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STATEWIDE INSTREAM SEDIMENT MONITORING PROGRAM FOR ILLINOIS: ANNUAL REPORT - WATER YEAR 1981 (EXCLUDING APPENDIX B)

by
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Richard L Allgire, and D. Kevin Davie

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CONTENTS

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INTRODUCTION

Sedimentation in Illinois lakes and sediment transported by Illinois streams are major pollution issues. The interactions between sediment and water are now recognized as major water resources problems. The magnitude of these problems has not yet been fully realized.

Various physical means to control soil erosion and stream erosion are now being considered. Their implementation will have enormous societal and environmental ramifications. Unfortunately, many of the physical and chemical aspects of sediments in rivers and lakes are not yet known or understood clearly.

Knowledge of sediments in Illinois water affects a multitude of agency and business decisions in Illinois. For example, there are major questions with poorly quantified information on:

- Impacts of sediment on stream biota and stream environment
- Impacts of sediment on water treatment plants
- Lake sedimentation
- Locations and causes of sheet, gully, and stream bank erosion
- Effects of reduced field erosion on instream erosion
- Pollutants carried by sediment
- Quantity and magnitudes of sediment carried by Illinois streams

The state needs a strategy to deal with these impacts, and to make regulatory decisions related to:

- Reductions in watershed erosion
- Best management practices to be followed
- Effects of changing land use and cropping patterns
- Stream channelization
- Land use and management along stream banks and lake shores

Sedimentation also affects the capacity and water quality of water supply lakes. It reduces storage capacity in flood control reservoirs. Sediment deposition in streams affects the conveyance of the stream and its capacity to sustain a viable aquatic habitat. The biota in all of these waters are potentially affected by the chemical composition of the sediments, sediment deposition, and sediment load.

As a consequence of these complex, wide-ranging impacts, sediment is of concern in major state activities. These include: 1) the maintenance of water quality (Environmental Protection Agency); 2) farming (Department of Agriculture); 3) regulation of our waterways, construction of hydraulic structures, and development of surface water impoundments (Division of Water Resources); and 4) the preservation of natural stream courses (Department of Conservation). All of these impact areas relate to the overall maintenance and management of the state's natural resources (Department of Energy and Natural Resources).

Correct answers to this myriad of technological, scientific, and policy questions can come only from quality data of sufficient breadth, in both time and space, to allow research and development of reliable answers. Unfortunately, these data do not exist. Data are among the key components to the formulation of plans and policy.

There is a definite need for a long-term, statewide sediment monitoring network. The key values of the data and information derived will be: 1) to provide realistic answers to new or current problems, and 2) to provide answers and information for planning based on long-term data bases.

In the latter application, existing and envisioned issues relate to: 1) trends in sedimentation related to man-made changes; 2) the water quality in streams as affected by sediment load; 3) the magnitude of sedimentation in lakes and the sediment load in streams during prolonged wet and dry (drought) periods; 4) the pollutants (pesticides, nutrients, and heavy metals) being transported by sediments; and 5) the development of a set of direct relationships between rain and soil factors for different physiographic areas. Developing such relationships will permit development of adequate models for transferring results to all parts of the state and for predicting sediment load in unmeasured streams and sedimentation rates in lakes.

To address these issues, there is a need for a comprehensive statewide sediment network consisting of 50 or more stations operated for 10 to 20 years. This project was developed and is being conducted to meet these ends. Its twin goals are: 1) to collect and study data at 50 sediment monitoring stations located at strategic locations around the state; and 2) to act as a catalyst for a long-term multi-faceted resource monitoring program involving installation, operation, and study of data from a statewide benchmark network.

In its first year of operation this project has been able to fulfill its first goal by receiving broad-based support from several state and federal agencies and financial support from three state agencies: the Illinois Environmental Protection Agency, the Illinois Department of Energy and Natural Resources (formerly the Institute of Natural Resources), and the Division of Water Resources of the Illinois Department of Transportation.

This annual report summarizes the data collected in the first year of this program (Water Year 1981) and includes some generalized analyses.

Acknowledgements

This project is being conducted under the administrative guidance of Stanley A. Changnon, Jr., Chief, Illinois State Water Survey, and Michael L. Terstriep, Head, Surface Water Section.

The authors wish to thank William Fitzpatrick of the Surface Water Section and John Nicol and Pamela S. Shipplett, undergraduate student employees at the Water Survey, for their help in collecting the data. William C. Bogner contributed his time and ideas in helping to set up the monitoring stations, and helped plan the network. Ming T. Lee also participated in the planning process.

All sediment samples were analyzed by the State Water Survey's Sediment Materials Laboratory, under the general supervision of Michael V. Miller.

The data generated by the network were entered into computer files by members of the Computer Support Group. Robert A. Sinclair also assisted in the initial phase of the project. All computer programs and data management systems were developed by Carl G. Lonnquist and Marvin C. Clevenger.

Karen Vivian typed the rough draft; John Brother, Jr., William Motherway, and Linda Riggin prepared the illustrations. Kathleen Brown prepared the camera ready copy, and Gail Taylor edited the report.

The cooperation of the Illinois District of the Water Resources Division of the U.S. Geological Survey (USGS) under the general supervision of Larry G. Toler, District Chief, was extremely important to the success of this program. In particular, the authors wish to thank G. Wayne Curtis, Paul Hayes, Tim Lazaro, Al Noehre, and Richard Stahl for their efforts in providing the tables and records needed to make the data sets complete and accurate.

Finally, the authors are grateful for the recommendations and advice of the Advisory Committee for Sediment Monitoring in Illinois during the planning stages of this project. The authors also wish to thank Dave Jones, Bill Frerichs, and Tim Warren of the Department of Energy and Natural Resources (DENR), Bob Clark and Bill Rice of the Illinois Environmental Protection Agency (IEPA), and Sam Mostoufi and Gary Clark of the Division of Water Resources (DOWR) for their constant support in helping this project achieve its goals. Thanks also to Marv Hubbell and Jim Frank of the Illinois Department of Agriculture for their support of the Sediment Monitoring Network for the State of Illinois.

DESCRIPTION OF SEDIMENT MONITORING NETWORK

The primary goal of this project was to establish 50 sediment monitoring stations within the state of Illinois. The project coordinators felt that this number of stations, when combined with the approximately 25 to 30 stations monitored by the U.S. Geological Survey in Water Year 1981, would be ideal for measuring sediment transported through all the major streams and rivers within the state.

The following criteria were established for selecting the 50 monitoring stations:

1. Avoid any duplication with other agencies monitoring for suspended sediments (i.e., USGS).
2. Select stations that would allow an adequate sampling of all the representative basins and physiographic regions of the state.
3. Locate stations at established USGS stream gaging stations (preferably continuous-record stations).
4. Select stations that would complement USGS sediment stations by establishing a complete record of sediment transported within a basin.
5. Attempt to select stations which were already part of the IEPA Water Quality Monitoring Network.
6. Request input from interested state and federal agencies in order to locate stations in areas that were of importance to those agencies..
7. Select stations which would complement the State Water Survey Lake Sedimentation Program.

All the appropriate information was gathered and reviewed and 50 tentative monitoring stations were selected.

To fulfill criterion number six, a ten-member Advisory Committee for Sediment Monitoring in Illinois was established. It was composed of representatives from interested state and federal agencies. This committee was presented the list of 50 tentative stations and given an opportunity to recommend changes. After a review by this committee, the 50 permanent sediment monitoring stations were established (figure 1 and table 1).

These stations were divided into three "districts" (see figure 1 and table 1). The northern district contained all the stations bounded by the state line on the north and a line at the 41° north latitude on the south; the central district contained all the stations between the 41° north latitude and the 39°30' north latitude; and the southern district contained all the stations south of the 39°30' north latitude. The Water Survey's main office in Champaign was responsible for monitoring stations in the central district. Personnel at field offices in Marion and Warrenville, which were established for this program, monitored the southern and northern districts, respectively.

The sediment network's 1981 budget allowed for 27 stations to be monitored on an intensive basis (see table 1). This meant that locally hired observers collected a sample at least once a day during the period of approximately April 1 through July 31. Previous studies at the Water Survey (Bhowmik et al., 1980) have shown that from 60 to 90 percent of the total suspended sediment load is carried by a stream during this period. It is hoped that this intensive monitoring will better reflect the total yearly tonnages of sediment transported by a particular stream at a given site.

An effort was made to complement the USGS sediment monitoring program by locating intensive stations where they could supplement data already

