DEVELOPMENT AND ORGANIZATION OF A GEOGRAPHIC INFORMATION SYSTEM DATA BASE AND ITS APPLICATION TO INVESTIGATION OF RAINFALL/RUNOFF-MODEL PARAMETERS IN ILLINOIS

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ILLUSTRATIONS

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CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer

GLOSSARY OF TECHNICAL TERMS

Antecedent-precipitation index.--An index of the moisture stored within a drainage basin before a storm.

Arc.--A continuous string of (x,y) coordinate pairs (vertices) beginning at one location and ending at another location, having length but no area. Arcs represent line features, the borders of area features, or both. Arcs are topologically linked at their endpoints (nodes) and to the areas (polygons) on each side of them.

ASCII.--A standard for defining codes for information interchange between computer equipment. [A(merican) S(tandard) C(ode for) I(nformation) I(interchange)].

Attribute.--A characteristic of a map feature, described by numbers or characters stored in a data file and linked to the feature by an assigned identifier.

Block.--A contiguous group of records in a data file with some common attribute.

Clip.--The process of extracting data from a coverage that reside entirely within the boundary of features in another coverage.

Coverage.--A digital analog of a map sheet. Usually a set of thematically associated data considered to be a unit. A coverage usually represents a single theme, such as land use or streams.

Digitizer.--A device consisting of a table and a cursor with crosshairs and keys used to record the locations of map features as (x,y) Cartesian coordinates.

Directory.--A disk location containing data files and other directories (subdirectories).

Drainage area.--The drainage area of a stream at a specified location is that area, measured in a horizontal plane, that is enclosed by a drainage divide.

Drainage basin.--A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water, together with all tributary surface streams or bodies of impounded surface water.

Drainage divide.--The rim of a drainage basin.

Feature.--A distinct characteristic or item included on a map or in a coverage as an area, a line, or a point.

Label.--A location and associated data items used to represent point features, such as wells or gaging stations, or to assign data to polygon features. For point features, the label's location describes the location of the feature. For polygon-identification labels, the label can occur anywhere within the polygon.

Node.--The beginning and ending points of an arc. A node is topologically linked to all arcs that meet at that node.

Point.--A single (x,y) coordinate that represents a geographic feature too small to be displayed as a line or an area.

Polygon.--An areal feature defined by a series of arcs comprising its boundary. A polygon contains a label point inside its boundary and has attributes that describe the geographic feature it represents.

Projection.--A mathematical model that transforms locations on the Earth's surface to locations on a two-dimensional surface, such as a map.

Soil association.--Groupings of several soil types that developed from similar parent materials and have similar surface color.

Tick.--Registration or geographic control points for a coverage representing known locations on the Earth's surface. Ticks allow all coverages to be recorded to a common coordinate system.

Topology.--The spatial relations between coverage features. For example, the topology of an arc includes the nodes that form its endpoints and the polygons on each side of the arc.

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ABSTRACT

A geographic information system data base was compiled for use in an analysis of basin and climatic factors affecting rainfall/runoff-model parameters. This data base included drainage-basin boundaries, land use, soil association, elevation, and antecedent-precipitation-index data for Illinois, and calibrated parameters for the HEC-1 rainfall-runoff model for 98 drainage basins in Illinois. Drainage-basin boundaries were digitized from existing maps of the entire State. Procedures were developed to extract the boundaries for a selected drainage basin from these digital maps. Daily antecedent-precipitation-index values were calculated for the period of record for 169 recording precipitation gages and averaged to obtain monthly and annual mean values, which were stored in the data base. Runoff-curve numbers from the Soil Conservation Service were parameterized to develop an infiltration-index number for selected land-use classifications. These were modified to correspond to the land-use classifications used in the geographic information system data base.

The geographic information system was used to limit data for land use and soils to only those features within the border of a selected drainage basin. The geographic information system also was used to select the antecedent-precipitation-index data for the appropriate month for each modeled storm; to produce a statewide, three-dimensional surface of these data; and to calculate the average of this surface over the drainage basin. Once coverages were developed for the characteristics of each basin, the geographic information system was used to calculate the area-weighted averages for parameters describing these basin characteristics. Procedures were developed to output these averages, along with the model parameters for the basin, to a file for further processing by other programs.

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Illinois Department of Transportation, Division of Water Resources (DWR), has been involved in an ongoing series of investigations of rainfall/runoff-model parameters for ungaged drainage basins in Illinois. These investigations have all focused on parameters for the U.S. Army Corps of Engineers' Hydrologic Engineering Center flood-hydrograph model (HEC-1) (1981).

The HEC-1 model was designed to simulate storm events at a gaged drainage basin using calibrated model parameters developed for that basin. The calibrated parameters were developed by simulating individual storm events and adjusting values for the model parameters until the simulated and observed storm-runoff hydrographs matched within a specified tolerance. These parameters that best simulate a storm event are referred to in this report as optimized parameters. This was repeated for several storms, and the parameters were averaged to define calibrated parameters for the drainage basin.

Model parameters considered in this series of investigations are those describing timing and attenuation of the storm-runoff hydrograph and timing and volume of rainfall losses. The model, as used by water-resources planners in Illinois, uses the Clark unit hydrograph (Clark, 1945) to calculate the amount and timing of runoff at the outlet of a drainage basin from excess precipitation over the drainage basin. Excess precipitation is calculated as the precipitation in excess of that required to satisfy a loss estimated by one of four rainfall-loss functions in the model (U.S. Army Corps of Engineers, 1981). Rainfall-loss parameters describe the volumetric rate and timing of rainfall losses caused by land-surface interception, depression storage, and infiltration. Precipitation that does not contribute to runoff is considered as lost from the surface-water system.

The calibration process used with this model does not provide a means to estimate parameters to simulate runoff at ungaged drainage basins. At ungaged drainage basins, there is no record of the observed storm-runoff hydrograph to compare simulated results with. In addition, the unit-hydrograph and rainfall-loss parameters are not defined by physical properties of the drainage basin but rather by the calibration process. The purpose of this series of investigations has been to provide methods to estimate parameters for the HEC-1 model for ungaged basins in Illinois and to quantify the error in these estimated parameters.

Purpose and Scope

The purpose of this report is to describe the geographic information system (GIS) data base used in an investigation of relations between physical drainage basin characteristics and HEC-1 rainfall loss-rate parameters. This report describes the compilation of the GIS data base, including the source, scale, and accuracy of the included data sets; the physical attributes associated with each data set, and how these were determined; and the steps taken to compile the different data sets into the data base for this investigation. The report also describes the organization of the data base and the procedures used to identify and extract the appropriate data for analysis of HEC-1 model parameters.

Previous Studies

In an investigation presented by Graf and others (1982a and 1982b), the HEC-1 model was used to estimate unit-hydrograph parameters for 98 gaged drainage basins in Illinois (fig. 1). These unit-hydrograph parameters were used to develop a technique to estimate these parameters for ungaged drainage basins in Illinois. These techniques involve regionalization of the parameters and empirical equations involving the main-channel slope and length. As part of the calibrations in this study, rainfall-loss rates were determined using a four-parameter, exponential loss-rate function.

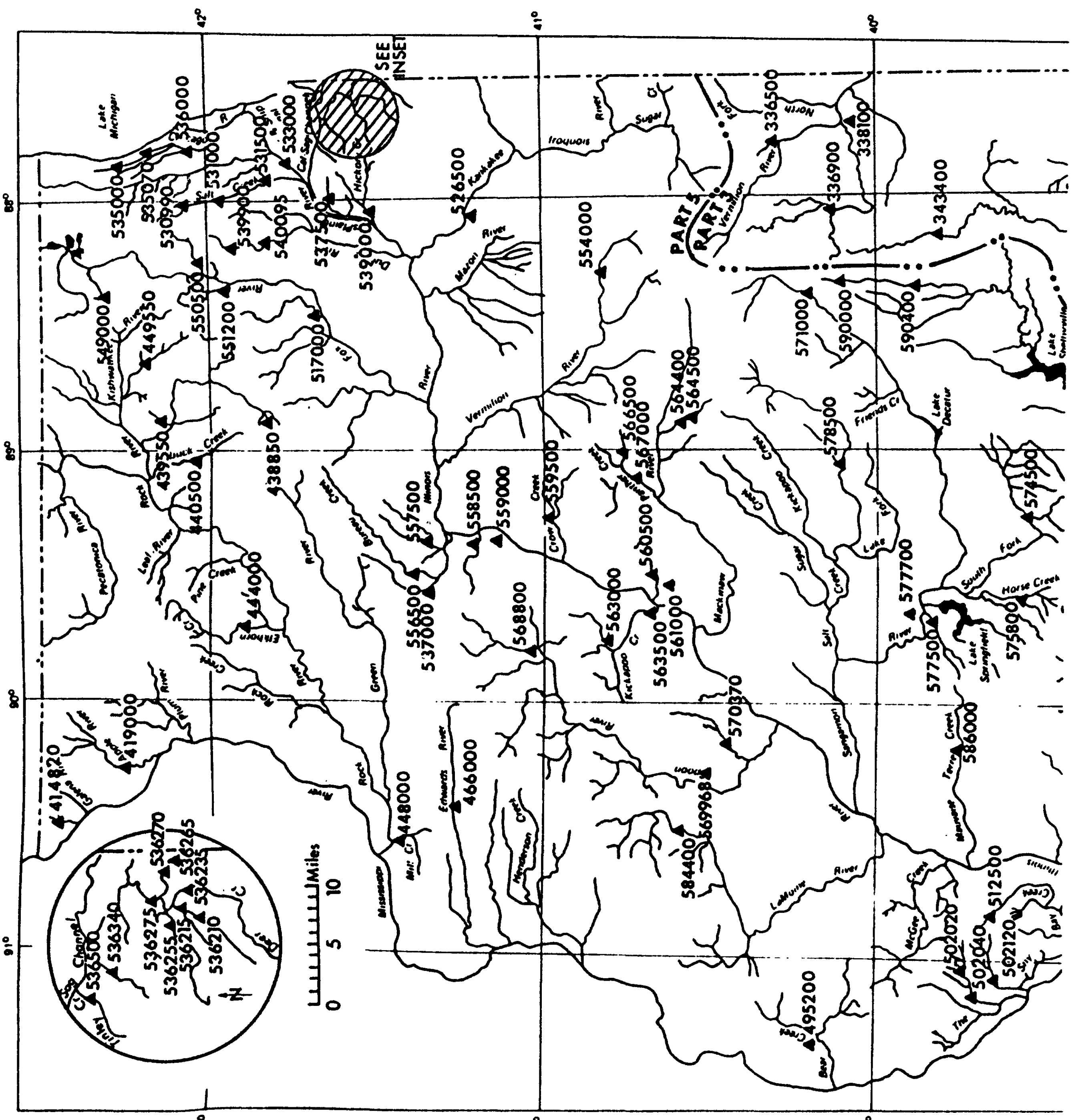
A second study (Garklavs and Oberg, 1986) compared unit-hydrograph parameters estimated by Graf and others (1982a) with those obtained when the model was calibrated using a different, two-parameter, linear loss-rate function. This comparison was performed for 32 of the 98 gaged drainage basins and showed no significant differences in the accuracy of simulated unit hydrographs.

A third study (Weiss and Ishii, 1987) developed techniques to estimate rainfall loss-rate parameters for both of the loss-rate functions used in the previous studies. In their study, the model was calibrated for the remaining 66 (of the 98) basins using the second loss-rate function. The estimation techniques developed include regionalization of parameters and empirical relations involving main-channel slope and length, and the month of the storm.

The parameter-estimation techniques developed in these studies were evaluated by Weiss and Ishii (1987). The estimation techniques were evaluated by determining the sensitivity of the simulated hydrographs to changes in the parameters and by simulating storm events at gaged basins not included in development of the techniques, and comparing the simulated and observed runoff hydrographs. Sensitivity analyses, based on increasing and decreasing parameters by one standard error of estimate, indicated error ranges in the total runoff volume as large as +60 to -57 percent of observed, and error ranges in the peak discharge as large as +65 to -61 percent of observed. Simulation of storm events at previously unmodeled basins resulted in invalid hydrographs (errors greater than three standard deviations from the mean hydrograph error or no simulated hydrograph produced) for 41 percent (84 of 204) of the simulations attempted. For the 120 simulations producing output hydrographs, errors in the total runoff volume ranged from +94 to -152 percent of observed, and errors in the peak discharge ranged from +92 to -157 percent of observed. Weiss and Ishii (1987, p. 26) concluded that there is a large degree of uncertainty in hydrographs computed using these techniques.

Acknowledgments

The authors would like to thank Don McKay and Dawn McHwa of the Illinois State Geological Survey, Dr. Warren Brigham of the Illinois State Natural History Survey, and Bob Sinclair of the Illinois State Water Survey for their assistance in providing digital data in GIS format for use in this study.



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Kankakee
Vermilion
Illinois
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Pecatonica
Kishwaukee
Fox
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Mackinaw
Sangamon
Salt
South Fork
Lake Decatur
Lake Springfield
Lake Shelbyville
Edwards River
La Moine River
Mississippi
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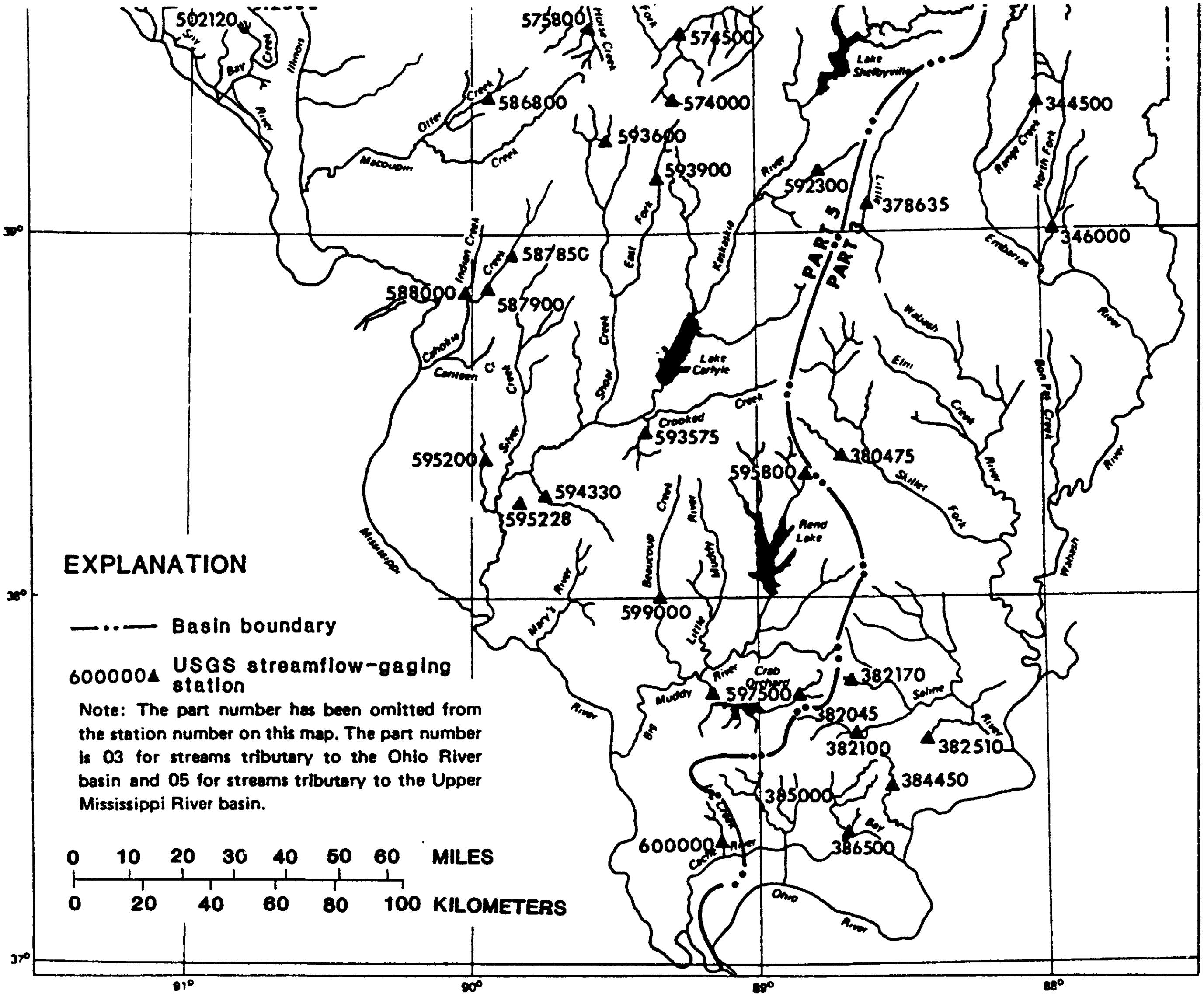


Base from U.S. Geological Survey
State base map, 1:1,000,000

Figure 1.--Location of U.S. Geological Survey streamflow-gaging stations used in this investigation.

