Contract Report 2000-03

Kankakee River Basin in Illinois: Hydraulics, Hydrology, River Geometry, and Sand Bars

Interim Report

by

Principal Investigators:

Nani G. Bhowmik and Misganaw Demissie

Prepared for the
Illinois Department of Natural Resources

February 2000

Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

Kankakee River Basin in Illinois: Hydraulics, Hydrology, River Geometry, and Sand Bars

Interim Report

Contract Report
Prepared by:

Illinois State Water Survey
Watershed Science Section
2204 Griffith Drive
Champaign, IL 61820-7495

Principal Investigators:

Nani G. Bhowmik, P.E., Ph.D.
Principal Scientist
Watershed Science Section

and

Misganaw Demissie, P.E., Ph.D.
Principal Scientist
Watershed Science Section

Contributors:

William C. Bogner, Professional Scientist
Erin Hessler, Assistant Supportive Scientist
H. Vernon Knapp, Senior Professional Scientist
Paminder S. Parmar, Assistant Professional Scientist
James Slowikowski, Assistant Professional Scientist
David T. Soong, Professional Scientist

Report Prepared for the:
Illinois Department of Natural Resources

Table of Contents

Page

List of Figures

List of Figures (Continued)

Page

List of Tables

Page

Kankakee River Basin in Illinois: Hydraulics, Hydrology, River Geometry, and Sand Bars

Nani G. Bhowmik, P.E., Ph.D.
and Misganaw Demissie, P.E., Ph.D.
Principal Scientists
Watershed Science Section

Abstract

This interim report summarizes the work completed within the first nine months of the project. This report summarizes all of the existing streamflow records for Illinois and for two stations from Indiana, lists the available literature, and describes the field trip to the site. Analyses of the bed and bank material samples collected during the field trip also are included. Maps of the bank lines from the Route 30 Bridge in Indiana to the confluence of the Kankakee River with the Des Plaines River have been completed and will be available with the final report.

Bank conditions of the entire main stem of the Kankakee River from the Route 30 Bridge in Indiana to its confluence with the Des Plaines River are also summarized. This includes general bank conditions, shoreline stability, erosion sites and severity, pumping stations, log and tree jams, and other features.

Additional work on the surveying of the river and sand bar geometries is now being done. A final report will be prepared that summarizes all of the existing and newly collected data on hydraulics, hydrology, sediment transport, bed and bank material distributions, and sedimentation patterns.

Keywords: Hydraulics, Hydrology, Kankakee River, Illinois, Indiana, Bed materials, Bank erosion.

Kankakee River Basin in Illinois: Hydraulics, Hydrology, River Geometry, and Sand Bars

Interim Report

Background

The Kankakee River flows westward from Indiana into Illinois. The headwaters are near South Bend, Indiana, and the mouth is at the confluence of the Kankakee with the Des Plaines River where those two rivers become the Illinois River.

Of the 5,165 square miles in the Kankakee River drainage basin, 2,169 miles are in Illinois and 2,996 miles are in Indiana. The river has a total length of about 150 miles, with 59 miles in Illinois. Figure 1 shows the drainage basin of the Kankakee River.

Almost the entire main channel of the Kankakee River in Indiana was channelized by drainage improvement work beginning in the late nineteenth century and essentially completed by 1918. Today, that channel is essentially human-made, extending straight for many miles between small bends. All of the natural meanders were bypassed, though many remain today as oxbow lakes or marsh areas.

In Illinois, a small side channel dam exists at Momence, a larger dam at Kankakee, and an overflow dam at Wilmington, but most of the river remains a naturally meandering stream. A major tributary to the Kankakee River in Illinois is the Iroquois River, which joins the Kankakee River just below Aroma Park. Most of the Iroquois drainage basin also is in Indiana. Singleton Ditch, a channelized tributary in Indiana, joins the Kankakee River just above Illiana Heights in Illinois.

Before channelization, much of the drainage area of the river in Indiana was wetland - swamps and marshes - called the "Kankakee/Grand Marsh." The Grand Marsh encompassed approximately 400,000 acres and ranged from 3 to 5 miles in width with a water depth of 1 to 4 feet for eight or nine months of the year (Bhowmik et al., 1980). The marshplain was only about 85 miles long, but the river course was about 250 miles long with an average slope of 5 to 6 inches per mile. The nature of the marsh caused the Kankakee River to alter its course continuously, resulting in the formation of a variety of meanders, oxbow lakes, sloughs, and bayous.

In Illinois, especially in Kankakee County, the river continues to be a scenic, cultural, and recreational resource. The reach between the state line and Momence is a naturally meandering stream with a sandy bottom, traversing an area of timber and relatively undisturbed wetlands, commonly called the "Momence Wetlands."

The reach between the cities of Momence and Aroma Park is also a natural stream, traversing an area of alternating bedrock and sandy bottom. Between Aroma Park and the city of Kankakee, a deepwater area called Six-Mile Pool (actually 4.7 miles long) was formed by the construction of the Kankakee dam. The deeper water has long been used for recreational

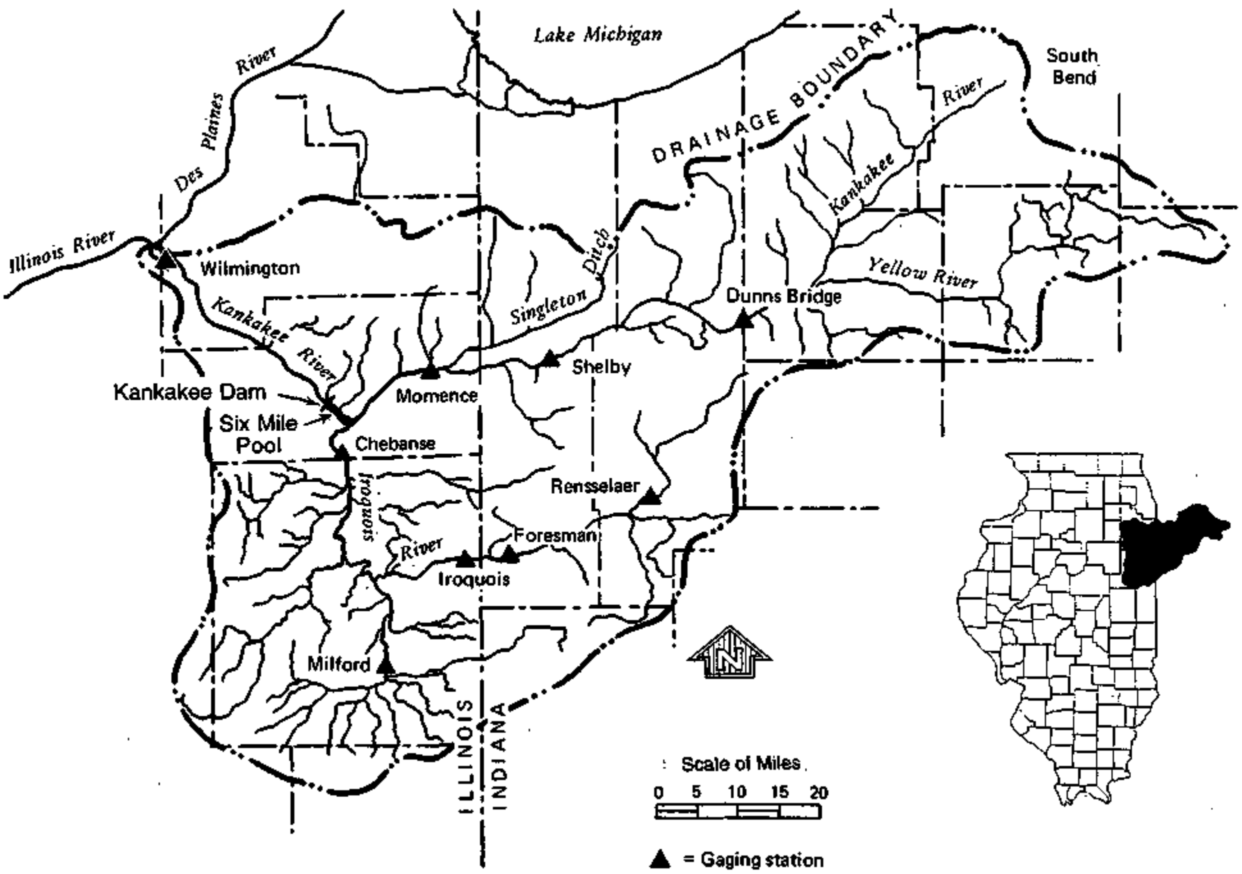


Figure 1. Drainage basin of the Kankakee River in Illinois and Indiana

boating, and fine homes have been built adjacent to the river. The entire river in Kankakee County is noted for high quality water, excellent sport fishing, and scenic beauty.

Although river basin management practices differ significantly between the two states, some important geological differences occur near the state line. The wetlands, which are a result of continental glaciation, occur mainly on the Indiana side of the state line except for the small area east of Momence. The areas of bedrock outcrops, where the glacial deposits are thin or absent, occur mainly on the Illinois side of the line. These bedrock outcrops in Kankakee County have long been an important factor in the hydraulics of the river.

The present project was initiated in response to a letter from Mr. J.R. Black of the "Kankakee River Basin Partnership," which has received three grants from the Conservation 2000 program of the Illinois Department of Natural Resources (IDNR). This project is being conducted to address those three grants. In order to formulate a comprehensive work plan, all three projects were combined into two projects, and an overall plan was developed.

Scope of Work

I. Project No. 007-98: Compilation of Hydrologic Data for the Kankakee River Basin

The tasks to be completed for this specific project will include a compilation of the hydraulic and hydrologic data for the Kankakee basin collected in the past. These data will be converted into a format suitable for mathematical modeling, such as UNET.

Hydraulic and hydrologic studies including field data collection have been conducted on the Kankakee River in Illinois since the late 1970s. Several of these studies were completed by the Illinois State Water Survey. Other studies were conducted by various state, federal, and local entities. This extensive scientific data set on the hydraulics, hydrology, and sediment transport characteristics of the Kankakee and Iroquois Rivers will be extremely useful in any mathematical modeling work. Data compilation has been initiated, and upon completion these data will be made available to all concerned entities, including local, state, and federal agencies.

II. Project No. 008-98: Kankakee River Sand Bar Survey

During a 1978-1980 research project conducted by the present Project Director and his associates, several significant sand bars were observed and surveyed, and related maps were developed.

For the present project the following tasks will be conducted:

- *A boat trip from LaPorte (Route 30), Indiana, to the mouth of the Kankakee River near Wilmington, Illinois.* During this boat trip, sand bars above the water line will be identified, positions will be located by a global positioning system (GPS), selected bed material samples will be collected, and shorelines will be mapped from the boat and recorded on 7.5-minute topographic maps.

- *Major sand bars in Illinois will be surveyed*. Geographic Information System (GIS) maps will be developed, and the volume of each sand bar will be calculated.

- *All maps developed will be provided to the sponsors*.

- *Bed material samples will be analyzed for particle size distributions*. Plots of these distributions will be included with the final report.

The following discussion summarizes progress for the first nine months.

Acknowledgments

The following Water Survey staff participated in the field and office work: David Soong, K. Erin Hessler, James Slowikowski, Paminder Parmar, William C. Bogner, and Amy Mitchell. J.R. Black and the Kankakee River Partnership Council were extremely helpful in conducting this investigation. Jim Mick of the Department of Natural Resources was instrumental in the initiation of this project. Funding for this project was provided by the C-2000 Program of the Illinois Department of Natural Resources. Linda Hascall prepared the graphics, and Eva Kingston edited the report. Cynthia Bauer, Taryn Kelly, and Pamela Lovett typed the report.

Literature Survey

A literature survey was completed to identify existing publications about the Kankakee River (Appendix A). This literature survey was completed to summarize all the known work completed so far on the Kankakee River. The literature survey will enable future managers, decision makers, researchers, and others to review the relevant literature on the Kankakee River. Some of the important early work on the Kankakee River were completed by Bhowmik et al. (1980) and summarized by Ivens et al. (1981).

Streamflows

Knapp (1998) analyzed streamflows for the Kankakee River for the gaging stations in Illinois. The following materials are essentially those contained in that contribution by Knapp and supplemented by some additional analyses for the present project.

Surface water resources are an essential component of any ecosystem because they provide different types of habitats for aquatic and terrestrial biota. In addition to their natural functions, they are sources of water supply for domestic, industrial, and agricultural use. Changes in natural and human factors, such as climate, land and water use, and hydrologic modifications, can greatly affect the quantity, quality, and distribution (both in space and time) of surface waters in a river basin.

There are at least 2,600 miles of rivers and streams in the Kankakee River basin. Streamgaging stations monitor the flow of these rivers and streams over time, providing information on the amount and distribution of river flow moving past the station. Since it is not feasible to monitor all streams in a basin, gaging stations are established at selected locations, and the data collected are transferred to other parts of the watershed by applying hydrologic principles. Streamflow records are used to evaluate the impacts of changes in climate, land use, and other factors on the water resources of a river basin. A more complete analysis of streamflows in the basin and the factors influencing these flows appears in Knapp (1992).

Streamgaging Records

Eight gaging stations in the Illinois portion of the Kankakee River basin, operated by the U.S. Geological Survey (USGS), have five or more years of continuous daily flow data. Table 1 lists these stations, and Figure 2 shows their locations. The gage on the Kankakee River at Custer Park was relocated to the site near Wilmington in 1933. Although the flow records at these two gaging sites are not totally equivalent, analysis has shown them to be similar, and the two records are normally combined to form an 82-year consecutive record from 1914 to 1996. Some analyses were also performed for low, average, and peak flows for two additional stations from Indiana: Shelby on the main stem of the Kankakee River and Foresman on the Iroquois River.

Human Influences on Streamflows in the Kankakee River Basin

Three activities have significantly changed the variability of streamflow in the Kankakee River over the last 100 years: 1) draining of the Kankakee Marsh, 2) channelization of the Kankakee River, and 3) use of river water and ground water, primarily for irrigation, but also for public water supply. There is little gaging information from which to estimate the streamflow regime prior to the drainage and channelization. The USGS operated three streamgages in the Kankakee River watershed for several months in 1905 and 1906. However, the amount and quality of data collected during this period were insufficient to evaluate the potential impact of channelization and drainage on streamflows.

Table 1. USGS Streamgaging Stations with Continuous Discharge Records

USGS ID	*Station name*	*Drainage area (mi^2)*	*Record length (years)*	*Period of record*
05520000	Singleton Ditch near Illinois	220.0	34	1944-78
05520500	Kankakee River at Momence	2294.0	82	1914-96
05525000	Iroquois River at Iroquois	686.0	52	1944-96
05525500	Sugar Creek at Milford	446.0	48	1948-96
05526000	Iroquois River near Chebanse	2091.0	73	1923-96
05526500	Terry Creek near Custer Park	12.1	26	1949-75
05527000	Kankakee River at Custer Park	4810.0	20	1914-34
05527500	Kankakee River near Wilmington	5150.0	46	1933-96

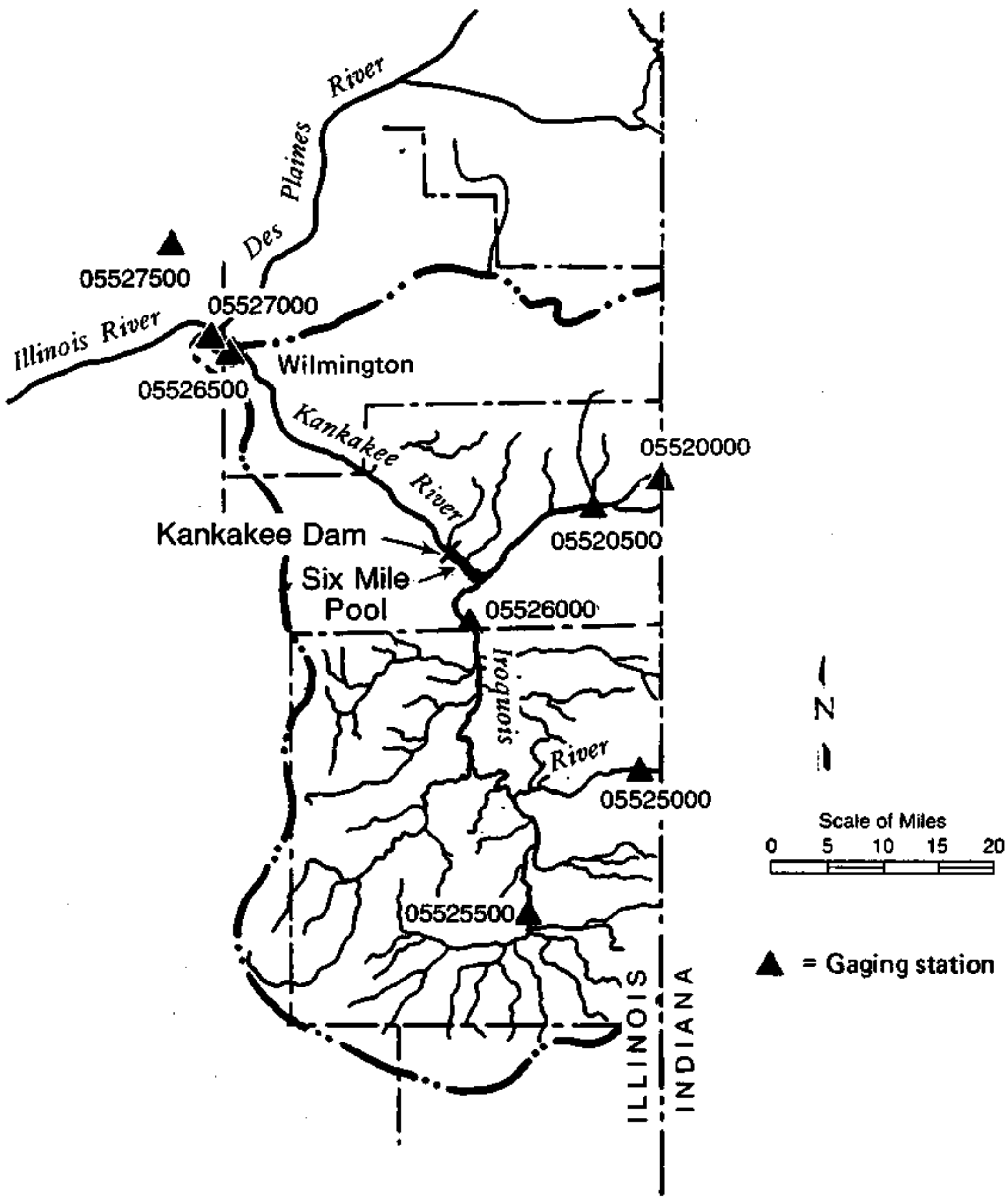


Figure 2. Streamgaging stations in the Kankakee River basin

Leverett (1896) reported that discharge measurements were made on the Kankakee River at Wilmington during a 12-year period from 1871-1883. The data collected during this period were lost, but Leverett reported that the discharges during extreme high water and extreme low water conditions were 30,000-35,000 and 420 cfs, respectively. Although this early data can have a high degree of error, two general conclusions can be drawn: 1) high flows have increased since the late 1800s, and 2) low flows have not changed substantially. Further discussion of the impacts of drainage and channelization is provided in IDNR (1976).

Public and Industrial Water Supplies on Streamflows

The net impact of water use (withdrawals and return flows) to the Kankakee and Iroquois River is to increase the flows, but only by a relatively small amount. For the Kankakee River, in particular, the natural streamflow is considerably larger than the rates of water withdrawals or return flows, as discussed below.

The primary user of surface water in the Illinois portion of the Kankakee River basin is Consumers Illinois Water Company, which supplies the cities of Kankakee, Bradley, and Bourbonnais. This water supply withdraws an average of 11.6 million gallons per day (mgd), or 18 cubic feet per second (cfs) from the Kankakee River. Summer withdrawals are typically 10-15 percent higher than winter withdrawals (LaTour, 1991). Water is also withdrawn from the Kankakee River near Custer Park for use in cooling Commonwealth Edison's Braidwood power plant. This withdrawal is discontinued during severe low flows to avoid an adverse impact on aquatic habitat.

There are 17 major effluent return flows to streams in the Illinois portion of the Kankakee watershed, with 11 of these being from public wastewater treatment facilities. The average amount of the return flows is 35 cfs, compared to an average flow in the river of more than 2,000 cfs. During extreme drought the return flows can be reduced to 20 cfs, compared to river flows of 400-500 cfs.

Irrigation Withdrawals and Returns

Most irrigation withdrawals in the Illinois portion of the Kankakee River basin are from the dolomite bedrock (Cravens et al, 1990). Portions of the Kankakee River between Six Mile Pool and the state line are hydraulically connected to the dolomite bedrock with a stretch of the river receiving discharge from the aquifer, and another stretch recharging the aquifer (Cravens et al., 1990). As estimated by Singh et al. (1988) and Knapp (1992), there is not a significant change in the river's low flow along these reaches. However, a large portion of the irrigation water use in the Indiana portion of the basin is from the Kankakee River and from shallow sand-and-gravel aquifers, which are hydraulically connected to the stream. The total impact of all these withdrawals on streamflow varies depending on the irrigation rate, but given the high irrigation rates during the drought of summer 1988, the effective withdrawal rate from the river was estimated to be 195 cfs (Knapp, 1992).

A portion of the irrigation withdrawals are returned to the stream in three ways: 1) direct return flows when water diverted from the Kankakee River is not applied to irrigated fields,

2) induced runoff to the streams (via ground-water seepage) whenever the irrigation application rate exceeds the potential evapotranspiration rate, and 3) increased baseflow in the stream because of the raised water table and increased soil moisture storage. Knapp (1992) estimated total return flows from these three sources during the 1988 drought of approximately 145 cfs. Thus the net impact of the irrigation withdrawals on the Kankakee River during the 1988 drought is estimated to be approximately -50 cfs. The net loss of flows will be small during normal years.

Variability in Annual Streamflows

Average streamflow varies greatly from year to year and between decades. Figure 3 shows the annual series of average streamflow in inches for the streamgage records in the Kankakee River basin. As seen in this figure, the average flow during any given year is similar for most stations. Over the 82 years of record, the annual flows on the Kankakee River near Wilmington range from a low of 4 inches in the drought years of 1931 and 1964 to a high of more than 25 inches in 1993. Annual flows in the Kankakee River at Momence are less variable, ranging from 6 to 21 inches, and the variability of annual flows in the Iroquois River is greater, ranging from 2 to 29 inches.

The long-term average flow in the Kankakee River basin is approximately 12 inches per year. Prior to 1966, the average annual flow was less than 10 inches, but since then it has averaged 15.5 inches. Figure 4 shows the 11-year moving average of streamflow for the Kankakee River at Momence for the period 1920-1991. Also shown is the 11 -year moving average of precipitation for the northwest climatic division of Indiana, which represents the average precipitation over the upstream contributing drainage area for the Momence gage. The moving average streamflow is the average flow for 11 consecutive years; for example, the 11-year moving average for 1968 is the average flow for the period 1963-1973. The precipitation moving averages ranged from a high of 40 inches in 1984-1994 to a low of 35 inches in 1955-1965. The streamflow moving average ranged from nearly 17 inches in 1986-1996 to 9.7 inches in 1931-1941.

Figure 4 shows that both average streamflow and precipitation have increased in the last 70 years. Ordinarily it should be expected that a one-inch increase in precipitation should produce, at most, a one-inch increase in streamflow. However, as shown in Figure 4, the magnitude of observed increase in streamflow is greater than the coincident increase in precipitation. The reason for this inconsistency is unknown; however, it is most probable that the average precipitation for the northwest climate division of Indiana is not completely representative of precipitation over the Kankakee River watershed.

Statistical Trend Analysis

Table 2 presents trend coefficients estimated for the annual flow record for individual stations. All of the gaging stations show a significant increasing trend in average flows over the period of record, although the trend is not as strong for streams in the Iroquois River basin. Trend analysis on those portions of the streamgage records since the mid-1960s shows that the Kankakee River has experienced small additional increases in flow, but only the gage near

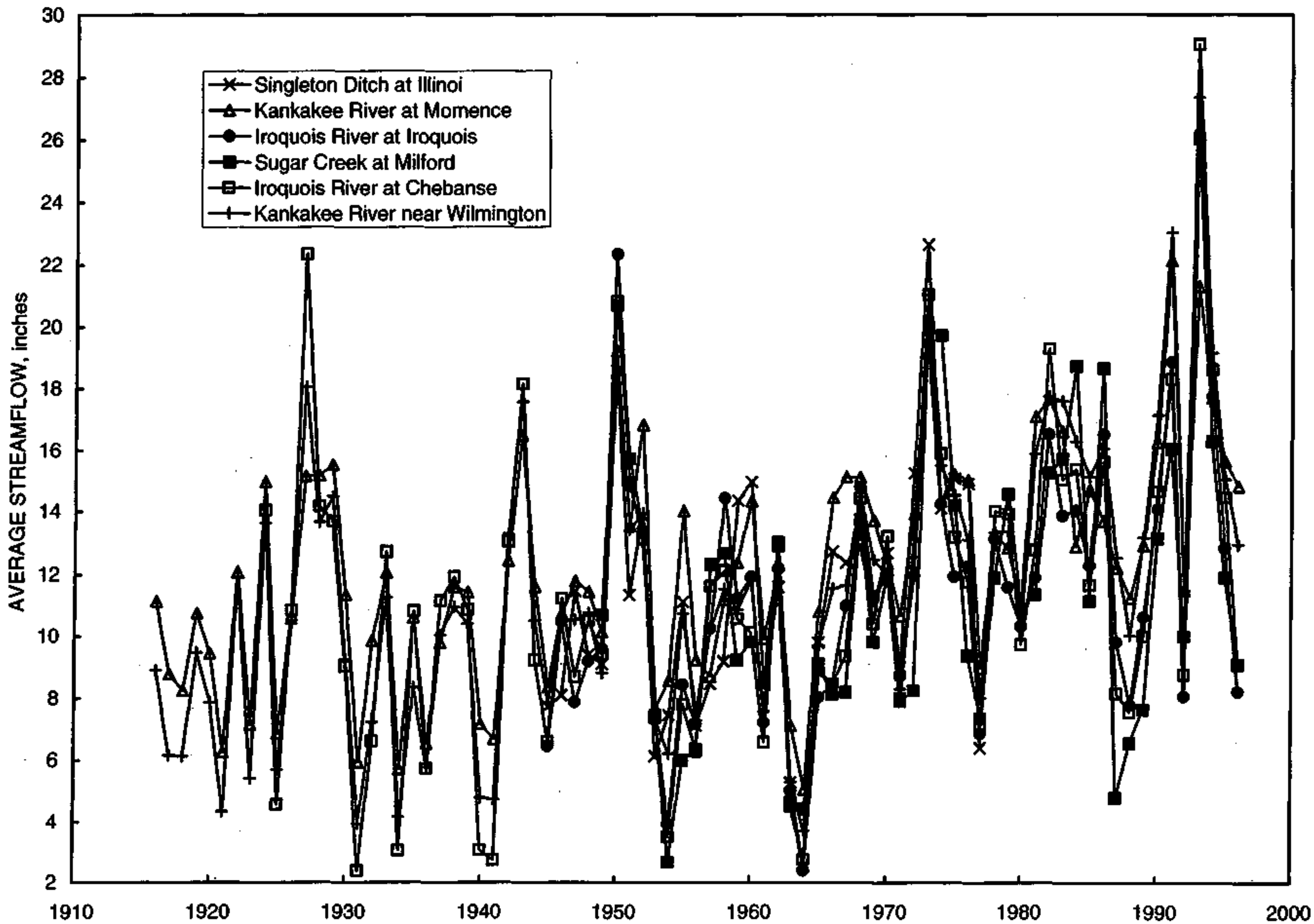


Figure 3. Average annual streamflows for gaging stations
in the Kankakee River basin in Illinois

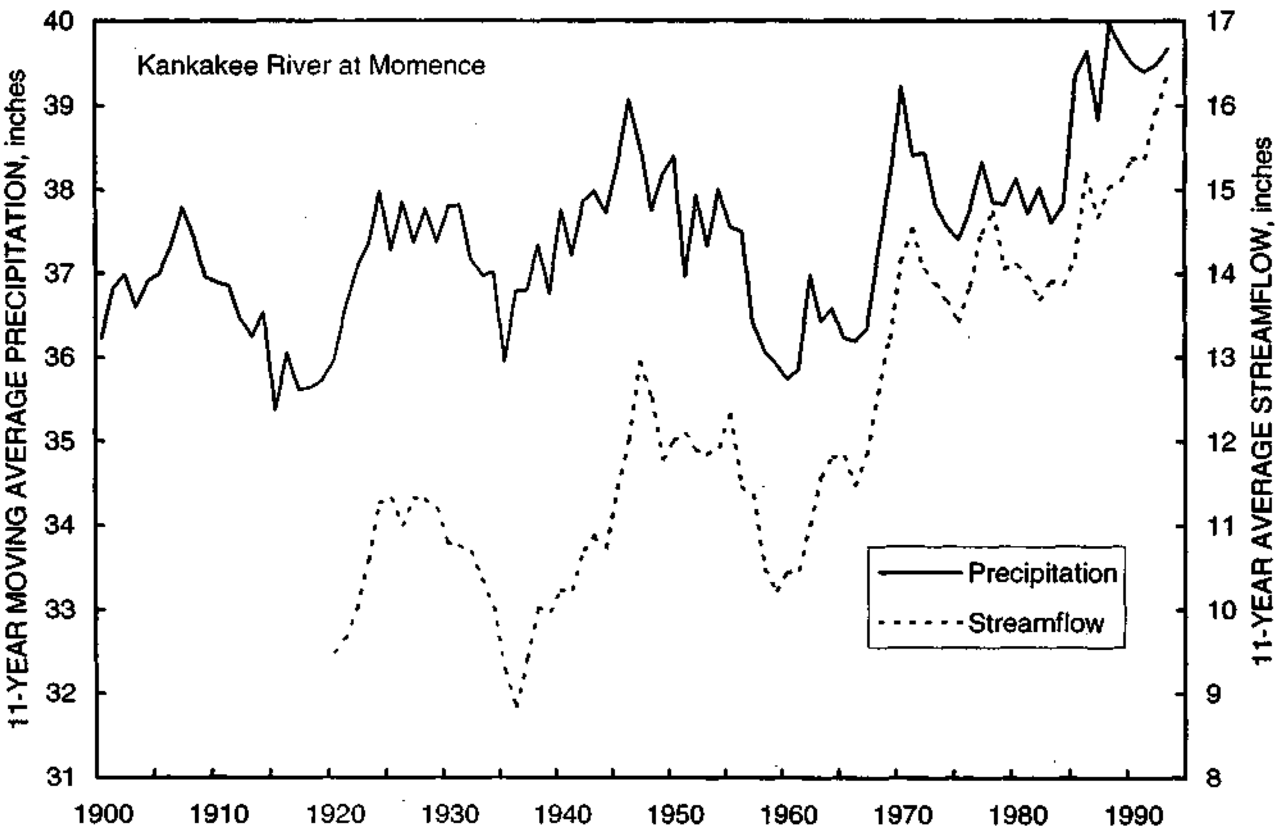


Figure 4. Eleven-year moving averages for streamflows and precipitation, 1900-1920

Table 2. Trend Correlations for Annual and Seasonal Flows

	Kendall trend correlation				
	Annual	*Fall*	*Winter*	*Spring*	*Summer*
Full Period of Streamflow Record					
Kankakee River at Momence	0.338	0.252	0.227	0.247	0.228
Sugar Creek at Milford	0.168	0.238	0.129	0.101	0.010
Iroquois River near Chebanse	0.178	0.150	0.092	0.138	0.172
Kankakee River near Wilmington	0.365	0.245	0.239	0.255	0.299
Streamflow Record since 1966					
Kankakee River at Momence	0.138	0.206	0.169	0.040	-0.015
Sugar Creek at Milford	0.065	0.182	0.046	0.009	-0.046
Iroquois River near Chebanse	0.052	0.206	0.046	0.015	-0.083
Kankakee River near Wilmington	0.225	0.249	0.151	0.108	0.034

Wilmington has a statistically significant trend. Analysis of the Wilmington gaging record suggests that the computed trend is caused by an inconsistency in the record, and thus may not be caused entirely by natural or human-induced changes to streamflows.

Geographic Variation in Flows

Figure 5 plots the flow duration curves for seven gages in the Kankakee River basin from Illinois. The flow duration curve provides an estimate of the frequency with which the given flows are exceeded. As can be seen in this figure, the flows for all streams vary significantly and generally range from one-tenth to ten times the stream's average flow.

Variations in the general shapes of the flow duration curves can often point to significant differences in the hydrology of each stream. The Kankakee River at Momence and the Iroquois River near Chebanse drain watersheds of similar size and have similar average flow rates. However, the variability in flows for the Kankakee River at Momence is considerably smaller than that for the Iroquois River, as seen in Figure 5. This reduced range in flows for the upper Kankakee River basin is caused by: 1) its coarse-grained soils, which have increased infiltration and less direct surface runoff, and 2) the direct connection of the river and its tributaries with shallow sand-and-gravel aquifers. Much of the streamflow in this region originates from the ground water, and as a result the upper Kankakee River has substantial low flow even during the most severe droughts.

The variability of flows in the Iroquois River watershed is significantly greater than that for the upper Kankakee River and is more typical of streams throughout much of central Illinois. The Iroquois River watershed is the source of much of the direct surface runoff in the Kankakee River basin, and high flows on the Iroquois River are often more than twice as great as those on the upper Kankakee River. The lower Kankakee River, downstream of the confluence of the Iroquois and Kankakee Rivers, has flow characteristics that combine the high flood discharges

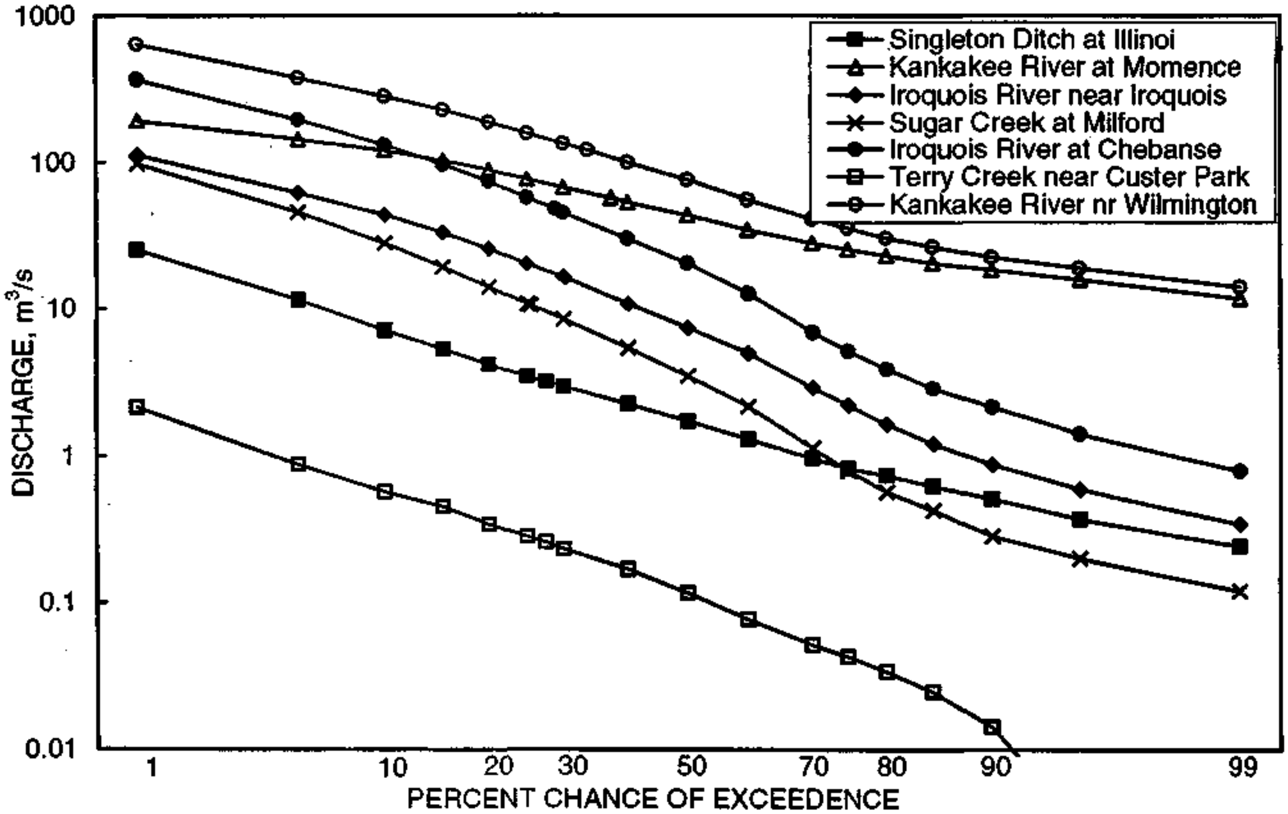


Figure 5. Row duration curves (discharge vs. probability)
for gaging stations in the Kankakee River basin in Illinois

from the Iroquois River with the sustained low flows contributed from the upper Kankakee River.

Seasonal Variation in Flows

As with all other locations in Illinois, streams in the Kankakee River basin display a well-defined seasonal cycle. Figure 6 shows the monthly flow probabilities for the Iroquois River near Chebanse and the Kankakee River at Momence. As shown, flows are greatest during the spring months, March-May, while lower flows are more common in late summer and autumn. However, the variability of flows during any given month are considerably different for the two rivers. The median or average expected flow rate for the Iroquois River is considerably less than that for the Kankakee River, as are the low flow rates (90 percent exceedence). For the latter half of the year, the median flow rate for the Iroquois River is less than the flow rate that would be expected in that month on the Kankakee River during a drought year. The high flow rates (10 percent exceedence) for the Iroquois River are considerably higher than those on the Kankakee River, except during the late summer and fall months, August-November, when the soil moisture and ground-water storage levels in the Iroquois basin are depressed and thus limit the runoff from storm events.

Table 2 presented the results of trend analysis for each season of the year. All of the longer gaging records show an increasing trend for all seasons, generally similar in magnitude to the observed increase in average annual flows. Over the past 30 years, however, only the fall season shows a significant trend in flows.

Flooding and High Flows

Figure 7 shows the annual series of peak flood discharges for the Kankakee River and tributaries in Illinois. An examination of this figure indicates a clear increasing trend in peak discharges for Momence and Wilmington gages on the Kankakee River. On the Iroquois River, the magnitude of the high flood levels has not changed substantially; however, the frequency of moderate flood events has increased and there are fewer years with little or no flooding. Part of this increase in flood frequency is related to a corresponding decrease in droughts and increase in average flows.

Table 3 presents results of the statistical trend analysis of the flood records. This trend analysis validates the observations discussed in the previous paragraph, with the Kankakee River gage records showing the strongest trends in flooding and the Iroquois River having a weaker, but statistically significant trend. Sugar Creek at Milford shows no trend in flooding. None of the gages show an increase in flooding over the last 30 years.

Table 4 presents the monthly distribution of the top 25 flood events for six stations. This table shows that major flooding occurs predominantly in late winter and spring. Interestingly, for the Iroquois River the most common month of flooding is February. This flooding is generally caused by snowmelt or a combination of snowmelt and heavy rainfall and the flooding is often exacerbated by the low stream gradients and the accumulation of ice in the channel and floodplain. Flooding on the mainstem of the Kankakee River more commonly occurs later in the

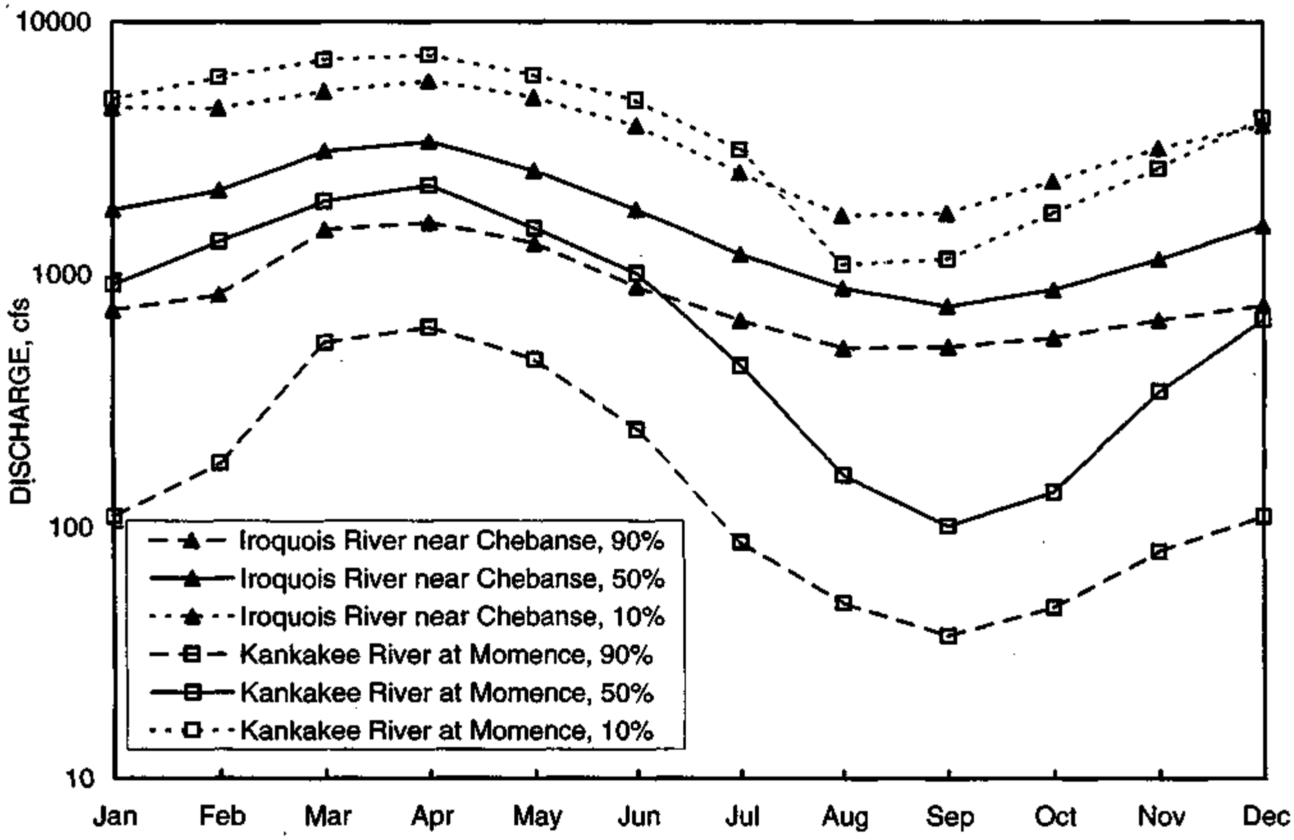


Figure 6. Monthly flow probabilities for the Kankakee River at Momence and Iroquois River near Chebanse

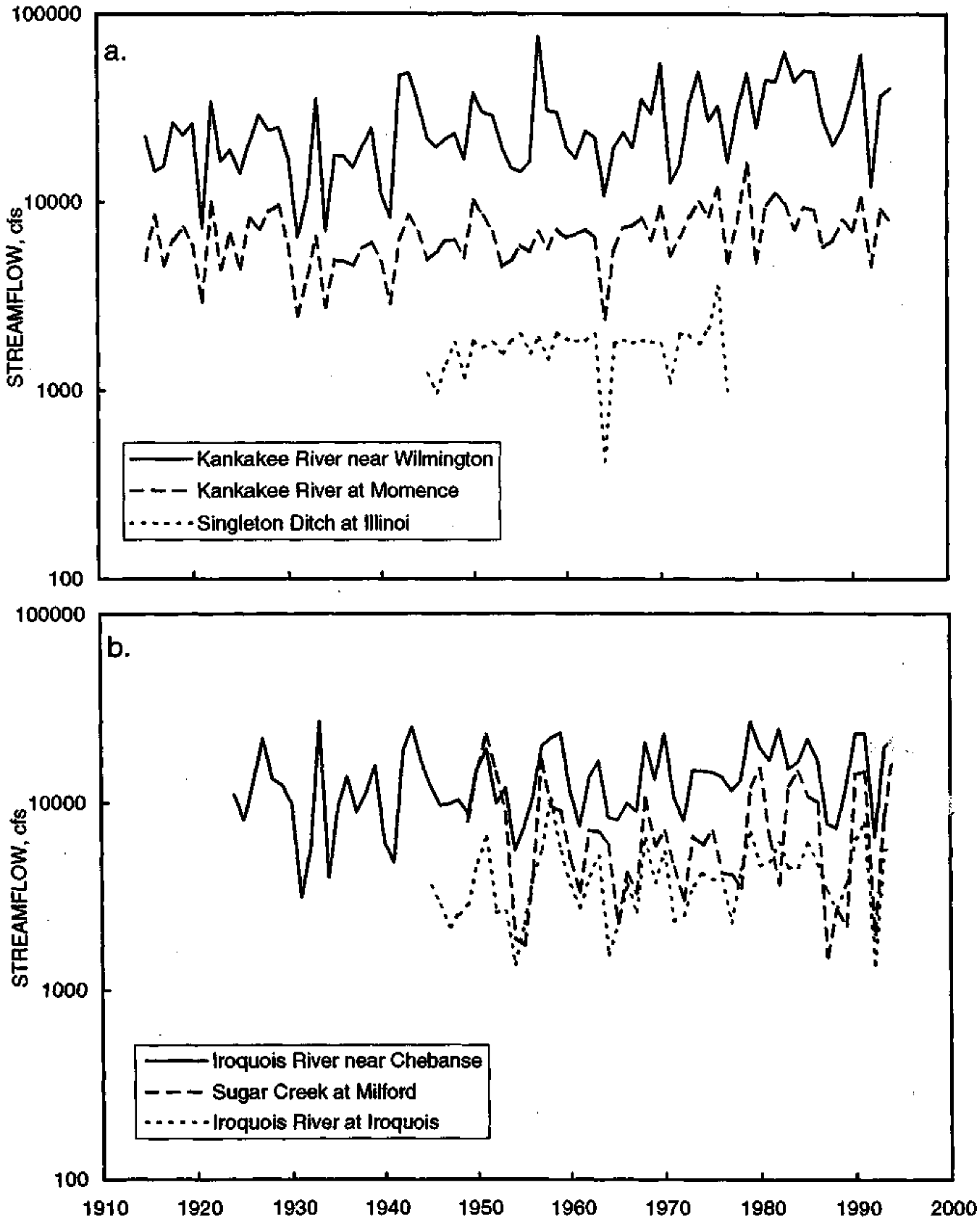


Figure 7. Annual peak discharges for gaging stations
in the Kankakee River basin in Illinois

Table 3. Trend Correlations for Flood Volume and Peak Flow

Streamgaging station	*Period of record*	*Kendall trend correlation* Flood volume	*Kendall trend correlation* Peak flow
Kankakee River at Momence	1914-1995	0.259	0.270
	1967-1995	-0.022	-0.022
Sugar Creek at Milford	1948-1995	0.099	-0.030
	1967-1995	0.009	0.105
Iroquois River near Chebanse	1923-1995	0.153	0.210
	1967-1995	0.052	0.122
Kankakee River near Wilmington	1915-1995	0.244	0.283
	1967-1995	0.071	0.077

Table 4. Monthly Distribution of Top 25 Flood Events

Month	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Kankakee River at Momence	3	2	4	6	3	2	0	0	0	1	1	3
Iroquois River at Iroquois	3	6	4	2	3	2	2	0	0	1	1	1
Sugar Creek at Milford	3	7	2	2	2	3	2	0	0	1	1	2
Iroquois River near Chebanse	2	7	3	2	5	2	2	0	0	1	1	0
Terry Creek near Custer Park	0	4	0	3	4	8	3	0	0	0	0	3
Kankakee River near Wilmington	1	4	4	3	4	2	1	0	0	1	2	3

spring when soil moisture and shallow ground water are most saturated. Flooding on smaller tributaries, such as Terry Creek near Custer Park, also occurs in the spring, but it is most common during the early summer months.