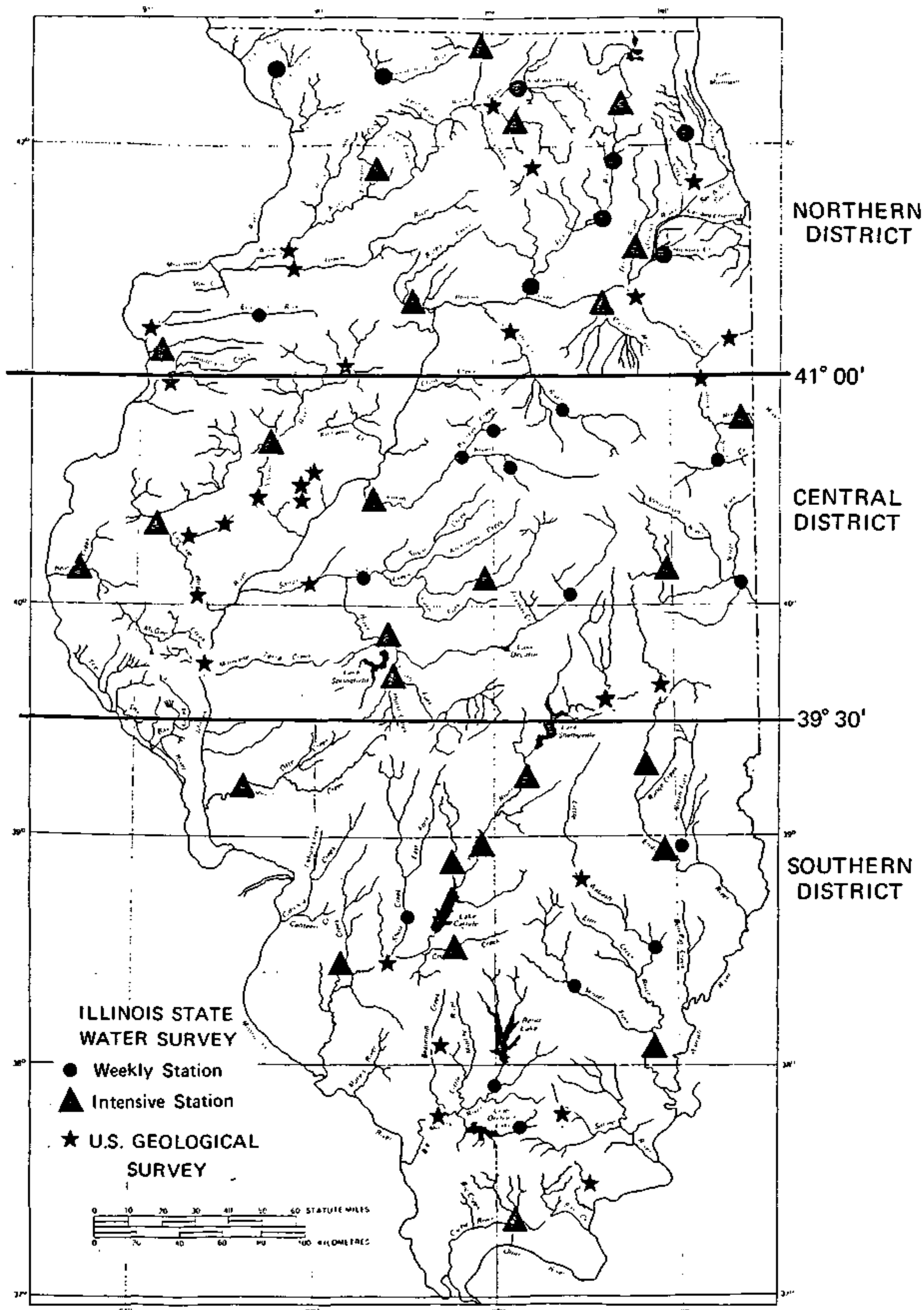

Figure 1. Sediment Monitoring Network for Illinois for Water Year 1981 (October 1980 through September 1981)

Table 1. Illinois State Water Survey Sediment Monitoring Network, Water Year 1981

USGS No.	Station Name
I. Northern District	
05418950	Apple River near Elizabeth, IL (D.A. 207 sq mi)
05435500	Pecatonica River at Freeport, IL (D.A. 1326 sq mi)
*05437500	Rock River at Rockton, IL (D.A. 6363 sq mi)
05438500	Kishwaukee River at Belvldere, IL (D.A. 538 sq mi)
*05439500	South Branch Kishwaukee River near Fairdale, IL(D.A. 387 sq mi)
*05444000	Elkhorn Creek near Penrose, IL (D.A. 146 sq mi)
05466000	Edwards River near Orion, IL (D.A. 155 sq mi)
*05467000	Pope Creek near Keithsburg, IL (D.A. 183 sq mi)
05529000	Des Plaines River at Des Plaines, IL (D.A. 360 sq mi)
05539000	Hickory Creek at Joliet, IL (D.A. 107 sq mi)
*05540500	DuPage River at Shorewood, IL (D.A. 324 sq mi)
*05542000	Mazon River near Coal City, IL (D.A. 455 sq mi)
*05550000	Fox River at Algonquin, IL (D.A. 1403 sq mi)
05551200	Ferson Creek near St. Charles, IL (D.A. 51.7 sq mi)
05551540	Fox River at Montgomery, IL (D.A. 1732 sq mi)
05552500	Fox River at Dayton, IL (D.A. 2642 sq mi)
*05556500	Big Bureau Creek at Princeton, IL (D.A. 196 sq mi)
II. Central District	
*03336900	Salt Fork near St. Joseph, IL (D.A. 134 sq mi)
03339000	Vermilion River near Danville, IL (D.A. 1290 sq mi)
*05495500	Bear Creek near Marcelline, IL (D.A. 349 sq mi)
*05525000	Iroquois River at Iroquois, IL (D.A. 686 sq mi)
05525500	Sugar Creek at Milford, IL (D.A. 446 sq mi)
05554490	Vermilion River at McDowell, IL (D.A. 551 sq mi)
05564400	Money Creek near Towanda, IL (D.A. 49.0 sq mi)
05566500	East Branch Panther Creek at El Paso, IL (D.A. 30.5 sq mi)
05567510	Mackinaw River below Congerville, IL (D.A. 776 sq mi)
*05568005	Mackinaw River below Green Valley, IL (D.A. 1092 sq mi)
*05569500	Spoon River at London Mills, IL (D.A. 1062 sq mi)
05572000	Sangamon River at Monticello, IL (D.A. 550 sq mi)
*05576022	South Fork Sangamon River below Rochester, IL (D.A. 870 sq mi)
*05576500	Sangamon River at Riverton, IL (D.A. 2618 sq mi)
*05578500	Salt Creek near Rowell, IL (D.A. 335 sq mi)
05582000	Salt Creek near Greenview, IL (D.A. 1804 sq mi)
*05584500	La Moine River at Colmar, IL (D.A. 655 sq mi)
III. Southern District	
*03344000	Embarras River near Diona, IL (D.A. 919 sq mi)
*03345500	Embarras River at Ste. Marie, IL (D.A. 1516 sq mi)
03346000	North Fork Embarras River near Oblong, IL (D.A. 318 sq mi)
03379600	Little Wabash at Blood, IL (D.A. 1387 sq mi)
03380500	Skillet Fork at Wayne City, IL (D.A. 464 sq mi)
*03381500	Little Wabash at Carmi, IL (D.A. 3102 sq mi)
*03612000	Cache River at Forman, IL (D.A. 244 sq mi)
*05587000	Macoupin Creek near Kane, IL (D.A. 868 sq mi)
*05592100	Kaskaskia River near Cowden, IL (D.A. 1330 sq mi)
*05592500	Kaskaskia River at Vandalia, IL (D.A. 1940 sq mi)
*05592800	Hurricane Creek near Mulberry Grove, IL (D.A. 152 sq mi)
*05593520	Crooked Creek near Hoffman, IL (D.A. 254 sq mi)
05594000	Shoal Creek near Breese, IL (D.A. 735 sq mi)
*05594800	Silver Creek near Freeburg, IL (D.A. 464 sq mi)
05597000	Big Muddy River at Plumfield, IL (D.A. 794 sq mi)
05597500	Crab Orchard Creek near Marion, IL (D.A. 31.7 sq mi)

*Intensively monitored station

being collected within a basin. It would have been desirable to expand this intensive monitoring to all the stations all year, but budgetary constraints and logistic problems limited this to only 27 stations for four months.

In addition to the 50 stations mentioned in this report, the USGS also monitored about 27 to 29 stations in Water Year 1981 (see figure 1). The sediment records for these data can be found in the USGS publications titled Water Resources Data for Illinois, Water Year 1981, Volumes 1 and 2 (U.S. Geological Survey, 1981).

METHODOLOGY

The Water Survey's sediment data collection program uses methods and instruments compatible with and similar to those used by the U.S. Geological Survey. This is necessary to insure that the data collected by the SWS have the same level of quality control and quality assurance as those collected by the USGS. Descriptions of these methods and instruments are detailed in the U.S. Department of the Interior's series of publications entitled Techniques of Water-Resources Investigations of the United States Geological Survey (Buchanan and Somers, 1969; Guy, 1969; Guy and Norman, 1970; Porterfield, 1972).

Field Sampling

Suspended Sediment. Two types of sampling for suspended sediment concentrations were used in this project. First, all weekly and daily samples were collected at a single location, or vertical, in each channel cross section. This location was termed the "box site."

The positioning of this box site was somewhat arbitrary, since no previous knowledge of the dynamics of the sediment flow at the site was available. The box sites were located in the deepest, fastest portion of the stream cross section. As more information on the sediment flow characteristics of each stream is made available, it is hoped that it will be possible to reposition the box sites so that the ratio of the concentration of the sample collected at the box site and the mean concentration in the cross section remain consistent.

The second type of sediment sampling involved collecting suspended sediment samples at several verticals along the entire channel cross section approximately once every six weeks. The purpose of this sampling was to calibrate the samples taken at the box site by determining the ratio of the sediment concentration at the box site to the average concentration in the entire cross section. This value could then be used to adjust the concentration values at the box site so they would better reflect the average suspended sediment concentration in the channel cross section. The reader is referred to Porterfield (1972) for an explanation of this "adjustment" method.

For this first year (Water Year 1981) no adjustments were made in the concentration values of the box samples. The depth and range of cross section (calibration) data for each of the sediment monitoring stations are too limited to accurately identify any consistent trends in coefficient values. Once additional calibration data are accumulated and compiled, an attempt will be made to apply appropriate coefficients to some or all of the box sample data. When this adjustment occurs, the Water Survey will announce the availability of a revised data set for the 1981 water year.

The equal transit-rate (ETR) method was used to collect the water-sediment samples. In addition, the equal width-increment (EWI) method was used for all the cross section analyses. A complete and detailed discussion of these sampling techniques is given by Guy and Norman (1970).

Twenty-seven of the sediment stations were monitored by locally hired observers on an intensive basis for approximately four months in the spring and summer. These stations were referred to as "intensive" stations. During this period, the observers were instructed to collect one sample a day during steady or falling stages and to collect two samples a day (8- to 10-hour separations) during rising, bankfull, and flood stages. This sampling schedule was designed to yield a good representation of the sediment hydrograph and was based on the general understanding of the temporal relationship between sediment and water discharge in a stream. As more data for each stream are made available, it will be possible to adjust the sampling routine to better fit each individual stream cross section.

Water Discharge. Forty-three (86 percent) of the 50 network stations were located at continuous record USGS stream gaging stations. The remaining seven stations were located at sites which have been rated by the USGS or where discharge could be estimated from data available from a nearby gaging station. Locating the sediment stations at USGS stream gaging stations was important because it enabled the field technician to read the river stage each time a sample was taken and to obtain a water discharge value corresponding to the recorded stage. Combining this discharge value with the sediment concentration value of the sample yields the total suspended sediment load transported by the stream through that gaging station at that moment (Porterfield, 1972).