DEVELOPMENT OF THE DATA BASE

The GIS data base described in this report contains data describing a variety of drainage basin and climatologic features, including slope, land use, soil association, antecedent-precipitation conditions, model parameters, and location of drainage divides. These data were compiled from several sources, including original maps, digital data produced by other State and Federal agencies, and tabular data with locational data in the table. The map projections and scales used differed between data sources. These data needed to be collected, checked for accuracy, projected to a common map projection to be used for all coverages, and stored in a manner compatible with intended use of the data. The following sections of the report describe the data features included in the data base, the source and accuracy of the data, and the steps used to compile these data into the data base.

Digitizing Template

The first step toward producing a uniform GIS data base was to develop a template that allowed transformation of coordinates of features digitized from maps to the map projection and coordinate system used in the data base (map registration). This template consisted of a set of ticks (points that are identifiable on maps and whose locations are well defined) spaced at intervals of 7.5 minutes of latitude and 7.5 minutes of longitude, computer files that relate the ticks to printed maps, and a series of template programs (computer programs to automate selection of the appropriate ticks, map projection, projection parameters, and map identification for any map including all or part of Illinois). The set of ticks is a grid of points used for registration of maps to be digitized. The ticks extend from 36 degrees North latitude and 87 degrees West latitude to 42 degrees North latitude and 92 degrees West latitude. Tick spacing is at intervals of 7.5 minutes of latitude and 7.5 minutes of longitude for all USGS 7.5-minute quadrangle maps that contain portions of Illinois. For areas outside Illinois, ticks are spaced at a coarser resolution. The resolution outside of Illinois was determined to provide tick coverage for the corners for all USGS map series that contain all or part of Illinois (7.5-minute, 15-minute, 30-minute by 60-minute, 1-degree by 2-degree, and 1:500,000 and 1:1,000,000-scale State base maps). Additional ticks can be added to the set as needed. These are not restricted to the 5-degree by 6-degree rectangle of the original set.

Each tick in the set is stored as a unique identification number and a location (latitude and longitude). The ticks are stored both as a file of identification numbers, latitudes, and longitudes (tick file), and as a GIS coverage (tick coverage). This allows the template programs, which are not part of the GIS, to select the appropriate ticks by the locations stored in the file, yet allows registration of maps to be digitized based on only the identification numbers of the ticks in the GIS coverage.

Maps for Illinois are indexed by the location of the lower right (southeastern) corner of the map, using a system described by the U.S. Geological Survey (1987). In this index system, the State is divided into zones of

1 degree of latitude by 1 degree of longitude. Each zone is identified by a five-digit number, where the left two digits are the latitude of the southeastern corner of the zone and the right three digits are the longitude of the same corner. Each zone is subdivided into 64 quadrangles, each of which covers 7.5 minutes of latitude by 7.5 minutes of longitude. Each of these is identified by a two-character alpha-numeric code. The left character of this code is one of the characters A through H and indicates the latitude of the quadrangle, with A corresponding to the southernmost latitude of the zone. The right character of the code is a numeral between 1 and 8 and indicates the longitude of the quadrangle, with increasing value corresponding to increasing longitude. Figure 2 illustrates the system of zones and codes for Illinois maps. Maps at scales smaller than 1:24,000 are identified by the zone and code number of the southeastern corner of the map.

Several computer files are used to define the tick set and to relate these to printed maps. The location and identification of the ticks are stored in an American Standard Code for Information Interchange (ASCII) file and also as a GIS coverage. These are referred to as the tick file and the tick coverage, respectively. In addition, two other ASCII files, the map-selection file and the tick-selection file, are required for each map series to identify the ticks necessary to digitize a map from that series.

The tick file contains one record for each tick, as well as an initialization record. The initialization record tells the total number of ticks in the data base. The record for each tick contains the latitude and longitude in decimal degrees, the tick identification number, and a pointer. The pointer indicates which record in the tick file contains the data for the tick given by

$$ID = RECORD - 1 \qquad (1)$$

where ID is the tick identification number; and
RECORD is the current record number.

This allows the program to locate ticks by identification number by reading the record given by that number (corrected for the initial record) and then reading the correct record, as given by the pointer from the first record read. This also allows for quick searching of the file to identify ticks by their location, as the file is sorted by latitude and by longitude within groups of equal latitude, allowing binary searches for specific locations. The map-selection file contains one record for each map in that map series. Each record in this file consists of a field for the map name and fields for the zone and code identification. This file is sorted by the map name to allow maps to be located by the map name.

The tick-selection file contains one record for each map in the selected map series. Each record consists of the identification numbers for four ticks for the selected 7.5-minute map and a pointer to the record in the map-selection file for that map. Entries in this file are grouped into blocks of records for each zone in the template area, with each block containing one record for each map in that zone. Thus, for 7.5-minute maps, each block consists of 64 records; for 15-minute maps, each block contains 16 records; and

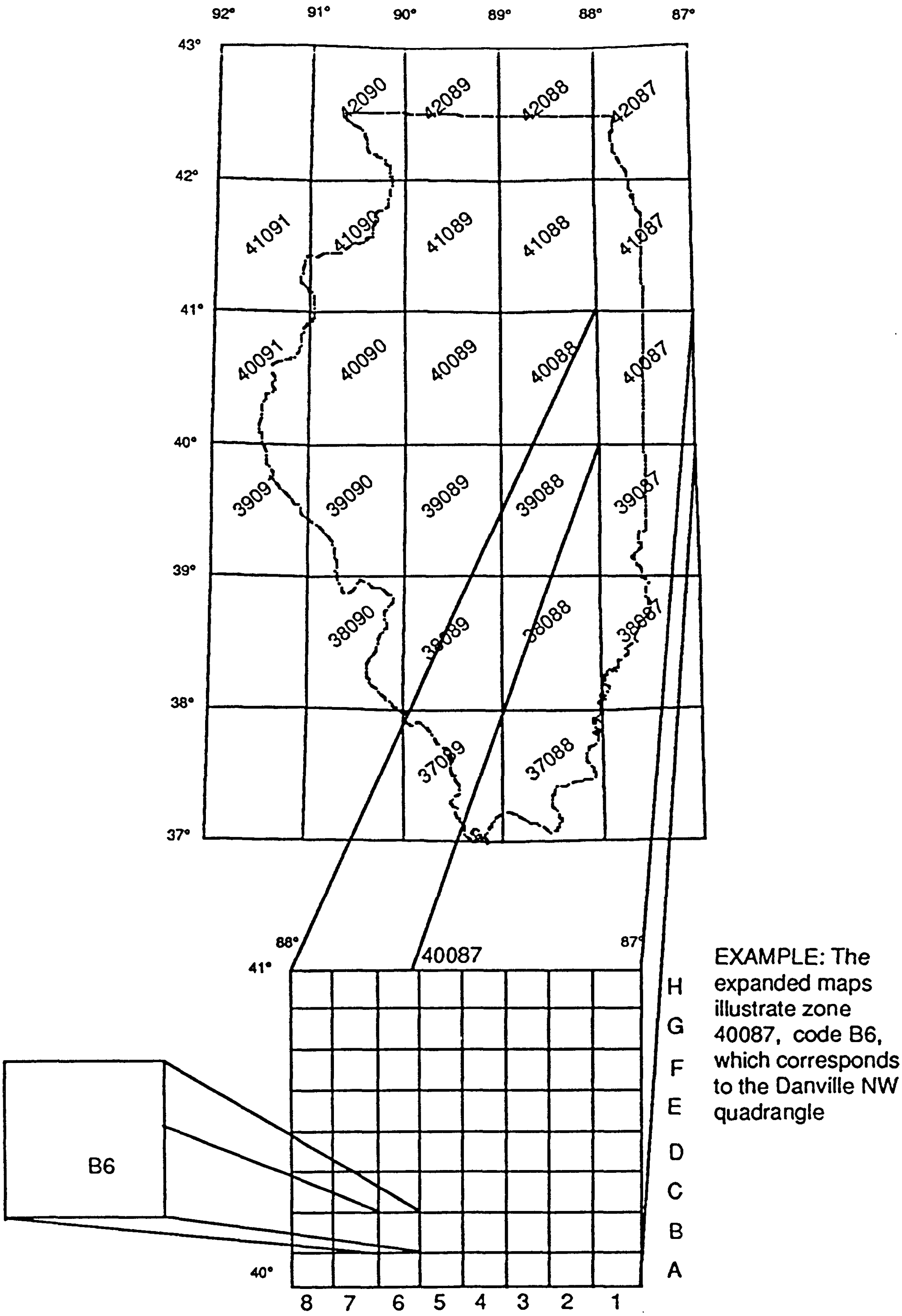


Figure 2.--Layout of zones and codes for identification of map locations.

for 1:100,000 scale maps, each block contains two records. The records for each zone are sorted by rows of maps of equal latitude, with each row of maps sorted by longitude from east to west. The blocks of data are ordered by rows of blocks of equal latitude, sorted from north to south, with each row of blocks ordered by longitude, sorted from west to east. With the blocks and records arranged in this manner, the location of the record describing any map can be calculated by knowing the zone and code for that map. Figure 3 illustrates the different files used to identify ticks and map names and the relations between them.

The template programs are those that create and update the tick file and coverage, and those that select the appropriate ticks and prepare the workspace needed to digitize a given map. The ticks needed for a given map are selected based on the scale and location of the map. Recognized map scales are those for the common USGS map series (7.5 minute at 1:24,000; 15 minute at 1:62,500; 30 minute by 60 minute at 1:100,000; 1 degree by 2 degree at 1:250,000; and State base maps at 1:500,000 and 1:1,000,000). For the large- and intermediate-scale map series (7.5 minute, 15 minute, and 30 minute by 60 minute), the map can be identified by the map name, by specifying a point in the interior of the map or by specifying an identification zone and code for the map, as described below.

All maps are identified by the map series and the zone and code. The zone and code are used to calculate the location of the appropriate record in the tick-selection file. If the user wishes to locate a map by the map name, the map-selection file is searched for that name. The zone and code are then read from this file and used to locate the record in the tick-selection file. Once the correct record in the tick-selection file is read, the pointer to the map-selection file is used to read the name for the selected map. The tick identification numbers are used to read the latitude and longitude of the ticks from the tick file.

Once a map is selected, the program displays the map name, zone and code number, the projection parameters for that map, a graphic display of the tick distribution, and a table giving the tick numbers, latitudes, and longitudes. Figure 4 illustrates a typical display from this program. The user can then interactively change or add a name for the map, change the map projection and parameters, and add or change ticks for the map.

Once all changes have been made, the user exits the program. At this point, the program creates a computer directory for the map, if one does not exist. The program then creates, within this directory, a file of the ticks for the map; creates and executes a file of GIS commands to project the tick coordinates from latitude-longitude to the map projection used in printing the source map; and creates a second file of GIS commands to automate entry to the digitizing program and registration of the source map to the selected ticks. When the user has completed digitizing the selected features from the map, another sequence of GIS commands is executed to project the digitized data from the map projection of the source map to that used for the statewide data base, to calculate topological relations (connections between arcs, lists of arcs forming closed polygons, length of arcs, areas and perimeters of polygons) for the digitized data, and to write a file to keep a record of the history of digitizing the map.

MAP-SELECTION FILE

Contains map indexing information

Record number	Quadrangle name	Zone	Code
213	CULLOM, ILL.	40088	59
214	CYPRESS	37089	17
215	DAHLGREN, ILL.	38088	14
216	DAKOTA, ILL.	42089	29
217	DALLAS CITY, IA.-ILL.	40091	42
218	DALTON CITY, ILL.	39088	47
219	DANA, ILL.	40088	64
220	DANVERS	40089	34
221	DANVILLE NE, ILL.-IND.	40087	13
222	**DANVILLE NW, ILL.**	**40087**	**14**
223	DANVILLE SE, ILL.-IND.	40087	5
224	DANVILLE SW, ILL.	40087	6
225	DARROW	38089	17
226	DARROW	41088	58
227	DARROW, ILL.-IND.	40087	45

TICK-SELECTION FILE

Gives ticks for selected map

Record number	Name pointer	TICK 1	TICK2	TICK3	TICK4
835					
836		716	0	753	0
837	223	715	716	752	753
838	224	714	715	751	752
839	621	713	714	750	751
840	406	712	713	749	750
841					
842					
843					
844		681	0	716	0
845	221	680	681	715	716
846	**222**	**679**	**680**	**714**	**715**
847	192	678	679	713	714
848	738	677	678	712	713
849					

Data for a map is located in the tick-selection file by the zone and code. Each zone has 64 records in this file. The map of interest is for zone 40087, code B6, which is the 14th record in the 13th zone; thus the data is in record 846 (13X64 + 14).

Based on this record, the four ticks are numbers 679, 680, 714, and 715; and the map name is in record 222 of the name-selection file. Note that the name-selection file contains the zone of the map and the record number of the code of the map to allow this process to be reversed and the map located by just its name.