Low Flows and Drought

Two flow parameters are used here to describe dry period flows: the 7-day low flow and the 18-month drought flow. The 7-day low flow is representative of the minimum streamflows that are measured during any given year, whereas the 18-month minimum flow is specifically estimated for drought periods and represents the persistence of a drought and its resulting impact on reservoir supplies. All of the major surface water supplies in the Kankakee River basin are direct withdrawals from streams; therefore the 7-day low flow is the more important value for assessing drought impacts in this region.

Geographic Differences in Low Flows

Low-flow characteristics are a direct reflection of shallow ground-water storage and its connection to the streams in the basin. The upper Kankakee River has the greatest connection with shallow ground water and has substantial low flow even during the most severe droughts. The Iroquois River has a much lower but sustained flow during drought years. Almost all of the low flows on the Kankakee River and over half of those on the Iroquois River originate from the shallow ground waters in the Indiana portion of the basin.

The 7-day, 10-year low flow (Q7,10) for the Kankakee River ranges from 400 cfs at the Indiana border to 480 cfs at its confluence with the Illinois River (Singh et al., 1988). Much of the increase in low flows over this distance is provided by two tributaries, Singleton Ditch (near the Indiana border) and the Iroquois River. The Q7,10 for the Iroquois River ranges from 14 cfs at the Indiana border to 31 cfs at its confluence with the Kankakee River. Sugar Creek is the only other tributary in the basin that has a Q7,10 in excess of 1 cfs, and most tributaries have no flow during most dry years.

Table 5 lists the 7-day low flow and 18-month flows of major droughts for the Kankakee River at Momence and the Iroquois River near Chebanse. Different types of dry periods cause extreme low flows on the Kankakee and Iroquois Rivers. The lowest flows on the Kankakee River are most common during intensely hot and dry summers when there is a relatively quick reduction in ground-water storage near the streams. Lowest flows on the Iroquois River tend to occur more often during extended droughts when there is a sustained reduction in ground-water storage throughout the watershed. In some cases, but not all, the intense and sustained dry periods occur during the same year. On the Kankakee River, the lowest 7-day low flows occurred in the drought years of 1934, 1964, and 1988, as well as several times in the period 1917-1925. For the Iroquois River, the lowest 7-day low flows occurred during the drought years of 1934, 1941, and 1956.

Table 5. Low Flows and Drought Flows Experienced during Major Droughts

Drought years	*18-month drought flows (cfs)* Momence	Chebanse	*7-day low flows (cfs)* Momence	Chebanse
1917-1918	1260	----	330	----
1920-1921	996	----	365	----
1924-1925	1138	646	406	18.0
1930-1931	1018	367	521	27.3
1933-1934	977	456	384	14.1
1935-1936	1104	783	431	19.1
1940-1941	1131	371	411	15.3
1953-1954	1092	521	460	33.3
1955-1956	1273	680	481	14.3
1963-1964	838	341	355	16.6
1988-1989	1716	929	271	26.6

Temporal Trends in Low Flows

Figure 8 presents the Illinois series of 7-day low flows for six streamgages in the Kankakee River basin in Illinois. Both the Kankakee and Iroquois Rivers show noticeably higher low flows since the mid-1960s. Low flows on Sugar Creek at Milford show little if any trend. The increases in low flows are most likely directly related to the increased average flow in the basin since the mid-1960s.

Table 6 presents results of the statistical trend analysis of the low flows. The results confirm the observations in Figure 8, with all gaging records showing an increase in low flows except for Sugar Creek at Milford. All gages show a slight but statistically insignificant decrease in low flows over the last 30 years.

Table 6. Trend Correlations for 7-Day Low Flows

Streamgaging Station	*Period of record*	*Kendall trend correlation 7-day low flow*
Kankakee River at Momence	1914-1995	0.208
	1967-1995	-0.100
Sugar Creek at Milford	1948-1995	0.072
	1967-1995	-0.060
Iroquois River near Chebanse	1923-1995	0.247
	1967-1995	-0.093
Kankakee River near Wilmington	1915-1995	0.244
	1967-1995	-0.080

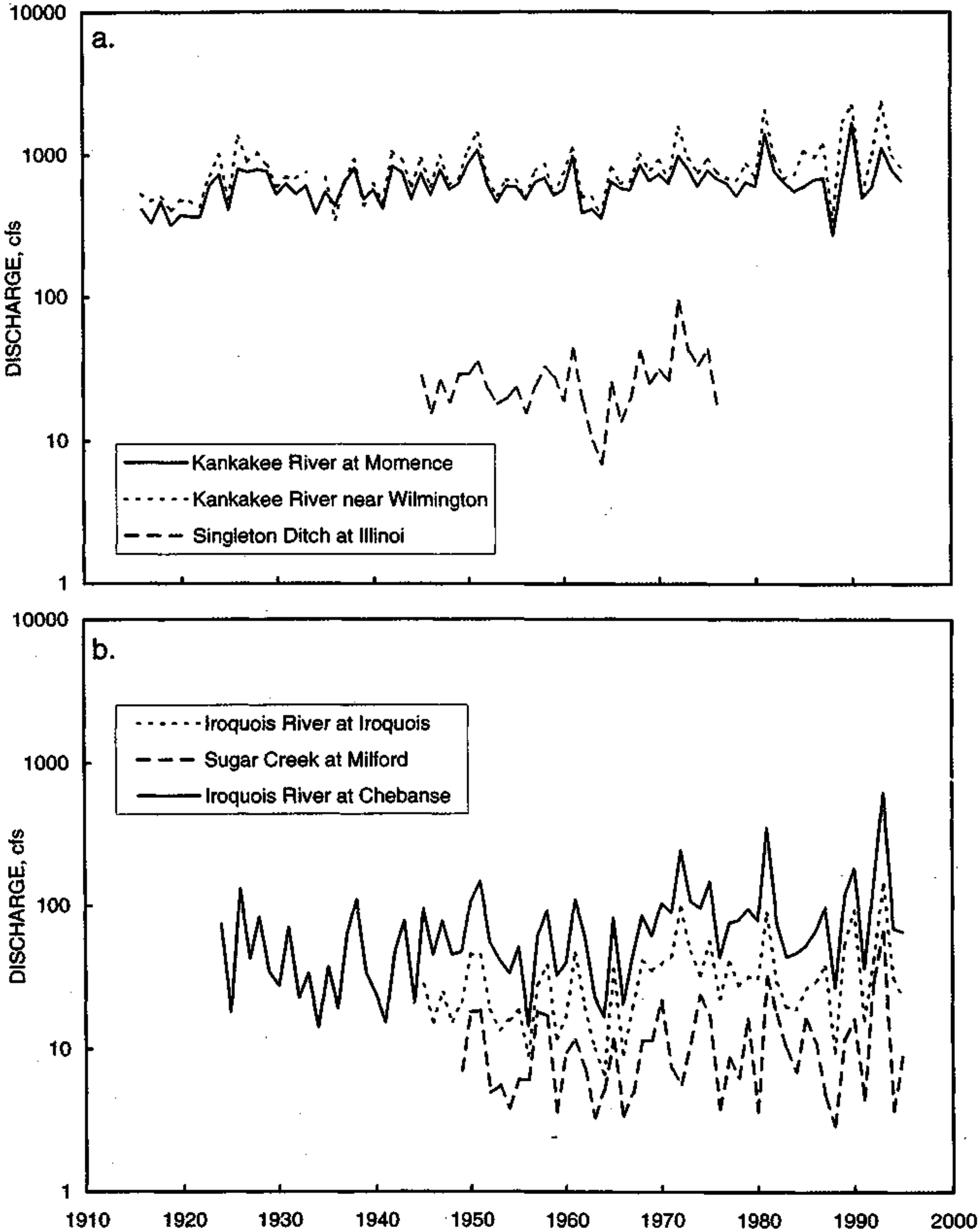


Figure 8. Seven-day low flows for the Kankakee River and tributaries

Remarks on Streamflows

The Kankakee River, more than any other river in the State, shows definite increasing trends of high, medium, and low streamflows. Streamflow records on the Kankakee River show that a major jump in the flow amounts occurred in the mid- to late-1960s. All trends appear to be related to a coincident increase in average annual precipitation. Examination of land use in the watershed has not identified a direct cause for the increase in average flow conditions, but may play a secondary role in high and low flow trends. Irrigation withdrawals from streams have some impact on reducing low flows during drought years. Trend analysis does not identify any continued increases in high or low flows over the past 30 years.

Flows in the remainder of the basin have also increased, but to a much smaller degree, and also appear to be related to precipitation changes. Flow records for the southern portion of the Iroquois River basin on Sugar Creek do not show any trends in flow.

Peak, Average Annual, and Low Flows

Appendix B shows summary plots of the annual peak, average annual, and 7-day low flows for seven gaging stations on the Kankakee River in Illinois and Indiana: Kankakee River near Wilmington; Kankakee River at Momence; Kankakee River at Shelby, Indiana; Iroquois River near Chebanse; Iroquois River at Iroquois; Iroquois River near Foresman, Indiana; and Sugar Creek at Milford. The flow variability and trends on the Kankakee River at Shelby, Indiana, is similar to those observed at the Momence gaging station. Similarly, the flow variability on the Iroquois river at Foresman, Indiana, is similar to the flows observed on the Iroquois River at Iroquois, Illinois. These types of intergaging station relationships are expected since the Momence station is downstream of the Shelby station on the main stem of the river. The Iroquois station is also downstream of the Foresman station on the Iroquois River (Figure 1).

Field Data Collection and Analysis

In 1998 and 1999, field data were collected from the main stem of the Kankakee River during a boat trip survey on the main stem of the Kankakee River from the U.S. Route 30 Bridge near LaPorte, Indiana, to the confluence of the Kankakee River with the Des Plaines River. This activity included collecting bed and bank material samples, photographing the river and shorelines, and mapping bank lines to identify erosion sites and reaches.

Boat Trip Survey

A boat trip from the U.S. Route 30 bridge in LaPorte, Indiana, to the confluence with the Des Plaines River was completed between November 18, 1998 and December 1, 1998. The purpose of the trip, which included six days on the river, was to develop an initial evaluation of the present condition of the river. During the trip, activities included detailed mapping of the bank conditions for the full length of the river, regular stops for bed and bank material sampling and photographic records, and irregular stops at points of interest.

Bank conditions for the full length of the river were mapped using a combination of colored pencil and written notations on USGS 7.5-minute quadrangle maps. Regular sample stops were made at 1-mile intervals to collect a differentially corrected GPS position, water depth and bed condition, a bed material sample (when conditions allowed), and upstream and downstream photographs. Bank material samples were collected at every fifth 1-mile sample on alternating sides of the river.

Observations related to the Indiana reach of the river and preliminary comparison to earlier conditions observed under a similar reconnaissance survey in 1978 and 1979 (Bhowmik et al., 1980) are as follows:

- Bank conditions appear to have deteriorated since the early 1980s when "armored" by tree root growth. This no longer appears to be the general condition.
- Water depth averaged 4 feet, ranging from 2.5 to 6 feet.
- Bed conditions appeared to be similar to those in the 1980s with a preponderance of fine to medium sand.
- Conditions at the State Line were similar to late-summer sand bar conditions observed in the 1980s. In the spring of 1979, this sand bar was completely washed out by high flows that redeveloped over the summer.

Observations related to the Illinois reach of the river and preliminary comparison to earlier conditions are:

- In the Momence wetlands, several developed and fairly stable sand bars were observed at the inside of bends during this trip.
- Between Momence and Route 17, sand bars surveyed during the 1980s studies seem to have been washed out or reshaped by conditions in intervening years. Most of the riverbed is sand covered, but there were only minimal areas of exposed sand along the banks.
- From about a mile above the Route 17 bridge to Aroma Park, the river goes through a series of deep water, sand-blanketed sections and shallow water, rock, bedrock riffles, or ledges.
- Through the Six-Mile Pool, the conditions are similar to those in the early 1980s except that the sand bar along the right bank looking downstream has become more pronounced.
- Below Kankakee, the rock exposures obviously stabilize the river. Sand was found in very limited quantities in this reach. This is the most incised reach of the river with 20-foot cliff faces at or near the bank in extended sections forcing a constriction of the channel.

Figures 9-15 show a series of photographs taken during and after this reconnaissance survey.

Bed and Bank Materials Sampling and Analysis

The bed and bank material samples were collected while conducting a reconnaissance survey to determine the current status of the streambanks within the study area. In tandem with

Figure 9a. A typical view of the Kankakee River channelization
and bank vegatation in Indiana

Figure 9b. An example of a rural pump station and bank erosion
conditions along the Kankakee River in Indiana

Figure 10a. An example of mass wasting
along the Kankakee River in Indiana

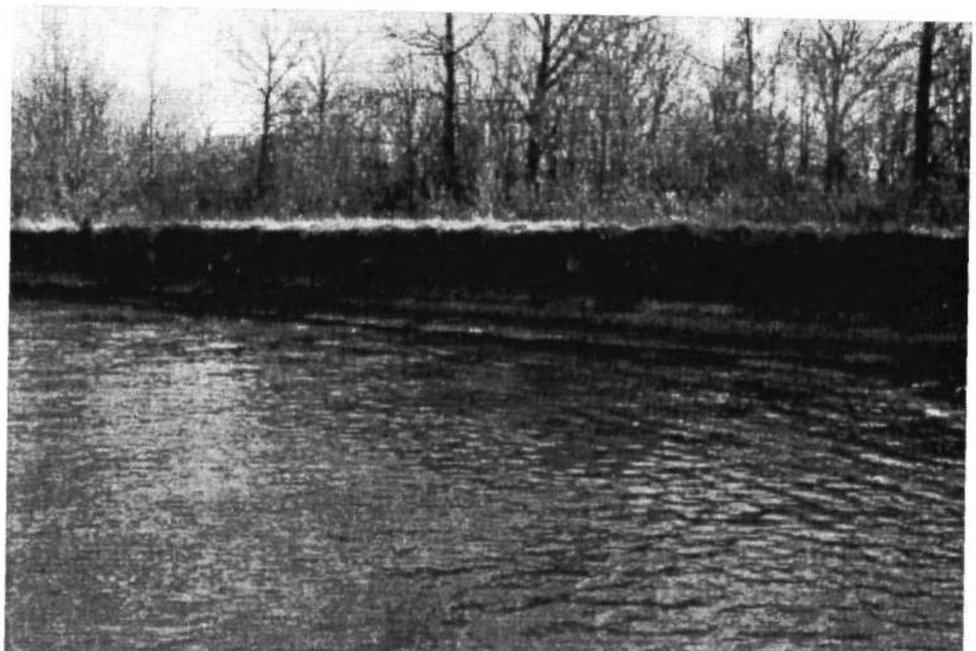


Figure 10b. An example of a 5-foot scarp with underlying piping
above a steep sandy bench on the Kankakee River in Indiana

Figure 1 la. An example of exposed and undercut tree roots on a steeply sloped, sandy bank on the Kankakee River in Indiana

Figure 1 lb. A sandy deposit along the bank on the Kankakee River in Illinois

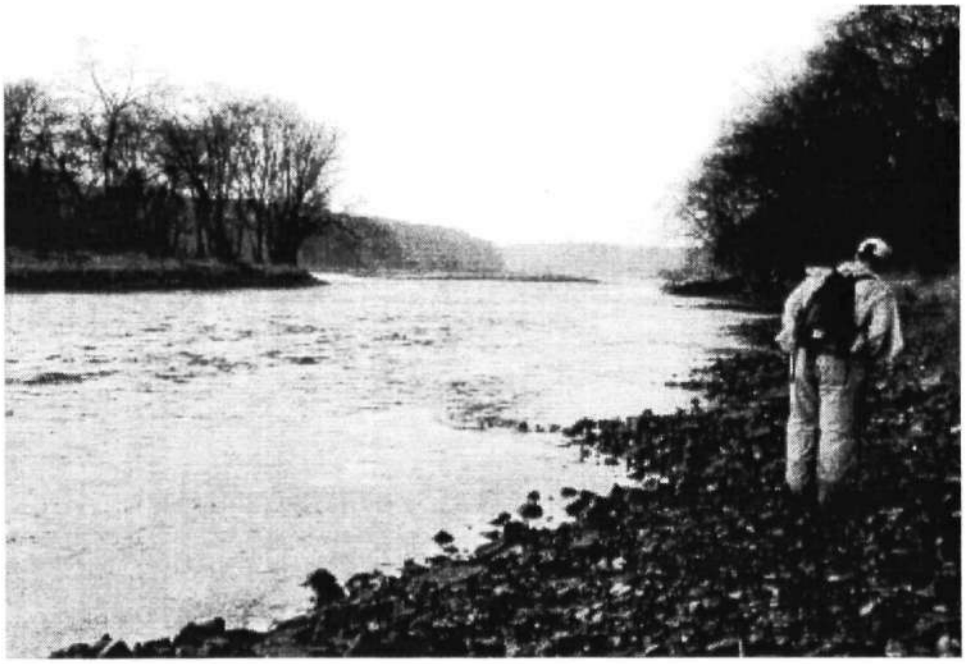


Figure 12a. A section of cobble and gravel riverbank, opposite an island on the Kankakee River in Illinois. Note the additional sediment deposit downstream in the river channel

Figure 12b. An example of a riffle formed by the edge of a bedrock section and gravel deposits on the Kankakee River in Illinois

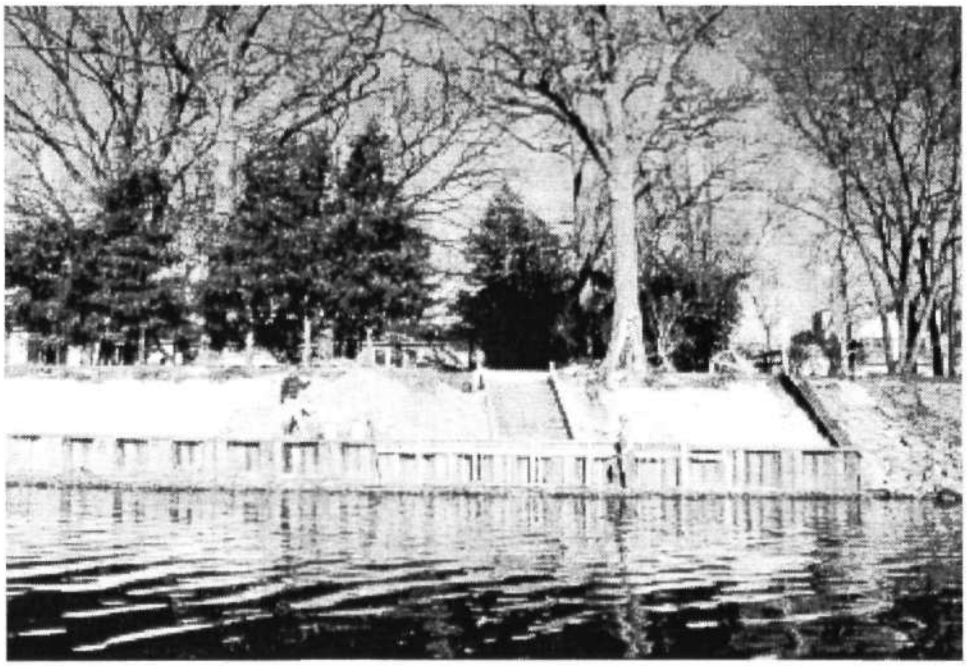


Figure 13a. An example of the installation of bank protection residential sheet-piling on the Kankakee River in Kankakee, Illinois

Figure 13b. A typical view of the limestone cliffs and riverbank in the Kankakee State Park on the Kankakee River in Illinois

Figure 14a. A view of the Wilmington Dam
on the Kankakee River in Illinois

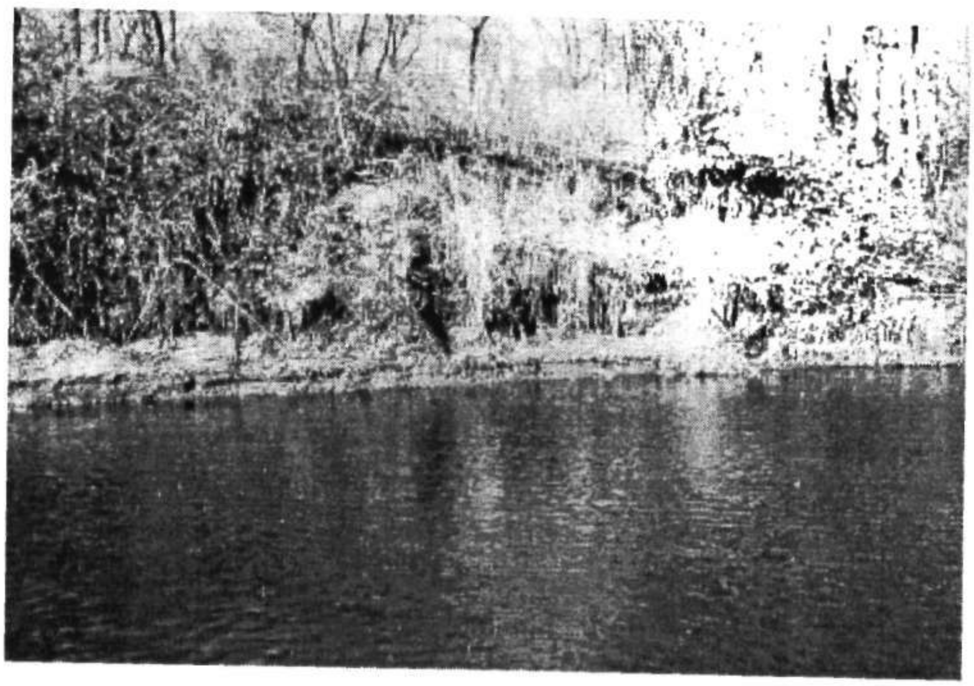


Figure 14b. A typical vegetated bank; lower bank shows a 6-inch scarp
at the water's edge on the Kankakee River in Illinois

Figure 15a. Reconnaissance survey crew preparing to depart for the day's work. Field equipment includes RTCM corrected GPS and maps

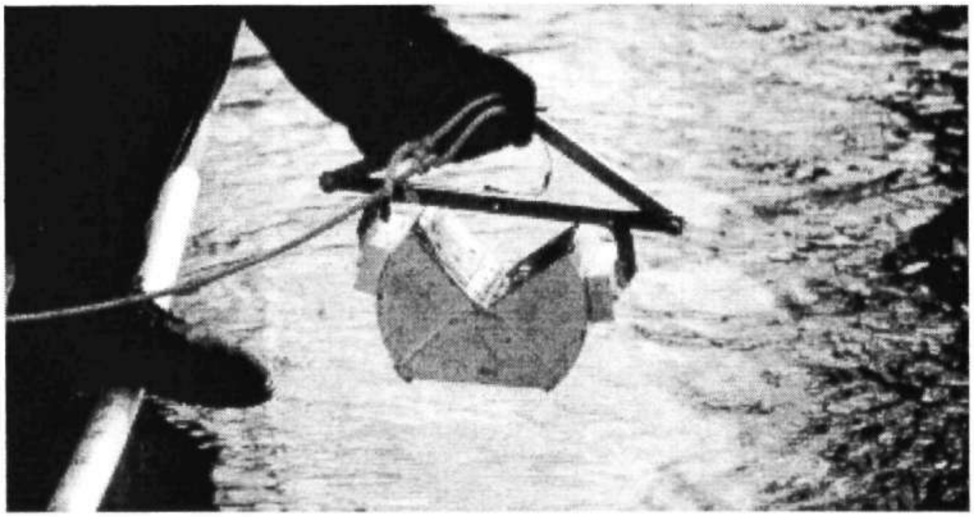


Figure 15b. The Ekman Dredge used to collect bed material samples on the Kankakee River

Figure 15c. Using a sounding pole to survey the depth and extent of a sandy deposit on the Kankakee River in Illinois

this mapping process, bed and bank material samples were collected. Bed samples were collected using a manually lowered mini-Ponar sampler while visually estimating mid-channel and simply using the motor to hold the boat in position. Bed samples were collected approximately every mile by scaling distances off from 7.5-minute quad maps and a bank sample was taken on alternating sides of the channel at every fifth site. Bank samples were generally taken at the toe of the bank after removing approximately 1 inch of surface material to ensure samples contained undisturbed bank materials. The exact location of all bed and bank samples was determined by using a Leica real time differential global positioning system (RDGPS). A total of 82 mid-channel samples and 19 bank samples were collected. Each sample was marked with the date, time, and RDGPS fix number.

Laboratory analyses of the samples consisted of dry sieving the samples using standard techniques. A particle size of 0.062 millimeters (mm) was used as the break between the sand and silt/clay fractions. For each sample, the total weight was recorded, a split was taken and weighed, and a split weight factor was determined. Each sample was then sieved and the weight, cumulative weight, cumulative percentage, and percent finer of retained materials were determined and tabulated. No further analysis was performed on the silt/clay fraction.

To date, bed material samples from every fifth mile and all bank material samples were analyzed for particle size distribution. A total of 21 bed material and 19 bank samples were analyzed by the sediment laboratory at the Water Survey. Particle size distribution plots were developed for all samples. Appendix C presents all particle size distribution plots. In addition to the plots, values of uniformity coefficient, U, and the standard deviation, a, were determined for each sample. This information is included on the particle size distribution plots and summarized in Table 7 for bed material samples and Table 8 for bank material samples.

Bed material samples consisted primarily of sand. In general, bed materials become finer in the downstream direction. Data from this sampling effort supported this generalization. The d_{35}, d_{50}, and d_{85} sediment particle sizes (Figures 16-19) for each sample were plotted upstream to downstream and the best-fit line for each data set was negatively sloped. However, the slope was very small. A Kendall-Mann test for trend analysis was performed on the data set. One sample was dropped from the analysis because it was collected at the confluence of the Des Plaines and Kankakee Rivers in the backwater of Dresden Island Lock and Dam. This analysis revealed a correlation between river mile and the d_{35}, d_{50}, and d_{85} sediment particle sizes but only at the 80 percent confidence interval. Both the standard deviation and the uniformity coefficient indicated that samples were quite homogenous.

Similar analyses were performed for all the bank samples. The trends evident in the results were similar to those for the bed material samples although variability in particle size within samples was higher in the bank samples. When data for the d_{35}, d_{50}, and d_{85} sediment particle sizes (Figures 20-23) for each bank material sample are plotted in downstream order, the best-fit lines are all negatively sloped. When the Kendall-Mann test is applied to all of the bank material data, the d_{35} sediment particle size shows no correlation to river mile, while d_{50} and d_{85} sediment particle sizes were significantly correlated at the 80 percent and 90 percent confidence intervals, respectively. The standard deviation and the uniformity coefficient for the bed material samples also indicated greater variability within each sample with uniformity coefficients

Table 7. Bed Material Sample Characteristics Mid-Channel Samples

Sample ID	*Particle diameter (mm)* d_{35}	d_{50}	d_{85}	*Uniformity coefficient, U*
KKRIN01	0.312	0.365	0.615	1.82
KKRIN05	0.374	0.424	0.647	1.71
KKRIN09	0.348	0.430	0.644	1.72
KKRIN13	0.326	0.395	0.717	2.68
KKRIN17	0.235	0.266	0.349	1.52
KKRIN21	0.245	0.288	0.462	1.68
KKRIN25	0.297	0.343	0.558	1.78
KKRIN29	0.372	0.436	0.841	1.84
KKRIN33	0.295	0.349	0.752	1.97
KKRIN37	0.312	0.385	1.120	2.15
KKRIN41	0.419	0.520	1.120	2.36
KKRIN45	0.294	0.336	0.521	1.72
KKRIN49	0.302	0.348	0.542	1.74
KKRIL53	0.300	0.340	0.478	1.6
KKRIL57	0.321	0.370	0.523	1.59
KKRIL65	0.242	0.274	0.363	1.58
KKRIL69	0.311	0.357	0.565	1.64
KKRIL74	0.262	0.296	0.431	1.69
KKRIL89	0.253	0.332	0.676	2.41
KKRIL93	0.478	1.900	>8.00	17.99
KKRIL104	0.238	0.272	0.353	N/A

Note: NA = not applicable.

Table 8. Bank Material Characteristics

Bank Samples		*Particle Diameter (mm)*		*Uniformity coefficient, U*
	d_{35}	d_{50}	d_{85}	
Sample ID				
KKRIN4 LB	0.212	0.273	0.863	5.13
KKRIN09 RB	< 0.063	0.16	0.391	N/A
KKRIN14 LB	0.274	0.363	2.07	5.17
KKRIN17 RDB	0.28	0.322	0.489	1.78
KKRIN19 LDB	< 0.063	0.112	0.235	N/A
KKRIN22 LDB Bench	0.256	0.318	0.981	2.7
KKRIN22 LDB Upper Bank	0.8	4.54	23.1	37.6
KKRIN22 LDB Berm	0.276	0.316	0.498	1.78
KKRIN24 RDB	0.194	0.225	0.34	2.29
KKR1N29 LDB	0.328	0.405	0.682	2.39
KKRIN35 RDB	< 0.063	0.063	0.335	N/A
KKRIN40 RDB	0.201	0.248	0.5	4.44
KKRIN46 RDB	0.23	0.305	0.595	2.45
KKRIL52 LDB	0.136	0.155	0.218	N/A
KKRIL56 RDB	0.103	0.155	0.413	N/A
KKRIL65 LDB	< 0.063	0.068	0.188	N/A
Aroma Park	0.23	0.26	0.344	1.51
KKRIL71 RDB	0.302	0.35	0.516	1.81
KKRIL75 LDB	< 0.063	< 0.063	< 0.063	N/A

Note:
LB = left bank
RB = right bank
LDB = left descending bank
RDB = right descending bank
NA = not applicable

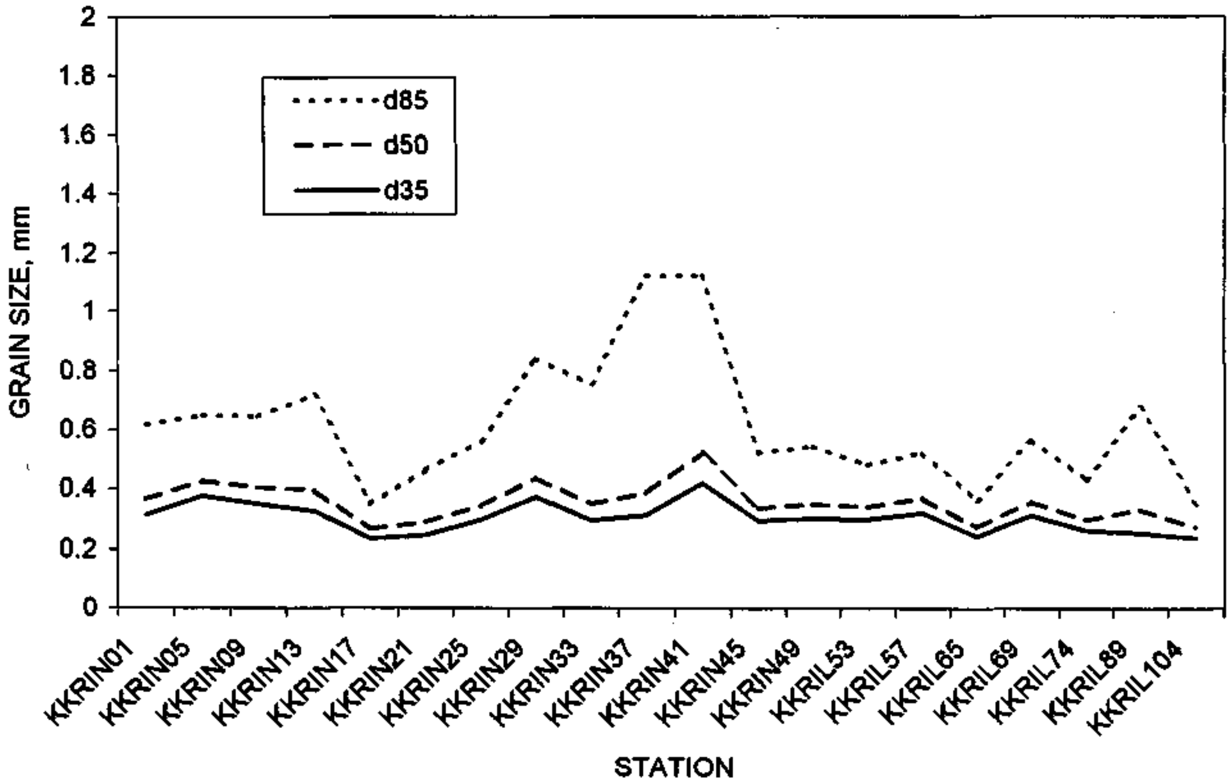


Figure 16. Variabilities of d_{35}, d_{50}, and d_{85} of the bed material samples

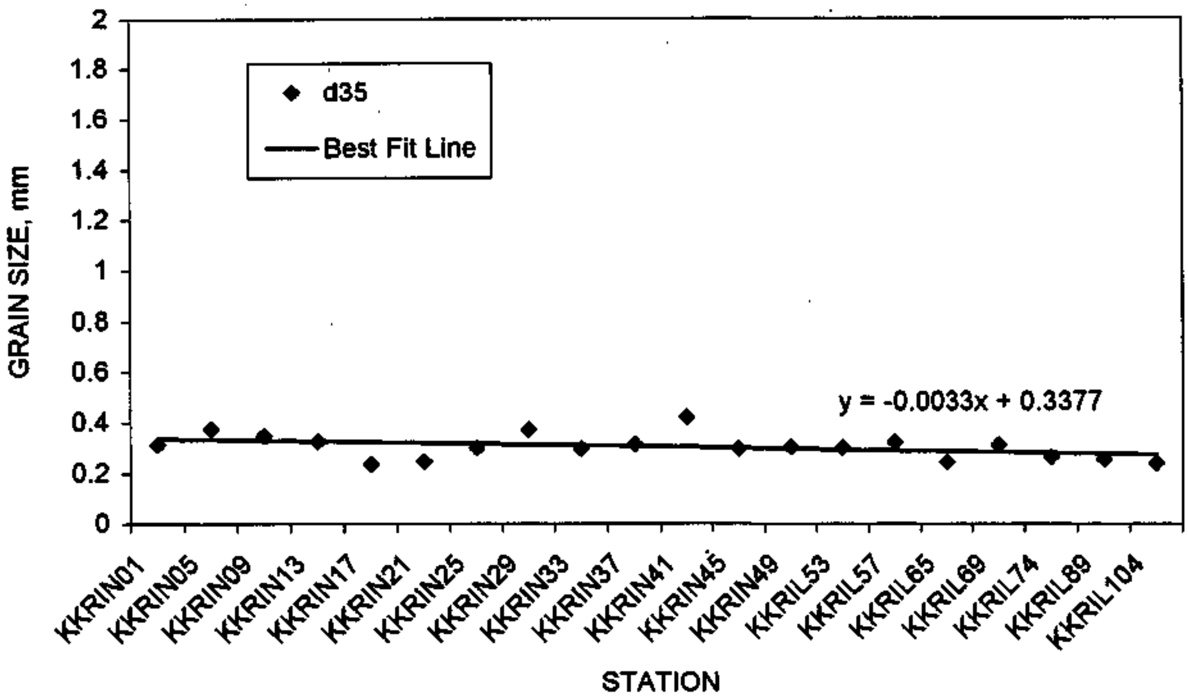


Figure 17. Longitudinal variations of d_{35} sizes of the bed materials

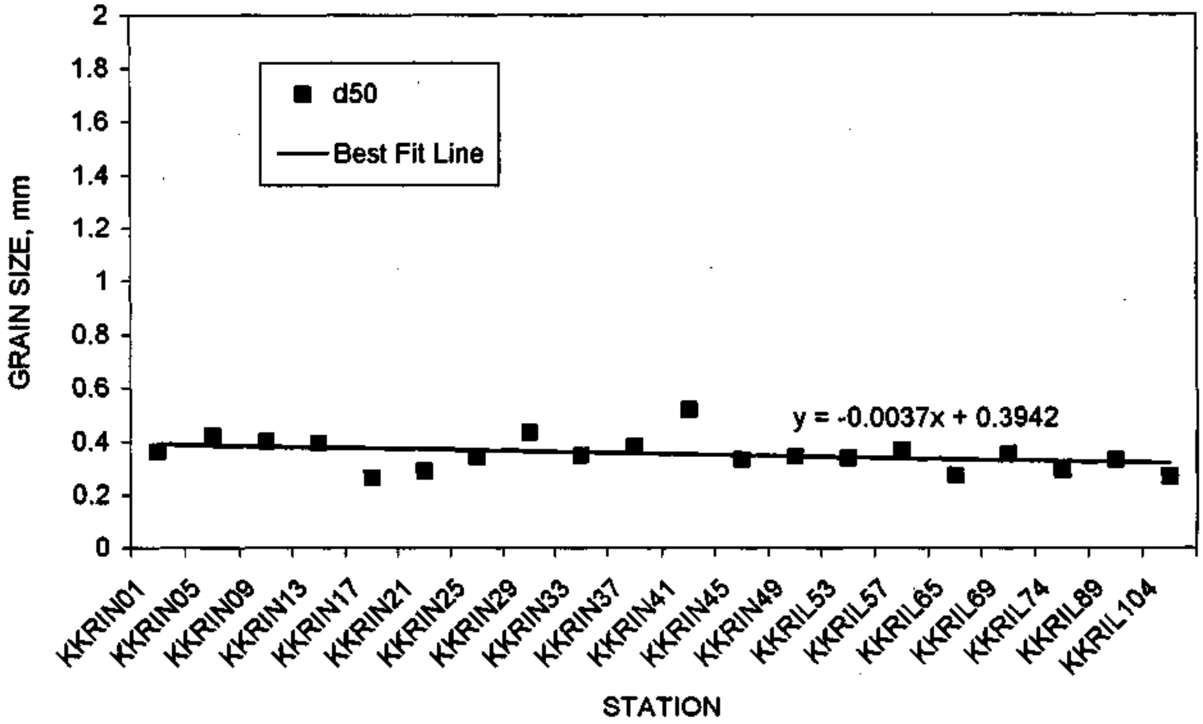


Figure 18. Longitudinal variations of d_{50} sizes of the bed materials

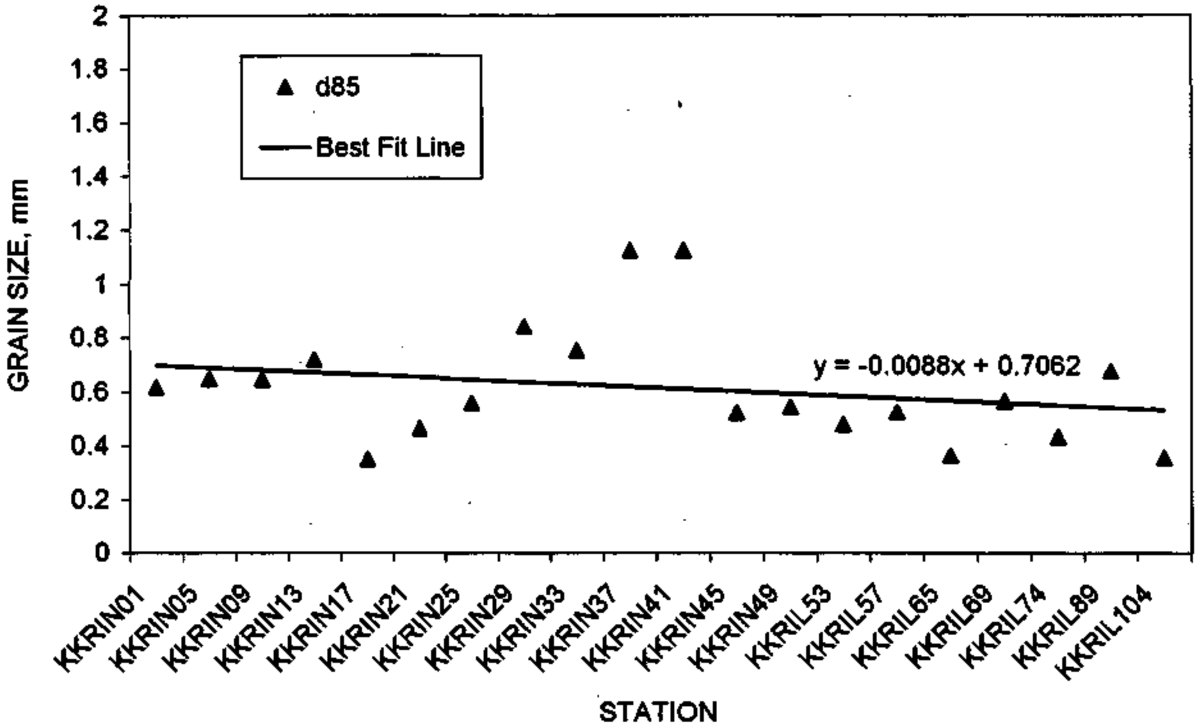


Figure 19. Longitudinal variations of d_{85} sizes of the bed materials

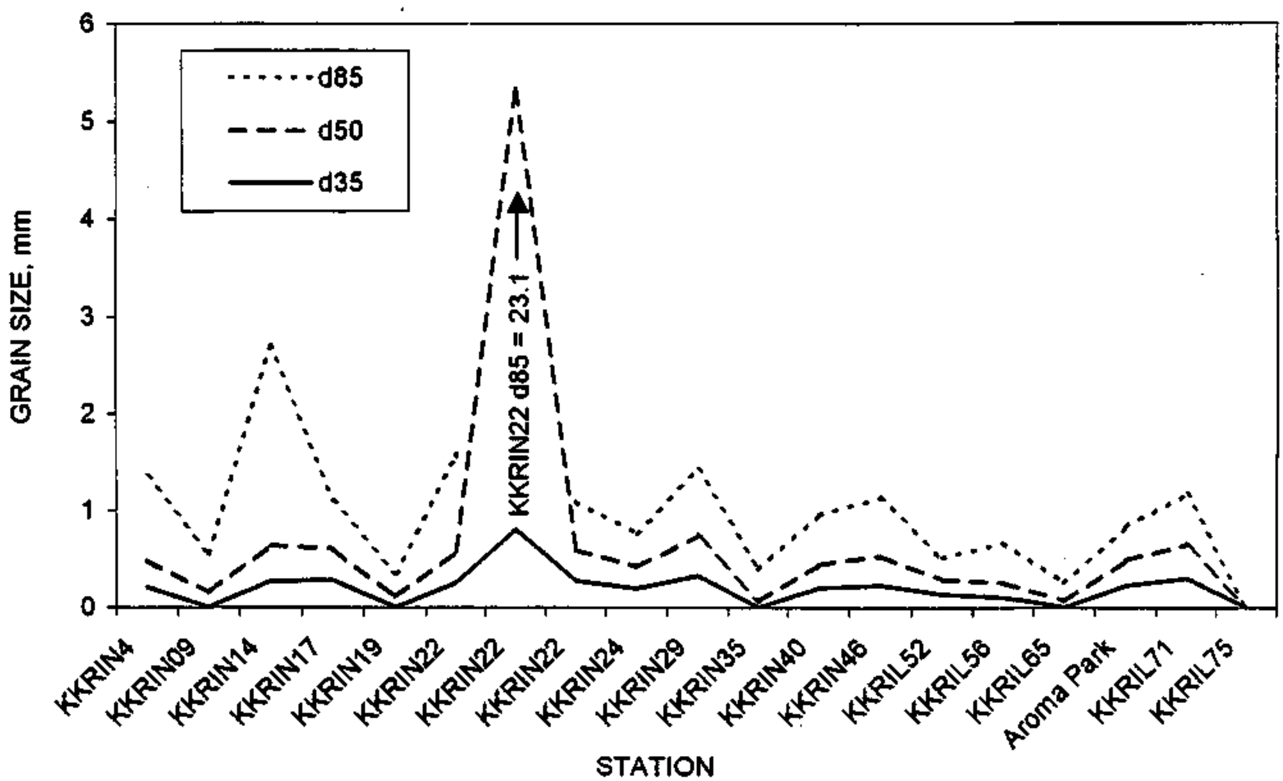


Figure 20. Longitudinal variations of d_{35}, d_{50}, and d_{85} of the bank material samples