Whenever sediment samples were collected throughout a channel cross section, a water discharge measurement was made according to the techniques and procedures described by Buchanan and Somers (1969). Measuring water discharge at the same time complete sediment concentration data are collected allows accurate calculation of the sediment discharge at each station. These data may then be used to develop a sediment-water discharge rating curve at that particular location.

Laboratory Analysis

Suspended Sediment Concentration. Suspended sediment samples were analyzed by the filtration method or evaporation dish method at the Illinois State Water Survey Sediment Materials Laboratory. The methods used are described by Guy (1969).

Particle Size. Suspended sediment samples were analyzed for particle size by the pipet/sieve methods described in the National Handbook of Recommended Methods for Water Data Acquisition (U.S. Geological Survey, 1978). The analyses were conducted in the Water Survey Sediment Materials Laboratory.

Percent Volatile Solids. Suspended sediment samples were analyzed to determine the percentage of volatile solids present. The procedure for volatile solids analysis is identical to that for suspended sediment concentrations up through the filtering stage. After the sample has been filtered, it is dried in an oven at 105°C overnight. The sediment is cooled in a desiccator and weighed to determine the dry weight. The sample is then placed in a muffle furnace for 15 minutes at 550°C. It is cooled in a desiccator and weighed again, and the weight loss is used to calculate the percentage of volatile solids that was present in the sample.

EXPLANATION OF DATA SET

The data set used in generating this report (Appendix B) is for data collected during Water Year 1981 (October 1, 1980 through September 30, 1981). This data set can be made available to interested users in machine readable or hard copy form. Inquiries should be addressed to the Illinois Department of Energy and Natural Resources, State Water Survey Division, Surface Water Section, P.O. Box 5050, Station A, Champaign, Illinois 61820, or call (217) 333-2210.

General Format

The format for presenting the data is generally the same for each station. Each page is headed by the name of the river basin in which the station is located and the USGS number and name designation for the station. A description of the location of the stream gage, the type and datum of the gage, and the drainage area at the station are listed in the upper part of the first page. All of this information was obtained from the publication Water Resources Data for Illinois, Water Year 1981 (U.S. Geological Survey, 1981).

The rest of the first page consists of pertinent information regarding the data collected at the station. Information is incuded on the type of equipment used. (All sampling equipment used in this project has been approved and calibrated by the Federal Inter-Agency Sedimentation Project of the Inter-Agency Committee on Water Resources, St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota, and is commonly used by the USGS.) Information is also given on the location of the sampling site and the sampling frequency. In addition, the type and origin of data used to compute suspended sediment discharge are briefly explained; the results of the particle size data analyses are summarized; an explanation of the types of data used to generate the various graphs is given; and remarks highlighting important information regarding the sampling and gaging station, data collection, results, and graphs are included. Quality ratings (excellent, good, etc.) that appear in the remarks are based on subjective analyses of the results.

Tables

The tabulation of the data begins on the second page, with the suspended sediment discharge measurement table. The date and time (24-hour clock) when each sample was collected are recorded. The gage height is generally the value recorded by the individual who collected the sample at the time of sampling. The water temperature is recorded to the nearest degree centigrade. Suspended sediment concentration values and percent volatile solids present are instantaneous values, determined from lab analyses of each of the collected suspended sediment samples. Instantaneous water discharge values are taken from the appropriate rating tables for the recorded gage heights. (All rating tables were supplied by the USGS and IEPA). Instantaneous suspended sediment discharge values are calculated using the formula:

$$q_s = C_s \bullet q_w \bullet 0.0027$$

where C_s is the instantaneous suspended sediment concentration, q_w is the instantaneous water discharge, and q_s is the instantaneous suspended sediment discharge in tons per day. The remarks' are single-letter codes which coincide with the codes and explanations listed in table 2.

User note: All suspended sediment concentration and discharge values given in this report are instantaneous values and are accurate only for

Table 2. Key to Letter Codes in "Remarks" Column for All Data Tables

Letter Code	Explanation
G	Grab sample taken from stream surface (as opposed to a depth integrated sample).
I	Ice cover on river when sample was taken.
O	Suspended sediment sample volume was in the range of 400.0 to 410.0 ml, which, by our definition, is an overfilled sample that may still yield fairly accurate results. However, caution must be used in evaluating these pieces of data.
P	Accuracy of suspended sediment figures are suspect and are rated poor quality.
U	Suspended sediment sample volume was below 100.0 ml, which, by our definition, is an underfilled sample that may still yield fairly accurate results. However, caution must be used in evaluating these ' pieces of data.
PLE	The laboratory was not satisfied with their procedure and analysis; therefore the data could reflect a possible laboratory error.
#BM	The number designates the number of bottles missing from the sample set when the laboratory performed the analyses. These data were reported although the accuracy of this information is questionable,and they should be used cautiously.

measuring the suspended sediment load for the time the sample was collected. They are not intended to reflect the daily mean value of suspended sediment load. In addition, no adjustments were made in the concentration values of the box samples. The depth and range of calibration data for each of the sediment monitoring stations are too limited to accurately identify any consistent trends in coefficient values. Once additional calibration data are collected and compiled, an attempt will be made to apply coefficents to some or all of the box sample data. When this adjustment occurs, and/or if daily mean suspended sediment discharge values are computed, the Water Survey will announce the availability of a revised data set for the 1981 water year.

The next table in the sequence lists the particle size distribution of a select number of suspended sediment samples for each station. Generally, samples were collected for particle size analysis three times in the water year for each station. However, unforeseen problems in the handling of the samples in the laboratory forced the rejection of some of the particle size data.

Within the context of the table, the suspended sediment concentration values are for the composite samples. The percent of sediment finer than .062 mm was measured using the sieve method as referred to earlier in this report. This value also represents the sand/fine split value when sediment sample sizes were inadequate for making a complete analysis of the fine material. The remaining five "percent finer" values, when present, were measured using the pipet method referred to earlier in this report and reflect a breakdown of the sizing of the fine materials in the sample. The remarks are three-lettered codes which coincide with codes and explanations listed in table 2.

User Note: Particle size samples that show percent finer values for .062 mm, .031 mm, .008 mm, and .002 mm only, were very small samples and were analyzed using modified equipment for the pipet method (250-ml cylinders and 10-ml pipets). These values carry with them a reduced level of accuracy as reflected in the fact that standards run using this equipment had larger standard deviation and variance but comparable means than standards run using the proper equipment. Therefore these values can only be considered to be approximate and should be used cautiously.

Graphs

The first graph is the sediment transport curve, which depicts the relationship between instantaneous suspended sediment discharge and instantaneous water discharge. The upper and lower confidence limits of 80 and 95 percent (dotted lines) are shown on this graph as well as the regression line (solid line). The corresponding regression equation and correlation coefficient can be found just below the graph.

The sediment transport curves and regression equations developed for this report used data collected in Water Year 1981 only. The regression equations may be used to estimate an average instantaneous suspended sediment load for their respective stations whenever the instantaneous water discharge is known. One must recognize the limitations of this relationship considering the size and duration of the data set. As more data are accumulated over several years of sampling, new and more reliable regression equations will be developed to improve the accuracy and usefulness of this relationship.

The second and third graphs shown for each station depict the instantaneous water discharge hydrograph and the instantaneous suspended sediment discharge hydrograph, respectively. Since these graphs reflect instantaneous values for water and suspended sediment discharge, and since some stations were monitored more than once a day for certain periods of time, there are some instances where more than one value is plotted for any one day. Individual data points (not connected to any other points by a solid line) and breaks in solid lines represent a gap of several days between data points. (These gaps reflect the sensitivity and accuracy of the plot at this reduced scale.) Solid lines suggest data collected on a more frequent basis. These graphical representations of the hydrographs are intended to visually represent general relationships and trends. They should not be used to make specific determinations regarding the temporal relationship between instantaneous water discharge and instantaneous suspended sediment discharge.

GENERALIZED ANALYSES

Stream sediment data collected over a period of one year are not enough to form the basis for any substantial and detailed generalized analyses. However, it is imperative that an attempt be made to perform a generalized analysis of the sediment load in Illinois even though the data base is minimal.

The gaging stations where the Water Survey's sediment data were collected are listed in table 3. The station identification numbers are given in the first column. The locations of these stations are shown in figure 2. In this figure, the numbers shown next to each station are the last two digits of the station identification number as given in table 3.

Before any definite interpretations of these data are made, it must be pointed out that the sediment load values for all the Water Survey monitoring stations shown in the following original illustrations are based on calculations using the instantaneous sediment load, not the daily mean or weekly mean values. These instantaneous sediment loads and their corresponding water discharges were plotted by computer on log-log paper. A least square regression line was then fitted through these plotted values. This was done for all of the Water Survey monitoring stations. Each graph showing the plot of the data and the regression line was examined visually and the correlation coefficients were evaluated to determine whether or not the fit appeared to be good and also to examine the spread of the points around the fitted line. For all stations where the plotted points were found to be reasonably close to the fitted line, the graphs were accepted as being reasonable sediment rating curves for those stations.

