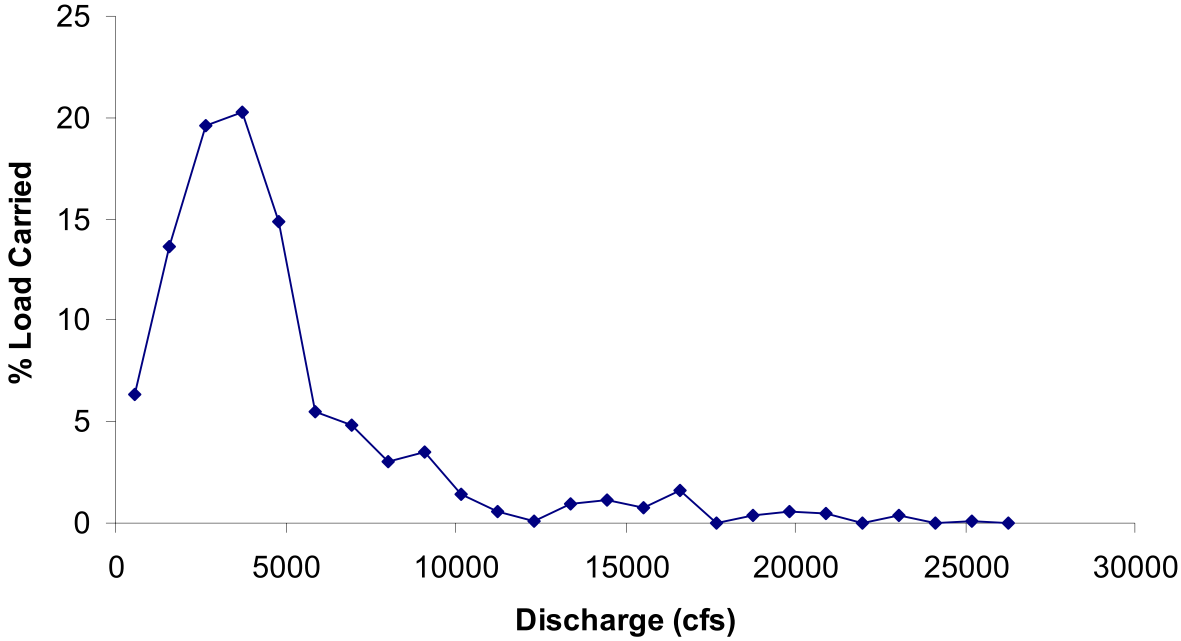
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1461	1461
Min.	15.00	0.8681
Max.	25100.00	217726.9276
Mean	1176.52	2410.6682
Median	262.00	52.4688
< (%)	3.0800	
> (%)	0.0034	
r^2	0.8976	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1071.96
Discharge (cfs)	3752.83
Exceedance (%)	5.78
Cumulative load (%)	59.79

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Load (tons/day)
≤ 0.96	0	0	0.000000	0.0000
0.96 - 1072.922	23636	1161	0.813408	130.4821
1072.922 - 2144.883	2394	111	0.082387	2764.7979
2144.883 - 3216.845	1037	39	0.035687	9195.3171
3216.845 - 4288.806	624	37	0.021474	15826.0529
4288.806 - 5360.768	480	32	0.016519	15128.0206
5360.768 - 6432.73	286	18	0.009842	9428.9656
6432.73 - 7504.691	206	11	0.007089	11452.9217
7504.691 - 8576.653	118	7	0.004061	12552.8210
8576.653 - 9648.614	80	8	0.002753	21166.4082
9648.614 - 10720.576	55	7	0.001893	12680.8156
10720.576 - 11792.538	29	6	0.000998	9327.1871
11792.538 - 12864.499	19	1	0.000654	3593.4939
12864.499 - 13936.461	25	4	0.000860	18758.8051
13936.461 - 15008.422	15	3	0.000516	35439.8518
15008.422 - 16080.384	15	5	0.000516	23705.8516
16080.384 - 17152.346	12	5	0.000413	64627.9013
17152.346 - 18224.307	4	0	0.000138	0.0000
18224.307 - 19296.269	5	1	0.000172	34242.6678
19296.269 - 20368.23	5	1	0.000172	57289.1081
20368.23 - 21440.192	4	2	0.000138	57546.2793
21440.192 - 22512.154	3	0	0.000103	0.0000
22512.154 - 23584.115	3	1	0.000103	63728.3682
23584.115 - 24656.077	1	0	0.000034	0.0000
24656.077 - 25728.038	1	1	0.000034	40722.8121
25728.038 - 26800.0	1	0	0.000034	0.0000
> 26800.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
537	6.3336
1609	13.5930
2681	19.5827
3753	20.2808
4825	14.9125
5897	5.5381
6969	4.8452
8041	3.0419
9113	3.4775
10185	1.4323
11257	0.5555
12329	0.1402
13400	0.9631
14472	1.0917
15544	0.7303
16616	1.5927
17688	0.0000
18760	0.3516
19832	0.5883
20904	0.4727
21976	0.0000
23048	0.3926
24120	0.0000
25192	0.0836
26264	0.0000
0	0.0000

LaMoine River at Ripley: USGS # 05585000



Load histogram curve using the mean approach.

Little Wabash River at Louisville: USGS # 03378900

Discharge record	
	Mean daily discharge (cfs)
Records	6263
Min.	0.50
Max.	21000.00
Mean	579.55
Median	94.00

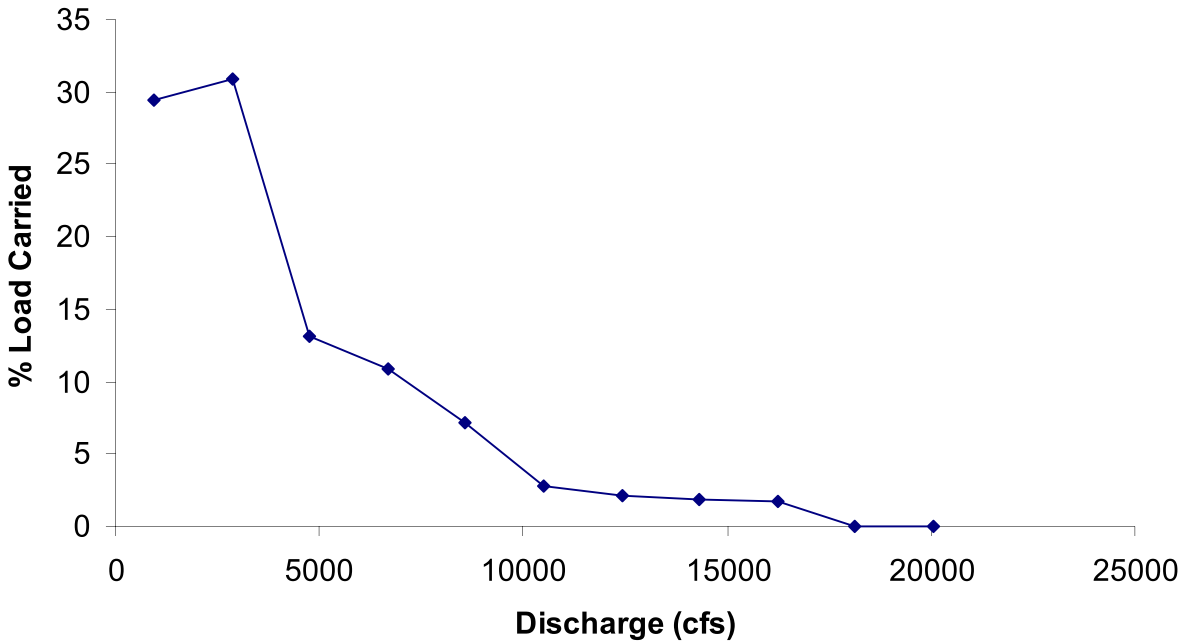
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1666	1666
Min.	2.00	0.0971
Max.	15800.00	29836.5601
Avg.	543.36	471.5379
Median	77.00	13.8348
< (%)	0.2076	
> (%)	0.0479	
r^2	0.8861	

Effective discharge results	
Mean approach	
Bins	11
Bin size (cfs)	1909.05
Discharge (cfs)	2864.07
Exceedance (%)	6.39
Cumulative load (%)	60.37

Bin values (Mean Approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.5	0	0	0.000000	0.0000
0.5 - 1909.545	5717	1547	0.912821	162.3527
1909.545 - 3818.591	293	50	0.046783	3320.4808
3818.591 - 5727.636	123	29	0.019639	3357.6119
5727.636 - 7636.682	71	18	0.011336	4834.3459
7636.682 - 9545.727	34	15	0.005429	6672.5302
9545.727 - 11454.773	11	4	0.001756	7832.2083
11454.773 - 13363.818	7	1	0.001118	9291.4449
13363.818 - 15272.864	2	1	0.000319	29836.5601
15272.864 - 17181.909	4	1	0.000639	13464.8147
17181.909 - 19090.955	0	0	0.000000	0.0000
19090.955 - 21000.0	1	0	0.000160	0.0000
> 21000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
955	29.4761
2864	30.8966
4773	13.1153
6682	10.9003
8591	7.2046
10500	2.7360
12409	2.0655
14318	1.8951
16227	1.7104
18136	0.0000
20045	0.0000
0	0.0000

Little Wabash River at Louisville: USGS # 03378900



Load histogram curve using the mean approach.

Mackinaw River below Green Valley: USGS # 05568000

Discharge record	
	Mean daily discharge (cfs)
Records	17472
Min.	17.00
Max.	23500.00
Mean	712.26
Median	252.00

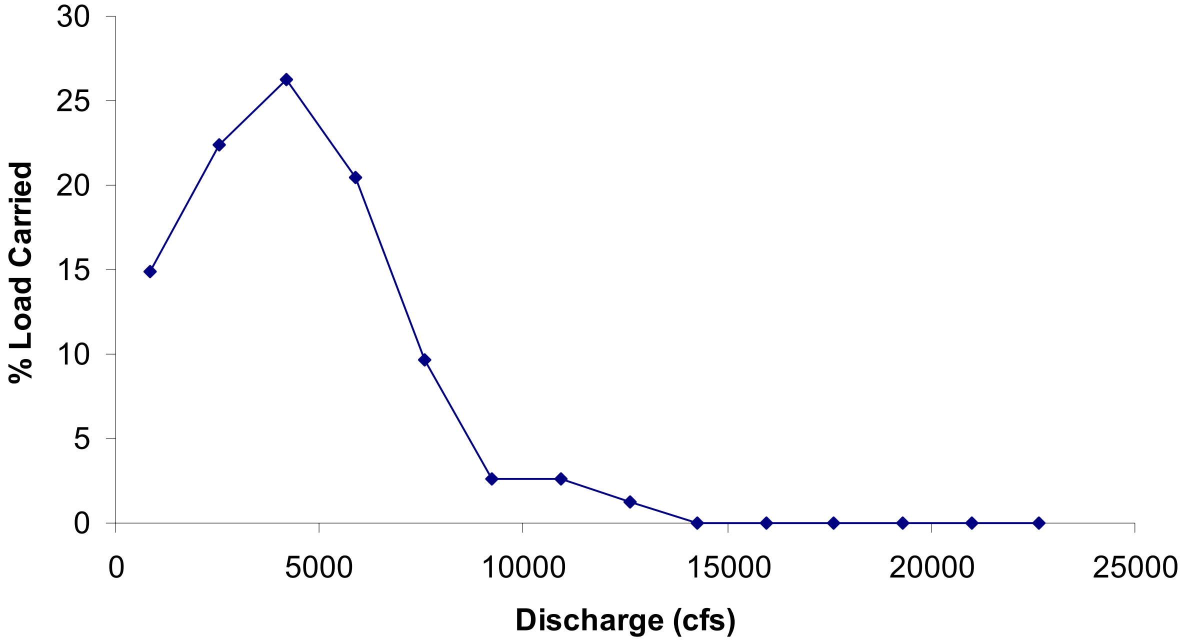
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1096	1096
Min.	38.00	0.8329
Max.	12000.00	97230.8865
Mean	638.00	943.9866
Median	193.50	27.6567
< (%)	6.1470	
> (%)	0.1431	
r^2	0.8800	

Effective discharge results	
Mean approach	
Bins	14
Bin size (cfs)	1677.36
Discharge (cfs)	4210.39
Exceedance (%)	7.11
Cumulative load (%)	63.53

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 17.0	0	0	0.000000	0.0000
17.0 - 1694.357	15630	1007	0.894574	144.9929
1694.357 - 3371.714	1201	47	0.068739	2821.5929
3371.714 - 5049.071	347	13	0.019860	11473.4515
5049.071 - 6726.429	137	13	0.007841	22630.6843
6726.429 - 8403.786	71	12	0.004064	20606.5341
8403.786 - 10081.143	38	1	0.002175	10496.7734
10081.143 - 11758.5	19	2	0.001087	20449.9166
11758.5 - 13435.857	13	1	0.000744	13957.7982
13435.857 - 15113.214	5	0	0.000286	0.0000
15113.214 - 16790.571	5	0	0.000286	0.0000
16790.571 - 18467.929	2	0	0.000114	0.0000
18467.929 - 20145.286	2	0	0.000114	0.0000
20145.286 - 21822.643	1	0	0.000057	0.0000
21822.643 - 23500.0	1	0	0.000057	0.0000
> 23500.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
856	14.9403
2533	22.3404
4210	26.2469
5888	20.4396
7565	9.6453
9242	2.6296
10920	2.5615
12597	1.1962
14275	0.0000
15952	0.0000
17629	0.0000
19307	0.0000
20984	0.0000
22661	0.0000
0	0.0000

Mackinaw River below Green Valley: USGS # 05568000



Load histogram curve using the mean approach.

Sangamon River near Oakford: USGS # 05583000

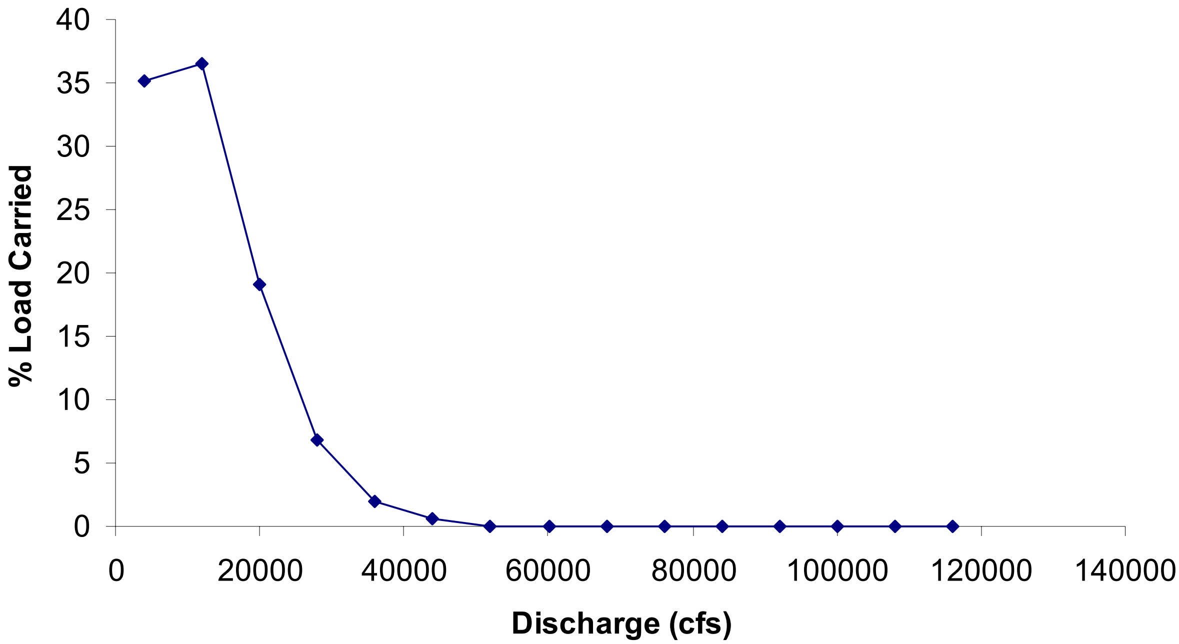
Discharge record	
	Mean daily discharge (cfs)
Records	26845
Min.	45.00
Max.	120000.00
Mean	3450.66
Median	1600.00

Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	2679	2679
Min.	281.00	1.5818
Max.	40700.00	119459.5081
Mean	3840.69	3796.3880
Median	1700.00	367.8498
< (%)	8.4858	
> (%)	0.0931	
r^2	0.8685	

Effective discharge results	
Mean approach	
Bins	15
Bin size (cfs)	7997.00
Discharge (cfs)	12040.50
Exceedance (%)	7.44
Cumulative load (%)	71.69

Bin values (Mean approach)					Effective discharge histogram (Mean approach)	
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)	Bin value (cfs)	% Load carried
≤ 45.0	0	0	0.000000	0.0000	—	—
45.0 - 8042.0	23730	2332	0.883963	1333.5057	4044	35.1890
8042.0 - 16039.0	2235	215	0.083256	14685.5465	12041	36.4991
16039.0 - 24036.0	607	87	0.022611	28228.6765	20038	19.0543
24036.0 - 32033.0	191	28	0.007115	32037.7840	28035	6.8047
32033.0 - 40030.0	55	15	0.002049	31338.1984	36032	1.9167
40030.0 - 48027.0	12	2	0.000447	40184.9261	44029	0.5362
48027.0 - 56024.0	5	0	0.000186	0.0000	52026	0.0000
56024.0 - 64021.0	3	0	0.000112	0.0000	60023	0.0000
64021.0 - 72018.0	2	0	0.000075	0.0000	68020	0.0000
72018.0 - 80015.0	1	0	0.000037	0.0000	76017	0.0000
80015.0 - 88012.0	2	0	0.000075	0.0000	84014	0.0000
88012.0 - 96009.0	0	0	0.000000	0.0000	92011	0.0000
96009.0 - 104006.0	1	0	0.000037	0.0000	100008	0.0000
104006.0 - 112003.0	0	0	0.000000	0.0000	108005	0.0000
112003.0 - 120000.0	1	0	0.000037	0.0000	116002	0.0000
> 120000.0	0	0	0.000000	0.0000	0	0.0000

Sangamon River near Oakford: USGS # 05583000



Load histogram curve using the mean approach.

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Spoon River at Seville: USGS # 05570000

Discharge record	
	Mean daily discharge (cfs)
Records	31412
Min.	6.00
Max.	32800.00
Mean	1103.80
Median	481.00

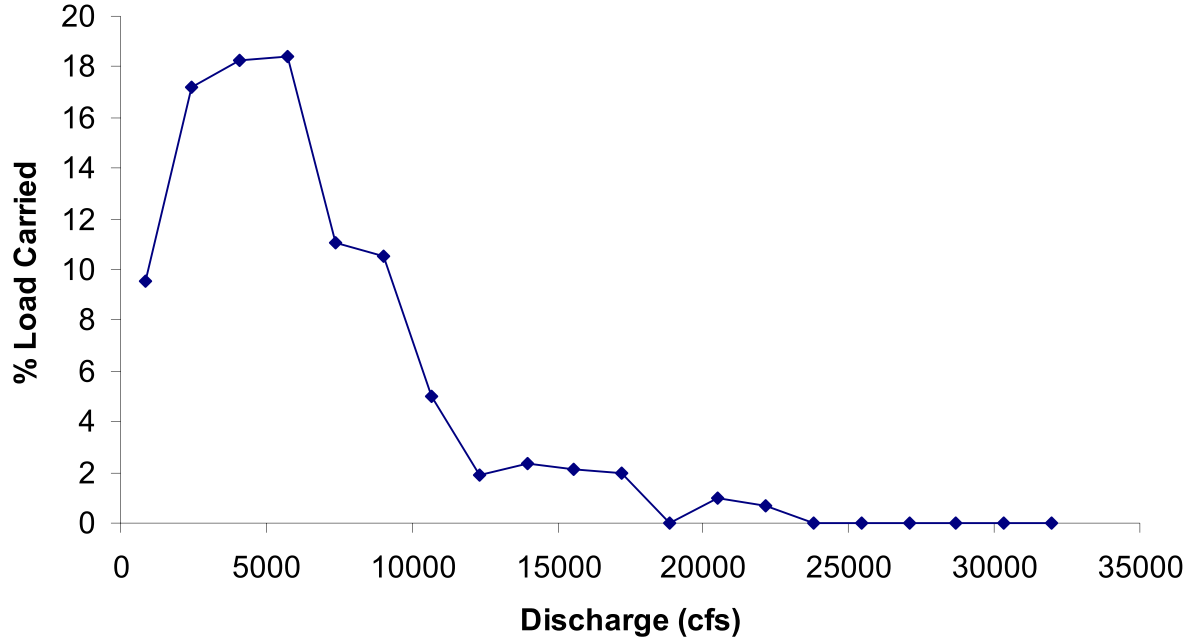
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1461	1461
Min.	38.00	2.9053
Max.	22300.00	124745.5968
Mean	1322.48	3478.5461
Median	560.00	179.8737
< (%)	3.8361	
> (%)	0.0414	
r^2	0.9065	

Effective discharge results	
Mean approach	
Bins	20
Bin size (cfs)	1639.70
Discharge (cfs)	5744.95
Exceedance (%)	3.48
Cumulative load (%)	63.40

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 6.0	0	0	0.000000	0.0000
6.0 - 1645.7	25958	1175	0.826372	316.6158
1645.7 - 3285.4	3221	156	0.102540	4572.6388
3285.4 - 4925.1	913	45	0.029065	17180.6661
4925.1 - 6564.8	458	27	0.014580	34452.4638
6564.8 - 8204.5	315	12	0.010028	30212.0578
8204.5 - 9844.2	216	15	0.006876	41811.9510
9844.2 - 11483.9	113	13	0.003597	38111.8449
11483.9 - 13123.6	61	7	0.001942	26534.2101
13123.6 - 14763.3	55	4	0.001751	36743.9119
14763.3 - 16403.0	39	2	0.001242	45974.6238
16403.0 - 18042.7	23	2	0.000732	74309.3102
18042.7 - 19682.4	11	0	0.000350	0.0000
19682.4 - 21322.1	12	2	0.000382	69835.9163
21322.1 - 22961.8	6	1	0.000191	95321.3844
22961.8 - 24601.5	2	0	0.000064	0.0000
24601.5 - 26241.2	1	0	0.000032	0.0000
26241.2 - 27880.9	2	0	0.000064	0.0000
27880.9 - 29520.6	1	0	0.000032	0.0000
29520.6 - 31160.3	2	0	0.000064	0.0000
31160.3 - 32800.0	3	0	0.000096	0.0000
> 32800.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
826	9.5768
2466	17.1623
4105	18.2780
5745	18.3867
7385	11.0894
9024	10.5238
10664	5.0183
12304	1.8861
13943	2.3549
15583	2.0893
17223	1.9915
18863	0.0000
20502	0.9765
22142	0.6664
23782	0.0000
25421	0.0000
27061	0.0000
28701	0.0000
30340	0.0000
31980	0.0000
0	0.0000

Spoon River at Seville: USGS # 05570000



Load histogram curve using the mean approach.