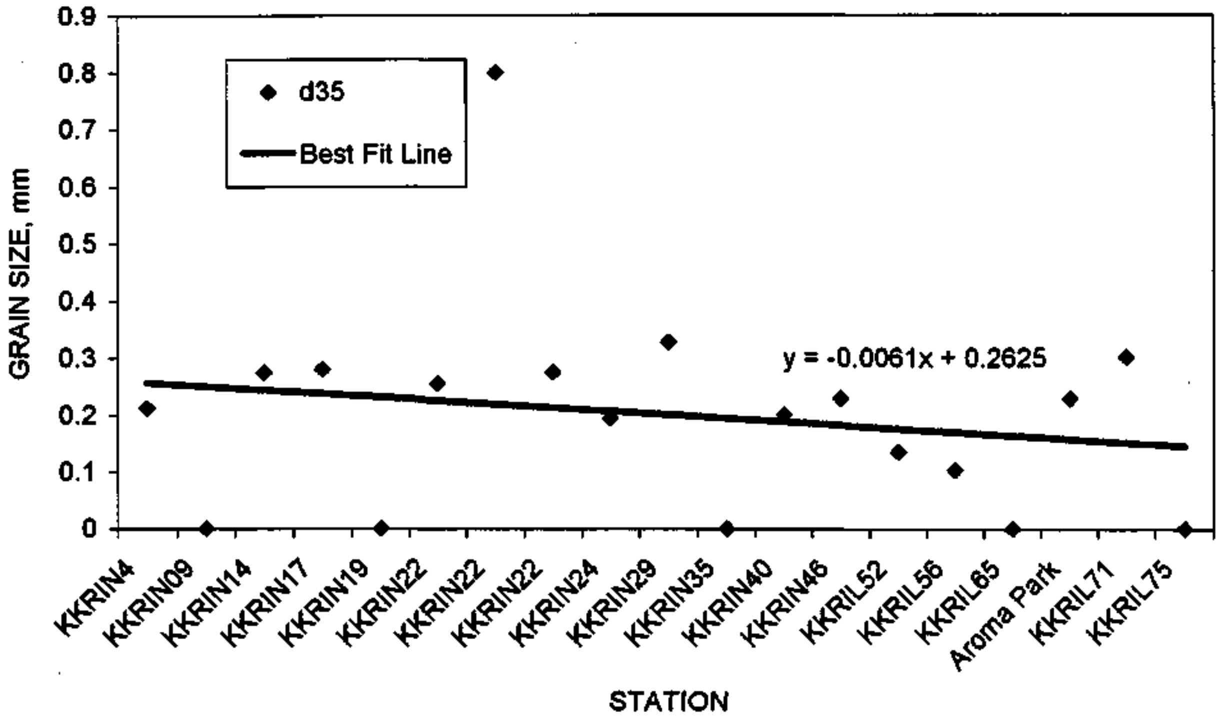


Figure 21. Longitudinal variations of d_{35} sizes of the bank materials

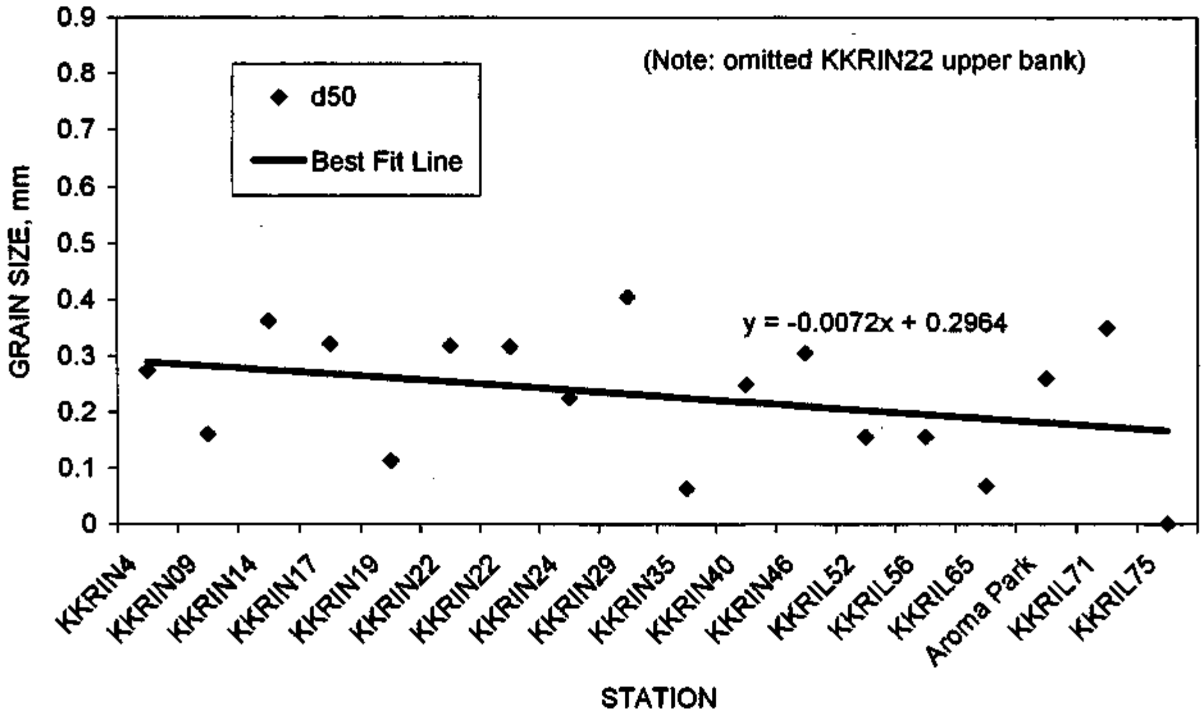


Figure 22. Longitudinal variations of d_{50} sizes of the bank materials

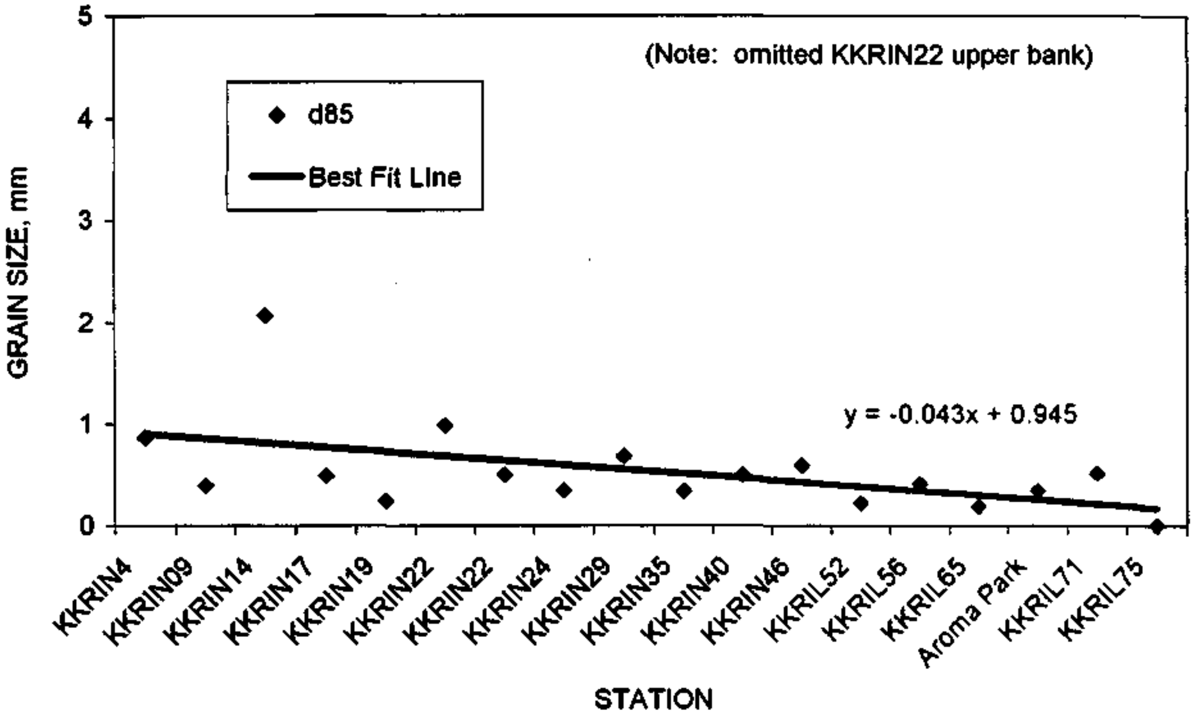


Figure 23. Longitudinal variations of d_{85} sizes of the bank materials

between 2 and 5 while the standard deviation was generally less than 2. Appendix C shows the results of the laboratory analyses of the bed and bank materials.

Bank Erosion Conditions

Bank conditions for the Kankakee River were qualitatively assessed during the field reconnaissance survey from the Route 30 Bridge in Starke County, Indiana, to the confluence of the Kankakee, Des Plaines, and Illinois Rivers. Approximately 105 miles of riverbank conditions were evaluated between November 19 and December 1, 1998. The bank conditions could be easily observed during this time due to the low river stage and reduced riparian foliage of the season. The bank conditions described during the reconnaissance survey refer only to near shore bank conditions that could be associated with hydraulic forces of river flow. Other classifications of bank erosion resulting from regional geomorphology are not discussed here.

Methodology

The field reconnaissance survey was made from a boat traveling in the downstream direction. Observations of bank features were recorded on USGS quadrangle maps with a survey system previously developed and used on the upper Mississippi and Illinois Rivers (Bhowmik et al., 1997). The survey details bank features, erosion and deposition features, causative processes, and bed features. Attributes of the riverbank describe and identify the severity of erosion along the bank and regions of the bank that are considered stable or are protected by rock or other structures. The same attributes were used to describe the bank conditions of river islands. Table 9 lists the classes of information recorded.

In addition to these records, the location of pump stations, USGS streamgages, boat ramps, bed material sample sites, established stands of trees, and regions of relatively new, above water level accumulation of sand were also marked on the map for reference.

Description Format

The following descriptions present a general overview of the survey data on each 7.5-minute USGS quad map in the Indiana portion, and in Illinois, relative to the map sections indexed as shown in Figures 14 and Figure 15. The survey data have been transferred into a Geographical Information System (GIS) database. Appendix D defines most scientific terms in these descriptions. Table 10 provides unified soil classifications used in these descriptions.

Bank Condition Maps

Bank conditions on both sides of the river were mapped on 7.5-minute quad maps. These maps will be available in a limited supply when the final report is prepared in 2000. All the maps will be color coded to identify the severity of erosion and/or the stability of the bank conditions on both sides of the river. This is the first attempt in the history of the Kankakee River investigation that such detailed bank condition maps have been prepared.

Table 9. Parameters Used in Describing Bank Conditions

Classification	*Parameters*	*Description*
Bank Features	Bank angle	Approximation in degrees
	Bank height	Approximation in feet
	Soil composition	Universal soil classification codes, also noted homogeneous or composite soils
	Bank attributes	Mature trees, pasture, weeds, rocks, graded land, and artificial structures
	Stable or erosion	Color coded with assigned Attributes
Erosion/Deposition Features	Scarp	Location and height
	Berm	As observed
	Bench	Width, angle, soil types
	Tension cracks	As observed
	Horizontal soil layer or lenses	As observed
	Mass wasting	Location and height
	Rotational slip	
	Plane slip	
	Undercut below water stages	
	Undercut below tree roots	Location and degree
	Down trees with bank failures	As observed
	Trees with exposed roots	As observed
	Trees with buried roots	As observed
	Sediment accretion	Size and location noted on map
Island Erosion Features	Head erosion	As observed
	Tail deposition	As observed
Causative Processes	Rework and transport by	
	Current	
	Waves	
	Constrictions	
	Piping/seepage	
	Surface drainage	
	Animal activities on bank	
	Human activities on bank	
Bed Features	Substrate	Gravel, rocks, sand, sand bars, bed rocks
	Depth	Measured sounding depths

Table 10. Unified Soil Classification System

Major division		*Type*	*Letter symbol*	*Typical names*
COARSE-GRAIN SOILS >50 percent of material is retained on #200 sieve	GRAVELS >50 percent of Coarse fraction is Retained on #4 sieve		GW	gravel, well graded, gravel-sand mixtures, little or no fines
		Clean gravels	GP	gravel, poorly graded, gravel-sand mixtures, little or no fines
		Gravels with fines	GM	silty gravel, gravel-sand-silt, mixtures
			GC	clayey gravel, gravel-sand-clay mixtures
	SAND >50 percent of coarse fraction passes #4 sieve	Clean sands	SW	sand, well graded, gravelly sands
				sand, poorly graded, gravelly sands
		Sands with fines	SM	silty sand, sand-silt mixtures
			SC	clayey sand, sand-clay mixtures
FINE-GRAINED SOILS >50 percent of material passes a #200 sieve		Silts and clays LL<50	ML	silt and very fine sand, silty or clayey find sand or clayey silt
			CL	lean clay, sandy clay, silty clay, of low to medium plasticity
		Silts and clays LL>50	OL	organic silts and organic silty clays of low plasticity
			MH	silt, fine sandy or silty soil with high plasticity
			CH	fat clay inorganic clay of high plasticity
			OH	organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		PT		peat, and high organic soil

Notes:
#4 sieve: particles with diameter of 4.75 mm or less can go though.
#200 sieve: particles with diameter of 0.075 mm or less can go through.
LL: Liquidation Limit

Source: Waterways Experiment Station (1982)

General Description of Indiana Bank Conditions

Channelization of the river in Indiana by public and private groups was completed by 1918 (Bhowmik et al., 1980). The channel is generally trapezoidal in shape. High water marks were generally visible at the top of the scarps. Eddies induced by the presence of trees and tree roots during periods of flood were the major cause of bank erosion. In general, mature trees on bank slopes and on the top of the bank were observed. The following is a description of the bank conditions for each of the surveyed quad maps. The locations are given in Figure 24. For definitions for many technical terms used in the subsequent discussions, the readers are referred to the Glossary given in Appendix D.

Kingsford, IN: Regions of undercut root zones, mass wasting, and slip failures were prevalent along this reach. Bank height was generally 8 to 12 feet and bank slope was greater than 70°. SC type soils were on the right hand side (RHS), while those on the left hand side (LHS) were SM type soils. Water depth in this reach was generally 3 feet during the survey. The RHS and LHS were based on someone standing in the mid-channel and looking in the downstream direction. Definitions of mass wasting, SC, and SM soil types are given in the Glossary in Appendix D.

Knox West, IN: Several localized mass wasting sites were observed. A more severe bank erosion site was also observed. Sand lenses near the base of the scarp indicate the composite soil structure of the bank along this portion of the reach. Riprap and sheet piling have been installed along a few sections of this reach. Trucks and other vehicles travelling on the crest of the riverbanks may be contributing to the local bank failures along this reach. Vegetation along both riverbanks includes tall mature trees. Several logjams were encountered. Bank height on the RHS varied between 8 and 12 feet with rather steep angles. Soil types varied between SC and SM. Sand lenses within the banks were occasionally visible nearby and above the water level. Bank height on the RHS ranged from 8 to 10 feet; bank slope varied between 45° and 60°.

English Lake, IN: Vegetation along both riverbanks includes tall mature trees. Banks were higher than 12 feet. Exposed tree roots became less frequent; several logjams and severe bank failures were observed. In the SM/SC portion of the reach, erosion and bank failure may be related to the soil type, composite bank structure, local trees, and tree roots. Riprap protected a few river bends and contractions or transition zones. In sandstone and rock reaches, erosion occurred where SM or SC soil types and sand lenses were present. Bank material soil types changed dramatically from SM and SC to sandstone and rock, a short distance downstream from the Chesapeake & Ohio Pennsylvania Railroad Bridge.

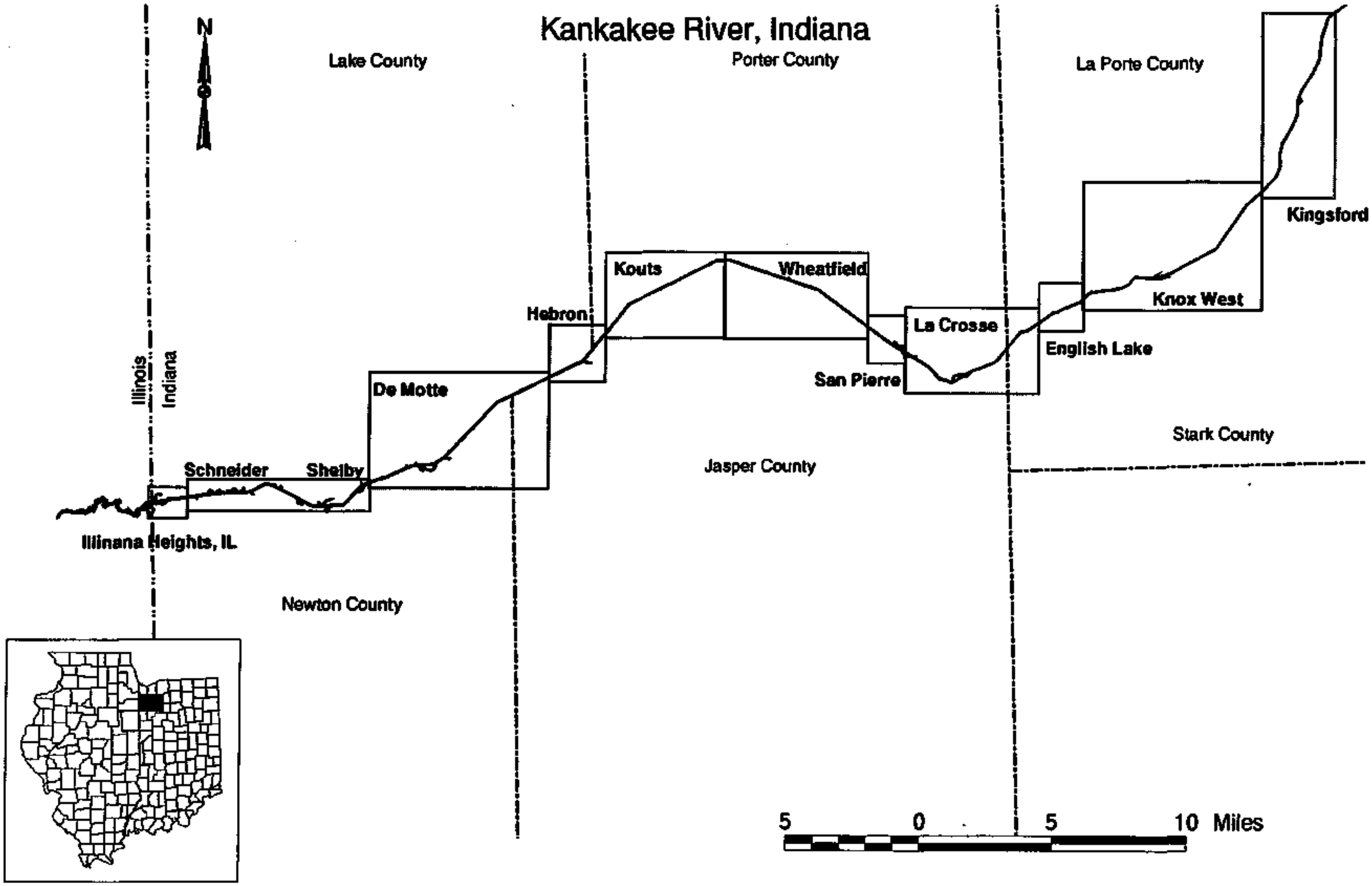


Figure 24. Index map for Indiana Bank Condition Survey

La Crosse, IN: Bank material was primarily sand. Along this section, 1 to 2 foot scarps at the water's edge were common. A single isolated 6 foot scarp (see Appendix D, Glossary) on the RHS was observed along this reach where bank height was generally about 8 to 10 feet. Another mass wasting site was observed between sections of riprap. Shells were observed along the riverbank.

San Pierre, IN: Bank materials consisted of mainly sand and coarse sand. Vegetation along both riverbanks includes tall mature trees. Bank slope angles were in the range of 30° to 45°. Downed trees were present along the water's edge, but logjams may have been cleared by local residents. Some isolated rural residences and some abandoned buildings were located along the river. Main erosion features include scarps at the water's edge and regions of mass wasting.

Wheatfield, IN: Steeply sloping sand benches have developed along the river. Some scarps occurred above these sand benches. Along this reach, the soil type gradually changed from SM and SC to SP (see Appendix D, Glossary) soil types. A logjam was encountered, and downed trees were commonly observed along the water's edge.

Kouts, IN: Bank material soil type was predominantly SP with some SC soil types. Bank height was in the range of 10 to 20 feet with bank slopes in the range of 60°. Erosion features included mass wasting and scarps above the bench. As soil types transitioned to SP types, piping features were observed. Seepage and high-flow river forces that interact with the trees and tree roots along the water's edge have contributed to bank failures.

Hebron, IN: Bank material soil type was predominantly SP with some SC soil types. Bank height was in the range of 12 to 15 feet with a slope in the range of 45°. Scarps formed along downed tree sites and were common in the vicinity of human-made structures. Several sections of riprap had been installed.

De Motte, IN: Scarps formed along downed tree sites and were common in the vicinity of human-made structures. A 20 to 25 foot wide sand bar was observed downstream of the Stone Road Bridge.

Shelby, IN: Entering the Kankakee Marsh, soil types changed from SP to ML (see Appendix D, Glossary) or SM with a few remaining sections of SP. Mild benches with trees were observed. Erosion features were scarps at the water's edge associated with downed trees and seepage. Some mass wasting sites were observed at the outside of bends. Piping was also present along the lower bank. Banks along residential areas were protected.

Schneider, IN: This section of river flows through the La Salle State Fish and Wildlife Area. Dominant soil type was ML. Sand covered ML soil type benches were commonly observed. Many tree roots were exposed along this reach. Scarps at the water's edge and piping were common erosion features. There were indications of erosion due to waves and tree-induced flow turbulence during periods of high flow. Banks along residential areas or nearby water bodies close to the river were protected.

Illiana Heights: At the State Line Bridge, the riverbank profile changed dramatically from a trapezoidal-shaped channel in Indiana to a meandering river without dominant levees in Illinois. Bank material consisted of SP type soils, east of the bridge. Bench features were common, and only a few mild scarps at the water's edge were observed.

General Description of Illinois Bank Conditions

Channel features in Illinois were much more variable including long pool-riffle sequences, rock ledges and sand bars, broad and sharp meanders, and islands. General bank features in Illinois ranged from sand-and-gravel deposits along the water's edge to mild bank slopes and human-made graded slopes to natural rock cliffs, and human-made bank protection structures. Dwellings located within 100 feet of the riverbank were common. Figure 25 shows an index map of the Kankakee River in Illinois referred to in the following sections:

A - B, IL: A large sand bar was observed beneath the Illinois-Indiana State Line Bridge extending approximately 500 feet into Illinois. Local residents mentioned that there had not been any major flood in the past two or three years to wash away this sand deposit. Open channel water depths in this reach were approximately 2 to 3 feet. Along this reach, the river meandered sharply and frequently. Some sand deposits were observed on both sides of the main channel, especially in the lower portions of this reach. Most residential areas were protected by bank protection structures. Trees were on the lower bank region along the water's edge where SP type sediment deposits have buried tree roots. Scarps revealed ML soil types beneath the SP soil type. Scarps at the water's edge and scarps associated with piping were common erosion features. Local scour features were visible along the bank behind downed trees. Several regions were observed where the root zone of mature trees had been partially undercut above the water's edge.

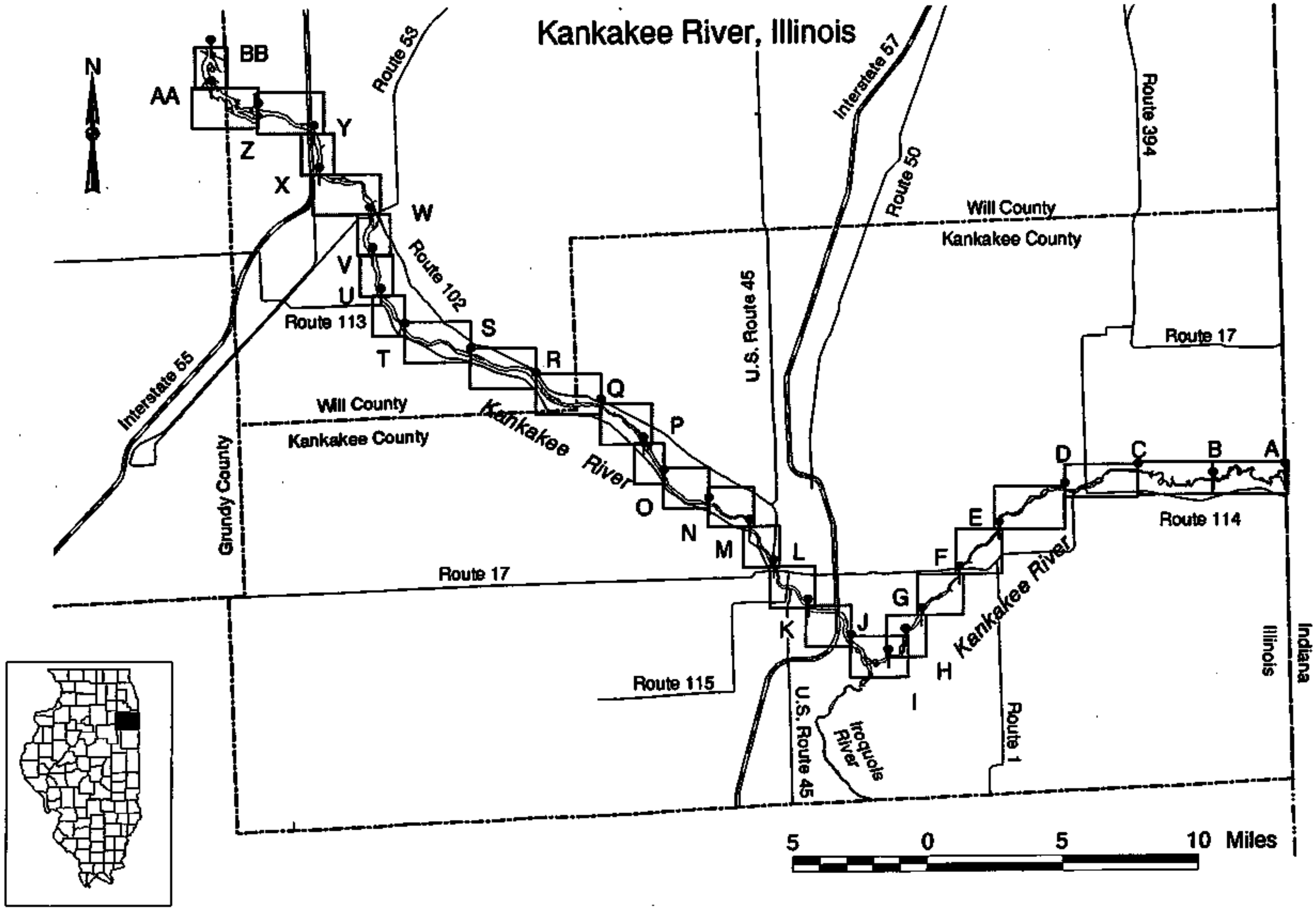


Figure 25. Index map for Dlinois Bank Condition Survey

B - C, IL: Water depths varied between 1.5 and 4 feet. Larger sand deposits were observed along the water's edge. Scarps at the water's edge primarily occurred downstream of or along the opposite bank of residential areas where bank protection structures had been installed. Seepage lines on scarped banks were common. Other bank erosion features included undercut root zones and scour behind downed trees.

C - D, IL: Several in-channel, lens-shaped islands were observed along this reach. The heads of these islands were commonly eroded. Water depths varied between 2 and 3 feet. The river started to widen and become more shallow near sample point KKRIL57. Downstream of Momence, bedrock structures and sand deposits become dominant channel features. Between sample points KKRIL59 and KKRIL60, the water depth was 1 to 1.5 feet deep in a solid bedrock channel. Most of the bank along developed property was protected.

D - E, IL: Solid bedrock structures transitioned to sandy beds after sample point KKRIL61. Water depths gradually increased from 2 to 3 feet along this reach. Sand bars were spread throughout the width of the main channel, with intermittent gravel deposits between the sand bars. The river width narrowed near large islands. River meandering became more frequent. Sand deposit accumulations were observed along the bank. Erosion features such as scarps and undercuts occurred at the head of or along the sides of islands. Residential riverbanks were protected by human-made structures.

E - F, IL: The channel bed material alternated between gravel and sandy bed deposits. Water depths varied between 2 and 8 feet, exhibiting clear riffle and pool features. The numbers and sizes of islands diminished, but sand deposits along the riverbanks remained frequent. Exposed tree roots and small scarps at water's edge were common along this reach of the river. Just upstream of the Route 17 Bridge, the river channel was defined by a long rocky ledge.

F - G, IL: Ripple and pool features were clearly exhibited. Exposed tree roots and minor scarps at the water's edge were main erosion features along the natural riverbanks. Downstream of the Route 17 Bridge a large region of mass wasting was observed. The head of the island within this reach was severely eroded. Bank materials consisted mainly of ML soil types.

G -I, IL: Channel bed materials consisted of mainly bedrock with a few sand deposits. A long sand bar deposit was located across from the large island upstream of Aroma Park. Downed trees, minor scarps, and some piping features were the main erosion features along the generally natural and relatively stable river bank. A small region directly upstream of a protected bank section showed some moderate to severe erosion near Aroma Park. Bank materials consisted of SP, SM, and ML soil types.

I - J, IL: Large sand deposits were common. Some mid-channel sand deposits occupied the entire width of the river. Water depth varied from 0.5 to 2 feet near the railroad bridge at Aroma Park. Water depth increased near the confluence of the Kankakee and Iroquois Rivers from 4 feet to more than 12 feet. Downstream of the Iroquois River confluence, most of the bank is protected. Exposed tree roots were the main cause of bank erosion. Bank material consisted of mainly SP type soils. Steep channel sand deposits were noted at the confluence.

J - K, IL: In this section of the river, several large sand deposits have formed on the toes of the islands. One large continuous sand deposit extended more than one-half mile and filled approximately half of the channel width along the right descending bank (RDB). Immediately upstream of the Interstate 57 Bridge, large sediment deposits have accumulated along both banks. Mid-channel depth varied from 8 to 10 feet. Most of the riverbank was protected along this reach. Moderate to severe erosion was occurring near the river bend at the Interstate 57 Bridge. Steep benches with downed trees were the main bank erosion features along this section. Downstream and adjacent to the Interstate 57 Bridge, a 6 foot scarp at the water's edge has caused some severe bank erosion. Severe bank erosion was also occurring at the mouth of Bar Creek Ditch across from the Kankakee City Waterworks.

K - L, IL: This section of the river flows through the city of Kankakee and includes river sections upstream and downstream of the dam at Jobbers Park. Islands were not observed in this reach. The banks were almost entirely protected. Unprotected bank sections were stable or showed minor bank erosion. Channel bed material downstream of the dam consisted of large rock and gravel. Water depth increased from 0.5 feet downstream of the dam to 8 feet at the bend of the river near Bird Park where the channel was very broad. Channel bed material consisted of pea-sized gravel and shells.

L - M, IL: Bank conditions were stable, consisting of mildly sloping graded banks with mature trees. Channel bed material consisted of gravel with one stretch of sandy bottom followed closely by a group of closely spaced sand deposits. Water depth varied from less than 1 foot to 4 feet. A 4 foot scarp, near the wastewater treatment plant showed localized erosion within ML type soil.

At this location there exists a geological transition. A continuous layered sandstone outcrop strata bounds the river starting from the west end of the city of Kankakee continuing through Kankakee State Park, and diminishing upstream of the city of Custer Park. These layered sandstone cliffs were approximately 50 feet high. Evidence of weathering, jointing, and caving of the cliff faces was observed.

M - O, IL: Banks along this section were stable or protected by rock cliffs. Channel bed material consisted mainly of gravels on bedrock. A few sand deposits had formed near the water's edge and on the toe of the island. Water depth ranged from 1 to 4 feet.

O - P, IL: Several large islands and many small islands were observed near and downstream of the town of Altorf. Bank conditions were stable or protected by rock cliffs. Channel bed materials consisted mainly of gravels and bedrock. About 2 miles upstream of Rock Creek, a water depth of greater than 12 feet was measured. At the mouth of Rock Creek, the channel depth was 3 feet.

P - R, IL: Banks were mostly protected by rock cliffs with little or no notable erosion conditions. Rocky bench and banks were commonly steeper than 20 degrees. A section of moderate bank erosion conditions was observed where some seepage was occurring on a mildly sloping bench of ML type soil. Sand deposits were observed along the Smith Islands.

R - S, IL: Bank erosion conditions varied greatly along this section. Moderate bank erosion conditions with 2 to 4 foot scarps on SP soil type benches were observed on both sides of the river. Minor erosion was occurring within SM and ML type soils. A 6 foot scarp at the water's edge was observed on Hoffman Island. Channel depth varied from 4 feet to more than 8 feet.

S - T, IL: Bank erosion conditions were primarily stable. A few areas of moderate erosion were observed with 2 foot scarps on the bench in SM, ML, and SP type soils. A 4 foot scarp was observed in SM type soil. Channel bed material were cobbles with occasional sand deposits. Channel depths varied from 2 feet to more than 9 feet.

T - U, IL: Bank erosion conditions were primarily stable, except for the protected section downstream and across from the mouth of Horse

Creek. Immediately downstream of Horse Creek, a 3 to 4 foot scarp was observed in SM and ML type soils. Channel bed material was sand and gravel. Sand deposits also flanked the outlet of Horse Creek.

U - V, IL: Bank erosion conditions were primarily stable with low bank height, mature trees along the water's edge, some graded banks, and a section of gravel bench. A 2 to 3 foot scarp at the water's edge in ML type soil was observed across from and along the length of the town of Lakewood Shores. Channel depths ranged from 1 to 3 feet.

V - W, IL: This section of the river flowed through the city of Wilmington and includes river sections upstream and downstream of the Wilmington Spillway. Bank erosion conditions were primarily stable or protected. Minor erosion was observed in residential areas on narrow benches of GM and GC (see Appendix D for Glossary) type soils. The spillway was located at the upstream end of Island Park. Upstream of the dam, some sections of bedrock were as shallow as 0.5 feet. Some sand-and-gravel deposits were observed across the width of the channel downstream of the spillway. The rock-protected bank of Island Park was overlaying GW bench material. Channel bottom materials were mainly gravels and bedrock.

W - X, IL: The section from the Wilmington Spillway to the dominant westerly bend of the river at the Des Plaines State Conservation Area was less than 1 foot in depth. Several gravel deposits were observed between the railroad bridge and the mouth of Forked Creek. A rock cliff entirely protected the west bank to the bend. Downstream of the sewage disposal facility, on the east bank, minor bank erosion conditions were observed on a low, wide bench of ML type soil. Severe erosion conditions were observed on a section of the island facing this east bank. Downstream of the westerly bend at the Des Plaines State Conservation Area, water depth ranged from 6 to 9 feet. Channel bed features included rocks, gravel bars, and sand deposits. In general, the banks on this section were well vegetated on a low bench with trees.

X - Y, IL: The bank erosion conditions were primarily stable with a short section of protected bank. Channel bed materials were primarily gravels on bedrock. Water depth varied from 0.5 to 2 feet.

Y - Z, IL Bank erosion conditions were stable. Channel bed materials were primarily gravels on bedrock. Water depths varied from 0.5 to 2 feet from the beginning of this reach to near the island between the

Interstate 55 Bridge and the railroad bridge. The height of the northern bank varied from 2 feet to 4 feet along a low bench with 10-year-old trees. Bank materials were considered to be SP or SM type soils. The southern bank height was about 20 feet with an approximate 45 degree slope. Water depth varied from 0.5 to 4 feet.

Z - AA, IL: Bank erosion conditions were mainly stable or protected, except on Bardwell and Mulberry Islands where some moderate erosion and a section of severe erosion conditions were observed. Protected banks were located along residential and developed areas. Channel depth varied from 10 to 12 feet. A large, submerged, stump area was observed outside of a bend near the end of this reach. Channel bed material was mainly silty sand.

AA - BB, IL: Bank erosion conditions were stable or were protected along residential sections. Channel depths were 12 feet to 18 feet at the confluence. Channel bed material was mainly silty sand.

Remaining Work

During the rest of the project duration, identified sand bars will be surveyed, river cross sections will be measured wherever needed, available data will be entered into a database, and a report will be prepared and submitted to the sponsor.

Summary

This interim report reviews work completed within the first nine months of the project. It summarizes all of the existing streamflow records for Illinois and for two stations from Indiana, lists the available literature, and describes the field trip. Analyses of the bed and bank material samples collected during the field trip have also been included in the report. Maps of the bank lines from the Route 30 Bridge in Indiana to the confluence of the Kankakee River with the Des Plaines River have been completed.

Bank conditions of the entire main stem of the Kankakee River from Route 30 Bridge in Indiana to its confluence with the Des Plaines River have also been summarized. This included general bank conditions, shoreline stability, erosion sites and severity, apparent pumping stations, log and tree jams and other features.

Additional work on the surveying of the river and sand bar geometries is now being done, A final report will be prepared that summarizes all of the existing and newly collected data on hydraulics, hydrology, sediment transport, bed and bank material distributions, and sedimentation patterns.

References Cited

Bhowmik, N.G., A.P. Bonini, W.C. Bogner and R.P. Byrne. 1980. *Hydraulics of Flow and Sediment Transport in the Kankakee River in Illinois.* Illinois State Water Survey Report of Investigation 98, Champaign, IL.

Bhowmik, N.G., T.W. Soong, and T. Nakato. 1997. *Bank Erosion Field Survey Report on the Upper Mississippi River and Illinois Waterway.* Interim Report for the Upper Mississippi River - Illinois Waterway System Navigation Study. U.S. Army Corps of Engineers - St. Paul, Rock Island, and St. Louis Districts.

Cravens, S.J., S.D. Wilson, and R.C. Barry. 1990. *Regional Assessment of the Ground-Water Resources in Eastern Kankakee and Northern Iroquois Counties.* Illinois State Water Survey Report of Investigation 111, Champaign, IL.

Indiana Department of Natural Resources. 1976. *Kankakee River Basin. Indiana: Report on the Water and Related Land Resources.* Indiana Department of Natural Resources, Indianapolis, IN.

Ivens, J.L., N.G. Bhowmik, A.R. Brigham, and D.L. Gross. 1981. *The Kankakee River: Yesterday and Today.* Illinois State Water Survey Miscellaneous Publication 60, Champaign, IL.

Knapp, H. Vernon. 1998. *Kankakee River Area Assessment Vol. 2.* Illinois Department of Natural Resources, Springfield, IL.

Knapp, H.V. 1992. *Kankakee River Basin Streamflow Assessment Model: Ilydrologic Analysis.* Illinois State Water Survey Contract Report 541, Champaign, IL.

LaTour, J.K. 1991. *Determination of Water Use in Rockford and Kankakee Areas, Illinois.* U.S. Geological Survey Water-Resources Investigations Report 90-4166. U.S. Geological Survey, Urbana, IL.

Leverett, F. 1896. *The Water Resources of Illinois.* In Seventeenth Annual Report, Part 2, pp. 740-741, U.S. Geological Survey, Washington, D.C.

Singh, K.P., G.S. Ramamurthy, and I.W. Seo. 1988. *7-Day 10-year Low Flows of Streams in the Rock, Spoon, La Moine, and Kaskaskia Regions.* Illinois State Water Survey Contract Report 440, Champaign, IL.

Waterways Experiment Station. 1982. *The Unified Soil Classification System. Technical Memorandum No. 3357. Appendix A: Characteristics of Soil Groups Pertaining to Embankments and Foundations. Appendix B: Characteristics of Soil Groups Pertaining to Roads and Airfields.* Geotechnical Laboratory, U.S. Army Corps of Engineers, Waterway Experiment Station, Vicksburg, MS.