Of the seven stations for which the rating curves were not used, Pecatonica River at Freeport and Fox River at Algonquin had relatively poor

Table 3. Key to State Water Survey Sediment Monitoring Stations

Station ID No.	Location
101	Apple River near Elizabeth
•102	Pecatonica River at Freeport
103	Rock River at Rockton
104	Kishwaukee River at Belvidere
106	South Branch Kishwaukee River near Fairdale
107	Fox River at Algonquin
108	Des Plaines River at Des Plaines
110	Ferson Creek near St. Charles
112	Elkhorn Creek near Penrose
114	Fox River at Montgomery
115	Hickory Creek at Joliet
116	DuPage River at Shorewood
117	Fox River at Dayton
118	Big Bureau Creek at Princeton
121	Edwards River near Orion
123	Mazon River near Coal City
127	Pope Creek near Keithsburg
229	Spoon River at London Mills
230	East Branch Panther Creek at El Paso
231	Vermilion River at McDowell
233	Iroquois River at Iroquois
234	Sugar Creek at Milford
235	Money Creek near Towanda
236	Mackinaw River below Congerville
237	Mackinaw River below Green Valley
242	La Moine River at Colmar
243	Bear Creek near Marcelline
247	Salt Creek near Greenview
248	Salt Creek near Rowell
249	Sangamon River at Monticello
250	Salt Fork near St. Joseph
251	Vermilion River near Danville
252	Sangamon River at Riverton
254	South Fork Sangamon River below Rochester
357 .	Embarras River near Diona
358	Kaskaskia River near Cowden
359	Macoupin Creek near Kane
360	Hurricane Creek near Mulberry Grove
361	Kaskaskia River at Vandalia
362	Embarras River at Ste. Marie
363	North Fork Embarras River near Oblong
365	Crooked Creek near Hoffman
366	Shoal Creek near Breese
367	Silver Creek near Freeburg
368	Skillet Fork at Wayne City
369	Little Wabash River at Blood
370	Little Wabash River at Carmi
371	Big Muddy River at Plumfield
374	Crab Orchard Creek near Marion
378	Cache River at Forman

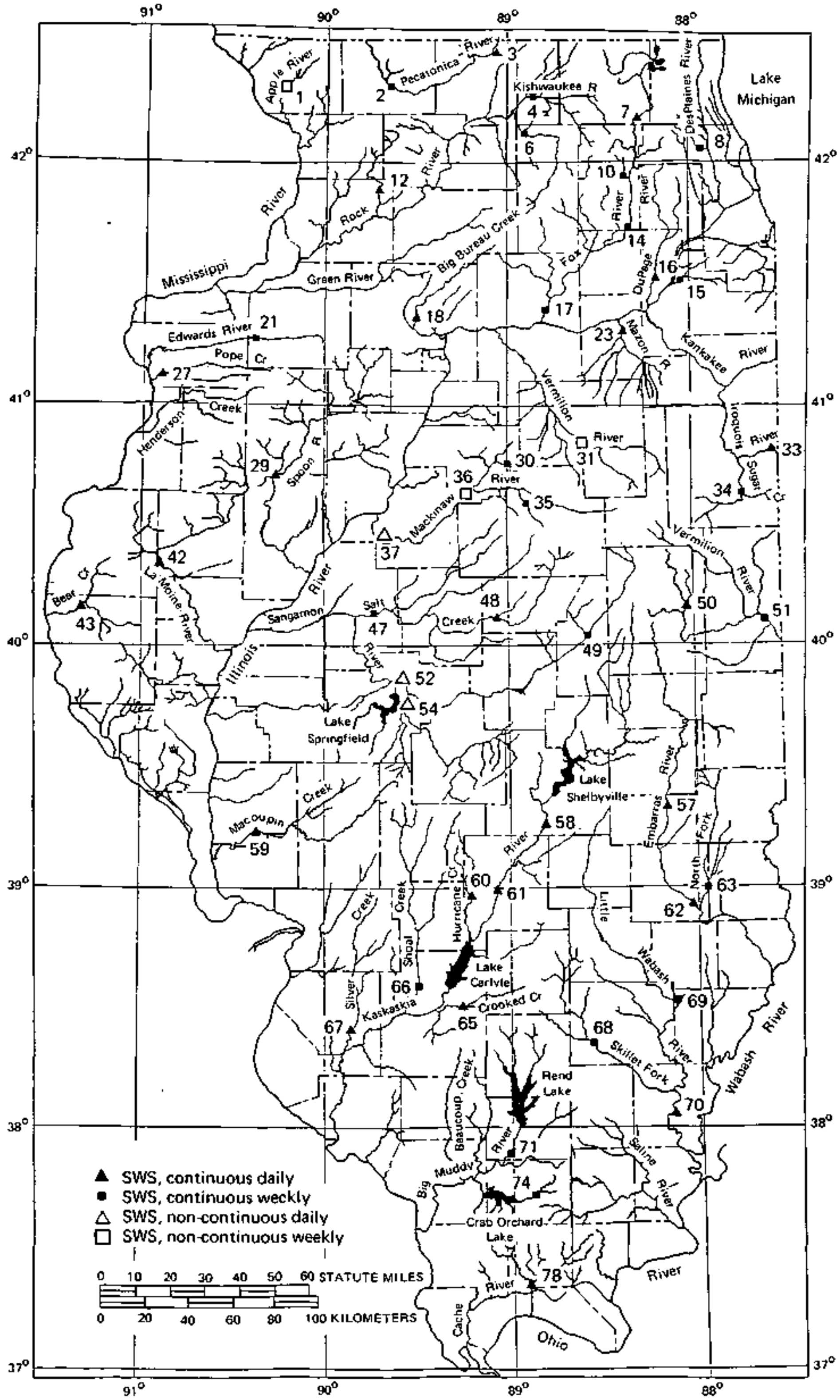

Figure 2. Locations of the State Water Survey sediment monitoring stations, Water Year 1981

correlation coefficient values; Fox River at Montgomery, Mackinaw River below Green Valley, Sangamon River at Riverton, and Little Wabash River at Blood did not have a record of mean daily discharge and thus could not have been used to calculate annual sediment loads; and at Crab Orchard Creek near Marion there were serious questions raised as to the validity of the data due to the severe backwater effects of Crab Orchard Lake on the flows at the monitoring station. At one station, Rock River at Rockton, the rating curve was used even though the correlation coefficient for the regression equation was very poor. The size of the drainage area at this station and the importance of this station in terms of its location on the main stem of the Rock River influenced the decision to allow this rating curve to be used in calculating annual sediment loads for this station.

It must be pointed out that for many stations, fewer than 40 data points were available from the first year's operation of the network for use in developing the rating curves. Therefore, the regression line that was fitted to these curves probably will change as more and more data become available.

After this review of the rating curves was completed, the regression equations for the selected stations were used to compute the annual sediment load at these stations. Daily mean discharge values were utilized to compute the daily sediment load, and these daily sediment loads were summed for the 365 days in the year to obtain the annual sediment load. Daily discharge values were taken from records published by the USGS (1981). These calculated annual load values as well as the parameters for the regression equations are listed in Appendix A.

The regression equations were developed using instantaneous sediment and water discharge values, while the annual sediment loads were calculated using mean daily discharge values. This approach was selected as the best available option for calculating yearly sediment loads since the sediment record was not collected on a continuous, daily basis by which mean daily sediment discharges could be estimated directly from the field data.

In order to verify that this approach was valid, the annual sediment load values calculated with this method were compared with annual sediment load values published by the USGS (1981) for their sediment stations located in or near the same basins as the Water Survey stations. This comparison was made by first converting these values to a common denominator (i.e., tons per square mile) and then inspecting them to verify that SWS and USGS data have reasonably similar values. In addition, all available USGS sediment data were plotted on a statewide map along with the SWS data to check for any significant changes in the positioning of the isobars (see figures 3 and 4). A detailed discussion of these two figures is provided in the next section.

Average Annual Sediment Yield

The calculated annual sediment loads shown in Appendix A are the total suspended sediment loads in tons per year for each gaging station. The sediment generated within a basin from its sub-watersheds will probably not be uniform. Some areas may contribute two or three times more sediment than other areas. However, if it is assumed that the drainage basin above each gaging station contributed uniformly toward the total sediment load, then the sediment load per unit area of the basin can be computed and a statewide comparison of the sediment yield can be made.

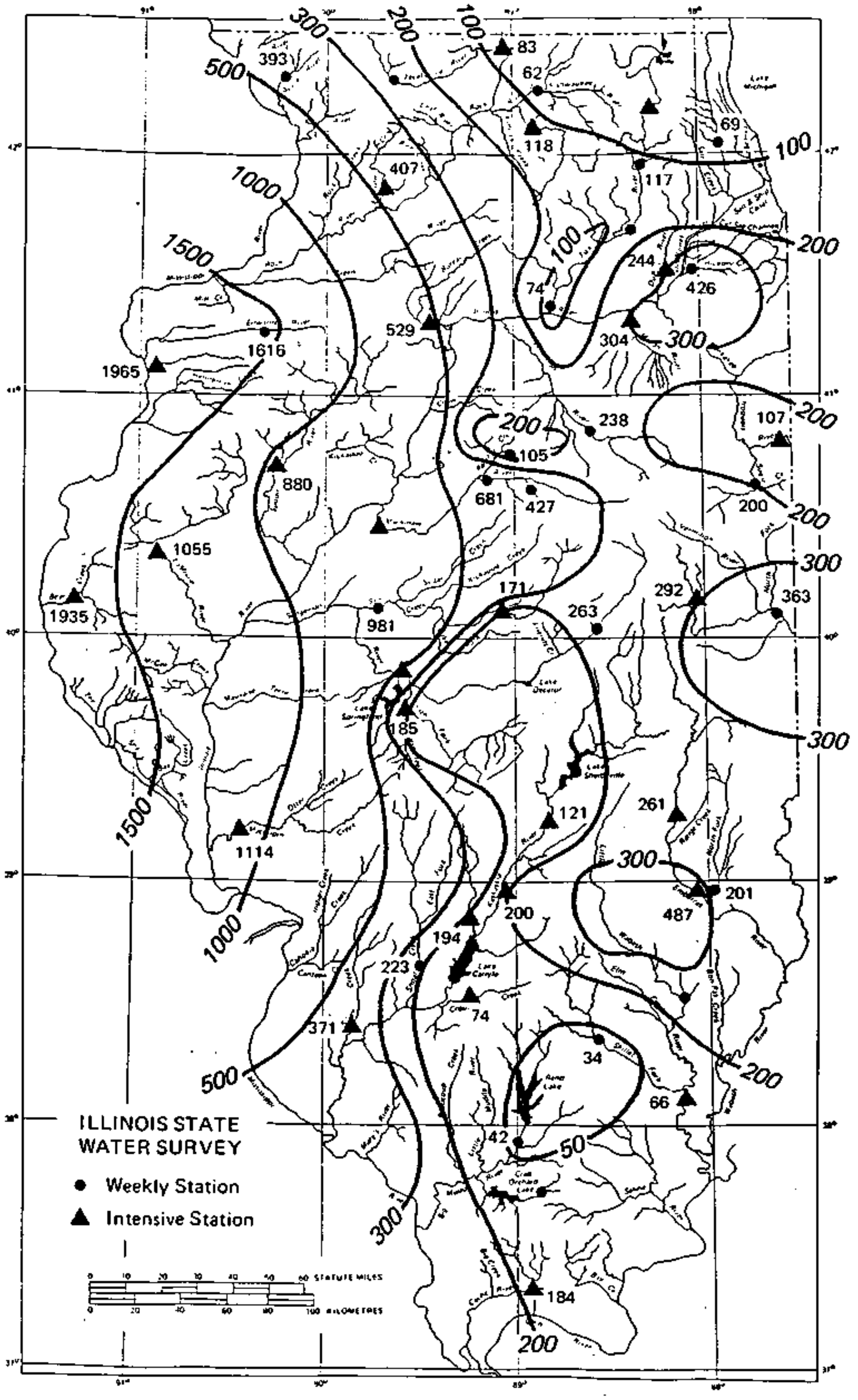

Figure 3. Average annual sediment yield (tons per square mile)