APPENDIX B

Effective Discharge Results for the Qualified Stations that Use ISWS Suspended Sediment Data

Notation for tables in Appendix B:

< (%) The percent of flow events less than the minimum discharge at which suspended sediment samples were collected

< (%) The percent of flow events greater than the maximum discharge at which suspended sediment samples were collected

Exceedance (%) The percent of flows exceeding the magnitude of the station's effective discharge

Cumulative load (%)[*] The percent of suspended sediment load carried by flows less than or equal to the effective discharge

% load carried[*] The percent of suspended sediment load carried by a discharge class.

Bin value (cfs) The average of the uppermost and lowest discharge values in a discharge class

Note:
[*] Values are based on the mean approach which assigns zero sediment load to discharge classes that having no sediment samples falling within them. Assuming or extrapolating sediment loads for these discharge classes would result in different percentage values.

Cache River at Forman: USGS # 03612000

Discharge record	
	Mean daily discharge (cfs)
Records	28387
Min.	0.00
Max.	8780.00
Mean	297.33
Median	55.00

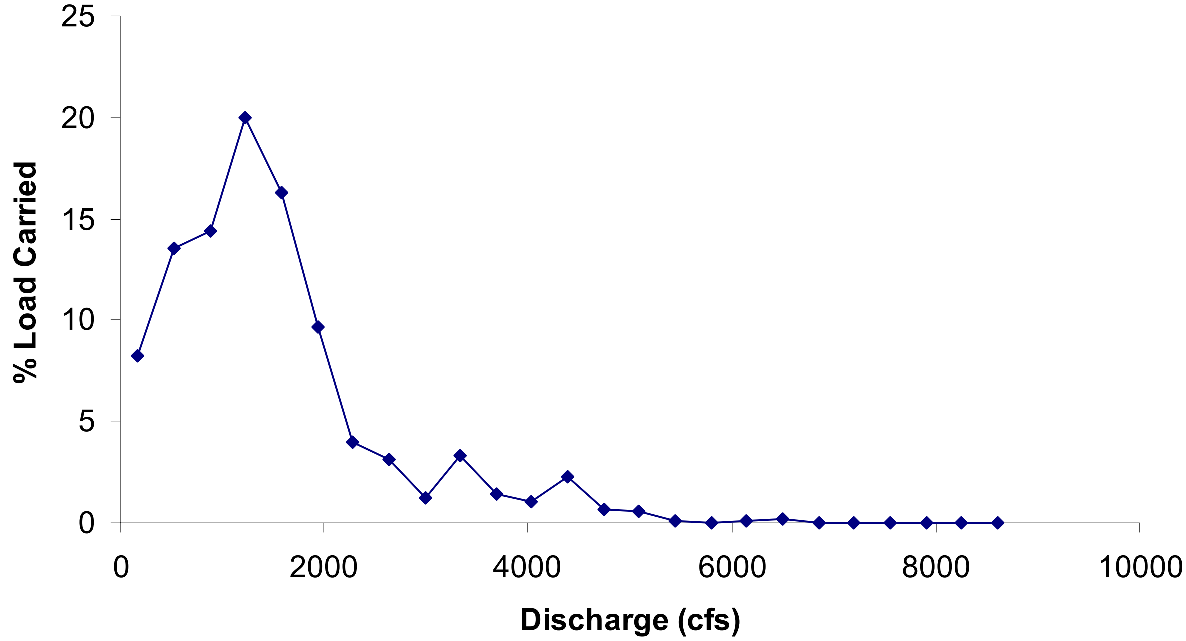
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1315	1315
Min.	0.10	0.0029
Max.	6328.00	16928.7494
Mean	421.89	385.5902
Median	102.50	15.1313
< (%)	0.9406	
> (%)	0.1268	
r^2	0.9178	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	351.20
Discharge (cfs)	1229.20
Exceedance (%)	5.90
Cumulative load (%)	56.18

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	253	0	0.008913	0.0000
0.0 - 351.2	21532	894	0.758516	25.7149
351.2 - 702.4	2955	152	0.104097	308.6673
702.4 - 1053.6	1579	92	0.055624	611.2524
1053.6 - 1404.8	786	58	0.027689	1711.8022
1404.8 - 1756.0	447	52	0.015747	2445.1214
1756.0 - 2107.2	276	29	0.009723	2347.8716
2107.2 - 2458.4	139	11	0.004897	1921.0373
2458.4 - 2809.6	95	9	0.003347	2202.8636
2809.6 - 3160.8	68	4	0.002395	1240.6169
3160.8 - 3512.0	56	2	0.001973	3961.5096
3512.0 - 3863.2	33	1	0.001163	2926.4532
3863.2 - 4214.4	33	2	0.001163	2078.7150
4214.4 - 4565.6	19	2	0.000669	7950.5744
4565.6 - 4916.8	23	3	0.000810	1918.7425
4916.8 - 5268.0	22	1	0.000775	1676.9589
5268.0 - 5619.2	12	1	0.000423	785.3891
5619.2 - 5970.4	10	0	0.000352	0.0000
5970.4 - 6321.6	13	1	0.000458	439.5105
6321.6 - 6672.8	11	1	0.000388	904.4791
6672.8 - 7024.0	10	0	0.000352	0.0000
7024.0 - 7375.2	5	0	0.000176	0.0000
7375.2 - 7726.4	3	0	0.000106	0.0000
7726.4 - 8077.6	4	0	0.000141	0.0000
8077.6 - 8428.8	1	0	0.000035	0.0000
8428.8 - 8780.0	2	0	0.000070	0.0000
> 8780.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% load carried
—	—
176	8.2367
527	13.5685
878	14.3577
1229	20.0152
1580	16.2589
1932	9.6398
2283	3.9722
2634	3.1131
2985	1.2550
3336	3.3001
3688	1.4366
4039	1.0205
4390	2.2472
4741	0.6565
5092	0.5488
5444	0.1402
5795	0.0000
6146	0.0850
6497	0.1480
6848	0.0000
7200	0.0000
7551	0.0000
7902	0.0000
8253	0.0000
8604	0.0000
0	0.0000

Cache River at Forman: USGS # 03612000



Load histogram curve using mean approach.

Kankakee River at Momence: USGS # 05520500

Discharge record	
	Mean daily discharge (cfs)
Records	31795
Min.	248.00
Max.	14800.00
Mean	2072.56
Median	1580.00

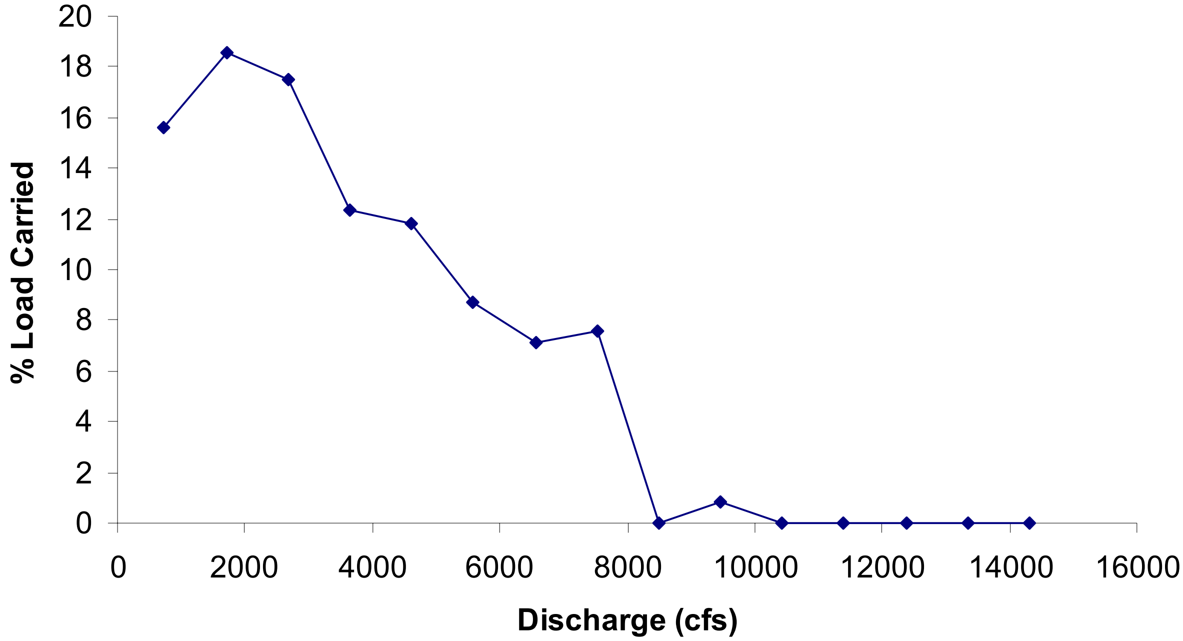
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	615	615
Min.	428.80	24.3256
Max.	11850.00	27739.7405
Mean	2999.47	747.4566
Median	2504.00	369.3978
< (%)	1.1385	
> (%)	0.0094	
r^2	0.5195	

Effective discharge results	
Mean approach	
Bins	15
Bin size (cfs)	970.13
Discharge (cfs)	1703.20
Exceedance (%)	48.45
Cumulative load (%)	34.18

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean Load (tons/day)
≤ 248.0	0	0	0.000000	0.0000
248.0 - 1218.133	12207	94	0.383928	176.9290
1218.133 - 2188.267	8369	168	0.263217	305.8894
2188.267 - 3158.4	4650	111	0.146249	518.9316
3158.4 - 4128.533	2956	83	0.092971	575.6496
4128.533 - 5098.667	1934	74	0.060827	844.4276
5098.667 - 6068.8	974	41	0.030634	1233.0677
6068.8 - 7038.933	431	24	0.013556	2278.5554
7038.933 - 8009.067	165	18	0.005190	6336.7733
8009.067 - 8979.2	66	0	0.002076	0.0000
8979.2 - 9949.333	28	1	0.000881	4061.9625
9949.333 - 10919.467	11	0	0.000346	0.0000
10919.467 - 11889.6	1	1	0.000031	432.1032
11889.6 - 12859.733	1	0	0.000031	0.0000
12859.733 - 13829.867	1	0	0.000031	0.0000
13829.867 - 14800.0	1	0	0.000031	0.0000
> 14800.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
733	15.6388
1703	18.5368
2673	17.4727
3643	12.3214
4614	11.8254
5584	8.6964
6554	7.1110
7524	7.5709
8494	0.0000
9464	0.8235
10434	0.0000
11405	0.0031
12375	0.0000
13345	0.0000
14315	0.0000
0	0.0000

Kankakee River at Momence: USGS # 05520500



Load histogram curve using mean approach.

Kankakee River near Wilmington: USGS # 05527500

Discharge record	
	Mean daily discharge (cfs)
Records	30824
Min.	250.00
Max.	55100.00
Mean	4446.59
Median	2800.00

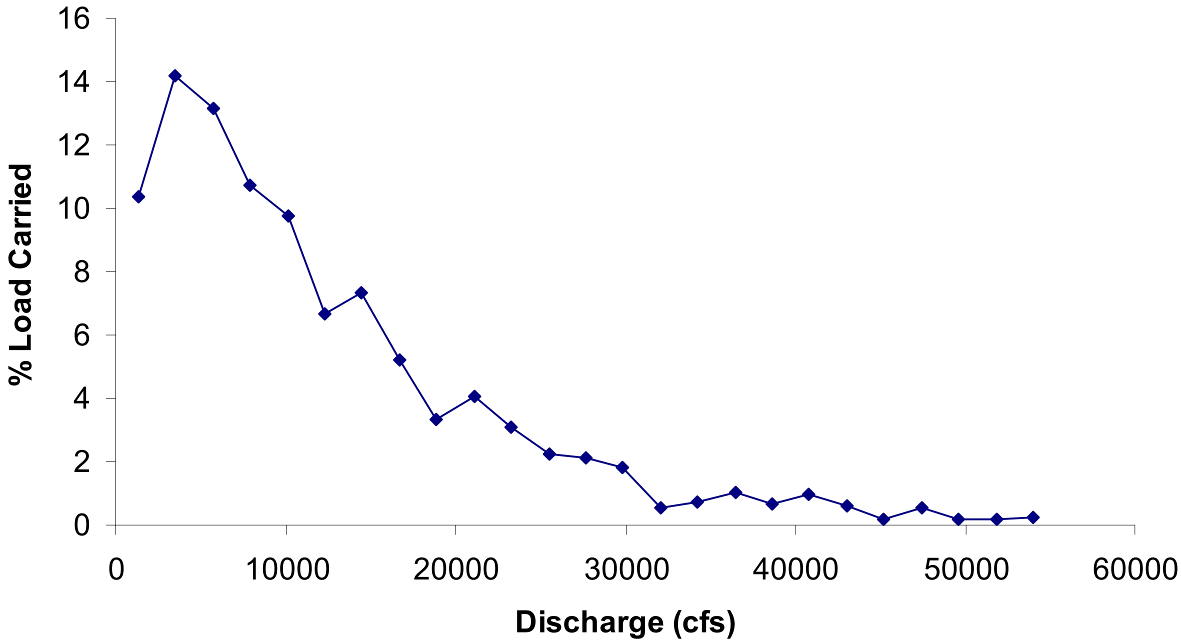
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	856	856
Min.	177.00	4.7161
Max.	85360.00	239006.2592
Mean	11109.70	4578.8221
Median	7303.00	1000.6543
< (%)	0.0000	
> (%)	0.0000	
r^2	0.7600	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	2194.00
Discharge (cfs)	3541.00
Exceedance (%)	43.34
Cumulative load (%)	24.54

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean Load (tons/day)
≤ 249.999	0	4	0.000000	0.0000
249.999 - 2443.999	14023	170	0.454938	207.7917
2443.999 - 4637.999	6886	115	0.223397	577.3355
4637.999 - 6831.999	3655	119	0.118576	1010.3835
6831.999 - 9025.999	2285	73	0.074131	1320.2672
9025.999 - 11219.999	1455	77	0.047203	1881.4176
11219.999 - 13413.999	916	52	0.029717	2047.8044
13413.999 - 15607.999	533	45	0.017292	3854.8991
15607.999 - 17801.999	347	30	0.011257	4214.8338
17801.999 - 19995.999	201	30	0.006521	4670.5053
19995.999 - 22189.999	167	21	0.005418	6797.4320
22189.999 - 24383.999	121	20	0.003926	7216.6324
24383.999 - 26578.0	64	28	0.002076	9877.3013
26578.0 - 28772.0	50	10	0.001622	11918.1261
28772.0 - 30966.0	37	6	0.001200	13951.2818
30966.0 - 33160.0	27	5	0.000876	5950.9530
33160.0 - 35354.0	16	6	0.000519	12419.2380
35354.0 - 37548.0	10	6	0.000324	29088.0388
37548.0 - 39742.0	7	10	0.000227	26722.4832
39742.0 - 41936.0	8	5	0.000260	33687.9245
41936.0 - 44130.0	7	5	0.000227	24702.4874
44130.0 - 46324.0	2	4	0.000065	25464.5613
46324.0 - 48518.0	4	2	0.000130	38241.9292
48518.0 - 50712.0	1	4	0.000032	47333.1870
50712.0 - 52906.0	1	4	0.000032	54404.0285
52906.0 - 55100.0	1	1	0.000032	72717.7663
> 55100.0	0	4	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
1347	10.3773
3541	14.1583
5735	13.1520
7929	10.7440
10123	9.7491
12317	6.6804
14511	7.3174
16705	5.2087
18899	3.3433
21093	4.0428
23287	3.1098
25481	2.2513
27675	2.1222
29869	1.8384
32063	0.5722
34257	0.7077
36451	1.0359
38645	0.6662
40839	0.9598
43033	0.6158
45227	0.1814
47421	0.5448
49615	0.1686
51809	0.1938
54003	0.2590
0	0.0000

Kankakee River near Wilmington: USGS # 05527500



Load histogram curve using mean approach.

Kaskaskia River at Vandalia: USGS # 05592500

Discharge record	
	Mean daily discharge (cfs)
Records	33207
Min.	3.50
Max.	54000.00
Mean	1514.66
Median	660.00

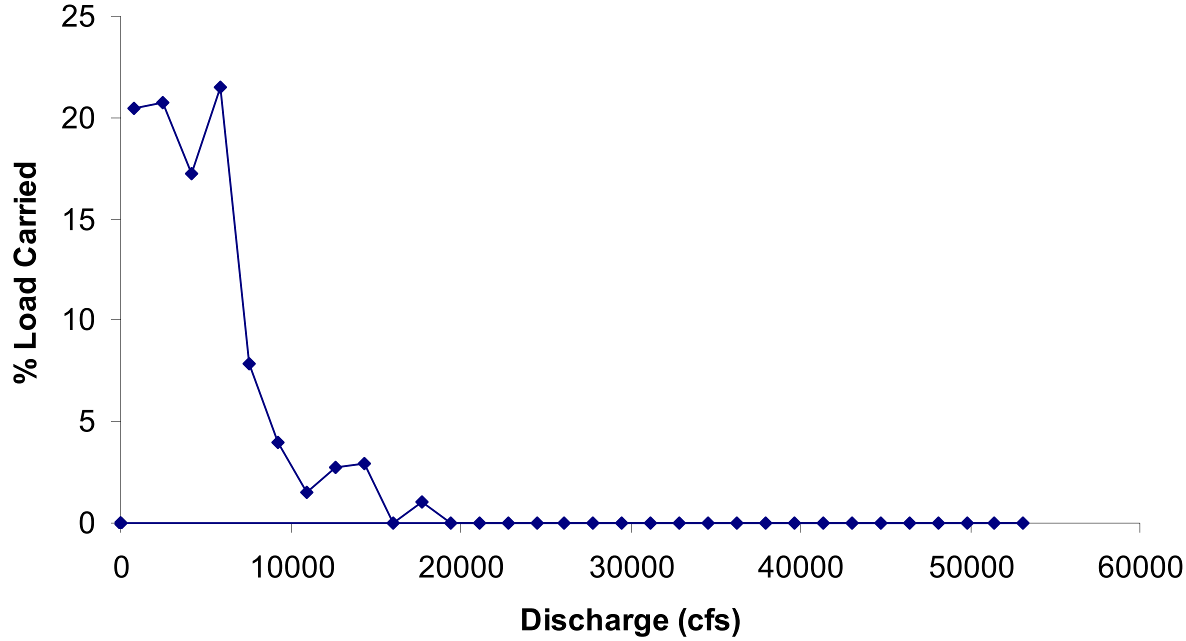
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	975	975
Min.	0.00	0.0000
Max.	18090.00	27887.7536
Mean	1825.81	1585.7148
Median	1277.00	537.2010
< (%)	0.0000	
> (%)	0.1807	
r^2	0.8603	

Effective discharge results	
Mean Approach	
Bins	32
Bin size (cfs)	1687.39
Discharge (cfs)	5909.37
Exceedance (%)	19.55
Cumulative load (%)	79.92

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 3.5	0	7	0.000000	0.0000
3.5 - 1690.891	24463	578	0.736682	353.5729
1690.891 - 3378.281	4506	253	0.135694	1953.6074
3378.281 - 5065.672	1712	56	0.051555	4267.4503
5065.672 - 6753.062	1222	45	0.036799	7449.4062
6753.062 - 8440.453	573	17	0.017255	5824.1707
8440.453 - 10127.844	257	5	0.007739	6609.9372
10127.844 - 11815.234	167	5	0.005029	3858.2532
11815.234 - 13502.625	113	5	0.003403	10157.2419
13502.625 - 15190.016	65	3	0.001957	19176.1185
15190.016 - 16877.406	44	0	0.001325	0.0000
16877.406 - 18564.797	32	1	0.000964	13577.2278
18564.797 - 20252.187	16	0	0.000482	0.0000
20252.187 - 21939.578	12	0	0.000361	0.0000
21939.578 - 23626.969	5	0	0.000151	0.0000
23626.969 - 25314.359	5	0	0.000151	0.0000
25314.359 - 27001.75	0	0	0.000000	0.0000
27001.75 - 28689.141	4	0	0.000120	0.0000
28689.141 - 30376.531	2	0	0.000060	0.0000
30376.531 - 32063.922	0	0	0.000000	0.0000
32063.922 - 33751.313	2	0	0.000060	0.0000
33751.313 - 35438.703	1	0	0.000030	0.0000
35438.703 - 37126.094	0	0	0.000000	0.0000
37126.094 - 38813.484	0	0	0.000000	0.0000
38813.484 - 40500.875	1	0	0.000030	0.0000
40500.875 - 42188.266	0	0	0.000000	0.0000
42188.266 - 43875.656	1	0	0.000030	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
847	20.4139
2535	20.7762
4222	17.2428
5909	21.4847
7597	7.8764
9284	4.0093
10972	1.5207
12659	2.7089
14346	2.9418
16034	0.0000
17721	1.0254
19408	0.0000
21096	0.0000
22783	0.0000
24471	0.0000
26158	0.0000
27845	0.0000
29533	0.0000
31220	0.0000
32908	0.0000
34595	0.0000
36282	0.0000
37970	0.0000
39657	0.0000
41345	0.0000
43032	0.0000

Kaskaskia River at Vandalia: USGS # 05592500



Load histogram curve using mean approach.