Appendices

Appendix A. Related Literature

Literature Survey

Adams, J. Rodger, and A.P. Bonini. *Kankakee Dam discharge characteristics.* Contract Report 383. Champaign, IL: Illinois State Water Survey, 1986.

Areawide Water Quality Management Plan. Chicago, IL: Northeastern Illinois Planning Commission. 1978. (15 v.)

Barker, B., J.B. Carlisle, and R. Nyberg. *Kankakee River Basin Study: A Comprehensive Plan for Water Resource Development.* Springfield, IL: Illinois Bureau of Water Resources, 1967.

Berggren, D.J., D.L. Reinertsen, and M.M. Killey. *St. Anne-Momence area: Kankakee County, Kankakee and Momence 15-minute quadrangles.* Guide Leaflet 1975 B-C. Champaign, IL: Illinois State Geological Survey, 1976.

Bhowmik, N.G. "Measurement of Suspended Sediment and Bed Load in Sand Bed Channels and the Associated Problems." *Erosion and Sediment Transport Measurement: Proceedings of the Florence Symposium, International Association of Hydraulic Scientists, June 22-26,1981*, pp. 295-303. 1981.

Bhowmik, N.G. *Physical Impacts of Human Alterations Within River Basins: The Case of the Kankakee, Mississippi, and Illinois Rivers.* LTRMP 93-R004. Onalaska, WI: U.S. Fish and Wildlife Service, Environmental Management Technical Center. 1993. Reprinted from: Proceedings of the XXIII Congress of the International Association for Hydraulic Research, Ottawa, Canada, 1989.

Bhowmik, N.G., and J.R. Adams. "Sediment Transport, Hydraulic Retention Devices, and Aquatic Habitat in Sand-Bed Channels." *Hydraulic Engineering: Proceedings of the 1990 National Conference.* American Society of Civil Engineers, New York. 1990.

Bhowmik, N.G., and W.C. Bogner. *Sediment Transport and Hydraulics of Flow in the Kankakee River, Illinois: Phase II.* Contract Report 282. Champaign, IL: Illinois State Water Survey. 1981.

Bhowmik, N.G., and A.P. Bonini. "A Historical Review of the Kankakee River Basin Development." *Transactions of the Illinois State Academy of Sciences,* v. 74, no. 1-2 , pp. 203-216. 1989.

Bhowmik, N.G., A.P. Bonini, W.C. Bogner, and R.P. Byrne. *Hydraulics of Flow and Sediment Transport in the Kankakee River in Illinois.* Report of Investigations 98. Champaign, IL: Illinois State Water Survey. 1980.

Bobo, L.L., and D.E. Renn. *Water-Quality Assessment of the Porter County Watershed, Kankakee River Basin, Porter County, Indiana.* Open File Report 80-331. Indianapolis: U.S. Geological Survey. 1980.

Brigham, A.R., L.B. Suloway, and L.M. Page. *The Effects of Sedimentation on Aquatic Life of the Kankakee River, Phase II: Quantitative Studies and Threatened, Endangered, and Rare Species.* Document No. 81/37. Chicago: Illinois Department of Energy and Natural Resources. 1981.

Butts, T. A., and E.L. Evans. *Sediment Oxygen Demand Studies of Selected Northastern Illinois Streams.* Circular 129. Champaign, IL: Illinois State Water Survey. 1978.

Campbell, J.L. *Report Upon the Improvement of the Kankakee River and the Drainage of the Marsh Lands in Indiana.* Indianapolis: W.B. Burford, State Printer. 1882.

Capt. Gougar and His Steamboats: Excursions on the Kankakee River. Kankakee, IL: Lindsay Publications Inc. for the Kankakee County Historical Society. 1987.

Changnon, S.A., D. Winstanley, and K.E. Kunkel. *An Investigation of Historical Temperature and Precipitation Data at Climate Benchmark Stations in Illinois.* Circular 184. Champaign, IL: Illinois State Water Survey. 1997.

Chicago Aerial Survey. *Kankakee River.* Springfield: Department of Public Works and Buildings, Illinois Division of Waterways. 1970.

Construction and Preoperational Aquatic Monitoring Program for the Kankakee River. Annual report: Braidwood Station. Champaign, IL: Illinois Natural History Survey. 1978.

Cravens, S.J., S.D. Wilson, and R.C. Barry. *Regional Assessment of Ground-Water Resources in Eastern Kankakee and Northern Iroquois Counties.* Report of Investigation 111. Champaign, IL: Illinois State Water Survey. 1990.

Cravens, S.J., S.D. Wilson, and R.C. Barry. *Summary Report: Regional Assessment of the Ground-Water Resources in Eastern Kankakee and Northern Iroquois Counties.* Contract report 456. Champaign, IL: Illinois State Water Survey. 1989.

Demissie, M, N.G. Bhowmik, and J.R. Adams. *Hydrology, Hydraulics, and Sediment Transport, Kankakee and Iroquois Rivers.* Report of Investigation 103. Champaign, IL: Illinois State Water Survey. 1983.

Demonstration Project: Study for Control of Ice Jam Flooding on Kankakee River: Will and Grundy Counties. Springfield: Illinois Department of Transportation. 1986.

The Development Plan, Kankakee River State Park. Peoria, IL: Scruggs and Hammond. 1959.

Dickson, B.C. *Kankakee River Fishes of the Braidwood Station Aquatic Monitoring Area, August 1987.* Aquatic Biology Technical Report 88/01. Champaign, IL: Illinois Natural History Survey. 1988.

The Effects of Sedimentation on Aquatic Life of the Kankakee River: Phase I. Champaign, IL: Illinois Natural History Survey. [1979].

Ehrlinger, H.P., J.M. Masters. *Commercial Feldspar Resources in Southeastern Kankakee County, Illinois.* Illinois Mineral Notes 56. Champaign, IL: Illinois State Geological Survey. 1974.

Ehrlinger, H P., W.G. Ten K, and H.W. Jackman. *Kankakee Dune Sands as a Commercial Source of Feldspar.* Illinois Mineral Notes 38. Champaign, IL: Illinois State Geological Survey. 1969.

Ekblaw, G.E. *Kankakee Arch in Illinois.* Circular 40. Champaign, IL: Illinois State Geological Survey. 1938. Reprinted from: Geological Society of America Bulletin, v. 49, pp. 1425-1430, 1938.

Elmore, G.R. *Historical Water Quality Data: Des Plaines, DuPage, and Kankakee River Basins.* Staff Paper 17. Chicago: Northeastern Illinois Planning Commission. 1977.

Final Environmental Statement Related to Operation of Dresden Nuclear Power Station, Units 2 and 3, Commonwealth Edison Company. Washington, D.C.: U.S. Atomic Energy Commission. 1973.

Final Environmental Statement Related to the Proposed Braidwood Station, Commonwealth Edison Company. Washington, D.C.: U.S. Atomic Energy Commission. 1974.

Fins and Feathers Sportsman's Map: Kankakee River, Illinois. Chicago, IL: Fins and Feathers Sportsmens's Club, 1986.

Flemal, R.C. *Analysis of Water Quality, Kankakee River Basin, Illinois.* DeKalb, IL: Illinois Water Information System Group. 1981.

Flood Insurance Rate Map: Village of Sun River Terrace, Illinois, Kankakee County. Washington, D.C.: Federal Emergency Management Association. 1997.

Frankie, W.T. *Guide to the Geology of the Kankakee River State Park Area, Kankakee County, Illinois.* Field Trip Guidebook 1997 A-B. Champaign, IL: Illinois State Geological Survey. 1997.

Fraser, G.S., N.K. Bleuer. *Geologic Framework of the Aquifers in the Kankakee River Lowland.* Occasional Paper 60. Bloomington: Indiana Geological Survey. 1991.

Graham, R.J. *Recreational Fishing in the Kankakee River, Illinois.* Champaign, IL: Illinois Natural History Survey. 1984.

Gross, D.L., and R.C.Berg. *Geology of the Kankakee River System in Kankakee County, Illinois.* Environmental Geology 92. Champaign, IL: Illinois State Geological Survey. 1981.

Harmeson, R.H., and T.E. Larson. *Quality of Surface Water in Illinois, 1956-1966.* Bulletin 54. Champaign, IL: Illinois State Water Survey. 1969.

Harmeson, R.H., T.E. Larson, L.M. Henley, R.A. Sinclair, and J.C. Neill. *Quality of Surface Water in Illinois, 1966-1971.* Bulletin 56. Champaign, IL: Illinois State Water Survey. 1973.

Herricks, E.E., J.W. Eheart,and C.J. Grantzer. *Technical Report: Report of Instream Flow Needs Analysis of the Kankakee River Basin.* Environmental Engineering Series 69. Urbana, IL: University of Illinois, Dept. of Civil Engineering. 1983.

Hey, D.L. *Stream Use Inventory: Kankakee River.* Staff Paper. Chicago: Northern Illinois Planning Commission. 1981.

Historical Water Quality Data: Des Plaines, DuPage, and Kankakee River Basins. Staff paper no. 17. Chicago, IL: Northeastern Illinois Planning Commission. 1977.

Holmes, R.R. *Suspended-Sediment Budget for the Kankakee River Basin, 1993-95.* Open-file report 97-120. Urbana, EL: U.S. Geological Survey. 1997.

Illinois and Michigan Canal. *Levels of the Kankakee River and the Head of the Kankakee Feeder Up to Beards ley's Dam.* [n.p.]. 1856.

Illinois Natural Areas Section. *A Proposal for Dedication of a Nature Preserve at Kankakee River State Park.* Rockford, IL: Illinois Nature Preserves Commission. 1973.

Isaacs, M. C. *The Kankakee: River of History.* [Indiana]: [s.n.]. [1969].

Ivens, J.L., N.G. Bhowmik, A.R. Brigham, and D.L. Gross. *The Kankakee River Yesterday and Today.* Miscellaneous publication 60. Champaign, IL: Illinois State Water Survey. 1981.

Jones, D.W. "A Plan for the Kankakee River Area." M.S. Thesis, Illinois Institute of Technology. Chicago, IL. 1969.

Kankakee River Aquatic Monitoring Program for the Braidwood Station. 2 vol. Champaign, IL: Illinois Natural History Survey. 1981.

Kankakee River Area Assessment. Springfield, IL: Illinois Department of Natural Resources. 1997. (5 vol.)

Kankakee River Basin: Indiana. Washington, D.C.: U.S. Soil Conservation District. 1976.

Kankakee River Basin, Indiana: Report on the Water and Related Land Resources. Washington, D.C.: U.S. Soil Conservation Service. 1976.

Kankakee River Basin Special Study for Land Treatment, Illinois and Indiana: A Report of Soil Erosion Related Problems, Land Treatment Needs, and the Economic and Environmental Effects of Alternative Management System Plans. Washington, D.C.: U.S. Department of Agriculture. 1986.

Kankakee River, Illinois, From Its Mouth to the Illinois State Line. Map. Chicago, IL: United States Engineer Office. 1924.

Kankakee River Master Plan: A Guide for Flood Control and Land Use Alternatives in Indiana. Indianapolis, IN: Kankakee River Basin Commission. 1989.

Kankakee River State Park. Springfield, IL: Illinois Department of Conservation. 1988.

Kankakee River State Park Master Management Plan. Springfield, IL: Illinois Department of Conservation. 1979.

The Kankakee River Valley: An Inventory of the Region's Resources. Springfield: Illinois Office of Realty and Environmental Planning. 1997.

The Kankakee River Valley: An Inventory of the Region's Resources. Springfield, IL: Illinois Department of Natural Resources. 1997.

Kasprowicz, J.M. *Survey of Kankakee River Fishes and Mussels at Illinois Route 53 Bridge in Wilmington, Will County, Illinois.* Champaign, IL: Illinois Natural History Survey. 1985.

Knapp, H. V. *Kankakee River Basin Streamflow Assessment Model: Hydrologic Analysis.* Contract report 541. Champaign, IL: Illinois State Water Survey. 1992.

Kothandaraman, V., R.A. Sinclair, and R.L. Evans. *Water Chemistry of the Illinois Waterway.* Circular 147. Champaign, IL: Illinois State Water Survey. 1981.

Kwak, T.J. *Kankakee River Fishes of the Braidwood Station Aquatic Monitoring Area, August 1986.* Aquatic Biology Technical Report 86/1. Champaign, IL: Illinois Natural History Survey. 1987.

Kwak, T.J. *An Analysis of Environmental and Biotic Factors Affecting Catch Per Unit Effort of Kankakee River Fishes.* Aquatic Biology Technical Report 87/09. Champaign, IL: Illinois Natural History Survey, Aquatic Biology Section. 1987.

Kwak, T.J. *Kankakee River Fishes of the Braidwood Station Aquatic Monitoring Area, July and August, 1985.* Aquatic Biology Technical Report 87/1. Champaign, IL: Illinois Natural History Survey. 1986.

Lamb, J.M. *The Kankakee Co. and Other Attempts to Make the Kankakee River Navigable.* Lockport, IL: Illinois Canal Society. 1979.

Land Treatment Study: Kankakee River Basin Special Report. [Indianapolis, IN]: Kankakee River Basin Commission. 1984.

LaTour, J.K. *Determination of Water Use in Rockford and Kankakee Areas, Illinois.* Water Resources Investigation 90-4166. Urbana, IL: U.S. Geological Survey. 1991.

Letter from the Secretary of War: Transmitting Report of Maj. J. A. Smith, Corps of Engineers, of Survey of Kankakee River, in Indiana and Illinois. [Washington, D.C.]: G.P.O. 1880.

Lewis, R.B. *A Comparison of the Past and Present Freshwater Mussel Fauna of the Kankakee River in Illinois.* Natural History Miscellanea, no. 211. Chicago, IL: Chicago Academy of Sciences. 1980.

Lindsey, G., and D. Sweeney. *Phase II Report - Preliminary Investigation of Small-Scale Hydropower Potential at Five Sites in Illinois.* Illinois Institute of Natural Resources Document No 81/05, January 1981.

Mathewson, A. J. *Map and Profile of Kankakee River from Guard Lock at the Head of Kankakee Feeder to Beardsleys Dam at Aroma.* Indianapolis, IN: U.S. Engineer's Office. 1878.

Mitsch, William J. *Environmental Observations of a Riparian Ecosystem During Flood Season.* WRC report no. 142. Urbana, IL: Univ. of Illinois Water Resources Center. 1979.

Mitsch, W.J., M.D. Hutchinson, and G.A. Paulson. *The Momence Wetlands of the Kankakee River in Illinois An Assessment of Their Value, A Descriptive and Economic Approach to the Appraisal of Natural Ecosystem Function.* Document 79-17. Chicago: Illinois Institute of Natural Resources, Division of Environmental Management. 1979.

Mullady, E. *Ed Mullady's Kankakee River Fisherman's Atlas: Illinois.* 27th ed. [Kankakee, IL]: Sportsman's Letter. 1992.

Nichols, F.F. *The Kankakee: Chronicle of an Indiana River and Its Fabled Marshes.* Brooklyn, NY: T. Gaus' Sons. 1965.

Petitdidier, O.L. *Map of Kankakee River in Illinois.* [S.I.]: [s.n.] 1986.

Phipps, R.L., G.P. Johnson, and P.J. Terrio. *Dendrogeomorphic Estimate of Changes in Sedimentation Rate Along the Kankakee River Near Momence, Illinois.* Water Resources Investigation 94-4190. Urbana, IL: U.S. Geological Survey. 1995.

Plan for flood control project on Kankakee River, Illinois and Indiana for Flood Control. Momence, IL: Kankakee River Preservation Association. 1942.

Profile of Illinois River from Grafton to Mouth of Kankakee Showing Water Levels, Gages, and Other Data. [S.I]: Illinois Rivers and Lakes Commission. 1922.

Profile of Kankakee River in Illinois. [S.I.]: Illinois Rivers and Lakes Commission 1922.

Reinertsen, D.L., Myrna M. Killey, Philip C. Reed, and Ross D. Brower. *Guide to the Geology of the Morris Area: Grundy County and Parts of Kankakee, Kendall, La Salle, and Will Counties, Illinois.* Guide leaflet; field trip guidebook. Champaign, IL: Illinois State Geological Survey. 1992.

Reischauer, B.D., and R.G. Simms. *Hydroelectric Development on the Kankakee River.* ILENR/AE-92-07. Springfield, IL: Illinois Dept of Energy and Natural Resources. 1993.

Report on Development of Hydraulic and Hydrologic Models for Kankakee River Basin, Indiana. [S.I.]: U.S. Soil Conservation Service. 1987.

A Report Upon the Drainage of Agricultural Lands in the Kankakee River Valley, Indiana. [S.I.]: U.S. Department of Agriculture. 1909.

Report on Water Quality Criteria and Plan for Implementation: Indiana Waters of the Kankakee River Basin. Indianapolis, IN: Indiana Stream Pollution Control Board. 1967.

Rust, W.G. *The Effect of River Flooding on Tree Growth in the Momence Wetlands of the Kankakee River.* M.S. Thesis. Illinois Institute of Technology, Environmental Engineering. 1980

Singh, K.P., and J.R. Adams. *Adequacy and Economics of Water Supply in Northeastern Illinois: Proposed Groundwater and Regional Surface Water Systems, 1985-2010.* Contract Report 229. Urbana, IL: Illinois State Water Survey. 1980.

Singh, K.P., G.S. Ramamurthy, and I.W. Seo. *Seven-day ten-year low flows of streams in the Kankakee, Sangamon, Embarras, Little Wabash, and Southern Regions.* Contract Report 441. Champaign, IL: Illinois State Water Survey. 1988.

Skelly, T.M. *Kankakee River Fishes of the Braidwood Aquatic Monitoring Area, July/August 1984.* Aquatic Biology Techncial Report 1985/1. Champaign, IL: Illinois Natural History Survey. 1984.

Skelly, T.M. *Kankakee River Fishes of the Braidwood Aquatic Monitoring Area, August 1983.* Aquatic Biology Technical Report 1984/4. Champaign, IL: Illinois Natural History Survey. 1983.

Smith, W.H. *Strippable Coal Reserves of Illinois. Part 6, La Salle, Livingston, Grundy, Kankakee, Will, Putnam, and Parts of Bureau and Marchall Counties.* Circular 419. Champaign, IL: Illinois State Geological Survey. 1968.

Sule, M.J. *The Life History of the Shorthead Redhorse, Moxostoma Macrolepidotum, in the Kankakee River Drainage, Illinois.* Biological Notes, no. 123 0073-490x. Champaign, IL: Illinois Natural History Survey. 1985.

Terrio, P.J. *Water-quality Assessment of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin: Nutrients, Dissolved Oxygen, and Fecal-indicator Bacteria in Surface Water, April 1987 through August 1990.* Water Resources Investigations Report 95-4005. Denver, CO: U.S. Geological Survey. 1995.

Terrio, P. J.; Nezimek, J.E. *Changes in Cross-Section Geometry and Channel Volume in Two Reaches of the Kankakee River in Illinois, 1959-94.* Water-resources investigation 96-4261. Urbana, IL and Denver CO: U.S. Geological Survey. 1997.

Vierling, P.E. *Illinois Country Canoe Trails: Du Page River, Kankakee River, Aux Sable Creek, Des Plaines River.* Chicago, IL: Illinois Country Outdoor Guides. 1977.

Water Quality Management Basin Plan, Phase I: Kankakee River Basin. Springfield: Illinois Environmental Protection Agency. 1976.

Water Quality Network, 1976 Summary of Data, Volume 2: Illinois, Fox, Sangamon, and Kankakee Basins. Springfield: Illinois Environmental Protection Agency, Division of Water Pollution Control. 1977.

Water Quality Standards: Interstate Waters, Rock River, Fox River, DesPlaines River, Kankakee River and Certain Named Interstate Tributaries: Rules and Regulations. [S.I.]: Illinois Sanitary Water Board 1968.

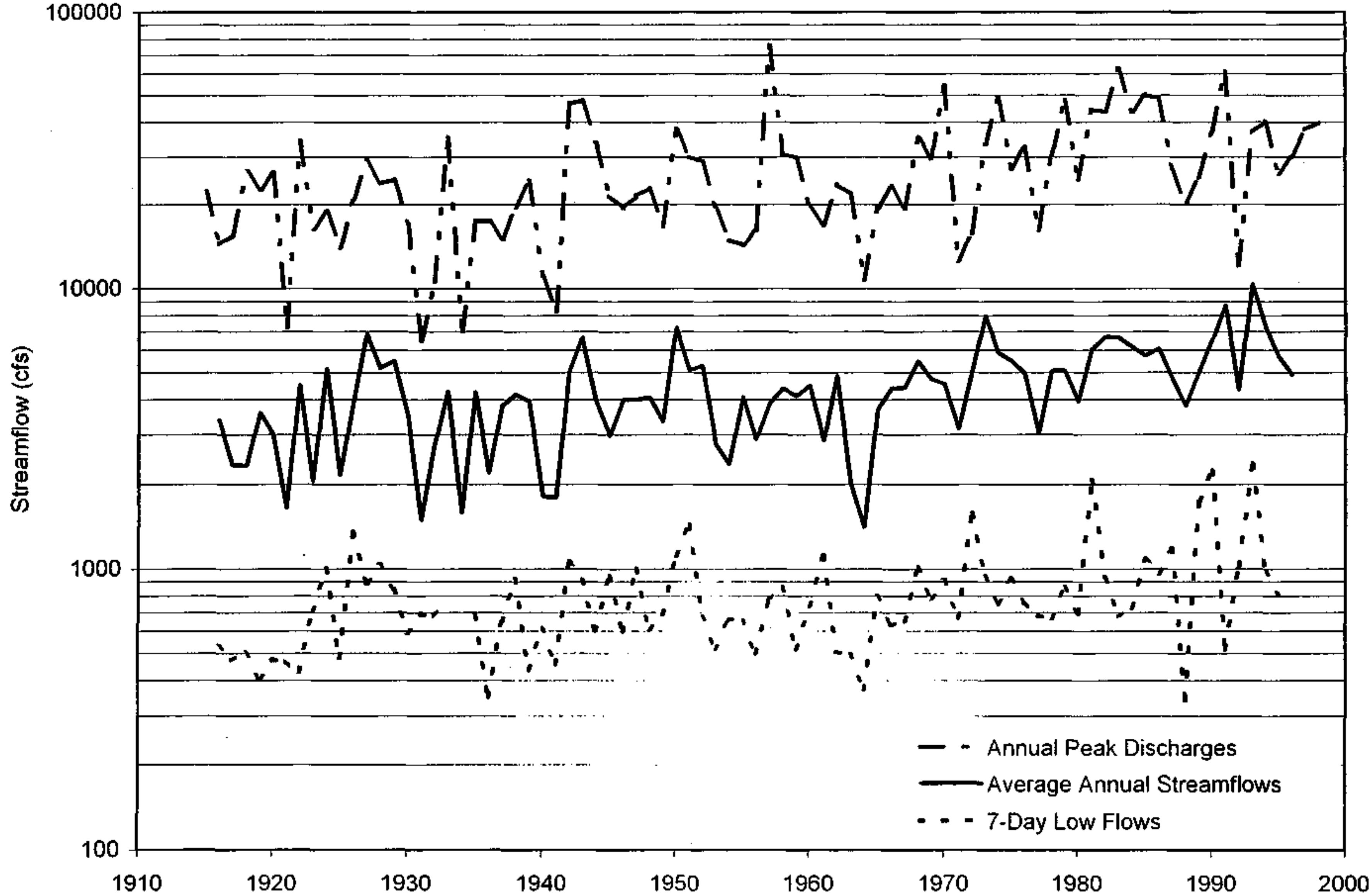
Water Resource availability in the Kankakee River Basin, Indiana. Water Resource Assessment 90-3. Indianapolis: Indiana Department of Natural Resources. 1990.

Weston, B.R. "An Archaeological Survey of the Kankakee and Iroquois River Valleys, Illinois: *A* Casebook in Surface-Survey Theory and Method." M.A. Thesis. Univ. of Illinois at Chicago Circle. Chicago, IL. 1977.

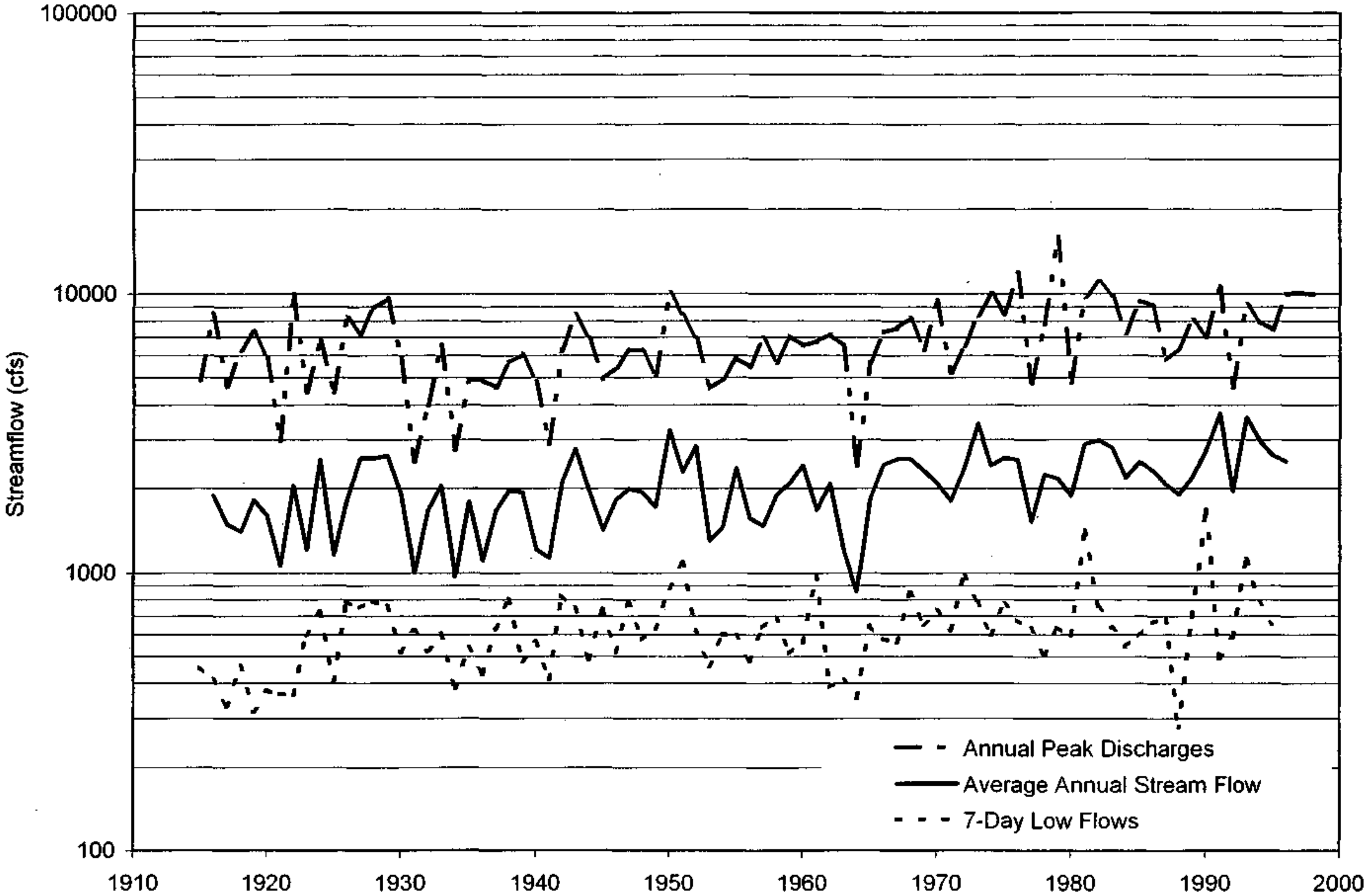
Westview High School Field Biology Class. *A Study of the Distribution of the Kankakee Mallow (Iliamna Remota) and Dominant Plants on a Kankakee River Island.* [Rockford, IL]: Illinois Nature Preserves Commission. 1973.

Wetzel, M.J. *Survey of Kankakee River Fishes and Mussels at Washington Avenue Bridge, FA U 6198, U.S. Routes 45 and 52, City of Kankakee, Kankakee County, Illinois.* Champaign, IL: Illinois Natural History Survey. 1985.

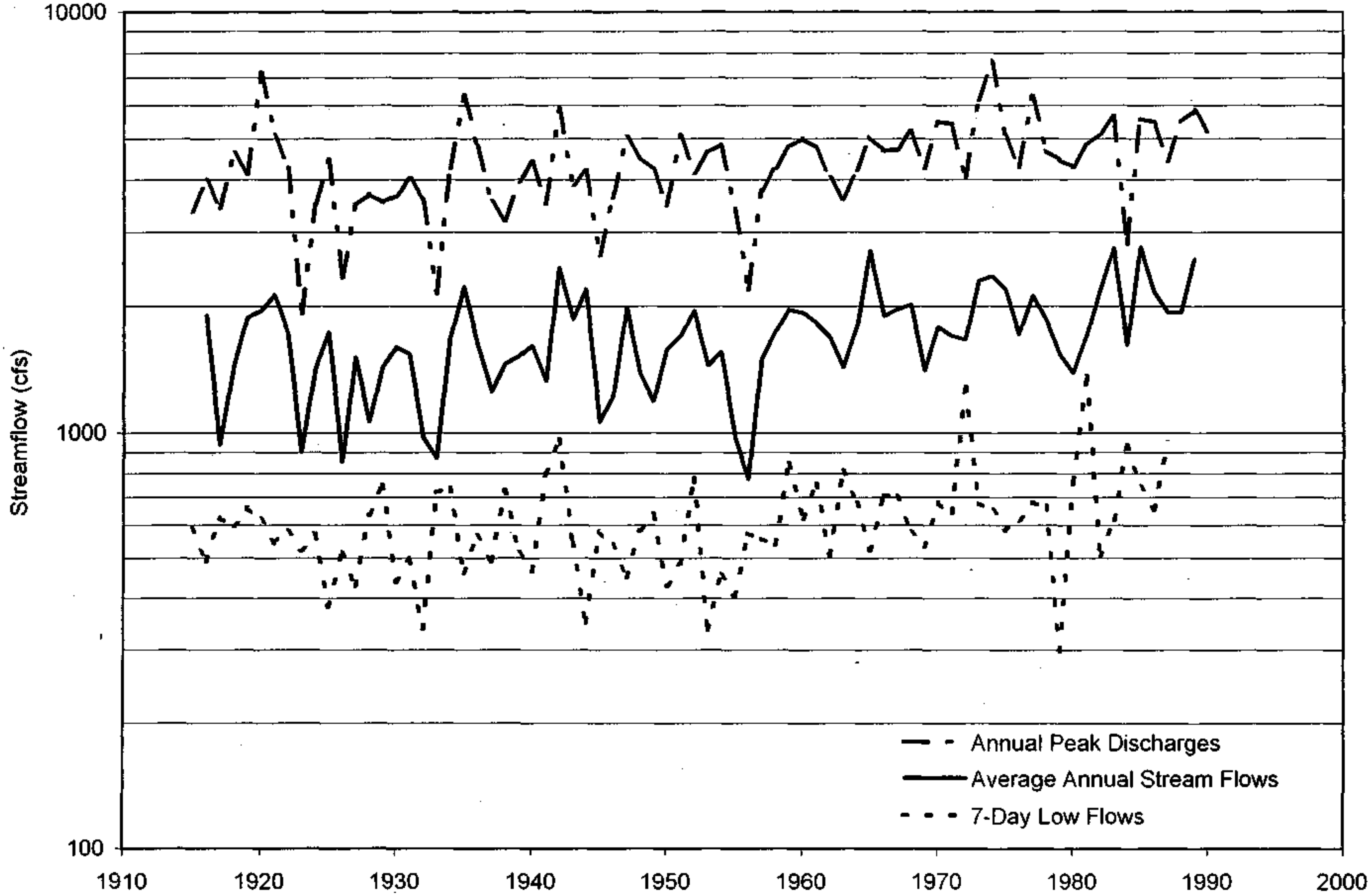
Appendix B. Annual Peak, Average Annual, and Seven Day Low Flows for Seven Gaging Stations on the Kankakee River Basin in Illinois and Indiana



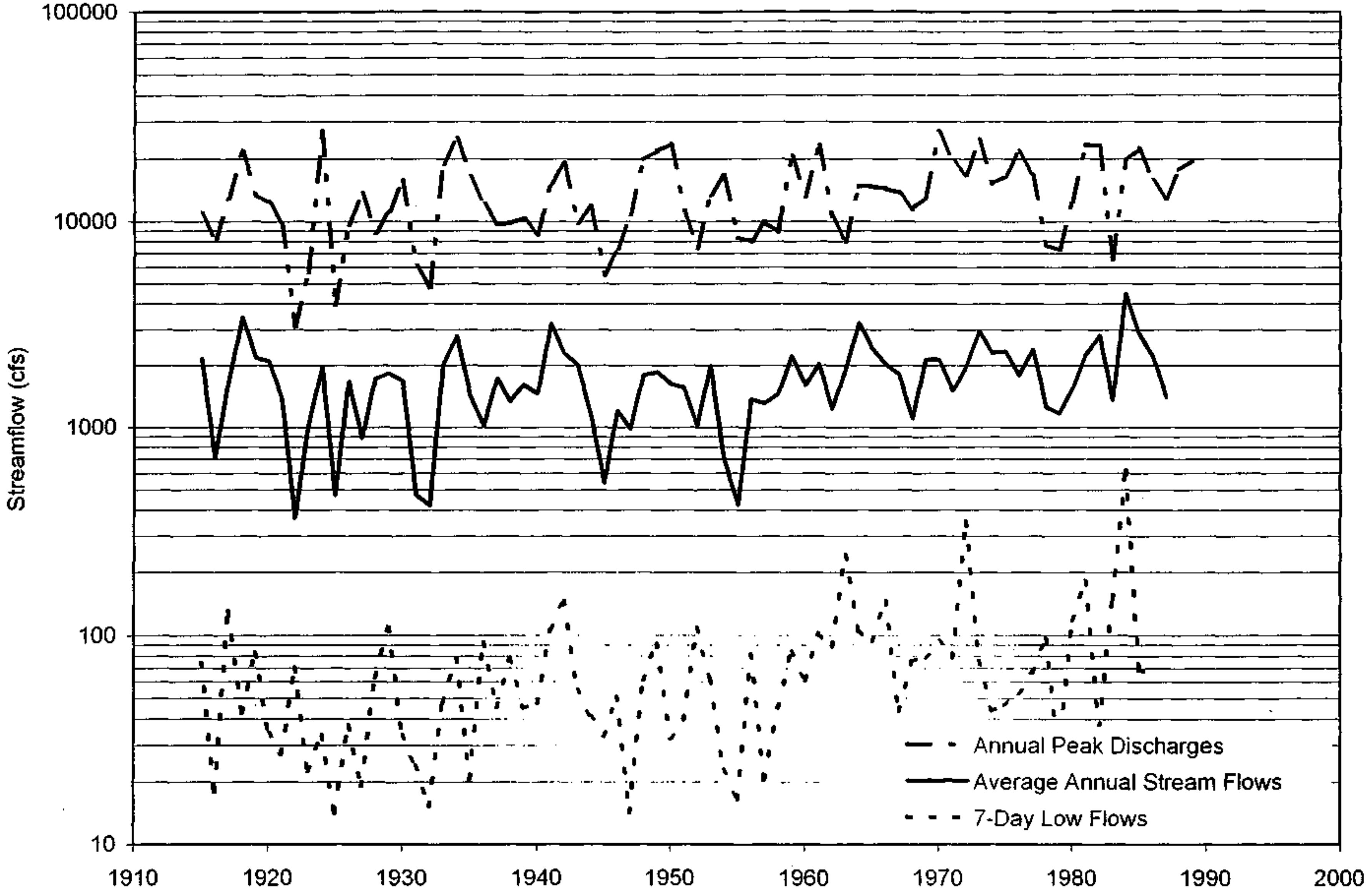
Annual Peak, Average Annual, and 7-Day Low Flows for Kankakee River near Wilmington, IL



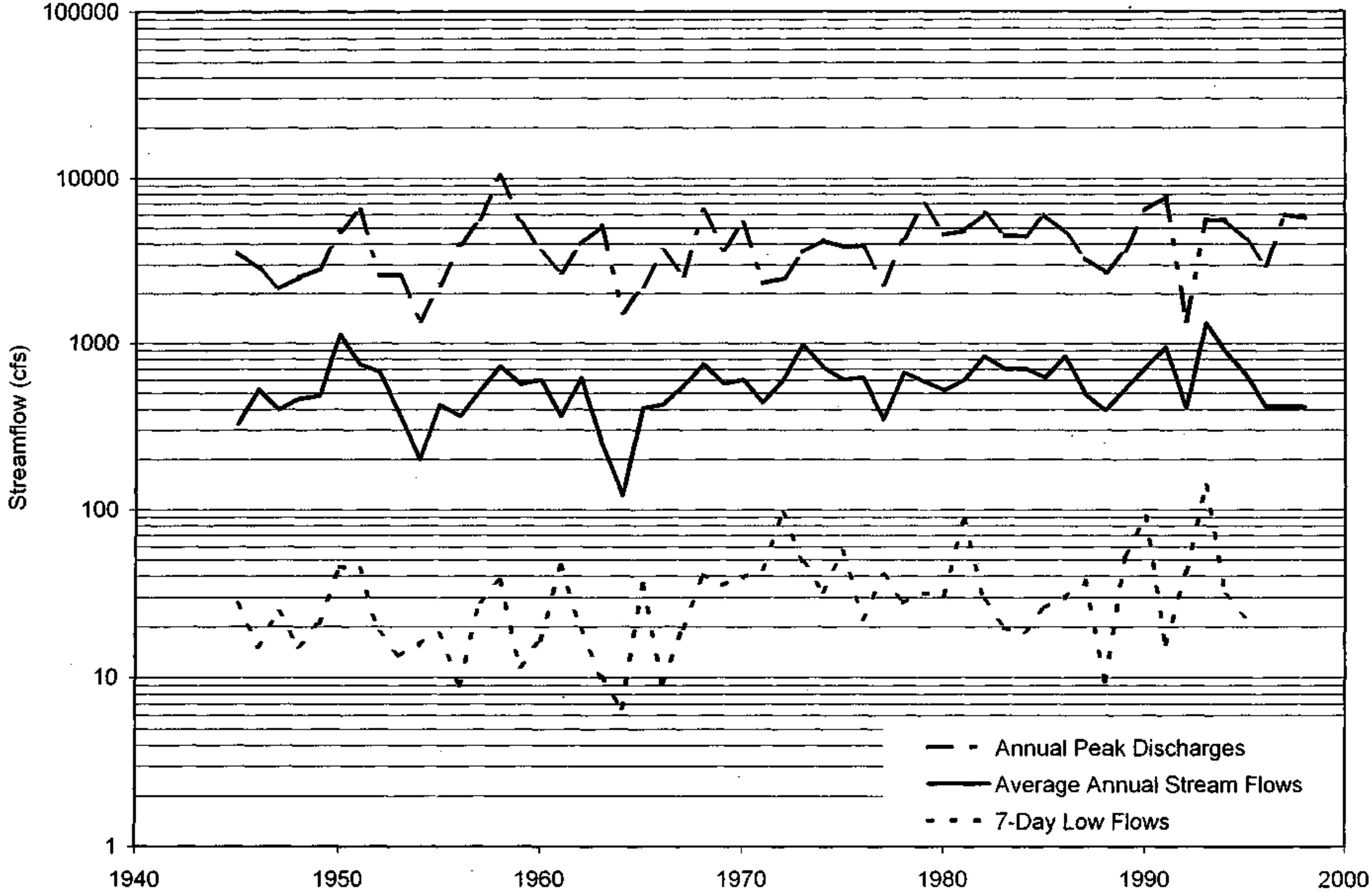
Annual Peak, Average Annual, and 7-Day Low Flows for Kankakee River at Momence, IL



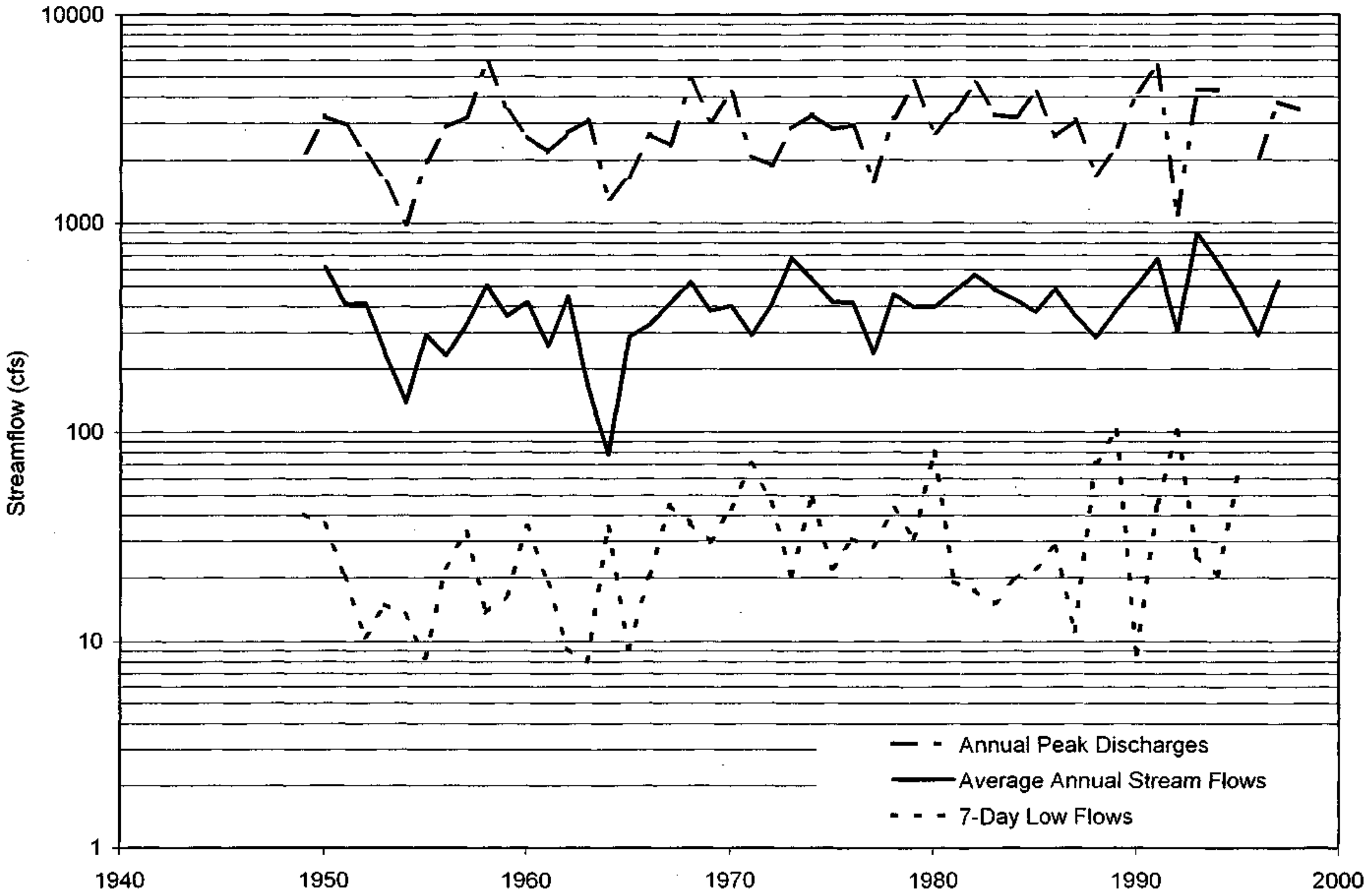
Annual Peak, Average Annual, and 7-Day Low Flows for Kankakee River at Shelby, IN