TICK FILE

Gives location of ticks

Record number	Longitude	Latitude	Tick ID	Pointer
660	88° 0' 0"	40° 22' 30"	642	677
661	87° 52' 30"	40° 22' 30"	643	678
662	87° 45' 0"	40° 22' 30"	644	679
663	87° 37' 30"	40° 22' 30"	645	680
664	87° 30' 0"	40° 22' 30"	646	681
665	91° 37' 30"	40° 15' 0"	647	682
666	91° 30' 0"	40° 15' 0"	648	683
667	91° 22' 30"	40° 15' 0"	649	684
668	91° 15' 0"	40° 15' 0"	650	685
669	91° 7' 30"	40° 15' 0"	651	686
670	91° 0' 0"	40° 15' 0"	652	687
671	90° 52' 30"	40° 15' 0"	653	688
672	90° 45' 0"	40° 15' 0"	654	689
673	90° 37' 30"	40° 15' 0"	655	690
674	90° 30' 0"	40° 15' 0"	656	691
675	90° 22' 30"	40° 15' 0"	657	692
676	90° 15' 0"	40° 15' 0"	658	693
677	90° 7' 30"	40° 15' 0"	659	694
678	90° 0' 0"	40° 15' 0"	660	695
679	90° 0' 0"	40° 15' 0"	661	696
680	89° 52' 30"	40° 15' 0"	662	**697**
681	89° 45' 0"	40° 15' 0"	663	**698**
682	89° 37' 30"	40° 15' 0"	664	699
683	89° 30' 0"	40° 15' 0"	665	700
684	89° 22' 30"	40° 15' 0"	666	701
685	89° 15' 0"	40° 15' 0"	667	702
686	89° 7' 30"	40° 15' 0"	668	703
687	89° 0' 0"	40° 15' 0"	669	704
688	88° 52' 30"	40° 15' 0"	670	705
689	88° 45' 0"	40° 15' 0"	671	706
690	88° 37' 30"	40° 15' 0"	672	707
691	88° 30' 0"	40° 15' 0"	673	708
692	88° 22' 30"	40° 15' 0"	674	709
693	88° 15' 0"	40° 15' 0"	675	710
694	88° 7' 30"	40° 15' 0"	676	711
695	88° 0' 0"	40° 15' 0"	677	712
696	87° 52' 30"	40° 15' 0"	678	713
697	**87° 45' 0"**	**40° 15' 0"**	**679**	714
698	**87° 37' 30"**	**40° 15' 0"**	**680**	715
699	87° 30' 0"	40° 15' 0"	681	716
700	91° 37' 30"	40° 7' 30"	682	717
701	91° 30' 0"	40° 7' 30"	683	718
702	91° 22' 30"	40° 7' 30"	684	719
703	91° 15' 0"	40° 7' 30"	685	720
704	91° 7' 30"	40° 7' 30"	686	721

The latitude and longitude of ticks for the map are located from the tick file. To locate tick 680, record 681 is read. The pointer in this record is 698, indicating that the data for tick 680 is in record 698.

Figure 3.--Organization of files on the digitizing template.

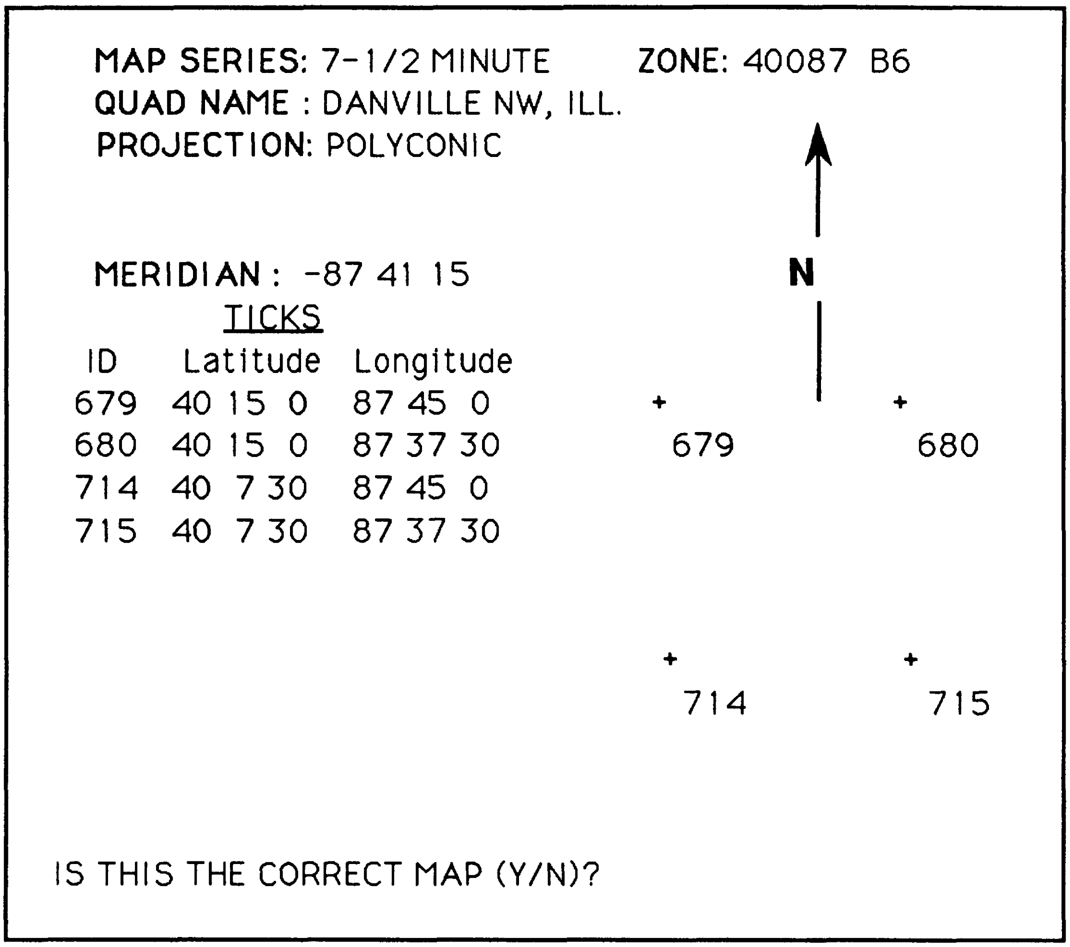


Figure 4.--Example display of program to locate map to be digitized.

The map projection used for the statewide data base is the Albers equal-area projection (Snyder, 1987). Parameters of this projection used for the statewide data base are a central meridian at 89° West longitude, standard parallels at 33° and 45° North latitude, and the origin at the equator (0° North). The units used for the projection are meters. This map projection was used because determination of the area of different basin characteristics is a primary use of the GIS data base, and this is a commonly used projection that preserves area (Snyder, 1987).

Drainage Area Determination

Digital representation of the drainage divides forming the boundary of each drainage basin was essential for this project. Divides for drainage basins upstream from every USGS-operated gaging station and water-sampling location in Illinois have been delineated on 7.5-minute topographic quadrangle sheets. Subareas on these quadrangles (closed regions formed by drainage divides and the map border) have been planimetered to determine their area following the procedure given by the Federal Interagency River Basin Committee, Subcommittee on Hydrology (1951). The sum of the areas of all subareas upstream from the station gives the total area drained by the stream at that station. The quadrangle maps marked with the drainage divides, together with the planimetered areas and the calculated area upstream from each station, form the historical drainage-area file for Illinois.

For each drainage basin in the investigation, all 7.5-minute topographic quadrangles containing parts of the drainage basin were identified. The ticks corresponding to the corners of each quadrangle were identified and their coordinates projected to the projection used to print the map sheet, as described earlier. Each map was then registered by digitizing the four corner ticks. The GIS software computed a bilinear transformation that would map the coordinates given by the digitizer (inches from the lower right corner of the digitizer table, hereafter referred to as digitizer inches) to the coordinates of the ticks. The transformation was calculated to minimize the root mean square (RMS) error between the estimated and actual coordinates. Once the transformation was calculated, it was used to map every coordinate pair sent from the digitizer, as it was received by the GIS software, to the coordinates of the map.

After the transformation was calculated, all drainage divides shown on the map and the map border were digitized as arcs [a line feature composed of two endpoints (nodes) and a variable number of sequentially connected intermediate points (vertices)]. The map border was digitized because this allowed the area of each subarea to be calculated. These areas were then compared with planimetered values from the historical drainage-area file for quality-assurance purposes. In any instances where the areas differed from the historical values by more than 0.01 mi^2 or 1.0 percent, the area in question was redigitized. If the discrepancy persisted, the digitized drainage divides were compared to those on the map, and, if they matched, the digitized area superseded the planimetered area. The locations of all gaging stations shown on the map also were digitized as labels (a point feature with an associated list of user-defined attributes). Statistics calculated for 1,607 subareas showed a median absolute-value error between digitized and historical values of 0.09 mi^2 (0.47 percent) and a maximum error of 2.60 mi^2 (22.17 percent).

When all quadrangle sheets for a drainage basin were digitized, the coverages for each map were joined together to form a coverage containing all the drainage divides and borders of each map. The resulting composite map was plotted, along with the label points marking the centroid of each subarea. All the arcs defining drainage divides were checked for continuity across map borders. Causes of discontinuity include missing or improperly delineated or digitized arcs and errors caused by the GIS software moving nodes in the process of joining adjacent maps. The cause of the errors was identified by comparing the historical area for the appropriate subareas with that calculated by the GIS. If these agreed, the original maps were checked for delineation errors. If delineation errors were identified, the divides were corrected and redigitized. If no delineation errors were identified, it was assumed that the divides were incorrectly digitized, and they were redigitized. The areas of the affected subareas were recalculated and compared to the historical values. In the case of discrepancies at this point, the new values were considered to be correct.

The GIS software adds a label located inside of each closed polygon. This label is used to identify the polygon and to index data pertaining to that polygon (area, perimeter, and other user-input data). The labels of each subarea contained in the basin were identified on the plot of the composite joined area. A closed polygon that enclosed all subarea labels included in the basin was drawn on this plot and digitized. This polygon enclosed all labels for subareas in the basin but excluded all labels that are not part of the basin. All labels within this polygon were set to the same identification number (1000), while all other labels were set to a different identification number (-999). A GIS command to eliminate all arcs separating polygons with the same identification number was used on the resulting coverage to eliminate all arcs except the basin border. In practice, this procedure always leaves a few unnecessary arcs that need to be manually identified and deleted. After all arcs except the basin boundary were eliminated, the coverage was checked to identify any nodes that needed to be joined to produce a closed drainage-basin border. Figure 5 illustrates the process of identifying a drainage-basin border from digitized drainage-area maps. Figure 6 shows the final drainage-basin border, as well as the GIS-defined boundary for this coverage.

After the border of the drainage basin was identified, the area of the drainage basin was calculated and compared with the historical value. Comparison of values for 67 drainage basins in Illinois gave a median absolute-value error of 0.07 mi^2 (0.29 percent) and a maximum error of 2.38 mi^2 (0.81 percent). As the area of each subarea on all quadrangle sheets forming a drainage basin had been checked, differences between new and historical drainage-area values reflect improvements in drainage-divide delineation from using better resolution maps and more accurate equipment. Therefore, the new value superseded the historical value for the drainage basins, both for this investigation and in the appropriate data files of the USGS's National Water Information System.

Soils

Soil association data for the State were digitized by the Illinois Department of Energy and Natural Resources from the General Soil Map of Illinois (1:500,000 base map) as published by Fehrenbacher and others (1984). Tabular data describing the typical slope range, the permeability and drainage classes, the surface and subsurface thicknesses, and the water available to 60 in. from the land surface were entered from the same reference to a file in the GIS data base. The Soil Conservation Service (SCS) soil-classification code for each soil, as given in the Illinois Engineering Field Manual (Harry Means, State Conservation Engineer, U.S. Department of Agriculture, Soil Conservation Service, written commun., 1985) was entered into the same file. Records in this file can be related to the digitized soil locations by the soil-association number. The drainage, the permeability, and the SCS classifications are given as alphabetic descriptions or codes. In order to allow averaging of these factors for all the soils in a soil association and for all

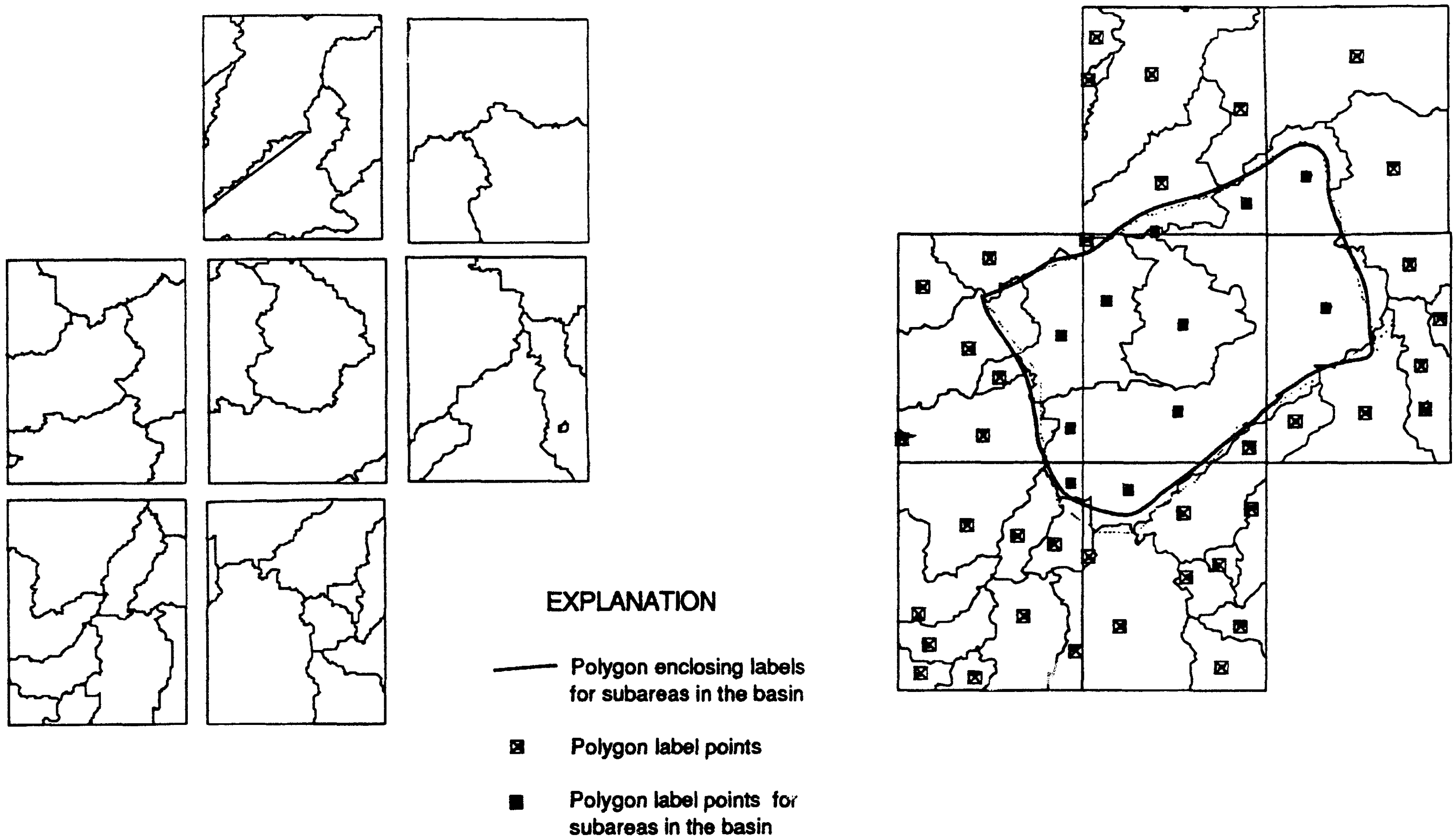


Figure 5.--Procedure to mosaic adjacent drainage-area maps and to describe a polygon that includes the labels for subareas included in the basin.