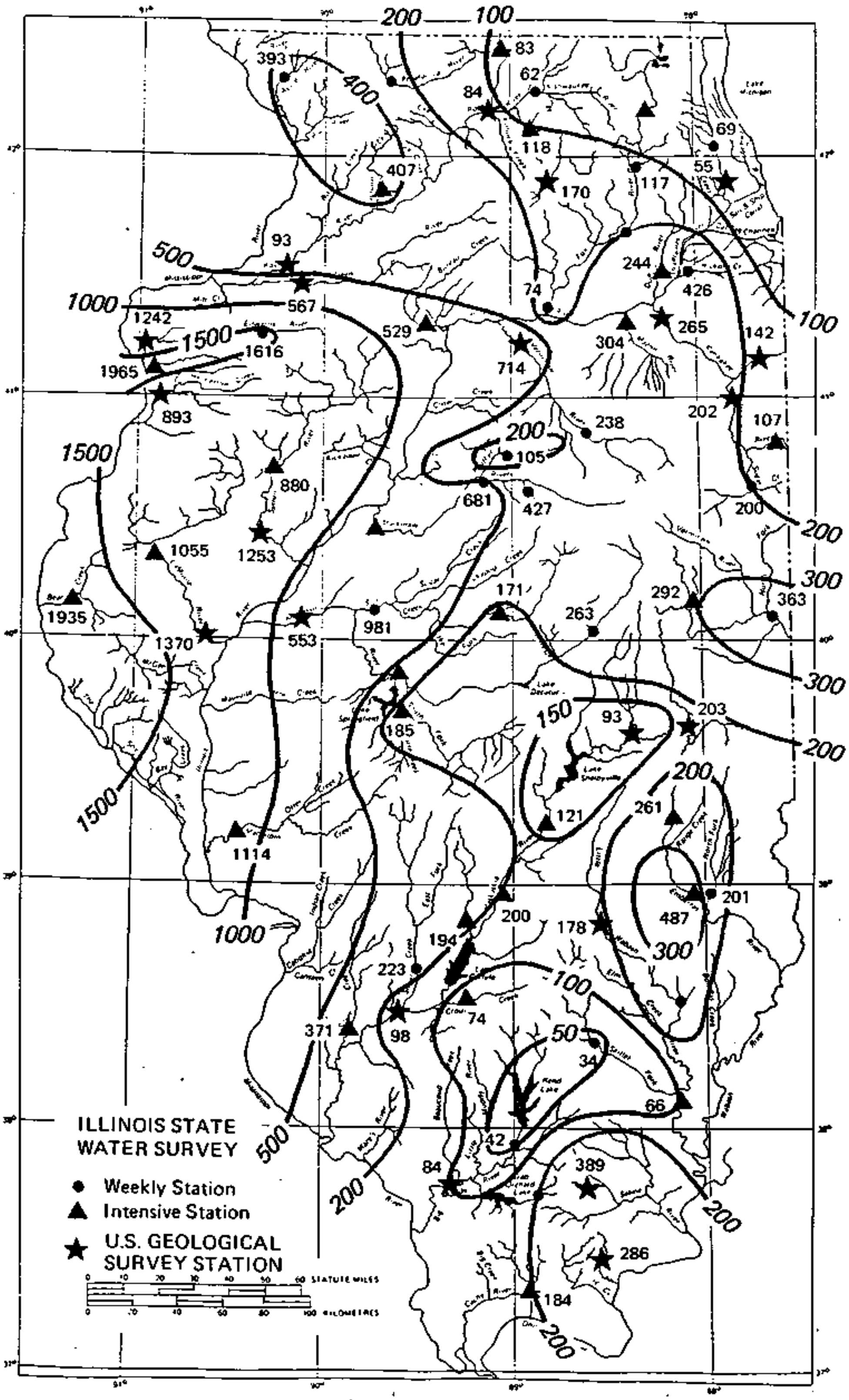

Figure 4. Average annual sediment yield (tons per square mile), including U.S. Geological Survey data (USGS, 1981)

In Appendix A, the total calculated annual sediment load from each station operated by the Water Survey was divided by the drainage area above each gaging station, and the average annual suspended sediment yield in tons per square mile was obtained. These values have been plotted in figure 3 next to their respective station locations.

If we assume that these numbers represent the sediment yield from each sub-basin within the state, and if a straight line interpolation of the variation of sediment load from one station to the next is made, then a set of contour lines of equal annual sediment load per square mile of drainage area can be drawn. Such a plot has been developed and is shown in figure 3. (For a few contour lines the straight line interpolation was not strictly followed. A surficial geologic map of the state of Illinois [Lineback, 1979] was utilized to help draw some of the sediment contour lines.)

The isobar plot in figure 3 shows a clear and unmistakable trend of heavy sediment loads in certain areas of the state. It is obvious from this map that the west-central part of the state, mostly in the Galesburg and Springfield Plains (Leighton et al., 1948) and the bluff areas of the Mississippi River, contributed the maximum amounts of sediment load in Water Year 1981. In the western-most part of the state, the maximum value was close to 2,000 tons per square mile.

As was mentioned in the previous section, the yearly sediment yield values from the USGS sediment monitoring stations were plotted with those from the Water Survey stations in order to verify the method used to calculate sediment loads for the Water Survey monitoring stations. This plot is shown in figure 4. A close examination of this figure and its contour lines, when compared to the contour lines shown in figure 3, suggests that the relative location of the isobars remains the same. The overall trend in the sediment yield remained unchanged, with the heavier sediment yields occurring in the west-central portion of the state and the maximum yield occurring near the western edge of the state. In fact, the addition of the USGS data to the contour map improves the resolution of the contour lines. This suggests that the method used in this report to calculate annual sediment loads for the Water Survey monitoring stations is permissible and valid.

Figure 5 shows an outline of the areas of excessive sediment load for Water Year 1981, based on the contour map shown in figure 4. In drawing the boundary lines for these areas, the 200 tons per square mile isobar was generally used as a guide. These areas encompass the Wisconsin Driftless Section, Galesburg Plain and Lincoln Hills Section, and portions of the Springfield Plain, Bloomington Ridged Plain, Kankakee Plain, Green River Lowland, and Rock River Hill Country. Portions of the Shawnee Hills Section and Coastal Plain Province are also included (Leighton et al., 1948). In terms of land resource areas of Illinois (IEPA, 1979), these areas cover all of the Northern Mississippi Valley Loess Hills, major portions of the Illinois and Iowa Deep Loess Hills and the Central Mississippi Valley Wooded Slopes, and lesser portions of the Southeastern Wisconsin Drift Plain and the Northern Illinois and Indiana Heavy Till Plain. These areas of excessive sediment load also encompass the intensive row cropping areas of the state.

Another interesting point indicated in figures 3, 4, and 5 is the increasing trend of sediment loads from east to west and from north and south to the central part of the state. If two lines are drawn in figure 4, one east-west at the 40° north latitude, and another one north-south at the 90° west longitude, and if curves are then plotted for

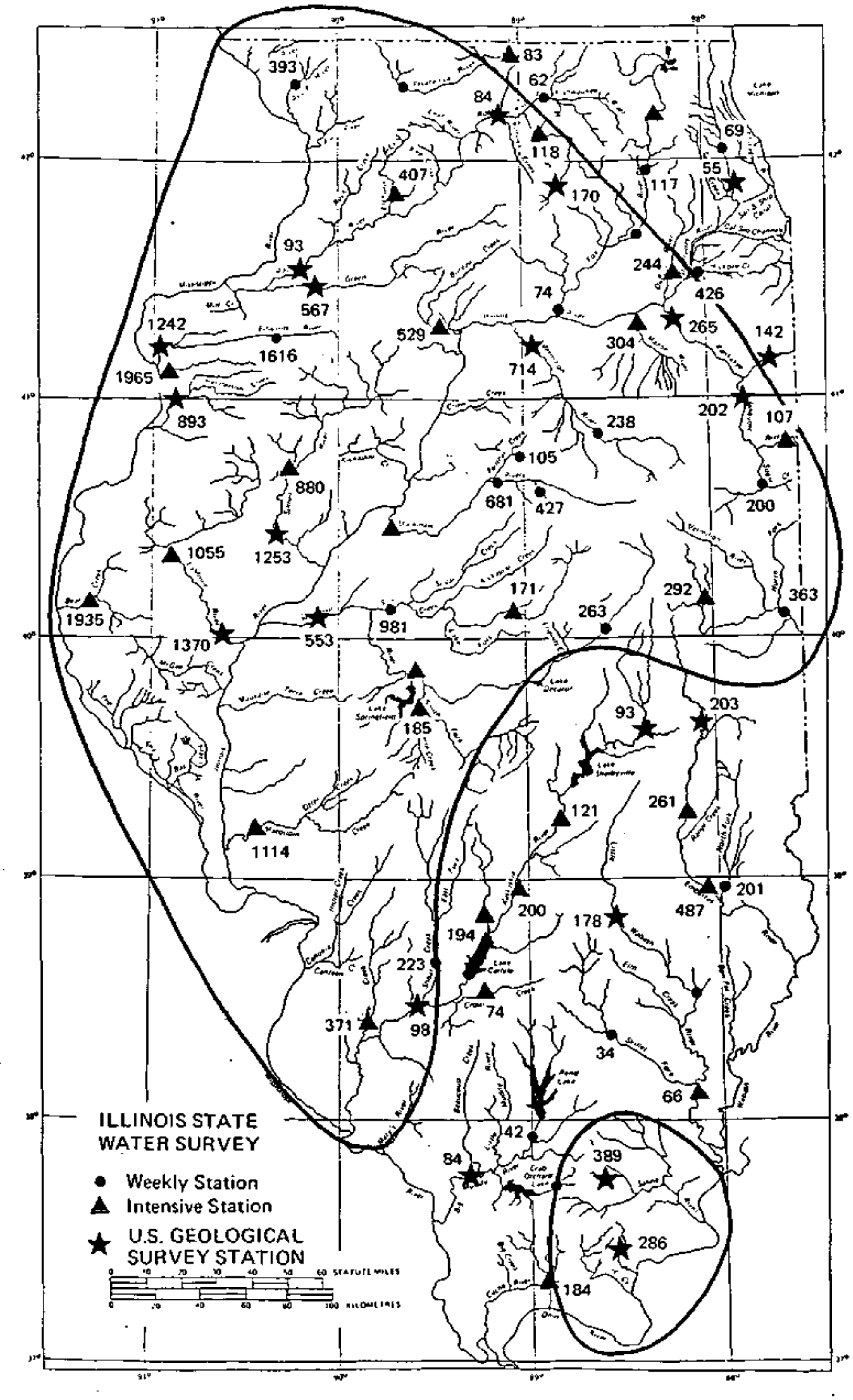

Figure 5. Average annual sediment yield (tons per square mile) and areas of heavy sediment yield

sediment yield versus distance along these lines, the plots appear as shown in figure 6 and reflect this trend.

In evaluating the sediment yield values presented in Appendix A and in figures 3 through 6, one must remember that these values are for measurements of instream sediment loads. These instream sediment loads include not only the sediment delivered from the upland watersheds, but also the net sediment load generated within the stream environment, such as from bank erosion and bed scour. Our present knowledge precludes us from separating these two sources: watershed-generated and instream-generated sediment.

Comparisons with Other Variables and Data

Two of the most important variables in the generation and transport of sediment in any stream environment are surface runoff and streamflow. Data analyzed from the Kankakee River (Demissie et al., 1983) have clearly demonstrated the variability of sediment load from a relatively dry year to a wet year.

Figure 7 shows the total precipitation by crop district in Illinois for Water Year 1981, in inches. The departures from normal are also given under each value within each crop district. If all the areas of above normal precipitation are considered, two boundary areas of excess precipitation can be drawn (figure 7—solid lines). If the Chicago Metropolitan Area, which is highly urbanized and where agricultural-related sediment generation would be relatively small, is ignored (figure 7—dashed line), the areas of high precipitation in WY 1981 would be very similar to the areas outlined in figure 5. Figures 5 and 7 seem to indicate that there is a very good correlation between high precipitation and relatively large

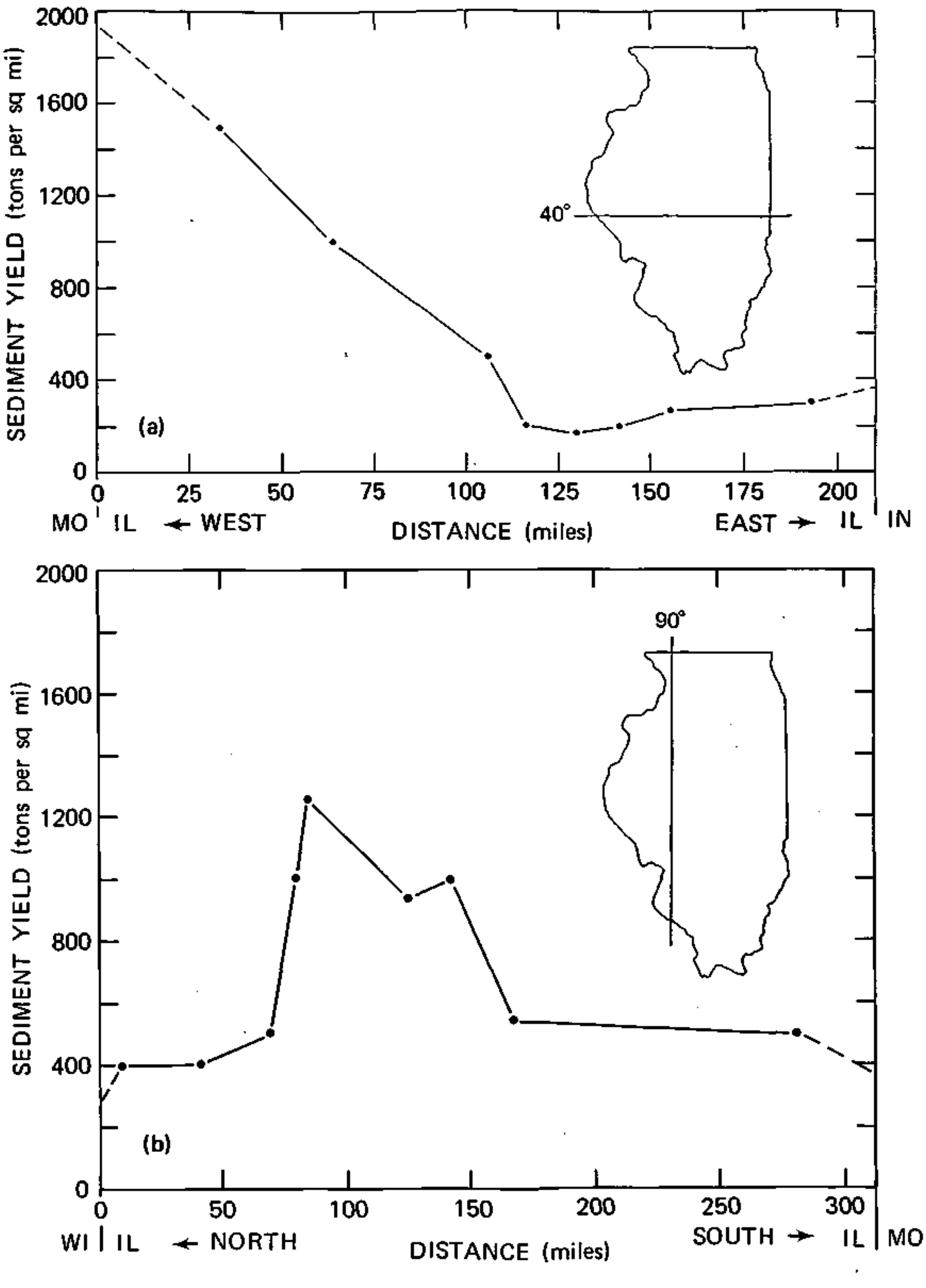

Figure 6. Gradient of the sediment yield in Illinois; sediment yield (tons per square mile) versus distance (miles) along lines at the 40° north latitude and the 90° west longitude

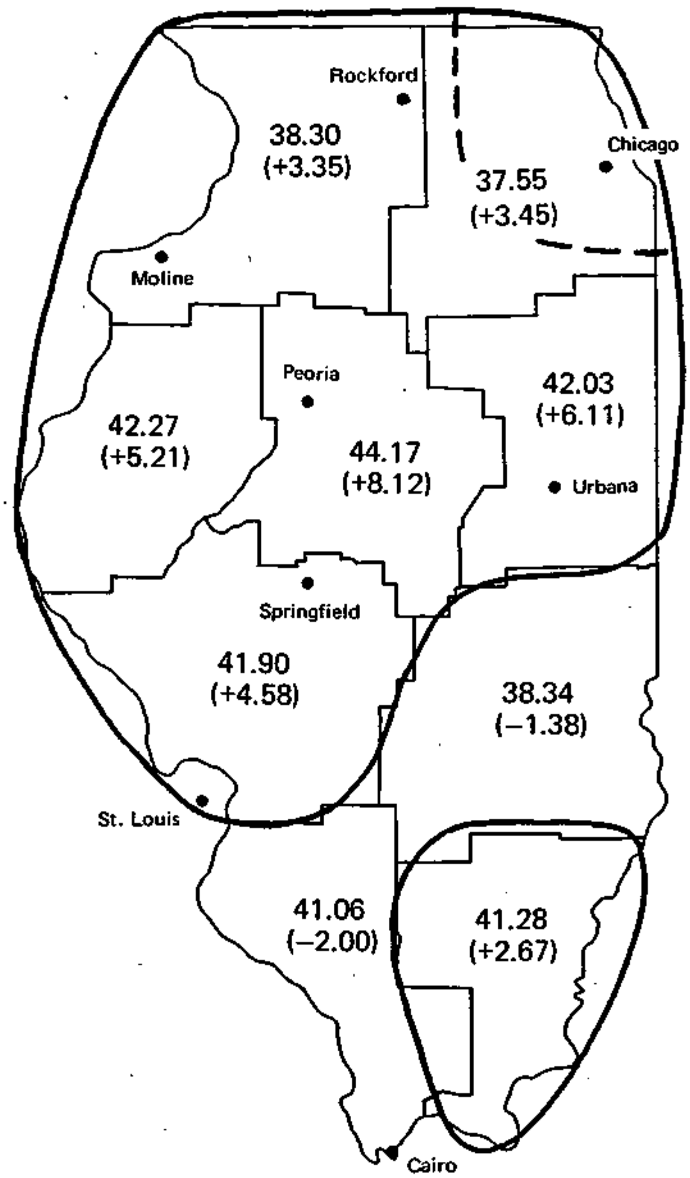

Figure 7. Total precipitation by crop district and departure from normal (in inches) for Water Year 1981

amounts of sediment load in streams and rivers within the state of Illinois. Therefore, it is obvious that any sediment yield computations or analyses cannot ignore the precipitation variability within a certain area.

Located within the area of high precipitation in Water Year 1981 are the Galesburg and Springfield Plains, two areas with soils that are highly erodible and easily transportable. Therefore, at least three factors which contribute to sediment yields have been matched for WY 1981—intense row crop agriculture, relatively high precipitation rates, and highly erodible soils.

It may be interesting to compare the sediment isolines shown in figure 4 with a map developed by the Illinois Environmental Protection Agency (1979) on the average thickness of topsoils in Illinois (figure 8). A close comparison of figure 8 and figure 4 suggests that there is a modest correlation between the relationship of the present topsoil thickness to the original topsoil thickness and the sediment yield in WY 1981. This may indicate that trends shown in figures 3 and 4 have been in existence for a considerable amount of time. The implications of this assessment are, of course, many and varied. Additional field data and research are needed in order to determine whether or not such an assessment is reasonable and valid.

The Task Force on Agriculture Non-Point Sources of Pollution (1978) has developed a map which illustrates the estimated average annual sediment yield from sheet and rill erosion in Illinois in tons per acre. This illustration is shown in figure 9.

Figure 10 shows the sediment yield values for Water Year 1981 in terms of tons per acre instead of tons per square mile as shown in figure 4.

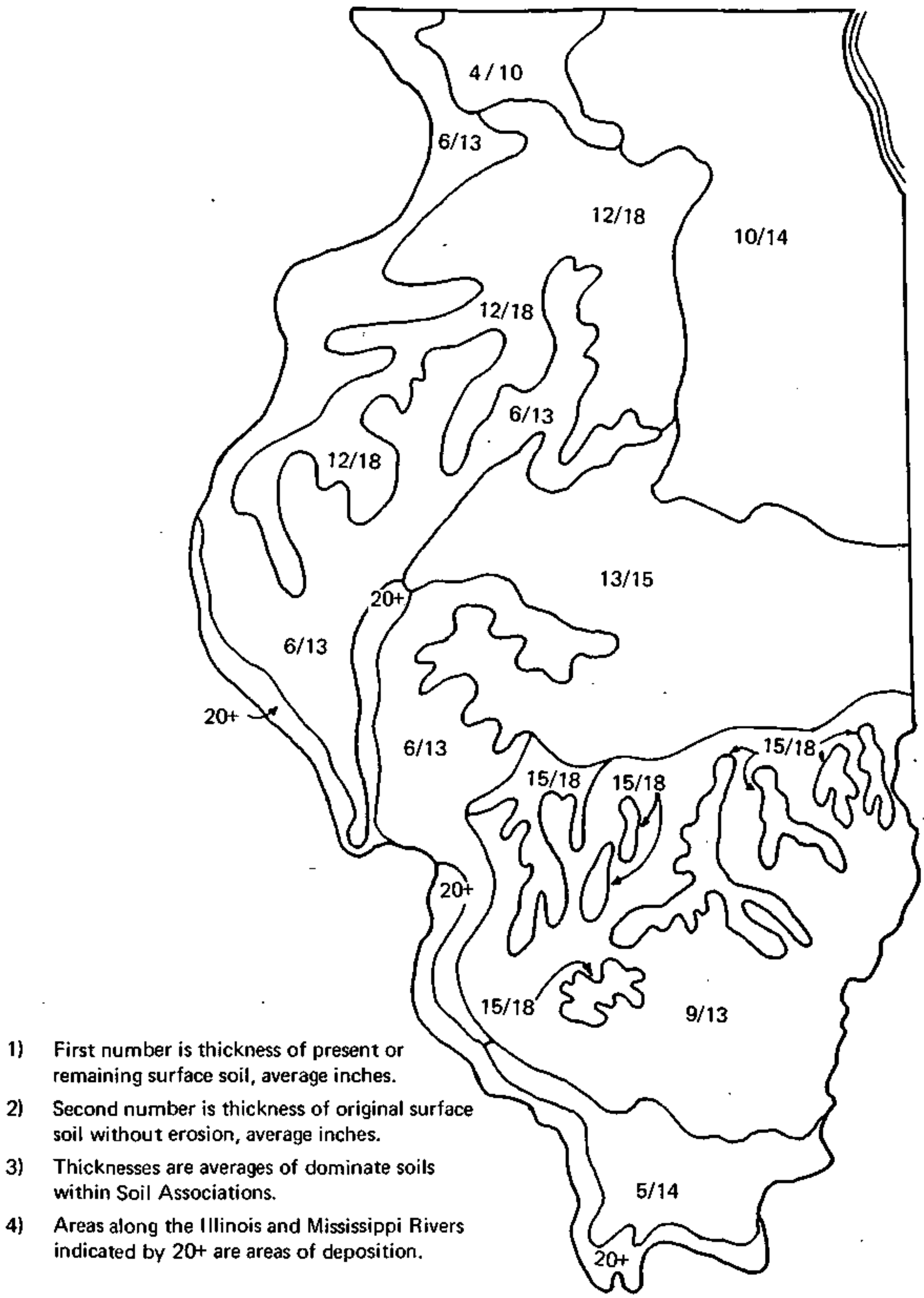

Figure 8. Average thickness of topsoils in Illinois (after IEPA, 1979)

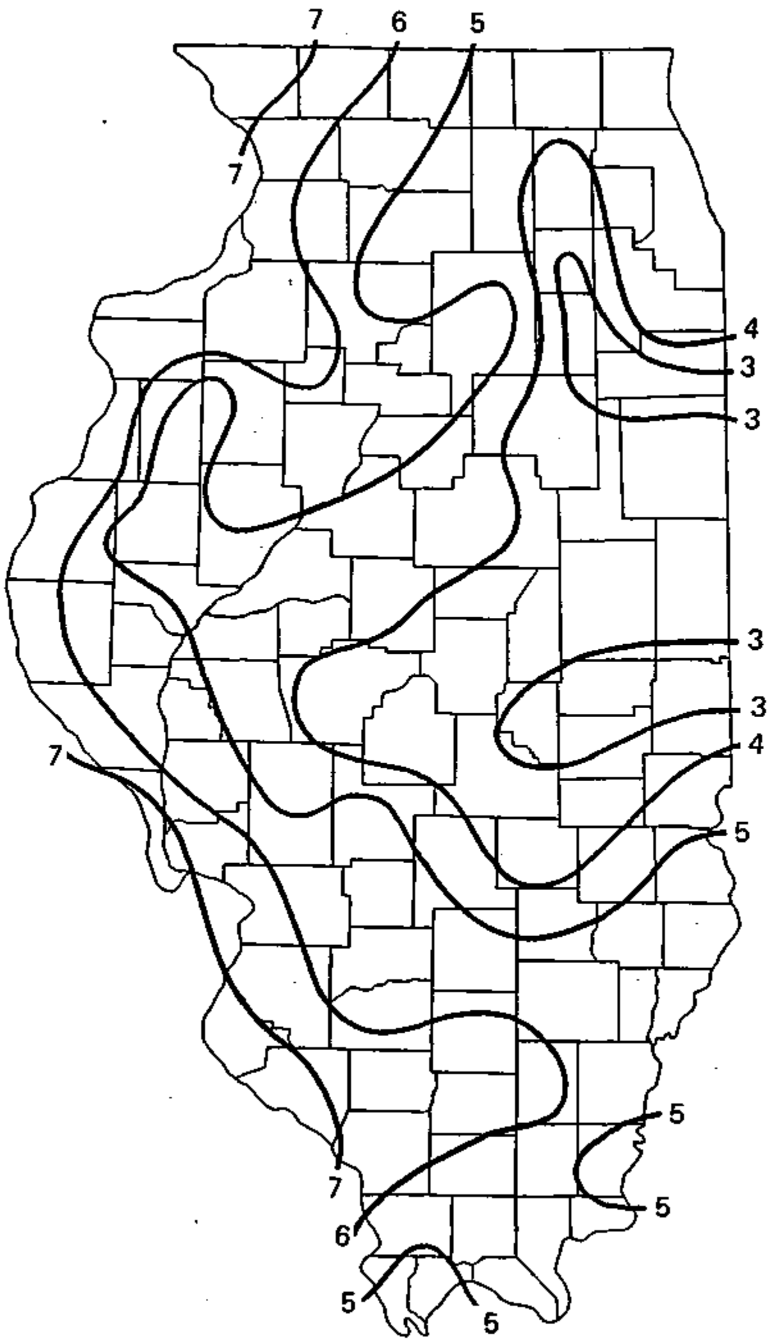

Figure 9. Average annual soil erosion rates (tons per acre) for sheet and rill erosion (after Task Force on Agriculture Non-Point Sources of Pollution, 1978)

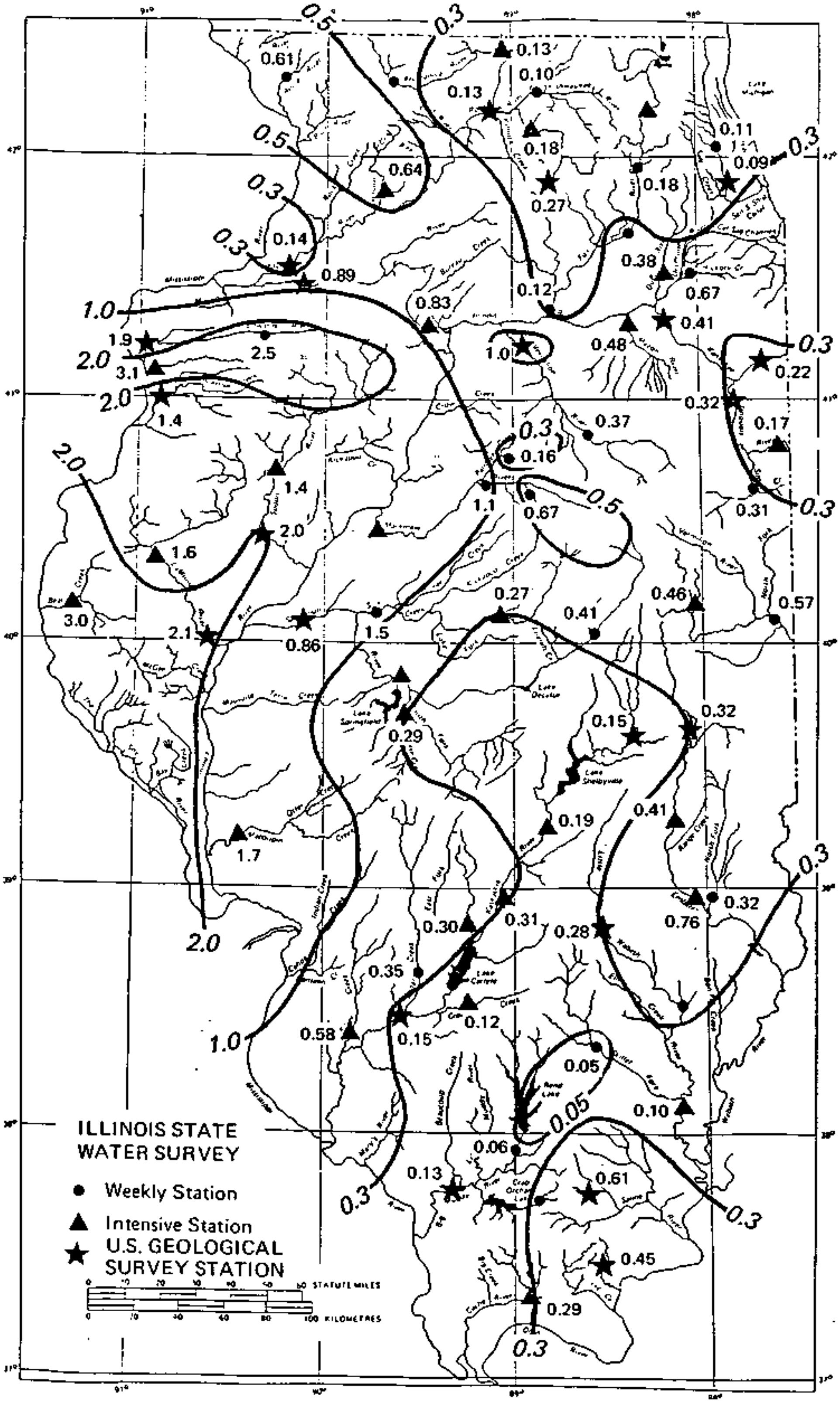

Figure 10. Average annual sediment yield (tons per acre), including U.S. Geological Survey data (USGS, 1981)

Comparing figure 10 with figure 9 shows some general correlations in many areas. However, the values associated with figure 9 are several times greater than those shown in figure 10. The values in figure 9 reflect sheet and rill erosion in the watershed. Those in figure 10 reflect the net instream sediment yield from all types of erosion, including gully, construction site, and other forms of erosion, as well as stream bank and bed erosion and deposition.

From the preliminary analyses presented in this section, which have been based on one year's data, it appears that the areas shown in figure 5 are the areas where resources should be targeted to reduce soil erosion. In the process of evaluating watershed protection strategies and priorities, planners and administrators must direct their limited resources to the areas where the greatest potential benefit may be realized.

SUMMARY AND CONCLUSIONS

This report summarizes the data collected from the Illinois State Water Survey Instream Sediment Monitoring Program for Water Year 1981 (October 1980 through September 1981).

An attempt has been made to explain the necessity for the network and its base of financial support; to describe the site selection process and the structure of the network; to explain the techniques followed in the data collection, laboratory analyses, and data evaluation processes; and to explain the format utilized in the presentation of the data set. In addition, descriptions of the limits of use of this data set as well as its availability to interested users in machine readable form are included.

Although the data base is minimal as far as sediment data are concerned, generalized analyses have been included in order to show the variability in the suspended sediment yield in Illinois for WY 1981.

According to these analyses, it has been demonstrated that the northwest, west, central, and far southeast parts of the state did produce excessive amounts of sediment load in WY 1981. Good correlations exist between this excessive sediment load and above normal precipitation rates within these specified areas. The rates of topsoil loss in Illinois and the areas of high sediment yield also indicate a fairly good correlation. There was a gradient of increased sediment yield from the Indiana-Illinois state line close to Danville toward the western part of the state up to the Mississippi River. In Water Year 1981 this gradient from the eastern to the western part of the state (along a line at the 40° north latitude) was such that the sediment yields in the west were nearly seven times higher than those in the east.

The data analyzed for this report were from only a 12-month period. Therefore, any extrapolation and inference that are made from these data should be made with a clear reference to this important constraint.

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APPENDIX A. SEDIMENT LOAD AND YIELD COMPUTATIONS - WATER YEAR 1981

SAMPLING STATION	STATION I.D. NO.	NUMBER OF DATA POINTS	-REGRESSION EQUATION PARAMETERS- (Qs=M*Qw**N) M	N	CORRELATION COEFFICIENT	STANDARD ERROR OF ESTIMATE	ANNUAL SEDIMENT LOAD (TONS/YR) -CALCULATED-	AVERAGE ANNUAL SEDIMENT YIELD -CALCULATED- (TONS/SQ.MI.)	(TONS/ACRE)
Apple River near Elizabeth, IL	101	31	0.0053	1.84	0.96	0.18	81294	393	.61
Rock River at Rockton, IL	103	221	7.26	0.64	0.43	0.26	526333	83	.13
Kishvaukee River at Belvidere, IL	104	33	0.038	1.33	0.80	0.24	33193	62	.10
S. Br. Kishvaukee R. near Fairdale, IL	106	213	0.066	1.32	0.94	0.18	45710	118	.18
Des Plaines River at Des Plaines, IL	108	26	0.068	1.17	0.76	0.23	21116	69	.11
Ferson Creek near St. Charles, IL	110	33	0.041	1.51	0.89	0.23	6057	117	.18
Elkhorn Creek near Penrose, IL	112	170	0.018	1.77	0.92	0.21	59476	407	.64
Hickory Creek at Joliet, IL	115	29	0.020	1.54	0.88	0.44	45597	426	.67
DuPage River at Shorewood, IL	116	222	.75E-4	2.36	0.91	0.33	79049	244	.38
Fox River at Dayton, IL	117	34	0.0021	1.60	0.80	0.28	194459	74	.12
Big Bureau Creek at Princeton, IL	118	165	0.0073	1.83	0.89	0.37	103765	529	.83
Edwards River near Orion, IL	121	29	0.0043	2.08	0.94	0.29	250523	1616	2.52
Mazon River near Coal City, IL	123	229	0.017	1.52	0.97	0.21	138476	304	.48
Pope Creek near Keithsburg, IL	127	172	.40E-3	2.60	0.95	0.27	359620	1965	3.07
Spoon River at London Mills, IL	229	211	0.0028	1.89	0.87	0.38	934542	880	1.38
E. Br. Panther Cr. at El Paso, IL	230	23	0.16	1.10	0.90	0.31	3207	105	.16
Vermilion River at McDowell, IL	231	24	0.032	1.42	0.95	0.24	131196	238	.37
Iroquois River at Iroquois, IL	233	242	0.48	0.95	0.87	0.25	73742	107	.17
Sugar Creek at Milford, IL	234	27	0.099	1.27	0.96	0.24	89123	200	.31
Money Creek near Tovanda, IL	235	27	0.21	1.23	0.92	0.37	20902	427	.67
Mackinaw River below Congerville, IL	236	23	0.017	1.58	0.96	0.24	528301	681	1.06

APPENDIX A. SEDIMENT LOAD AND YIELD COMPUTATIONS - WATER YEAR 1981 (Concluded)

SAMPLING STATION	STATION I.D. NO.	NUMBER "OF DATA POINTS	-REGRESSION EQUATION PARAMETERS- (Qs=M*Qw**N) M	N	CORRELATION COEFFICIENT	STANDARD ERROR OF ESTIMATE	ANNUAL SEDIMENT LOAD (TONS/YR) -CALCULATED-	AVERAGE ANNUAL SEDIMENT YIELD -CALCULATED- (TONS/SQ.MI.)	(TONS/ACRE)
La Moine River at Colmar, IL	242	213	0.026	1.59	0.93	0.32	691022	1055	1.65
Bear Creek near Marcelline, IL	243	217	0.020 ''	1.70	0.97	0.31	675379	1935	3.02
Salt Creek near Greenview, IL	247	26	0.0074	1.64	0.95	0.31	1769576	981	1.53
Salt Creek near Rowe11, IL	248	220	0.057	1.26	0.88	0.29	60631	171	.27
Sangamon River at Monticello, IL	249	25	0.075	1.30	0.95	0.27	144413	263	.41
Salt Fork near St. Joseph, IL	250	222	0.0074	1.71	0.95	0.30	39168	292	.46
Vermilion River near Danville, IL	251	24	0.0011	1.84	0.95	0.39	468816	363	.57
S. Fk. Sangamon River below Rochester, IL	254	220	0.14	1.25	0.91	0.35	160524	185	.29
Embarras River near Diona, IL	357	148	0.022	1.49	0.97	0.20	239895	261	.41
Kaskaskia River near Cowden, IL	358	150	0.014	1.50	0.83	0.28	161052	121	.19
Macoupin Creek near Kane, IL	359	144	0.042	1.57	0.96	0.36	966952	1114	1.74
Hurricane Creek near Mulberry Grove, II	360	85	0.24	1.31	0.96	0.32	29538	194	.30
Kaskaskia River at Vandalia, IL	361	181	0.0025	1.79	0.93	0.27	381164	200	.31
Embarras River at Ste. Marie, IL	362	161	0.0045	1.77	0.93	0.27	738782	487	.76
N. Fk. Embarras River near Oblong, IL	363	23.	0.094	1.34	0.98	0.22	64073	201	.32
Crooked Creek near Hoffman, IL	365	152	0.21	1.27.	0.92	0.36	18910	74	•12
Shoal Creek near Breese, IL	366	24	0.013	1.70	0.94	0.36	163794	223	.35
Silver Creek near Freeburg, IL	367	128	0.056	1.65	0.97	0.28	172051	371	.58
Skillet Fork at Wayne City, IL	368	24	0.050	1.36	0.96	0.28	15619	34	.05
Little Wabash River at Carmi, IL	370	117	0.030	1.34	0.97	0.25	203745	66	.10
Big Muddy River at Plumfield, IL	371	26	0.13	1.09	0.91	0.29	33174	42	.06
Cache River at Forman, IL	378	173	0.082	1.31	0.97	0.26	44995	184	.29

A NOTE CONCERNING APPENDIX B

Appendix B consists of data collected during Water Year 1981 (October 1, 1980 through September 30, 1981). The data are presented on a station-by-station basis with the stations organized in numerical order on the basis of the 8-digit station numbers assigned by the USGS (U.S. Geological Survey, 1981). Any or all of the data that make up Appendix B can be made available to interested users in machine readable or hard copy form. Inquiries should be addressed to the Illinois Department of Energy and Natural Resources, State Water Survey Division, Surface Water Section, P.O. Box 5050, Station A, Champaign, Illinois 61820, or call (217) 333-2210.