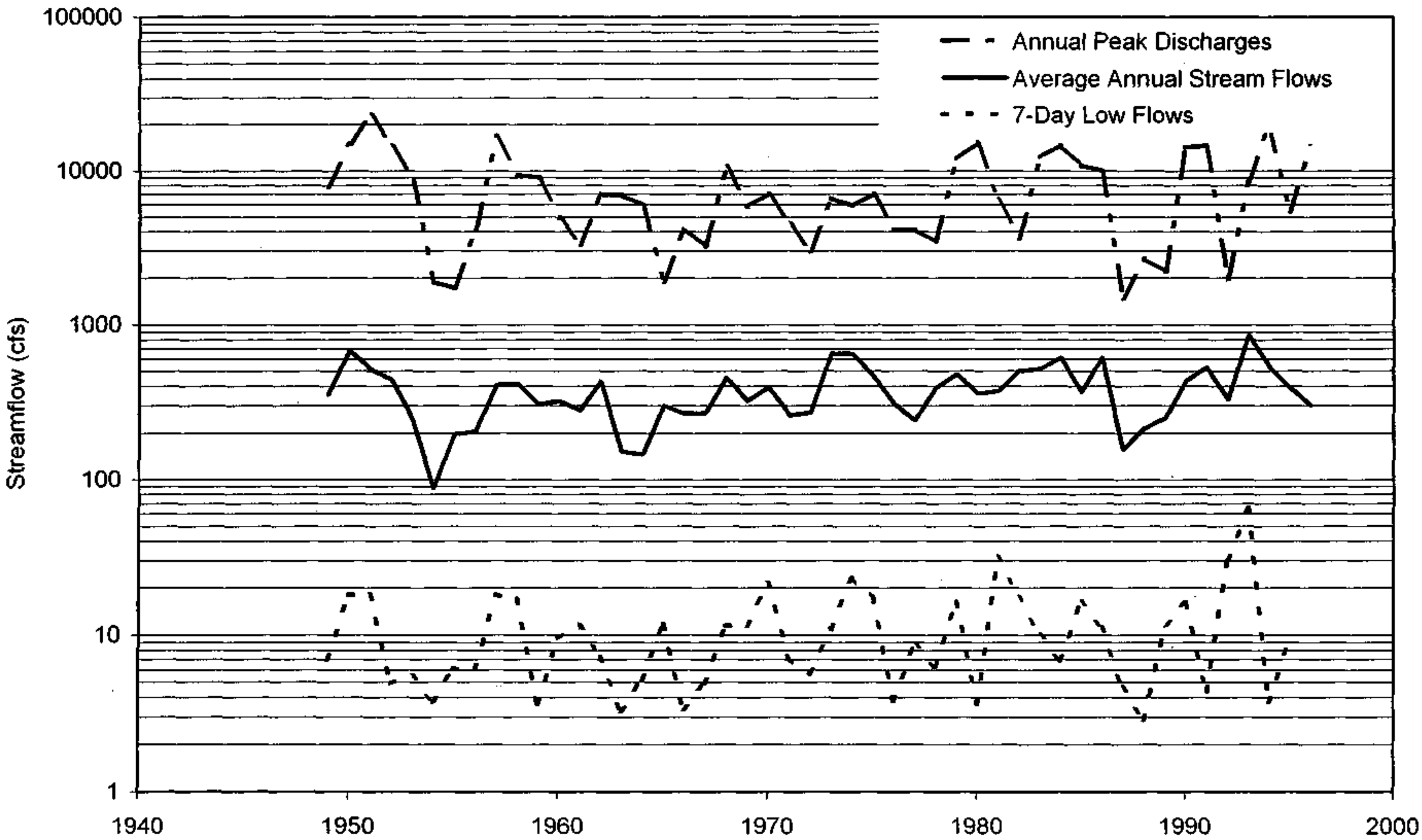
Annual Peak, Average Annual, and 7-Day Low Flows for Iroquois River near Chebanse, IL



Annual Peak, Average Annual, and 7-Day Low Flows for Iroquois River at Iroquois, IL



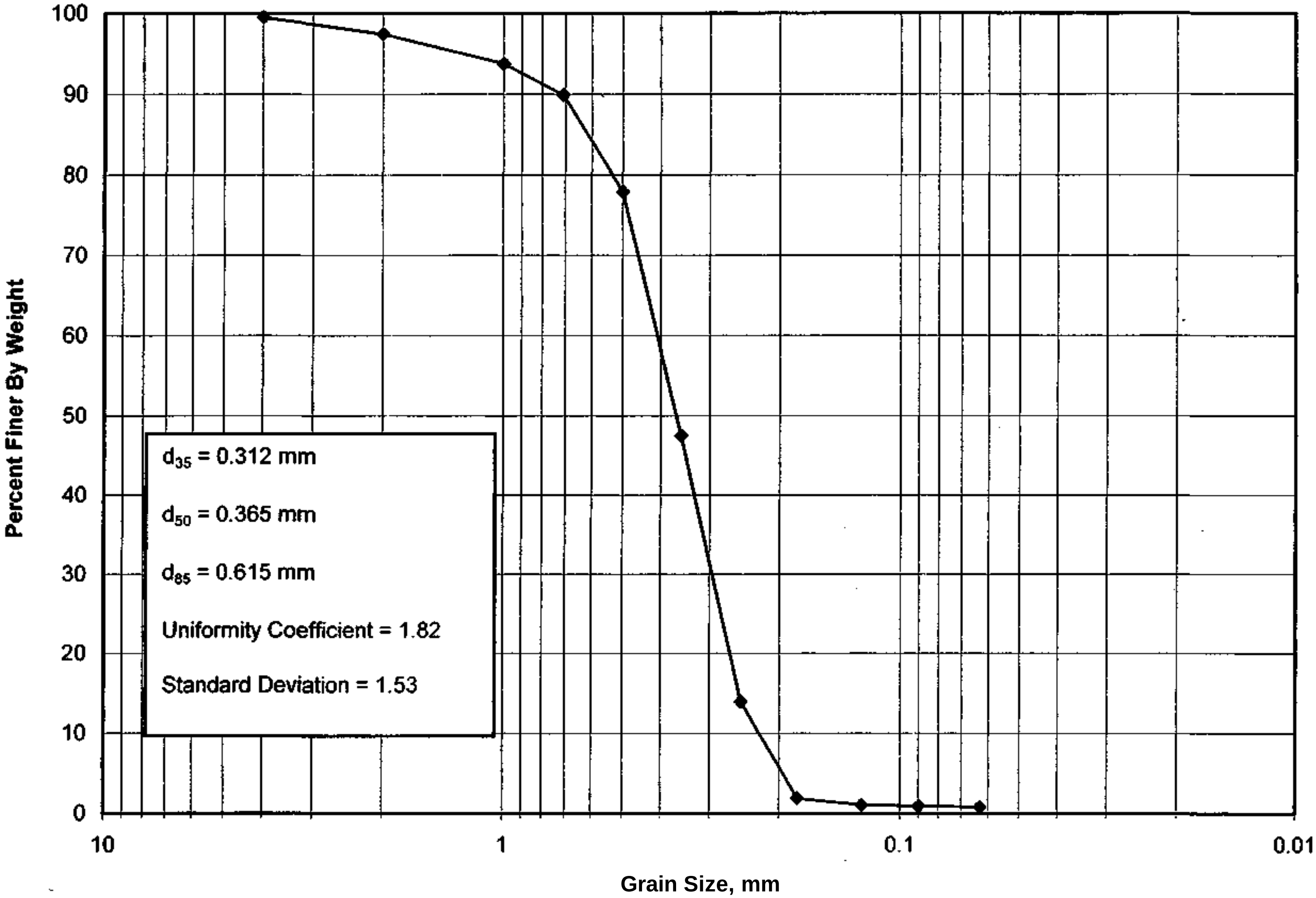
Annual Peak, Average Annual, and 7-Day Low Flows for Iroquois River near Foresman, IN



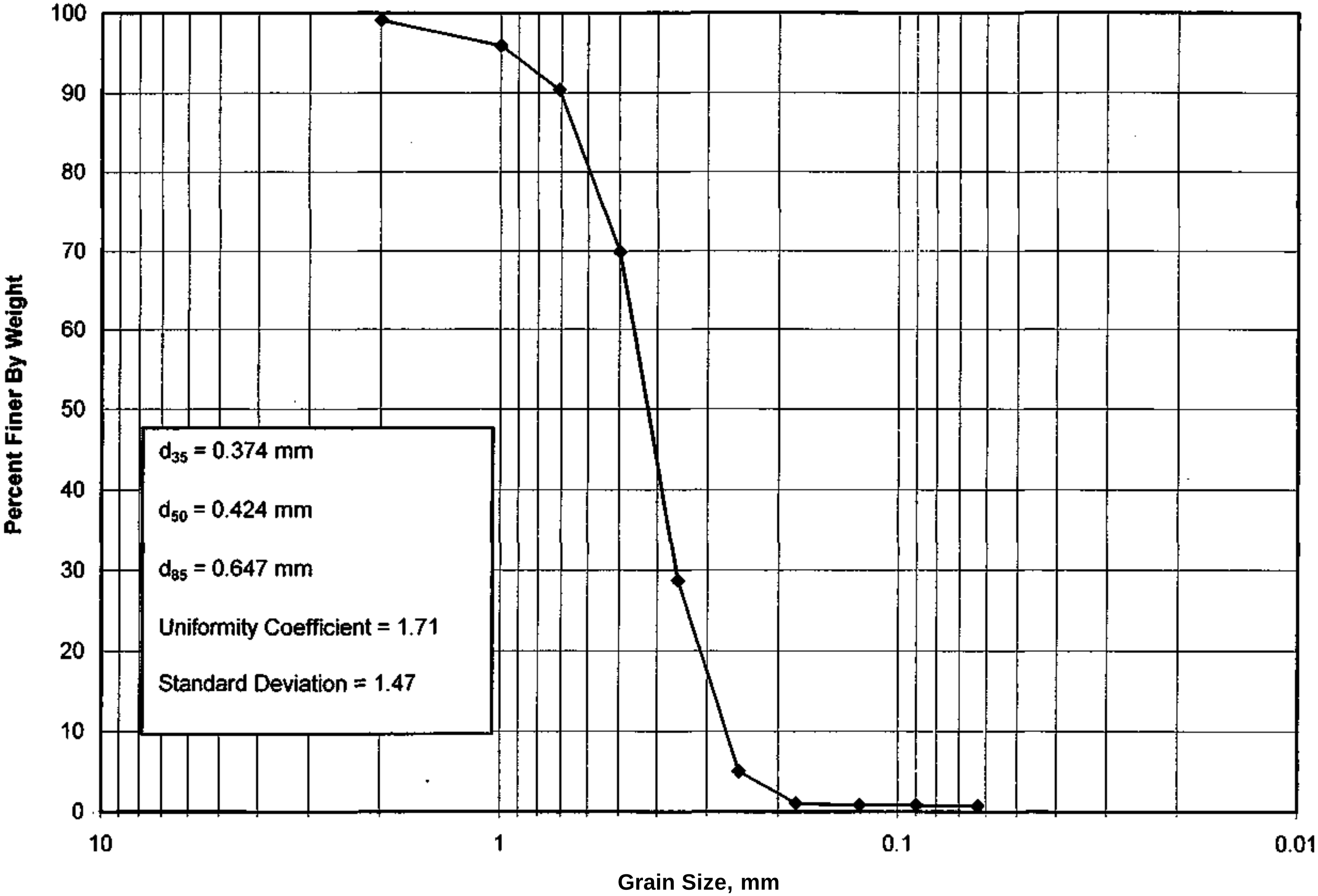
Annual Peak, Average Annual, and 7-Day Low Flows for Sugar Creek at Milford, IL

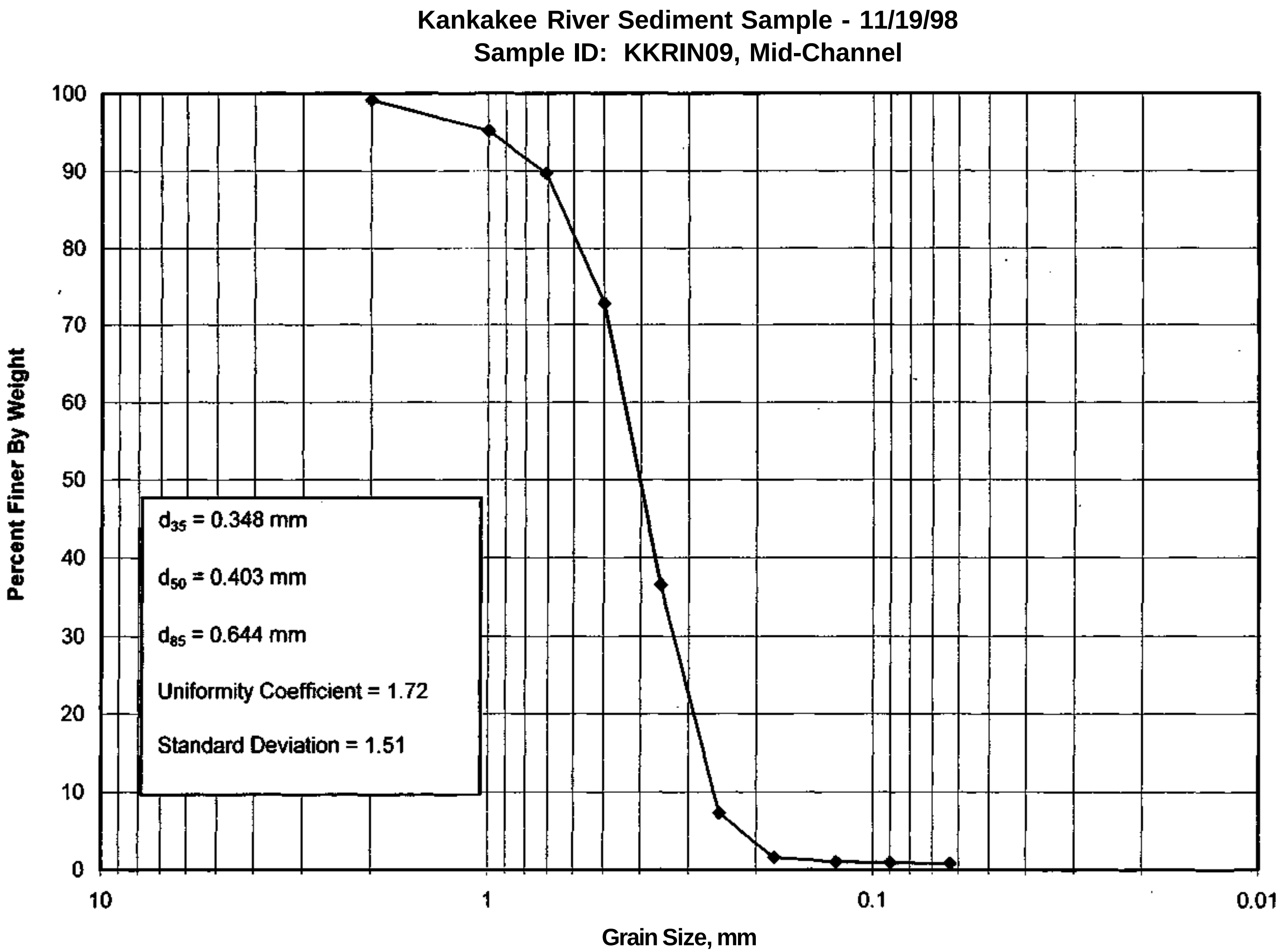
Appendix C. Particle Size Distributions of the Bed and Bank Materials

Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN01, Mid-Channel

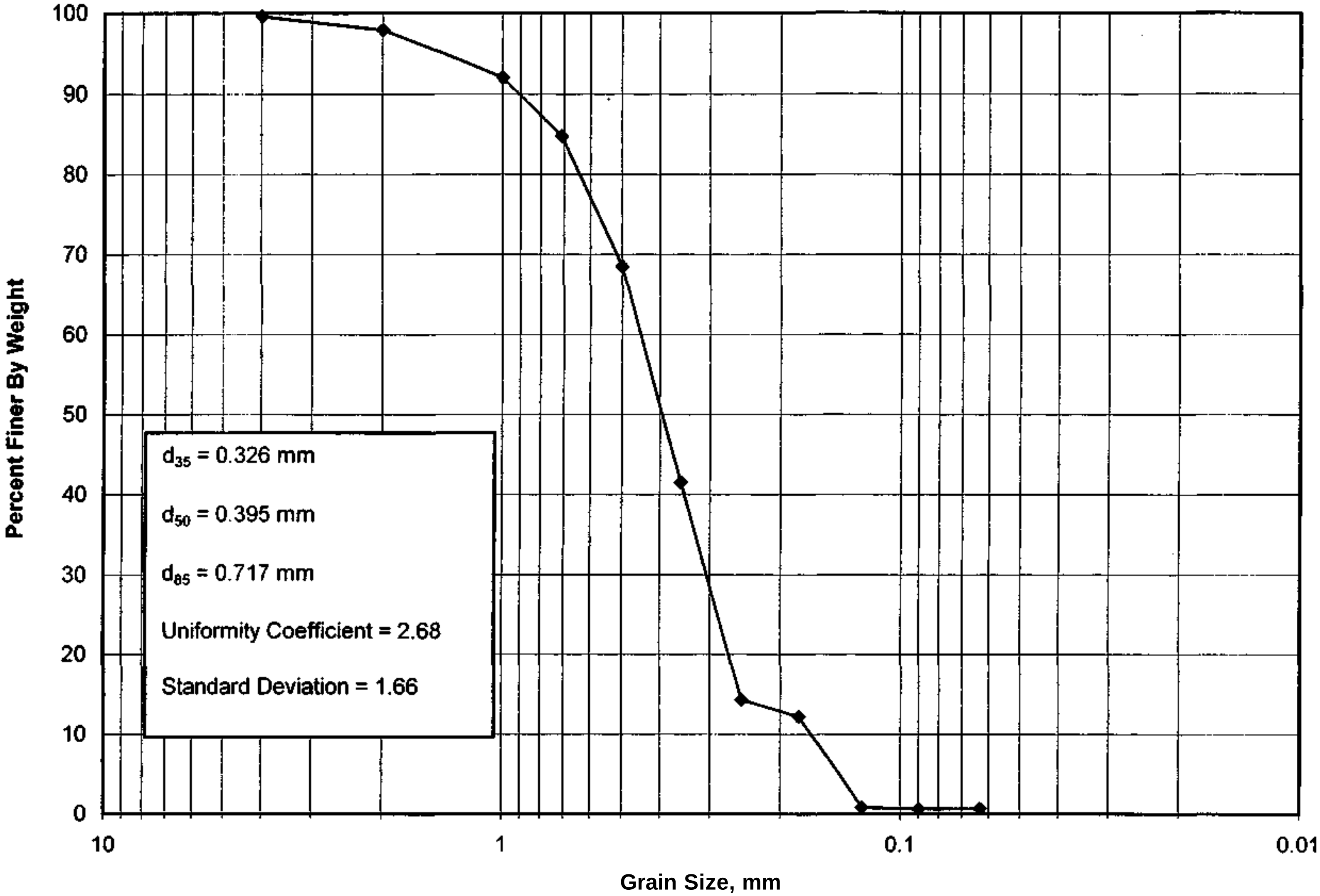


Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN05, Mid-Channel

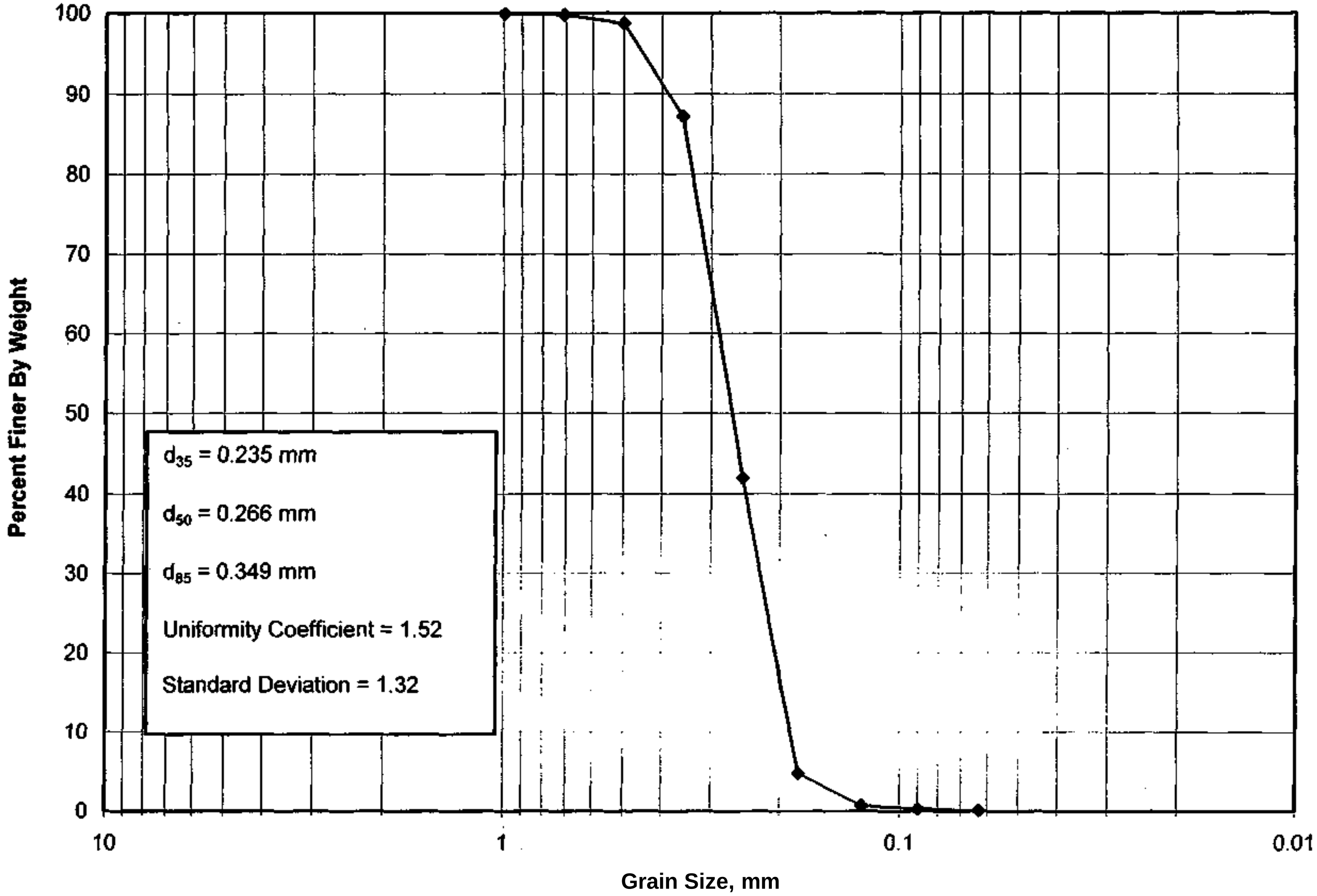



Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN09, Mid-Channel
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d_{35} = 0.348 mm
d_{50} = 0.403 mm
d_{85} = 0.644 mm
Uniformity Coefficient = 1.72
Standard Deviation = 1.51

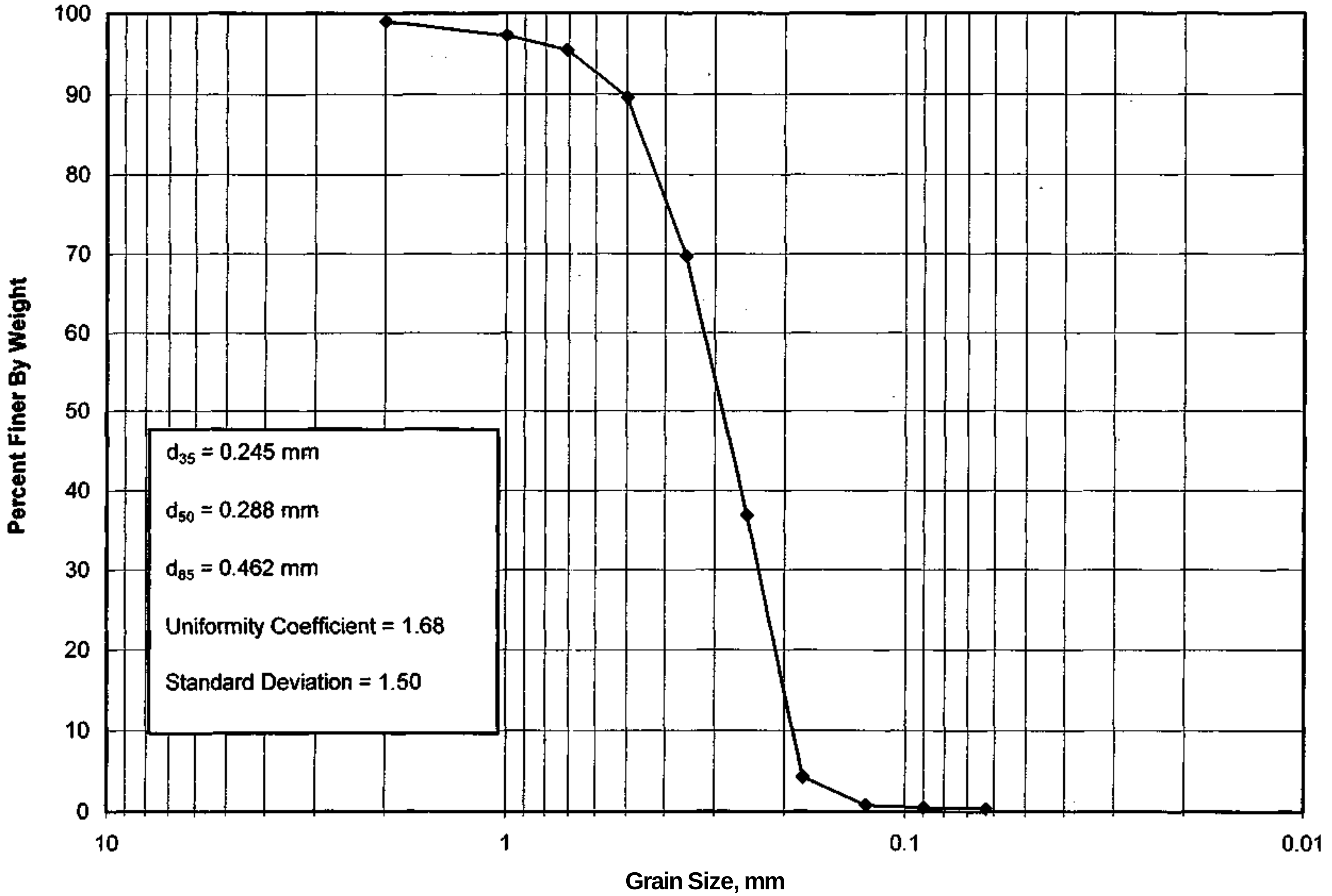
Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN13, Mid-Channel



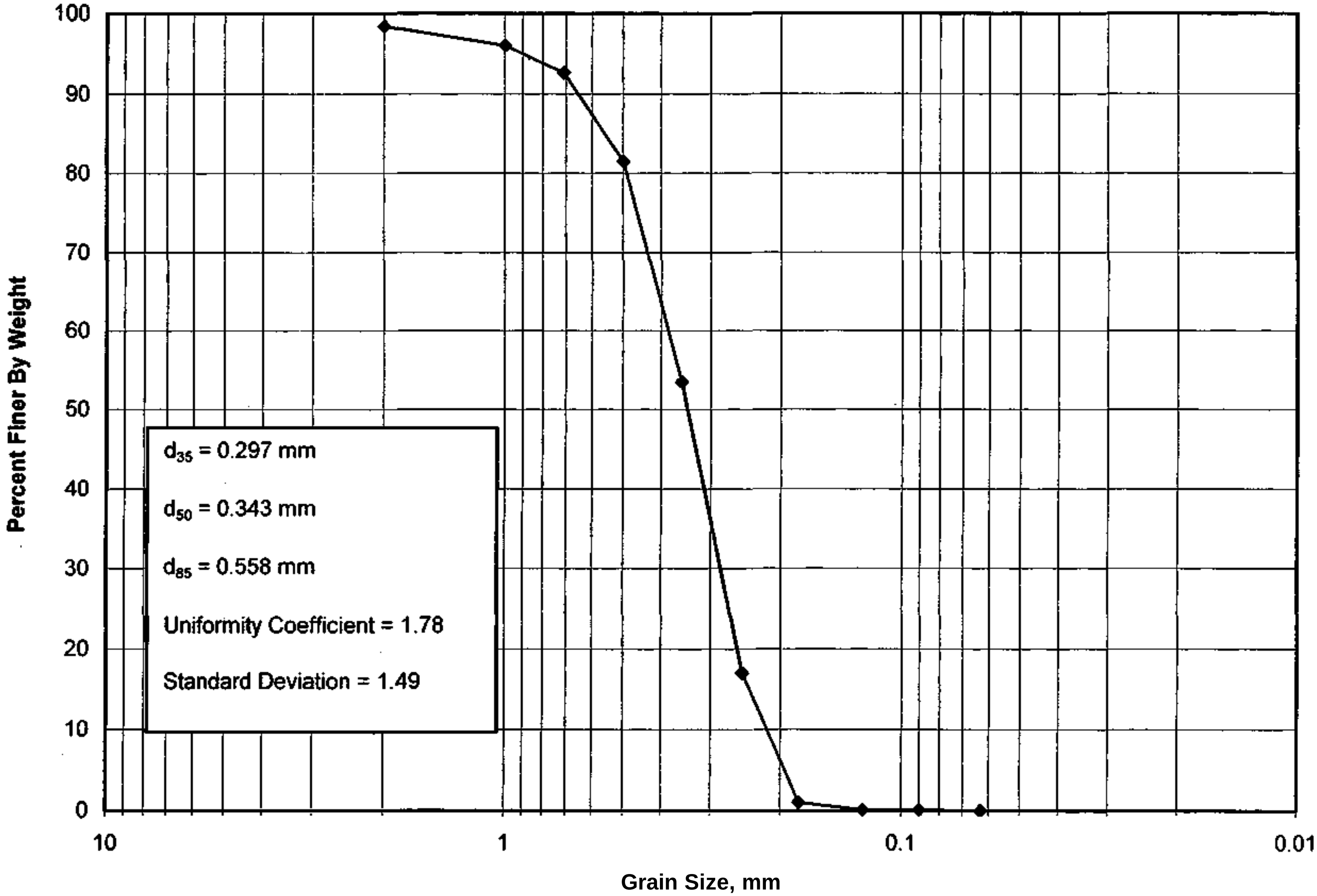
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN17, Mid-Channel

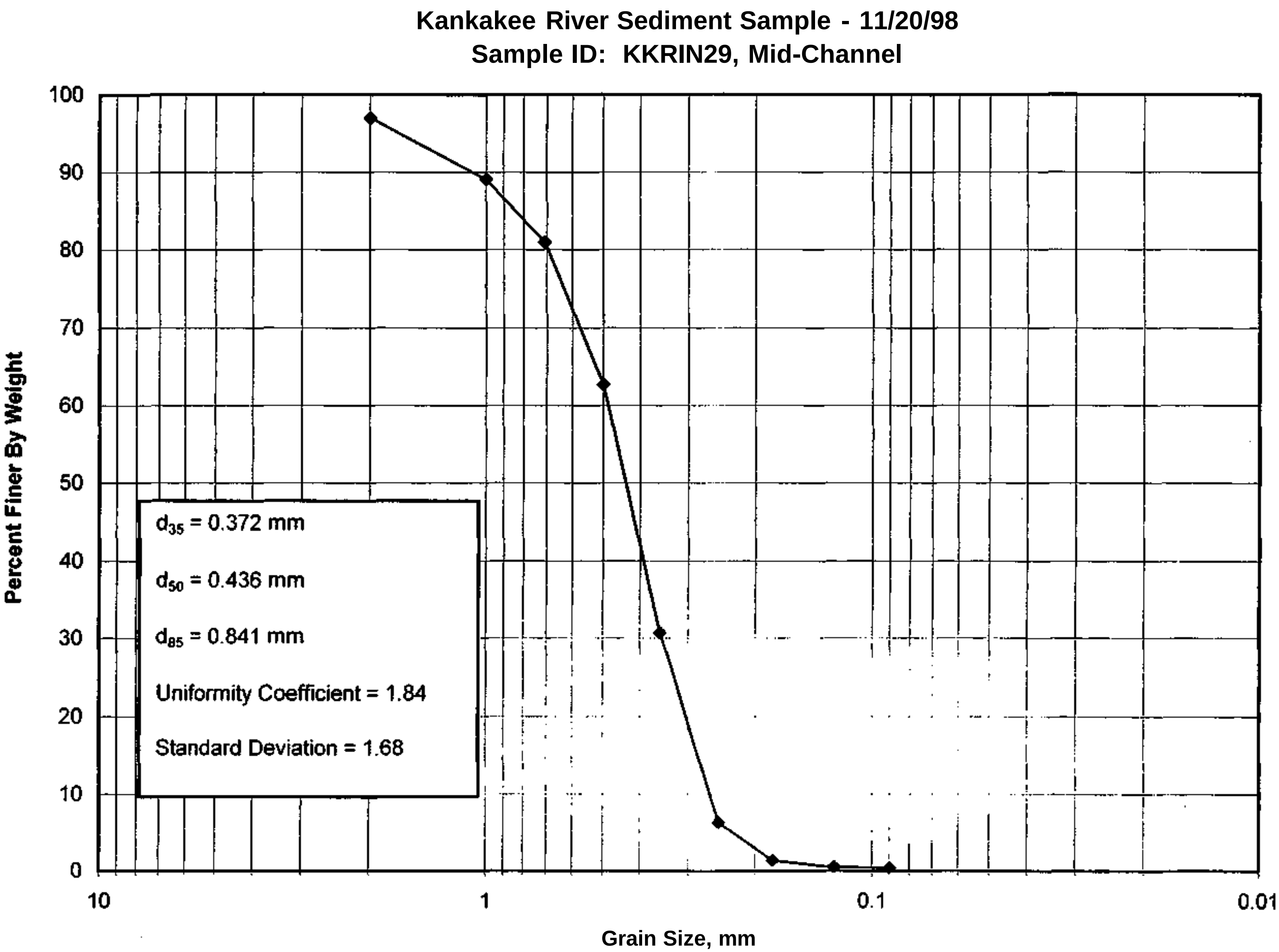


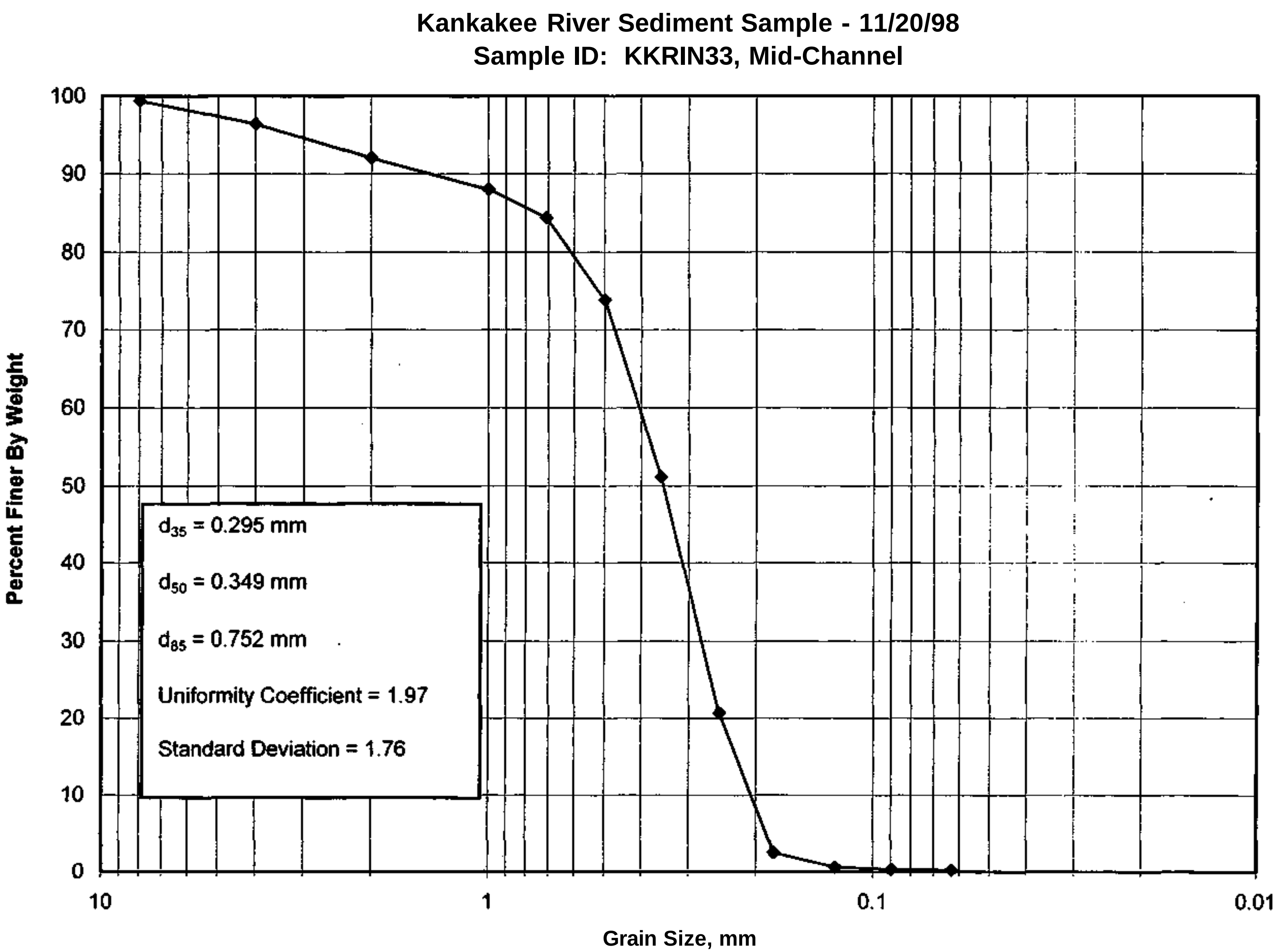
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN21, Mid-Channel



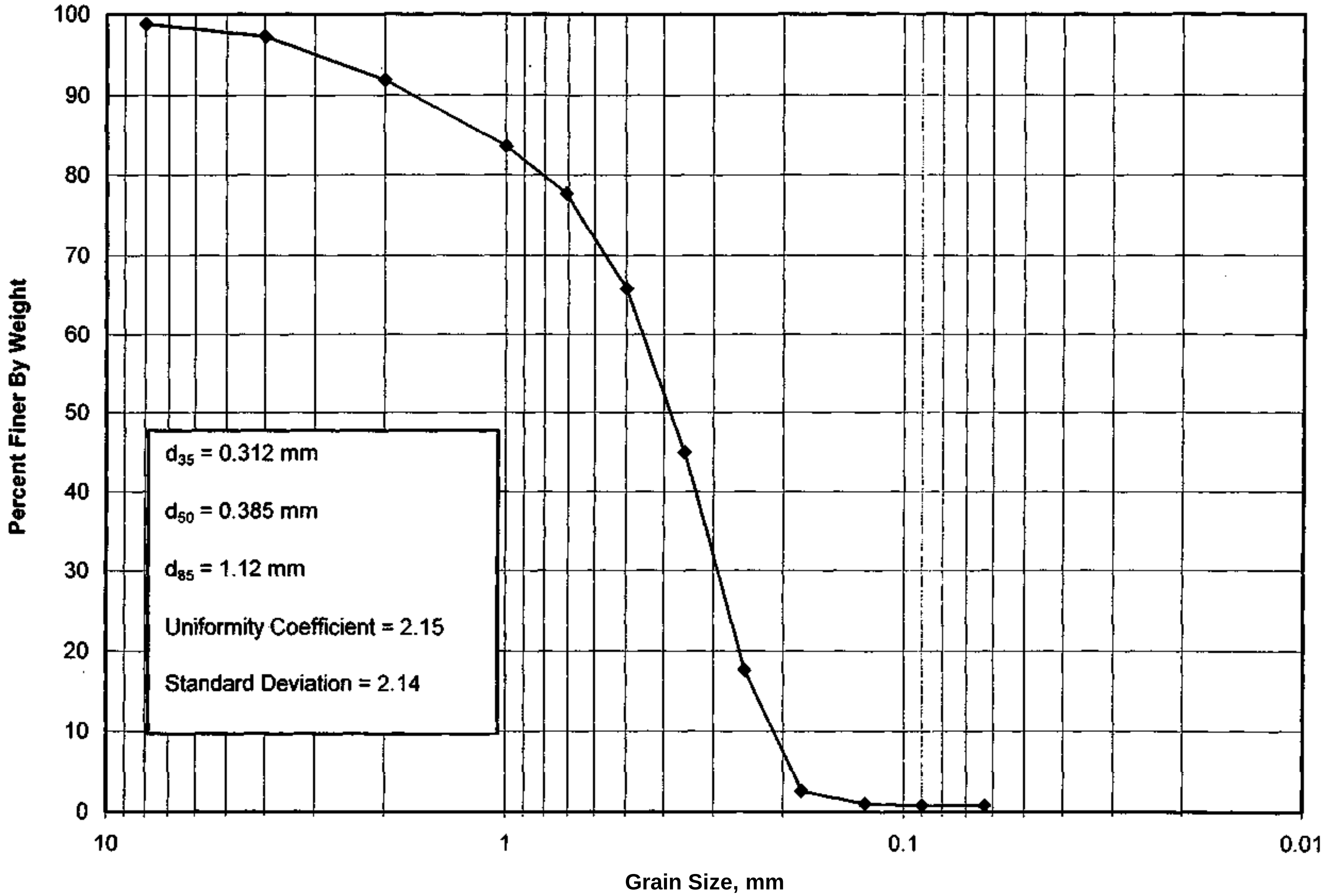
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN25, Mid-Channel



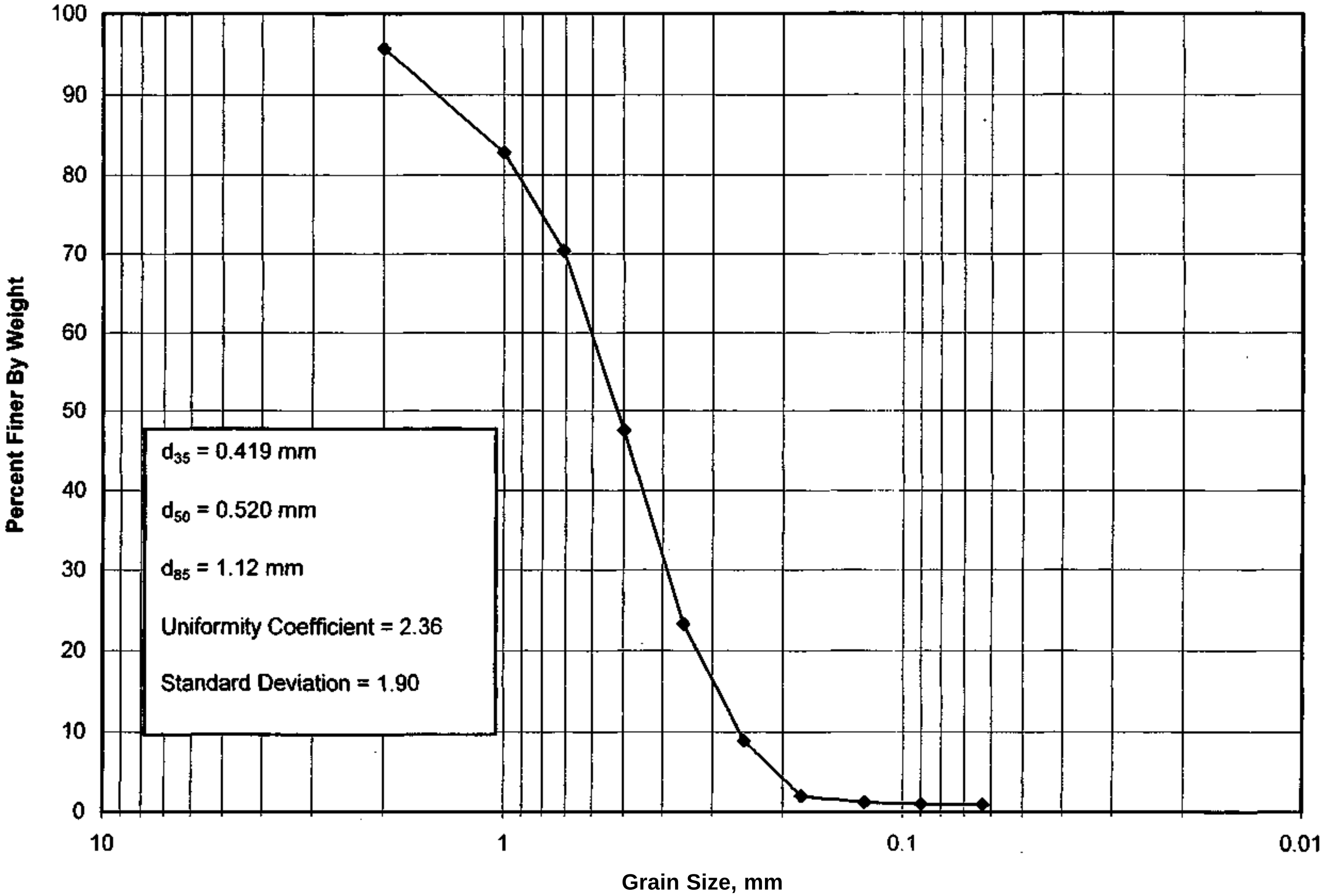

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN29, Mid-Channel
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d35 = 0.372 mm
d50 = 0.436 mm
d85 = 0.841 mm
Uniformity Coefficient = 1.84
Standard Deviation = 1.68