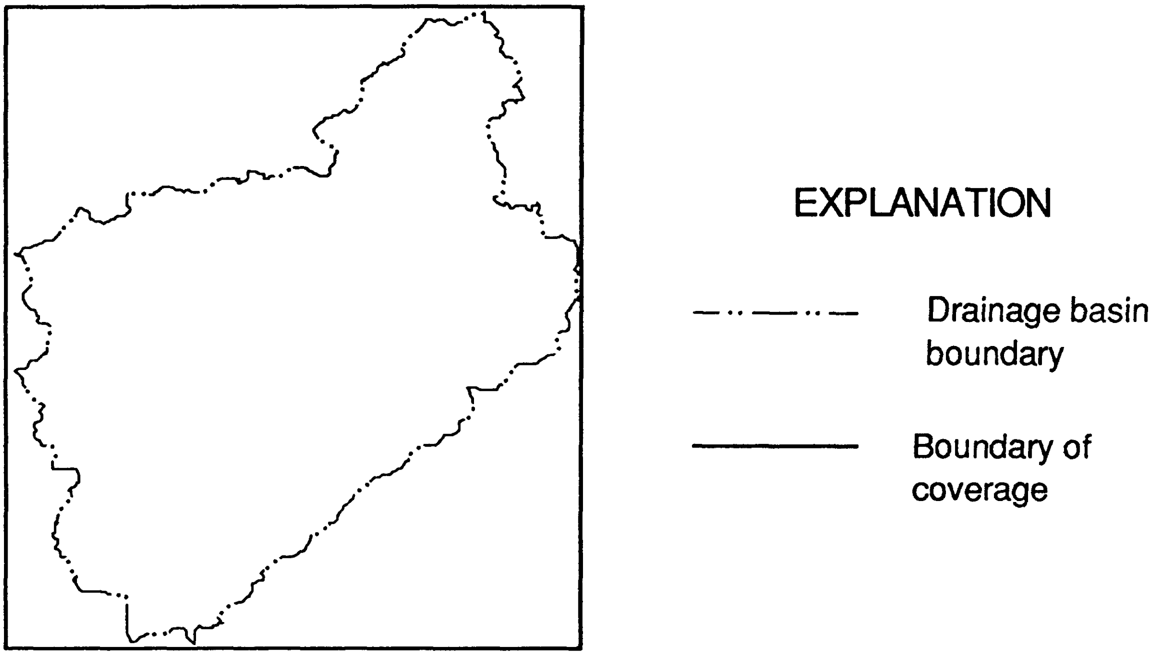


Figure 6.--Drainage-basin and coverage boundaries for station 05572450.

the soil associations in a drainage basin, each of these classifications were assigned a numeric value, which was stored in the file in the GIS data base. Table 1 shows the classifications for each of these properties and the corresponding numeric values.

The digitized soil-association areas provided resolution to a minimum area of 0.0015 mi^2 (43,000 ft^2). The digitized areas were for soil associations, which are groupings of several soil types that developed from similar parent materials and have similar surface color. These soil associations are described in greater detail by Fehrenbacher and others (1984). The tabular data are for individual soil types; thus, a soil association area on the map has 3 to 35 records in the tabular data file.

Land Use

Land-use data for Illinois were obtained from the USGS's 1:250,000 scale digital line graph (DLG) data base, as described by U.S Geological Survey (1986). These data provide resolution to a minimum area of 0.015 mi^2 (430,000 ft^2) and identification of 37 Level II land-use classifications. Two methods were developed to attempt to relate land use to infiltration for the purposes of this study. The first method used the percent impervious area for each land-use type as tabulated by the Denver Regional Council of Governments (1984). The second method involved parameterizing the runoff-curve number (U.S. Soil Conservation Service, 1986) to remove the effect of soil type. The SCS runoff-curve numbers were parameterized to give an "infiltration-index number" that gives an estimate of rainfall losses for land-use categories. The procedure

Table 1.--Drainage, permeability, and Soil Conservation Service soil classifications and corresponding numeric values

[Drainage and permeability classifications from Fehrenbacher and others (1984). Soil Conservation Service soil-classification numbers from U.S. Soil Conservation Service (1986)]

Classification	Numeric value
Drainage classification	
Very poor	1
Poor	2
Somewhat poor	3
Moderate	4
Moderately well	5
Well	6
Very well	7
Permeability classification	
Very slow	1
Slow	2
Somewhat slow	3
Moderate	4
Moderately rapid	5
Rapid	6
Very rapid	7
Soil Conservation Service soil classification	
A	1
B	2
C	3
D	4

followed to produce these infiltration-index numbers was to first subtract the runoff-curve number from 100. This was done because runoff-curve numbers range from 0 to 100, with larger numbers indicating a larger fraction of the rainfall contributing to runoff. This subtraction gave an "infiltration number" for each land-use type and each of the four soil classifications. Factor analyses of the resulting infiltration numbers identified one parameter, IPARAM, the infiltration-index number, that could replace the four infiltration numbers for the four soil classifications. This empirical parameter was calculated for each land use classification by

$$IPARAM = 0.251(INUMA) + 0.255(INUMB) + 0.255(INUMC) + 0.250(INUMD), \quad (2)$$

where

INUMA is the infiltration number for the land use for soil classification A,
INUMB is the infiltration number for the land use for soil classification B,
INUMC is the infiltration number for the land use for soil classification C, and
INUMD is the infiltration number for the land use for soil classification D.

The coefficients are empirically derived from the factor analysis.

This infiltration-index number explains 97.8 percent of the variance between the curves for the different soil classifications and, thus, provides an indication of the effect of land use on rainfall losses independent of soil type. Table 2 lists the SCS land-use classifications and the corresponding infiltration-index numbers.

The level II land-use classifications used in the DLG data are not the same as the land-use classifications used by the SCS to define the runoff-curve numbers; thus, the infiltration indices do not correspond to the land-use classifications in the GIS data base. Statistics from the SCS (1987) were used to estimate relations between the level II and the SCS land-use categories. Whenever available, the statewide percentages of different agricultural practices were used as weights to convert infiltration indices for the SCS land-use classifications to level II classifications. Where no statistics were available, relations between SCS and level II land-use classifications were selected based on judgment, and weights were estimated to convert the infiltration indices to the level II classifications. Table 3 lists the level II land-use classifications, the corresponding SCS categories, the percentages used to convert the infiltration-index numbers, the resulting index numbers, and the percentage of impervious area for that land use.

Antecedent-Precipitation Indices

An empirical index was calculated to estimate the antecedent-precipitation conditions for each National Oceanic and Atmospheric Administration (NOAA) daily-value recording rain gage in Illinois. The antecedent-precipitation index (API) for each station for each day was calculated from the equation given by Chow (1964)--

$$API_j = k\ (API_{j-1} + P_{j-1}), \quad (3)$$

where API_j is the antecedent-precipitation index for the jth day, in inches;
P_{j-1} is the precipitation on the (j-1)th day, in inches; and
k is the constant.

Subscripts indicate days since the beginning of the calculation.

Table 2.--Land-use classifications and the corresponding infiltration-index numbers

Land-use classification	Infiltration-index number	Land-use classification	Infiltration-index number
Residential, lot sizes of 2 acres	32.58	Pasture or range, no mechanical treatment, fair condition	30.06
Pavement and roofs--commercial and business areas	2.02	Pasture or range, no mechanical treatment, poor condition	19.70
Residential, lot sizes of 1 acre	29.81	Fallow, conservation tillage, good condition	16.42
Residential, lot sizes of 1/2 acre	28.04	Fallow, straight row	13.14
Residential, lot sizes of 1/4 acre	23.75	Close-seeded legumes or rotation meadow, straight row, good condition	26.27
Row houses, town houses, and residential with lot sizes of 1/8 acre or less	12.64	Close-seeded legumes or rotation meadow, straight row, poor condition	20.97
Lawns, parks, golf courses, cemeteries, and so forth	36.88	Small grain, conservation tillage, good condition	26.28
Roads, including rights-of-way, hard surface	15.15	Small grain, straight row, good condition	23.24
Roads, including rights-of-way, dirt	17.68	Small grain, straight row, poor condition	21.98
Farmsteads	25.01	Row crops, conservation tillage, good condition	23.75
Woods, good condition	43.70	Row crops, straight row, good condition	20.46
Woods, fair condition	38.40	Row crops, straight row, poor condition	17.18
Woods, poor condition	32.59		
Meadow, good condition	41.17		
Pasture or range, contoured, fair condition	39.90		
Pasture or range, no mechanical treatment, good condition	36.88		

Table 3.--Level II land-use classifications, relations to Soil Conservation Service land-use classifications, infiltration-index numbers, and percentages of impervious area for land-use classifications in this study

Level II land-use classification	Description	Soil Conservation Service land-use classification and percentage of area	Percentage of Level II area	Infiltration-index number	Percentage of impervious area
		Urban or built-up land			
11	Residential	1/4-acre residential	100	23.75	[1]38
12	Commercial and services	Commercial	100	2.02	[2]90
13	Industrial	Commercial	100	2.02	[2]78
14	Transportation, communication, and utilities	Roads	100	16.42	[3]51
15	Industrial and commercial complexes	Commercial	100	2.02	[2]78
16	Mixed urban or built-up land	1/8-acre residential Parks	50 50	24.76	[4]34
17	Other built-up land	1/8-acre residential Parks	50 50	24.76	[4]34
		Agricultural land			
21	Cropland and pasture	Row crops Grain Meadow Legume Fallow Pasture	79.2 8.5 2.8 2.8 .9 5.7	21.95	[5]2
22	Orchards, groves, vineyards, nurseries, and ornamental horticultural areas	Woods	100	38.23	[5]2
23	Confined feeding operations	Farmsteads	100	25.01	[5]45
24	Other agricultural alnd	Farmsteads	100	25.01	[5]45
		Rangeland			
31	Herbaceous rangeland	Pasture	100	30.6	[5]2
32	Shrub and brush rangeland	Pasture	100	30.6	[5]2
33	Mixed rangeland	Pasture	100	30.6	[5]2
		Forest land			
41	Deciduous forest land	Woods	100	38.23	[5]2
42	Evergreen forest land	Woods	100	38.23	[5]2
43	Mixed forest land	Woods	100	38.23	[5]2
		Wetland			
61	Forested wetlands	Woods	100	38.23	[5]2
62	Nonforested wetlands	Pasture (poor)	100	19.7	[5]2

[1]From U.S. Soil Conservation Service, 1986, table 2-2a.

[2]Mean of values from U.S. Soil Conservation Service, 1986, table 2-2a, and Denver Regional Council of Governments, 1984, table 3-1.

[3]Mean of values from Denver Regional Council of Governments, 1984, table 3-1 values for railroad yards, paved roads, and gravel roads.

[4]Mean of values from Denver Regional Council of Governments, 1984, table 3-1 values for parks, schools, and playgrounds, and 1/8-acre residential from U.S. Soil Conservation Service, 1986, table 2-2a.

[5]From Denver Regional Council of Governments, 1984, table 3-1 values for undeveloped areas.

The constant, k, was set to 0.90 for this investigation, which is within the range specified by Chow (1964). The beginning value for each calculation, API_0, was assumed to be 1.0. Error caused by improper specification of initial conditions is less than 0.2 percent after 60 days with k set to 0.90; thus, this error was assumed negligible over the period of record.

Monthly and annual means of the daily API values were determined for each station for the period of record at that station. In addition, the mean of the monthly and annual mean values over the entire period of record were calculated.

A GIS coverage of the locations of the 279 NOAA daily-value precipitation gages used in this analysis was created. These gages are shown in figures 7 and 8 and are listed in table 6 (at end of report). This coverage consisted of the station location, the NOAA station-identification number, and the station name. Along with this coverage, tabular files were created in the GIS for each year from 1901 through 1983, as well as one file for the mean of the entire period of record. These files contained one record for each station, with each record containing the station-identification number, mean API values for each month of that year or the period of record, and the mean of the daily API for the year or the entire period of record. The station-identification number was used to relate the tabular data to the spatial location. This scheme allowed the GIS to provide both temporal and spatial data describing the API in Illinois.

Model Parameters

Optimized HEC-1 parameters for all the storms simulated for each drainage basin and calibrated parameters for each drainage basin were stored in data files external to the GIS, as well as in tabular files in the GIS. Each record of these files contained the station-identification number, the storm date, the recurrence interval of the resulting measured peak discharge, and the optimized or calibrated model parameters. A GIS coverage of the locations of the 98 USGS stream gages used in this investigation was created. This coverage consisted of the station location, the USGS's station-identification number, and the station name. The tabular files described above, along with this coverage, allowed the GIS to describe the spatial variation of model parameters and the variation of parameters between storms.

DATA-BASE ORGANIZATION

Organization of the GIS data base determines the accessibility of the data for later analysis. The data base for this investigation consisted of spatial data organized by source map sheets, spatial data organized by drainage basins, and time-varying data referenced to gaging station (stream and precipitation) locations. Data-base organization was complicated in that individual drainage basins typically require data from several map sheets, but no basin required all data shown on any map sheet. The following sections describe how the GIS data base was organized to simplify the process of identifying, extracting, and combining data from different sources and scales for a drainage basin and to simplify the process of mapping time-varying data from a region to a drainage basin in that region.