LaMoine River at Colmar: USGS # 05584500

Discharge record	
	Mean daily discharge (cfs)
Records	20454
Min.	0.00
Max.	35600.00
Mean	460.02
Median	125.00

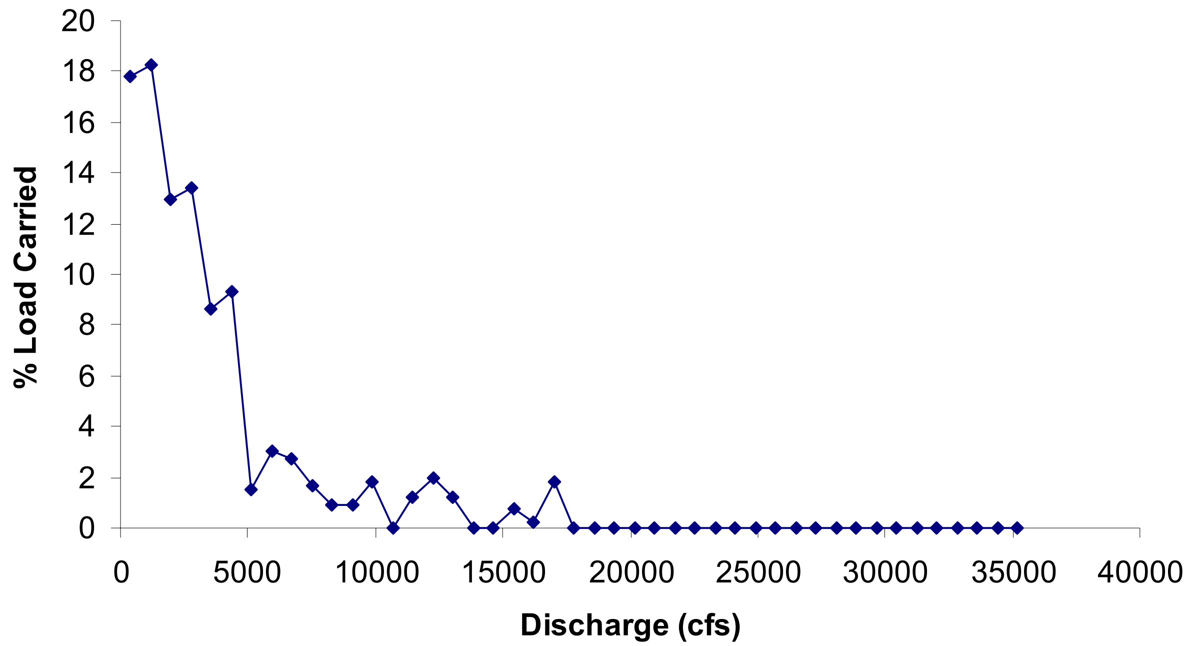
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	782	782
Min.	0.00	0.0000
Max.	23940.00	90814.3608
Mean	1046.73	2556.3302
Median	416.60	143.0339
< (%)	0.0000	
> (%)	0.0049	
r^2	0.8345	

Effective discharge results	
Mean approach	
Bins	45
Bin size (cfs)	791.11
Discharge (cfs)	1186.67
Exceedance (%)	3.28
Cumulative load (%)	36.03

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	1	1	0.000049	0.0000
0.0 - 791.111	17808	571	0.870637	202.3607
791.111 - 1582.222	1373	80	0.067126	2691.2630
1582.222 - 2373.333	477	35	0.023321	5495.6089
2373.333 - 3164.444	251	29	0.012271	10834.7916
3164.444 - 3955.556	145	23	0.007089	12026.6837
3955.556 - 4746.667	112	14	0.005476	16799.0853
4746.667 - 5537.778	71	3	0.003471	4250.4912
5537.778 - 6328.889	48	4	0.002347	12672.0853
6328.889 - 7120.0	36	3	0.001760	15305.3414
7120.0 - 7911.111	20	5	0.000978	17187.2796
7911.111 - 8702.222	20	1	0.000978	9176.1817
8702.222 - 9493.333	12	1	0.000587	15159.9795
9493.333 - 10284.444	16	1	0.000782	22990.3567
10284.444 - 11075.556	11	0	0.000538	0.0000
11075.556 - 11866.667	9	5	0.000440	27591.1897
11866.667 - 12657.778	9	1	0.000440	45117.5391
12657.778 - 13448.889	9	1	0.000440	26840.3638
13448.889 - 14240.0	7	0	0.000342	0.0000
14240.0 - 15031.111	3	0	0.000147	0.0000
15031.111 - 15822.222	3	1	0.000147	52277.9899
15822.222 - 16613.333	1	1	0.000049	40468.2298
16613.333 - 17404.444	4	1	0.000196	90814.3608
17404.444 - 18195.556	1	0	0.000049	0.0000
18195.556 - 18986.667	2	0	0.000098	0.0000
18986.667 - 19777.778	1	0	0.000049	0.0000
19777.778 - 20568.889	1	0	0.000049	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
396	17.7873
1187	18.2388
1978	12.9391
2769	13.4234
3560	8.6076
4351	9.2869
5142	1.4896
5933	3.0023
6724	2.7197
7516	1.6967
8307	0.9059
9098	0.8979
9889	1.8157
10680	0.0000
11471	1.2257
12262	2.0043
13053	1.1923
13844	0.0000
14636	0.0000
15427	0.7741
16218	0.1997
17009	1.7930
17800	0.0000
18591	0.0000
19382	0.0000
20173	0.0000

LaMoine River at Colmar: USGS # 05584500



Load histogram curve using mean approach.

LaMoine River at Ripley: USGS # 05585000

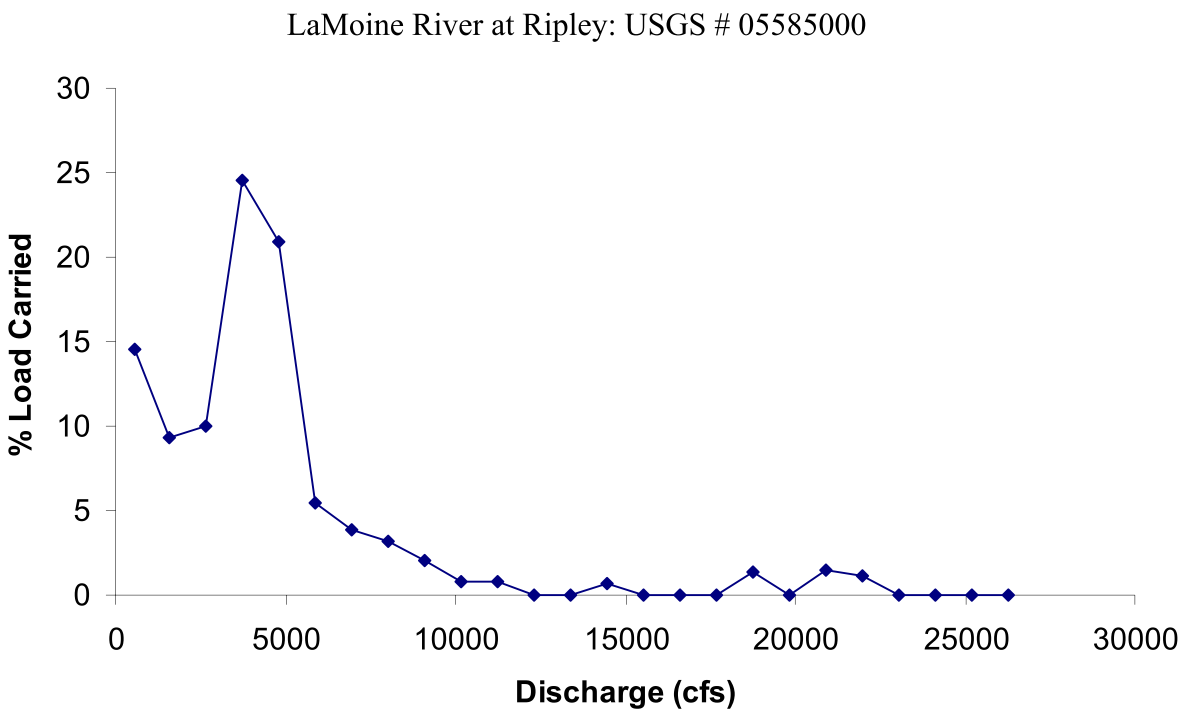
Discharge record	
	Mean daily discharge (cfs)
Records	29058
Min.	0.96
Max.	26800.00
Mean	841.17
Median	235.00

Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	631	631
Min.	1.90	0.0000
Max.	21560.00	110137.7761
Mean	1327.96	1787.0409
Median	720.80	221.5055
< (%)	0.0206	
> (%)	0.0310	
r^2	0.7760	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1071.96
Discharge (cfs)	3752.83
Exceedance (%)	3.88
Cumulative load (%)	58.39

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.96	0	0	0.000000	0.0000
0.96 - 1072.922	23636	392	0.813408	175.1185
1072.922 - 2144.883	2394	139	0.082387	1111.7857
2144.883 - 3216.845	1037	43	0.035687	2759.3687
3216.845 - 4288.806	624	20	0.021474	11198.9702
4288.806 - 5360.768	480	9	0.016519	12414.8954
5360.768 - 6432.73	286	7	0.009842	5463.9627
6432.73 - 7504.691	206	8	0.007089	5308.3552
7504.691 - 8576.653	118	3	0.004061	7598.4827
8576.653 - 9648.614	80	3	0.002753	7279.5725
9648.614 - 10720.576	55	2	0.001893	3896.2457
10720.576 - 11792.538	29	1	0.000998	7468.3767
11792.538 - 12864.499	19	0	0.000654	0.0000
12864.499 - 13936.461	25	0	0.000860	0.0000
13936.461 - 15008.422	15	1	0.000516	11988.4664
15008.422 - 16080.384	15	0	0.000516	0.0000
16080.384 - 17152.346	12	0	0.000413	0.0000
17152.346 - 18224.307	4	0	0.000138	0.0000
18224.307 - 19296.269	5	1	0.000172	80437.2195
19296.269 - 20368.23	5	0	0.000172	0.0000
20368.23 - 21440.192	4	1	0.000138	106898.7865
21440.192 - 22512.154	3	1	0.000103	110137.7761
22512.154 - 23584.115	3	0	0.000103	0.0000
23584.115 - 24656.077	1	0	0.000034	0.0000
24656.077 - 25728.038	1	0	0.000034	0.0000
25728.038 - 26800.0	1	0	0.000034	0.0000
> 26800.0	0	0	0.000000	0.0000

Effective discharge distogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
537	14.5152
1609	9.3339
2681	10.0347
3753	24.5064
4825	20.8979
5897	5.4801
6969	3.8348
8041	3.1443
9113	2.0423
10185	0.7515
11257	0.7595
12329	0.0000
13400	0.0000
14472	0.6306
15544	0.0000
16616	0.0000
17688	0.0000
18760	1.4104
19832	0.0000
20904	1.4995
21976	1.1587
23048	0.0000
24120	0.0000
25192	0.0000
26264	0.0000
0	0.0000



Load histogram curve using mean approach.

Little Wabash River at Carmi: USGS # 03381500

Discharge record	Mean daily discharge (cfs)
Records	22281
Min.	0.00
Max.	46000.00
Mean	2752.76
Median	567.00

Suspended sediment record	Discharge (cfs)	Load (tons/day)
Records	560	560
Min.	17.80	0.5068
Max.	30960.00	31032.7194
Mean	3646.30	1608.3140
Median	1217.00	291.5861
< (%)	3.1013	
> (%)	0.1167	
r^2	0.9133	

Effective discharge results	Mean approach
Bins	13
Bin size (cfs)	3538.46
Discharge (cfs)	5307.69
Exceedance (%)	20.11
Cumulative load (%)	49.85

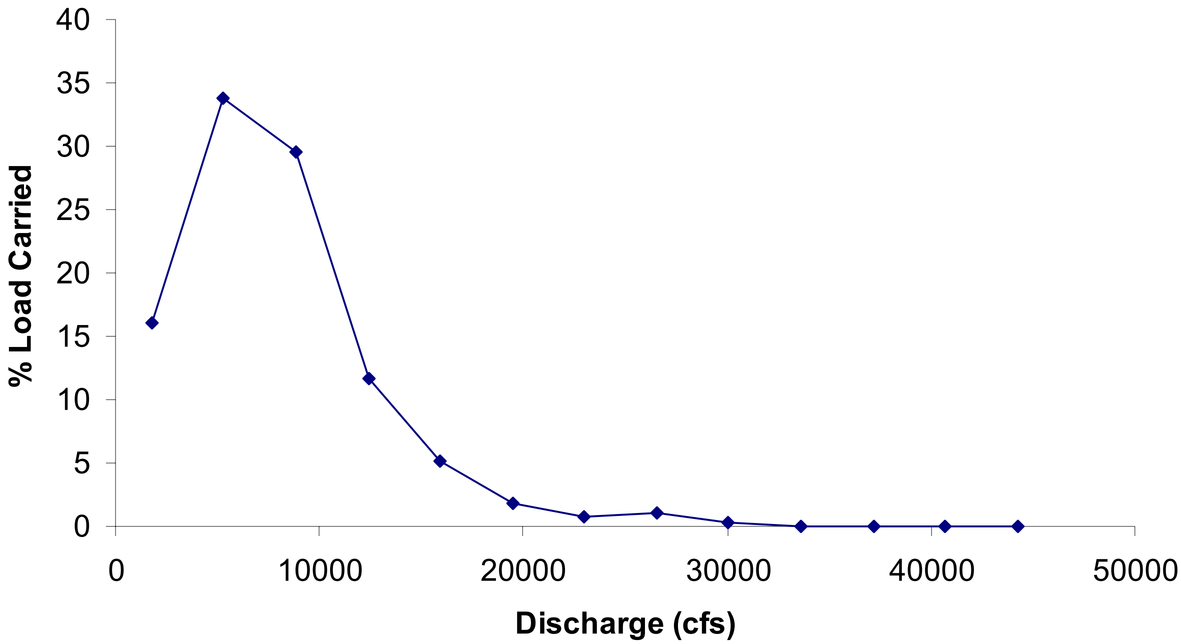
Bin values (Mean approach)

Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	3	0	0.000135	0.0000
0.0 - 3538.462	16494	369	0.740272	279.6901
3538.462 - 7076.923	2607	76	0.117006	3706.5784
7076.923 - 10615.385	1637	56	0.073471	5173.4286
10615.385 - 14153.846	896	36	0.040214	3711.0427
14153.846 - 17692.308	354	10	0.015888	4149.9382
17692.308 - 21230.769	152	6	0.006822	3535.5305
21230.769 - 24769.231	57	5	0.002558	3710.3913
24769.231 - 28307.692	33	1	0.001481	8587.0232
28307.692 - 31846.154	26	1	0.001167	2589.1602
31846.154 - 35384.615	14	0	0.000628	0.0000
35384.615 - 38923.077	3	0	0.000135	0.0000
38923.077 - 42461.539	1	0	0.000045	0.0000
42461.539 - 46000.0	4	0	0.000180	0.0000
> 46000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)

Bin value (cfs)	% Load carried
—	—
1769	16.1082
5308	33.7410
8846	29.5713
12385	11.6104
15923	5.1297
19462	1.8765
23000	0.7385
26538	0.9895
30077	0.2351
33615	0.0000
37154	0.0000
40692	0.0000
44231	0.0000
0	0.0000

Little Wabash River at Carmi: USGS # 03381500



Load histogram curve using mean approach.

Pecatonica River at Freeport: USGS # 05435500

Discharge record	Mean daily discharge (cfs)
Records	31432
Min.	118.00
Max.	17000.00
Mean	948.41
Median	660.00

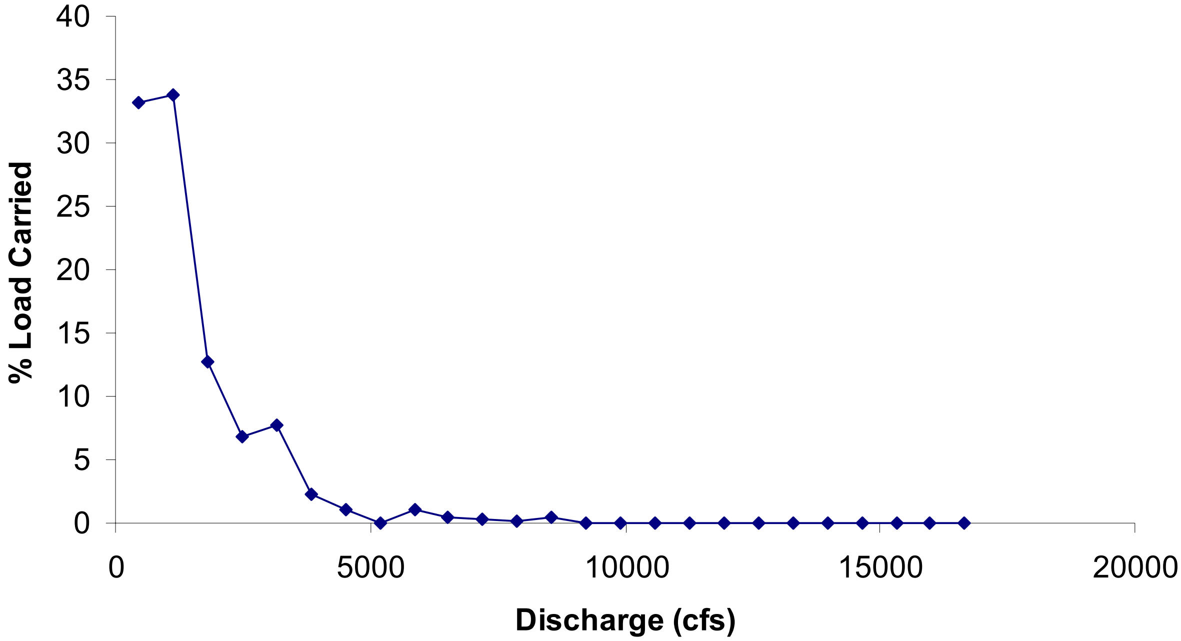
Suspended sediment record	Discharge (cfs)	Load (tons/day)
Records	726	726
Min.	297.90	20.1228
Max.	8593.00	10401.1729
Mean	1222.62	674.3756
Median	965.30	460.0637
< (%)	7.7532	
> (%)	0.2100	
r^2	0.4566	

Effective Discharge Results	Mean approach
Bins	25
Bin size (cfs)	675.28
Discharge (cfs)	1130.92
Exceedance (%)	69.59
Cumulative load (%)	66.94

Bin values (Mean approach) Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 118.0	0	0	0.000000	0.0000
118.0 - 793.28	19120	272	0.608297	279.8795
793.28 - 1468.56	7966	305	0.253436	684.9995
1468.56 - 2143.84	2063	62	0.065634	997.1156
2143.84 - 2819.12	864	44	0.027488	1282.5201
2819.12 - 3494.4	522	22	0.016607	2381.0634
3494.4 - 4169.68	319	9	0.010149	1141.3409
4169.68 - 4844.96	184	3	0.005854	956.0637
4844.96 - 5520.24	126	0	0.004009	0.0000
5520.24 - 6195.52	75	2	0.002386	2351.2926
6195.52 - 6870.8	49	1	0.001559	1296.4912
6870.8 - 7546.08	35	2	0.001114	1299.0864
7546.08 - 8221.36	32	1	0.001018	806.3328
8221.36 - 8896.64	21	3	0.000668	3788.4388
8896.64 - 9571.92	6	0	0.000191	0.0000
9571.92 - 10247.2	11	0	0.000350	0.0000
10247.2 - 10922.48	11	0	0.000350	0.0000
10922.48 - 11597.76	10	0	0.000318	0.0000
11597.76 - 12273.04	4	0	0.000127	0.0000
12273.04 - 12948.32	3	0	0.000095	0.0000
12948.32 - 13623.6	1	0	0.000032	0.0000
13623.6 - 14298.88	4	0	0.000127	0.0000
14298.88 - 14974.16	2	0	0.000064	0.0000
14974.16 - 15649.44	2	0	0.000064	0.0000
15649.44 - 16324.72	0	0	0.000000	0.0000
16324.72 - 17000.0	2	0	0.000064	0.0000
> 17000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach) Bin value (cfs)	% Load carried
—	—
456	33.1416
1131	33.7944
1806	12.7397
2481	6.8627
3157	7.6976
3832	2.2549
4507	1.0895
5183	0.0000
5858	1.0921
6533	0.3934
7208	0.2816
7884	0.1598
8559	0.4927
9234	0.0000
9910	0.0000
10585	0.0000
11260	0.0000
11935	0.0000
12611	0.0000
13286	0.0000
13961	0.0000
14637	0.0000
15312	0.0000
15987	0.0000
16662	0.0000
0	0.0000

Pecatonica River at Freeport: USGS # 05435500



Load histogram curve using mean approach.