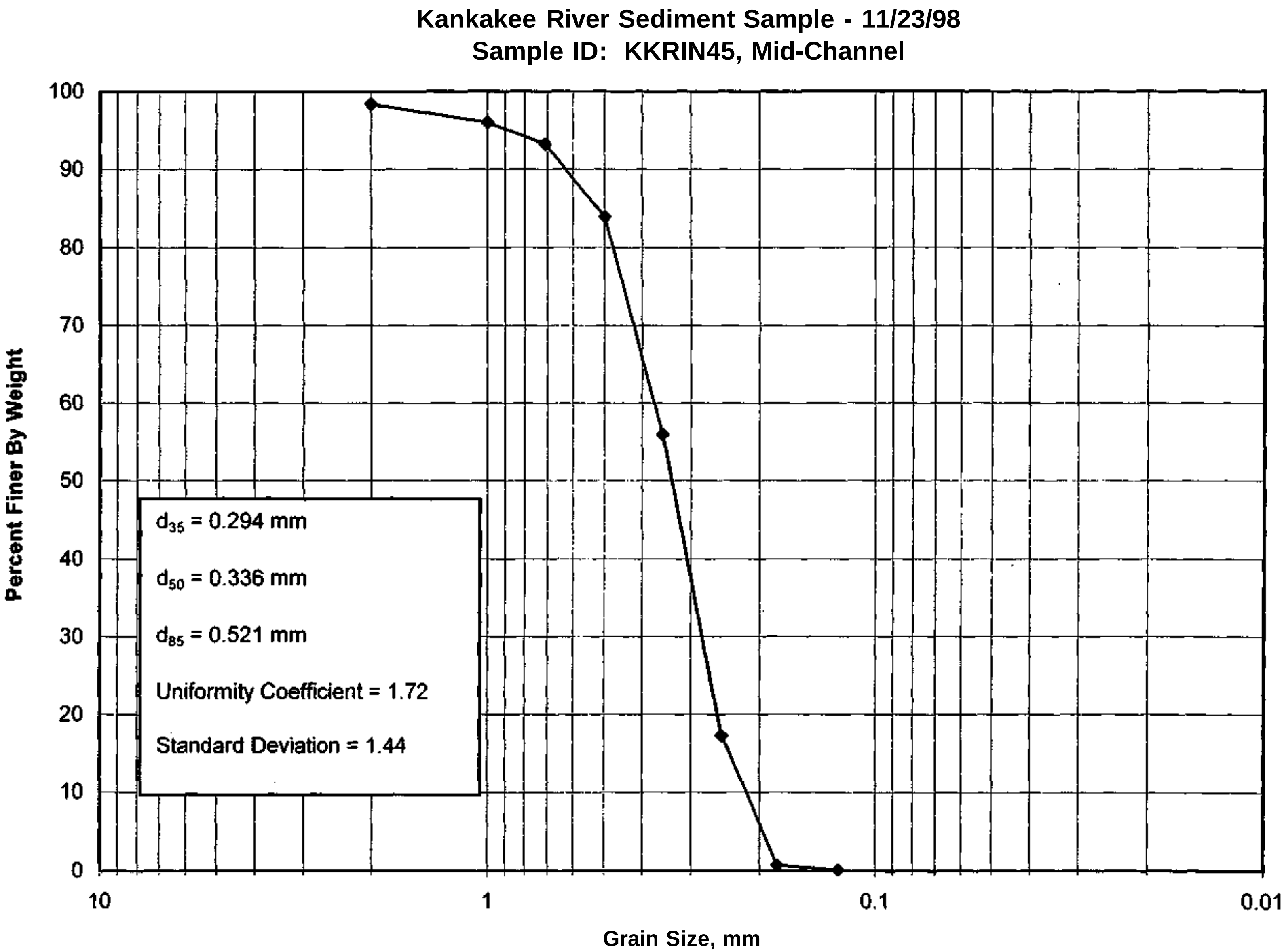

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN33, Mid-Channel
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d35 = 0.295 mm
d50 = 0.349 mm
d85 = 0.752 mm
Uniformity Coefficient = 1.97
Standard Deviation = 1.76

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN37, Mid-Channel

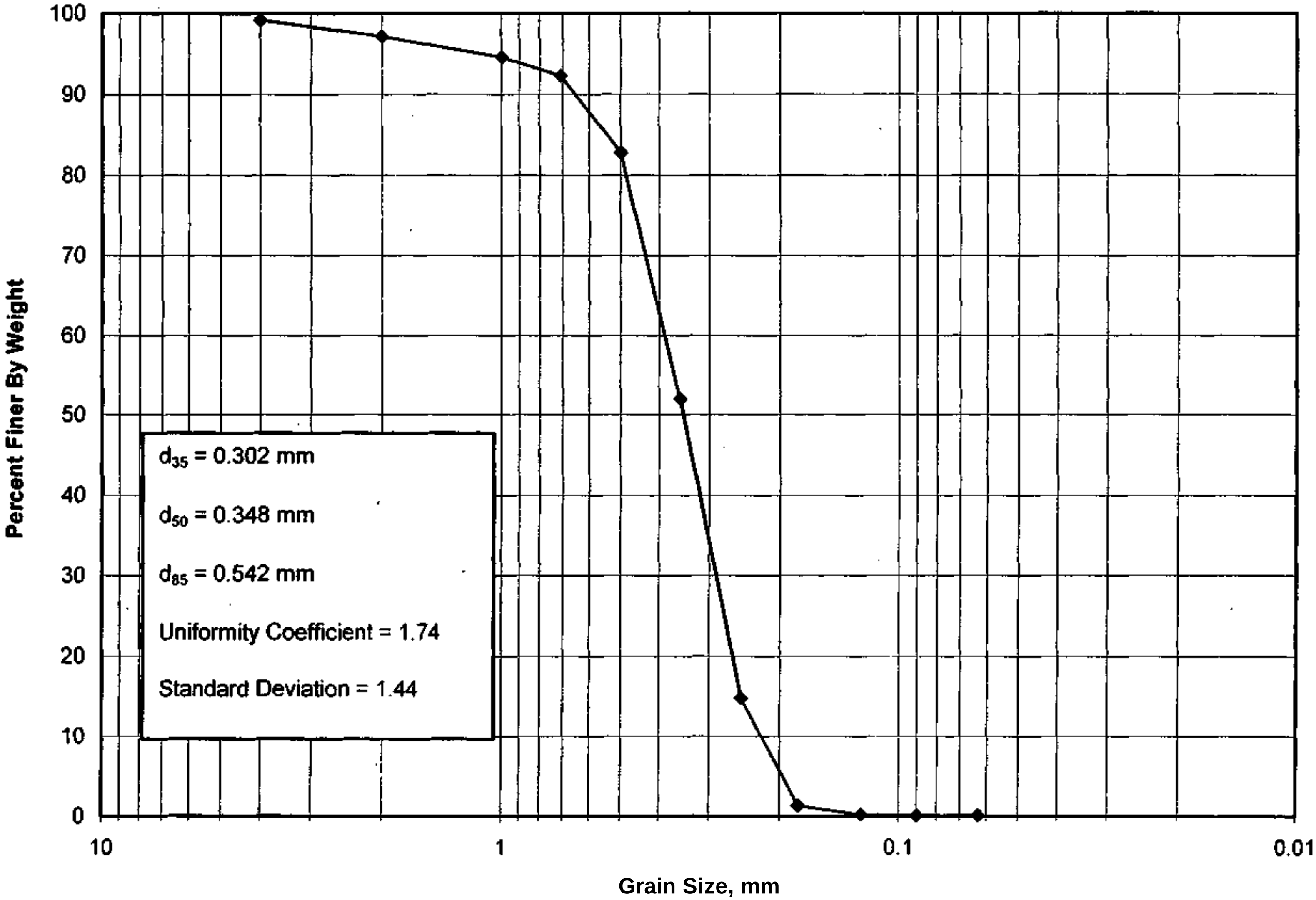


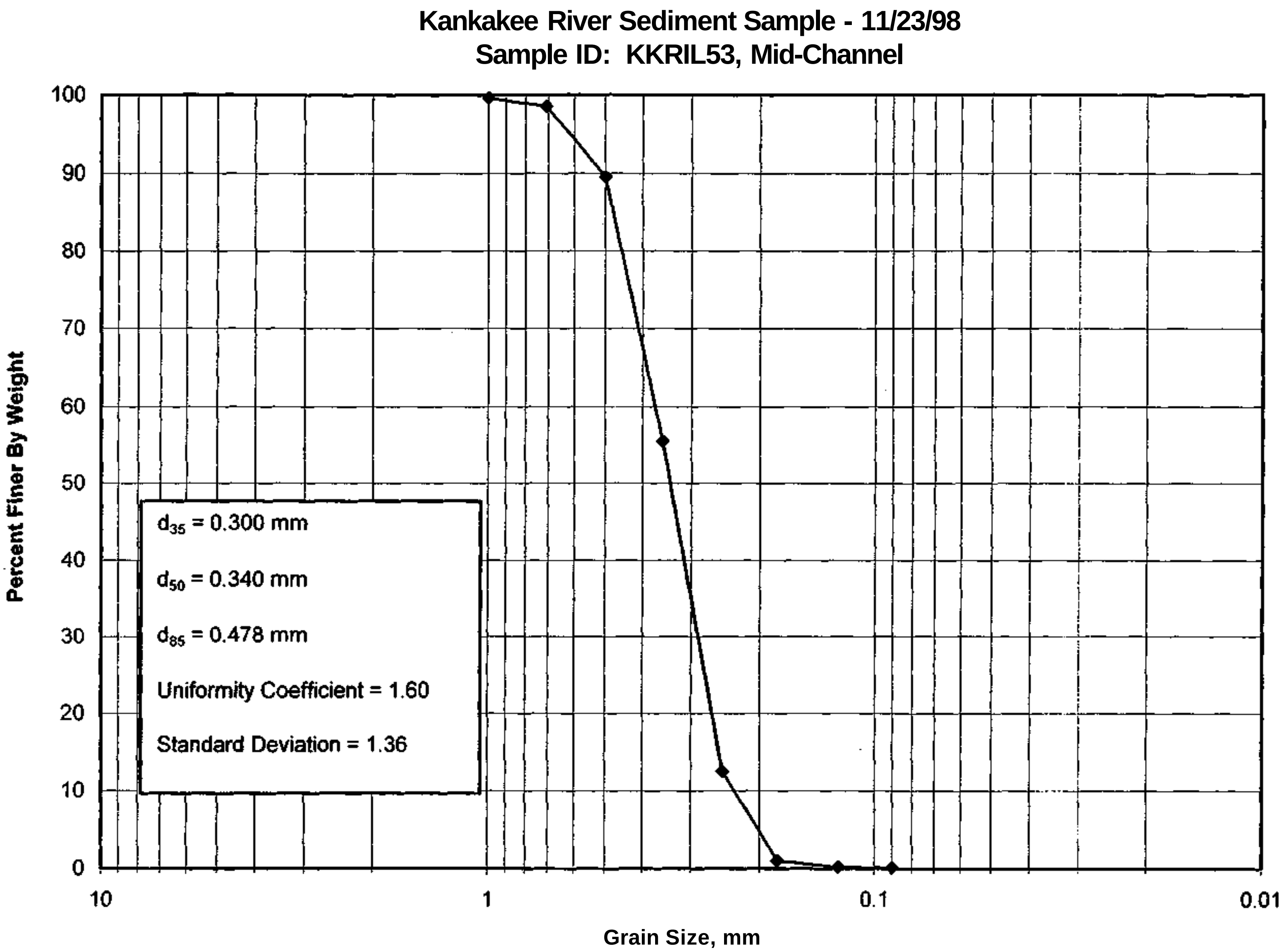
Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIN41, Mid-Channel




Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIN45, Mid-Channel
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d35 = 0.294 mm
d50 = 0.336 mm
d85 = 0.521 mm
Uniformity Coefficient = 1.72
Standard Deviation = 1.44

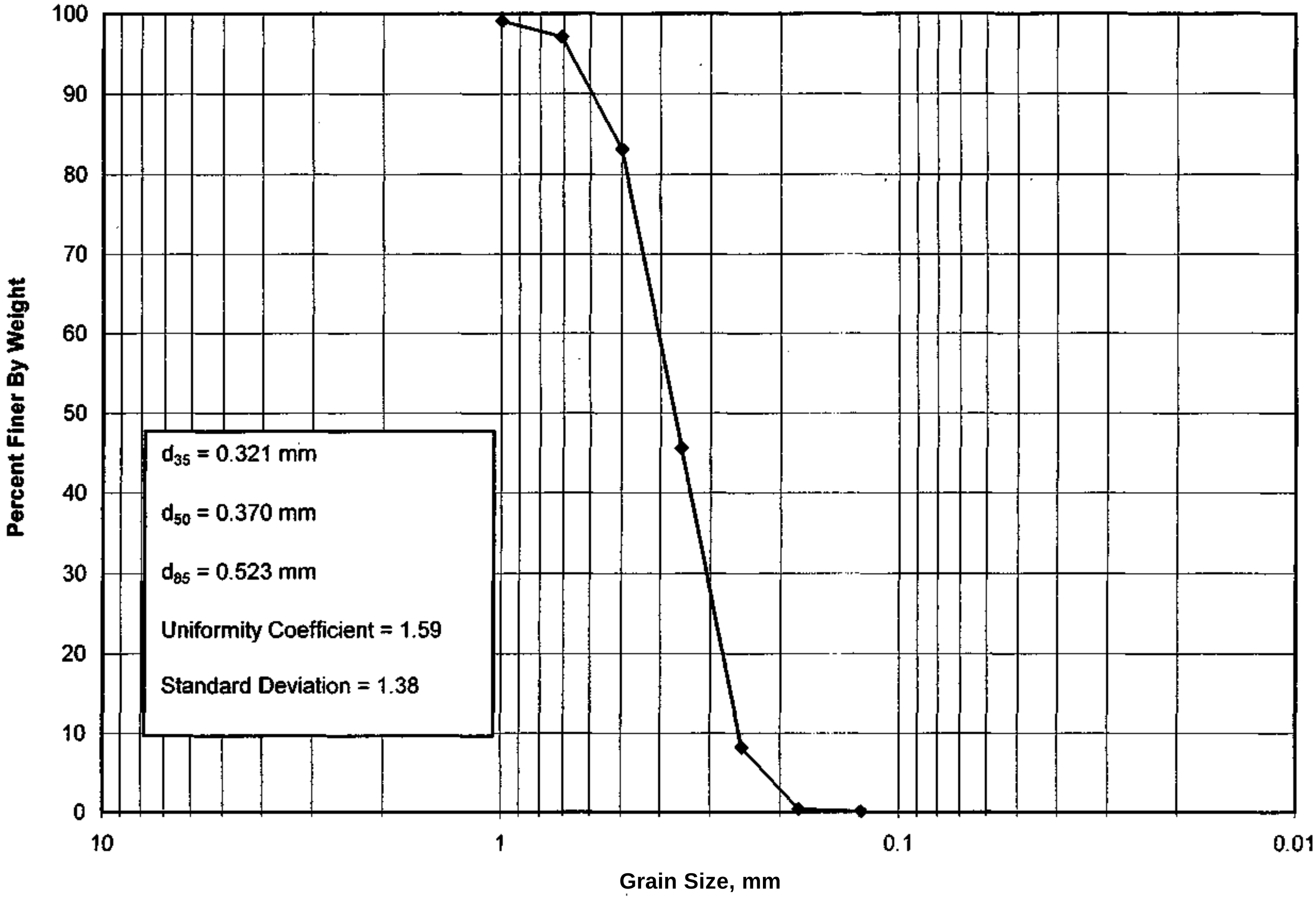
Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIN49, Mid-Channel



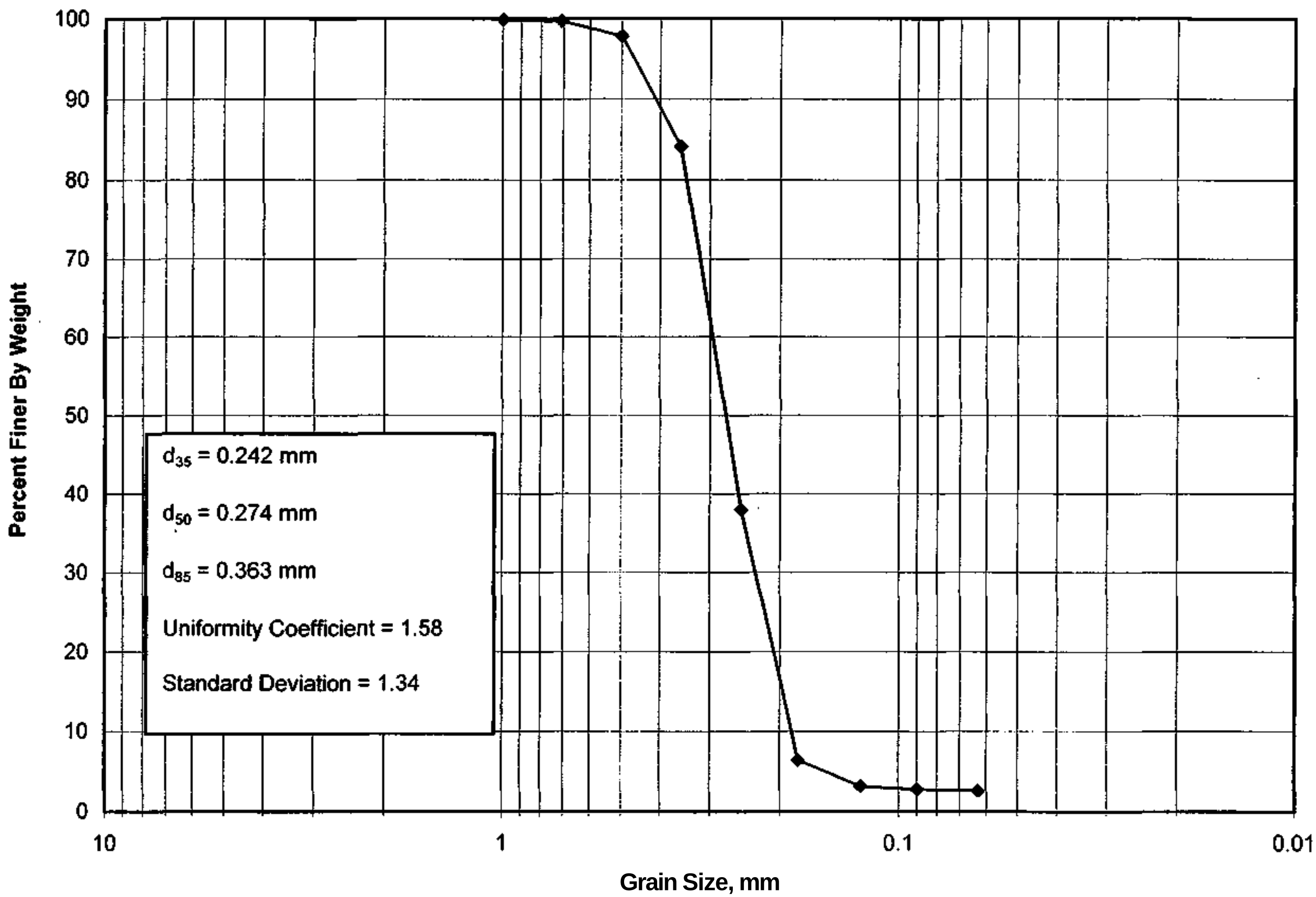


Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIL53, Mid-Channel
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d_{35} = 0.300 mm
d_{50} = 0.340 mm
d_{85} = 0.478 mm
Uniformity Coefficient = 1.60
Standard Deviation = 1.36

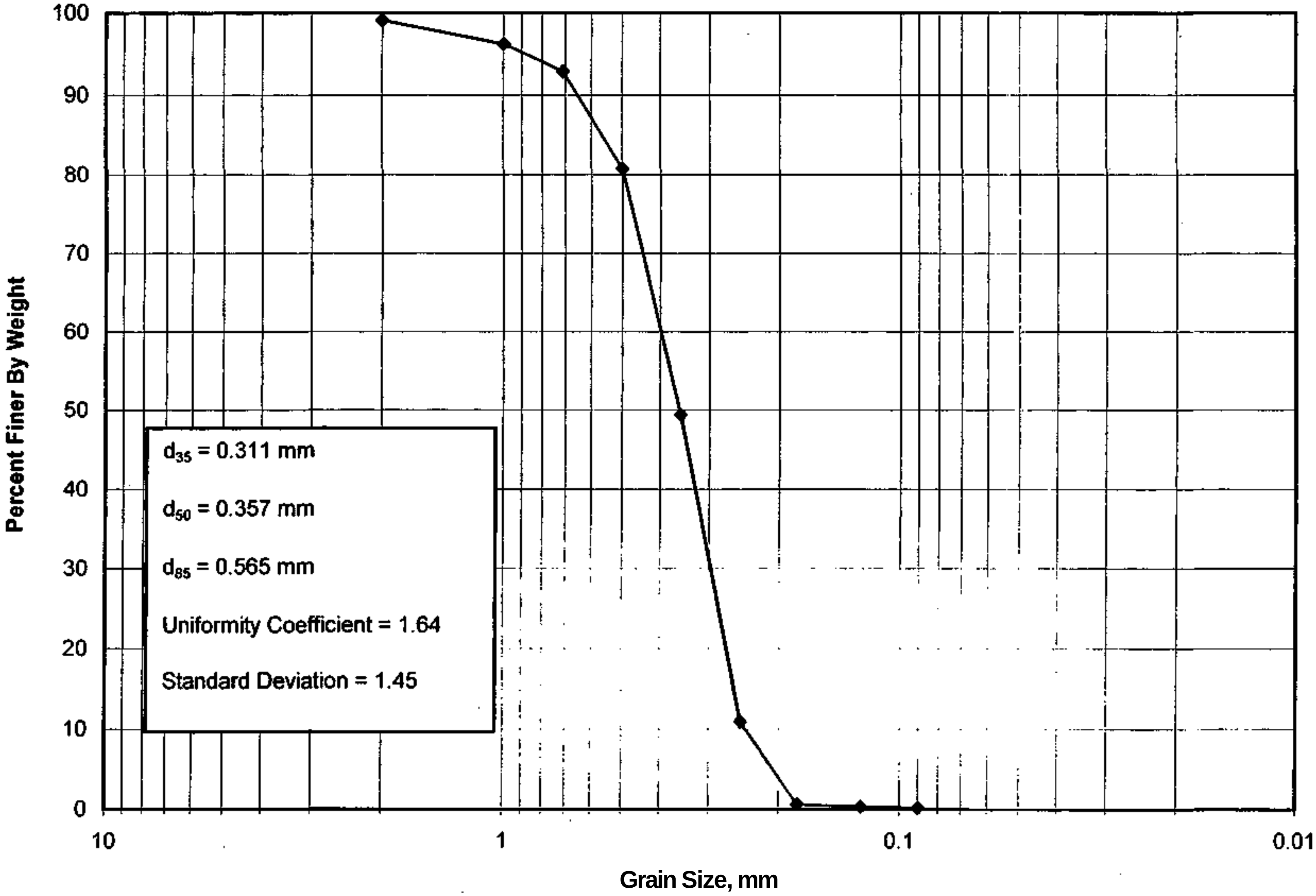
Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIL57, Mid-Channel



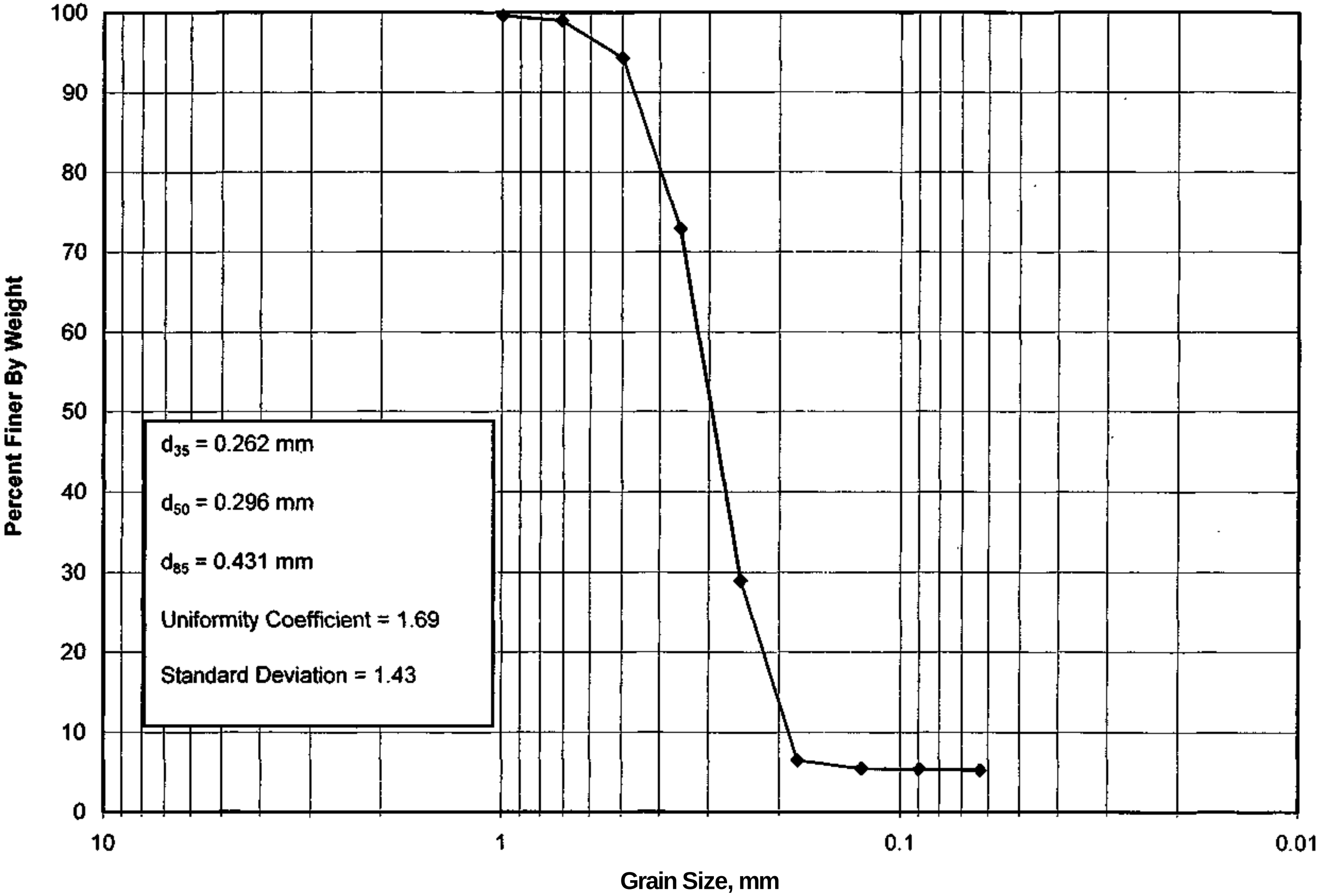
Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL65, Mid-Channel



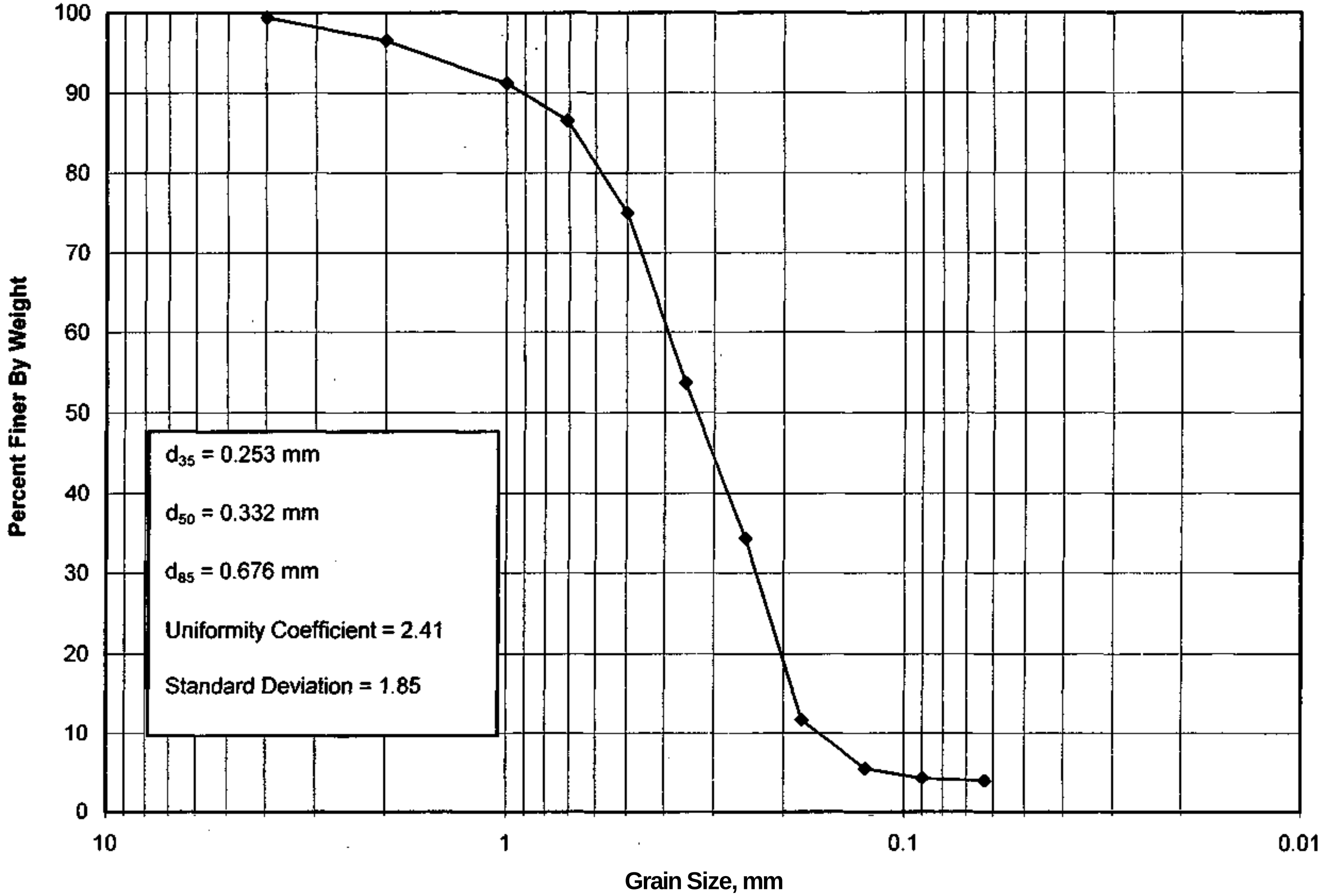
Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL69, Mid-Channel

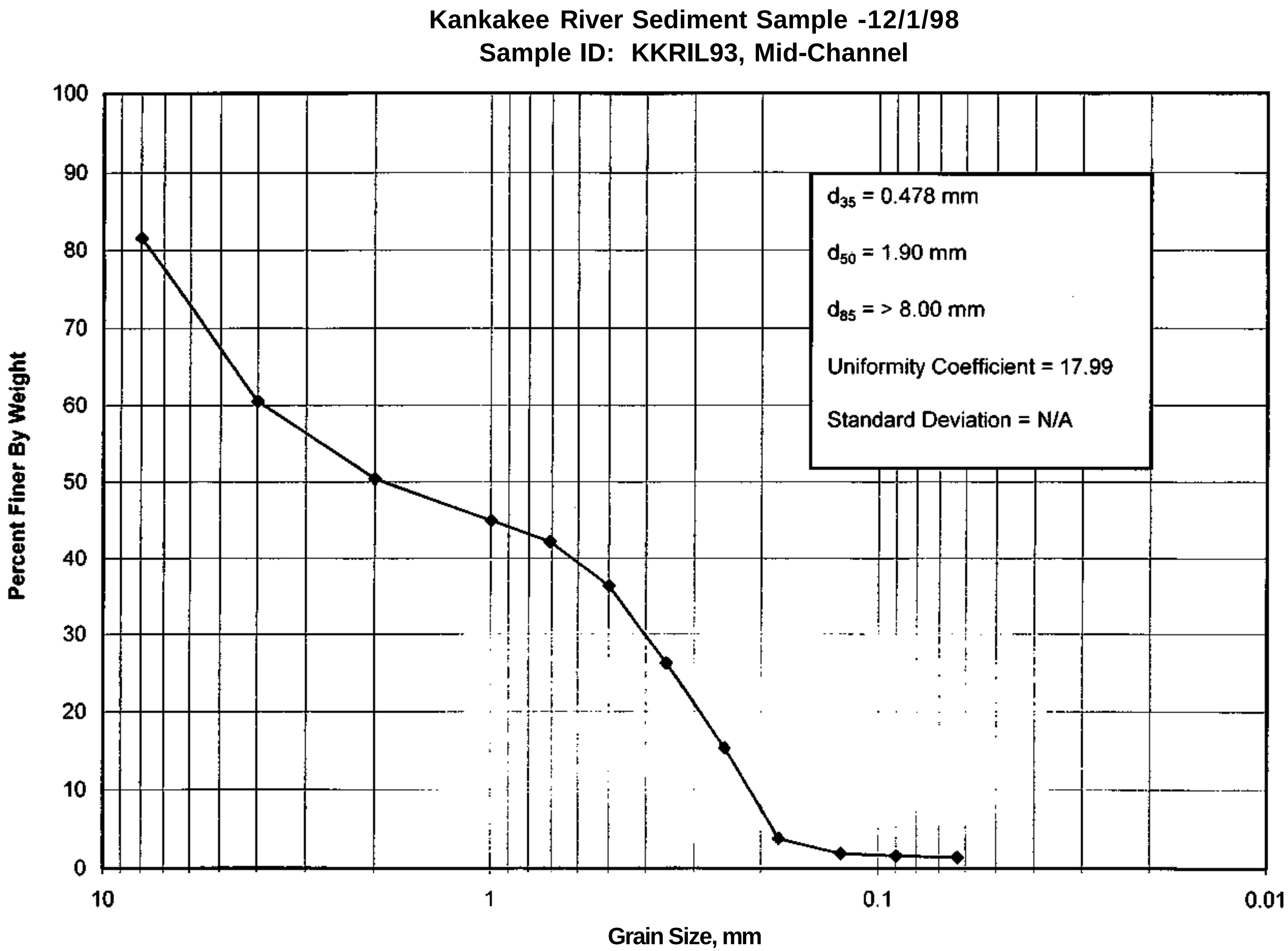


Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL74, Mid-Channel

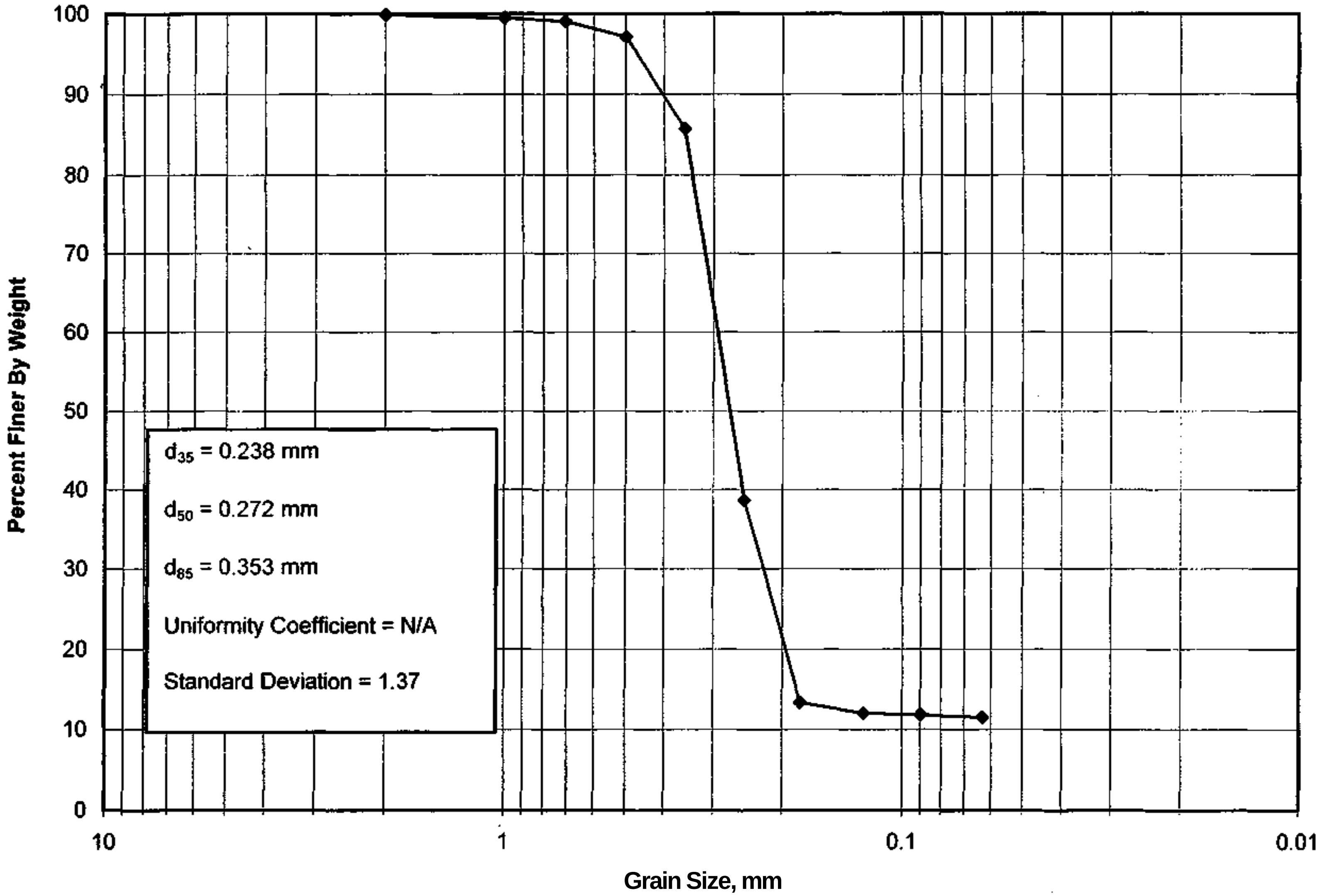


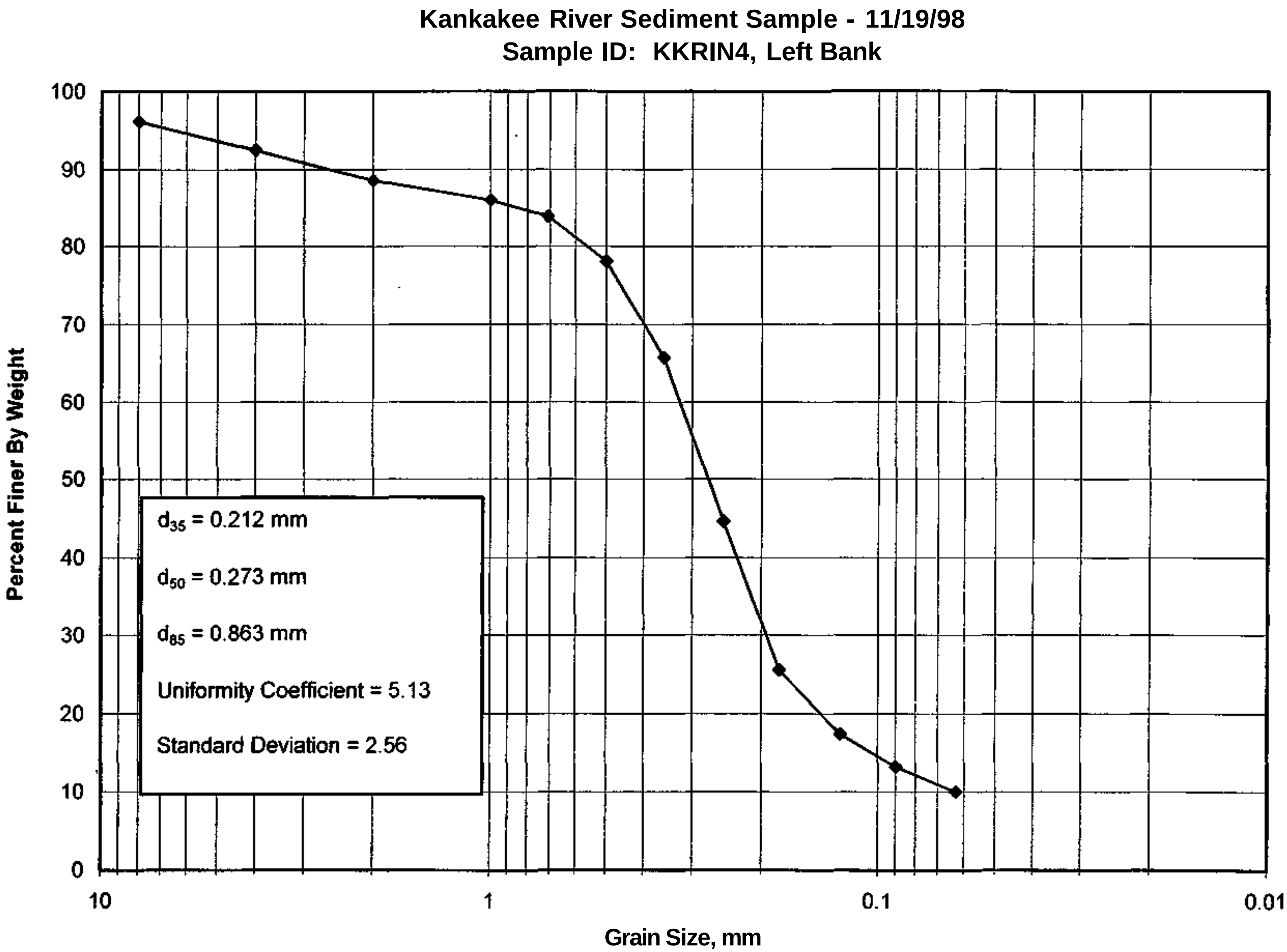
Kankakee River Sediment Sample -12/1/98
Sample ID: KKRIL89, Mid-Channel