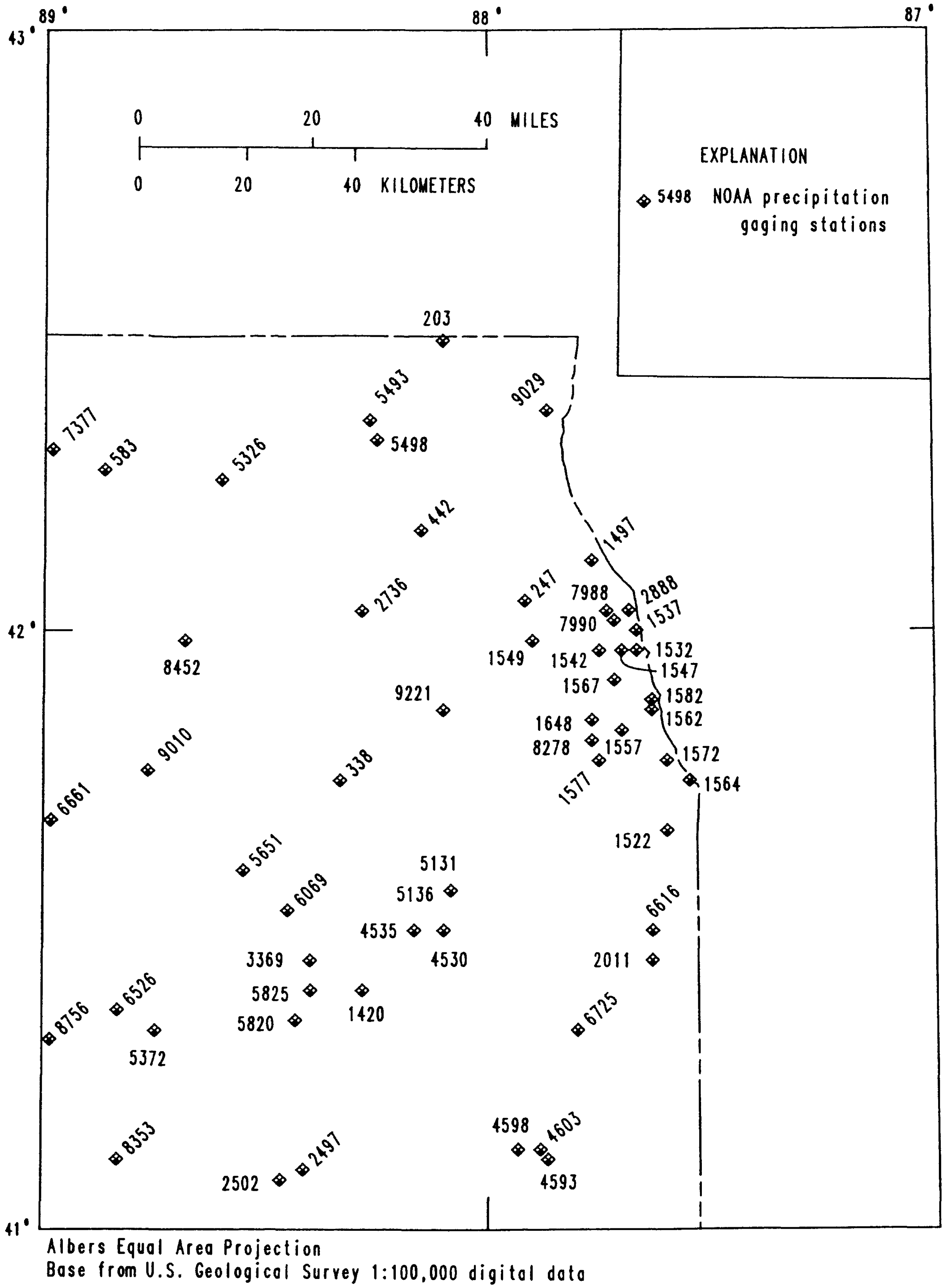
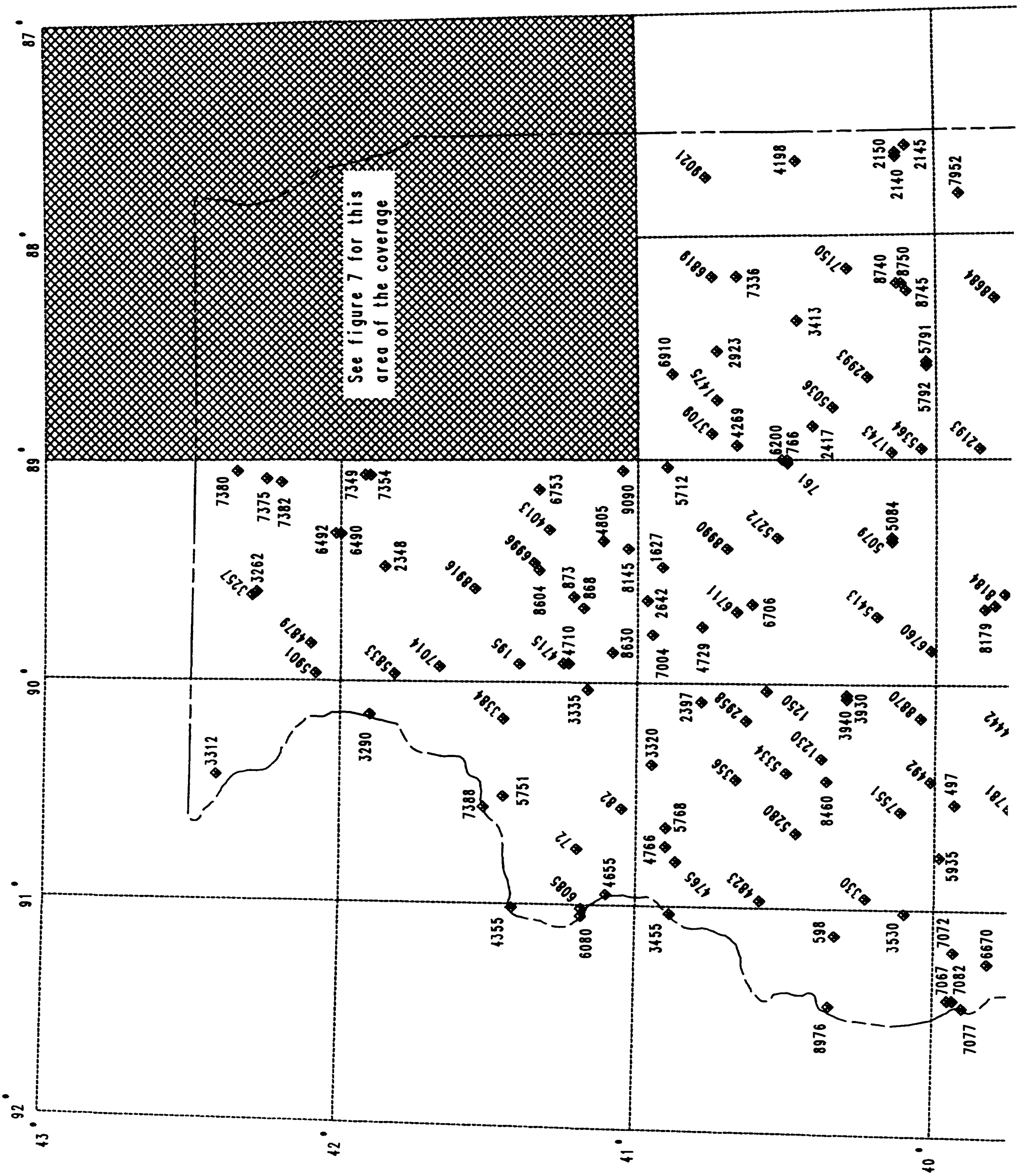


Figure 7.--Location of the National Oceanic and Atmospheric Administration precipication gaging stations in northeastern Illinois.



See figure 7 for this area of the coverage
87°
88°
89°
90°
91°
92°
43°
42°
41°
40°
9021
4198
2150
2140
2145
7952
6819
7336
7150
8740
8750
8745
8684
3413
6910
2923
2993
5791
5792
1475
5036
3709
4269
6200
766
2417
1743
5364
2193
761
7380
7375
7382
7349
7354
6753
9090
5712
4013
4805
6492
6490
2348
3262
3257
6996
8916
8604
873
868
8145
1627
8990
5272
5079
5084
2642
6711
6706
5413
8184
8179
4879
5901
5833
7014
195
4715
4710
8630
7004
4729
6760
3384
3335
2397
2958
1250
3940
3930
8870
4442
3312
3290
3320
5334
1230
356
492
497
781
7388
5751
82
5768
5280
8460
7551
72
4766
4765
4823
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7077
8976

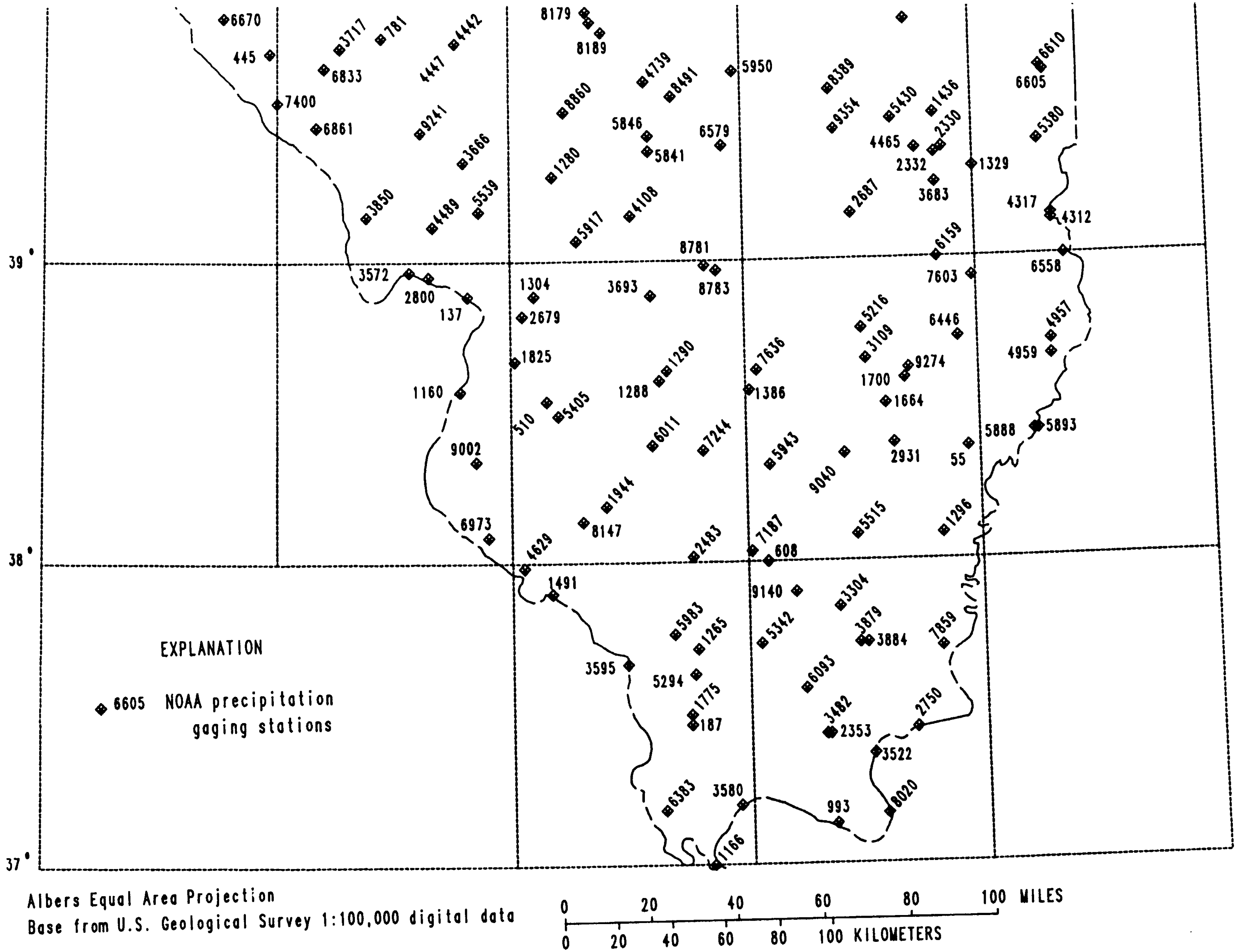

Figure 8.--Location of the National Oceanic and Atmospheric Administration precipitation gaging stations included in the data base.

Data Organized by Source Map Sheet

All coverages used in this investigation are originally organized based on the map sheets of the source data. Table 4 lists the coverages, sizes of the source maps, number of source maps, and the naming convention used for the source data base for this investigation. These data will hereafter be referred to as the statewide data base, although data from outside Illinois are included, and some maps within Illinois have yet to be added to the data base.

Table 4.--Coverages, map scales, number of source maps, and naming conventions used for the data base

[Drainage area included 1,070 maps, soil associations included 1 map, and land use included 18 maps]

Coverage	Map scale	Naming convention	Basis for naming convention
Drainage area	1:24,000	#####.CC[1]	Zone and code
Soil associations	1:500,000	SOILASSOC	- -
Land use	1:250,000	AURLU	Aurora, Ill. quadrangle
Land use	1:250,000	BELLU	Belleville, Ill. quadrangle
Land use	1:250,000	BURLU	Burlington, Ia. quadrangle
Land use	1:250,000	CHGLU	Chicago, Ill. quadrangle
Land use	1:250,000	DANLU	Danville, Ill. quadrangle
Land use	1:250,000	DAVLU	Davenport, Ia. quadrangle
Land use	1:250,000	DECLU	Decatur, Ill. quadrangle
Land use	1:250,000	DUBLU	Dubuque, Ia. quadrangle
Land use	1:250,000	FTWLU	Fort Wayne, Ind. quadrangle
Land use	1:250,000	INDLU	Indianapolis, Ind. quadrangle
Land use	1:250,000	MADLU	Madison, Wis. quadrangle
Land use	1:250,000	PADLU	Paducah, Ky. quadrangle
Land use	1:250,000	PERLU	Peoria, Ill. quadrangle
Land use	1:250,000	QCYLU	Quincy, Ill. quadrangle
Land use	1:250,000	RACLU	Racine, Wis. quadrangle
Land use	1:250,000	ROCLU	Rockford, Ill. quadrangle
Land use	1:250,000	STLLU	St. Louis, Mo. quadrangle
Land use	1:250,000	VINLU	Vincennes, Ind. quadrangle

[1]##### refers to the five-digit zone number, and CC refers to the two character alpha-numeric code that combine to give the location of the south-eastern corner of the quadrangle. These zones and codes are described in the text and in U.S. Geological Survey (1987).

Data Organized by Drainage Basin

Drainage-basin borders (drainage divides) were compiled, as described earlier, by assembling drainage divides from adjacent map sheets and then eliminating all divides except the drainage-basin border. Once the drainage-basin border was identified, data describing land use, soil associations, and API within the drainage basin were extracted from the statewide data base to produce coverages showing these features within each drainage basin. Details of the process used to produce these coverages for a drainage basin will be given in subsequent sections.

The coverages produced for each drainage basin were stored in a computer directory for that drainage basin identified by the station number of the stream gage at the downstream end of the drainage basin. This organization allows access to all features for a drainage basin, using only the station number as an identifier and not requiring extraction and compilation of data from map files.

Time-varying data referenced to each basin were stored as separate coverages for each period in the analysis. This requires more storage space than one coverage of locations related to tabular data for each period. However, maintaining separate coverages simplifies access to the data for later analysis.

A computer directory of sequential-access, fixed format, ASCII files was maintained outside the GIS. These files all contained the gaging-station number to index each record. Files in this directory list the calibrated model parameters for each drainage basin and the optimized model parameters for each storm at each drainage basin. These files were accessed by Fortran programs, which read the station number and storm date, and then extracted the appropriate drainage-basin data from the GIS data base.

APPLICATION OF DATA BASE

Application of the GIS data base described in this report to investigate rainfall/runoff-model parameters involves locating the required features in the statewide data base and limiting them to the spatial extent of the basin being studied. It also involves identifying the appropriate time-varying data, producing a coverage for the correct period, and limiting this to the spatial extent of the basin. Once coverages are produced for individual drainage basins, data for each feature are averaged to give a mean value for each feature for the entire drainage basin. The following sections describe the steps taken to identify the spatial and temporal limits for data to be analyzed, to produce coverages for these data for each storm and drainage basin, and to compile these coverages to produce a data set of all storms, basins, and features for further analysis.

Identification of Data

The first step to apply the GIS data base to investigate rainfall/runoff-model parameters is to identify the data from the statewide data base that apply to the conditions being studied. This includes limiting the physical scope of the data to the drainage basin in question and the temporal scope of the data to the period of the storm event. The procedures used for different features are described below.

Data describing HEC-1 parameters were stored in an ASCII file with one record for each storm at 98 stations. This file contained the station number, the year and month of the storm, and the calibrated model parameters used to simulate the storm event. These were sorted by the (USGS) station-identification number of the stream gage used to calibrate the model, and further sorted by the year and month of the storm event. This file was read sequentially. Each time a new station was read, the procedures described in the following sections were initiated to identify the appropriate basin-characteristics data. Each time a new storm date was read, the procedures described in the following sections were initiated to identify the appropriate storm-specific data. Once the data were identified, these procedures produced the necessary coverages for further analysis.

Land Use

Land-use data are stored in sections spanning 1 degree of latitude and 2 degrees of longitude. Land-use data for each basin were identified by the overlap of the boundary of the drainage-area coverage with the boundaries of the sections of the land-use coverage. The boundary is a rectangular region, aligned with the axes of the coordinate system, that completely encloses all features of the coverage. The boundary is automatically calculated by the GIS and is stored as part of each coverage (see fig. 6). Depending on its size and location, a drainage basin will include data from one or more land-use sections. The land-use maps are identified by comparing the boundary of the drainage-basin coverage with the boundaries of the land-use sections. A land-use section includes data for the drainage basin if its minimum coordinate is less than the maximum of the drainage-basin boundary, and its maximum coordinate is greater than the minimum of the drainage-basin boundary, in both the north-south and east-west directions. An automated procedure to identify the correct land-use sections was developed. This procedure made the comparison of boundaries described above and also plotted the State outline, the location of the basin in the State, and the boundaries of the land-use sections for visual identification of the appropriate sections. The procedure then highlighted the appropriate land-use sections, displayed their names, and initiated another procedure that created land-use coverages limited to the interior of the drainage basin. Figure 9 shows an example of the display of this procedure, illustrating how land-use data were identified.