Rock River at Rockton: USGS # 05437500

Discharge record	
	Mean daily discharge (cfs)
Records	26151
Min.	501.00
Max.	32000.00
Mean	4316.43
Median	3200.00

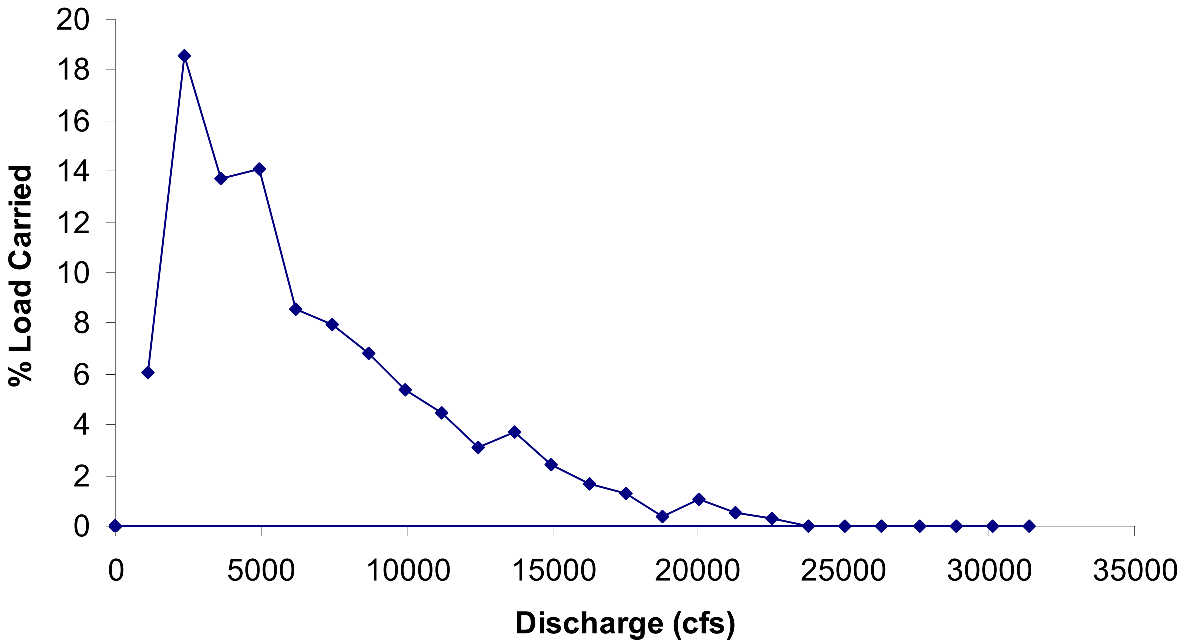
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1052	1052
Min.	78.54	18.5653
Max.	22220.00	27871.9614
Mean	5190.11	1391.9845
Median	4453.00	951.7444
< (%)	0.0000	
> (%)	0.2218	
r^2	0.3179	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1259.96
Discharge (cfs)	2390.94
Exceedance (%)	66.58
Cumulative load (%)	24.57

Bin values (Mean approach)				
Discharge Class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 501.0	0	1	0.000000	0.0000
501.0 - 1760.96	5208	53	0.199151	349.5519
1760.96 - 3020.92	7064	255	0.270124	793.0779
3020.92 - 4280.88	4539	192	0.173569	911.7909
4280.88 - 5540.84	2990	191	0.114336	1425.7381
5540.84 - 6800.8	1946	128	0.074414	1331.8926
6800.8 - 8060.76	1284	74	0.049099	1866.2888
8060.76 - 9320.72	900	58	0.034416	2277.6984
9320.72 - 10580.68	615	19	0.023517	2637.3493
10580.68 - 11840.64	438	28	0.016749	3108.5966
11840.64 - 13100.6	318	10	0.012160	2920.1284
13100.6 - 14360.56	232	15	0.008872	4800.1590
14360.56 - 15620.52	149	8	0.005698	4991.8890
15620.52 - 16880.48	130	10	0.004971	3842.4143
16880.48 - 18140.44	107	4	0.004092	3535.9254
18140.44 - 19400.4	60	1	0.002294	1978.3955
19400.4 - 20660.36	64	3	0.002447	5108.0899
20660.36 - 21920.32	41	1	0.001568	3724.2443
21920.32 - 23180.28	28	1	0.001071	3630.1915
23180.28 - 24440.24	15	0	0.000574	0.0000
24440.24 - 25700.2	9	0	0.000344	0.0000
25700.2 - 26960.16	4	0	0.000153	0.0000
26960.16 - 28220.12	4	0	0.000153	0.0000
28220.12 - 29480.08	2	0	0.000076	0.0000
29480.08 - 30740.04	2	0	0.000076	0.0000
30740.04 - 32000.0	2	0	0.000076	0.0000
> 32000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
1131	6.0261
2391	18.5446
3651	13.6996
4911	14.1112
6171	8.5795
7431	7.9322
8691	6.7856
9951	5.3690
11211	4.5070
12471	3.0738
13731	3.6863
14991	2.4621
16251	1.6535
17510	1.2524
18770	0.3929
20030	1.0822
21290	0.5054
22550	0.3365
23810	0.0000
25070	0.0000
26330	0.0000
27590	0.0000
28850	0.0000
30110	0.0000
31370	0.0000
0	0.0000

Rock River at Rockton: USGS # 05437500



Load histogram curve using mean approach.

Sangamon River at Monticello: USGS # 05572000

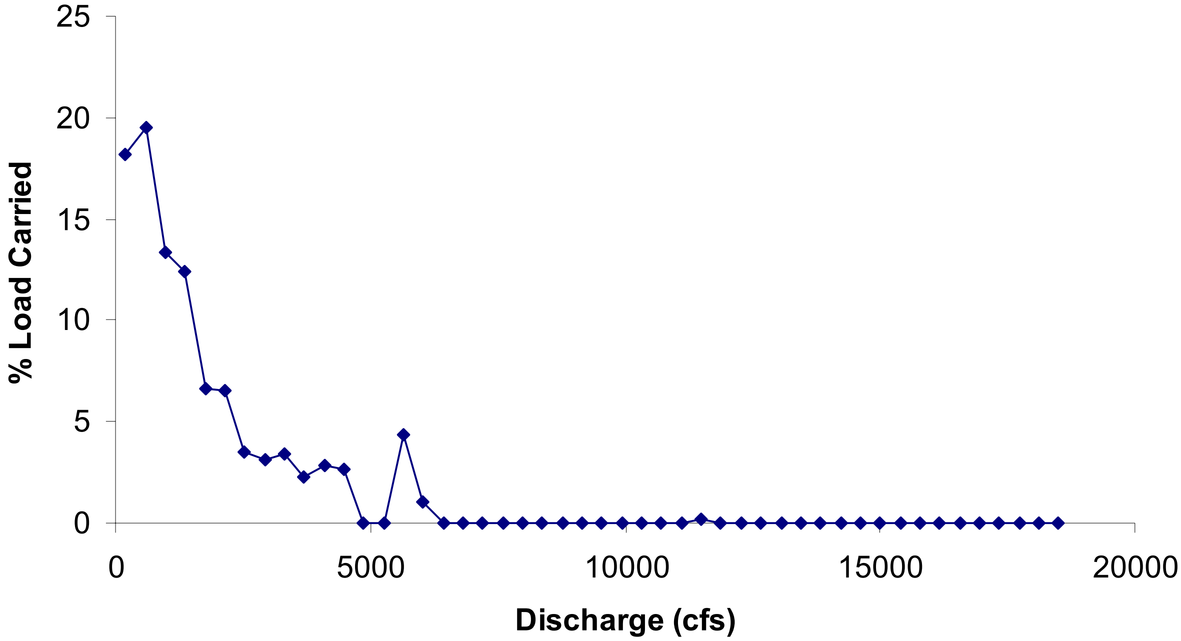
Discharge record	
	Mean daily discharge (cfs)
Records	33213
Min.	0.00
Max.	18700.00
Mean	419.84
Median	160.00

Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	646	646
Min.	0.36	0.0410
Max.	11440.00	25347.5272
Mean	590.72	268.6486
Median	258.70	69.2526
< (%)	0.1355	
> (%)	0.0241	
r^2	0.8642	

Effective discharge results	
Mean approach	
Bins	48
Bin size (cfs)	389.58
Discharge (cfs)	584.38
Exceedance (%)	21.58
Cumulative load (%)	37.67

Bin values (Mean approach)					Effective discharge histogram (Mean approach)	
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)	Bin value (cfs)	% Load carried
≤ 0.0	8	0	0.000241	0.0000	—	—
0.0 - 389.583	23720	394	0.714178	41.2824	195	18.1677
389.583 - 779.167	4640	119	0.139704	226.5114	584	19.4997
779.167 - 1168.75	1787	45	0.053804	401.6580	974	13.3169
1168.75 - 1558.333	1049	13	0.031584	636.0493	1364	12.3790
1558.333 - 1947.917	666	24	0.020052	534.5231	1753	6.6048
1947.917 - 2337.5	420	15	0.012646	842.7814	2143	6.5673
2337.5 - 2727.083	234	12	0.007045	807.0992	2532	3.5040
2727.083 - 3116.667	179	10	0.005389	945.0931	2922	3.1387
3116.667 - 3506.25	118	1	0.003553	1577.0241	3311	3.4526
3506.25 - 3895.833	87	4	0.002619	1429.5554	3701	2.3075
3895.833 - 4285.417	59	2	0.001776	2623.3223	4091	2.8716
4285.417 - 4675.0	59	2	0.001776	2390.8687	4480	2.6172
4675.0 - 5064.583	40	0	0.001204	0.0000	4870	0.0000
5064.583 - 5454.167	32	0	0.000963	0.0000	5259	0.0000
5454.167 - 5843.75	18	2	0.000542	13181.5028	5649	4.4021
5843.75 - 6233.333	16	2	0.000482	3387.2134	6039	1.0055
6233.333 - 6622.917	12	0	0.000361	0.0000	6428	0.0000
6622.917 - 7012.5	6	0	0.000181	0.0000	6818	0.0000
7012.5 - 7402.083	10	0	0.000301	0.0000	7207	0.0000
7402.083 - 7791.667	10	0	0.000301	0.0000	7597	0.0000
7791.667 - 8181.25	8	0	0.000241	0.0000	7986	0.0000
8181.25 - 8570.833	6	0	0.000181	0.0000	8376	0.0000
8570.833 - 8960.417	6	0	0.000181	0.0000	8766	0.0000
8960.417 - 9350.0	7	0	0.000211	0.0000	9155	0.0000
9350.0 - 9739.583	4	0	0.000120	0.0000	9545	0.0000
9739.583 - 10129.167	1	0	0.000030	0.0000	9934	0.0000

Sangamon River at Monticello: USGS # 05572000



Load histogram curve using mean approach.

Silver Creek near Freeburg: USGS # 05594800

Discharge record	
	Mean daily discharge (cfs)
Records	10958
Min.	0.00
Max.	15000.00
Mean	366.91
Median	71.00

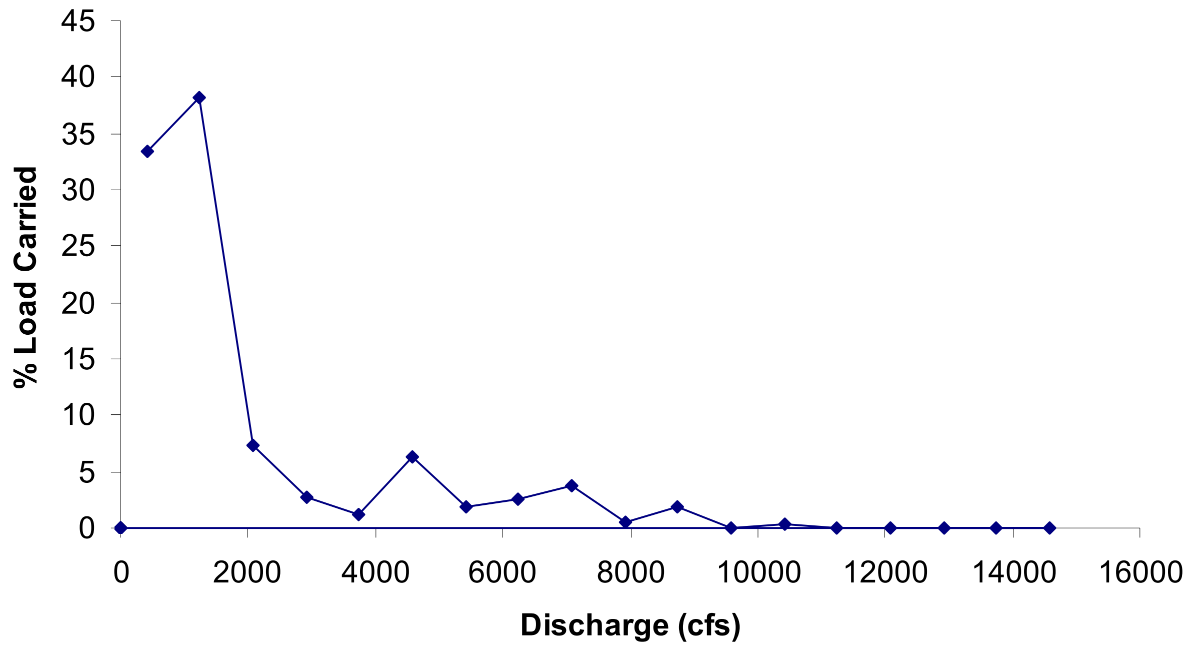
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	869	869
Min.	0.00	0.0000
Max.	10040.00	22905.1759
Mean	442.44	552.8932
Median	102.10	20.9854
< (%)	0.0000	
> (%)	0.0730	
r^2	0.8152	

Effective discharge results	
Mean approach	
Bins	18
Bin size (cfs)	833.33
Discharge (cfs)	1250.00
Exceedance (%)	9.12
Cumulative load (%)	71.63

Bin values (Mean approach)				
Discharge class	Flow Records	Sediment Records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	3	2	0.000274	0.0000
0.0 - 833.333	9545	728	0.871053	173.3164
833.333 - 1666.667	824	89	0.075196	2301.1142
1666.667 - 2500.0	293	25	0.026738	1235.2771
2500.0 - 3333.333	100	7	0.009126	1310.6709
3333.333 - 4166.667	67	1	0.006114	840.0245
4166.667 - 5000.0	51	6	0.004654	6152.0993
5000.0 - 5833.333	25	5	0.002281	3565.9215
5833.333 - 6666.667	19	1	0.001734	6806.6622
6666.667 - 7500.0	12	1	0.001095	15767.0439
7500.0 - 8333.333	5	1	0.000456	4382.1426
8333.333 - 9166.667	5	1	0.000456	18429.8357
9166.667 - 10000.0	1	1	0.000091	2019.0753
10000.0 - 10833.333	3	1	0.000274	6447.0751
10833.333 - 11666.667	1	0	0.000091	0.0000
11666.667 - 12500.0	1	0	0.000091	0.0000
12500.0 - 13333.333	1	0	0.000091	0.0000
13333.333 - 14166.667	0	0	0.000000	0.0000
14166.667 - 15000.0	2	0	0.000183	0.0000
> 15000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
417	33.3760
1250	38.2547
2083	7.3022
2917	2.6443
3750	1.1355
4583	6.3301
5417	1.7986
6250	2.6092
7083	3.8173
7917	0.4421
8750	1.8591
9583	0.0407
10417	0.3902
11250	0.0000
12083	0.0000
12917	0.0000
13750	0.0000
14583	0.0000
0	0.0000

Silver Creek near Freeburg: USGS # 05594800



Load histogram curve using mean approach.

APPENDIX C

Effective Discharge Results for the Partially Qualified Stations that Use USGS Suspended Sediment Data

Notation for tables in Appendix C:

< (%) The percent of flow events less than the minimum discharge at which suspended sediment samples were collected

> (%) The percent of flow events greater than the maximum discharge at which suspended sediment samples were collected

Exceedance (%) The percent of flows exceeding the magnitude of the station's effective discharge

Cumulative load (%)* The percent of suspended sediment load carried by flows less than or equal to the effective discharge

% load carried* The percent of suspended sediment load carried by a discharge class.

Bin value (cfs) The average of the uppermost and lowest discharge values in a discharge class

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Note:
* Values are based on the mean approach which assigns zero sediment load to discharge classes that having no sediment samples falling within them. Assuming or extrapolating sediment loads for these discharge classes would result in different percentage values.

Apple River near Hanover: USGS # 05419000

Discharge record	
	Mean daily discharge (cfs)
Records	24107
Min.	3.50
Max.	9010.00
Mean	180.07
Median	87.00

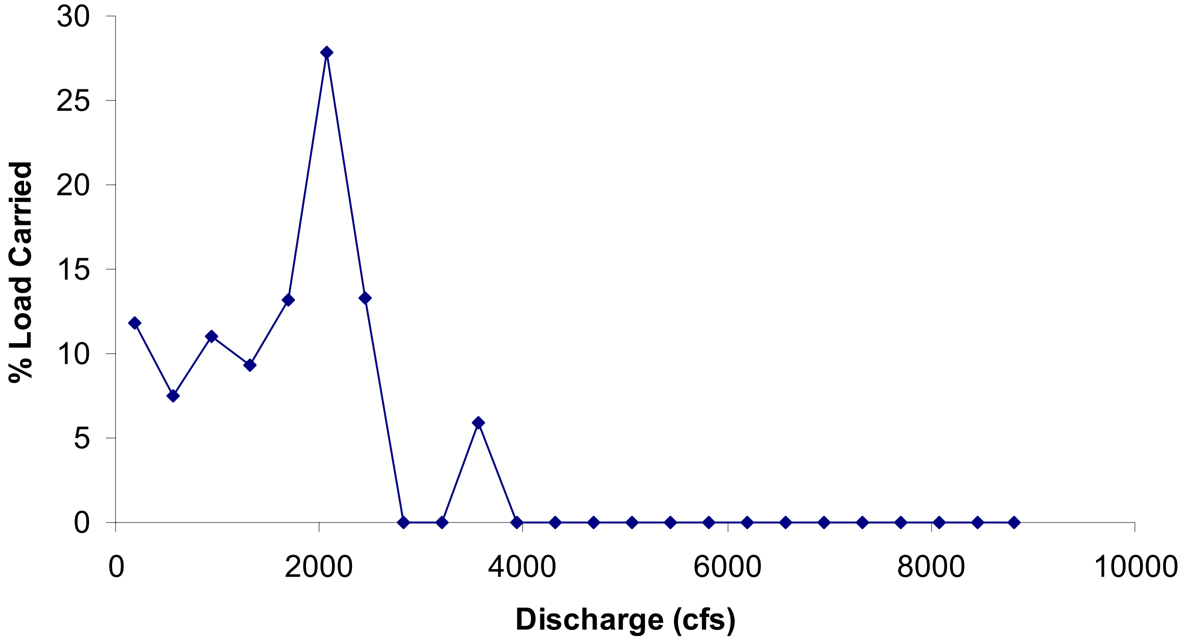
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1096	1096
Min.	44.00	0.7880
Max.	3450.00	20463.6705
Mean	183.31	161.6710
Median	110.00	11.8493
< (%)	20.9151	
> (%)	0.2613	
r^2	0.8210	

Effective Discharge Results	
Mean approach	
Bins	24
Bin size (cfs)	375.27
Discharge (cfs)	2067.49
Exceedance (%)	0.79
Cumulative load (%)	80.71

Bin Values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 3.5	0	0	0.000000	0.0000
3.5 - 378.771	22059	1002	0.915045	19.5887
378.771 - 754.042	1175	60	0.048741	235.5324
754.042 - 1129.312	376	17	0.015597	1079.5011
1129.312 - 1504.583	184	6	0.007633	1861.0667
1504.583 - 1879.854	90	4	0.003733	5363.8306
1879.854 - 2255.125	69	3	0.002862	14760.6224
2255.125 - 2630.396	45	3	0.001867	10867.1044
2630.396 - 3005.667	26	0	0.001079	0.0000
3005.667 - 3380.937	17	0	0.000705	0.0000
3380.937 - 3756.208	14	1	0.000581	15575.0970
3756.208 - 4131.479	12	0	0.000498	0.0000
4131.479 - 4506.75	7	0	0.000290	0.0000
4506.75 - 4882.021	3	0	0.000124	0.0000
4882.021 - 5257.292	4	0	0.000166	0.0000
5257.292 - 5632.563	5	0	0.000207	0.0000
5632.563 - 6007.833	3	0	0.000124	0.0000
6007.833 - 6383.104	1	0	0.000041	0.0000
6383.104 - 6758.375	5	0	0.000207	0.0000
6758.375 - 7133.646	5	0	0.000207	0.0000
7133.646 - 7508.917	3	0	0.000124	0.0000
7508.917 - 7884.188	1	0	0.000041	0.0000
7884.188 - 8259.458	1	0	0.000041	0.0000
8259.458 - 8634.729	1	0	0.000041	0.0000
8634.729 - 9010.0	1	0	0.000041	0.0000
> 9010.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
191	11.7886
566	7.5502
942	11.0734
1317	9.3422
1692	13.1700
2067	27.7858
2443	13.3412
2818	0.0000
3193	0.0000
3569	5.9488
3944	0.0000
4319	0.0000
4694	0.0000
5070	0.0000
5445	0.0000
5820	0.0000
6195	0.0000
6571	0.0000
6946	0.0000
7321	0.0000
7697	0.0000
8072	0.0000
8447	0.0000
8822	0.0000
0	0.0000

Apple River near Hanover: USGS # 05419000



Load histogram curve using the mean approach.

Des Plaines River at Riverside: USGS # 05532500

Discharge record	
	Mean daily discharge (cfs)
Records	20820
Min.	0.00
Max.	9180.00
Mean	551.13
Median	297.00

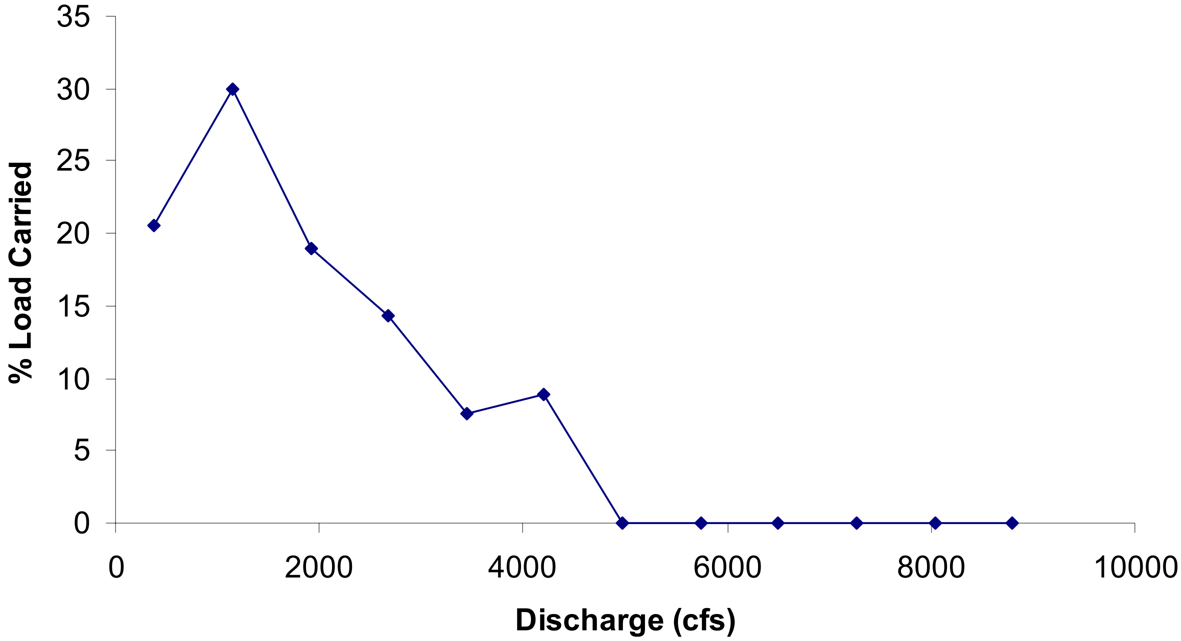
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1279	1279
Min.	110.00	1.5372
Max.	4320.00	3267.9306
Mean	636.08	115.5427
Median	410.00	26.2996
% <	22.7762	
% >	0.4803	
r^2	0.8911	

Effective Discharge Results	
Mean approach	
Bins	12
Bin size (cfs)	765.00
Discharge (cfs)	1147.50
Exceedance (%)	15.14
Cumulative load (%)	50.51

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	1	0	0.000048	0.0000
0.0 - 765.0	16176	962	0.776945	28.4147
765.0 - 1530.0	2985	203	0.143372	223.5385
1530.0 - 2295.0	919	74	0.044140	458.7846
2295.0 - 3060.0	420	24	0.020173	757.1857
3060.0 - 3825.0	146	10	0.007012	1147.7589
3825.0 - 4590.0	103	6	0.004947	1910.9719
4590.0 - 5355.0	39	0	0.001873	0.0000
5355.0 - 6120.0	22	0	0.001057	0.0000
6120.0 - 6885.0	4	0	0.000192	0.0000
6885.0 - 7650.0	2	0	0.000096	0.0000
7650.0 - 8415.0	1	0	0.000048	0.0000
8415.0 - 9180.0	2	0	0.000096	0.0000
> 9180.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
383	20.6028
1148	29.9094
1913	18.8989
2678	14.2549
3443	7.5113
4208	8.8227
4973	0.0000
5738	0.0000
6503	0.0000
7268	0.0000
8033	0.0000
8798	0.0000
0	0.0000

Des Plaines River at Riverside: USGS # 05532500



Load histogram curve using the mean approach.

Green River near Geneseo: USGS # 05447500

Discharge record	Mean daily discharge (cfs)
Records	23590
Min.	22.00
Max.	10100.00
Mean	658.02
Median	390.00

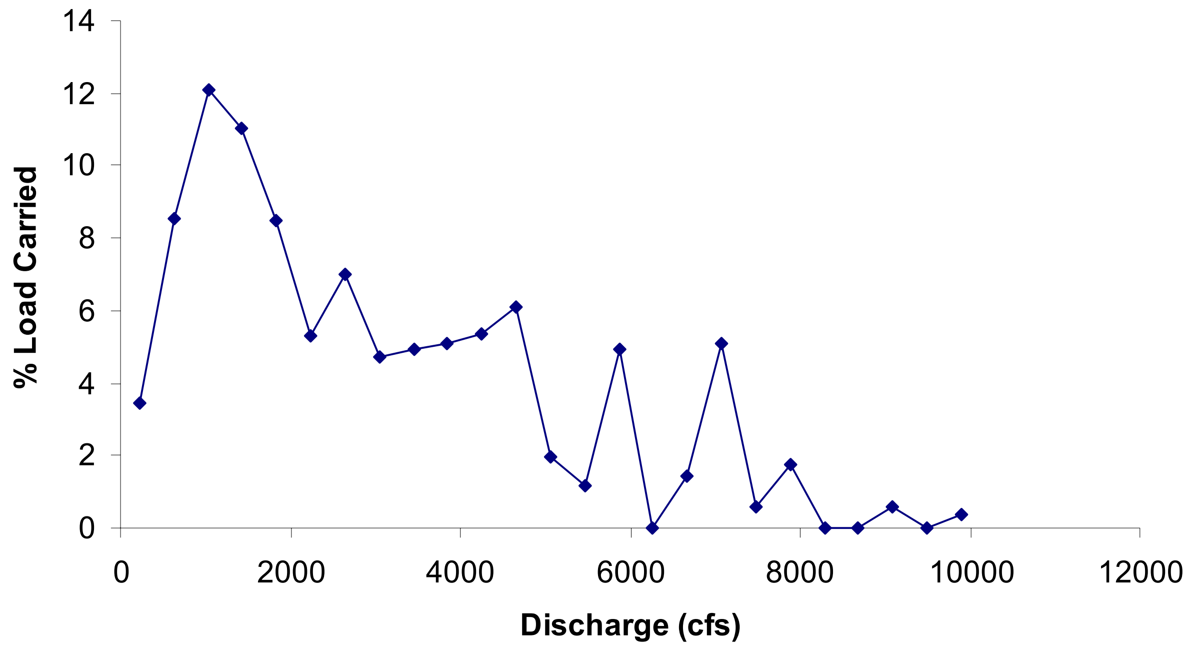
Suspended sediment record	Discharge (cfs)	Load (tons/day)
Records	1287	1287
Min.	140.00	7.3354
Max.	10100.00	132506.8510
Mean	785.17	1355.5823
Median	460.00	147.4420
< (%)	19.4065	
> (%)	0.0000	
r^2	0.8545	

Effective discharge results	Mean approach
Bins	25
Bin size (cfs)	403.12
Discharge (cfs)	1029.80
Exceedance (%)	18.38
Cumulative load (%)	24.07

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 22.0	0	0	0.000000	0.0000
22.0 - 425.12	12542	578	0.531666	59.8356
425.12 - 828.24	5499	373	0.233107	334.9756
828.24 - 1231.36	2429	146	0.102967	1075.0795
1231.36 - 1634.48	1142	78	0.048410	2089.4730
1634.48 - 2037.6	659	30	0.027936	2775.6662
2037.6 - 2440.72	383	19	0.016236	2992.6095
2440.72 - 2843.84	254	12	0.010767	5975.6183
2843.84 - 3246.96	155	10	0.006571	6570.1300
3246.96 - 3650.08	132	5	0.005596	8045.8039
3650.08 - 4053.2	91	10	0.003858	12105.4099
4053.2 - 4456.32	72	5	0.003052	16159.8488
4456.32 - 4859.44	56	3	0.002374	23610.8902
4859.44 - 5262.56	46	3	0.001950	9311.3117
5262.56 - 5665.68	26	1	0.001102	9682.7573
5665.68 - 6068.8	27	6	0.001145	39382.9020
6068.8 - 6471.92	13	0	0.000551	0.0000
6471.92 - 6875.04	17	1	0.000721	18547.5611
6875.04 - 7278.16	13	2	0.000551	84695.1354
7278.16 - 7681.28	9	1	0.000382	14311.3548
7681.28 - 8084.4	10	2	0.000424	37675.2139
8084.4 - 8487.52	4	0	0.000170	0.0000
8487.52 - 8890.64	3	0	0.000127	0.0000
8890.64 - 9293.76	3	1	0.000127	41209.1614
9293.76 - 9696.88	4	0	0.000170	0.0000
9696.88 - 10100.0	1	1	0.000042	81986.8274
> 10100.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
224	3.4708
627	8.5193
1030	12.0775
1433	11.0360
1836	8.4598
2239	5.3010
2642	7.0198
3045	4.7099
3449	4.9119
3852	5.0948
4255	5.3812
4658	6.1152
5061	1.9810
5464	1.1643
5867	4.9179
6270	0.0000
6673	1.4583
7077	5.0922
7480	0.5957
7883	1.7425
8286	0.0000
8689	0.0000
9092	0.5718
9495	0.0000
9898	0.3792
0	0.0000

Green River near Geneseo: USGS # 05447500



Load histogram curve using the mean approach.

Henderson Creek near Oquawka: USGS # 05469000

Discharge record	
	Mean daily discharge (cfs)
Records	23742
Min.	1.70
Max.	25800.00
Mean	299.95
Median	129.00

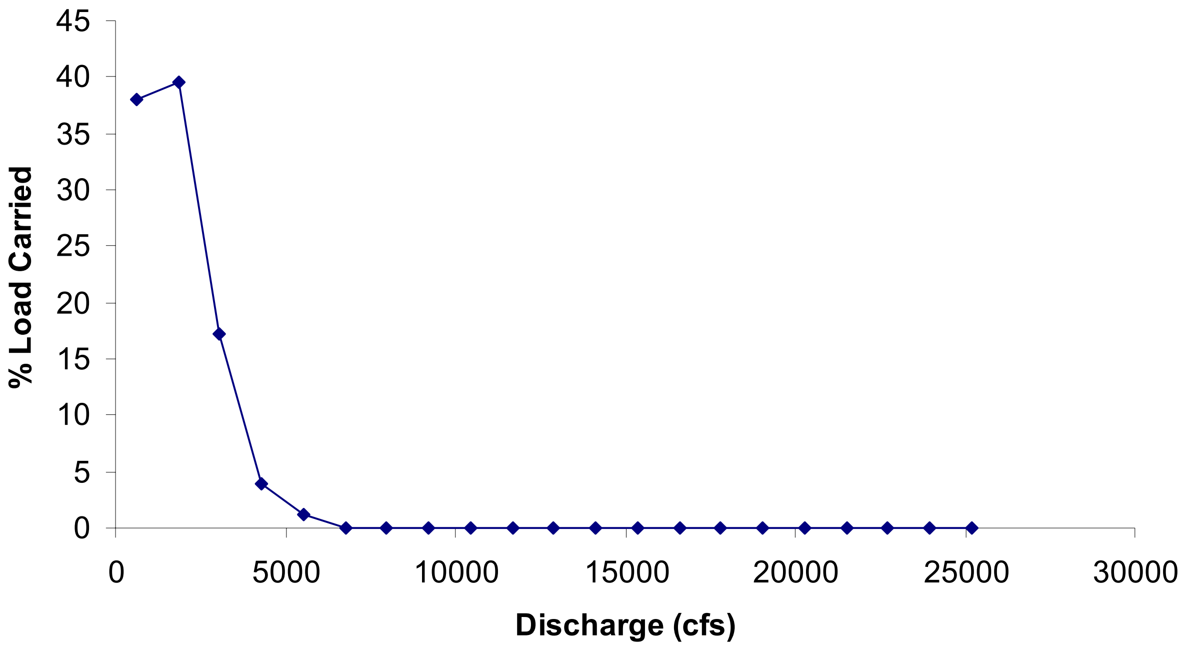
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	1279	1279
Min.	17.00	0.8738
Max.	5980.00	34620.7657
Mean	313.56	949.9354
Median	131.00	25.6740
< (%)	8.1922	
> (%)	0.1474	
r^2	0.8697	

Effective discharge results	
Mean approach	
Bins	21
Bin size (cfs)	1228.49
Discharge (cfs)	1844.44
Exceedance (%)	2.81
Cumulative load (%)	77.61

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 1.7	0	0	0.000000	0.0000
1.7 - 1230.19	22746	1215	0.958049	318.8134
1230.19 - 2458.681	659	39	0.027757	11430.3933
2458.681 - 3687.171	200	21	0.008424	16372.8113
3687.171 - 4915.662	74	3	0.003117	10245.8588
4915.662 - 6144.152	32	1	0.001348	7257.2137
6144.152 - 7372.643	11	0	0.000463	0.0000
7372.643 - 8601.133	12	0	0.000505	0.0000
8601.133 - 9829.624	1	0	0.000042	0.0000
9829.624 - 11058.114	1	0	0.000042	0.0000
11058.114 - 12286.605	0	0	0.000000	0.0000
12286.605 - 13515.095	2	0	0.000084	0.0000
13515.095 - 14743.586	1	0	0.000042	0.0000
14743.586 - 15972.076	0	0	0.000000	0.0000
15972.076 - 17200.567	0	0	0.000000	0.0000
17200.567 - 18429.057	0	0	0.000000	0.0000
18429.057 - 19657.548	0	0	0.000000	0.0000
19657.548 - 20886.038	1	0	0.000042	0.0000
20886.038 - 22114.529	0	0	0.000000	0.0000
22114.529 - 23343.019	0	0	0.000000	0.0000
23343.019 - 24571.51	1	0	0.000042	0.0000
24571.51 - 25800.0	1	0	0.000042	0.0000
> 25800.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
616	38.0681
1844	39.5427
3073	17.1899
4301	3.9802
5530	1.2191
6758	0.0000
7987	0.0000
9215	0.0000
10444	0.0000
11672	0.0000
12901	0.0000
14129	0.0000
15358	0.0000
16586	0.0000
17815	0.0000
19043	0.0000
20272	0.0000
21500	0.0000
22729	0.0000
23957	0.0000
25186	0.0000
0	0.0000

Henderson Creek near Oquawka: USGS # 05469000



Load histogram curve using the mean approach.

Illinois River at Chillicothe: USGS # 05559600

Discharge record	
	Mean daily discharge (cfs)
Records	6940
Min.	2040.00
Max.	111000.00
Mean	15325.36
Median	11400.00

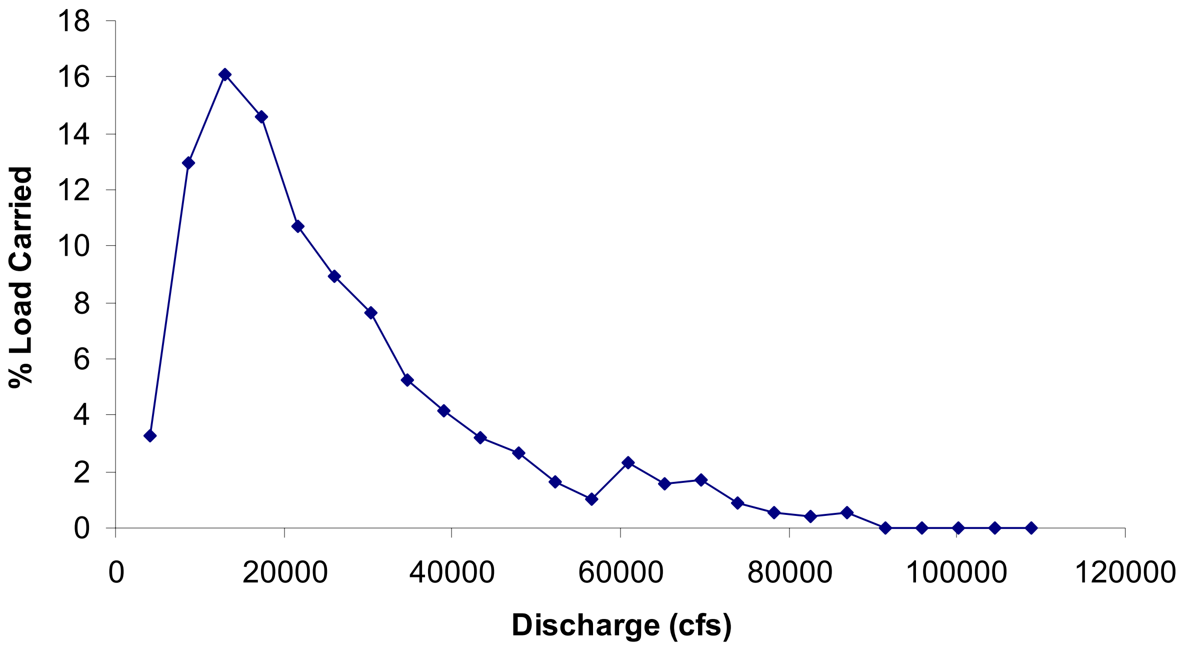
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	2231	2231
Min.	2600.00	190.2693
Max.	85900.00	93693.7837
Mean	14753.77	2836.5002
Median	11100.00	1724.1856
< (%)	0.1729	
> (%)	0.2450	
r^2	0.7580	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	4358.40
Discharge (cfs)	12936.00
Exceedance (%)	44.34
Cumulative load (%)	32.36

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 2040.0	0	0	0.000000	0.0000
2040.0 - 6398.4	980	475	0.141210	675.2731
6398.4 - 10756.8	2241	617	0.322911	1167.5399
10756.8 - 15115.2	1285	346	0.185159	2531.9733
15115.2 - 19473.6	775	242	0.111671	3793.1290
19473.6 - 23832.0	474	151	0.068300	4553.0989
23832.0 - 28190.4	373	154	0.053746	4822.5569
28190.4 - 32548.8	274	90	0.039481	5623.5572
32548.8 - 36907.2	155	48	0.022334	6858.5730
36907.2 - 41265.6	106	34	0.015274	7938.2553
41265.6 - 45624.0	88	21	0.012680	7369.4759
45624.0 - 49982.4	58	16	0.008357	9239.2771
49982.4 - 54340.8	34	14	0.004899	9714.2729
54340.8 - 58699.2	13	6	0.001873	15551.0587
58699.2 - 63057.6	19	7	0.002738	24398.3127
63057.6 - 67416.0	14	2	0.002017	22265.9594
67416.0 - 71774.4	8	3	0.001153	43614.7664
71774.4 - 76132.8	12	2	0.001729	14422.1871
76132.8 - 80491.2	5	1	0.000720	20947.0532
80491.2 - 84849.6	5	1	0.000720	15656.4878
84849.6 - 89208.0	8	1	0.001153	14175.2207
89208.0 - 93566.4	2	0	0.000288	0.0000
93566.4 - 97924.8	2	0	0.000288	0.0000
97924.8 - 102283.2	5	0	0.000720	0.0000
102283.2 - 106641.6	3	0	0.000432	0.0000
106641.6 - 111000.0	1	0	0.000144	0.0000
> 111000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
4219	3.2786
8578	12.9628
12936	16.1193
17294	14.5641
21653	10.6923
26011	8.9119
30370	7.6339
34728	5.2668
39086	4.1688
43445	3.2129
47803	2.6549
52162	1.6363
56520	1.0016
60878	2.2967
65237	1.5444
69595	1.7287
73954	0.8574
78312	0.5189
82670	0.3878
87029	0.5618
91387	0.0000
95746	0.0000
100104	0.0000
104462	0.0000
108821	0.0000
0	0.0000

Illinois River at Chillicothe: USGS # 05559600



Load histogram curve using the mean approach.

Illinois River at Pekin: USGS # 05563800

Discharge record	Mean daily discharge (cfs)
Records	10692
Min.	548.00
Max.	75970.00
Mean	14625.79
Median	10192.50

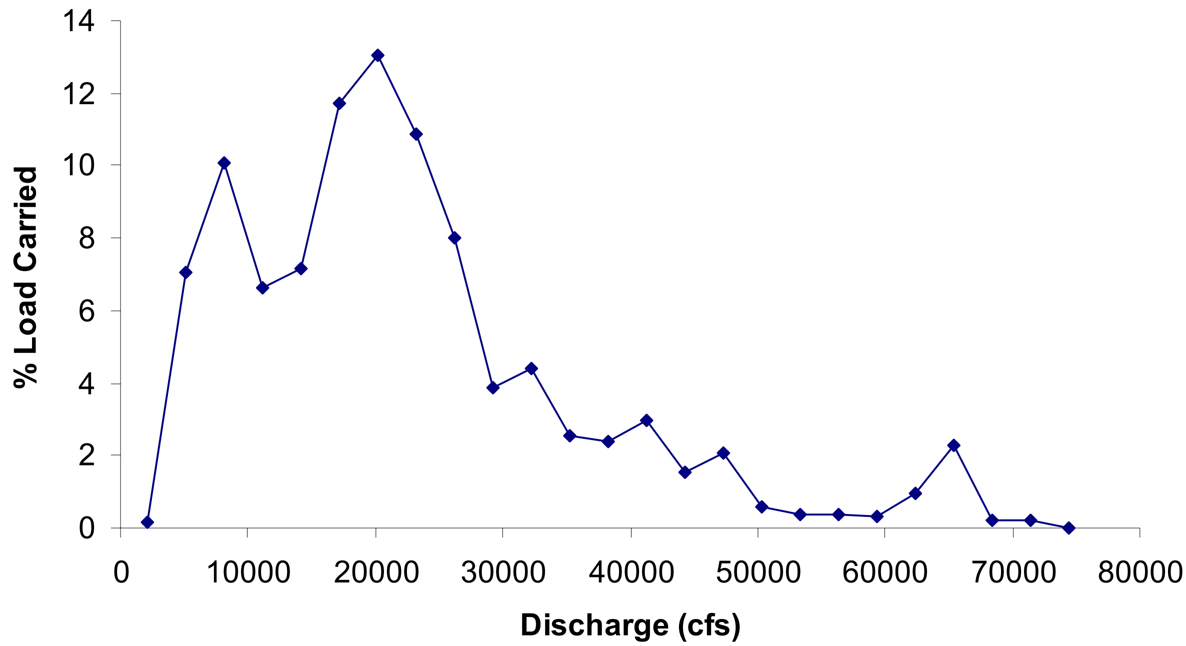
Sediment record	Discharge (cfs)	Load (tons/day)
Records	1096	1096
Min.	3280.00	294.2974
Max.	72900.00	91408.7606
Mean	15657.59	4115.4517
Median	11344.50	2254.3749
< (%)	0.5986	
> (%)	0.0187	
r^2	0.6040	

Effective discharge results	Mean approach
Bins	25
Bin size (cfs)	3016.88
Discharge (cfs)	20157.72
Exceedance (%)	25.40
Cumulative load (%)	55.95

Bin values (Mean Approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 548.0	0	0	0.000000	0.0000
548.0 - 3564.88	124	1	0.011597	553.0304
3564.88 - 6581.76	2520	233	0.235690	1104.4567
6581.76 - 9598.64	2415	245	0.225870	1643.6794
9598.64 - 12615.52	1117	120	0.104471	2335.9179
12615.52 - 15632.4	710	98	0.066405	3976.1752
15632.4 - 18649.28	710	55	0.066405	6502.8369
18649.28 - 21666.16	763	94	0.071362	6732.7393
21666.16 - 24683.04	561	59	0.052469	7614.7285
24683.04 - 27699.92	412	34	0.038533	7644.8759
27699.92 - 30716.8	364	21	0.034044	4208.9768
30716.8 - 33733.68	251	28	0.023476	6889.2326
33733.68 - 36750.56	194	27	0.018144	5209.6625
36750.56 - 39767.44	174	22	0.016274	5341.8642
39767.44 - 42784.32	118	22	0.011036	9860.0098
42784.32 - 45801.2	94	13	0.008792	6353.2733
45801.2 - 48818.08	63	9	0.005892	13022.8678
48818.08 - 51834.96	29	1	0.002712	8060.6797
51834.96 - 54851.84	16	1	0.001496	9268.3936
54851.84 - 57868.72	14	1	0.001309	10991.6132
57868.72 - 60885.6	10	1	0.000935	13477.7825
60885.6 - 63902.48	8	2	0.000748	47891.7297
63902.48 - 66919.36	16	5	0.001496	56440.5356
66919.36 - 69936.24	4	1	0.000374	20202.1357
69936.24 - 72953.12	3	3	0.000281	28021.4477
72953.12 - 75970.0	2	0	0.000187	0.0000
> 75970.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
2056	0.1743
5073	7.0760
8090	10.0919
11107	6.6336
14124	7.1773
17141	11.7381
20158	13.0603
23175	10.8606
26191	8.0076
29208	3.8951
32225	4.3962
35242	2.5695
38259	2.3631
41276	2.9580
44293	1.5183
47310	2.0859
50327	0.5943
53343	0.3770
56360	0.3912
59377	0.3427
62394	0.9741
65411	2.2959
68428	0.2054
71445	0.2137
74462	0.0000
0	0.0000

Illinois River at Pekin: USGS # 05563800



Load histogram curve using the mean approach.

Illinois River at Valley City: USGS # 05586100

Discharge record	
	Mean daily discharge (cfs)
Records	22646
Min.	1330.00
Max.	123000.00
Mean	22780.46
Median	16100.00

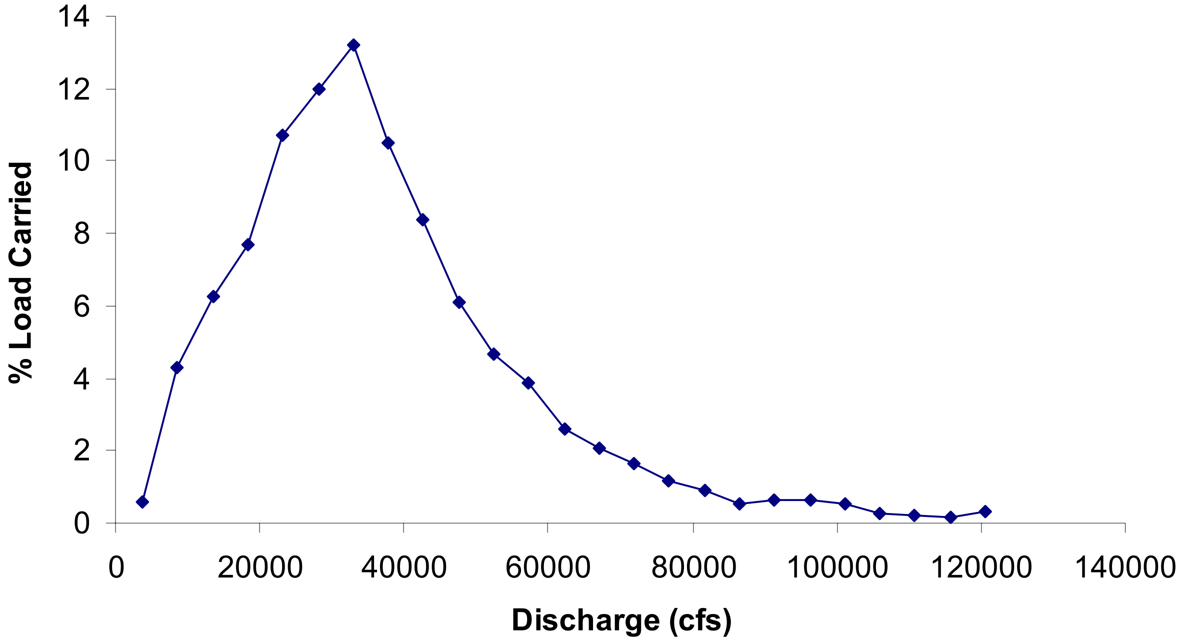
Sediment record		
	Discharge (cfs)	Load (tons/day)
Records	7535	7535
Min.	1330.00	172.1667
Max.	120000.00	409623.9997
Mean	25806.26	15199.1283
Median	19300.00	7640.7052
< (%)	0.0000	
> (%)	0.0177	
r^2	0.6413	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	4866.80
Discharge (cfs)	32964.20
Exceedance (%)	23.23
Cumulative load (%)	54.79

Bin values (Mean Approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 1330.0	0	0	0.000000	0.0000
1330.0 - 6196.8	1814	330	0.080102	1015.8267
6196.8 - 11063.6	5942	1809	0.262386	2219.5003
11063.6 - 15930.4	3476	1112	0.153493	5538.2292
15930.4 - 20797.2	2102	707	0.092820	11203.7592
20797.2 - 25664.0	1687	682	0.074494	19454.7174
25664.0 - 30530.8	1642	558	0.072507	22422.6874
30530.8 - 35397.6	1448	443	0.063941	28013.9874
35397.6 - 40264.4	1112	373	0.049104	28985.9731
40264.4 - 45131.2	808	283	0.035680	31887.8428
45131.2 - 49998.0	598	234	0.026406	31172.1762
49998.0 - 54864.8	466	213	0.020578	30726.1917
54864.8 - 59731.6	364	209	0.016073	32413.6127
59731.6 - 64598.4	305	152	0.013468	25989.7110
64598.4 - 69465.2	224	108	0.009891	28030.7305
69465.2 - 74332.0	199	109	0.008787	25358.5534
74332.0 - 79198.8	119	63	0.005255	30501.3228
79198.8 - 84065.6	93	43	0.004107	30435.8522
84065.6 - 88932.4	58	26	0.002561	27954.1099
88932.4 - 93799.2	58	19	0.002561	32454.9656
93799.2 - 98666.0	45	19	0.001987	42802.4378
98666.0 - 103532.8	40	20	0.001766	41138.5189
103532.8 - 108399.6	19	10	0.000839	42011.0148
108399.6 - 113266.4	10	6	0.000442	72476.3986
113266.4 - 118133.2	6	3	0.000265	89629.6901
118133.2 - 123000.0	11	4	0.000486	95115.7499
> 123000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
3763	0.6008
8630	4.3003
13497	6.2771
18364	7.6790
23231	10.7016
28097	12.0052
32964	13.2267
37831	10.5099
42698	8.4013
47565	6.0782
52431	4.6688
57298	3.8471
62165	2.5847
67032	2.0473
71899	1.6455
76765	1.1835
81632	0.9229
86499	0.5287
91366	0.6138
96233	0.6280
101099	0.5366
105966	0.2603
110833	0.2363
115700	0.1754
120567	0.3412
0	0.0000

Illinois River at Valley City: USGS # 05586100



Load histogram curve using mean approach.

Kishwaukee River near Perryville: USGS # 05440000

Discharge record	
	Mean daily discharge (cfs)
Records	22281
Min.	49.00
Max.	16700.00
Mean	781.10
Median	430.00

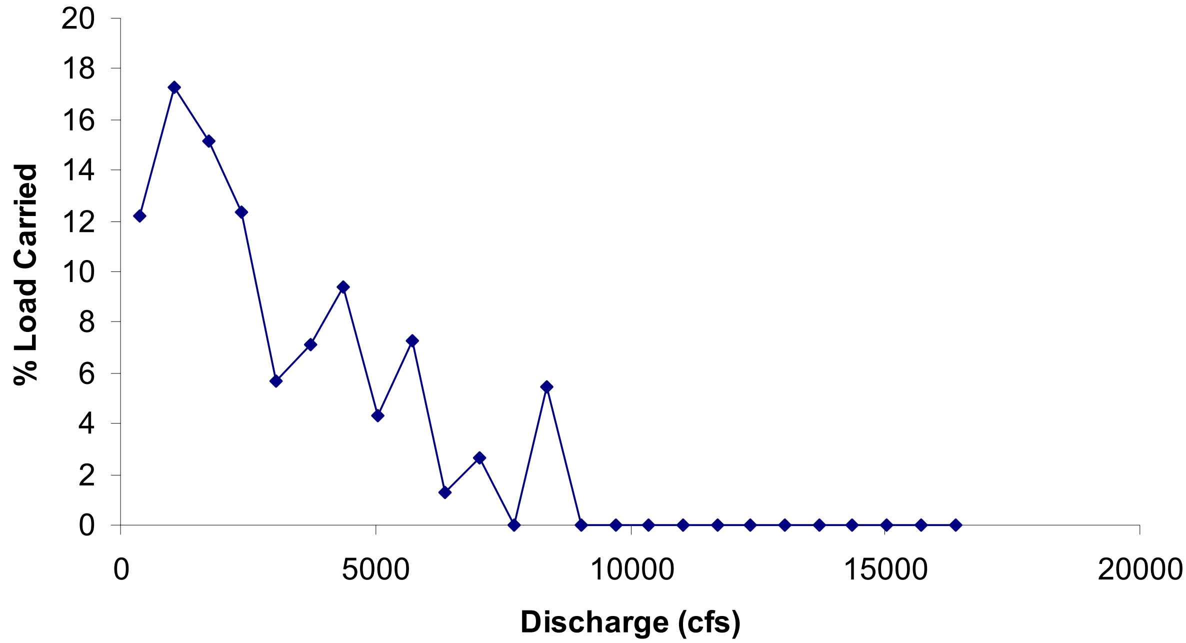
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	914	914
Min.	220.00	11.2189
Max.	8670.00	24083.1080
Mean	879.70	472.5804
Median	556.00	99.7172
< (%)	24.6084	
> (%)	0.2693	
r^2	0.7899	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	666.04
Discharge (cfs)	1048.06
Exceedance (%)	22.54
Cumulative load (%)	29.48

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 49.0	0	0	0.000000	0.0000
49.0 - 715.04	15260	569	0.684888	74.5983
715.04 - 1381.08	3999	202	0.179480	401.7024
1381.08 - 2047.12	1322	67	0.059333	1065.6508
2047.12 - 2713.16	619	30	0.027782	1853.2054
2713.16 - 3379.2	381	18	0.017100	1381.9959
3379.2 - 4045.24	218	13	0.009784	3042.1838
4045.24 - 4711.28	143	6	0.006418	6137.5819
4711.28 - 5377.32	93	3	0.004174	4319.1164
5377.32 - 6043.36	54	2	0.002424	12488.7586
6043.36 - 6709.4	51	1	0.002289	2304.5901
6709.4 - 7375.44	31	2	0.001391	7890.5006
7375.44 - 8041.48	30	0	0.001346	0.0000
8041.48 - 8707.52	21	1	0.000943	24083.1080
8707.52 - 9373.56	13	0	0.000583	0.0000
9373.56 - 10039.6	11	0	0.000494	0.0000
10039.6 - 10705.64	10	0	0.000449	0.0000
10705.64 - 11371.68	4	0	0.000180	0.0000
11371.68 - 12037.72	2	0	0.000090	0.0000
12037.72 - 12703.76	3	0	0.000135	0.0000
12703.76 - 13369.8	5	0	0.000224	0.0000
13369.8 - 14035.84	1	0	0.000045	0.0000
14035.84 - 14701.88	1	0	0.000045	0.0000
14701.88 - 15367.92	4	0	0.000180	0.0000
15367.92 - 16033.96	1	0	0.000045	0.0000
16033.96 - 16700.0	4	0	0.000180	0.0000
> 16700.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
382	12.2247
1048	17.2508
1714	15.1287
2380	12.3188
3046	5.6544
3712	7.1219
4378	9.4251
5044	4.3135
5710	7.2421
6376	1.2622
7042	2.6268
7708	0.0000
8375	5.4311
9041	0.0000
9707	0.0000
10373	0.0000
11039	0.0000
11705	0.0000
12371	0.0000
13037	0.0000
13703	0.0000
14369	0.0000
15035	0.0000
15701	0.0000
16367	0.0000
0	0.0000

Kishwaukee River near Perryville: USGS # 05440000



Load histogram curve using the mean approach.

Rock River near Joslin: USGS # 05446500

Discharge record	
	Mean daily discharge (cfs)
Records	22281
Min.	834.00
Max.	44700.00
Mean	6526.88
Median	4950.00

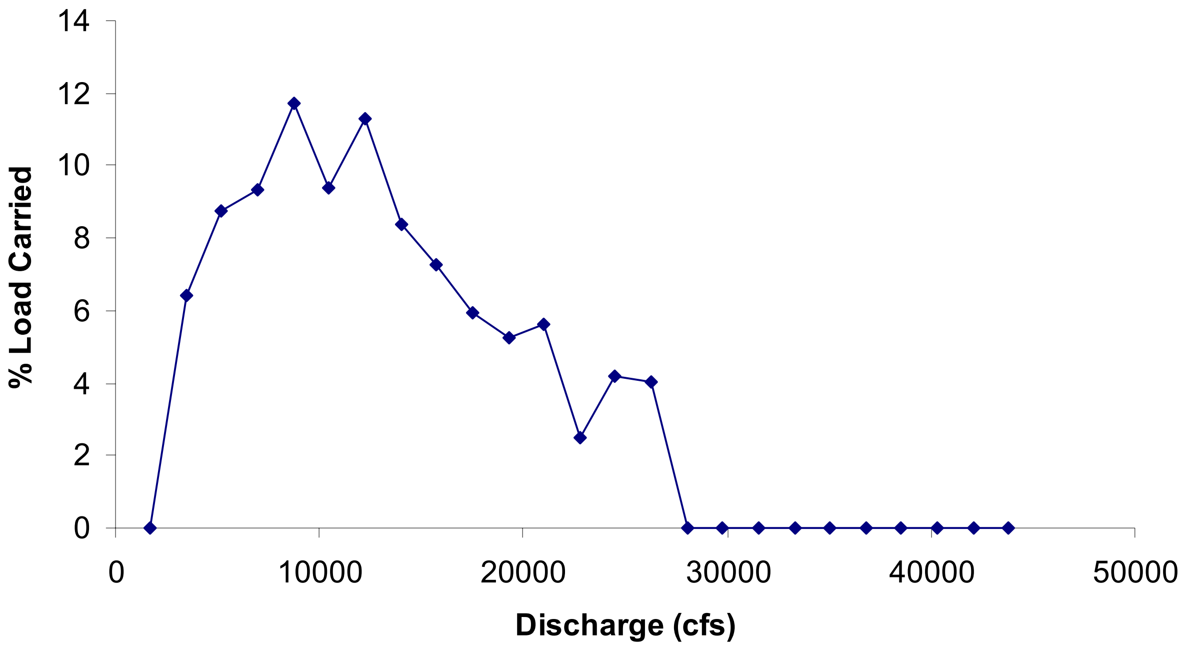
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	883	883
Min.	2820.00	130.6622
Max.	26500.00	48367.9402
Mean	7284.89	3304.0863
Median	6530.00	1781.3210
< (%)	22.2432	
> (%)	1.0502	
r^2	0.7347	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	1754.64
Discharge (cfs)	8729.88
Exceedance (%)	22.54
Cumulative load (%)	36.24

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 834.0	0	0	0.000000	0.0000
834.0 - 2588.64	4119	0	0.184866	0.0000
2588.64 - 4343.28	5578	224	0.250348	707.8793
4343.28 - 6097.92	3849	167	0.172748	1394.0085
6097.92 - 7852.56	2745	182	0.123199	2089.5363
7852.56 - 9607.2	1937	147	0.086935	3705.4754
9607.2 - 11361.84	1124	59	0.050447	5118.7557
11361.84 - 13116.48	762	46	0.034200	9087.2760
13116.48 - 14871.12	517	14	0.023204	9939.8631
14871.12 - 16625.76	432	9	0.019389	10307.7665
16625.76 - 18380.4	289	13	0.012971	12595.8701
18380.4 - 20135.04	230	6	0.010323	14008.9484
20135.04 - 21889.68	157	6	0.007046	21873.7166
21889.68 - 23644.32	154	1	0.006912	9838.0957
23644.32 - 25398.96	100	4	0.004488	25667.7750
25398.96 - 27153.6	78	5	0.003501	31528.5076
27153.6 - 28908.24	42	0	0.001885	0.0000
28908.24 - 30662.88	42	0	0.001885	0.0000
30662.88 - 32417.52	31	0	0.001391	0.0000
32417.52 - 34172.16	30	0	0.001346	0.0000
34172.16 - 35926.8	23	0	0.001032	0.0000
35926.8 - 37681.44	13	0	0.000583	0.0000
37681.44 - 39436.08	14	0	0.000628	0.0000
39436.08 - 41190.72	8	0	0.000359	0.0000
41190.72 - 42945.36	3	0	0.000135	0.0000
42945.36 - 44700.0	4	0	0.000180	0.0000
> 44700.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
1711	0.0000
3466	6.4377
5221	8.7480
6975	9.3516
8730	11.7022
10485	9.3805
12239	11.2897
13994	8.3785
15748	7.2601
17503	5.9350
19258	5.2532
21012	5.5991
22767	2.4702
24522	4.1849
26276	4.0095
28031	0.0000
29786	0.0000
31540	0.0000
33295	0.0000
35049	0.0000
36804	0.0000
38559	0.0000
40313	0.0000
42068	0.0000
43823	0.0000
0	0.0000

Rock River near Joslin: USGS # 05446500



Load histogram curve using the mean approach.

APPENDIX D

Effective Discharge Results for the Partially Qualified Stations that Use ISWS Suspended Sediment Data

Notation for tables in Appendix D

< (%) The percent of flow events less than the minimum discharge at which suspended sediment samples were collected

> (%) The percent of flow events greater than the maximum discharge at which suspended sediment samples were collected

Exceedance (%) The percent of flows exceeding the magnitude of the station's effective discharge

Cumulative load (%)[*] The percent of suspended sediment load carried by flows less than or equal to the effective discharge

% load carried[*] The percent of suspended sediment load carried by a discharge class.

Bin value (cfs) The average of the uppermost and lowest discharge values in a discharge class

Note:
[*] Values are based on the mean approach which assigns zero sediment load to discharge classes that having no sediment samples falling within them. Assuming or extrapolating sediment loads for these discharge classes would result in different percentage values.

Embarras River at Ste. Marie: USGS # 03345500

Discharge record	
	Mean daily discharge (cfs)
Records	32606
Min.	1.00
Max.	38200.00
Mean	1251.41
Median	459.00

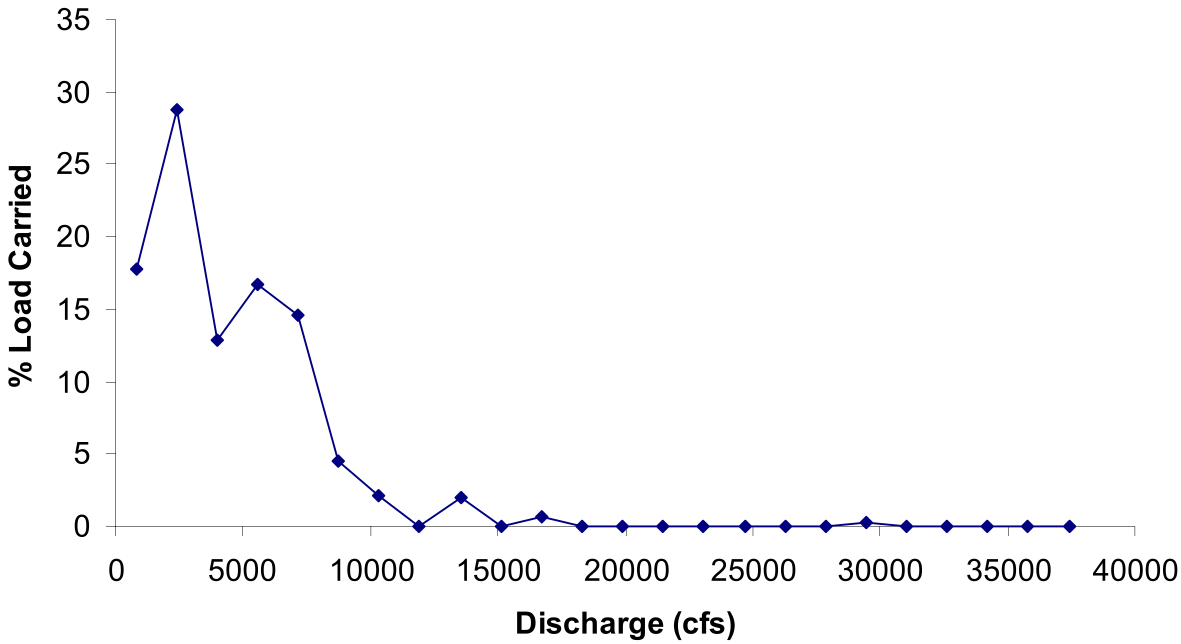
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	378	378
Min.	13.00	1.4347
Max.	30080.00	64734.6695
Mean	1611.07	3139.1655
Median	837.25	504.8772
< (%)	0.9507	
> (%)	0.0184	
r^2	0.8710	

Effective discharge results	
Mean approach	
Bins	24
Bin size (cfs)	1591.63
Discharge (cfs)	2388.44
Exceedance (%)	15.62
Cumulative load (%)	46.47

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 1.0	0	0	0.000000	0.0000
1.0 - 1592.625	25842	272	0.792554	496.3635
1592.625 - 3184.25	3345	54	0.102588	6207.1010
3184.25 - 4775.875	1371	21	0.042047	6756.4286
4775.875 - 6367.5	751	17	0.023033	16122.8286
6367.5 - 7959.125	552	8	0.016929	19070.2246
7959.125 - 9550.75	291	1	0.008925	11124.8905
9550.75 - 11142.375	152	1	0.004662	10007.1879
11142.375 - 12734.0	95	0	0.002914	0.0000
12734.0 - 14325.625	71	2	0.002178	19670.1581
14325.625 - 15917.25	33	0	0.001012	0.0000
15917.25 - 17508.875	20	1	0.000613	22668.2885
17508.875 - 19100.5	27	0	0.000828	0.0000
19100.5 - 20692.125	17	0	0.000521	0.0000
20692.125 - 22283.75	10	0	0.000307	0.0000
22283.75 - 23875.375	11	0	0.000337	0.0000
23875.375 - 25467.0	4	0	0.000123	0.0000
25467.0 - 27058.625	3	0	0.000092	0.0000
27058.625 - 28650.25	2	0	0.000061	0.0000
28650.25 - 30241.875	3	1	0.000092	64734.6695
30241.875 - 31833.5	1	0	0.000031	0.0000
31833.5 - 33425.125	1	0	0.000031	0.0000
33425.125 - 35016.75	1	0	0.000031	0.0000
35016.75 - 36608.375	2	0	0.000061	0.0000
36608.375 - 38200.0	1	0	0.000031	0.0000
> 38200.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
797	17.7437
2388	28.7213
3980	12.8137
5572	16.7494
7163	14.5618
8755	4.4782
10347	2.1041
11938	0.0000
13530	1.9319
15121	0.0000
16713	0.6271
18305	0.0000
19896	0.0000
21488	0.0000
23080	0.0000
24671	0.0000
26263	0.0000
27854	0.0000
29446	0.2686
31038	0.0000
32629	0.0000
34221	0.0000
35813	0.0000
37404	0.0000
0	0.0000

Embarras River at Ste. Marie: USGS # 03345500



Load histogram curve using mean approach.

Fox River at Algonquin: USGS # 05550000

Discharge record	
	Mean daily discharge (cfs)
Records	31047
Min.	12.00
Max.	6610.00
Mean	895.67
Median	600.00

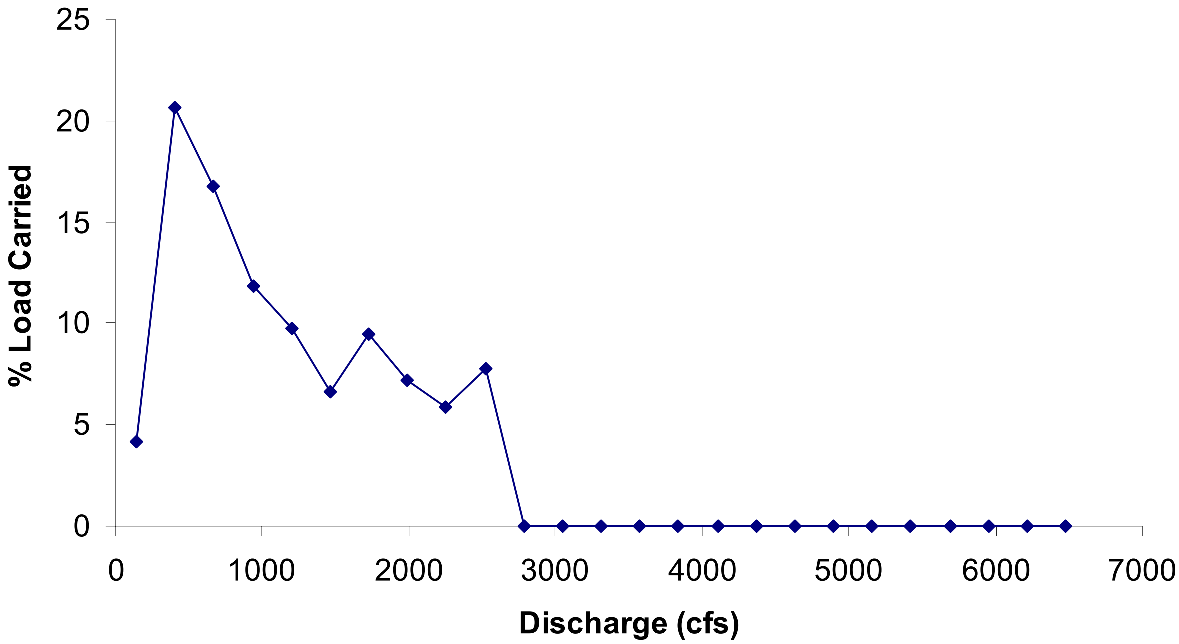
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	222	222
Min.	264.50	19.9728
Max.	2413.00	886.6994
Mean	859.86	174.1186
Median	716.15	126.3041
< (%)	18.5461	
> (%)	6.4934	
r^2	0.2799	

Effective discharge results	
Mean approach	
Bins	25
Bin size (cfs)	263.92
Discharge (cfs)	407.88
Exceedance (%)	67.16
Cumulative load (%)	24.83

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 12.0	0	0	0.000000	0.0000
12.0 - 275.92	6156	3	0.198280	30.8946
275.92 - 539.84	8078	61	0.260186	115.9528
539.84 - 803.76	4863	74	0.156633	156.5132
803.76 - 1067.68	3244	27	0.104487	165.2981
1067.68 - 1331.6	2177	23	0.070120	202.4172
1331.6 - 1595.52	1566	13	0.050440	192.6052
1595.52 - 1859.44	1227	6	0.039521	350.7388
1859.44 - 2123.36	991	5	0.031919	328.5697
2123.36 - 2387.28	658	8	0.021194	402.7811
2387.28 - 2651.2	534	2	0.017200	657.2565
2651.2 - 2915.12	378	0	0.012175	0.0000
2915.12 - 3179.04	297	0	0.009566	0.0000
3179.04 - 3442.96	204	0	0.006571	0.0000
3442.96 - 3706.88	166	0	0.005347	0.0000
3706.88 - 3970.8	126	0	0.004058	0.0000
3970.8 - 4234.72	72	0	0.002319	0.0000
4234.72 - 4498.64	80	0	0.002577	0.0000
4498.64 - 4762.56	81	0	0.002609	0.0000
4762.56 - 5026.48	50	0	0.001610	0.0000
5026.48 - 5290.4	27	0	0.000870	0.0000
5290.4 - 5554.32	25	0	0.000805	0.0000
5554.32 - 5818.24	16	0	0.000515	0.0000
5818.24 - 6082.16	16	0	0.000515	0.0000
6082.16 - 6346.08	8	0	0.000258	0.0000
6346.08 - 6610.0	7	0	0.000225	0.0000
> 6610.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
144	4.1906
408	20.6384
672	16.7705
936	11.8152
1200	9.7095
1464	6.6459
1727	9.4824
1991	7.1745
2255	5.8396
2519	7.7333
2783	0.0000
3047	0.0000
3311	0.0000
3575	0.0000
3839	0.0000
4103	0.0000
4367	0.0000
4631	0.0000
4895	0.0000
5158	0.0000
5422	0.0000
5686	0.0000
5950	0.0000
6214	0.0000
6478	0.0000
0	0.0000

Fox River at Algonquin: USGS # 05550000



Load histogram curve using mean approach.

Iroquois River at Iroquois: USGS # 05525000

Discharge record	
	Mean daily discharge (cfs)
Records	20454
Min.	5.50
Max.	10200.00
Mean.	587.87
Median	267.00

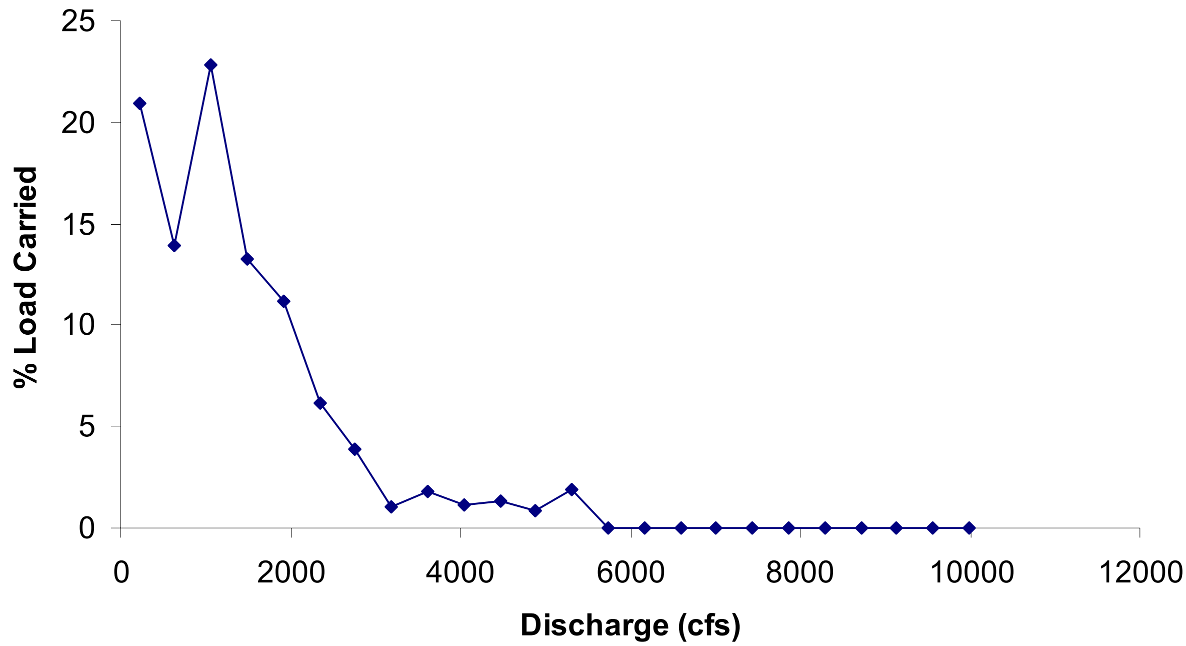
Sediment record		
	Discharge (cfs)	Load (tons/day)
Records	492	492
Min.	38.20	10.7140
Max.	34109.00	4634.1719
Mean	1031.31	360.8488
Median	483.15	152.3149
< (%)	12.5746	
> (%)	0.0000	
r^2	0.7609	

Effective discharge results	
Mean approach	
Bins	24
Bin size (cfs)	424.77
Discharge (cfs)	1067.43
Exceedance (%)	68.74
Cumulative load (%)	57.63

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 5.5	0	0	0.000000	0.0000
5.5 - 430.271	12790	226	0.625306	81.6628
430.271 - 855.042	3236	92	0.158209	214.7411
855.042 - 1279.812	1560	38	0.076269	729.5359
1279.812 - 1704.583	1015	32	0.049624	650.3241
1704.583 - 2129.354	692	44	0.033832	803.9104
2129.354 - 2554.125	410	18	0.020045	746.2646
2554.125 - 2978.896	222	9	0.010854	865.6799
2978.896 - 3403.667	153	6	0.007480	352.2113
3403.667 - 3828.437	108	6	0.005280	851.4964
3828.437 - 4253.208	90	4	0.004400	624.2788
4253.208 - 4677.979	67	8	0.003276	964.3363
4677.979 - 5102.75	41	4	0.002005	1026.3746
5102.75 - 5527.521	36	4	0.001760	2566.4363
5527.521 - 5952.292	16	0	0.000782	0.0000
5952.292 - 6377.063	9	0	0.000440	0.0000
6377.063 - 6801.833	4	0	0.000196	0.0000
6801.833 - 7226.604	1	0	0.000049	0.0000
7226.604 - 7651.375	0	0	0.000000	0.0000
7651.375 - 8076.146	0	0	0.000000	0.0000
8076.146 - 8500.917	1	0	0.000049	0.0000
8500.917 - 8925.688	0	0	0.000000	0.0000
8925.688 - 9350.458	1	0	0.000049	0.0000
9350.458 - 9775.229	1	0	0.000049	0.0000
9775.229 - 10200.0	1	0	0.000049	0.0000
> 10200.0	0	1	0.000000	0.0000
	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
218	20.9182
643	13.9173
1067	22.7930
1492	13.2198
1917	11.1415
2342	6.1278
2767	3.8489
3191	1.0793
3616	1.8418
4041	1.1253
4466	1.2940
4890	0.8428
5315	1.8504
5740	0.0000
6165	0.0000
6589	0.0000
7014	0.0000
7439	0.0000
7864	0.0000
8289	0.0000
8713	0.0000
9138	0.0000
9563	0.0000
9988	0.0000
0	0.0000
0	0.0000

Iroquois River at Iroquois: USGS # 05525000



Load histogram curve using mean approach.

Iroquois River near Chebanse: USGS # 05526000

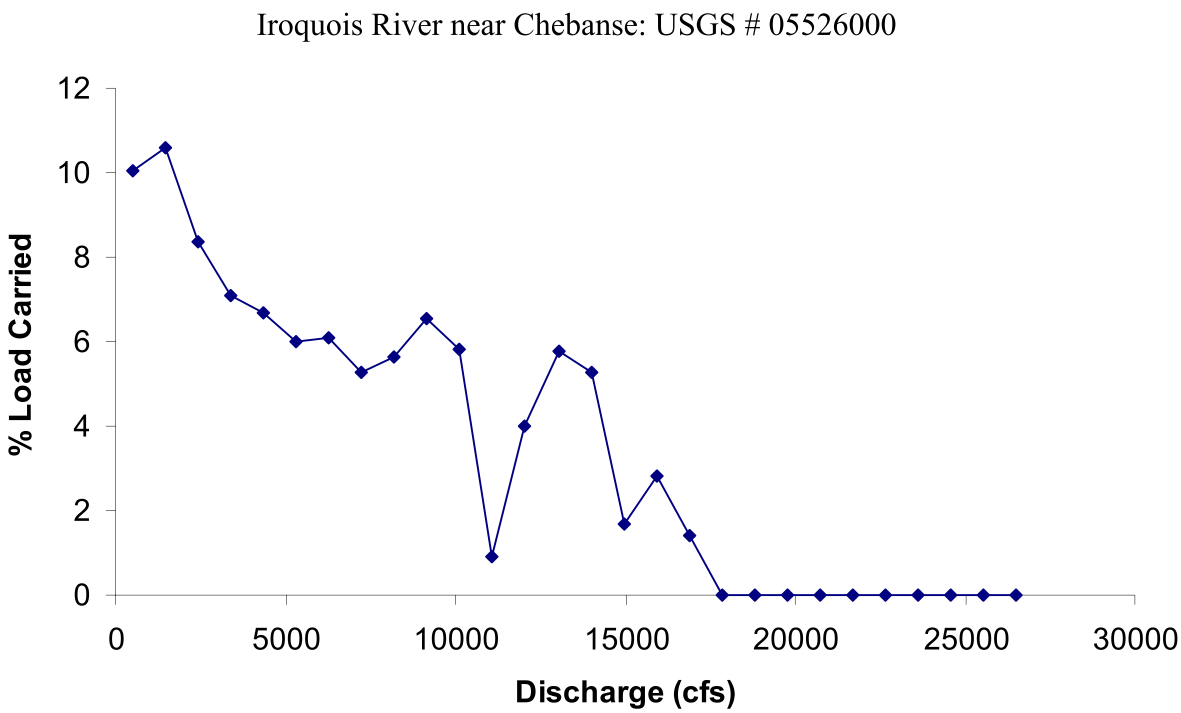
Discharge record	
	Mean daily discharge (cfs)
Records	27931
Min.	10.00
Max.	27000.00
Mean	1737.49
Median	735.00

Sediment record		
	Discharge (cfs)	Load (tons/day)
Records	357	357
Min.	41.40	6.1407
Max.	17350.00	40484.5997
Mean	3677.94	2303.4811
Median	1875.00	518.5227
< (%)	2.8570	
> (%)	0.3115	
r^2	0.8723	

Effective discharge results	
Mean approach	
Bins	28
Bin size (cfs)	963.93
Discharge (cfs)	1455.89
Exceedance (%)	34.56
Cumulative load (%)	20.62

Bin values (Mean Approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 9.999	0	0	0.000000	0.0000
9.999 - 973.928	15951	105	0.571086	138.5132
973.928 - 1937.856	4655	79	0.166661	498.9996
1937.856 - 2901.785	2221	37	0.079517	829.8282
2901.785 - 3865.713	1421	26	0.050875	1094.9862
3865.713 - 4829.642	961	14	0.034406	1523.2495
4829.642 - 5793.571	642	10	0.022985	2051.4166
5793.571 - 6757.499	518	13	0.018546	2593.1371
6757.499 - 7721.428	421	10	0.015073	2760.6926
7721.428 - 8685.356	272	12	0.009738	4547.7644
8685.356 - 9649.285	183	12	0.006552	7853.1794
9649.285 - 10613.214	150	11	0.005370	8533.1716
10613.214 - 11577.142	98	2	0.003509	2004.6738
11577.142 - 12541.071	104	4	0.003723	8406.0972
12541.071 - 13505.0	100	5	0.003580	12698.7701
13505.0 - 14468.928	58	6	0.002077	19984.3959
14468.928 - 15432.857	32	6	0.001146	11640.1060
15432.857 - 16396.785	34	1	0.001217	18295.2442
16396.785 - 17360.714	23	4	0.000823	13550.2980
17360.714 - 18324.643	23	0	0.000823	0.0000
18324.643 - 19288.571	17	0	0.000609	0.0000
19288.571 - 20252.5	11	0	0.000394	0.0000
20252.5 - 21216.428	15	0	0.000537	0.0000
21216.428 - 22180.357	6	0	0.000215	0.0000
22180.357 - 23144.286	7	0	0.000251	0.0000
23144.286 - 24108.214	0	0	0.000000	0.0000
24108.214 - 25072.143	6	0	0.000215	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load Carried
—	—
492	10.0531
1456	10.5691
2420	8.3860
3384	7.0798
4348	6.6606
5312	5.9925
6276	6.1119
7239	5.2884
8203	5.6284
9167	6.5391
10131	5.8240
11095	0.8939
12059	3.9778
13023	5.7781
13987	5.2740
14951	1.6948
15915	2.8303
16879	1.4181
17843	0.0000
18807	0.0000
19771	0.0000
20734	0.0000
21698	0.0000
22662	0.0000
23626	0.0000
24590	0.0000



Load histogram curve using mean approach.

Salt Creek near Rowell: USGS # 05578500

Discharge record	
	Mean daily discharge (cfs)
Records	21185
Min.	0.90
Max.	18200.00
Mean	256.99
Median	100.00

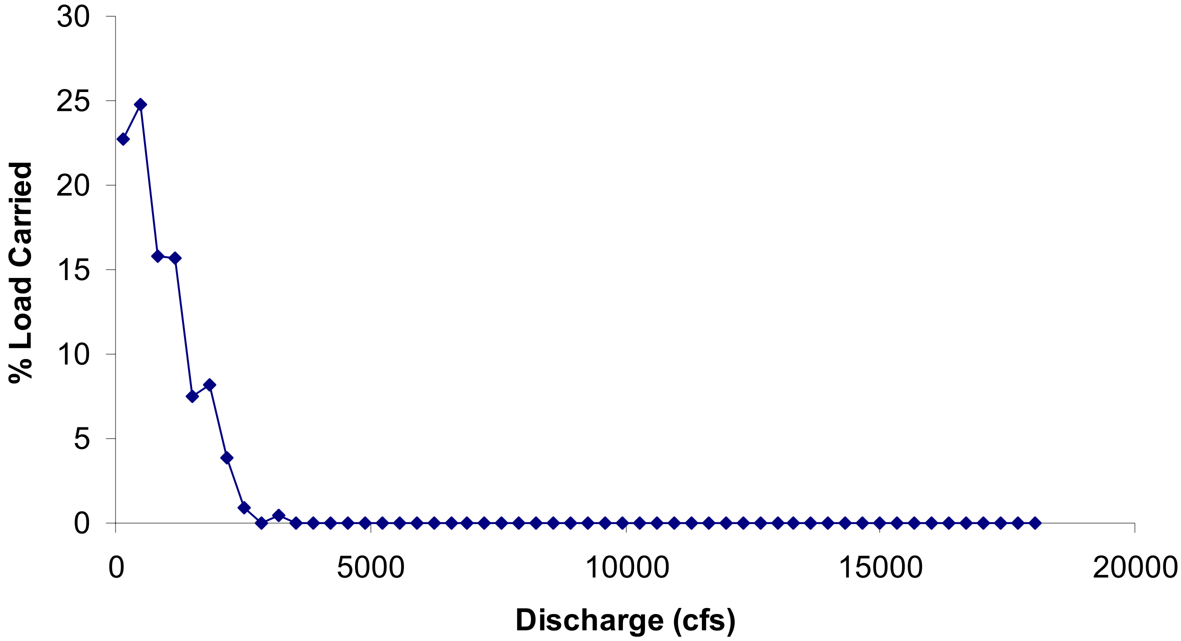
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	293	293
Min.	11.50	0.6200
Max.	3188.00	6524.3564
Mean	736.51	320.2074
Median	484.90	151.3966
< (%)	11.4893	
> (%)	0.4059	
r^2	0.8301	

Effective discharge results	
Mean approach	
Bins	54
Bin size (cfs)	337.02
Discharge (cfs)	506.43
Exceedance (%)	15.09
Cumulative load (%)	47.48

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.9	6	0	0.000283	0.0000
0.9 - 337.92	16728	100	0.789615	27.9898
337.92 - 674.941	2509	78	0.118433	202.7096
674.941 - 1011.961	849	37	0.040076	381.7771
1011.961 - 1348.981	412	19	0.019448	782.4764
1348.981 - 1686.002	234	20	0.011046	663.4528
1686.002 - 2023.022	189	20	0.008921	895.1664
2023.022 - 2360.043	93	15	0.004390	858.5085
2360.043 - 2697.063	35	3	0.001652	553.4567
2697.063 - 3034.083	34	0	0.001605	0.0000
3034.083 - 3371.104	20	1	0.000944	507.2552
3371.104 - 3708.124	14	0	0.000661	0.0000
3708.124 - 4045.144	15	0	0.000708	0.0000
4045.144 - 4382.165	6	0	0.000283	0.0000
4382.165 - 4719.185	11	0	0.000519	0.0000
4719.185 - 5056.206	2	0	0.000094	0.0000
5056.206 - 5393.226	2	0	0.000094	0.0000
5393.226 - 5730.246	4	0	0.000189	0.0000
5730.246 - 6067.267	4	0	0.000189	0.0000
6067.267 - 6404.287	1	0	0.000047	0.0000
6404.287 - 6741.307	3	0	0.000142	0.0000
6741.307 - 7078.328	4	0	0.000189	0.0000
7078.328 - 7415.348	1	0	0.000047	0.0000
7415.348 - 7752.369	2	0	0.000094	0.0000
7752.369 - 8089.389	1	0	0.000047	0.0000
8089.389 - 8426.409	1	0	0.000047	0.0000
8426.409 - 8763.43	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
169	22.7607
506	24.7239
843	15.7565
1180	15.6715
1517	7.5469
1855	8.2245
2192	3.8812
2529	0.9417
2866	0.0000
3203	0.4932
3540	0.0000
3877	0.0000
4214	0.0000
4551	0.0000
4888	0.0000
5225	0.0000
5562	0.0000
5899	0.0000
6236	0.0000
6573	0.0000
6910	0.0000
7247	0.0000
7584	0.0000
7921	0.0000
8258	0.0000
8595	0.0000

Salt Creek near Rowell: USGS # 05578500



Load histogram curve using mean approach.

Sangamon River at Riverton: USGS # 05576500

Discharge record	
	Mean daily discharge (cfs)
Records	22189
Min.	3.00
Max.	67700.00
Mean	1720.77
Median	656.00

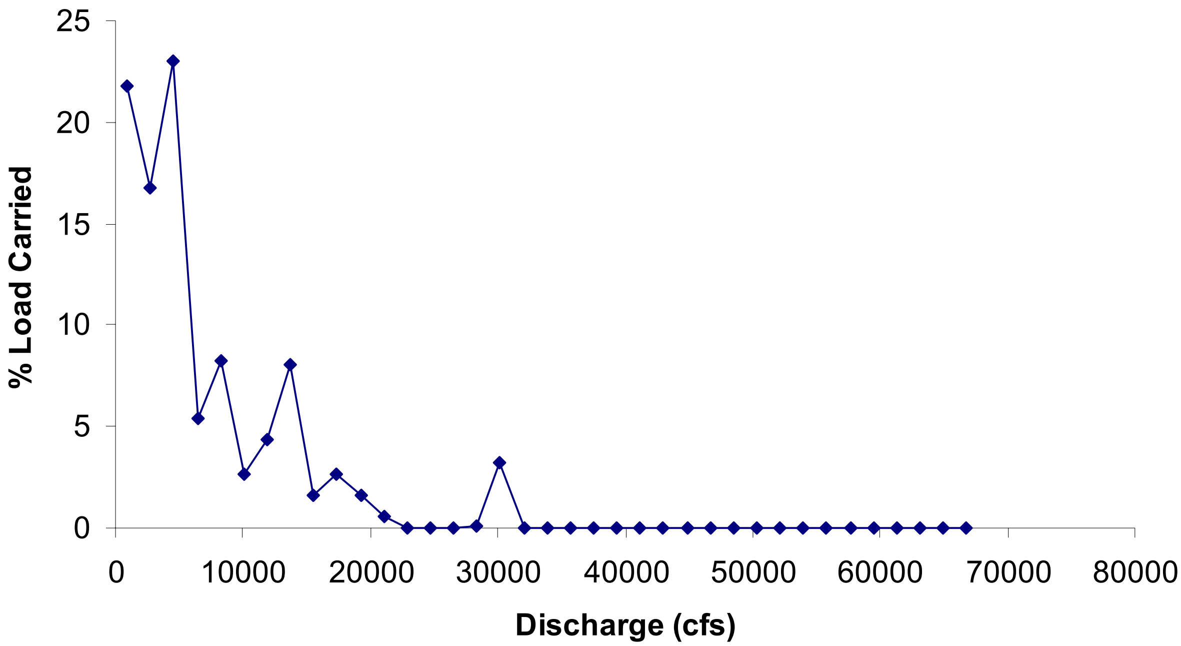
Sediment record		
	Discharge (cfs)	Load (tons/day)
Records	316	316
Min.	84.40	5.6903
Max.	29930.00	143675.5707
Mean	3947.62	3429.7167
Median	2673.00	1082.1487
< (%)	16.0620	
> (%)	0.0811	
r^2	0.7772	

Effective discharge results	
Mean approach	
Bins	37
Bin size (cfs)	1829.65
Discharge (cfs)	4577.12
Exceedance (%)	10.68
Cumulative load (%)	61.52

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean Load (tons/day)
≤ 3.0	0	0	0.000000	0.0000
3.0 - 1832.649	16440	105	0.740908	414.7374
1832.649 - 3662.297	2803	102	0.126324	1867.9274
3662.297 - 5491.946	1155	42	0.052053	6235.4041
5491.946 - 7321.595	655	26	0.029519	2595.2956
7321.595 - 9151.243	428	13	0.019289	6002.6760
9151.243 - 10980.892	247	7	0.011132	3352.0499
10980.892 - 12810.54	186	5	0.008383	7384.4832
12810.54 - 14640.189	92	3	0.004146	27408.5444
14640.189 - 16469.838	52	5	0.002344	9632.9789
16469.838 - 18299.486	37	2	0.001667	22729.0080
18299.486 - 20129.135	34	3	0.001532	14893.4961
20129.135 - 21958.784	15	1	0.000676	10950.0054
21958.784 - 23788.432	7	0	0.000315	0.0000
23788.432 - 25618.081	7	0	0.000315	0.0000
25618.081 - 27447.73	5	0	0.000225	0.0000
27447.73 - 29277.378	5	1	0.000225	6773.6421
29277.378 - 31107.027	7	1	0.000315	143675.5707
31107.027 - 32936.676	3	0	0.000135	0.0000
32936.676 - 34766.324	0	0	0.000000	0.0000
34766.324 - 36595.973	2	0	0.000090	0.0000
36595.973 - 38425.622	1	0	0.000045	0.0000
38425.622 - 40255.27	1	0	0.000045	0.0000
40255.27 - 42084.919	1	0	0.000045	0.0000
42084.919 - 43914.568	1	0	0.000045	0.0000
43914.568 - 45744.216	1	0	0.000045	0.0000
45744.216 - 47573.865	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
918	21.7835
2747	16.7277
4577	23.0091
6407	5.4310
8236	8.2081
10066	2.6452
11896	4.3882
13725	8.0561
15555	1.6004
17385	2.6868
19214	1.6178
21044	0.5248
22874	0.0000
24703	0.0000
26533	0.0000
28363	0.1082
30192	3.2132
32022	0.0000
33852	0.0000
35681	0.0000
37511	0.0000
39340	0.0000
41170	0.0000
43000	0.0000
44829	0.0000
46659	0.0000

Sangamon River at Riverton: USGS # 05576500



Load histogram curve using mean approach.

South Fork Sangamon River below Rochester: USGS # 05576022

Discharge record	Mean daily discharge (cfs)
Records	18628
Min.	0.00
Max.	19000.00
Mean	585.42
Median	160.00

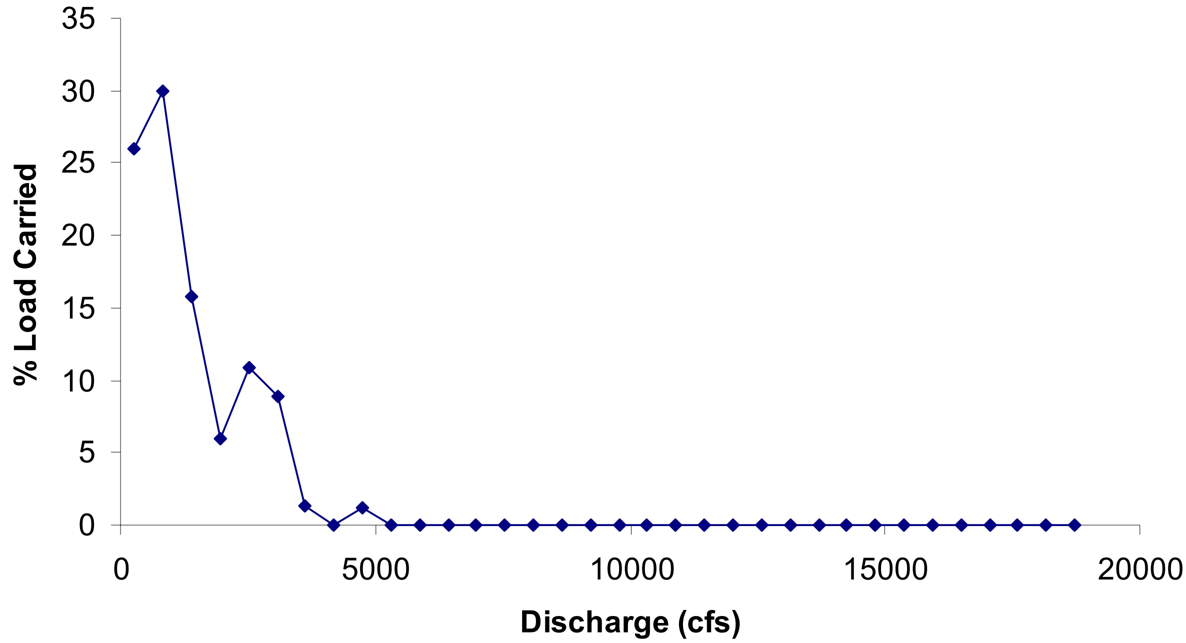
Suspended sediment record	Discharge (cfs)	Load (tons/day)
Records	251	251
Min.	0.70	0.0642
Max.	5028.00	10450.7275
Mean	882.66	951.9778
Median	567.20	335.8731
< (%)	2.5016	
> (5)	1.4977	
r^2	0.9114	

Effective discharge results	Mean approach
Bins	34
Bin size (cfs)	558.82
Discharge (cfs)	838.24
Exceedance (%)	19.93
Cumulative load (%)	55.99

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 0.0	242	0	0.012991	0.0000
0.0 - 558.824	13633	119	0.731855	167.6228
558.824 - 1117.647	2084	54	0.111875	1267.1722
1117.647 - 1676.471	927	40	0.049764	1494.3763
1676.471 - 2235.294	519	13	0.027861	1015.7243
2235.294 - 2794.118	323	14	0.017339	2962.0080
2794.118 - 3352.941	203	9	0.010898	3821.5479
3352.941 - 3911.765	166	1	0.008911	713.5208
3911.765 - 4470.588	145	0	0.007784	0.0000
4470.588 - 5029.412	107	1	0.005744	1016.9808
5029.412 - 5588.235	68	0	0.003650	0.0000
5588.235 - 6147.059	55	0	0.002953	0.0000
6147.059 - 6705.882	39	0	0.002094	0.0000
6705.882 - 7264.706	20	0	0.001074	0.0000
7264.706 - 7823.529	27	0	0.001449	0.0000
7823.529 - 8382.353	17	0	0.000913	0.0000
8382.353 - 8941.177	17	0	0.000913	0.0000
8941.177 - 9500.0	9	0	0.000483	0.0000
9500.0 - 10058.824	7	0	0.000376	0.0000
10058.824 - 10617.647	7	0	0.000376	0.0000
10617.647 - 11176.471	2	0	0.000107	0.0000
11176.471 - 11735.294	2	0	0.000107	0.0000
11735.294 - 12294.118	0	0	0.000000	0.0000
12294.118 - 12852.941	0	0	0.000000	0.0000
12852.941 - 13411.765	2	0	0.000107	0.0000
13411.765 - 13970.588	2	0	0.000107	0.0000
13970.588 - 14529.412	1	0	0.000054	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
279	25.9735
838	30.0151
1397	15.7451
1956	5.9917
2515	10.8741
3074	8.8174
3632	1.3462
4191	0.0000
4750	1.2368
5309	0.0000
5868	0.0000
6426	0.0000
6985	0.0000
7544	0.0000
8103	0.0000
8662	0.0000
9221	0.0000
9779	0.0000
10338	0.0000
10897	0.0000
11456	0.0000
12015	0.0000
12574	0.0000
13132	0.0000
13691	0.0000
14250	0.0000

South Fork Sangamon River below Rochester: USGS # 05576022



Load histogram curve using mean approach.

Spoon River at London Mills: USGS # 05569500

Discharge record	Mean daily discharge (cfs)
Records	21185
Min.	3.00
Max.	35100.00
Mean	750.81
Median	330.00

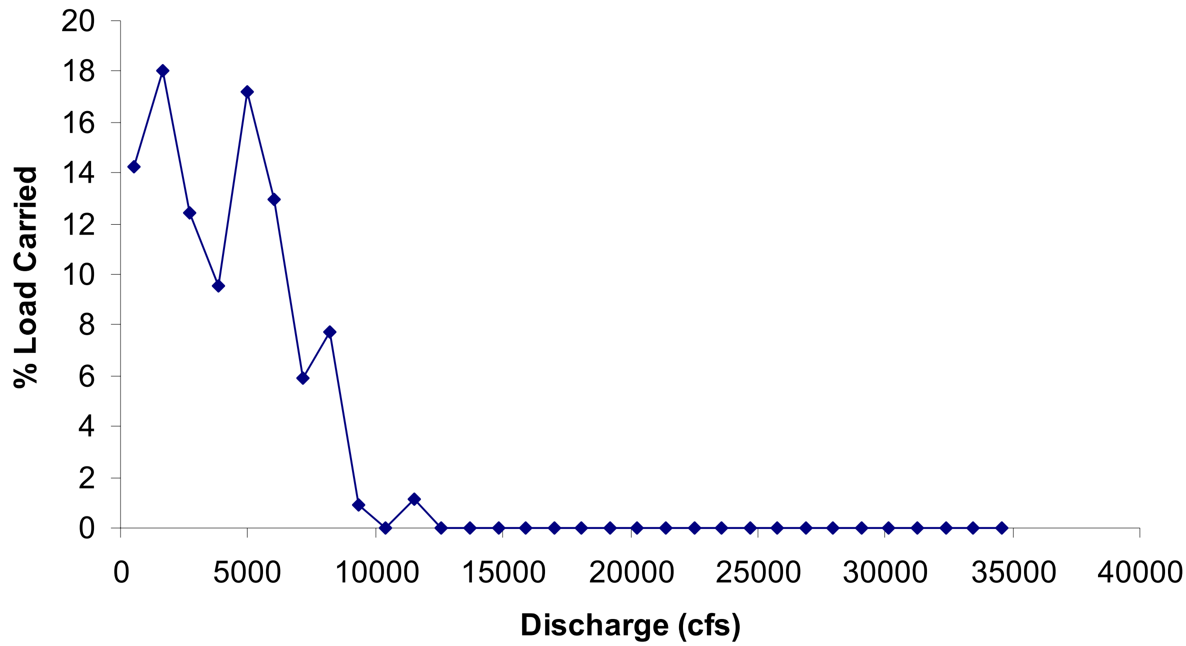
Sediment record	Discharge (cfs)	Load (tons/day)
Records	762	762
Min.	25.00	5.0161
Max.	23470.00	196847.4034
Mean	1287.36	4640.4109
Median	703.55	349.3293
< (%)	3.6535	
> (%)	0.0236	
r^2	0.8474	

Effective Discharge Results	Mean approach
Bins	32
Bin size (cfs)	1096.78
Discharge (cfs)	1648.17
Exceedance (%)	2.33
Cumulative load (%)	32.23

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 3.0	0	0	0.000000	0.0000
3.0 - 1099.781	17492	487	0.825679	364.5704
1099.781 - 2196.562	2223	142	0.104933	3630.4928
2196.562 - 3293.344	590	70	0.027850	9454.6616
3293.344 - 4390.125	298	19	0.014067	14340.5936
4390.125 - 5486.906	177	21	0.008355	43490.5898
5486.906 - 6583.687	132	8	0.006231	43948.3992
6583.687 - 7680.469	99	7	0.004673	26733.4616
7680.469 - 8777.25	65	3	0.003068	53335.1916
8777.25 - 9874.031	31	2	0.001463	12845.2981
9874.031 - 10970.812	22	0	0.001038	0.0000
10970.812 - 12067.594	14	2	0.000661	37026.1774
12067.594 - 13164.375	5	0	0.000236	0.0000
13164.375 - 14261.156	13	0	0.000614	0.0000
14261.156 - 15357.937	5	0	0.000236	0.0000
15357.937 - 16454.719	2	0	0.000094	0.0000
16454.719 - 17551.5	4	0	0.000189	0.0000
17551.5 - 18648.281	1	0	0.000047	0.0000
18648.281 - 19745.063	3	0	0.000142	0.0000
19745.063 - 20841.844	2	0	0.000094	0.0000
20841.844 - 21938.625	2	0	0.000094	0.0000
21938.625 - 23035.406	0	0	0.000000	0.0000
23035.406 - 24132.188	0	1	0.000000	196847.4034
24132.188 - 25228.969	1	0	0.000047	0.0000
25228.969 - 26325.75	0	0	0.000000	0.0000
26325.75 - 27422.531	2	0	0.000094	0.0000
27422.531 - 28519.313	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
551	14.2255
1648	18.0033
2745	12.4436
3842	9.5330
4939	17.1718
6035	12.9409
7132	5.9039
8229	7.7335
9326	0.8883
10422	0.0000
11519	1.1563
12616	0.0000
13713	0.0000
14810	0.0000
15906	0.0000
17003	0.0000
18100	0.0000
19197	0.0000
20293	0.0000
21390	0.0000
22487	0.0000
23584	0.0000
24681	0.0000
25777	0.0000
26874	0.0000
27971	0.0000

Spoon River at London Mills: USGS # 05569500



Load histogram curve using mean approach.

Vermilion River near Lenore: USGS # 05555300

Discharge record	
	Mean daily discharge (cfs)
Records	10739
Min.	2.60
Max.	30000.00
Mean	1056.04
Median	390.00

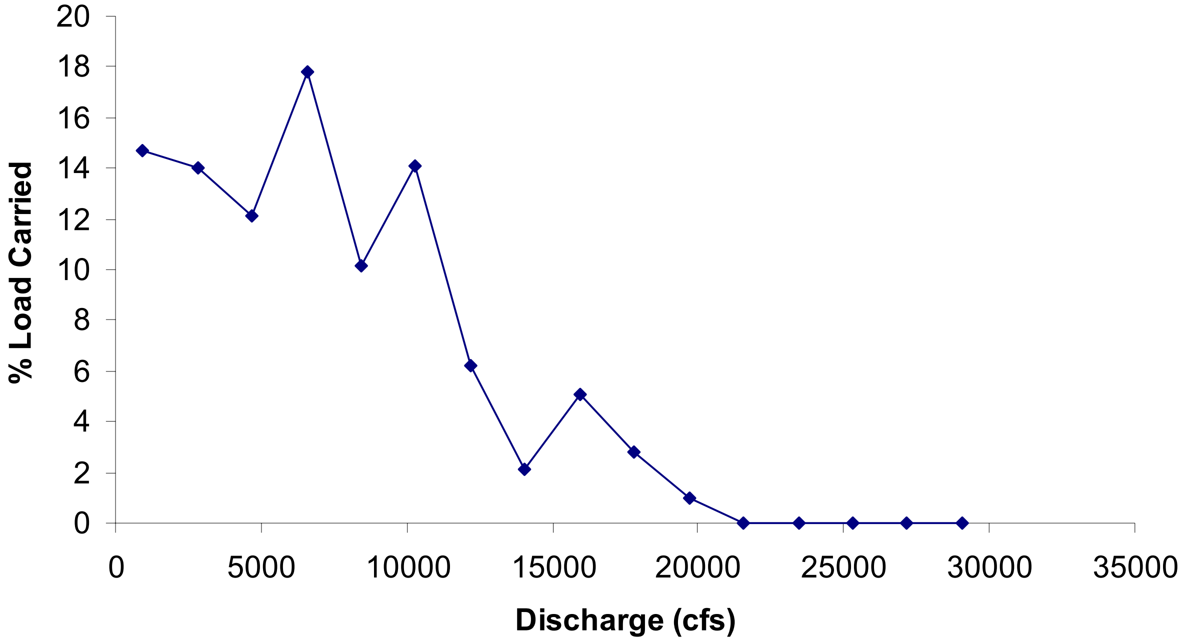
Suspended sediment record		
	Discharge (cfs)	Load (tons/day)
Records	710	710
Min.	0.20	0.0416
Max.	19040.00	85220.2954
Mean	1454.65	1353.8426
Median	505.50	82.5261
< (%)	0.0000	
> (%)	0.0466	
r^2	0.8724	

Effective discharge results	
Mean approach	
Bins	16
Bin size (cfs)	1874.84
Discharge (cfs)	6564.53
Exceedance (%)	2.62
Cumulative load (%)	58.55

Bin values (Mean approach)				
Discharge class	Flow records	Sediment records	Frequency of occurrence	Mean load (tons/day)
≤ 2.6	0	1	0.000000	0.0000
2.6 - 1877.437	9115	556	0.848775	144.0274
1877.437 - 3752.275	953	94	0.088742	1312.9091
3752.275 - 5627.112	318	20	0.029612	3398.3340
5627.112 - 7501.95	145	6	0.013502	10972.5786
7501.95 - 9376.787	67	11	0.006239	13575.4972
9376.787 - 11251.625	54	6	0.005028	23333.1542
11251.625 - 13126.462	29	6	0.002700	19174.5717
13126.462 - 15001.3	26	2	0.002421	7373.3487
15001.3 - 16876.138	14	3	0.001304	32573.6746
16876.138 - 18750.975	11	4	0.001024	22526.4302
18750.975 - 20625.813	5	1	0.000466	16983.0795
20625.813 - 22500.65	0	0	0.000000	0.0000
22500.65 - 24375.488	0	0	0.000000	0.0000
24375.488 - 26250.325	1	0	0.000093	0.0000
26250.325 - 28125.163	0	0	0.000000	0.0000
28125.163 - 30000.0	1	0	0.000093	0.0000
> 30000.0	0	0	0.000000	0.0000

Effective discharge histogram (Mean approach)	
Bin value (cfs)	% Load carried
—	—
940	14.6818
2815	13.9928
4690	12.0857
6565	17.7932
8439	10.1720
10314	14.0911
12189	6.2187
14064	2.1440
15939	5.1000
17814	2.7712
19688	0.9496
21563	0.0000
23438	0.0000
25313	0.0000
27188	0.0000
29063	0.0000
0	0.0000

Vermilion River near Lenore: USGS # 05555300



Load histogram curve using mean approach.

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