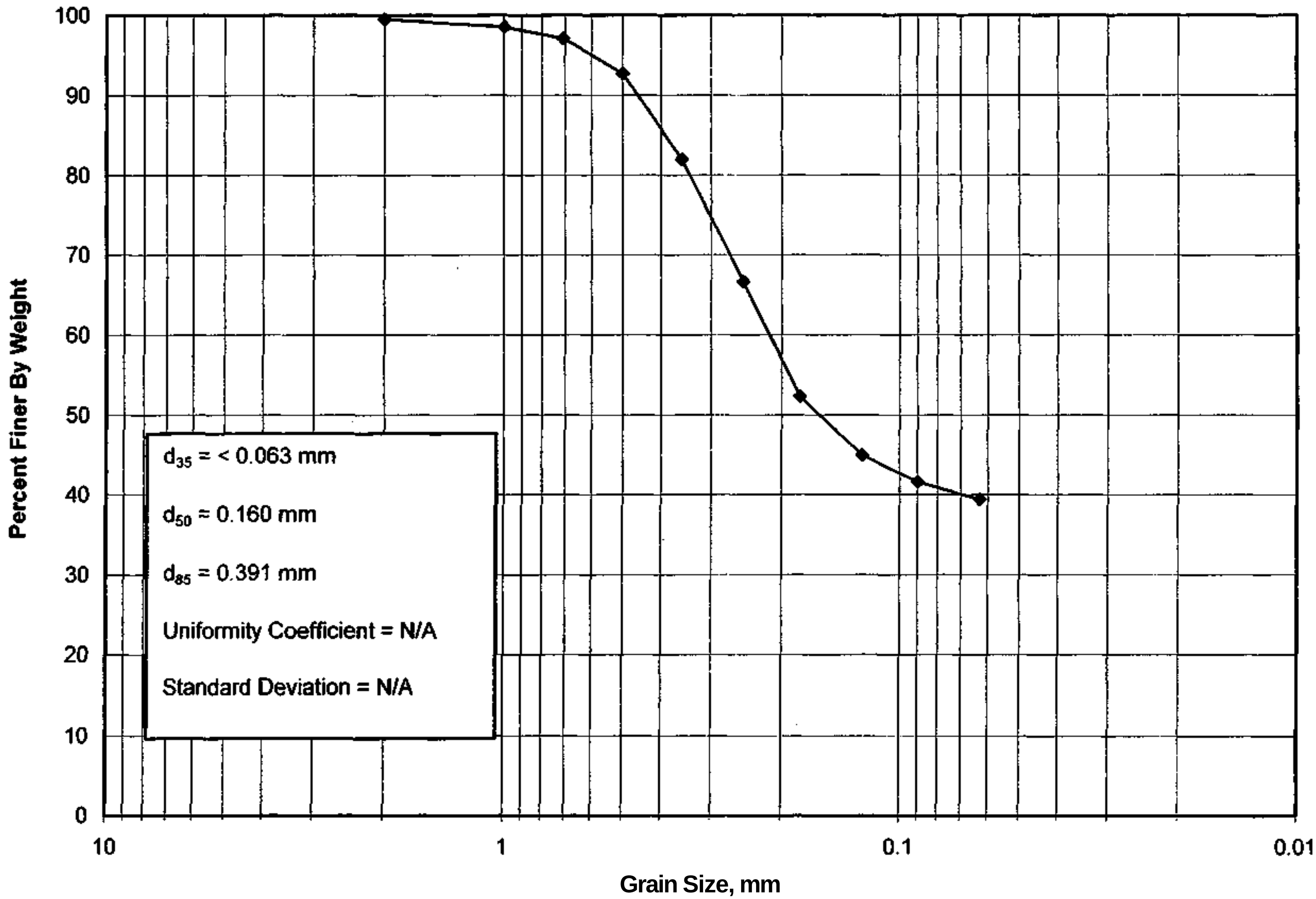

Kankakee River Sediment Sample -12/1/98
Sample ID: KKRIL93, Mid-Channel
Percent Finer By Weight
Grain Size, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
d35 = 0.478 mm
d50 = 1.90 mm
d85 = > 8.00 mm
Uniformity Coefficient = 17.99
Standard Deviation = N/A

Kankakee River Sediment Sample -12/1/98
Sample ID: KKRIL104, Mid-Channel

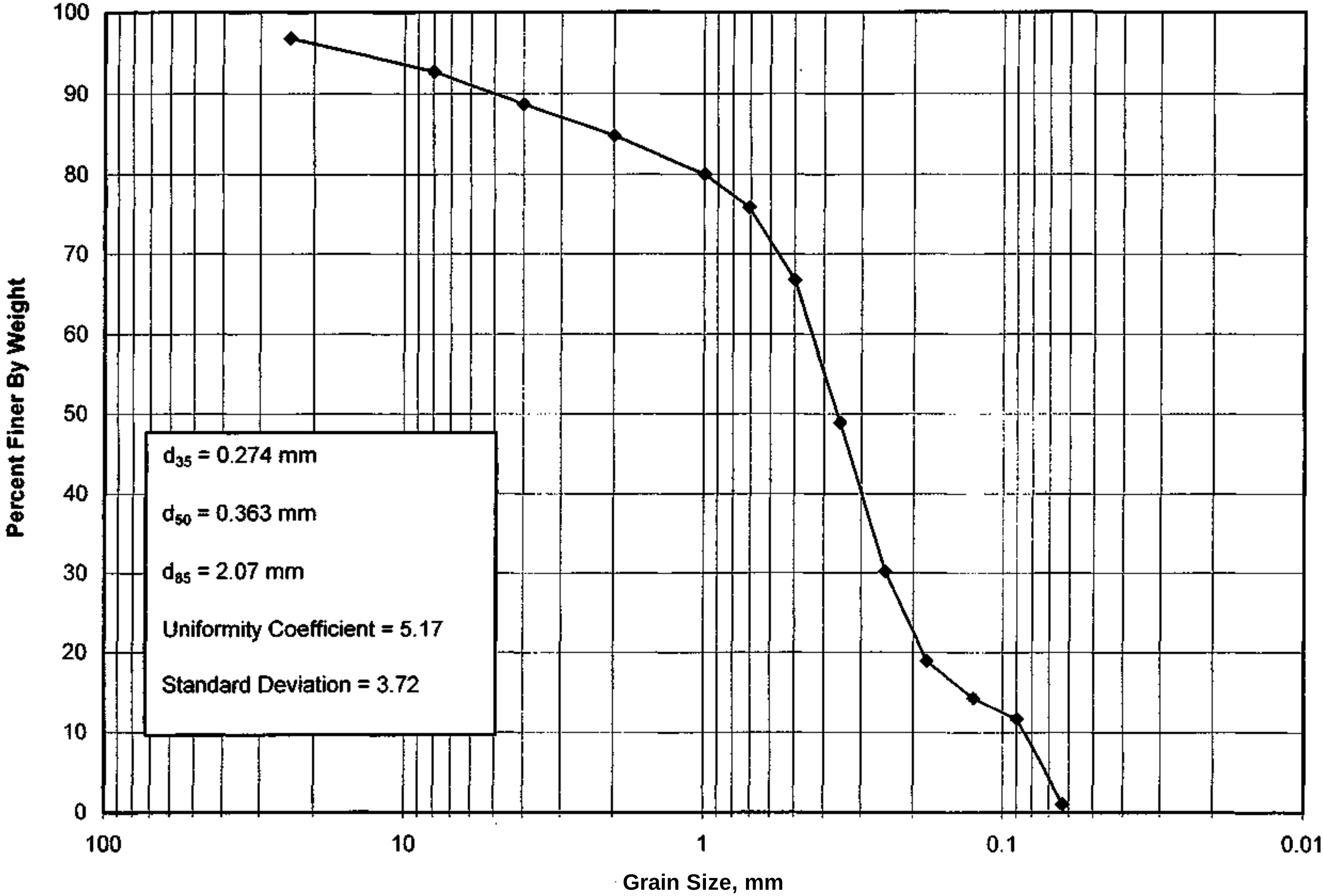


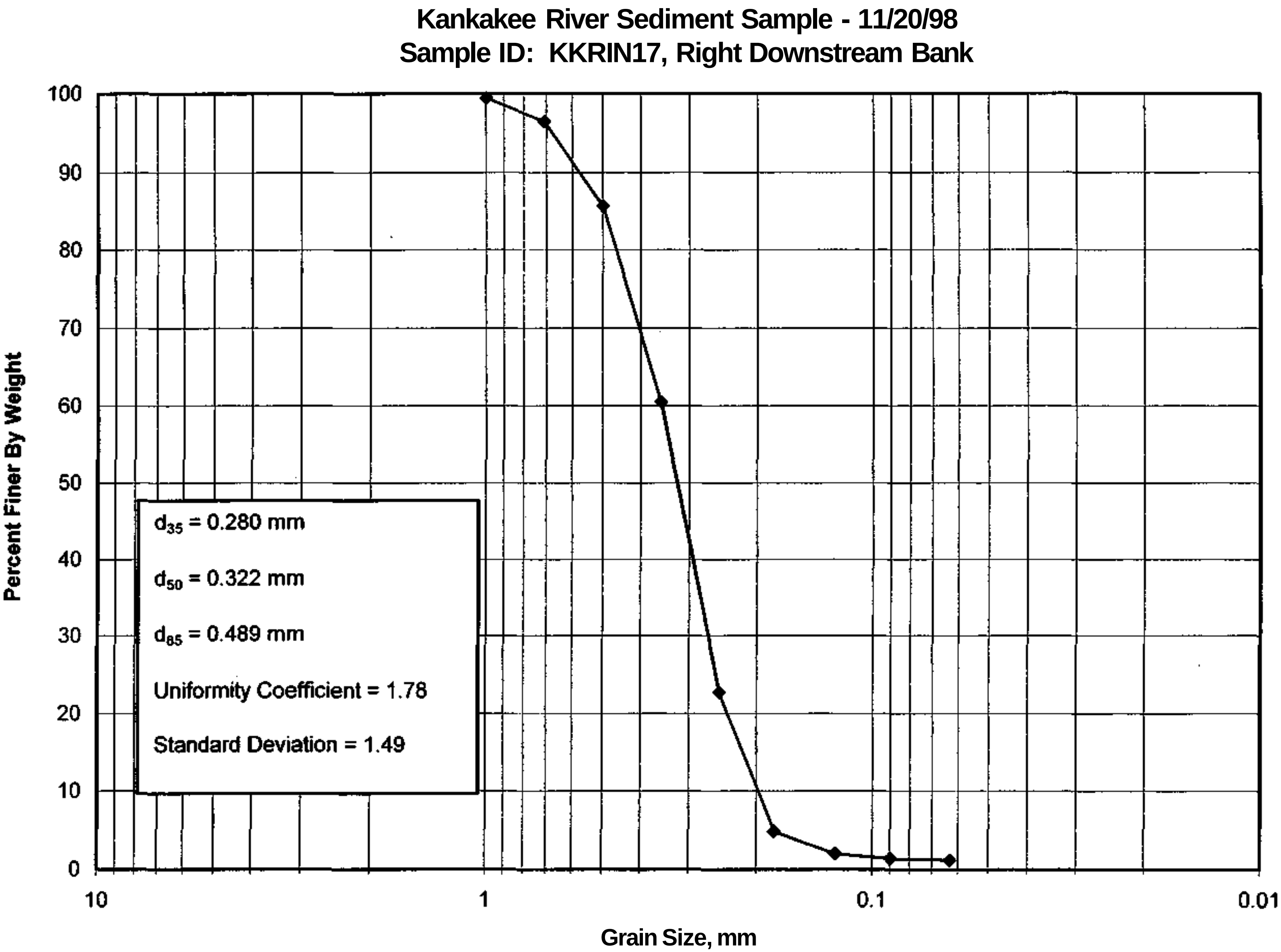

Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN4, Left Bank
Percent Finer By Weight
Grain Size, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
d35 = 0.212 mm
d50 = 0.273 mm
d85 = 0.863 mm
Uniformity Coefficient = 5.13
Standard Deviation = 2.56

Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN09, Right Bank

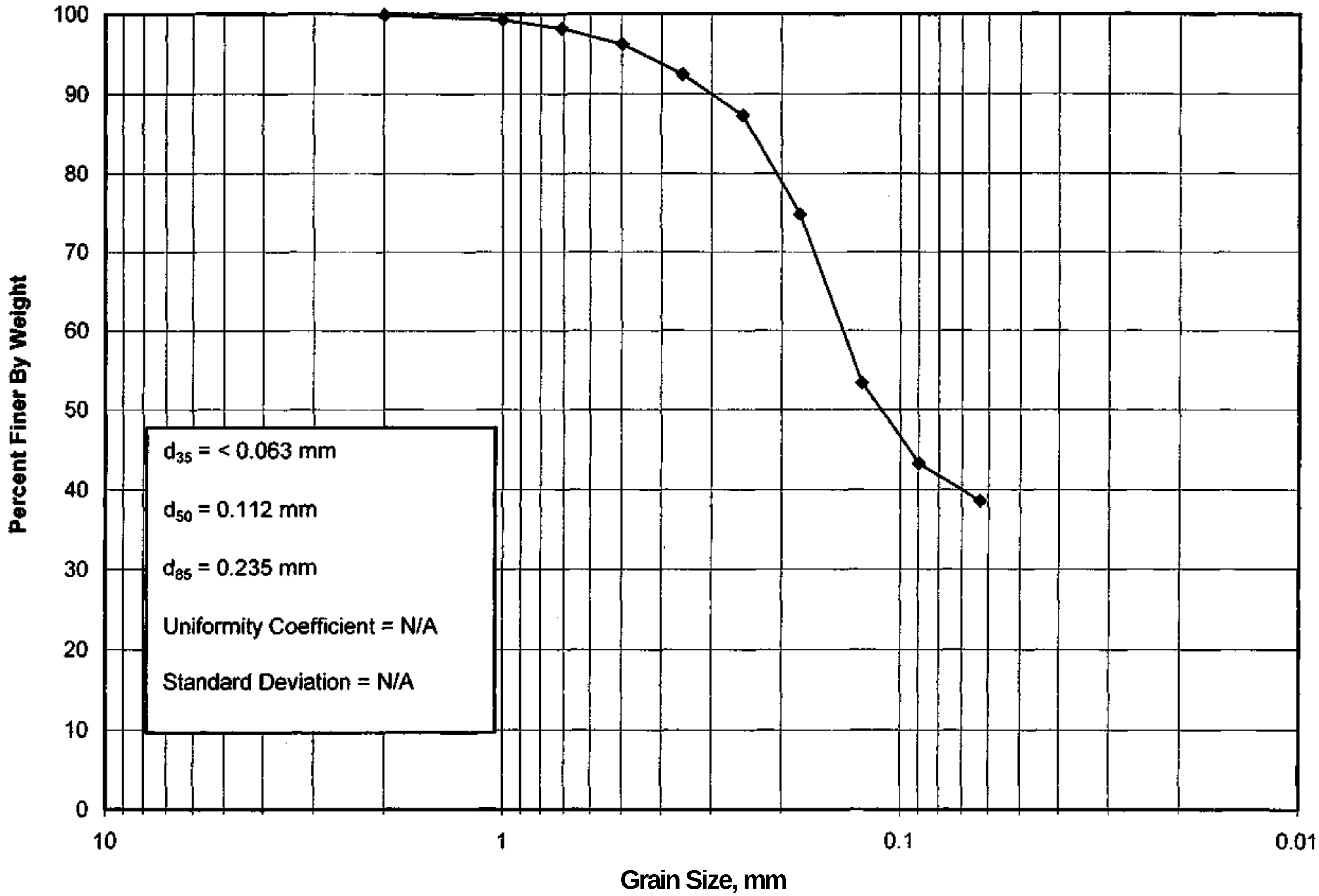


Kankakee River Sediment Sample - 11/19/98
Sample ID: KKRIN14, Left Bank

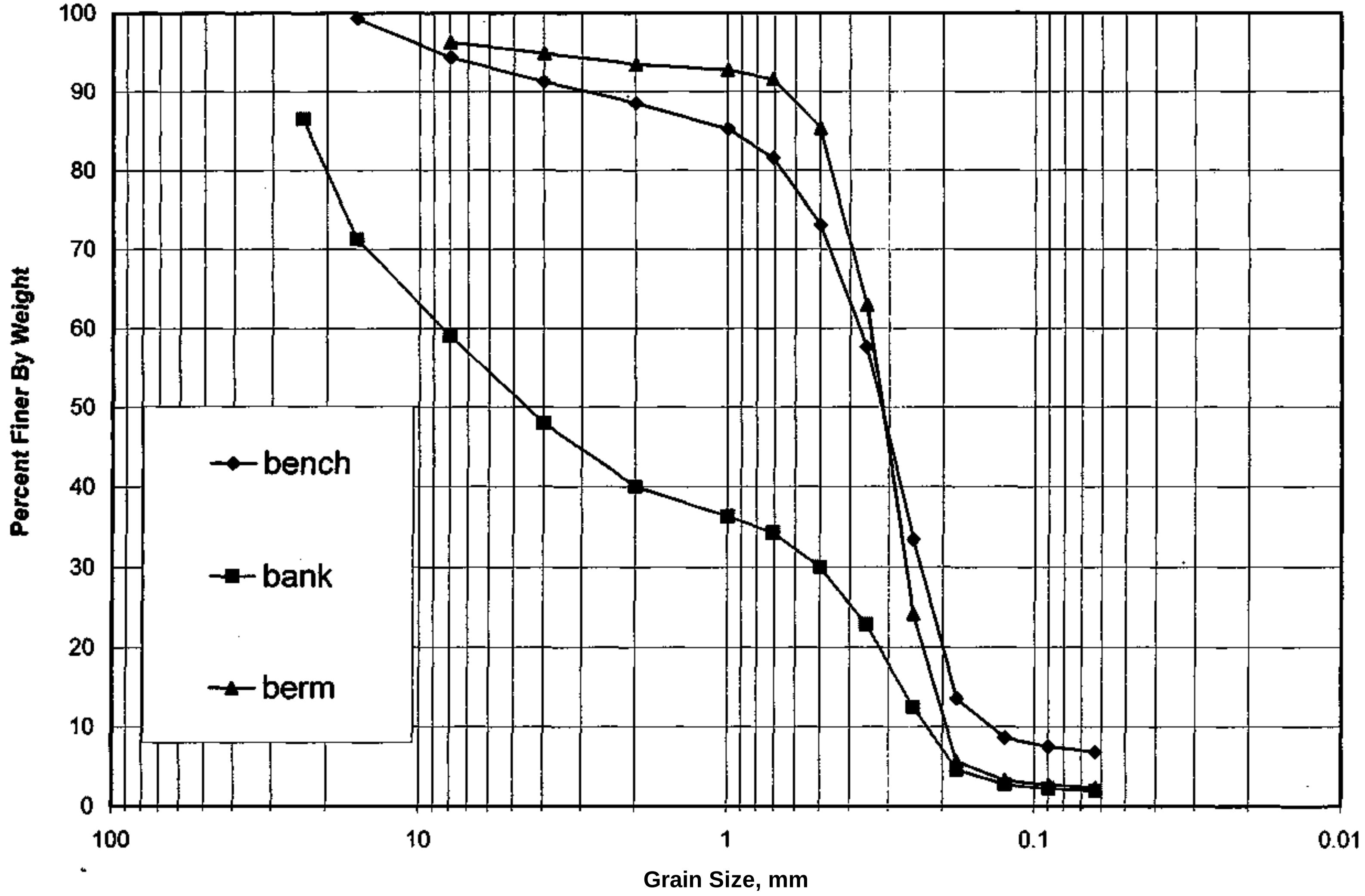



Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN17, Right Downstream Bank
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d35 = 0.280 mm
d50 = 0.322 mm
d85 = 0.489 mm
Uniformity Coefficient = 1.78
Standard Deviation = 1.49

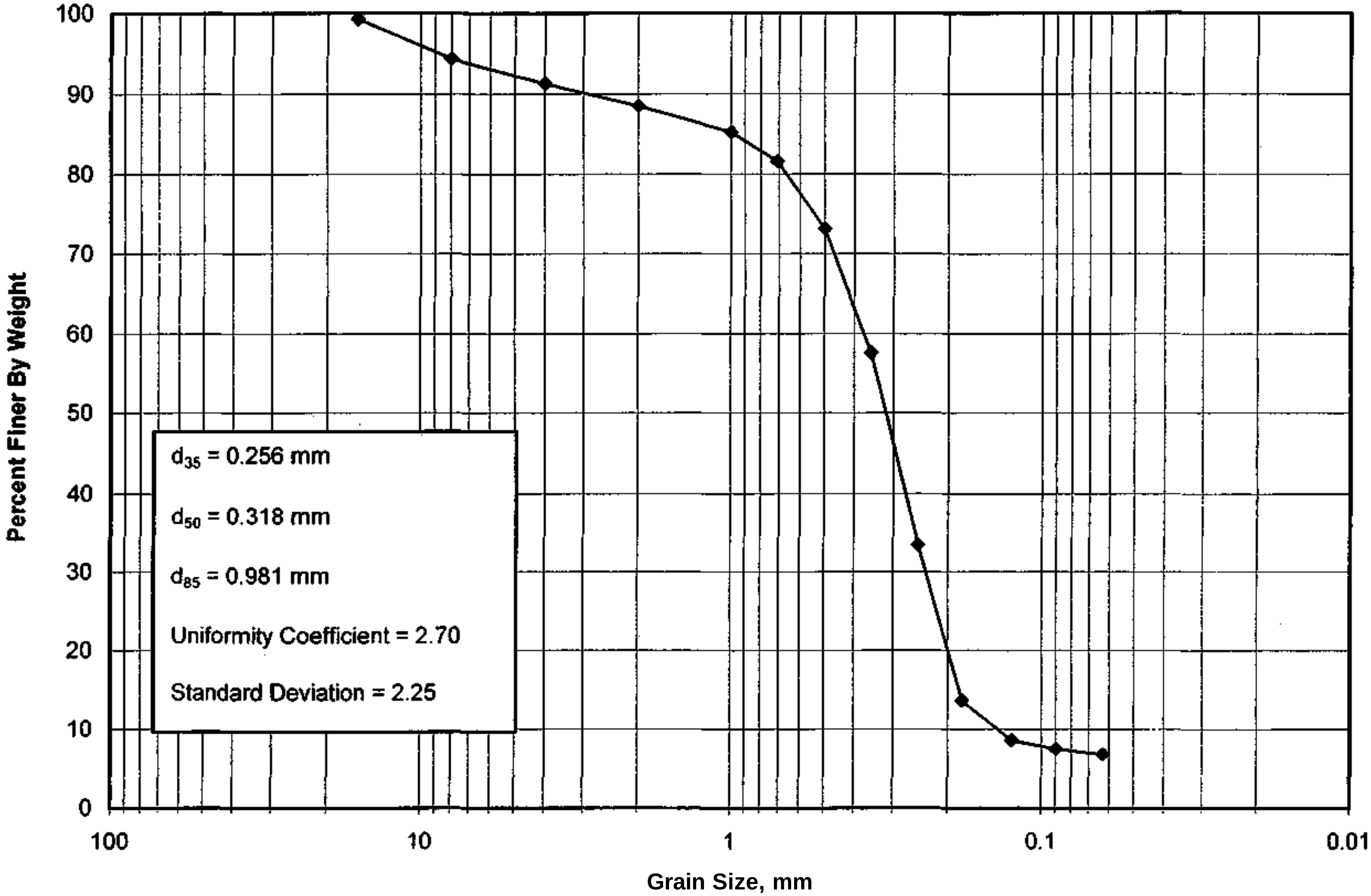
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN19, Left Downstream Bank



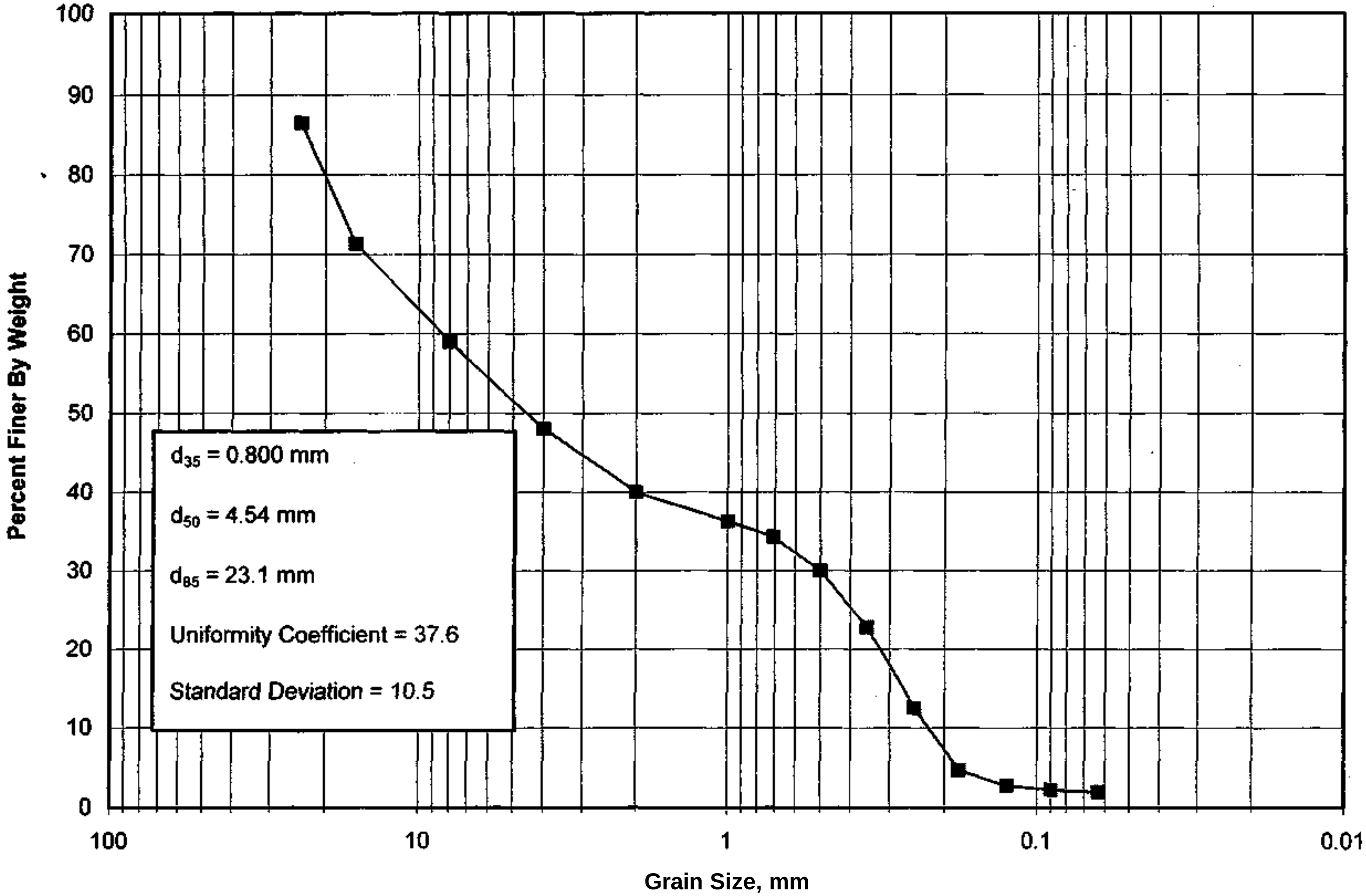
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN22, Left Downstream Bank



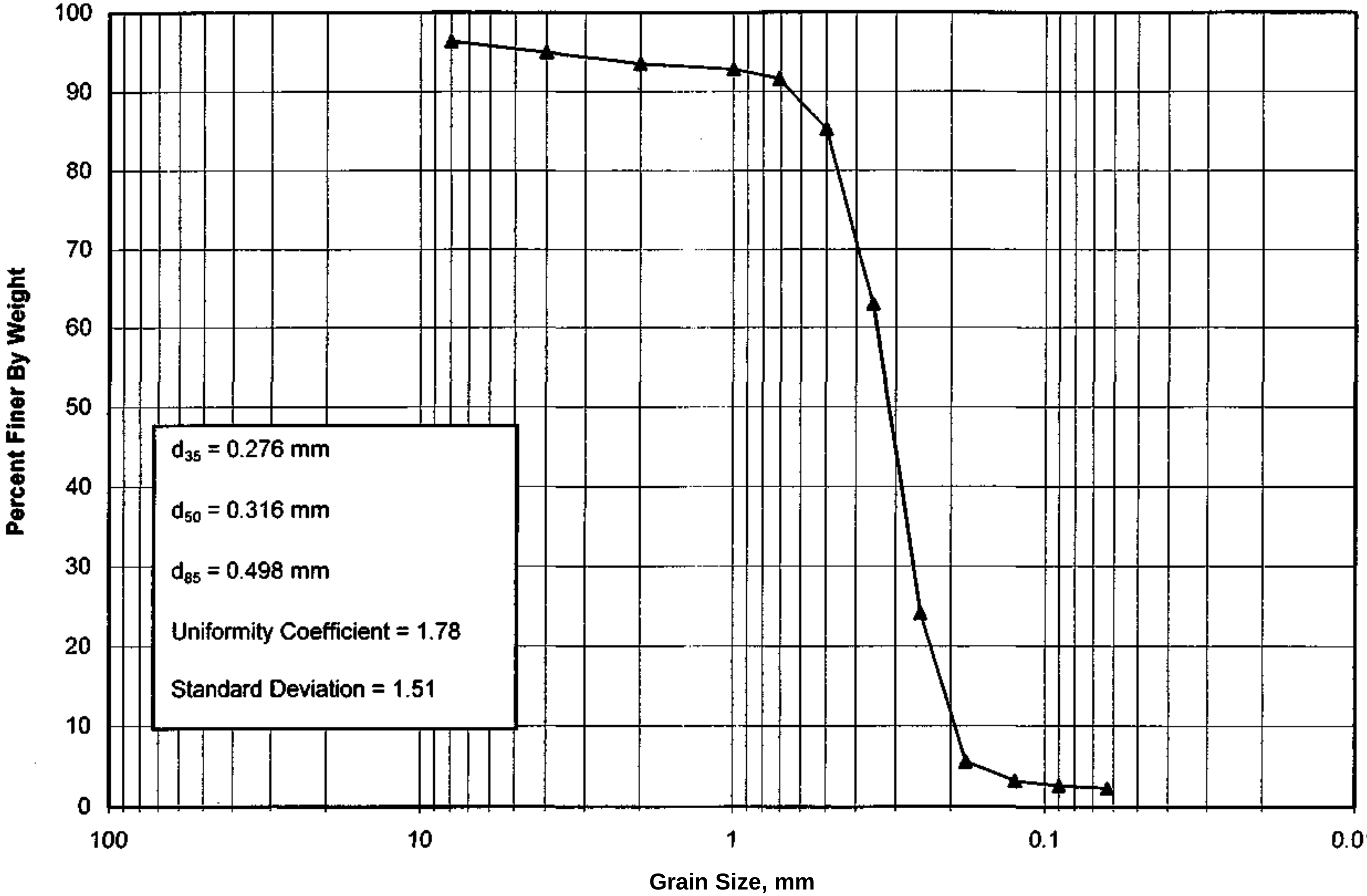
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN22, High Bank LDB Bench

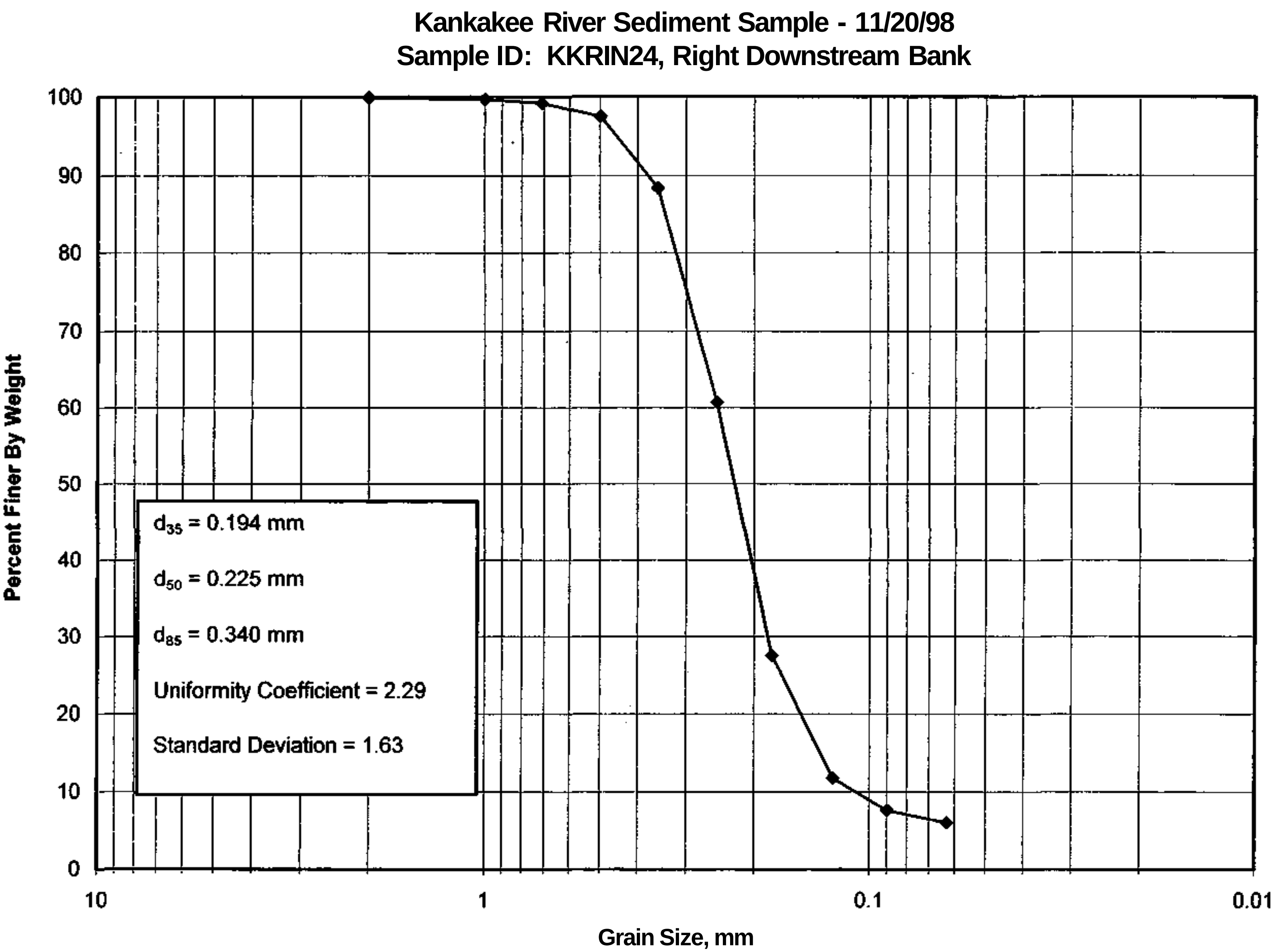


Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN22, High Bank LDB Upper Bank

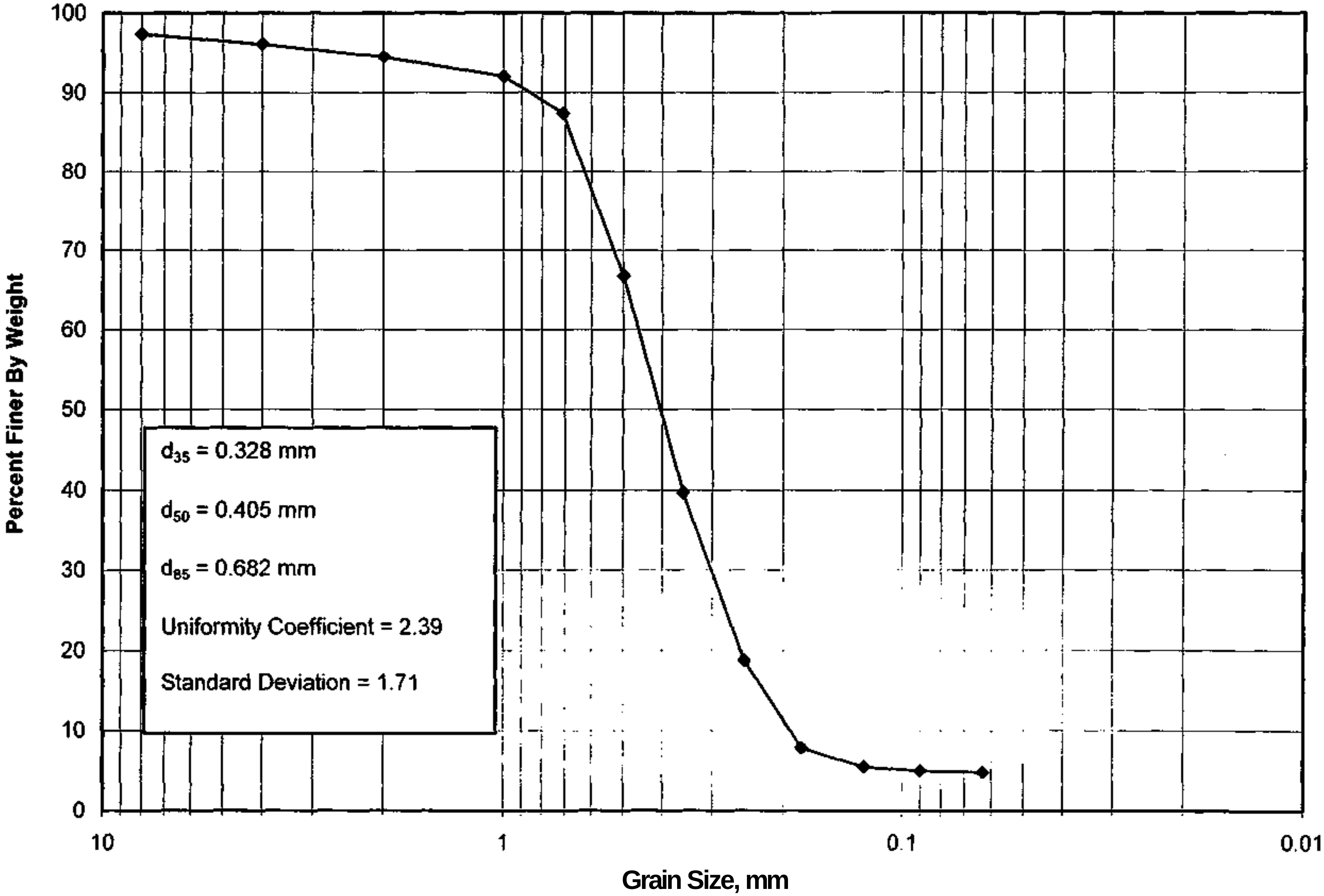


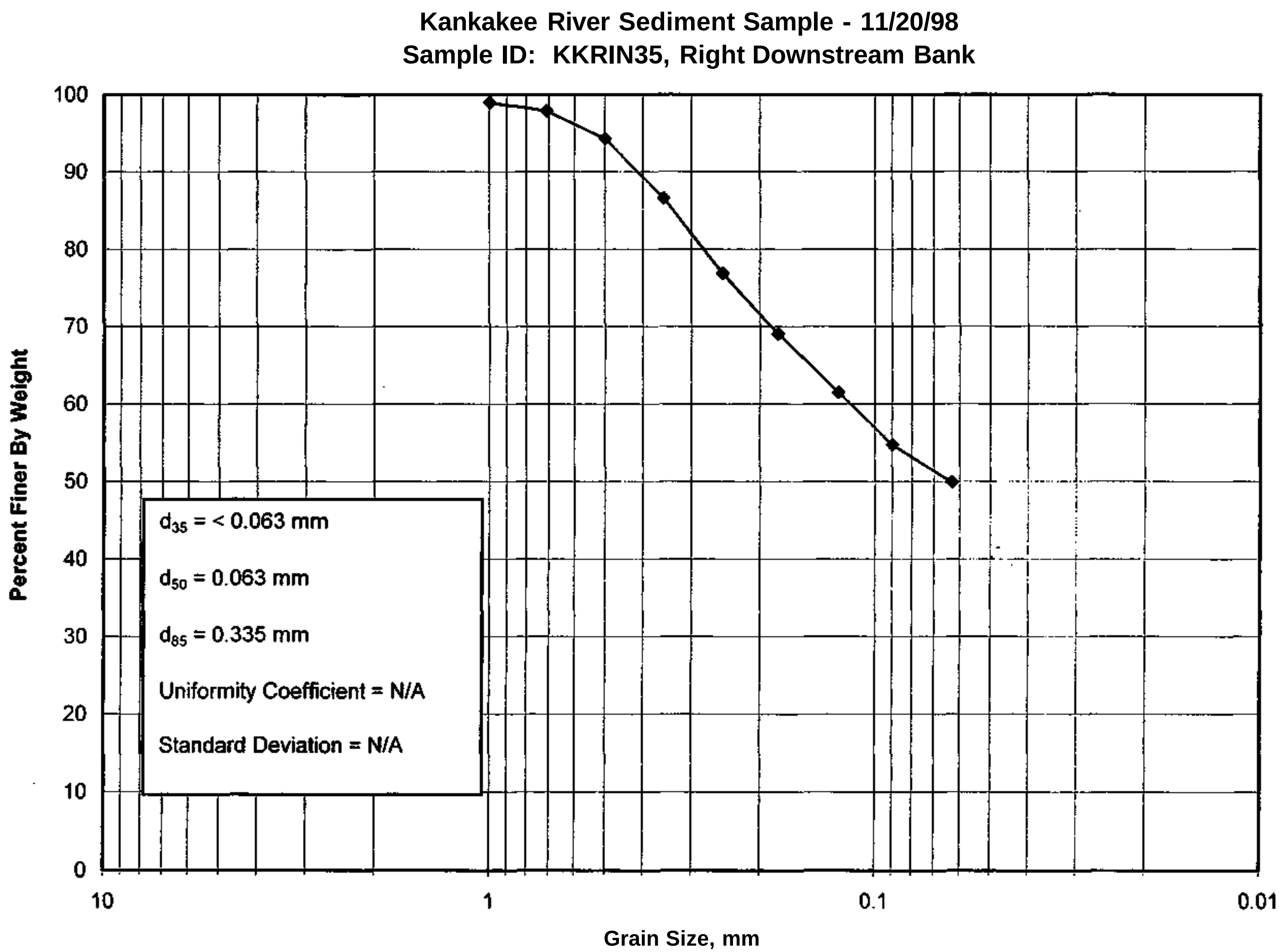
Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN22, High Bank LDB Berm