Soils

The soil association data were stored as a single coverage for the entire State. Because all the drainage basins used in this study were located entirely within Illinois, no step was needed to identify the spatial extent of the basin prior to producing the coverage of soil associations for the drainage basin. Therefore, there was no "data identification" step needed for the soil-association data.

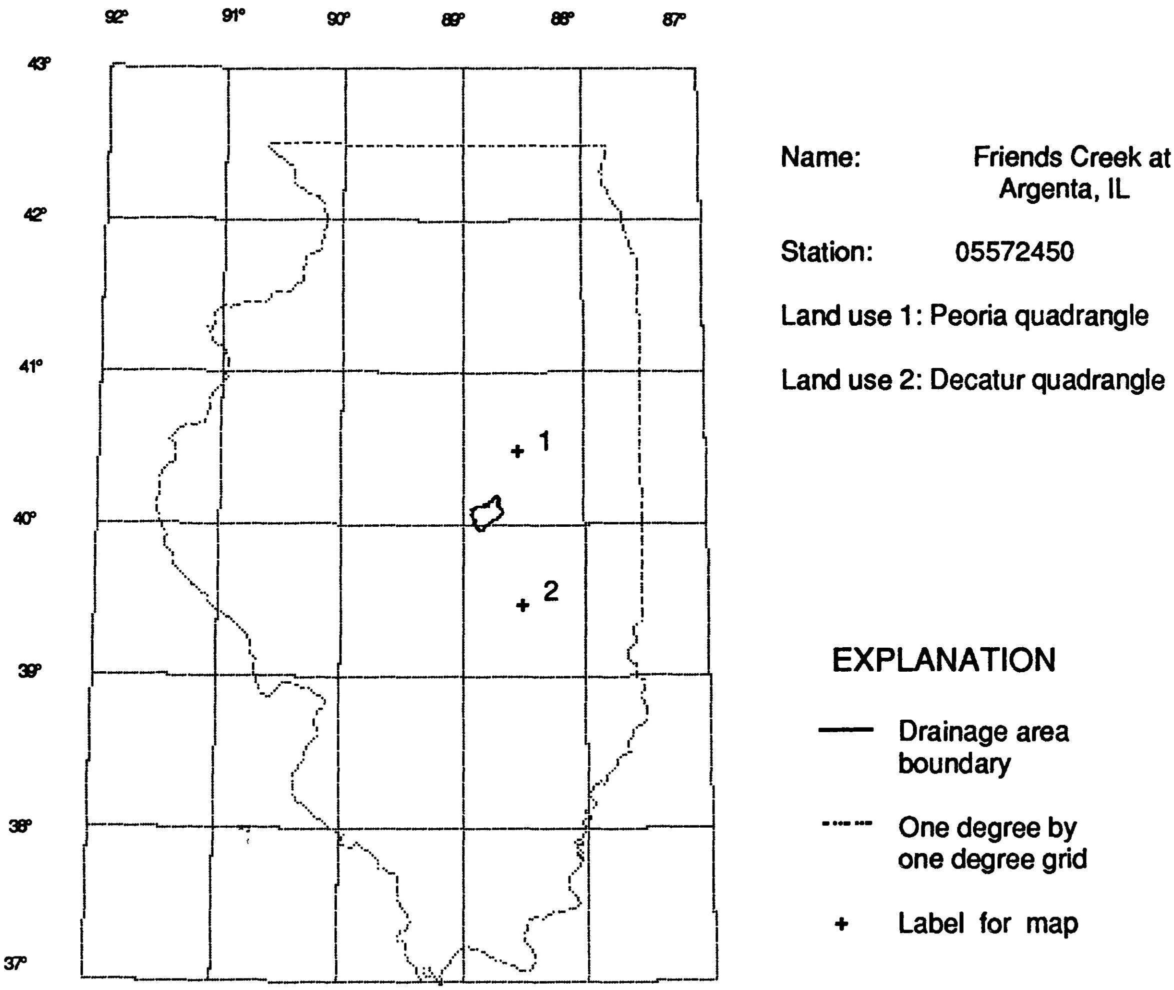

Figure 9.--Procedure used to identify land-use maps for the drainage basin for station 05572450.

Antecedent-Precipitation Index

The API varies spatially and temporally. Identification of API data was done by first identifying the appropriate period and then identifying the appropriate spatial extent. The year of the storm was used to identify the appropriate data file, and the month of the storm was used to identify the appropriate field in that data file. Monthly mean API data were combined with a GIS coverage describing the location of each precipitation gage to produce a statewide coverage of the monthly mean API for the storm. These coverages were defined using a three-dimensional surface model in the GIS in which the vertical coordinate is the API value. These surfaces were further processed, as described below, to produce coverages of the mean API in each drainage basin with a storm during the month described by a coverage.

Production of Analysis Coverages

Once the GIS coverages needed to describe a drainage basin were identified, they were processed to produce coverages limited to the border of the drainage basin. First, a procedure in the GIS software (clipping) was used to limit data to within the border of the drainage basin. This procedure overlays two coverages to produce a new coverage containing all features of the first coverage that fall within the exterior border of the second (clip) coverage. This new coverage has the same border as the clip coverage. In cases, where more than one land use section was needed for a drainage basin, the separate sections were first clipped to the interior of the drainage basin and then the separate sections were joined and edited to produce a single coverage of the feature for the drainage basin. The following paragraphs describe the steps taken to produce a single coverage that describes each feature and is limited to the drainage-basin boundary.

Land Use

After the sections of the land-use coverage needed for a drainage basin were identified, they were clipped to the border of the drainage basin. For drainage basins with data from more than one land-use section, the new coverages were joined together and edited to remove the arcs showing the border of the land-use sections. When features from the different land-use sections did not align at the border, the GIS data were compared to the original, published maps to determine which feature to correct. Figure 10 illustrates the steps in producing a land-use coverage for a drainage basin and shows an example of a completed land-use coverage for a drainage basin.

Soils

The statewide soil-associations coverage was clipped to eliminate all arcs outside the drainage-basin boundary, using the procedure described above, to produce a map of the soil associations within the drainage basin. An example of a completed soil-associations map for a drainage basin is shown in figure 11.

Antecedent-Precipitation Index

Monthly mean API values for the month of the storm event at each precipitation gage were used to produce a three-dimensional surface model of the monthly mean API over the entire State. This three-dimensional surface model consisted of a network of connected triangular elements. These elements were constructed with a rain gage at each vertex of a triangle, with the monthly mean API at that gage giving the "elevation" of that vertex. With this definition, each triangle describes a plane in space. This allows the API of any point on the plane to be calculated. The network of triangular elements defines the mean API at any location for the given month.

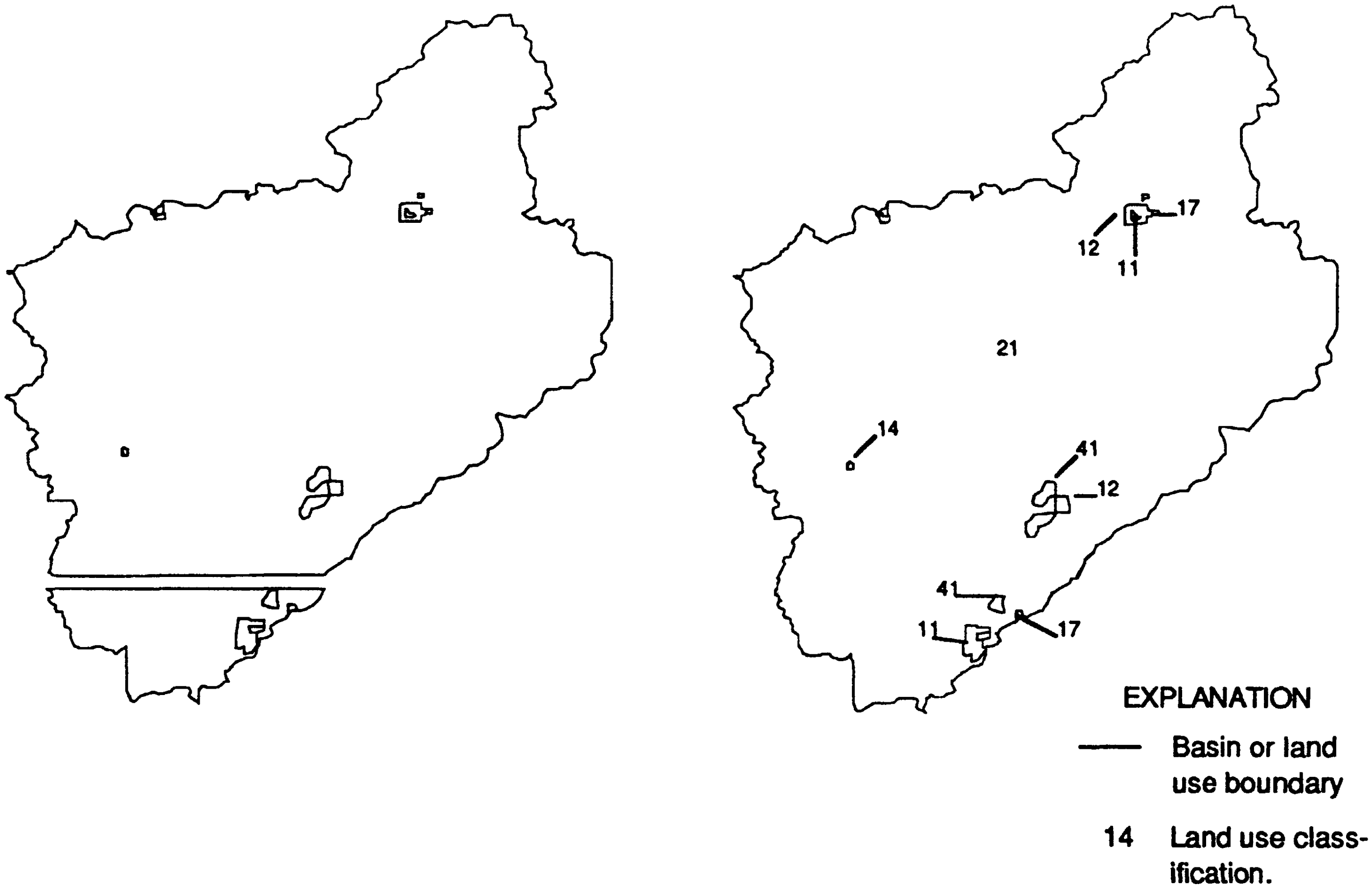

Figure 10.--Steps used to produce a land-use coverage for the drainage basin for station 05572450.

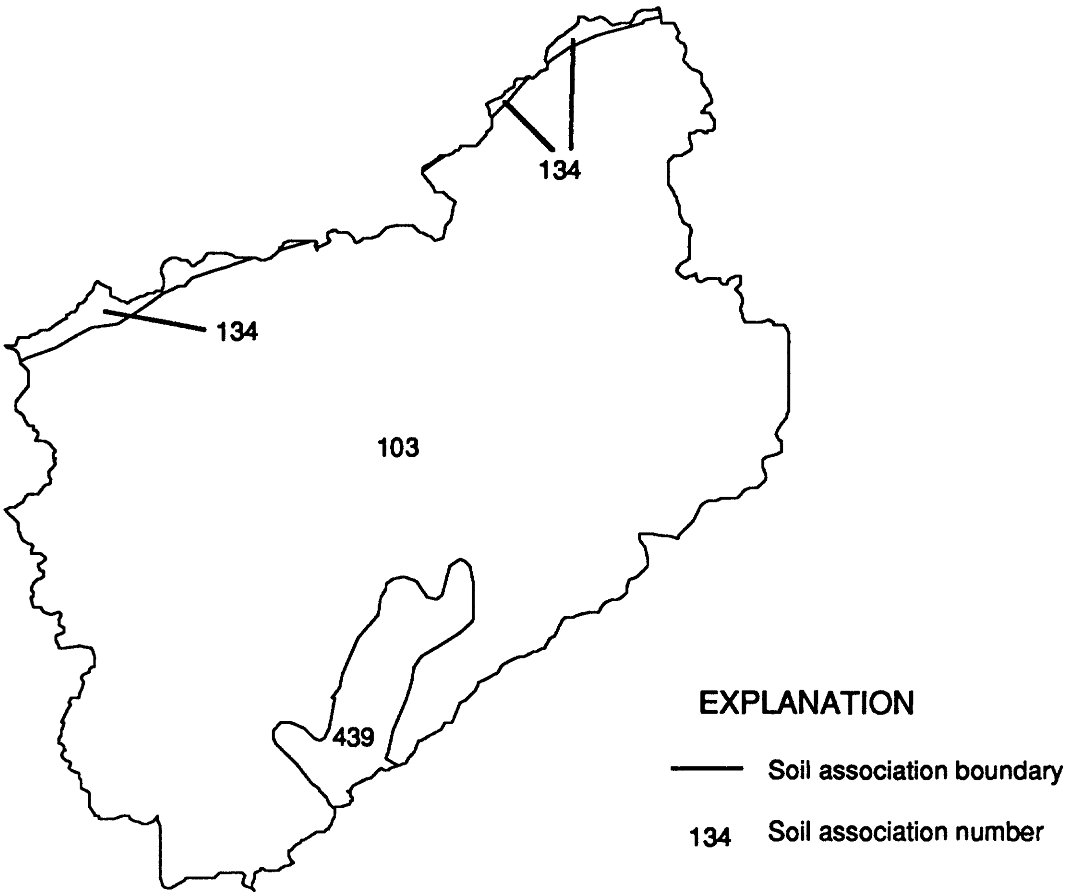

Figure 11.--Soil associations for the drainage basin for station 05572450.

A coverage consisting of a grid of points was produced to estimate the mean API over the drainage basin by a two-dimensional numeric integration. The grid of points was produced by calculating the dimension of the boundary rectangle along both coordinate axes, increasing this by 10 percent in both directions, and determining the grid spacing. The grid spacing was equidistant in both directions, provided at least 100 and not more than 500 points, and provided at least 5 points along the shorter side of the rectangle. The clipping procedure described earlier was then used with this grid of points to produce a grid of equally spaced points within the drainage basin (fig. 12). A command from the GIS system determined the API value for each point in this grid by interpolating from the three-dimensional API coverage described earlier. Because the grid is equally spaced, the mean of the API values at all the grid points gives the area-weighted-mean API for the drainage basin.

Application of Data Base

Data describing the features included in the coverages for each drainage basin were averaged to give an area-weighted-mean value for the drainage basin and compiled, along with mean values for model parameter values, to produce a

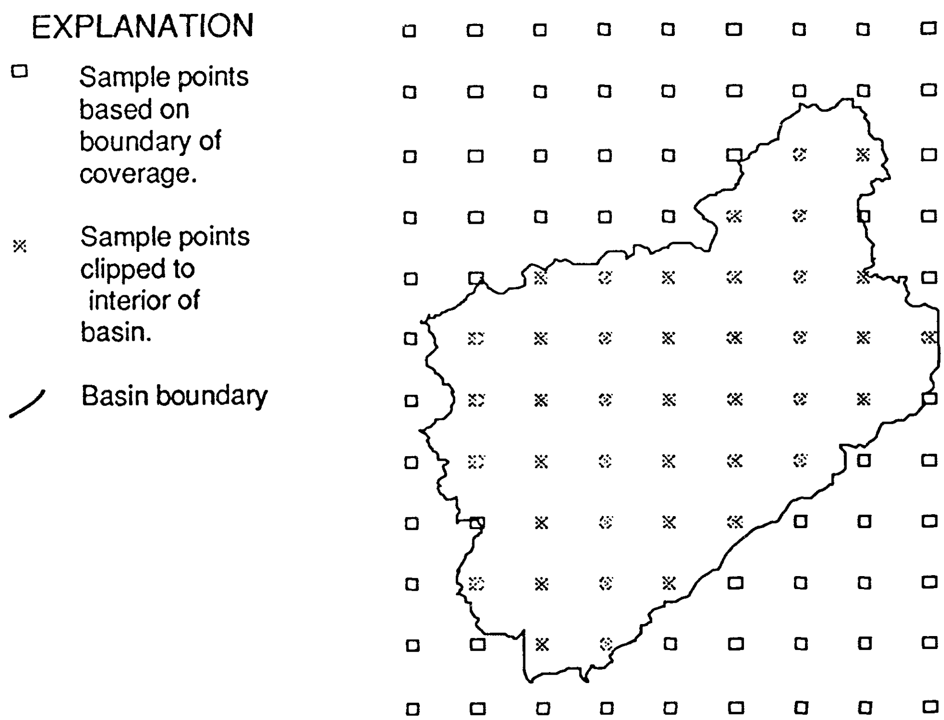

Figure 12.--Points used to calculate the average antecedent precipitation index for the basin for station 05572450.

data set for later analysis. For the purpose of this investigation, this data set was used for statistical analyses of the relations between model parameters and physical basin characteristics. The same data set also could be used as input for parameter-estimation techniques, input to a computer model, and other applications. The following sections describe the steps used to calculate the area-weighted-mean value for each feature and write this to a file for later analysis.

The same general procedure was applied to all of the drainage-basin parameters considered in this investigation. The identification code (soil-association number or land-use classification) for each polygon within the drainage basin was used to determine values describing physical characteristics of that polygon from data stored in the data base. These values were weighted by the area of the polygon to calculate the area-weighted-mean value for the entire drainage basin for that characteristic. For each land-use polygon in a drainage basin the infiltration indices given in table 6 were weighted by the area of the polygon and averaged to give an area-weighted-mean for the basin. For each soil-association polygon in the drainage basin, the values for each property for all soils in that association were averaged. The mean values for the association were weighted by the area of the polygon to calculate an area-weighted-mean value for each soil-association property for the drainage basin.

The area-weighted values were stored as part of the GIS data base for that drainage basin. The GIS command to produce an ASCII file for export to other GIS systems was used with each feature from the drainage basin (land use, soil association, and API) to produce a file that could be read by a Fortran program. The data for all the features were combined into a file containing all the model parameters for each storm, the API for the month of each storm at the drainage basin, and the area-weighted-mean values for soil associations and land-use characteristics for the drainage basin. A sample listing of a few records from this file are shown in table 5 (at end of report).

SUMMARY

A GIS data base was produced to use in an analysis of basin and climatic factors affecting rainfall/runoff-model parameters. This data base consisted of drainage-basin boundaries, land use, soil association, and antecedent-precipitation-index data for Illinois, and calibrated HEC-1 model parameters for 98 drainage basins in Illinois. The drainage-basin boundaries were digitized from existing maps to produce coverages of all the drainage-basin boundaries in the State. Procedures were developed to extract the boundaries for a selected drainage basin from these coverages. Daily antecedent-precipitation-index values were calculated for the period of record for 279 recording precipitation gages. These were averaged to give monthly and annual mean values, which were stored in the data base. Runoff-curve numbers from the Soil Conservation Service were parameterized to develop an infiltration-index number for each land-use classification. These were modified to correspond to the land-use classifications used in the GIS data base.

The GIS was used to identify coverages that included all or part of a drainage basin. These coverages were then clipped to include only those features within the border of the basin. If necessary, the GIS was used to join adjacent clipped coverages to form one complete coverage for the basin. The GIS also was used to select the antecedent-precipitation-index data for the appropriate month for each modeled storm; to produce a statewide, three-dimensional surface of these data; and to clip this surface to the drainage-basin border. Once coverages were developed for the characteristics of each basin, the GIS was used to calculate the area-weighted averages for parameters describing these basin characteristics. These were output, along with the model parameters for the basin, to a file suitable for further processing by other programs.

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page 35 follows

TABLES 5 and 6

Table 5.--Example records from file of basin

[in/h, inches per hour; in., inches; h, hours, SCS, Soil Conservation
functions are from Graf and others (1982a), Weiss and Ishii (1987),
are described by U.S. Army Corps of Engineers (1981). Soils data
Schmidt and Romack (this report). Land-use data are from

Storm date	Model parameters--exponential loss-rate function						Model parameters--linear loss-rate function			
	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)	TC (h)	R (h)
							03382510 Eagle Creek			
05/11/68	0.44	15.70	0.19	2.3	4.05	2.33	1.56	0.04	7.44	1.42
03/24/69	.47	8.50	.09	.84	8.81	3.23	.44	.02	6.47	3.52
03/11/73	.33	4.16	.11	.59	9.09	1.15	.18	.04	5.48	5.74
05/27/73	.33	3.07	.47	.86	6.80	4.38	1.82	.09	6.33	2.84
03/12/75	.10	1.50	.00	.00	9.89	2.16	.00	.00	5.35	7.56
07/03/76	.52	4.24	.34	1.01	10.65	1.95	1.23	.12	11.88	.58
03/14/78	1.23	2.25	.00	.00	5.27	7.17	.00	.00	5.36	6.95
							03384450 Lusk Creek			
04/09/69	1.55	10.13	.00	.00	134.46	15.37	.42	.03	7.99	6.40
06/23/69	.76	1.78	.57	.75	2.60	2.05	.41	.17	2.06	2.60
05/10/70	.42	1.73	.32	.44	2.64	6.88	.70	.07	2.76	5.41
06/13/73	.49	1.00	.22	.43	2.06	4.47	.11	.04	2.18	1.94
08/09/74	.48	1.20	.43	1.39	9.26	3.94	1.24	.11	8.01	2.85
07/03/76	.51	2.44	.42	1.10	7.00	3.50	1.02	.04	6.40	2.76
							03385000 Hayes Creek			
05/18/66	.24	2.00	.11	.32	9.33	8.00	.41	.04	9.20	7.78
05/24/66	.52	14.56	.15	1.54	12.92	5.90	1.14	.02	8.91	10.43
05/10/70	1.07	4.50	.00	.00	7.78	5.57	.97	.00	6.61	5.53
04/15/72	.78	4.57	.29	1.34	5.72	4.06	2.19	.11	3.96	4.89
03/11/73	.13	7.24	.04	.78	11.39	3.79	.58	.02	8.98	6.52
08/29/74	.37	10.36	.11	1.74	16.2	6.55	1.23	.07	12.02	10.22
							03386500 Sugar Creek			
03/18/52	.50	1.77	.25	.62	1.25	2.02	.48	.10	1.05	1.82
04/06/54	.42	1.00	.25	.05	1.03	1.97	.02	.14	1.03	2.14
04/21/55	.55	4.40	.30	.73	4.47	2.42	.51	.06	1.04	3.52
04/03/56	.67	1.00	.48	.18	1.03	1.07	.77	.07	1.03	1.81
07/22/58	1.00	1.00	.17	.03	1.03	2.00	.17	.10	1.03	1.81
04/12/61	.49	2.24	.16	.40	1.51	1.68	.33	.07	1.06	1.75
03/25/63	.57	1.62	.49	1.27	1.69	2.34	.82	.08	1.15	2.64

characteristics and runoff-model parameters

Service; mi^2, square miles. Model-parameter values using both loss-rate and unpublished defined work by the same investigators. These parameters are from Fehrenbacher and others (1984) and averaged as described by U.S. Geological Survey 1:250,000 digital line graphs]

Slope percent	SCS number	Permea-bility	Drainage	Surface thick-ness (in.)	Sub-surface thick-ness (in.)	Water to 60 in. (in.)	Area (mi^2)	Infil-tration index	Ante-cedent-precipi-tation index
near Equality, Ill.									
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	102
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	75.1
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	142
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	231
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	231
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	205
6.00	2.72	3.50	5.48	9.18	29.31	7.78	8.07	35.30	141
near Eddyville, Ill.									
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	152
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	212
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	257
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	185
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	217
6.42	2.80	3.53	5.55	9.00	27.90	7.47	42.9	34.14	197
at Glendale, Ill.									
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	293
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	293
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	289
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	290
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	106
6.42	2.80	3.53	5.55	9.00	27.90	7.47	19.1	30.63	230
near Dixon Springs, Ill.									
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	223
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	101
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29:35	164
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	143
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	337
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	176
6.42	2.80	3.53	5.55	9.00	27.90	7.47	9.81	29.35	225

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois

[Information from David Calloway, National Climatic Data Center, Information Services Division, Asheville, North Carolina, written commun., 1984; station number refers to figure 7; period of record refers to partial or complete calendar years during which the station was operated; latitude and longitude are shown as degrees and decimal portions thereof; elevation is in feet above sea level; dashes indicate no data]

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
55	ALBION	1948-83	38.3667	88.0500	450
72	ALEDO	1901-83	41.2000	90.7500	740
82	ALEXIS WATERWORKS	1948-51	41.0500	90.5667	690
137	ALTON DAM 26	1948-83	38.8833	90.1833	430
187	ANNA 1 NW	1901-83	37.4667	89.2500	640
195	ANNAWAN	1948-60	41.4000	89.9167	620
203	ANTIOCH	1948-83	42.4833	88.1000	770
247	DES PLAINES 1 NW	1951-62	42.0500	87.9167	700
330	AUGUSTA HIGH SCHOOL	1948-51	40.2333	90.9500	680
338	AURORA COLLEGE	1901-83	41.7500	88.3333	740
356	AVON	1901-50	40.6667	90.4333	640
442	BARRINGTON 1 NW	1962-83	42.1667	88.1500	810
445	BARRY	1948-76	39.7000	91.0333	740
492	BEARDSTOWN	1948-83	40.0167	90.4333	440
497	BEARDSTOWN LAGRANGE DAM	1948-51	39.9333	90.5333	430
510	BELLEVILLE SCOTT AF BSE	1948-83	38.5333	89.8500	450
583	BELVIDERE SEWAGE PLANT	1948-51	42.2667	88.8667	750
598	BENTLEY	1948-83	40.3333	91.1167	670
608	BENTON	1948-83	38.0000	88.9167	450
761	BLOOMINGTON WATERWORKS	1949-83	40.5000	89.0167	780
766	BLOOMINGTON NORMAL	1901-77	40.5000	89.0000	810
781	BLUFFS	1948-83	39.7500	90.5500	470
868	BRADFORD 1 W	1980-83	41.1833	89.6667	790
873	BRADFORD CAA AP	1948-59	41.2167	89.6167	800
993	BROOKPORT DAM 52	1948-83	37.1333	88.6500	340
1160	CAHOKIA	1969-83	38.5667	90.2167	400
1166	CAIRO WB CITY	1948-83	37.0000	89.1667	310
1230	CAMP ELLIS	1948-50	40.3833	90.3333	640
1250	CANTON	1948-83	40.5667	90.0333	660
1265	CARBONDALE AIRPORT	1910-83	37.7167	89.2167	420

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
1280	CARLINVILLE 4 E	1901-83	39.2833	89.8167	630
1288	CARLYLE	1948-64	38.6000	89.3667	460
1290	CARLYLE RESERVOIR	1962-83	38.6333	89.3333	500
1296	CARMI	1948-83	38.0833	88.1667	400
1304	CARPENTER 1 SW	1948-51	38.8833	89.9000	520
1329	CASEY	1948-53	39.3000	88.0000	650
1386	CENTRALIA 8 E	1948-83	38.5667	88.9833	550
1420	CHANNAHON DRESDEN ISL	1948-83	41.4000	88.2833	510
1436	CHARLESTON	1901-83	39.4833	88.1667	690
1475	CHENOA	1948-83	40.7333	88.7333	710
1491	CHESTER	1948-83	37.9000	89.8333	380
1497	CHICAGO BOTANICAL GRDN	1981-83	42.1167	87.7667	630
1522	CHICAGO CAL TREAT WKS	1948-59	41.6667	87.6000	590
1532	CHICAGO LAKEVIEW PUMP	1948-51	41.9667	87.6667	650
1537	CHICAGO LOYOLA UNIV	1948-51	42.0000	87.6667	590
1542	CHICAGO MAYFAIR PUMP ST	1948-51	41.9667	87.7500	650
1547	CHICAGO N BRA PUMP STN	1948-51	41.9667	87.7000	600
1549	CHICAGO O HARE AIRPORT	1958-83	41.9833	87.9000	660
1557	CHICAGO SAN DIST DISPAT	1948-53	41.8333	87.7000	600
1562	CHICAGO SAN DIST OFF	1948-51	41.8667	87.6333	900
1564	CHICAGO S FILTER PL	1948-51	41.7500	87.5500	610
1567	CHICAGO SPRINGFLD PUMP	1948-51	41.9167	87.7167	630
1572	CHICAGO UNIVERSITY	1948-83	41.7833	87.6000	590
1577	CHICAGO WB AIRPORT	1928-83	41.7833	87.7500	630
1582	CHICAGO WB CITY	1948-70	41.8833	87.6333	590
1627	CHILLICOTHE	1948-83	40.9167	89.4833	460
1648	CICERO	1948-59	41.8500	87.7667	610
1664	CISNE BROWN CAMP	1946-51	38.5167	88.4000	460
1700	WILCOXITY 6 SSE	1977-83	38.6000	88.3167	460
1743	CLINTON	1948-83	40.1500	88.9667	750
1775	COBDEN 2 S	1951-76	37.5000	89.2500	620
1825	COLLINSVILLE	1948-51	38.6667	89.9833	500
1944	COULTERVILLE	1948-82	38.1833	89.6000	590
2011	CRETE	1948-51	41.4500	87.6333	680
2140	DANVILLE	1901-83	40.1333	87.6333	600

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
2145	DANVILLE SEWAGE PLANT	1948-83	40.1000	87.6000	530
2150	DANVILLE WATERWORKS	1948-83	40.1333	87.6500	560
2166	DAVENPORT IOWA L D 15	1953-54	41.5167	90.5667	570
2193	DECATUR	1901-83	39.8500	88.9500	680
2330	DIONA	1948-50	39.3667	88.1333	660
2332	DIONA 3 SW	1977-83	39.3500	88.1667	530
2348	DIXON	1901-83	41.8500	89.4833	700
2353	DIXON SPRINGS AGR CNTR	1967-83	37.4333	88.6667	540
2397	DOUGLAS	1948-51	40.7833	90.0833	650
2417	DOWNS 2 NE	1948-51	40.4167	88.8500	790
2483	DU QUOIN	1901-83	38.0167	89.2333	460
2497	DWIGHT	1948-50	41.1000	88.4167	640
2502	DWIGHT STATE REFORM	1948-51	41.0833	88.4667	640
2642	LAWN RIDGE	1950-51	40.9667	89.6333	830
2679	EDWARDSVILLE	1948-83	38.8167	89.9500	530
2687	EFFINGHAM CAA AP	1901-83	39.1500	88.5333	610
2736	ELGIN	1948-83	42.0333	88.2833	820
2750	ELIZABETHTOWN	1948-83	37.4500	88.3000	360
2800	ELSAH PRINCIPIA COLLEGE	1948-60	38.9500	90.3500	630
2888	EVANSTON PUMP STN	1948-51	42.0333	87.6833	620
2923	FAIRBURY WATERWORKS	1948-83	40.7333	88.5167	690
2931	FAIRFIELD	1890-83	38.3833	88.3667	450
2958	FAIRVIEW	1948	40.6333	90.1667	730
2993	FARMER CITY	1948-83	40.2333	88.6333	730
3109	FLORA	1901-83	38.6667	88.4833	490
3257	FREEPORT	1909-73	42.3000	89.6167	780
3262	FREEPORT SEWAGE PLANT	1948-83	42.2833	89.6000	750
3290	FULTON DAM 13	1948-83	41.9000	90.1500	590
3304	GALATIA 1 W	1948-51	37.8500	88.6167	410
3312	GALENA	1948-83	42.4167	90.4333	600
3320	GALESBURG	1948-83	40.9500	90.3667	780
3335	GALVA	1901-83	41.1667	90.0333	850
3369	MORRIS 5 N	1970-83	41.4500	88.4000	580
3384	GENESEO	1948-83	41.4500	90.1667	640
3413	GIBSON CITY	1948-83	40.4667	88.3833	750

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
3455	GLADSTONE DAM 18	1948-83	40.8833	91.0333	540
3482	GLENDALE EXP FARM	1948-67	37.4333	88.6833	500
3522	GOLCONDA DAM 51	1948-80	37.3667	88.4833	350
3530	GOLDEN	1948-83	40.1000	91.0167	730
3572	GRAFTON	1948-83	38.9667	90.4333	400
3580	GRAND CHAIN DAM 53	1948-49	37.2000	89.0500	390
3595	GRAND TOWER 2 N	1948-83	37.6667	89.5167	370
3666	GREENFIELD	1948-83	39.3333	90.2000	560
3683	GREENUP	1948-83	39.2500	88.1667	550
3693	GREENVILLE	1901-83	38.8833	89.4000	560
3709	GRIDLEY	1948-60	40.7500	88.8833	750
3717	GRIGGSVILLE	1901-83	39.7167	90.7333	690
3850	HARDIN	1948-74	39.1500	90.6167	440
3879	HARRISBURG	1901-83	37.7333	88.5333	370
3884	HARRISBURG HIWAY 13 BR	1948-83	37.7333	88.5000	--
3930	HAVANA	1901-66	40.3000	90.0500	450
3940	HAVANA 2	1948-83	40.3000	90.0667	460
4013	HENNEPIN POWER PLANT	1962-83	41.3000	89.3167	460
4108	HILLSBORO	1901-83	39.1500	89.4833	630
4198	HOOPESTON	1902-83	40.4667	87.6667	720
4269	HUDSON LK BLOOMINGTON	1948-51	40.6667	88.9333	740
4312	HUTSONVILLE	1948-51	39.1167	87.6667	--
4317	HUTSONVILLE POWER PLANT	1948-83	39.1333	87.6667	460
4355	ILLINOIS CITY DAM 16	1948-83	41.4167	91.0167	550
4442	JACKSONVILLE	1901-83	39.7333	90.2333	610
4447	JACKSONVILLE SEWAGE PL	1948-70	39.7333	90.2333	580
4465	JANESVILLE	1951	39.3667	88.2500	--
4489	JERSEYVILLE	1948-83	39.1167	90.3333	640
4530	JOLIET BRANDON ROAD DAM	1948-83	41.5000	88.1000	540
4535	JOLIET WB AP	1901-74	41.5000	88.1667	580
4593	KANKAKEE	1917-73	41.1167	87.8667	630
4598	KANKAKEE 4 NW	1948-60	41.1333	87.9333	630
4603	KANKAKEE SEWAGE PLANT	1948-83	41.1333	87.8833	640
4629	KASKASKIA R NAV LOCK	1974-83	37.9833	89.9500	380
4655	KEITHSBURG	1948-83	41.1000	90.9500	540

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
4710	KEWANEE	1948-83	41.2333	89.9167	850
4715	KEWANEE BAKER PARK	1948-51	41.2500	89.9167	800
4729	KICKAPOO ST MARYS CH	1948-50	40.7833	89.7500	--
4739	KINCAID	1973-83	39.6000	89.4167	540
4765	KIRKWOOD 3 W	1956-58	40.8667	90.8000	700
4766	KIRKWOOD 2 NNE	1956-58	40.9000	90.7333	760
4805	HENRY	1948-83	41.1167	89.3667	490
4823	LA HARPE 1 SW	1901-83	40.5833	90.9667	690
4879	LANARK	1948-54	42.1000	89.8333	880
4957	LAWRENCEVILLE	1967-83	38.7167	87.6833	450
4959	LAWRENCEVILLE 5 S	1948-66	38.6667	87.6833	470
5036	LEROY	1948-60	40.3500	88.7667	780
5079	LINCOLN	1906-83	40.1500	89.3667	590
5084	LINCOLN 2	1948-53	40.1500	89.3500	600
5131	LOCKPORT LOCK AND DAM	1948-51	41.5667	88.0833	580
5136	LOCKPORT POWER HOUSE	1948-51	41.5667	88.0833	580
5216	LOUISVILLE	1948-51	38.7667	88.5000	480
5272	MACKINAW	1948-83	40.5333	89.3500	650
5280	MACOMB	1948-83	40.4667	90.6667	610
5294	MAKANDA 1 NW	1951-76	37.6333	89.2333	680
5326	MARENGO	1901-83	42.2500	88.6000	820
5334	MARIETTA	1948-51	40.5000	90.4000	550
5342	MARION 2 W	1948-83	37.7333	88.9500	450
5364	MAROA SEWAGE PLANT	1948-51	40.0500	88.9500	0
5372	MARSEILLES LOCK	1948-83	41.3333	88.7500	490
5380	MARSHALL 1 W	1948-76	39.3833	87.7167	610
5405	MASCOUTAH	1948-54	38.4833	89.8000	430
5413	MASON CITY	1948-83	40.2000	89.7000	580
5430	MATTOON	1948-83	39.4667	88.3500	720
5493	MCHENRY	1948-83	42.3500	88.2667	750
5498	MCHENRY 2 S	1948-60	42.3167	88.2500	740
5515	MCLEANSBORO	1901-83	38.0833	88.5333	500
5539	MEDORA	1948-83	39.1667	90.1333	620
5651	MILLBROOK	1948-70	41.6000	88.5500	610
5712	MINONK	1901-83	40.9000	89.0333	750

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
5751	MOLINE WB AIRPORT	1948-83	41.4500	90.5167	590
5768	MONMOUTH	1901-83	40.9000	90.6500	760
5791	MONTICELLO	1948-64	40.0333	88.5667	630
5792	MONTICELLO 2	1964-83	40.0333	88.5833	660
5820	MORRIS	1948-81	41.3500	88.4333	--
5825	MORRIS 3 NNE	1948-70	41.4000	88.4000	550
5833	MORRISON	1901-83	41.8167	89.9667	670
5841	MORRISONVILLE 4 SE	1948-83	39.3667	89.4000	--
5846	MORRISONVILLE 3 E	1901-71	39.4167	89.4000	630
5888	MT CARMEL	1948-83	38.4167	87.7667	470
5893	MT CARMEL WATERWORKS	1902-77	38.4167	87.7500	420
5901	MOUNT CARROLL	1901-83	42.0833	89.9667	820
5917	MOUNT OLIVE	1948-83	39.0667	89.7167	680
5935	MOUNT STERLING	1948-83	39.9833	90.7667	710
5943	MOUNT VERNON	1901-83	38.3167	88.9000	460
5950	MOWEAQUA	1963-83	39.6333	89.0333	620
5983	MURPHYSBORO WATERWORKS	1948-51	37.7667	89.3167	420
6011	NASHVILLE 3 NW	1948-83	38.3833	89.4000	460
6069	NEWARK 7 E	1948-64	41.5333	88.4500	710
6080	NEW BOSTON DAM 17	1948-83	41.1833	91.0500	550
6085	NEW BOSTON 2 NW	1948-60	41.1833	91.0167	--
6093	NEW BURNSIDE	1901-64	37.5833	88.7667	560
6159	NEWTON	1948-83	39.0000	88.1667	510
6200	BLOOMINGTON NORMAL	1977-83	40.5167	89.0000	790
6383	OLIVE BRANCH 1 NW	1983	37.1833	89.3667	350
6446	OLNEY	1901-83	38.7333	88.0833	480
6490	OREGON	1949-51	42.0000	89.3333	690
6492	OREGON POWER PLANT	1948-56	42.0167	89.3333	700
6526	OTTAWA	1901-83	41.3667	88.8333	470
6558	PALESTINE	1901-83	39.0000	87.6167	520
6579	PANA	1901-83	39.3833	89.0833	700
6605	PARIS SEWAGE PLANT	1948-51	39.6167	87.6833	740
6610	PARIS WATERWORKS	1901-83	39.6333	87.7000	740
6616	CHICAGO HEIGHTS	1952-83	41.5000	87.6333	630
6661	PAW PAW	1948-83	41.6833	88.9833	930

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
6670	PAYSON	1948-83	39.8167	91.2333	760
6706	PEORIA LOCK AND DAM	1948-51	40.6167	89.6500	440
6711	PEORIA WB AIRPORT	1948-83	40.6667	89.6833	650
6725	PEOTONE	1948-83	41.3333	87.8000	720
6753	LA SALLE PERU	1948-83	41.3333	89.1333	520
6760	PETERSBURG	1948-83	40.0167	89.8500	520
6819	PIPER CITY	1949-83	40.7500	88.1833	670
6833	PITTSFIELD WATERWORKS	1948-51	39.6500	90.8000	720
6861	PLEASANT HILL 2 E	1948-76	39.4500	90.8333	540
6910	PONTIAC	1903-83	40.8833	88.6167	650
6973	PRAIRIE DU ROCHER	1948-83	38.0833	90.1000	390
6996	PRINCETON 1 S	1948-51	41.3500	89.4667	700
7004	PRINCEVILLE 2 NW	1948-83	40.9500	89.7833	750
7014	PROPHETSTOWN	1948-51	41.6667	89.9333	620
7067	QUINCY	1901-77	39.9500	91.4000	600
7072	QUINCY CAA AP	1948-83	39.9333	91.1833	760
7077	QUINCY DAM 21	1948-83	39.9000	91.4333	480
7082	QUINCY MEMORIAL BRIDGE	1948-83	39.9333	91.4000	480
7150	RANTOUL CHANUTE AF BASE	1948-83	40.3000	88.1500	740
7187	REND LAKE DAM	1974-83	38.0333	88.9833	460
7244	RICHVIEW	1948-51	38.3667	89.1833	540
7336	ROBERTS 3 N	1912-68	40.6667	88.1833	740
7349	ROCHELLE	1948-78	41.9167	89.0667	800
7354	ROCHELLE	1978-83	41.9000	89.0667	780
7375	ROCKFORD	1905-57	42.2500	89.0833	720
7377	ROCKFORD 6 ENE	1950-83	42.3000	88.9833	850
7380	ROCKFORD CAA AP	1900-55	42.3500	89.0500	740
7382	ROCKFORD CAA AP	1951-83	42.2000	89.1000	730
7388	ROCK ISLAND DAM 15	1948-53	41.5167	90.5667	570
7400	ROCKPORT	1948-71	39.5333	91.0000	470
7551	RUSHVILLE	1901-83	40.1167	90.5667	660
7603	STE MARIE MISSION HSE	1948-83	38.9333	88.0167	--
7636	SALEM	1948-83	38.6333	88.9500	540
7859	SHAWNEETOWN NEW TOWN	1948-83	37.7167	88.1833	400
7952	SIDELL	1948-83	39.9167	87.8167	690

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
7988	SKOKIE	1954-62	42.0333	87.7333	600
7990	SKOKIE N S TREAT WKS	1948-51	42.0167	87.7167	600
8020	SMITHLAND L AND D	1980-83	37.1667	88.4333	360
8145	LACON	1952-53	41.0333	89.4000	480
8147	SPARTA	1901-83	38.1333	89.7000	540
8179	SPRINGFIELD WB AP	1948-83	39.8333	89.6667	590
8184	SPRINGFIELD WB CITY	1948-55	39.8000	89.6500	600
8189	SPRINGFIELD 4 SE	1969-73	39.7667	89.6000	570
8278	STICKNEY W SIDE TREAT	1948-51	41.8167	87.7667	640
8353	STREATOR	1948-53	41.1167	88.8333	630
8389	SULLIVAN WATERWORKS	1948-83	39.5667	88.6167	690
8452	SYCAMORE	1901-83	41.9833	88.6833	840
8460	TABLE GROVE	1948-56	40.3667	90.4333	730
8491	TAYLORVILLE	1948-72	39.5500	89.3000	630
8604	TISKILWA 1 N	1948-83	41.3333	89.5000	510
8630	TOULON	1948-75	41.0833	89.8667	750
8684	TUSCOLA	1948-83	39.8000	88.2833	650
8740	URBANA	1903-83	40.1333	88.2167	740
8745	URBANA EXP FARM	1948-51	40.1000	88.2500	--
8750	URBANA WATERWORKS	1948-63	40.1167	88.2167	--
8756	UTICA STARVED ROCK DAM	1948-83	41.3167	88.9833	460
8781	VANDALIA	1948-83	38.9667	89.1167	500
8783	VANDALIA CAA AP	1951-73	38.9833	89.1667	530
8860	VIRDEN	1948-83	39.5000	89.7667	670
8870	CHANDLERVILLE	1963-83	40.0500	90.1500	480
8916	WALNUT	1901-83	41.5500	89.5833	710
8976	WARSAW	1948-62	40.3500	91.4333	490
8990	WASHINGTON	1948-51	40.7000	89.4000	740
9002	WATERLOO	1948-83	38.3333	90.1500	720
9010	WATERMAN	1948-51	41.7667	88.7667	780
9021	WATSEKA	1948-83	40.7667	87.7333	630
9029	WAUKEGAN	1923-83	42.3667	87.8667	680
9040	WAYNE CITY	1948-83	38.3500	88.5833	--
9090	WENONA	1948-51	41.0500	89.0500	700
9140	WEST FRANKFORT 8 E	1948-51	37.9000	88.8000	480

Table 6.--Precipitation gages included in the data base to describe antecedent-precipitation indices for Illinois--Continued

Station number	Station name[1]	Period of record	Latitude	Longitude	Elevation
9221	WHEATON COLLEGE	1948-83	41.8667	88.1000	750
9241	WHITE HALL 1 E	1902-83	39.4333	90.3833	580
9274	WILCOX	1948-77	38.6333	88.3000	--
9354	WINDSOR	1904-83	39.4333	88.6000	690

[1]Station names are exactly as shown in National Oceanic and Atmospheric Administration report series "Climatological Data, Illinois" (National Oceanic and Atmospheric Administration, National Climatic Data Center, Information Services Division, Asheville, North Carolina).

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