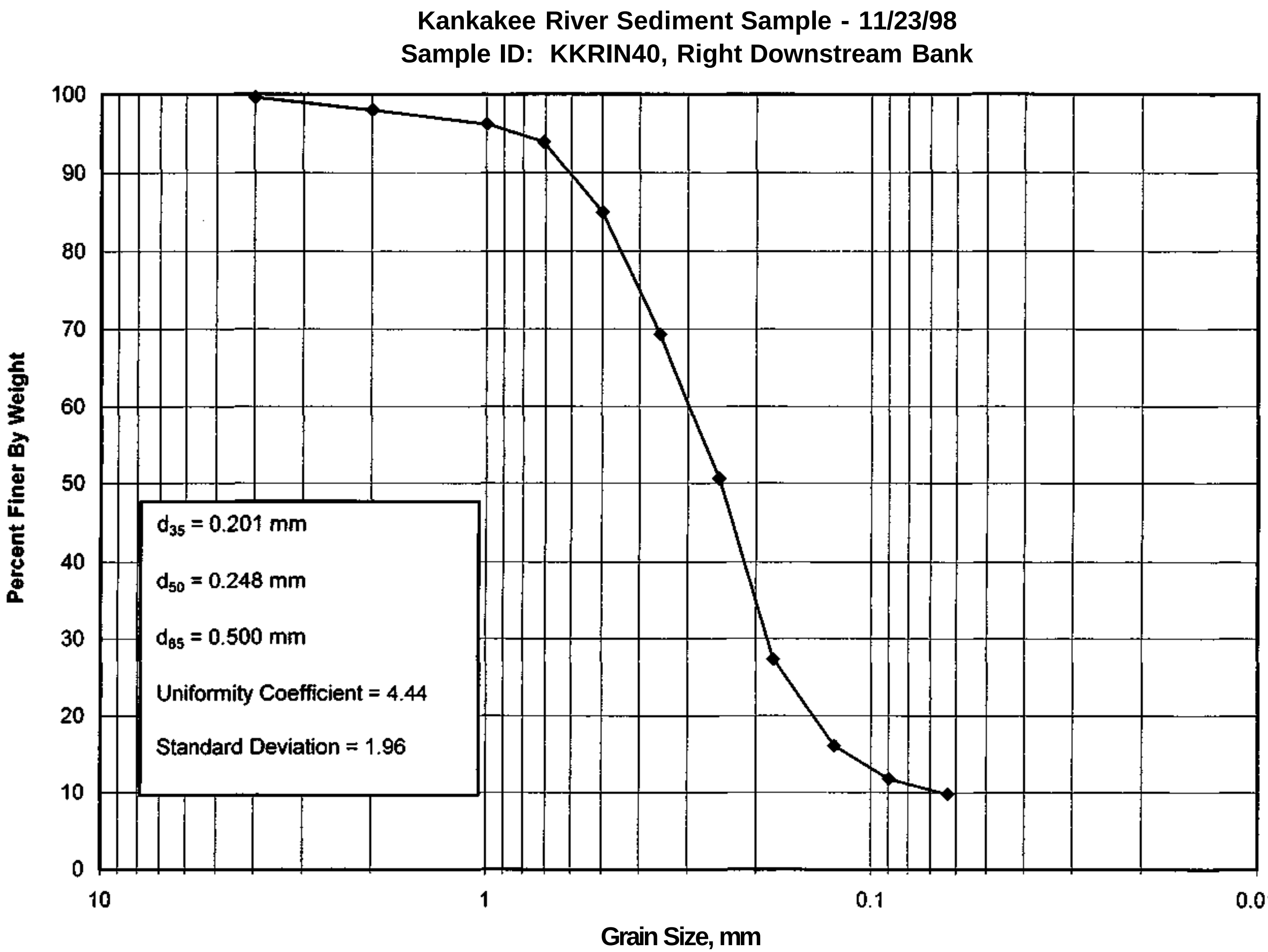


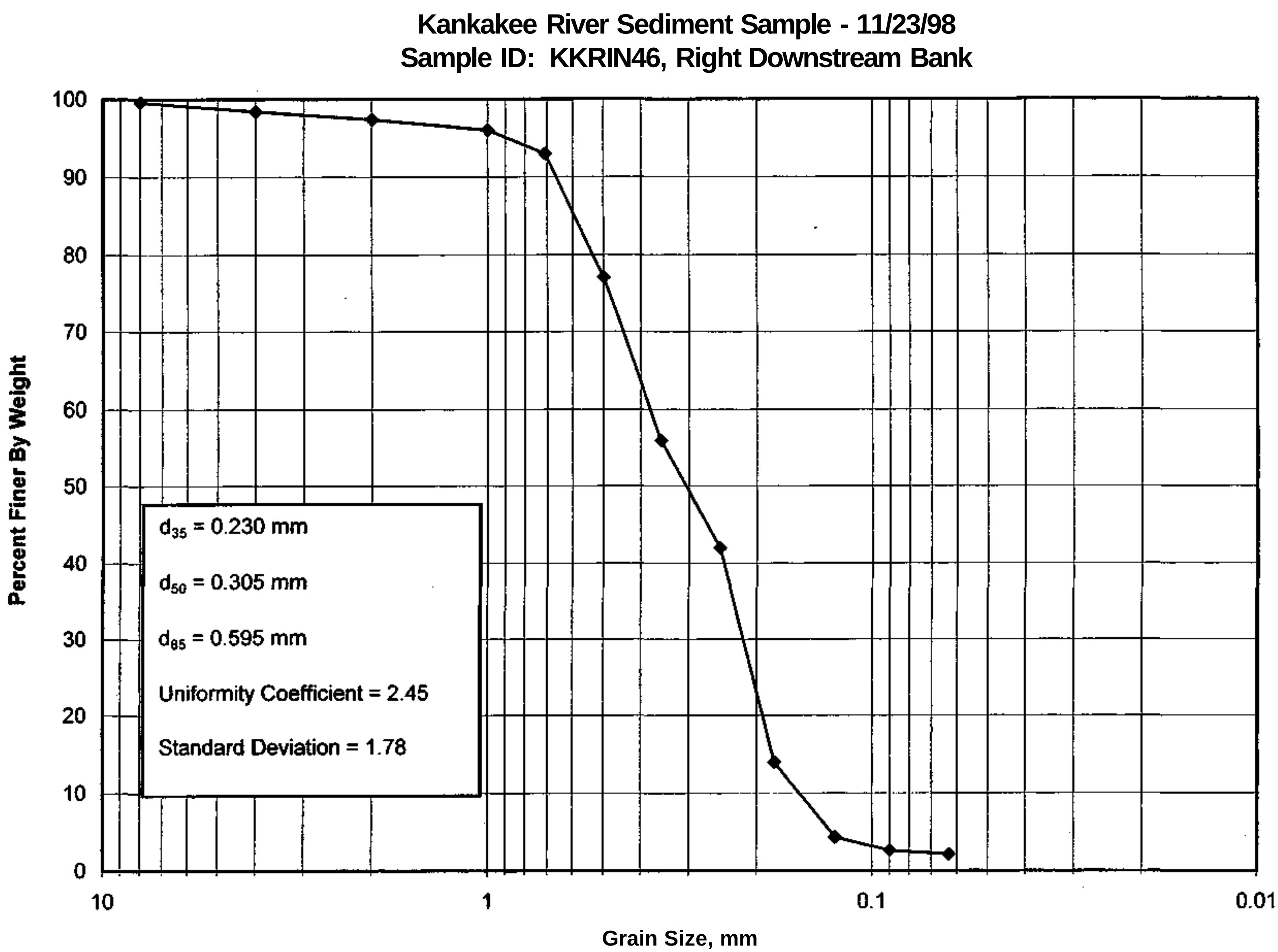

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN24, Right Downstream Bank
Percent Finer By Weight
Grain Size, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
d35 = 0.194 mm
d50 = 0.225 mm
d85 = 0.340 mm
Uniformity Coefficient = 2.29
Standard Deviation = 1.63

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN29, Left Downstream Bank



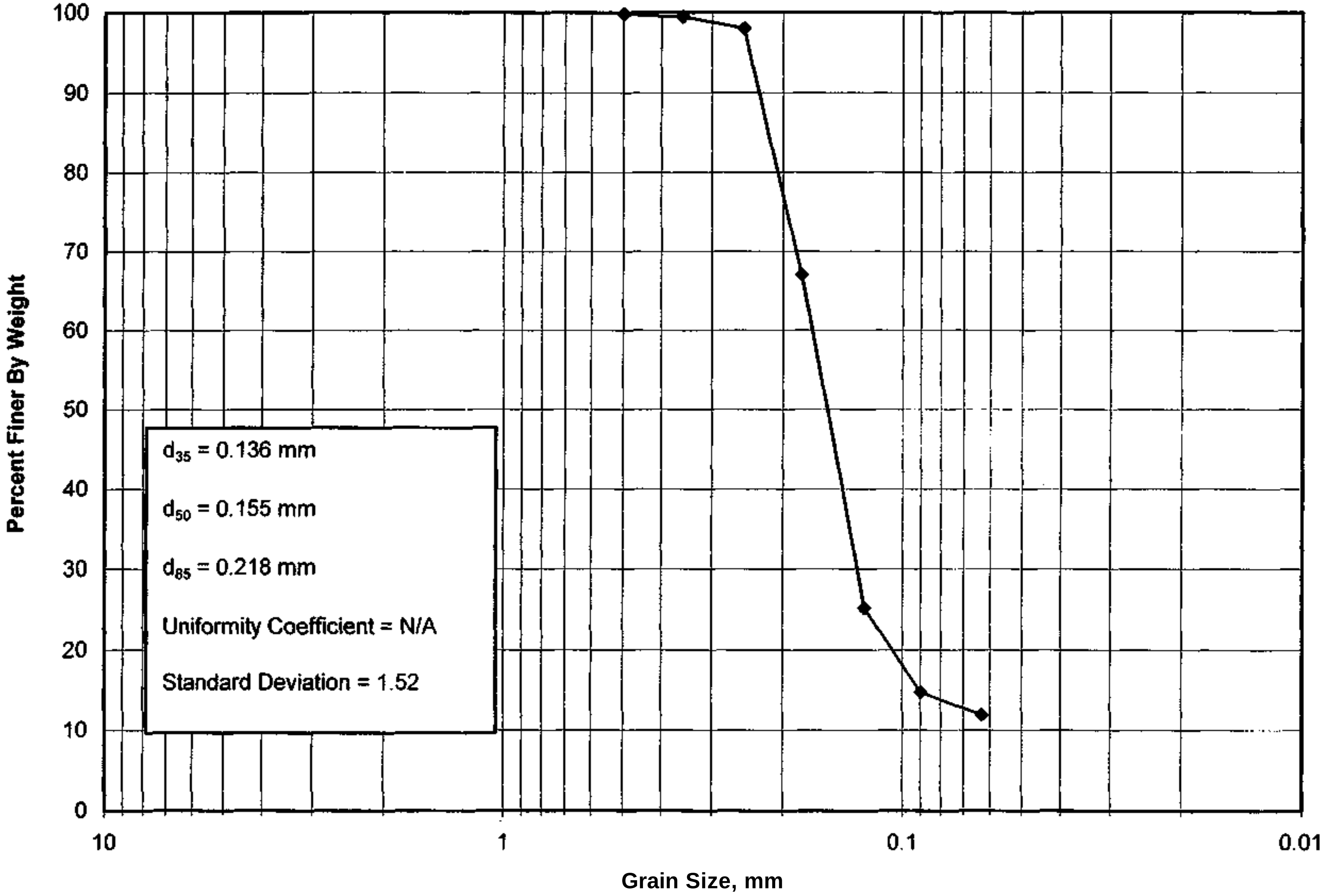

Kankakee River Sediment Sample - 11/20/98
Sample ID: KKRIN35, Right Downstream Bank
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
Grain Size, mm
d35 = < 0.063 mm
d50 = 0.063 mm
d85 = 0.335 mm
Uniformity Coefficient = N/A
Standard Deviation = N/A


Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIN40, Right Downstream Bank
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
d_{35} = 0.201 mm
d_{50} = 0.248 mm
d_{85} = 0.500 mm
Uniformity Coefficient = 4.44
Standard Deviation = 1.96
10
1
0.1
0.01
Grain Size, mm

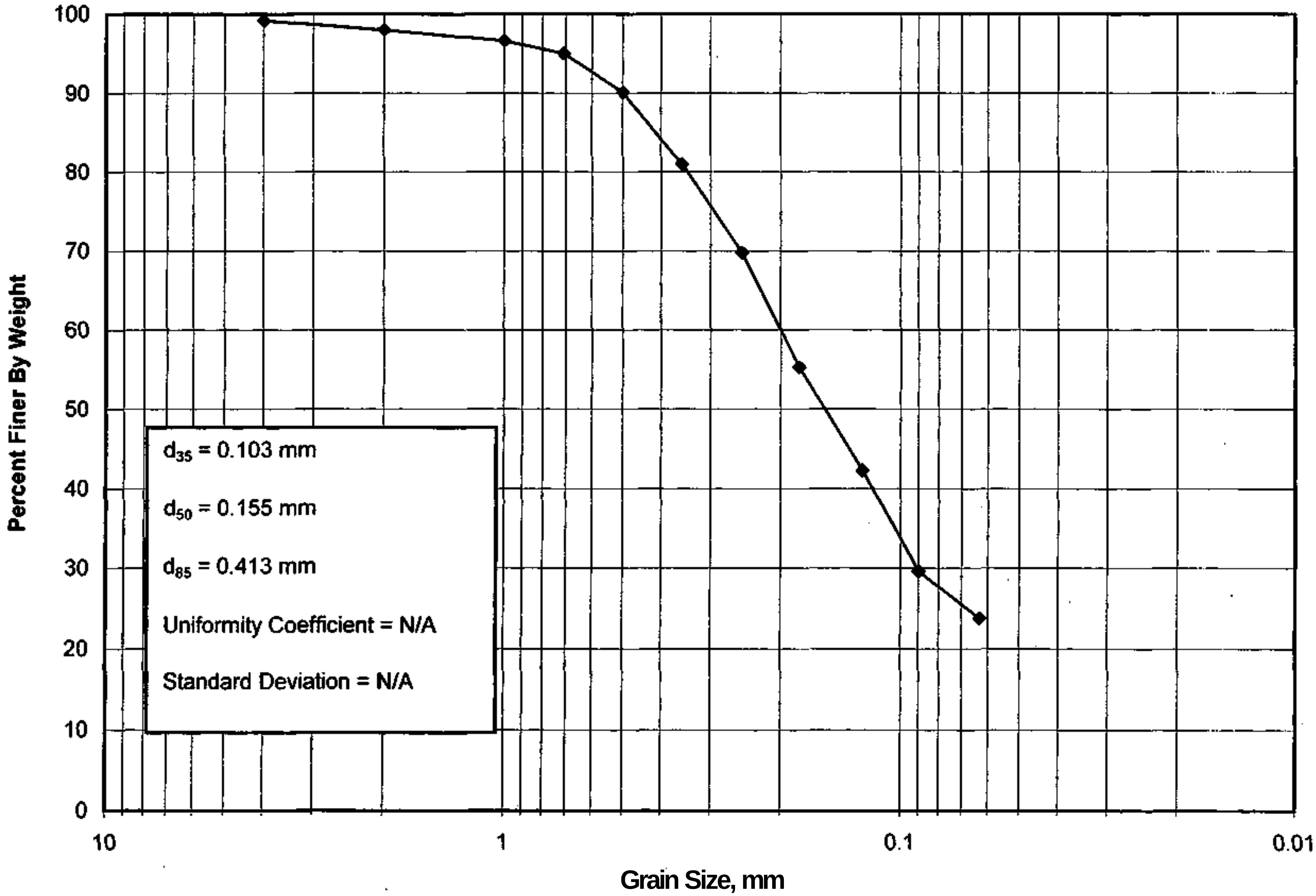


Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIN46, Right Downstream Bank
Percent Finer By Weight
Grain Size, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
d35 = 0.230 mm
d50 = 0.305 mm
d85 = 0.595 mm
Uniformity Coefficient = 2.45
Standard Deviation = 1.78

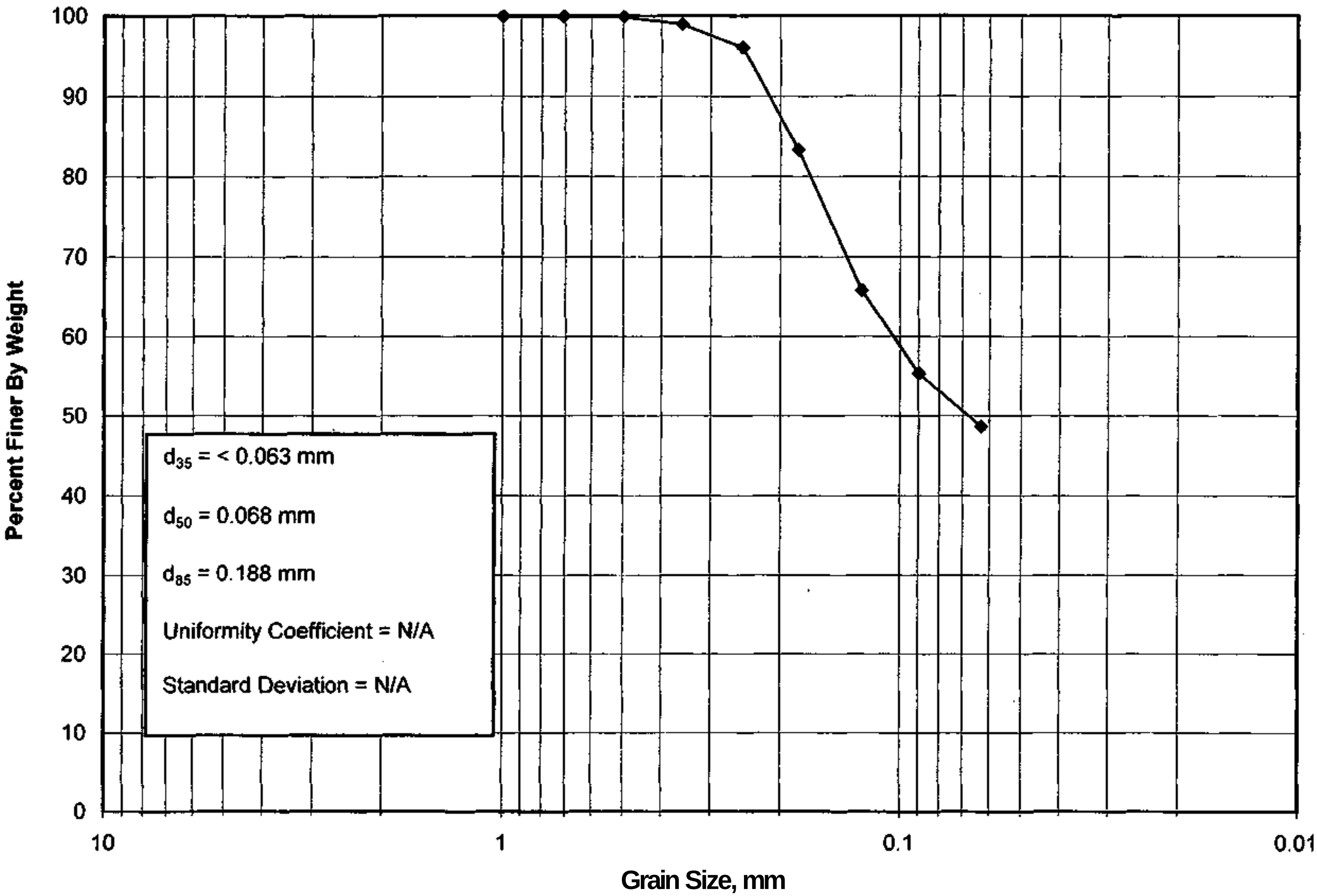
Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIL52, Left Downstream Bank



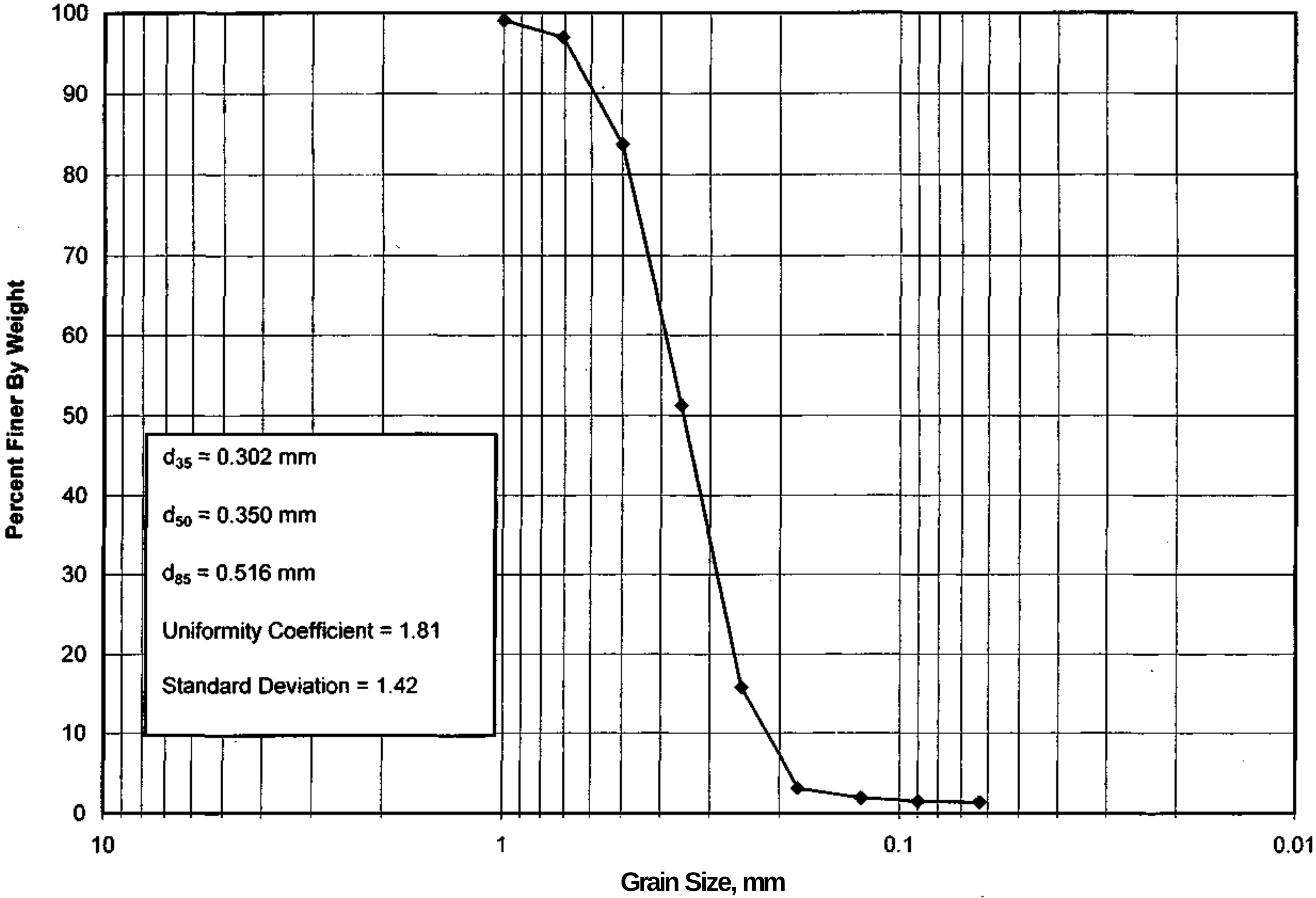
Kankakee River Sediment Sample - 11/23/98
Sample ID: KKRIL56, Right Downstream Bank



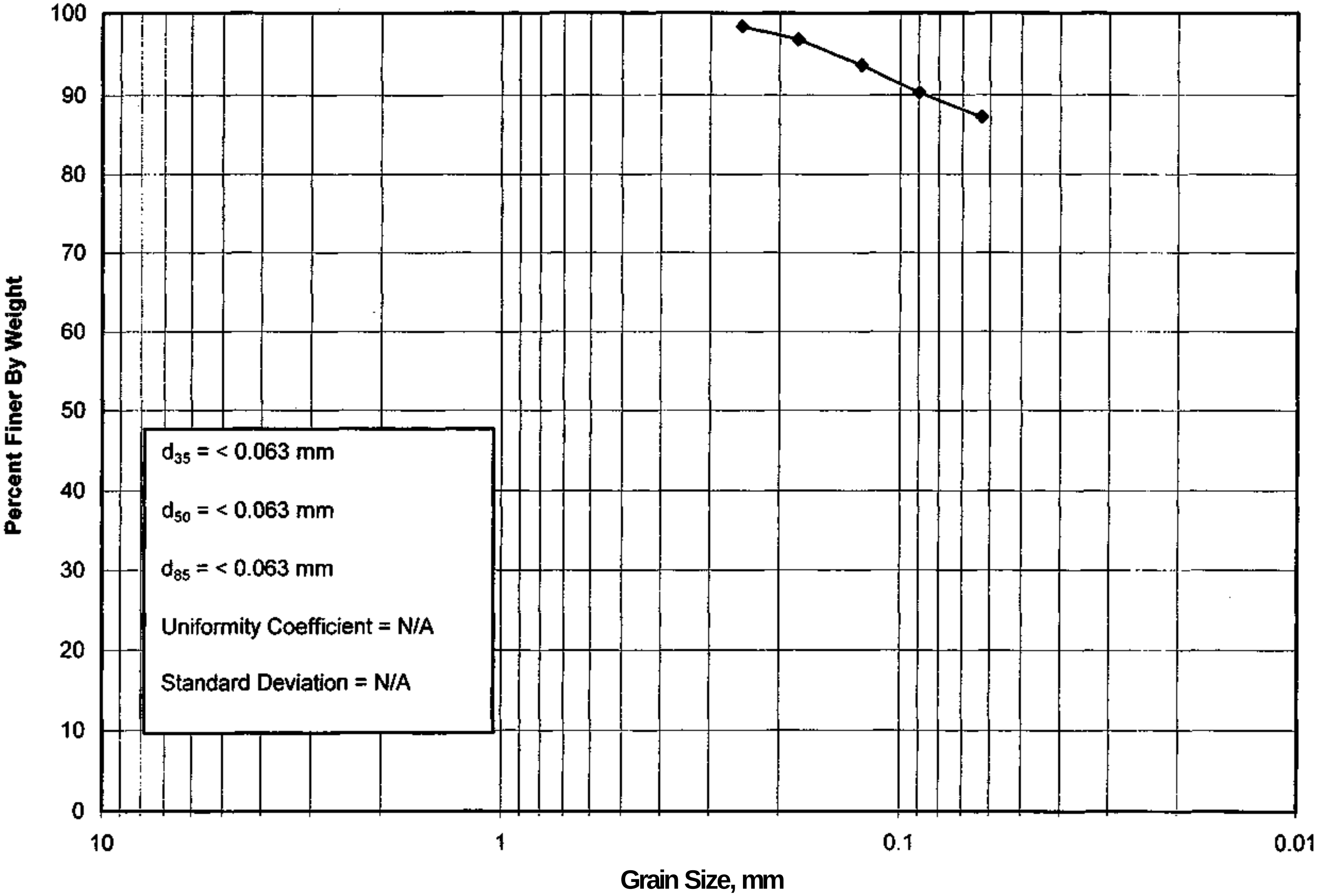
Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL65, Left Downstream Bank



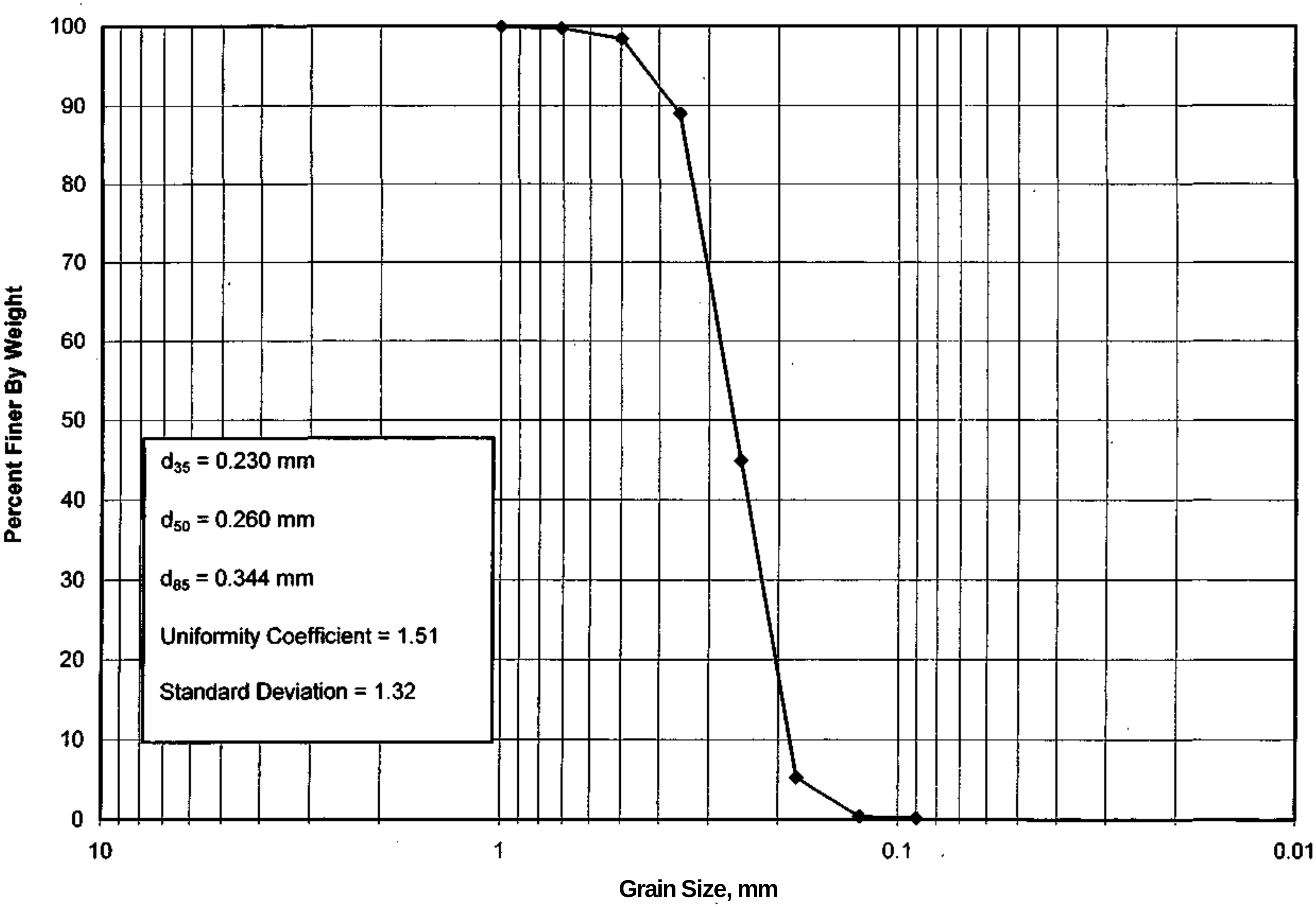
Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL71, Right Downstream Bank



Kankakee River Sediment Sample - 11/24/98
Sample ID: KKRIL75, Left Downstream Bank



Kankakee River Sediment Sample - 11/24/98
Sample ID: Aroma Park, Downstream of KKRIL67



Appendix D. Glossary of Terms

GLOSSARY OF TERMS

Accretion - The process of building by accumulation.

Alluvium - The general name for all sediments deposited on the surface by streams.

Anthropic - A diagnostic surface layer of soil, about 1 foot in thickness, in which the content of soluble P_2O_5 is greater than 250 parts per million. A condition that develops due to long periods of cultivation and fertilization.

Aquatic - Those organisms (plant and animal) that live in the water.

Aquifer - Stream or zone below the surface of the earth capable of producing water.

Archaeology - Relates to occupation sites, work areas, evidence of farming or hunting and gathering, burial sites, artifacts, and structures of all types, usually dating from prehistoric or aboriginal periods, or from historic periods and nonaboriginal activities for which only vestiges remain.

Bank - Topographic feature which, together with the bed, defines the stream channel and may include scarp, berm, and bench areas indicative of failure and erosion processes.

Bank Erosion - Erosion in which the ground bordering a stream and serving to confine the water to the natural channel during normal course of flow is removed.

Bed - A stratum 1 centimeter or more thick. Also, the floor of a stream channel.

Bed Load - The coarse solid particles, within a body of flowing fluid moving along or close above the bed.

Bedrock - Continuous solid rock that underlies weathered rock in soil everywhere and in a particular spot forms the consolidated portion of the earth's surface.

Bench - The relatively mild slope that occurs riverward of the scarp and berm. This mildly sloping area generally is visible at normal pool levels and in many areas extends a considerable distance riverward of the land-water contact at normal pool. The visible portion of the bench is termed "subaerial bench" and the underwater portion is termed the "subaqueous bench."

Berm - Failed soils that accumulate at the base of the scarp at a failed or eroded bank, generally resulting in a wedge-shaped failed soil deposit.

Channel Erosion - Erosion in which material is removed by water flowing in well-defined channels; erosion caused by channel flow.

Chute Cutoff - A new channel cut across a point bar, resulting in the abandonment of part of a meander.

Clay - As a soil separate, the mineral soil particles less than 0.002 millimeter (mm) in diameter. As a textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay Skins - A modification of the texture, structure, or fabric of a soil material consisting of a coating of clay minerals on the surface of a ped or the wall of a void in a soil mineral.

Cleft Pressures - Pressures caused by a sudden cut, breach, or other sharp opening such as a wave-cut gully in a cliff.

Cohesion - In general, an electrostatic force of attraction among fine soil particles. In soil mechanics, the term "cohesion" refers to that portion of the resistance to shearing deformation possessed by a soil, which is not due to friction between particles or to the physical interference of one particle with another in resisting shearing movements.

Colluvium - Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposits at the base of steep slopes.

Concretion - A hard, compact rounded, normally sub-spherical mass or aggregate of mineral matter generally formed by orderly and localized precipitation from aqueous solution in the pores of a sedimentary or fragmented volcanic rock and usually of a composition widely different from that of the rock in which it is found and from which it is rather sharply separated. It represents a concentration of some minor constituent or of cementing material such as silica, calcite, dolomite, iron oxide, pyrite, or gypsum, and is characterized by concentric shells of slightly varying properties due to variation during growth.

Confluence - The place where two streams meet.

Consistence, Soil - The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

Loose - Non-coherent; will not hold together in a mass.

Friable - When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm - When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic - When wet, readily deformed by moderate pressure, but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky - When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard - When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft - When dry, breaks into powder or individual grains under very slight pressure.

Cemented - Hard and brittle, little affected by moistening.

Creep - The imperceptibly slow downslope movement of weathered rock and soil materials. This term is interchangeable with solidification in general usage.

Cycle of Erosion - The sequence of landforms, essentially valleys and hills, through which a land mass is considered to evolve from the time it begins to be eroded until it is reduced to an equilibrium condition.

Datum - A reference element, such as a line or plane, in relation to which the position of other elements is determined. Also called the "reference plane" or "datum plane".

Debris Flow - The rapid downslope plastic flow of a mass of debris.

Discharge - The quantity of water passing a given point in a given unit if time.

Drawdown - The difference in elevation between the water surface elevation at a constriction and what the elevation would be if there were no constriction.

Dredge Materials - Sediments obtained from dredging.

Dredging Maintenance - Removal of material from the river channel, locks, and approaches to the locks.

Eluviation - The downward movement of soluble or suspended material in a soil, from the A horizon to the B horizon, by ground-water percolation. The term refers especially, but not exclusively, to the movement of colloids, whereas the term leaching refers to the complete removal of soluble materials.

Eolian - Wind-blown transport of sediment.

Erosion - A general term that describes the physical breaking-down, chemical solution, and movement of rock fragments and soils from place to place on the surface of the earth.

Frost Heaving - The lifting of soil or rock materials by expansion of ice during freezing of water contained within the soil or rock mass.

Frost Wedging - The mechanism involving the pushing-up or apart of rock particles by the action of the ice.

Geologic Time Scale -

Era	Period	Approx. # of years ago
Cenozoic	Quarternary	1 Million
	Tertiary	60 Million
Mesozoic	Cretaceous	130 Million
	Jurassic	165 Million
	Triassic	195 Million
Paleozoic	Permian	220 Million
	Pennsylvanian	240 Million
	Mississippian	260 Million
	Devonian	320 Million
	Silurian	360 Million
	Ordovician	430 Million
	Cambrian	510 Million
Precambrian Eras		3 Billion

Geology - The science dealing with the structure if the earth's crust and the formation and development of its various layers. It includes the study of individual rock types and early forms of life found as fossils in rocks.

Glaciation - The alternation of a land surface movement of glacier ice.

Ground cover - The lowermost vegetationed zone.

Ground water - That water beneath the earth's surface that is contained in the pore spaces within the soil and bedrock. (In this connection, geologists frequently refer to water within the regolith, meaning that water contained within the bedrock and overlying weathered rock materials, but not the water contained within the uppermost soil layers which support plant growth.)

Habitat - A place where a given species lives, generally the kind of place rather than a geographic location.

Historical - References to features generally consisting of post-European structures or sites relevant to an event, person, or period specifically commemorative to previous generations.

Holocene - An epoch of the Quaternary period, from the end of the Pleistocene (0.01 million years before present) to the present time: also, the corresponding series of rocks and deposits.

Horizon, Soil - A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

Hydrograph - A graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water with respect to time.

Hydrology - A science dealing with the properties, distribution, and circulation of water on the surface of land, in the soil, and underlying rocks, and in the atmosphere.

Kansan, Pre-Illinoian - Older studies suggested two early Pleistocene glacial advances, the Nebraskan and Kansan. More recent work by the Iowa Geological Survey suggests many more early glacial advances and retreats. They suggest using the term Prc-Illinoian for the early Pleistocene events 500,000 years ago and older. Following the Prc-Illinoian is the **Yarmouth interglacial.** At about 225,000 years ago is the **lllinoian glacial** stage. Following the Illinoian is the **Sangamon interglacial stage.** The Sangamon continues to about 60,000 years ago and is followed by the **Wisconsinan.**

Leaching - The removal in solution of the more soluble minerals by percolating waters.

Levee: Natural - A broad, low ridge of fine alluvium built along the side of a stream channel by water spreading out if the channel during floods.

Liquefaction - A term utilized in soil mechanics to describe the loss of shearing resistance in a non-cohesive material caused by vibration or shock loading and the consequent decrease in friction and interference between individual particles within the mass of soil. In such an instance, the granular soil will flow like a viscous fluid.

Loess - A type of soil composed of finely graded, wind-blown, silt-sized angular particles which are frequently cemented. Loess soils are frequently deep and appear homogeneous for most of their depth.

Map, Topographic - A map showing correct horizontal and vertical positions of features represented.

Mass-Wasting - The movement of rock debris downslope under the influence of gravity, without the aid of a flowing medium to assist transport (air at ordinary pressure, water, or glacial ice).

Meander - A looplike bend of a stream channel.

Mesozoic - See Geologic Time Scale.

Morphology, Soil - The physical constitution of the soil expressed in the kinds of horizons, their thickness and arrangement in the profile, and their color, texture, structure, consistence, and chemical and biological properties.

Mottling, Soil - Irregular spots or patches of different colors, usually indicating poor aeration and lack of drainage. The pattern of mottles is described as to abundance, size, and contrast. Descriptive terms are as follows:

Abundance - few, common, and many.

Size - fine, medium, and coarse.

Contrast - faint, distinct, and prominent.

The size measurements are these:

Fine - less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension.

Medium - 5 to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension.

Coarse - more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Native soils - Soils or group of soils that are restricted to a particular region or environment.

Natural Drainage - Refers to the condition that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation, but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

- *Excessively drained soils* are commonly very porous and rapidly permeable and have a low water-holding capacity.
- *Somewhat excessively drained soils* are also very permeable and are free from mottling throughout their profile.
- *Well-drained soils* are nearly free from mottling and are commonly of intermediate texture.
- *Moderately well-drained soils* commonly have a slowly permeable layer in or immediately beneath the solemn. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.
- *Imperfectly or somewhat poorly drained soils* are wet for significant periods, but not all the time, podzolic soils that are somewhat poorly drained commonly have mottling in the lower part of the A horizon and in the B and C horizons (at a depth below 6 to 16 inches).
- *Poorly drained soils* are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly absent in some.
- Very poorly drained soils are wet nearly all the time. They have a dark gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Ordinary High Water - That elevation on the river bank which defines river dominance.

Overburden - Materials of any nature, consolidated or unconsolidated, that overlie inplace rock or a deposit of ores, or coal, especially those deposits that are mined from the surface by open cuts.

Paleosol - A buried soil horizon of the geologic past. When uncovered, it is said to be exhumed.

Parent Material (Soil) - The horizon of weathered rock or partly weathered soil material from which soil has formed; C horizon in the soil profile.

Pastureland - Land covered with grass or herbage suitable for grazing livestock.

Ped - A naturally formed unit of soil structure, e.g., granule, block, crumb, aggregrate.

Pedogenic - Pertaining to soil formation.

Pennsylvanian - The sixth system and period of the Paleozoic era; contains units younger than Mississippian, older than Permian.

Period - Unit of geologic time.

Piping - That mode of failure in soil masses produced by the removal of a grain of soil at the surface of the soil mass by water flowing from within the mass, with a progressive removal of other particles to form a conduit or pipe into the interior of the soil mass, with subsequent collapse of the mass after creation of this conduit or pipe.

Plant Community - The association of all the plants found living together in specific environmental situations.

Pleistocene - The earlier of the two epochs of the Quarternary period, also called Glacial epoch and formerly called Ice Age. The Ice Age occurred during the Pleistocene epoch, which began about 1,000,000 years ago.

Point Bar - A crescent-shaped bar built out from each convex (inside) bank of a stream channel.

Soil Profile - A vertical section of a soil through all of its horizons and extending into the parent material.

Relief - The elevations or inequalities of the land surface, considered collectively.

Rework and Transport - Removal and displacement of material by natural agents from its place of origin. Carried by flowing water and redeposited in another locality.

Riparian - Relating to, or living on, the bank of a river.

Runoff - Term referring to that rainwater which actually reaches a stream after losses from infiltration, transpiration, and evaporation.

Sailing Line - The line actually navigated - not necessarily the center of channel.

Sample, Disturbed - A soil sample containing all the constituents of a particular stratum, but the original soil sample has been altered.

Sample, Undisturbed - As above, but the original soil structure has been maintained.

Sand - As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, soil material that is 85 percent or more sand and not more than 10 percent clay.

Scarp - The generally steeply sloping, and many times near vertical portion of an eroding or failed bank which is located landward of the bench and berm, extending to the top of the bank.

Sediment - Rock or soil material that has been transported and deposited by water, air, or ice.

Sedimentation - The settling of solids, such as soil particles, by gravity.

Silt - As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil material that is 80 percent or more silt and less than 12 percent clay.

Siltation - The deposition of finely divided soil particles.

Slaking - The crumbling and disintegration of the earth materials upon exposure to air or moisture: specifically the breaking up of dried clay or indurated soil when saturated with or immersed in water.

Slip and Failure - Actual relative movement of a material that has been stressed beyond its ultimate strength.

Soil - A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Spoil - See Dredge Materials.

Stage, River - The height of water surface of a stream above some referenced datum.

Stratum - A definite layer of rock or soil consisting of material that has been out upon the surface of the earth.

Stream Terrace - A bench along the side of a valley, the upper surface of which was formerly the alluvial floor of the valley.

Stress - Force per unit area.

Stress: Shearing - A stress causing parts of a solid to slip past one another, like playing cards in a pack.

Structure, Soil - The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an angel mass of unaggregated and have properties unlike those of an equal mass of unaggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are: Platy (laminated); Prismatic (vertical axis of aggregates longer than horizontal); Columnar (prisms with rounded tops); Blocky (angular or sub-angular); and Granular. Structureless soils are (1) single grain (each grain by itself, as in dune sand) or (2) Massive (the particles adhering without any regular cleavage, as in many claypans and hardpans).

Subaerial - Occurring beneath the atmosphere or in the open air; especially said of conditions and processes that exist or operate on or immediately adjacent to the land surface, or of features and materials that are formed or situated on the land surface.

Subsoil - Technically, the B horizon; commonly, that part of the profile below plow depth.

Substrate - The material comprising the bottom of a stream or the surface to which living organisms attach themselves.

Substratum - Any larger beneath the solum, or true soil; applied to both parent material and other layers unlike the parent material below the B horizon.

Surcharge - An additional excessive burden: overload.

Surface Runoff - The water that flows off the land surface.

Surface Layer - The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness.

Suspended Load - The fine solid particles turbulently suspended within a body of flowing fluid.

Swash - A narrow sound or secondary channel of water lying within a sandbank or between a sandbank and the shore.

Terrace - An embankment or ridge constructed across sloping soils on the contour or at a slight angle to the contour. A terrace intercepts surface runoff so that it will soak into the soil or flow slowly to a prepared outlet without harm.

Terrace (Geological) - An old alluvial plain, usually flat or undulating, bordering a stream; frequently called a second bottom, as contrasted to a first bottom or flood plain; seldom subject to overflow.

Terrestrial - Those organisms (plants and animals) that live on land.

Thalweg - the line joining the deepest points of a stream channel.

Topsoil - A presumed fertile soil or soil material, generally rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Turbidity - A measure of the clouded or muddy appearance of water (unit: NTU).

UTM - Universal Transverse Meridian. The grid system in which the earth is mapped and divided into coordinates.

Water Table - The upper surface of the zone of water saturation in soil or rock masses.

Weathering - The chemical alteration and mechanical breakdown of rock materials during exposure to air, moisture, and organic matter, as well as changing temperatures.

Wisconsinan - The uppermost Pleistocene stage in Illinois and Wisconsin. Pertaining to the last glacial stage of the Pleistocene epoch in North America, following the Sangamon interglacial stage. It began about 85,000+/- 15,000 years ago and ended about 7,000 years ago.

ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES